Retrieving sensible and latent heat flux profiles within the planetary boundary layer

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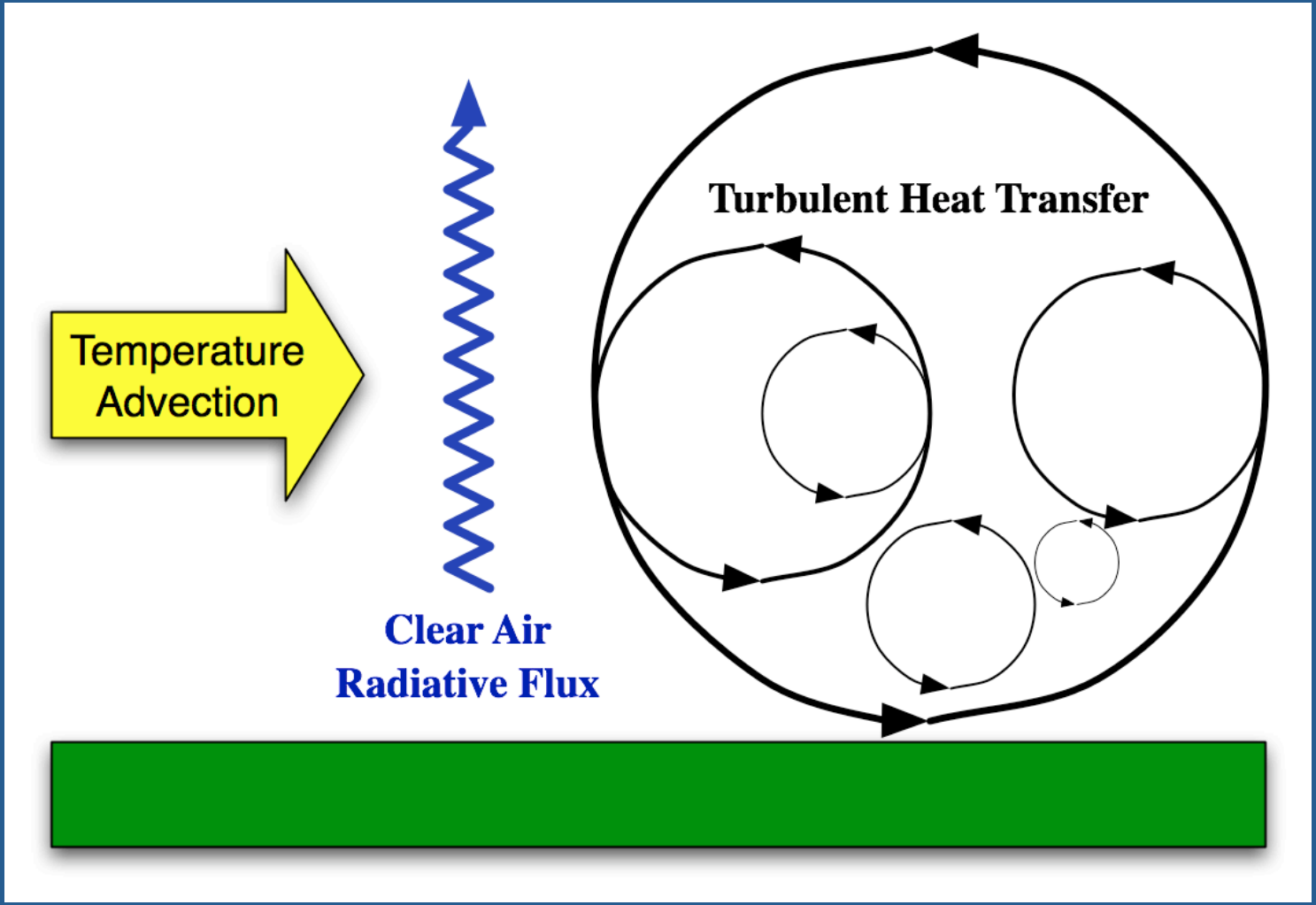
Motivation

- Exchange of heat and moisture between the surface and lower atmosphere is one of most critical components of Earth-Atmosphere system
  - Affects boundary layer evolution
  - Implications for the climate on long time scales
- Quantified by sensible and latent heat fluxes
- Typically measured using eddy-flux technique
  - Only provides observation at measurement height

Estimating the Sensible Heat Flux



Estimating Sensible/Latent Heat Flux Profiles

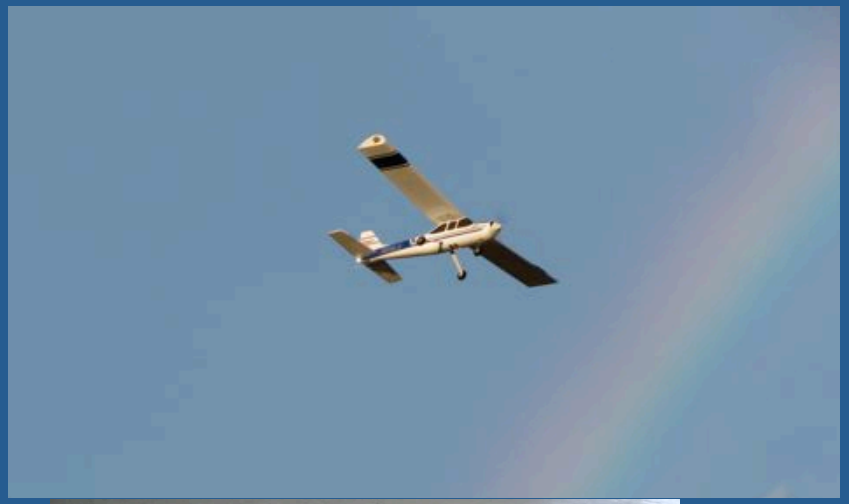
- Using a method described by Deardorff (1980), heat fluxes can be estimated from sequential thermodynamic profiles through integration: $$\overline{w'\theta'}(z) = \int_z^{h_3} (\frac{\partial \overline{\theta}}{\partial t} + \overline{w}\frac{\partial \overline{\theta}}{\partial z})dz + \kappa[\frac{\partial \overline{\theta}}{\partial z} - (\frac{\partial \overline{\theta}}{\partial z})_3]$$
- Since thermal diffusivity is small in the atmosphere, the last term can be thrown out
- Mean vertical velocity over flat land near the surface is treated as zero $$\overline{w'\theta'}(z) = \int_z^{h_3} \frac{\partial \overline{\theta}}{\partial t} dz$$
- Utilizing finite differencing, heat flux can be solved for: $$H = \sum_{n=x}^{top} c_p \rho \frac{\Delta \theta}{\Delta t} \Delta h$$
- Assumption: No significant temperature advection
- Latent heat flux can be estimated similarly: $$F = \sum_{n=x}^{top} \lambda \rho \frac{\Delta q}{\Delta t} \Delta h$$

(latent heat of vaporization, λ, is 2.5×10^{-6} J kg^{-1})

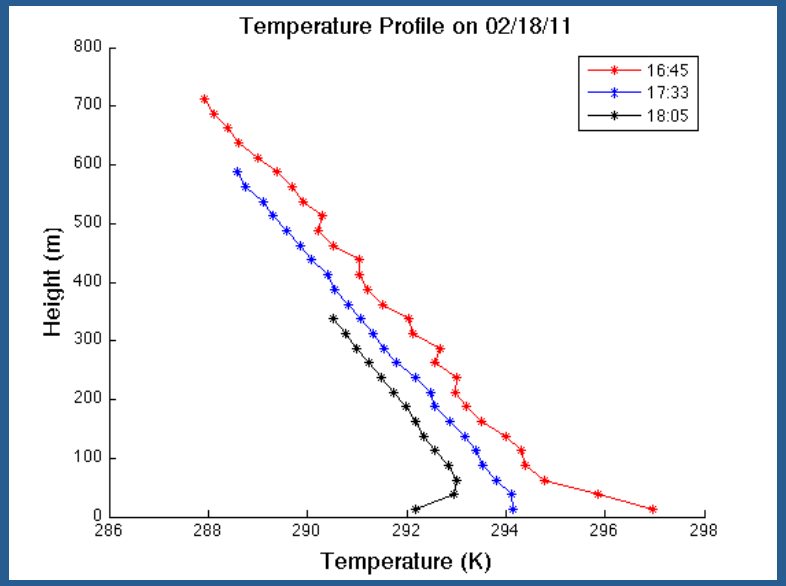
SMARTSonde

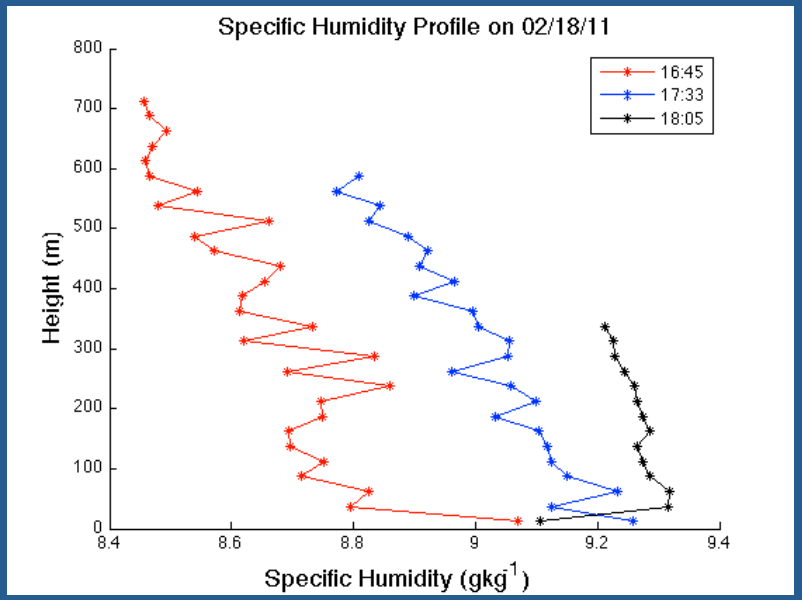
- Small Multi-function Autonomous Research and Teaching sonde

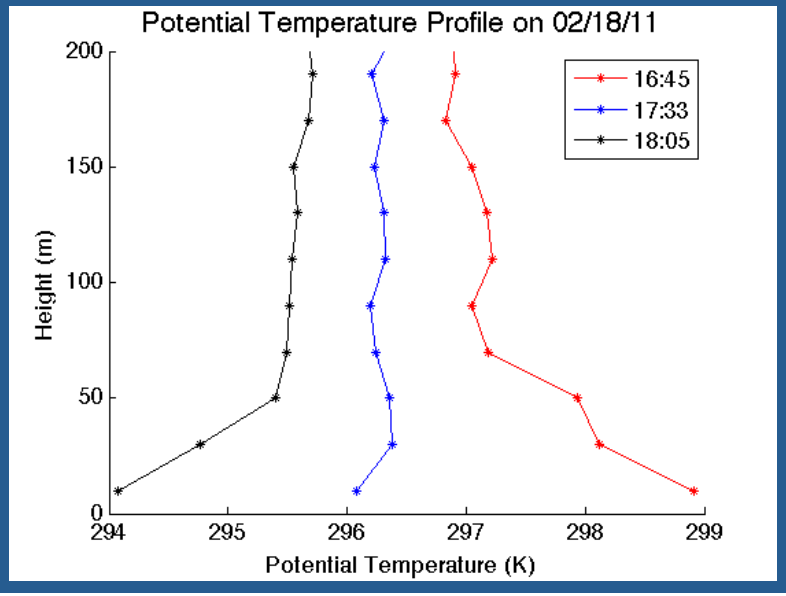
- NexSTAR EP Select for measurements, early in project
- SHT 75 – T, q, slow response

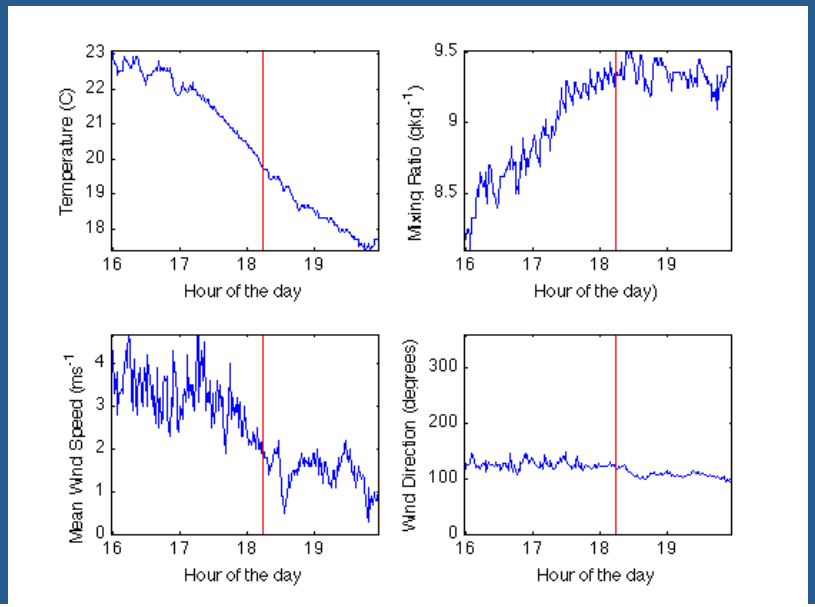


February 18, 2011 Transition
Sunset: 18:14

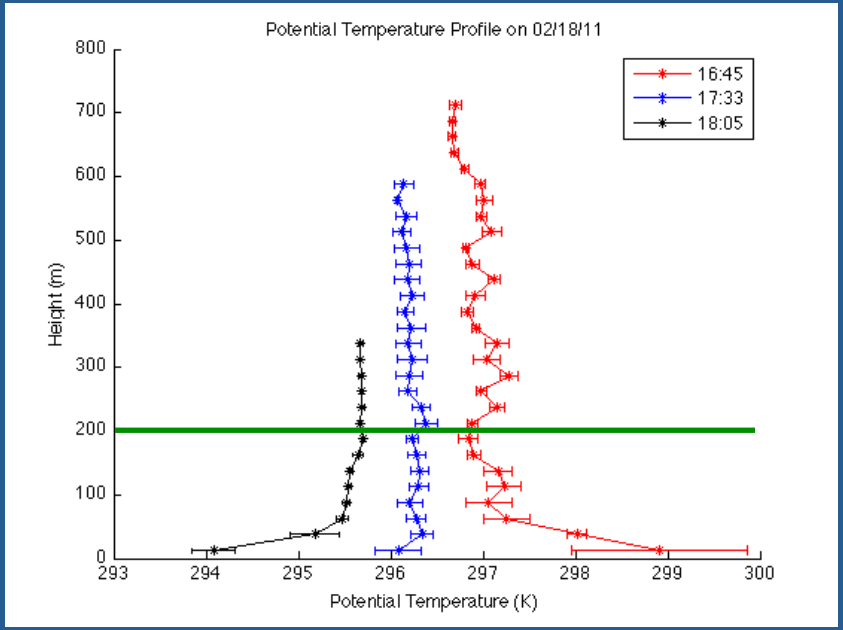


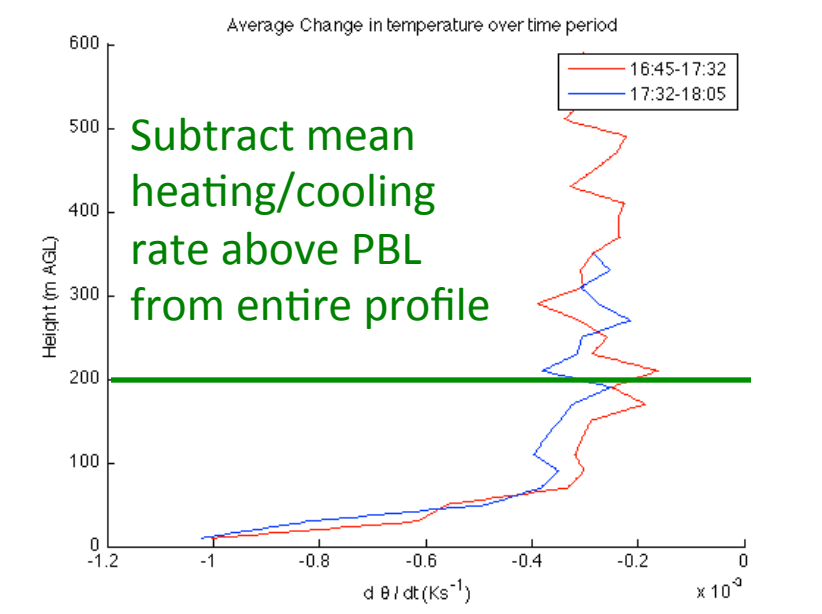


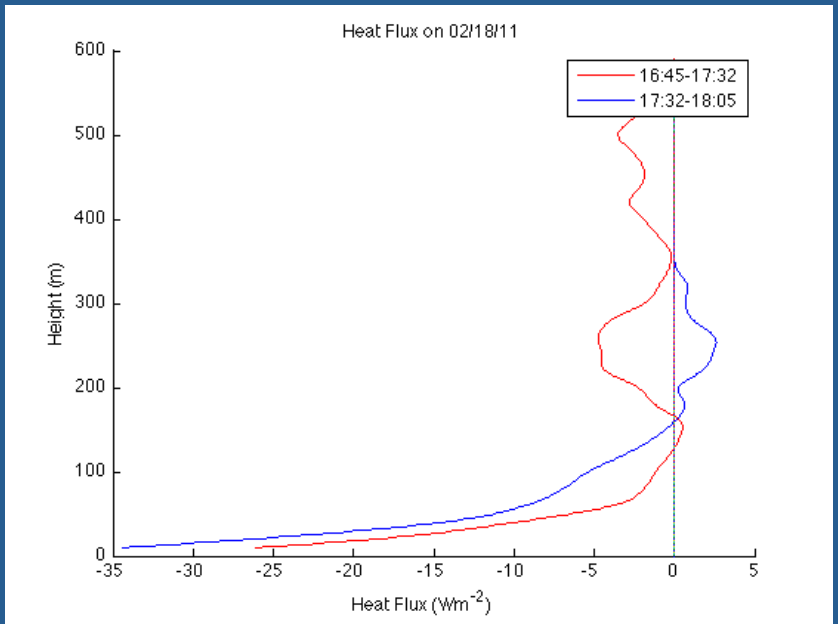


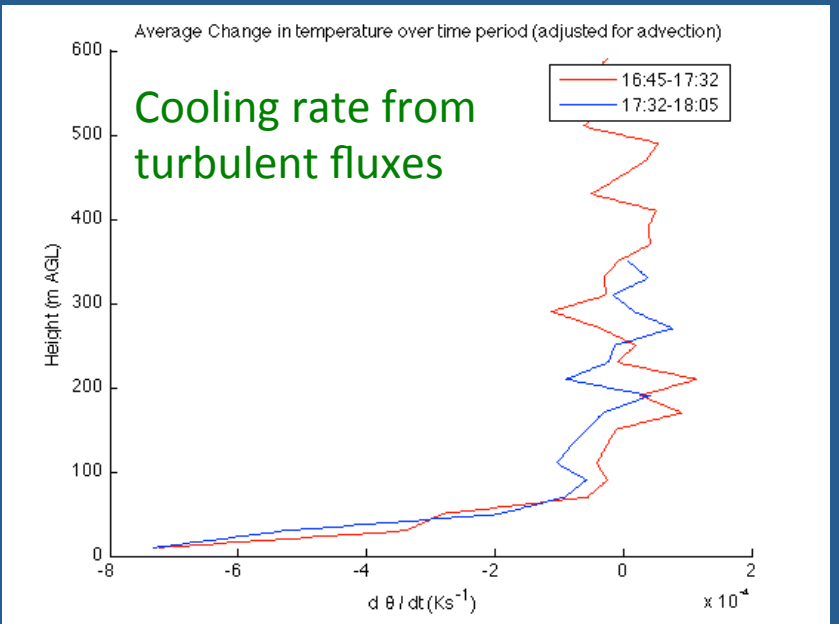


Correcting for Advection Effects









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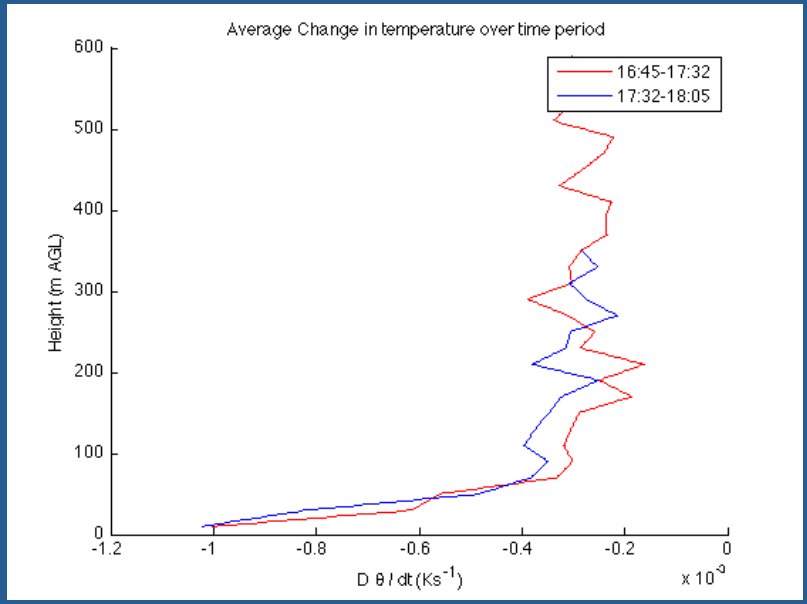
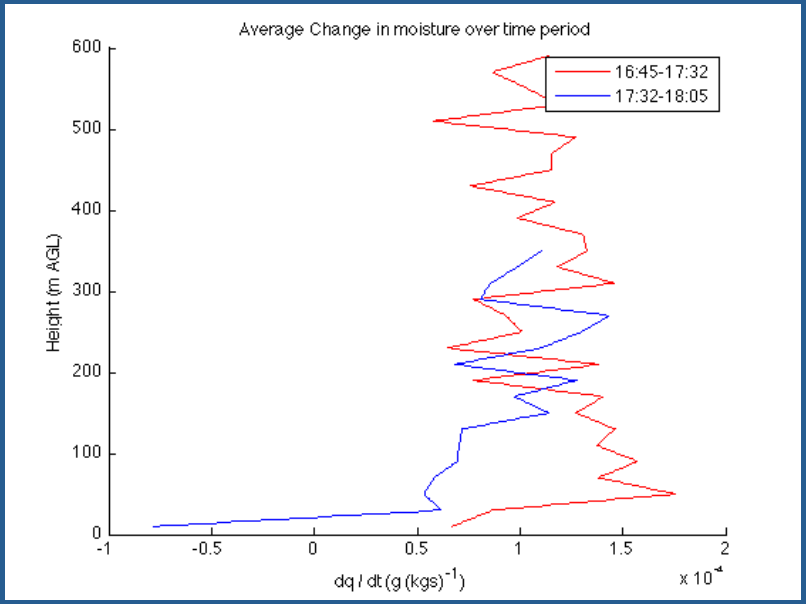
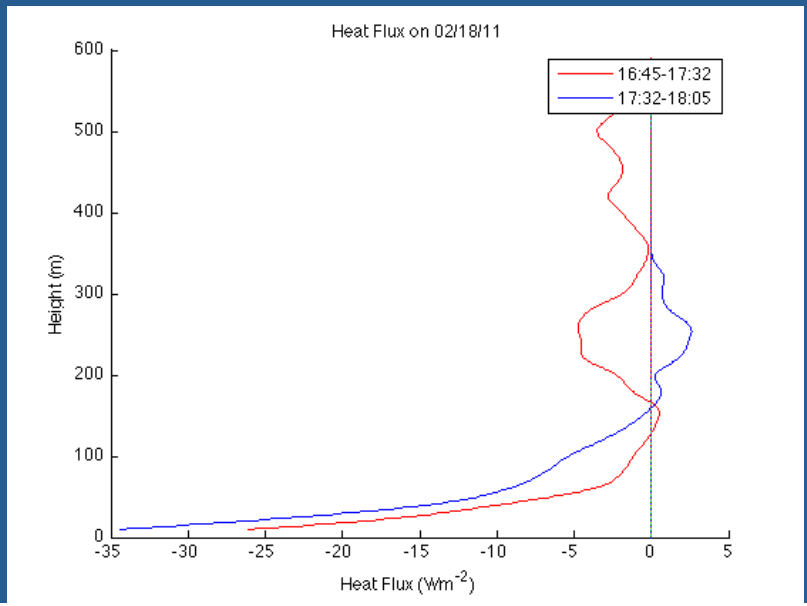
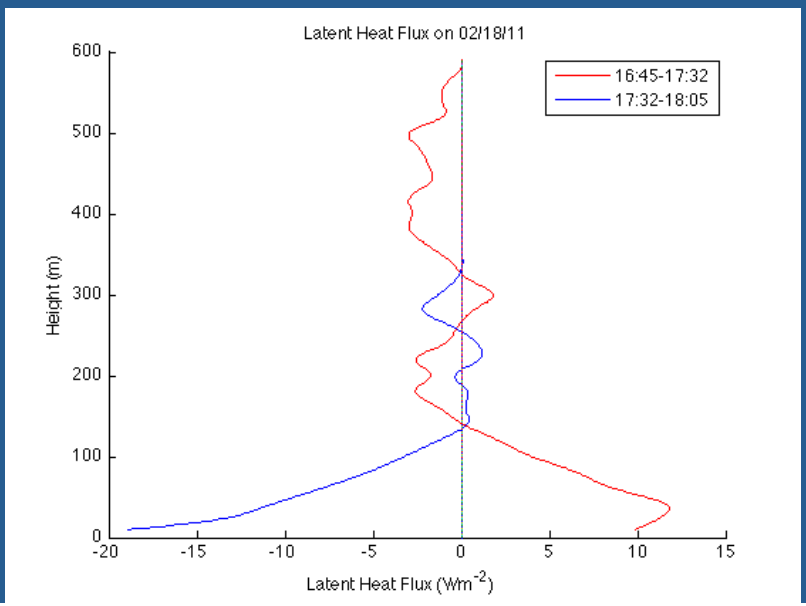
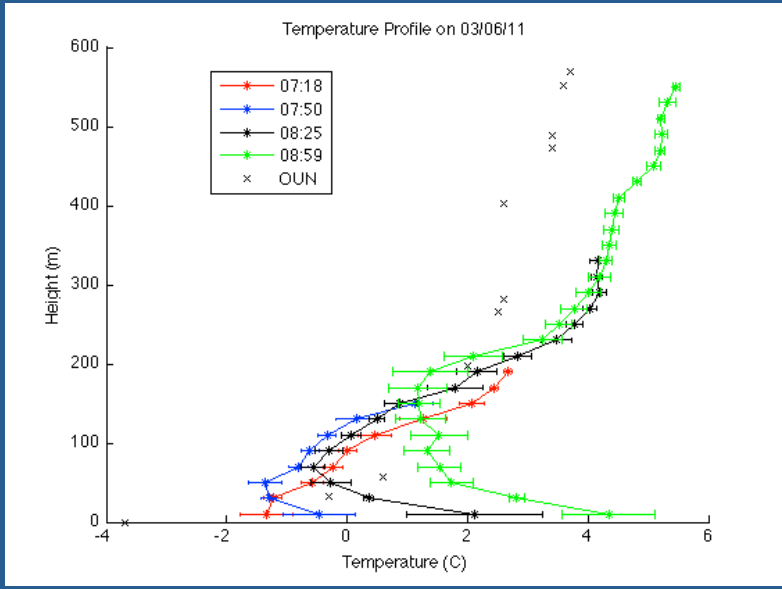


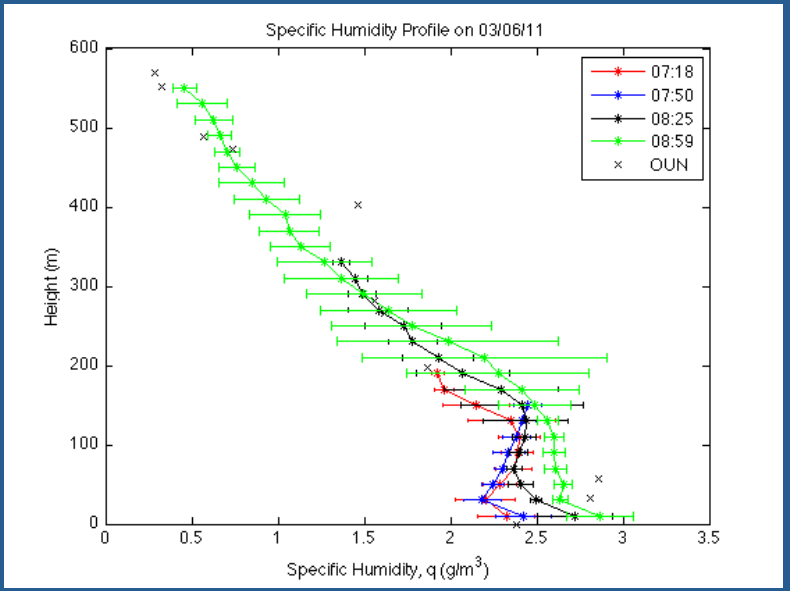


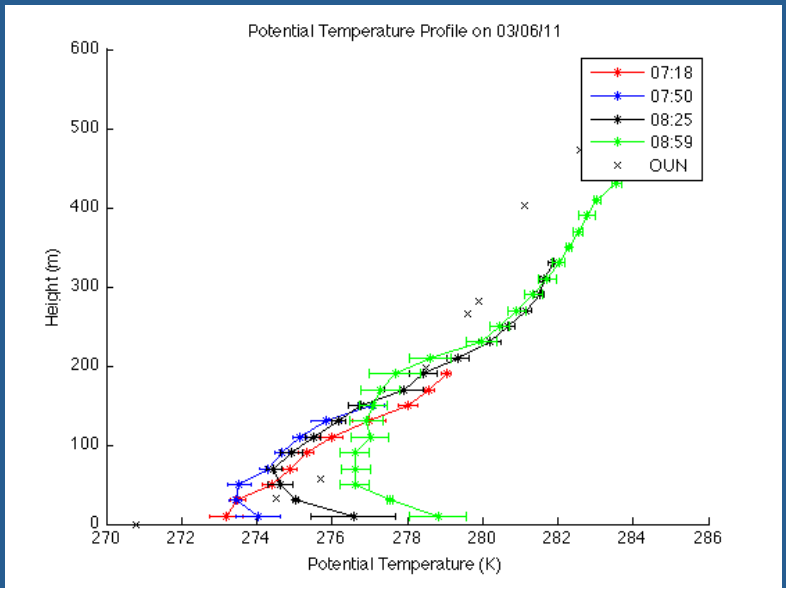


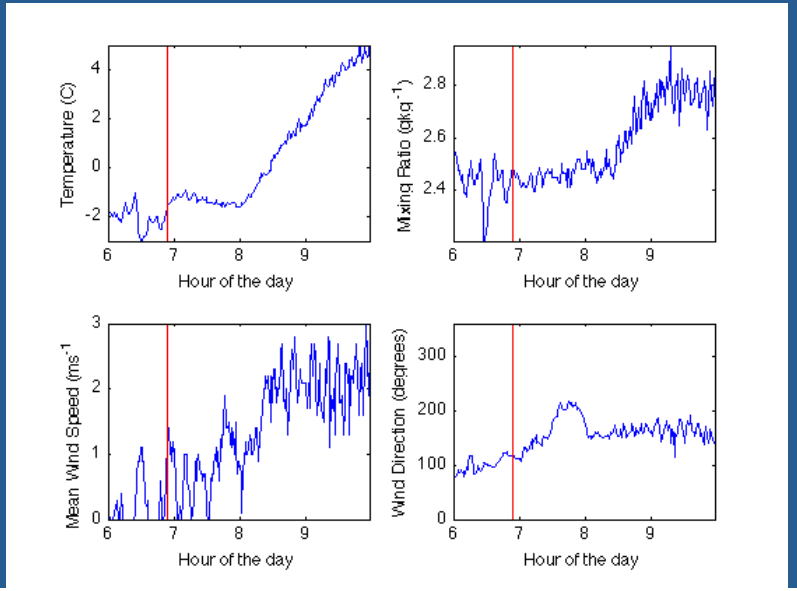


March 6th Morning Transition Observations Sunrise: 6:53









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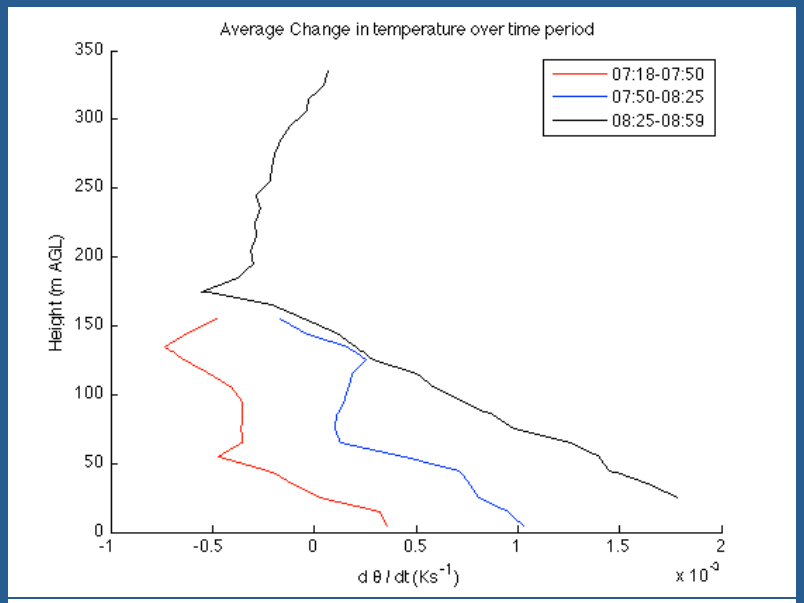

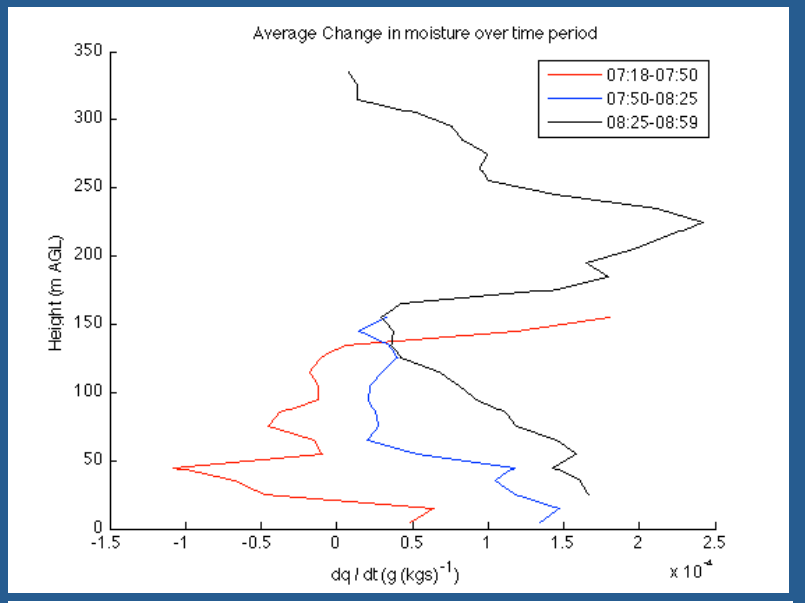

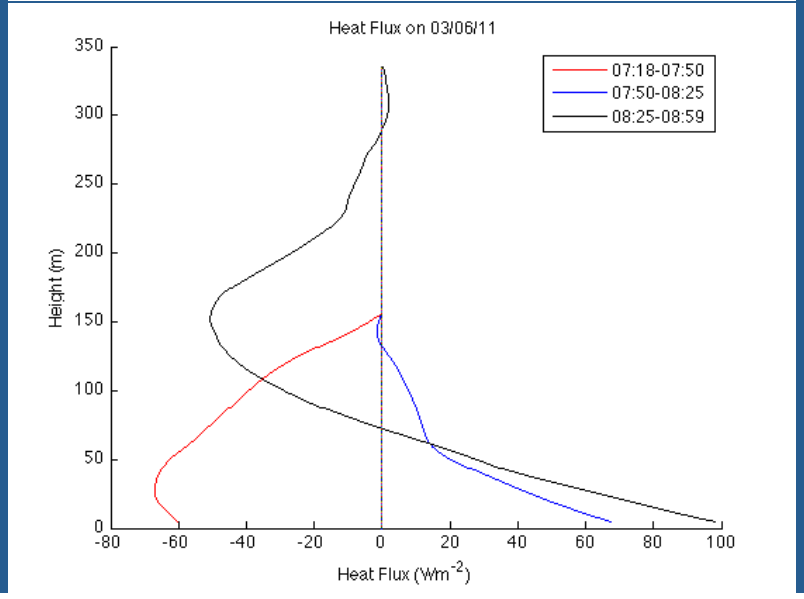

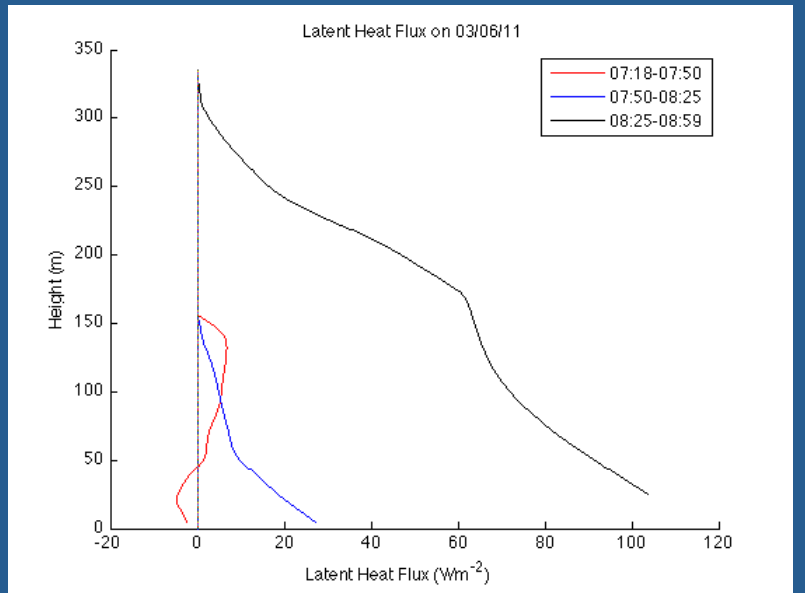

Future Plans

- Eddy-flux tower has recently been installed at KAEFS
- Compare surface flux measurements from the sonic anemometer with those estimated from UAS
  - Determine accuracy of estimates under a variety of conditions
  - Evaluate the validity of correcting for temperature advection

Summary

- Low-cost method of estimating sensible and latent heat flux profiles within the PBL
- Case studies of the evolution of the PBL during the morning and evening transitions
  - Well-suited for UASs; can easily penetrate the top of the PBL under these conditions which is needed for measurements
- Plan to verify measurements in near future

March 6th Morning Transition