The Potential of Using Airborne Raman Lidar Water Vapor Measurements to Observe Cloud Top Entrainment

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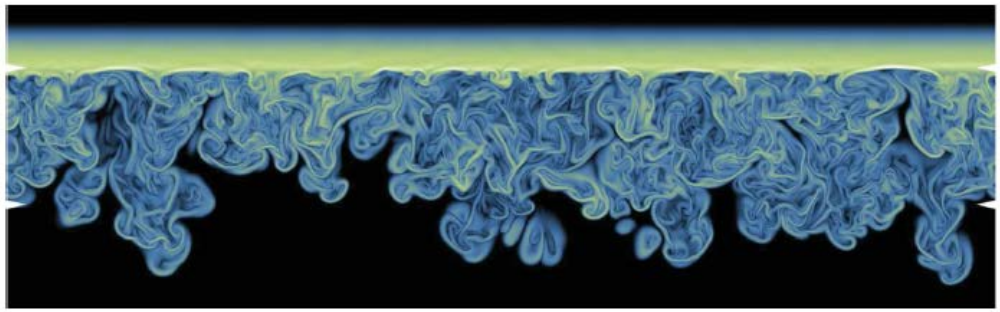
Cloud top entrainment is important !

(a)



(b)

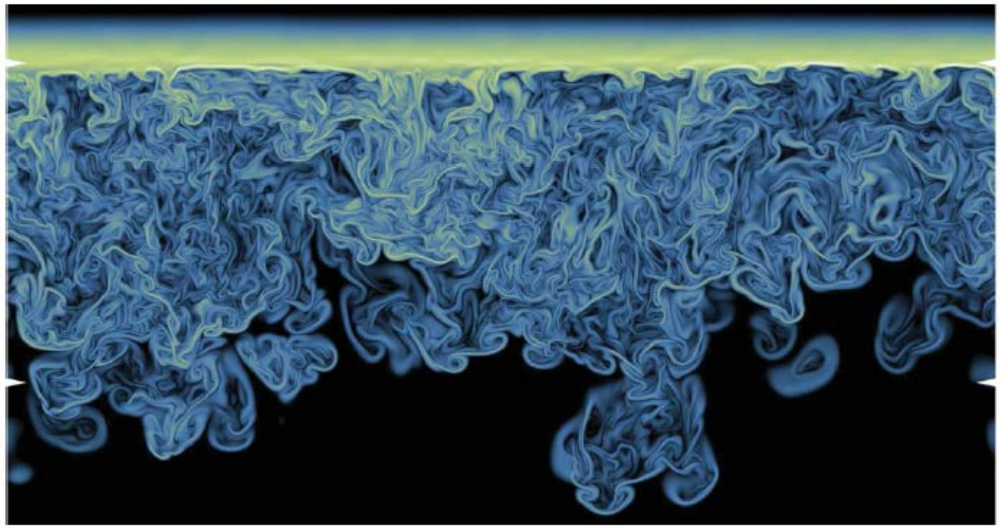


FIGURE 3. Evolution inside a vertical plane (same as figure 2) of the logarithm of the scalar dissipation rate ϵ_χ. Colour scale starting at black for the threshold $10^{-6}\max\{\langle\epsilon_\chi\rangle\}$ and increasing in the sequence b

J. Fluid Mech. (2010), *vol.* 660, *pp.* 5–36. © Cambridge University Press 2010
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The evaporatively driven cloud-top mixing layer

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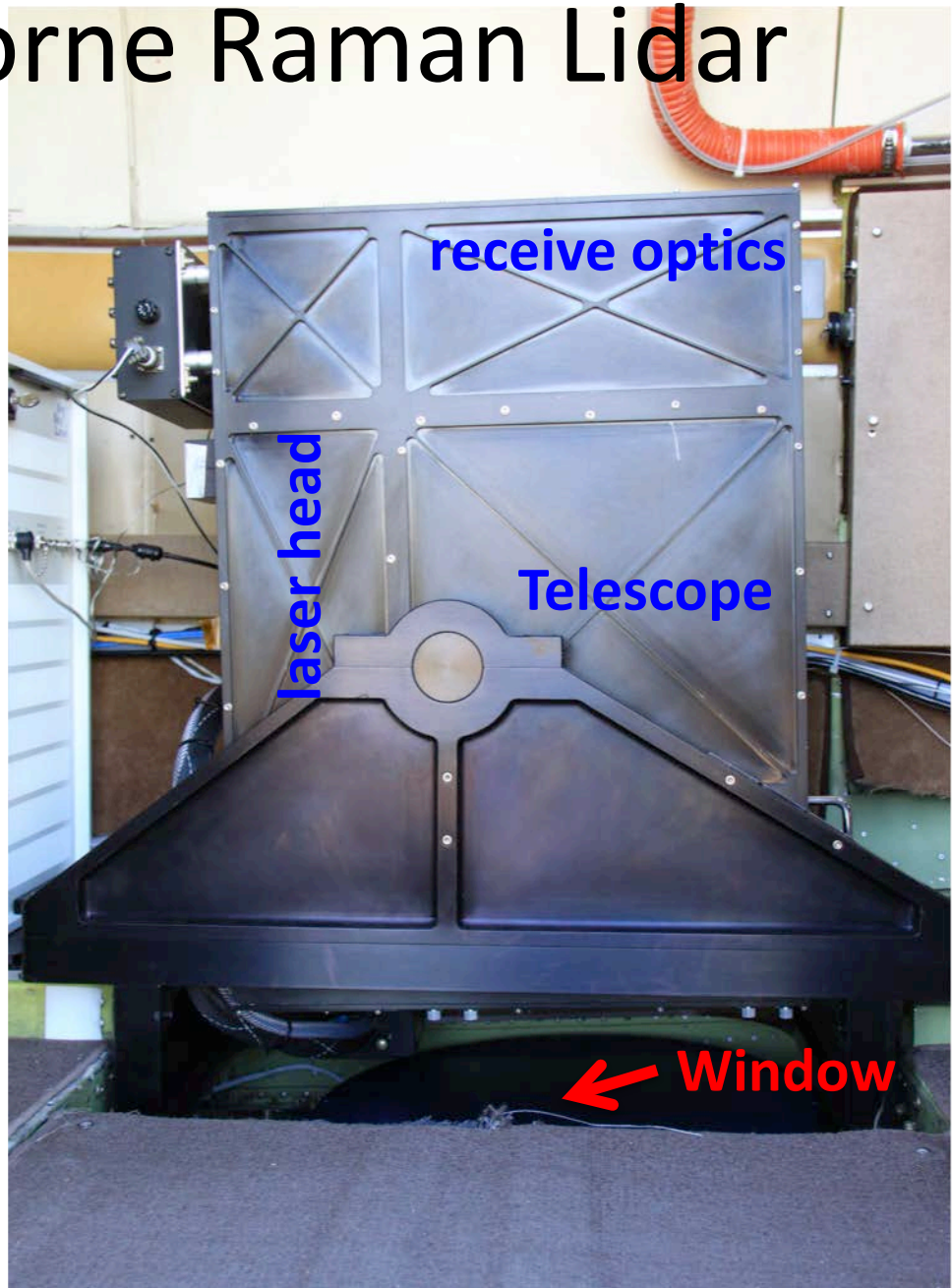
The challenges to observe entrainment

- Have to deal with high temporal and spatial variations
- Require at least 2-D fine scale observations
- Water vapor and temperature could be an important parameters to study entrainment
- **CARL**- fine scale water vapor and temperature around Cu may be useful to study entrainment around Cu.
- For Stratiform cloud top entrainments, It is hard to observe with ground base measurements

A Compact Airborne Raman Lidar

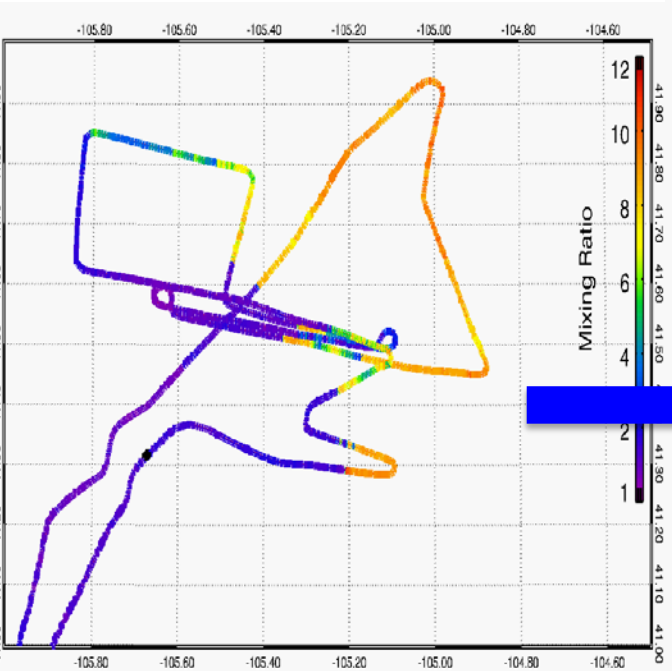
- **Compact:**
  - 12 inch telescope
  - Laser: 50 mJ at 30 Hz
  - Telescope, laser head and receive optics are integrated in one box with good optical stability.
- Four detection channels: water vapor and nitrogen Raman signals; perpendicular and parallel elastic signals.

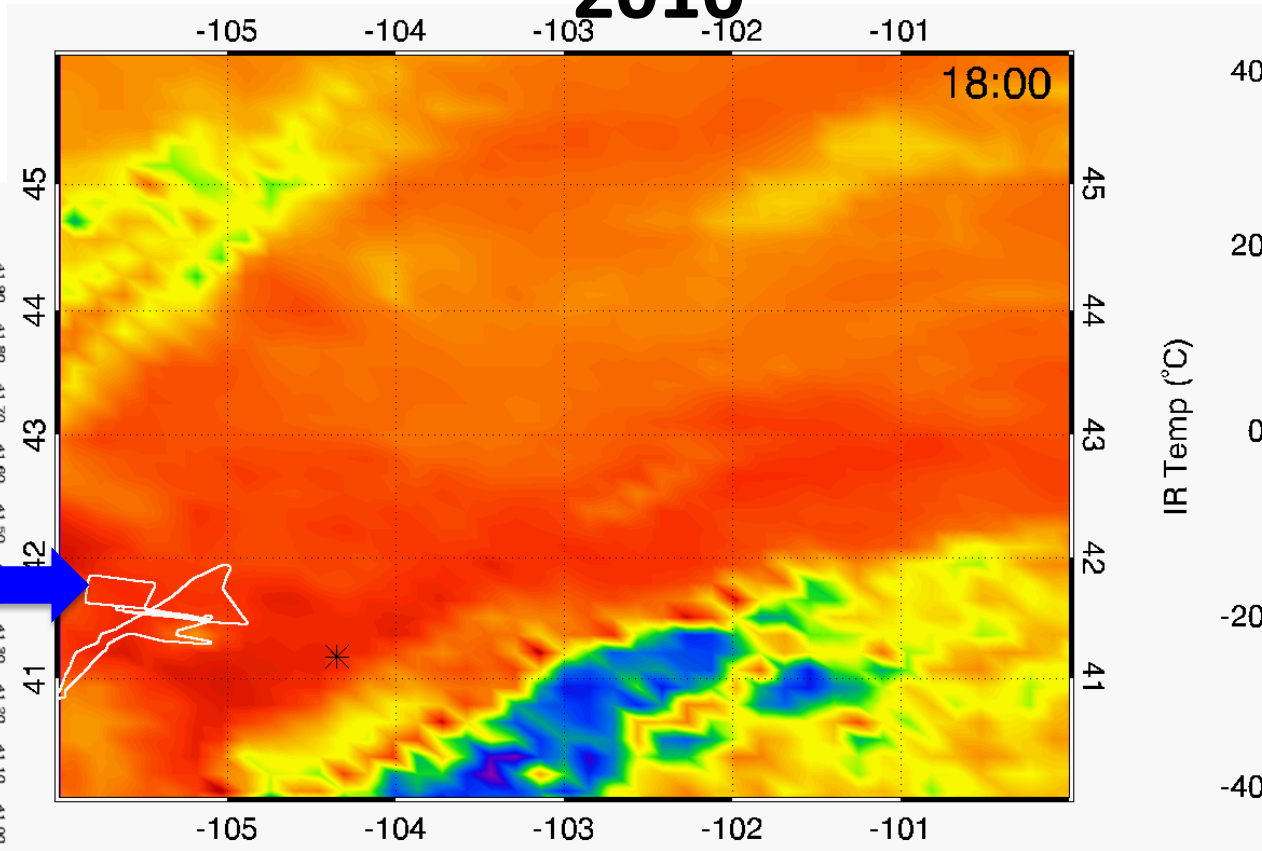


A Dry Line Case Observed Northeast of Laramie, WY

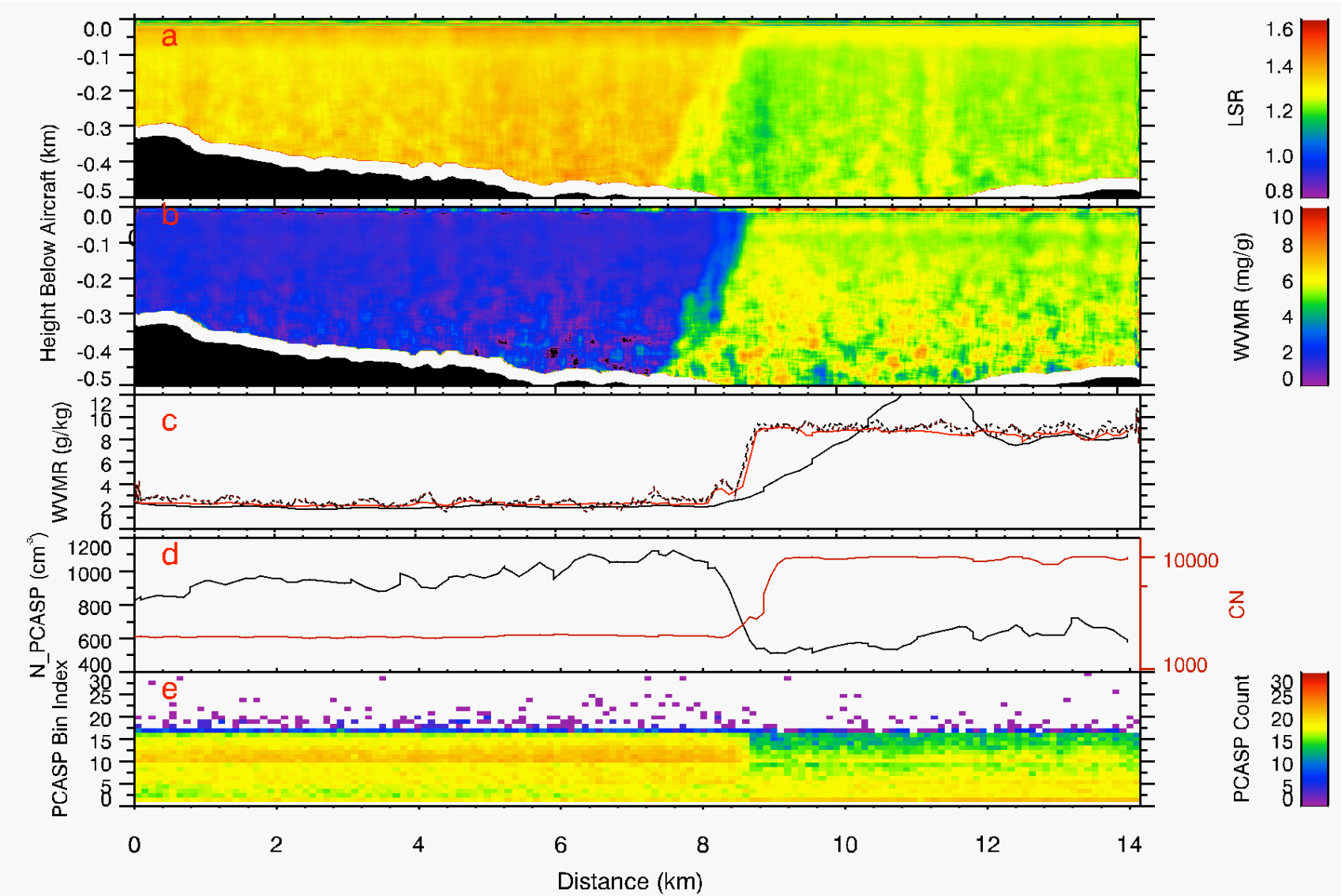
Flight level (constant AGL flight) water vapor mixing ratio

GOES IR images, June 22, 2010

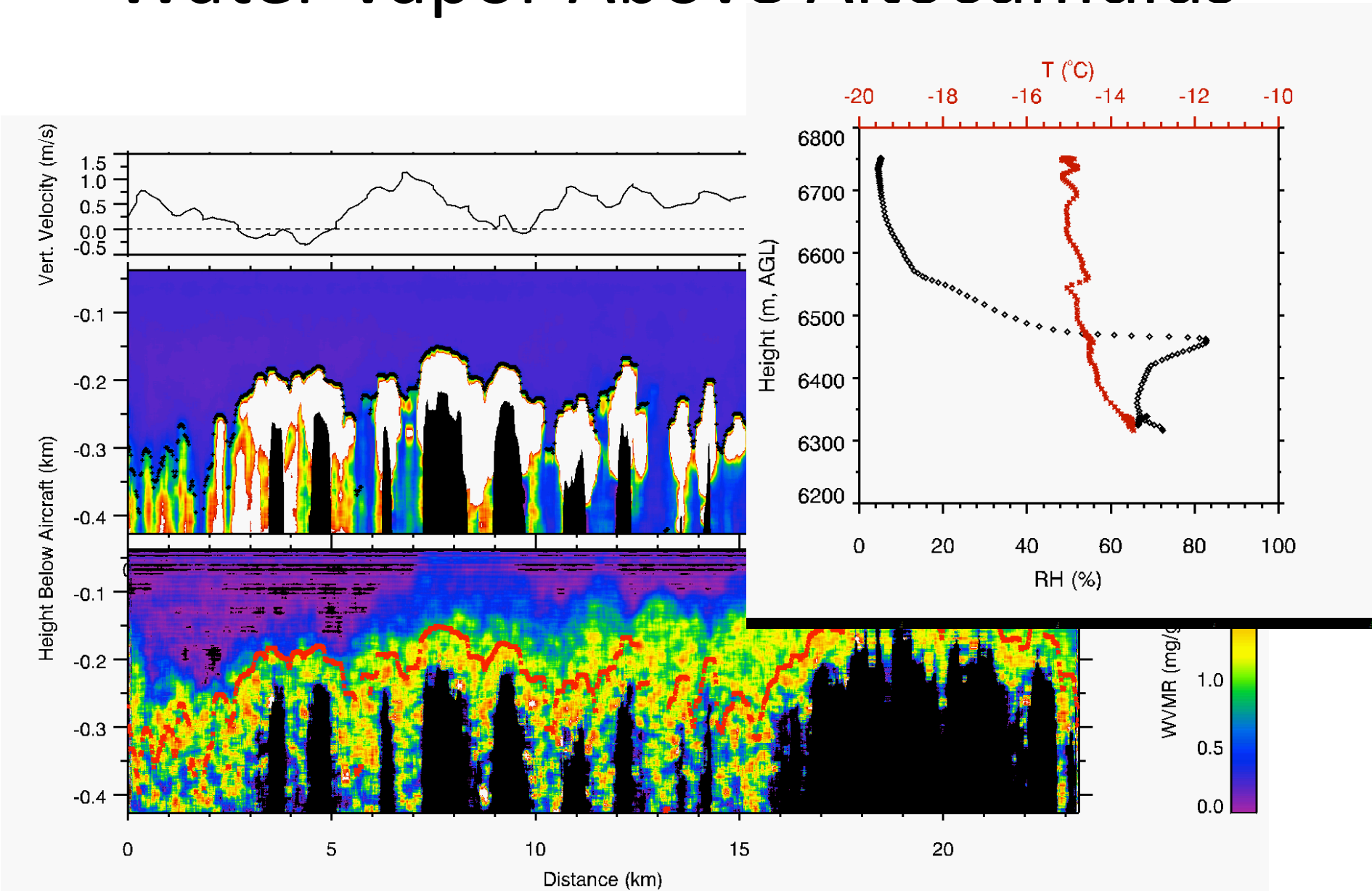




A Dry-line Case

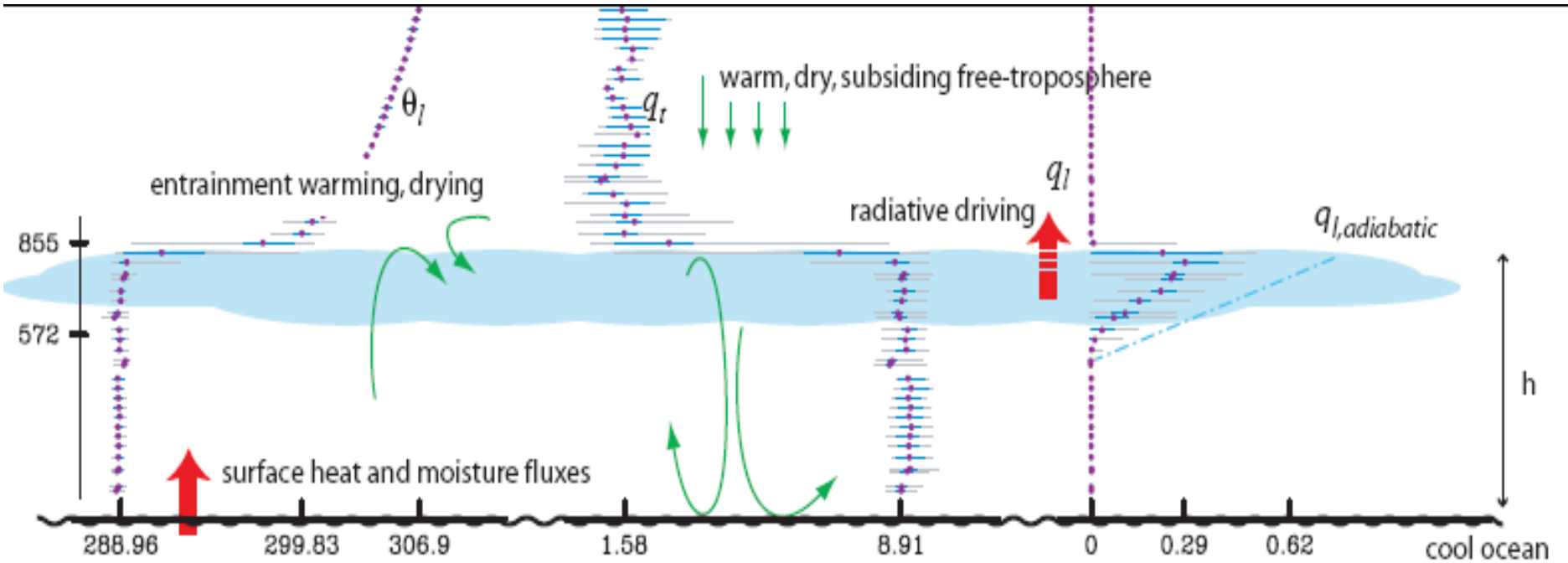


Water Vapor Above Altocumulus



The synergy of model simulations with observations.

- LES simulation of water vapor and temperature around clouds.
  - How these structure depending on entrainment.
- Comparison with observations.



New Airborne Raman lidar for fine scale temperature and water vapor measurements

- Funded by NSF MRI project (~1.7 million total budget).
  - Available around summer 2015

- A new tool for future ARM/ASR field campaign.