TCAP Breakout Session: Discussion
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 4STAR—Conditions in the summer and winter
  - Redemann 10 min.
- 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 be useful or needed?
  - Aerosol best estimate (AEROSOLBE)
  - ARSCL
  - Boundary-layer height (PBLHT)

- Could TCAP be used to evaluate existing VAPs?
  - AEROSOLBE
  - PBLHT
Teams have provided snapshots of plans
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 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
\[ y = \left(4 \cdot 10^{-9}\right) \exp(\text{SSA} / 0.5) + 0.26 \] 

\[ R^2 = 0.77 \]

Exponential fit using only the SSA:

- Darker particles (SSA > 0.95) are less hygroscopic.
- Larger particles (SSA > 0.7) are more hygroscopic (puissach colors).

\[ y = \left(4 \cdot 10^{-9}\right) \exp(x / 0.05) + 0.26 ; R^2 = 0.77 \]

\[ R^2 = 0.77 \]

Spectral Angstrom: SAE -> scattering Angstrom

SSA -> single scattering albedo

Enhancement, magnitude of the scattering parameterizes the deployment at Cape Cod:

\[ f(RH) = e^{a(T - RH)} \]

Measurements from the AMF
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).
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.
„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:

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

Kampf et al., 2013, ES&T
Waxman et al., 2013, GRL
„Salting-in“ triggered by particulate $\text{SO}_4^{2-}$

Setschenow (1889):

$K_{\text{CHOCHO}} = (-0.24 \pm 0.02) \text{ kg mol}^{-1}$

Independent from organic seed constituents and radiative conditions

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

$\rightarrow$ Phase separation?
$\rightarrow$ Viscosity?

Kampf et al., 2013, ES&T
HCHO/NO$_2$ as an indicator of VOC oxidation chemistry

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

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

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

O$_3$ production in TCAP is limited by NOx

Likely biogenic influenced is dominant
TCAP in contrast with other sites

**Table:**

<table>
<thead>
<tr>
<th>Site</th>
<th>$R_{GF}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Page, AZ (desert)</td>
<td>$0.050 \pm 0.008$</td>
</tr>
<tr>
<td>Bakersfield, CA</td>
<td>$0.029 \pm 0.003$</td>
</tr>
<tr>
<td>Santa Monica, CA</td>
<td>$0.048 \pm 0.004$</td>
</tr>
<tr>
<td>Brackett, CA</td>
<td>$0.027 \pm 0.003$</td>
</tr>
<tr>
<td>Ontario, CA</td>
<td>$0.039 \pm 0.001$</td>
</tr>
<tr>
<td>Banning, CA</td>
<td>$0.044 \pm 0.003$</td>
</tr>
</tbody>
</table>
Note: For cloudy episodes the MFRSR does not report data.

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