The LASSO-CACTI Large-Eddy Simulation Library for Studying Deep Convection

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Mesoscale and LES Simulation Library for CACTI

This poster showcases the U. S. Deptartment of Energy's Atmospheric Radiation Measurement (ARM) facility's **Large-Eddy Simulation (LES) ARM Symbiotic Simulation and Observation (LASSO)** activity focused on the **Cloud, Aerosol, and Complex Terrain Interactions (CACTI)** field campaign in the Sierras de Córdoba mountain range of north-central Argentina.

CACTI focused on large convective systems that develop along the Sierras de Córdoba and propagate east over the plains.

LASSO-CACTI freely provides mesoscale and large-eddy (LES) simulations to the community to foster research and add value to the suite of CACTI observations.

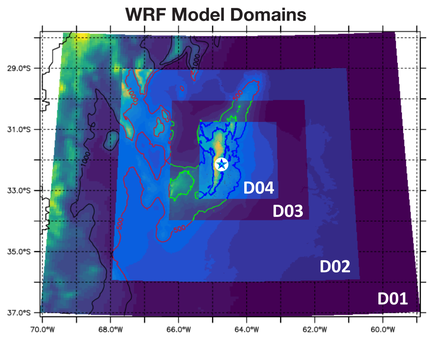

Figure 1. LASSO-CACTI modeling domains from WRF. Mesoscale domains, d01 and 02; LES domains, d03 and d04. Shading shows topography; contours the 500 and 1000 m terrain heights. The star shows the ARM Mobile Facility (AMF) location.

Observations Combined with the LES

LASSO-CACTI simulations augment observations from the concurrent ARM CACTI and NSF RELAMPAGO campaigns as well as from satellites. Examples include:

1. **Soundings:** Multiple radiosondes launched from multiple locations per day
2. **Scanning radars:** Scanning cloud and precipitation radars
3. **GEOS16 satellite:** Rapid scan, parallax-corrected VISST satellite product

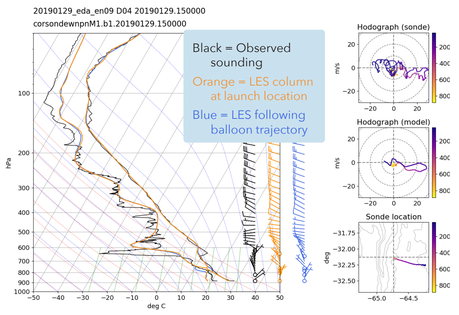

Figure 2. Sounding at AMF site (black) vs. LES with Δx=100 m (orange and blue) for 29-Jan-2019 15 UTC.

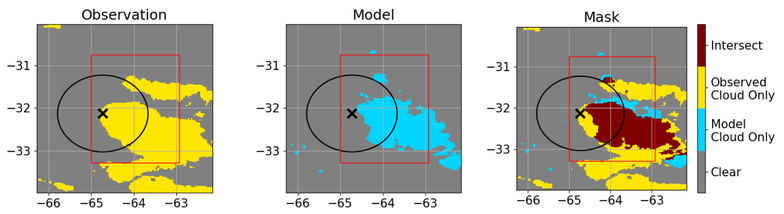

Figure 3. Cloud mask comparison at 29-Jan-2019 20 UTC between observed GEOS16 (yellow) and mesoscale simulation (blue) cloud masks based on a brightness temperature threshold of 240 K. Overlapping masks shown in burgandy. Black circle roughly indicates the radar visibility; red box shows the LES domain.

Mesoscale Ensembles for 20 Case Dates

LASSO-CACTI provides 32-member ensembles at 7.5 and 2.5 km grid spacings for deep convective initiation. Ensemble members differ based on initial and boundary conditions. Available members driven by:

- ECMWF Reanalysis v5 (ERA5)
- ECMWF Ensemble of Data Assimlation (EDA), 10 members
- NCEP Final Analysis (FNL)
- Global Ensemble Forecast System (GEFS), 21 members

The ensembles provide a range of model behaviors, which can be compared to observations and used to understand boundary layer and cloud processes as well as model parameterizations.

Example uses for the mesoscale ensembles

- Understanding synoptic context of convection
- Examining cloud sensitivity to environmental differences
- Tracking clouds throughout their cloud lifecycle

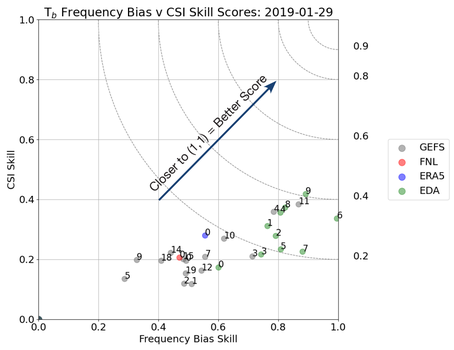

Figure 4. Scoring of the 29-Jan-2019 mesoscale ensemble based on cloud masks, as shown in Figure 3. Each simulation rated based on frequency of cloud formation and ability to simulate the correct location using the Frequency Bias and the Critical Success Index (CSI).

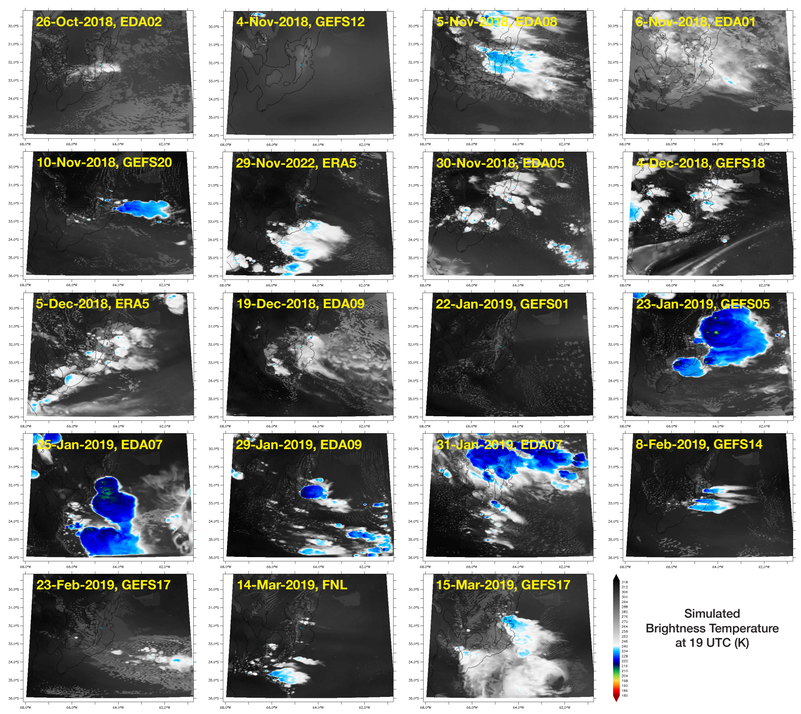

Figure 5. Availble simulations for each date span an array of convective behaviors as shown by simulated brightness temperature at 19 UTC for high-scoring Δx=2.5 km runs. Scoring is based on CSI and Frequency Bias from 15–24 UTC.

LES for Convective Initiation

LASSO-CACTI has LES simulations for a subset of ~10 case dates using grid nesting within the mesoscale simulations. LES grid spacings are Δx=500 and 100 m for grids d03 and d04, respectively, shown in Figure 1.

Extra output provided for selected microphsysical process rates and four tracer types to enable analasyes of cloud processes. Figure 7 shows the tracer concentration for a tracer initialized to the vaue of 1 within the boundary layer at 14 UTC and then allowed to freely evolve.

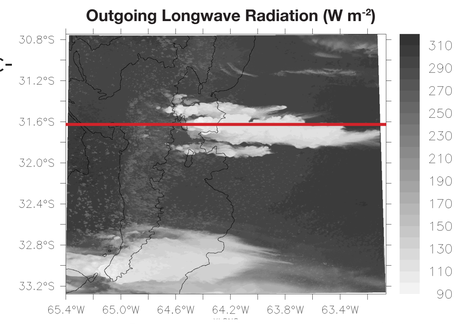

Figure 6. Outgoing longwave radiation at 8-Feb-2019 20 UTC from LES ensemble member EDA08. Red line shows location of cross section in Figure 7.

Working with LES data

Total size of LES output and supporting files expcted to approach 2 PB.

ARM is providing compute resources for working with the data to ease the burden on researchers. Access to a Jupyterlab server and compute nodes can be requested.

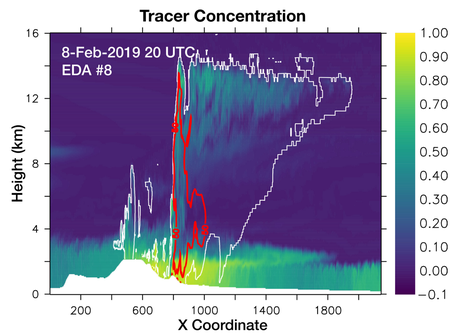

Figure 7. Tracer concentration (colors) for "PBL" tracer for cross section through cloud. Ensemble member EDA08, 8-Feb-2019 20 UTC. Also shown are the cloud boundary (white contour) and 50 dBZ radar reflectivity (red contour).

LASSO-CACTI Beta Release and Timeline

A beta release for LASSO-CACTI is now availalble. See https://www.arm.gov/news/blog/post/77833 for details on how to apply for access via ARM's compute cluster and/or Jupyterlab server.

The mesoscale ensembles are available and an example LES run with subsetted groupings of variables. Other preliminary LES runs can be made available upon request.

Send feedback to William Gustafson and Andrew Vogelmann at lasso@arm.gov or post a comment at https://discourse.arm.gov/c/lasso/lasso-cacti-scenario/7.

Plans include releasing the bulk of the LES runs in September 2022. The LASSO team is currently working on fine tuning simulations and converting data to the final production format.

To be included in LASSO e-mail updates, sign up for the LASSO Information e-mail list at http://eepurl.com/bCS8s5

FOR MORE INFORMATION

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