Characterizing the Turbulent Structure of the Convective Boundary Layer over the SGP Using ARM/ASR Observations and LES Model Output

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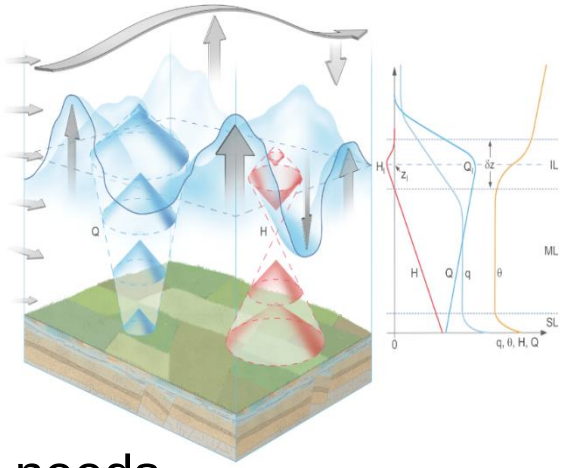
Background



- Turbulence redistributes heat, momentum, and moisture in the boundary layer
- Subgrid scale in most models and needs to be parameterized in CRMs/GCMs
- Accurate representation of the fluxes of heat and moisture at the top of convective boundary layer (also called interfacial layer – IL) is critical
- Turner et al (2014) suggested strong correlation between the variance at the inversion and the higher order moments
- Do LES models accurately capture structure of turbulence in CBL and fluxes at IL?

Overall goals of the project

- Started (effectively) this winter
- Study boundary layer dynamics with help of the truth of observations and the completeness of LES
- Topics:
  - Scaling of the variance and other moments in the entrainment zone
  - onset of boundary layer clouds
  - interactions between the clouds and the mixed layer

- Get experience with effectively comparing models and observations

The entrainment zone of the Dry CBL

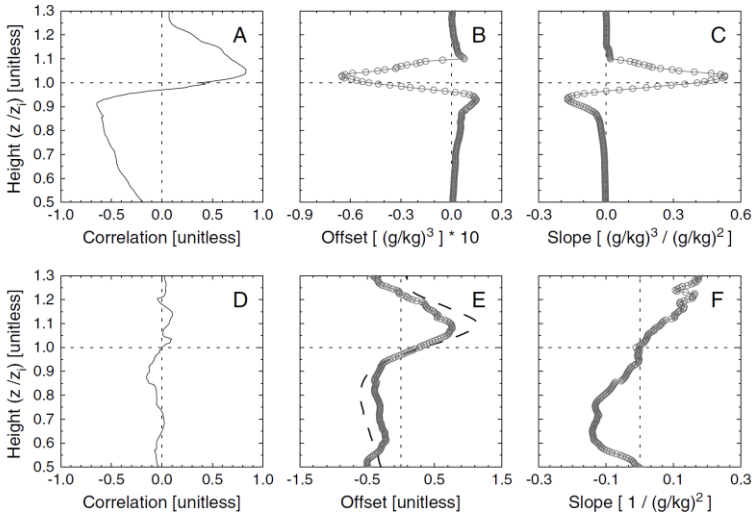


Figure 8. The (a, d) correlation between, and the (b, e) offset and (c, f) slope derived from a linear regression, of the third moment in Figures 8a–8c and skewness in Figures 8d–8f of q at different heights versus the variance of q at z_i. The thin dashed line in Figure 8e is the median skewness profile from Figure 5c.

Starting point: Can we use LES to replicate and interpret the observed higher order moments of the humidity? (From Turner et al, 2014)

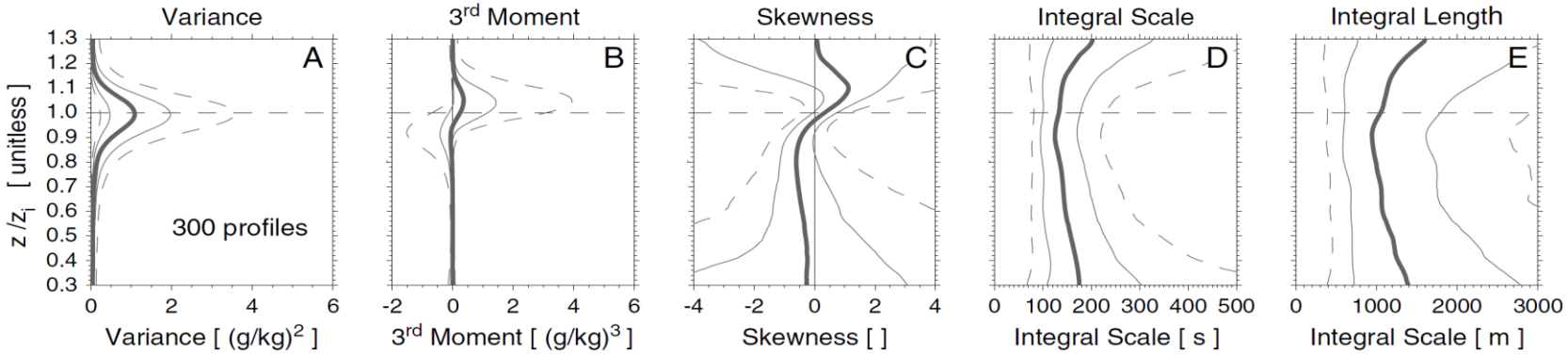


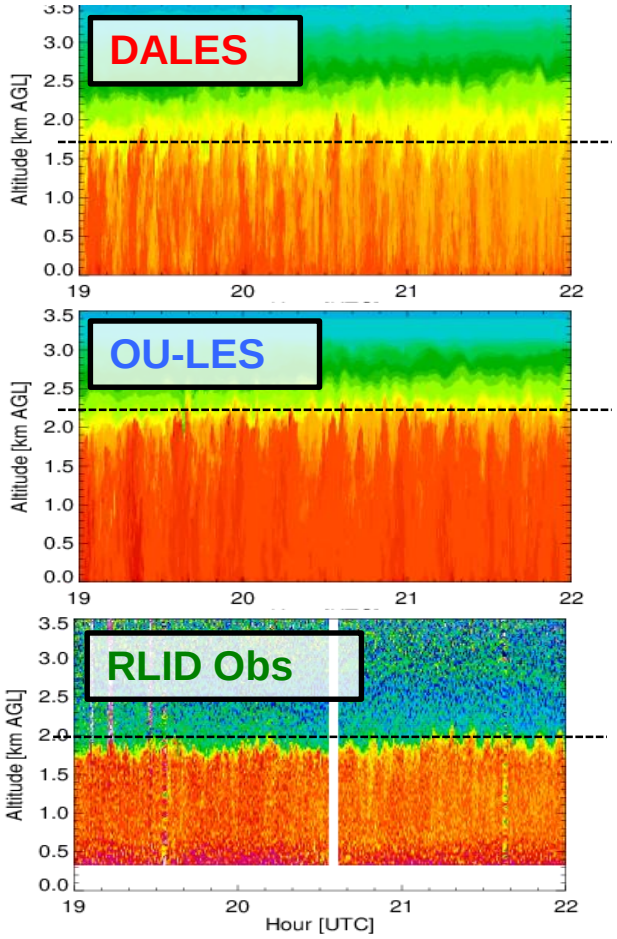
Figure 5. Average profiles of statistical quantities and their variability. The bold solid lines denote the median profiles of the (a) variance, (b) third moment, (c) skewness, (d) integral scale, and (e) integral length of q. The thin solid lines are the 25th and 75th percentiles, while the 10th and 90th percentiles are represented with dashed lines.

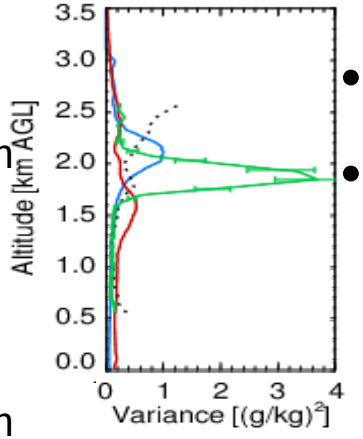
Model Setup – Walk before running

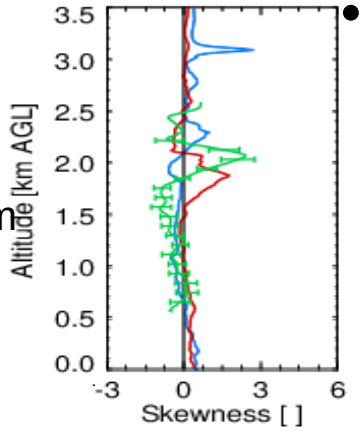
- Focus on clear BL, so decent resolution is important $\Delta x = 25; \Delta z = 15m; L_x = 6km$
- Prescribed surface fluxes, large scale forcing and radiative forcing (for now)
- Nudging towards large scale state to keep the run from diverging (should be small)
- Large Scale state defined by WRF Mesoscale runs or ARM variational analysis

- Runs in about real time

Driving the LES model with WRF



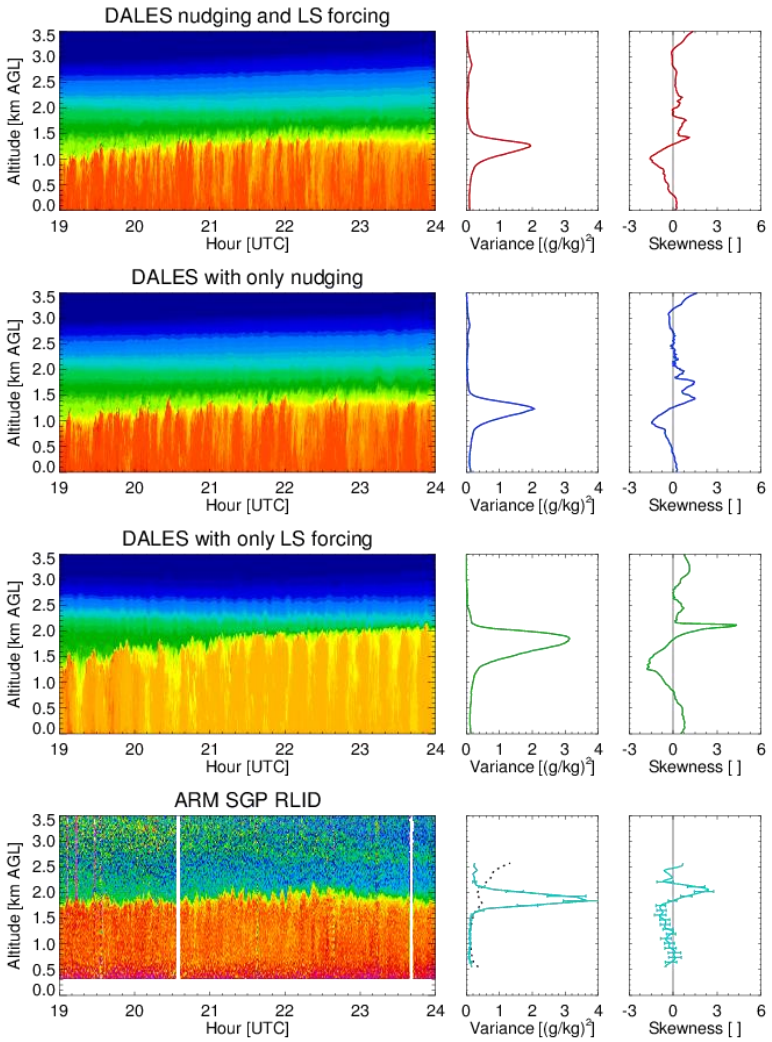




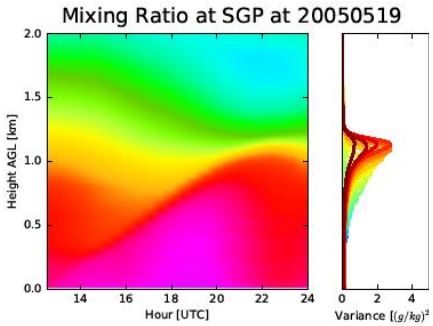
- WRF based runs
- Significant differences between the different models, but overall qualitatively similar
- ….Except for the higher order moments

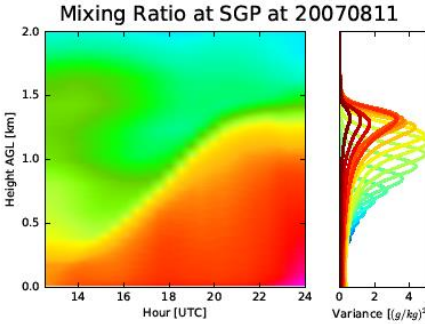
Driving LES with observations

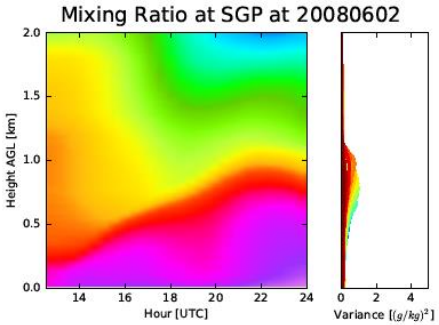
- A much better comparison/increased variance is obtained when driving the model with ARM varanal
- The most variance is found in the no-nudging run – but likely for the wrong reasons

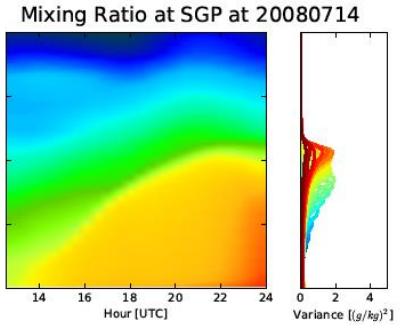


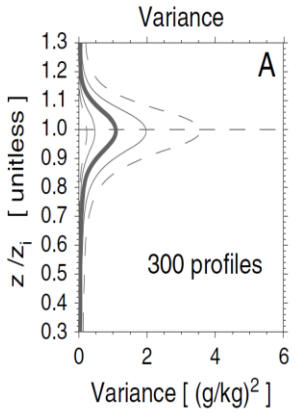
Multiple days – same procedure

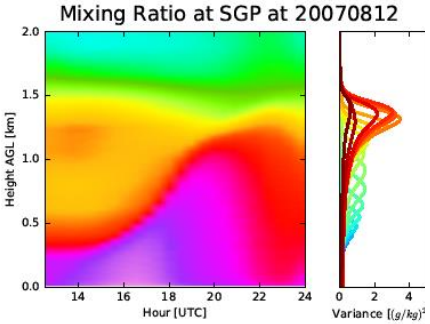


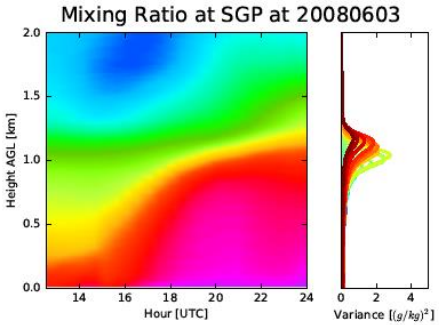


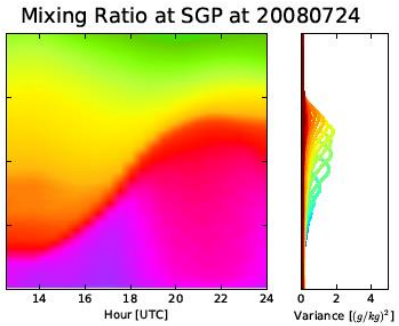


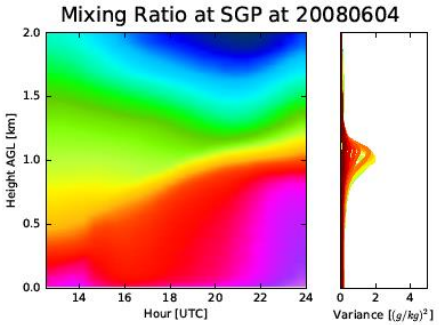








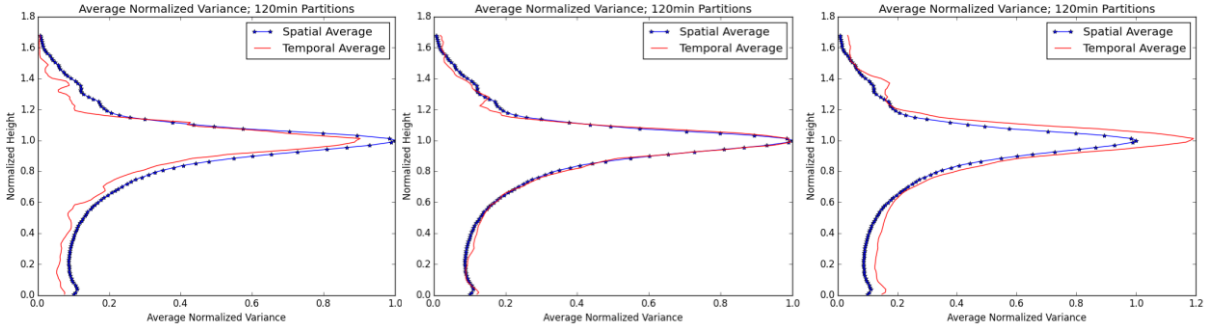




- Eyeballing suggests a decent agreement with RL data; need to tease out statistics next
- The spatial size of the LES does provide a sufficiently large dataset to look at the morning and evening transition

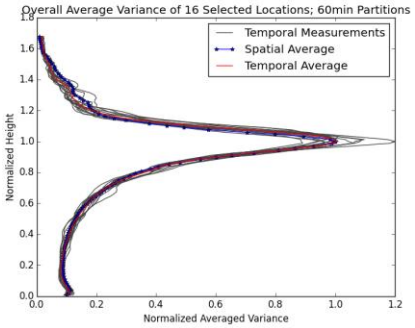
LES as a simulator

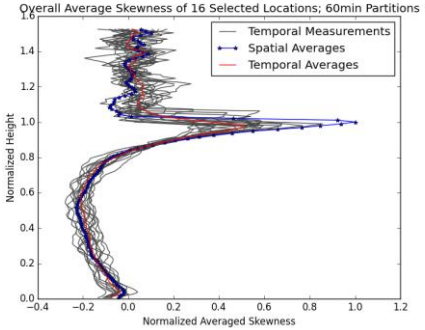
- If LES is not too far from a possible version of the truth, it can help to asses data quality and representativity



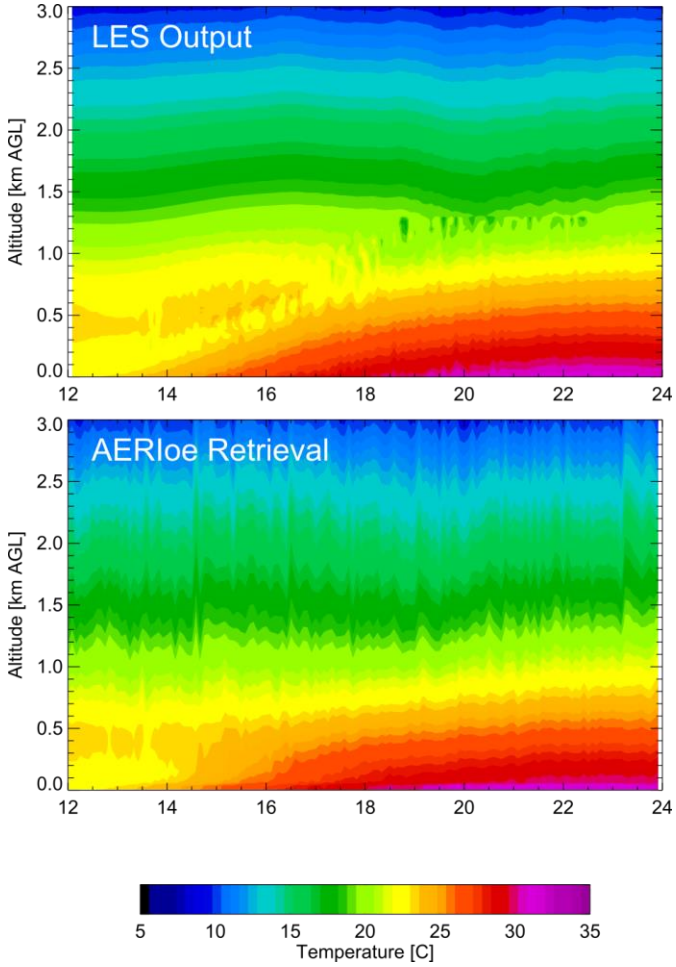
Variance temporally averaged over

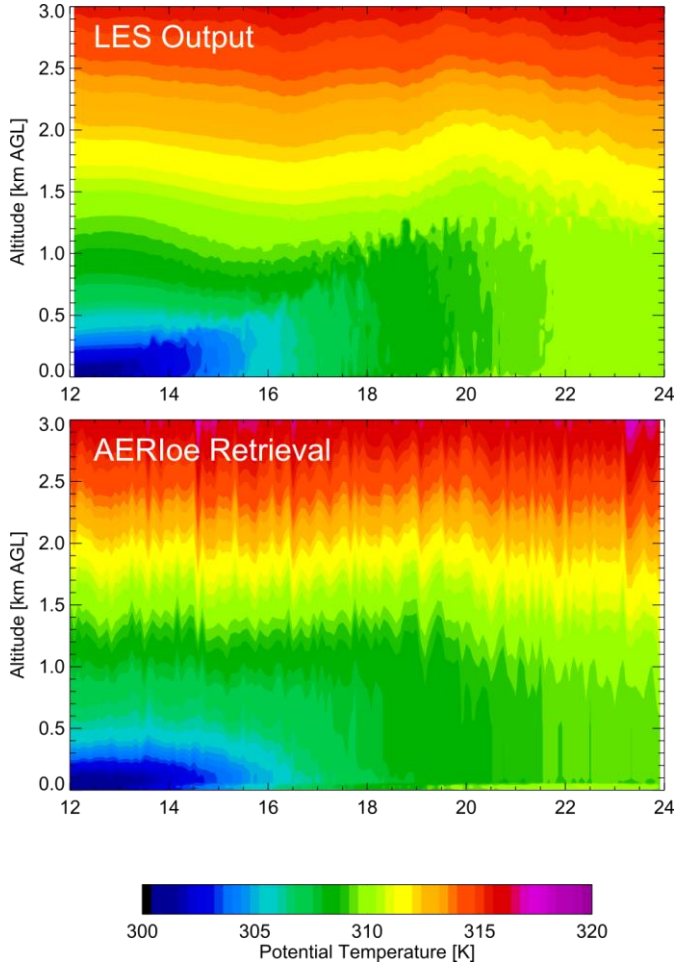
15min 60 120min



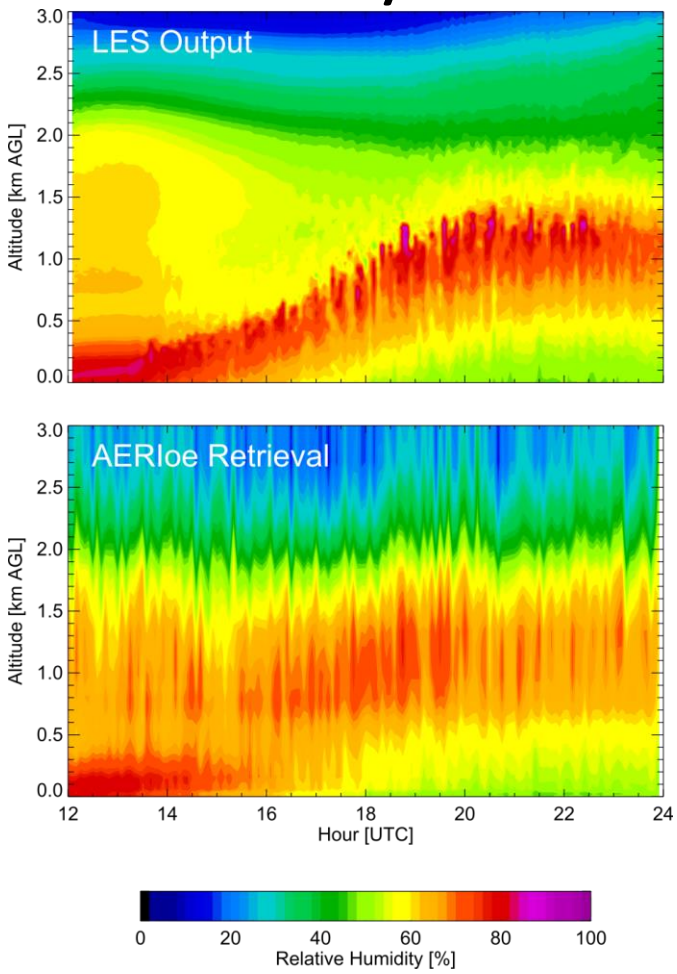


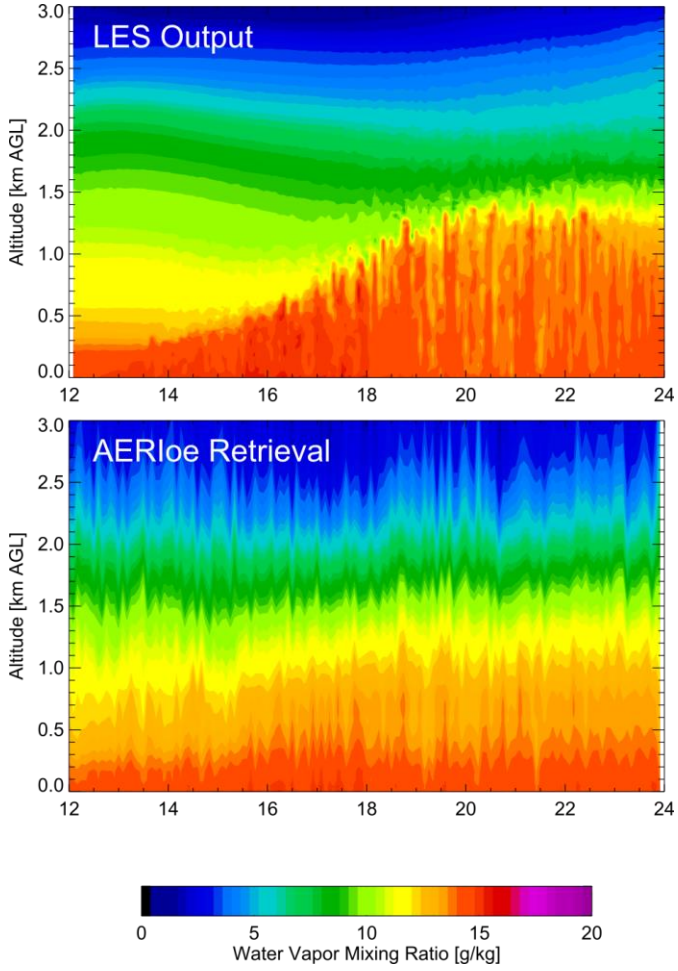
AERIoe retrieval of LES data - Temperature





AERIoe retrieval of LES data - Humidity





Outlook

- Poster this afternoon
- Get the scaling of the moments
- Tweak the LES driving method (e.g., play with radiation and land surface)
- Improve AERI based on the simulator results
- Start looking at shallow convection for various Bowen Ratios
- Keep talking to the LASSO Cowboy’s