Better living through chemistry:
Contributions of the CSU atmospheric chemistry program

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What do we mean by “chemistry”
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We are interested in how constituents of the atmosphere affect clouds, climate, air quality and natural ecosystems.

impacts on clouds (CCN, IN)
cloud impacts on chemistry

impacts on ecosystems
(acid rain, nitrogen deposition)

impacts on radiation

impacts on visibility, human health
The basic approach to improve understanding

Images courtesy Jacob group, Harvard University; European Space Agency; A. J. Prenni (CSU)
Our group has mostly focused on measurements
National Parks
Nitrogen deposition to national parks

Deposited nitrogen perturbs loadings and promotes changes in natural ecosystems, particularly in nitrogen sensitive environments.

CSU has supported this effort through targeted field studies in heavily impacted parks.

- RoMANS (Rocky Mountain NP) 2005, 2007
- Grand TReNDS (Grand Teton NP), 2011
National Parks: Visibility studies

Regional Haze Rule:
*Mandates the return of visibility in protected areas to natural conditions by 2064.*

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- SEAVS (Great Smoky Mt NP), 1995
- BRAVO (Big Bend NP), 1999
- YACS (Yosemite NP), 2002

*Bench and Herckes, ES&T, 2004  
McMeeking et al., AFM, 2006*
Fire emissions
Laboratory measurements of fire emissions

Over 25 papers published since 2006 from the FLAME studies.

Photo credit: Dan Welsh-Bon (NOAA)
Field measurements of fire emissions

**Ground studies**

NOAA project examining ice nuclei emitted by prescribed fires

Colorado, southern Georgia

**Aircraft studies**

South Carolina fiRe Emissions and Ageing Measurements (SCREAM)
South Carolina

San Luis Obispo Biomass Burning Experiment (SLOBBE)
Central California
Measuring emissions of strongly absorbing species

Black carbon (BC) is a strongly light-absorbing aerosol species that has a large impact on radiative forcing.

Approximate range of BC/CO ratios measured in or directly downwind of urban environments.

Modified combustion efficiency = \frac{\text{excess } CO_2}{\text{excess } CO + \text{excess } CO_2}
Sometimes we don’t need to leave the lab...

High Park Fire west of Fort Collins
Summer, 2012

Associated Press
Cold clouds: Ice nuclei measurements

IN parameterization based on temperature and concentrations of D>500 nm particles

Continuous flow diffusion chamber

Rogers et al., JAOT, 2001

BIOGENIC

SMOKE

MARINE/DUST

DeMott et al., PNAS, 2010
National parks
• Identify major species present in different locations to assist efforts to reach visibility goals
• Identify major species contributing to N deposition to national parks

Fire emissions
• Help quantify emissions from fires as function of fuel and combustion conditions
• Characterize the CCN and IN activity of fire emissions
• Improve/evaluate measurements of common smoke tracers

Clouds
• Improve our fundamental understanding of the chemical and physical properties of particles that govern their impacts on clouds
• Examine the composition of cloud and fog water to understand how aqueous chemistry affects air quality and atmospheric deposition
Thanks to

NPS, JFSP, NSF, NASA, DOE, DOD, CARB

...and...

Sonia Kreidenweis, Paul DeMott, Jeff Collett and everyone at ATS chemistry
Warm clouds: Cloud condensation nuclei

What factors control the CCN activity of aerosol particles and how can we best represent that activity?

Levin et al, JGR, 2012

Petters and Kreidenweis, ACP, 2007

Annual cycle of $\kappa$ at a remote, forested site.
Chemical stability of wood smoke tracers

Levoglucosan is a product of cellulose combustion and commonly used smoke tracer

**Lab:** Stability as function of simulated aging

*Hennigan, Sullivan, Collett and Robinson, GRL, 2010*

**Field:** Airborne measurements in smoke plumes (South Carolina study)

*Photo credit: Dan Welsh-Bon (NOAA)*

*Photo credit: Amy Sullivan (CSU)*
Chemistry in clouds and fog

Cloud water composition over eastern Pacific

Sulfate production in clouds

CSU/NCAR cloud water collector