Pacific Northwest
NATIONAL LABORATORY
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# TCAP Breakout Session: Discussion

# Agenda



- Overview of TCAP analysis

| | | |
|---|---|---|
| Review of TCAP science goals | Berg | 15 min. |
| Aerosol optical properties measured using HSRL | Ferrare | 10 min. |
| Aerosol optical properties measured using min.4STAR—Conditions in the summer and winter | Redemann | 10 |
| Measurement of particle mixing state | Zelenyuk | 10 min. |
| Particle size distributions | Tomlinson | 10 min. |
| WRF-Chem results | Fast | 5 min. |

- Discussion of research status and future efforts
  - Status of data, known issues
  - Additional data products needed by the community
  - Ongoing/planned research using TCAP data
  - Status of papers (1 published, 1 nearing end of review process, 1 near submission)

# Known Data Issues



- Significant weather events
  - Remnants of Hurricane Sandy
    - No balloon launches from 10/29/12-11/1/12
    - RWP inverted
    - Other instrument issues
  - Nemo blizzard
    - No balloon launches from 2/8/2013-2/14/2013
    - No shore power from 2/7/2013-2/14/2013
- Skyrad calibration issues from 6/25/12-9/5/12
- Doppler lidar issues from 4/3/13-6/25/13
- Aircraft CO (Phase 1)
- MAOS f(RH) system and HTDMA (Phase 1)
- AOS f(RH) started on 10/1/12, flooded during Sandy missing Oct.-Dec.

# Data Products



- Which VAPs have been prepared?
  - Aerosol intensive properties (AIP)
  - AOD
  - Average CCN (AOSCCNAVG)
  - Cloud mask from MPL (MPLCMASK)
  - Data quality assessment of radiation data (QCRAD)
- What VAPs would useful or needed?
  - Aerosol best estimate (AEROSOLBE)
  - ARSCL
  - Boundary-layer height (PBLHT)
- Could TCAP be used to evaluate existing VAPs?
  - AEROSOLBE
  - PBLHT

# Ongoing and Future Work



- Teams have provided snapshots of plans

# Optical Closure Studies (PNNL)



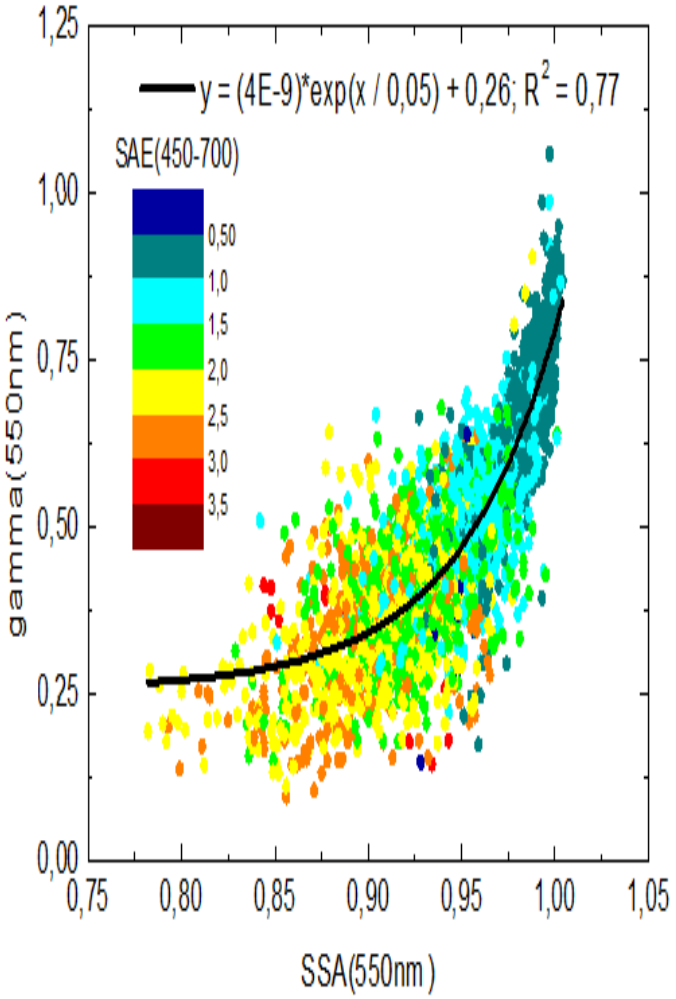
**Based on measurements of aerosol size distribution and chemical composition can we reproduce the observed aerosol optical properties?**

- Two sets of studies, one focused on AOS/MOAS observations and and based on data from the G-1
- Use Mie code to go from observed particle size distribution, chemical composition, and mixing state to predict aerosol optical properties
- Drive WRF-Chem and CAM aerosol and radiation packages with observed particle size distributions and chemical composition to predict the aerosol optical properties

Contacts: L. Berg, D. Chand, E. Kassianov

# Can we predict aerosol hygroscopicity from dry optical properties?

- Measurements from the AMF deployment at Cape Cod.
- $f(RH) = a(1 - RH)^{\gamma}$
- Gamma parameterizes the magnitude of the scattering enhancement.
- SSA -> single scattering albedo
- SAE -> scattering Ångström exponent



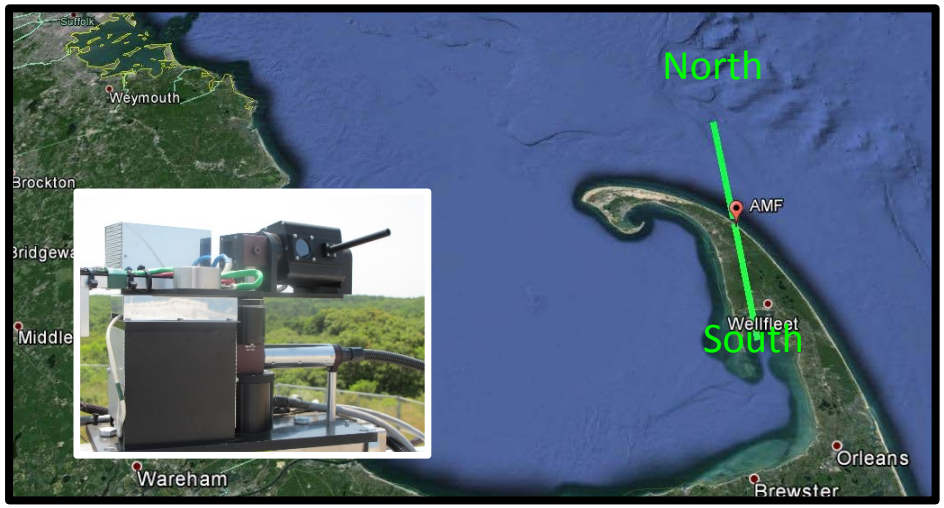

- Larger particles (SAE<1) are more hygroscopic (bluish colors).
- Darker particles (SSA<0.95) are less hygroscopic.
- Exponential fit using only the SSA:

$$\gamma = (4 \cdot 10^{-9}) * \exp(SSA/0.5) + 0.26 \quad (R^2 = 0.77)$$

# Future TCAP-4STAR work

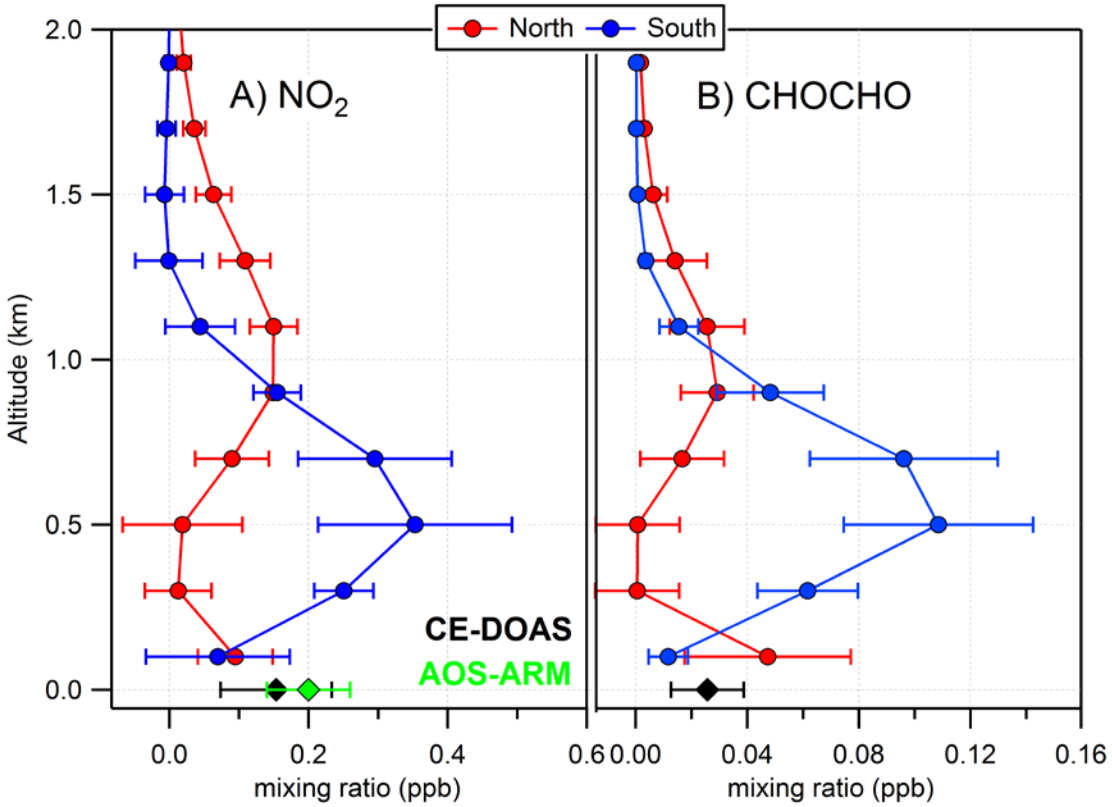
- **Refine direct beam measurements -**
  - Provide refined measurements of 4STAR AOD and trace gas column concentrations for comparisons with climate model output and independent observations (TCAP RP 6 and 7);
  - Derive AOD-CCN relationships and study the information content in UV AOD (ASR Process Research focus 2.2.2 Microphysics and 2.3.1 Cloud Particle Formation, and TCAP RP 1);
  - Support the TCAP objective (RP 4) of passive AOD retrievals in the presence of clouds by scrutinizing the 4STAR near-cloud measurements and cloud screening of 4STAR AOD data.
- **Invert sky radiance measurements –**
  - Develop 4STAR algorithms for the retrieval of aerosol absorption, scattering phase function, asymmetry parameter, and size distribution;
  - Test the sensitivity of retrieved aerosol properties to aerosol loading and conditions ($\Theta$, $A_{S+atm}$);
  - Carry out radiative closure studies (TCAP RP 2) by comparing the measured sky radiances with radiances calculated using in situ aerosol properties and HSRL-2 retrievals.
  - Calculate aerosol induced changes in heating rate profiles from 4STAR retrieved aerosol properties (ASR Process Res. focus 2.1.3 Aerosol Direct Rad. Forcing and 2.2.3 Radiation).
- **Analyze zenith mode measurements –**
  - Develop 4STAR algorithmic capabilities to retrieve cloud optical depth and droplet effective radii from zenith mode operations;
  - Compare 4STAR cloud retrievals to independent observations (e.g., polarimeter retrievals, in situ measurements, satellites) in support of the TCAP aerosol-cloud interaction focus (RP 5).

# Anthropogenic triggers for SOA formation during TCAP – 2D-MAX-DOAS




Rainer Volkamer, CU Boulder

The average effective path length of 15km, green line, represents the footprint of the spatial scale where the MAX-DOAS is sensitive.

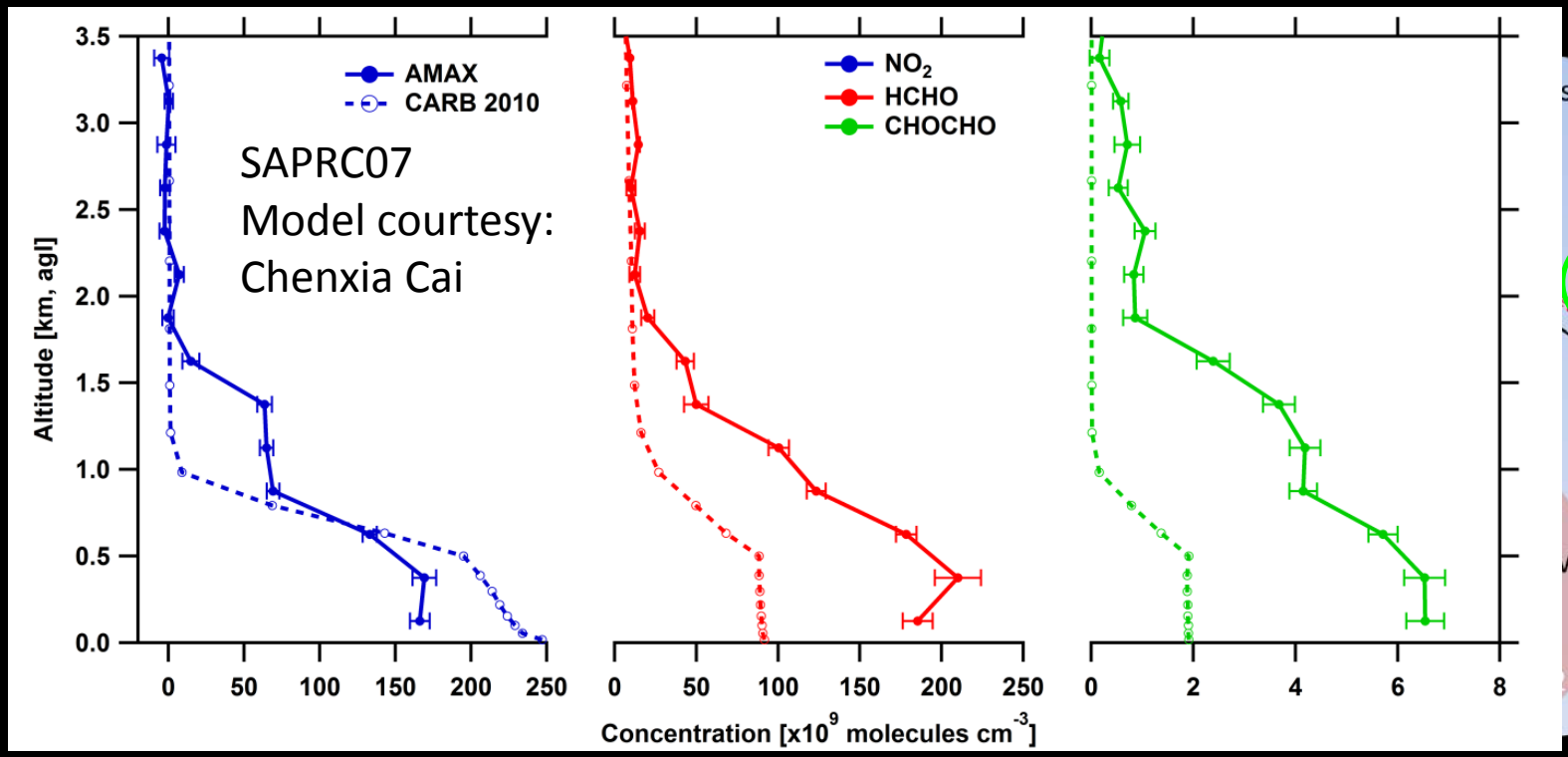


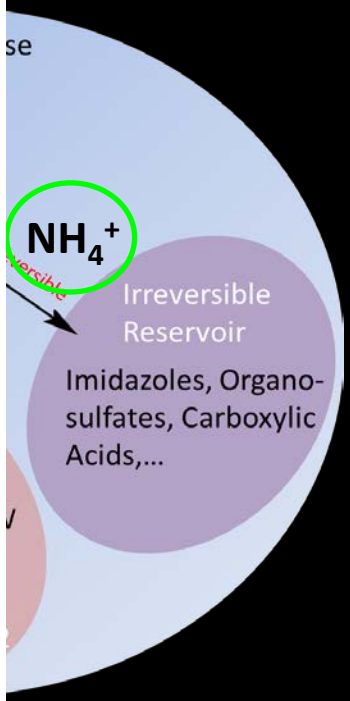

Example of $NO_2$ (A) and CHOCHO (B) vertical profiles on July 25 2012 at SZA of 32.8 deg. For comparison, at the bottom of each graph the surface mixing ratio retrieved with both in-situ sensors: the CU-CE-DOAS and NOx-AOS-ARM analyzer are plotted.

CIRES Cooperative Institute for Research in Environmental Sciences

University of Colorado Boulder

# „Salting-in“ triggered by particulate $SO_4^{2-}$




**TCAP: US wide hotspot for glyoxal multiphase chemistry (lower limit?)**

**CARES: SOA potential is inhibited by high viscosity**

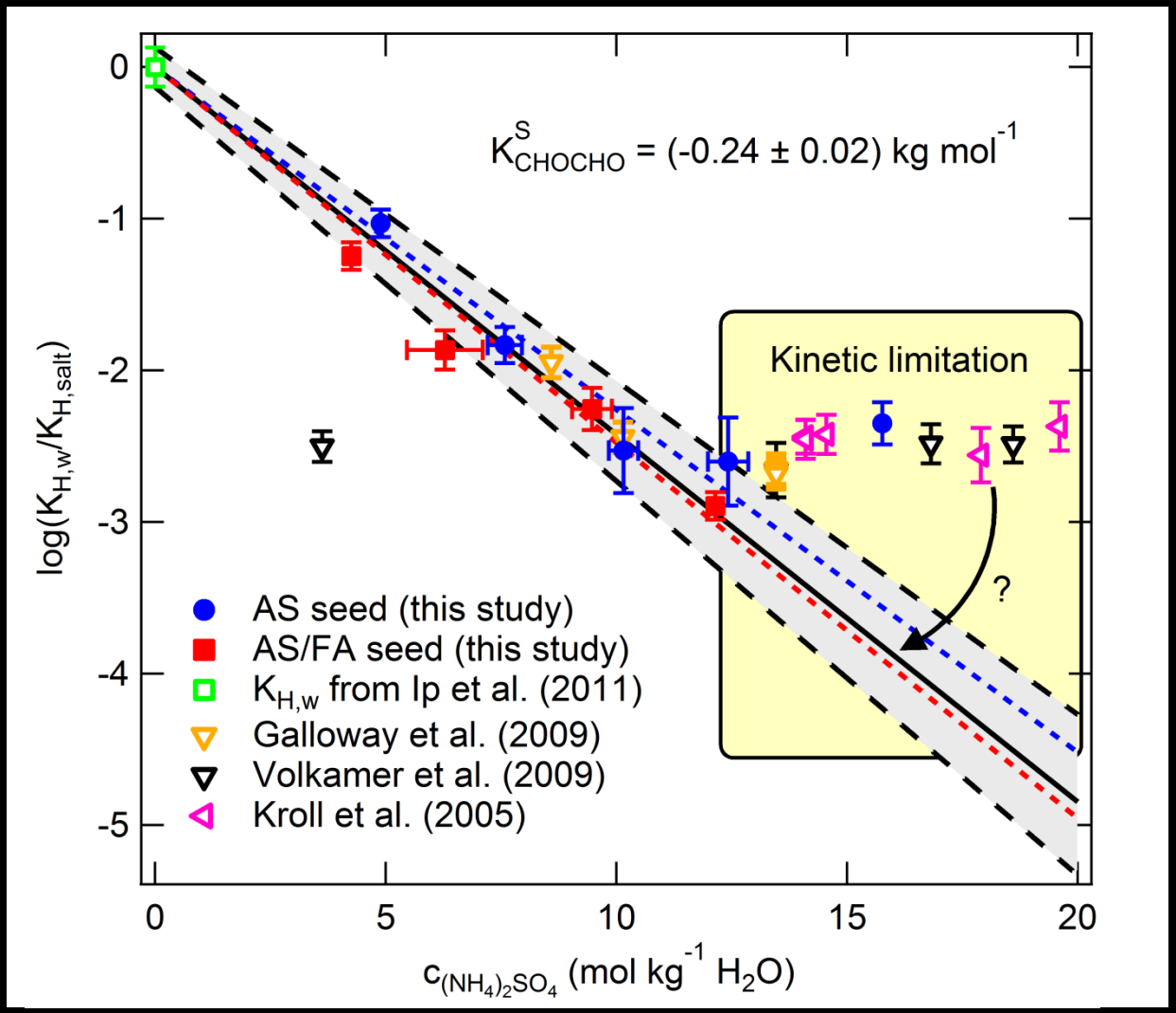
**Fundamental relevance of H for reactive uptake:**

$$\frac{1}{\gamma} = \frac{1}{\gamma_{diff}} + \frac{1}{\alpha} + \frac{1}{\gamma_{sat} + \gamma_{rxn}} \approx \frac{1}{\alpha} + \frac{\langle c \rangle}{4HRT\sqrt{kD_a}}$$

Kampf et al., 2013, ES&T
Waxman et al., 2013, GRL

# „Salting-in“ triggered by particulate $SO_4^{2-}$

Setschenow (1889):




Independent from organic seed constituents and radiative conditions

Deviation from expected behavior above $c_{AS}$ = 12 M

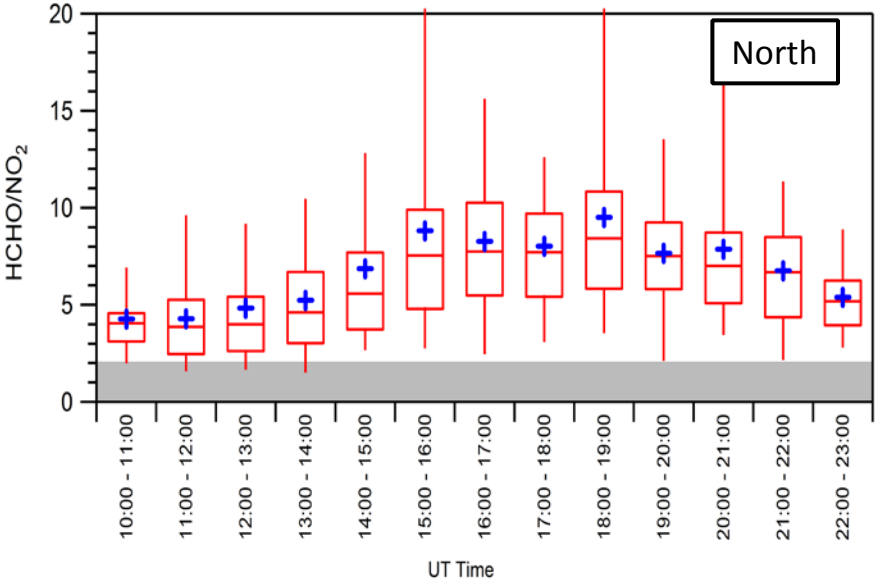
**-> Phase separation?**

**-> Viscosity?**

Kampf et al., 2013, ES&T

# Diurnal Profiles of trace gas ratios

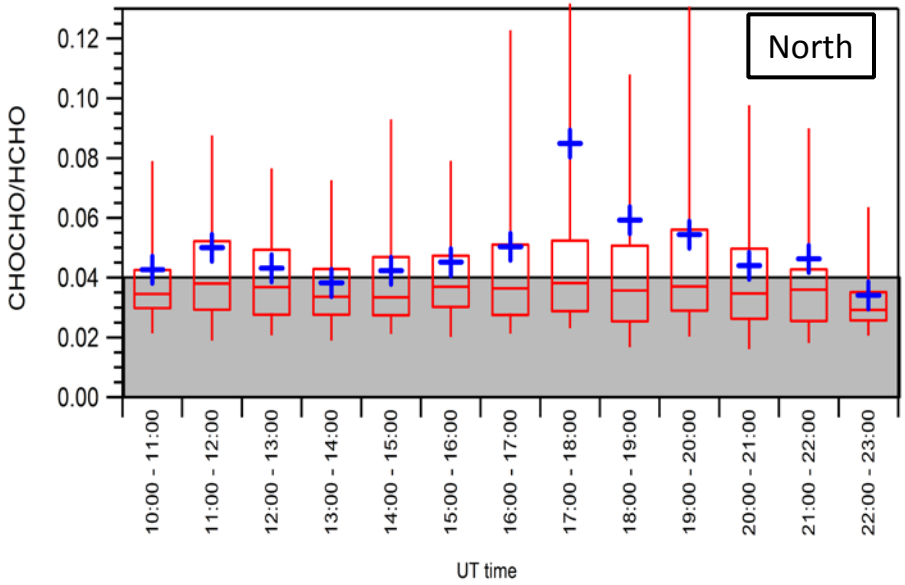
HCHO/$NO_2$ as an indicator of VOC oxidation chemistry




**VOC limited regime < 1**
**NOx limited regime: >2**
**Transition regime: 1-2**
**(Duncan et al., 2010)**

**O3 production in TCAP is limited by NOx**

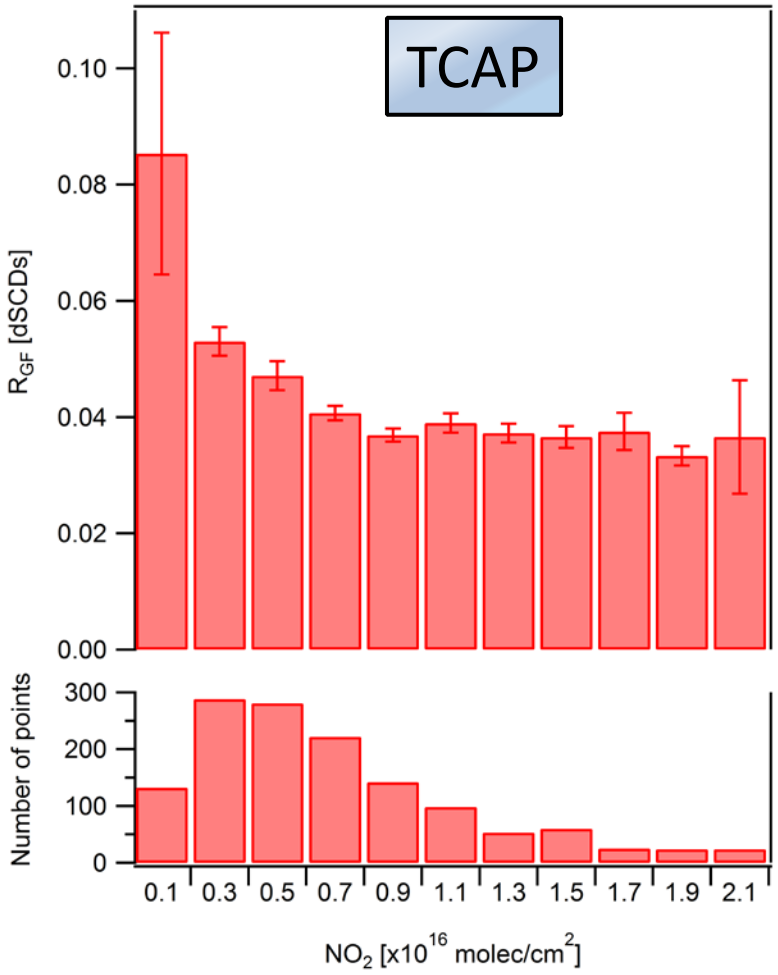
CHOCHO/HCHO ($R_{GF}$) as an indicator of biogenic and/or anthropogenic VOC emissions

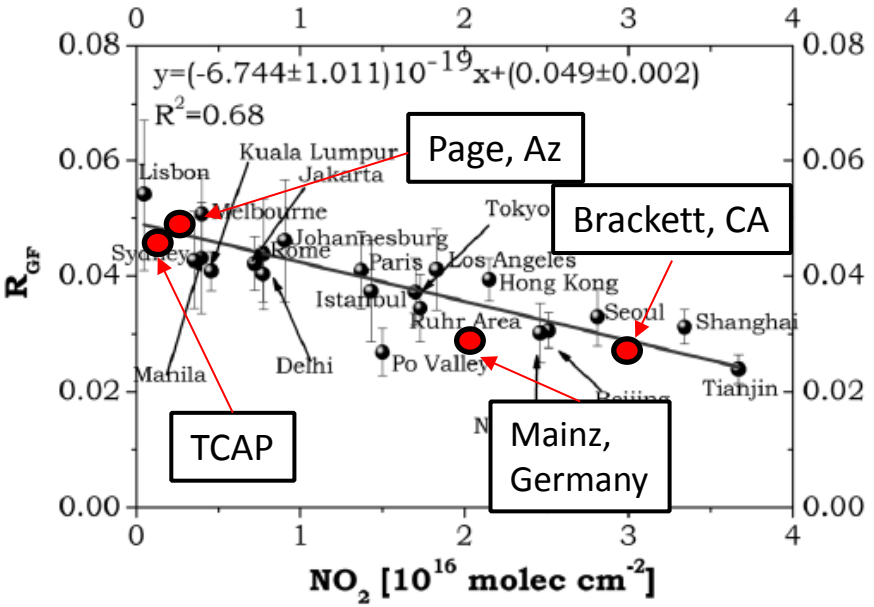



**Biogenic: 0.04-0.06**
**Anthropogenic: <0.04**
**(Vrekoussis et al., 2010)**

**Likely biogenic influenced is dominant**

# TCAP in contrast with other sites



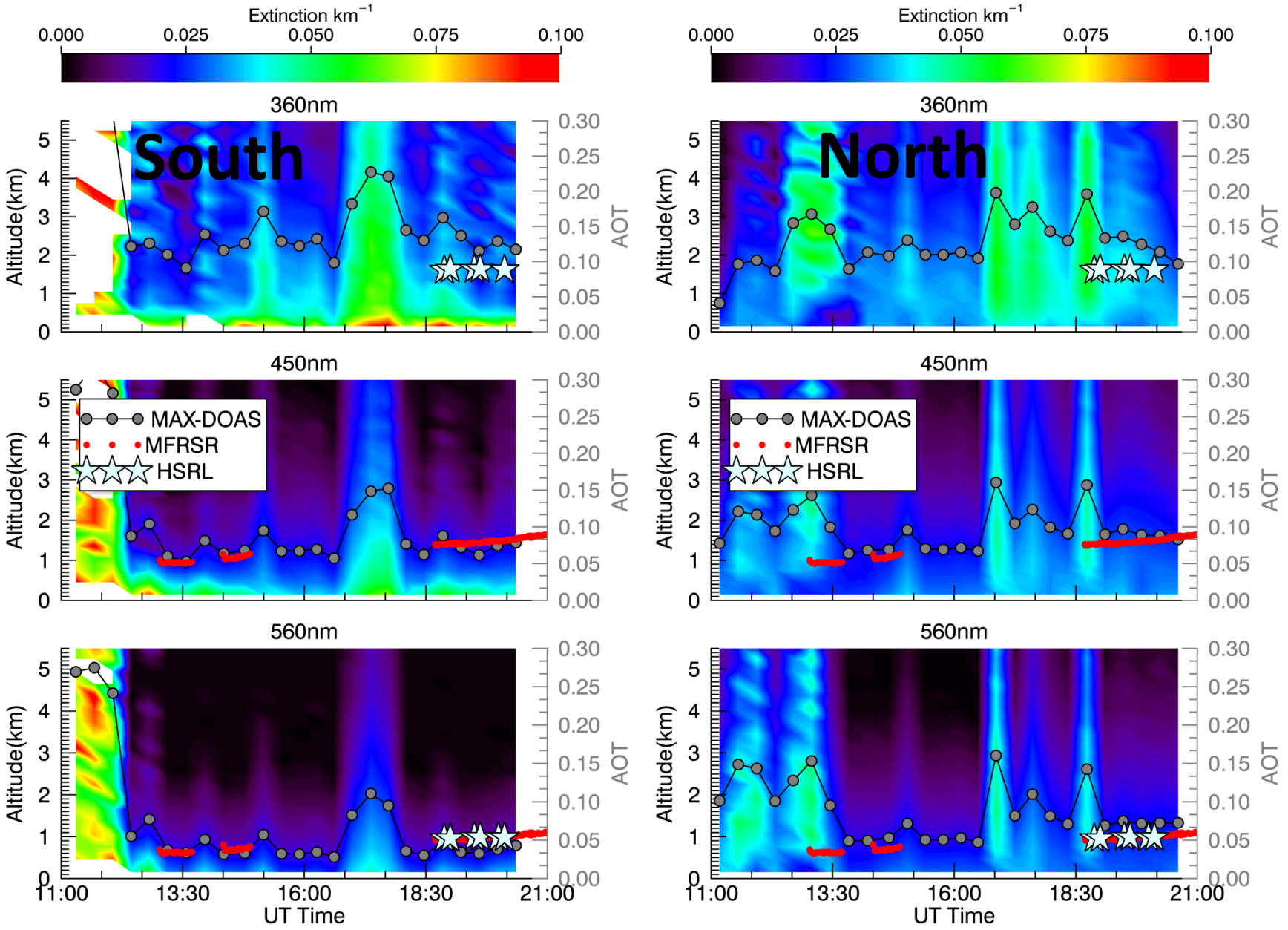




## AMAX-DOAS in SCAB

| Site | $R_{GF}$ |
|---|---|
| Page, AZ (desert) | 0.050 ± 0.008 |
| Bakersfield, CA | 0.029 ± 0.003 |
| Santa Monica, CA | 0.048 ± 0.004 |
| Brackett, CA | 0.027 ± 0.003 |
| Ontario, CA | 0.039 ± 0.001 |
| Banning, CA | 0.044 ± 0.003 |

# 2D-MAX-DOAS extinction profiles for a broken cloud day (07/21/2012)

Note: For cloudy episodes the MFRSR does not report data



# On to Clouds….

# Retrieving Liquid Water Contents of Boundary-layer Clouds at TCAP Using Dual-frequency Cloud Radars

Courtney Laughlin, Dong Huang, Eugene Clothiaux

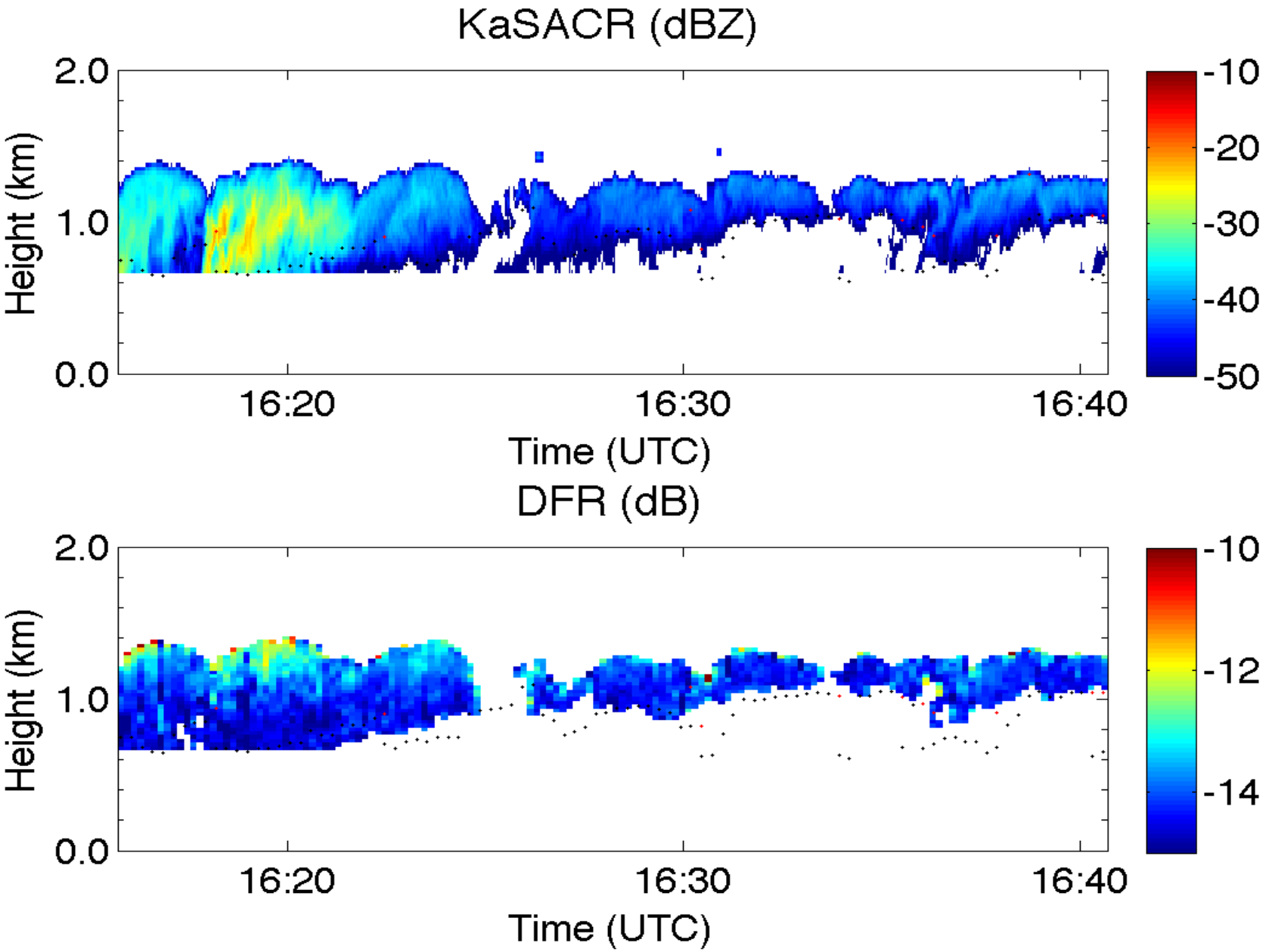
*The Pennsylvania State University*

ARM CLIMATE RESEARCH FACILITY

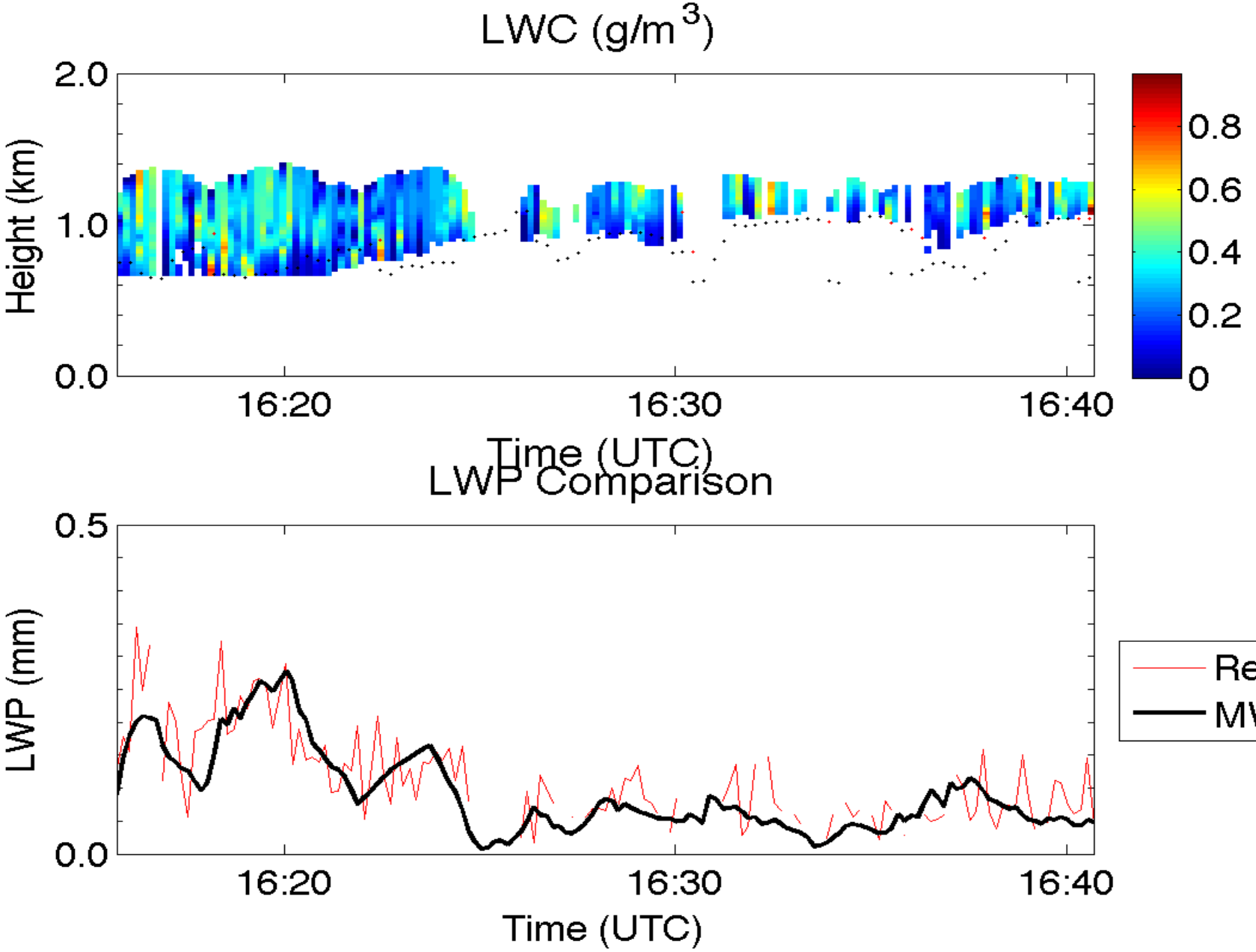
THE PENNSYLVANIA STATE UNIVERSITY · 1855 ·

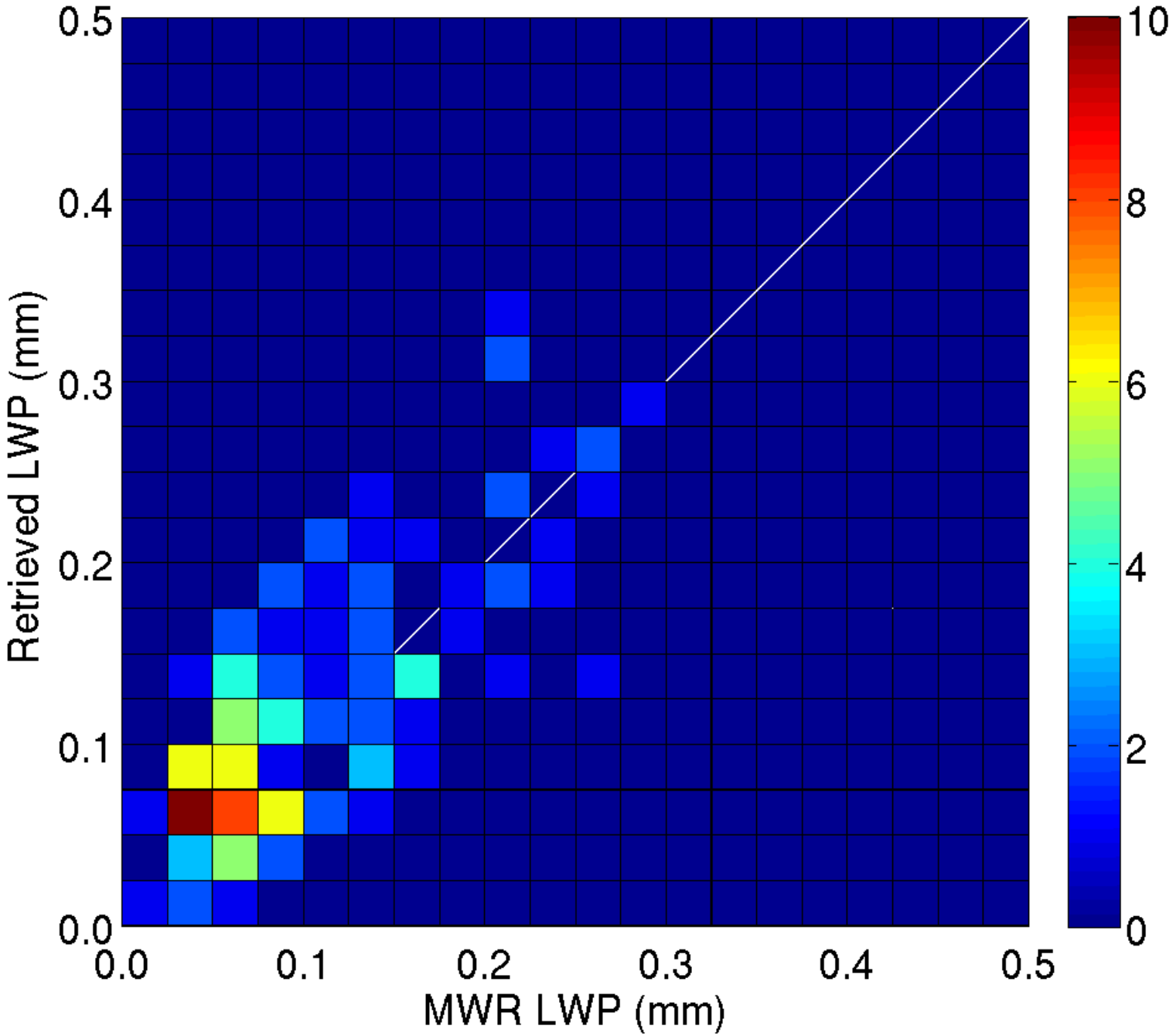
ASR Atmospheric System Research

# TCAP Case: 20121114 16:16-16:41 UTC

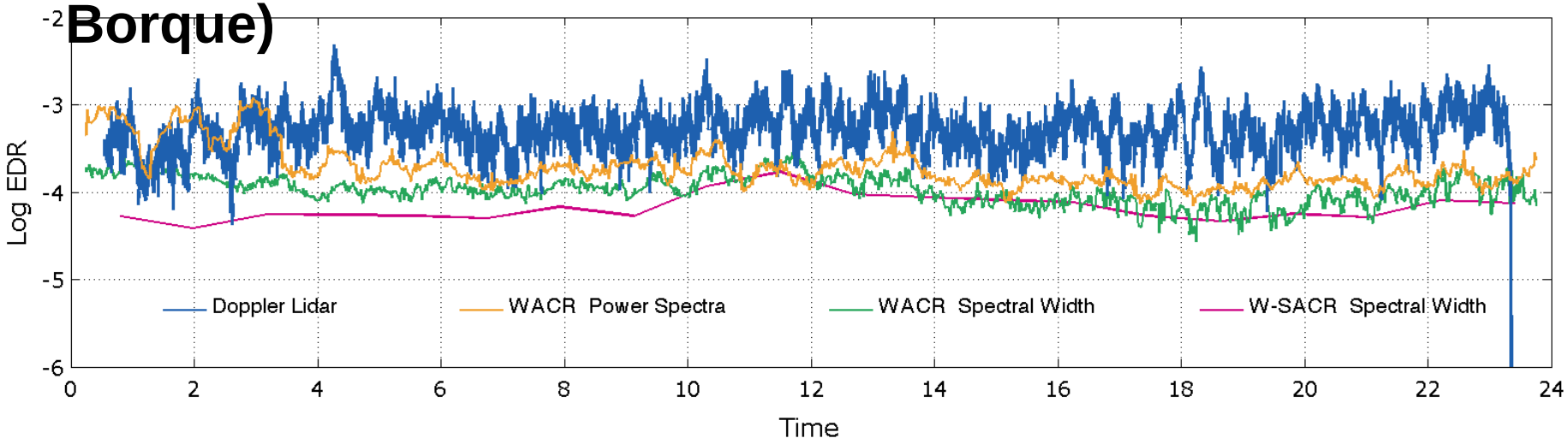


# TCAP Case: 20121114 16:16-16:41 UTC




TCAP 20121114 Time (UTC): 16:16-16:41
Retrieved LWP (mm)
MWR LWP (mm)
0.0
0.1
0.2
0.3
0.4
0.5
0
2
4
6
8
10

# Estimation of Eddy Dissipation Rate Retrieval Techniques in Clouds Using Doppler Measurements (Lead: Paloma Borque)




## Why?

Affect the collisional rate of cloud droplets

Determine the turbulent mixing time scales

Allow deconvolution of microphysical and dynamical effects in radar Doppler spectra

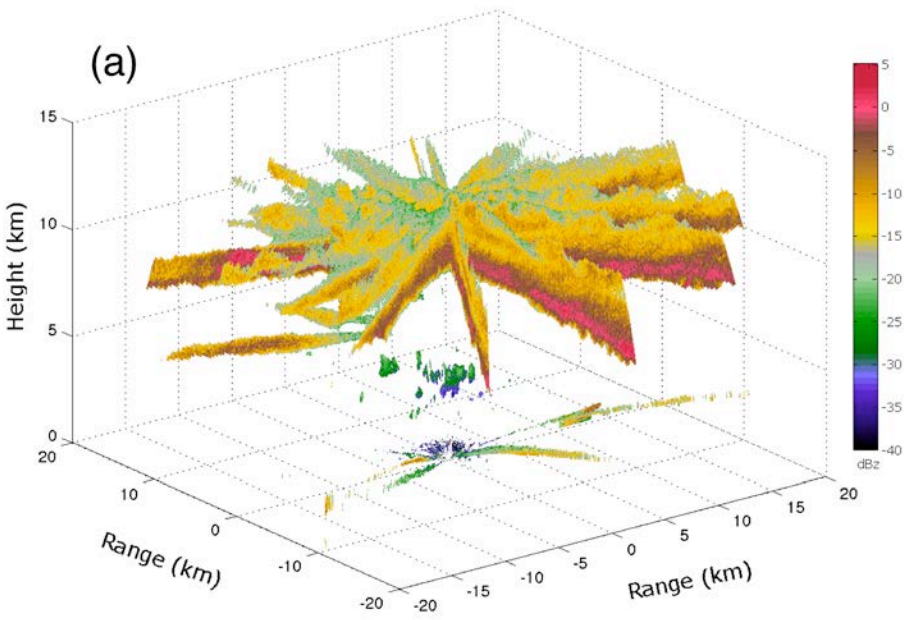
## How

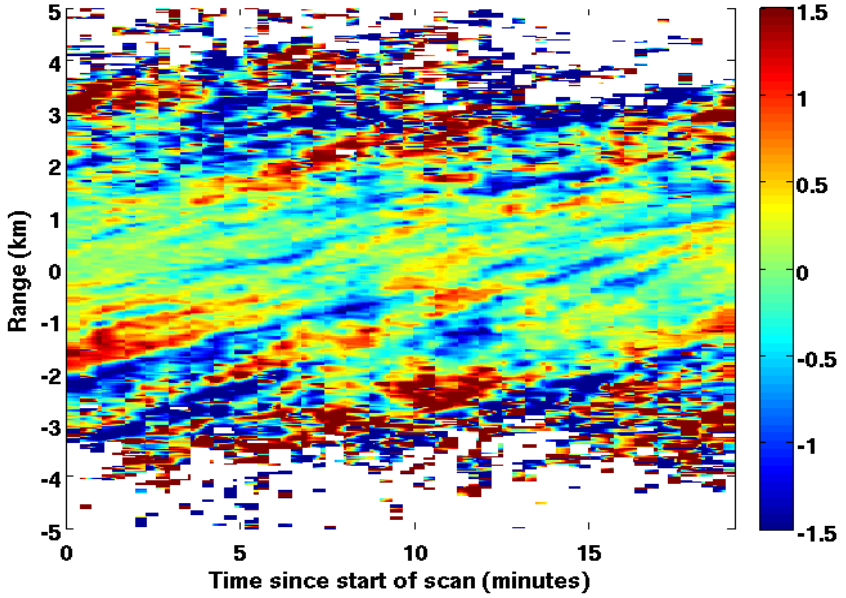
Time-series of Doppler velocity measurements from Cloud Radars/Lidars

Single radar Doppler spectrum width measurements in precipitation-free regions

Dual radar Doppler spectrum width measurements in any cloud condition

# Study of 3D cloud anisotropy and 3D cloud dynamics (Lead: Katia Lamer)




Use the HS-RHI scan strategy to study cloud anisotropy (structure function)

Use 3D vertical velocity best estimate to study updraft and downdraft organization in stratus clouds