Routine LES: LASSO and beyond

Breakout Organizers
William Gustafson (PNNL), Andrew Vogelmann (BNL), &
Jim Mather, ARM Technical Director (PNNL)

Core LASSO Team
PNNL: William Gustafson (PI), Heng Xiao
BNL: Andrew Vogelmann (Co-PI), Satoshi Endo, Tami Toto
UCLA: Zhijin Li
NUDT, China: Xiaoping Cheng
ORNL: Bhargavi Krishna

Breakout at the 2018 ARM/ASR PI Meeting, Mar. 2018

Agenda

- LASSO review: current state & implementation plans (Gustafson)
- Science applications (Heus, Xiao, Oue, & Glenn)
- Discussion & feedback on LASSO implementation (Vogelmann)
- Approaching the LASSO expansion decisions (Mather)
- Guided discussion of candidate expansion scenarios (Gustafson & Vogelmann)
- Open discussion of LASSO expansion (Gustafson & Vogelmann)
- Summarizing action items (Gustafson)

LASSO is an approach with an associated product

- **Goal:** The LASSO Workflow is designed to complement ARM megasite observations with LES output to support the study of atmospheric processes and the improved parameterization of these processes in atmospheric models

- **Approach:** Provide a library of cases and use an ensemble of LES combined with observations to simplify data discovery and bridge the gap from point observations to model grid cells—the modeling adds value to ARM's observations

- **Status:** Completed the pilot phase testing and currently implementing the first iteration to routinely run the LES for shallow convection days at SGP, working on expansion options during 2018/2019

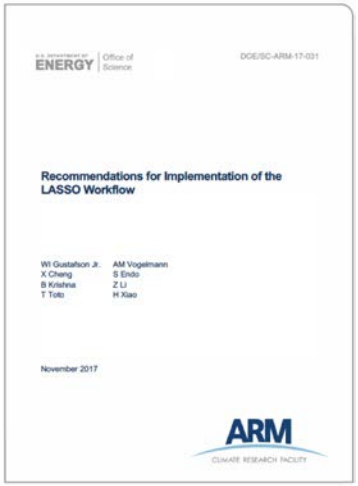
What makes LASSO special?

1. Ever-growing library of LES cases to build robust statistical analyses and confidence
2. Focus on blending observations, forcings, and LES into user-friendly data bundles
3. Steps back from the tradition of fine-tuned, idealized forcings by employing an ensemble of plausible forcings constrained by observations
4. Backing of US Department of Energy's Atmospheric Radiation Measurement (ARM) Facility with a commitment to ongoing production and expansion

The road to LES at SGP

https://www.arm.gov/capabilities/modeling

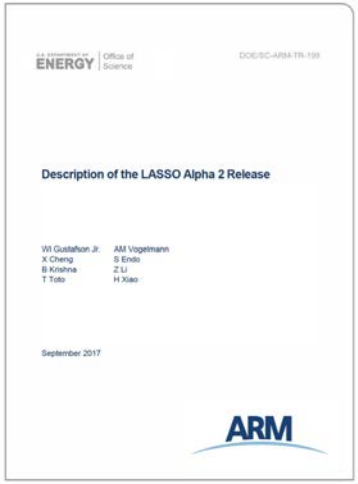
Important LASSO Reports



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



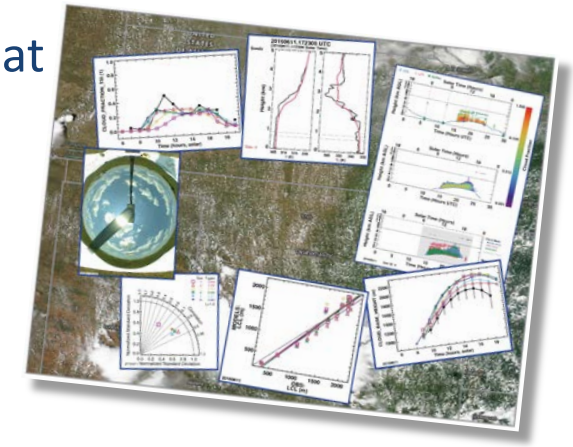
Description of the LASSO Alpha 2 Release

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

https://www.arm.gov/capabilities/modeling

Core LASSO components



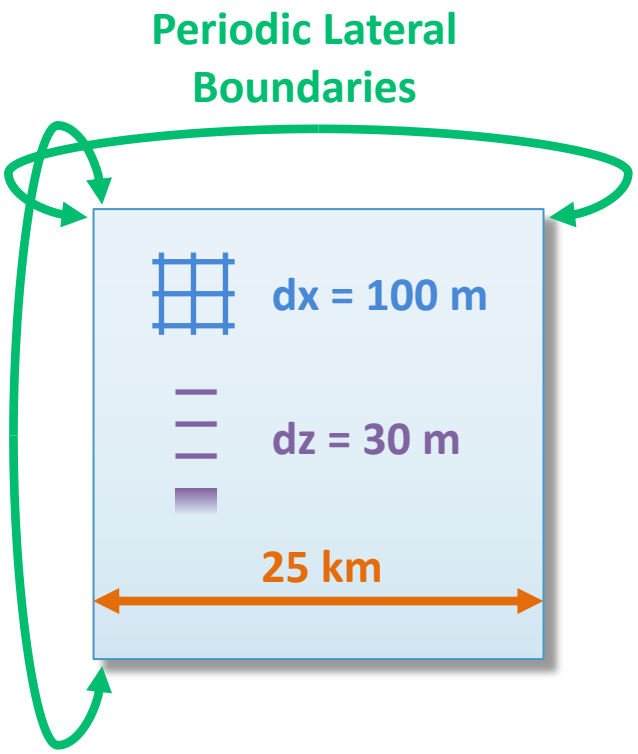
- Library of LES simulations for shallow convection cases at ARM's Southern Great Plains observatory: currently 18 days and growing

- 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

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
  - VARANAL
  - 3 spatial scales for MSDA & ECMWF
  - Static large scale (only init. from sonde)



Currently available products
https://www.arm.gov/capabilities/modeling/lasso

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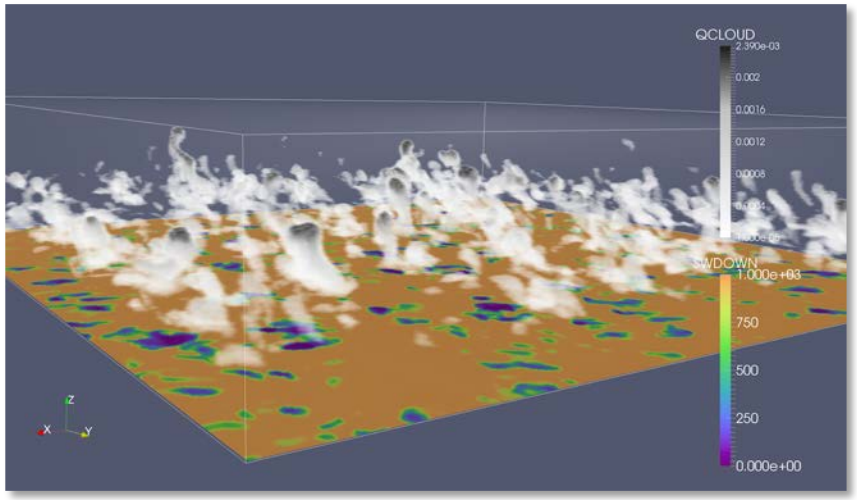
- **Alpha 1 Release**
  - 5 case days from spring–summer 2015
  - 192 simulations
  - Aimed at getting initial concept to the community for feedback
  - Currently re-running to make consistent with Alpha 2 and to fix some bugs

- **Alpha 2 Release**
  - 13 case days from spring–summer 2016
  - 544 simulations
  - Systematic comparison of domain size, grid spacing, microphysics, and model choice

- **2017 Cases (to be released later this year)**
  - Selected 32 cases for April–November 2017

Discover LASSO

- 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



Science applications…

Science Application Playlist (6 min. each)

- Reconciling chord length and cloud area distributions using LASSO data (Thijs Heus, Cleveland State U)
- Comparing LASSO shallow cloud simulations with HI-SCALE in-situ observation (Heng Xiao, PNNL)
- Challenge to evaluate 3D LES using ground-based profiling observations for shallow cumulus (Mariko Oue, Stony Brook U)
- Detectability of aerosol-cloud interactions relative to meteorological variability during LASSO (Ian Glenn, NOAA ESRL/CIRES)

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Discussion, question, and answer time for the current LASSO implementation…

Approaching the LASSO expansion decisions…

Guided discussion of candidate expansion scenarios…

Scenario title

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High-level description

Science drivers

Model configuration

Forcing & boundary condition options

Evaluation data/approach

Potential sticking points & possible mitigations

Example:
Shallow Convection at SGP

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High-level description
Statistically representative LES of shallow convection at the SGP site

Science drivers
NWP and climate models poorly simulate the impact of shallow convection due to their sub-grid scale and tenuous nature. LES of many ShCu cases can provide a statistically robust library to supplement observations for informing process understanding, OSSEs, and parameterization development.

Model configuration
LES with doubly periodic LBCs; dx~100 m; daytime

Forcing & boundary condition options
Observed sfc. fluxes, VARANAL, NWP analyses, data assimilation including ARM obs.

Evaluation data/approach
TSI, ARSCL, MWR, AERIoe, Raman lidar, sondes

Potential sticking points & possible mitigations
Mishandling of cirrus: use a short model top
Regional variability (east-west gradient at SGP): try nested LES instead of periodic BCs

Continental Deep Convection at SGP

High-level description

Simulating deep convection at SGP

Science drivers

Diurnal cycle, cold pools, cloud organization, sfc temp. biases, population dynamics, non-equilibrium sfc conditions, lateral cloud-side entrainment & detrainment, w PDFs, convective triggering, shallow-to-deep transition, aerosol effects on clouds, precip. MP

Model configuration

time dependent LBCs, domain size (MCS or smaller?); need dx=200 m for transitions, entrainment needs higher res.; ice MP; multiday/full diurnal cycle

Forcing & boundary condition options

MSDA w/ ARM data; HRRR; soil model that assimilates ARM soil obs.

Evaluation data/approach

ARM radar, precip., NEXRAD, RWP, new GOES, lidar for cold pool & updraft, sfc radiation, polarimetry radar (HIDs); thermodynamic profiles at wider radius than BFs

Potential sticking points & possible mitigations

convection develops upstream of ARM obs, probability of passing by SGP, forcing & convection not independent/population dynamics, precip can complicate many measurements, compromise of res. vs. domain size, competition HRRR

Marine Boundary Layer Clouds at ENA

High-level description

Simulate marine boundary layer clouds

Science drivers

Drizzle properties & evaporation, aerosol-cloud interactions, StCu evolution & lateral entrainment, population selection between met. regimes (cloud outbreaks, StCu-Cu transitions), island effects (internal gravity waves), contrast to continental ShCu at SGP, diurnal cycle, higher order moments for PBL schemes

Model configuration

high vertical resolution near cloud top, day & night to get nighttime precip.,
Option 1: heterogeneous sfc with island (time-dependent LBCs)
Option 2: only over ocean (periodic)
Option 3: Lagrangian a couple times a day
Possibly restrict to conducive upstream conditions (island and/or synoptic)

Forcing & boundary condition options

ECMWF gridded data or DDH (IFS does not see Ascension but have Gracioca); VARANAL is an option with some modifications (will be done for ACE-ENA); satellite or NWP SSTs

Evaluation data/approach

SST fluxes, Doppler lidar, MWR, XSAPR and other radars, Raman lidar, AOS at site and UAVs

Potential sticking points & possible mitigations

island effects, wind direction dependence; ARM needs a buoy for SST; desire SST fluxes and spatial variability

Arctic clouds at [NSA and/or MOSAiC]

High-level description

Mixed phase clouds & PBL/lower atm evolution; clear sky and cloudy sky for MOSAiC; aerosol-cloud interactions. Changing Arctic climate driver.

Science drivers

transition of cloud state, understanding cloud & aerosol layering, St/sensitivity to higher cloud forcing with LW forcing. Campaign planning [advance sims]

Model configuration

need to look into appropriate dz and SGS, variation of sfc albedo and roughness, interactive sea ice? MOSAiC stepping stone → NSA (easier than Barrow).

Forcing & boundary condition options

more reliant on sondes and in situ measurements due to less reliable reanalyses

Evaluation data/approach

Needs ARM VAP on MP phase/speciation, MWR phase VAP no longer avail but could be restarted; retrievals of snowfall from cloud soon to be available. More in-cloud micro obs. Sensitivity of microphysics parameters. Can we "toggle" the config between clear/cloud settings?

Potential sticking points & possible mitigations

land-oean-ice contrast (NSA); risk of MOSAiC having good data; obs of mixed phase clouds are difficult to interpret; LES of mixed phase clouds are more problematic than warm clouds (but could be a driver)—maybe do initial phased approach & survey community of existing Arctic modelers; very stable conditions not necessarily compatible with SGS models; initiation of model and long cloud memory

Dry Convection / Stable BL at SGP

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- High-level description
- Science drivers
- Model configuration
- Forcing & boundary condition options
- Evaluation data/approach
- Potential sticking points & possible mitigations

Scenario title

High-level description

Multiple convection types/regimes at SGP (e.g. tied to field campaigns)
LASSO IOP with AMF deployments
Interactive surface for land/sea ice—gradients for land-ocean-sea—add value to NWP that way
Tropical deep convection, e.g., GoAmazon, TWP
MARCUS in Southern Ocean
GPCI / MAGIC region
Katabatic winds over Greenland/Iceland/AWARE and impact on net snowfall

Science drivers

Model configuration

Forcing & boundary condition options

Evaluation data/approach

Potential sticking points & possible mitigations

Scenario title

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High-level description

Science drivers

Model configuration

Forcing & boundary condition options

Evaluation data/approach

Potential sticking points & possible mitigations

Session summary & action items

Extra slides…

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			

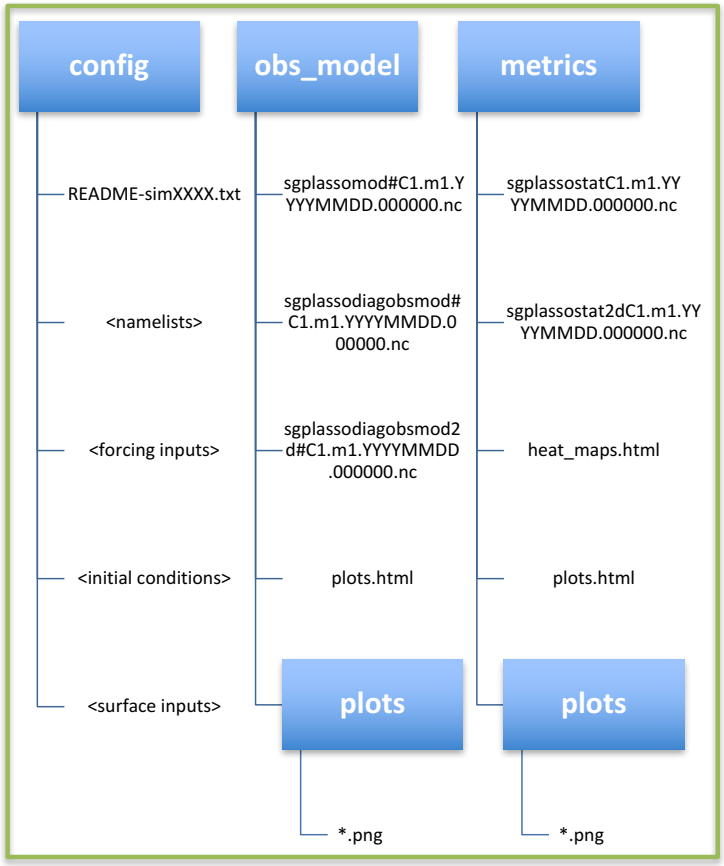
Readiness Levels

1 = Available observations implemented in the data bundles

2 = Partially implemented observations

3 = Implies aspirational observations

Data bundles for easing data digestion



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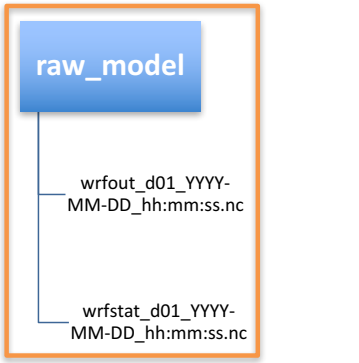

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Configuration-observation-model tarball

- 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

http://archive.arm.gov/lassobrowser

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

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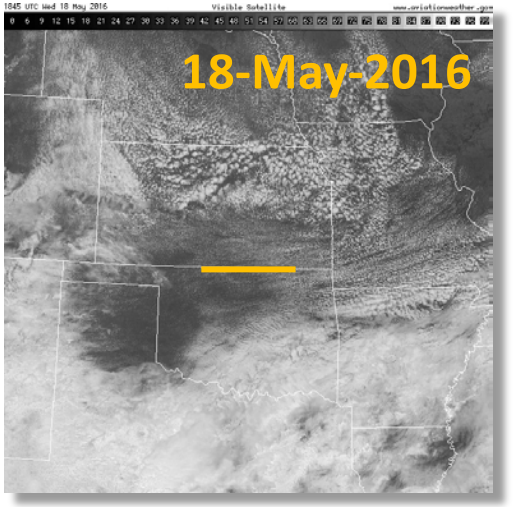
Large-scale forcing datasets generated from 3 sources

- 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



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