Multiscale Data Assimilation Forcing for LASSO

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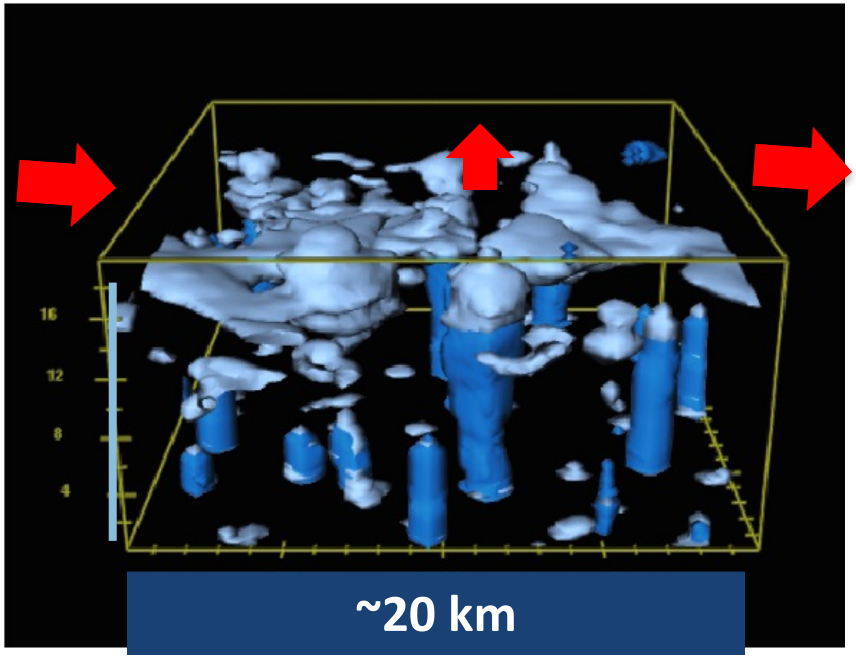
LASSO LES Initialization and Large Scale Forcing

Vertical Profiles for Initializing LES:

- Temperature, moisture, and winds

Large Scale Forcing:

- Horizontal advection of temperature and moisture
- Vertical velocity
- Geostrophic winds
- Horizontal advection of hydrometeors (?)



LES is driven by

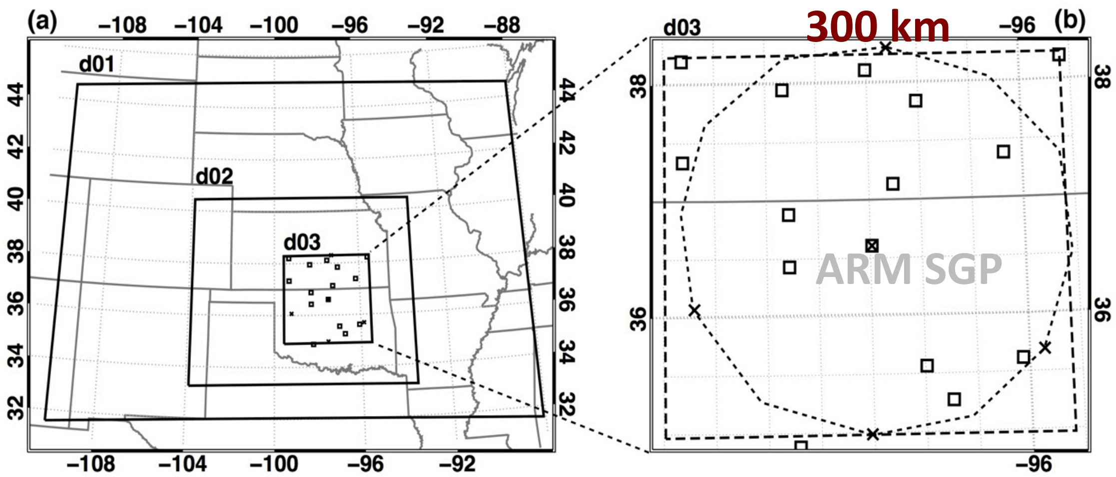
- Large scale horizontal and vertical advection
- Surface sensible heat flux, latent heat flux, albedo and skin temperature

Challenges and Requirements on Large Scale Forcing

1. Multi-scale/scale-aware forcing
2. Forcing for non-periodic domains
3. Cloud and precipitation related variables (?)

Three domain nested configuration

A resolution of 2 km in the inner domain



Strategy: Nested WRF at a cloud resolving resolution with multiscale data assimilation (MSDA)

A Multi-Scale Three-Dimensional Variational Data Assimilation (MSDA) System

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Decomposition of large and small scales

$$x = x_L + x_S$$

$$\min_x J(\delta x) = \frac{1}{2}\delta x^T (B_L + B_S)^{-1} \delta x + \frac{1}{2}(H\delta x - \delta y)^T R^{-1} (H\delta x - \delta y)$$

Existing analysis/reanalysis (FNL, NARR, …)

$$\min_{\delta x_L} J(\delta x_L) = \frac{1}{2}\delta x_L{}^T B_L^{-1}\delta x_L + \frac{1}{2}(H\delta x_L - \delta y)^T \left(HB_S H^T + R\right)^{-1} (H\delta x_L - \delta y)$$

$$\min_{\delta x_S} J(\delta x_S) = \frac{1}{2}\delta x_S{}^T B_S^{-1}\delta x_S + \frac{1}{2}(H\delta x_S - \delta y)^T \left(HB_L H^T + R\right)^{-1} (H\delta x_S - \delta y)$$

Small scale data assimilation

MSDA Features:

1. Existing analysis/reanalysis plus MSDA $\boldsymbol{\delta x}$
2. Developed on top of the NCEP WRF GSI
3. Enhanced effectiveness of assimilating ARM observations

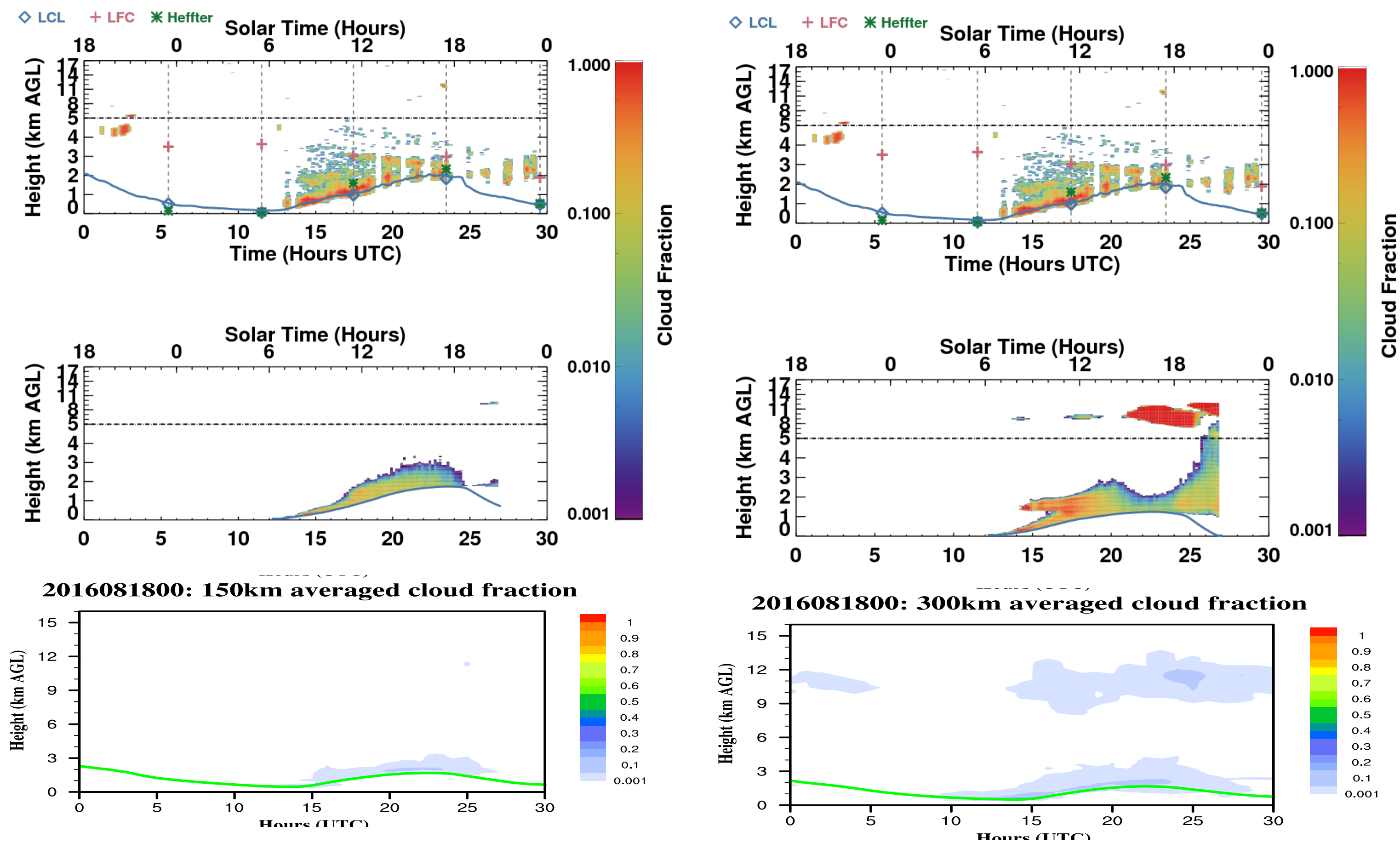
(Li et al. 2015 MWR; 2015, JGR)

Impact of MSDA forcing on LES

Obs

LES

MSDA



Clouds in MSDA have much similarity with those in LES

MSDA Impact on Vertical Profiles

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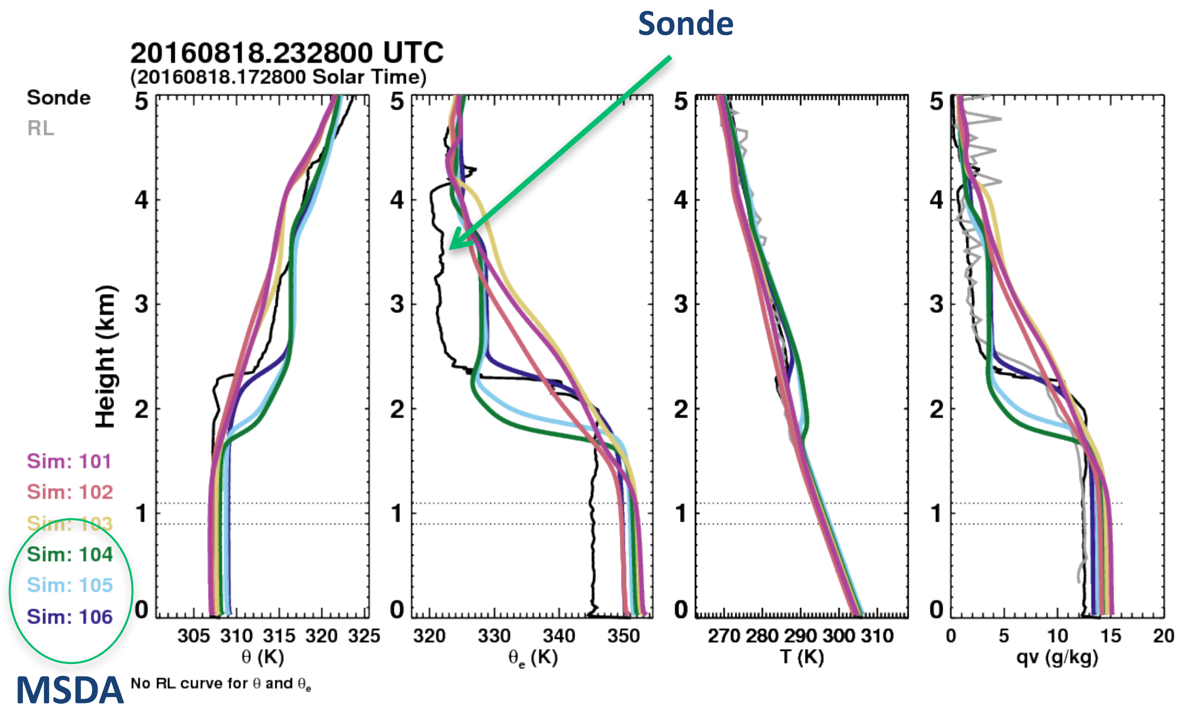
- MSDA helps LES represent the boundary layer
- Discrepancies from the Sonde profile significant
- Multiple vertical profiles needed to evaluate



Ready to explore secondary discrepancies when more vertical profiles are available ?

Improved effectiveness of MSDA Using Observing System Experiment (OSE)

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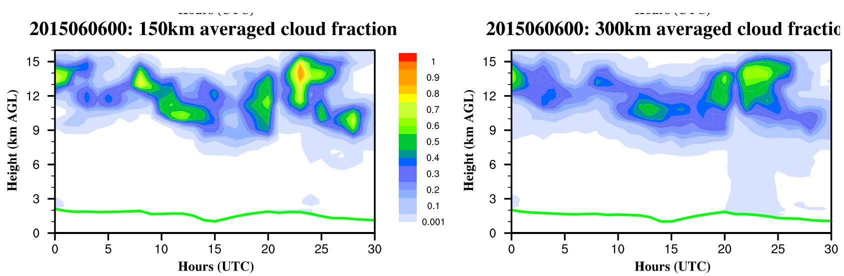
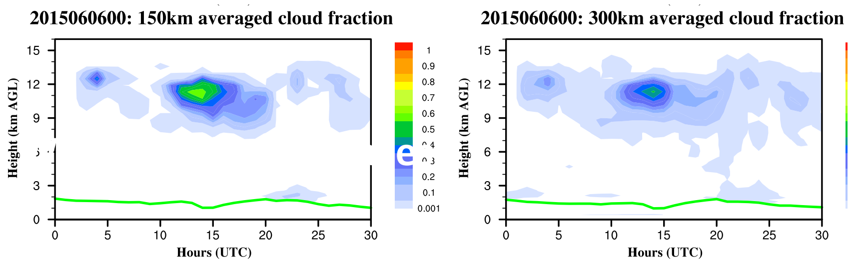
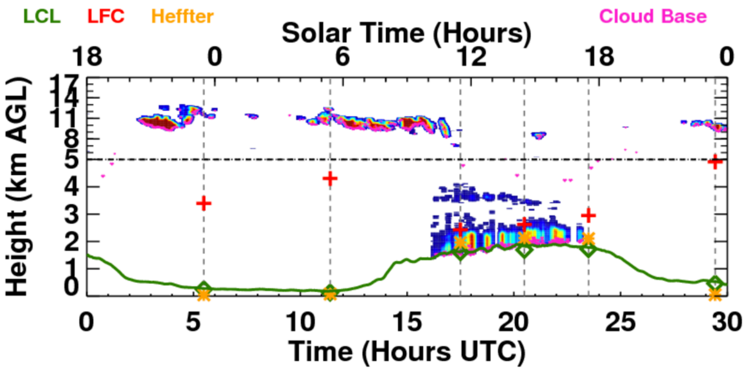
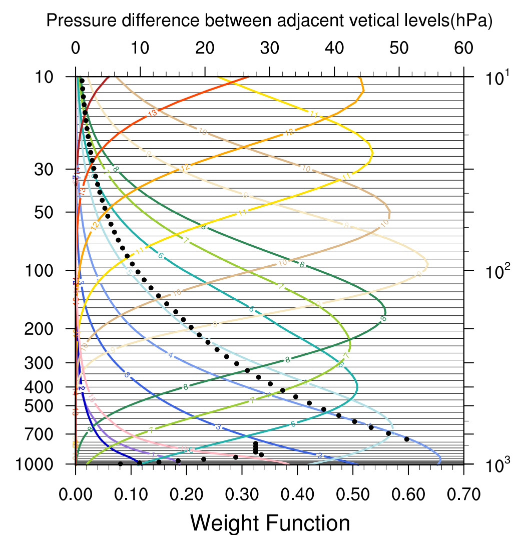
W/O satellite infrared radiance



With satellite infrared radiance







Improved effectiveness of assimilating radiances

1. Raised the top level to 10 hPa
2. Increased the vertical resolution
3. Adjusted error covariance

We will use OSEs to improve the assimilation of various measurements

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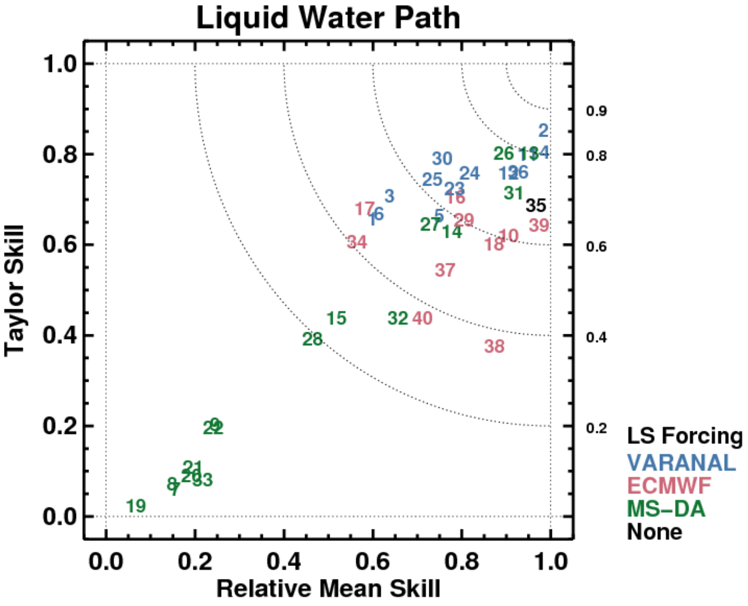
On-going and Future Work

1. Preparation for being used as a quasi-realtime system
2. Observing system experiments (OSEs) to improve the impact of Raman lidar profile, wind profilers and others on LES.
3. Nesting LES to Cloud-resolving WRF with MSDA
4. Optimization of forcing ensemble members: wide spread of skill scores
5. Implementation of ensemble-MSDA



Wide spread of skill scores of MSDA members ?