

Observationally Driven Routine Large-Eddy Simulations: Enhancing Community Research through the DOE LASSO Project

Core LASSO Team

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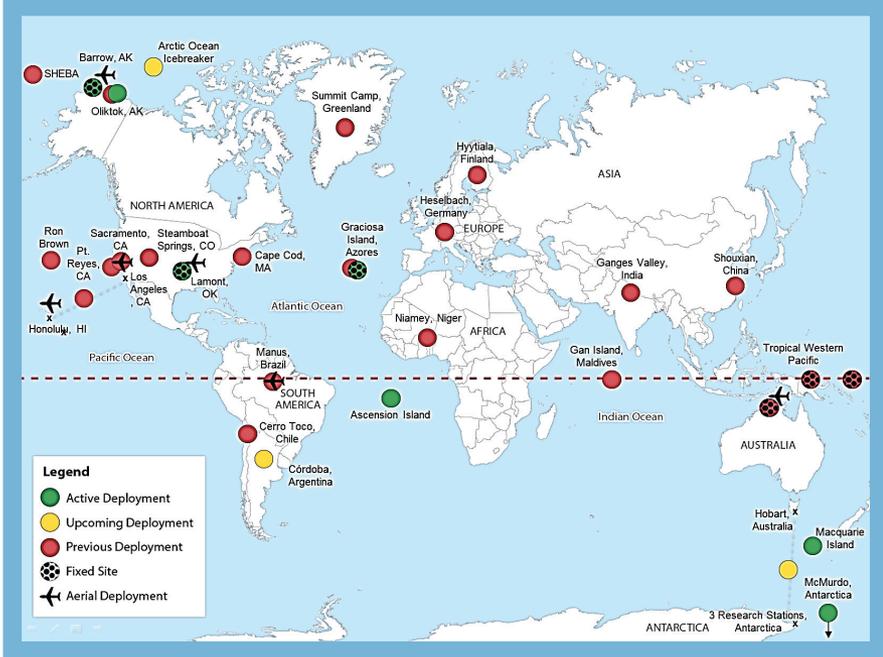
Town Hall at the AGU Fall Meeting, 12-Dec-2017

The DOE Atmospheric Radiation Measurement (ARM) Climate Research Facility



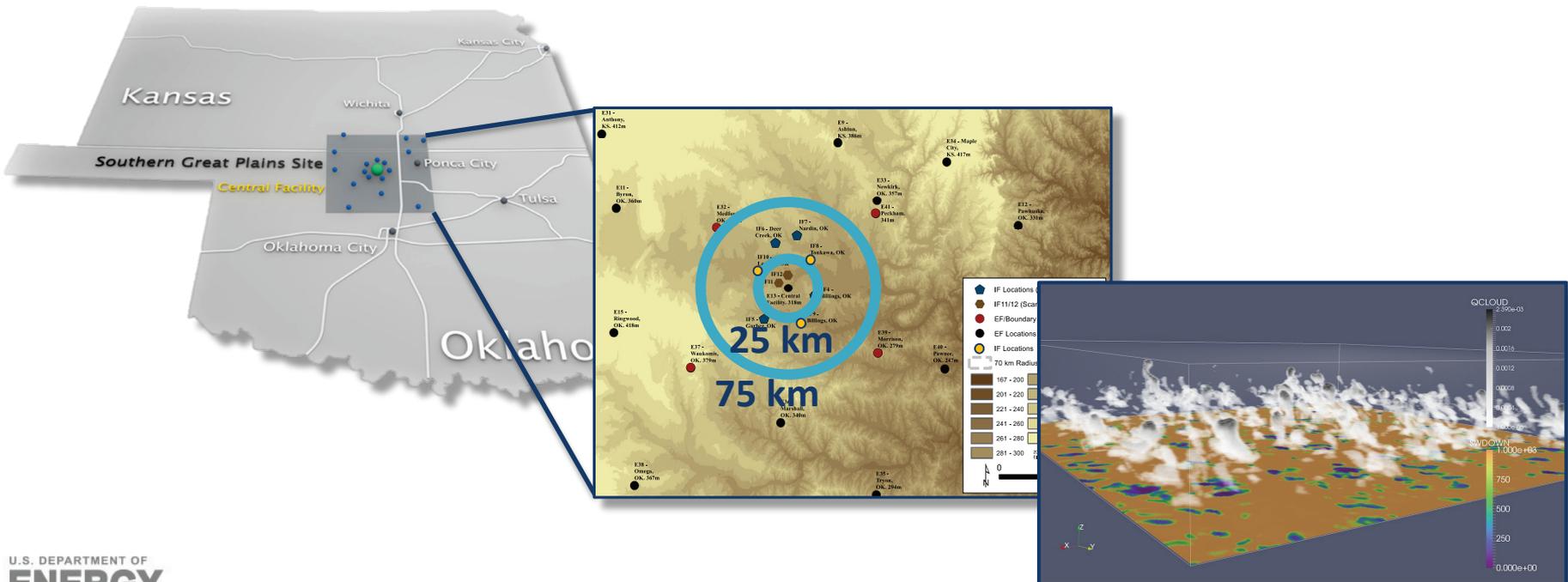
ARM Vision Statement

To provide a detailed & accurate description of the earth atmosphere in diverse climate regimes to resolve the uncertainties in climate and earth system models toward the development of sustainable solutions for the Nation's energy & environmental challenges.

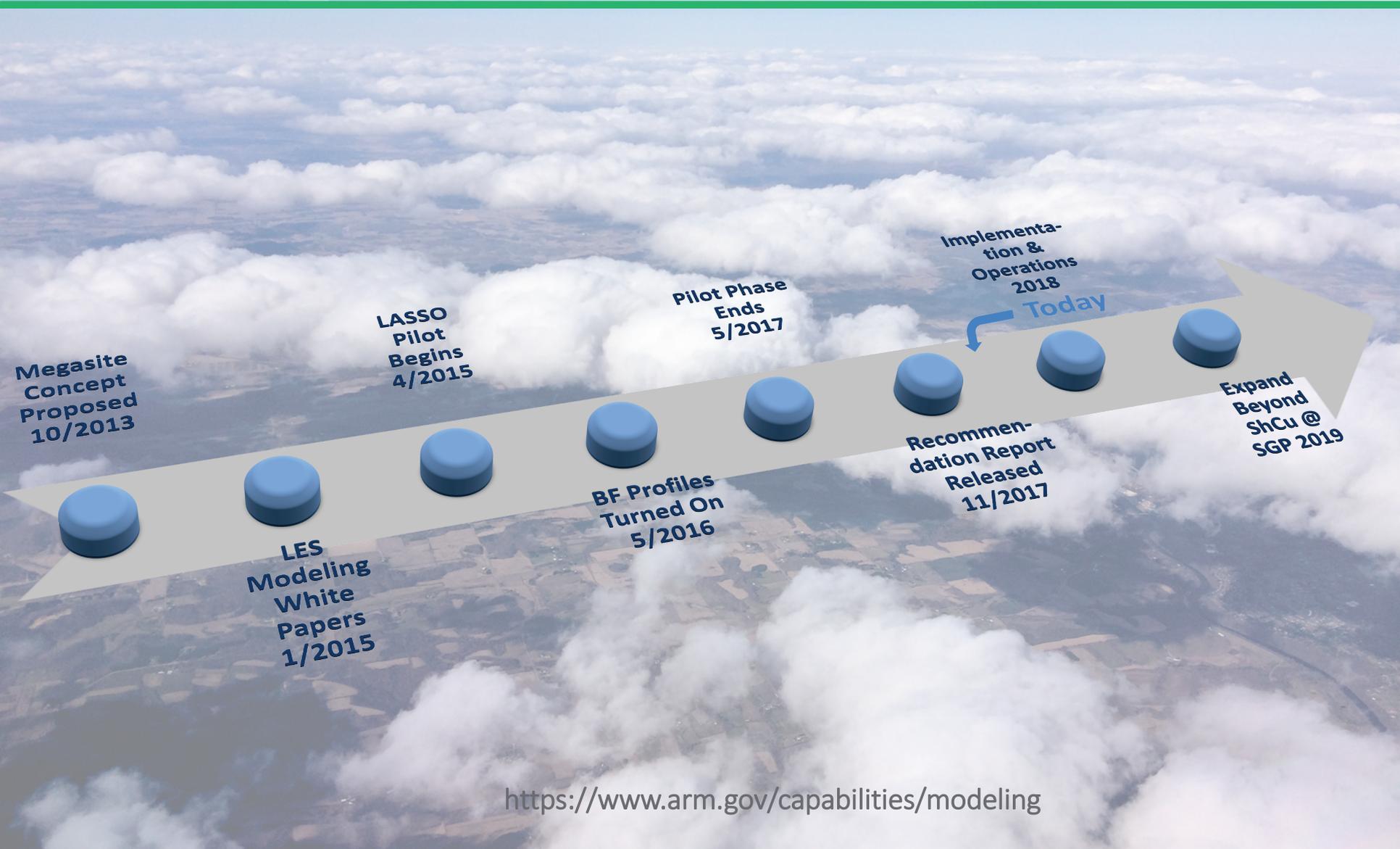


What is LASSO?

- LASSO = LES ARM Symbiotic Simulation and Observation workflow
 - ▶ <https://www.arm.gov/capabilities/modeling/lasso>
- The DOE Atmospheric Radiation Measurement (ARM) Facility completed the LASSO pilot phase and is working to make LASSO operational



The road to LES at SGP



Megasite
Concept
Proposed
10/2013

LES
Modeling
White
Papers
1/2015

LASSO
Pilot
Begins
4/2015

BF Profiles
Turned On
5/2016

Pilot Phase
Ends
5/2017

Recommendation Report
Released
11/2017

Implementa-
tion &
Operations
2018
Today

Expand
Beyond
ShCu @
SGP 2019

- Bridging the scale gap between ARM observations and models

- Use LES to add value to ARM 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
 - ▶ Ensemble of large-scale forcings for each case
 - ▶ 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

Recommendations for Implementation of LASSO

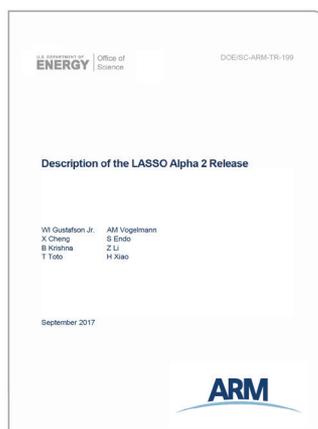
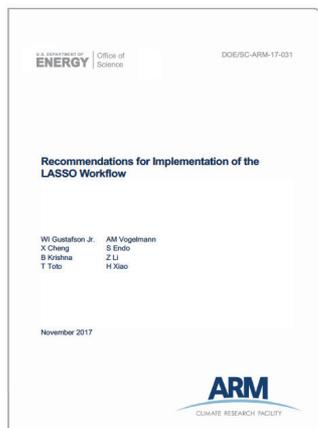
Gustafson, et al., 2017. Recommendations for Implementation of the LASSO Workflow. doi:10.2172/1406259.

- ▶ Contains recommendations from the LASSO Pilot Phase regarding what should be implemented for operations
- ▶ We are still accepting feedback and have not yet locked down the implementation

Description of the LASSO Alpha 2 Release

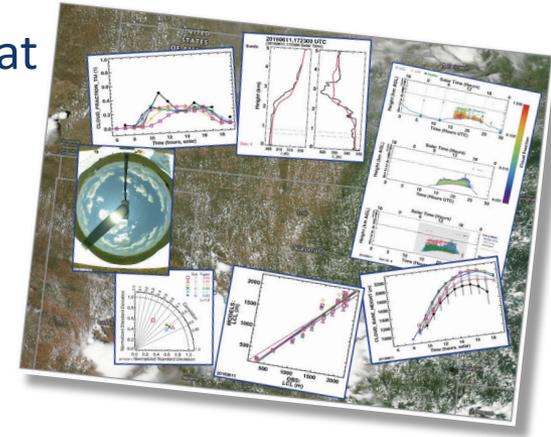
Gustafson, et al., 2017: Description of the LASSO Alpha 2 Release. doi:10.2172/1376727.

- ▶ Contains technical details about the LASSO data bundles, e.g., skill score descriptions, lists of variables



Core LASSO components

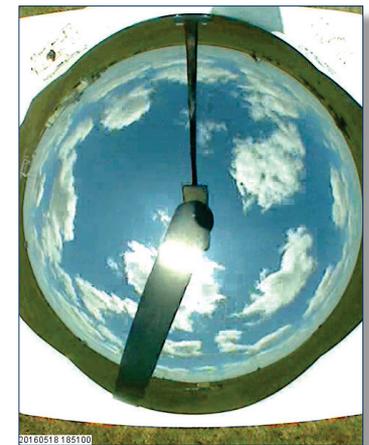
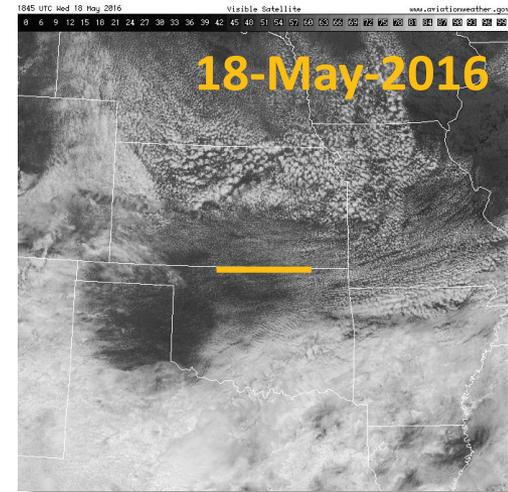
- Library of LES simulations for **shallow convection** cases at ARM's **Southern Great Plains** observatory: currently 18 days and growing
- For each case:
 - ▶ Ensemble of large-scale forcing data sets drives the LES
 - ▶ LES inputs and outputs for the ensemble
 - ▶ Selection of concurrent observations for cloud and boundary layer variables
 - ▶ Skill scores and diagnostics evaluating the simulations
- Bundle Browser interface to find simulations of interest
 - ▶ <http://archive.arm.gov/lassobrowser>



LASSO employs an ensemble of forcings to capture the range of possible conditions

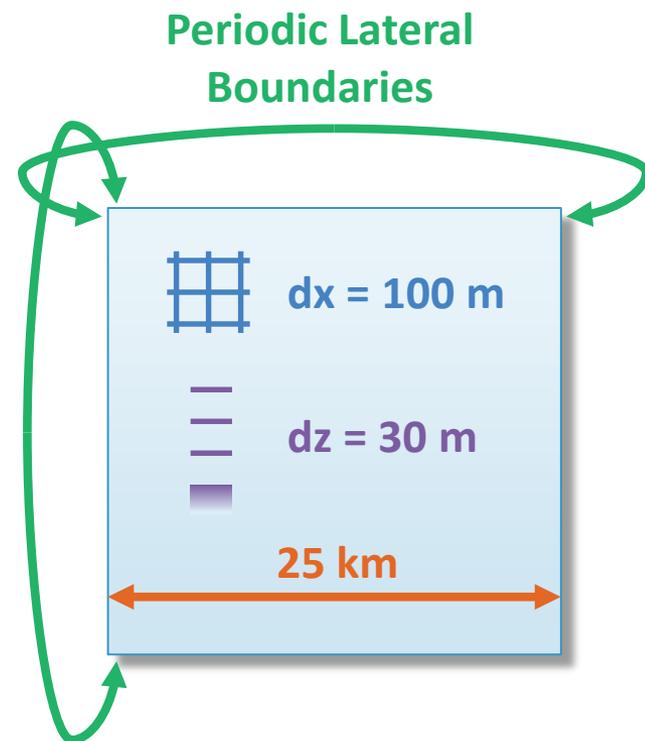
Large-scale forcing datasets generated from 3 sources

- Variational Analysis: ARM product, 300 km spatial scale
- ECMWF IFS model: ~16, 115, & 413 km spatial scales
- Multiscale Data Assimilation (MSDA): 75, 150, & 300 km scales; can directly incorporate ARM observations into the analysis
 - ▶ Hybrid AERI + Raman Lidar temperature profiles
 - ▶ Raman Lidar water vapor profiles
 - ▶ RWP wind profiles
 - ▶ Surface meteorology

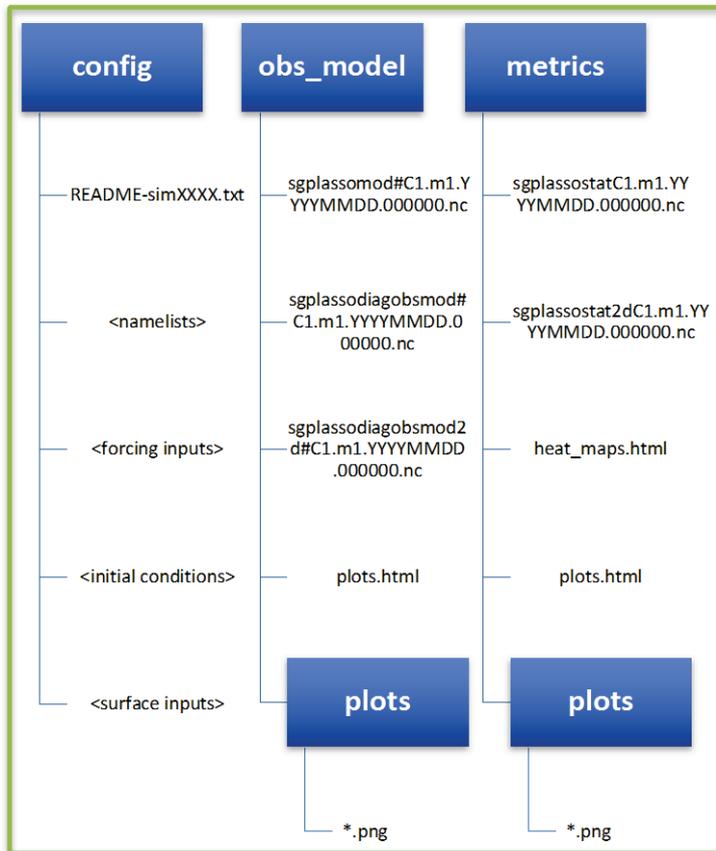


Large-eddy simulation configuration

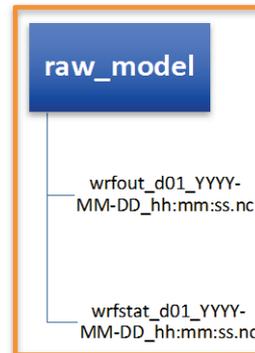
- Weather Research and Forecasting (WRF) model with “FASTER” LES package
- Uniform lower boundary with specified surface fluxes based on ARM observations
- Thompson microphysics & RRTMG radiation
- 8-member ensemble for each case based on forcings



Data bundles for easing data digestion



sgplassodiagconfobsmod#C1.m1.YYYYMMDD.tar



sgplassodiagraw#C1.m1.YYYYMMDD.tar

Configuration-observation-model tarball

- ▶ Model config. & inputs
- ▶ Hourly observations & concurrent, subsetted model output
- ▶ Diagnostic plots & skill scores

Raw model output tarball

- ▶ 10 min. output frequency
- ▶ Instantaneous domain snapshots
- ▶ Time and domain-averaged statistics, e.g. $w'w'$
- ▶ Time-averaged column statistics

Observations recommended for data bundles

Physical Process Category	Hourly Observation	Readiness at Locations				
		CF	IF	BF	EF	Meso
Boundary layer state	Surface temperature	1	3	3	3	3
	Surface water vapor mixing ratio	1	3	3	3	3
	Surface relative humidity	1	3	3	3	3
	Radiosonde soundings (4x daily)	1				
	Mid-boundary layer temperature	2			3	
	Mid-boundary layer mixing ratio	2			3	
	Mid-boundary layer relative humidity	2			3	
	Full boundary layer thermodynamic profile	3				
	Lifting condensation level	1	1	1	1	1
	Planetary boundary layer height	3	3			
	Boundary layer vertical velocity	3			3	
	Inversion strength	3				
	Inversion wind shear	3			3	
Cloud characteristics	Low-cloud fraction from ARSCL	1				
	Time-height cloud frequency from ARSCL	1				
	Cloud fraction from TSI	1				
	Regional cloud fraction from Doppler lidar	3			3	
	Liquid water path	2			2	
	Cloud-base height	2			2	
Meteorological forcing	ARM Variational Analysis with sensible and latent heat fluxes	1	Spatial scales: 300 km			
	ECMWF forcing for multiple spatial scales	1	16, 114, 413 km			
	MSDA forcing for multiple spatial scales	2&3	75, 150, 300 km			

Readiness Levels

1 = Available observations implemented in the data bundles

2 = Partially implemented observations

3 = Implies aspirational observations



Introduction

Welcome to the LASSO Bundle Browser that is designed to assist users with identifying LASSO large-eddy simulations (LES) of interest for their research. The plots and associated data table update dynamically based on user search criteria, and links within the table enable direct access to order the data bundles of the displayed simulations. More information on LASSO and the data bundles can be found at the [LASSO home page](#) and on the [Alpha 1 Release web page](#). Note that this is an initial evaluation version of the browser that specifically queries and displays observed and simulated cloud properties for the five days worth of simulations released in the LASSO Alpha 1 release. There are 192 simulations between the five days that differ in terms of the LES model, forcing dataset, domain size, and model physics.

Select All

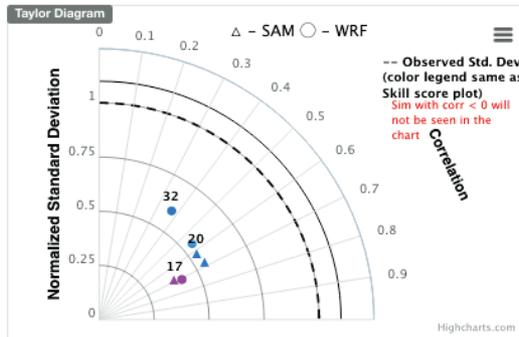
- ▶ Date
- ▶ Measurements
- ▶ Model Type
- ▶ Output Domain Size
- ▶ Number of Levels
- ▶ Large Scale Forcing
- ▶ Large Scale Forcing Scale
- ▶ Initial Condition
- ▶ Surface Treatment
- ▶ Microphysics

Submit

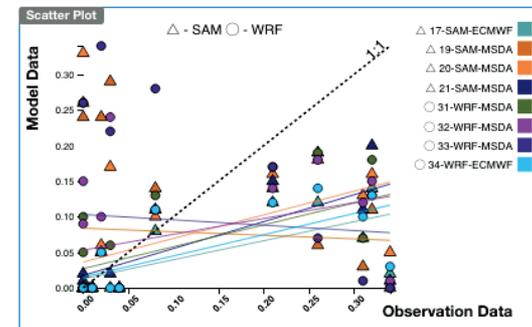
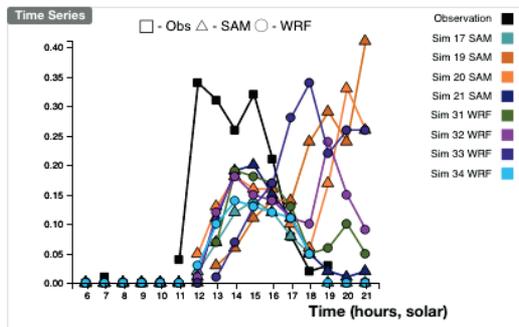
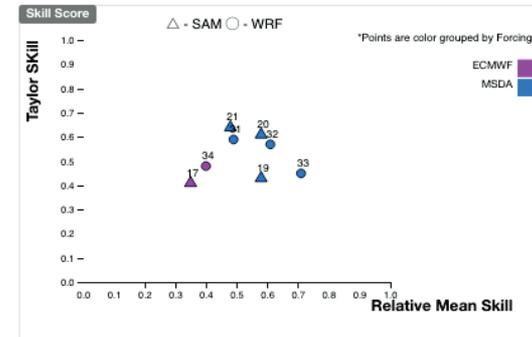
Overview Plots

- Heat Maps
- Metrics

Date: June 9, 2015



Measurement: Cloud Fraction TSI



Skill Scores on June 9, 2015

Measurement Skill
 0 1

1D Cloud Skill
 0 1

Copy CSV Print PDF Search:

Simulation ID	Measurement Skill (Cloud Fraction TSI)	1D Cloud Skill	2D Cloud Mask Skill	Total Cloud Skill
17 (Diagnostics) (Data)	0.38	0.5	0.23	0.34
19 (Diagnostics) (Data)	0.5	0.47	0.26	0.35
20 (Diagnostics) (Data)	0.6	0.67	0.28	0.43

Currently available products

<https://www.arm.gov/capabilities/modeling/lasso>



■ Alpha 1 Release

- ▶ 5 case days from spring–summer 2015
- ▶ 192 simulations
- ▶ Aimed at getting initial concept to the community for feedback
- ▶ Currently re-running to make consistent with Alpha 2 and to fix some bugs

■ Alpha 2 Release

- ▶ 13 case days from spring–summer 2016
- ▶ 544 simulations
- ▶ Systematic comparison of domain size, grid spacing, microphysics, and model choice

■ Primary foci during 2018

- ▶ Running 2017 shallow convection cases—looks to have a lot of case days
- ▶ Implementing the infrastructure components
- ▶ Document LASSO in peer-reviewed papers

■ Begin decision process for LASSO expansion

- ▶ ShCu at Southern Great Plains is intentionally the simplest possibility to be used for implementing the overall methodology within ARM
- ▶ ARM's Decadal Vision calls for expanding LASSO to include multiple cloud types and/or locations
- ▶ What's next? The plan for how to make the decision is due the end of Feb.

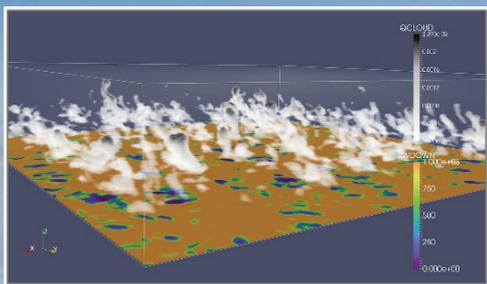
- Top-level webpage: <https://www.arm.gov/capabilities/modeling>
- Bundle Browser interface: <http://www.archive.arm.gov/lassobrowser>
- E-mail list: <http://eepurl.com/bCS8s5>
- Contacts: William Gustafson and Andrew Vogelmann at lasso@arm.gov

- More LASSO opportunities
 - ▶ Andrew Vogelmann's talk, Tues. 9:20, [A21O-06: ShCu cloud-base mass flux...](#)
 - ▶ Zhijin Li's talk, Tues. 5:30, [NG31A-0167: Multiscale data assimilation for LES](#)
 - ▶ William Gustafson's talk, Fri. 11:05, [A52C-04: LASSO forcing data set comparison...](#)
 - ▶ Office hours at AGU vendor booth
 - William Gustafson: Wed. 2:30-3:30 & Thur. 11:30-12:30
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Flash talks...

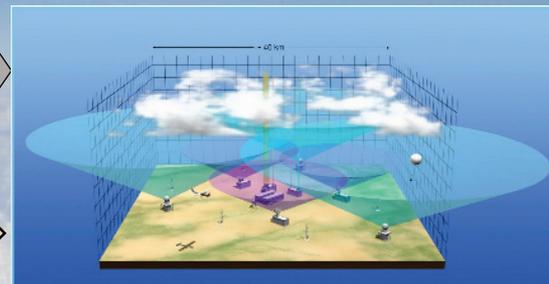
How well can observation capture a cloud field?

Cloud Model Simulations



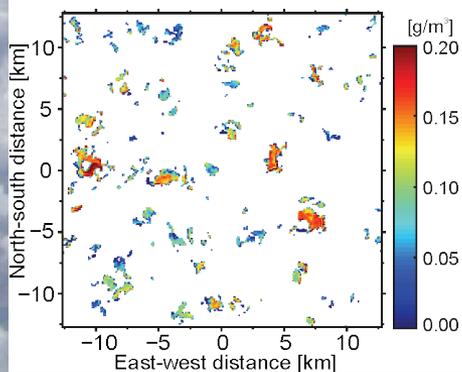
Cloud Resolving Model
Radar SIMulator (CR-SIM)

Virtual Observational Products

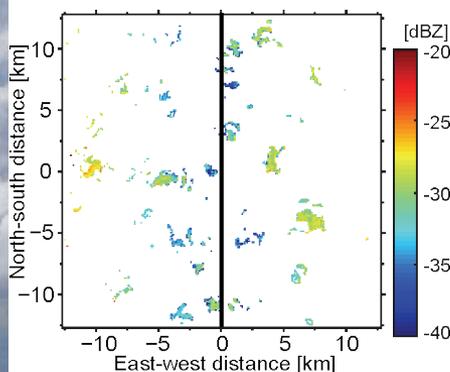


Compare simulated observational cloud field with the original model output to address potential uncertainties in observational products.

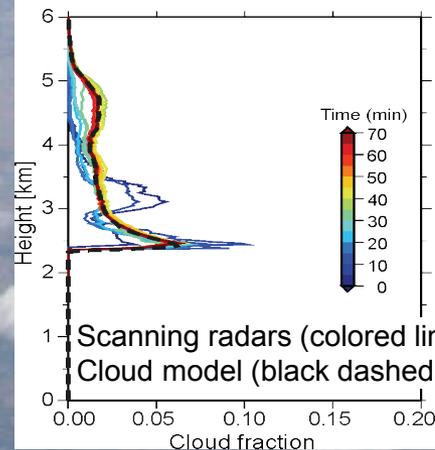
Model Cloud Field



Simulated Observation



Cloud Fraction Profiles

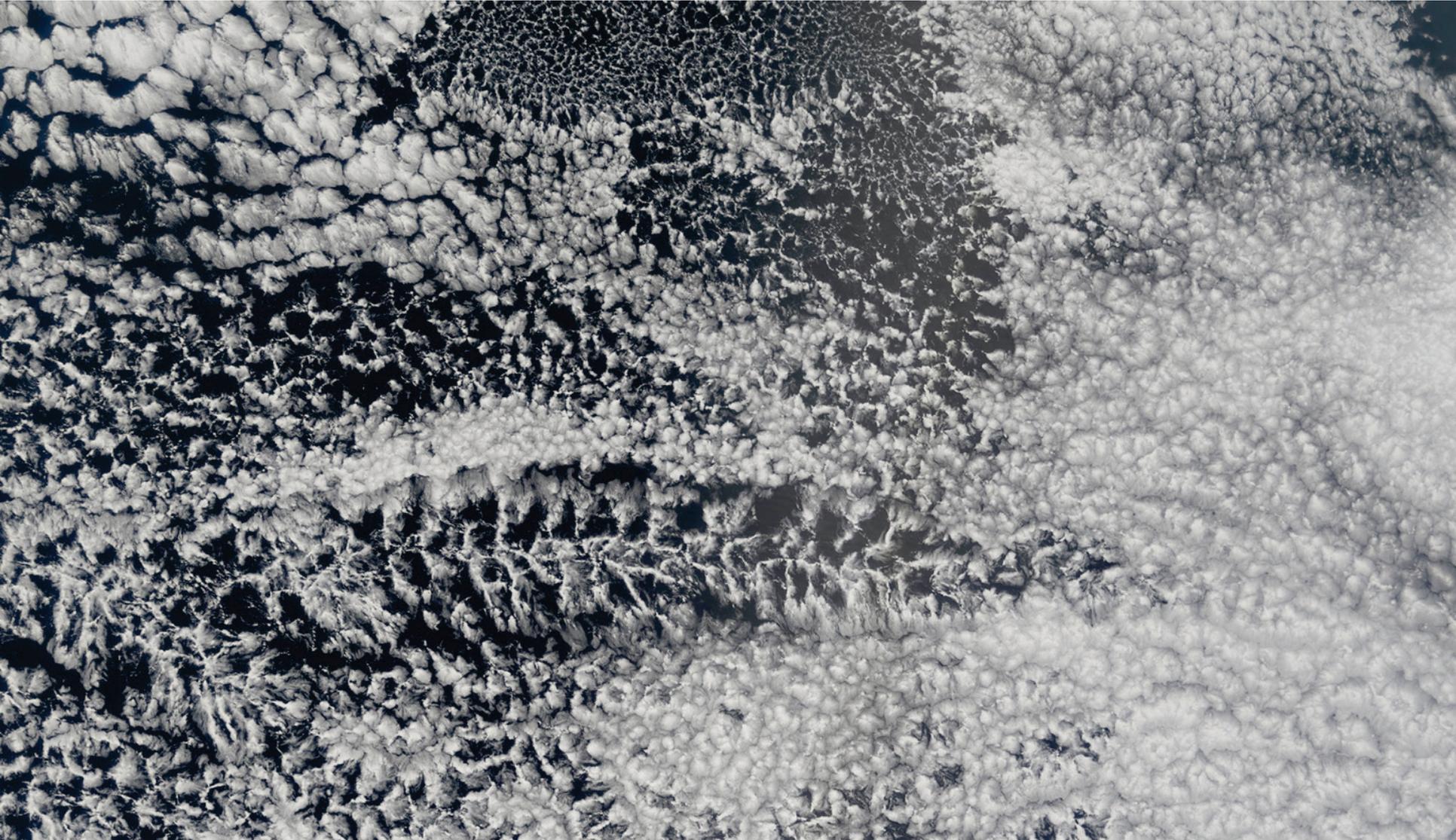


35 min or more scans can capture the domain averaged CFP.

Learning from LASSO: Machine Learning Clouds and Turbulence

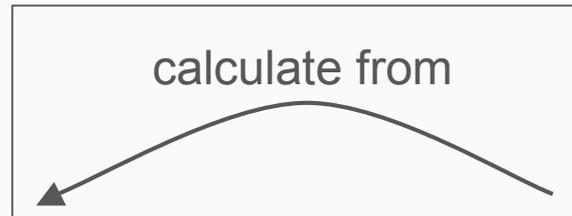
Jeremy McGibbon and Chris Bretherton
University of Washington







Higher-order Turbulence Closure



Low order

e.g., mean,
correlations

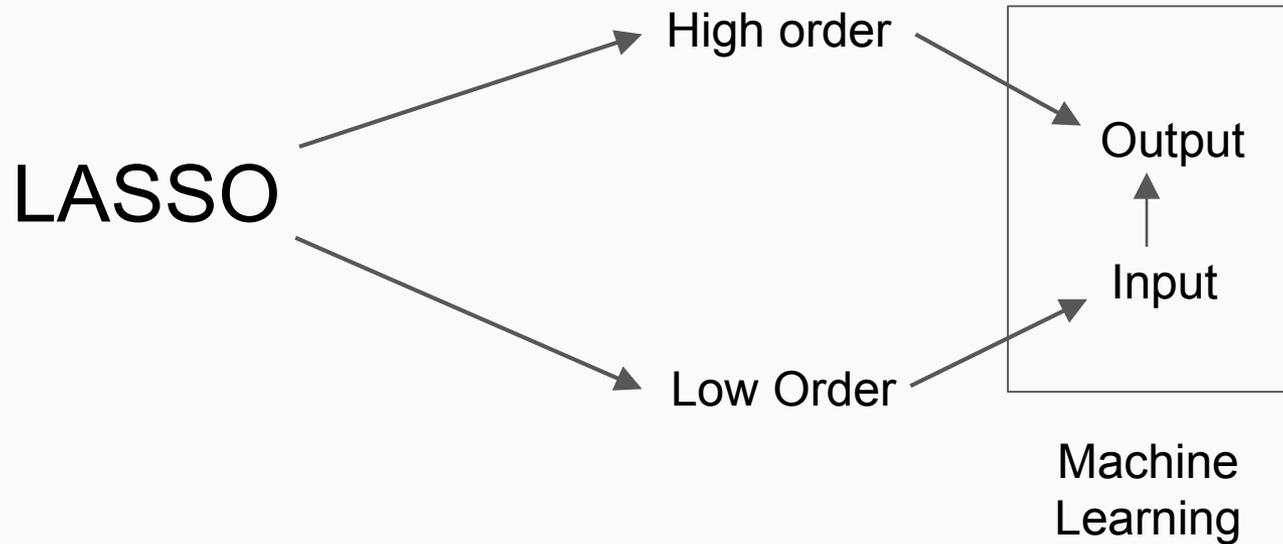
depends on



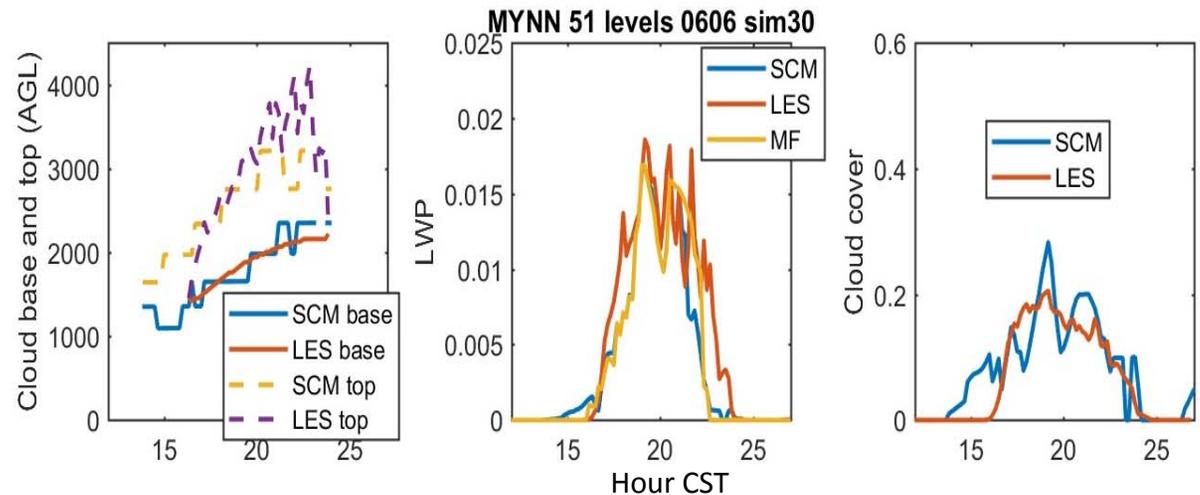
Higher Order

e.g., skewness

Learn it from Data!



MYNN-EDMF PBL & shallow Cu scheme development and evaluation with LASSO



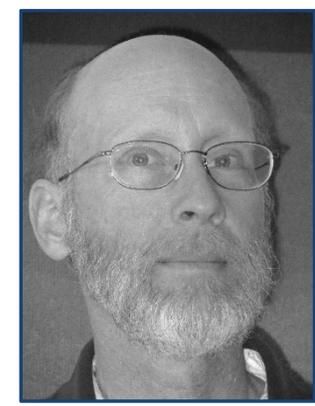
LASSO LES benchmark allows us to evaluate the new scheme's performance against LES on multiple days and with multiple forcing options

Here I show 6 June 2015 with VARANAL initial & boundary conditions and advection

WRF run in single-column mode

Features to note:

- SCM cloud base good
- Cloud onset early
- LWP good
- Cloud cover good



Wayne Angevine and Joe Olson
NOAA ESRL

Discussion and question and answer time...

Let's learn about you!



- How much did you know about LASSO prior to attending today?
- What is your funding/organizational affiliation?
- Have you downloaded LASSO data (Alpha 1 or 2)?
- Do you plan to use LASSO in the future?

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