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Description of the LASSO Data Bundles Product

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LASSO web page: https:///www.arm.gov/capabilities/modeling/lasso/
LASSO data bundle documentation, v1 doi:10.2172/1469590
LASSO data set doi:10.5439/1342961

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Acronyms and Abbreviations

1D	one-dimensional
2D	two-dimensional
3D	three-dimensional
ADC	ARM Data Center
AERI	atmospheric emitted radiance interferometer
AERIoe	optimally interpolated AERI
AGL	above ground level
ARM	Atmospheric Radiation Measurement
ARSCL	Active Remote Sensing of Clouds
BNL	Brookhaven National Laboratory
CF	cloud fraction
Co-PI	co-principal investigator
COGS	Clouds Optically Gridded by Stereo
DDH	Diagnostics in the Horizontal Domains
DOE	U.S. Department of Energy
DOI	digital object identifier
ECMWF	European Centre for Medium-Range Weather Forecasting
EOSDIS	Earth Observing System Data and Information System
ESRL	Earth System Research Laboratory
ETS	equitable threat score
FASTER	Fast-physics System Testbed & Research
FTP	file transfer protocol
GOES	Geostationary Operational Environmental Satellite
ID	identification number
IFS	Integrated Forecast System
KAZRARSCL	Ka-band ARM Zenith Radar Active Remote Sensing of Clouds Value-Added Product
LASSO	Large-Eddy Simulation (LES) ARM Symbiotic Simulation and Observation
LASSO-O	LASSO operations software
LCL	lifting condensation level
LES	large-eddy simulation
LFC	level of free connection
LLNL	Lawrence Livermore National Laboratory
LWP	liquid water path
MET	surface meteorological instrumentation

MSDA	Multiscale Data Assimilation
MWR	microwave radiometer
MWRRet	Microwave Radiometer Retrieval
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NWS	National Weather Service
OSSE	observation system simulation experiment
PBL	planetary boundary layer
PI	principal investigator
PNNL	Pacific Northwest National Laboratory
QC	quality control
RAP	Rapid Refresh
RL	Raman lidar
RMS	root mean square
RRTMG	Rapid Radiation Transfer Model for Global Climate Models
RWP	radar wind profiler
SAM	System for Atmospheric Modeling
SGP	Southern Great Plains
SNR	signal-to-noise ratio
SONDE	balloon-borne sounding system
THREDDS	Thematic Real-time Environmental Distributed Data Services
TKE	turbulent kinetic energy
TSI	total sky imager
UTC	coordinated universal time
VAP	value-added product
VARANAL	variational analysis
WRF	Weather Research and Forecasting Model

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1.0 Introduction

1.1 The LASSO Project

The U. S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) user facility began a pilot project in May 2015 to design a routine, high-resolution modeling capability to complement ARM's extensive suite of measurements. This modeling capability has evolved into the Large-Eddy Simulation (LES) ARM Symbiotic Simulation and Observation (LASSO) activity (Gustafson et al. 2020). The associated LASSO datastream broadly consists of "data bundles" that contain high-resolution model output, input files, observations for evaluation, and skill scores for the simulations. The initial focus of LASSO is on shallow convection at the ARM Southern Great Plains (SGP) atmospheric observatory.

The availability of LES simulations with concurrent observations serves many purposes. LES helps bridge the scale gap between DOE ARM observations and models, and the use of routine LES adds value to observations. It provides a self-consistent representation of the atmosphere and a dynamical context for the observations. Further, it elucidates unobservable processes and properties. LASSO generates a simulation library for researchers that enables statistical approaches beyond a single-case mentality. It also provides tools necessary for modelers to reproduce the LES and conduct their own sensitivity experiments.

The LASSO library of data bundles is designed to facilitate a wide range of research. For an observationalist, LASSO can help inform instrument remote-sensing retrievals, conduct observation system simulation experiments (OSSEs), and test implications of radar scan strategies or flight paths. For a theoretician, LASSO can help calculate estimates of fluxes and co-variability of values, and test relationships without having to run the model personally. For a modeler, LASSO can help one know ahead of time which days have good forcing, have co-registered observations at high-resolution scales, and have simulation inputs and corresponding outputs to test parameterizations. Further details on the overall LASSO project are available at https://www.arm.gov/capabilities/modeling/lasso.

1.2 LASSO's History

The current data bundle approach to the LASSO datastream has evolved through two preliminary versions during the LASSO pilot phase. The Alpha 2 release was the second and final early data release for the LASSO pilot phase, which closely matches the format established for version 1 of LASSO. Briefly:

- The Alpha 1 release occurred in July 2016 and was the first dissemination of simulations and analysis tools from LASSO, focusing on five shallow convection cases from spring-summer 2015 at the SGP site. More information on the Alpha 1 release is available at https://www.arm.gov/capabilities/modeling/lasso/releases/alpha1 and via the Description of the LASSO Alpha 1 Release (Gustafson et al. 2016).
- The Alpha 2 release (Gustafson et al. 2018), released in September 2017, focuses on 13 shallow convection cases during May to August 2016 at the SGP site. These 13 cases from 2016 have been expanded to include the 2015 case dates from Alpha 1 via a supplemental release to Alpha 2 in July

2018. Alpha 2 expands upon Alpha 1 through the use of additional ARM observations when deriving model forcing data and when evaluating the LES results. Improvements were also made in the LES to increase accuracy. A list of changes between versions is provided in Appendix A.

- The complete set of LASSO data products and tools can be accessed via https://www.arm.gov/capabilities/modeling/lasso/releases. This web page serves as a high-level interface to the data files, collectively called data bundles, which consist of LES inputs and outputs, ARM observations co-registered on the model grid, model diagnostics and skill scores, and quicklooks of various fields. An interface is provided through a web browsing tool, called the LASSO Bundle Browser, for users to find simulations of interest through examination of the LES performance relative to select ARM observations.
- At the conclusion of the LASSO pilot project, a recommendation report (Gustafson et al. 2017) was released for implementing the ongoing LASSO datastream. This established the framework for LASSO version 1, which consists of cases for 2017 and later. The version 1 framework differs from the alpha versions in that sensitivity tests are no longer included. These were designed to assist with choosing the final configuration for the SGP shallow convection scenario, and the operational cost has been reduced by only generating the final domain configuration using the Weather Research and Forecasting (WRF) model. Simulations with different domain sizes, grid spacing, and with the System for Atmospheric Modeling (SAM) are no longer produced.

The LASSO simulations represent the typical behavior to be expected from LES using best-practice configurations and are valid for use in various research applications. However, as made evident by the comparisons to observations, there is a range of simulation behavior, so we encourage users to contact the LASSO team to ensure the details of the simulations are understood and that they are used appropriately for a given application.

The LASSO shallow-convection scenario currently has data bundles available during the years 2015–2019, culminating in ensemble simulations for 95 case days. Further production of shallow-convection data bundles at the SGP has been put into hiatus to redirect resources toward additional scenario types, such as deep convection and maritime clouds. The decision was also influenced by a portion of the 2020 season being impacted by COVID-19, which prevented radiosondes from being launched and the inability to perform maintenance on some instruments required them to be turned off. When time and resources permit, additional shallow-convection days may be processed in the future.

LASSO will continue to evolve over time, both for the configuration used for shallow convection at the SGP, and for additional locations and/or weather regimes. Efforts to improve the model configuration, forcings, and analysis tools are ongoing and will be based on user feedback and continued effort. We encourage users to explore the available simulations and tools and to share their experience and ideas for improvement with the LASSO team (lasso@arm.gov).

1.3 Highlighted Links

The LASSO ecosystem consists of several components that are intended to be viewed as a single entity. The documentation is referenced as doi:10.2172/1469590, the data bundles are referenced as doi:10.5439/1342961, and the Bundle Browser is the primary web interface for accessing the data bundles. Links to quicklook plots and ordering of data bundles can be accessed from the Bundle Browser. The Bundle Browser is the recommended method for accessing the data bundles due to its ease of use with LASSO data. Links to the different components are listed below.

Overview web page: https://www.arm.gov/capabilities/modeling/lasso

Information for most recent release: https://www.arm.gov/capabilities/modeling/lasso/releases/v1

Documentation: https://www.arm.gov/capabilities/modeling/lasso/releases/v1/citing-lasso

Bundle Browser: https://adc.arm.gov/lassobrowser

Metadata Table: https://adc.arm.gov/lassometadata

1.4 Proper Acknowledgment when Using LASSO

The primary citation for LASSO is the peer-reviewed article Gustafson et al. (2020). Additionally, the technical documentation and data set have separate DOIs, which also should be cited based on the applicable context. The technical documentation is an evolving document with updates as changes occur within the data bundles. A history of the documentation and links to each version of the document can be found at https://www.arm.gov/capabilities/modeling/lasso/releases/v1/citing-lasso. The citations for the LASSO article and technical document are:

> Gustafson, WI, AM Vogelmann, Z Li, X Cheng, KK Dumas, S Endo, KL Johnson, B Krishna, T Fairless, and H Xiao. 2020. The Large-Eddy Simulation (LES) Atmospheric Radiation Measurement (ARM) Symbiotic Simulation and Observation (LASSO) activity for continental shallow convection. *Bulletin of the American Meteorological Society* 101(4): E462–E479, https://doi.org/10.1175/BAMS-D-19-0065.1

> Gustafson, WI, AM Vogelmann, X Cheng, KK Dumas, S Endo, KL Johnson, B Krishna, Z Li, T Fairless, and H Xiao. 2020. Description of the LASSO Data Bundles Product. U.S. Department of Energy. DOE/SC-ARM-TR-216, http://dx.doi.org/10.2172/1469590

And, the citation directly referencing the data is:

> Atmospheric Radiation Measurement (ARM) user facility, 2017: LASSO Data Bundles. <<dates of the data used, e.g., 10 Jun 2016 or various dates>>, 36° 36′ 18.0″ N, 97° 29′ 6.0″ W: Southern Great Plains Central Facility (C1). Compiled by WI Gustafson, AM Vogelmann, X Cheng, S Endo, KL Johnson, B Krishna, Z Li, T Toto, and H Xiao. ARM Data Center: Oak Ridge, Tennessee, USA. Data set accessed <<insert date downloaded from web>> at http://dx.doi.org/10.5439/1342961

2.0 Modeling Details

2.1 LES Model Configuration

The LES model used for LASSO version 1 is the WRF model version 3.8.1 (Skamarock et al. 2008) with additional components developed for the DOE FAst-physics System TEstbed & Research (FASTER) project (Endo et al. 2015). The WRF-FASTER modification to WRF includes LES-specific output, such as domain-averaged profiles that are time-averaged between output times based on a specified sampling frequency. The model domain uses doubly periodic lateral boundary conditions with specified homogeneous surface fluxes.

The physics suite used with WRF is as follows: the Thompson microphysics scheme (Thompson et al. 2004, 2008), the shortwave and longwave Rapid Radiation Transfer Model for Global Climate Models (RRTMG) radiation schemes (Clough et al. 2005, Iacono et al. 2008, Mlawer et al. 1997), and the 1.5 order turbulent kinetic energy (TKE) approach (Deardorff 1980).

The domain configuration for the version 1 release use 100-m grid spacing and a domain that is 25 km across. The simulations use 226 levels that extend from the surface to 14.7 km. Vertical grid spacing is 30 m up to 5 km and then stretches to 300 m near the model top. We recognize that, while this all-purpose configuration is sufficient for testing the model forcings and various scientific applications, researchers may require higher resolutions or larger domains for some applications. To assist those researchers, we make the input forcings, assessments of their quality, and model evaluation data available so that the LASSO simulations may serve as a starting point for additional simulations configured and tailored to other needs (see the Data Bundles Section).

Other details for the model setup can be found in the “config” directories associated with each data bundle. The model code is mostly out of the box. Interested parties can contact the LASSO team (lasso@arm.gov) to obtain the specific code used for this release. The intent is to make a public repository of the code once automation of LASSO is complete.

2.2 Large-Scale Forcing, Surface Fluxes, and Initial Conditions

Initial profiles and surface forcings for the simulations come from multiple sources. All simulations for the 2017 and later case dates use 12 UTC radiosonde soundings from the Central Facility for the initial profiles and surface fluxes come from the observationally based ARM constrained variational analysis (VARANAL) product, discussed below. Note that the available Alpha 2 simulations for the 2015 and 2016 case dates include alternative input options as outlined in Gustafson et al. (2018).

Each LASSO data bundle contains the forcing file used to generate the associated LES output. The forcing data consist of horizontal advective tendencies of potential temperature and moisture, large-scale vertical velocity, and relaxation profiles for potential temperature, water vapor, and wind components. The tendencies due to large-scale vertical advection are calculated dynamically at each grid point using the prescribed vertical velocity. Note that the relaxation profiles are provided but nudging to these profiles is not done for LASSO. Surface fluxes for sensible and latent heat are also provided. Table 1 shows the different forcing-related variables and which files hold them within each data bundle. The large-scale forcing files contain both the tendency of the large-scale state as well as the tendency of the tendency. The latter are used within WRF for accumulating the large-scale tendency, which is applied to update the model state each time step.

Three different methodologies have been applied for deriving large-scale forcings to drive the LES models. The goal is to provide a vetted ensemble of LES runs for each case based on multiple forcings since the forcings are arguably one of the largest uncertainties for LES modeling. The three methodologies are also supplemented with different forcing region scales that may add additional model spread, as the best scale varies from case to case. This is particularly important for days when large variations occur around SGP that get averaged into the overall forcing, which is represented as a single profile that varies on an hourly basis.

VARANAL

The first forcing method is the ARM constrained variational analysis, VARANAL (Xie et al. 2004), which is based on Zhang and Lin (1997) and Zhang et al. (2001). VARANAL for this release uses the National Oceanic and Atmospheric Administration (NOAA) Rapid Refresh (RAP) analyses as a background gridded field that is then optimally merged with ARM and other observations using a variational approach. The standard VARANAL represents conditions over a 300-km region. Packaged with VARANAL are observation-based estimates of surface sensible and latent heat fluxes over the forcing region, which are used to drive the bottom boundary conditions of the LES.

ECMWF

The second forcing method is a data set derived from European Centre for Medium-Range Weather Forecasts (ECMWF) forecasts. This version of the large-scale forcing is based on the Diagnostics in the Horizontal Domains (DDH) system, which uses physical and dynamical tendencies directly from the ECMWF Integrated Forecast System (IFS) model to calculate closed budget terms. The three forcing scales generated for the 2016 and later cases using the DDH approach are 413 km, 114 km, and 9 km (a single IFS column). The Alpha 1 cases for 2015 use 16 km for the smallest scale due to the IFS using a coarser resolution during that period. The DDH domains larger than a single column are defined based on longitude and latitude and thus have the same size across years, with the possible exception of minor increments when the native grid changes due to the DDH algorithm selecting only whole-grid columns. Note that the spatial scales listed here are average side dimensions based on the square root of the forcing domain area.

MSDA

The third forcing method derives the large-scale forcing from convection-permitting WRF simulations constrained using the multiscale data assimilation (MSDA) methodology developed by Zhijin Li (Li et al. 2015a, 2015b, 2016). MSDA is implemented using the community-based Gridpoint Statistical Interpolation (GSI) data assimilation software in conjunction with a scale separation algorithm to combine observations representing coarse and fine scales to accurately reflect the atmospheric state. It leverages the large-scale fields from existing reanalyses or forecasts produced by operational centers, but constrains small-scale fields by assimilating ARM observations, satellite measurements, and observations from other meteorological observing networks.

In the case of LASSO, the MSDA is carried out on a nested region over the central United States with the finest grid using 2-km grid spacing for the SGP region. The 2-km grid spacing offers the flexibility of generating large-scale forcing for selected area sizes. In the released cases, the areas for 75 km, 150 km, and 300 km are used for examining the sensitivity of large-scale forcing to the selected area sizes.

Details regarding specific data included as inputs to MSDA varies based on what was available. In the 2015 cases, the assimilated ARM observations include ARM radiosonde soundings from the Central Facility, and temperatures and moistures from the surface meteorological instrumentation (MET) stations across the site. Additional measurements included in the assimilation process include NOAA operational observations and satellite radiances. These measurements have been supplemented with additional hourly wind profiles for the 2016 cases in Alpha 2. Alpha 2 provides two versions of MSDA, one with the Alpha 1 set of input data and a second that adds wind profiles. The wind profiles come from the four SGP radar wind profilers (RWP). One is located at the Central Facility and the other three are spaced approximately 15 km away from the Central Facility. These profiles have been quality-controlled to remove clutter effects and spurious values and are used within the MSDA. The MSDA forcing used for the 2017 cases matches the Alpha 2 methodology that includes RWP wind profiles.

2.3 Converting WRF Inputs for Use in Alternative Models

One aim for LASSO is to be a launching point for researchers that require doing their own simulations. These researchers can estimate the expected behavior of their models through the LASSO LES behavior. Then, particular forcings and case dates can be more quickly chosen. To facilitate this approach, the WRF input files need to be converted for use with whichever models the researchers use. Toward this end, an example program is available that converts the WRF-FASTER input files for use with SAM. The Python script is located in the config directory of each data bundle and is called sam_input_generation.py. Instructions for using the script are embedded at the top of the code.

Note that assumptions must be made when converting the model inputs due to differences in how the models operate. For the case of converting from WRF to SAM, the surface pressure is held constant in WRF LES runs throughout the entire simulation, whereas in SAM the surface pressure varies and is used to convert forcing data to SAM’s vertical coordinate system. This is straightforward except for one caveat. The surface pressure provided by the spatially averaged forcing data set source, i.e., MSDA, ECMWF, or VARANAL, can be inconsistent with the point-based surface pressure from the radiosonde used to initialize the model. So, one must make an assumption for how to handle the discrepancy when integrating from the initial model time to the next forcing update. In the sample conversion code, the LASSO team uses the initial offset between the two surface pressures to adjust the subsequent surface pressure values for the remainder of the simulation. This assumes that the bias changes only slightly throughout the simulation period but has the advantage of not introducing a discontinuity early in the simulation.

Another example of differing assumptions between models is noted in Angevine et al. (2018) for the handling of surface fluxes. In his case, Angevine needed to account for differences in how WRF in LES mode handles specified surface fluxes compared to how his single-column model version of WRF handles surface fluxes and the coupling of the skin and surface layers.

Table 1 maps the variables in the WRF input files to the equivalent variables in a SAM input file. This can be used as an example for determining how to convert inputs to other models besides SAM.

Table 1. Contents of input files and mapping of forcing-related variables between WRF and SAM inputs.

	WRF File-name	WRF Variable Name	SAM File-name	SAM Variable Name	Variable Description
Surface Forcing	input_sfc_forcing.nc	Times	sfc	day	Timing info (date-time string; day of year)
		PRE_TSK		sst	Skin temperature (K)
		PRE_SH_FLX		H	Surface sensible heat flux (W m^{-2})
		PRE_LH_FLX		LE	Surface latent heat flux (W m^{-2})
				TAU	Surface momentum flux (m^{2} s^{-2}) NOT PRESCRIBED
		PRE_ALBEDO			Surface albedo (unitless)
		PRE_TSK_TEND			Skin temperature tendency (K s^{-1})
		PRE_SH_FLX_TEND			Surface sensible heat flux tendency (W m^{-2} s^{-1})
		PRE_LH_FLX_TEND			Surface latent heat flux tendency (W m^{-2} s^{-1})
		PRE_ALBEDO_TEND			Surface albedo tendency (s^{-1})
Initial Sounding	wrfinput_d01	Times	snd	day	Timing info (date-time string; day of year)
		PSFC		pres0	Surface pressure (WRF: Pa, SAM: hPa)
		(PH + PHB)/9.81		z	Height above ground level (m)
		P + PB		p	Pressure (WRF: Pa, SAM: hPa) NOT USED FOR SAM
		T + 300		tp	Potential temperature (K)
		QVAPOR		q	Water vapor mixing ratio (WRF: kg kg^{-1}, SAM: g kg^{-1})
		U, V		u, v	Horizontal wind components (m s^{-1})
Large-Scale Forcing	input_ls_forcing.nc	Times	lsf	day	Timing info (date-time string; day of year)
		P_SFC_OPT		pres0	surface pressure (hPa) (not used by WRF but included for use by other models)
		Z_LS		z	Height above ground level (m)
		TH_ADV		tpls	Large-scale potential temperature tendency (K s^{-1}) (only potential temperature tendency due to large-scale horizontal advection is applied)
		QV_ADV		qls	Large-scale moisture tendency (WRF: kg kg^{-1} s^{-1}, SAM: g kg^{-1} s^{-1}) (only moisture tendency due to large-scale horizontal advection is applied)
		U_LS, V_LS		uls, vls	Large-scale horizontal winds to nudge toward (m s^{-1}) NOT USED
		W_LS		wls	Large-scale vertical velocity (m s^{-1}) (tendencies due to large-scale vertical advection are calculated dynamically at each grid point using this prescribed vertical velocity)
		Z_LS_TEND			Time tendencies of Z_LS (m s^{-1})
		TH_ADV_TEND			Time tendency of TH_ADV (K s^{-2})
		QV_ADV_TEND			Time tendency of QV_ADV (kg kg^{-1} s^{-2})
		U_LS_TEND, V_LS_TEND, W_LS_TEND			Time tendencies of wind components (m s^{-2})
		TH_RLX			Potential temperature profile for nudging (K) NOT USED
		QV_RLX			Water vapor mixing ratio profile for nudging (kg kg^{-1}) NOT USED
		TH_RLX_TEND			Time tendency of TH_RLX (K s^{-1}) NOT USED
		QV_RLX_TEND			Time tendency of QV_RLX (kg kg^{-1} s^{-1}) NOT USED

3.0 Evaluation Data

Simulations are evaluated using ground-based ARM observations and retrievals of boundary-layer cloud and thermodynamic properties. This section describes the observations used thus far, and the next section describes the diagnostics and metrics. As discussed below, a meaningful comparison between observations and model output requires that they be co-registered on the same spatial and temporal grid and processed, as necessary, such that an apples-to-apples comparison may be made between a model-comparable observational quantity and an observation-comparable model quantity. Some of the methodology is based on Appendix B in Vogelmann et al. (2015). LASSO output provides 1-h averages for model-observation comparisons unless otherwise noted. High-frequency (in time) observations are also provided for observations used by LASSO for 2018 and 2019 at near-native resolution. See Appendix C for details on ARM value-added products (VAPs) used directly by LASSO.

In-Cloud Liquid Water Path (LWP)

Currently, the observed in-cloud liquid water path (LWP) (g m^{-2}) is based on microwave radiometer (MWR)-only retrievals from the 2-channel MWR retrieval (MWRRet) (Turner et al. 2007) and retrievals from a new optimal estimation framework (AERIoe) (Turner and Löhnert 2014) that uses spectral infrared radiances measured by the atmospheric emitted radiance interferometer (AERI) and MWR radiances. The resulting LWP data have excellent sensitivity at low LWP ($1 < LWP < 40$ g m^{-2}) and a full dynamic LWP range (up to 1000 g m^{-2}). Note that these retrievals have passed preliminary quality control (QC) but more rigorous QC is needed before they should be considered final. Additional work is ongoing to get improved LWP observations, and the AERIoe product is expected to improve as it better incorporates the MWR data.

Clear-sky screening is applied to the observations and simulations in a consistent manner so that only in-cloud values are used in the averaging (i.e., it is not a domain-averaged, all-sky value) for values in the *sgplassodiagobsmod1C1* files. Note that the LWP values in the *wrfstat* file are all-sky values averaged for the entire model domain. Only retrievals from a single site at the SGP Central Facility are currently available. (See Appendix B for further details and Appendix C for a description of the LASSO Liquid Water Path VAP used to provide these values and their high-frequency output.)

1D Boundary-Layer Cloud Fraction (1D CF)

Two estimates of cloud fraction are used to approximate the measurement uncertainty of the shallow cloud fraction experienced at the surface. One is the hemispheric sky cover from the total sky imager (TSI), and the other is a column measurement of the cloud frequency of occurrence below 5 km derived from the ARM Active Remote Sensing of Clouds (ARSCL) VAP (Clothiaux et al. 2000), which uses radar and lidar measurements to generate a vertically resolved cloud mask for the narrow column above the instruments. High-frequency values of the two estimates of observational cloud fraction are provided directly by the *sgpcldfrac* VAP, discussed in Appendix C.

Cloud fraction is computed from the simulations in a manner following from the computation of in-cloud LWP (described in Appendix B). The recommended one-dimensional (1D) CF measurement is from the TSI, as clouds above the boundary-layer clouds, e.g., cirrus, generally have a negligible impact on CF for the cases provided when boundary-layer cloud is present. (See Appendix B for further details.) Correlation between the TSI CF and ARSCL CF in the diagnostic plots indicates that clouds above the boundary layer have a negligible impact on the TSI CF whereas lack of correlation indicates the opposite.

2D Time-Height Cloud Mask

Two-dimensional (2D) cloud masks of the time-height location of cloud are used to assess the simulated cloud-base height, approximate vertical extent, and timing of cloud onset and decay. The observed cloud mask is generated from the ARSCL VAP, in which cloud fractional occurrence is determined for

15-minute windows and frequencies greater than zero are masked as being cloud. The lowest ARSCL cloud mask is 160 m above the ground, so only clouds at or above this level are compared to the simulations. The current cloud mask for simulations is obtained from grid cells with total hydrometeor mixing ratios greater than 10^{-7} kg kg^{-1}. The presence of liquid water cloud is relatively insensitive to this mixing ratio threshold value, but the presence of cirrus clouds is much more sensitive to the threshold. Only clouds below 5 km are treated in the 2D metric, as discussed later. Note that the *sgpcldfrac* VAP, discussed in detail in Appendix C, is the direct source for the high-frequency observations of cloud fraction.

The cloud masks available in the LASSO data bundles are useful for assessing the gross features of the simulated vertical distribution of cloud, but caution should be used to not over-interpret the results. This comparison assumes that the frozen turbulence assumption is valid, where the clouds sampled in the narrow column above the instruments is representative of the cloud field, which becomes more problematic for lower values of the 1D CF. Boundary-layer clouds may also be difficult to observe adequately when their radar reflectivity is low or when there is insect contamination (Lamer and Kollias 2015). For example, Figure 1 shows a case when pronounced insect contamination is likely. A methodology is being investigated to identify and possibly account for insects in the 2D cloud mask. Finally, improved estimates of CF will be included from multiview stereophotogrammetry (Romps and Öktem 2018) available from the Clouds Optically Gridded by Stereo (COGS) VAP. A release of a LASSO evaluation product that uses COGS for the observation in the skill scores is anticipated in fall 2020.

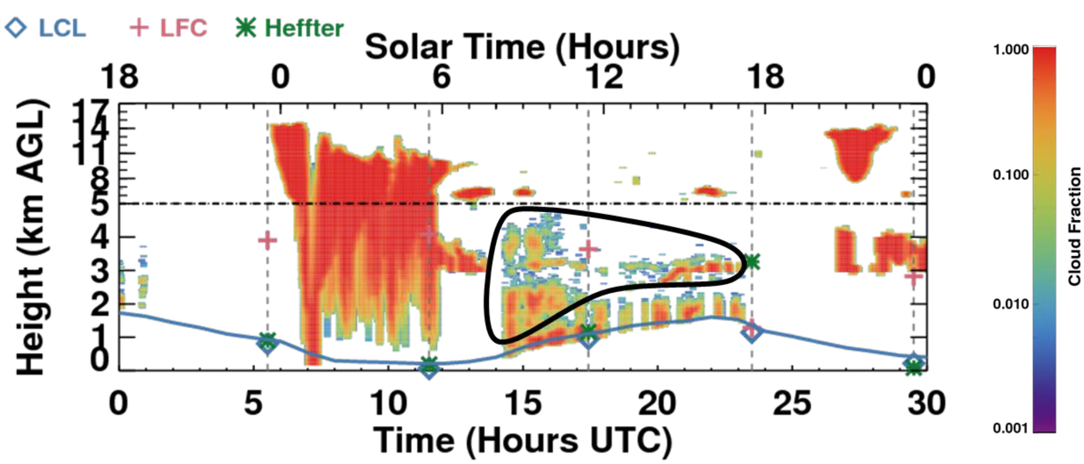

Figure 1. The 2D time-height cloud frequency from ARSCL for 30 June 2017. Based on close inspection of the data, much of the cloud fraction encircled by the black line is likely from insect contamination.

Regional Lifting Condensation Level Height

The lifting condensation level height (LCL, m) is determined from continuous surface air observations of relative humidity and temperature as the altitude where the surface air moisture equals saturation following a dry-adiabatic ascent. Values are computed from surface meteorological observations and the same calculation is applied to the lowest air layer in the simulations, enabling a consistent observation-model comparison. In Alpha 1, LCL values were computed from the MET observations at the ARM Central Facility. In Alpha 2 and later, this value is available ("LCL") plus a domain-averaged LCL ("LCL_domain") computed from all ARM MET stations and the Mesonet stations within 60 km of the Central Facility. The regional variation of the latter is quantified as a standard deviation. The LCL heights of the individual values for the latter are offset according to site altitude to account for any height difference of the station relative to the SGP Central Facility. LASSO obtains this data from the *sgplcl* VAP (Toto et al. 2020).

Surface Temperature and Moisture

The SGP Central Facility MET station provides continuous measurements of surface air temperature, $T_{surface}$ (K), and moisture in the forms of mixing ratio, $QV_{surface}$ (g kg^{-1}), and relative humidity, $RH_{surface}$ (%), that are compared to values from the lowest model layer.

Boundary-Layer Thermodynamic Profiles

At sonde launch times, simulated thermodynamic profiles are compared to the lowest 5 km of the atmosphere observed by soundings and Raman lidar-based profiles of temperature and water vapor mixing ratio at the Central Facility. Raman lidar measurements provide high-frequency vertical profiles (~75 m vertical spacing every 10 minutes) of the boundary-layer water vapor mixing ratio, temperature, and relative humidity up to cloud base (see Appendix B for details). Water vapor profiles are provided from the Raman lidar above 0.1 km. Temperature profiles are a blend of the AERIoe profile retrievals and Raman lidar retrievals (see Appendix B).

Mid-Boundary-Layer Moisture and Temperature

The mid-boundary-layer moisture and temperature are an average over a 200-m-thick layer from 0.5– 0.7 km. The Raman lidar-based thermodynamic profiles described above are used for the averaging. The values are averaged using a one-hour moving window to produce mid-boundary-layer-averaged water vapor mixing ratio, $QV_{boundary\ layer}$ (g kg^{-1}), temperature, $T_{boundary\_layer}$ (K), and relative humidity, $RH_{boundary\_layer}$ (%). These values are compared to the simulated values within the same height range. The *lassobltherm*o VAP, discussed in detail in Appendix C, provides the high-frequency observations used in LASSO's hourly averaged values for evaluation.

Regional Boundary-Layer Cloud-Base Height

A regional-averaged boundary-layer cloud-base height is determined from five Doppler lidar estimates. Doppler lidars are located at the Central Facility and at four extended facilities surrounding the Central Facility about 45 km away. The Doppler lidar cloud-base heights are available at 10-minute intervals and are screened for clouds linked to boundary-layer fluxes through a comparison to the LCL at each site. Hourly averages are taken of values that pass the screening and a standard deviation characterizes the regional variability. The *lassodlcbhshcu* VAP, discussed in detail in Appendix C, provides the high-frequency observations.

4.0 Diagnostics and Skill Scores

The evaluation data are used to assess model behavior using diagnostic plots and quantify model performance using skill scores. Diagnostics plots display comparable observed and simulated values that have been co-registered on the same spatial and temporal grid and may be accompanied by basic statistical quantities (e.g., mean, root mean square [RMS], etc.). Skill scores are metrics that quantify the model performance seen in the diagnostic plots such that simulation quality can be numerically compared for different variables. Data files and quicklook plots of the diagnostics and skill scores are available within the data bundles, and a set of key skill scores are used in the LASSO Bundle Browser for users to find and select simulations based on their performance (see the LASSO Data Bundles and Tools Section).

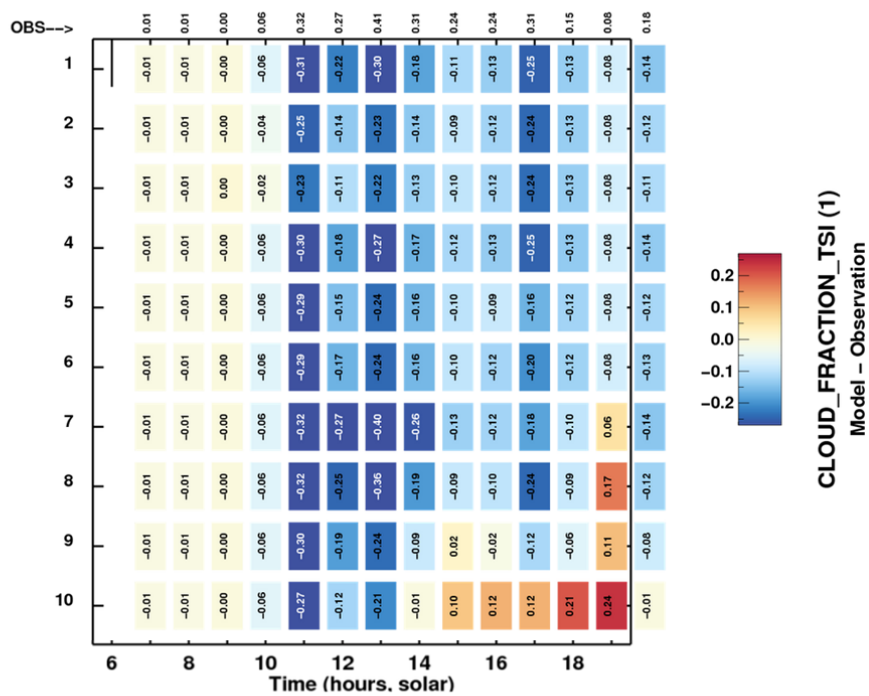

Figure 2. Heat map example of simulated cloud fraction compared to the TSI for the 27-Jun-2015 case. Simulation number is given by the left column and the local, solar time is given at the bottom. The top row gives the observational mean for each hour and the last value outside the box is the daily mean. The grid provides the corresponding differences of the simulated values (model-observation) that are color-coded by the key at the right.

4.1 Diagnostic Plots

Heat maps provide in a single plot an overview of model performance of a variable for all simulations within a case day. An example is given in Figure 2 where the magnitudes of the model-observation differences are provided as colored boxes for the diurnal cycle of each simulation. Heat map quicklooks (.png) are generated for: LCL, LCL_Domain; boundary-layer cloud-base height, CF(ARSCL); CF(TSI); LWP (linear y-axis); LWP (log y-axis); mid-boundary-layer Qv, RH, T; and surface Qv, RH, T. They are available for display via the “Heat Maps” button within the left column of the Bundle Browser and they are also stored within the data bundles, where they can be accessed using "heat_maps.html" located within the metrics directory of the *sgplassodiagconfobsmod#C1.m1.YYYYMMDD.tar* file of each data bundle, where YYYYMMDD is the case date and # is the simulation ID.

A series of other quicklook diagnostics plots are used to compare specific simulations to observations, which includes thermodynamic profiles at sounding times. Examples are given in Figure 3. They are available for display from within the Bundle Browser via the "Diagnostics" links in the browser's table. And, the diagnostic plots are stored in the *sgplassodiagconfobsmod#C1.m1.YYYYMMDD.tar* file for each simulation where they can be easily viewed using the "plots.html" file within the obs_model directory.

Top Panel

Contains plots of time series, Taylor diagrams, and regressions. Diagnostics plots are available for: LCL; LCL_Domain; boundary-layer cloud-base height; CF(ARSCL); CF(TSI); LWP (linear y-axis); LWP (log y-axis); mid-boundary-layer Qv, RH, T; and surface Qv, RH, T. The time series are accompanied by simple statistics: means of the observations and simulation, ratio of the means (Sim/Obs), mean difference (Sim-Obs), RMS difference, and correlation coefficient. Taylor diagrams graphically summarize how closely a pattern matches observations in terms of their correlation and normalized standard deviation (Taylor 2001). A perfect match of these terms in polar coordinates is at (1,1) (although, as discussed in the next section, the mean bias must also be considered). The regression plots provide the slope (m) and intercept (b).

Lower-Left Panel

Contains the 2D time-height cloud frequency of occurrence derived from ARSCL observations, the LES simulation, and 2D cloud masks from the ARSCL observations overlaid with those from the simulation. In the latter, green indicates where the simulation and observations both have cloud (i.e., a model hit), red is where cloud is present only in the observations (model miss), and blue is where cloud is present only in the simulation (model false positive). Local solar time is indicated at the top and UTC at the bottom. A two-toned vertical scale is used where the vertical region below 5 km is expanded and above 5 km is reduced to show the full tropospheric cloud profiles without sacrificing details of the boundary-layer clouds; the partition between the regions is indicated by a dashed line. Simulated clouds lower than 160 m are not plotted since the ARSCL cloud mask begins at 160 m above the ground. Also included is the observed LCL (blue line), and computations from the sonde profiles of the level of free convection (LFC, red +) and boundary-layer height from the Heffter (1980) method (green*).

Lower-Right Panel

Contains comparisons of the simulations to available sonde profiles at ~11:30 and ~17:30 solar time. The quantities compared are temperature, T (K), water vapor mixing ratio, qv (g kg^{-1}), potential temperature, θ (K), and equivalent potential temperature, θ_e (K). Also included are the Raman lidar profiles of temperature and water vapor mixing ratio above 300 m.

Diagnostic Plot Examples

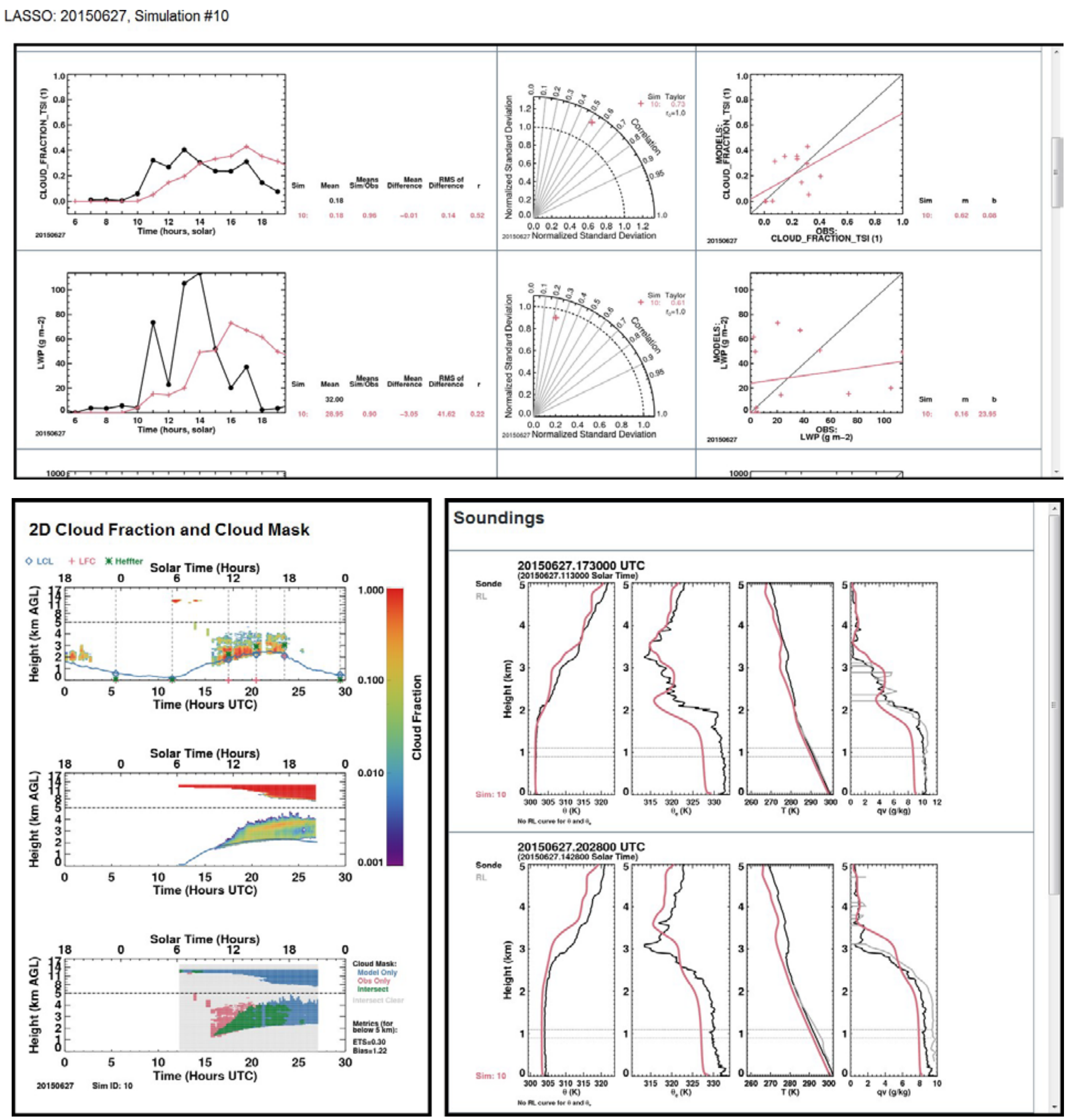

Figure 3. Example of diagnostic plots available for each simulation within the data bundles (see text for details). (Top panel) Quicklooks are available for various time series, Taylor diagrams, and regression plots. (Bottom-left panel) Top plot is the 2D time-height cloud frequency from ARSCL, middle is from the simulation, and bottom is the 2D cloud masks from ARSCL and the simulation. (Bottom-right panel) Comparison of simulated profiles with those from sondes and the Raman lidar.

4.2 Skill Scores

Skill scores quantify model performance compared to observations. They monotonically increase with improved skill from 0 to 1, where 0 indicates no skill and 1 indicates perfect agreement in terms of the metric. LASSO draws as much as possible on skill scores commonly used within the community. The purpose of providing the skill scores is to help users find cases of suitable quality for their applications. As there may be a cluster of simulations with high skill scores for a given variable, there may be several suitable simulations that exceed a desired threshold. However, that number may dwindle as skill scores are considered for other variables important for the application of interest. Thus, the purpose of the skill scores is not to identify a "best" simulation, as what is best may depend on the application; rather, the purpose is to identify the "better" cases for consideration.

Time-Series Skill Score

Model performance in terms of its time series is quantified using two skill scores, where one characterizes the agreement of the variation/shape of the time series and the other characterizes its mean. The Taylor skill score (Equation 4 in Taylor [2001]), S_T, is used for the variation/shape of the distribution for a given variable, *var* (e.g., LWP), as

$$S_T\left(var\right) = \frac{4\left(1+R\right)}{\left[\left(\sigma_r + \frac{1}{\sigma_r}\right)^2 \left(1+R_0\right)\right]} \tag{1}$$

where σ_r is the normalized standard deviation given by model root mean square (RMS) divided by the observed RMS, R is the correlation coefficient, and R_0 is the maximum correlation attainable, which is set to 1. Thus, if the correlation coefficient and normalized standard deviation are 1, the Taylor skill is 1. However, the Taylor skill alone cannot characterize the time series performance because it does not include information regarding the mean. To include this information, a skill score for the relative mean, S_{RM}, was developed as

$$S_{RM}(var) = \begin{cases} x \text{ for } x \le 1 \\ 1/x \text{ for } x > 1 \end{cases} \tag{2}$$

where x is the model mean divided by the observed mean. Through this formulation, the skill score has the range (0,1) and is symmetric around one. It is designed to quantify the relative difference from 1 and will yield the same value if the model underestimates or overestimates by the same factor. For example, two relative means that are different from observations by a factor of 2 on the low and high side, i.e., relative means of 0.5 and 2.0, would have the same skill score of 0.5 implying comparable performance relative to 1. Should users want to examine the relative means themselves, they are also included in the data bundles.

The Taylor and relative mean skill scores may be used in scatter plots to show how different simulations behave. See Figure 4, for an example. The closer the values are to the upper right-hand corner (1,1) the better the model performance in terms of the time series variable.

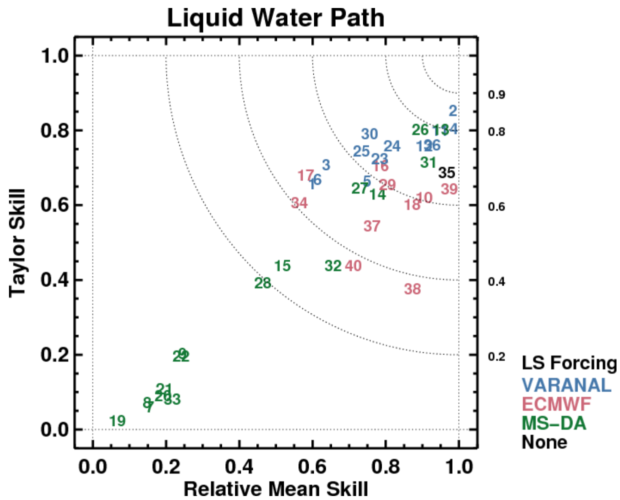

Figure 4. Scatter plot shows LWP Taylor skill score, S_T (LWP), and relative mean skill score, S_{RM} (LWP), obtained from their time series comparison to observations. Each point represents a simulated day and the numbers indicate the simulation ID. Colors indicate the large-scale forcing used as indicated in the legend, where "none" is a simulation without large-scale forcing. The 40 simulations shown are from the 27-Jun-2015 case. Dashed curves are for constant values of net skill scores, S (LWP), notated at the right axis. The closer a point is to the upper-right-hand corner (1,1), the better the simulation performance for this metric.

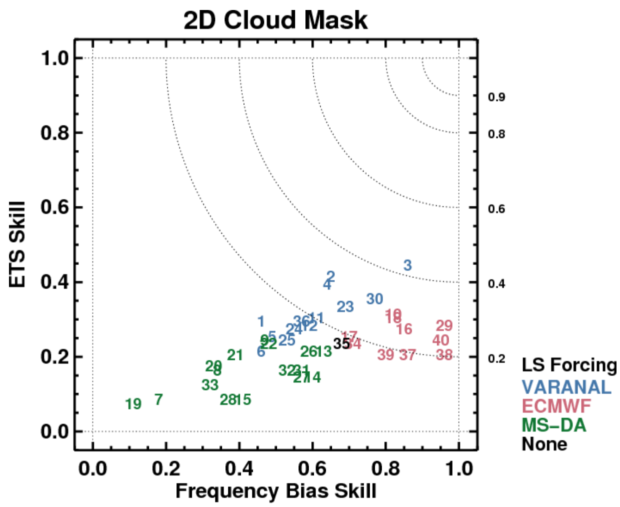

Figure 5. Scatter plot of 2D cloud mask skill scores shows S_{Bias} and S_{ETS}. S_{ETS} is often lower than other skill scores, but this happens uniformly such that the relative ordering of their values corresponds with relative visual agreement between simulations and observations in the 2D plots. When comparing skill scores for different variables, the relative ordering within each variable is most important rather than the absolute values between variables.

Finally, we found it useful to combine the Taylor and the relative mean skill scores into a single-variable net skill score, S, that quantifies how close a simulation is to (1,1) in Figure 4. To do so, we use

$$S(var) = \left(S_T\left(var\right) * S_{RM}\left(var\right)\right)^{\frac{1}{2}} \tag{3}$$

In this way, should the Taylor skill and relative mean skill both be 0.8, the combined single-variable net skill score would be returned as 0.8. This multiplication is preferable to, say, the square root of the sum of the squares, because it requires that both skill scores perform well for S to rank well; it does not allow a high score in one term to compensate for a much lower score in the other term. For example, if there were two sets of skill scores, (0.5, 0.5) and (1, 0.1), the former would score better using Equation 3 while the latter would score better with the square root of the sum of the squares. Note that while high net skill scores can only be achieved by having both high Taylor and relative mean skills, medium-to-low values need not have the same level of consistency in their component skill scores since multiple combinations of high and low scores can yield the same net score.

2D Cloud Mask Skill Score

The 2D cloud mask in Figure 3 shows the ability of the model to simulate cloud-base height, vertical cloud extent, and the timing of cloud onset and decay. (As previously mentioned, application of an ARSCL simulator is in progress that will enable a closer comparison of the simulated cloud fields to ARSCL observations.) The skill for the simulated 2D mask is quantified using the frequency bias and the equitable threat score (ETS), also called the Gilbert skill score (Mesinger and Black 1992; see "Forecast Verification Metrics" at https://hwt.nssl.noaa.gov/Spring_2012/),

$$ETS = \frac{\left(Hits - Hits_{random}\right)}{\left(Hits + Misses + False\ alarms - Hits_{random}\right)} \tag{4}$$

The ETS skill score is only applied to cloud below 5 km as boundary-layer clouds are the focus of this release. In this equation, *Hits* is the number of cloud pixels both correctly simulated and observed (green in bottom-left panel in Figure 3), *Misses* is the number of cloud pixels not simulated but observed (red), and *False alarms* is the number of cloud pixels simulated but not observed (blue). $Hits_{random}$ is the number of hits that might happen at random, given by,

$$Hits_{random} = \frac{\left(Hits + False\ alarms\right)\left(Hits + Misses\right)}{Total} \tag{5}$$

where *Total* is the total number of pixels below 5 km. ETS has the range of −1/3 to 1, where 0 indicates no skill. To have ETS conform to our other skills scores that are within the range [(,1), we truncate the low end of ETS at 0 and refer to it as the truncated ETS skill score, S_{ETS}.

The ETS-related frequency bias is the ratio of the frequency of simulated cloud pixels to the frequency of observed cloud pixels,

$$Bias = \frac{\left(Hits + False\ alarms\right)}{\left(Hits + Misses\right)} \tag{6}$$

The frequency bias is in terms of a ratio where a perfect score is 1; so, following the approach used to compute the skill for the relative mean, the skill score for the frequency bias, S_{Bias}, may be computed by replacing x in Equation 2 with *Bias* from Equation 6. The skill score is referred to as the frequency bias skill.

These two skill scores may be used in scatter plots to show how different simulations behave in terms of 2D cloud mask. See Figure 5 for an example. Generally speaking, simulations usually score better in terms of frequency bias skill than in ETS skill. While ETS skill can be a rather exacting skill score compared to its peers, it has the virtue of not giving errantly high values (i.e., a high value can be believed) and awarding values more consistent with visual inspections of plots.

Similar to the time series metrics, we find it useful to combine the ETS skill score with the frequency bias into a single-variable net skill score, *S*(*2D*), that quantifies how close a simulation is to (1,1) in Figure 5,

$$S(2D) = \left(S_{ETS} * S_{Bias}\right)^{\frac{1}{2}} \tag{7}$$

Multivariable Net Skill Score

The advantage of having a net skill score for a variable (Equations 3 and 7) is that it allows comparison of the net skill scores for two variables in scatter plots. An example is in Figure 6 for a comparison of the net time-series skill scores for LWP and CF(TSI). As in Figure 4, the closer the values are to the upper-right-hand corner, the better the model performance. The values for two net skill scores may be combined into a single multivariable net skill score similar to Equation 3,

$$S(x,y) = \left(S(x) * S(y)\right)^{\frac{1}{2}} \tag{8}$$

where *S* (X) and *S* (Y) are the net skill scores for two variables. The multivariable net skill score for LWP and CF (TSI), *S* (LWP,CF(TSI)), is considered to be a special case that is referred to as the *1D cloud skill score*.

Following Equation 8, it is also possible to combine a single-variable net skill score with a multivariable net skill score. For example, we combine the 1D cloud skill, *S*(LWP,CF(TSI)), with the 2D mask net skill, *S* (*2D*), to produce one skill score that characterizes model performance of the LWP and CF (TSI) time series *and* the 2D cloud mask,

$$S\left(S(2D), S\left(LWP, CF(TSI)\right)\right) = \left(S(2D) * S\left(LWP, CF(TSI)\right)\right)^{\frac{1}{2}} \tag{9}$$

This is a special case that is referred to as the *total cloud skill score*.

We note that while one could continue to combine more multivariable skill scores using Equation 8 in series, one should be cautioned about diminishing returns. As noted earlier, a high net skill score can only be obtained by having two high input values, but the reason for a low skill score becomes more ambiguous since there are non-unique paths to the same low value. As more variables are added, the likelihood of a low score increases and, along with it, the ambiguity of comparing two low scores.

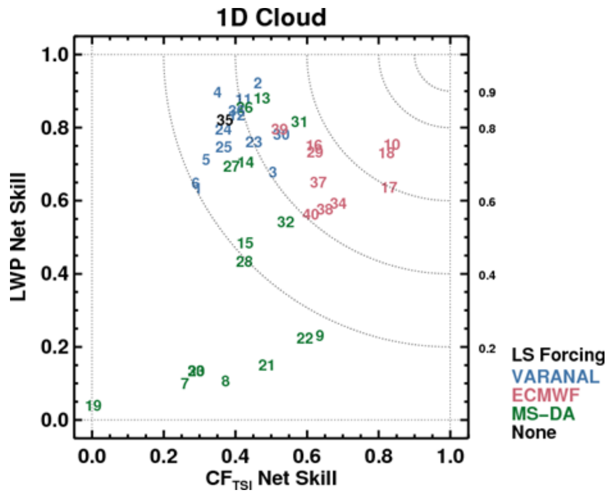

Figure 6. Scatter plot for two single-variable net-skill scores shows *S* (LWP) and *S* (CF(TSI)). In this way, simulation performance for two separate skill scores can be visualized. Should Equation 8 use these two skill scores as input, it would result in a single multivariable net skill score for each pairing, *S* (LWP,CF(TSI)), that is referred to as the 1D cloud skill score.

5.0 LASSO Data Bundles and Tools

The overall concept for data organization within LASSO is the use of "data bundles." Each bundle is associated with a single simulation and contains the information necessary to repeat the simulation, the output from the simulation, subsetted output co-registered with observations, quicklook plots, and the skill scores and diagnostics for evaluating the simulation. Complementing the data bundles is a web tool called the Bundle Browser for quickly searching through simulations by querying skill score values and configuration details.

The browser additionally serves as an interface for users to view quicklook plots for simulations prior to downloading them, as well as summary statistics data and plots that conglomerate information across multiple simulations. A typical user employs the Bundle Browser to identify case dates and/or simulations of interest, as described in the next section. Links in the browser permit viewing of simulation-specific quicklook plots, providing a method for selecting data bundles for download from the ARM Data Center (ADC). Ordered data bundles are delivered in the form of two tar files per simulation, with the user able to request one or both of the tar files.

As an alternative to downloading the data bundles from ARM, users also have the option of requesting access to one of the ARM clusters supported by the ADC Computing Facility. The ADC maintains two clusters where ARM data can be staged to simplify analysis by users (Prakash et al. 2016). This is particularly useful for large data sets, such as LASSO, that can overwhelm some users' available computing resources. More information and a link to request access to the ARM clusters can be obtained from https://www.arm.gov/capabilities/computing-resources.

5.1 The LASSO Bundle Browser

The LASSO Bundle Browser provides an interactive web interface for users to find simulations of interest through examination of the LES performance relative to select ARM observations. It allows users to visualize the LASSO data bundle diagnostics and skill scores on the fly using plots and tables while also providing links to data. Values for plots and the data table are fetched dynamically from a Cassandra NoSQL database. The conditional query to retrieve data is formed based on the user-selected traits in the browser.

The LASSO Bundle Browser is available for use at https://adc.arm.gov/lassobrowser, and Figure 7 shows an example of the display. The left-hand side is occupied by selection options within (A) and (C) whose results are displayed to the right, plus case-specific overview plots in (B). The selection options and display features are described below referencing the labeling in Figure 7.

A. Expandable menus allow the user to select multiple dates and a single measurement type for any combination of traits that characterize the forcing and model configurations. “Select all” is an option within each trait category and the “Select All (Excludes Date)” button at the top of (A) selects all forcing and model configuration options while not altering the date selection(s). This essentially results in selecting all possible simulations for the selected date(s). Clicking the “Submit” button at the bottom of (A) applies the selected query and updates the plot in (D) for the Taylor diagrams, skill score plots, scatter plots, and time series plots. These plots are created using the D3.js and highcharts software libraries. The data table in (E) is also updated, which displays the skill scores and provides links for downloading the resulting simulations.

B. Precomputed overview plots for all simulations and variables for a selected day are available for display as heat maps (Figure 2) and skill scores (e.g., Figures 4–6). These overview plots can assist users to locate the variables of interest for use in (A). This section also provides a link to Geostationary Operational Environmental Satellite (GOES) images for the selected date. This section has its own date dropdown menu to view images for a single date, which is independent of the multiple-date selection capability in (A).

C. Slide rulers allow choosing the range of net skill scores that are displayed in (D) and (E). Place the mouse over the label for a brief description of the variable. Moving the sliders or entering specific values in the boxes will update the table and plots to only include simulations within the selected score values.

D. Dynamically updated plots are shown in (D) for the selected measurement and date(s). The simulations included in the plots reflect the query selections from (A) and (C), and the selections from (A) are reflected as “breadcrumbs” (in blue) above the plots. The plot types include Taylor diagrams, skill score plots, scatter plots, and time series plots. The black line in the time series plot is the observations. The plots are interactive; mouse over the points to see the simulation ID and coordinate values. Click on a given plot to enlarge it and print.

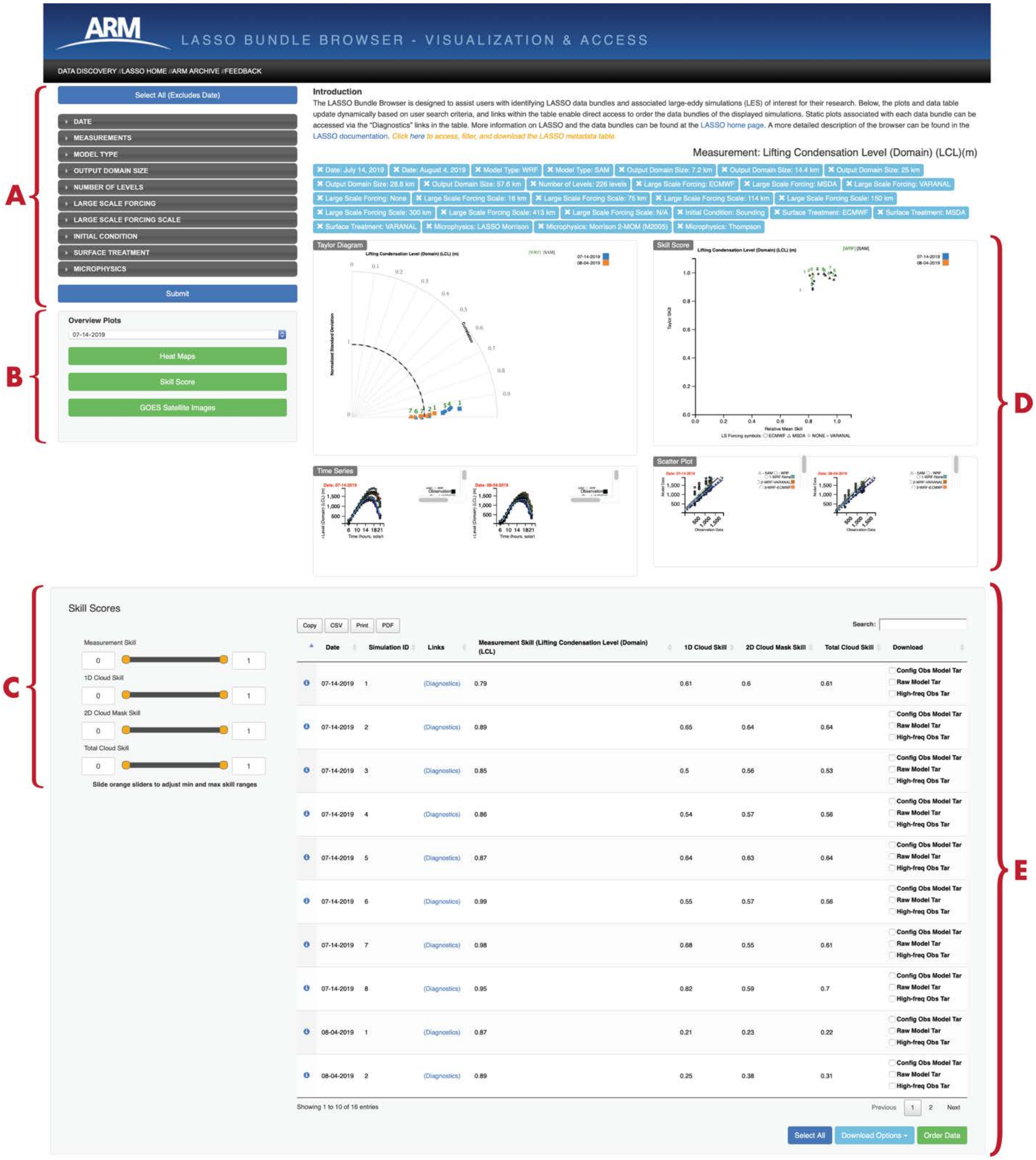

Figure 7. LASSO Bundle Browser interface at https://adc.arm.gov/lassobrowser. See text for descriptions.

E. Tabulated results are given for the net skill scores of the simulations selected via (A) and (C). The "i" circle to the left of the simulation identification number (ID) provides a short readme file containing a detailed summary of the simulation run configuration that includes information not available in (A). "Diagnostics" hyperlinks are provided in the column to the right of the simulation ID. These links return the precomputed diagnostic plots shown in Figure 3 for each simulation (e.g., 2D cloud-mask time series plots, etc.). Also within the table are arrows at the top of each column that sort the table entries according to the column variable and the order may be reversed by a subsequent click. The "Search" box finds a given value within the table. Above the simulation ID are options to "print" or "copy" the results or download as a "CVS" or "PDF" file. Below the table are buttons for ordering data bundle tar files selected within the table based on selected check boxes in the table.

There are two methods for downloading LASSO data bundles. The first is via the table in section (E) of the Bundle Browser. The table of simulations in the browser includes a column with checkboxes for each type of tar file in the bundle. Users can check which tars they want to download, or alternatively, they can use the "Select All" button to select all tar files in the table for download. A "Download Options" button permits selection of either receiving the data via either file transfer protocol (FTP) or Globus. After clicking the "Order Data" button, users are provided with a login pop-up to enter their credentials. Once entered, the order is created and its ID will be displayed. Users then will receive an email with download instructions when the order is ready.

The second method for downloading the data bundles is via the Data Discovery application (https://www.adc.arm.gov/discovery/). Data Discovery is a timeline-based application designed for ordering data from a time range. To search for LASSO data, the model-related metadata traits are made available for narrowing one's search. When users search for LASSO data, every simulation will be listed as a datastream embracing the timeline structure of the Data Discovery application. Data Discovery can be easier than the Bundle Browser for downloading LASSO data for a particular simulation from all days. However, multiple requests must be made if the desired dates are not consecutive within the available cases. It is generally quicker to use the Bundle Browser to download data for non-consecutive dates. Integration of LASSO datastreams (LASSO being a new kind of data for ARM) into Data Discovery is an ongoing effort and we would like to hear from users regarding how to improve the user experience.

Note that the Globus download methodology is more stable for downloading the raw model output files. Users that experience difficulties with the FTP interface should try Globus if they have a Globus Endpoint that they can use to receive the files. This solves many issues users have noted in the past related to downloading the large raw model tar files.

5.2 Organization of Data Bundle Files

Once ordered, users download data bundles by simulation. Depending on whether one or both are requested, users receive up to three tar files per simulation. The first has the filename structured as *sgplassodiagconfobsmod#C1.m1.YYYYMMDD.tar*, and it contains three primary directories, as shown in Figure 8. The *config* directory contains model inputs and configuration files necessary for reproducing the simulation, and the *obs_model* directory contains subsetted model output and observations that are co-registered in space and time. Quicklook plots associated with the simulation are also available in a *plots* directory within *obs_model*. These are the same quicklook plots available directly from the Bundle

Browser. The *metrics* directory contains the results of the skill scores comparing the simulation against observations. It also has a *plots* subdirectory that contains plots of the skill scores comparing all the simulations on the selected date. These are static quicklooks similar to what can be generated dynamically via the Bundle Browser. The files in the *metrics* directory have information for all simulations on the selected date. The contents of this directory are identical for all simulations for the selected date.

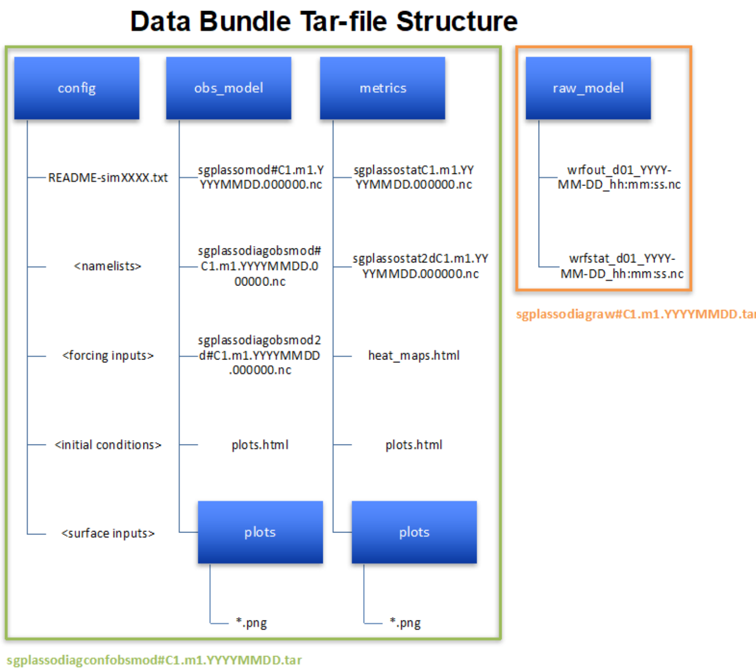

Figure 8. Schematic shows the contents of the two simulation-specific tar files associated with each data bundle. Users can choose to download one or both of these tar files when ordering LASSO data from the ARM Data Center.

The second tar file has a filename structured as *sgplassodiagraw#C1.m1.YYYYMMDD.tar*. This tar file contains the raw model output and is, therefore, noticeably larger. For WRF simulations, this will include multiple *wrfout* files plus a *wrfstat* file as shown in Figure 8. For SAM simulations available for 2015 and 2016, this will contain the corresponding SAM 1D, 2D, and three-dimensional (3D) files in netCDF format. The SAM model initially outputs in binary, which has been converted to netCDF. Note that the statistics variables from both SAM and WRF are time-averaged over a 10-minute period with sampling every minute. *Note also that the time label for these SAM statistics files represents the middle of the averaging period, whereas the time label represents the end of the period for the WRF statistics file.* The instantaneous output has time labels corresponding with the time step when the output occurs.

The third tar file contains the LASSO High-Frequency Observations VAP used with LASSO and has a filename structured as *sgplassohighfreqobsC1.c1.YYYYMMDD.000000.tar*. This file is identical for all data bundles within a given case date. Details regarding the variables within this tar file are provided in Appendix C, "LASSO High-Frequency Observations Value-Added Product."

Listings of the netCDF headers for each file within the tar files are provided in Appendix D, "LASSO File Contents," and Appendix E, "LASSO High-Frequency Observations Datastream File Contents".

5.3 Support Files and Information

Supporting information for the cases and simulations is available to users in addition to the data bundles. The Bundle Browser provides links to:

- List of metadata associated with each simulation, such as the associated forcing and grid configuration.
- GOES visible image animation loops for each case date to provide a perspective of the cloud field.
- Plots of skill scores spanning all simulations in a case day. These are static versions appropriate for referencing and using in presentations compared to the dynamically generated versions produced directly by the browser. Additional varieties are also available, such as heat map plots showing the range of simulation behavior for a given case date.
- Quicklook plot for each case, where these are duplicates of the quicklooks within the data bundles, but are more easily accessible without going through the data ordering and download process.

6.0 References

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Appendix A:

Release History and Change Log

LASSO is an evolving datastream with versioned releases similar to model code. Below is a reverse chronological list of updates corresponding to each data bundle release.

Version 1: 2019 Cases and an ECMWF processing error correction

136 data bundles for 17 days from 2019, released August 2020.

The 2019 case dates are an incremental addition to v1, similar to the 2018 cases. The primary difference is a change to the ECMWF large-scale forcing, which precipitated from how we are able to obtain the input ECMWF IFS model data used for the forcing generation. A new high-frequency observation data file has also been added.

LES-Related Updates

- Prior LASSO cases obtained data from the ECMWF IFS model directly from ECMWF to generate the ECMWF-based large-scale forcing used within LASSO. This is no longer an option, but an alternative is now available using a combination of variables from the *sgpecmwften*, *sgpecmwfvar*, *sgpecmwfsfc11*, and *sgpecmwfsfce* datastreams that ARM began archiving from ECMWF for the SGP location in 2018. The impact is a change in the methodology for calculating the forcing tendencies. However, a comparison between the old and new methods does not reveal a systematic bias between them. However, an exhaustive comparison was not possible. Users comparing model behavior across time with the ECMWF forcing should be aware that this methodological change could impact long-term trends and model behavior.
- Users should be aware that an error was discovered in the processing of the large-scale vertical velocity field of the ECMWF forcing for the 2018 and earlier runs. The vertical velocities all need to be multiplied by a factor of 10 for data bundle cases from 2015 to 2018. This impacts the LES data within these bundles and any use of the ECMWF large-scale forcing data. As of August 2020, reprocessing is being done of all impacted cases and they will be re-released when ready.

Metric- and Diagnostic-Related Updates

- Development of the LASSO operations software (LASSO-O) has enabled release of the high-frequency observation datastream, which bundles together many of the observations used in the LASSO data bundles at near-native time sampling frequencies. This new product is known as *lassohighfreqobs* and is described in Appendix C.

- The names of the files containing the skill scores in the data bundles changed from *sgplassostat* and *sgplassostat2d* to *sgplassoscore* and *sgplassoscorez*, respectively. The contents of the files remain unchanged.
- We note that LASSO evaluations using improved estimates of the vertical distribution of CF will soon be released for 2018 and 2019 cases. The improved observations will be obtained from multiview stereophotogrammetry (Romps and Öktem 2018) available from the COGS VAP. A release of a LASSO evaluation product that uses COGS for the observation in the skill scores is anticipated in fall 2020.

Bundle Browser- and Data Retrieval-Related Updates

- The Bundle Browser has been updated to access the high-frequency observation files associated with each LASSO case.

Version 1: 2018 Cases

240 data bundles for 30 days from 2018, released July 2019.

The 2018 case dates are released as an incremental addition to v1. A few small changes have been made to update the processing software and some metadata, but all input and output data for the data bundles are the same as for the 2017 cases with the exceptions noted below due to data availability and quality issues.

LES-Related Updates

- Errors were identified in the sam_input_generation.py script provided for users to prepare inputs for the SAM model from the LASSO forcings. These have been fixed in the updated script. Specifically, the latent and sensible heat fluxes were transposed in the SAM-formatted output file and a column of missing values was missing in the SAM sounding file.

Metric- and Diagnostic-Related Updates

- The metadata in the *sgplassostat* file has been changed to include a "complete_flag" and "observation_data_availability_comments." The complete_flag indicates whether all input data is available to calculate the skill scores for the simulation. A value of 0 indicates all data is available and a value of 1 indicates incomplete data. The comments field provides additional information when necessary. These were added to accommodate the missing Raman lidar data, noted next.
- The Raman lidar was down due to a hardware failure for portions of August and September 2018, which prevents calculation of the mid-boundary-layer temperature and moisture skill scores. The impacted LASSO cases are 11-Aug, 1-Sep, 2-Sep, 9-Sep, 11-Sep, 14-Sep, 16-Sep, 17-Sep, and 18-Sep-2018.
- The temperature and relative humidity sensors for the *sgpmet* datastream at the C1 location (the Central Facility) were replaced in January 2018. The new relative humidity values at C1 appear to be improved, but the temperature has gone from a previous cold bias to a warm bias of over 1 °K. Compared to simulations from previous years, this makes the model appear to have a dry bias versus *sgpmet* due to the conversion of relative humidity to water vapor mixing ratio in the skill score

calculations even though the modeling approach has not changed from previous releases. Therefore, the surface meteorological values used for the skill score calculations are now taken from the *sgpmaws* data set instead of *sgpmet* until further notice. This impacts both surface meteorological comparisons and the LCL at the Central Facility. Comparisons of simulations across years should take this change into consideration when interpreting simulation behavior.

The *sgpmaws* data set provides the surface meteorological values used for the lowest level of the radiosonde profiles. Thus, the LES is initialized with *spgmaws* and also evaluated with it. This has been deemed a better choice than using a biased measurement since *sgpmaws* is only used at the LES initial time for the lowest level.

- A new, related data set called *sgplcl* is provided that is calculated for every day of the year. *Sgplcl* provides an estimate of the lifting condensation level for the ARM surface meteorology stations and Oklahoma Mesonet stations, for a total of 190 locations around Oklahoma. Thirteen of these locations within the vicinity of the Central Facility are used for the LCL comparison in the LASSO data bundles.
- LWP is obtained from the AERIoe algorithm; if those data are not available, MWRRet values are used without any offset correction.

Version 1: 2017 Cases

240 data bundles for 30 days from 2017, released September 2018.

Version 1 is the first release as an operational product. The formats and software for this version closely follow Alpha 2 with very few changes. As an operational product, the extra sensitivity simulations and use of multiple LES models have been pruned to only use WRF with a single domain configuration.

LES-Related Updates

- Domain size set to 25 km across for all simulations.
- Simulations use the Thompson microphysics parameterization.
- Added time series of pressure to the large-scale forcing input file for use when converting WRF inputs to SAM input.
- Provide program to convert WRF-FASTER inputs to SAM inputs.
- Stopped including the large-scale forcing input file in data bundles when the associated simulation did not use large-scale forcing.

Metric- and Diagnostic-Related Updates

- LWP for LWP < 50 g m^{-2} uses AERIoe and for LWP > 50 g m^{-2} uses MWRRet1 offset by -3.5 g m^{-2}.
- In the observations and simulations, cloudy sky is when LWP > 3 g m^{-2}. This affects the LWP hourly averages and also the determination of the simulated cloud fraction amount.

- Mid-boundary-layer moisture and temperature changed from one that is determined specifically for each case to one that is an average over constant height range of 0.5–0.7 km.
- CBH diagnostic modified to use cloud-base heights only after 14 UTC.
- Substituted TSI data from site E42 for times when C1 was down. This site is less than 1 km southeast of C1 and sees almost the identical cloud field as at C1.
- Added time zone to time units in diagnostic files within the data bundles.

Bundle Browser- and Data Retrieval-Related Updates

- Added capability to use THREDDS for accessing LASSO data.
- Replaced Microsoft Excel spreadsheet for providing simulation metadata to users with the ability to download the information via the Bundle Browser.
- Modified date selection to better accommodate the growing list of cases.

Alpha 2 Supplement: Re-release of 2015 Cases

140 data bundles for 5 days from 2015, released July 2018.

The Alpha 2 supplemental release consists of a re-run of a selection of simulations for the five 2015 cases from Alpha 1. The code and data bundle contents follow that from Alpha 2. Results differ slightly from similar simulations in Alpha 1 due to bug fixes and configuration changes noted for Alpha 2. Compiler options were also modified slightly due to using a different computer to run the new simulations (ARM's Cumulus cluster versus Eos at the Oakridge Leadership Computing Facility). More detail about the supplement is available in Appendix D of Gustafson et al. (2018).

To avoid possible issues with incorrect statistical output calculations with the WRF simulations and an error with an uninitialized variable in the SAM simulations from Alpha 1, we recommend that users use the newer 2015 runs. Users should contact the LASSO team if there is a need to use the original Alpha 1 simulations so that the specific data used can be verified for its integrity.

Alpha 2: 2016 Cases

544 data bundles for 13 days from 2016, released September 2017.

The Alpha 2 release occurred as part of the LASSO pilot project and includes changes to both the modeling and analysis portions of LASSO. The following lists the updates for Alpha 2.

Forcing Data Set-Related Updates

- Versions of MSDA are included that incorporate wind profiles from the four SGP radar wind profilers.

LES-Related Updates

- Standardized on 10-minute output interval.

- Standardized vertical grid to 226 levels.
- SAM model changes
  - Fixed uninitialized array in relation to background aerosol in Morrison microphysics.
  - Patch for handling long file names.
- WRF model changes
  - Updated to v3.8.1.
  - Changed cloud masking for statistical output in WRF to consider cloud ice in addition to cloud water.
  - Added low-cloud, vertical-velocity variance, and cloud-core vertical-velocity variance to statistical output.
  - Added time-averaged values for each grid column (CSV variables for volume variables and CSS for surface/slab variables) in the WRF statistical output to complement the domain-wide time-averaged values (CSP for profile variables and CST for time series variables).
  - Fixed many bugs related to averaging in the statistics output (recommend avoiding using these variables from the Alpha 1 release).
  - Fixed halo treatment of TKE for periodic boundaries.
  - To enable parallel execution of WRF initialization, improved handling of random temperature perturbations during model initialization to avoid imposing signatures of the model domain decomposition within the perturbations.

Metric- and Diagnostic-Related Updates

- LWP is based on AERIoe retrievals using AERI and microwave radiances, augmented with MWRRet1 retrievals.
- Added LCL_Domain metric that provides the domain-averaged LCL value and standard deviation.
- Temperatures for the boundary-layer profiles and mid-boundary layer are now based on a hybrid profile from Raman lidar and AERIoe retrievals.
- Mid-boundary-layer moisture and temperature changed from a constant height range to one that is fixed to a value determined specifically for each case.
- Added cloud-base-height metric based on Doppler lidar data at the Central Facility and boundary facilities.
- Minor bug fixes to metric calculations.

Bundle Browser- and Data Retrieval-Related Updates

- Added a multi-day comparison capability to the Bundle Browser.
- Linked sliders for metric values to the plots in the Bundle Browser so that the plots dynamically redraw when the slider is moved to change the selected metric range.

- Linked the data-ordering process directly to selections in the Bundle Browser.
- Added ability to find and order LASSO data from Data Discovery.
- Can now take advantage of Globus for downloading files.
- Data bundle files grouped into two tar files to simplify retrieval.

Alpha 1: 2015 Cases

192 data bundles for 5 days from 2015, released July 2016.

This was the first release of LASSO data bundles, which occurred as part of the LASSO pilot project. These have been mostly superseded by the Alpha 2 supplement. The Alpha 1 bundles are only available via the ARM Principal Investigator data area and are no longer accessible via the Bundle Browser.

Appendix B:

Evaluation Data

In the Evaluation Data Section, the surface-based observations of in-cloud LWP, 1D cloud fraction, and mid-boundary-layer moisture and temperature were introduced. In this appendix their scientific backgrounds are described in further detail. Note that Appendix C provides information on the ARM VAPs that are the source of the variables discussed here via the LASSO high-frequency observations VAP.

In-Cloud Liquid Water Path (LWP)

Retrieval of in-cloud LWP (g m^{-2}) is based on a 'hybrid' product that uses MWR-only retrievals from the 2-channel MWRRet1 microwave radiometer retrieval (Turner et al. 2007) and retrievals from a new optimal estimation framework (AERIoe) (Turner and Löhnert 2014) that uses spectral infrared radiances measured by the atmospheric emitted radiance interferometer (AERI) and MWR radiances. (The AERIoe algorithm also retrieves thermodynamic profiles for the lower atmosphere that are used below.) The resulting LWP data have excellent sensitivity at low LWP (<40 g m^{-2}) and a full dynamic LWP range (up to 1000 g m^{-2}). Details on the retrievals and how they are combined into a single LWP datum are described next.

The implementation of AERIoe uses AERI radiances and the MWR-2C microwave radiometer radiances at 23.834 and 30 GHz. The use of infrared radiances (8–13 µm) provides sensitivity at small LWP (<~50 g m^{-2}), yielding an uncertainty of ~30% for LWP <5 g m^{-2} but manifesting signal saturation by 50 g m^{-2}. As retrievals approach this saturation limit of the AERI signal, AERIoe uses more information from the MWR channels until it reaches a point where LWP is based solely on MWR data.

- Prior to the 2018 release, the AERI portion of the retrieval is used but not the portion that also relies on MWR radiances; the development of the latter portion is nearing completion and is expected to be available in the release of 2018 cases. The AERIoe and MWRRet1 retrievals were combined into a single 'hybrid' data set in a procedure that uses AERIoe values for LWP < 50 g m^{-2}, and uses MWRRet1 for LWP > 50 g m^{-2} after a minor offset correction of −3.5 g m^{-2} is applied. These preferences are because AERIoe will have superior quality for low LWP where the retrieval relies on AERI radiances, and for larger LWP MWRRet1 has the benefit from a long operating history for both the MWR-2C instrument and the retrieval algorithm.

- For the 2018 release and after, AERIoe is used whenever available, regardless of LWP value. MWRRet1 is used if AERIoe is unavailable.

AERIoe retrievals have been regridded and interpolated to 10-s resolution. Times for which data are missing in the native data sets remain missing in the 10-s data sets. For MWRRet1, which has a high-frequency time grid (~30s), such missing points are indicated in the QC information. This data can be found in the *lassolwp* VAP, described in Appendix C.

To obtain the in-cloud LWP values used for model evaluation, cloud screening has been applied to the observations and simulations so that clear-sky values are not used in the time-averaged quantities. For observations, LWP values >3 g m^{-2} are screened as being cloudy values. In the simulations, the summation of the cloud and rainwater mixing ratios within a model grid cell is $>10^{-7}$ kg kg^{-1} to be considered ‘cloud’ and column integrals are computed of the cloudy cells to yield a 2D LWP field. The average is taken of the LWP columns with values >3 g m^{-2} to produce the simulated in-cloud, domain-averaged LWP. In this procedure, the largest source of uncertainty is the incomplete sampling of broken clouds across the domain in the observations. Additionally, there is some uncertainty in the hybrid LWP product due to different sample volumes between AERI and the MWR, but this is not easily quantifiable. The LWP observations are available only from the SGP Central Facility (a single point).

1D Cloud Fraction (CF)

One-dimensional (1D) cloud fraction is determined from the TSI and ARSCL. The TSI is a hemispheric-viewing camera providing retrievals of fractional sky cover during daytime for ‘opaque’ and ‘thin’ clouds. The opaque fractional value is used, which is most relevant to the boundary-layer clouds of interest. Measurements from the 50° field of view are used to minimize cloud fraction (CF) overestimation due to scattering from cloud edges, particularly from clouds on the horizon.

One-dimensional cloud fraction from ARSCL is derived as the cloud frequency per time interval as described in Xie et al. (2010), which assumes a horizontally uniform cloud field distribution (i.e., the frozen turbulence assumption). Boundary-layer cloud fractions are 15-minute averages of fractional occurrence, reported at 1-minute intervals, computed from the vertically resolved ARSCL cloud mask for clouds lower than 5 km. Detailed information on the direct high-frequency (time) source product of the TSI- and Ka-band ARM Zenith Radar Active Remote Sensing of Clouds product (KAZRARSCL)-based cloud fractions, the *sgpcldfrac* VAP, is provided in Appendix C. For the purposes of model-to-observation evaluation, the cloud fractions are averaged up to a 1-h value.

For ARSCL CF, the largest uncertainties are from the application of the frozen turbulence assumption to broken cloud fields and insect contamination of the radar returns. ARSCL CF are often greater than TSI CF, which may be due to the greater sensitivity of the active sensors used in ARSCL to the presence of cloud compared to the detection of scattered light used by the TSI. For the version 1 release, the recommended 1D CF measurement is from the TSI, as cloud above the boundary layer generally has a negligible impact on CF for the cases provided when boundary-layer cloud is present. Correlation between the TSI CF and ARSCL CF in the diagnostic plots indicates that clouds above the boundary layer have a negligible impact on the TSI CF whereas lack of correlation indicates the opposite.

In simulations, CF is computed from the simulations in a manner that follows from the computation of in-cloud LWP: a grid cell is identified as cloudy if the sum of the cloud and rainwater mixing ratios is $>10^{-7}$ kg kg^{-1}, column integrals are taken of the cloudy cells to yield a 2D LWP field, and CF is determined as the fraction of the 2D grid with LWP >3 g m^{-2}, which is roughly the lower detectability limit of the measurements. Below this value, retrievals might measure haze or thin cirrus. The 3 g m^{-2} cutoff is somewhat arbitrary but yields similar cloud fractions to when 0.1 g m^{-2} is used. Note, however, that a 0 g m^{-2} cutoff can yield greater cloud fractions by up to 0.2 (Vogelmann et al. 2015).

Boundary-Layer Thermodynamic Profiles

A Raman lidar (Goldsmith et al. 1998) provides high-frequency vertical profiles of the boundary-layer Q_v (Wulfmeyer et al. 2010), temperature (Newsom et al. 2013), and relative humidity (RH) computed from these measurements. The native temporal and vertical resolutions of the measurements are 10 s and 7.5 m, which are averaged and provided at 10-minute and ~60-m resolution using automated processing algorithms (Newsom et al. 2013, Turner et al. 2002). The lidar signal saturates above cloud base. Based on comparisons with sondes, Raman lidar water vapor measurements are used above 0.1 km and temperature measurements are used above 1.25 km. For the temperature profiles, values are used from AERIoe retrievals (see LWP description above) below 1.25 km, Raman lidar values are used above 1.5 km, and a linear weighting with height of the two values is used between these two heights. The high spatial and temporal resolution of the Raman lidar and AERIoe data are valuable for assessing the simulated boundary-layer evolution; however, note that it is a point measurement that cannot represent the total variation across the model-simulated domain. These data are used for the evaluation of the thermodynamics mid-boundary-layer moisture and temperature.

Appendix C:

LASSO High-Frequency Observations Value-Added Product

This appendix describes the LASSO High-Frequency (in time) Observations VAP that aggregates the multiple observation datastreams used for LASSO. Figure 9 depicts the dataflow of ARM observations, from input datastreams (dark gray parallelograms), through VAP processing (cyan squares), to output datastreams (also dark gray parallelograms). Ultimately, the contents of the LASSO High-Frequency Observations VAP (except for *rwpwindcon*) are used in LASSO observation-to-model data evaluation, while *rwpwindcon* is assimilated in the generation of the MSDA forcing. The high-frequency observations are made available to users for each LASSO case date via the *lassohighfreqobs* datastream.

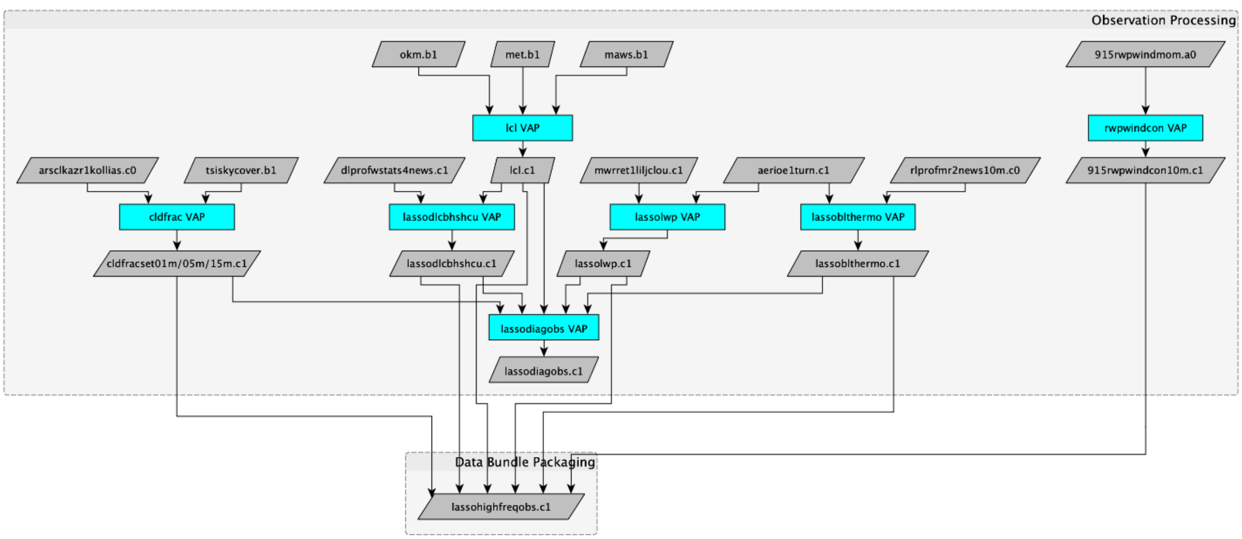

Figure 9. Data flow and processing steps for the LASSO High-Frequency Observations VAP. Processing steps are indicated by cyan rectangles, and corresponding input and output datastreams by dark gray parallelograms. Ultimately, the output of all but one (*rwpwindcon*) of the high-frequency observations are gathered in hourly averages via the *lassodiagobs* VAP for directly evaluating model quantities, while *rwpwindcon* is assimilated in the generation of the MSDA forcing. This diagram also reflects the fact that all of the high-frequency observations are bundled into a single datastream, *lassohighfreqobs*.

The remainder of this appendix discusses the technical aspects of each component of the LASSO High-Frequency Observation VAP.

LASSO Liquid Water Path VAP

The LASSO Liquid Water Path VAP, *lassolwp*, was created exclusively for use in LASSO to streamline the operational data flow. The output of the LWP VAP is used in the LWP evaluation diagnostic metric.

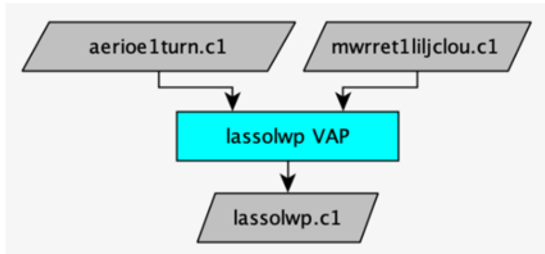

Figure 10. Dataflow for LASSO Liquid Water Path VAP showing input and output datastreams.

The *lassolwp* VAP provides a hybrid LWP comprised of LWP from two sources: the preferred AERIoe VAP whenever it is available, and LWP from the Microwave Radiometer Retrievals (MWRRet1) VAP if AERIoe is unavailable. The AERIoe LWPs and the quality screened MWRRet1 LWPs are first interpolated onto a 10-s time grid. Note that the valid range for interpolation of AERIoe values is 20 s and 60 s for MWRRet values; thus, for example, if valid AERIoe data points are more than 20 s apart, then interpolation cannot be accomplished, data points are deemed unavailable, and the lack of data reported in ancillary QC variables. After interpolation, the hybrid LWP assumes the AERIoe time series as a starting point and MWRRet LWP values are substituted when valid AERIoe values are unavailable for more than 5 minutes. In addition to the hybrid LWP, the VAP contains the individually interpolated AERIoe and MWRRet1 LWP estimates as well as a time-resolved source flag to indicate the data source composition of the hybrid LWP (e.g., AERIoe or MWRRet1).

Table 2 details the input and output datastreams and variables, output frequency, and data availability of the *lassolwp* VAP.

Table 2. Summary of the LASSO Liquid Water Path (LWP) VAP. "*" denotes a primary output variable used in LASSO.

LASSOLWP VAP		
Input Data	**Datastreams**	**Variables**
	aerioe1turn.c1	lwp
	mwrret1liljclou.c1	be_retrieval_flag be_lwp qc_be_lwp
Output Data	**Datastream**	**Variables**
	lassolwp.c1	*lwp source_lwp aerioe_lwp qc_aerioe_lwp mwrret_lwp qc_mwrret_lwp
Frequency	Time: 10 second	
Availability	sgp.C1, 2018 and 2019 LASSO Cases	

Note that the *lassolwp* is only produced for LASSO case dates for 2018 and subsequent years. Figure 11 presents sample plots generated from *lassolwp*.

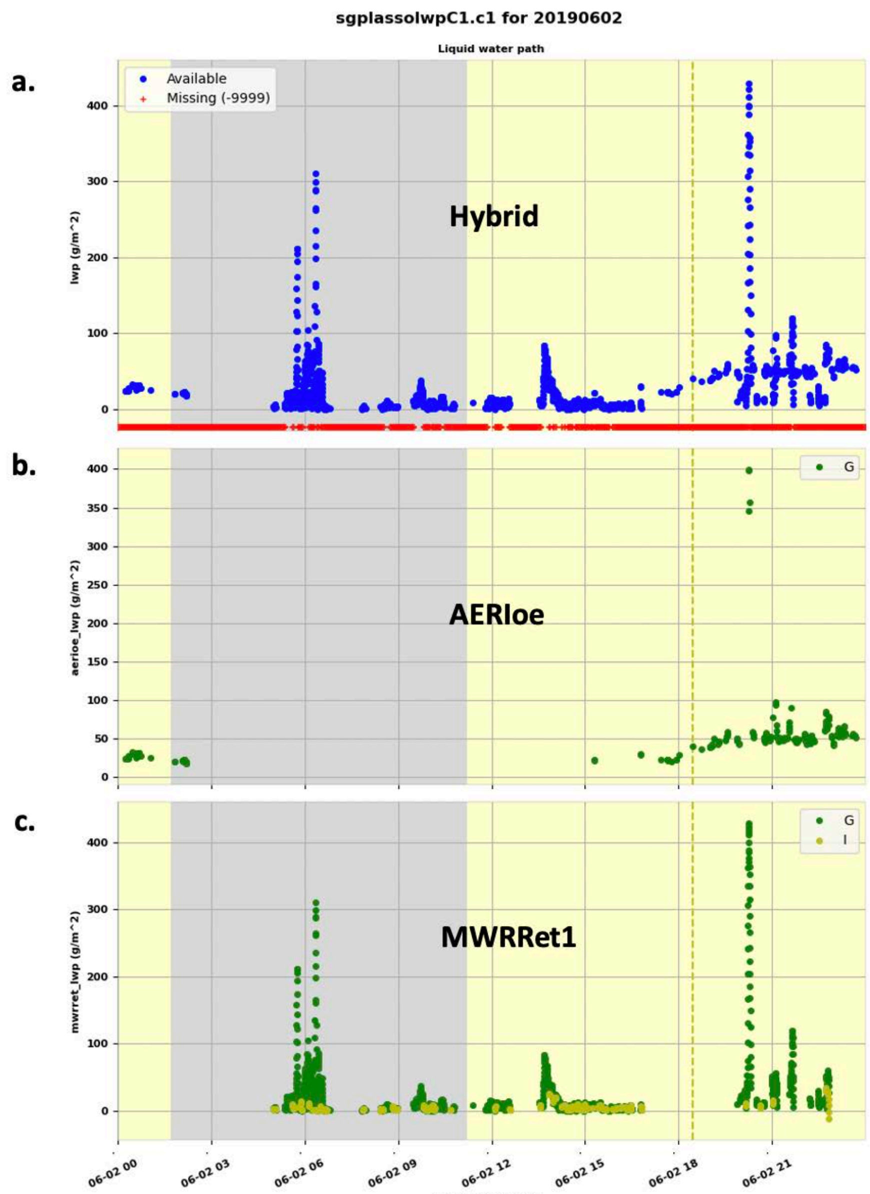

Figure 11. Plots of LWP from the a) hybrid, b) AERIoe, and c) MWRRet1 from the LASSO Liquid Water Path VAP for 2-Jun-2019 at the SGP (SGP.C1). For plots (b)and (c), quality checks are reflected in the legend: "G" indicates points for which interpolation is good and "I" indicates points for which interpolation is deemed indeterminate. Quality check assessments are found in the ancillary variables associated with aerioe_lwp and mwrret_lwp.

Cloud Fraction VAP

The Cloud Fraction VAP, *sgpcldfrac*, was created for LASSO to compute the profile and total cloud fraction estimates from the KAZRARSCL VAP (Clothiaux et al. 2001) and the 1D cloud fraction from the TSI. The output from *sgpcldfrac* is used for the 1D in time and 2D in time-height cloud fraction diagnostics in LASSO.

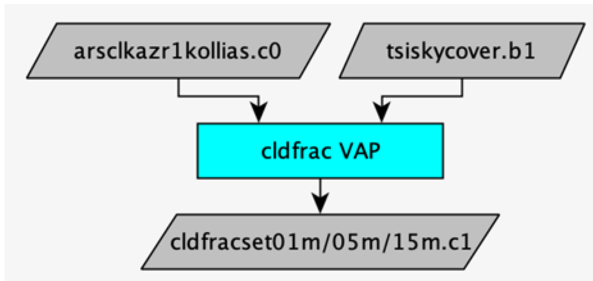

Figure 12. Data flow for the Cloud Fraction VAP showing input and output datastreams.

One way to estimate “cloud fraction” from a zenith-pointing cloud radar is based on the frequency of occurrence of cloud during a specified time period. The *sgpcldfrac* VAP provides two types of cloud fraction calculated from KAZRARSCL. The first, called the “profile cloud fraction,” provides the cloud frequency of occurrence at each range gate of the KAZR, making it a 2D variable (time, height). The second, termed “total cloud fraction,” is 1D (time) and based on a cumulative cloud frequency of occurrence as seen above the radar per time interval.

There are multiple ways to compute the profile of cloud fraction from KAZRARSCL. The method employed by *sgpcldfrac* maximizes the estimate by including both hydrometer-only and mixed hydrometer-and-clutter detections. The *sgpcldfrac* methodology also includes both KAZR and micropulse lidar observations of cloud. Echoes from precipitation are screened out using KAZRARSCL’s ‘cloud_base_best_estimate’ variable, which is the lowest lidar-observed cloud base as a function of time. The (profile) cloud fraction is the frequency of occurrence computed for each range gate over the period of the averaging window (given below). The total-cloud-fraction time series is computed at each height for the range gates including and below it, again, over the period of the averaging window. The hourly LASSO estimates of total cloud fraction use the estimate from the highest range gate (effectively making it a1D variable) less than or equal to 5km AGL.

The cloud fraction estimated from the TSI is actually the hemispherical sky cover, which uses the opaque pixel fraction from the zenith region of the TSI. The exact zenith angle used for the calculation varies over the long record of ARM TSI data. However, for the LASSO time period (2015 forward), the analysis region extends from zenith down to the 50° solar zenith angle (Morris 2005).

The *sgpcldfrac* VAP produces three output files for each day: 1-min, 5-min, and 15-min averaging windows. All of the output files report values at a 1-min time resolution and only the 1-min output file includes the TSI-based cloud fraction.

Table 3 details the input and output datastreams and variables, output frequency, and data availability of the *sgpcldfrac* VAP.

Table 3. Summary of the Cloud Fraction VAP. "*" denotes primary output variables used in LASSO.

CLDFRAC VAP		
Input Data	**Datastreams**	**Variables**
	arsclkazr1kollias.c0	cloud_base_best_estimate cloud_layer_base_height cloud_layer_top_height cloud_mask_mplzwang instrument_availability_flag precip_mean reflectivity_clutter_flag
	tsiskycover.b1	percent_opaque region_zenith_count region_zenith_count_opaque solar_altitude
Output Data	**Datastreams**	**Major Variables**
	cldfracset01m.c1	*cloud_fraction_kazrarscl cloud_fraction_kazrarscl_std, *total_cloud_fraction_kazrarscl total_cloud_fraction_kazrarscl_std *cloud_fraction_tsi
	cldfraset05m.c1 cldfracset15m.c1	*cloud_fraction_kazrarscl cloud_fraciont_kazrarscl_std *total_cloud_fraction_kazrarscl total_cloud_fraction_kazrarscl_std
Frequency	Time frequency: 1 minute; Time averaging: 1, 5, and 15 minutes; Height interval: 30 m	
Availability	sgp.C1, 2018 and 2019 LASSO Cases	

Note that the *sgpcldfrac* VAP has only been produced for LASSO case dates for 2018 and subsequent years so far, but it can be produced for other time periods and sites that have a KAZR. Figure 13 presents sample plots generated from *sgpcldfrac*.

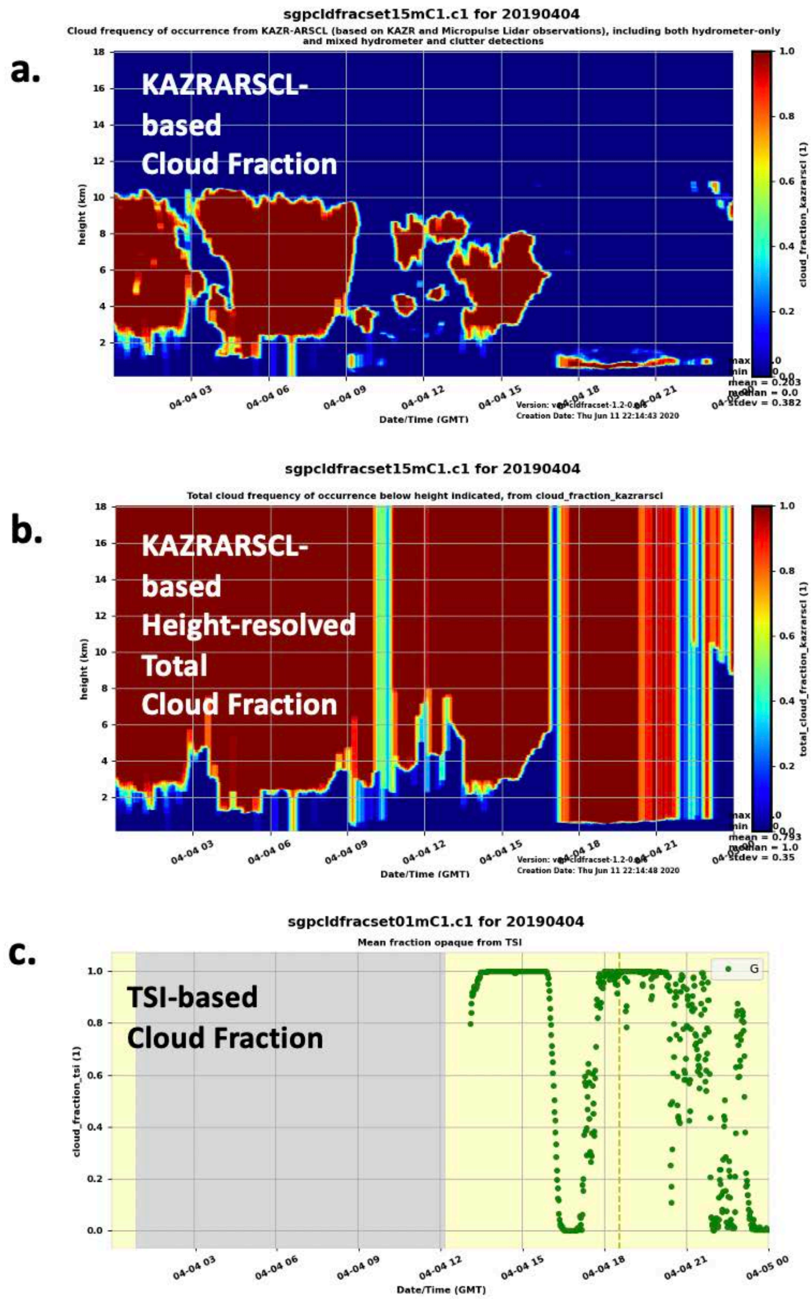

Figure 13. Plots from the Cloud Fraction VAP for 4-Apr-2019 at the SGP (SGP.C1). a) profile of 15-min cloud fraction, also referred to as cloud frequency of occurrence, b) profile of 15-min total cloud fraction, defined as cumulative cloud frequency of occurrence below the each range gate, which corresponds to what is seen from the ground, and c) 1-min opaque-pixel cloud fraction as seen in the zenith area of the TSI.

LASSO Boundary-Layer Thermodynamics VAP

The LASSO Boundary-Layer Thermodynamics VAP, *lassoblthermo*, was created exclusively for the LASSO project to provide an estimate of mid boundary layer (500–700 m AGL) thermodynamic variables for model evaluation.

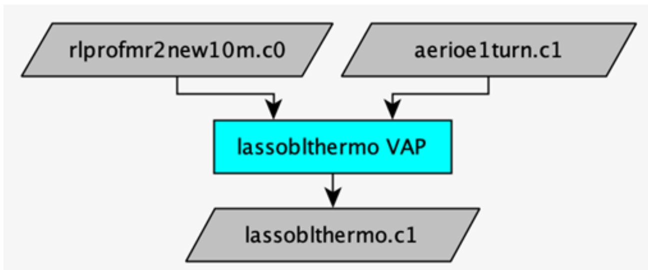

Figure 14. Data flow for the LASSO Boundary-Layer Thermodynamics VAP showing input and output datastreams.

The VAP output is a daily file containing time series at 10-min temporal resolution of temperature, water vapor mixing ratio, and relative humidity. Water vapor mixing ratio (q_v), and barometric pressure from the rawinsonde soundings (nominally four times daily) are also provided, obtained from the 10-min Raman Lidar (RL) Profiles Best Estimate VAP (Newsom 2012). The RL mixing ratios having an error greater than 2 g kg^{-1} are removed. Temperature, from the AERIoe VAP, like the RL variables, is interpolated in time to the *lassoblthermo* regular 10-min output grid. The valid range for interpolation is 150 s; thus, for example, if valid AERIoe data points are greater than 150 s from the interpolation time, then interpolation cannot be accomplished, and data points are deemed unavailable. For each 10-min time increment, the profiles of temperature, q_v, and pressure between 500 and 700 m AGL are averaged, and the relative humidity is computed from the averages.

The *lassoblthermo* VAP has been produced for the LASSO 2018 cases and subsequent years. The table below details the input and output variables, output frequency, and data availability of *lassoblthermo*.

Table 4. Summary of the LASSO Boundary-Layer Thermodynamics VAP. "*" denotes primary output variables used in LASSO.

<table>
<tr><th colspan="3">LASSOBLTHERMO VAP</th></tr>
<tr><td rowspan="3">Input Data</td><td>Datastreams</td><td>Variables</td></tr>
<tr><td>aerioe1turn.c1</td><td>temperature</td></tr>
<tr><td>rlprofmr2news10m.c0</td><td>cbh
mr_merged
mr_merged_err
mr_sonde
pres_sonde
temp_sonde
time_sonde</td></tr>
<tr><td rowspan="2">Output Data</td><td>Datastream</td><td>Variables</td></tr>
<tr><td>lassoblthermo.c1</td><td>*temperature
qc_temperature
*water_vapor_mixing_ratio
qc_water_vapor_mixing_ratio
*relative_humidity
qc_relative_humidity
pressure
qc_pressure</td></tr>
<tr><td>Frequency</td><td colspan="2">Time: 10 minutes</td></tr>
<tr><td>Availability</td><td colspan="2">sgp.C1, 2018 and 2019 LASSO Cases</td></tr>
</table>

Figure 15 presents sample plots generated by the LASSOBLTHERMO VAP.

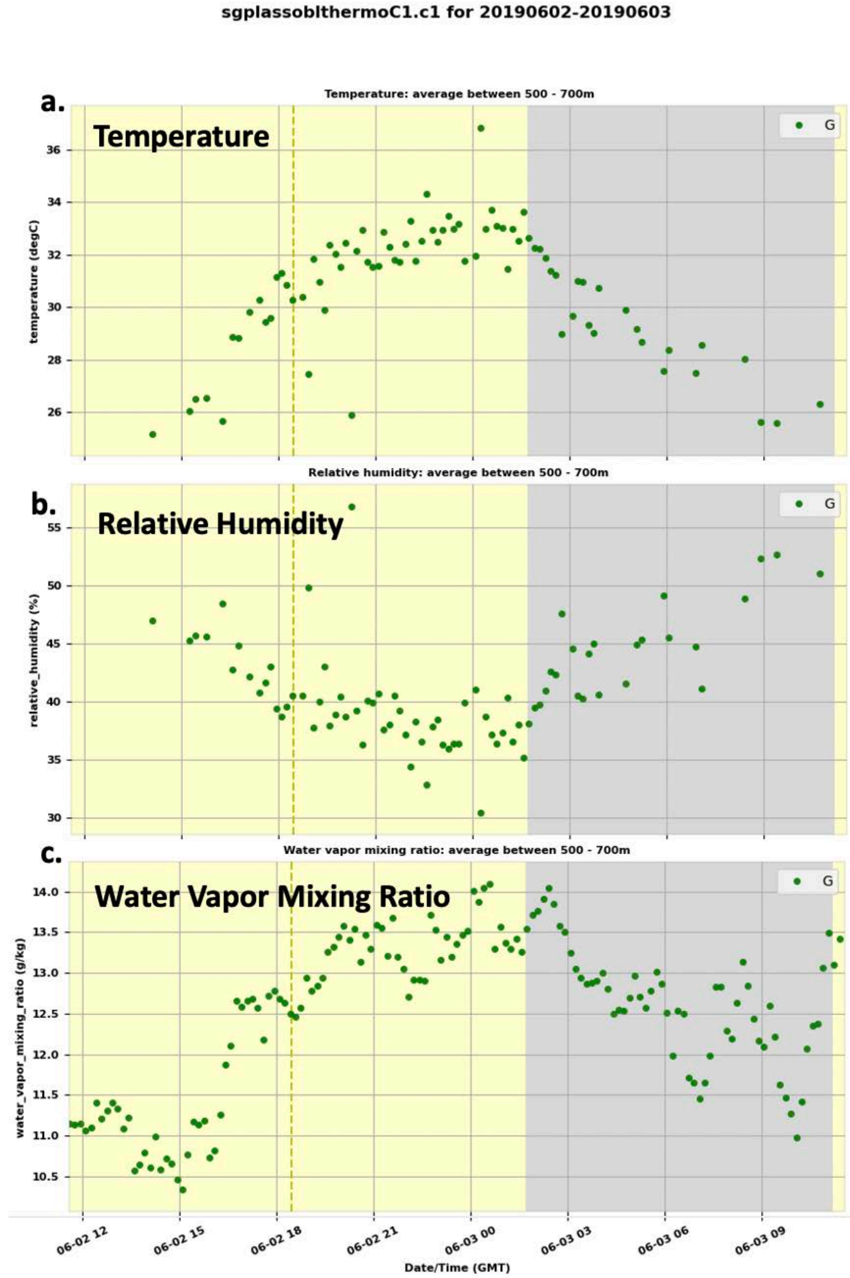

Figure 15. Plots from the LASSO Boundary-Layer Thermodynamics VAP: time series of (a) boundary-layer temperature, (b) relative humidity, and (c) water vapor mixing ratio, from approximately 12 UTC on 2-Jun-2019 through 12 UTC on 3-Jun-2019, at the ARM SGP Central Facility (SGP.C1).

LASSO Doppler Lidar Cloud-Base Height for Shallow Cumulus VAP

The LASSO Doppler Lidar Cloud-Base Height for Shallow Cumulus VAP, lassodlcbhshcu, was created for the LASSO project. The output of the VAP is used in the regional cloud base height diagnostic metric.

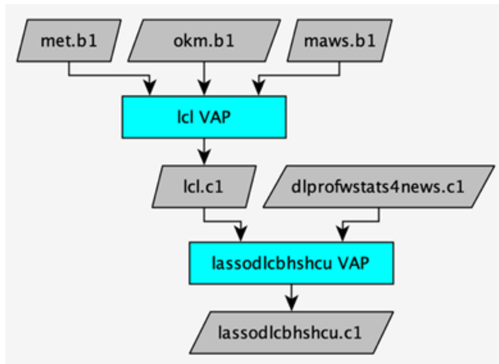

Figure 16. Data flow for LASSO Doppler Lidar Cloud-Base Height for Shallow Cumulus VAP showing input and output datastreams.

As indicated by the name of the VAP, lassodlcbhshcu uses Doppler-lidar-based estimates to report shallow cumulus cloud-base heights. It is executed separately for each of the Doppler lidars in the SGP vicinity: C1, E32, E37, E39, and E41. The VAP is processed in daily increments, from 11.5 UTC to 26.5 UTC (i.e., 11.5 UTC to 2.5 UTC on the next day). The associated algorithm is depicted in Figure 17. The algorithm starts with each 10-min time series of the 25th percentile of cloud-base heights from the *dlprofwind4news* VAP (Newsom et al. 2019). Then cloud-base heights above 5 km are eliminated from the time series. Then, using the Lifting Condensation Level Height (LCL) VAP (Toto et al. 2020), cloud-base heights higher or lower than the LCL by 30 percent are removed. Finally, an iterative loop fits the remaining cloud-base height points between 15 UTC and 26 UTC (i.e., 15 UTC and 2 UTC the next day), removing points that deviate from the curve of the polynomial fit by more than three standard deviations, until all points fall within three standard deviations of the fit.

Note that for SGP.C1 the LCL VAP input to the lassodlcbhshcu VAP, for 2018 and 2019, uses maws.b1 instead of met.b1 for the LCL. For this reason the LCL VAP is included in the LASSO High-Frequency Observations bundle.

The table below details the input and output datastreams and variables, output frequency, and data availability of the lassodlcbhshcu VAP.

Table 5. Summary of the LASSO Doppler Lidar Cloud-Base Height for Shallow Cumulus VAP. "*" denotes primary output variable used in LASSO.

LASSODLCBHSHCU VAP		
Input Data	**Datastreams**	**Variables**
	lcl.c1	alt lat lon lcl stations_name
	dlprofwstats4news.c1	dl_cbh_25
Output Data	**Datastream**	**Major Variables**
	lassodlcbhshcu.c1	dl_cbh_25 lcl *cloud_base_height
Frequency	Time: 10 minutes	
Availability	C1, E32, E37, E39, and E41 for 2018 and 2019 LASSO Cases	

Note that the high-frequency *lassodlcbhshcu* VAP has only been produced for the LASSO 2018 cases and subsequent years.

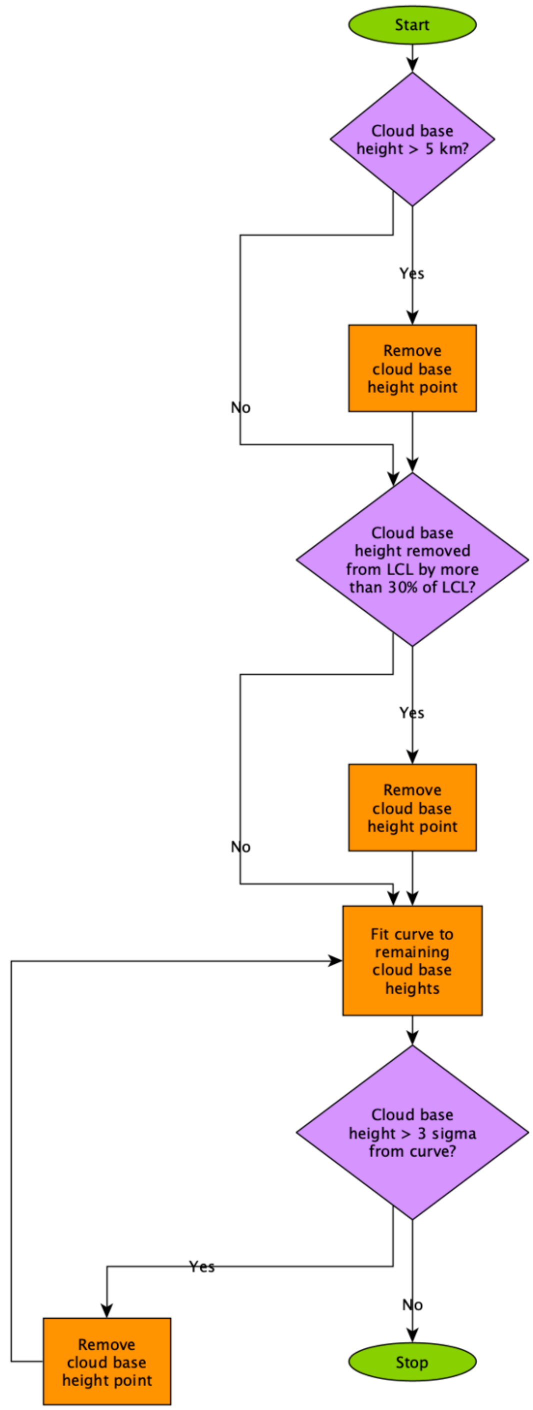

Figure 17. Flowchart describing the processing algorithm for one site and one day of the LASSO Doppler Lidar Cloud-Base Height Shallow Cumulus VAP.

Figure 18 presents sample plots generated by the *lassodlcbhshcu* VAP.

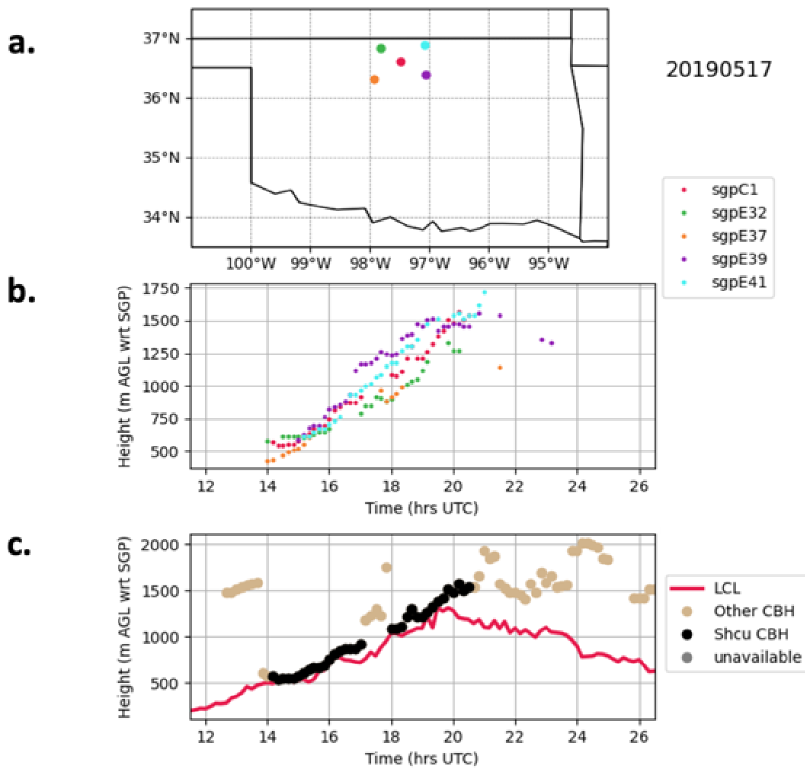

Figure 18. Plots from the LASSO Doppler Lidar Cloud-Base Height for Shallow Cumulus VAP for 17-May-2019. The top plot, (a), shows the locations of the five Doppler lidar (DL) sites at SGP, the middle plot, (b), shows the time series of cloud-base heights from all five DL sites relative to the site altitude of the ARM SGP Central Facility (SGP.C1), and the bottom plot, (c), shows the time series at SGP.C1 of the lifting condensation level (LCL) heights, shallow cumulus CBHs in black, and other cloud type CBHs (that have been excluded) in tan.

Radar Wind Profiler Wind Consensus VAP

The Radar Wind Profiler Wind Consensus VAP, *rwpwindcon*, provides radar wind profiler short-mode horizontal-wind estimates that are used for data assimilation with MSDA to generate the MSDA-based large-scale forcing, as described in Section 2.2. Note that the data from this VAP, unlike the others described above, is not used for model evaluation.

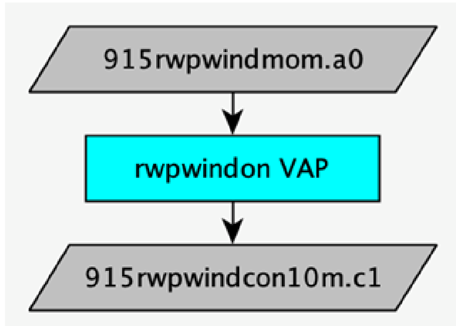

Figure 19. Data flow for Radar Wind Profiler Wind Consensus VAP showing input and output datastreams.

The algorithm for the *rwpwind* VAP starts by collecting all velocities within the consensus period (10 minutes). A directional mean is used to average the velocity after screening, which involves using complementary signal-to-noise ratio (SNR) points by an empirical threshold as well as a screening for precipitation using a threshold mean-doppler-velocity of -4 m s^{-1}. For each range gate and beam, consensus velocities are calculated and used to compute the components of the horizontal wind (u and v) using the equations in Helmus and Ghate (2017).

The time-height resolved components are further screened by the following criteria in this order: 1) at least 2 beams (any 2) must have at least 20% of their consensus points; 2) removal of outliers with a simple comparison of adjacent points in height: if the center point exceeds both of the two surrounding points by 15 m s^{-1}, then the point is removed; 3) removal of outliers with a simple comparison of adjacent points in height — if the center point exceeds both of the two surrounding points by 5 m s^{-1}, then the point is removed; 4) a threshold wind speed of 45 m s^{-1}. Finally, at the SGP Central Facility (C1), for the short mode, a band of heights from 1.2 to 1.4 km is masked out due to interference.

The table below details the input and output datastreams and variables, output frequency, and data availability of the *rwpwindcon* VAP.

Table 6. Summary of the Radar Wind Profiler Wind Consensus VAP.

RWPWINDCON VAP		
Input Data	**Datastream**	**Variables**
	915rwpwindmom.a0	beam_azimuth beam_elevation height_t ipp mdf ncoh nheight noise snr specw vband
Output Data	**Datastream**	**Major Variables**
	915rwpwindcon10m.c1	wind_speed wind_direction u_wind v_wind
Frequency	Time: 10-minute, Height interval: varies according to RWP mode	
Availability	sgp.C1, I8, I9, and I10 2019 LASSO Cases	

Note that the *rwpwindcon* VAP has only been produced for LASSO case dates for 2018 and subsequent years so far, but it can be produced for other time periods and sites that have boundary layer RWP data.

Figure 20 presents sample plots generated from *rwpwindcon* VAP data.

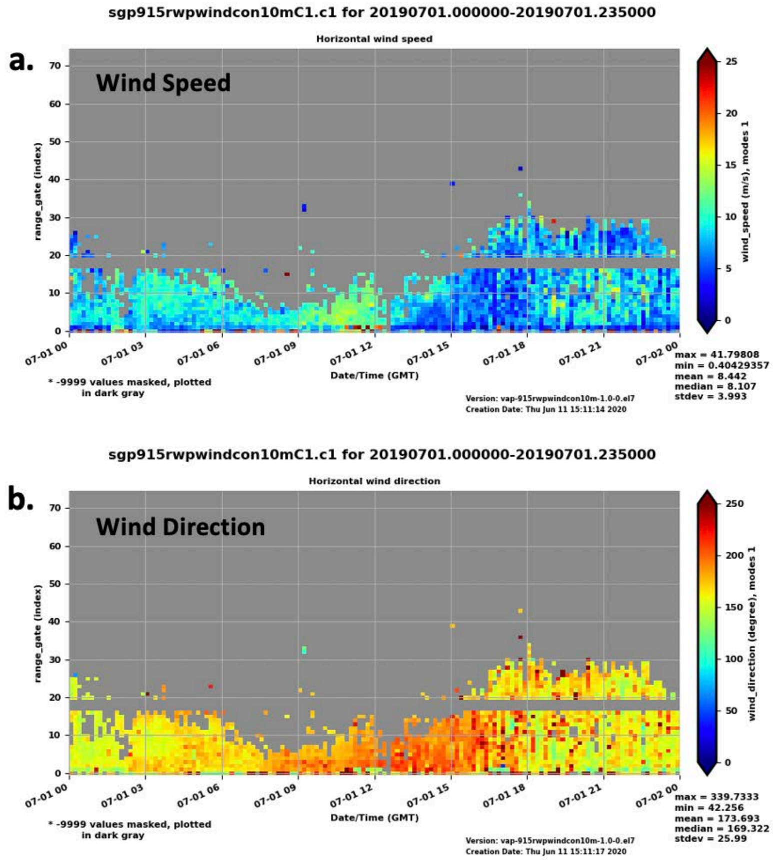

Figure 20. Plots from the Radar Wind Profiler Wind Consensus VAP for 1-Jul-2019 at the ARM SGP Central Facility (SGP.C1). The top plot, (a), shows the two-dimensional, time-height wind speed, and the bottom plot, (b), shows the corresponding wind direction.

Appendix D:

LASSO Data Bundle File Contents

This appendix lists the contents of the files contained in data bundles in this release outside of the *config* directory. The file listings take the form of netCDF header dumps that include the associated metadata for each variable. The list is organized by the directory structure shown in Figure 8. Contents of files in the *lassohighfreqobs* datastream can be found in Appendix E.

File: .../20190512/sim0002/metrics/sgplassoscoreC1.m1.20190512.120000.nc

Description: Contains metrics for surface meteorology and cloud variables comparing the simulations in the case to observations.

```
netcdf sgplassoscoreC1.m1.20190512.120000 {
dimensions:
      time = UNLIMITED ; // (1 currently)
      simulation_id = 8 ;
      bound = 2 ;
      variable = 12 ;
      variable_name_length = 100 ;
variables:
      int base_time ;
            base_time:string = "2019-05-12 00:00:00 0:00" ;
            base_time:long_name = "Base time in Epoch" ;
            base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
            base_time:ancillary_variables = "time_offset" ;
      double time_offset(time) ;
            time_offset:long_name = "Time offset from base_time" ;
            time_offset:units = "seconds since 2019-05-12 00:00:00 0:00" ;
            time_offset:ancillary_variables = "base_time" ;
      double time(time) ;
            time:long_name = "Time offset from midnight" ;
            time:units = "seconds since 2019-05-12 00:00:00 0:00" ;
            time:calendar = "gregorian" ;
            time:standard_name = "time" ;
            time:bounds = "time_bounds" ;
      double time_bounds(time, bound) ;
            time_bounds:long_name = "Time cell bounds" ;
            time_bounds:bound_offsets = 0., 54000. ;
      int simulation_id(simulation_id) ;
            simulation_id:long_name = "Simulation ID" ;
            simulation_id:units = "1" ;
      int variable(variable) ;
            variable:long_name = "Variable index" ;
```

```
            variable:units = "1" ;
      char variable_name(variable, variable_name_length) ;
            variable_name:long_name = "Variable name" ;
            variable_name:units = "1" ;
      float taylor_skill(time, variable, simulation_id) ;
            taylor_skill:long_name = "Taylor skill score" ;
            taylor_skill:units = "1" ;
            taylor_skill:missing_value = -9999.f ;
      float taylor_r0(time, variable, simulation_id) ;
            taylor_r0:long_name = "Taylor_r0" ;
            taylor_r0:units = "1" ;
            taylor_r0:missing_value = -9999.f ;
      float relative_mean_skill(time, variable, simulation_id) ;
            relative_mean_skill:long_name = "Skill of relative mean" ;
            relative_mean_skill:units = "1" ;
            relative_mean_skill:missing_value = -9999.f ;
      float net_skill(time, variable, simulation_id) ;
            net_skill:long_name = "Skill of: relative mean skill and taylor
skill" ;
            net_skill:units = "1" ;
            net_skill:missing_value = -9999.f ;
      float cloud_1d_skill(time, simulation_id) ;
            cloud_1d_skill:long_name = "Skill of: LWP net skill and TSI cloud
fraction net skill" ;
            cloud_1d_skill:units = "1" ;
            cloud_1d_skill:missing_value = -9999.f ;
      float total_cloud_skill(time, simulation_id) ;
            total_cloud_skill:long_name = "Skill of: cloud mask net skill and
1D cloud skill (cloud_1d_skill)" ;
            total_cloud_skill:units = "1" ;
            total_cloud_skill:missing_value = -9999.f ;
            total_cloud_skill:comments = "Cloud mask net skill found in
datastream: lassostat2d.c1" ;
      int complete_flag ;
            complete_flag:long_name = "Observational data found across all
variables" ;
            complete_flag:units = "1" ;
            complete_flag:flag_values = 0, 1 ;
            complete_flag:flag_meanings = "Complete Incomplete" ;
            complete_flag:flag_0_description = "Complete" ;
            complete_flag:flag_1_description = "Incomplete" ;
            complete_flag:comments = "See
observation_data_availability_comments global attribute for details" ;
      float lat ;
            lat:long_name = "North latitude" ;
            lat:units = "degree_N" ;
            lat:valid_min = -90.f ;
            lat:valid_max = 90.f ;
            lat:standard_name = "latitude" ;
      float lon ;
            lon:long_name = "East longitude" ;
            lon:units = "degree_E" ;
            lon:valid_min = -180.f ;
            lon:valid_max = 180.f ;
            lon:standard_name = "longitude" ;
```

```
      float alt ;
            alt:long_name = "Altitude above mean sea level" ;
            alt:units = "m" ;
            alt:standard_name = "altitude" ;

// global attributes:
            :command_line = "lassoscore -n lassoscore -s sgp -f C1 -b
20190512.115900 -R" ;
            :Conventions = "ARM-1.2" ;
            :process_version = "vap-lassoscore-1.0-0.el7" ;
            :dod_version = "lassoscore-m1-1.0" ;
            :input_datastreams = "sgplassodiagobsmod1C1.m1 : 2.0 :
20190512.120000\n",
                  "sgplassodiagobsmod2C1.m1 : 2.0 : 20190512.120000\n",
                  "sgplassodiagobsmod3C1.m1 : 2.0 : 20190512.120000\n",
                  "sgplassodiagobsmod4C1.m1 : 2.0 : 20190512.120000\n",
                  "sgplassodiagobsmod5C1.m1 : 2.0 : 20190512.120000\n",
                  "sgplassodiagobsmod6C1.m1 : 2.0 : 20190512.120000\n",
                  "sgplassodiagobsmod7C1.m1 : 2.0 : 20190512.120000\n",
                  "sgplassodiagobsmod8C1.m1 : 2.0 : 20190512.120000\n",
                  "sgplassoscorezC1.m1 : 1.0 : 20190512.120000" ;
            :site_id = "sgp" ;
            :platform_id = "lassoscore" ;
            :facility_id = "C1" ;
            :data_level = "m1" ;
            :location_description = "Southern Great Plains (SGP), Lamont,
Oklahoma" ;
            :datastream = "sgplassoscoreC1.m1" ;
            :boundary_layer_top = "700 m AGL" ;
            :boundary_layer_bottom = "500 m AGL" ;
            :lcl_domain_sites = "sgpC1, sgpE32, sgpE33, sgpE36, sgpE37,
sgpE39, sgpE41, BLAC, BREC, CARL, MRSH, MEDF, REDR" ;
            :observation_data_availability_comments = "Observations are
complete; sufficient data is available for diagnostics." ;
            :contacts = "lasso@arm.gov, LASSO PI: William Gustafson
(William.Gustafson@pnnl.gov), LASSO Co-PI: Andrew Vogelmann
(vogelmann@bnl.gov)" ;
            :doi = "10.5439/1342961" ;
            :history = "created by user ttoto on machine agate at 2020-06-11
17:26:36, using vap-lassoscore-1.0-0.el7" ;
} }
```

File: .../20190512/sim0002/metrics/sgplassoscorezC1.m1.20190512.120000.nc

Description: Skill scores for time-height cloud comparisons by simulation within the given case date.

```
netcdf sgplassoscorezC1.m1.20190512.120000 {
dimensions:
      time = UNLIMITED ; // (1 currently)
      bound = 2 ;
      simulation_id = 8 ;
variables:
      int base_time ;
            base_time:string = "2019-05-12 00:00:00 0:00" ;
            base_time:long_name = "Base time in Epoch" ;
```

```
        base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
        base_time:ancillary_variables = "time_offset" ;
  double time_offset(time) ;
        time_offset:long_name = "Time offset from base_time" ;
        time_offset:units = "seconds since 2019-05-12 00:00:00 0:00" ;
        time_offset:ancillary_variables = "base_time" ;
  double time(time) ;
        time:long_name = "Time offset from midnight" ;
        time:units = "seconds since 2019-05-12 00:00:00 0:00" ;
        time:calendar = "gregorian" ;
        time:standard_name = "time" ;
        time:bounds = "time_bounds" ;
  double time_bounds(time, bound) ;
        time_bounds:long_name = "Time cell bounds" ;
        time_bounds:bound_offsets = 0., 54000. ;
  int simulation_id(simulation_id) ;
        simulation_id:long_name = "Simulation ID" ;
        simulation_id:units = "1" ;
  float critical_success_index(time, simulation_id) ;
        critical_success_index:long_name = "Critical success index" ;
        critical_success_index:units = "1" ;
        critical_success_index:missing_value = -9999.f ;
        critical_success_index:resolution = 0.01f ;
  float frequency_bias(time, simulation_id) ;
        frequency_bias:long_name = "Frequency bias" ;
        frequency_bias:units = "1" ;
        frequency_bias:missing_value = -9999.f ;
        frequency_bias:resolution = 0.01f ;
  float equitable_threat_score(time, simulation_id) ;
        equitable_threat_score:long_name = "Equitable threat score" ;
        equitable_threat_score:units = "1" ;
        equitable_threat_score:missing_value = -9999.f ;
        equitable_threat_score:resolution = 0.01f ;
  float ets_skill(time, simulation_id) ;
        ets_skill:long_name = "Equitable threat score skill" ;
        ets_skill:units = "1" ;
        ets_skill:missing_value = -9999.f ;
        ets_skill:resolution = 0.01f ;
  float frequency_bias_skill(time, simulation_id) ;
        frequency_bias_skill:long_name = "Frequency bias skill" ;
        frequency_bias_skill:units = "1" ;
        frequency_bias_skill:missing_value = -9999.f ;
        frequency_bias_skill:resolution = 0.01f ;
  float cloud_mask_2d_net_skill(time, simulation_id) ;
        cloud_mask_2d_net_skill:long_name = "2D Cloud mask net skill" ;
        cloud_mask_2d_net_skill:units = "1" ;
        cloud_mask_2d_net_skill:missing_value = -9999.f ;
        cloud_mask_2d_net_skill:resolution = 0.01f ;
  float lat ;
        lat:long_name = "North latitude" ;
        lat:units = "degree_N" ;
        lat:valid_min = -90.f ;
        lat:valid_max = 90.f ;
        lat:standard_name = "latitude" ;
  float lon ;
```

```
            lon:long_name = "East longitude" ;
            lon:units = "degree_E" ;
            lon:valid_min = -180.f ;
            lon:valid_max = 180.f ;
            lon:standard_name = "longitude" ;
      float alt ;
            alt:long_name = "Altitude above mean sea level" ;
            alt:units = "m" ;
            alt:standard_name = "altitude" ;

// global attributes:
            :command_line = "lassoscorez -n lassoscorez -s sgp -f C1 -b
20190512.115900 -R" ;
            :Conventions = "ARM-1.2" ;
            :process_version = "vap-lassoscorez-1.0-0.el7" ;
            :dod_version = "lassoscorez-m1-1.0" ;
            :input_datastreams = "sgplassodiagobsmodz1C1.m1 : 1.1 :
20190512.120000\n",
                  "sgplassodiagobsmodz2C1.m1 : 1.1 : 20190512.120000\n",
                  "sgplassodiagobsmodz3C1.m1 : 1.1 : 20190512.120000\n",
                  "sgplassodiagobsmodz4C1.m1 : 1.1 : 20190512.120000\n",
                  "sgplassodiagobsmodz5C1.m1 : 1.1 : 20190512.120000\n",
                  "sgplassodiagobsmodz6C1.m1 : 1.1 : 20190512.120000\n",
                  "sgplassodiagobsmodz7C1.m1 : 1.1 : 20190512.120000\n",
                  "sgplassodiagobsmodz8C1.m1 : 1.1 : 20190512.120000" ;
            :site_id = "sgp" ;
            :platform_id = "lassoscorez" ;
            :facility_id = "C1" ;
            :data_level = "m1" ;
            :location_description = "Southern Great Plains (SGP), Lamont,
Oklahoma" ;
            :datastream = "sgplassoscorezC1.m1" ;
            :contacts = "lasso@arm.gov, LASSO PI: William Gustafson
(William.Gustafson@pnnl.gov), LASSO Co-PI: Andrew Vogelmann
(vogelmann@bnl.gov)" ;
            :doi = "10.5439/1342961" ;
            :history = "created by user ttoto on machine agate at 2020-06-11
17:13:48, using vap-lassoscorez-1.0-0.el7" ;
}
```

File: .../20180514/sim0002/obs_model/sgplassodiagobsmod2C1.m1.20180514.000000.nc

Description: Directly comparable model output from sgplassomod2C1.m1.20180514.120000.nc and observations on coincident hourly time intervals.

```
netcdf sgplassodiagobsmod2C1.m1.20180514.000000 {
dimensions:
      time = UNLIMITED ; // (16 currently)
      source_type = 2 ;
variables:
      int base_time ;
            base_time:string = "14-May-2018,00:00:00 UTC" ;
            base_time:long_name = "Base time in Epoch, UTC" ;
            base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
            base_time:ancillary_variables = "time_offset" ;
```

```
      double time_offset(time) ;
            time_offset:long_name = "Time offset from base_time UTC" ;
            time_offset:units = "seconds since 2018-05-14 00:00:00 0:00" ;
            time_offset:ancillary_variables = "base_time" ;
            time_offset:comments = "time offset corresponds to center of
averaging interval" ;
      double time(time) ;
            time:long_name = "Time offset from midnight UTC" ;
            time:units = "seconds since 2018-05-14 00:00:00 0:00" ;
            time:calendar = "gregorian" ;
            time:standard_name = "time" ;
      int source_type(source_type) ;
            source_type:long_name = "Type of data source" ;
            source_type:units = "unitless" ;
            source_type:description = "This field contains integer values
which should be interpreted as listed." ;
            source_type:flag_method = "integer" ;
            source_type:flag_0_description = "Observation" ;
            source_type:flag_1_description = "Model" ;
      float low_cloud_fraction_arscl(time, source_type) ;
            low_cloud_fraction_arscl:long_name = "Frequency of 15-min cloud
occurrence, as identified by ARSCL, below 5km AGL" ;
            low_cloud_fraction_arscl:units = "1" ;
            low_cloud_fraction_arscl:missing_value = -9999.f ;
            low_cloud_fraction_arscl:valid_min = 0.f ;
            low_cloud_fraction_arscl:valid_max = 1.f ;
            low_cloud_fraction_arscl:cell_methods = "time: mean" ;
            low_cloud_fraction_arscl:ancillary_variables =
"qc_low_cloud_fraction_arscl low_cloud_fraction_arscl_goodfraction" ;
      int qc_low_cloud_fraction_arscl(time, source_type) ;
            qc_low_cloud_fraction_arscl:long_name = "Quality check results on
field: Frequency of 15-min cloud occurrence, as identified by ARSCL, below
5km AGL" ;
            qc_low_cloud_fraction_arscl:units = "unitless" ;
            qc_low_cloud_fraction_arscl:description = "This field contains
bit packed integer values, where each bit represents a QC test on the data."
;
            qc_low_cloud_fraction_arscl:flag_method = "bit" ;
            qc_low_cloud_fraction_arscl:bit_1_description = "Calculated with
valid points between 30% and 50%" ;
            qc_low_cloud_fraction_arscl:bit_2_description = "Calculated with
valid points less than 30%" ;
            qc_low_cloud_fraction_arscl:bit_2_assessment = "Bad" ;
            qc_low_cloud_fraction_arscl:bit_1_assessment = "Indeterminate" ;
      float low_cloud_fraction_arscl_goodfraction(time, source_type) ;
            low_cloud_fraction_arscl_goodfraction:long_name = "Metric
goodfraction for Frequency of 15-min cloud occurrence, as identified by
ARSCL, below 5km" ;
            low_cloud_fraction_arscl_goodfraction:units = "unitless" ;
            low_cloud_fraction_arscl_goodfraction:missing_value = -9999.f ;
      float low_cloud_fraction_arscl_std(time, source_type) ;
            low_cloud_fraction_arscl_std:long_name = "Metric standard
deviation for field Frequency of 15-min cloud occurrence, as identified by
ARSC" ;
            low_cloud_fraction_arscl_std:units = "m" ;
```

```
            low_cloud_fraction_arscl_std:missing_value = -9999.f ;
      float cloud_fraction_tsi(time, source_type) ;
            cloud_fraction_tsi:long_name = "Hemispheric cloud fraction, as
identified by TSI (opaque)" ;
            cloud_fraction_tsi:units = "1" ;
            cloud_fraction_tsi:missing_value = -9999.f ;
            cloud_fraction_tsi:valid_min = 0.f ;
            cloud_fraction_tsi:valid_max = 1.f ;
            cloud_fraction_tsi:cell_methods = "time: mean" ;
            cloud_fraction_tsi:ancillary_variables = "qc_cloud_fraction_tsi
cloud_fraction_tsi_goodfraction" ;
      int qc_cloud_fraction_tsi(time, source_type) ;
            qc_cloud_fraction_tsi:long_name = "Quality check results on
field: Hemispheric cloud fraction, as identified by TSI (opaque)" ;
            qc_cloud_fraction_tsi:units = "unitless" ;
            qc_cloud_fraction_tsi:description = "This field contains bit
packed integer values, where each bit represents a QC test on the data." ;
            qc_cloud_fraction_tsi:flag_method = "bit" ;
            qc_cloud_fraction_tsi:bit_1_description = "Calculated with valid
points between 30% and 50%" ;
            qc_cloud_fraction_tsi:bit_1_assessment = "Indeterminate" ;
            qc_cloud_fraction_tsi:bit_2_description = "Calculated with valid
points less than 30%" ;
            qc_cloud_fraction_tsi:bit_2_assessment = "Bad" ;
      float cloud_fraction_tsi_goodfraction(time, source_type) ;
            cloud_fraction_tsi_goodfraction:long_name = "Metric goodfraction
for Hemispheric cloud fraction, as identified by TSI (opaque)" ;
            cloud_fraction_tsi_goodfraction:units = "unitless" ;
            cloud_fraction_tsi_goodfraction:missing_value = -9999.f ;
      float cloud_fraction_tsi_std(time, source_type) ;
            cloud_fraction_tsi_std:long_name = "Metric standard deviation for
field Hemispheric cloud fraction, as identified by TSI (opaque)" ;
            cloud_fraction_tsi_std:units = "1" ;
            cloud_fraction_tsi_std:missing_value = -9999.f ;
      float lwp(time, source_type) ;
            lwp:long_name = "Liquid water path" ;
            lwp:units = "g m-2" ;
            lwp:missing_value = -9999.f ;
            lwp:cell_methods = "time: mean" ;
            lwp:ancillary_variables = "qc_lwp lwp_goodfraction" ;
      int qc_lwp(time, source_type) ;
            qc_lwp:long_name = "Quality check results on field: Liquid water
path" ;
            qc_lwp:units = "unitless" ;
            qc_lwp:description = "This field contains bit packed integer
values, where each bit represents a QC test on the data." ;
            qc_lwp:flag_method = "bit" ;
            qc_lwp:bit_1_description = "Calculated with valid points between
30% and 50%" ;
            qc_lwp:bit_1_assessment = "Indeterminate" ;
            qc_lwp:bit_2_description = "Calculated with valid points less
than 30%" ;
            qc_lwp:bit_2_assessment = "Bad" ;
      float lwp_goodfraction(time, source_type) ;
```

```
            lwp_goodfraction:long_name = "Metric goodfraction for Liquid
water path" ;
            lwp_goodfraction:units = "unitless" ;
            lwp_goodfraction:missing_value = -9999.f ;
      float lwp_std(time, source_type) ;
            lwp_std:long_name = "Metric standard deviation for field Liquid
water path" ;
            lwp_std:units = "g m-2" ;
            lwp_std:missing_value = -9999.f ;
      float lcl(time, source_type) ;
            lcl:long_name = "Lifting condensation level" ;
            lcl:units = "m" ;
            lcl:missing_value = -9999.f ;
            lcl:cell_methods = "time: mean" ;
            lcl:ancillary_variables = "qc_lcl lcl_goodfraction" ;
            lcl:standard_name =
"atmosphere_lifting_condensation_level_wrt_surface" ;
      int qc_lcl(time, source_type) ;
            qc_lcl:long_name = "Quality check results on field: Lifting
condensation level" ;
            qc_lcl:units = "unitless" ;
            qc_lcl:description = "This field contains bit packed integer
values, where each bit represents a QC test on the data." ;
            qc_lcl:flag_method = "bit" ;
            qc_lcl:bit_1_description = "Calculated with valid points between
30% and 50%" ;
            qc_lcl:bit_1_assessment = "Indeterminate" ;
            qc_lcl:bit_2_description = "Calculated with valid points less
than 30%" ;
            qc_lcl:bit_2_assessment = "Bad" ;
      float lcl_goodfraction(time, source_type) ;
            lcl_goodfraction:long_name = "Metric goodfraction for Lifting
condensation level" ;
            lcl_goodfraction:units = "unitless" ;
            lcl_goodfraction:missing_value = -9999.f ;
      float lcl_std(time, source_type) ;
            lcl_std:long_name = "Metric standard deviation for field Lifting
condensation level" ;
            lcl_std:units = "m" ;
            lcl_std:missing_value = -9999.f ;
      float lcl_domain(time, source_type) ;
            lcl_domain:long_name = "Lifting condensation level, domain" ;
            lcl_domain:units = "m" ;
            lcl_domain:missing_value = -9999.f ;
            lcl_domain:cell_methods = "time: mean" ;
            lcl_domain:ancillary_variables = "qc_lcl_domain
lcl_domain_goodfraction" ;
            lcl_domain:standard_name =
"atmosphere_lifting_condensation_level_wrt_surface" ;
      int qc_lcl_domain(time, source_type) ;
            qc_lcl_domain:long_name = "Quality check results on field:
Lifting condensation level, domain" ;
            qc_lcl_domain:units = "unitless" ;
            qc_lcl_domain:description = "This field contains bit packed
integer values, where each bit represents a QC test on the data." ;
```

```
            qc_lcl_domain:flag_method = "bit" ;
            qc_lcl_domain:bit_1_description = "Calculated with valid points
between 30% and 50%" ;
            qc_lcl_domain:bit_1_assessment = "Indeterminate" ;
            qc_lcl_domain:bit_2_description = "Calculated with valid points
less than 30%" ;
            qc_lcl_domain:bit_2_assessment = "Bad" ;
      float lcl_domain_goodfraction(time, source_type) ;
            lcl_domain_goodfraction:long_name = "Metric goodfraction for
Lifting condensation level, domain" ;
            lcl_domain_goodfraction:units = "unitless" ;
            lcl_domain_goodfraction:missing_value = -9999.f ;
      float lcl_domain_std(time, source_type) ;
            lcl_domain_std:long_name = "Metric standard deviation for field
Lifting condensation level, domain" ;
            lcl_domain_std:units = "m" ;
            lcl_domain_std:missing_value = -9999.f ;
      float cloud_base_height(time, source_type) ;
            cloud_base_height:long_name = "Cloud base height" ;
            cloud_base_height:units = "m" ;
            cloud_base_height:missing_value = -9999.f ;
            cloud_base_height:cell_methods = "time: mean" ;
            cloud_base_height:ancillary_variables = "qc_cloud_base_height
cloud_base_height_goodfraction" ;
            cloud_base_height:standard_name = "convective_cloud_base_height"
;
      int qc_cloud_base_height(time, source_type) ;
            qc_cloud_base_height:long_name = "Quality check results on field:
Cloud base height" ;
            qc_cloud_base_height:units = "unitless" ;
            qc_cloud_base_height:description = "This field contains bit
packed integer values, where each bit represents a QC test on the data." ;
            qc_cloud_base_height:flag_method = "bit" ;
            qc_cloud_base_height:bit_1_description = "Calculated with valid
points between 30% and 50%" ;
            qc_cloud_base_height:bit_1_assessment = "Indeterminate" ;
            qc_cloud_base_height:bit_2_description = "Calculated with valid
points less than 30%" ;
            qc_cloud_base_height:bit_2_assessment = "Bad" ;
      float cloud_base_height_goodfraction(time, source_type) ;
            cloud_base_height_goodfraction:long_name = "Metric goodfraction
for Cloud base height" ;
            cloud_base_height_goodfraction:units = "unitless" ;
            cloud_base_height_goodfraction:missing_value = -9999.f ;
      float cloud_base_height_std(time, source_type) ;
            cloud_base_height_std:long_name = "Metric standard deviation for
field Cloud base height" ;
            cloud_base_height_std:units = "m" ;
            cloud_base_height_std:missing_value = -9999.f ;
      float water_vapor_mixing_ratio_surface(time, source_type) ;
            water_vapor_mixing_ratio_surface:long_name = "Water vapor mixing
ratio at surface" ;
            water_vapor_mixing_ratio_surface:units = "g kg-1" ;
            water_vapor_mixing_ratio_surface:missing_value = -9999.f ;
            water_vapor_mixing_ratio_surface:cell_methods = "time: mean" ;
```

```
            water_vapor_mixing_ratio_surface:ancillary_variables = 
"qc_water_vapor_mixing_ratio_surface" ;
      int qc_water_vapor_mixing_ratio_surface(time, source_type) ;
            qc_water_vapor_mixing_ratio_surface:long_name = "Quality check 
results on field: Water vapor mixing ratio at surface" ;
            qc_water_vapor_mixing_ratio_surface:units = "unitless" ;
            qc_water_vapor_mixing_ratio_surface:description = "This field 
contains bit packed integer values, where each bit represents a QC test on 
the data." ;
            qc_water_vapor_mixing_ratio_surface:flag_method = "bit" ;
            qc_water_vapor_mixing_ratio_surface:bit_1_description = 
"Calculated with valid points between 30% and 50%" ;
            qc_water_vapor_mixing_ratio_surface:bit_1_assessment = 
"Indeterminate" ;
            qc_water_vapor_mixing_ratio_surface:bit_2_description = 
"Calculated with valid points less than 30%" ;
            qc_water_vapor_mixing_ratio_surface:bit_2_assessment = "Bad" ;
      float water_vapor_mixing_ratio_surface_std(time, source_type) ;
            water_vapor_mixing_ratio_surface_std:long_name = "Metric standard 
deviation for field Water vapor mixing ratio at surface" ;
            water_vapor_mixing_ratio_surface_std:units = "g kg-1" ;
            water_vapor_mixing_ratio_surface_std:missing_value = -9999.f ;
      float water_vapor_mixing_ratio_surface_goodfraction(time, source_type) 
;
            water_vapor_mixing_ratio_surface_goodfraction:long_name = "Metric 
goodfraction for Water vapor mixing ratio at surface" ;
            water_vapor_mixing_ratio_surface_goodfraction:units = "unitless" 
;
            water_vapor_mixing_ratio_surface_goodfraction:missing_value = -
9999.f ;
      float temperature_surface(time, source_type) ;
            temperature_surface:long_name = "Temperature at surface" ;
            temperature_surface:units = "K" ;
            temperature_surface:missing_value = -9999.f ;
            temperature_surface:cell_methods = "time: mean" ;
            temperature_surface:ancillary_variables = 
"qc_temperature_surface" ;
            temperature_surface:standard_name = "surface_temperature" ;
      int qc_temperature_surface(time, source_type) ;
            qc_temperature_surface:long_name = "Quality check results on 
field: Temperature at surface" ;
            qc_temperature_surface:units = "unitless" ;
            qc_temperature_surface:description = "This field contains bit 
packed integer values, where each bit represents a QC test on the data." ;
            qc_temperature_surface:flag_method = "bit" ;
            qc_temperature_surface:bit_1_description = "Calculated with valid 
points between 30% and 50%" ;
            qc_temperature_surface:bit_1_assessment = "Indeterminate" ;
            qc_temperature_surface:bit_2_description = "Calculated with valid 
points less than 30%" ;
            qc_temperature_surface:bit_2_assessment = "Bad" ;
      float temperature_surface_std(time, source_type) ;
            temperature_surface_std:long_name = "Metric standard deviation 
for field Temperature at surface" ;
            temperature_surface_std:units = "K" ;
```

```
            temperature_surface_std:missing_value = -9999.f ;
      float temperature_surface_goodfraction(time, source_type) ;
            temperature_surface_goodfraction:long_name = "Metric goodfraction
for Temperature at surface" ;
            temperature_surface_goodfraction:units = "unitless" ;
            temperature_surface_goodfraction:missing_value = -9999.f ;
      float rh_surface(time, source_type) ;
            rh_surface:long_name = "Relative humidity" ;
            rh_surface:units = "%" ;
            rh_surface:missing_value = -9999.f ;
            rh_surface:cell_methods = "time: mean" ;
            rh_surface:ancillary_variables = "qc_rh_surface" ;
      int qc_rh_surface(time, source_type) ;
            qc_rh_surface:long_name = "Quality check results on field:
Relative humidity" ;
            qc_rh_surface:units = "unitless" ;
            qc_rh_surface:description = "This field contains bit packed
integer values, where each bit represents a QC test on the data." ;
            qc_rh_surface:flag_method = "bit" ;
            qc_rh_surface:bit_1_description = "Calculated with valid points
between 30% and 50%" ;
            qc_rh_surface:bit_1_assessment = "Indeterminate" ;
            qc_rh_surface:bit_2_description = "Calculated with valid points
less than 30%" ;
            qc_rh_surface:bit_2_assessment = "Bad" ;
      float rh_surface_std(time, source_type) ;
            rh_surface_std:long_name = "Metric standard deviation for field
Relative humidity at surface" ;
            rh_surface_std:units = "%" ;
            rh_surface_std:missing_value = -9999.f ;
      float rh_surface_goodfraction(time, source_type) ;
            rh_surface_goodfraction:long_name = "Metric goodfraction for
Relative humidity at surface" ;
            rh_surface_goodfraction:units = "unitless" ;
            rh_surface_goodfraction:missing_value = -9999.f ;
      float water_vapor_mixing_ratio_boundary_layer(time, source_type) ;
            water_vapor_mixing_ratio_boundary_layer:long_name = "Water vapor
mixing ratio; average of boundary layer" ;
            water_vapor_mixing_ratio_boundary_layer:units = "g kg-1" ;
            water_vapor_mixing_ratio_boundary_layer:missing_value = -9999.f ;
            water_vapor_mixing_ratio_boundary_layer:cell_methods = "time:
mean" ;
            water_vapor_mixing_ratio_boundary_layer:ancillary_variables =
"qc_water_vapor_mixing_ratio_boundary_layer" ;
      int qc_water_vapor_mixing_ratio_boundary_layer(time, source_type) ;
            qc_water_vapor_mixing_ratio_boundary_layer:long_name = "Quality
check results on field: Water vapor mixing ratio; average of boundary layer"
;
            qc_water_vapor_mixing_ratio_boundary_layer:units = "unitless" ;
            qc_water_vapor_mixing_ratio_boundary_layer:description = "This
field contains bit packed integer values, where each bit represents a QC test
on the data." ;
            qc_water_vapor_mixing_ratio_boundary_layer:flag_method = "bit" ;
            qc_water_vapor_mixing_ratio_boundary_layer:bit_1_description =
"Calculated with valid points between 30% and 50%" ;
```

```
            qc_water_vapor_mixing_ratio_boundary_layer:bit_1_assessment =
"Indeterminate" ;
            qc_water_vapor_mixing_ratio_boundary_layer:bit_2_description =
"Calculated with valid points less than 30%" ;
            qc_water_vapor_mixing_ratio_boundary_layer:bit_2_assessment =
"Bad" ;
      float water_vapor_mixing_ratio_boundary_layer_std(time, source_type) ;
            water_vapor_mixing_ratio_boundary_layer_std:long_name = "Metric
standard deviation for field Water vapor mixing ratio: average of boundary
layer" ;
            water_vapor_mixing_ratio_boundary_layer_std:units = "g kg-1" ;
            water_vapor_mixing_ratio_boundary_layer_std:missing_value = -
9999.f ;
      float water_vapor_mixing_ratio_boundary_layer_goodfraction(time,
source_type) ;
            water_vapor_mixing_ratio_boundary_layer_goodfraction:long_name =
"Metric goodfraction for Water vapor mixing ratio: average of boundary layer"
;
            water_vapor_mixing_ratio_boundary_layer_goodfraction:units =
"unitless" ;

      water_vapor_mixing_ratio_boundary_layer_goodfraction:missing_value = -
9999.f ;
      float temperature_boundary_layer(time, source_type) ;
            temperature_boundary_layer:long_name = "Temperature; average of
boundary layer" ;
            temperature_boundary_layer:units = "K" ;
            temperature_boundary_layer:missing_value = -9999.f ;
            temperature_boundary_layer:cell_methods = "time: mean" ;
            temperature_boundary_layer:ancillary_variables =
"qc_temperature_boundary_layer" ;
      int qc_temperature_boundary_layer(time, source_type) ;
            qc_temperature_boundary_layer:long_name = "Quality check results
on field: Temperature; average of boundary layer" ;
            qc_temperature_boundary_layer:units = "unitless" ;
            qc_temperature_boundary_layer:description = "This field contains
bit packed integer values, where each bit represents a QC test on the data."
;
            qc_temperature_boundary_layer:flag_method = "bit" ;
            qc_temperature_boundary_layer:bit_1_description = "Calculated
with valid points between 30% and 50%" ;
            qc_temperature_boundary_layer:bit_1_assessment = "Indeterminate"
;
            qc_temperature_boundary_layer:bit_2_description = "Calculated
with valid points less than 30%" ;
            qc_temperature_boundary_layer:bit_2_assessment = "Bad" ;
      float temperature_boundary_layer_std(time, source_type) ;
            temperature_boundary_layer_std:long_name = "Metric standard
deviation for field Temperature: average of boundary layer" ;
            temperature_boundary_layer_std:units = "K" ;
            temperature_boundary_layer_std:missing_value = -9999.f ;
      float temperature_boundary_layer_goodfraction(time, source_type) ;
            temperature_boundary_layer_goodfraction:long_name = "Metric
goodfraction for Temperature: average of boundary layer" ;
            temperature_boundary_layer_goodfraction:units = "unitless" ;
```

```
            temperature_boundary_layer_goodfraction:missing_value = -9999.f ;
      float rh_boundary_layer(time, source_type) ;
            rh_boundary_layer:long_name = "Relative humidity; average of
boundary layer" ;
            rh_boundary_layer:units = "%" ;
            rh_boundary_layer:missing_value = -9999.f ;
            rh_boundary_layer:cell_methods = "time: mean" ;
            rh_boundary_layer:ancillary_variables = "qc_rh_boundary_layer" ;
      int qc_rh_boundary_layer(time, source_type) ;
            qc_rh_boundary_layer:long_name = "Quality check results on field:
Relative humidity; average of boundary layer" ;
            qc_rh_boundary_layer:units = "unitless" ;
            qc_rh_boundary_layer:description = "This field contains bit
packed integer values, where each bit represents a QC test on the data." ;
            qc_rh_boundary_layer:flag_method = "bit" ;
            qc_rh_boundary_layer:bit_1_description = "Calculated with valid
points between 30% and 50%" ;
            qc_rh_boundary_layer:bit_1_assessment = "Indeterminate" ;
            qc_rh_boundary_layer:bit_2_description = "Calculated with valid
points less than 30%" ;
            qc_rh_boundary_layer:bit_2_assessment = "Bad" ;
      float rh_boundary_layer_std(time, source_type) ;
            rh_boundary_layer_std:long_name = "Metric standard deviation for
field Relative humidity: average of boundary layer" ;
            rh_boundary_layer_std:units = "%" ;
            rh_boundary_layer_std:missing_value = -9999.f ;
      float rh_boundary_layer_goodfraction(time, source_type) ;
            rh_boundary_layer_goodfraction:long_name = "Metric goodfraction
for Relative humidity: average of boundary layer" ;
            rh_boundary_layer_goodfraction:units = "unitless" ;
            rh_boundary_layer_goodfraction:missing_value = -9999.f ;
      int complete_flag ;
            complete_flag:long_name = "Observational data found across all
variables" ;
            complete_flag:units = "unitless" ;
            complete_flag:description = "This field contains integer values
which should be interpreted as listed." ;
            complete_flag:flag_method = "integer" ;
            complete_flag:flag_meanings = "Complete Incomplete" ;
            complete_flag:flag_0_description = "Complete" ;
            complete_flag:flag_1_description = "Incomplete" ;
            complete_flag:comments = "See
observation_data_availability_comments global attribute for details" ;
      float lat ;
            lat:long_name = "North latitude" ;
            lat:units = "degree_N" ;
            lat:valid_min = -90.f ;
            lat:valid_max = 90.f ;
            lat:standard_name = "latitude" ;
      float lon ;
            lon:long_name = "East longitude" ;
            lon:units = "degree_E" ;
            lon:valid_min = -180.f ;
            lon:valid_max = 180.f ;
            lon:standard_name = "longitude" ;
```

```
      float alt ;
            alt:long_name = "Altitude above mean sea level" ;
            alt:units = "m" ;
            alt:standard_name = "altitude" ;

// global attributes:
            :process_version = "LASSO version 1" ;
            :dod_version = "lassodiagobsmod.m1-2.0.hdr" ;
            :input_source =
"sgplassodiagmod2C1.m1.20180514.120000.nc,sgplassodiagobsC1.c1.20180514.00000
0.nc" ;
            :site_id = "sgp" ;
            :platform_id = "lassodiagobsmod" ;
            :facility_id = "C1" ;
            :data_level = "m1" ;
            :location_description = "Southern Great Plains (SGP),  Lamont,
Oklahoma" ;
            :datastream = "sgplassodiagobsmod2C1.m1" ;
            :simulation_id_number = "2" ;
            :simulation_origin_host = "cumulus-login2.ccs.ornl.gov" ;
            :model_type = "WRF" ;
            :model_version = "3.8.1" ;
            :model_github_hash = "b6b6a5cc4229eec1ea9b005746b5ebef2205fb07" ;
            :output_domain_size = "25.0 km" ;
            :output_number_of_levels = "226" ;
            :output_horizontal_grid_spacing = "100 m" ;
            :config_large_scale_forcing = "VARANAL" ;
            :config_large_scale_forcing_scale = "300 km" ;
            :config_large_scale_forcing_specifics = "sgp60varanarapC1.c1
(v20190228)" ;
            :config_surface_treatment = "VARANAL" ;
            :config_surface_treatment_specifics = "sgp60varanarapC1.c1
(v20190228)" ;
            :config_initial_condition = "Sounding" ;
            :config_initial_condition_specifics = "sgpsondewnpnC1" ;
            :config_aerosol = "NA" ;
            :config_forecast_time = "15.0 h" ;
            :config_boundary_method = "Periodic" ;
            :config_microphysics = "Thompson (mp_physics=8)" ;
            :config_nickname = "runlas20180514v1var" ;
            :boundary_layer_top = "700 m AGL" ;
            :boundary_layer_bottom = "500 m AGL" ;
            :lcl_domain_sites = "sgpC1, sgpE32, sgpE33, sgpE36, sgpE37,
sgpE39, sgpE41, BLAC, BREC, CARL, MRSH, MEDF, REDR" ;
            :observation_data_availability_comments = "Observations are
complete; sufficient data is available for diagnostics." ;
            :contacts = "lasso@arm.gov, LASSO PI: William Gustafson
(William.Gustafson@pnnl.gov), LASSO Co-PI: Andrew Vogelmann
(vogelmann@bnl.gov)" ;
            :doi = "10.5439/1342961" ;
            :history = "Wed May 29 16:25:48 2019" ;
}
```

File: .../20180514/sim0002/obs_model/sgplassodiagobsmod2d2C1.m1.20180514.000000.nc

Description: Model output and observations for time-height cloud fraction on comparable 10-minute sampling intervals.

```
netcdf sgplassodiagobsmod2d2C1.m1.20180514.000000 {
dimensions:
	time = UNLIMITED ; // (91 currently)
	height = 226 ;
variables:
	int base_time ;
		base_time:string = "14-May-2018,00:00:00 UTC" ;
		base_time:long_name = "Base time in Epoch, UTC" ;
		base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
		base_time:ancillary_variables = "time_offset" ;
	double time_offset(time) ;
		time_offset:long_name = "Time offset from base_time UTC" ;
		time_offset:units = "seconds since 2018-05-14 00:00:00 0:00" ;
		time_offset:ancillary_variables = "base_time" ;
	double time(time) ;
		time:long_name = "Time offset from midnight UTC" ;
		time:units = "seconds since 2018-05-14 00:00:00 0:00" ;
		time:calendar = "gregorian" ;
		time:standard_name = "time" ;
	float height(time, height) ;
		height:long_name = "Height above ground level" ;
		height:units = "km" ;
		height:standard_name = "height" ;
	float cloud_fraction(time, height) ;
		cloud_fraction:long_name = "Cloud fraction (from simulation)" ;
		cloud_fraction:units = "1" ;
		cloud_fraction:missing_value = -9999.f ;
		cloud_fraction:valid_min = 0.f ;
		cloud_fraction:valid_max = 1.f ;
	float cloud_fraction_mask_arscl(time, height) ;
		cloud_fraction_mask_arscl:long_name = "Cloud fraction mask (from
ARSCL)" ;
		cloud_fraction_mask_arscl:units = "unitless" ;
		cloud_fraction_mask_arscl:description = "This field contains
integer values which should be interpreted as listed." ;
		cloud_fraction_mask_arscl:flag_method = "integer" ;
		cloud_fraction_mask_arscl:flag_0_description = "no cloud" ;
		cloud_fraction_mask_arscl:flag_1_description = "cloud" ;
		cloud_fraction_mask_arscl:flag_2_description = "no data
available" ;
	float lat ;
		lat:long_name = "North latitude" ;
		lat:units = "degree_N" ;
		lat:valid_min = -90.f ;
		lat:valid_max = 90.f ;
		lat:standard_name = "latitude" ;
	float lon ;
		lon:long_name = "East longitude" ;
		lon:units = "degree_E" ;
		lon:valid_min = -180.f ;
		lon:valid_max = 180.f ;
		lon:standard_name = "longitude" ;
```

```
      float alt ;
            alt:long_name = "Altitude above mean sea level" ;
            alt:units = "m" ;
            alt:standard_name = "altitude" ;

// global attributes:
            :process_version = "LASSO version 1" ;
            :dod_version = "lassodiagobsmod2d.m1-2.0.hdr" ;
            :input_source =
"sgplassomod2d2C1.m1.20180514.120000.nc,sgplassomod2C1.m1.20180514.120000.nc,
sgpcloudfraction15mC1.c0.20180514.000030.nc,sgpcloudfraction15mC1.c0.20180515
.000030.nc" ;
            :site_id = "sgp" ;
            :platform_id = "lassodiagobsmod2d" ;
            :facility_id = "C1" ;
            :data_level = "m1" ;
            :location_description = "Southern Great Plains (SGP),  Lamont,
Oklahoma" ;
            :datastream = "sgplassodiagobsmod2d2C1.m1" ;
            :simulation_id_number = "2" ;
            :simulation_origin_host = "cumulus-login2.ccs.ornl.gov" ;
            :model_type = "WRF" ;
            :model_version = "3.8.1" ;
            :model_github_hash = "b6b6a5cc4229eec1ea9b005746b5ebef2205fb07" ;
            :output_domain_size = "25.0 km" ;
            :output_number_of_levels = "226" ;
            :output_horizontal_grid_spacing = "100 m" ;
            :config_large_scale_forcing = "VARANAL" ;
            :config_large_scale_forcing_scale = "300 km" ;
            :config_large_scale_forcing_specifics = "sgp60varanarapC1.c1
(v20190228)" ;
            :config_surface_treatment = "VARANAL" ;
            :config_surface_treatment_specifics = "sgp60varanarapC1.c1
(v20190228)" ;
            :config_initial_condition = "Sounding" ;
            :config_initial_condition_specifics = "sgpsondewnpnC1" ;
            :config_aerosol = "NA" ;
            :config_forecast_time = "15.0 h" ;
            :config_boundary_method = "Periodic" ;
            :config_microphysics = "Thompson (mp_physics=8)" ;
            :config_nickname = "runlas20180514v1var" ;
            :contacts = "lasso@arm.gov, LASSO PI: William Gustafson
(William.Gustafson@pnnl.gov), LASSO Co-PI: Andrew Vogelmann
(vogelmann@bnl.gov)" ;
            :doi = "10.5439/1342961" ;
            :history = "Wed May 29 14:49:51 2019" ;
}
```

File: .../20180514/sim0002/obs_model/sgplassomod2C1.m1.20180514.120000.nc

Description: Subsetted model output for domain-averaged values at 10-minute intervals for variables used in the metrics. Starting with the 2018 cases, this file contains all of the model output handled via an ingest step in the LASSO processing workflow. This includes both single-level time series as well as time-height data and X-Y cloud base heights. Data bundles for prior years separate the multi-dimensional, subsetted model data into additional files called *sgplassomod2d2C1* and *sgplassomodxy2C1*.

```
netcdf sgplassomod2C1.m1.20180514.120000 {
dimensions:
      time = UNLIMITED ; // (91 currently)
      height = UNLIMITED ; // (226 currently)
      south_north = 250 ;
      west_east = 250 ;
variables:
      int base_time ;
            base_time:string = "2018-05-14 00:00:00 0:00" ;
            base_time:long_name = "Base time in Epoch" ;
            base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
            base_time:ancillary_variables = "time_offset" ;
      double time_offset(time) ;
            time_offset:long_name = "Time offset from base_time" ;
            time_offset:units = "seconds since 2018-05-14 00:00:00 0:00" ;
            time_offset:ancillary_variables = "base_time" ;
      double time(time) ;
            time:long_name = "Time offset from midnight" ;
            time:units = "seconds since 2018-05-14 00:00:00 0:00" ;
            time:calendar = "gregorian" ;
            time:standard_name = "time" ;
      float height(time, height) ;
            height:long_name = "Height above ground level" ;
            height:units = "km" ;
            height:standard_name = "height" ;
      float south_north(south_north) ;
            south_north:long_name = "Coordinate variable for south_north" ;
            south_north:units = "m" ;
      float west_east(west_east) ;
            west_east:long_name = "Coordinate variable for west_east" ;
            west_east:units = "m" ;
      float low_cloud_fraction_arscl(time) ;
            low_cloud_fraction_arscl:long_name = "Frequency of 15-min cloud
occurrence, as identified by ARSCL, below 5km AGL" ;
            low_cloud_fraction_arscl:units = "1" ;
            low_cloud_fraction_arscl:missing_value = -9999.f ;
            low_cloud_fraction_arscl:valid_min = 0.f ;
            low_cloud_fraction_arscl:valid_max = 1.f ;
      float lwp(time) ;
            lwp:long_name = "Liquid water path" ;
            lwp:units = "g m-2" ;
            lwp:missing_value = -9999.f ;
      float lcl(time) ;
            lcl:long_name = "Lifting condensation level" ;
            lcl:units = "m" ;
            lcl:missing_value = -9999.f ;
            lcl:standard_name =
"atmosphere_lifting_condensation_level_wrt_surface" ;
      float water_vapor_mixing_ratio_surface(time) ;
            water_vapor_mixing_ratio_surface:long_name = "Water vapor mixing
ratio at surface" ;
            water_vapor_mixing_ratio_surface:units = "g kg-1" ;
```

```
            water_vapor_mixing_ratio_surface:missing_value = -9999.f ;
      float temperature_surface(time) ;
            temperature_surface:long_name = "Temperature at surface" ;
            temperature_surface:units = "K" ;
            temperature_surface:missing_value = -9999.f ;
            temperature_surface:standard_name = "surface_temperature" ;
      float cloud_fraction_tsi(time) ;
            cloud_fraction_tsi:long_name = "Hemispheric cloud fraction, as
identified by TSI (opaque)" ;
            cloud_fraction_tsi:units = "1" ;
            cloud_fraction_tsi:missing_value = -9999.f ;
            cloud_fraction_tsi:valid_min = 0.f ;
            cloud_fraction_tsi:valid_max = 1.f ;
      float pressure_surface(time) ;
            pressure_surface:long_name = "Pressure at surface" ;
            pressure_surface:units = "kPa" ;
            pressure_surface:missing_value = -9999.f ;
            pressure_surface:standard_name = "surface_air_pressure" ;
      float rh_surface(time) ;
            rh_surface:long_name = "Relative humidity" ;
            rh_surface:units = "%" ;
            rh_surface:missing_value = -9999.f ;
      float water_vapor_mixing_ratio_boundary_layer(time) ;
            water_vapor_mixing_ratio_boundary_layer:long_name = "Water vapor
mixing ratio; average of boundary layer" ;
            water_vapor_mixing_ratio_boundary_layer:units = "g kg-1" ;
            water_vapor_mixing_ratio_boundary_layer:missing_value = -9999.f ;
      float temperature_boundary_layer(time) ;
            temperature_boundary_layer:long_name = "Temperature; average of
boundary layer" ;
            temperature_boundary_layer:units = "K" ;
            temperature_boundary_layer:missing_value = -9999.f ;
      float pressure_boundary_layer(time) ;
            pressure_boundary_layer:long_name = "Pressure; average of
boundary layer" ;
            pressure_boundary_layer:units = "kPa" ;
            pressure_boundary_layer:missing_value = -9999.f ;
      float rh_boundary_layer(time) ;
            rh_boundary_layer:long_name = "Relative humidity; average of
boundary layer" ;
            rh_boundary_layer:units = "%" ;
            rh_boundary_layer:missing_value = -9999.f ;
      float cloud_base_height(time, south_north, west_east) ;
            cloud_base_height:long_name = "Cloud base height" ;
            cloud_base_height:units = "m" ;
            cloud_base_height:missing_value = -9999.f ;
            cloud_base_height:valid_range = 0.f, 25000.f ;
            cloud_base_height:flag_values = -1.f ;
            cloud_base_height:flag_meanings = "clear_sky" ;
            cloud_base_height:comment = "-1. Clear sky, >= 0. Valid cloud
base height" ;
            cloud_base_height:standard_name = "convective_cloud_base_height"
;
      float cloud_fraction(time, height) ;
            cloud_fraction:long_name = "Cloud fraction" ;
```

```
            cloud_fraction:units = "1" ;
            cloud_fraction:missing_value = -9999.f ;
            cloud_fraction:valid_min = 0.f ;
            cloud_fraction:valid_max = 1.f ;
            cloud_fraction:cell_methods = "area: mean time: point height:
point" ;
            cloud_fraction:standard_name = "cloud_area_fraction" ;
      float potential_temp(time, height) ;
            potential_temp:long_name = "Potential temperature" ;
            potential_temp:units = "K" ;
            potential_temp:missing_value = -9999.f ;
            potential_temp:cell_methods = "area: mean time: point height:
point" ;
            potential_temp:standard_name = "air_potential_temperature" ;
      float water_vapor_mixing_ratio(time, height) ;
            water_vapor_mixing_ratio:long_name = "Water vapor mixing ratio" ;
            water_vapor_mixing_ratio:units = "g kg-1" ;
            water_vapor_mixing_ratio:missing_value = -9999.f ;
            water_vapor_mixing_ratio:cell_methods = "area: mean time: point
height: point" ;
      float bar_pres(time, height) ;
            bar_pres:long_name = "Barometric pressure" ;
            bar_pres:units = "kPa" ;
            bar_pres:standard_name = "air_pressure" ;
            bar_pres:valid_min = 0.f ;
            bar_pres:valid_max = 110.f ;
            bar_pres:missing_value = -9999.f ;
            bar_pres:cell_methods = "area: mean time: point height: point" ;
      float lat ;
            lat:long_name = "North latitude" ;
            lat:units = "degree_N" ;
            lat:valid_min = -90.f ;
            lat:valid_max = 90.f ;
            lat:standard_name = "latitude" ;
      float lon ;
            lon:long_name = "East longitude" ;
            lon:units = "degree_E" ;
            lon:valid_min = -180.f ;
            lon:valid_max = 180.f ;
            lon:standard_name = "longitude" ;
      float alt ;
            alt:long_name = "Altitude above mean sea level" ;
            alt:units = "m" ;
            alt:standard_name = "altitude" ;

// global attributes:
            :_NCProperties =
"version=1|netcdflibversion=4.6.1|hdf5libversion=1.10.2" ;
            :Conventions = "ARM-1.2" ;
            :command_line = "idl -R -n lassomod2 -s sgp -f C1 -b
20180514.115900 -R -a sqlite --disable_db_updates" ;
            :process_version = "vap-lassomod-0.0-0.dev0.dirty.4.4.103-
6.38_4.0.103-cray_ari_s" ;
            :dod_version = "lassomod2-m1-1.0" ;
            :input_datastreams = "sgpwrfout2C1.m0 : 0.0 : 20180514.120000\n",
```

```
                  "sgpwrfstat2C1.m0 : 0.0 : 20180514.120000" ;
            :site_id = "sgp" ;
            :platform_id = "lassomod2" ;
            :facility_id = "C1" ;
            :data_level = "m1" ;
            :location_description = "Southern Great Plains (SGP), Lamont,
Oklahoma" ;
            :datastream = "sgplassomod2C1.m1" ;
            :doi = "10.5439/1342961" ;
            :contacts = "lasso@arm.gov, LASSO PI: William Gustafson
(William.Gustafson@pnnl.gov), LASSO Co-PI: Andrew Vogelmann
(vogelmann@bnl.gov)" ;
            :simulation_id_number = "2" ;
            :simulation_origin_host = "cumulus-login2.ccs.ornl.gov" ;
            :model_type = "WRF" ;
            :model_version = "3.8.1" ;
            :model_github_hash = "b6b6a5cc4229eec1ea9b005746b5ebef2205fb07" ;
            :output_domain_size = "25.0 km" ;
            :output_number_of_levels = "226" ;
            :output_horizontal_grid_spacing = "100 m" ;
            :config_large_scale_forcing = "VARANAL" ;
            :config_large_scale_forcing_scale = "300 km" ;
            :config_large_scale_forcing_specifics = "sgp60varanarapC1.c1
(v20190228)" ;
            :config_surface_treatment = "VARANAL" ;
            :config_surface_treatment_specifics = "sgp60varanarapC1.c1
(v20190228)" ;
            :config_initial_condition = "Sounding" ;
            :config_initial_condition_specifics = "sgpsondewnpnC1" ;
            :config_aerosol = "NA" ;
            :config_forecast_time = "15.0 h" ;
            :config_boundary_method = "Periodic" ;
            :config_microphysics = "Thompson (mp_physics=8)" ;
            :config_nickname = "runlas20180514v1var" ;
            :history = "created by user ttoto on machine cumulus-login1 at
2019-04-29 21:58:11, using vap-lassomod-0.0-0.dev0.dirty.4.4.103-
6.38_4.0.103-cray_ari_s" ;
            :nco_openmp_thread_number = 1 ;
            :boundary_layer_top = "700 m AGL" ;
            :boundary_layer_bottom = "500 m AGL" ;
}
```

File: .../20180514/sim0002/raw_model/wrfout_d01_2018-05-14_12:00:00.nc

Description: WRF output with instantaneous variables for the full domain. Output is every 10-minutes with six output times per file, i.e., each file contains the outputs for one hour.

```
netcdf wrfout_d01_2018-05-14_12\:00\:00 {
dimensions:
      Time = UNLIMITED ; // (6 currently)
      DateStrLen = 19 ;
      west_east = 250 ;
      south_north = 250 ;
      bottom_top = 226 ;
      bottom_top_stag = 227 ;
```

```
      soil_layers_stag = 5 ;
      west_east_stag = 251 ;
      south_north_stag = 251 ;
      force_layers = 751 ;
variables:
      char Times(Time, DateStrLen) ;
      float XLAT(Time, south_north, west_east) ;
            XLAT:FieldType = 104 ;
            XLAT:MemoryOrder = "XY " ;
            XLAT:description = "LATITUDE, SOUTH IS NEGATIVE" ;
            XLAT:units = "degree_north" ;
            XLAT:stagger = "" ;
            XLAT:coordinates = "XLONG XLAT" ;
      float XLONG(Time, south_north, west_east) ;
            XLONG:FieldType = 104 ;
            XLONG:MemoryOrder = "XY " ;
            XLONG:description = "LONGITUDE, WEST IS NEGATIVE" ;
            XLONG:units = "degree_east" ;
            XLONG:stagger = "" ;
            XLONG:coordinates = "XLONG XLAT" ;
      float LU_INDEX(Time, south_north, west_east) ;
            LU_INDEX:FieldType = 104 ;
            LU_INDEX:MemoryOrder = "XY " ;
            LU_INDEX:description = "LAND USE CATEGORY" ;
            LU_INDEX:units = "" ;
            LU_INDEX:stagger = "" ;
            LU_INDEX:coordinates = "XLONG XLAT XTIME" ;
      float ZNU(Time, bottom_top) ;
            ZNU:FieldType = 104 ;
            ZNU:MemoryOrder = "Z  " ;
            ZNU:description = "eta values on half (mass) levels" ;
            ZNU:units = "" ;
            ZNU:stagger = "" ;
      float ZNW(Time, bottom_top_stag) ;
            ZNW:FieldType = 104 ;
            ZNW:MemoryOrder = "Z  " ;
            ZNW:description = "eta values on full (w) levels" ;
            ZNW:units = "" ;
            ZNW:stagger = "Z" ;
      float ZS(Time, soil_layers_stag) ;
            ZS:FieldType = 104 ;
            ZS:MemoryOrder = "Z  " ;
            ZS:description = "DEPTHS OF CENTERS OF SOIL LAYERS" ;
            ZS:units = "m" ;
            ZS:stagger = "Z" ;
      float DZS(Time, soil_layers_stag) ;
            DZS:FieldType = 104 ;
            DZS:MemoryOrder = "Z  " ;
            DZS:description = "THICKNESSES OF SOIL LAYERS" ;
            DZS:units = "m" ;
            DZS:stagger = "Z" ;
      float VAR_SSO(Time, south_north, west_east) ;
            VAR_SSO:FieldType = 104 ;
            VAR_SSO:MemoryOrder = "XY " ;
            VAR_SSO:description = "variance of subgrid-scale orography" ;
```

```
        VAR_SSO:units = "m2" ;
        VAR_SSO:stagger = "" ;
        VAR_SSO:coordinates = "XLONG XLAT XTIME" ;
    float U(Time, bottom_top, south_north, west_east_stag) ;
        U:FieldType = 104 ;
        U:MemoryOrder = "XYZ" ;
        U:description = "x-wind component" ;
        U:units = "m s-1" ;
        U:stagger = "X" ;
        U:coordinates = "XLONG_U XLAT_U XTIME" ;
    float V(Time, bottom_top, south_north_stag, west_east) ;
        V:FieldType = 104 ;
        V:MemoryOrder = "XYZ" ;
        V:description = "y-wind component" ;
        V:units = "m s-1" ;
        V:stagger = "Y" ;
        V:coordinates = "XLONG_V XLAT_V XTIME" ;
    float W(Time, bottom_top_stag, south_north, west_east) ;
        W:FieldType = 104 ;
        W:MemoryOrder = "XYZ" ;
        W:description = "z-wind component" ;
        W:units = "m s-1" ;
        W:stagger = "Z" ;
        W:coordinates = "XLONG XLAT XTIME" ;
    float PH(Time, bottom_top_stag, south_north, west_east) ;
        PH:FieldType = 104 ;
        PH:MemoryOrder = "XYZ" ;
        PH:description = "perturbation geopotential" ;
        PH:units = "m2 s-2" ;
        PH:stagger = "Z" ;
        PH:coordinates = "XLONG XLAT XTIME" ;
    float PHB(Time, bottom_top_stag, south_north, west_east) ;
        PHB:FieldType = 104 ;
        PHB:MemoryOrder = "XYZ" ;
        PHB:description = "base-state geopotential" ;
        PHB:units = "m2 s-2" ;
        PHB:stagger = "Z" ;
        PHB:coordinates = "XLONG XLAT XTIME" ;
    float T(Time, bottom_top, south_north, west_east) ;
        T:FieldType = 104 ;
        T:MemoryOrder = "XYZ" ;
        T:description = "perturbation potential temperature (theta-t0)" ;
        T:units = "K" ;
        T:stagger = "" ;
        T:coordinates = "XLONG XLAT XTIME" ;
    float HFX_FORCE(Time) ;
        HFX_FORCE:FieldType = 104 ;
        HFX_FORCE:MemoryOrder = "0  " ;
        HFX_FORCE:description = "SCM ideal surface sensible heat flux" ;
        HFX_FORCE:units = "W m-2" ;
        HFX_FORCE:stagger = "" ;
    float LH_FORCE(Time) ;
        LH_FORCE:FieldType = 104 ;
        LH_FORCE:MemoryOrder = "0  " ;
        LH_FORCE:description = "SCM ideal surface latent heat flux" ;
```

```
            LH_FORCE:units = "W m-2" ;
            LH_FORCE:stagger = "" ;
      float TSK_FORCE(Time) ;
            TSK_FORCE:FieldType = 104 ;
            TSK_FORCE:MemoryOrder = "0  " ;
            TSK_FORCE:description = "SCM ideal surface skin temperature" ;
            TSK_FORCE:units = "W m-2" ;
            TSK_FORCE:stagger = "" ;
      float HFX_FORCE_TEND(Time) ;
            HFX_FORCE_TEND:FieldType = 104 ;
            HFX_FORCE_TEND:MemoryOrder = "0  " ;
            HFX_FORCE_TEND:description = "SCM ideal surface sensible heat
flux tendency" ;
            HFX_FORCE_TEND:units = "W m-2 s-1" ;
            HFX_FORCE_TEND:stagger = "" ;
      float LH_FORCE_TEND(Time) ;
            LH_FORCE_TEND:FieldType = 104 ;
            LH_FORCE_TEND:MemoryOrder = "0  " ;
            LH_FORCE_TEND:description = "SCM ideal surface latent heat flux
tendency" ;
            LH_FORCE_TEND:units = "W m-2 s-1" ;
            LH_FORCE_TEND:stagger = "" ;
      float TSK_FORCE_TEND(Time) ;
            TSK_FORCE_TEND:FieldType = 104 ;
            TSK_FORCE_TEND:MemoryOrder = "0  " ;
            TSK_FORCE_TEND:description = "SCM ideal surface skin temperature
tendency" ;
            TSK_FORCE_TEND:units = "W m-2 s-1" ;
            TSK_FORCE_TEND:stagger = "" ;
      float MU(Time, south_north, west_east) ;
            MU:FieldType = 104 ;
            MU:MemoryOrder = "XY " ;
            MU:description = "perturbation dry air mass in column" ;
            MU:units = "Pa" ;
            MU:stagger = "" ;
            MU:coordinates = "XLONG XLAT XTIME" ;
      float MUB(Time, south_north, west_east) ;
            MUB:FieldType = 104 ;
            MUB:MemoryOrder = "XY " ;
            MUB:description = "base state dry air mass in column" ;
            MUB:units = "Pa" ;
            MUB:stagger = "" ;
            MUB:coordinates = "XLONG XLAT XTIME" ;
      float NEST_POS(Time, south_north, west_east) ;
            NEST_POS:FieldType = 104 ;
            NEST_POS:MemoryOrder = "XY " ;
            NEST_POS:description = "-" ;
            NEST_POS:units = "-" ;
            NEST_POS:stagger = "" ;
            NEST_POS:coordinates = "XLONG XLAT XTIME" ;
      float TKE(Time, bottom_top, south_north, west_east) ;
            TKE:FieldType = 104 ;
            TKE:MemoryOrder = "XYZ" ;
            TKE:description = "TURBULENCE KINETIC ENERGY" ;
            TKE:units = "m2 s-2" ;
```

```
            TKE:stagger = "" ;
            TKE:coordinates = "XLONG XLAT XTIME" ;
      float P(Time, bottom_top, south_north, west_east) ;
            P:FieldType = 104 ;
            P:MemoryOrder = "XYZ" ;
            P:description = "perturbation pressure" ;
            P:units = "Pa" ;
            P:stagger = "" ;
            P:coordinates = "XLONG XLAT XTIME" ;
      float ALT(Time, bottom_top, south_north, west_east) ;
            ALT:FieldType = 104 ;
            ALT:MemoryOrder = "XYZ" ;
            ALT:description = "inverse density" ;
            ALT:units = "m3 kg-1" ;
            ALT:stagger = "" ;
            ALT:coordinates = "XLONG XLAT XTIME" ;
      float PB(Time, bottom_top, south_north, west_east) ;
            PB:FieldType = 104 ;
            PB:MemoryOrder = "XYZ" ;
            PB:description = "BASE STATE PRESSURE" ;
            PB:units = "Pa" ;
            PB:stagger = "" ;
            PB:coordinates = "XLONG XLAT XTIME" ;
      float FNM(Time, bottom_top) ;
            FNM:FieldType = 104 ;
            FNM:MemoryOrder = "Z  " ;
            FNM:description = "upper weight for vertical stretching" ;
            FNM:units = "" ;
            FNM:stagger = "" ;
      float FNP(Time, bottom_top) ;
            FNP:FieldType = 104 ;
            FNP:MemoryOrder = "Z  " ;
            FNP:description = "lower weight for vertical stretching" ;
            FNP:units = "" ;
            FNP:stagger = "" ;
      float RDNW(Time, bottom_top) ;
            RDNW:FieldType = 104 ;
            RDNW:MemoryOrder = "Z  " ;
            RDNW:description = "inverse d(eta) values between full (w)
levels" ;
            RDNW:units = "" ;
            RDNW:stagger = "" ;
      float RDN(Time, bottom_top) ;
            RDN:FieldType = 104 ;
            RDN:MemoryOrder = "Z  " ;
            RDN:description = "inverse d(eta) values between half (mass)
levels" ;
            RDN:units = "" ;
            RDN:stagger = "" ;
      float DNW(Time, bottom_top) ;
            DNW:FieldType = 104 ;
            DNW:MemoryOrder = "Z  " ;
            DNW:description = "d(eta) values between full (w) levels" ;
            DNW:units = "" ;
            DNW:stagger = "" ;
```

```
      float DN(Time, bottom_top) ;
            DN:FieldType = 104 ;
            DN:MemoryOrder = "Z  " ;
            DN:description = "d(eta) values between half (mass) levels" ;
            DN:units = "" ;
            DN:stagger = "" ;
      float CFN(Time) ;
            CFN:FieldType = 104 ;
            CFN:MemoryOrder = "0  " ;
            CFN:description = "extrapolation constant" ;
            CFN:units = "" ;
            CFN:stagger = "" ;
      float CFN1(Time) ;
            CFN1:FieldType = 104 ;
            CFN1:MemoryOrder = "0  " ;
            CFN1:description = "extrapolation constant" ;
            CFN1:units = "" ;
            CFN1:stagger = "" ;
      int THIS_IS_AN_IDEAL_RUN(Time) ;
            THIS_IS_AN_IDEAL_RUN:FieldType = 106 ;
            THIS_IS_AN_IDEAL_RUN:MemoryOrder = "0  " ;
            THIS_IS_AN_IDEAL_RUN:description = "T/F flag: this is an ARW
ideal simulation" ;
            THIS_IS_AN_IDEAL_RUN:units = "-" ;
            THIS_IS_AN_IDEAL_RUN:stagger = "" ;
      float P_HYD(Time, bottom_top, south_north, west_east) ;
            P_HYD:FieldType = 104 ;
            P_HYD:MemoryOrder = "XYZ" ;
            P_HYD:description = "hydrostatic pressure" ;
            P_HYD:units = "Pa" ;
            P_HYD:stagger = "" ;
            P_HYD:coordinates = "XLONG XLAT XTIME" ;
      float Q2(Time, south_north, west_east) ;
            Q2:FieldType = 104 ;
            Q2:MemoryOrder = "XY " ;
            Q2:description = "QV at 2 M" ;
            Q2:units = "kg kg-1" ;
            Q2:stagger = "" ;
            Q2:coordinates = "XLONG XLAT XTIME" ;
      float T2(Time, south_north, west_east) ;
            T2:FieldType = 104 ;
            T2:MemoryOrder = "XY " ;
            T2:description = "TEMP at 2 M" ;
            T2:units = "K" ;
            T2:stagger = "" ;
            T2:coordinates = "XLONG XLAT XTIME" ;
      float TH2(Time, south_north, west_east) ;
            TH2:FieldType = 104 ;
            TH2:MemoryOrder = "XY " ;
            TH2:description = "POT TEMP at 2 M" ;
            TH2:units = "K" ;
            TH2:stagger = "" ;
            TH2:coordinates = "XLONG XLAT XTIME" ;
      float PSFC(Time, south_north, west_east) ;
            PSFC:FieldType = 104 ;
```

```
        PSFC:MemoryOrder = "XY " ;
        PSFC:description = "SFC PRESSURE" ;
        PSFC:units = "Pa" ;
        PSFC:stagger = "" ;
        PSFC:coordinates = "XLONG XLAT XTIME" ;
  float U10(Time, south_north, west_east) ;
        U10:FieldType = 104 ;
        U10:MemoryOrder = "XY " ;
        U10:description = "U at 10 M" ;
        U10:units = "m s-1" ;
        U10:stagger = "" ;
        U10:coordinates = "XLONG XLAT XTIME" ;
  float V10(Time, south_north, west_east) ;
        V10:FieldType = 104 ;
        V10:MemoryOrder = "XY " ;
        V10:description = "V at 10 M" ;
        V10:units = "m s-1" ;
        V10:stagger = "" ;
        V10:coordinates = "XLONG XLAT XTIME" ;
  float RDX(Time) ;
        RDX:FieldType = 104 ;
        RDX:MemoryOrder = "0  " ;
        RDX:description = "INVERSE X GRID LENGTH" ;
        RDX:units = "" ;
        RDX:stagger = "" ;
  float RDY(Time) ;
        RDY:FieldType = 104 ;
        RDY:MemoryOrder = "0  " ;
        RDY:description = "INVERSE Y GRID LENGTH" ;
        RDY:units = "" ;
        RDY:stagger = "" ;
  float RESM(Time) ;
        RESM:FieldType = 104 ;
        RESM:MemoryOrder = "0  " ;
        RESM:description = "TIME WEIGHT CONSTANT FOR SMALL STEPS" ;
        RESM:units = "" ;
        RESM:stagger = "" ;
  float ZETATOP(Time) ;
        ZETATOP:FieldType = 104 ;
        ZETATOP:MemoryOrder = "0  " ;
        ZETATOP:description = "ZETA AT MODEL TOP" ;
        ZETATOP:units = "" ;
        ZETATOP:stagger = "" ;
  float CF1(Time) ;
        CF1:FieldType = 104 ;
        CF1:MemoryOrder = "0  " ;
        CF1:description = "2nd order extrapolation constant" ;
        CF1:units = "" ;
        CF1:stagger = "" ;
  float CF2(Time) ;
        CF2:FieldType = 104 ;
        CF2:MemoryOrder = "0  " ;
        CF2:description = "2nd order extrapolation constant" ;
        CF2:units = "" ;
        CF2:stagger = "" ;
```

```
float CF3(Time) ;
      CF3:FieldType = 104 ;
      CF3:MemoryOrder = "0  " ;
      CF3:description = "2nd order extrapolation constant" ;
      CF3:units = "" ;
      CF3:stagger = "" ;
int ITIMESTEP(Time) ;
      ITIMESTEP:FieldType = 106 ;
      ITIMESTEP:MemoryOrder = "0  " ;
      ITIMESTEP:description = "" ;
      ITIMESTEP:units = "" ;
      ITIMESTEP:stagger = "" ;
float XTIME(Time) ;
      XTIME:FieldType = 104 ;
      XTIME:MemoryOrder = "0  " ;
      XTIME:description = "minutes since 2018-05-14 12:00:00" ;
      XTIME:units = "minutes since 2018-05-14 12:00:00" ;
      XTIME:stagger = "" ;
float QVAPOR(Time, bottom_top, south_north, west_east) ;
      QVAPOR:FieldType = 104 ;
      QVAPOR:MemoryOrder = "XYZ" ;
      QVAPOR:description = "Water vapor mixing ratio" ;
      QVAPOR:units = "kg kg-1" ;
      QVAPOR:stagger = "" ;
      QVAPOR:coordinates = "XLONG XLAT XTIME" ;
float QCLOUD(Time, bottom_top, south_north, west_east) ;
      QCLOUD:FieldType = 104 ;
      QCLOUD:MemoryOrder = "XYZ" ;
      QCLOUD:description = "Cloud water mixing ratio" ;
      QCLOUD:units = "kg kg-1" ;
      QCLOUD:stagger = "" ;
      QCLOUD:coordinates = "XLONG XLAT XTIME" ;
float QRAIN(Time, bottom_top, south_north, west_east) ;
      QRAIN:FieldType = 104 ;
      QRAIN:MemoryOrder = "XYZ" ;
      QRAIN:description = "Rain water mixing ratio" ;
      QRAIN:units = "kg kg-1" ;
      QRAIN:stagger = "" ;
      QRAIN:coordinates = "XLONG XLAT XTIME" ;
float QICE(Time, bottom_top, south_north, west_east) ;
      QICE:FieldType = 104 ;
      QICE:MemoryOrder = "XYZ" ;
      QICE:description = "Ice mixing ratio" ;
      QICE:units = "kg kg-1" ;
      QICE:stagger = "" ;
      QICE:coordinates = "XLONG XLAT XTIME" ;
float QSNOW(Time, bottom_top, south_north, west_east) ;
      QSNOW:FieldType = 104 ;
      QSNOW:MemoryOrder = "XYZ" ;
      QSNOW:description = "Snow mixing ratio" ;
      QSNOW:units = "kg kg-1" ;
      QSNOW:stagger = "" ;
      QSNOW:coordinates = "XLONG XLAT XTIME" ;
float QGRAUP(Time, bottom_top, south_north, west_east) ;
      QGRAUP:FieldType = 104 ;
```

```
        QGRAUP:MemoryOrder = "XYZ" ;
        QGRAUP:description = "Graupel mixing ratio" ;
        QGRAUP:units = "kg kg-1" ;
        QGRAUP:stagger = "" ;
        QGRAUP:coordinates = "XLONG XLAT XTIME" ;
    float QNICE(Time, bottom_top, south_north, west_east) ;
        QNICE:FieldType = 104 ;
        QNICE:MemoryOrder = "XYZ" ;
        QNICE:description = "Ice Number concentration" ;
        QNICE:units = "  kg-1" ;
        QNICE:stagger = "" ;
        QNICE:coordinates = "XLONG XLAT XTIME" ;
    float QNRAIN(Time, bottom_top, south_north, west_east) ;
        QNRAIN:FieldType = 104 ;
        QNRAIN:MemoryOrder = "XYZ" ;
        QNRAIN:description = "Rain Number concentration" ;
        QNRAIN:units = "  kg(-1)" ;
        QNRAIN:stagger = "" ;
        QNRAIN:coordinates = "XLONG XLAT XTIME" ;
    float SHDMAX(Time, south_north, west_east) ;
        SHDMAX:FieldType = 104 ;
        SHDMAX:MemoryOrder = "XY " ;
        SHDMAX:description = "ANNUAL MAX VEG FRACTION" ;
        SHDMAX:units = "" ;
        SHDMAX:stagger = "" ;
        SHDMAX:coordinates = "XLONG XLAT XTIME" ;
    float SHDMIN(Time, south_north, west_east) ;
        SHDMIN:FieldType = 104 ;
        SHDMIN:MemoryOrder = "XY " ;
        SHDMIN:description = "ANNUAL MIN VEG FRACTION" ;
        SHDMIN:units = "" ;
        SHDMIN:stagger = "" ;
        SHDMIN:coordinates = "XLONG XLAT XTIME" ;
    float SNOALB(Time, south_north, west_east) ;
        SNOALB:FieldType = 104 ;
        SNOALB:MemoryOrder = "XY " ;
        SNOALB:description = "ANNUAL MAX SNOW ALBEDO IN FRACTION" ;
        SNOALB:units = "" ;
        SNOALB:stagger = "" ;
        SNOALB:coordinates = "XLONG XLAT XTIME" ;
    float TSLB(Time, soil_layers_stag, south_north, west_east) ;
        TSLB:FieldType = 104 ;
        TSLB:MemoryOrder = "XYZ" ;
        TSLB:description = "SOIL TEMPERATURE" ;
        TSLB:units = "K" ;
        TSLB:stagger = "Z" ;
        TSLB:coordinates = "XLONG XLAT XTIME" ;
    float SMOIS(Time, soil_layers_stag, south_north, west_east) ;
        SMOIS:FieldType = 104 ;
        SMOIS:MemoryOrder = "XYZ" ;
        SMOIS:description = "SOIL MOISTURE" ;
        SMOIS:units = "m3 m-3" ;
        SMOIS:stagger = "Z" ;
        SMOIS:coordinates = "XLONG XLAT XTIME" ;
    float SH2O(Time, soil_layers_stag, south_north, west_east) ;
```

```
        SH2O:FieldType = 104 ;
        SH2O:MemoryOrder = "XYZ" ;
        SH2O:description = "SOIL LIQUID WATER" ;
        SH2O:units = "m3 m-3" ;
        SH2O:stagger = "Z" ;
        SH2O:coordinates = "XLONG XLAT XTIME" ;
  float SEAICE(Time, south_north, west_east) ;
        SEAICE:FieldType = 104 ;
        SEAICE:MemoryOrder = "XY " ;
        SEAICE:description = "SEA ICE FLAG" ;
        SEAICE:units = "" ;
        SEAICE:stagger = "" ;
        SEAICE:coordinates = "XLONG XLAT XTIME" ;
  float XICEM(Time, south_north, west_east) ;
        XICEM:FieldType = 104 ;
        XICEM:MemoryOrder = "XY " ;
        XICEM:description = "SEA ICE FLAG (PREVIOUS STEP)" ;
        XICEM:units = "" ;
        XICEM:stagger = "" ;
        XICEM:coordinates = "XLONG XLAT XTIME" ;
  float SFROFF(Time, south_north, west_east) ;
        SFROFF:FieldType = 104 ;
        SFROFF:MemoryOrder = "XY " ;
        SFROFF:description = "SURFACE RUNOFF" ;
        SFROFF:units = "mm" ;
        SFROFF:stagger = "" ;
        SFROFF:coordinates = "XLONG XLAT XTIME" ;
  float UDROFF(Time, south_north, west_east) ;
        UDROFF:FieldType = 104 ;
        UDROFF:MemoryOrder = "XY " ;
        UDROFF:description = "UNDERGROUND RUNOFF" ;
        UDROFF:units = "mm" ;
        UDROFF:stagger = "" ;
        UDROFF:coordinates = "XLONG XLAT XTIME" ;
  int IVGTYP(Time, south_north, west_east) ;
        IVGTYP:FieldType = 106 ;
        IVGTYP:MemoryOrder = "XY " ;
        IVGTYP:description = "DOMINANT VEGETATION CATEGORY" ;
        IVGTYP:units = "" ;
        IVGTYP:stagger = "" ;
        IVGTYP:coordinates = "XLONG XLAT XTIME" ;
  int ISLTYP(Time, south_north, west_east) ;
        ISLTYP:FieldType = 106 ;
        ISLTYP:MemoryOrder = "XY " ;
        ISLTYP:description = "DOMINANT SOIL CATEGORY" ;
        ISLTYP:units = "" ;
        ISLTYP:stagger = "" ;
        ISLTYP:coordinates = "XLONG XLAT XTIME" ;
  float VEGFRA(Time, south_north, west_east) ;
        VEGFRA:FieldType = 104 ;
        VEGFRA:MemoryOrder = "XY " ;
        VEGFRA:description = "VEGETATION FRACTION" ;
        VEGFRA:units = "" ;
        VEGFRA:stagger = "" ;
        VEGFRA:coordinates = "XLONG XLAT XTIME" ;
```

```
float GRDFLX(Time, south_north, west_east) ;
      GRDFLX:FieldType = 104 ;
      GRDFLX:MemoryOrder = "XY " ;
      GRDFLX:description = "GROUND HEAT FLUX" ;
      GRDFLX:units = "W m-2" ;
      GRDFLX:stagger = "" ;
      GRDFLX:coordinates = "XLONG XLAT XTIME" ;
float ACGRDFLX(Time, south_north, west_east) ;
      ACGRDFLX:FieldType = 104 ;
      ACGRDFLX:MemoryOrder = "XY " ;
      ACGRDFLX:description = "ACCUMULATED GROUND HEAT FLUX" ;
      ACGRDFLX:units = "J m-2" ;
      ACGRDFLX:stagger = "" ;
      ACGRDFLX:coordinates = "XLONG XLAT XTIME" ;
float ACSNOM(Time, south_north, west_east) ;
      ACSNOM:FieldType = 104 ;
      ACSNOM:MemoryOrder = "XY " ;
      ACSNOM:description = "ACCUMULATED MELTED SNOW" ;
      ACSNOM:units = "kg m-2" ;
      ACSNOM:stagger = "" ;
      ACSNOM:coordinates = "XLONG XLAT XTIME" ;
float SNOW(Time, south_north, west_east) ;
      SNOW:FieldType = 104 ;
      SNOW:MemoryOrder = "XY " ;
      SNOW:description = "SNOW WATER EQUIVALENT" ;
      SNOW:units = "kg m-2" ;
      SNOW:stagger = "" ;
      SNOW:coordinates = "XLONG XLAT XTIME" ;
float SNOWH(Time, south_north, west_east) ;
      SNOWH:FieldType = 104 ;
      SNOWH:MemoryOrder = "XY " ;
      SNOWH:description = "PHYSICAL SNOW DEPTH" ;
      SNOWH:units = "m" ;
      SNOWH:stagger = "" ;
      SNOWH:coordinates = "XLONG XLAT XTIME" ;
float CANWAT(Time, south_north, west_east) ;
      CANWAT:FieldType = 104 ;
      CANWAT:MemoryOrder = "XY " ;
      CANWAT:description = "CANOPY WATER" ;
      CANWAT:units = "kg m-2" ;
      CANWAT:stagger = "" ;
      CANWAT:coordinates = "XLONG XLAT XTIME" ;
float SSTSK(Time, south_north, west_east) ;
      SSTSK:FieldType = 104 ;
      SSTSK:MemoryOrder = "XY " ;
      SSTSK:description = "SKIN SEA SURFACE TEMPERATURE" ;
      SSTSK:units = "K" ;
      SSTSK:stagger = "" ;
      SSTSK:coordinates = "XLONG XLAT XTIME" ;
float COSZEN(Time, south_north, west_east) ;
      COSZEN:FieldType = 104 ;
      COSZEN:MemoryOrder = "XY " ;
      COSZEN:description = "COS of SOLAR ZENITH ANGLE" ;
      COSZEN:units = "dimensionless" ;
      COSZEN:stagger = "" ;
```

```
            COSZEN:coordinates = "XLONG XLAT XTIME" ;
      float LAI(Time, south_north, west_east) ;
            LAI:FieldType = 104 ;
            LAI:MemoryOrder = "XY " ;
            LAI:description = "LEAF AREA INDEX" ;
            LAI:units = "m-2/m-2" ;
            LAI:stagger = "" ;
            LAI:coordinates = "XLONG XLAT XTIME" ;
      float VAR(Time, south_north, west_east) ;
            VAR:FieldType = 104 ;
            VAR:MemoryOrder = "XY " ;
            VAR:description = "OROGRAPHIC VARIANCE" ;
            VAR:units = "" ;
            VAR:stagger = "" ;
            VAR:coordinates = "XLONG XLAT XTIME" ;
      float MAPFAC_M(Time, south_north, west_east) ;
            MAPFAC_M:FieldType = 104 ;
            MAPFAC_M:MemoryOrder = "XY " ;
            MAPFAC_M:description = "Map scale factor on mass grid" ;
            MAPFAC_M:units = "" ;
            MAPFAC_M:stagger = "" ;
            MAPFAC_M:coordinates = "XLONG XLAT XTIME" ;
      float MAPFAC_U(Time, south_north, west_east_stag) ;
            MAPFAC_U:FieldType = 104 ;
            MAPFAC_U:MemoryOrder = "XY " ;
            MAPFAC_U:description = "Map scale factor on u-grid" ;
            MAPFAC_U:units = "" ;
            MAPFAC_U:stagger = "X" ;
            MAPFAC_U:coordinates = "XLONG_U XLAT_U XTIME" ;
      float MAPFAC_V(Time, south_north_stag, west_east) ;
            MAPFAC_V:FieldType = 104 ;
            MAPFAC_V:MemoryOrder = "XY " ;
            MAPFAC_V:description = "Map scale factor on v-grid" ;
            MAPFAC_V:units = "" ;
            MAPFAC_V:stagger = "Y" ;
            MAPFAC_V:coordinates = "XLONG_V XLAT_V XTIME" ;
      float MAPFAC_MX(Time, south_north, west_east) ;
            MAPFAC_MX:FieldType = 104 ;
            MAPFAC_MX:MemoryOrder = "XY " ;
            MAPFAC_MX:description = "Map scale factor on mass grid, x
direction" ;
            MAPFAC_MX:units = "" ;
            MAPFAC_MX:stagger = "" ;
            MAPFAC_MX:coordinates = "XLONG XLAT XTIME" ;
      float MAPFAC_MY(Time, south_north, west_east) ;
            MAPFAC_MY:FieldType = 104 ;
            MAPFAC_MY:MemoryOrder = "XY " ;
            MAPFAC_MY:description = "Map scale factor on mass grid, y
direction" ;
            MAPFAC_MY:units = "" ;
            MAPFAC_MY:stagger = "" ;
            MAPFAC_MY:coordinates = "XLONG XLAT XTIME" ;
      float MAPFAC_UX(Time, south_north, west_east_stag) ;
            MAPFAC_UX:FieldType = 104 ;
            MAPFAC_UX:MemoryOrder = "XY " ;
```

```
            MAPFAC_UX:description = "Map scale factor on u-grid, x direction"
;
            MAPFAC_UX:units = "" ;
            MAPFAC_UX:stagger = "X" ;
            MAPFAC_UX:coordinates = "XLONG_U XLAT_U XTIME" ;
      float MAPFAC_UY(Time, south_north, west_east_stag) ;
            MAPFAC_UY:FieldType = 104 ;
            MAPFAC_UY:MemoryOrder = "XY " ;
            MAPFAC_UY:description = "Map scale factor on u-grid, y direction"
;
            MAPFAC_UY:units = "" ;
            MAPFAC_UY:stagger = "X" ;
            MAPFAC_UY:coordinates = "XLONG_U XLAT_U XTIME" ;
      float MAPFAC_VX(Time, south_north_stag, west_east) ;
            MAPFAC_VX:FieldType = 104 ;
            MAPFAC_VX:MemoryOrder = "XY " ;
            MAPFAC_VX:description = "Map scale factor on v-grid, x direction"
;
            MAPFAC_VX:units = "" ;
            MAPFAC_VX:stagger = "Y" ;
            MAPFAC_VX:coordinates = "XLONG_V XLAT_V XTIME" ;
      float MF_VX_INV(Time, south_north_stag, west_east) ;
            MF_VX_INV:FieldType = 104 ;
            MF_VX_INV:MemoryOrder = "XY " ;
            MF_VX_INV:description = "Inverse map scale factor on v-grid, x
direction" ;
            MF_VX_INV:units = "" ;
            MF_VX_INV:stagger = "Y" ;
            MF_VX_INV:coordinates = "XLONG_V XLAT_V XTIME" ;
      float MAPFAC_VY(Time, south_north_stag, west_east) ;
            MAPFAC_VY:FieldType = 104 ;
            MAPFAC_VY:MemoryOrder = "XY " ;
            MAPFAC_VY:description = "Map scale factor on v-grid, y direction"
;
            MAPFAC_VY:units = "" ;
            MAPFAC_VY:stagger = "Y" ;
            MAPFAC_VY:coordinates = "XLONG_V XLAT_V XTIME" ;
      float F(Time, south_north, west_east) ;
            F:FieldType = 104 ;
            F:MemoryOrder = "XY " ;
            F:description = "Coriolis sine latitude term" ;
            F:units = "s-1" ;
            F:stagger = "" ;
            F:coordinates = "XLONG XLAT XTIME" ;
      float E(Time, south_north, west_east) ;
            E:FieldType = 104 ;
            E:MemoryOrder = "XY " ;
            E:description = "Coriolis cosine latitude term" ;
            E:units = "s-1" ;
            E:stagger = "" ;
            E:coordinates = "XLONG XLAT XTIME" ;
      float SINALPHA(Time, south_north, west_east) ;
            SINALPHA:FieldType = 104 ;
            SINALPHA:MemoryOrder = "XY " ;
            SINALPHA:description = "Local sine of map rotation" ;
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        SINALPHA:units = "" ;
        SINALPHA:stagger = "" ;
        SINALPHA:coordinates = "XLONG XLAT XTIME" ;
  float COSALPHA(Time, south_north, west_east) ;
        COSALPHA:FieldType = 104 ;
        COSALPHA:MemoryOrder = "XY " ;
        COSALPHA:description = "Local cosine of map rotation" ;
        COSALPHA:units = "" ;
        COSALPHA:stagger = "" ;
        COSALPHA:coordinates = "XLONG XLAT XTIME" ;
  float HGT(Time, south_north, west_east) ;
        HGT:FieldType = 104 ;
        HGT:MemoryOrder = "XY " ;
        HGT:description = "Terrain Height" ;
        HGT:units = "m" ;
        HGT:stagger = "" ;
        HGT:coordinates = "XLONG XLAT XTIME" ;
  float TSK(Time, south_north, west_east) ;
        TSK:FieldType = 104 ;
        TSK:MemoryOrder = "XY " ;
        TSK:description = "SURFACE SKIN TEMPERATURE" ;
        TSK:units = "K" ;
        TSK:stagger = "" ;
        TSK:coordinates = "XLONG XLAT XTIME" ;
  float P_TOP(Time) ;
        P_TOP:FieldType = 104 ;
        P_TOP:MemoryOrder = "0  " ;
        P_TOP:description = "PRESSURE TOP OF THE MODEL" ;
        P_TOP:units = "Pa" ;
        P_TOP:stagger = "" ;
  float T00(Time) ;
        T00:FieldType = 104 ;
        T00:MemoryOrder = "0  " ;
        T00:description = "BASE STATE TEMPERATURE" ;
        T00:units = "K" ;
        T00:stagger = "" ;
  float P00(Time) ;
        P00:FieldType = 104 ;
        P00:MemoryOrder = "0  " ;
        P00:description = "BASE STATE PRESURE" ;
        P00:units = "Pa" ;
        P00:stagger = "" ;
  float TLP(Time) ;
        TLP:FieldType = 104 ;
        TLP:MemoryOrder = "0  " ;
        TLP:description = "BASE STATE LAPSE RATE" ;
        TLP:units = "" ;
        TLP:stagger = "" ;
  float TISO(Time) ;
        TISO:FieldType = 104 ;
        TISO:MemoryOrder = "0  " ;
        TISO:description = "TEMP AT WHICH THE BASE T TURNS CONST" ;
        TISO:units = "K" ;
        TISO:stagger = "" ;
  float TLP_STRAT(Time) ;
```

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            TLP_STRAT:FieldType = 104 ;
            TLP_STRAT:MemoryOrder = "0  " ;
            TLP_STRAT:description = "BASE STATE LAPSE RATE (DT/D(LN(P)) IN
STRATOSPHERE" ;
            TLP_STRAT:units = "K" ;
            TLP_STRAT:stagger = "" ;
      float P_STRAT(Time) ;
            P_STRAT:FieldType = 104 ;
            P_STRAT:MemoryOrder = "0  " ;
            P_STRAT:description = "BASE STATE PRESSURE AT BOTTOM OF
STRATOSPHERE" ;
            P_STRAT:units = "Pa" ;
            P_STRAT:stagger = "" ;
      float MAX_MSTFX(Time) ;
            MAX_MSTFX:FieldType = 104 ;
            MAX_MSTFX:MemoryOrder = "0  " ;
            MAX_MSTFX:description = "Max map factor in domain" ;
            MAX_MSTFX:units = "" ;
            MAX_MSTFX:stagger = "" ;
      float MAX_MSTFY(Time) ;
            MAX_MSTFY:FieldType = 104 ;
            MAX_MSTFY:MemoryOrder = "0  " ;
            MAX_MSTFY:description = "Max map factor in domain" ;
            MAX_MSTFY:units = "" ;
            MAX_MSTFY:stagger = "" ;
      float RAINC(Time, south_north, west_east) ;
            RAINC:FieldType = 104 ;
            RAINC:MemoryOrder = "XY " ;
            RAINC:description = "ACCUMULATED TOTAL CUMULUS PRECIPITATION" ;
            RAINC:units = "mm" ;
            RAINC:stagger = "" ;
            RAINC:coordinates = "XLONG XLAT XTIME" ;
      float RAINSH(Time, south_north, west_east) ;
            RAINSH:FieldType = 104 ;
            RAINSH:MemoryOrder = "XY " ;
            RAINSH:description = "ACCUMULATED SHALLOW CUMULUS PRECIPITATION"
;
            RAINSH:units = "mm" ;
            RAINSH:stagger = "" ;
            RAINSH:coordinates = "XLONG XLAT XTIME" ;
      float RAINNC(Time, south_north, west_east) ;
            RAINNC:FieldType = 104 ;
            RAINNC:MemoryOrder = "XY " ;
            RAINNC:description = "ACCUMULATED TOTAL GRID SCALE PRECIPITATION"
;
            RAINNC:units = "mm" ;
            RAINNC:stagger = "" ;
            RAINNC:coordinates = "XLONG XLAT XTIME" ;
      float SNOWNC(Time, south_north, west_east) ;
            SNOWNC:FieldType = 104 ;
            SNOWNC:MemoryOrder = "XY " ;
            SNOWNC:description = "ACCUMULATED TOTAL GRID SCALE SNOW AND ICE"
;
            SNOWNC:units = "mm" ;
            SNOWNC:stagger = "" ;
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            SNOWNC:coordinates = "XLONG XLAT XTIME" ;
      float GRAUPELNC(Time, south_north, west_east) ;
            GRAUPELNC:FieldType = 104 ;
            GRAUPELNC:MemoryOrder = "XY " ;
            GRAUPELNC:description = "ACCUMULATED TOTAL GRID SCALE GRAUPEL" ;
            GRAUPELNC:units = "mm" ;
            GRAUPELNC:stagger = "" ;
            GRAUPELNC:coordinates = "XLONG XLAT XTIME" ;
      float HAILNC(Time, south_north, west_east) ;
            HAILNC:FieldType = 104 ;
            HAILNC:MemoryOrder = "XY " ;
            HAILNC:description = "ACCUMULATED TOTAL GRID SCALE HAIL" ;
            HAILNC:units = "mm" ;
            HAILNC:stagger = "" ;
            HAILNC:coordinates = "XLONG XLAT XTIME" ;
      float CLDFRA(Time, bottom_top, south_north, west_east) ;
            CLDFRA:FieldType = 104 ;
            CLDFRA:MemoryOrder = "XYZ" ;
            CLDFRA:description = "CLOUD FRACTION" ;
            CLDFRA:units = "" ;
            CLDFRA:stagger = "" ;
            CLDFRA:coordinates = "XLONG XLAT XTIME" ;
      float SWDOWN(Time, south_north, west_east) ;
            SWDOWN:FieldType = 104 ;
            SWDOWN:MemoryOrder = "XY " ;
            SWDOWN:description = "DOWNWARD SHORT WAVE FLUX AT GROUND SURFACE"
;
            SWDOWN:units = "W m-2" ;
            SWDOWN:stagger = "" ;
            SWDOWN:coordinates = "XLONG XLAT XTIME" ;
      float GLW(Time, south_north, west_east) ;
            GLW:FieldType = 104 ;
            GLW:MemoryOrder = "XY " ;
            GLW:description = "DOWNWARD LONG WAVE FLUX AT GROUND SURFACE" ;
            GLW:units = "W m-2" ;
            GLW:stagger = "" ;
            GLW:coordinates = "XLONG XLAT XTIME" ;
      float SWNORM(Time, south_north, west_east) ;
            SWNORM:FieldType = 104 ;
            SWNORM:MemoryOrder = "XY " ;
            SWNORM:description = "NORMAL SHORT WAVE FLUX AT GROUND SURFACE
(SLOPE-DEPENDENT)" ;
            SWNORM:units = "W m-2" ;
            SWNORM:stagger = "" ;
            SWNORM:coordinates = "XLONG XLAT XTIME" ;
      float ACSWUPT(Time, south_north, west_east) ;
            ACSWUPT:FieldType = 104 ;
            ACSWUPT:MemoryOrder = "XY " ;
            ACSWUPT:description = "ACCUMULATED UPWELLING SHORTWAVE FLUX AT
TOP" ;
            ACSWUPT:units = "J m-2" ;
            ACSWUPT:stagger = "" ;
            ACSWUPT:coordinates = "XLONG XLAT XTIME" ;
      float ACSWUPTC(Time, south_north, west_east) ;
            ACSWUPTC:FieldType = 104 ;
```

```
            ACSWUPTC:MemoryOrder = "XY " ;
            ACSWUPTC:description = "ACCUMULATED UPWELLING CLEAR SKY SHORTWAVE
FLUX AT TOP" ;
            ACSWUPTC:units = "J m-2" ;
            ACSWUPTC:stagger = "" ;
            ACSWUPTC:coordinates = "XLONG XLAT XTIME" ;
      float ACSWDNT(Time, south_north, west_east) ;
            ACSWDNT:FieldType = 104 ;
            ACSWDNT:MemoryOrder = "XY " ;
            ACSWDNT:description = "ACCUMULATED DOWNWELLING SHORTWAVE FLUX AT
TOP" ;
            ACSWDNT:units = "J m-2" ;
            ACSWDNT:stagger = "" ;
            ACSWDNT:coordinates = "XLONG XLAT XTIME" ;
      float ACSWDNTC(Time, south_north, west_east) ;
            ACSWDNTC:FieldType = 104 ;
            ACSWDNTC:MemoryOrder = "XY " ;
            ACSWDNTC:description = "ACCUMULATED DOWNWELLING CLEAR SKY
SHORTWAVE FLUX AT TOP" ;
            ACSWDNTC:units = "J m-2" ;
            ACSWDNTC:stagger = "" ;
            ACSWDNTC:coordinates = "XLONG XLAT XTIME" ;
      float ACSWUPB(Time, south_north, west_east) ;
            ACSWUPB:FieldType = 104 ;
            ACSWUPB:MemoryOrder = "XY " ;
            ACSWUPB:description = "ACCUMULATED UPWELLING SHORTWAVE FLUX AT
BOTTOM" ;
            ACSWUPB:units = "J m-2" ;
            ACSWUPB:stagger = "" ;
            ACSWUPB:coordinates = "XLONG XLAT XTIME" ;
      float ACSWUPBC(Time, south_north, west_east) ;
            ACSWUPBC:FieldType = 104 ;
            ACSWUPBC:MemoryOrder = "XY " ;
            ACSWUPBC:description = "ACCUMULATED UPWELLING CLEAR SKY SHORTWAVE
FLUX AT BOTTOM" ;
            ACSWUPBC:units = "J m-2" ;
            ACSWUPBC:stagger = "" ;
            ACSWUPBC:coordinates = "XLONG XLAT XTIME" ;
      float ACSWDNB(Time, south_north, west_east) ;
            ACSWDNB:FieldType = 104 ;
            ACSWDNB:MemoryOrder = "XY " ;
            ACSWDNB:description = "ACCUMULATED DOWNWELLING SHORTWAVE FLUX AT
BOTTOM" ;
            ACSWDNB:units = "J m-2" ;
            ACSWDNB:stagger = "" ;
            ACSWDNB:coordinates = "XLONG XLAT XTIME" ;
      float ACSWDNBC(Time, south_north, west_east) ;
            ACSWDNBC:FieldType = 104 ;
            ACSWDNBC:MemoryOrder = "XY " ;
            ACSWDNBC:description = "ACCUMULATED DOWNWELLING CLEAR SKY
SHORTWAVE FLUX AT BOTTOM" ;
            ACSWDNBC:units = "J m-2" ;
            ACSWDNBC:stagger = "" ;
            ACSWDNBC:coordinates = "XLONG XLAT XTIME" ;
      float ACLWUPT(Time, south_north, west_east) ;
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            ACLWUPT:FieldType = 104 ;
            ACLWUPT:MemoryOrder = "XY " ;
            ACLWUPT:description = "ACCUMULATED UPWELLING LONGWAVE FLUX AT
TOP" ;
            ACLWUPT:units = "J m-2" ;
            ACLWUPT:stagger = "" ;
            ACLWUPT:coordinates = "XLONG XLAT XTIME" ;
      float ACLWUPTC(Time, south_north, west_east) ;
            ACLWUPTC:FieldType = 104 ;
            ACLWUPTC:MemoryOrder = "XY " ;
            ACLWUPTC:description = "ACCUMULATED UPWELLING CLEAR SKY LONGWAVE
FLUX AT TOP" ;
            ACLWUPTC:units = "J m-2" ;
            ACLWUPTC:stagger = "" ;
            ACLWUPTC:coordinates = "XLONG XLAT XTIME" ;
      float ACLWDNT(Time, south_north, west_east) ;
            ACLWDNT:FieldType = 104 ;
            ACLWDNT:MemoryOrder = "XY " ;
            ACLWDNT:description = "ACCUMULATED DOWNWELLING LONGWAVE FLUX AT
TOP" ;
            ACLWDNT:units = "J m-2" ;
            ACLWDNT:stagger = "" ;
            ACLWDNT:coordinates = "XLONG XLAT XTIME" ;
      float ACLWDNTC(Time, south_north, west_east) ;
            ACLWDNTC:FieldType = 104 ;
            ACLWDNTC:MemoryOrder = "XY " ;
            ACLWDNTC:description = "ACCUMULATED DOWNWELLING CLEAR SKY
LONGWAVE FLUX AT TOP" ;
            ACLWDNTC:units = "J m-2" ;
            ACLWDNTC:stagger = "" ;
            ACLWDNTC:coordinates = "XLONG XLAT XTIME" ;
      float ACLWUPB(Time, south_north, west_east) ;
            ACLWUPB:FieldType = 104 ;
            ACLWUPB:MemoryOrder = "XY " ;
            ACLWUPB:description = "ACCUMULATED UPWELLING LONGWAVE FLUX AT
BOTTOM" ;
            ACLWUPB:units = "J m-2" ;
            ACLWUPB:stagger = "" ;
            ACLWUPB:coordinates = "XLONG XLAT XTIME" ;
      float ACLWUPBC(Time, south_north, west_east) ;
            ACLWUPBC:FieldType = 104 ;
            ACLWUPBC:MemoryOrder = "XY " ;
            ACLWUPBC:description = "ACCUMULATED UPWELLING CLEAR SKY LONGWAVE
FLUX AT BOTTOM" ;
            ACLWUPBC:units = "J m-2" ;
            ACLWUPBC:stagger = "" ;
            ACLWUPBC:coordinates = "XLONG XLAT XTIME" ;
      float ACLWDNB(Time, south_north, west_east) ;
            ACLWDNB:FieldType = 104 ;
            ACLWDNB:MemoryOrder = "XY " ;
            ACLWDNB:description = "ACCUMULATED DOWNWELLING LONGWAVE FLUX AT
BOTTOM" ;
            ACLWDNB:units = "J m-2" ;
            ACLWDNB:stagger = "" ;
            ACLWDNB:coordinates = "XLONG XLAT XTIME" ;
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      float ACLWDNBC(Time, south_north, west_east) ;
            ACLWDNBC:FieldType = 104 ;
            ACLWDNBC:MemoryOrder = "XY " ;
            ACLWDNBC:description = "ACCUMULATED DOWNWELLING CLEAR SKY
LONGWAVE FLUX AT BOTTOM" ;
            ACLWDNBC:units = "J m-2" ;
            ACLWDNBC:stagger = "" ;
            ACLWDNBC:coordinates = "XLONG XLAT XTIME" ;
      int I_ACSWUPT(Time, south_north, west_east) ;
            I_ACSWUPT:FieldType = 106 ;
            I_ACSWUPT:MemoryOrder = "XY " ;
            I_ACSWUPT:description = "BUCKET FOR UPWELLING SHORTWAVE FLUX AT
TOP" ;
            I_ACSWUPT:units = "J m-2" ;
            I_ACSWUPT:stagger = "" ;
            I_ACSWUPT:coordinates = "XLONG XLAT XTIME" ;
      int I_ACSWUPTC(Time, south_north, west_east) ;
            I_ACSWUPTC:FieldType = 106 ;
            I_ACSWUPTC:MemoryOrder = "XY " ;
            I_ACSWUPTC:description = "BUCKET FOR UPWELLING CLEAR SKY
SHORTWAVE FLUX AT TOP" ;
            I_ACSWUPTC:units = "J m-2" ;
            I_ACSWUPTC:stagger = "" ;
            I_ACSWUPTC:coordinates = "XLONG XLAT XTIME" ;
      int I_ACSWDNT(Time, south_north, west_east) ;
            I_ACSWDNT:FieldType = 106 ;
            I_ACSWDNT:MemoryOrder = "XY " ;
            I_ACSWDNT:description = "BUCKET FOR DOWNWELLING SHORTWAVE FLUX AT
TOP" ;
            I_ACSWDNT:units = "J m-2" ;
            I_ACSWDNT:stagger = "" ;
            I_ACSWDNT:coordinates = "XLONG XLAT XTIME" ;
      int I_ACSWDNTC(Time, south_north, west_east) ;
            I_ACSWDNTC:FieldType = 106 ;
            I_ACSWDNTC:MemoryOrder = "XY " ;
            I_ACSWDNTC:description = "BUCKET FOR DOWNWELLING CLEAR SKY
SHORTWAVE FLUX AT TOP" ;
            I_ACSWDNTC:units = "J m-2" ;
            I_ACSWDNTC:stagger = "" ;
            I_ACSWDNTC:coordinates = "XLONG XLAT XTIME" ;
      int I_ACSWUPB(Time, south_north, west_east) ;
            I_ACSWUPB:FieldType = 106 ;
            I_ACSWUPB:MemoryOrder = "XY " ;
            I_ACSWUPB:description = "BUCKET FOR UPWELLING SHORTWAVE FLUX AT
BOTTOM" ;
            I_ACSWUPB:units = "J m-2" ;
            I_ACSWUPB:stagger = "" ;
            I_ACSWUPB:coordinates = "XLONG XLAT XTIME" ;
      int I_ACSWUPBC(Time, south_north, west_east) ;
            I_ACSWUPBC:FieldType = 106 ;
            I_ACSWUPBC:MemoryOrder = "XY " ;
            I_ACSWUPBC:description = "BUCKET FOR UPWELLING CLEAR SKY
SHORTWAVE FLUX AT BOTTOM" ;
            I_ACSWUPBC:units = "J m-2" ;
            I_ACSWUPBC:stagger = "" ;
```

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            I_ACSWUPBC:coordinates = "XLONG XLAT XTIME" ;
      int I_ACSWDNB(Time, south_north, west_east) ;
            I_ACSWDNB:FieldType = 106 ;
            I_ACSWDNB:MemoryOrder = "XY " ;
            I_ACSWDNB:description = "BUCKET FOR DOWNWELLING SHORTWAVE FLUX AT
BOTTOM" ;
            I_ACSWDNB:units = "J m-2" ;
            I_ACSWDNB:stagger = "" ;
            I_ACSWDNB:coordinates = "XLONG XLAT XTIME" ;
      int I_ACSWDNBC(Time, south_north, west_east) ;
            I_ACSWDNBC:FieldType = 106 ;
            I_ACSWDNBC:MemoryOrder = "XY " ;
            I_ACSWDNBC:description = "BUCKET FOR DOWNWELLING CLEAR SKY
SHORTWAVE FLUX AT BOTTOM" ;
            I_ACSWDNBC:units = "J m-2" ;
            I_ACSWDNBC:stagger = "" ;
            I_ACSWDNBC:coordinates = "XLONG XLAT XTIME" ;
      int I_ACLWUPT(Time, south_north, west_east) ;
            I_ACLWUPT:FieldType = 106 ;
            I_ACLWUPT:MemoryOrder = "XY " ;
            I_ACLWUPT:description = "BUCKET FOR UPWELLING LONGWAVE FLUX AT
TOP" ;
            I_ACLWUPT:units = "J m-2" ;
            I_ACLWUPT:stagger = "" ;
            I_ACLWUPT:coordinates = "XLONG XLAT XTIME" ;
      int I_ACLWUPTC(Time, south_north, west_east) ;
            I_ACLWUPTC:FieldType = 106 ;
            I_ACLWUPTC:MemoryOrder = "XY " ;
            I_ACLWUPTC:description = "BUCKET FOR UPWELLING CLEAR SKY LONGWAVE
FLUX AT TOP" ;
            I_ACLWUPTC:units = "J m-2" ;
            I_ACLWUPTC:stagger = "" ;
            I_ACLWUPTC:coordinates = "XLONG XLAT XTIME" ;
      int I_ACLWDNT(Time, south_north, west_east) ;
            I_ACLWDNT:FieldType = 106 ;
            I_ACLWDNT:MemoryOrder = "XY " ;
            I_ACLWDNT:description = "BUCKET FOR DOWNWELLING LONGWAVE FLUX AT
TOP" ;
            I_ACLWDNT:units = "J m-2" ;
            I_ACLWDNT:stagger = "" ;
            I_ACLWDNT:coordinates = "XLONG XLAT XTIME" ;
      int I_ACLWDNTC(Time, south_north, west_east) ;
            I_ACLWDNTC:FieldType = 106 ;
            I_ACLWDNTC:MemoryOrder = "XY " ;
            I_ACLWDNTC:description = "BUCKET FOR DOWNWELLING CLEAR SKY
LONGWAVE FLUX AT TOP" ;
            I_ACLWDNTC:units = "J m-2" ;
            I_ACLWDNTC:stagger = "" ;
            I_ACLWDNTC:coordinates = "XLONG XLAT XTIME" ;
      int I_ACLWUPB(Time, south_north, west_east) ;
            I_ACLWUPB:FieldType = 106 ;
            I_ACLWUPB:MemoryOrder = "XY " ;
            I_ACLWUPB:description = "BUCKET FOR UPWELLING LONGWAVE FLUX AT
BOTTOM" ;
            I_ACLWUPB:units = "J m-2" ;
```

```
            I_ACLWUPB:stagger = "" ;
            I_ACLWUPB:coordinates = "XLONG XLAT XTIME" ;
      int I_ACLWUPBC(Time, south_north, west_east) ;
            I_ACLWUPBC:FieldType = 106 ;
            I_ACLWUPBC:MemoryOrder = "XY " ;
            I_ACLWUPBC:description = "BUCKET FOR UPWELLING CLEAR SKY LONGWAVE
FLUX AT BOTTOM" ;
            I_ACLWUPBC:units = "J m-2" ;
            I_ACLWUPBC:stagger = "" ;
            I_ACLWUPBC:coordinates = "XLONG XLAT XTIME" ;
      int I_ACLWDNB(Time, south_north, west_east) ;
            I_ACLWDNB:FieldType = 106 ;
            I_ACLWDNB:MemoryOrder = "XY " ;
            I_ACLWDNB:description = "BUCKET FOR DOWNWELLING LONGWAVE FLUX AT
BOTTOM" ;
            I_ACLWDNB:units = "J m-2" ;
            I_ACLWDNB:stagger = "" ;
            I_ACLWDNB:coordinates = "XLONG XLAT XTIME" ;
      int I_ACLWDNBC(Time, south_north, west_east) ;
            I_ACLWDNBC:FieldType = 106 ;
            I_ACLWDNBC:MemoryOrder = "XY " ;
            I_ACLWDNBC:description = "BUCKET FOR DOWNWELLING CLEAR SKY
LONGWAVE FLUX AT BOTTOM" ;
            I_ACLWDNBC:units = "J m-2" ;
            I_ACLWDNBC:stagger = "" ;
            I_ACLWDNBC:coordinates = "XLONG XLAT XTIME" ;
      float SWUPT(Time, south_north, west_east) ;
            SWUPT:FieldType = 104 ;
            SWUPT:MemoryOrder = "XY " ;
            SWUPT:description = "INSTANTANEOUS UPWELLING SHORTWAVE FLUX AT
TOP" ;
            SWUPT:units = "W m-2" ;
            SWUPT:stagger = "" ;
            SWUPT:coordinates = "XLONG XLAT XTIME" ;
      float SWUPTC(Time, south_north, west_east) ;
            SWUPTC:FieldType = 104 ;
            SWUPTC:MemoryOrder = "XY " ;
            SWUPTC:description = "INSTANTANEOUS UPWELLING CLEAR SKY SHORTWAVE
FLUX AT TOP" ;
            SWUPTC:units = "W m-2" ;
            SWUPTC:stagger = "" ;
            SWUPTC:coordinates = "XLONG XLAT XTIME" ;
      float SWDNT(Time, south_north, west_east) ;
            SWDNT:FieldType = 104 ;
            SWDNT:MemoryOrder = "XY " ;
            SWDNT:description = "INSTANTANEOUS DOWNWELLING SHORTWAVE FLUX AT
TOP" ;
            SWDNT:units = "W m-2" ;
            SWDNT:stagger = "" ;
            SWDNT:coordinates = "XLONG XLAT XTIME" ;
      float SWDNTC(Time, south_north, west_east) ;
            SWDNTC:FieldType = 104 ;
            SWDNTC:MemoryOrder = "XY " ;
            SWDNTC:description = "INSTANTANEOUS DOWNWELLING CLEAR SKY
SHORTWAVE FLUX AT TOP" ;
```

```
            SWDNTC:units = "W m-2" ;
            SWDNTC:stagger = "" ;
            SWDNTC:coordinates = "XLONG XLAT XTIME" ;
      float SWUPB(Time, south_north, west_east) ;
            SWUPB:FieldType = 104 ;
            SWUPB:MemoryOrder = "XY " ;
            SWUPB:description = "INSTANTANEOUS UPWELLING SHORTWAVE FLUX AT
BOTTOM" ;
            SWUPB:units = "W m-2" ;
            SWUPB:stagger = "" ;
            SWUPB:coordinates = "XLONG XLAT XTIME" ;
      float SWUPBC(Time, south_north, west_east) ;
            SWUPBC:FieldType = 104 ;
            SWUPBC:MemoryOrder = "XY " ;
            SWUPBC:description = "INSTANTANEOUS UPWELLING CLEAR SKY SHORTWAVE
FLUX AT BOTTOM" ;
            SWUPBC:units = "W m-2" ;
            SWUPBC:stagger = "" ;
            SWUPBC:coordinates = "XLONG XLAT XTIME" ;
      float SWDNB(Time, south_north, west_east) ;
            SWDNB:FieldType = 104 ;
            SWDNB:MemoryOrder = "XY " ;
            SWDNB:description = "INSTANTANEOUS DOWNWELLING SHORTWAVE FLUX AT
BOTTOM" ;
            SWDNB:units = "W m-2" ;
            SWDNB:stagger = "" ;
            SWDNB:coordinates = "XLONG XLAT XTIME" ;
      float SWDNBC(Time, south_north, west_east) ;
            SWDNBC:FieldType = 104 ;
            SWDNBC:MemoryOrder = "XY " ;
            SWDNBC:description = "INSTANTANEOUS DOWNWELLING CLEAR SKY
SHORTWAVE FLUX AT BOTTOM" ;
            SWDNBC:units = "W m-2" ;
            SWDNBC:stagger = "" ;
            SWDNBC:coordinates = "XLONG XLAT XTIME" ;
      float LWUPT(Time, south_north, west_east) ;
            LWUPT:FieldType = 104 ;
            LWUPT:MemoryOrder = "XY " ;
            LWUPT:description = "INSTANTANEOUS UPWELLING LONGWAVE FLUX AT
TOP" ;
            LWUPT:units = "W m-2" ;
            LWUPT:stagger = "" ;
            LWUPT:coordinates = "XLONG XLAT XTIME" ;
      float LWUPTC(Time, south_north, west_east) ;
            LWUPTC:FieldType = 104 ;
            LWUPTC:MemoryOrder = "XY " ;
            LWUPTC:description = "INSTANTANEOUS UPWELLING CLEAR SKY LONGWAVE
FLUX AT TOP" ;
            LWUPTC:units = "W m-2" ;
            LWUPTC:stagger = "" ;
            LWUPTC:coordinates = "XLONG XLAT XTIME" ;
      float LWDNT(Time, south_north, west_east) ;
            LWDNT:FieldType = 104 ;
            LWDNT:MemoryOrder = "XY " ;
```

```
            LWDNT:description = "INSTANTANEOUS DOWNWELLING LONGWAVE FLUX AT
TOP" ;
            LWDNT:units = "W m-2" ;
            LWDNT:stagger = "" ;
            LWDNT:coordinates = "XLONG XLAT XTIME" ;
      float LWDNTC(Time, south_north, west_east) ;
            LWDNTC:FieldType = 104 ;
            LWDNTC:MemoryOrder = "XY " ;
            LWDNTC:description = "INSTANTANEOUS DOWNWELLING CLEAR SKY
LONGWAVE FLUX AT TOP" ;
            LWDNTC:units = "W m-2" ;
            LWDNTC:stagger = "" ;
            LWDNTC:coordinates = "XLONG XLAT XTIME" ;
      float LWUPB(Time, south_north, west_east) ;
            LWUPB:FieldType = 104 ;
            LWUPB:MemoryOrder = "XY " ;
            LWUPB:description = "INSTANTANEOUS UPWELLING LONGWAVE FLUX AT
BOTTOM" ;
            LWUPB:units = "W m-2" ;
            LWUPB:stagger = "" ;
            LWUPB:coordinates = "XLONG XLAT XTIME" ;
      float LWUPBC(Time, south_north, west_east) ;
            LWUPBC:FieldType = 104 ;
            LWUPBC:MemoryOrder = "XY " ;
            LWUPBC:description = "INSTANTANEOUS UPWELLING CLEAR SKY LONGWAVE
FLUX AT BOTTOM" ;
            LWUPBC:units = "W m-2" ;
            LWUPBC:stagger = "" ;
            LWUPBC:coordinates = "XLONG XLAT XTIME" ;
      float LWDNB(Time, south_north, west_east) ;
            LWDNB:FieldType = 104 ;
            LWDNB:MemoryOrder = "XY " ;
            LWDNB:description = "INSTANTANEOUS DOWNWELLING LONGWAVE FLUX AT
BOTTOM" ;
            LWDNB:units = "W m-2" ;
            LWDNB:stagger = "" ;
            LWDNB:coordinates = "XLONG XLAT XTIME" ;
      float LWDNBC(Time, south_north, west_east) ;
            LWDNBC:FieldType = 104 ;
            LWDNBC:MemoryOrder = "XY " ;
            LWDNBC:description = "INSTANTANEOUS DOWNWELLING CLEAR SKY
LONGWAVE FLUX AT BOTTOM" ;
            LWDNBC:units = "W m-2" ;
            LWDNBC:stagger = "" ;
            LWDNBC:coordinates = "XLONG XLAT XTIME" ;
      float OLR(Time, south_north, west_east) ;
            OLR:FieldType = 104 ;
            OLR:MemoryOrder = "XY " ;
            OLR:description = "TOA OUTGOING LONG WAVE" ;
            OLR:units = "W m-2" ;
            OLR:stagger = "" ;
            OLR:coordinates = "XLONG XLAT XTIME" ;
      float XLAT_U(Time, south_north, west_east_stag) ;
            XLAT_U:FieldType = 104 ;
            XLAT_U:MemoryOrder = "XY " ;
```

```
            XLAT_U:description = "LATITUDE, SOUTH IS NEGATIVE" ;
            XLAT_U:units = "degree_north" ;
            XLAT_U:stagger = "X" ;
            XLAT_U:coordinates = "XLONG_U XLAT_U" ;
      float XLONG_U(Time, south_north, west_east_stag) ;
            XLONG_U:FieldType = 104 ;
            XLONG_U:MemoryOrder = "XY " ;
            XLONG_U:description = "LONGITUDE, WEST IS NEGATIVE" ;
            XLONG_U:units = "degree_east" ;
            XLONG_U:stagger = "X" ;
            XLONG_U:coordinates = "XLONG_U XLAT_U" ;
      float XLAT_V(Time, south_north_stag, west_east) ;
            XLAT_V:FieldType = 104 ;
            XLAT_V:MemoryOrder = "XY " ;
            XLAT_V:description = "LATITUDE, SOUTH IS NEGATIVE" ;
            XLAT_V:units = "degree_north" ;
            XLAT_V:stagger = "Y" ;
            XLAT_V:coordinates = "XLONG_V XLAT_V" ;
      float XLONG_V(Time, south_north_stag, west_east) ;
            XLONG_V:FieldType = 104 ;
            XLONG_V:MemoryOrder = "XY " ;
            XLONG_V:description = "LONGITUDE, WEST IS NEGATIVE" ;
            XLONG_V:units = "degree_east" ;
            XLONG_V:stagger = "Y" ;
            XLONG_V:coordinates = "XLONG_V XLAT_V" ;
      float ALBEDO(Time, south_north, west_east) ;
            ALBEDO:FieldType = 104 ;
            ALBEDO:MemoryOrder = "XY " ;
            ALBEDO:description = "ALBEDO" ;
            ALBEDO:units = "-" ;
            ALBEDO:stagger = "" ;
            ALBEDO:coordinates = "XLONG XLAT XTIME" ;
      float CLAT(Time, south_north, west_east) ;
            CLAT:FieldType = 104 ;
            CLAT:MemoryOrder = "XY " ;
            CLAT:description = "COMPUTATIONAL GRID LATITUDE, SOUTH IS
NEGATIVE" ;
            CLAT:units = "degree_north" ;
            CLAT:stagger = "" ;
            CLAT:coordinates = "XLONG XLAT XTIME" ;
      float ALBBCK(Time, south_north, west_east) ;
            ALBBCK:FieldType = 104 ;
            ALBBCK:MemoryOrder = "XY " ;
            ALBBCK:description = "BACKGROUND ALBEDO" ;
            ALBBCK:units = "" ;
            ALBBCK:stagger = "" ;
            ALBBCK:coordinates = "XLONG XLAT XTIME" ;
      float EMISS(Time, south_north, west_east) ;
            EMISS:FieldType = 104 ;
            EMISS:MemoryOrder = "XY " ;
            EMISS:description = "SURFACE EMISSIVITY" ;
            EMISS:units = "" ;
            EMISS:stagger = "" ;
            EMISS:coordinates = "XLONG XLAT XTIME" ;
      float NOAHRES(Time, south_north, west_east) ;
```

```
            NOAHRES:FieldType = 104 ;
            NOAHRES:MemoryOrder = "XY " ;
            NOAHRES:description = "RESIDUAL OF THE NOAH SURFACE ENERGY
BUDGET" ;
            NOAHRES:units = "W m{-2}" ;
            NOAHRES:stagger = "" ;
            NOAHRES:coordinates = "XLONG XLAT XTIME" ;
      float TMN(Time, south_north, west_east) ;
            TMN:FieldType = 104 ;
            TMN:MemoryOrder = "XY " ;
            TMN:description = "SOIL TEMPERATURE AT LOWER BOUNDARY" ;
            TMN:units = "K" ;
            TMN:stagger = "" ;
            TMN:coordinates = "XLONG XLAT XTIME" ;
      float XLAND(Time, south_north, west_east) ;
            XLAND:FieldType = 104 ;
            XLAND:MemoryOrder = "XY " ;
            XLAND:description = "LAND MASK (1 FOR LAND, 2 FOR WATER)" ;
            XLAND:units = "" ;
            XLAND:stagger = "" ;
            XLAND:coordinates = "XLONG XLAT XTIME" ;
      float UST(Time, south_north, west_east) ;
            UST:FieldType = 104 ;
            UST:MemoryOrder = "XY " ;
            UST:description = "U* IN SIMILARITY THEORY" ;
            UST:units = "m s-1" ;
            UST:stagger = "" ;
            UST:coordinates = "XLONG XLAT XTIME" ;
      float PBLH(Time, south_north, west_east) ;
            PBLH:FieldType = 104 ;
            PBLH:MemoryOrder = "XY " ;
            PBLH:description = "PBL HEIGHT" ;
            PBLH:units = "m" ;
            PBLH:stagger = "" ;
            PBLH:coordinates = "XLONG XLAT XTIME" ;
      float HFX(Time, south_north, west_east) ;
            HFX:FieldType = 104 ;
            HFX:MemoryOrder = "XY " ;
            HFX:description = "UPWARD HEAT FLUX AT THE SURFACE" ;
            HFX:units = "W m-2" ;
            HFX:stagger = "" ;
            HFX:coordinates = "XLONG XLAT XTIME" ;
      float QFX(Time, south_north, west_east) ;
            QFX:FieldType = 104 ;
            QFX:MemoryOrder = "XY " ;
            QFX:description = "UPWARD MOISTURE FLUX AT THE SURFACE" ;
            QFX:units = "kg m-2 s-1" ;
            QFX:stagger = "" ;
            QFX:coordinates = "XLONG XLAT XTIME" ;
      float LH(Time, south_north, west_east) ;
            LH:FieldType = 104 ;
            LH:MemoryOrder = "XY " ;
            LH:description = "LATENT HEAT FLUX AT THE SURFACE" ;
            LH:units = "W m-2" ;
            LH:stagger = "" ;
```

```
            LH:coordinates = "XLONG XLAT XTIME" ;
      float ACHFX(Time, south_north, west_east) ;
            ACHFX:FieldType = 104 ;
            ACHFX:MemoryOrder = "XY " ;
            ACHFX:description = "ACCUMULATED UPWARD HEAT FLUX AT THE SURFACE"
;
            ACHFX:units = "J m-2" ;
            ACHFX:stagger = "" ;
            ACHFX:coordinates = "XLONG XLAT XTIME" ;
      float ACLHF(Time, south_north, west_east) ;
            ACLHF:FieldType = 104 ;
            ACLHF:MemoryOrder = "XY " ;
            ACLHF:description = "ACCUMULATED UPWARD LATENT HEAT FLUX AT THE
SURFACE" ;
            ACLHF:units = "J m-2" ;
            ACLHF:stagger = "" ;
            ACLHF:coordinates = "XLONG XLAT XTIME" ;
      float SNOWC(Time, south_north, west_east) ;
            SNOWC:FieldType = 104 ;
            SNOWC:MemoryOrder = "XY " ;
            SNOWC:description = "FLAG INDICATING SNOW COVERAGE (1 FOR SNOW
COVER)" ;
            SNOWC:units = "" ;
            SNOWC:stagger = "" ;
            SNOWC:coordinates = "XLONG XLAT XTIME" ;
      float SR(Time, south_north, west_east) ;
            SR:FieldType = 104 ;
            SR:MemoryOrder = "XY " ;
            SR:description = "fraction of frozen precipitation" ;
            SR:units = "-" ;
            SR:stagger = "" ;
            SR:coordinates = "XLONG XLAT XTIME" ;
      int SAVE_TOPO_FROM_REAL(Time) ;
            SAVE_TOPO_FROM_REAL:FieldType = 106 ;
            SAVE_TOPO_FROM_REAL:MemoryOrder = "0  " ;
            SAVE_TOPO_FROM_REAL:description = "1=original topo from
real/0=topo modified by WRF" ;
            SAVE_TOPO_FROM_REAL:units = "flag" ;
            SAVE_TOPO_FROM_REAL:stagger = "" ;
      int ISEEDARR_RAND_PERTURB(Time, bottom_top) ;
            ISEEDARR_RAND_PERTURB:FieldType = 106 ;
            ISEEDARR_RAND_PERTURB:MemoryOrder = "Z  " ;
            ISEEDARR_RAND_PERTURB:description = "Array to hold seed for
restart, RAND_PERT" ;
            ISEEDARR_RAND_PERTURB:units = "" ;
            ISEEDARR_RAND_PERTURB:stagger = "" ;
      int ISEEDARR_SPPT(Time, bottom_top) ;
            ISEEDARR_SPPT:FieldType = 106 ;
            ISEEDARR_SPPT:MemoryOrder = "Z  " ;
            ISEEDARR_SPPT:description = "Array to hold seed for restart,
SPPT" ;
            ISEEDARR_SPPT:units = "" ;
            ISEEDARR_SPPT:stagger = "" ;
      int ISEEDARR_SKEBS(Time, bottom_top) ;
            ISEEDARR_SKEBS:FieldType = 106 ;
```

```
            ISEEDARR_SKEBS:MemoryOrder = "Z  " ;
            ISEEDARR_SKEBS:description = "Array to hold seed for restart,
SKEBS" ;
            ISEEDARR_SKEBS:units = "" ;
            ISEEDARR_SKEBS:stagger = "" ;
      float m11(Time, bottom_top, south_north, west_east) ;
            m11:FieldType = 104 ;
            m11:MemoryOrder = "XYZ" ;
            m11:description = "11 component of NBA subgrid stress tensor" ;
            m11:units = "m2 s-2" ;
            m11:stagger = "" ;
            m11:coordinates = "XLONG XLAT XTIME" ;
      float m22(Time, bottom_top, south_north, west_east) ;
            m22:FieldType = 104 ;
            m22:MemoryOrder = "XYZ" ;
            m22:description = "22 component of NBA subgrid stress tensor" ;
            m22:units = "m2 s-2" ;
            m22:stagger = "" ;
            m22:coordinates = "XLONG XLAT XTIME" ;
      float m33(Time, bottom_top, south_north, west_east) ;
            m33:FieldType = 104 ;
            m33:MemoryOrder = "XYZ" ;
            m33:description = "33 component of NBA subgrid stress tensor" ;
            m33:units = "m2 s-2" ;
            m33:stagger = "" ;
            m33:coordinates = "XLONG XLAT XTIME" ;
      float m12(Time, bottom_top, south_north, west_east) ;
            m12:FieldType = 104 ;
            m12:MemoryOrder = "XYZ" ;
            m12:description = "12 component of NBA subgrid stress tensor" ;
            m12:units = "m2 s-2" ;
            m12:stagger = "" ;
            m12:coordinates = "XLONG XLAT XTIME" ;
      float m13(Time, bottom_top, south_north, west_east) ;
            m13:FieldType = 104 ;
            m13:MemoryOrder = "XYZ" ;
            m13:description = "13 component of NBA subgrid stress tensor" ;
            m13:units = "m2 s-2" ;
            m13:stagger = "" ;
            m13:coordinates = "XLONG XLAT XTIME" ;
      float m23(Time, bottom_top, south_north, west_east) ;
            m23:FieldType = 104 ;
            m23:MemoryOrder = "XYZ" ;
            m23:description = "23 component of NBA subgrid stress tensor" ;
            m23:units = "m2 s-2" ;
            m23:stagger = "" ;
            m23:coordinates = "XLONG XLAT XTIME" ;
      float U_LS(Time, force_layers) ;
            U_LS:FieldType = 104 ;
            U_LS:MemoryOrder = "Z  " ;
            U_LS:description = "large-scale zonal wind velocity" ;
            U_LS:units = "m s-1" ;
            U_LS:stagger = "" ;
      float U_LS_TEND(Time, force_layers) ;
            U_LS_TEND:FieldType = 104 ;
```

```
            U_LS_TEND:MemoryOrder = "Z  " ;
            U_LS_TEND:description = "tendency large-scale zonal wind
velocity" ;
            U_LS_TEND:units = "m s-2" ;
            U_LS_TEND:stagger = "" ;
      float V_LS(Time, force_layers) ;
            V_LS:FieldType = 104 ;
            V_LS:MemoryOrder = "Z  " ;
            V_LS:description = "large-scale meridional wind velocity" ;
            V_LS:units = "m s-1" ;
            V_LS:stagger = "" ;
      float V_LS_TEND(Time, force_layers) ;
            V_LS_TEND:FieldType = 104 ;
            V_LS_TEND:MemoryOrder = "Z  " ;
            V_LS_TEND:description = "tendency large-scale meridional wind
velocity" ;
            V_LS_TEND:units = "m s-2" ;
            V_LS_TEND:stagger = "" ;
      float W_LS(Time, force_layers) ;
            W_LS:FieldType = 104 ;
            W_LS:MemoryOrder = "Z  " ;
            W_LS:description = "large-scale vertical velocity" ;
            W_LS:units = "m s-1" ;
            W_LS:stagger = "" ;
      float W_LS_TEND(Time, force_layers) ;
            W_LS_TEND:FieldType = 104 ;
            W_LS_TEND:MemoryOrder = "Z  " ;
            W_LS_TEND:description = "tendency large-scale vertical velocity"
;
            W_LS_TEND:units = "m s-2" ;
            W_LS_TEND:stagger = "" ;
      float INV_TAU_S(Time, force_layers) ;
            INV_TAU_S:FieldType = 104 ;
            INV_TAU_S:MemoryOrder = "Z  " ;
            INV_TAU_S:description = "inverse relaxation time for scalars" ;
            INV_TAU_S:units = "s-1" ;
            INV_TAU_S:stagger = "" ;
      float INV_TAU_M(Time, force_layers) ;
            INV_TAU_M:FieldType = 104 ;
            INV_TAU_M:MemoryOrder = "Z  " ;
            INV_TAU_M:description = "inverse relaxation time for scalars" ;
            INV_TAU_M:units = "s-1" ;
            INV_TAU_M:stagger = "" ;
      float TH_ADV(Time, force_layers) ;
            TH_ADV:FieldType = 104 ;
            TH_ADV:MemoryOrder = "Z  " ;
            TH_ADV:description = "tendency theta advection" ;
            TH_ADV:units = "K s-1" ;
            TH_ADV:stagger = "" ;
      float TH_ADV_TEND(Time, force_layers) ;
            TH_ADV_TEND:FieldType = 104 ;
            TH_ADV_TEND:MemoryOrder = "Z  " ;
            TH_ADV_TEND:description = "tendency of tendency theta advection"
;
            TH_ADV_TEND:units = "K s-2" ;
```

```
        TH_ADV_TEND:stagger = "" ;
    float TH_RLX(Time, force_layers) ;
        TH_RLX:FieldType = 104 ;
        TH_RLX:MemoryOrder = "Z  " ;
        TH_RLX:description = "theta relaxation" ;
        TH_RLX:units = "K" ;
        TH_RLX:stagger = "" ;
    float TH_RLX_TEND(Time, force_layers) ;
        TH_RLX_TEND:FieldType = 104 ;
        TH_RLX_TEND:MemoryOrder = "Z  " ;
        TH_RLX_TEND:description = "tendency theta relaxation" ;
        TH_RLX_TEND:units = "K s-1" ;
        TH_RLX_TEND:stagger = "" ;
    float QV_ADV(Time, force_layers) ;
        QV_ADV:FieldType = 104 ;
        QV_ADV:MemoryOrder = "Z  " ;
        QV_ADV:description = "tendency qv advection" ;
        QV_ADV:units = "kg kg-1 s-1" ;
        QV_ADV:stagger = "" ;
    float QV_ADV_TEND(Time, force_layers) ;
        QV_ADV_TEND:FieldType = 104 ;
        QV_ADV_TEND:MemoryOrder = "Z  " ;
        QV_ADV_TEND:description = "tendency of tendency qv advection" ;
        QV_ADV_TEND:units = "kg kg-1 s-2" ;
        QV_ADV_TEND:stagger = "" ;
    float QV_RLX(Time, force_layers) ;
        QV_RLX:FieldType = 104 ;
        QV_RLX:MemoryOrder = "Z  " ;
        QV_RLX:description = "qv relaxation" ;
        QV_RLX:units = "kg kg-1" ;
        QV_RLX:stagger = "" ;
    float QV_RLX_TEND(Time, force_layers) ;
        QV_RLX_TEND:FieldType = 104 ;
        QV_RLX_TEND:MemoryOrder = "Z  " ;
        QV_RLX_TEND:description = "tendency qv relaxation" ;
        QV_RLX_TEND:units = "kg kg-1 s-1" ;
        QV_RLX_TEND:stagger = "" ;
    float Z_LS(Time, force_layers) ;
        Z_LS:FieldType = 104 ;
        Z_LS:MemoryOrder = "Z  " ;
        Z_LS:description = "z of large-scale forcings" ;
        Z_LS:units = "m" ;
        Z_LS:stagger = "" ;
    float Z_LS_TEND(Time, force_layers) ;
        Z_LS_TEND:FieldType = 104 ;
        Z_LS_TEND:MemoryOrder = "Z  " ;
        Z_LS_TEND:description = "tendency of z of large-scale forcings" ;
        Z_LS_TEND:units = "m s-1" ;
        Z_LS_TEND:stagger = "" ;
    float PRE_SH_FLX(Time) ;
        PRE_SH_FLX:FieldType = 104 ;
        PRE_SH_FLX:MemoryOrder = "0  " ;
        PRE_SH_FLX:description = "prescribed sensible heat flux" ;
        PRE_SH_FLX:units = "W m-2" ;
        PRE_SH_FLX:stagger = "" ;
```

```
      float PRE_SH_FLX_TEND(Time) ;
            PRE_SH_FLX_TEND:FieldType = 104 ;
            PRE_SH_FLX_TEND:MemoryOrder = "0  " ;
            PRE_SH_FLX_TEND:description = "tendency prescribed sensible heat
flux" ;
            PRE_SH_FLX_TEND:units = "W m-2 s-1" ;
            PRE_SH_FLX_TEND:stagger = "" ;
      float PRE_LH_FLX(Time) ;
            PRE_LH_FLX:FieldType = 104 ;
            PRE_LH_FLX:MemoryOrder = "0  " ;
            PRE_LH_FLX:description = "prescribed latent heat flux" ;
            PRE_LH_FLX:units = "W m-2" ;
            PRE_LH_FLX:stagger = "" ;
      float PRE_LH_FLX_TEND(Time) ;
            PRE_LH_FLX_TEND:FieldType = 104 ;
            PRE_LH_FLX_TEND:MemoryOrder = "0  " ;
            PRE_LH_FLX_TEND:description = "tendency prescribed latent heat
flux" ;
            PRE_LH_FLX_TEND:units = "W m-2 s-1" ;
            PRE_LH_FLX_TEND:stagger = "" ;
      float PRE_ALBEDO(Time) ;
            PRE_ALBEDO:FieldType = 104 ;
            PRE_ALBEDO:MemoryOrder = "0  " ;
            PRE_ALBEDO:description = "prescribed albedo" ;
            PRE_ALBEDO:units = "" ;
            PRE_ALBEDO:stagger = "" ;
      float PRE_ALBEDO_TEND(Time) ;
            PRE_ALBEDO_TEND:FieldType = 104 ;
            PRE_ALBEDO_TEND:MemoryOrder = "0  " ;
            PRE_ALBEDO_TEND:description = "tendency prescribed albedo" ;
            PRE_ALBEDO_TEND:units = "s-1" ;
            PRE_ALBEDO_TEND:stagger = "" ;
      float PRE_TSK(Time) ;
            PRE_TSK:FieldType = 104 ;
            PRE_TSK:MemoryOrder = "0  " ;
            PRE_TSK:description = "prescribed skin temperature" ;
            PRE_TSK:units = "K" ;
            PRE_TSK:stagger = "" ;
      float PRE_TSK_TEND(Time) ;
            PRE_TSK_TEND:FieldType = 104 ;
            PRE_TSK_TEND:MemoryOrder = "0  " ;
            PRE_TSK_TEND:description = "tendency prescribed skin temperature"
;
            PRE_TSK_TEND:units = "K s-1" ;
            PRE_TSK_TEND:stagger = "" ;
      int NUM_MODES_AER(Time) ;
            NUM_MODES_AER:FieldType = 106 ;
            NUM_MODES_AER:MemoryOrder = "0  " ;
            NUM_MODES_AER:description = "Number of aerosol distribution
modes" ;
            NUM_MODES_AER:units = "" ;
            NUM_MODES_AER:stagger = "" ;
      float RULSTEN(Time, bottom_top, south_north, west_east) ;
            RULSTEN:FieldType = 104 ;
            RULSTEN:MemoryOrder = "XYZ" ;
```

```
        RULSTEN:description = "coupled u tendency due to LS forcing" ;
        RULSTEN:units = "Pa m s-2" ;
        RULSTEN:stagger = "" ;
        RULSTEN:coordinates = "XLONG XLAT XTIME" ;
    float RVLSTEN(Time, bottom_top, south_north, west_east) ;
        RVLSTEN:FieldType = 104 ;
        RVLSTEN:MemoryOrder = "XYZ" ;
        RVLSTEN:description = "coupled v tendency due to LS forcing" ;
        RVLSTEN:units = "Pa m s-2" ;
        RVLSTEN:stagger = "" ;
        RVLSTEN:coordinates = "XLONG XLAT XTIME" ;
    float RTHLSTEN(Time, bottom_top, south_north, west_east) ;
        RTHLSTEN:FieldType = 104 ;
        RTHLSTEN:MemoryOrder = "XYZ" ;
        RTHLSTEN:description = "coupled theta tendency due to LS forcing"
;
        RTHLSTEN:units = "Pa K s-1" ;
        RTHLSTEN:stagger = "" ;
        RTHLSTEN:coordinates = "XLONG XLAT XTIME" ;
    float RQVLSTEN(Time, bottom_top, south_north, west_east) ;
        RQVLSTEN:FieldType = 104 ;
        RQVLSTEN:MemoryOrder = "XYZ" ;
        RQVLSTEN:description = "coupled Q_V tendency due to LS forcing" ;
        RQVLSTEN:units = "Pa kg kg-1 s-1" ;
        RQVLSTEN:stagger = "" ;
        RQVLSTEN:coordinates = "XLONG XLAT XTIME" ;
    float W_DTHDZ(Time, bottom_top, south_north, west_east) ;
        W_DTHDZ:FieldType = 104 ;
        W_DTHDZ:MemoryOrder = "XYZ" ;
        W_DTHDZ:description = "th tendency due to LS vertical adv" ;
        W_DTHDZ:units = "K s-1" ;
        W_DTHDZ:stagger = "" ;
        W_DTHDZ:coordinates = "XLONG XLAT XTIME" ;
    float W_DQVDZ(Time, bottom_top, south_north, west_east) ;
        W_DQVDZ:FieldType = 104 ;
        W_DQVDZ:MemoryOrder = "XYZ" ;
        W_DQVDZ:description = "qv tendency due to LS vertical adv" ;
        W_DQVDZ:units = "kg kg-1 s-1" ;
        W_DQVDZ:stagger = "" ;
        W_DQVDZ:coordinates = "XLONG XLAT XTIME" ;
    float W_DUDZ(Time, bottom_top, south_north, west_east) ;
        W_DUDZ:FieldType = 104 ;
        W_DUDZ:MemoryOrder = "XYZ" ;
        W_DUDZ:description = "u tendency due to LS vertical adv" ;
        W_DUDZ:units = "m s-2" ;
        W_DUDZ:stagger = "" ;
        W_DUDZ:coordinates = "XLONG XLAT XTIME" ;
    float W_DVDZ(Time, bottom_top, south_north, west_east) ;
        W_DVDZ:FieldType = 104 ;
        W_DVDZ:MemoryOrder = "XYZ" ;
        W_DVDZ:description = "v tendency due to LS vertical adv" ;
        W_DVDZ:units = "m s-2" ;
        W_DVDZ:stagger = "" ;
        W_DVDZ:coordinates = "XLONG XLAT XTIME" ;
    float THDT_LSHOR(Time, bottom_top) ;
```

```
        THDT_LSHOR:FieldType = 104 ;
        THDT_LSHOR:MemoryOrder = "Z  " ;
        THDT_LSHOR:description = "th tendency due to LS horizontal adv" ;
        THDT_LSHOR:units = "K s-1" ;
        THDT_LSHOR:stagger = "" ;
    float QVDT_LSHOR(Time, bottom_top) ;
        QVDT_LSHOR:FieldType = 104 ;
        QVDT_LSHOR:MemoryOrder = "Z  " ;
        QVDT_LSHOR:description = "qv tendency due to LS horizontal adv" ;
        QVDT_LSHOR:units = "kg kg-1 s-1" ;
        QVDT_LSHOR:stagger = "" ;
    float THDT_LSRLX(Time, bottom_top) ;
        THDT_LSRLX:FieldType = 104 ;
        THDT_LSRLX:MemoryOrder = "Z  " ;
        THDT_LSRLX:description = "th tendency due to relaxation to LS" ;
        THDT_LSRLX:units = "K s-1" ;
        THDT_LSRLX:stagger = "" ;
    float QVDT_LSRLX(Time, bottom_top) ;
        QVDT_LSRLX:FieldType = 104 ;
        QVDT_LSRLX:MemoryOrder = "Z  " ;
        QVDT_LSRLX:description = "qv tendency due to relaxation to LS" ;
        QVDT_LSRLX:units = "kg kg-1 s-1" ;
        QVDT_LSRLX:stagger = "" ;
    float UDT_LSRLX(Time, bottom_top) ;
        UDT_LSRLX:FieldType = 104 ;
        UDT_LSRLX:MemoryOrder = "Z  " ;
        UDT_LSRLX:description = "u tendency due to relaxation to LS" ;
        UDT_LSRLX:units = "m s-2" ;
        UDT_LSRLX:stagger = "" ;
    float VDT_LSRLX(Time, bottom_top) ;
        VDT_LSRLX:FieldType = 104 ;
        VDT_LSRLX:MemoryOrder = "Z  " ;
        VDT_LSRLX:description = "v tendency due to relaxation to LS" ;
        VDT_LSRLX:units = "m s-2" ;
        VDT_LSRLX:stagger = "" ;
    float EFFCS(Time, bottom_top, south_north, west_east) ;
        EFFCS:FieldType = 104 ;
        EFFCS:MemoryOrder = "XYZ" ;
        EFFCS:description = "CLOUD DROPLET EFFECTIVE RADIUS" ;
        EFFCS:units = "micron" ;
        EFFCS:stagger = "" ;
        EFFCS:coordinates = "XLONG XLAT XTIME" ;
    float LWF0(Time, bottom_top, south_north, west_east) ;
        LWF0:FieldType = 104 ;
        LWF0:MemoryOrder = "XYZ" ;
        LWF0:description = "Net LW radiative flux" ;
        LWF0:units = "W m-2" ;
        LWF0:stagger = "" ;
        LWF0:coordinates = "XLONG XLAT XTIME" ;
    float LWF1(Time, bottom_top, south_north, west_east) ;
        LWF1:FieldType = 104 ;
        LWF1:MemoryOrder = "XYZ" ;
        LWF1:description = "Net LW radiative flux, term1" ;
        LWF1:units = "W m-2" ;
        LWF1:stagger = "" ;
```

```
            LWF1:coordinates = "XLONG XLAT XTIME" ;
      float LWF2(Time, bottom_top, south_north, west_east) ;
            LWF2:FieldType = 104 ;
            LWF2:MemoryOrder = "XYZ" ;
            LWF2:description = "Net LW radiative flux, term2" ;
            LWF2:units = "W m-2" ;
            LWF2:stagger = "" ;
            LWF2:coordinates = "XLONG XLAT XTIME" ;
      float LWF3(Time, bottom_top, south_north, west_east) ;
            LWF3:FieldType = 104 ;
            LWF3:MemoryOrder = "XYZ" ;
            LWF3:description = "Net LW radiative flux, term3" ;
            LWF3:units = "W m-2" ;
            LWF3:stagger = "" ;
            LWF3:coordinates = "XLONG XLAT XTIME" ;
      float ZI_QT8(Time, south_north, west_east) ;
            ZI_QT8:FieldType = 104 ;
            ZI_QT8:MemoryOrder = "XY " ;
            ZI_QT8:description = "zi defined by qt" ;
            ZI_QT8:units = "m" ;
            ZI_QT8:stagger = "" ;
            ZI_QT8:coordinates = "XLONG XLAT XTIME" ;
      float SEDFQC(Time, bottom_top, south_north, west_east) ;
            SEDFQC:FieldType = 104 ;
            SEDFQC:MemoryOrder = "XYZ" ;
            SEDFQC:description = "sedimentation flux of cloud water" ;
            SEDFQC:units = "kg m-2 s-1" ;
            SEDFQC:stagger = "" ;
            SEDFQC:coordinates = "XLONG XLAT XTIME" ;
      float SEDFQR(Time, bottom_top, south_north, west_east) ;
            SEDFQR:FieldType = 104 ;
            SEDFQR:MemoryOrder = "XYZ" ;
            SEDFQR:description = "sedimentation flux of rain water" ;
            SEDFQR:units = "kg m-2 s-1" ;
            SEDFQR:stagger = "" ;
            SEDFQR:coordinates = "XLONG XLAT XTIME" ;
      float QVDT_PR(Time, bottom_top, south_north, west_east) ;
            QVDT_PR:FieldType = 104 ;
            QVDT_PR:MemoryOrder = "XYZ" ;
            QVDT_PR:description = "Production rate of vapor by conversion to 
rain" ;
            QVDT_PR:units = "" ;
            QVDT_PR:stagger = "" ;
            QVDT_PR:coordinates = "XLONG XLAT XTIME" ;
      float QVDT_COND(Time, bottom_top, south_north, west_east) ;
            QVDT_COND:FieldType = 104 ;
            QVDT_COND:MemoryOrder = "XYZ" ;
            QVDT_COND:description = "Production rate of vapor by conversion 
to rain" ;
            QVDT_COND:units = "" ;
            QVDT_COND:stagger = "" ;
            QVDT_COND:coordinates = "XLONG XLAT XTIME" ;
      float QCDT_PR(Time, bottom_top, south_north, west_east) ;
            QCDT_PR:FieldType = 104 ;
            QCDT_PR:MemoryOrder = "XYZ" ;
```

```
            QCDT_PR:description = "Production rate of vapor by conversion to
rain" ;
            QCDT_PR:units = "" ;
            QCDT_PR:stagger = "" ;
            QCDT_PR:coordinates = "XLONG XLAT XTIME" ;
      float QCDT_SED(Time, bottom_top, south_north, west_east) ;
            QCDT_SED:FieldType = 104 ;
            QCDT_SED:MemoryOrder = "XYZ" ;
            QCDT_SED:description = "Tendency of cloud water due to
sedimentation" ;
            QCDT_SED:units = "" ;
            QCDT_SED:stagger = "" ;
            QCDT_SED:coordinates = "XLONG XLAT XTIME" ;
      float QRDT_SED(Time, bottom_top, south_north, west_east) ;
            QRDT_SED:FieldType = 104 ;
            QRDT_SED:MemoryOrder = "XYZ" ;
            QRDT_SED:description = "Tendency of rain water due to
sedimentation" ;
            QRDT_SED:units = "" ;
            QRDT_SED:stagger = "" ;
            QRDT_SED:coordinates = "XLONG XLAT XTIME" ;
      float SMAXACT(Time, bottom_top, south_north, west_east) ;
            SMAXACT:FieldType = 104 ;
            SMAXACT:MemoryOrder = "XYZ" ;
            SMAXACT:description = "Maximum supersaturation in Morrison
microphysics" ;
            SMAXACT:units = "" ;
            SMAXACT:stagger = "" ;
            SMAXACT:coordinates = "XLONG XLAT XTIME" ;
      float RMINACT(Time, bottom_top, south_north, west_east) ;
            RMINACT:FieldType = 104 ;
            RMINACT:MemoryOrder = "XYZ" ;
            RMINACT:description = "Minimum activated radius in Morrison
microphysics" ;
            RMINACT:units = "" ;
            RMINACT:stagger = "" ;
            RMINACT:coordinates = "XLONG XLAT XTIME" ;
      float LANDMASK(Time, south_north, west_east) ;
            LANDMASK:FieldType = 104 ;
            LANDMASK:MemoryOrder = "XY " ;
            LANDMASK:description = "LAND MASK (1 FOR LAND, 0 FOR WATER)" ;
            LANDMASK:units = "" ;
            LANDMASK:stagger = "" ;
            LANDMASK:coordinates = "XLONG XLAT XTIME" ;
      float LAKEMASK(Time, south_north, west_east) ;
            LAKEMASK:FieldType = 104 ;
            LAKEMASK:MemoryOrder = "XY " ;
            LAKEMASK:description = "LAKE MASK (1 FOR LAKE, 0 FOR NON-LAKE)" ;
            LAKEMASK:units = "" ;
            LAKEMASK:stagger = "" ;
            LAKEMASK:coordinates = "XLONG XLAT XTIME" ;
      float SST(Time, south_north, west_east) ;
            SST:FieldType = 104 ;
            SST:MemoryOrder = "XY " ;
            SST:description = "SEA SURFACE TEMPERATURE" ;
```

```
            SST:units = "K" ;
            SST:stagger = "" ;
            SST:coordinates = "XLONG XLAT XTIME" ;
      float SST_INPUT(Time, south_north, west_east) ;
            SST_INPUT:FieldType = 104 ;
            SST_INPUT:MemoryOrder = "XY " ;
            SST_INPUT:description = "SEA SURFACE TEMPERATURE FROM WRFLOWINPUT
FILE" ;
            SST_INPUT:units = "K" ;
            SST_INPUT:stagger = "" ;
            SST_INPUT:coordinates = "XLONG XLAT XTIME" ;

// global attributes:
            :TITLE = " OUTPUT FROM WRF V3.8.1 MODEL" ;
            :START_DATE = "2018-05-14_12:00:00" ;
            :SIMULATION_START_DATE = "2018-05-14_12:00:00" ;
            :WEST-EAST_GRID_DIMENSION = 251 ;
            :SOUTH-NORTH_GRID_DIMENSION = 251 ;
            :BOTTOM-TOP_GRID_DIMENSION = 227 ;
            :DX = 100.f ;
            :DY = 100.f ;
            :SKEBS_ON = 0 ;
            :SPEC_BDY_FINAL_MU = 1 ;
            :USE_Q_DIABATIC = 0 ;
            :GRIDTYPE = "C" ;
            :DIFF_OPT = 2 ;
            :KM_OPT = 2 ;
            :DAMP_OPT = 3 ;
            :DAMPCOEF = 0.2f ;
            :KHDIF = 1.f ;
            :KVDIF = 1.f ;
            :MP_PHYSICS = 8 ;
            :RA_LW_PHYSICS = 4 ;
            :RA_SW_PHYSICS = 4 ;
            :SF_SFCLAY_PHYSICS = 1 ;
            :SF_SURFACE_PHYSICS = 1 ;
            :BL_PBL_PHYSICS = 0 ;
            :CU_PHYSICS = 0 ;
            :SF_LAKE_PHYSICS = 0 ;
            :SURFACE_INPUT_SOURCE = 3 ;
            :SST_UPDATE = 0 ;
            :GRID_FDDA = 0 ;
            :GFDDA_INTERVAL_M = 0 ;
            :GFDDA_END_H = 0 ;
            :GRID_SFDDA = 0 ;
            :SGFDDA_INTERVAL_M = 0 ;
            :SGFDDA_END_H = 0 ;
            :HYPSOMETRIC_OPT = 1 ;
            :USE_THETA_M = 1 ;
            :SF_URBAN_PHYSICS = 0 ;
            :SHCU_PHYSICS = 0 ;
            :MFSHCONV = 0 ;
            :FEEDBACK = 0 ;
            :SMOOTH_OPTION = 0 ;
            :SWRAD_SCAT = 1.f ;
```

```
:W_DAMPING = 0 ;
:RADT = 1.f ;
:BLDT = 0.f ;
:CUDT = 0.f ;
:AER_OPT = 0 ;
:SWINT_OPT = 0 ;
:AER_TYPE = 1 ;
:AER_AOD550_OPT = 1 ;
:AER_ANGEXP_OPT = 1 ;
:AER_SSA_OPT = 1 ;
:AER_ASY_OPT = 1 ;
:AER_AOD550_VAL = 0.12f ;
:AER_ANGEXP_VAL = 1.3f ;
:AER_SSA_VAL = 1.401298e-45f ;
:AER_ASY_VAL = 1.401298e-45f ;
:MOIST_ADV_OPT = 2 ;
:SCALAR_ADV_OPT = 2 ;
:TKE_ADV_OPT = 2 ;
:DIFF_6TH_OPT = 0 ;
:DIFF_6TH_FACTOR = 0.12f ;
:OBS_NUDGE_OPT = 0 ;
:BUCKET_MM = -1.f ;
:BUCKET_J = -1.f ;
:PREC_ACC_DT = 0.f ;
:SF_OCEAN_PHYSICS = 0 ;
:ISFTCFLX = 0 ;
:ISHALLOW = 0 ;
:ISFFLX = 11 ;
:ICLOUD = 1 ;
:ICLOUD_CU = 0 ;
:TRACER_PBLMIX = 1 ;
:SCALAR_PBLMIX = 0 ;
:YSU_TOPDOWN_PBLMIX = 0 ;
:GRAV_SETTLING = 0 ;
:DFI_OPT = 0 ;
:SIMULATION_INITIALIZATION_TYPE = "IDEALIZED DATA" ;
:WEST-EAST_PATCH_START_UNSTAG = 1 ;
:WEST-EAST_PATCH_END_UNSTAG = 250 ;
:WEST-EAST_PATCH_START_STAG = 1 ;
:WEST-EAST_PATCH_END_STAG = 251 ;
:SOUTH-NORTH_PATCH_START_UNSTAG = 1 ;
:SOUTH-NORTH_PATCH_END_UNSTAG = 250 ;
:SOUTH-NORTH_PATCH_START_STAG = 1 ;
:SOUTH-NORTH_PATCH_END_STAG = 251 ;
:BOTTOM-TOP_PATCH_START_UNSTAG = 1 ;
:BOTTOM-TOP_PATCH_END_UNSTAG = 226 ;
:BOTTOM-TOP_PATCH_START_STAG = 1 ;
:BOTTOM-TOP_PATCH_END_STAG = 227 ;
:GRID_ID = 1 ;
:PARENT_ID = 0 ;
:I_PARENT_START = 0 ;
:J_PARENT_START = 0 ;
:PARENT_GRID_RATIO = 1 ;
:DT = 0.5f ;
:CEN_LAT = 0.f ;
```

```
            :CEN_LON = 0.f ;
            :TRUELAT1 = 0.f ;
            :TRUELAT2 = 0.f ;
            :MOAD_CEN_LAT = 0.f ;
            :STAND_LON = 0.f ;
            :POLE_LAT = 0.f ;
            :POLE_LON = 0.f ;
            :GMT = 0.f ;
            :JULYR = 0 ;
            :JULDAY = 1 ;
            :MAP_PROJ = 0 ;
            :MAP_PROJ_CHAR = "Cartesian" ;
            :MMINLU = "" ;
            :NUM_LAND_CAT = 21 ;
            :ISWATER = 16 ;
            :ISLAKE = 0 ;
            :ISICE = 0 ;
            :ISURBAN = 0 ;
            :ISOILWATER = 0 ;
            :doi = "10.5439/1342961" ;
            :contacts = "lasso@arm.gov, LASSO PI: William Gustafson
(William.Gustafson@pnnl.gov), LASSO Co-PI: Andrew Vogelmann
(vogelmann@bnl.gov)" ;
            :process_version = "vap-lassomod-0.0-0.dev0.dirty.el6" ;
            :site_id = "sgp" ;
            :facility_id = "C1" ;
            :location_description = "Southern Great Plains (SGP), Lamont,
Oklahoma" ;
            :date = "20180514" ;
            :simulation_id_number = 2LL ;
            :model_type = "WRF" ;
            :model_version = "3.8.1" ;
            :model_github_hash = "b6b6a5cc4229eec1ea9b005746b5ebef2205fb07" ;
            :output_domain_size = "25.0 km" ;
            :output_number_of_levels = 226LL ;
            :output_horizontal_grid_spacing = "100 m" ;
            :config_large_scale_forcing = "VARANAL" ;
            :config_large_scale_forcing_scale = "300 km" ;
            :config_large_scale_forcing_specifics = "sgp60varanarapC1.c1
(v20190228)" ;
            :config_surface_treatment = "VARANAL" ;
            :config_surface_treatment_specifics = "sgp60varanarapC1.c1
(v20190228)" ;
            :config_initial_condition = "Sounding" ;
            :config_initial_condition_specifics = "sgpsondewnpnC1" ;
            :config_aerosol = "NA" ;
            :config_forecast_time = "15.0 h" ;
            :config_boundary_method = "Periodic" ;
            :config_microphysics = "Thompson (mp_physics=8)" ;
            :config_nickname = "runlas20180514v1var" ;
            :simulation_origin_host = "cumulus-login2.ccs.ornl.gov" ;
}
```

File: .../20180514/sim0002/raw_model/wrfstat_d01_2018-05-14_12:00:00.nc

Description: WRF LES statistical output for domain-wide profiles. Values are time averaged over 10-minute periods with 1-minute sampling and the time label is at the end of the averaging period. All output times from the entire simulation are included in one file. Variable names with the suffixes CSP, CST, CSV, and CSS represent horizontally averaged profiles, time series of horizontally averaged surface or column integrated quantities, cell-specific volume quantities only averaged in time, and time averaged slab quantities, respectively. CSV values represent the full 3D volume and are related to CSP values through horizontal averaging. Likewise, CSS values are horizontal slabs, e.g., of surface values, which relate to CST values through horizontal averaging.

```
netcdf wrfstat_d01_2018-05-14_12\:00\:00 {
dimensions:
	Time = UNLIMITED ; // (91 currently)
	DateStrLen = 19 ;
	bottom_top = 226 ;
	bottom_top_stag = 227 ;
	west_east = 250 ;
	south_north = 250 ;
	west_east_stag = 251 ;
	south_north_stag = 251 ;
variables:
	char Times(Time, DateStrLen) ;
	float XTIME(Time) ;
		XTIME:FieldType = 104 ;
		XTIME:MemoryOrder = "0  " ;
		XTIME:description = "minutes since 2018-05-14 12:00:00" ;
		XTIME:units = "minutes since 2018-05-14 12:00:00" ;
		XTIME:stagger = "" ;
	float CST_CLDLOW(Time) ;
		CST_CLDLOW:FieldType = 104 ;
		CST_CLDLOW:MemoryOrder = "0  " ;
		CST_CLDLOW:description = "Fractional low-cloud cover (<5 km)" ;
		CST_CLDLOW:units = "(0-1)" ;
		CST_CLDLOW:stagger = "" ;
	float CST_CLDTOT(Time) ;
		CST_CLDTOT:FieldType = 104 ;
		CST_CLDTOT:MemoryOrder = "0  " ;
		CST_CLDTOT:description = "Fractional cloud cover" ;
		CST_CLDTOT:units = "(0-1)" ;
		CST_CLDTOT:stagger = "" ;
	float CST_LWP(Time) ;
		CST_LWP:FieldType = 104 ;
		CST_LWP:MemoryOrder = "0  " ;
		CST_LWP:description = "Vertical integrated liquid water path
(based on ql)" ;
		CST_LWP:units = "kg/m^2" ;
		CST_LWP:stagger = "" ;
	float CST_IWP(Time) ;
		CST_IWP:FieldType = 104 ;
		CST_IWP:MemoryOrder = "0  " ;
		CST_IWP:description = "Vertical integrated ice water path (based
on qf)" ;
		CST_IWP:units = "kg/m^2" ;
		CST_IWP:stagger = "" ;
	float CST_PRECW(Time) ;
```

```
        CST_PRECW:FieldType = 104 ;
        CST_PRECW:MemoryOrder = "0  " ;
        CST_PRECW:description = "Vertical integrated water vapor" ;
        CST_PRECW:units = "kg/m^2" ;
        CST_PRECW:stagger = "" ;
  float CST_TKE(Time) ;
        CST_TKE:FieldType = 104 ;
        CST_TKE:MemoryOrder = "0  " ;
        CST_TKE:description = "Vertical integrated TKE" ;
        CST_TKE:units = "kg/s^2" ;
        CST_TKE:stagger = "" ;
  float CST_TSAIR(Time) ;
        CST_TSAIR:FieldType = 104 ;
        CST_TSAIR:MemoryOrder = "0  " ;
        CST_TSAIR:description = "Surface air temperature" ;
        CST_TSAIR:units = "K" ;
        CST_TSAIR:stagger = "" ;
  float CST_PS(Time) ;
        CST_PS:FieldType = 104 ;
        CST_PS:MemoryOrder = "0  " ;
        CST_PS:description = "Surface pressure" ;
        CST_PS:units = "Pa" ;
        CST_PS:stagger = "" ;
  float CST_PRECT(Time) ;
        CST_PRECT:FieldType = 104 ;
        CST_PRECT:MemoryOrder = "0  " ;
        CST_PRECT:description = "Total precipitation at surface" ;
        CST_PRECT:units = "mm/sec" ;
        CST_PRECT:stagger = "" ;
  float CST_SH(Time) ;
        CST_SH:FieldType = 104 ;
        CST_SH:MemoryOrder = "0  " ;
        CST_SH:description = "Surface sensible heat flux" ;
        CST_SH:units = "W/m^2" ;
        CST_SH:stagger = "" ;
  float CST_LH(Time) ;
        CST_LH:FieldType = 104 ;
        CST_LH:MemoryOrder = "0  " ;
        CST_LH:description = "Surface latent heat flux" ;
        CST_LH:units = "W/m^2" ;
        CST_LH:stagger = "" ;
  float CST_FSNTC(Time) ;
        CST_FSNTC:FieldType = 104 ;
        CST_FSNTC:MemoryOrder = "0  " ;
        CST_FSNTC:description = "TOA SW net upward clear-sky radiation" ;
        CST_FSNTC:units = "W/m^2" ;
        CST_FSNTC:stagger = "" ;
  float CST_FSNT(Time) ;
        CST_FSNT:FieldType = 104 ;
        CST_FSNT:MemoryOrder = "0  " ;
        CST_FSNT:description = "TOA SW net upward total-sky radiation" ;
        CST_FSNT:units = "W/m^2" ;
        CST_FSNT:stagger = "" ;
  float CST_FLNTC(Time) ;
        CST_FLNTC:FieldType = 104 ;
```

```
            CST_FLNTC:MemoryOrder = "0  " ;
            CST_FLNTC:description = "TOA LW (net) upward clear-sky radiation"
;
            CST_FLNTC:units = "W/m^2" ;
            CST_FLNTC:stagger = "" ;
      float CST_FLNT(Time) ;
            CST_FLNT:FieldType = 104 ;
            CST_FLNT:MemoryOrder = "0  " ;
            CST_FLNT:description = "TOA LW (net) upward total-sky radiation"
;
            CST_FLNT:units = "W/m^2" ;
            CST_FLNT:stagger = "" ;
      float CST_FSNSC(Time) ;
            CST_FSNSC:FieldType = 104 ;
            CST_FSNSC:MemoryOrder = "0  " ;
            CST_FSNSC:description = "Surface SW net upward clear-sky
radiation" ;
            CST_FSNSC:units = "W/m^2" ;
            CST_FSNSC:stagger = "" ;
      float CST_FSNS(Time) ;
            CST_FSNS:FieldType = 104 ;
            CST_FSNS:MemoryOrder = "0  " ;
            CST_FSNS:description = "Surface SW net upward total-sky
radiation" ;
            CST_FSNS:units = "W/m^2" ;
            CST_FSNS:stagger = "" ;
      float CST_FLNSC(Time) ;
            CST_FLNSC:FieldType = 104 ;
            CST_FLNSC:MemoryOrder = "0  " ;
            CST_FLNSC:description = "Surface LW net upward clear-sky
radiation" ;
            CST_FLNSC:units = "W/m^2" ;
            CST_FLNSC:stagger = "" ;
      float CST_FLNS(Time) ;
            CST_FLNS:FieldType = 104 ;
            CST_FLNS:MemoryOrder = "0  " ;
            CST_FLNS:description = "Surface LW net upward total-sky
radiation" ;
            CST_FLNS:units = "W/m^2" ;
            CST_FLNS:stagger = "" ;
      float CST_SWINC(Time) ;
            CST_SWINC:FieldType = 104 ;
            CST_SWINC:MemoryOrder = "0  " ;
            CST_SWINC:description = "TOA solar insolation" ;
            CST_SWINC:units = "W/m^2" ;
            CST_SWINC:stagger = "" ;
      float CST_TSK(Time) ;
            CST_TSK:FieldType = 104 ;
            CST_TSK:MemoryOrder = "0  " ;
            CST_TSK:description = "Surface skin temperature" ;
            CST_TSK:units = "K" ;
            CST_TSK:stagger = "" ;
      float CST_UST(Time) ;
            CST_UST:FieldType = 104 ;
            CST_UST:MemoryOrder = "0  " ;
```

```
        CST_UST:description = "Surface friction velocity" ;
        CST_UST:units = "m/s" ;
        CST_UST:stagger = "" ;
  float CSP_Z(Time, bottom_top) ;
        CSP_Z:FieldType = 104 ;
        CSP_Z:MemoryOrder = "Z  " ;
        CSP_Z:description = "Half level height" ;
        CSP_Z:units = "m" ;
        CSP_Z:stagger = "" ;
  float CSP_Z8W(Time, bottom_top_stag) ;
        CSP_Z8W:FieldType = 104 ;
        CSP_Z8W:MemoryOrder = "Z  " ;
        CSP_Z8W:description = "Full level height" ;
        CSP_Z8W:units = "m" ;
        CSP_Z8W:stagger = "Z" ;
  float CSP_DZ8W(Time, bottom_top) ;
        CSP_DZ8W:FieldType = 104 ;
        CSP_DZ8W:MemoryOrder = "Z  " ;
        CSP_DZ8W:description = "dz at full level" ;
        CSP_DZ8W:units = "m" ;
        CSP_DZ8W:stagger = "" ;
  float CSP_U(Time, bottom_top) ;
        CSP_U:FieldType = 104 ;
        CSP_U:MemoryOrder = "Z  " ;
        CSP_U:description = "Zonal wind" ;
        CSP_U:units = "m/s" ;
        CSP_U:stagger = "" ;
  float CSP_V(Time, bottom_top) ;
        CSP_V:FieldType = 104 ;
        CSP_V:MemoryOrder = "Z  " ;
        CSP_V:description = "Meridional wind" ;
        CSP_V:units = "m/s" ;
        CSP_V:stagger = "" ;
  float CSP_W(Time, bottom_top_stag) ;
        CSP_W:FieldType = 104 ;
        CSP_W:MemoryOrder = "Z  " ;
        CSP_W:description = "Vertical motion" ;
        CSP_W:units = "m/s" ;
        CSP_W:stagger = "Z" ;
  float CSP_P(Time, bottom_top) ;
        CSP_P:FieldType = 104 ;
        CSP_P:MemoryOrder = "Z  " ;
        CSP_P:description = "Pressure" ;
        CSP_P:units = "Pa" ;
        CSP_P:stagger = "" ;
  float CSP_TH(Time, bottom_top) ;
        CSP_TH:FieldType = 104 ;
        CSP_TH:MemoryOrder = "Z  " ;
        CSP_TH:description = "Potential temperature" ;
        CSP_TH:units = "K" ;
        CSP_TH:stagger = "" ;
  float CSP_THV(Time, bottom_top) ;
        CSP_THV:FieldType = 104 ;
        CSP_THV:MemoryOrder = "Z  " ;
        CSP_THV:description = "Virtual potential temperature" ;
```

```
            CSP_THV:units = "K" ;
            CSP_THV:stagger = "" ;
      float CSP_THL(Time, bottom_top) ;
            CSP_THL:FieldType = 104 ;
            CSP_THL:MemoryOrder = "Z  " ;
            CSP_THL:description = "Liquid water potential temperature" ;
            CSP_THL:units = "K" ;
            CSP_THL:stagger = "" ;
      float CSP_QV(Time, bottom_top) ;
            CSP_QV:FieldType = 104 ;
            CSP_QV:MemoryOrder = "Z  " ;
            CSP_QV:description = "Water vapor mixing ratio" ;
            CSP_QV:units = "kg/kg" ;
            CSP_QV:stagger = "" ;
      float CSP_QC(Time, bottom_top) ;
            CSP_QC:FieldType = 104 ;
            CSP_QC:MemoryOrder = "Z  " ;
            CSP_QC:description = "Cloud water mixing ratio" ;
            CSP_QC:units = "kg/kg" ;
            CSP_QC:stagger = "" ;
      float CSP_QI(Time, bottom_top) ;
            CSP_QI:FieldType = 104 ;
            CSP_QI:MemoryOrder = "Z  " ;
            CSP_QI:description = "Ice crystal (cloud ice) mixing ratio" ;
            CSP_QI:units = "kg/kg" ;
            CSP_QI:stagger = "" ;
      float CSP_QL(Time, bottom_top) ;
            CSP_QL:FieldType = 104 ;
            CSP_QL:MemoryOrder = "Z  " ;
            CSP_QL:description = "Liquid water mixing ratio" ;
            CSP_QL:units = "kg/kg" ;
            CSP_QL:stagger = "" ;
      float CSP_QF(Time, bottom_top) ;
            CSP_QF:FieldType = 104 ;
            CSP_QF:MemoryOrder = "Z  " ;
            CSP_QF:description = "Frozen water mixing ratio" ;
            CSP_QF:units = "kg/kg" ;
            CSP_QF:stagger = "" ;
      float CSP_QT(Time, bottom_top) ;
            CSP_QT:FieldType = 104 ;
            CSP_QT:MemoryOrder = "Z  " ;
            CSP_QT:description = "Total (vapor+liquid+frozen) water mixing
ratio" ;
            CSP_QT:units = "kg/kg" ;
            CSP_QT:stagger = "" ;
      float CSP_LWC(Time, bottom_top) ;
            CSP_LWC:FieldType = 104 ;
            CSP_LWC:MemoryOrder = "Z  " ;
            CSP_LWC:description = "Liquid water content (based on ql)" ;
            CSP_LWC:units = "kg/m^3" ;
            CSP_LWC:stagger = "" ;
      float CSP_IWC(Time, bottom_top) ;
            CSP_IWC:FieldType = 104 ;
            CSP_IWC:MemoryOrder = "Z  " ;
            CSP_IWC:description = "Ice water content (based on qf)" ;
```

```
        CSP_IWC:units = "kg/m^3" ;
        CSP_IWC:stagger = "" ;
    float CSP_SPEQV(Time, bottom_top) ;
        CSP_SPEQV:FieldType = 104 ;
        CSP_SPEQV:MemoryOrder = "Z  " ;
        CSP_SPEQV:description = "Specific humidity" ;
        CSP_SPEQV:units = "kg/kg" ;
        CSP_SPEQV:stagger = "" ;
    float CSP_A_CL(Time, bottom_top) ;
        CSP_A_CL:FieldType = 104 ;
        CSP_A_CL:MemoryOrder = "Z  " ;
        CSP_A_CL:description = "Fraction of cloudy grid points" ;
        CSP_A_CL:units = "(0-1)" ;
        CSP_A_CL:stagger = "" ;
    float CSP_RHO(Time, bottom_top) ;
        CSP_RHO:FieldType = 104 ;
        CSP_RHO:MemoryOrder = "Z  " ;
        CSP_RHO:description = "Density" ;
        CSP_RHO:units = "kg/m^3" ;
        CSP_RHO:stagger = "" ;
    float CSP_U2(Time, bottom_top) ;
        CSP_U2:FieldType = 104 ;
        CSP_U2:MemoryOrder = "Z  " ;
        CSP_U2:description = "u_p^2" ;
        CSP_U2:units = "m^2/s^2" ;
        CSP_U2:stagger = "" ;
    float CSP_V2(Time, bottom_top) ;
        CSP_V2:FieldType = 104 ;
        CSP_V2:MemoryOrder = "Z  " ;
        CSP_V2:description = "v_p^2" ;
        CSP_V2:units = "m^2/s^2" ;
        CSP_V2:stagger = "" ;
    float CSP_U2V2(Time, bottom_top) ;
        CSP_U2V2:FieldType = 104 ;
        CSP_U2V2:MemoryOrder = "Z  " ;
        CSP_U2V2:description = "u_p^2+v_p^2" ;
        CSP_U2V2:units = "m^2/s^2" ;
        CSP_U2V2:stagger = "" ;
    float CSP_W2(Time, bottom_top_stag) ;
        CSP_W2:FieldType = 104 ;
        CSP_W2:MemoryOrder = "Z  " ;
        CSP_W2:description = "w_p^2" ;
        CSP_W2:units = "m^2/s^2" ;
        CSP_W2:stagger = "Z" ;
    float CSP_W3(Time, bottom_top_stag) ;
        CSP_W3:FieldType = 104 ;
        CSP_W3:MemoryOrder = "Z  " ;
        CSP_W3:description = "w_p^3" ;
        CSP_W3:units = "m^3/s^3" ;
        CSP_W3:stagger = "Z" ;
    float CSP_WSKEW(Time, bottom_top_stag) ;
        CSP_WSKEW:FieldType = 104 ;
        CSP_WSKEW:MemoryOrder = "Z  " ;
        CSP_WSKEW:description = "Skewness <w3>/<w2>^(3/2)" ;
        CSP_WSKEW:units = "" ;
```

```
            CSP_WSKEW:stagger = "Z" ;
      float CSP_UW(Time, bottom_top) ;
            CSP_UW:FieldType = 104 ;
            CSP_UW:MemoryOrder = "Z  " ;
            CSP_UW:description = "x-momentum flux uw (rs+sgs)" ;
            CSP_UW:units = "m^2/s^2" ;
            CSP_UW:stagger = "" ;
      float CSP_VW(Time, bottom_top) ;
            CSP_VW:FieldType = 104 ;
            CSP_VW:MemoryOrder = "Z  " ;
            CSP_VW:description = "y-momentum flux vw (rs+sgs)" ;
            CSP_VW:units = "m^2/s^2" ;
            CSP_VW:stagger = "" ;
      float CSP_WTH(Time, bottom_top) ;
            CSP_WTH:FieldType = 104 ;
            CSP_WTH:MemoryOrder = "Z  " ;
            CSP_WTH:description = "Potential temperature flux (rs+sgs)" ;
            CSP_WTH:units = "K m/s" ;
            CSP_WTH:stagger = "" ;
      float CSP_WTHV(Time, bottom_top) ;
            CSP_WTHV:FieldType = 104 ;
            CSP_WTHV:MemoryOrder = "Z  " ;
            CSP_WTHV:description = "Virtual potential temperature flux
(rs+sgs)" ;
            CSP_WTHV:units = "K m/s" ;
            CSP_WTHV:stagger = "" ;
      float CSP_WTHL(Time, bottom_top) ;
            CSP_WTHL:FieldType = 104 ;
            CSP_WTHL:MemoryOrder = "Z  " ;
            CSP_WTHL:description = "Liquid water potential temperature flux
(rs+sgs)" ;
            CSP_WTHL:units = "K m/s" ;
            CSP_WTHL:stagger = "" ;
      float CSP_WQV(Time, bottom_top) ;
            CSP_WQV:FieldType = 104 ;
            CSP_WQV:MemoryOrder = "Z  " ;
            CSP_WQV:description = "Water vapor flux (rs+sgs)" ;
            CSP_WQV:units = "kg/kg m/s" ;
            CSP_WQV:stagger = "" ;
      float CSP_WQC(Time, bottom_top) ;
            CSP_WQC:FieldType = 104 ;
            CSP_WQC:MemoryOrder = "Z  " ;
            CSP_WQC:description = "Cloud water flux (rs+sgs)" ;
            CSP_WQC:units = "kg/kg m/s" ;
            CSP_WQC:stagger = "" ;
      float CSP_WQI(Time, bottom_top) ;
            CSP_WQI:FieldType = 104 ;
            CSP_WQI:MemoryOrder = "Z  " ;
            CSP_WQI:description = "Ice crystal (cloud ice) flux (rs+sgs)" ;
            CSP_WQI:units = "kg/kg m/s" ;
            CSP_WQI:stagger = "" ;
      float CSP_WQL(Time, bottom_top) ;
            CSP_WQL:FieldType = 104 ;
            CSP_WQL:MemoryOrder = "Z  " ;
            CSP_WQL:description = "Liquid water flux (rs+sgs)" ;
```

```
            CSP_WQL:units = "kg/kg m/s" ;
            CSP_WQL:stagger = "" ;
      float CSP_WQF(Time, bottom_top) ;
            CSP_WQF:FieldType = 104 ;
            CSP_WQF:MemoryOrder = "Z  " ;
            CSP_WQF:description = "Frozen water flux (rs+sgs)" ;
            CSP_WQF:units = "kg/kg m/s" ;
            CSP_WQF:stagger = "" ;
      float CSP_WQT(Time, bottom_top) ;
            CSP_WQT:FieldType = 104 ;
            CSP_WQT:MemoryOrder = "Z  " ;
            CSP_WQT:description = "Total water flux (rs+sgs)" ;
            CSP_WQT:units = "kg/kg m/s" ;
            CSP_WQT:stagger = "" ;
      float CSP_UW_SGS(Time, bottom_top) ;
            CSP_UW_SGS:FieldType = 104 ;
            CSP_UW_SGS:MemoryOrder = "Z  " ;
            CSP_UW_SGS:description = "x-momentum flux uw (sgs)" ;
            CSP_UW_SGS:units = "m^2/s^2" ;
            CSP_UW_SGS:stagger = "" ;
      float CSP_VW_SGS(Time, bottom_top) ;
            CSP_VW_SGS:FieldType = 104 ;
            CSP_VW_SGS:MemoryOrder = "Z  " ;
            CSP_VW_SGS:description = "y-momentum flux vw (sgs)" ;
            CSP_VW_SGS:units = "m^2/s^2" ;
            CSP_VW_SGS:stagger = "" ;
      float CSP_WTH_SGS(Time, bottom_top) ;
            CSP_WTH_SGS:FieldType = 104 ;
            CSP_WTH_SGS:MemoryOrder = "Z  " ;
            CSP_WTH_SGS:description = "Potential temperature flux (sgs)" ;
            CSP_WTH_SGS:units = "K m/s" ;
            CSP_WTH_SGS:stagger = "" ;
      float CSP_WTHV_SGS(Time, bottom_top) ;
            CSP_WTHV_SGS:FieldType = 104 ;
            CSP_WTHV_SGS:MemoryOrder = "Z  " ;
            CSP_WTHV_SGS:description = "Virtual potential temperature flux
(sgs)" ;
            CSP_WTHV_SGS:units = "K m/s" ;
            CSP_WTHV_SGS:stagger = "" ;
      float CSP_WTHL_SGS(Time, bottom_top) ;
            CSP_WTHL_SGS:FieldType = 104 ;
            CSP_WTHL_SGS:MemoryOrder = "Z  " ;
            CSP_WTHL_SGS:description = "Liquid water potential temperature
flux (sgs)" ;
            CSP_WTHL_SGS:units = "K m/s" ;
            CSP_WTHL_SGS:stagger = "" ;
      float CSP_WQV_SGS(Time, bottom_top) ;
            CSP_WQV_SGS:FieldType = 104 ;
            CSP_WQV_SGS:MemoryOrder = "Z  " ;
            CSP_WQV_SGS:description = "Water vapor flux (sgs)" ;
            CSP_WQV_SGS:units = "kg/kg m/s" ;
            CSP_WQV_SGS:stagger = "" ;
      float CSP_WQC_SGS(Time, bottom_top) ;
            CSP_WQC_SGS:FieldType = 104 ;
            CSP_WQC_SGS:MemoryOrder = "Z  " ;
```

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            CSP_WQC_SGS:description = "Cloud water flux (sgs)" ;
            CSP_WQC_SGS:units = "kg/kg m/s" ;
            CSP_WQC_SGS:stagger = "" ;
      float CSP_WQI_SGS(Time, bottom_top) ;
            CSP_WQI_SGS:FieldType = 104 ;
            CSP_WQI_SGS:MemoryOrder = "Z  " ;
            CSP_WQI_SGS:description = "Ice crystal (cloud ice) flux (sgs)" ;
            CSP_WQI_SGS:units = "kg/kg m/s" ;
            CSP_WQI_SGS:stagger = "" ;
      float CSP_WQL_SGS(Time, bottom_top) ;
            CSP_WQL_SGS:FieldType = 104 ;
            CSP_WQL_SGS:MemoryOrder = "Z  " ;
            CSP_WQL_SGS:description = "Liquid water flux (sgs)" ;
            CSP_WQL_SGS:units = "kg/kg m/s" ;
            CSP_WQL_SGS:stagger = "" ;
      float CSP_WQF_SGS(Time, bottom_top) ;
            CSP_WQF_SGS:FieldType = 104 ;
            CSP_WQF_SGS:MemoryOrder = "Z  " ;
            CSP_WQF_SGS:description = "Frozen water flux (sgs)" ;
            CSP_WQF_SGS:units = "kg/kg m/s" ;
            CSP_WQF_SGS:stagger = "" ;
      float CSP_WQT_SGS(Time, bottom_top) ;
            CSP_WQT_SGS:FieldType = 104 ;
            CSP_WQT_SGS:MemoryOrder = "Z  " ;
            CSP_WQT_SGS:description = "Total water flux (sgs)" ;
            CSP_WQT_SGS:units = "kg/kg m/s" ;
            CSP_WQT_SGS:stagger = "" ;
      float CSP_SEDFQC(Time, bottom_top) ;
            CSP_SEDFQC:FieldType = 104 ;
            CSP_SEDFQC:MemoryOrder = "Z  " ;
            CSP_SEDFQC:description = "Sedimentation flux of qc" ;
            CSP_SEDFQC:units = "kg /m^2/s" ;
            CSP_SEDFQC:stagger = "" ;
      float CSP_SEDFQR(Time, bottom_top) ;
            CSP_SEDFQR:FieldType = 104 ;
            CSP_SEDFQR:MemoryOrder = "Z  " ;
            CSP_SEDFQR:description = "Sedimentation (Precipitation) flux of
qr" ;
            CSP_SEDFQR:units = "kg /m^2/s" ;
            CSP_SEDFQR:stagger = "" ;
      float CSP_THDT_COND(Time, bottom_top) ;
            CSP_THDT_COND:FieldType = 104 ;
            CSP_THDT_COND:MemoryOrder = "Z  " ;
            CSP_THDT_COND:description = "dth/dt due to net condensation" ;
            CSP_THDT_COND:units = "K/s" ;
            CSP_THDT_COND:stagger = "" ;
      float CSP_THDT_LW(Time, bottom_top) ;
            CSP_THDT_LW:FieldType = 104 ;
            CSP_THDT_LW:MemoryOrder = "Z  " ;
            CSP_THDT_LW:description = "dth/dt due to LW radiation" ;
            CSP_THDT_LW:units = "K/s" ;
            CSP_THDT_LW:stagger = "" ;
      float CSP_THDT_SW(Time, bottom_top) ;
            CSP_THDT_SW:FieldType = 104 ;
            CSP_THDT_SW:MemoryOrder = "Z  " ;
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            CSP_THDT_SW:description = "dth/dt due to SW radiation" ;
            CSP_THDT_SW:units = "K/s" ;
            CSP_THDT_SW:stagger = "" ;
      float CSP_THDT_LS(Time, bottom_top) ;
            CSP_THDT_LS:FieldType = 104 ;
            CSP_THDT_LS:MemoryOrder = "Z  " ;
            CSP_THDT_LS:description = "dth/dt due to large-scale forcing" ;
            CSP_THDT_LS:units = "K/s" ;
            CSP_THDT_LS:stagger = "" ;
      float CSP_QVDT_PR(Time, bottom_top) ;
            CSP_QVDT_PR:FieldType = 104 ;
            CSP_QVDT_PR:MemoryOrder = "Z  " ;
            CSP_QVDT_PR:description = "dqv/dt due to conversion to
precipitation" ;
            CSP_QVDT_PR:units = "kg/kg/s" ;
            CSP_QVDT_PR:stagger = "" ;
      float CSP_QVDT_COND(Time, bottom_top) ;
            CSP_QVDT_COND:FieldType = 104 ;
            CSP_QVDT_COND:MemoryOrder = "Z  " ;
            CSP_QVDT_COND:description = "dqv/dt due to net condensation" ;
            CSP_QVDT_COND:units = "kg/kg/s" ;
            CSP_QVDT_COND:stagger = "" ;
      float CSP_QVDT_LS(Time, bottom_top) ;
            CSP_QVDT_LS:FieldType = 104 ;
            CSP_QVDT_LS:MemoryOrder = "Z  " ;
            CSP_QVDT_LS:description = "dqv/dt due to large-scale forcing" ;
            CSP_QVDT_LS:units = "kg/kg/s" ;
            CSP_QVDT_LS:stagger = "" ;
      float CSP_QCDT_PR(Time, bottom_top) ;
            CSP_QCDT_PR:FieldType = 104 ;
            CSP_QCDT_PR:MemoryOrder = "Z  " ;
            CSP_QCDT_PR:description = "dqc/dt due to conversion to
precipitation" ;
            CSP_QCDT_PR:units = "kg/kg/s" ;
            CSP_QCDT_PR:stagger = "" ;
      float CSP_QCDT_SED(Time, bottom_top) ;
            CSP_QCDT_SED:FieldType = 104 ;
            CSP_QCDT_SED:MemoryOrder = "Z  " ;
            CSP_QCDT_SED:description = "dqc/dt due to sedimentation" ;
            CSP_QCDT_SED:units = "kg/kg/s" ;
            CSP_QCDT_SED:stagger = "" ;
      float CSP_QRDT_SED(Time, bottom_top) ;
            CSP_QRDT_SED:FieldType = 104 ;
            CSP_QRDT_SED:MemoryOrder = "Z  " ;
            CSP_QRDT_SED:description = "dqr/dt due to sedimentation" ;
            CSP_QRDT_SED:units = "kg/kg/s" ;
            CSP_QRDT_SED:stagger = "" ;
      float CSP_THDT_LSHOR(Time, bottom_top) ;
            CSP_THDT_LSHOR:FieldType = 104 ;
            CSP_THDT_LSHOR:MemoryOrder = "Z  " ;
            CSP_THDT_LSHOR:description = "th tendency due to LS horizontal
adv" ;
            CSP_THDT_LSHOR:units = "K s-1" ;
            CSP_THDT_LSHOR:stagger = "" ;
      float CSP_QVDT_LSHOR(Time, bottom_top) ;
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            CSP_QVDT_LSHOR:FieldType = 104 ;
            CSP_QVDT_LSHOR:MemoryOrder = "Z  " ;
            CSP_QVDT_LSHOR:description = "qv tendency due to LS horizontal
adv" ;
            CSP_QVDT_LSHOR:units = "kg kg-1 s-1" ;
            CSP_QVDT_LSHOR:stagger = "" ;
      float CSP_THDT_LSVER(Time, bottom_top) ;
            CSP_THDT_LSVER:FieldType = 104 ;
            CSP_THDT_LSVER:MemoryOrder = "Z  " ;
            CSP_THDT_LSVER:description = "th tendency due to LS horizontal
adv" ;
            CSP_THDT_LSVER:units = "K s-1" ;
            CSP_THDT_LSVER:stagger = "" ;
      float CSP_QVDT_LSVER(Time, bottom_top) ;
            CSP_QVDT_LSVER:FieldType = 104 ;
            CSP_QVDT_LSVER:MemoryOrder = "Z  " ;
            CSP_QVDT_LSVER:description = "qv tendency due to LS horizontal
adv" ;
            CSP_QVDT_LSVER:units = "kg kg-1 s-1" ;
            CSP_QVDT_LSVER:stagger = "" ;
      float CSP_THDT_LSRLX(Time, bottom_top) ;
            CSP_THDT_LSRLX:FieldType = 104 ;
            CSP_THDT_LSRLX:MemoryOrder = "Z  " ;
            CSP_THDT_LSRLX:description = "th tendency due to relaxation to
LS" ;
            CSP_THDT_LSRLX:units = "K s-1" ;
            CSP_THDT_LSRLX:stagger = "" ;
      float CSP_QVDT_LSRLX(Time, bottom_top) ;
            CSP_QVDT_LSRLX:FieldType = 104 ;
            CSP_QVDT_LSRLX:MemoryOrder = "Z  " ;
            CSP_QVDT_LSRLX:description = "qv tendency due to relaxation to
LS" ;
            CSP_QVDT_LSRLX:units = "kg kg-1 s-1" ;
            CSP_QVDT_LSRLX:stagger = "" ;
      float CSP_UDT_LS(Time, bottom_top) ;
            CSP_UDT_LS:FieldType = 104 ;
            CSP_UDT_LS:MemoryOrder = "Z  " ;
            CSP_UDT_LS:description = "u tendency due to LS forcing" ;
            CSP_UDT_LS:units = "m s-2" ;
            CSP_UDT_LS:stagger = "" ;
      float CSP_VDT_LS(Time, bottom_top) ;
            CSP_VDT_LS:FieldType = 104 ;
            CSP_VDT_LS:MemoryOrder = "Z  " ;
            CSP_VDT_LS:description = "v tendency due to LS forcing" ;
            CSP_VDT_LS:units = "m s-2" ;
            CSP_VDT_LS:stagger = "" ;
      float CSP_UDT_LSVER(Time, bottom_top) ;
            CSP_UDT_LSVER:FieldType = 104 ;
            CSP_UDT_LSVER:MemoryOrder = "Z  " ;
            CSP_UDT_LSVER:description = "u tendency due to LS vertical adv" ;
            CSP_UDT_LSVER:units = "m s-2" ;
            CSP_UDT_LSVER:stagger = "" ;
      float CSP_VDT_LSVER(Time, bottom_top) ;
            CSP_VDT_LSVER:FieldType = 104 ;
            CSP_VDT_LSVER:MemoryOrder = "Z  " ;
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            CSP_VDT_LSVER:description = "v tendency due to LS vertical adv" ;
            CSP_VDT_LSVER:units = "m s-2" ;
            CSP_VDT_LSVER:stagger = "" ;
      float CSP_UDT_LSRLX(Time, bottom_top) ;
            CSP_UDT_LSRLX:FieldType = 104 ;
            CSP_UDT_LSRLX:MemoryOrder = "Z  " ;
            CSP_UDT_LSRLX:description = "u tendency due to relaxation to LS"
;
            CSP_UDT_LSRLX:units = "m s-2" ;
            CSP_UDT_LSRLX:stagger = "" ;
      float CSP_VDT_LSRLX(Time, bottom_top) ;
            CSP_VDT_LSRLX:FieldType = 104 ;
            CSP_VDT_LSRLX:MemoryOrder = "Z  " ;
            CSP_VDT_LSRLX:description = "v tendency due to relaxation to LS"
;
            CSP_VDT_LSRLX:units = "m s-2" ;
            CSP_VDT_LSRLX:stagger = "" ;
      float CSP_SWUPF(Time, bottom_top) ;
            CSP_SWUPF:FieldType = 104 ;
            CSP_SWUPF:MemoryOrder = "Z  " ;
            CSP_SWUPF:description = "SW flux upward" ;
            CSP_SWUPF:units = "W/m^2" ;
            CSP_SWUPF:stagger = "" ;
      float CSP_SWDNF(Time, bottom_top) ;
            CSP_SWDNF:FieldType = 104 ;
            CSP_SWDNF:MemoryOrder = "Z  " ;
            CSP_SWDNF:description = "SW flux downward" ;
            CSP_SWDNF:units = "W/m^2" ;
            CSP_SWDNF:stagger = "" ;
      float CSP_LWUPF(Time, bottom_top) ;
            CSP_LWUPF:FieldType = 104 ;
            CSP_LWUPF:MemoryOrder = "Z  " ;
            CSP_LWUPF:description = "LW flux upward" ;
            CSP_LWUPF:units = "W/m^2" ;
            CSP_LWUPF:stagger = "" ;
      float CSP_LWDNF(Time, bottom_top) ;
            CSP_LWDNF:FieldType = 104 ;
            CSP_LWDNF:MemoryOrder = "Z  " ;
            CSP_LWDNF:description = "LW flux downward" ;
            CSP_LWDNF:units = "W/m^2" ;
            CSP_LWDNF:stagger = "" ;
      float CSP_TKE_RS(Time, bottom_top) ;
            CSP_TKE_RS:FieldType = 104 ;
            CSP_TKE_RS:MemoryOrder = "Z  " ;
            CSP_TKE_RS:description = "RS TKE" ;
            CSP_TKE_RS:units = "m^2/s^2" ;
            CSP_TKE_RS:stagger = "" ;
      float CSP_TKE_SH(Time, bottom_top) ;
            CSP_TKE_SH:FieldType = 104 ;
            CSP_TKE_SH:MemoryOrder = "Z  " ;
            CSP_TKE_SH:description = "RS TKE shear production" ;
            CSP_TKE_SH:units = "m^2/s^3" ;
            CSP_TKE_SH:stagger = "" ;
      float CSP_TKE_BU(Time, bottom_top) ;
            CSP_TKE_BU:FieldType = 104 ;
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            CSP_TKE_BU:MemoryOrder = "Z  " ;
            CSP_TKE_BU:description = "RS TKE buoyancy production" ;
            CSP_TKE_BU:units = "m^2/s^3" ;
            CSP_TKE_BU:stagger = "" ;
      float CSP_TKE_TR(Time, bottom_top) ;
            CSP_TKE_TR:FieldType = 104 ;
            CSP_TKE_TR:MemoryOrder = "Z  " ;
            CSP_TKE_TR:description = "RS TKE turbulent + pressure transport"
;
            CSP_TKE_TR:units = "m^2/s^3" ;
            CSP_TKE_TR:stagger = "" ;
      float CSP_TKE_DI(Time, bottom_top) ;
            CSP_TKE_DI:FieldType = 104 ;
            CSP_TKE_DI:MemoryOrder = "Z  " ;
            CSP_TKE_DI:description = "TKE dissipation" ;
            CSP_TKE_DI:units = "m^2/s^3" ;
            CSP_TKE_DI:stagger = "" ;
      float CSP_TKE_SGS(Time, bottom_top) ;
            CSP_TKE_SGS:FieldType = 104 ;
            CSP_TKE_SGS:MemoryOrder = "Z  " ;
            CSP_TKE_SGS:description = "SGS TKE" ;
            CSP_TKE_SGS:units = "m^2/s^2" ;
            CSP_TKE_SGS:stagger = "" ;
      float CSP_W_C(Time, bottom_top) ;
            CSP_W_C:FieldType = 104 ;
            CSP_W_C:MemoryOrder = "Z  " ;
            CSP_W_C:description = "Average over all cloudy grid points of w"
;
            CSP_W_C:units = "m/s" ;
            CSP_W_C:stagger = "" ;
      float CSP_THL_C(Time, bottom_top) ;
            CSP_THL_C:FieldType = 104 ;
            CSP_THL_C:MemoryOrder = "Z  " ;
            CSP_THL_C:description = "Average over all cloudy grid points of
thl" ;
            CSP_THL_C:units = "K" ;
            CSP_THL_C:stagger = "" ;
      float CSP_QT_C(Time, bottom_top) ;
            CSP_QT_C:FieldType = 104 ;
            CSP_QT_C:MemoryOrder = "Z  " ;
            CSP_QT_C:description = "Average over all cloudy grid points of
qt" ;
            CSP_QT_C:units = "kg/kg" ;
            CSP_QT_C:stagger = "" ;
      float CSP_QV_C(Time, bottom_top) ;
            CSP_QV_C:FieldType = 104 ;
            CSP_QV_C:MemoryOrder = "Z  " ;
            CSP_QV_C:description = "Average over all cloudy grid points of
qv" ;
            CSP_QV_C:units = "kg/kg" ;
            CSP_QV_C:stagger = "" ;
      float CSP_QL_C(Time, bottom_top) ;
            CSP_QL_C:FieldType = 104 ;
            CSP_QL_C:MemoryOrder = "Z  " ;
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            CSP_QL_C:description = "Average over all cloudy grid points of
ql" ;
            CSP_QL_C:units = "kg/kg" ;
            CSP_QL_C:stagger = "" ;
      float CSP_QF_C(Time, bottom_top) ;
            CSP_QF_C:FieldType = 104 ;
            CSP_QF_C:MemoryOrder = "Z  " ;
            CSP_QF_C:description = "Average over all cloudy grid points of
qf" ;
            CSP_QF_C:units = "kg/kg" ;
            CSP_QF_C:stagger = "" ;
      float CSP_QC_C(Time, bottom_top) ;
            CSP_QC_C:FieldType = 104 ;
            CSP_QC_C:MemoryOrder = "Z  " ;
            CSP_QC_C:description = "Average over all cloudy grid points of
qc" ;
            CSP_QC_C:units = "kg/kg" ;
            CSP_QC_C:stagger = "" ;
      float CSP_QI_C(Time, bottom_top) ;
            CSP_QI_C:FieldType = 104 ;
            CSP_QI_C:MemoryOrder = "Z  " ;
            CSP_QI_C:description = "Average over all cloudy grid points of
qi" ;
            CSP_QI_C:units = "kg/kg" ;
            CSP_QI_C:stagger = "" ;
      float CSP_QNC_C(Time, bottom_top) ;
            CSP_QNC_C:FieldType = 104 ;
            CSP_QNC_C:MemoryOrder = "Z  " ;
            CSP_QNC_C:description = "Average over all cloudy grid points of
qnc" ;
            CSP_QNC_C:units = "cm-3" ;
            CSP_QNC_C:stagger = "" ;
      float CSP_THV_C(Time, bottom_top) ;
            CSP_THV_C:FieldType = 104 ;
            CSP_THV_C:MemoryOrder = "Z  " ;
            CSP_THV_C:description = "Average over all cloudy grid points of
thv" ;
            CSP_THV_C:units = "K" ;
            CSP_THV_C:stagger = "" ;
      float CSP_W2_C(Time, bottom_top) ;
            CSP_W2_C:FieldType = 104 ;
            CSP_W2_C:MemoryOrder = "Z  " ;
            CSP_W2_C:description = "Average over all cloudy grid points of w
variance" ;
            CSP_W2_C:units = "(m/s)^2" ;
            CSP_W2_C:stagger = "" ;
      float CSP_AW_C(Time, bottom_top) ;
            CSP_AW_C:FieldType = 104 ;
            CSP_AW_C:MemoryOrder = "Z  " ;
            CSP_AW_C:description = "Cloud fraction * average over all cloudy
grid points of w" ;
            CSP_AW_C:units = "m/s" ;
            CSP_AW_C:stagger = "" ;
      float CSP_AWTHL_C(Time, bottom_top) ;
            CSP_AWTHL_C:FieldType = 104 ;
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```
            CSP_AWTHL_C:MemoryOrder = "Z  " ;
            CSP_AWTHL_C:description = "Cloud fraction * average over all
cloudy grid points of wthl" ;
            CSP_AWTHL_C:units = "K m/s" ;
            CSP_AWTHL_C:stagger = "" ;
      float CSP_AWQT_C(Time, bottom_top) ;
            CSP_AWQT_C:FieldType = 104 ;
            CSP_AWQT_C:MemoryOrder = "Z  " ;
            CSP_AWQT_C:description = "Cloud fraction * average over all
cloudy grid points of wqt" ;
            CSP_AWQT_C:units = "kg/kg m/s" ;
            CSP_AWQT_C:stagger = "" ;
      float CSP_AWQV_C(Time, bottom_top) ;
            CSP_AWQV_C:FieldType = 104 ;
            CSP_AWQV_C:MemoryOrder = "Z  " ;
            CSP_AWQV_C:description = "Cloud fraction * average over all
cloudy grid points of wqv" ;
            CSP_AWQV_C:units = "kg/kg m/s" ;
            CSP_AWQV_C:stagger = "" ;
      float CSP_AWQL_C(Time, bottom_top) ;
            CSP_AWQL_C:FieldType = 104 ;
            CSP_AWQL_C:MemoryOrder = "Z  " ;
            CSP_AWQL_C:description = "Cloud fraction * average over all
cloudy grid points of wql" ;
            CSP_AWQL_C:units = "kg/kg m/s" ;
            CSP_AWQL_C:stagger = "" ;
      float CSP_AWQF_C(Time, bottom_top) ;
            CSP_AWQF_C:FieldType = 104 ;
            CSP_AWQF_C:MemoryOrder = "Z  " ;
            CSP_AWQF_C:description = "Cloud fraction * average over all
cloudy grid points of wqf" ;
            CSP_AWQF_C:units = "kg/kg m/s" ;
            CSP_AWQF_C:stagger = "" ;
      float CSP_AWQC_C(Time, bottom_top) ;
            CSP_AWQC_C:FieldType = 104 ;
            CSP_AWQC_C:MemoryOrder = "Z  " ;
            CSP_AWQC_C:description = "Cloud fraction * average over all
cloudy grid points of wqc" ;
            CSP_AWQC_C:units = "kg/kg m/s" ;
            CSP_AWQC_C:stagger = "" ;
      float CSP_AWQI_C(Time, bottom_top) ;
            CSP_AWQI_C:FieldType = 104 ;
            CSP_AWQI_C:MemoryOrder = "Z  " ;
            CSP_AWQI_C:description = "Cloud fraction * average over all
cloudy grid points of wqi" ;
            CSP_AWQI_C:units = "kg/kg m/s" ;
            CSP_AWQI_C:stagger = "" ;
      float CSP_AWTHV_C(Time, bottom_top) ;
            CSP_AWTHV_C:FieldType = 104 ;
            CSP_AWTHV_C:MemoryOrder = "Z  " ;
            CSP_AWTHV_C:description = "Cloud fraction * average over all
cloudy grid points of wthv" ;
            CSP_AWTHV_C:units = "K m/s" ;
            CSP_AWTHV_C:stagger = "" ;
      float CSP_A_CC(Time, bottom_top) ;
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```
            CSP_A_CC:FieldType = 104 ;
            CSP_A_CC:MemoryOrder = "Z  " ;
            CSP_A_CC:description = "Fraction of cloudcore grid points" ;
            CSP_A_CC:units = "(0-1)" ;
            CSP_A_CC:stagger = "" ;
      float CSP_W_CC(Time, bottom_top) ;
            CSP_W_CC:FieldType = 104 ;
            CSP_W_CC:MemoryOrder = "Z  " ;
            CSP_W_CC:description = "Average over all cloudcore grid points of
w" ;
            CSP_W_CC:units = "m/s" ;
            CSP_W_CC:stagger = "" ;
      float CSP_THL_CC(Time, bottom_top) ;
            CSP_THL_CC:FieldType = 104 ;
            CSP_THL_CC:MemoryOrder = "Z  " ;
            CSP_THL_CC:description = "Average over all cloudcore grid points
of thl" ;
            CSP_THL_CC:units = "K" ;
            CSP_THL_CC:stagger = "" ;
      float CSP_QT_CC(Time, bottom_top) ;
            CSP_QT_CC:FieldType = 104 ;
            CSP_QT_CC:MemoryOrder = "Z  " ;
            CSP_QT_CC:description = "Average over all cloudcore grid points
of qt" ;
            CSP_QT_CC:units = "kg/kg" ;
            CSP_QT_CC:stagger = "" ;
      float CSP_QV_CC(Time, bottom_top) ;
            CSP_QV_CC:FieldType = 104 ;
            CSP_QV_CC:MemoryOrder = "Z  " ;
            CSP_QV_CC:description = "Average over all cloudcore grid points
of qv" ;
            CSP_QV_CC:units = "kg/kg" ;
            CSP_QV_CC:stagger = "" ;
      float CSP_QL_CC(Time, bottom_top) ;
            CSP_QL_CC:FieldType = 104 ;
            CSP_QL_CC:MemoryOrder = "Z  " ;
            CSP_QL_CC:description = "Average over all cloudcore grid points
of ql" ;
            CSP_QL_CC:units = "kg/kg" ;
            CSP_QL_CC:stagger = "" ;
      float CSP_QF_CC(Time, bottom_top) ;
            CSP_QF_CC:FieldType = 104 ;
            CSP_QF_CC:MemoryOrder = "Z  " ;
            CSP_QF_CC:description = "Average over all cloudcore grid points
of qf" ;
            CSP_QF_CC:units = "kg/kg" ;
            CSP_QF_CC:stagger = "" ;
      float CSP_QC_CC(Time, bottom_top) ;
            CSP_QC_CC:FieldType = 104 ;
            CSP_QC_CC:MemoryOrder = "Z  " ;
            CSP_QC_CC:description = "Average over all cloudcore grid points
of qc" ;
            CSP_QC_CC:units = "kg/kg" ;
            CSP_QC_CC:stagger = "" ;
      float CSP_QI_CC(Time, bottom_top) ;
```

```
            CSP_QI_CC:FieldType = 104 ;
            CSP_QI_CC:MemoryOrder = "Z  " ;
            CSP_QI_CC:description = "Average over all cloudcore grid points
of qi" ;
            CSP_QI_CC:units = "kg/kg" ;
            CSP_QI_CC:stagger = "" ;
      float CSP_THV_CC(Time, bottom_top) ;
            CSP_THV_CC:FieldType = 104 ;
            CSP_THV_CC:MemoryOrder = "Z  " ;
            CSP_THV_CC:description = "Average over all cloudcore grid points
of thv" ;
            CSP_THV_CC:units = "K" ;
            CSP_THV_CC:stagger = "" ;
      float CSP_W2_CC(Time, bottom_top) ;
            CSP_W2_CC:FieldType = 104 ;
            CSP_W2_CC:MemoryOrder = "Z  " ;
            CSP_W2_CC:description = "Average over all cloudcore grid points
of w variance" ;
            CSP_W2_CC:units = "(m/s)^2" ;
            CSP_W2_CC:stagger = "" ;
      float CSP_AW_CC(Time, bottom_top) ;
            CSP_AW_CC:FieldType = 104 ;
            CSP_AW_CC:MemoryOrder = "Z  " ;
            CSP_AW_CC:description = "Cloudcore fraction * average over all
cloudcore grid points of w" ;
            CSP_AW_CC:units = "m/s" ;
            CSP_AW_CC:stagger = "" ;
      float CSP_AWTHL_CC(Time, bottom_top) ;
            CSP_AWTHL_CC:FieldType = 104 ;
            CSP_AWTHL_CC:MemoryOrder = "Z  " ;
            CSP_AWTHL_CC:description = "Cloudcore fraction * average over all
cloudcore grid points of wthl" ;
            CSP_AWTHL_CC:units = "K m/s" ;
            CSP_AWTHL_CC:stagger = "" ;
      float CSP_AWQT_CC(Time, bottom_top) ;
            CSP_AWQT_CC:FieldType = 104 ;
            CSP_AWQT_CC:MemoryOrder = "Z  " ;
            CSP_AWQT_CC:description = "Cloudcore fraction * average over all
cloudcore grid points of wqt" ;
            CSP_AWQT_CC:units = "kg/kg m/s" ;
            CSP_AWQT_CC:stagger = "" ;
      float CSP_AWQV_CC(Time, bottom_top) ;
            CSP_AWQV_CC:FieldType = 104 ;
            CSP_AWQV_CC:MemoryOrder = "Z  " ;
            CSP_AWQV_CC:description = "Cloudcore fraction * average over all
cloudcore grid points of wqv" ;
            CSP_AWQV_CC:units = "kg/kg m/s" ;
            CSP_AWQV_CC:stagger = "" ;
      float CSP_AWQL_CC(Time, bottom_top) ;
            CSP_AWQL_CC:FieldType = 104 ;
            CSP_AWQL_CC:MemoryOrder = "Z  " ;
            CSP_AWQL_CC:description = "Cloudcore fraction * average over all
cloudcore grid points of wql" ;
            CSP_AWQL_CC:units = "kg/kg m/s" ;
            CSP_AWQL_CC:stagger = "" ;
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```
      float CSP_AWQF_CC(Time, bottom_top) ;
            CSP_AWQF_CC:FieldType = 104 ;
            CSP_AWQF_CC:MemoryOrder = "Z  " ;
            CSP_AWQF_CC:description = "Cloudcore fraction * average over all
cloudcore grid points of wqf" ;
            CSP_AWQF_CC:units = "kg/kg m/s" ;
            CSP_AWQF_CC:stagger = "" ;
      float CSP_AWQC_CC(Time, bottom_top) ;
            CSP_AWQC_CC:FieldType = 104 ;
            CSP_AWQC_CC:MemoryOrder = "Z  " ;
            CSP_AWQC_CC:description = "Cloudcore fraction * average over all
cloudcore grid points of wqc" ;
            CSP_AWQC_CC:units = "kg/kg m/s" ;
            CSP_AWQC_CC:stagger = "" ;
      float CSP_AWQI_CC(Time, bottom_top) ;
            CSP_AWQI_CC:FieldType = 104 ;
            CSP_AWQI_CC:MemoryOrder = "Z  " ;
            CSP_AWQI_CC:description = "Cloudcore fraction * average over all
cloudcore grid points of wqi" ;
            CSP_AWQI_CC:units = "kg/kg m/s" ;
            CSP_AWQI_CC:stagger = "" ;
      float CSP_AWTHV_CC(Time, bottom_top) ;
            CSP_AWTHV_CC:FieldType = 104 ;
            CSP_AWTHV_CC:MemoryOrder = "Z  " ;
            CSP_AWTHV_CC:description = "Cloudcore fraction * average over all
cloudcore grid points of wthv" ;
            CSP_AWTHV_CC:units = "K m/s" ;
            CSP_AWTHV_CC:stagger = "" ;
      float CSP_SIGC_THL(Time, bottom_top) ;
            CSP_SIGC_THL:FieldType = 104 ;
            CSP_SIGC_THL:MemoryOrder = "Z  " ;
            CSP_SIGC_THL:description = "Incloud variance of thl" ;
            CSP_SIGC_THL:units = "K^2" ;
            CSP_SIGC_THL:stagger = "" ;
      float CSP_SIGC_QT(Time, bottom_top) ;
            CSP_SIGC_QT:FieldType = 104 ;
            CSP_SIGC_QT:MemoryOrder = "Z  " ;
            CSP_SIGC_QT:description = "Incloud variance of qt" ;
            CSP_SIGC_QT:units = "(kg/kg)^2" ;
            CSP_SIGC_QT:stagger = "" ;
      float CSP_SIGC_QL(Time, bottom_top) ;
            CSP_SIGC_QL:FieldType = 104 ;
            CSP_SIGC_QL:MemoryOrder = "Z  " ;
            CSP_SIGC_QL:description = "Incloud variance of ql" ;
            CSP_SIGC_QL:units = "(kg/kg)^2" ;
            CSP_SIGC_QL:stagger = "" ;
      float CSP_SIGC_QF(Time, bottom_top) ;
            CSP_SIGC_QF:FieldType = 104 ;
            CSP_SIGC_QF:MemoryOrder = "Z  " ;
            CSP_SIGC_QF:description = "Incloud variance of qf" ;
            CSP_SIGC_QF:units = "(kg/kg)^2" ;
            CSP_SIGC_QF:stagger = "" ;
      float CSP_SIGC_QC(Time, bottom_top) ;
            CSP_SIGC_QC:FieldType = 104 ;
            CSP_SIGC_QC:MemoryOrder = "Z  " ;
```

```
            CSP_SIGC_QC:description = "Incloud variance of qc" ;
            CSP_SIGC_QC:units = "(kg/kg)^2" ;
            CSP_SIGC_QC:stagger = "" ;
      float CSP_SIGC_QI(Time, bottom_top) ;
            CSP_SIGC_QI:FieldType = 104 ;
            CSP_SIGC_QI:MemoryOrder = "Z  " ;
            CSP_SIGC_QI:description = "Incloud variance of qi" ;
            CSP_SIGC_QI:units = "(kg/kg)^2" ;
            CSP_SIGC_QI:stagger = "" ;
      float CSP_SIGC_THV(Time, bottom_top) ;
            CSP_SIGC_THV:FieldType = 104 ;
            CSP_SIGC_THV:MemoryOrder = "Z  " ;
            CSP_SIGC_THV:description = "Incloud variance of thv" ;
            CSP_SIGC_THV:units = "K^2" ;
            CSP_SIGC_THV:stagger = "" ;
      float CSP_TH2(Time, bottom_top) ;
            CSP_TH2:FieldType = 104 ;
            CSP_TH2:MemoryOrder = "Z  " ;
            CSP_TH2:description = "Variance of th" ;
            CSP_TH2:units = "K^2" ;
            CSP_TH2:stagger = "" ;
      float CSP_THV2(Time, bottom_top) ;
            CSP_THV2:FieldType = 104 ;
            CSP_THV2:MemoryOrder = "Z  " ;
            CSP_THV2:description = "Variance of thv" ;
            CSP_THV2:units = "K^2" ;
            CSP_THV2:stagger = "" ;
      float CSP_THL2(Time, bottom_top) ;
            CSP_THL2:FieldType = 104 ;
            CSP_THL2:MemoryOrder = "Z  " ;
            CSP_THL2:description = "Variance of thl" ;
            CSP_THL2:units = "K^2" ;
            CSP_THL2:stagger = "" ;
      float CSP_QV2(Time, bottom_top) ;
            CSP_QV2:FieldType = 104 ;
            CSP_QV2:MemoryOrder = "Z  " ;
            CSP_QV2:description = "Variance of qv" ;
            CSP_QV2:units = "kg^2/kg^2" ;
            CSP_QV2:stagger = "" ;
      float CSP_SMAXACTMAX(Time, bottom_top) ;
            CSP_SMAXACTMAX:FieldType = 104 ;
            CSP_SMAXACTMAX:MemoryOrder = "Z  " ;
            CSP_SMAXACTMAX:description = "Max of max supersat in Morrison
microphysics" ;
            CSP_SMAXACTMAX:units = "" ;
            CSP_SMAXACTMAX:stagger = "" ;
      float CSP_RMINACTMIN(Time, bottom_top) ;
            CSP_RMINACTMIN:FieldType = 104 ;
            CSP_RMINACTMIN:MemoryOrder = "Z  " ;
            CSP_RMINACTMIN:description = "Min of min activated radius in
Morrison microphysics" ;
            CSP_RMINACTMIN:units = "" ;
            CSP_RMINACTMIN:stagger = "" ;
      float CSP_WMAX(Time, bottom_top) ;
            CSP_WMAX:FieldType = 104 ;
```

```
            CSP_WMAX:MemoryOrder = "Z  " ;
            CSP_WMAX:description = "Max value of vertical motion" ;
            CSP_WMAX:units = "m s^-1" ;
            CSP_WMAX:stagger = "" ;
      float CSP_WMIN(Time, bottom_top) ;
            CSP_WMIN:FieldType = 104 ;
            CSP_WMIN:MemoryOrder = "Z  " ;
            CSP_WMIN:description = "Min value of vertical motion" ;
            CSP_WMIN:units = "m s^-1" ;
            CSP_WMIN:stagger = "" ;
      float CSV_TH(Time, bottom_top, south_north, west_east) ;
            CSV_TH:FieldType = 104 ;
            CSV_TH:MemoryOrder = "XYZ" ;
            CSV_TH:description = "Time-averaged potential temperature" ;
            CSV_TH:units = "m s^-1" ;
            CSV_TH:stagger = "" ;
            CSV_TH:coordinates = "XLONG XLAT XTIME" ;
      float CSV_U(Time, bottom_top, south_north, west_east_stag) ;
            CSV_U:FieldType = 104 ;
            CSV_U:MemoryOrder = "XYZ" ;
            CSV_U:description = "Time-averaged meridional wind speed" ;
            CSV_U:units = "m s^-1" ;
            CSV_U:stagger = "X" ;
            CSV_U:coordinates = "XLONG_U XLAT_U XTIME" ;
      float CSV_V(Time, bottom_top, south_north_stag, west_east) ;
            CSV_V:FieldType = 104 ;
            CSV_V:MemoryOrder = "XYZ" ;
            CSV_V:description = "Time-averaged zonal wind speed" ;
            CSV_V:units = "m s^-1" ;
            CSV_V:stagger = "Y" ;
            CSV_V:coordinates = "XLONG_V XLAT_V XTIME" ;
      float CSV_W(Time, bottom_top_stag, south_north, west_east) ;
            CSV_W:FieldType = 104 ;
            CSV_W:MemoryOrder = "XYZ" ;
            CSV_W:description = "Time-averaged vertical wind speed" ;
            CSV_W:units = "m s^-1" ;
            CSV_W:stagger = "Z" ;
            CSV_W:coordinates = "XLONG XLAT XTIME" ;
      float CSV_W2(Time, bottom_top_stag, south_north, west_east) ;
            CSV_W2:FieldType = 104 ;
            CSV_W2:MemoryOrder = "XYZ" ;
            CSV_W2:description = "Time-averaged vertical wind speed variance"
;
            CSV_W2:units = "m^2 s^-2" ;
            CSV_W2:stagger = "Z" ;
            CSV_W2:coordinates = "XLONG XLAT XTIME" ;
      float CSV_QV(Time, bottom_top, south_north, west_east) ;
            CSV_QV:FieldType = 104 ;
            CSV_QV:MemoryOrder = "XYZ" ;
            CSV_QV:description = "Time-averaged water vapor mixing ratio" ;
            CSV_QV:units = "kg/kg" ;
            CSV_QV:stagger = "" ;
            CSV_QV:coordinates = "XLONG XLAT XTIME" ;
      float CSV_QC(Time, bottom_top, south_north, west_east) ;
            CSV_QC:FieldType = 104 ;
```

```
            CSV_QC:MemoryOrder = "XYZ" ;
            CSV_QC:description = "Time-averaged cloud droplet mixing ratio" ;
            CSV_QC:units = "kg/kg" ;
            CSV_QC:stagger = "" ;
            CSV_QC:coordinates = "XLONG XLAT XTIME" ;
      float CSV_QR(Time, bottom_top, south_north, west_east) ;
            CSV_QR:FieldType = 104 ;
            CSV_QR:MemoryOrder = "XYZ" ;
            CSV_QR:description = "Time-averaged rain droplet mixing ratio" ;
            CSV_QR:units = "kg/kg" ;
            CSV_QR:stagger = "" ;
            CSV_QR:coordinates = "XLONG XLAT XTIME" ;
      float CSV_QI(Time, bottom_top, south_north, west_east) ;
            CSV_QI:FieldType = 104 ;
            CSV_QI:MemoryOrder = "XYZ" ;
            CSV_QI:description = "Time-averaged cloud ice mixing ratio" ;
            CSV_QI:units = "kg/kg" ;
            CSV_QI:stagger = "" ;
            CSV_QI:coordinates = "XLONG XLAT XTIME" ;
      float CSV_QS(Time, bottom_top, south_north, west_east) ;
            CSV_QS:FieldType = 104 ;
            CSV_QS:MemoryOrder = "XYZ" ;
            CSV_QS:description = "Time-averaged snow mixing ratio" ;
            CSV_QS:units = "kg/kg" ;
            CSV_QS:stagger = "" ;
            CSV_QS:coordinates = "XLONG XLAT XTIME" ;
      float CSV_QG(Time, bottom_top, south_north, west_east) ;
            CSV_QG:FieldType = 104 ;
            CSV_QG:MemoryOrder = "XYZ" ;
            CSV_QG:description = "Time-averaged graupel mixing ratio" ;
            CSV_QG:units = "kg/kg" ;
            CSV_QG:stagger = "" ;
            CSV_QG:coordinates = "XLONG XLAT XTIME" ;
      float CSV_LWC(Time, bottom_top, south_north, west_east) ;
            CSV_LWC:FieldType = 104 ;
            CSV_LWC:MemoryOrder = "XYZ" ;
            CSV_LWC:description = "Time-averaged liquid water content (based
on ql)" ;
            CSV_LWC:units = "kg/m^3" ;
            CSV_LWC:stagger = "" ;
            CSV_LWC:coordinates = "XLONG XLAT XTIME" ;
      float CSV_IWC(Time, bottom_top, south_north, west_east) ;
            CSV_IWC:FieldType = 104 ;
            CSV_IWC:MemoryOrder = "XYZ" ;
            CSV_IWC:description = "Time-averaged ice water content (based on
qf)" ;
            CSV_IWC:units = "kg/m^3" ;
            CSV_IWC:stagger = "" ;
            CSV_IWC:coordinates = "XLONG XLAT XTIME" ;
      float CSV_CLDFRAC(Time, bottom_top, south_north, west_east) ;
            CSV_CLDFRAC:FieldType = 104 ;
            CSV_CLDFRAC:MemoryOrder = "XYZ" ;
            CSV_CLDFRAC:description = "Time-averaged cloud fraction" ;
            CSV_CLDFRAC:units = "(0-1)" ;
            CSV_CLDFRAC:stagger = "" ;
```

```
            CSV_CLDFRAC:coordinates = "XLONG XLAT XTIME" ;
      float CSS_LWP(Time, south_north, west_east) ;
            CSS_LWP:FieldType = 104 ;
            CSS_LWP:MemoryOrder = "XY " ;
            CSS_LWP:description = "Time-averaged liquid water path (based on
ql)" ;
            CSS_LWP:units = "kg/m^2" ;
            CSS_LWP:stagger = "" ;
            CSS_LWP:coordinates = "XLONG XLAT XTIME" ;
      float CSS_IWP(Time, south_north, west_east) ;
            CSS_IWP:FieldType = 104 ;
            CSS_IWP:MemoryOrder = "XY " ;
            CSS_IWP:description = "Time-averaged ice water path (based on
qf)" ;
            CSS_IWP:units = "kg/m^2" ;
            CSS_IWP:stagger = "" ;
            CSS_IWP:coordinates = "XLONG XLAT XTIME" ;
      float CSS_CLDTOT(Time, south_north, west_east) ;
            CSS_CLDTOT:FieldType = 104 ;
            CSS_CLDTOT:MemoryOrder = "XY " ;
            CSS_CLDTOT:description = "Time-averaged fractional cloud cover" ;
            CSS_CLDTOT:units = "(0-1)" ;
            CSS_CLDTOT:stagger = "" ;
            CSS_CLDTOT:coordinates = "XLONG XLAT XTIME" ;
      float CSS_CLDLOW(Time, south_north, west_east) ;
            CSS_CLDLOW:FieldType = 104 ;
            CSS_CLDLOW:MemoryOrder = "XY " ;
            CSS_CLDLOW:description = "Time-averaged fractional low-cloud
cover (<5 km)" ;
            CSS_CLDLOW:units = "(0-1)" ;
            CSS_CLDLOW:stagger = "" ;
            CSS_CLDLOW:coordinates = "XLONG XLAT XTIME" ;

// global attributes:
            :TITLE = " OUTPUT FROM WRF V3.8.1 MODEL" ;
            :START_DATE = "2018-05-14_12:00:00" ;
            :WEST-EAST_GRID_DIMENSION = 251 ;
            :SOUTH-NORTH_GRID_DIMENSION = 251 ;
            :BOTTOM-TOP_GRID_DIMENSION = 227 ;
            :DX = 100.f ;
            :DY = 100.f ;
            :GRIDTYPE = "C" ;
            :DIFF_OPT = 2 ;
            :KM_OPT = 2 ;
            :DAMP_OPT = 3 ;
            :DAMPCOEF = 0.2f ;
            :KHDIF = 1.f ;
            :KVDIF = 1.f ;
            :MP_PHYSICS = 8 ;
            :RA_LW_PHYSICS = 4 ;
            :RA_SW_PHYSICS = 4 ;
            :SF_SFCLAY_PHYSICS = 1 ;
            :SF_SURFACE_PHYSICS = 1 ;
            :BL_PBL_PHYSICS = 0 ;
            :CU_PHYSICS = 0 ;
```

```
            :SF_LAKE_PHYSICS = 0 ;
            :SURFACE_INPUT_SOURCE = 3 ;
            :SST_UPDATE = 0 ;
            :GRID_FDDA = 0 ;
            :GFDDA_INTERVAL_M = 0 ;
            :GFDDA_END_H = 0 ;
            :GRID_SFDDA = 0 ;
            :SGFDDA_INTERVAL_M = 0 ;
            :SGFDDA_END_H = 0 ;
            :HYPSOMETRIC_OPT = 1 ;
            :USE_THETA_M = 1 ;
            :WEST-EAST_PATCH_START_UNSTAG = 1 ;
            :WEST-EAST_PATCH_END_UNSTAG = 250 ;
            :WEST-EAST_PATCH_START_STAG = 1 ;
            :WEST-EAST_PATCH_END_STAG = 251 ;
            :SOUTH-NORTH_PATCH_START_UNSTAG = 1 ;
            :SOUTH-NORTH_PATCH_END_UNSTAG = 250 ;
            :SOUTH-NORTH_PATCH_START_STAG = 1 ;
            :SOUTH-NORTH_PATCH_END_STAG = 251 ;
            :BOTTOM-TOP_PATCH_START_UNSTAG = 1 ;
            :BOTTOM-TOP_PATCH_END_UNSTAG = 226 ;
            :BOTTOM-TOP_PATCH_START_STAG = 1 ;
            :BOTTOM-TOP_PATCH_END_STAG = 227 ;
            :GRID_ID = 1 ;
            :PARENT_ID = 0 ;
            :I_PARENT_START = 0 ;
            :J_PARENT_START = 0 ;
            :PARENT_GRID_RATIO = 1 ;
            :DT = 0.5f ;
            :CEN_LAT = 0.f ;
            :CEN_LON = 0.f ;
            :TRUELAT1 = 0.f ;
            :TRUELAT2 = 0.f ;
            :MOAD_CEN_LAT = 0.f ;
            :STAND_LON = 0.f ;
            :POLE_LAT = 0.f ;
            :POLE_LON = 0.f ;
            :GMT = 0.f ;
            :JULYR = 0 ;
            :JULDAY = 1 ;
            :MAP_PROJ = 0 ;
            :MAP_PROJ_CHAR = "Cartesian" ;
            :MMINLU = "" ;
            :NUM_LAND_CAT = 21 ;
            :ISWATER = 16 ;
            :ISLAKE = 0 ;
            :ISICE = 0 ;
            :ISURBAN = 0 ;
            :ISOILWATER = 0 ;
            :doi = "10.5439/1342961" ;
            :contacts = "lasso@arm.gov, LASSO PI: William Gustafson
(William.Gustafson@pnnl.gov), LASSO Co-PI: Andrew Vogelmann
(vogelmann@bnl.gov)" ;
            :process_version = "vap-lassomod-0.0-0.dev0.dirty.el6" ;
            :site_id = "sgp" ;
```

```
            :facility_id = "C1" ;
            :location_description = "Southern Great Plains (SGP), Lamont,
Oklahoma" ;
            :date = "20180514" ;
            :simulation_id_number = 2LL ;
            :model_type = "WRF" ;
            :model_version = "3.8.1" ;
            :model_github_hash = "b6b6a5cc4229eec1ea9b005746b5ebef2205fb07" ;
            :output_domain_size = "25.0 km" ;
            :output_number_of_levels = 226LL ;
            :output_horizontal_grid_spacing = "100 m" ;
            :config_large_scale_forcing = "VARANAL" ;
            :config_large_scale_forcing_scale = "300 km" ;
            :config_large_scale_forcing_specifics = "sgp60varanarapC1.c1
(v20190228)" ;
            :config_surface_treatment = "VARANAL" ;
            :config_surface_treatment_specifics = "sgp60varanarapC1.c1
(v20190228)" ;
            :config_initial_condition = "Sounding" ;
            :config_initial_condition_specifics = "sgpsondewnpnC1" ;
            :config_aerosol = "NA" ;
            :config_forecast_time = "15.0 h" ;
            :config_boundary_method = "Periodic" ;
            :config_microphysics = "Thompson (mp_physics=8)" ;
            :config_nickname = "runlas20180514v1var" ;
            :simulation_origin_host = "cumulus-login2.ccs.ornl.gov" ;
}
```

Appendix E:

LASSO High-Frequency Observations Datastream File Contents

This appendix lists the contents of the files contained in the LASSO High-Frequency Observations datastream, known as *lassohighfreqobs.c1*. The file listings take the form of netCDF header dumps that include the associated metadata for each variable. Contents of files in the LASSO data bundles for the model output and coarsened observations can be found in Appendix D.

Files: *.../sgp915rwpwindcon10mC1/data/sgp915rwpwindcon10mC1.c1.20190404.000000.nc*
.../sgp915rwpwindcon10mI8/data/sgp915rwpwindcon10mI8.c1.20190404.000000.nc
.../sgp915rwpwindcon10mI9/data/sgp915rwpwindcon10mI9.c1.20190404.000000.nc
.../sgp915rwpwindcon10mI10/data/sgp915rwpwindcon10mI10.c1.20190404.000000.nc

Description: Consensus winds from the RWP at 10-min frequency. There are separate data files for the four RWP locations around the SGP, sites C1, I8, I9, and I10. Because the LASSO cases cross day boundaries in UTC time, there are also two days worth of data for each case, with each day in a separate file. An example from C1 is shown.

```
netcdf sgp915rwpwindcon10mC1.c1.20190405.000000 {
dimensions:
      time = UNLIMITED ; // (144 currently)
      range_gate = 75 ;
      modes = 2 ;
      beams = 3 ;
      bound = 2 ;
      string_length = 64 ;
variables:
      int base_time ;
            base_time:string = "2019-04-05 00:00:00 0:00" ;
            base_time:long_name = "Base time in Epoch" ;
            base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
            base_time:ancillary_variables = "time_offset" ;
      double time_offset(time) ;
            time_offset:long_name = "Time offset from base_time" ;
            time_offset:units = "seconds since 2019-04-05 00:00:00 0:00" ;
            time_offset:ancillary_variables = "base_time" ;
      double time(time) ;
            time:long_name = "Time offset from midnight" ;
            time:units = "seconds since 2019-04-05 00:00:00 0:00" ;
            time:bounds = "time_bounds" ;
            time:standard_name = "time" ;
      double time_bounds(time, bound) ;
```

```
            time_bounds:long_name = "Time cell bounds" ;
            time_bounds:bound_offsets = 0., 600. ;
      float height(modes, range_gate) ;
            height:long_name = "Height above surface" ;
            height:units = "km" ;
            height:missing_value = -9999.f ;
            height:standard_name = "height" ;
      char mode_description(modes, string_length) ;
            mode_description:long_name = "Description of the RWP operational
modes" ;
            mode_description:units = "1" ;
      float wind_speed(time, range_gate, modes) ;
            wind_speed:long_name = "Horizontal wind speed" ;
            wind_speed:units = "m/s" ;
            wind_speed:missing_value = -9999.f ;
            wind_speed:standard_name = "wind_speed" ;
            wind_speed:valid_min = 0.f ;
            wind_speed:valid_max = 100.f ;
      float wind_direction(time, range_gate, modes) ;
            wind_direction:long_name = "Horizontal wind direction" ;
            wind_direction:units = "degree" ;
            wind_direction:missing_value = -9999.f ;
            wind_direction:standard_name = "wind_to_direction" ;
            wind_direction:valid_min = 0.f ;
            wind_direction:valid_max = 360.f ;
      float u_wind(time, range_gate, modes) ;
            u_wind:long_name = "Eastward wind component" ;
            u_wind:units = "m/s" ;
            u_wind:missing_value = -9999.f ;
            u_wind:standard_name = "eastward_wind" ;
            u_wind:valid_min = -75.f ;
            u_wind:valid_max = 75.f ;
      float v_wind(time, range_gate, modes) ;
            v_wind:long_name = "Northward wind component" ;
            v_wind:units = "m/s" ;
            v_wind:missing_value = -9999.f ;
            v_wind:standard_name = "northward_wind" ;
            v_wind:valid_min = -75.f ;
            v_wind:valid_max = 75.f ;
      float radial_velocity(time, range_gate, modes, beams) ;
            radial_velocity:long_name = "Radial velocity along path of beam"
;
            radial_velocity:units = "m/s" ;
            radial_velocity:missing_value = -9999.f ;
            radial_velocity:standard_name =
"radial_velocity_of_scatterers_away_from_instrument" ;
      int samples_in_consensus(time, range_gate, modes, beams) ;
            samples_in_consensus:long_name = "Number of samples that met
consensus criteria" ;
            samples_in_consensus:units = "1" ;
            samples_in_consensus:missing_value = -9999 ;
      int valid_height(modes) ;
            valid_height:long_name = "Number of valid heights" ;
            valid_height:units = "1" ;
            valid_height:missing_value = -9999 ;
```

```
      float nyquist_velocity(modes, beams) ;
            nyquist_velocity:long_name = "Nyquist velocity" ;
            nyquist_velocity:units = "m/s" ;
            nyquist_velocity:missing_value = -9999.f ;
      float azimuth(modes, beams) ;
            azimuth:long_name = "Azimuth angle of beam" ;
            azimuth:units = "degree" ;
            azimuth:missing_value = -9999.f ;
            azimuth:standard_name = "sensor_azimuth_angle" ;
      float elevation(modes, beams) ;
            elevation:long_name = "Elevation angle of beam" ;
            elevation:units = "degree" ;
            elevation:missing_value = -9999.f ;
      float lat ;
            lat:long_name = "North latitude" ;
            lat:units = "degree_N" ;
            lat:valid_min = -90.f ;
            lat:valid_max = 90.f ;
            lat:standard_name = "latitude" ;
      float lon ;
            lon:long_name = "East longitude" ;
            lon:units = "degree_E" ;
            lon:valid_min = -180.f ;
            lon:valid_max = 180.f ;
            lon:standard_name = "longitude" ;
      float alt ;
            alt:long_name = "Altitude above mean sea level" ;
            alt:units = "m" ;
            alt:standard_name = "altitude" ;

// global attributes:
            :command_line = "915rwpwindcon10m -s sgp -f C1 -b 20190405 -R" ;
            :Conventions = "ARM-1.2" ;
            :process_version = "vap-915rwpwindcon10m-1.0-0.el7" ;
            :dod_version = "915rwpwindcon10m-c1-1.2" ;
            :input_datastreams = "sgp915rwpwindmomC1.a0 : 9.10 :
20190405.000009" ;
            :site_id = "sgp" ;
            :platform_id = "915rwpwindcon10m" ;
            :facility_id = "C1" ;
            :location_description = "Southern Great Plains (SGP), Lamont,
Oklahoma" ;
            :data_level = "c1" ;
            :datastream = "sgp915rwpwindcon10mC1.c1" ;
            :title = "Atmospheric Radiation Measurement (ARM) Facility Radar
Wind Profiler Winds" ;
            :institution = "U.S. Department of Energy Atmospheric Radiation
Measurement (ARM) Facility" ;
            :description = "Radar Wind Profilers Winds." ;
            :doi = "10.5439/1499022" ;
            :frequency = "915 MHz" ;
            :snr_threshold = -14. ;
            :consensus_period = 10. ;
            :history = "created by user ttoto on machine agate at 2020-06-11
14:57:48, using vap-915rwpwindcon10m-1.0-0.el7" ;
```

```
}
```

Files: *.../sgpcldfracset01mC1.c1/data/sgpcldfracset01mC1.c1.20190404.000030.nc*
.../sgpcldfracset05mC1.c1/data/sgpcldfracset05mC1.c1.20190404.000030.nc
.../sgpcldfracset15mC1.c1/data/sgpcldfracset15mC1.c1.20190404.000030.nc

Description: Set of cloud fraction data from the TSI and KAZRARSCL, i.e., the *sgpcldfrac* VAP. Three variations are available with different averaging periods of 1, 5, and 15 min. Data is provided every minute for all three averaging periods. The TSI cloud fraction and associated ancillary variables are only provided in the 1-min averaging file. Because the LASSO cases cross day boundaries in UTC time, there are also two days worth of data for each case, with each day in a separate file. The 1-min averaging file is shown below.

```
netcdf sgpcldfracset01mC1.c1.20190404.000030 {
dimensions:
      time = UNLIMITED ; // (1440 currently)
      bound = 2 ;
      height = 596 ;
variables:
      int base_time ;
            base_time:string = "2019-04-04 00:00:00 0:00" ;
            base_time:long_name = "Base time in Epoch" ;
            base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
            base_time:ancillary_variables = "time_offset" ;
      double time_offset(time) ;
            time_offset:long_name = "Time offset from base_time" ;
            time_offset:units = "seconds since 2019-04-04 00:00:00 0:00" ;
            time_offset:ancillary_variables = "base_time" ;
      double time(time) ;
            time:long_name = "Time offset from midnight" ;
            time:units = "seconds since 2019-04-04 00:00:00 0:00" ;
            time:calendar = "gregorian" ;
            time:standard_name = "time" ;
            time:bounds = "time_bounds" ;
      double time_bounds(time, bound) ;
            time_bounds:long_name = "Time cell bounds" ;
            time_bounds:bound_offsets = -30., 30. ;
      float height(height) ;
            height:long_name = "Height above ground level" ;
            height:units = "km" ;
            height:standard_name = "height" ;
      float cloud_fraction_kazrarscl(time, height) ;
            cloud_fraction_kazrarscl:long_name = "Cloud frequency of
occurrence from KAZR-ARSCL (based on KAZR and Micropulse Lidar observations),
including both hydrometer-only and mixed hydrometer and clutter detections" ;
            cloud_fraction_kazrarscl:units = "1" ;
            cloud_fraction_kazrarscl:missing_value = -9999.f ;
            cloud_fraction_kazrarscl:ancillary_variables =
"fgp_cloud_fraction_kazrarscl std_cloud_fraction_kazrarscl" ;
      float cloud_fraction_kazrarscl_fgp(time, height) ;
            cloud_fraction_kazrarscl_fgp:long_name = "Fraction of KAZR-ARSCL
values in averaging interval for cloud_fraction_kazrarscl which contain valid
data" ;
```

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            cloud_fraction_kazrarscl_fgp:units = "1" ;
            cloud_fraction_kazrarscl_fgp:missing_value = -9999.f ;
      float cloud_fraction_kazrarscl_std(time, height) ;
            cloud_fraction_kazrarscl_std:long_name = "Standard deviation of
cloud frequency of occurrence from radar and lidar (KAZRARSCL layers), and
from radar field alone, including hydrometeor-only and mixed hydrometeor and
clutter detections" ;
            cloud_fraction_kazrarscl_std:units = "1" ;
            cloud_fraction_kazrarscl_std:missing_value = -9999.f ;
      float total_cloud_fraction_kazrarscl(time, height) ;
            total_cloud_fraction_kazrarscl:long_name = "Total cloud frequency
of occurrence below height indicated, from cloud_fraction_kazrarscl" ;
            total_cloud_fraction_kazrarscl:units = "1" ;
            total_cloud_fraction_kazrarscl:missing_value = -9999.f ;
            total_cloud_fraction_kazrarscl:ancillary_variables =
"fgp_total_cloud_fraction_kazrarscl std_total_cloud_fraction_kazrarscl" ;
      float total_cloud_fraction_kazrarscl_fgp(time, height) ;
            total_cloud_fraction_kazrarscl_fgp:long_name = "Good fraction for
total cloud frequency of occurrence below height indicated, from
cloud_fraction_kazrarscl" ;
            total_cloud_fraction_kazrarscl_fgp:units = "1" ;
            total_cloud_fraction_kazrarscl_fgp:missing_value = -9999.f ;
      float total_cloud_fraction_kazrarscl_std(time, height) ;
            total_cloud_fraction_kazrarscl_std:long_name = "Standard
deviation of total cloud frequency of occurrence below height indicated from
cloud_fraction_kazrarscl" ;
            total_cloud_fraction_kazrarscl_std:units = "1" ;
            total_cloud_fraction_kazrarscl_std:missing_value = -9999.f ;
      float cloud_fraction_tsi(time) ;
            cloud_fraction_tsi:long_name = "Mean fraction opaque from TSI" ;
            cloud_fraction_tsi:units = "1" ;
            cloud_fraction_tsi:comment = "Only provided when the cloud
fraction from KAZRARSCL above 5km is zero" ;
            cloud_fraction_tsi:valid_min = 0.f ;
            cloud_fraction_tsi:valid_max = 1.f ;
            cloud_fraction_tsi:missing_value = -9999.f ;
            cloud_fraction_tsi:ancillary_variables = "qc_cloud_fraction_tsi"
;
      int qc_cloud_fraction_tsi(time) ;
            qc_cloud_fraction_tsi:long_name = "Quality check results on
field: Mean fraction opaque from TSI" ;
            qc_cloud_fraction_tsi:units = "1" ;
            qc_cloud_fraction_tsi:description = "This field contains bit
packed integer values, where each bit represents a QC test on the data. Non-
zero bits indicate the QC condition given in the description for those bits;
a value of 0 (no bits set) indicates the data has not failed any QC tests." ;
            qc_cloud_fraction_tsi:flag_method = "bit" ;
            qc_cloud_fraction_tsi:bit_1_description = "Value is less than the
valid_min." ;
            qc_cloud_fraction_tsi:bit_1_assessment = "Bad" ;
            qc_cloud_fraction_tsi:bit_2_description = "Value is greater than
the valid_max." ;
            qc_cloud_fraction_tsi:bit_2_assessment = "Bad" ;
            qc_cloud_fraction_tsi:bit_3_description = "Data value not
available in input file, data value has been set to missing_value." ;
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            qc_cloud_fraction_tsi:bit_3_assessment = "Bad" ;
      float region_zenith_count_opaque(time) ;
            region_zenith_count_opaque:long_name = "Pixel count: number
opaque in zenith circle" ;
            region_zenith_count_opaque:units = "count" ;
            region_zenith_count_opaque:valid_min = 0.f ;
            region_zenith_count_opaque:valid_max = 307200.f ;
            region_zenith_count_opaque:resolution = 1.f ;
            region_zenith_count_opaque:missing_value = -9999.f ;
            region_zenith_count_opaque:ancillary_variables =
"qc_region_zenith_count_opaque" ;
            region_zenith_count_opaque:cell_transform = "time:
TRANS_BIN_AVERAGE" ;
      int qc_region_zenith_count_opaque(time) ;
            qc_region_zenith_count_opaque:long_name = "Quality check results
on field: Pixel count: number opaque in zenith circle" ;
            qc_region_zenith_count_opaque:units = "1" ;
            qc_region_zenith_count_opaque:description = "This field contains
bit packed integer values, where each bit represents a QC test on the data.
Non-zero bits indicate the QC condition given in the description for those
bits; a value of 0 (no bits set) indicates the data has not failed any QC
tests." ;
            qc_region_zenith_count_opaque:flag_method = "bit" ;
            qc_region_zenith_count_opaque:bit_1_description = "QC_BAD:
Transformation could not finish, value set to missing_value." ;
            qc_region_zenith_count_opaque:bit_1_assessment = "Bad" ;
            qc_region_zenith_count_opaque:bit_2_description =
"QC_INDETERMINATE:  Some, or all, of the input values used to create this
output value had a QC assessment of Indeterminate." ;
            qc_region_zenith_count_opaque:bit_2_assessment = "Indeterminate"
;
            qc_region_zenith_count_opaque:bit_1_comment = "An example that
will trip this bit is if all values are bad or outside range." ;
            qc_region_zenith_count_opaque:bit_3_description =
"QC_INTERPOLATE:  Indicates a non-standard interpolation using points other
than the two that bracket the target index was applied." ;
            qc_region_zenith_count_opaque:bit_3_assessment = "Indeterminate"
;
            qc_region_zenith_count_opaque:bit_3_comment = "An example of why
this may occur is if one or both of the nearest points was flagged as bad.
Applies only to interpolate transformation method." ;
            qc_region_zenith_count_opaque:bit_4_description =
"QC_EXTRAPOLATE:  Indicates extrapolation is performed out from two points on
the same side of the target index." ;
            qc_region_zenith_count_opaque:bit_4_assessment = "Indeterminate"
;
            qc_region_zenith_count_opaque:bit_4_comment = "This occurs
because the input grid does not span the output grid, or because all the
points within range and on one side of the target were flagged as bad.
Applies only to the interpolate transformation method." ;
            qc_region_zenith_count_opaque:bit_5_description =
"QC_NOT_USING_CLOSEST:  Nearest good point is not the nearest actual point."
;
            qc_region_zenith_count_opaque:bit_5_assessment = "Indeterminate"
;
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            qc_region_zenith_count_opaque:bit_5_comment = "Applies only to
subsample transformation method." ;
            qc_region_zenith_count_opaque:bit_6_description =
"QC_SOME_BAD_INPUTS:  Some, but not all, of the inputs in the averaging
window were flagged as bad and excluded from the transform." ;
            qc_region_zenith_count_opaque:bit_6_assessment = "Indeterminate"
;
            qc_region_zenith_count_opaque:bit_6_comment = "Applies only to
the bin average transformation method." ;
            qc_region_zenith_count_opaque:bit_7_description =
"QC_ZERO_WEIGHT:  The weights for all the input points to be averaged for
this output bin were set to zero." ;
            qc_region_zenith_count_opaque:bit_7_assessment = "Indeterminate"
;
            qc_region_zenith_count_opaque:bit_7_comment = "The output
\"average\" value is set to zero, independent of the value of the input.
Applies only to bin average transformation method." ;
            qc_region_zenith_count_opaque:bit_8_description =
"QC_OUTSIDE_RANGE:  No input samples exist in the transformation region,
value set to missing_value." ;
            qc_region_zenith_count_opaque:bit_8_assessment = "Bad" ;
            qc_region_zenith_count_opaque:bit_8_comment = "Nearest good
bracketing points are farther away than the \"range\" transform parameter if
transformation is done using the interpolate or subsample method, or
\"width\" if a bin average transform is applied.  Test can also fail if more
than half an input bin is extrapolated beyond the first or last point of the
input grid." ;
            qc_region_zenith_count_opaque:bit_9_description =
"QC_ALL_BAD_INPUTS:  All the input values in the transformation region are
bad, value set to missing_value." ;
            qc_region_zenith_count_opaque:bit_9_assessment = "Bad" ;
            qc_region_zenith_count_opaque:bit_9_comment = "The transformation
could not be completed. Values in the output grid are set to -9999 and the
QC_BAD bit is also set." ;
            qc_region_zenith_count_opaque:bit_10_description = "QC_BAD_STD:
Standard deviation over averaging interval is greater than limit set by
transform parameter std_bad_max." ;
            qc_region_zenith_count_opaque:bit_10_assessment = "Bad" ;
            qc_region_zenith_count_opaque:bit_10_comment = "Applies only to
the bin average transformation method." ;
            qc_region_zenith_count_opaque:bit_11_description =
"QC_INDETERMINATE_STD:  Standard deviation over averaging interval is greater
than limit set by transform parameter std_ind_max." ;
            qc_region_zenith_count_opaque:bit_11_assessment = "Indeterminate"
;
            qc_region_zenith_count_opaque:bit_11_comment = "Applies only to
the bin average transformation method." ;
            qc_region_zenith_count_opaque:bit_12_description =
"QC_BAD_GOODFRAC:  Fraction of good and indeterminate points over averaging
interval are less than limit set by transform parameter goodfrac_bad_min." ;
            qc_region_zenith_count_opaque:bit_12_assessment = "Bad" ;
            qc_region_zenith_count_opaque:bit_12_comment = "Applies only to
the bin average transformation method." ;
            qc_region_zenith_count_opaque:bit_13_description =
"QC_INDETERMINATE_GOODFRAC:  Fraction of good and indeterminate points over
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averaging interval is less than limit set by transform parameter
goodfrac_ind_min." ;
            qc_region_zenith_count_opaque:bit_13_assessment = "Indeterminate"
;
            qc_region_zenith_count_opaque:bit_13_comment = "Applies only to
the bin average transformation method." ;
      float region_zenith_count(time) ;
            region_zenith_count:long_name = "Pixel count: number total in
zenith circle" ;
            region_zenith_count:units = "count" ;
            region_zenith_count:valid_min = 0.f ;
            region_zenith_count:valid_max = 307200.f ;
            region_zenith_count:resolution = 1.f ;
            region_zenith_count:missing_value = -9999.f ;
            region_zenith_count:ancillary_variables =
"qc_region_zenith_count" ;
            region_zenith_count:cell_transform = "time: TRANS_BIN_AVERAGE" ;
      int qc_region_zenith_count(time) ;
            qc_region_zenith_count:long_name = "Quality check results on
field: Pixel count: number total in zenith circle" ;
            qc_region_zenith_count:units = "1" ;
            qc_region_zenith_count:description = "This field contains bit
packed integer values, where each bit represents a QC test on the data. Non-
zero bits indicate the QC condition given in the description for those bits;
a value of 0 (no bits set) indicates the data has not failed any QC tests." ;
            qc_region_zenith_count:flag_method = "bit" ;
            qc_region_zenith_count:bit_1_description = "QC_BAD:
Transformation could not finish, value set to missing_value." ;
            qc_region_zenith_count:bit_1_assessment = "Bad" ;
            qc_region_zenith_count:bit_2_description = "QC_INDETERMINATE:
Some, or all, of the input values used to create this output value had a QC
assessment of Indeterminate." ;
            qc_region_zenith_count:bit_2_assessment = "Indeterminate" ;
            qc_region_zenith_count:bit_1_comment = "An example that will trip
this bit is if all values are bad or outside range." ;
            qc_region_zenith_count:bit_3_description = "QC_INTERPOLATE:
Indicates a non-standard interpolation using points other than the two that
bracket the target index was applied." ;
            qc_region_zenith_count:bit_3_assessment = "Indeterminate" ;
            qc_region_zenith_count:bit_3_comment = "An example of why this
may occur is if one or both of the nearest points was flagged as bad.
Applies only to interpolate transformation method." ;
            qc_region_zenith_count:bit_4_description = "QC_EXTRAPOLATE:
Indicates extrapolation is performed out from two points on the same side of
the target index." ;
            qc_region_zenith_count:bit_4_assessment = "Indeterminate" ;
            qc_region_zenith_count:bit_4_comment = "This occurs because the
input grid does not span the output grid, or because all the points within
range and on one side of the target were flagged as bad.  Applies only to the
interpolate transformation method." ;
            qc_region_zenith_count:bit_5_description = "QC_NOT_USING_CLOSEST:
Nearest good point is not the nearest actual point." ;
            qc_region_zenith_count:bit_5_assessment = "Indeterminate" ;
            qc_region_zenith_count:bit_5_comment = "Applies only to subsample
transformation method." ;
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```
		qc_region_zenith_count:bit_6_description = "QC_SOME_BAD_INPUTS:  
Some, but not all, of the inputs in the averaging window were flagged as bad 
and excluded from the transform." ;
		qc_region_zenith_count:bit_6_assessment = "Indeterminate" ;
		qc_region_zenith_count:bit_6_comment = "Applies only to the bin 
average transformation method." ;
		qc_region_zenith_count:bit_7_description = "QC_ZERO_WEIGHT:  The 
weights for all the input points to be averaged for this output bin were set 
to zero." ;
		qc_region_zenith_count:bit_7_assessment = "Indeterminate" ;
		qc_region_zenith_count:bit_7_comment = "The output \"average\" 
value is set to zero, independent of the value of the input.  Applies only to 
bin average transformation method." ;
		qc_region_zenith_count:bit_8_description = "QC_OUTSIDE_RANGE:  No 
input samples exist in the transformation region, value set to 
missing_value." ;
		qc_region_zenith_count:bit_8_assessment = "Bad" ;
		qc_region_zenith_count:bit_8_comment = "Nearest good bracketing 
points are farther away than the \"range\" transform parameter if 
transformation is done using the interpolate or subsample method, or 
\"width\" if a bin average transform is applied.  Test can also fail if more 
than half an input bin is extrapolated beyond the first or last point of the 
input grid." ;
		qc_region_zenith_count:bit_9_description = "QC_ALL_BAD_INPUTS:  
All the input values in the transformation region are bad, value set to 
missing_value." ;
		qc_region_zenith_count:bit_9_assessment = "Bad" ;
		qc_region_zenith_count:bit_9_comment = "The transformation could 
not be completed. Values in the output grid are set to -9999 and the QC_BAD 
bit is also set." ;
		qc_region_zenith_count:bit_10_description = "QC_BAD_STD:  
Standard deviation over averaging interval is greater than limit set by 
transform parameter std_bad_max." ;
		qc_region_zenith_count:bit_10_assessment = "Bad" ;
		qc_region_zenith_count:bit_10_comment = "Applies only to the bin 
average transformation method." ;
		qc_region_zenith_count:bit_11_description = 
"QC_INDETERMINATE_STD:  Standard deviation over averaging interval is greater 
than limit set by transform parameter std_ind_max." ;
		qc_region_zenith_count:bit_11_assessment = "Indeterminate" ;
		qc_region_zenith_count:bit_11_comment = "Applies only to the bin 
average transformation method." ;
		qc_region_zenith_count:bit_12_description = "QC_BAD_GOODFRAC:  
Fraction of good and indeterminate points over averaging interval are less 
than limit set by transform parameter goodfrac_bad_min." ;
		qc_region_zenith_count:bit_12_assessment = "Bad" ;
		qc_region_zenith_count:bit_12_comment = "Applies only to the bin 
average transformation method." ;
		qc_region_zenith_count:bit_13_description = 
"QC_INDETERMINATE_GOODFRAC:  Fraction of good and indeterminate points over 
averaging interval is less than limit set by transform parameter 
goodfrac_ind_min." ;
		qc_region_zenith_count:bit_13_assessment = "Indeterminate" ;
		qc_region_zenith_count:bit_13_comment = "Applies only to the bin 
average transformation method." ;
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      float solar_altitude(time) ;
            solar_altitude:long_name = "Sun altitude above horizon" ;
            solar_altitude:units = "degree" ;
            solar_altitude:valid_min = -90.f ;
            solar_altitude:valid_max = 90.f ;
            solar_altitude:resolution = 1.f ;
            solar_altitude:missing_value = -9999.f ;
            solar_altitude:ancillary_variables = "qc_solar_altitude" ;
            solar_altitude:cell_transform = "time: TRANS_BIN_AVERAGE" ;
      int qc_solar_altitude(time) ;
            qc_solar_altitude:long_name = "Quality check results on field:
Sun altitude above horizon" ;
            qc_solar_altitude:units = "1" ;
            qc_solar_altitude:description = "This field contains bit packed
integer values, where each bit represents a QC test on the data. Non-zero
bits indicate the QC condition given in the description for those bits; a
value of 0 (no bits set) indicates the data has not failed any QC tests." ;
            qc_solar_altitude:flag_method = "bit" ;
            qc_solar_altitude:bit_1_description = "QC_BAD:  Transformation
could not finish, value set to missing_value." ;
            qc_solar_altitude:bit_1_assessment = "Bad" ;
            qc_solar_altitude:bit_2_description = "QC_INDETERMINATE:  Some,
or all, of the input values used to create this output value had a QC
assessment of Indeterminate." ;
            qc_solar_altitude:bit_2_assessment = "Indeterminate" ;
            qc_solar_altitude:bit_1_comment = "An example that will trip this
bit is if all values are bad or outside range." ;
            qc_solar_altitude:bit_3_description = "QC_INTERPOLATE:  Indicates
a non-standard interpolation using points other than the two that bracket the
target index was applied." ;
            qc_solar_altitude:bit_3_assessment = "Indeterminate" ;
            qc_solar_altitude:bit_3_comment = "An example of why this may
occur is if one or both of the nearest points was flagged as bad.  Applies
only to interpolate transformation method." ;
            qc_solar_altitude:bit_4_description = "QC_EXTRAPOLATE:  Indicates
extrapolation is performed out from two points on the same side of the target
index." ;
            qc_solar_altitude:bit_4_assessment = "Indeterminate" ;
            qc_solar_altitude:bit_4_comment = "This occurs because the input
grid does not span the output grid, or because all the points within range
and on one side of the target were flagged as bad.  Applies only to the
interpolate transformation method." ;
            qc_solar_altitude:bit_5_description = "QC_NOT_USING_CLOSEST:
Nearest good point is not the nearest actual point." ;
            qc_solar_altitude:bit_5_assessment = "Indeterminate" ;
            qc_solar_altitude:bit_5_comment = "Applies only to subsample
transformation method." ;
            qc_solar_altitude:bit_6_description = "QC_SOME_BAD_INPUTS:  Some,
but not all, of the inputs in the averaging window were flagged as bad and
excluded from the transform." ;
            qc_solar_altitude:bit_6_assessment = "Indeterminate" ;
            qc_solar_altitude:bit_6_comment = "Applies only to the bin
average transformation method." ;
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```
            qc_solar_altitude:bit_7_description = "QC_ZERO_WEIGHT:  The
weights for all the input points to be averaged for this output bin were set
to zero." ;
            qc_solar_altitude:bit_7_assessment = "Indeterminate" ;
            qc_solar_altitude:bit_7_comment = "The output \"average\" value
is set to zero, independent of the value of the input.  Applies only to bin
average transformation method." ;
            qc_solar_altitude:bit_8_description = "QC_OUTSIDE_RANGE:  No
input samples exist in the transformation region, value set to
missing_value." ;
            qc_solar_altitude:bit_8_assessment = "Bad" ;
            qc_solar_altitude:bit_8_comment = "Nearest good bracketing points
are farther away than the \"range\" transform parameter if transformation is
done using the interpolate or subsample method, or \"width\" if a bin average
transform is applied.  Test can also fail if more than half an input bin is
extrapolated beyond the first or last point of the input grid." ;
            qc_solar_altitude:bit_9_description = "QC_ALL_BAD_INPUTS:  All
the input values in the transformation region are bad, value set to
missing_value." ;
            qc_solar_altitude:bit_9_assessment = "Bad" ;
            qc_solar_altitude:bit_9_comment = "The transformation could not
be completed. Values in the output grid are set to -9999 and the QC_BAD bit
is also set." ;
            qc_solar_altitude:bit_10_description = "QC_BAD_STD:  Standard
deviation over averaging interval is greater than limit set by transform
parameter std_bad_max." ;
            qc_solar_altitude:bit_10_assessment = "Bad" ;
            qc_solar_altitude:bit_10_comment = "Applies only to the bin
average transformation method." ;
            qc_solar_altitude:bit_11_description = "QC_INDETERMINATE_STD:
Standard deviation over averaging interval is greater than limit set by
transform parameter std_ind_max." ;
            qc_solar_altitude:bit_11_assessment = "Indeterminate" ;
            qc_solar_altitude:bit_11_comment = "Applies only to the bin
average transformation method." ;
            qc_solar_altitude:bit_12_description = "QC_BAD_GOODFRAC:
Fraction of good and indeterminate points over averaging interval are less
than limit set by transform parameter goodfrac_bad_min." ;
            qc_solar_altitude:bit_12_assessment = "Bad" ;
            qc_solar_altitude:bit_12_comment = "Applies only to the bin
average transformation method." ;
            qc_solar_altitude:bit_13_description =
"QC_INDETERMINATE_GOODFRAC:  Fraction of good and indeterminate points over
averaging interval is less than limit set by transform parameter
goodfrac_ind_min." ;
            qc_solar_altitude:bit_13_assessment = "Indeterminate" ;
            qc_solar_altitude:bit_13_comment = "Applies only to the bin
average transformation method." ;
      float lat ;
            lat:long_name = "North latitude" ;
            lat:units = "degree_N" ;
            lat:valid_min = -90.f ;
            lat:valid_max = 90.f ;
            lat:standard_name = "latitude" ;
      float lon ;
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```
            lon:long_name = "East longitude" ;
            lon:units = "degree_E" ;
            lon:valid_min = -180.f ;
            lon:valid_max = 180.f ;
            lon:standard_name = "longitude" ;
      float alt ;
            alt:long_name = "Altitude above mean sea level" ;
            alt:units = "m" ;
            alt:standard_name = "altitude" ;

// global attributes:
            :command_line = "idl -R -n cldfracset -n cldfracset -s sgp -f C1
-b 20190404 --asynchronous" ;
            :Conventions = "ARM-1.2" ;
            :process_version = "vap-cldfracset-1.2-0.el6" ;
            :dod_version = "cldfracset01m-c1-1.0" ;
            :input_datastreams = "sgparsclkazr1kolliasC1.c0 : 1.2 :
20190403.000000-20190405.000000\n",
                  "sgptsiskycoverC1.b1 : 12.8 : 20190403.000000-
20190405.000000" ;
            :site_id = "sgp" ;
            :platform_id = "cldfracset01m" ;
            :facility_id = "C1" ;
            :data_level = "c1" ;
            :location_description = "Southern Great Plains (SGP), Lamont,
Oklahoma" ;
            :datastream = "sgpcldfracset01mC1.c1" ;
            :averaging_interval = "1 min" ;
            :doi = "10.5439/1523482" ;
            :history = "created by user malynn on machine chalk at 2020-02-21
19:20:43, using vap-cldfracset-1.2-0.el6" ;
}
```

File: *.../sgplassoblthermoC1.c1/data/sgplassoblthermoC1.c1.20190404.113500.nc*

Description: The mid-boundary-layer moisture from the Raman lidar and temperature from the AERIoe VAP, i.e., the *lassoblthermo* VAP.

```
netcdf sgplassoblthermoC1.c1.20190404.113500 {
dimensions:
      time = UNLIMITED ; // (144 currently)
      bound = 2 ;
variables:
      int base_time ;
            base_time:string = "2019-04-04 00:00:00 0:00" ;
            base_time:long_name = "Base time in Epoch" ;
            base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
            base_time:ancillary_variables = "time_offset" ;
      double time_offset(time) ;
            time_offset:long_name = "Time offset from base_time" ;
            time_offset:units = "seconds since 2019-04-04 00:00:00 0:00" ;
            time_offset:ancillary_variables = "base_time" ;
      double time(time) ;
            time:long_name = "Time offset from midnight" ;
            time:units = "seconds since 2019-04-04 00:00:00 0:00" ;
```

```
            time:bounds = "time_bounds" ;
            time:calendar = "gregorian" ;
            time:standard_name = "time" ;
      double time_bounds(time, bound) ;
            time_bounds:long_name = "Time cell bounds" ;
            time_bounds:bound_offsets = -300., 300. ;
      float temperature(time) ;
            temperature:long_name = "Temperature: average between 500 - 700m"
;
            temperature:units = "degC" ;
            temperature:valid_min = -90.f ;
            temperature:valid_max = 50.f ;
            temperature:missing_value = -9999.f ;
            temperature:source = "sgpaerioe1turnC1.c1:temperature" ;
            temperature:ancillary_variables = "qc_temperature" ;
      int qc_temperature(time) ;
            qc_temperature:long_name = "Quality check results on field:
Temperature: average between 500 - 700m" ;
            qc_temperature:units = "1" ;
            qc_temperature:description = "This field contains bit packed
integer values, where each bit represents a QC test on the data. Non-zero
bits indicate the QC condition given in the description for those bits; a
value of 0 (no bits set) indicates the data has not failed any QC tests." ;
            qc_temperature:flag_method = "bit" ;
            qc_temperature:bit_1_description = "Value is less than the
valid_min." ;
            qc_temperature:bit_1_assessment = "Indeterminate" ;
            qc_temperature:bit_2_description = "Value is greater than the
valid_max." ;
            qc_temperature:bit_2_assessment = "Indeterminate" ;
            qc_temperature:bit_3_description = "Data value not available in
input file, data value has been set to missing_value." ;
            qc_temperature:bit_3_assessment = "Bad" ;
      float water_vapor_mixing_ratio(time) ;
            water_vapor_mixing_ratio:long_name = "Water vapor mixing ratio:
average between 500 - 700m" ;
            water_vapor_mixing_ratio:units = "g/kg" ;
            water_vapor_mixing_ratio:valid_min = 0.f ;
            water_vapor_mixing_ratio:valid_max = 100.f ;
            water_vapor_mixing_ratio:missing_value = -9999.f ;
            water_vapor_mixing_ratio:source =
"sgprlprofmr2news10mC1.c0:mr_merged" ;
            water_vapor_mixing_ratio:ancillary_variables =
"qc_water_vapor_mixing_ratio" ;
      int qc_water_vapor_mixing_ratio(time) ;
            qc_water_vapor_mixing_ratio:long_name = "Quality check results on
field: Water vapor mixing ratio: average between 500 - 700m" ;
            qc_water_vapor_mixing_ratio:units = "1" ;
            qc_water_vapor_mixing_ratio:description = "This field contains
bit packed integer values, where each bit represents a QC test on the data.
Non-zero bits indicate the QC condition given in the description for those
bits; a value of 0 (no bits set) indicates the data has not failed any QC
tests." ;
            qc_water_vapor_mixing_ratio:flag_method = "bit" ;
```

```
            qc_water_vapor_mixing_ratio:bit_1_description = "Value is less
than the valid_min." ;
            qc_water_vapor_mixing_ratio:bit_1_assessment = "Indeterminate" ;
            qc_water_vapor_mixing_ratio:bit_2_description = "Value is greater
than the valid_max." ;
            qc_water_vapor_mixing_ratio:bit_2_assessment = "Indeterminate" ;
            qc_water_vapor_mixing_ratio:bit_3_description = "Data value not
available in input file, data value has been set to missing_value." ;
            qc_water_vapor_mixing_ratio:bit_3_assessment = "Bad" ;
      float relative_humidity(time) ;
            relative_humidity:long_name = "Relative humidity: average between
500 - 700m" ;
            relative_humidity:units = "%" ;
            relative_humidity:valid_min = 0.f ;
            relative_humidity:valid_max = 100.f ;
            relative_humidity:missing_value = -9999.f ;
            relative_humidity:ancillary_variables = "qc_relative_humidity" ;
      int qc_relative_humidity(time) ;
            qc_relative_humidity:long_name = "Quality check results on field:
Relative humidity: average between 500 - 700m" ;
            qc_relative_humidity:units = "1" ;
            qc_relative_humidity:description = "This field contains bit
packed integer values, where each bit represents a QC test on the data. Non-
zero bits indicate the QC condition given in the description for those bits;
a value of 0 (no bits set) indicates the data has not failed any QC tests." ;
            qc_relative_humidity:flag_method = "bit" ;
            qc_relative_humidity:bit_1_description = "Value is less than the
valid_min." ;
            qc_relative_humidity:bit_1_assessment = "Indeterminate" ;
            qc_relative_humidity:bit_2_description = "Value is greater than
the valid_max." ;
            qc_relative_humidity:bit_2_assessment = "Indeterminate" ;
            qc_relative_humidity:bit_3_description = "Data value not
available in input file, data value has been set to missing_value." ;
            qc_relative_humidity:bit_3_assessment = "Bad" ;
      float pressure(time) ;
            pressure:long_name = "Pressure: average between 500 - 700m" ;
            pressure:units = "mb" ;
            pressure:valid_min = 0.f ;
            pressure:valid_max = 1100.f ;
            pressure:missing_value = -9999.f ;
            pressure:source = "sgprlprofmr2news10mC1.c0:pres_sonde" ;
            pressure:ancillary_variables = "qc_pressure" ;
      int qc_pressure(time) ;
            qc_pressure:long_name = "Quality check results on field:
Pressure: average between 500 - 700m" ;
            qc_pressure:units = "1" ;
            qc_pressure:description = "This field contains bit packed integer
values, where each bit represents a QC test on the data. Non-zero bits
indicate the QC condition given in the description for those bits; a value of
0 (no bits set) indicates the data has not failed any QC tests." ;
            qc_pressure:flag_method = "bit" ;
            qc_pressure:bit_1_description = "Value is less than the
valid_min." ;
            qc_pressure:bit_1_assessment = "Indeterminate" ;
```

```
            qc_pressure:bit_2_description = "Value is greater than the
valid_max." ;
            qc_pressure:bit_2_assessment = "Indeterminate" ;
            qc_pressure:bit_3_description = "Data value not available in
input file, data value has been set to missing_value." ;
            qc_pressure:bit_3_assessment = "Bad" ;
      float lat ;
            lat:long_name = "North latitude" ;
            lat:units = "degree_N" ;
            lat:valid_min = -90.f ;
            lat:valid_max = 90.f ;
            lat:standard_name = "latitude" ;
      float lon ;
            lon:long_name = "East longitude" ;
            lon:units = "degree_E" ;
            lon:valid_min = -180.f ;
            lon:valid_max = 180.f ;
            lon:standard_name = "longitude" ;
      float alt ;
            alt:long_name = "Altitude above mean sea level" ;
            alt:units = "m" ;
            alt:standard_name = "altitude" ;

// global attributes:
            :command_line = "idl -R -n lassoblthermo -s sgp -f C1 -b
20190404.113000 -e 20190405.113000 -R" ;
            :Conventions = "ARM-1.2" ;
            :process_version = "vap-lassoblthermo-1.1-2.el7" ;
            :dod_version = "lassoblthermo-c1-2.0" ;
            :input_datastreams = "sgpaerioe1turnC1.c1 : Unknown :
20190404.000748-20190405.000547\n",
                  "sgprlprofmr2news10mC1.c0 : 1.1 : 20190404.000500-
20190405.000500" ;
            :site_id = "sgp" ;
            :platform_id = "lassoblthermo" ;
            :facility_id = "C1" ;
            :data_level = "c1" ;
            :location_description = "Southern Great Plains (SGP), Lamont,
Oklahoma" ;
            :doi = "10.5439/1342961" ;
            :datastream = "sgplassoblthermoC1.c1" ;
            :history = "created by user ttoto on machine agate at 2020-06-08
19:10:46, using vap-lassoblthermo-1.1-2.el7" ;
}
```

Files: *.../sgplassodlcbhshcuC1.c1/data/sgplassodlcbhshcuC1.c1.20190404.113000.nc*
.../sgplassodlcbhshcuE32.c1/data/sgplassodlcbhshcuE32.c1.20190404.113000.nc
.../sgplassodlcbhshcuE37.c1/data/sgplassodlcbhshcuE37.c1.20190404.113000.nc
.../sgplassodlcbhshcuE39.c1/data/sgplassodlcbhshcuE39.c1.20190404.113000.nc
.../sgplassodlcbhshcuE41.c1/data/sgplassodlcbhshcuE41.c1.20190404.113000.nc

Description: Shallow convection cloud-base heights determined from the Doppler lidars at the SGP, i.e., the *lassodlcbhshcu* VAP. There are five locations, each with a separate file: C1, E32, E37, E39, and E41. The file from the C1 location is shown below.

```
netcdf sgplassodlcbhshcuC1.c1.20190404.113000 {
dimensions:
      time = UNLIMITED ; // (91 currently)
      bound = 2 ;
variables:
      int base_time ;
            base_time:string = "2019-04-04 00:00:00 0:00" ;
            base_time:long_name = "Base time in Epoch" ;
            base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
            base_time:ancillary_variables = "time_offset" ;
      double time_offset(time) ;
            time_offset:long_name = "Time offset from base_time" ;
            time_offset:units = "seconds since 2019-04-04 00:00:00 0:00" ;
            time_offset:ancillary_variables = "base_time" ;
      double time(time) ;
            time:long_name = "Time offset from midnight" ;
            time:units = "seconds since 2019-04-04 00:00:00 0:00" ;
            time:bounds = "time_bounds" ;
            time:calendar = "gregorian" ;
            time:standard_name = "time" ;
      double time_bounds(time, bound) ;
            time_bounds:long_name = "Time cell bounds" ;
            time_bounds:bound_offsets = -30., 30. ;
      float dl_cbh_25(time) ;
            dl_cbh_25:long_name = "Cloud base height with respect to ground
surface" ;
            dl_cbh_25:source = "sgpdlprofwstats4newsC1.c1:dl_cbh_25" ;
            dl_cbh_25:units = "m" ;
            dl_cbh_25:missing_value = -9999.f ;
      float lcl(time) ;
            lcl:long_name = "Lifting condensation level" ;
            lcl:units = "m" ;
            lcl:missing_value = -9999.f ;
            lcl:standard_name =
"atmosphere_lifting_condensation_level_wrt_surface" ;
      float cloud_base_height(time) ;
            cloud_base_height:long_name = "Shallow cumulus cloud base height
with respect to ground surface" ;
            cloud_base_height:units = "m" ;
            cloud_base_height:missing_value = -9999.f ;
            cloud_base_height:valid_range = 0.f, 5000.f ;
            cloud_base_height:flag_values = -1.f ;
            cloud_base_height:flag_meanings = "no_shallow_cumulus" ;
            cloud_base_height:comment = "-1. no shallow cumulus, >= 0. valid
cloud base height" ;
      float lat ;
            lat:long_name = "North latitude" ;
            lat:units = "degree_N" ;
            lat:valid_min = -90.f ;
            lat:valid_max = 90.f ;
            lat:standard_name = "latitude" ;
      float lon ;
            lon:long_name = "East longitude" ;
            lon:units = "degree_E" ;
            lon:valid_min = -180.f ;
```

```
            lon:valid_max = 180.f ;
            lon:standard_name = "longitude" ;
      float alt ;
            alt:long_name = "Altitude above mean sea level" ;
            alt:units = "m" ;
            alt:standard_name = "altitude" ;

// global attributes:
            :command_line = "lassodlcbhshcu -s sgp -f C1 -b 20190404 -R" ;
            :Conventions = "ARM-1.2" ;
            :process_version = "vap-lassodlcbhshcu-1.2-3.el7" ;
            :dod_version = "lassodlcbhshcu-c1-1.0" ;
            :input_datastreams = "sgpdlprofwstats4newsC1.c1 : 0.4 :
20190404.000000-20190405.000000\n",
                  "sgplclC1.c1 : 1.1 : 20190404.000000-20190405.000000" ;
            :site_id = "sgp" ;
            :platform_id = "lassodlcbhshcu" ;
            :facility_id = "C1" ;
            :data_level = "c1" ;
            :location_description = "Southern Great Plains (SGP), Lamont,
Oklahoma" ;
            :doi = "10.5439/1342961" ;
            :datastream = "sgplassodlcbhshcuC1.c1" ;
            :history = "created by user ttoto on machine agate at 2020-06-11
15:46:27, using vap-lassodlcbhshcu-1.2-3.el7" ;
}
```

File: *.../sgplassolwpC1.c1/data/sgplassolwpC1.c1.20190404.000000.nc*

Description: The LASSO LWP VAP, i.e., *lassolwp*, that contains LWP retrieved from the AERIoe VAP and MWRRet1 VAP.

```
netcdf sgplassolwpC1.c1.20190404.000000 {
dimensions:
      time = UNLIMITED ; // (8640 currently)
      bound = 2 ;
variables:
      int base_time ;
            base_time:string = "2019-04-04 00:00:00 0:00" ;
            base_time:long_name = "Base time in Epoch" ;
            base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
            base_time:ancillary_variables = "time_offset" ;
      double time_offset(time) ;
            time_offset:long_name = "Time offset from base_time" ;
            time_offset:units = "seconds since 2019-04-04 00:00:00 0:00" ;
            time_offset:ancillary_variables = "base_time" ;
      double time(time) ;
            time:long_name = "Time offset from midnight" ;
            time:units = "seconds since 2019-04-04 00:00:00 0:00" ;
            time:bounds = "time_bounds" ;
            time:calendar = "gregorian" ;
            time:standard_name = "time" ;
      double time_bounds(time, bound) ;
            time_bounds:long_name = "Time cell bounds" ;
            time_bounds:bound_offsets = -5., 5. ;
```

```
      float aerioe_lwp(time) ;
            aerioe_lwp:long_name = "Liquid water path from AERIoe" ;
            aerioe_lwp:units = "g/m^2" ;
            aerioe_lwp:missing_value = -9999.f ;
            aerioe_lwp:ancillary_variables = " qc_aerioe_lwp" ;
            aerioe_lwp:cell_transform = "time: TRANS_INTERPOLATE (range: 20)"
;
      int qc_aerioe_lwp(time) ;
            qc_aerioe_lwp:long_name = "Quality check results on field: Liquid
water path from AERIoe" ;
            qc_aerioe_lwp:units = "1" ;
            qc_aerioe_lwp:description = "This field contains bit packed
integer values, where each bit represents a QC test on the data. Non-zero
bits indicate the QC condition given in the description for those bits; a
value of 0 (no bits set) indicates the data has not failed any QC tests." ;
            qc_aerioe_lwp:flag_method = "bit" ;
            qc_aerioe_lwp:bit_1_description = "QC_BAD:  Transformation could
not finish, value set to missing_value." ;
            qc_aerioe_lwp:bit_1_assessment = "Bad" ;
            qc_aerioe_lwp:bit_2_description = "QC_INDETERMINATE:  Some, or
all, of the input values used to create this output value had a QC assessment
of Indeterminate." ;
            qc_aerioe_lwp:bit_2_assessment = "Indeterminate" ;
            qc_aerioe_lwp:bit_1_comment = "An example that will trip this bit
is if all values are bad or outside range." ;
            qc_aerioe_lwp:bit_3_description = "QC_INTERPOLATE:  Indicates a
non-standard interpolation using points other than the two that bracket the
target index was applied." ;
            qc_aerioe_lwp:bit_3_assessment = "Indeterminate" ;
            qc_aerioe_lwp:bit_3_comment = "An example of why this may occur
is if one or both of the nearest points was flagged as bad.  Applies only to
interpolate transformation method." ;
            qc_aerioe_lwp:bit_4_description = "QC_EXTRAPOLATE:  Indicates
extrapolation is performed out from two points on the same side of the target
index." ;
            qc_aerioe_lwp:bit_4_assessment = "Indeterminate" ;
            qc_aerioe_lwp:bit_4_comment = "This occurs because the input grid
does not span the output grid, or because all the points within range and on
one side of the target were flagged as bad.  Applies only to the interpolate
transformation method." ;
            qc_aerioe_lwp:bit_5_description = "QC_NOT_USING_CLOSEST:  Nearest
good point is not the nearest actual point." ;
            qc_aerioe_lwp:bit_5_assessment = "Indeterminate" ;
            qc_aerioe_lwp:bit_5_comment = "Applies only to subsample
transformation method." ;
            qc_aerioe_lwp:bit_6_description = "QC_SOME_BAD_INPUTS:  Some, but
not all, of the inputs in the averaging window were flagged as bad and
excluded from the transform." ;
            qc_aerioe_lwp:bit_6_assessment = "Indeterminate" ;
            qc_aerioe_lwp:bit_6_comment = "Applies only to the bin average
transformation method." ;
            qc_aerioe_lwp:bit_7_description = "QC_ZERO_WEIGHT:  The weights
for all the input points to be averaged for this output bin were set to
zero." ;
            qc_aerioe_lwp:bit_7_assessment = "Indeterminate" ;
```

```
            qc_aerioe_lwp:bit_7_comment = "The output \"average\" value is
set to zero, independent of the value of the input.  Applies only to bin
average transformation method." ;
            qc_aerioe_lwp:bit_8_description = "QC_OUTSIDE_RANGE:  No input
samples exist in the transformation region, value set to missing_value." ;
            qc_aerioe_lwp:bit_8_assessment = "Bad" ;
            qc_aerioe_lwp:bit_8_comment = "Nearest good bracketing points are
farther away than the \"range\" transform parameter if transformation is done
using the interpolate or subsample method, or \"width\" if a bin average
transform is applied.  Test can also fail if more than half an input bin is
extrapolated beyond the first or last point of the input grid." ;
            qc_aerioe_lwp:bit_9_description = "QC_ALL_BAD_INPUTS:  All the
input values in the transformation region are bad, value set to
missing_value." ;
            qc_aerioe_lwp:bit_9_assessment = "Bad" ;
            qc_aerioe_lwp:bit_9_comment = "The transformation could not be
completed. Values in the output grid are set to -9999 and the QC_BAD bit is
also set." ;
            qc_aerioe_lwp:bit_10_description = "QC_BAD_STD:  Standard
deviation over averaging interval is greater than limit set by transform
parameter std_bad_max." ;
            qc_aerioe_lwp:bit_10_assessment = "Bad" ;
            qc_aerioe_lwp:bit_10_comment = "Applies only to the bin average
transformation method." ;
            qc_aerioe_lwp:bit_11_description = "QC_INDETERMINATE_STD:
Standard deviation over averaging interval is greater than limit set by
transform parameter std_ind_max." ;
            qc_aerioe_lwp:bit_11_assessment = "Indeterminate" ;
            qc_aerioe_lwp:bit_11_comment = "Applies only to the bin average
transformation method." ;
            qc_aerioe_lwp:bit_12_description = "QC_BAD_GOODFRAC:  Fraction of
good and indeterminate points over averaging interval are less than limit set
by transform parameter goodfrac_bad_min." ;
            qc_aerioe_lwp:bit_12_assessment = "Bad" ;
            qc_aerioe_lwp:bit_12_comment = "Applies only to the bin average
transformation method." ;
            qc_aerioe_lwp:bit_13_description = "QC_INDETERMINATE_GOODFRAC:
Fraction of good and indeterminate points over averaging interval is less
than limit set by transform parameter goodfrac_ind_min." ;
            qc_aerioe_lwp:bit_13_assessment = "Indeterminate" ;
            qc_aerioe_lwp:bit_13_comment = "Applies only to the bin average
transformation method." ;
      float mwrret_lwp(time) ;
            mwrret_lwp:long_name = "Liquid water path from MWRRET" ;
            mwrret_lwp:units = "g/m^2" ;
            mwrret_lwp:missing_value = -9999.f ;
            mwrret_lwp:ancillary_variables = " qc_mwrret_lwp" ;
            mwrret_lwp:cell_transform = "time: TRANS_INTERPOLATE (range: 60)"
;
      int qc_mwrret_lwp(time) ;
            qc_mwrret_lwp:long_name = "Quality check results on field: Liquid
water path from MWRRET" ;
            qc_mwrret_lwp:units = "1" ;
            qc_mwrret_lwp:description = "This field contains bit packed
integer values, where each bit represents a QC test on the data. Non-zero
```

```
bits indicate the QC condition given in the description for those bits; a
value of 0 (no bits set) indicates the data has not failed any QC tests." ;
            qc_mwrret_lwp:flag_method = "bit" ;
            qc_mwrret_lwp:bit_1_description = "QC_BAD:  Transformation could
not finish, value set to missing_value." ;
            qc_mwrret_lwp:bit_1_assessment = "Bad" ;
            qc_mwrret_lwp:bit_2_description = "QC_INDETERMINATE:  Some, or
all, of the input values used to create this output value had a QC assessment
of Indeterminate." ;
            qc_mwrret_lwp:bit_2_assessment = "Indeterminate" ;
            qc_mwrret_lwp:bit_1_comment = "An example that will trip this bit
is if all values are bad or outside range." ;
            qc_mwrret_lwp:bit_3_description = "QC_INTERPOLATE:  Indicates a
non-standard interpolation using points other than the two that bracket the
target index was applied." ;
            qc_mwrret_lwp:bit_3_assessment = "Indeterminate" ;
            qc_mwrret_lwp:bit_3_comment = "An example of why this may occur
is if one or both of the nearest points was flagged as bad.  Applies only to
interpolate transformation method." ;
            qc_mwrret_lwp:bit_4_description = "QC_EXTRAPOLATE:  Indicates
extrapolation is performed out from two points on the same side of the target
index." ;
            qc_mwrret_lwp:bit_4_assessment = "Indeterminate" ;
            qc_mwrret_lwp:bit_4_comment = "This occurs because the input grid
does not span the output grid, or because all the points within range and on
one side of the target were flagged as bad.  Applies only to the interpolate
transformation method." ;
            qc_mwrret_lwp:bit_5_description = "QC_NOT_USING_CLOSEST:  Nearest
good point is not the nearest actual point." ;
            qc_mwrret_lwp:bit_5_assessment = "Indeterminate" ;
            qc_mwrret_lwp:bit_5_comment = "Applies only to subsample
transformation method." ;
            qc_mwrret_lwp:bit_6_description = "QC_SOME_BAD_INPUTS:  Some, but
not all, of the inputs in the averaging window were flagged as bad and
excluded from the transform." ;
            qc_mwrret_lwp:bit_6_assessment = "Indeterminate" ;
            qc_mwrret_lwp:bit_6_comment = "Applies only to the bin average
transformation method." ;
            qc_mwrret_lwp:bit_7_description = "QC_ZERO_WEIGHT:  The weights
for all the input points to be averaged for this output bin were set to
zero." ;
            qc_mwrret_lwp:bit_7_assessment = "Indeterminate" ;
            qc_mwrret_lwp:bit_7_comment = "The output \"average\" value is
set to zero, independent of the value of the input.  Applies only to bin
average transformation method." ;
            qc_mwrret_lwp:bit_8_description = "QC_OUTSIDE_RANGE:  No input
samples exist in the transformation region, value set to missing_value." ;
            qc_mwrret_lwp:bit_8_assessment = "Bad" ;
            qc_mwrret_lwp:bit_8_comment = "Nearest good bracketing points are
farther away than the \"range\" transform parameter if transformation is done
using the interpolate or subsample method, or \"width\" if a bin average
transform is applied.  Test can also fail if more than half an input bin is
extrapolated beyond the first or last point of the input grid." ;
```

```
            qc_mwrret_lwp:bit_9_description = "QC_ALL_BAD_INPUTS:  All the
input values in the transformation region are bad, value set to
missing_value." ;
            qc_mwrret_lwp:bit_9_assessment = "Bad" ;
            qc_mwrret_lwp:bit_9_comment = "The transformation could not be
completed. Values in the output grid are set to -9999 and the QC_BAD bit is
also set." ;
            qc_mwrret_lwp:bit_10_description = "QC_BAD_STD:  Standard
deviation over averaging interval is greater than limit set by transform
parameter std_bad_max." ;
            qc_mwrret_lwp:bit_10_assessment = "Bad" ;
            qc_mwrret_lwp:bit_10_comment = "Applies only to the bin average
transformation method." ;
            qc_mwrret_lwp:bit_11_description = "QC_INDETERMINATE_STD:
Standard deviation over averaging interval is greater than limit set by
transform parameter std_ind_max." ;
            qc_mwrret_lwp:bit_11_assessment = "Indeterminate" ;
            qc_mwrret_lwp:bit_11_comment = "Applies only to the bin average
transformation method." ;
            qc_mwrret_lwp:bit_12_description = "QC_BAD_GOODFRAC:  Fraction of
good and indeterminate points over averaging interval are less than limit set
by transform parameter goodfrac_bad_min." ;
            qc_mwrret_lwp:bit_12_assessment = "Bad" ;
            qc_mwrret_lwp:bit_12_comment = "Applies only to the bin average
transformation method." ;
            qc_mwrret_lwp:bit_13_description = "QC_INDETERMINATE_GOODFRAC:
Fraction of good and indeterminate points over averaging interval is less
than limit set by transform parameter goodfrac_ind_min." ;
            qc_mwrret_lwp:bit_13_assessment = "Indeterminate" ;
            qc_mwrret_lwp:bit_13_comment = "Applies only to the bin average
transformation method." ;
      float lwp(time) ;
            lwp:long_name = "Liquid water path" ;
            lwp:units = "g/m^2" ;
            lwp:missing_value = -9999.f ;
            lwp:ancillary_variables = " source_lwp" ;
      int source_lwp(time) ;
            source_lwp:long_name = "Source for field: Liquid water path" ;
            source_lwp:units = "unitless" ;
            source_lwp:description = "This field contains integer values
which should be interpreted as listed." ;
            source_lwp:flag_method = "integer" ;
            source_lwp:flag_0_description = "aerioe1turn.c1:lwp" ;
            source_lwp:flag_1_description = "mwrret1liljclou.c1:be_lwp" ;
            source_lwp:missing_value = -9999 ;
      float lat ;
            lat:long_name = "North latitude" ;
            lat:units = "degree_N" ;
            lat:valid_min = -90.f ;
            lat:valid_max = 90.f ;
            lat:standard_name = "latitude" ;
      float lon ;
            lon:long_name = "East longitude" ;
            lon:units = "degree_E" ;
            lon:valid_min = -180.f ;
```

```
            lon:valid_max = 180.f ;
            lon:standard_name = "longitude" ;
      float alt ;
            alt:long_name = "Altitude above mean sea level" ;
            alt:units = "m" ;
            alt:standard_name = "altitude" ;

// global attributes:
            :command_line = "idl -R -n lassolwp -s sgp -f C1 -b 20190404 -R"
;
            :Conventions = "ARM-1.2" ;
            :process_version = "vap-lassolwp-1.1-1.el7" ;
            :dod_version = "lassolwp-c1-1.0" ;
            :input_datastreams = "sgpaerioe1turnC1.c1 : Unknown :
20190404.000748\n",
                  "sgpmwrret1liljclouC1.c1 : 1.77 : 20190403.000014-
20190405.000015" ;
            :site_id = "sgp" ;
            :platform_id = "lassolwp" ;
            :facility_id = "C1" ;
            :data_level = "c1" ;
            :location_description = "Southern Great Plains (SGP), Lamont,
Oklahoma" ;
            :datastream = "sgplassolwpC1.c1" ;
            :doi = "10.5439/1342961" ;
            :history = "created by user ttoto on machine agate at 2020-06-08
19:22:33, using vap-lassolwp-1.1-1.el7" ;
}
```

File: *.../sgplclC1.c1/data/sgplclC1.c1.20190404.000000.nc*

Description: The LCL VAP for the SGP, i.e., *sgplcl*, that contains LCL values for 190 locations around Oklahoma. Because the LASSO cases cross day boundaries in UTC time, there are two days worth of data for each case, with each day in a separate file.

```
netcdf sgplclC1.c1.20190404.000000 {
dimensions:
      time = UNLIMITED ; // (1440 currently)
      bound = 2 ;
      strlen = 7 ;
      stations = 149 ;
variables:
      int base_time ;
            base_time:string = "2019-04-04 00:00:00 0:00" ;
            base_time:long_name = "Base time in Epoch" ;
            base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
            base_time:ancillary_variables = "time_offset" ;
      double time_offset(time) ;
            time_offset:long_name = "Time offset from base_time" ;
            time_offset:units = "seconds since 2019-04-04 00:00:00 0:00" ;
            time_offset:ancillary_variables = "base_time" ;
      double time(time) ;
            time:long_name = "Time offset from midnight" ;
            time:units = "seconds since 2019-04-04 00:00:00 0:00" ;
            time:bounds = "time_bounds" ;
```

```
            time:calendar = "gregorian" ;
            time:standard_name = "time" ;
      double time_bounds(time, bound) ;
            time_bounds:long_name = "Time cell bounds" ;
            time_bounds:bound_offsets = -30., 30. ;
      char stations_name(stations, strlen) ;
            stations_name:long_name = "Station names" ;
            stations_name:units = "1" ;
      float lcl(time, stations) ;
            lcl:long_name = "Lifting condensation level" ;
            lcl:units = "m" ;
            lcl:missing_value = -9999.f ;
            lcl:standard_name =
"atmosphere_lifting_condensation_level_wrt_surface" ;
            lcl:valid_min = 0.f ;
            lcl:valid_max = 6000.f ;
      float temperature(time, stations) ;
            temperature:long_name = "Atmospheric Temperature" ;
            temperature:units = "K" ;
            temperature:ancillary_variables = "qc_temperature" ;
            temperature:cell_methods = "time: mean" ;
            temperature:missing_value = -9999.f ;
            temperature:standard_name = "air_temperature" ;
            temperature:cell_transform = "time(stations: 0-15:
TRANS_INTERPOLATE (range: 60); time(stations: 16-148:); TRANS_INTERPOLATE
(range: 600) platform: TRANS_PASSTHROUGH qc_bad: -9999,3,4,5,6,7,8,9" ;
      int qc_temperature(time, stations) ;
            qc_temperature:long_name = "Quality check results on field:
Atmospheric Temperature" ;
            qc_temperature:units = "1" ;
            qc_temperature:description = "This field contains bit packed
integer values, where each bit represents a QC test on the data. Non-zero
bits indicate the QC condition given in the description for those bits; a
value of 0 (no bits set) indicates the data has not failed any QC tests." ;
            qc_temperature:flag_method = "bit" ;
            qc_temperature:bit_1_description = "QC_BAD:  Transformation could
not finish, value set to missing_value." ;
            qc_temperature:bit_1_assessment = "Bad" ;
            qc_temperature:bit_2_description = "QC_INDETERMINATE:  Some, or
all, of the input values used to create this output value had a QC assessment
of Indeterminate." ;
            qc_temperature:bit_2_assessment = "Indeterminate" ;
            qc_temperature:bit_1_comment = "An example that will trip this
bit is if all values are bad or outside range." ;
            qc_temperature:bit_3_description = "QC_INTERPOLATE:  Indicates a
non-standard interpolation using points other than the two that bracket the
target index was applied." ;
            qc_temperature:bit_3_assessment = "Indeterminate" ;
            qc_temperature:bit_3_comment = "An example of why this may occur
is if one or both of the nearest points was flagged as bad.  Applies only to
interpolate transformation method." ;
            qc_temperature:bit_4_description = "QC_EXTRAPOLATE:  Indicates
extrapolation is performed out from two points on the same side of the target
index." ;
            qc_temperature:bit_4_assessment = "Indeterminate" ;
```

```
            qc_temperature:bit_4_comment = "This occurs because the input
grid does not span the output grid, or because all the points within range
and on one side of the target were flagged as bad.  Applies only to the
interpolate transformation method." ;
            qc_temperature:bit_5_description = "QC_NOT_USING_CLOSEST:
Nearest good point is not the nearest actual point." ;
            qc_temperature:bit_5_assessment = "Indeterminate" ;
            qc_temperature:bit_5_comment = "Applies only to subsample
transformation method." ;
            qc_temperature:bit_6_description = "QC_SOME_BAD_INPUTS:  Some,
but not all, of the inputs in the averaging window were flagged as bad and
excluded from the transform." ;
            qc_temperature:bit_6_assessment = "Indeterminate" ;
            qc_temperature:bit_6_comment = "Applies only to the bin average
transformation method." ;
            qc_temperature:bit_7_description = "QC_ZERO_WEIGHT:  The weights
for all the input points to be averaged for this output bin were set to
zero." ;
            qc_temperature:bit_7_assessment = "Indeterminate" ;
            qc_temperature:bit_7_comment = "The output \"average\" value is
set to zero, independent of the value of the input.  Applies only to bin
average transformation method." ;
            qc_temperature:bit_8_description = "QC_OUTSIDE_RANGE:  No input
samples exist in the transformation region, value set to missing_value." ;
            qc_temperature:bit_8_assessment = "Bad" ;
            qc_temperature:bit_8_comment = "Nearest good bracketing points
are farther away than the \"range\" transform parameter if transformation is
done using the interpolate or subsample method, or \"width\" if a bin average
transform is applied.  Test can also fail if more than half an input bin is
extrapolated beyond the first or last point of the input grid." ;
            qc_temperature:bit_9_description = "QC_ALL_BAD_INPUTS:  All the
input values in the transformation region are bad, value set to
missing_value." ;
            qc_temperature:bit_9_assessment = "Bad" ;
            qc_temperature:bit_9_comment = "The transformation could not be
completed. Values in the output grid are set to -9999 and the QC_BAD bit is
also set." ;
            qc_temperature:bit_10_description = "QC_BAD_STD:  Standard
deviation over averaging interval is greater than limit set by transform
parameter std_bad_max." ;
            qc_temperature:bit_10_assessment = "Bad" ;
            qc_temperature:bit_10_comment = "Applies only to the bin average
transformation method." ;
            qc_temperature:bit_11_description = "QC_INDETERMINATE_STD:
Standard deviation over averaging interval is greater than limit set by
transform parameter std_ind_max." ;
            qc_temperature:bit_11_assessment = "Indeterminate" ;
            qc_temperature:bit_11_comment = "Applies only to the bin average
transformation method." ;
            qc_temperature:bit_12_description = "QC_BAD_GOODFRAC:  Fraction
of good and indeterminate points over averaging interval are less than limit
set by transform parameter goodfrac_bad_min." ;
            qc_temperature:bit_12_assessment = "Bad" ;
            qc_temperature:bit_12_comment = "Applies only to the bin average
transformation method." ;
```

```
            qc_temperature:bit_13_description = "QC_INDETERMINATE_GOODFRAC:
Fraction of good and indeterminate points over averaging interval is less
than limit set by transform parameter goodfrac_ind_min." ;
            qc_temperature:bit_13_assessment = "Indeterminate" ;
            qc_temperature:bit_13_comment = "Applies only to the bin average
transformation method." ;
      float relative_humidity(time, stations) ;
            relative_humidity:long_name = "Relative humidity" ;
            relative_humidity:units = "%" ;
            relative_humidity:ancillary_variables = "qc_relative_humidity" ;
            relative_humidity:cell_methods = "time: mean" ;
            relative_humidity:missing_value = -9999.f ;
            relative_humidity:standard_name = "relative_humidity" ;
            relative_humidity:cell_transform = "time(stations: 0-15:
TRANS_INTERPOLATE (range: 60); time(stations: 16-148:); TRANS_INTERPOLATE
(range: 600) platform: TRANS_PASSTHROUGH qc_bad: -9999,3,4,5,6,7,8,9" ;
      int qc_relative_humidity(time, stations) ;
            qc_relative_humidity:long_name = "Quality check results on field:
Relative humidity" ;
            qc_relative_humidity:units = "1" ;
            qc_relative_humidity:description = "This field contains bit
packed integer values, where each bit represents a QC test on the data. Non-
zero bits indicate the QC condition given in the description for those bits;
a value of 0 (no bits set) indicates the data has not failed any QC tests." ;
            qc_relative_humidity:flag_method = "bit" ;
            qc_relative_humidity:bit_1_description = "QC_BAD:  Transformation
could not finish, value set to missing_value." ;
            qc_relative_humidity:bit_1_assessment = "Bad" ;
            qc_relative_humidity:bit_2_description = "QC_INDETERMINATE:
Some, or all, of the input values used to create this output value had a QC
assessment of Indeterminate." ;
            qc_relative_humidity:bit_2_assessment = "Indeterminate" ;
            qc_relative_humidity:bit_1_comment = "An example that will trip
this bit is if all values are bad or outside range." ;
            qc_relative_humidity:bit_3_description = "QC_INTERPOLATE:
Indicates a non-standard interpolation using points other than the two that
bracket the target index was applied." ;
            qc_relative_humidity:bit_3_assessment = "Indeterminate" ;
            qc_relative_humidity:bit_3_comment = "An example of why this may
occur is if one or both of the nearest points was flagged as bad.  Applies
only to interpolate transformation method." ;
            qc_relative_humidity:bit_4_description = "QC_EXTRAPOLATE:
Indicates extrapolation is performed out from two points on the same side of
the target index." ;
            qc_relative_humidity:bit_4_assessment = "Indeterminate" ;
            qc_relative_humidity:bit_4_comment = "This occurs because the
input grid does not span the output grid, or because all the points within
range and on one side of the target were flagged as bad.  Applies only to the
interpolate transformation method." ;
            qc_relative_humidity:bit_5_description = "QC_NOT_USING_CLOSEST:
Nearest good point is not the nearest actual point." ;
            qc_relative_humidity:bit_5_assessment = "Indeterminate" ;
            qc_relative_humidity:bit_5_comment = "Applies only to subsample
transformation method." ;
```

```
		qc_relative_humidity:bit_6_description = "QC_SOME_BAD_INPUTS:  Some, but not all, of the inputs in the averaging window were flagged as bad and excluded from the transform." ;
		qc_relative_humidity:bit_6_assessment = "Indeterminate" ;
		qc_relative_humidity:bit_6_comment = "Applies only to the bin average transformation method." ;
		qc_relative_humidity:bit_7_description = "QC_ZERO_WEIGHT:  The weights for all the input points to be averaged for this output bin were set to zero." ;
		qc_relative_humidity:bit_7_assessment = "Indeterminate" ;
		qc_relative_humidity:bit_7_comment = "The output \"average\" value is set to zero, independent of the value of the input.  Applies only to bin average transformation method." ;
		qc_relative_humidity:bit_8_description = "QC_OUTSIDE_RANGE:  No input samples exist in the transformation region, value set to missing_value." ;
		qc_relative_humidity:bit_8_assessment = "Bad" ;
		qc_relative_humidity:bit_8_comment = "Nearest good bracketing points are farther away than the \"range\" transform parameter if transformation is done using the interpolate or subsample method, or \"width\" if a bin average transform is applied.  Test can also fail if more than half an input bin is extrapolated beyond the first or last point of the input grid." ;
		qc_relative_humidity:bit_9_description = "QC_ALL_BAD_INPUTS:  All the input values in the transformation region are bad, value set to missing_value." ;
		qc_relative_humidity:bit_9_assessment = "Bad" ;
		qc_relative_humidity:bit_9_comment = "The transformation could not be completed. Values in the output grid are set to -9999 and the QC_BAD bit is also set." ;
		qc_relative_humidity:bit_10_description = "QC_BAD_STD:  Standard deviation over averaging interval is greater than limit set by transform parameter std_bad_max." ;
		qc_relative_humidity:bit_10_assessment = "Bad" ;
		qc_relative_humidity:bit_10_comment = "Applies only to the bin average transformation method." ;
		qc_relative_humidity:bit_11_description = "QC_INDETERMINATE_STD:  Standard deviation over averaging interval is greater than limit set by transform parameter std_ind_max." ;
		qc_relative_humidity:bit_11_assessment = "Indeterminate" ;
		qc_relative_humidity:bit_11_comment = "Applies only to the bin average transformation method." ;
		qc_relative_humidity:bit_12_description = "QC_BAD_GOODFRAC:  Fraction of good and indeterminate points over averaging interval are less than limit set by transform parameter goodfrac_bad_min." ;
		qc_relative_humidity:bit_12_assessment = "Bad" ;
		qc_relative_humidity:bit_12_comment = "Applies only to the bin average transformation method." ;
		qc_relative_humidity:bit_13_description = "QC_INDETERMINATE_GOODFRAC:  Fraction of good and indeterminate points over averaging interval is less than limit set by transform parameter goodfrac_ind_min." ;
		qc_relative_humidity:bit_13_assessment = "Indeterminate" ;
		qc_relative_humidity:bit_13_comment = "Applies only to the bin average transformation method." ;
```

```
      float pressure(time, stations) ;
            pressure:long_name = "Atmospheric Pressure" ;
            pressure:units = "kPa" ;
            pressure:ancillary_variables = "qc_pressure" ;
            pressure:cell_methods = "time: mean" ;
            pressure:missing_value = -9999.f ;
            pressure:standard_name = "air_pressure" ;
            pressure:cell_transform = "time(stations: 0-15: TRANS_INTERPOLATE
(range: 60); time(stations: 16-148:); TRANS_INTERPOLATE (range: 600)
platform: TRANS_PASSTHROUGH qc_bad: -9999,3,4,5,6,7,8,9" ;
      int qc_pressure(time, stations) ;
            qc_pressure:long_name = "Quality check results on field:
Atmospheric Pressure" ;
            qc_pressure:units = "1" ;
            qc_pressure:description = "This field contains bit packed integer
values, where each bit represents a QC test on the data. Non-zero bits
indicate the QC condition given in the description for those bits; a value of
0 (no bits set) indicates the data has not failed any QC tests." ;
            qc_pressure:flag_method = "bit" ;
            qc_pressure:bit_1_description = "QC_BAD:  Transformation could
not finish, value set to missing_value." ;
            qc_pressure:bit_1_assessment = "Bad" ;
            qc_pressure:bit_2_description = "QC_INDETERMINATE:  Some, or all,
of the input values used to create this output value had a QC assessment of
Indeterminate." ;
            qc_pressure:bit_2_assessment = "Indeterminate" ;
            qc_pressure:bit_1_comment = "An example that will trip this bit
is if all values are bad or outside range." ;
            qc_pressure:bit_3_description = "QC_INTERPOLATE:  Indicates a
non-standard interpolation using points other than the two that bracket the
target index was applied." ;
            qc_pressure:bit_3_assessment = "Indeterminate" ;
            qc_pressure:bit_3_comment = "An example of why this may occur is
if one or both of the nearest points was flagged as bad.  Applies only to
interpolate transformation method." ;
            qc_pressure:bit_4_description = "QC_EXTRAPOLATE:  Indicates
extrapolation is performed out from two points on the same side of the target
index." ;
            qc_pressure:bit_4_assessment = "Indeterminate" ;
            qc_pressure:bit_4_comment = "This occurs because the input grid
does not span the output grid, or because all the points within range and on
one side of the target were flagged as bad.  Applies only to the interpolate
transformation method." ;
            qc_pressure:bit_5_description = "QC_NOT_USING_CLOSEST:  Nearest
good point is not the nearest actual point." ;
            qc_pressure:bit_5_assessment = "Indeterminate" ;
            qc_pressure:bit_5_comment = "Applies only to subsample
transformation method." ;
            qc_pressure:bit_6_description = "QC_SOME_BAD_INPUTS:  Some, but
not all, of the inputs in the averaging window were flagged as bad and
excluded from the transform." ;
            qc_pressure:bit_6_assessment = "Indeterminate" ;
            qc_pressure:bit_6_comment = "Applies only to the bin average
transformation method." ;
```

```
            qc_pressure:bit_7_description = "QC_ZERO_WEIGHT:  The weights for
all the input points to be averaged for this output bin were set to zero." ;
            qc_pressure:bit_7_assessment = "Indeterminate" ;
            qc_pressure:bit_7_comment = "The output \"average\" value is set
to zero, independent of the value of the input.  Applies only to bin average
transformation method." ;
            qc_pressure:bit_8_description = "QC_OUTSIDE_RANGE:  No input
samples exist in the transformation region, value set to missing_value." ;
            qc_pressure:bit_8_assessment = "Bad" ;
            qc_pressure:bit_8_comment = "Nearest good bracketing points are
farther away than the \"range\" transform parameter if transformation is done
using the interpolate or subsample method, or \"width\" if a bin average
transform is applied.  Test can also fail if more than half an input bin is
extrapolated beyond the first or last point of the input grid." ;
            qc_pressure:bit_9_description = "QC_ALL_BAD_INPUTS:  All the
input values in the transformation region are bad, value set to
missing_value." ;
            qc_pressure:bit_9_assessment = "Bad" ;
            qc_pressure:bit_9_comment = "The transformation could not be
completed. Values in the output grid are set to -9999 and the QC_BAD bit is
also set." ;
            qc_pressure:bit_10_description = "QC_BAD_STD:  Standard deviation
over averaging interval is greater than limit set by transform parameter
std_bad_max." ;
            qc_pressure:bit_10_assessment = "Bad" ;
            qc_pressure:bit_10_comment = "Applies only to the bin average
transformation method." ;
            qc_pressure:bit_11_description = "QC_INDETERMINATE_STD:  Standard
deviation over averaging interval is greater than limit set by transform
parameter std_ind_max." ;
            qc_pressure:bit_11_assessment = "Indeterminate" ;
            qc_pressure:bit_11_comment = "Applies only to the bin average
transformation method." ;
            qc_pressure:bit_12_description = "QC_BAD_GOODFRAC:  Fraction of
good and indeterminate points over averaging interval are less than limit set
by transform parameter goodfrac_bad_min." ;
            qc_pressure:bit_12_assessment = "Bad" ;
            qc_pressure:bit_12_comment = "Applies only to the bin average
transformation method." ;
            qc_pressure:bit_13_description = "QC_INDETERMINATE_GOODFRAC:
Fraction of good and indeterminate points over averaging interval is less
than limit set by transform parameter goodfrac_ind_min." ;
            qc_pressure:bit_13_assessment = "Indeterminate" ;
            qc_pressure:bit_13_comment = "Applies only to the bin average
transformation method." ;
      float lat(stations) ;
            lat:long_name = "North latitude" ;
            lat:units = "degree_N" ;
            lat:valid_min = -90.f ;
            lat:valid_max = 90.f ;
            lat:standard_name = "latitude" ;
      float lon(stations) ;
            lon:long_name = "East longitude" ;
            lon:units = "degree_E" ;
            lon:valid_min = -180.f ;
```

```
            lon:valid_max = 180.f ;
            lon:standard_name = "longitude" ;
      float alt(stations) ;
            alt:long_name = "Altitude above mean sea level" ;
            alt:units = "m" ;
            alt:standard_name = "altitude" ;

// global attributes:
            :command_line = "lassolcl -s sgp -f C1 -b 20190404 -R" ;
            :Conventions = "ARM-1.2" ;
            :process_version = "vap-lassolcl-1.1-0.el6" ;
            :dod_version = "lcl-c1-1.3" ;
            :input_datastreams = "sgp05okmX1.b1 : 9.0 : 20190404.000000-
20190405.000000\n",
                  "sgpmawsC1.b1 : 1.0 : 20190404.000005-20190405.000005\n",
                  "sgpmetE11.b1 : 4.39 : 20190404.000000-20190405.000000\n",
                  "sgpmetE15.b1 : 4.39 : 20190404.000000-20190405.000000\n",
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            :location_description = "Southern Great Plains (SGP), Lamont,
Oklahoma" ;
            :doi = "10.5439/1256454" ;
            :datastream = "sgplclC1.c1" ;
            :history = "created by user ttoto on machine tin at 2020-06-08
20:05:12, using vap-lassolcl-1.1-0.el6" ;
}
```

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