# Combined observational and modeling efforts to better understand aerosol-cloud-precipitation interactions over land: Preliminary results from 7-SEAS/BASELInE 2013


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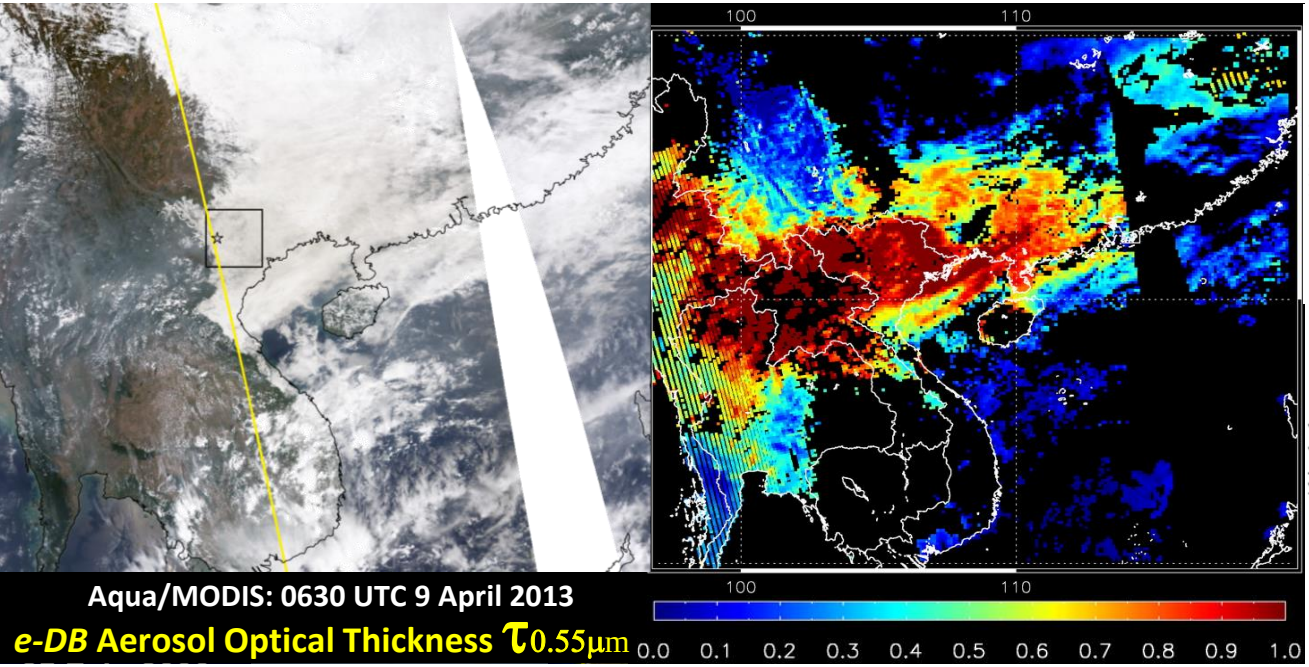
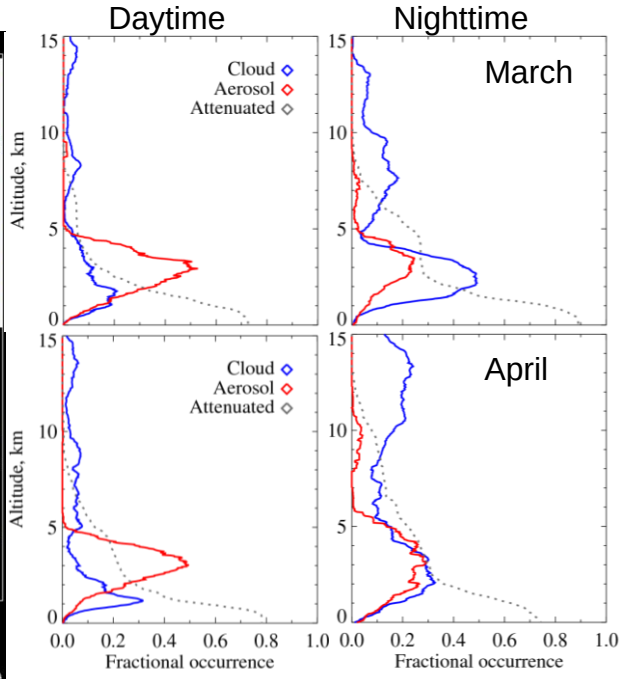
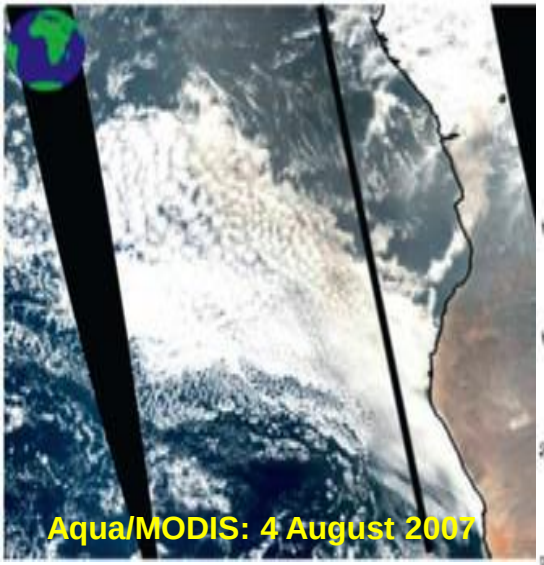
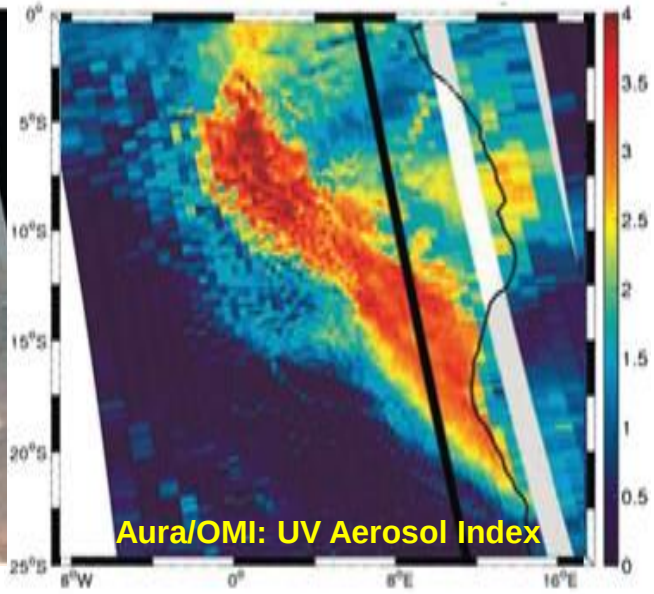
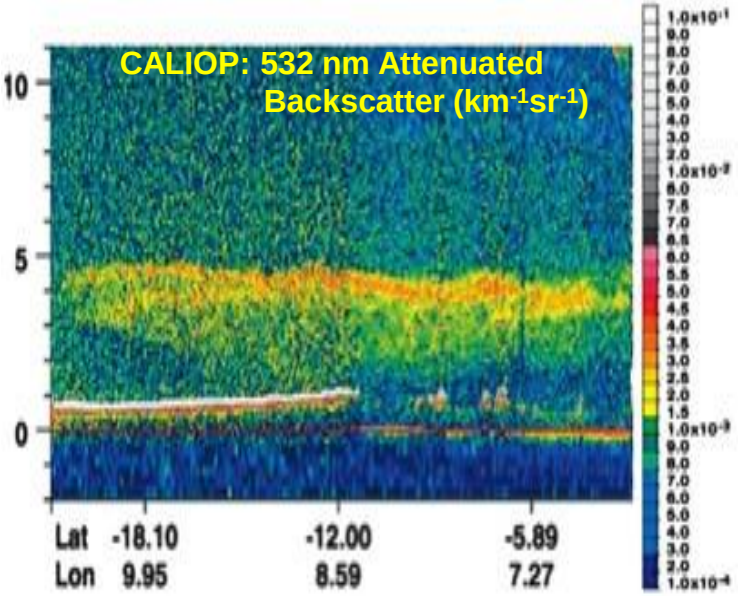
# *Global frequency distribution of* Smoke *in the presence of* Clouds*



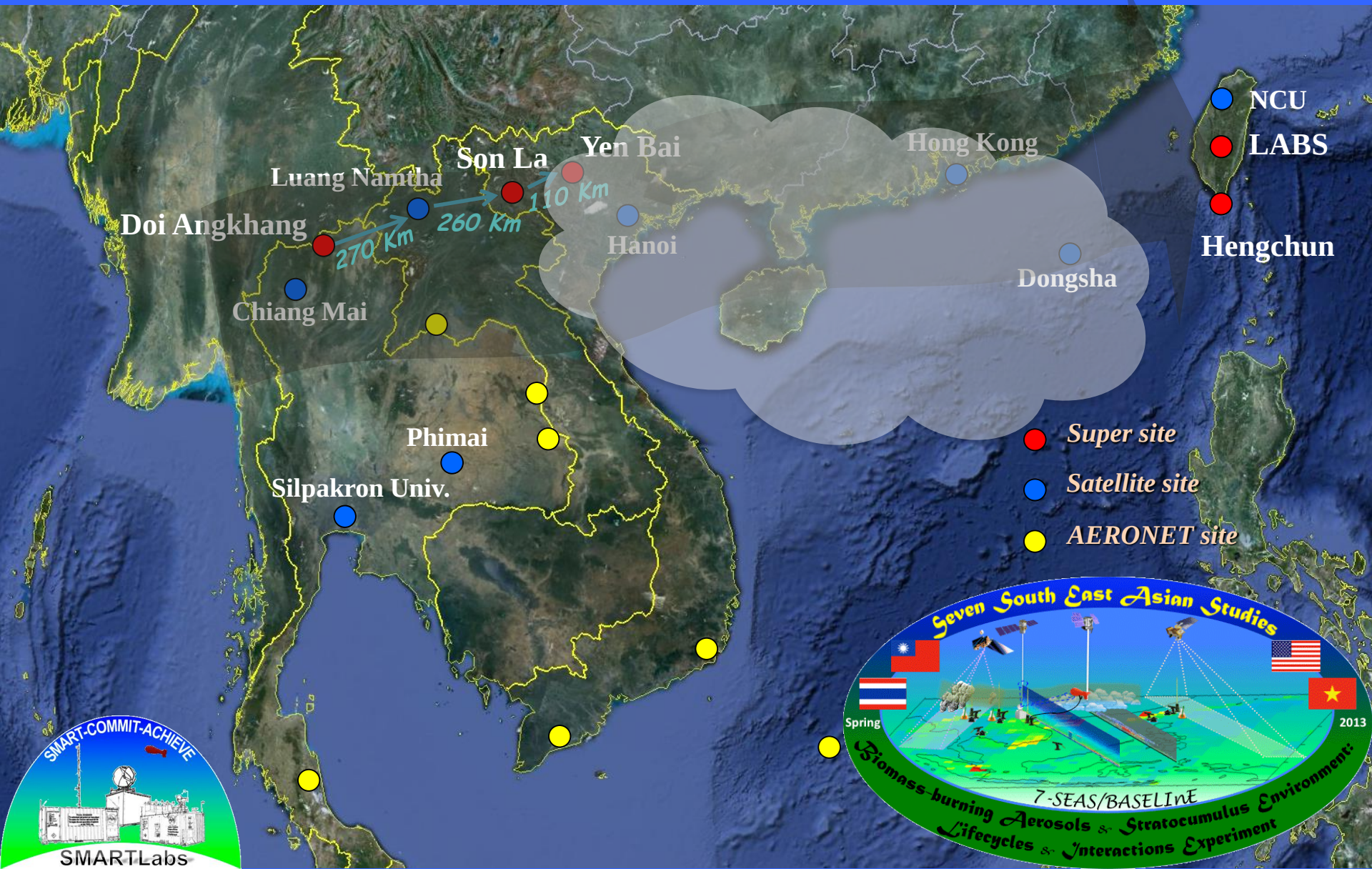



# 7-SEAS/BASELInE deployment 2013-2015: along the "river of smoke aerosols"

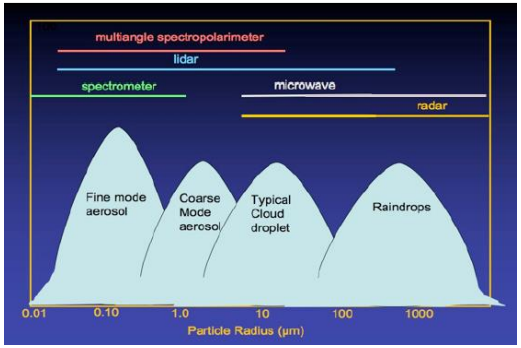


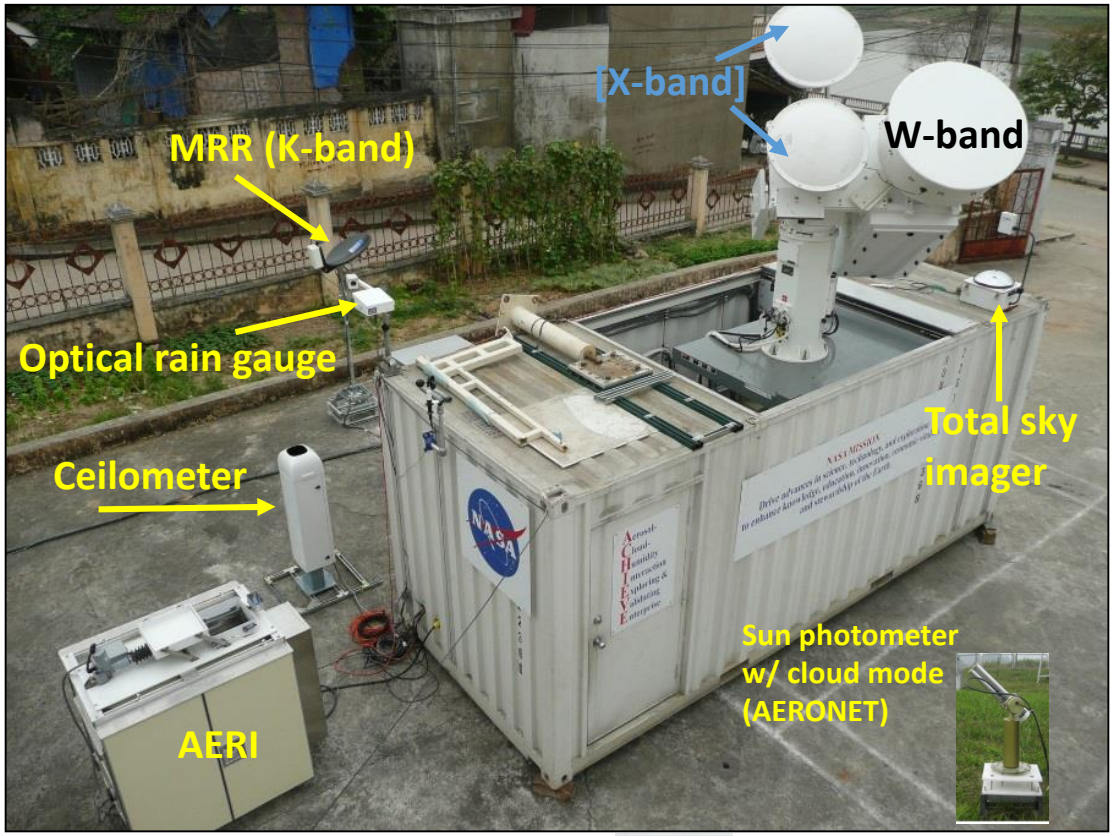
# Aerosol-cloud-precipitation interactions

- Importance to weather/climate; hydrologic cycle, energy budget
- Cause and effect not well established by observations
  - Satellite observations only provide snapshots of atmospheric state, long time periods between overpasses - CAN'T show processes
  - Measurements of co-existing aerosols and clouds very difficult [Stevens and Feingold 2009]; (typically only one or the other)
  - Aerosol observing sensors generally can't penetrate clouds of $\tau_c$> ~3-5; can't 'see' what's on the other side
- Representation of cloud properties still primary contributor to uncertainties in GCMs [Lohmann and Feichter 2005; Wyant et al. 2006; IPCC, 2007; 2014]

# ACHIEVE: Aerosol-Cloud-Humidity Interactions Exploring and Validating Enterprise

- ACHIEVE is one of 3 mobile laboratories comprising SMARTLabs (Surface-based Mobile Atmospheric Research and Testbed Laboratories; http://smartlabs.gfsc.nasa.gov)
  - SMART – radiative transfer
  - COMMIT – in-situ aerosol and trace gas properties
- Suite of instruments to cover spectral range associated with aerosols, clouds, and precipitation



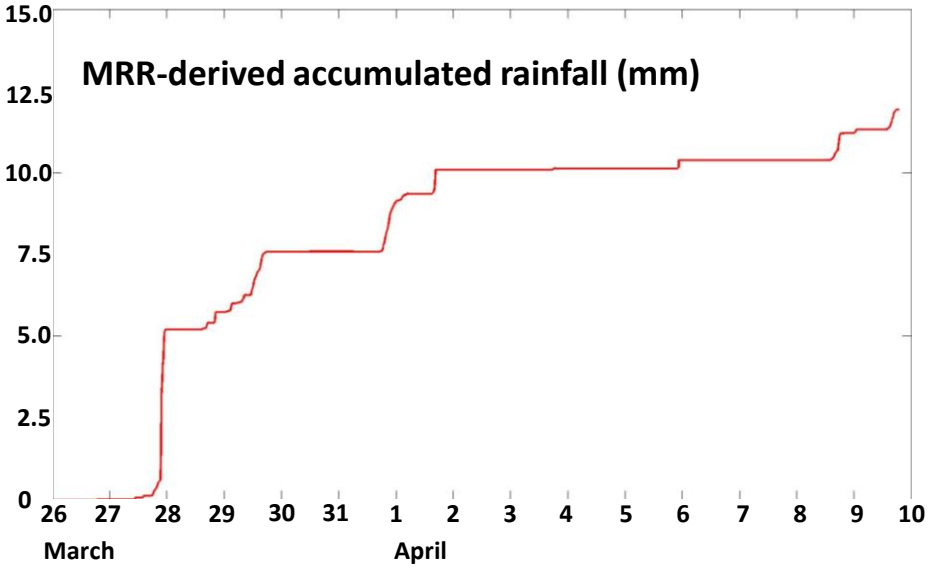



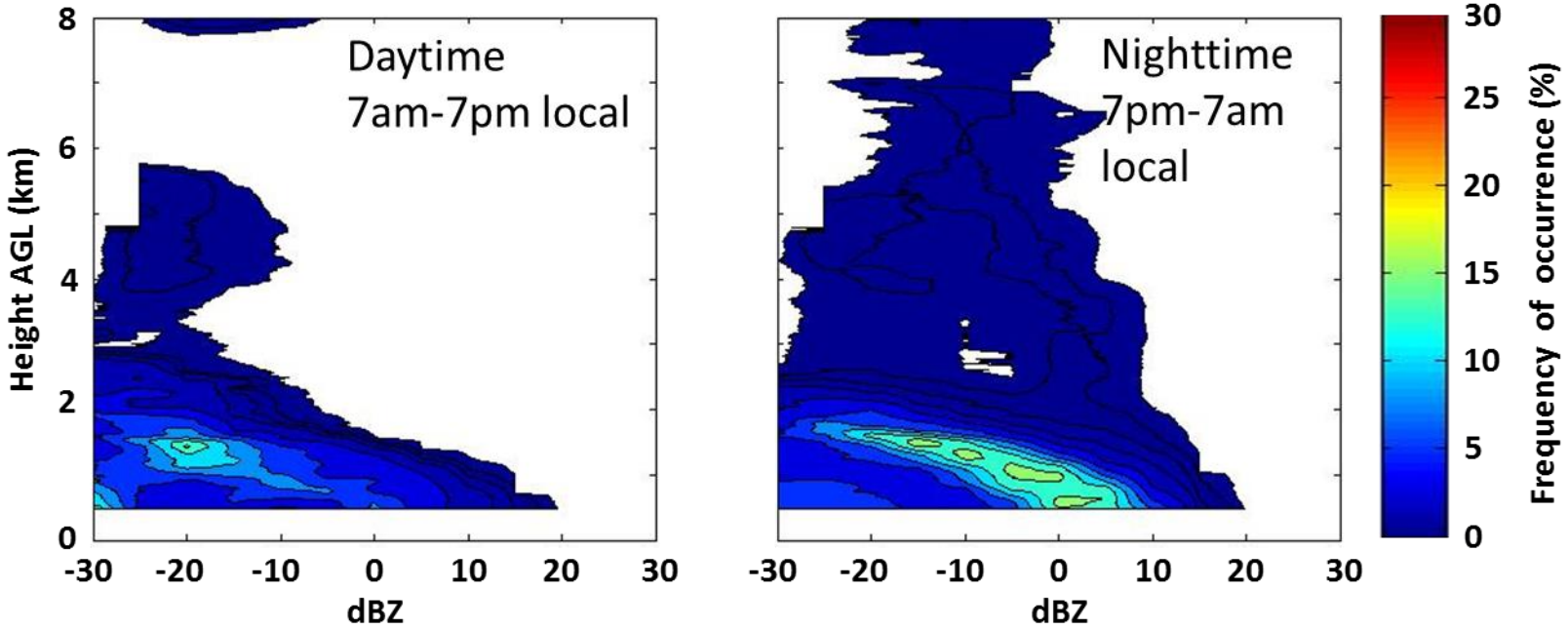

**COMING SOON!**

[VIS-NIR spectrometer]

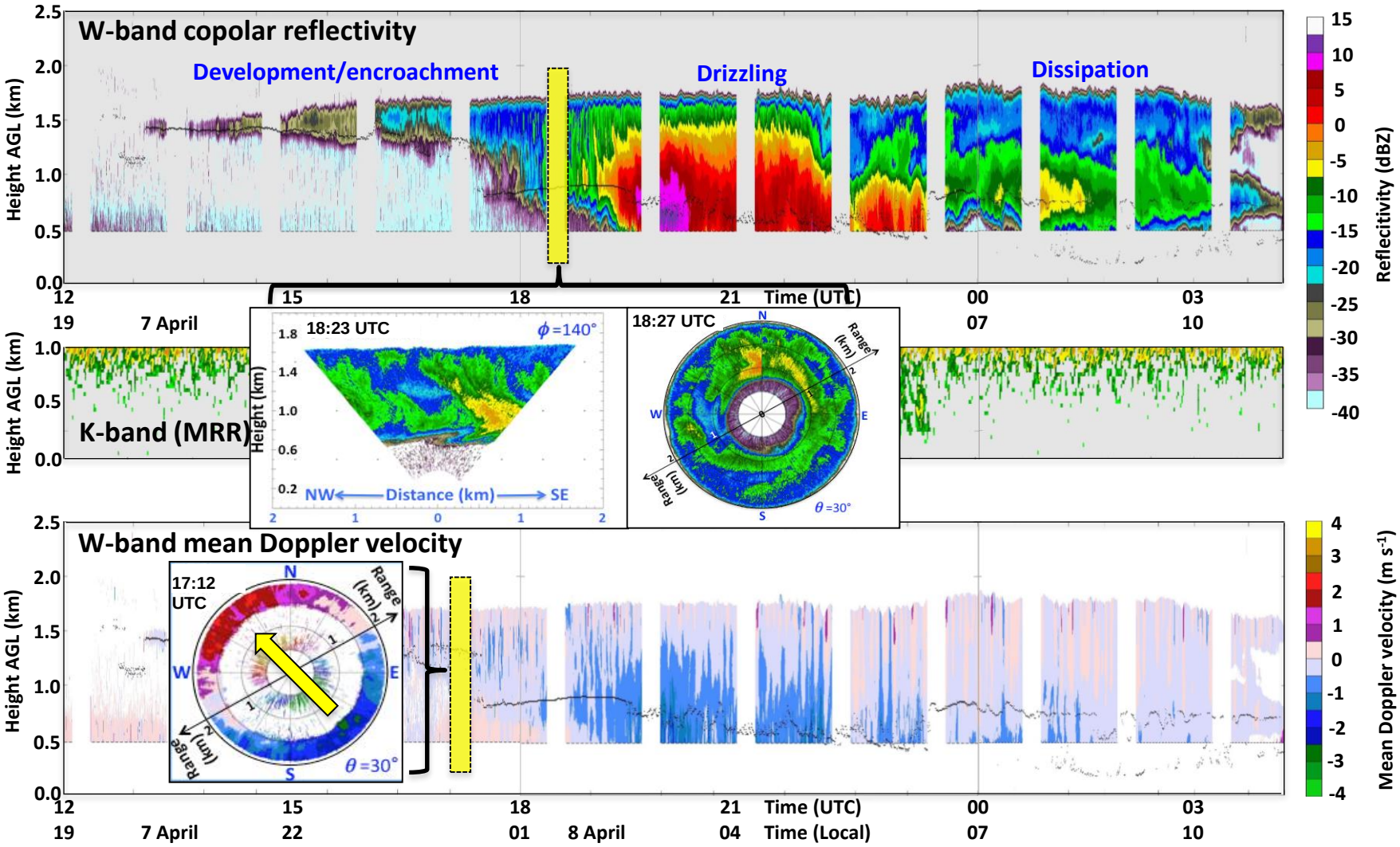
# Summary of ACHIEVE Observations

- 26 March – 9 April 2013
  - Power outages led to gaps in data
- Low-level clouds and drizzle/light rain most frequent at night

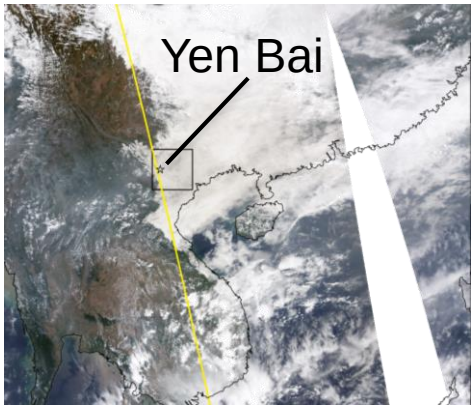


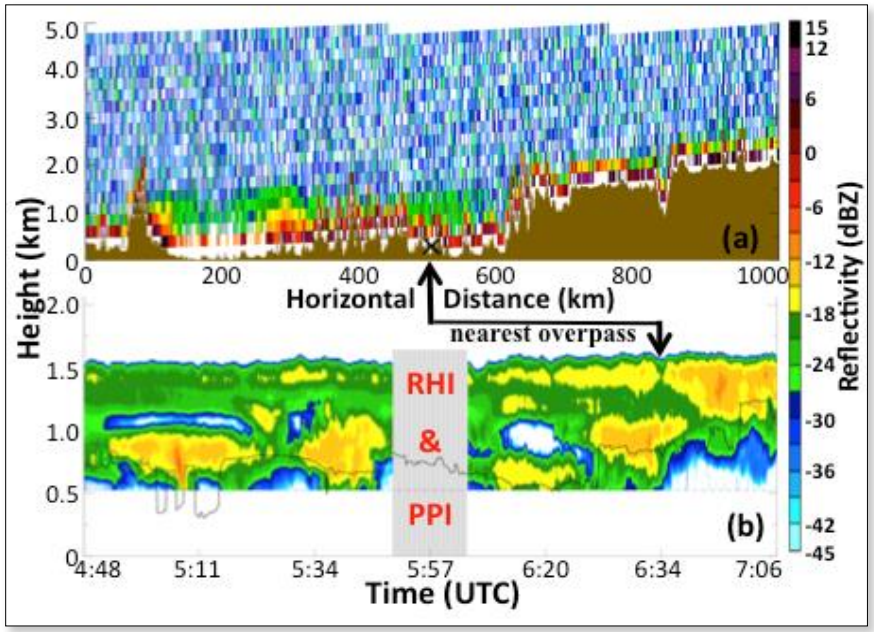
# 7 April 2013: ‘Golden scenario’ Stratocumulus (Sc) case



# 9 April 2013: A-Train overpass

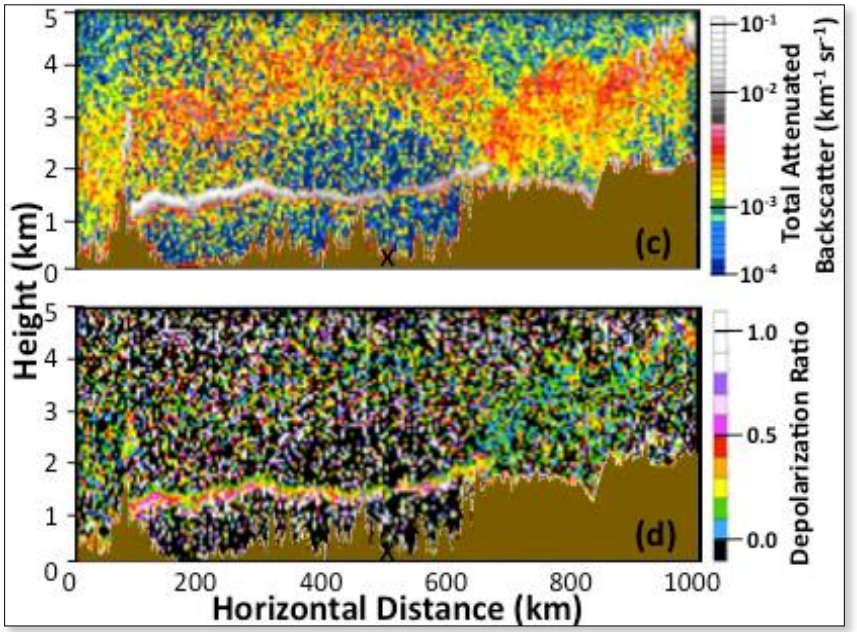



**Along-track CloudSat/CPR reflectivity**




**ACHIEVE W-band reflectivity time series**

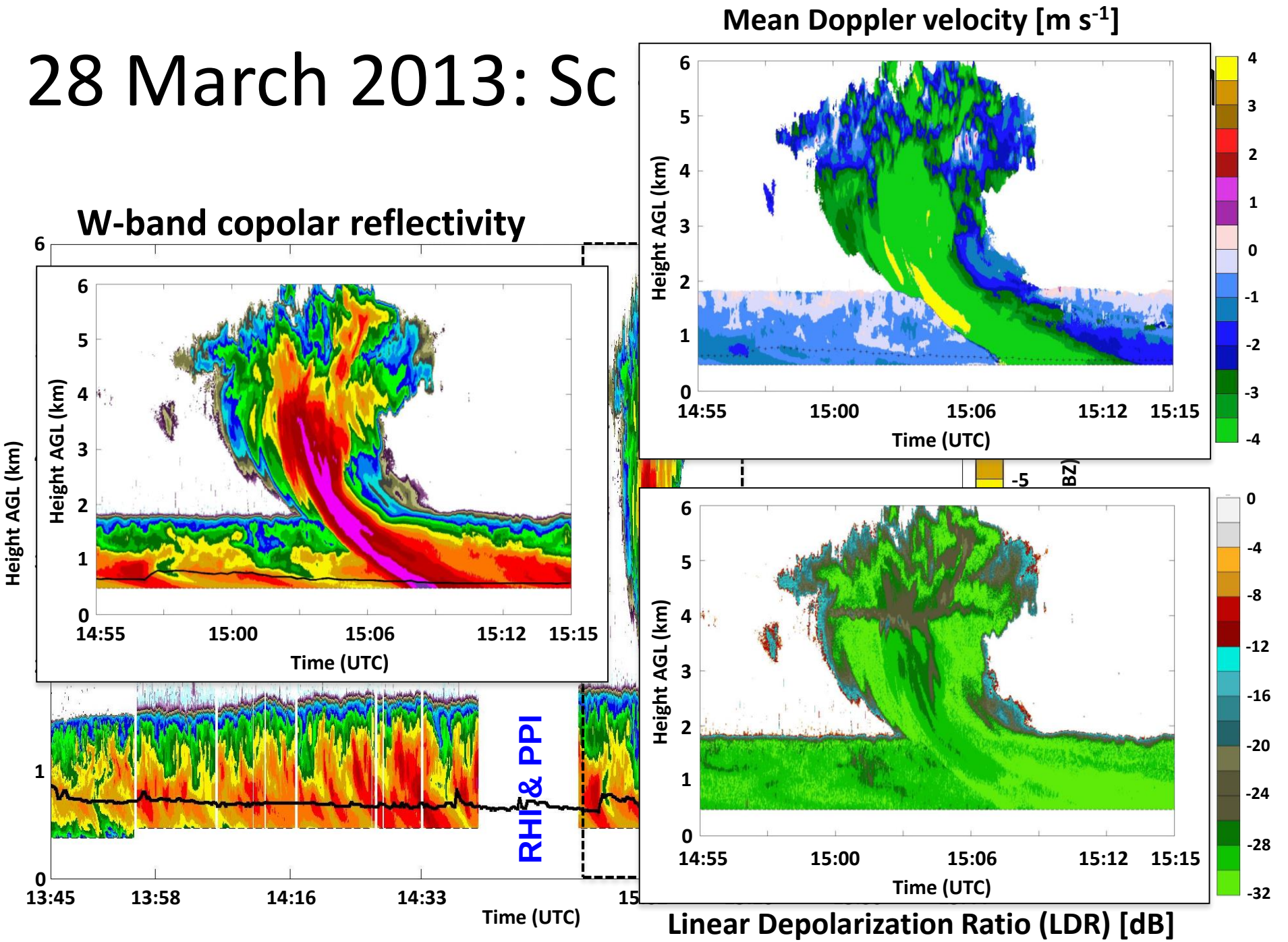
**Along-track CALIPSO/CALIOP profiles**




**Smoke and biomass-burning aerosols evident above low-level clouds**

***Surface clutter effects reduce CloudSat/CPR sensitivity below ~1km AGL [Christensen et al., 2013]**

# 28 March 2013: Sc



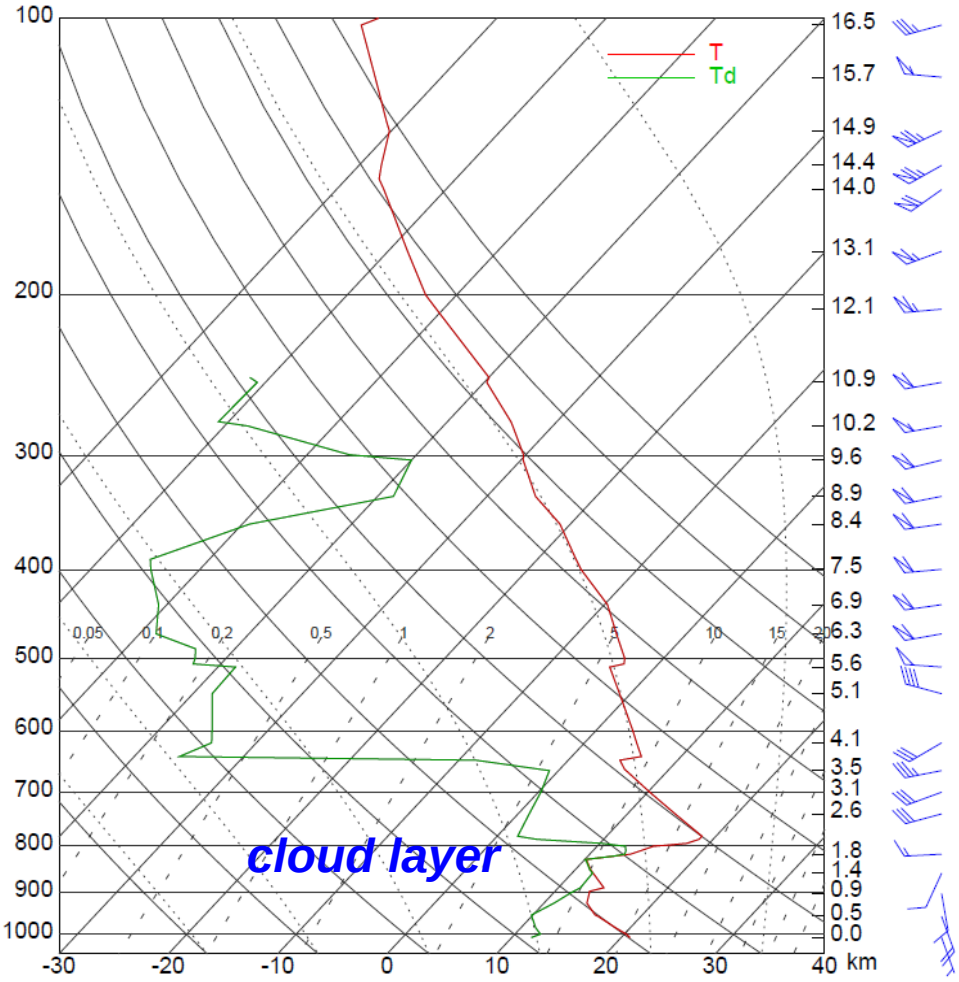
# Modeling aerosol-cloud interactions

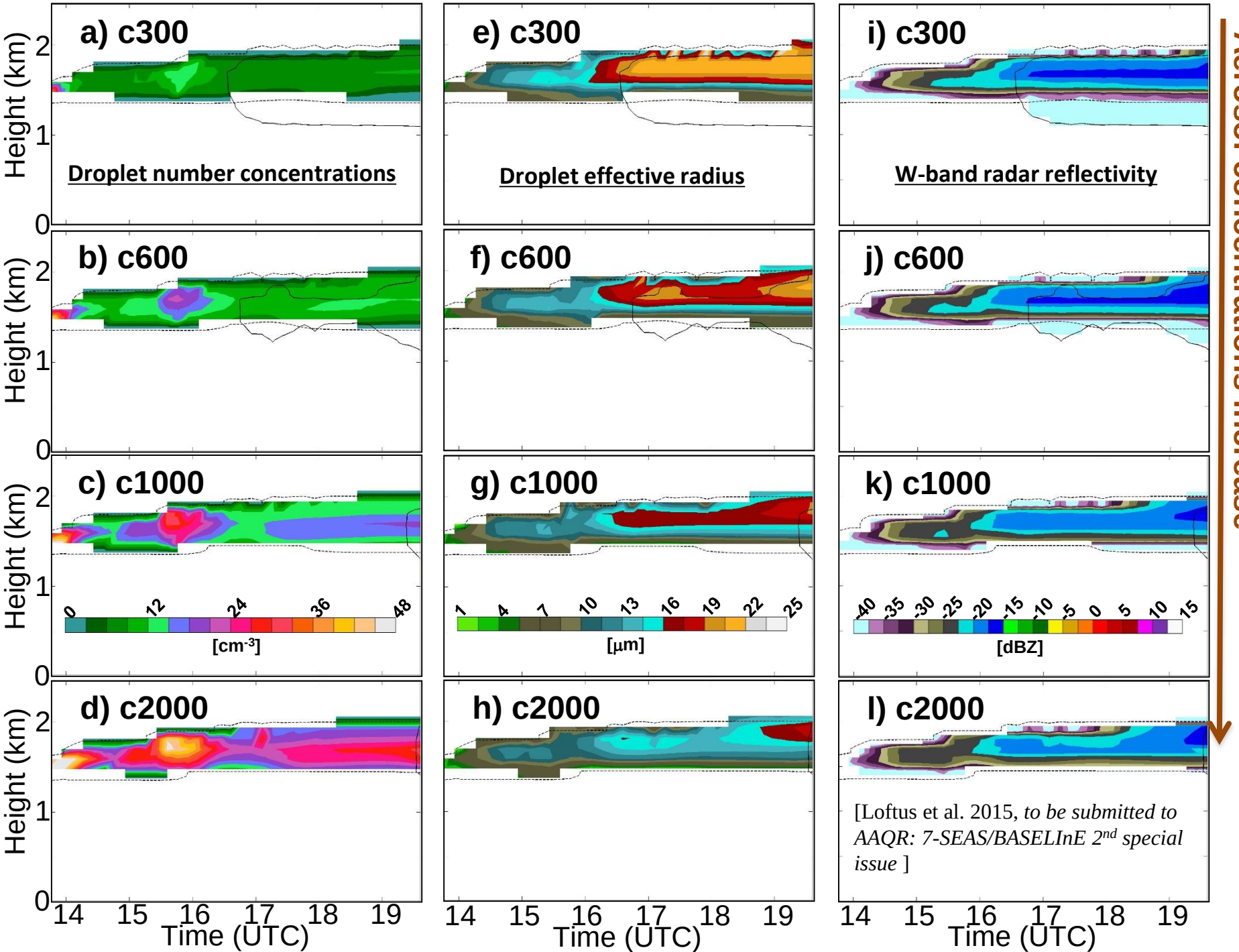
- Goddard Cumulus Ensemble (GCE) cloud-resolving model [Tao et al. 2009, 2014]
  - Numerous studies of aerosol impacts on convection [e.g., Tao et al. 2003; Li et al. 2009; Lee et al. 2009]
  - Triple-moment (3M) bulk microphysics [Loftus et al. 2014, *2015**] – computationally efficient
- Goddard Satellite Data Simulator Unit (G-SDSU) [Matsui et al. 2009, 2013; Masunaga 2010]
  - Forward model to simulate active and passive signals from model output (e.g., radiance, Tb, backscatter/reflectivity) .
  - Model evaluation

# Model setup: 7 April 2013 case

- LES-like setup
  - Domain: 14x14x13 km
  - Resolution: $\Delta x=\Delta y=200$ m, $\Delta$
  - 3M bulk microphysics
  - No aerosol sources/sinks
  - precipitation not expected b forcing
- Initialized with static aeroso 2000 $cm^{-3}$, maximum at surf
- COMMIT data from Son La, ' increase in biomass-burning

12 UTC skew-T sounding for Hanoi, Vietnam



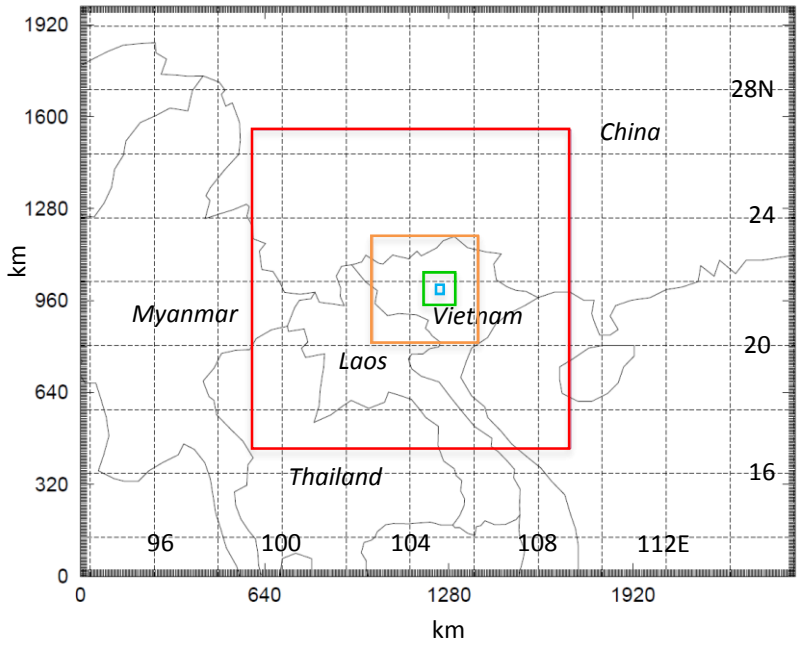

a) c300
e) c300
i) c300
Droplet number concentrations
Droplet effective radius
W-band radar reflectivity
b) c600
f) c600
j) c600
c) c1000
g) c1000
k) c1000
0 12 24 36 48
[cm-3]
1 4 7 10 13 16 19 22 25
[μm]
-40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15
[dBZ]
d) c2000
h) c2000
l) c2000
Height (km)
Time (UTC)
14 15 16 17 18 19
Aerosol concentrations increase
[Loftus et al. 2015, to be submitted to AAQR: 7-SEAS/BASELInE 2nd special issue ]

# Planning for the future

- Yen Bai region – confluence of BB aerosols and low-level Sc
  - ACHIEVE + COMMIT: co-located or COMMIT upstream for added in-situ aerosol information
  - SMART: network… (Si-Chee)
- Improved observations
  - More constraints (MWR: LWP), X-band for precipitation events
  - T, RH, p profiles for modeling
  - UAV for sampling in-cloud and near-cloud environment (entrainment of aerosols from above)

# Future model work

- Regional model (WRF): several week-long simulations – provide meteorological forcing, BB aerosol transport to GCE
- Include full aerosol prediction in GCE




WRF and GCE simulation domains

WRF Grid 1:
1200x1200x20 km
30 km horiz resolution (40x40 grid pts)

WRF Grid 2:
400x400x20 km
10 km horiz resolution (40x40 grid pts)

WRF Grid 3:
120x120x20 km, centered at Yen Bai, Vietnam
3 km horiz resolution (40x40 grid pts)

GCE grid: 30x30x14 km, centered at Yen Bai, Vietnam
200 m horiz resolution (150x150 grid pts)

# Thank-you.
# Cam on.


To be continued…