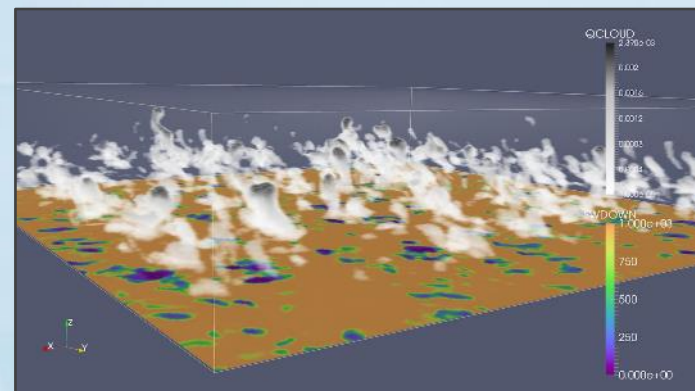


Part 2: Observations and Data Bundle Selection



Presenter: Andy Vogelmann, Brookhaven National Laboratory

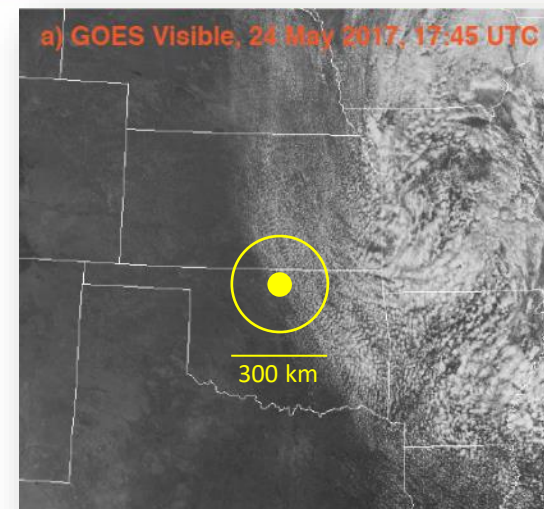
What you will learn

- Shallow convection case selection
- Observations used for simulation evaluation
- Skill scores for ranking the simulations
- LASSO Bundle Browser – Find and order the simulations you want



Shallow Convection Cases

- **LASSO only run for selected ShCu days**
- **Manually selected considering, e.g.:**
 - ShCu cloud field present over the SGP (many obs)
 - Cloud uniformity across forcing domain (GOES vis)
 - No wide-spread precipitation (NEXRAD, GOES IR)
 - Have critical measurements (e.g., 12Z sonde, LWP, etc.)
- **Skill scores used to rank ensemble simulations**
 - But any LES simulation is valid, right?
 - Want a statistical library of *representative* cases for study



Available ShCu Cases

Year	Number of Cases
2015	5
2016	13
2017	30
2018	30
2019	17
Total	95

> 760 simulations

Observations: 'Data scales'

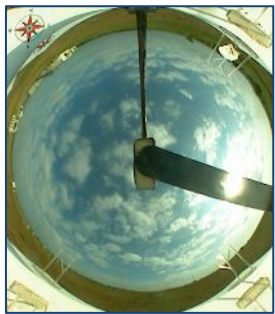
'Point' or Pencil-beam

In situ or Column obs



Ka-Band ARM Zenith Radar (KAZR)

'Local'



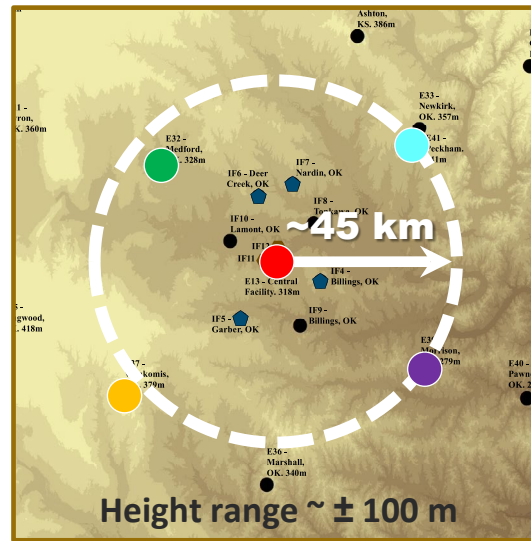
Total-Sky Imager (TSI)



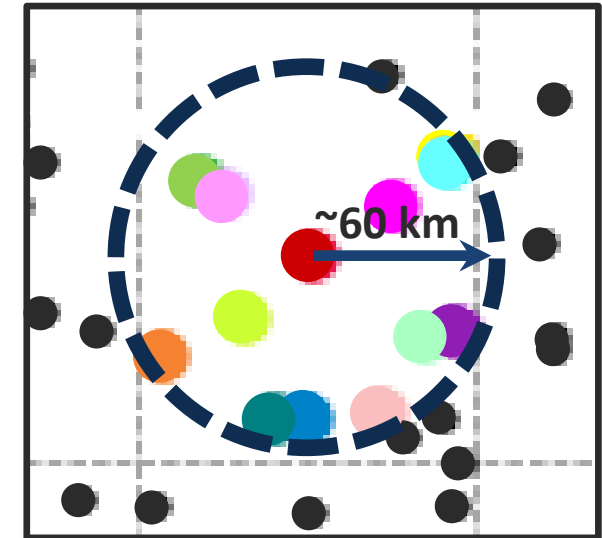
COGS (Clouds Optically Gridded by Stereo) VAP

Regional Networks

Doppler Lidar Network



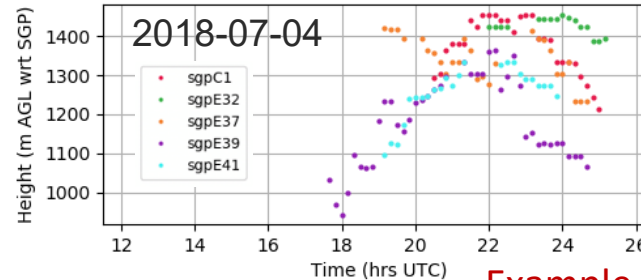
ARM Met and OK Mesonet Stations



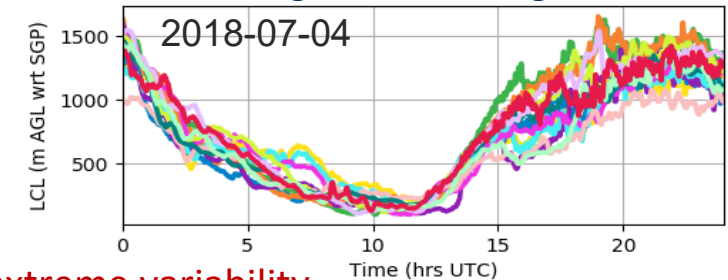
13 Stations

- sgpC1
- sgpE32
- sgpE33
- sgpE36
- sgpE37
- sgpE39
- sgpE41
- BLAC
- BREC
- CARL
- MRSH
- MEDF
- REDR

Regional Cloud-Base Heights



Regional LCL Heights



Example of extreme variability

Observations: Variables



Variable	'Point'	Local	Domain	Comments
In-cloud liquid water path (LWP)	X			Combined (1) AERloe & (2) MWRRet
Cloud fraction	ARSCL	TSI or COGS*		To be discussed
2-D Time-height cloud mask	ARSCL	COGS*		To be discussed
Cloud-base height			X	Doppler lidar network
Lifting condensation level (LCL) height	X		X	Met stations (CF or Met Network)
Thermo state variables: T, Qv, and RH				
At the surface	X			CF met station
Middle of the boundary layer (BL) (500-700 m average)	X			Blended Raman lidar & AERloe profiles

*COGS available for 2018 & 2019 only

Observations: Cloud fraction sources and comments

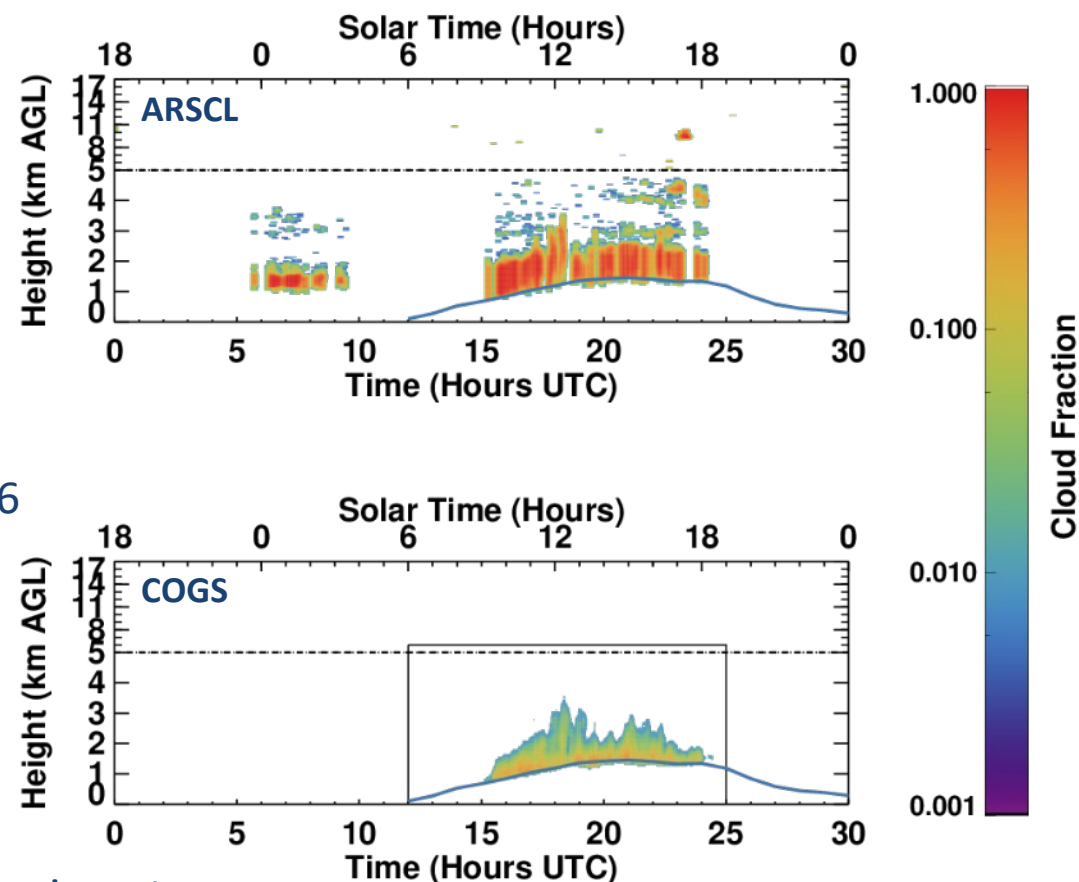
Cloud fraction

- Sources
 - Total-Sky Imager (TSI)
 - ARSCL ($z < 5$ km)
 - COGS (Romps and Öktem, *BAMS*, 2018)
- Comments
 - TSI can be contaminated by upper-level cloud
 - ARSCL too sensitive and is pencil-beam obs
 - Good correlation between TSI and ARSCL time series indicates no upper-level cloud influencing the TSI
 - COGS (when available) reliable for cloud frac $< \sim 0.5-0.6$

2-D cloud mask

- Sources
 - ARSCL
 - COGS (when available)
- Comments
 - ARSCL is a pencil-beam obs and can be contaminated by insects (correction method in progress by Christopher Williams et al.)

2-D Time-Height Cloud Frequency/Fraction



Observations: LASSO data sets

lassodiagobsmod

- Available for all data bundles
 - Contains hourly averages of the variables used for LASSO simulation evaluation

High-frequency observation products at native resolution

- Available for 2018, 2019, and (soon!) 2017
 - **LASSO Liquid Water Path (LASSOLWP)**: liquid water path from AERLoe & MWRRet, 10-second resolution
 - **Cloud Fraction (CLDFRAC)**: cloud cover from KAZRARSCl and TSI, 1-, 5-, 15-minute resolution
 - **LASSO Middle Boundary-Layer Thermodynamics (LASSOBLTHERMO)**: temperature and moisture in middle of the boundary layer (500-700 m) from AERI and Raman lidar, 10-minute resolution
 - **LASSO Doppler Lidar Cloud-Base Height for Shallow Cumulus (LASSODLCBHSVCU)**: cloud-base heights from the Doppler lidars, 10-minute resolution
 - **Lifting Condensation Level Height (LCLHEIGHT)**: LCL at 1-min resolution
 - **Radar Wind Profiler Wind Consensus (RWPWINDCON)**: horizontal wind from radar wind profilers (RWPs), 10-minute resolution (2019 only) [used in LASSO data assimilation]

COGS-based simulation evaluations

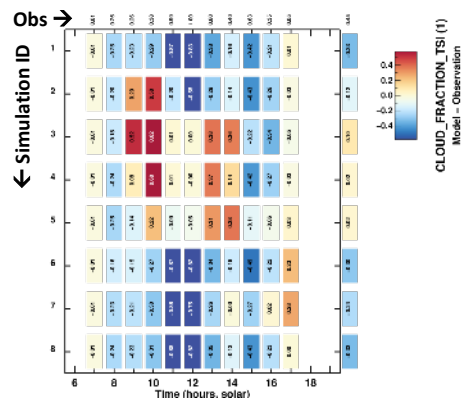
- Available 2018 and 2019 (*via the ARM Data Discovery under “lassocogs”; Bundle Browser inclusion pending*)
 - Cloud fraction
 - 2-D time-height cloud mask

Model-Observation Diagnostics

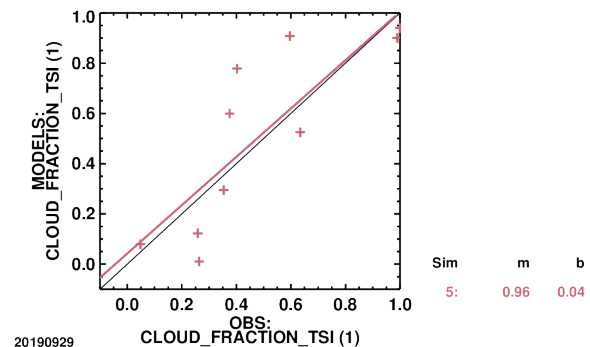
- **Simulated variables processed similarly to the observations for apples-to-apples comparison**
 - Co-registered model and observations (e.g., time, vertical grid)
 - Sample the simulated variables considering measurement sensitivity (e.g., LWP)
 - Ideally, use the same algorithm (e.g., LCL)
- **Diagnostic plots available**
 - **Heat maps** for differences of the simulated time series from observations
 - **Regression analyses** for slope and intercept, including phase space plots of cloud frac vs. LWP
 - **Thermodynamic profiles** at sonde times (Θ , Θ_e , T , q_v)
 - **Time series** with average difference, RMS, and correlation coefficient
 - **Taylor diagrams** for standard deviation and correlation phase space
 - **2-D cloud masks** for simulated model location and timing

Skill Scores

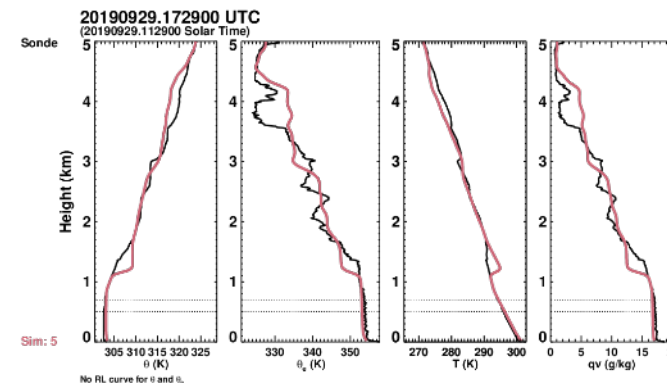
Note: All examples use case day 2019-09-29



Heat Map

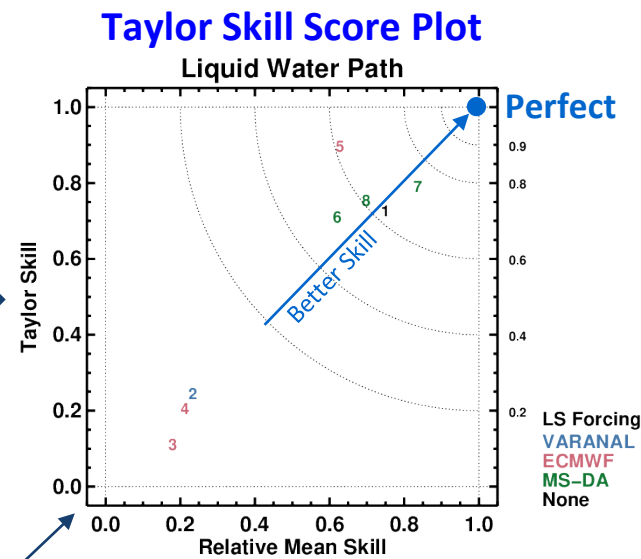
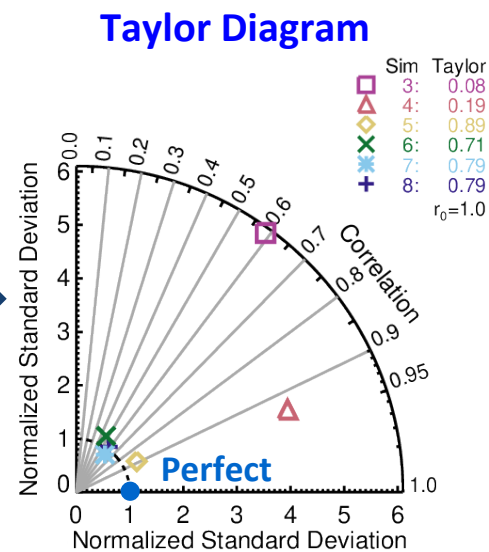
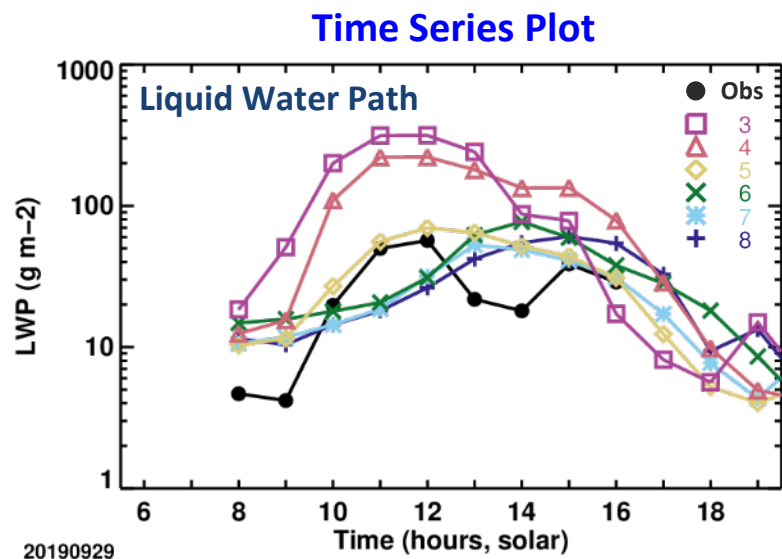


Regressions



Thermodynamic Profiles

Skill scores: Taylor Skill Score to assess Time Series



Net Taylor Skill Score: One number

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

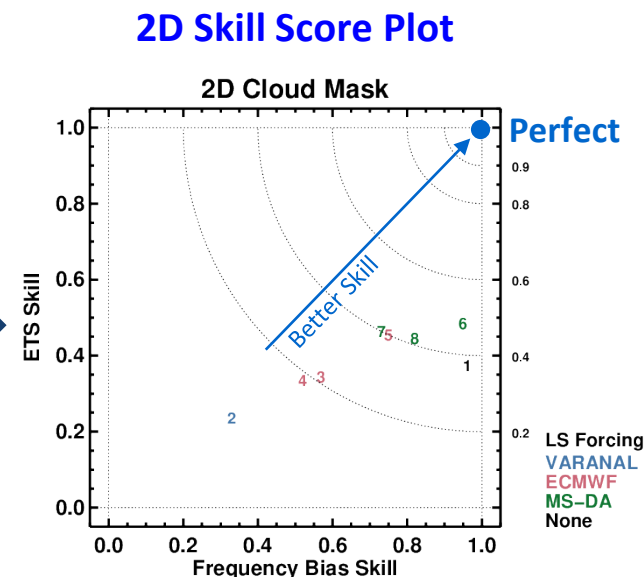
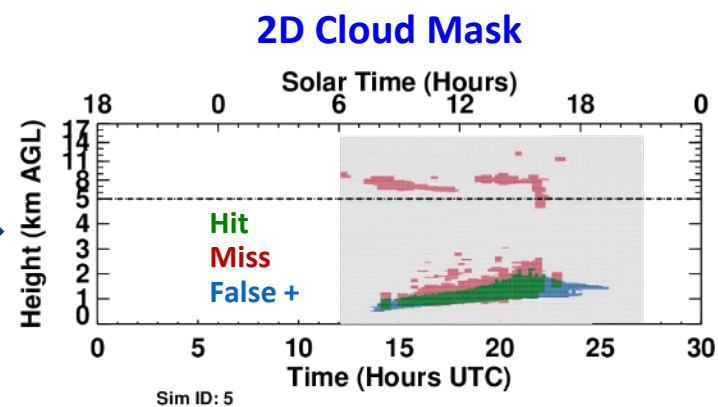
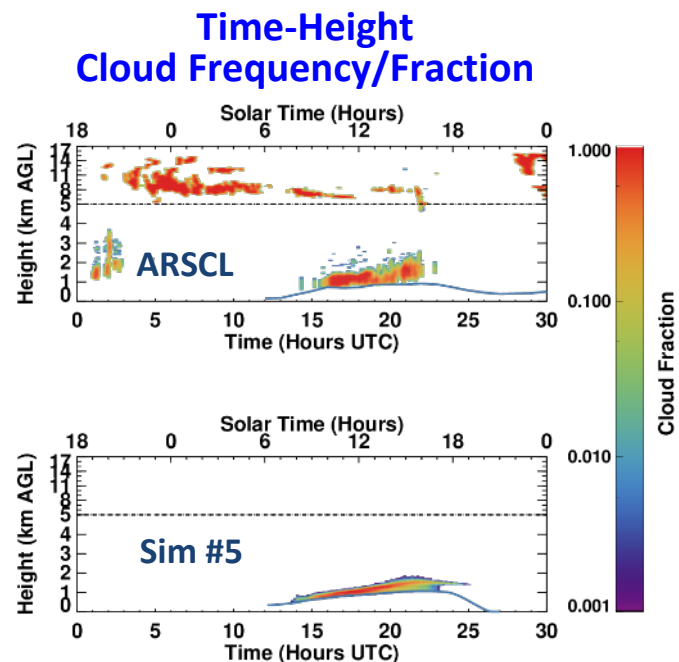
Taylor Skill Relative Mean Skill

Sim ID	LWP Net Taylor Skill Score
1	0.73
2	0.23
3	0.13
4	0.20
5	0.74
6	0.66
7	0.81
8	0.72

Notes on interpretation

- [0,1] where 1 is perfect
- High is 'good,' low is 'bad'
- **Do not** over interpret values; use plots when values close

Skill scores: Equitable Threat Score (ETS) to assess 2D Cloud Mask



Net ETS Skill Score

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

Sim ID	2D Cloud Mask Skill
1	0.59
2	0.27
3	0.43
4	0.41
5	0.58
6	0.67
7	0.57
8	0.60

Same notes on interpretation:

- [0,1] where 1 is perfect
- High is 'good,' low is 'bad'
- **Do not** over interpret values; use plots when values close

Skill scores: Multivariable Net Skill Scores

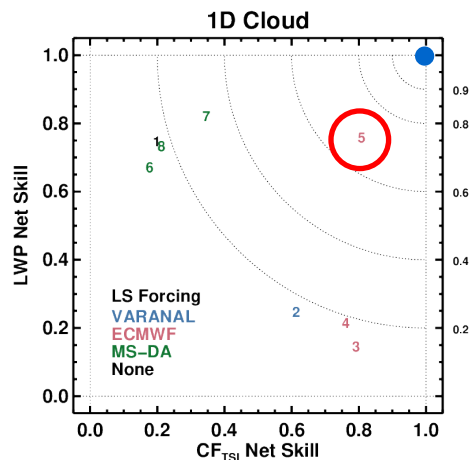
Combine two net skill scores (x,y) into one value

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

Two special multivariable scores are provided

1D Cloud Skill Score

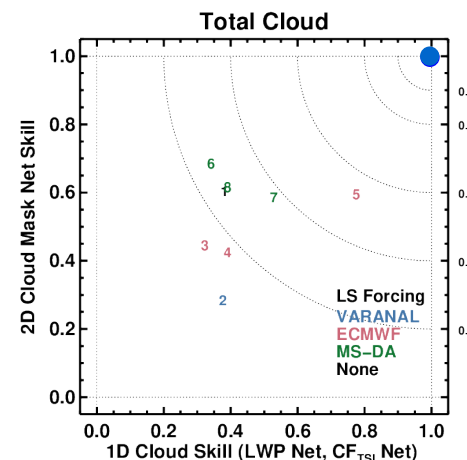
- LWP Net Taylor Skill
- TSI cloud fraction Net Taylor Skill



Sim ID	1D Cloud Skill
1	0.38
2	0.38
3	0.32
4	0.39
5	0.78
6	0.34
7	0.53
8	0.39

Total Cloud Skill Score

- 1D Cloud
- 2D ETS Net Skill



Sim ID	Total Cloud Skill
1	0.47
2	0.32
3	0.37
4	0.40
5	0.67
6	0.48
7	0.55
8	0.48

The LASSO Bundle Browser



<https://adc.arm.gov/lassobrowser>

Developed and/or maintained by

- Kyle Dumas
- Michael Giansiracusa
- Bhargavi Krishna

Enables:

1. Interactive querying of LASSO sims & skill
2. Contains diagnostic plots
3. Ordering of data bundles

The screenshot shows the LASSO Bundle Browser interface. Annotations are as follows:

- A:** Points to the search and filter sidebar on the left.
- B:** Points to the overview plots section below the sidebar.
- C:** Points to the 'Skill Scores' section at the bottom left.
- D:** Points to the diagnostic plots (radar, scatter, and line graphs) in the center.
- E:** Points to the table of simulation results at the bottom right.

Measurement Set	SEP	Simulation ID	Units	Employment Set (LASSO (LASSO) (LASSO))	10-CRUIE SEP	10-CRUIE MAX SEP	10-CRUIE MIN SEP	Countdown
0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8

LASSO Bundle Browser: Upper half (A, B, D)

A. Select date(s), Model config, *Measurement* →



B. Static plots for *selected date* summarizing model behavior

- Heat maps, Skill score plots for all simulations data and variables, GOES vis satellite loop

D. Interactive plots showing results for selected *Measurement* and choices in (C)

- Clockwise: Taylor diagram, Plot of Taylor score vs. Relative Mean, Regression, Time series

Select All (Excludes Date)

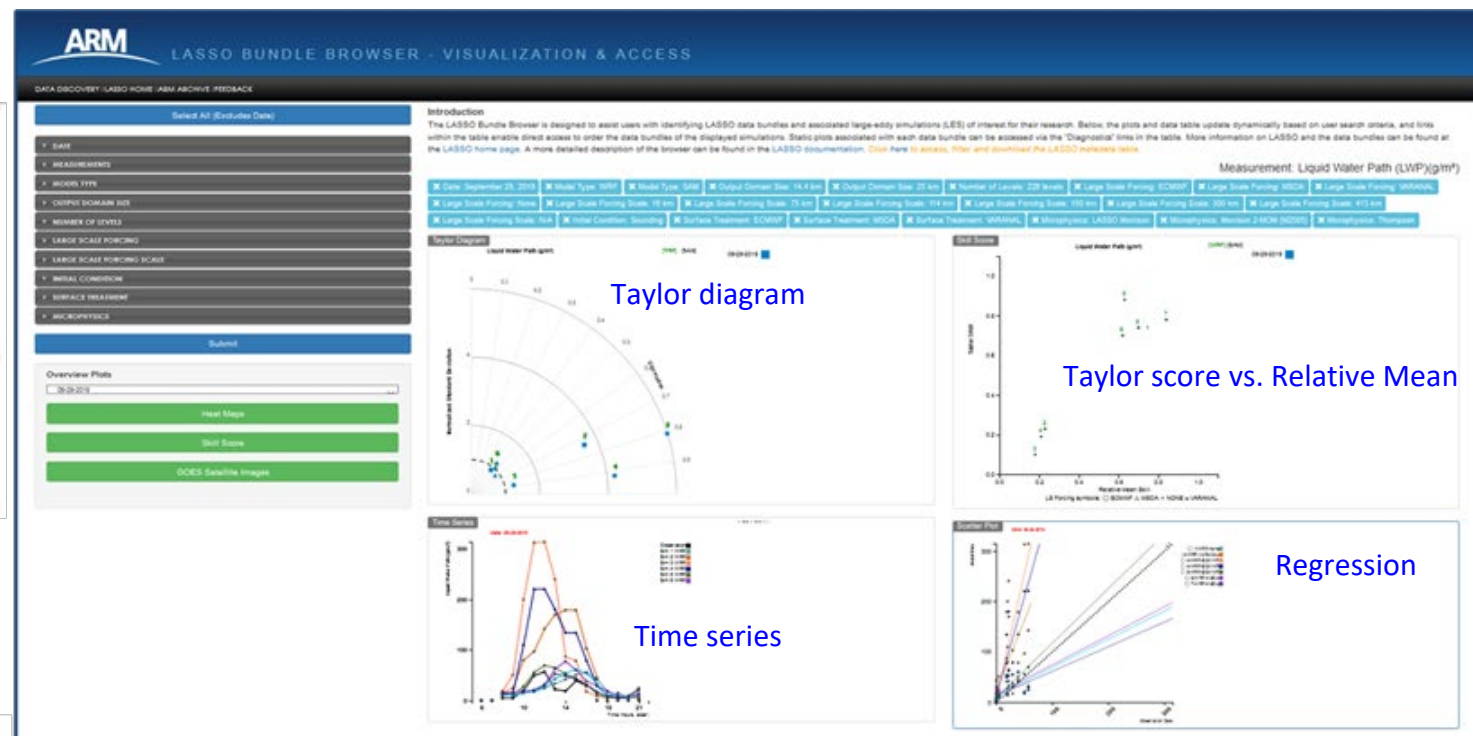
- DATE
- MEASUREMENTS
- MODEL TYPE
- OUTPUT DOMAIN SIZE
- NUMBER OF LEVELS
- LARGE SCALE FORCING
- LARGE SCALE FORCING SCALE
- INITIAL CONDITION
- SURFACE TREATMENT
- MICROPHYSICS

Submit

Overview Plots

09-29-2019

- Heat Maps
- Skill Score
- GOES Satellite Images



LASSO Bundle Browser: Lower half (C, E)

Skill Scores

Measurement Skill

0 1

1D Cloud Skill

0 1

2D Cloud Mask Skill

0 1

Total Cloud Skill

0 1

Slide orange sliders to adjust min and max skill ranges

C. Slide rulers to choose the range of net skill scores that are displayed in (D) and (E)

- Measurement Skill, 1D Cloud Skill, 2D Cloud Skill, Total Cloud Skill

E. Tabulated results are given for the selections from (A) and (C)

- Save table values Copy CSV Print PDF
- Summary of the simulation run configuration
- Diagnostic plots per simulation: Time series, Taylor diagram, Regression, 2D Cloud Mask, Soundings
- Ordering data

LASSO Version 1 Release

Attributes associated with this simulation...

doi: 10.5439/1342951

contacts: lasso@arm.gov; LASSO PI: William Gustafson (William.Gustafson@prnl.gov); LASSO Co-PI: Andrew Vogelmann (vogelmann@bri.gov)

site_id: sgp

facility_id: C1

location_description: Southern Great Plains (SGP), Lamont, Oklahoma

date: 20190929

simulation_id_number: 1

model_type: WRF

model_version: 3.8.1

model_github_hash: b6b6a5cc4229eac1aa9b005746b5ebef2205b07

output_domain_size: 25.0 km

output_number_of_levels: 226

output_horizontal_grid_spacing: 160 m

config_large_scale_forcing: None

config_large_scale_forcing_scale: NA

config_large_scale_forcing_specifics: NA

config_surface_treatment: VARANAM

Skill Scores

0 1

0 1

0 1

0 1

Slide orange sliders to adjust min and max skill ranges

Date	Simulation ID	Links	Measurement Skill (Liquid Water Path (LWP))	1D Cloud Skill	2D Cloud Mask Skill	Total Cloud Skill	Download
09-29-2019	1	Diagnostic	0.75	0.88	0.88	0.87	<input type="checkbox"/> Counting Obs Model Tar <input type="checkbox"/> Raw Model Tar <input type="checkbox"/> High-freq Obs Tar
09-29-2019	2	Diagnostic	0.22	0.88	0.27	0.22	<input type="checkbox"/> Counting Obs Model Tar <input type="checkbox"/> Raw Model Tar <input type="checkbox"/> High-freq Obs Tar
09-29-2019	3	Diagnostic	0.10	0.22	0.45	0.27	<input type="checkbox"/> Counting Obs Model Tar <input type="checkbox"/> Raw Model Tar <input type="checkbox"/> High-freq Obs Tar
09-29-2019	4	Diagnostic	0.2	0.88	0.41	0.4	<input type="checkbox"/> Counting Obs Model Tar <input type="checkbox"/> Raw Model Tar <input type="checkbox"/> High-freq Obs Tar
09-29-2019	5	Diagnostic	0.74	0.75	0.88	0.67	<input type="checkbox"/> Counting Obs Model Tar <input type="checkbox"/> Raw Model Tar <input type="checkbox"/> High-freq Obs Tar
09-29-2019	6	Diagnostic	0.88	0.24	0.67	0.48	<input type="checkbox"/> Counting Obs Model Tar <input type="checkbox"/> Raw Model Tar <input type="checkbox"/> High-freq Obs Tar
09-29-2019	7	Diagnostic	0.81	0.88	0.27	0.88	<input type="checkbox"/> Counting Obs Model Tar <input type="checkbox"/> Raw Model Tar <input type="checkbox"/> High-freq Obs Tar
09-29-2019	8	Diagnostic	0.72	0.88	0.88	0.48	<input type="checkbox"/> Counting Obs Model Tar <input type="checkbox"/> Raw Model Tar <input type="checkbox"/> High-freq Obs Tar

Config Obs Model Tar
Raw Model Tar
High-freq Obs Tar

Use GLOBUS for file transfer whenever possible to avoid corruption of downloaded files (e.g., via ftp).

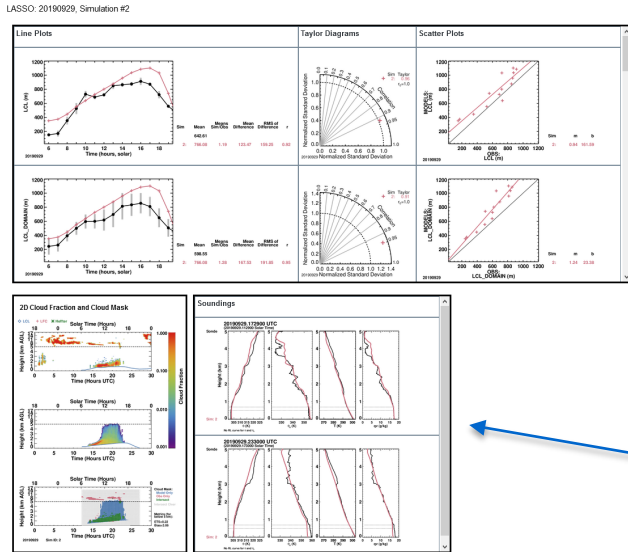
Observation locations in the LASSO data bundles

LASSO observations contained in a series of tar files

- sgplassodiagconfobsmod##C1.m1.YYYYMMDD.tar 70 MB
- sgplasso**highfreqobs**C1.c1.YYYYMMDD.000000.tar 145 MB
- sgplasso**cogs**C1.c1.YYYYMMDD.000000.tar 11/511 MB

Data Bundle Tar-file Structure for "Config Obs Model Tar"

→ sgplassodiagconfobsmod##C1.m1.YYYYMMDD.tar



(Note the scroll bar)

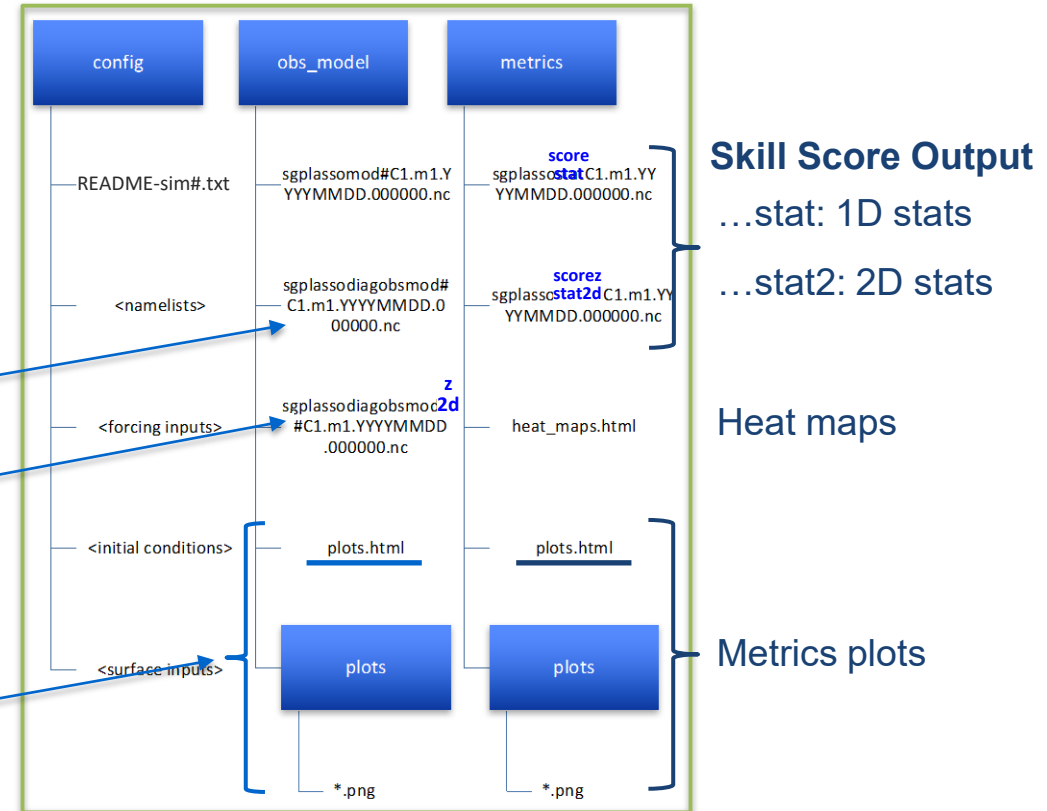
Observations posted with the post-processed model output

...diagobsmod: 1D Time series (hourly)

...diagobsmodz: 2D Time-height profiles

Diagnostics Plots

Time series, Taylor Plots, Soundings, Regressions, 2D cloud masks



Topics covered in Part 2

- Shallow Convection Cases
- Observations used for simulation evaluation
- Skill scores for ranking the simulations
- LASSO Bundle Browser – Find and order the simulations you want

