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Routine Large-Eddy Simulations by the DOE Atmospheric Radiation Measurement Facility:

The LES ARM Symbiotic Simulation and Observation (LASSO) Project

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LASSO Webpage: http://www.arm.gov/science/themes/lasso

LASSO e-mail list sign up: http://eepurl.com/bCS8s5

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The LASSO Vision

- Bridge the scale gap between DOE ARM observations and models
- Use routine LES to add value to observations
  - Self-consistent representation of the atmosphere
  - Provide a dynamical context for the observations
  - Elucidate unobservable processes & properties
- Generate a simulation library for researchers
  - Enable statistical approaches beyond single-case mentality
  - Provide tools necessary for modelers to reproduce the LES

What can you do with an Obs+LES library?

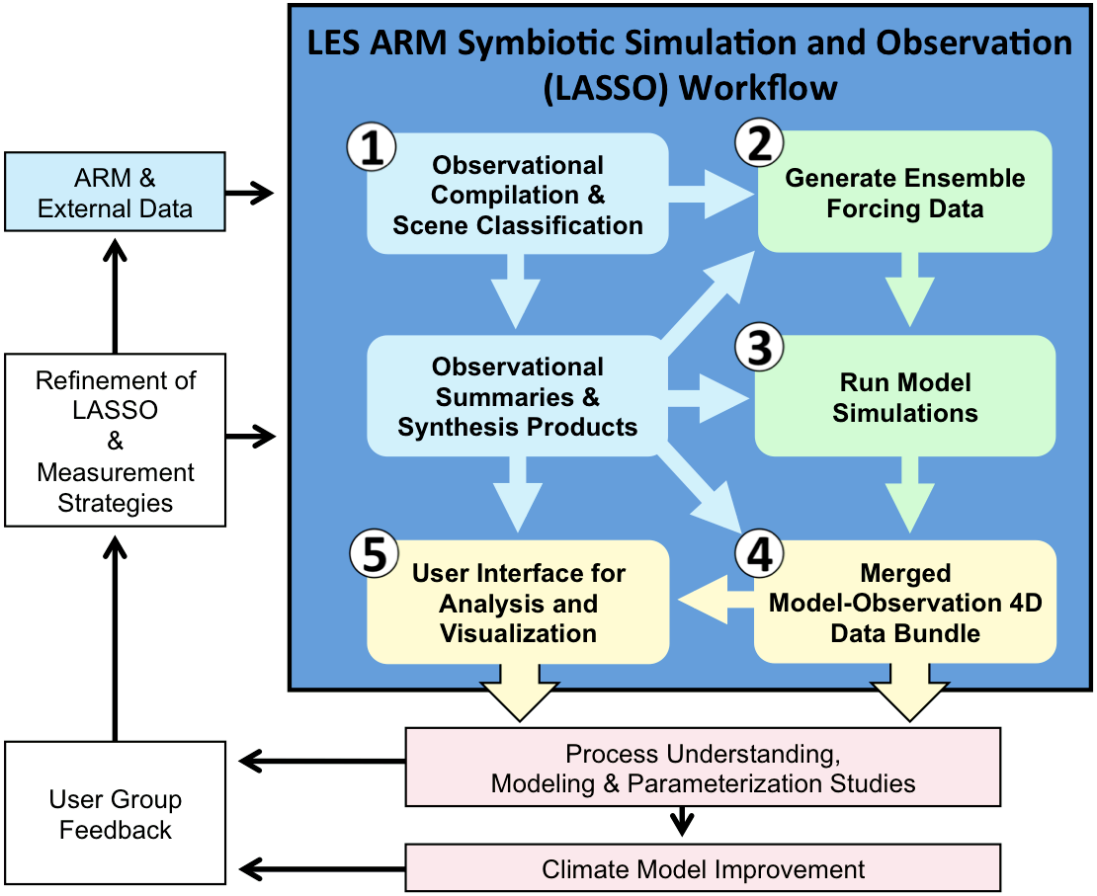
- As an observationalist
  - Inform instrument remote sensing retrievals
  - Conduct Observation System Simulation Experiments (OSSEs)
  - Test implications of radar scan strategies or flight paths
- As a theoretician
  - Get estimates of fluxes & co-variability of values
  - Test relationships w/o having to run the model yourself
- As a modeler
  - Know ahead of time which days have good forcing
  - Have co-registered observations at high-resolution scales
  - Have inputs and corresponding outputs to test parameterizations

The two-year pilot project

- Initial implementation is a proof-of-concept and targets *shallow convection* at the Southern Great Plains (SGP) site
  - Develop the ARM infrastructure for doing routine LES
  - Test interfaces and visualization methodologies for accessing the LASSO library
- Additional measurements at SGP
  - 4 boundary-layer profiling sites
  - 17 soil moisture sites
- Long-range vision: expand to multiple ARM locations and additional cloud regimes

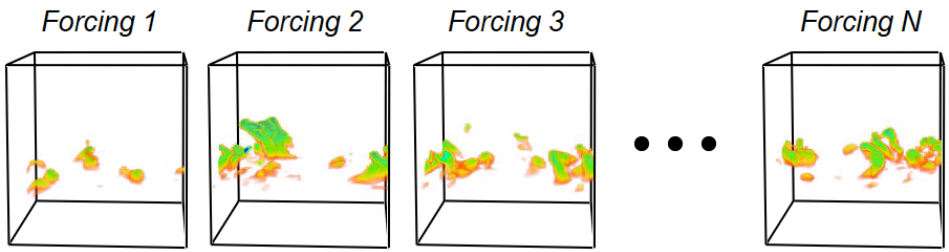
LASSO workflow

- Modular structure for flexibility and future growth
- Major focus on getting functionality in place and improving it over time



Ensemble of forcing datasets

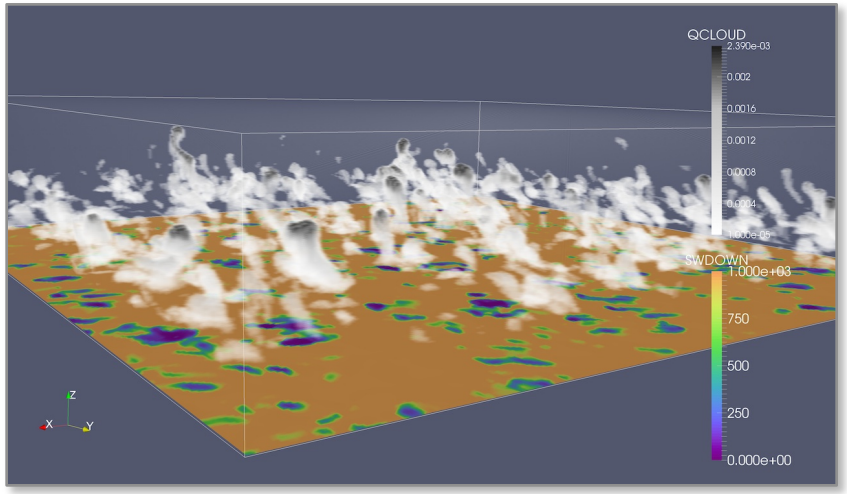
- Employ forcing ensembles to address forcing uncertainty



- Testing 3 forcing methods during pilot phase
  - ARM constrained variational analysis (VARANAL)
  - ECMWF-analysis–based forcing
  - Multi-scale data assimilation (MS-DA)
    - Based on WRF with GSI using two different error covariance scales
    - Initially using GSI w/ 3D-Var DA and plan to test hybrid EnKF DA

Model selection & configuration

- Evaluating both SAM & WRF during pilot phase
- Testing doubly-periodic & nested LES domains
- Initially targeting Δx=100 m
- Current tests with model top near tropopause



LASSO Alpha 1 Release

- First batch of 192 simulations from 5 ShCu days in 2015 at ARM SGP site in Oklahoma
- Simulations packaged into *data bundles*
  - Skill scores, metrics, and quick-looks for first-look evaluations
  - Coincident model & obs. for selected variables, e.g., CF, LWP
  - Forcing and other input data to reproduce simulations
  - Raw model output: instantaneous volumes and domain-averaged statistics
- LASSO Bundle Browser to find relevant simulations
- Will be available within the next couple weeks

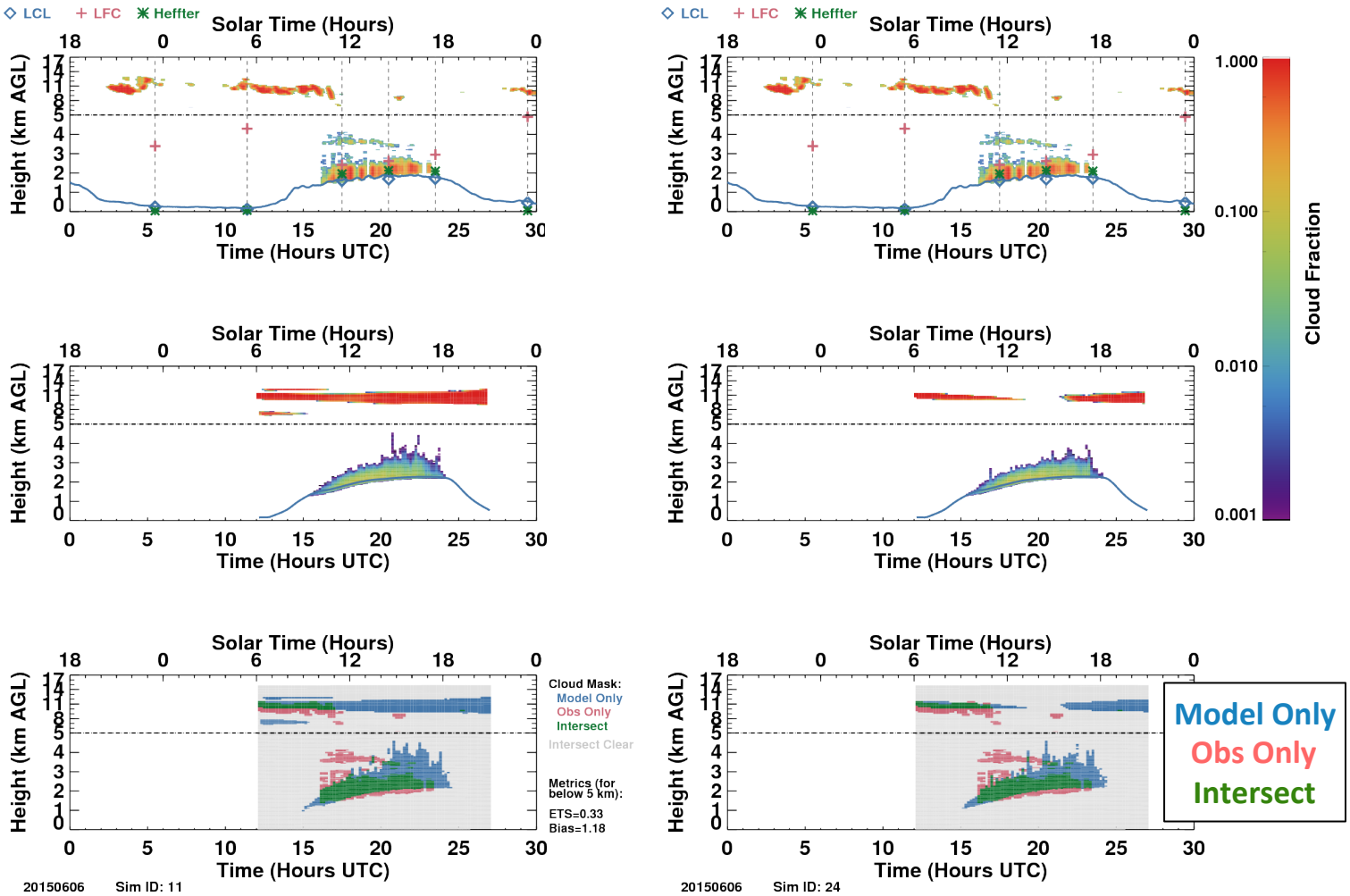
Working to simplify case comparisons

- For example, two different microphysics options…

KAZR-ARSCL Observed Cloud Freq.

WRF Simulated Cloud Fraction

Cloud Mask Comparison



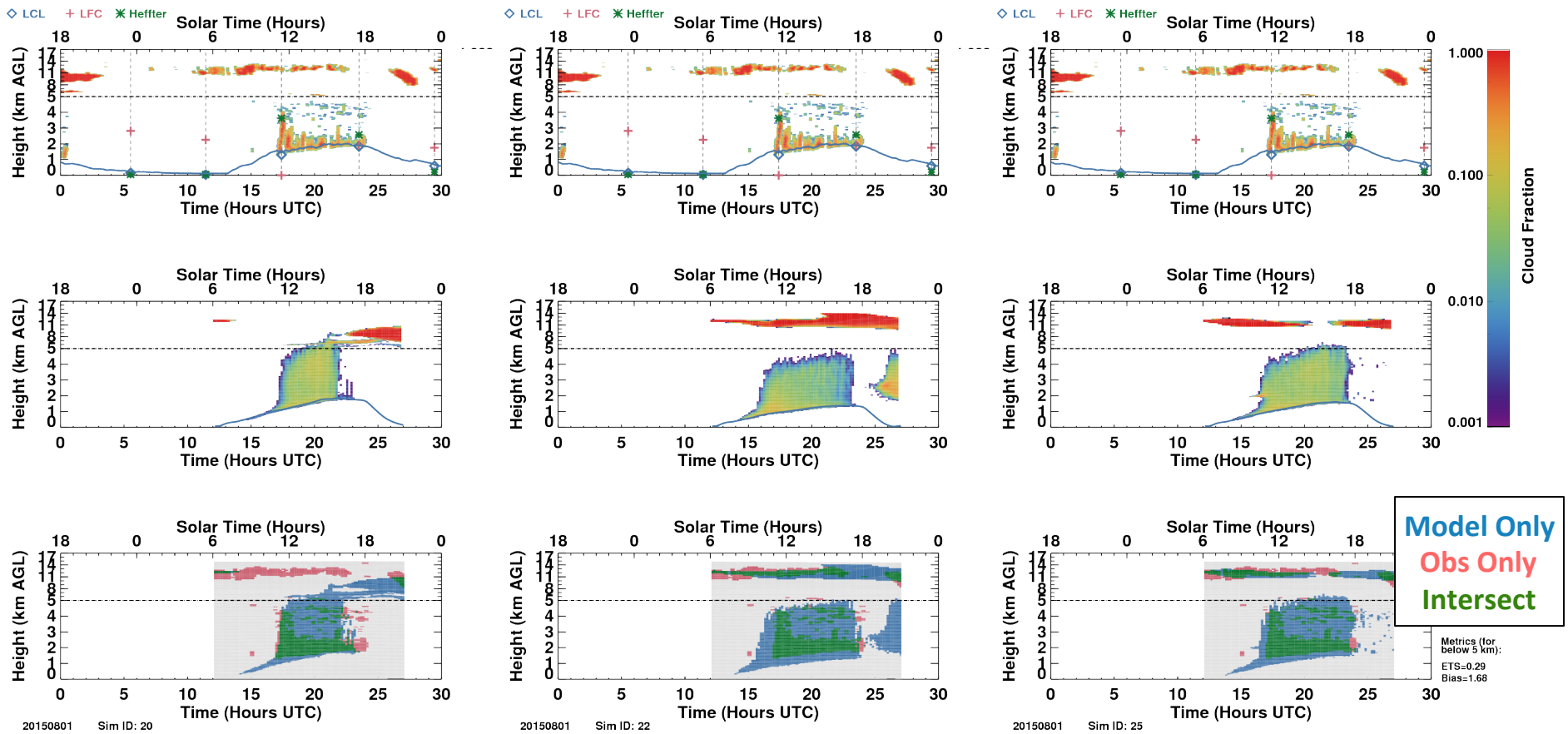
6-Jun-2015

Sensitivity to the forcing data

Variational Analysis

ECMWF, 413 km

MS-DA, 300 km



1-Aug-2015

LASSO Timeline

May 2015	Pilot project began
June 2016	Initial ShCu simulations from spring-summer 2015 made available • Ensemble of forcings • LES simulations from SAM and WRF (bulk microphysics) • Observations in comparable form • First cut at metrics and diagnostics
January 2017	2nd batch of ShCu simulations from spring-summer 2016 • Will include influence of boundary facility profiles • Both bulk and spectral-bin microphysics versions
April 2017	Additional test cases for year-round shallow cloud conditions Beta software suite Recommended configurations for ongoing simulations
May 2017	Pilot project over and transition to routine simulation mode

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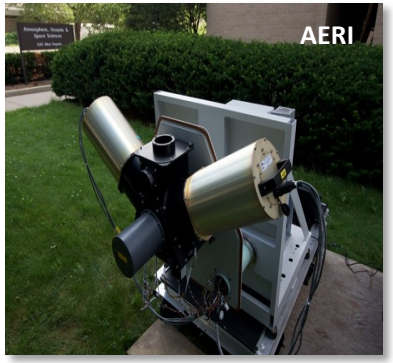
Extra slides…

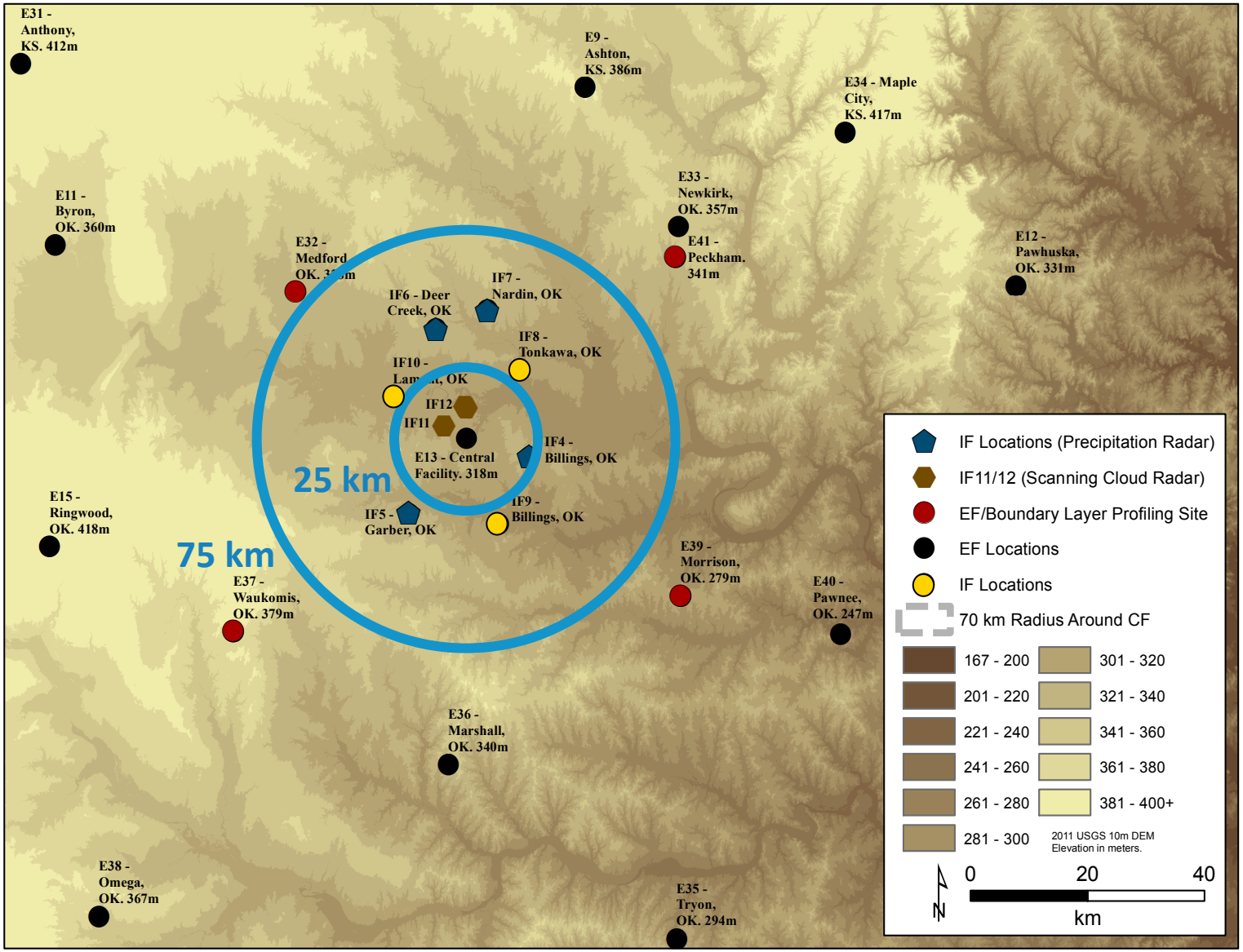
SGP Megasite Supports Integrated Measurements-Model Strategy

Measurement Enhancements:

- Boundary Layer Profiling Modules (4 locations)
- Upgrades to AOS and Raman Lidar Instruments
- Improved soil moisture network (17 locations)
- Considering deployment of multiple scanning cloud radars



The Southern Great Plains Megasite

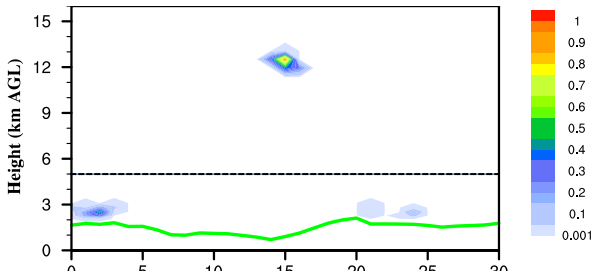


Multi-scale data assimilation

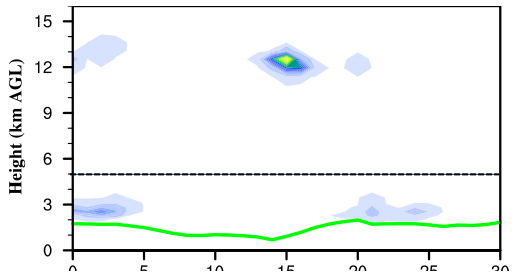
- Start with a gridded background field, e.g. FNL
- Incorporate ARM T, q, and wind profiles from boundary/intermediate facilities
- Provides a 3-D volumes for generating LES forcing

Cloud Fraction from Δx=2 km MS-DA

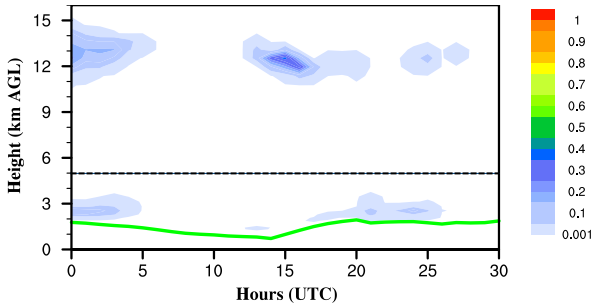
Averaged over 25 km



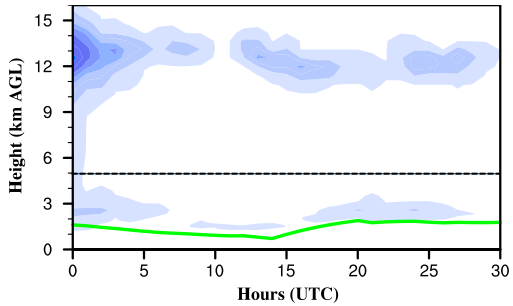
Averaged over 75 km



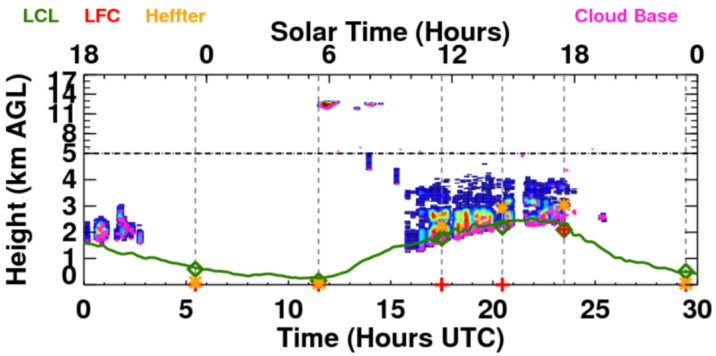
Averaged over 150 km



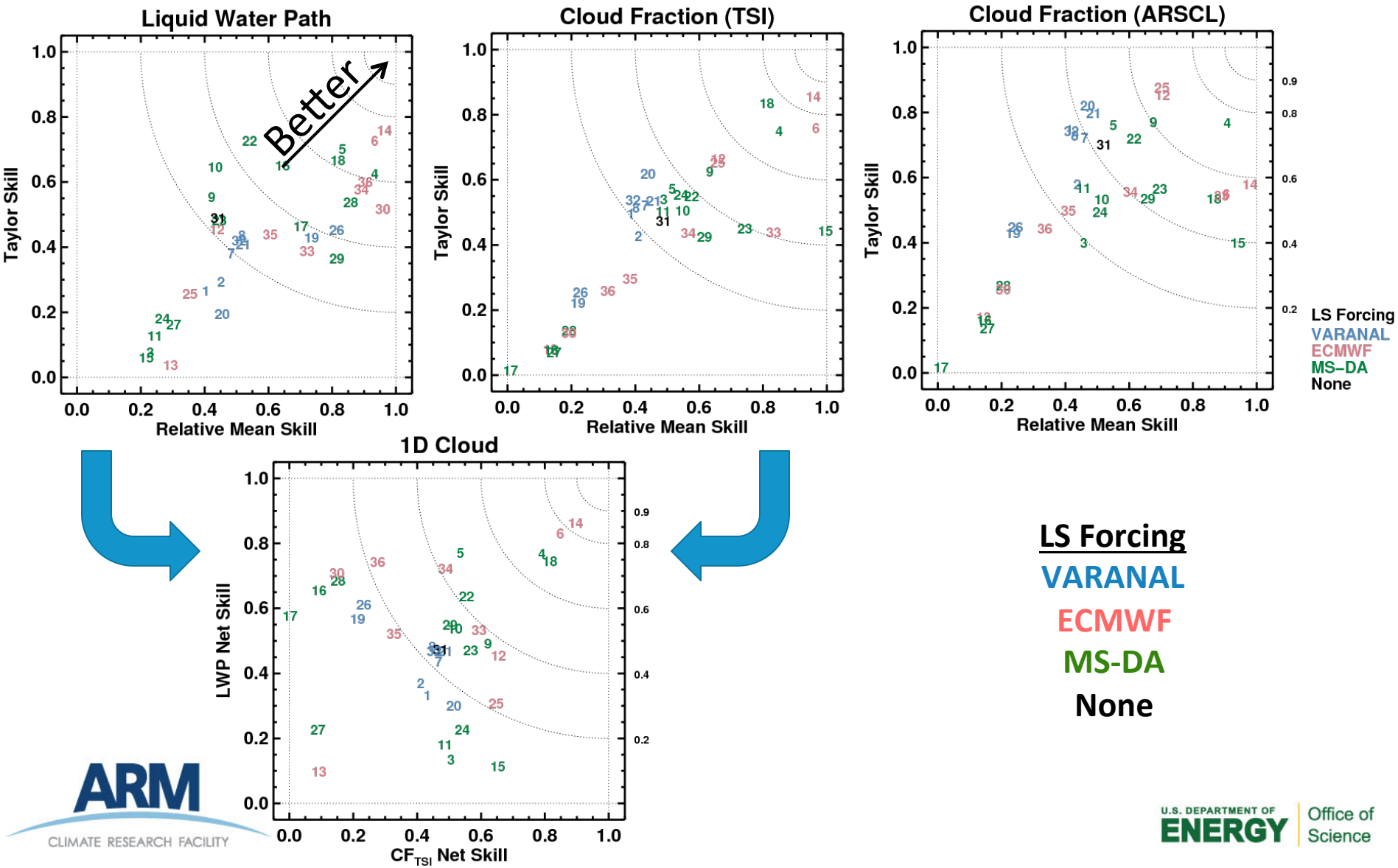
Averaged over 300 km



ARSCL Cloud Fraction



Skill scores summarizing model behavior



LS Forcing

VARANAL

ECMWF

MS-DA

None

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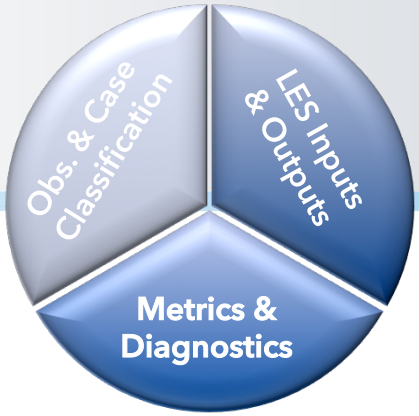
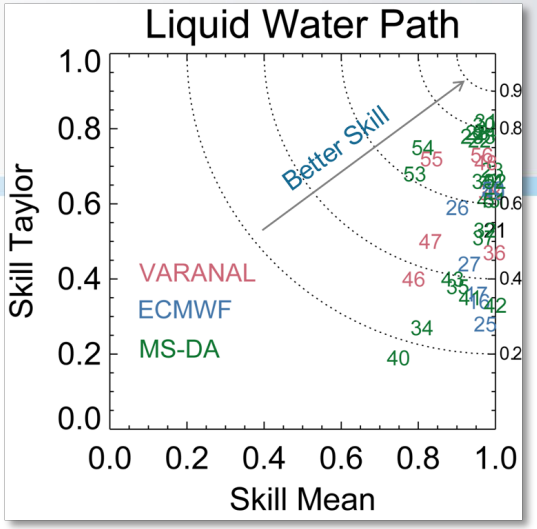
Data bundles



- Data bundles will provide the primary interface for LASSO data
- Contain observation & model output in comparable forms
  - Appropriate time sampling
  - Instrument simulators
- Include pre-computed quick-looks, metrics, and diagnostics to assist data discovery and quicken user analysis
- Include 3-D model fields, profile statistics, model-based budget terms, and GCM parameterization terms.
- Forcings and initial conditions provided for users to conduct their own sensitivity studies.

Data bundle metrics



- LES simulations assessed using diagnostics based on ARM observations of cloud and environmental properties
  - E.g., Time series, Regression analyses, Taylor diagrams, Heat maps, and Phase space relationships
- Skill scores based on the diagnostics will quantify the quality of the simulations
  - e.g., LWP, cloud fraction, temperature, water vapor concentration, relative cloud forcing, vertical velocity, etc.
- Searchable metrics will assist users in finding cases of interest.