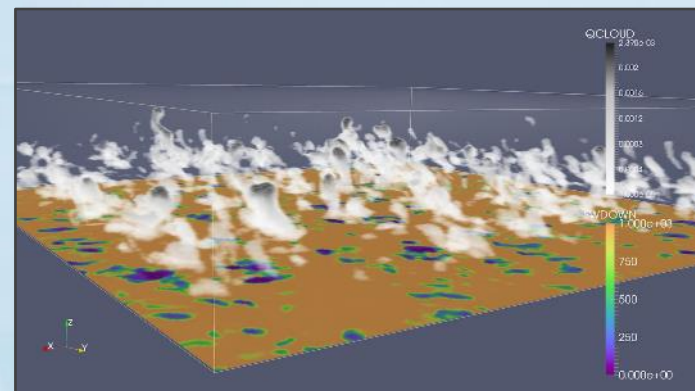# Part 2:
# Observations and Data Bundle Selection

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



a) GOES Visible, 24 May 2017, 17:45 UTC

300 km
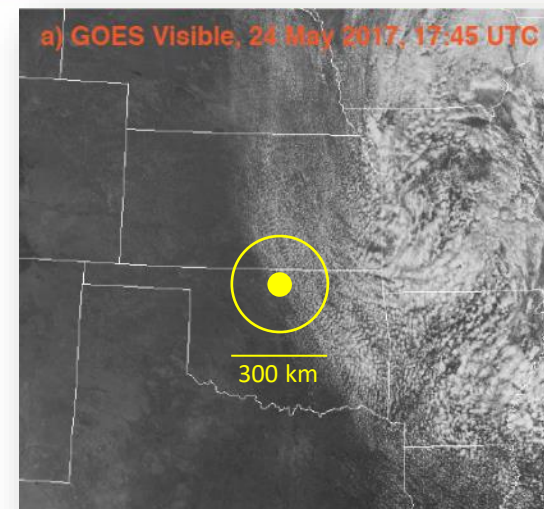
**Available ShCu Cases**

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

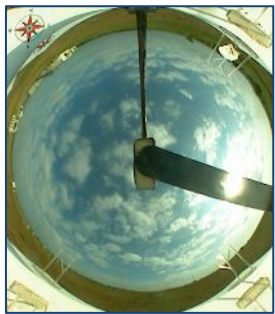> 760 simulations

# Observations: 'Data scales'

## 'Point' or Pencil-beam

### In situ or Column obs
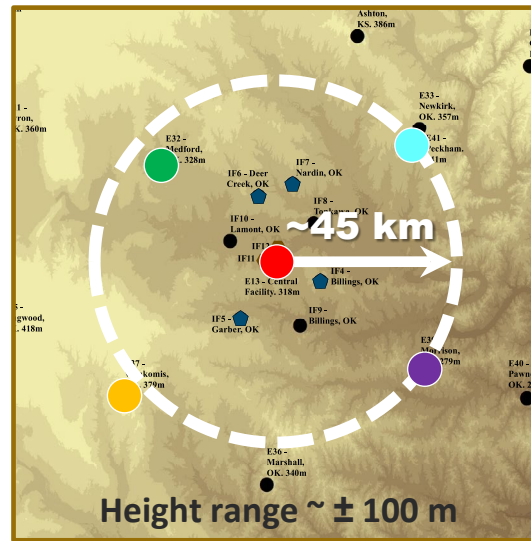


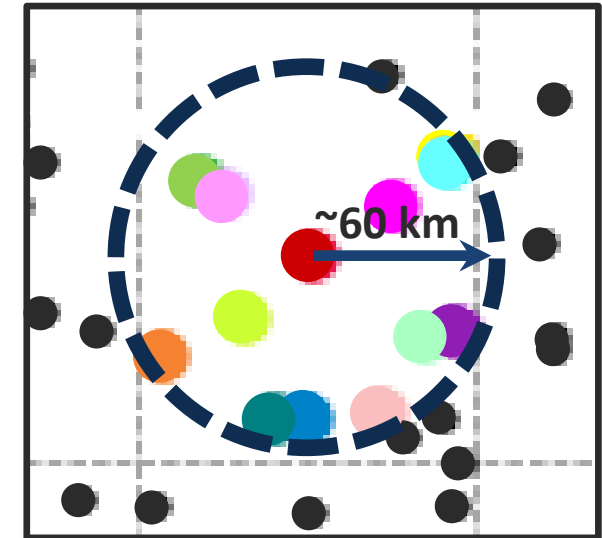Ka-Band ARM Zenith Radar (KAZR)

### 'Local'



Total-Sky Imager (TSI)

COGS (Clouds Optically Gridded by Stereo) VAP
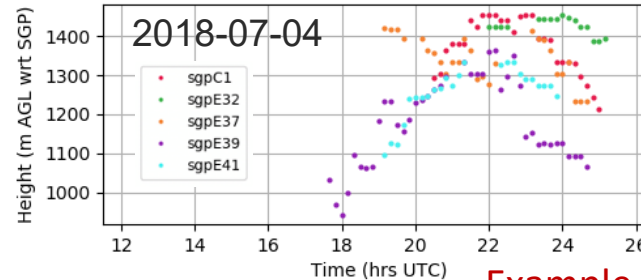
## Regional Networks

### Doppler Lidar Network



~45 km

Height range ~ ± 100 m

### ARM Met and OK Mesonet Stations



~60 km

13 Stations

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

### Regional Cloud-Base Heights



2018-07-04

### Regional LCL Heights



2018-07-04
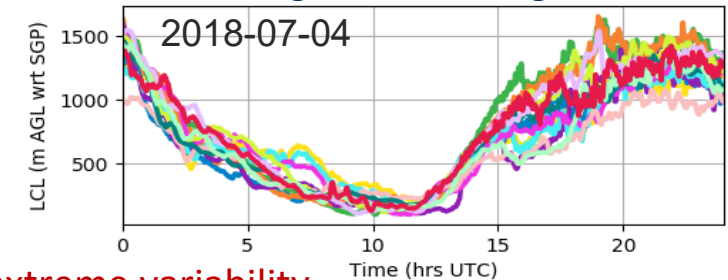
Example of extreme variability

# Observations: Variables

| Variable | 'Point' | Local | Domain | Comments |
|---|---|---|---|---|
| In-cloud liquid water path (LWP) | X | | | Combined (1) AERIoe & (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 & AERIoe 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 < ~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**
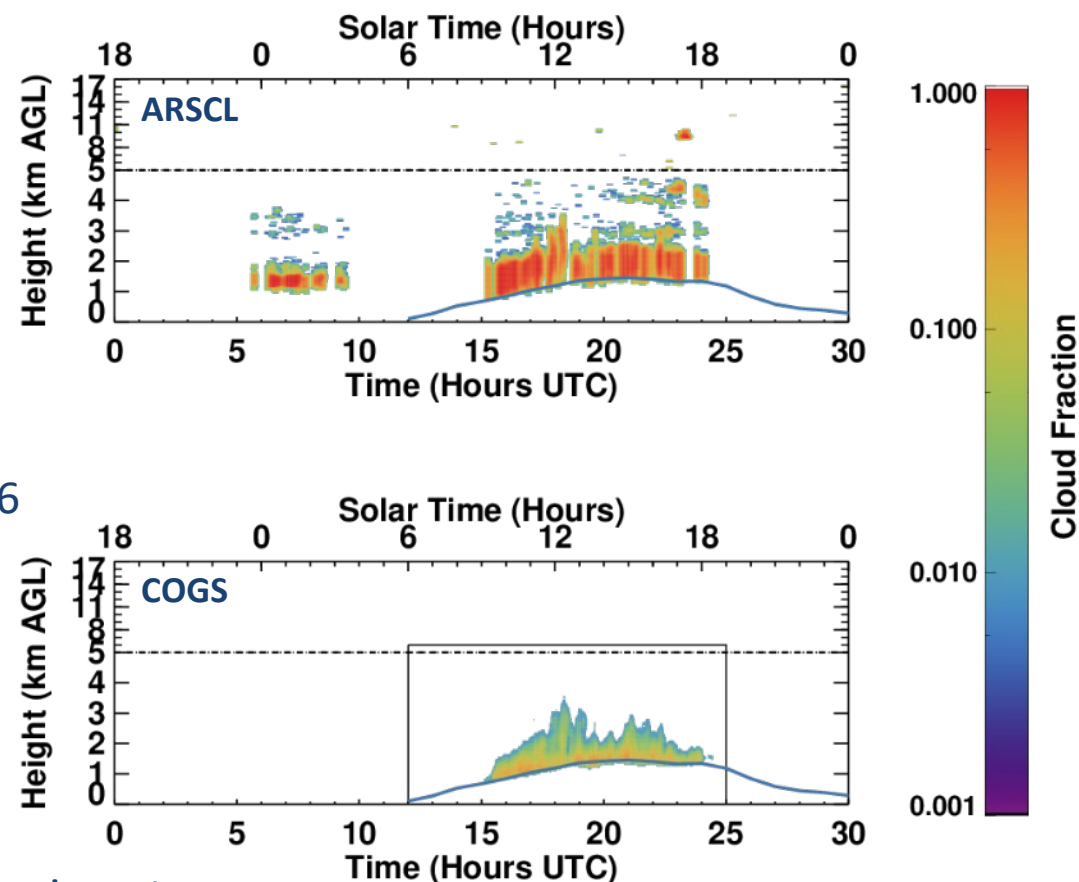
# Observations: LASSO data sets

**lasso*diag*obs*mod***

- 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 AERIoe & 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 (LASSODLCBHSHCU)**: 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 ($\Theta$, $\Theta_e$, $T$, $q_v$)
  - **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
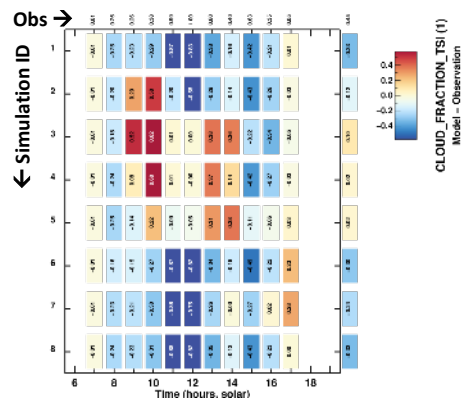


Heat Map
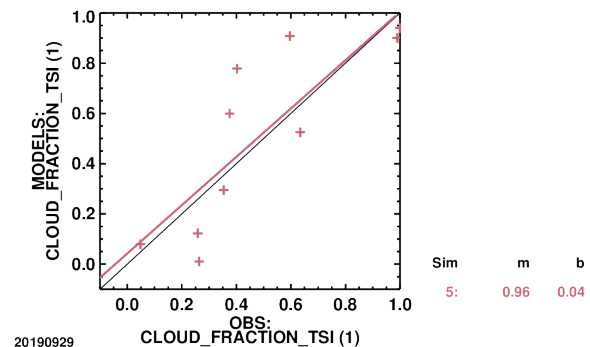


Regressions
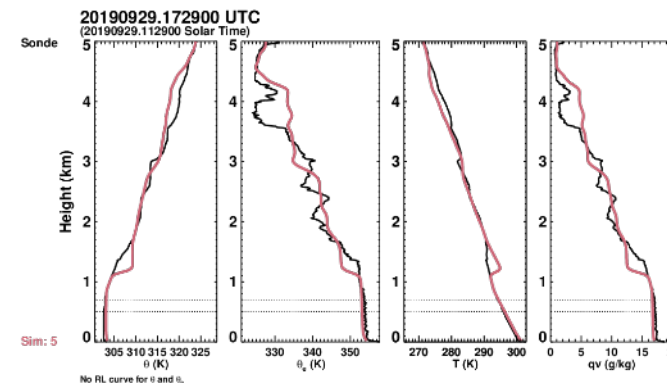


Thermodynamic Profiles

# Skill scores: Taylor Skill Score to assess Time Series



**Time Series Plot**

**Taylor Diagram**

**Taylor Skill Score Plot**
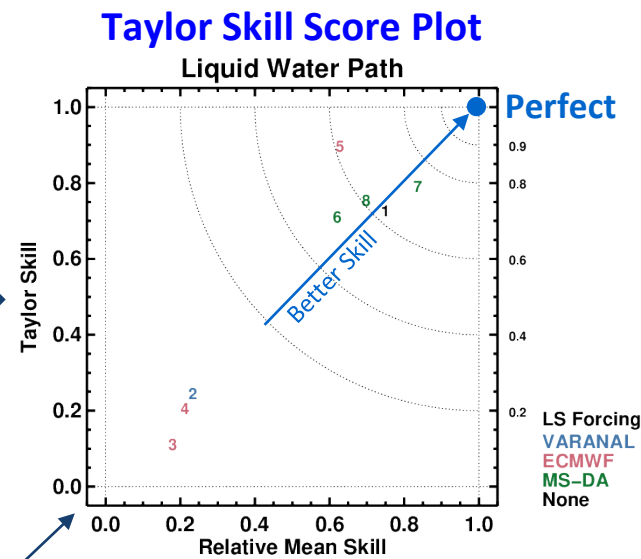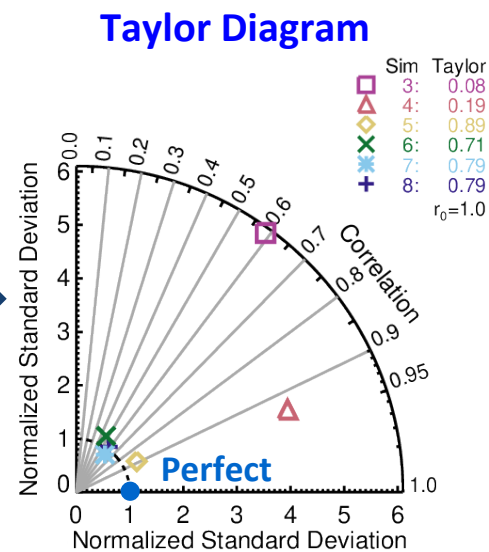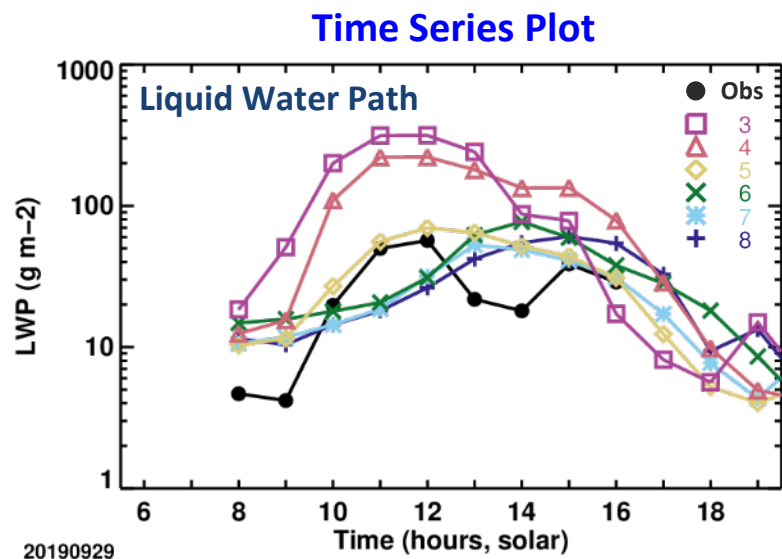
## Net Taylor Skill Score: One number

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

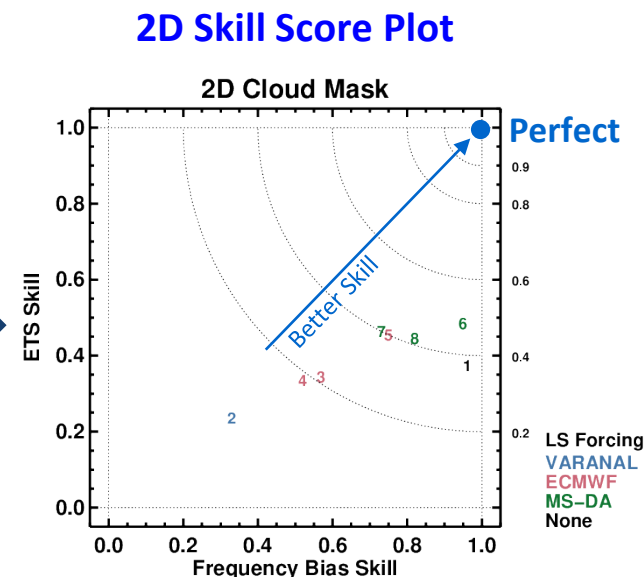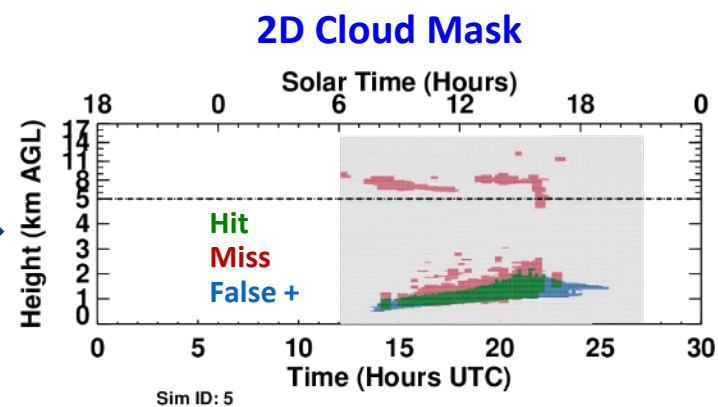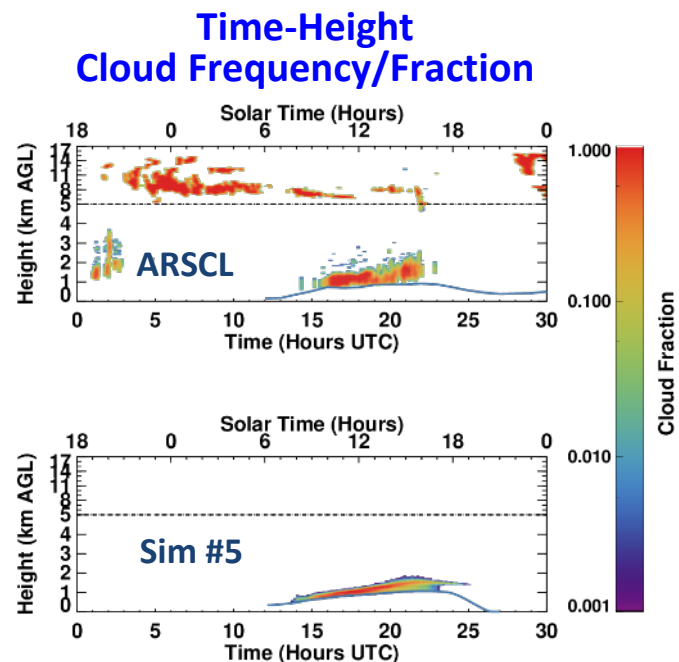Taylor Skill     Relative Mean Skill

| 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

**ARM**

**Time-Height Cloud Frequency/Fraction**

**2D Cloud Mask**

**2D Skill Score Plot**

Hit
Miss
False +

Perfect

Better Skill

LS Forcing
VARANAL
ECMWF
MS-DA
None

**Net ETS Skill Score**

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

| 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

**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
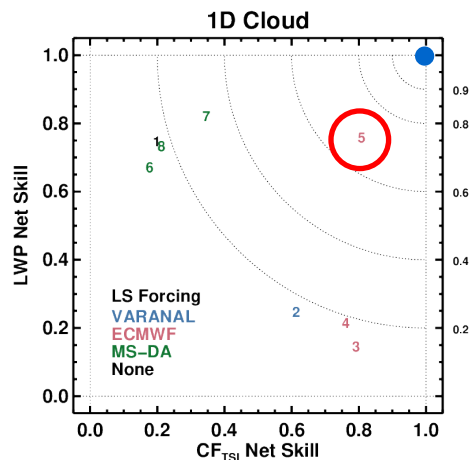


| Sim ID | 1D Cloud Skill |
|--------|----------------|
| 1 | 0.38 |
| 2 | 0.38 |
| 3 | 0.32 |
| 4 | 0.39 |
| 5 | 0.78 |
| 6 | 0.34 |
| 7 | 0.53 |
| 8 | 0.39 |

### Total Cloud Skill Score

- 1D Cloud
- 2D ETS Net Skill
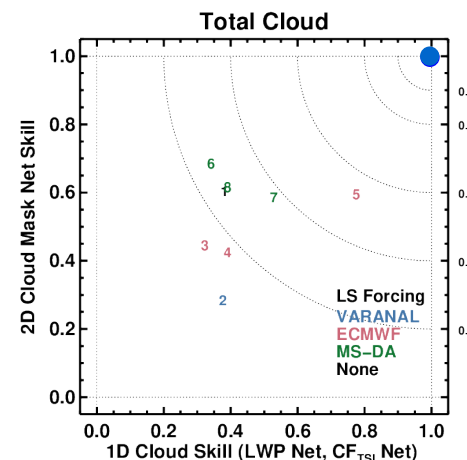


| Sim ID | Total Cloud Skill |
|--------|-------------------|
| 1 | 0.47 |
| 2 | 0.32 |
| 3 | 0.37 |
| 4 | 0.40 |
| 5 | 0.67 |
| 6 | 0.48 |
| 7 | 0.55 |
| 8 | 0.48 |

# 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

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

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

B. Static plots for *selected date* summarizing model behavior
- Heat maps, Skill score plots for all simulations 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
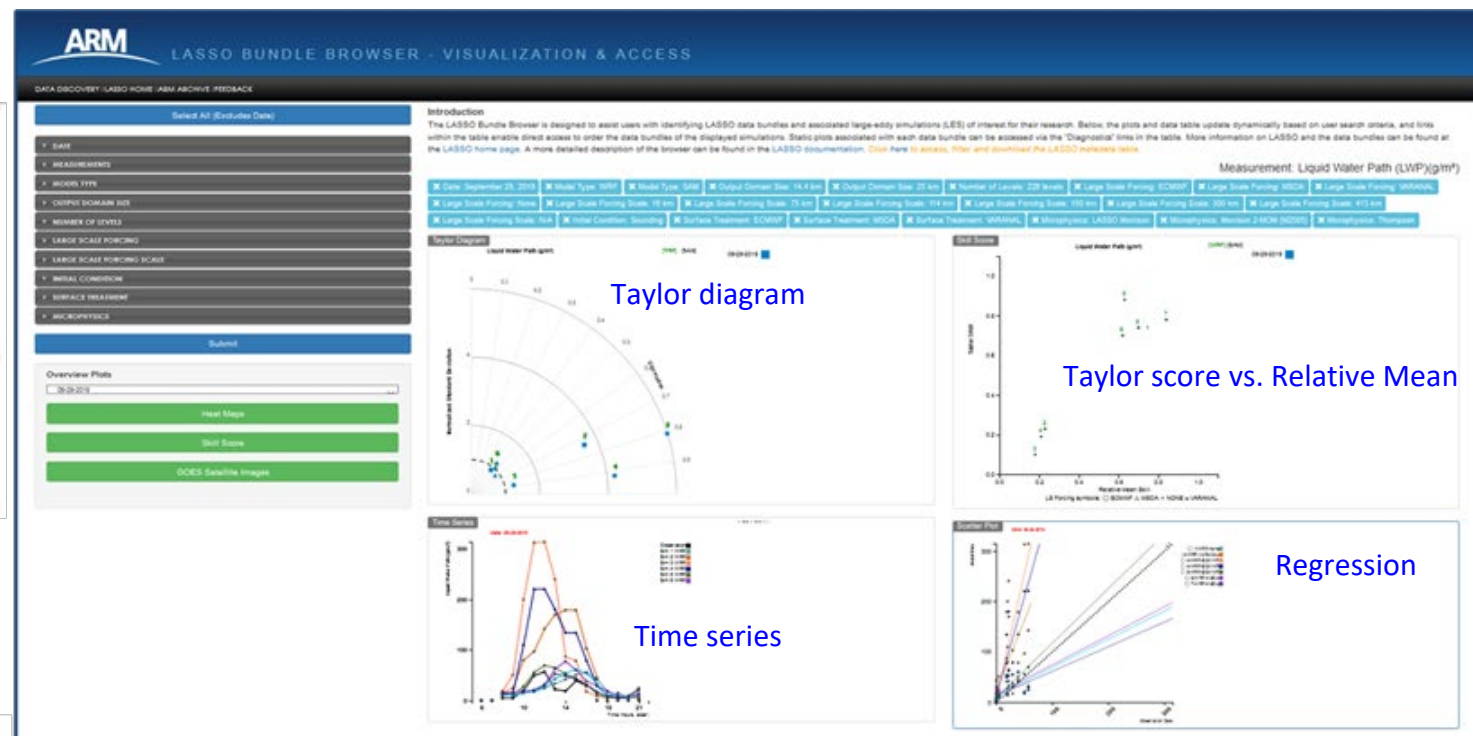
# LASSO Bundle Browser: Lower half (C, E)

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]
  - ℹ Summary of the simulation run configuration
  - Diagnostic plots per simulation: Time series, Taylor diagram, Regression, 2D Cloud Mask, Soundings
  - Ordering data



**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).
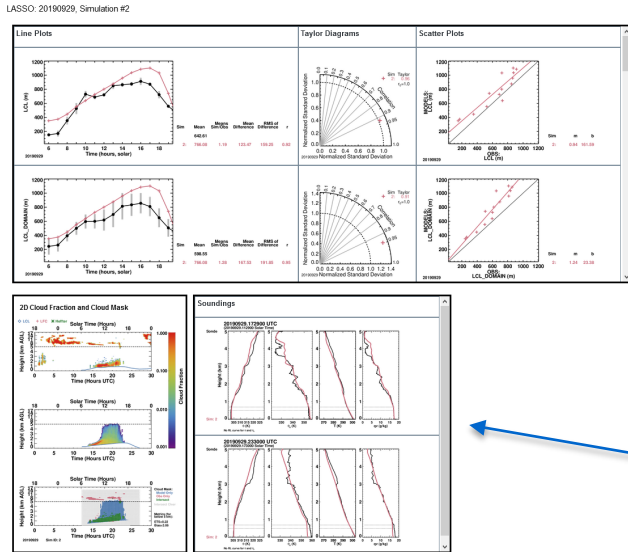
# Observation locations in the LASSO data bundles

**LASSO observations contained in a series of tar files**

- sgplassodiag**confobsmod**##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"**

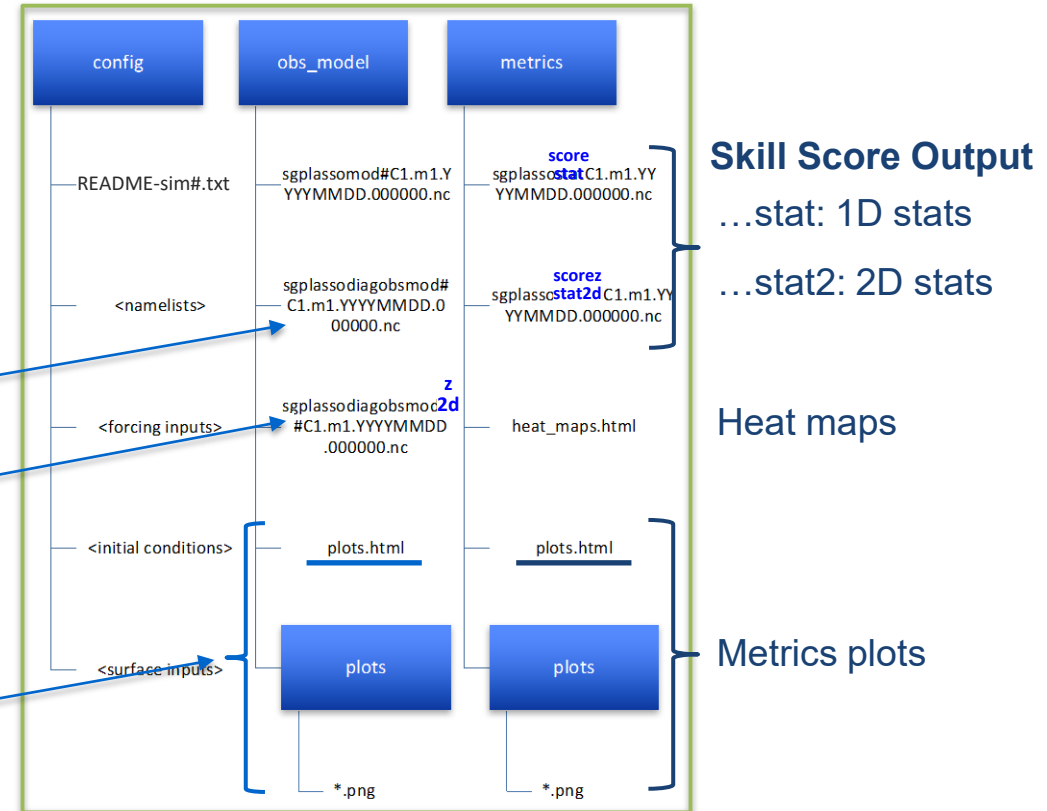sgplassodiagcon*obs*mod##C1.m1.YYYYMMDD.tar



*(Note the scroll bar)*

**Observations posted with the post-processed model output**

...diagobs**mod**: 1D Time series (hourly)

...diagobs**modz**: 2D Time-height profiles

**Diagnostic Plots**
Time series, Taylor Plots, Soudings, Regressions, 2D cloud masks

**Skill Score Output**

...stat: 1D stats

...stat2: 2D stats

Heat maps

Metrics plots

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# Questions?

**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