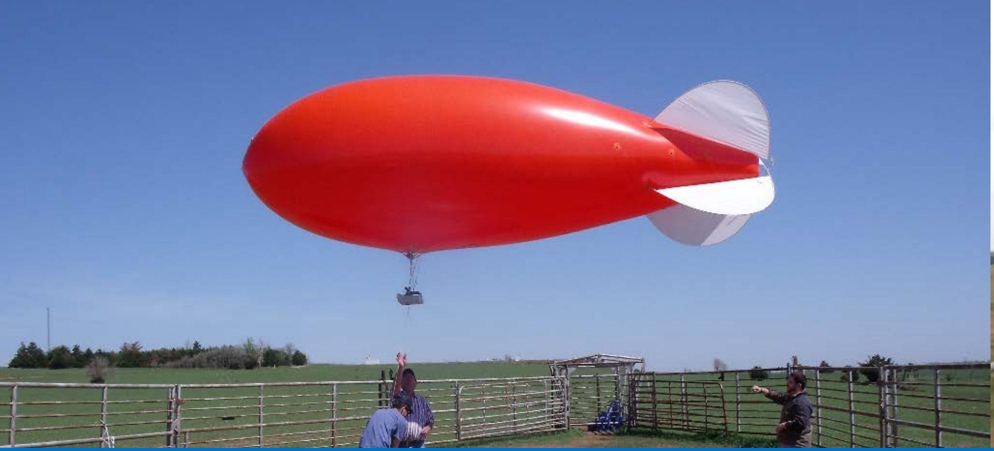

Vertically resolved physico-chemical properties of atmospheric nanoparticles at the ARM Southern Great Plains Site

Jim Smith, Haihan Chen
Department of Chemistry, University of California @ Irvine

John Ortega & Jim Greenberg
Atmospheric Chemistry Modeling and Observations Lab,
National Center for Atmospheric Research

Jeff Pierce
Department of Atmospheric Science, Colorado State University

Pete McMurry
Department of Mechanical Engineering,
University of Minnesota @ Minneapolis

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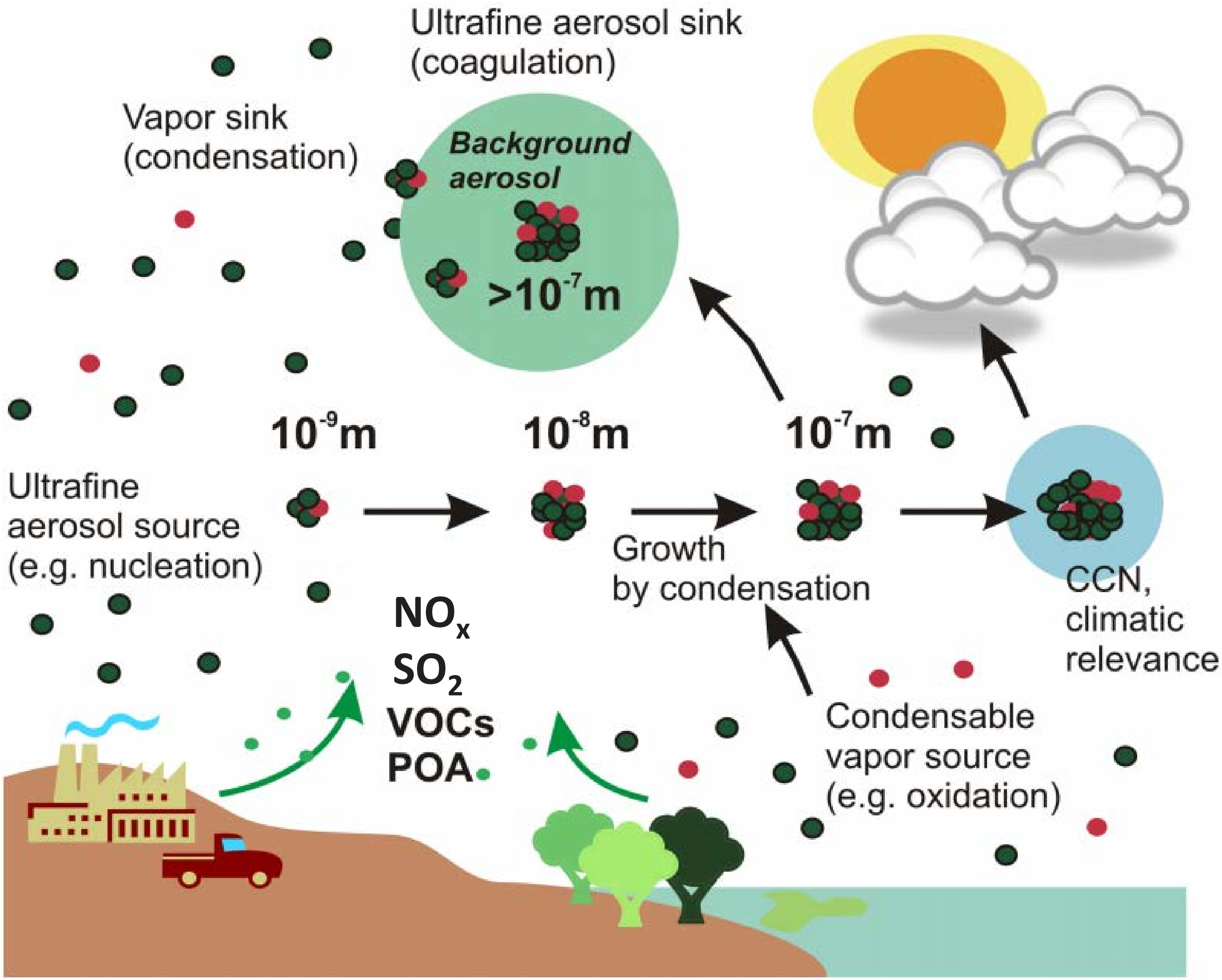
ARM/ASR PI Meeting

Motivation: How do ultrafine aerosol particles form in the atmosphere? What are their potential impacts?



Adapted from Riipinen, et al., ACP 2011

2013 New Particle Formation Study (NPFS)

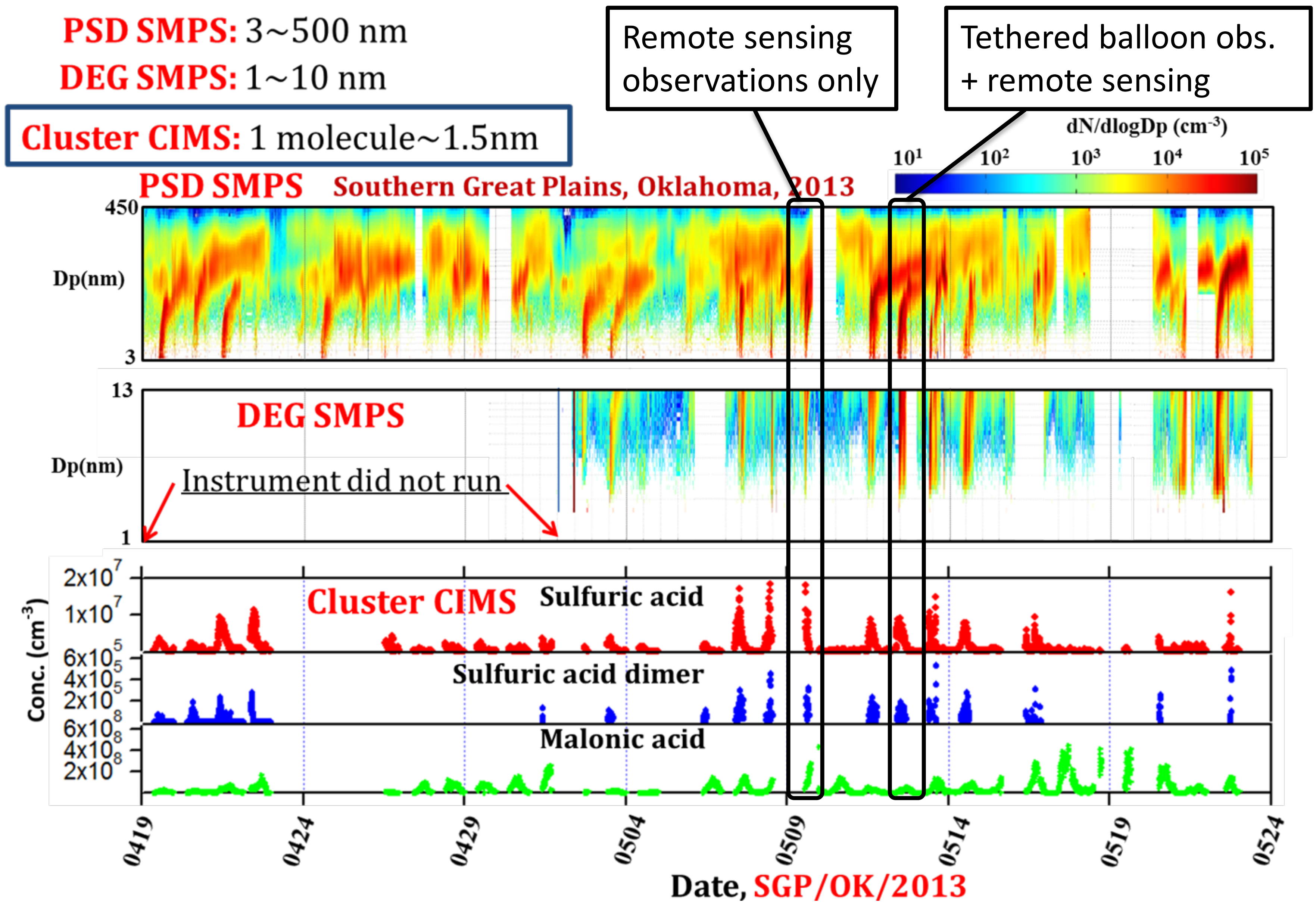
Vertically-resolved 10-20 nm diameter particle concentrations with meteorology

- Tethered Balloon with computer-controlled winch
- 2 x portable condensation particle counters (TSI model 3007) configured with 10 nm and 20 nm cut-off diameters.
- Portable weather station (Kestrel model 4500nv)

Ground-based measurements @ Southern Great Plains Central Facility:

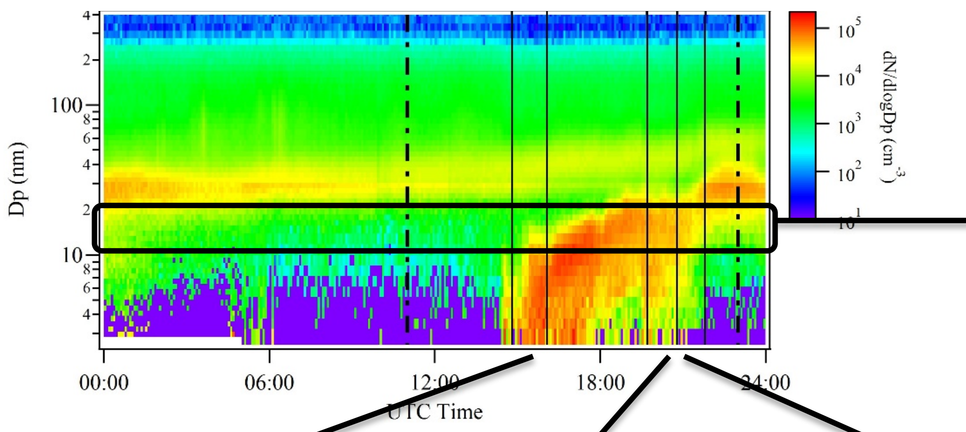
- Hygroscopicity (Tandem Differential Mobility Analyzer)
- Continuous vertical profiles of temperature and relative humidity (Raman Lidar)
- Continuous vertical profiles of vertical wind velocity (Doppler Lidar)
- Size distribution (1.5 – 400 nm diam., Scanning Mobility Particle Sizer)

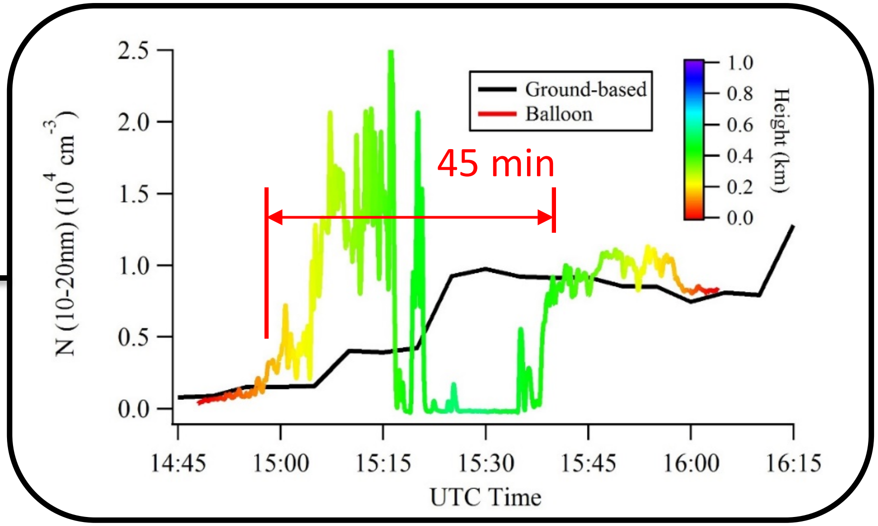
2013 New Particle Formation Study (NPFS)

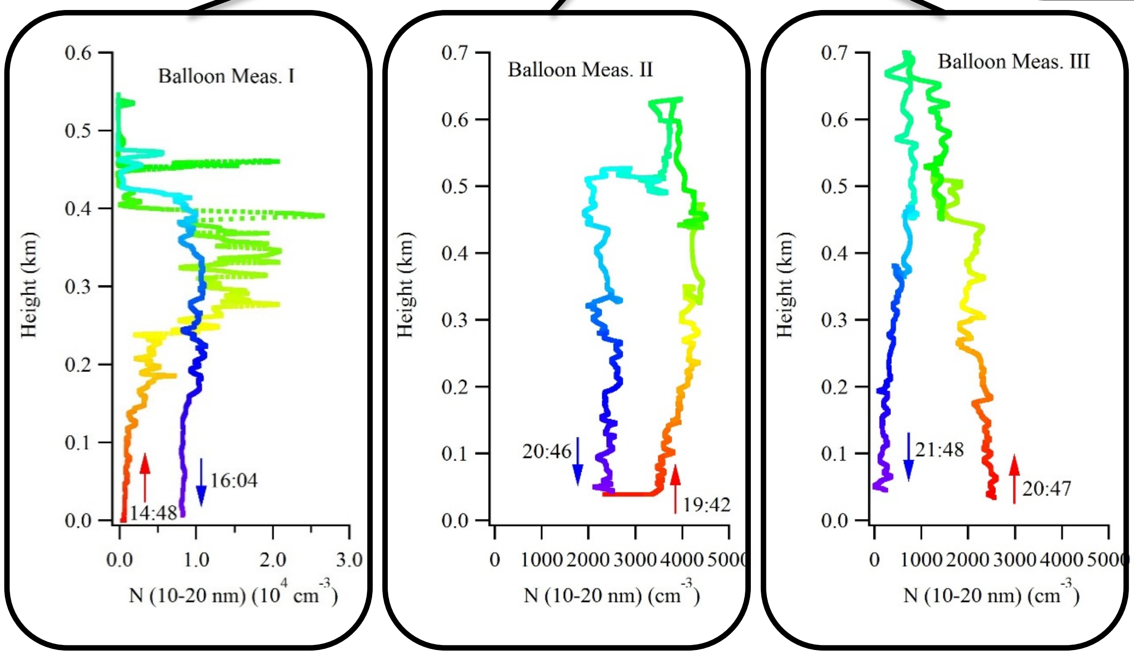


Vertical distribution of nanoparticles during new particle formation May 12, 2013

Ground-based particle size distribution



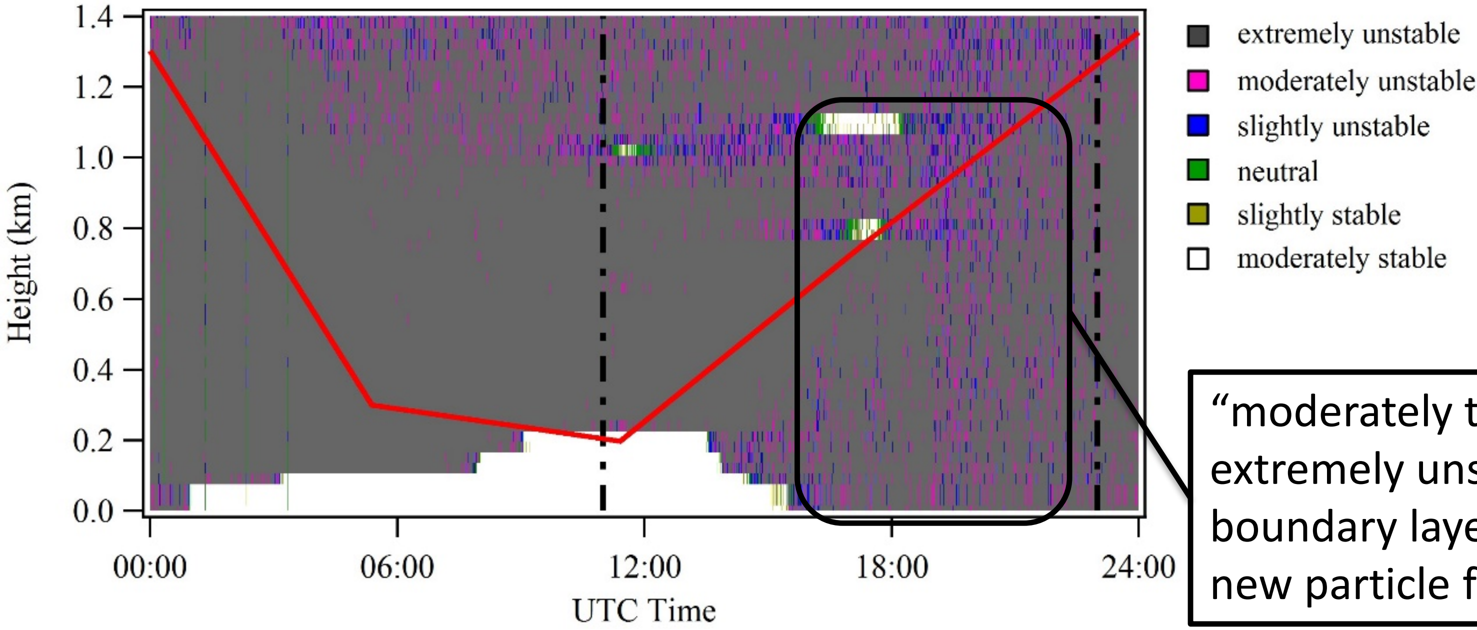




- Ambient nanoparticles are well-mixed less than an hour after formation
- Observed gradient in N(10-20 nm) is consistent with new particle formation initiated aloft, and then subsequently mixing down to ground level.

Chen et al., in preparation

Well-mixed boundary layer confirmed by remote sensing data May 12, 2013



"moderately to extremely unstable" boundary layer during new particle formation

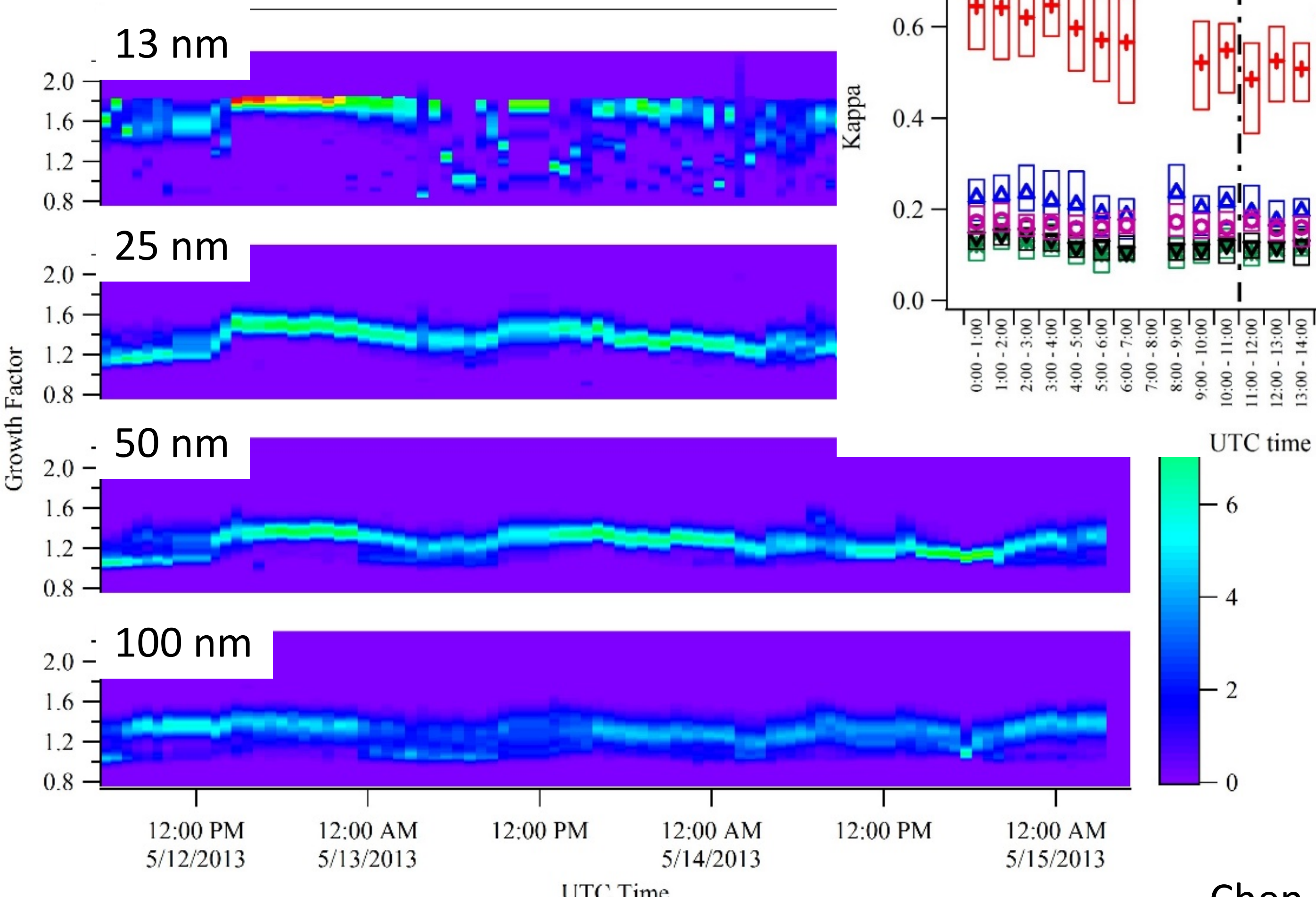
Stability calculation is based on the Richardson Number:

$$Ri = \frac{g(\Delta T/\Delta z)}{T(\Delta u/\Delta z)^2}$$

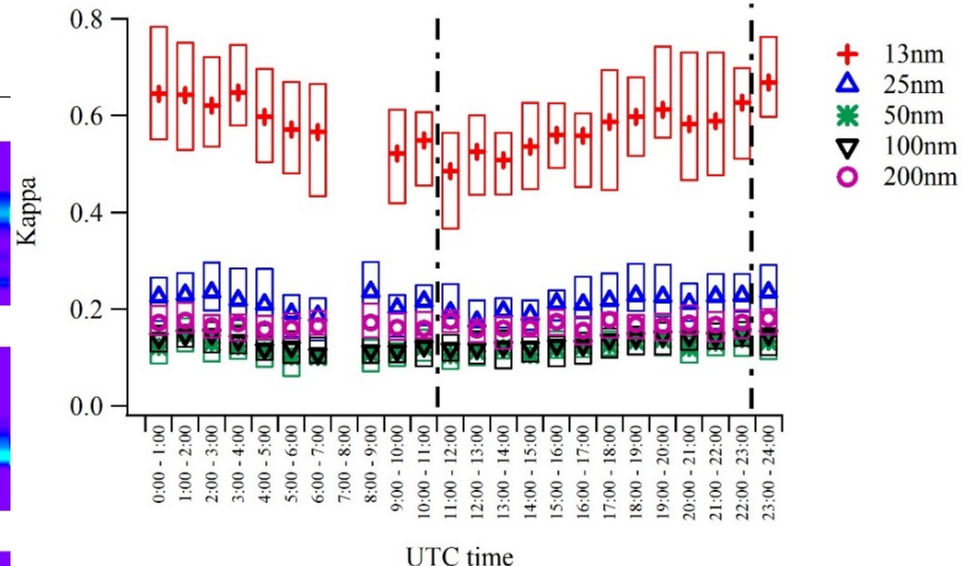
- vertical wind velocity (*u*) from the **Doppler Lidar**
- temperature (*T*) from the **Raman Lidar**
- *z* is height and *g* is the gravitational constant

Chen et al., in preparation

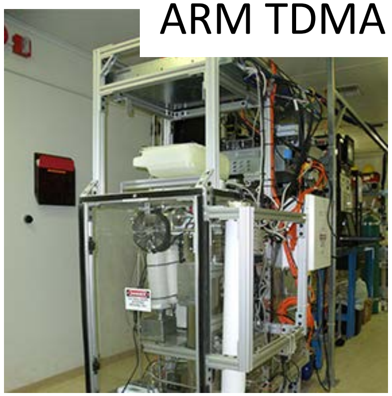
Ground-based aerosol hygroscopicity measurements show that 13 nm diameter particles are uniquely hygroscopic



Campaign-averaged kappa (hygroscopicity) diurnal plot



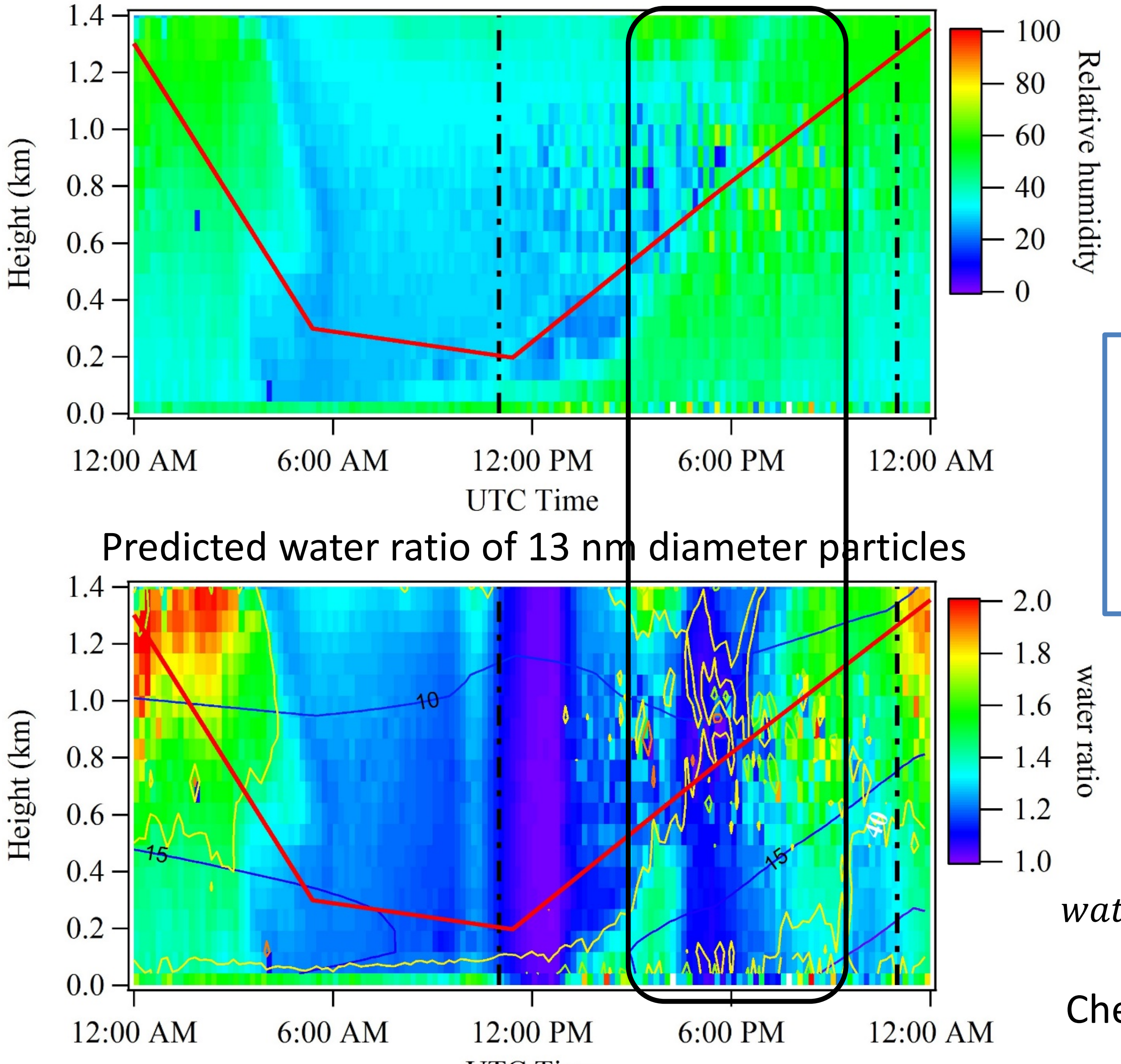
ARM TDMA



Chen et al., in preparation

What is the water content of 13 nm diameter particles in the boundary layer on May 12th?

Relative humidity from Raman lidar

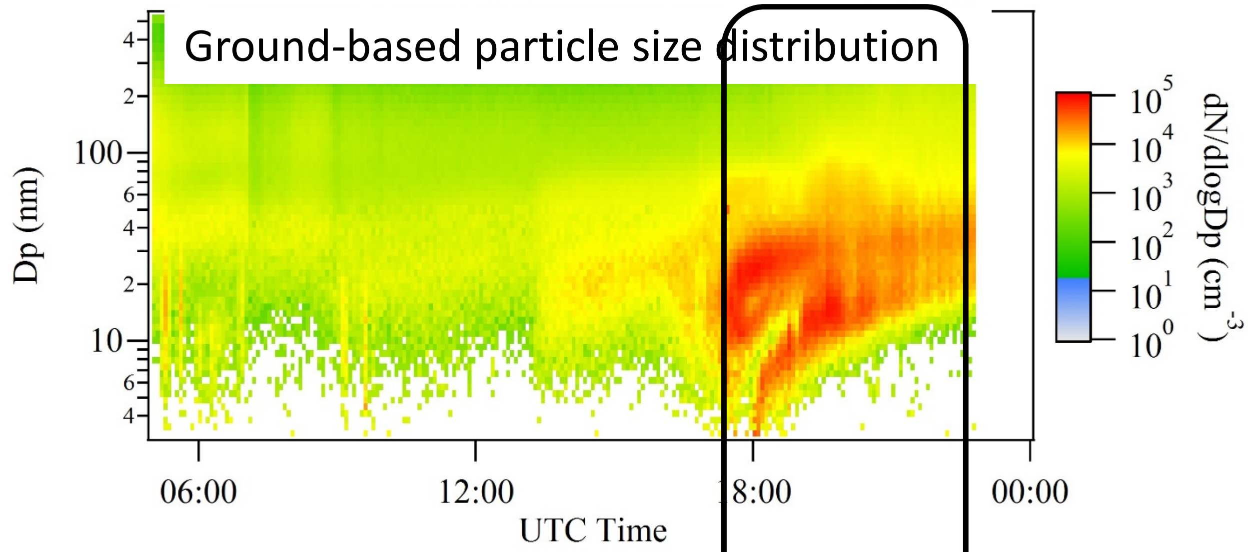


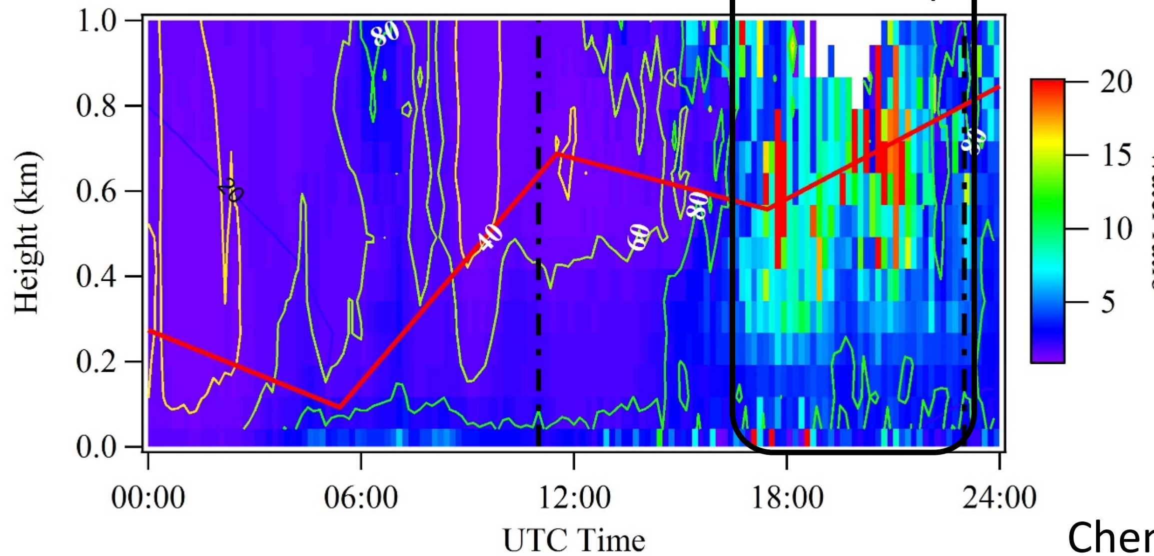
13 nm diameter particles formed by nucleation contain up to 50% water by volume on May 12th

$$water\ ratio \equiv \frac{wet\ volume}{dry\ volume}$$

Chen et al., in preparation

The water content of nanoparticles in the boundary layer may at times be quite high: May 9, 2013





Chen et al., in preparation

Take-home messages

- Ground-based observations may not always accurately represent new particle formation.
- Once nanoparticles are formed, they can be rapidly mixed throughout the boundary layer.
- Atmospheric nanoparticles are ***wet*** (up to 95 vol% water). Implications:
  1. Increases size, volume and surface area of particles for gas species condensation (esp. water-soluble gases) and heterogeneous reactions within particles
  2. Affects phase of particles - particles have lower viscosity and are more "liquid like."
  3. Mixing state could be affected.
  4. Vapor pressure of semi-volatile organics over particles can be affected by water content of particles.