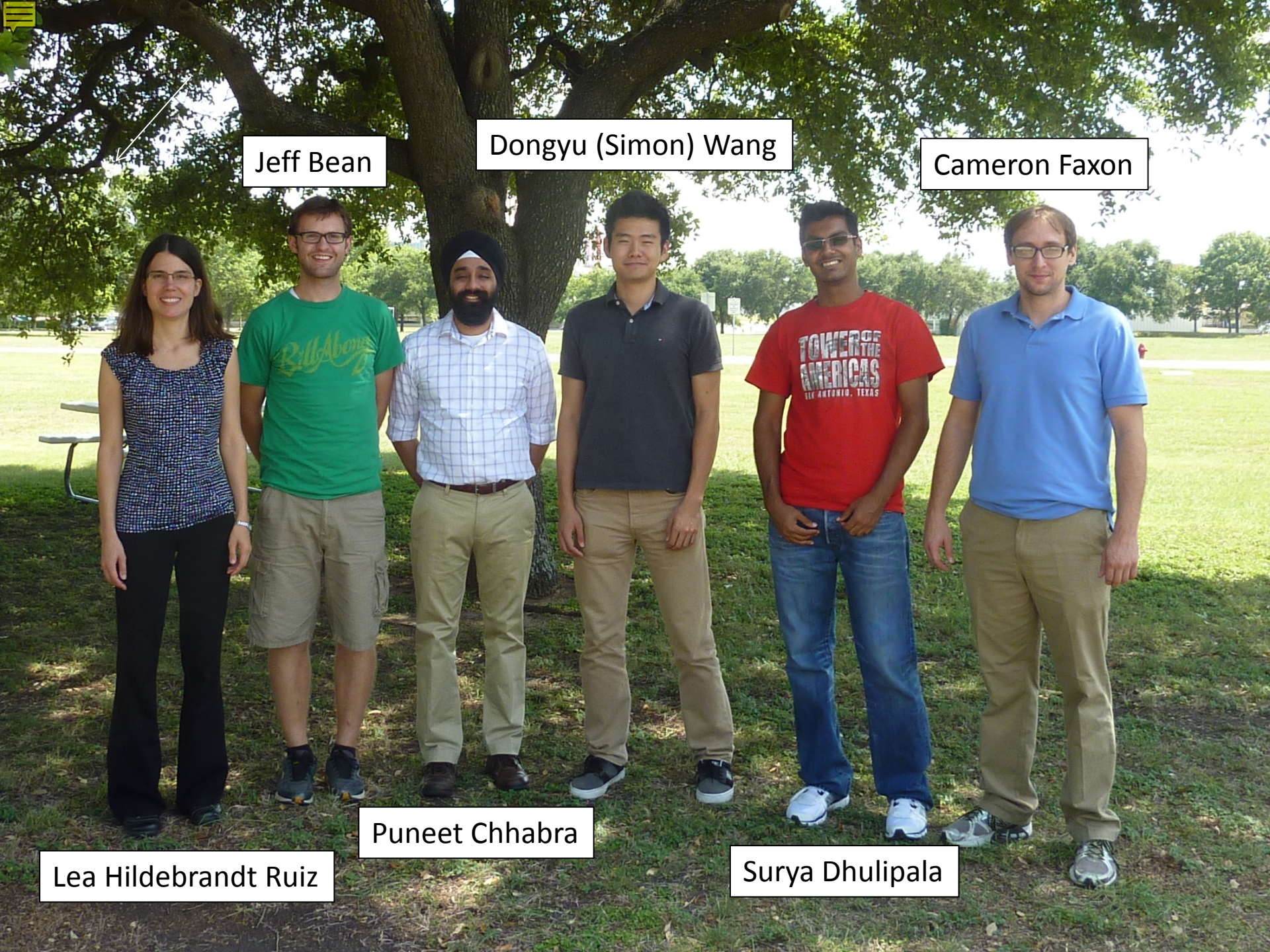
Atmospheric Physicochemical Processes

Lea Hildebrandt Ruiz
Assistant Professor
Department of Chemical Engineering
Center for Energy and Environmental Resources

March 6, 2015

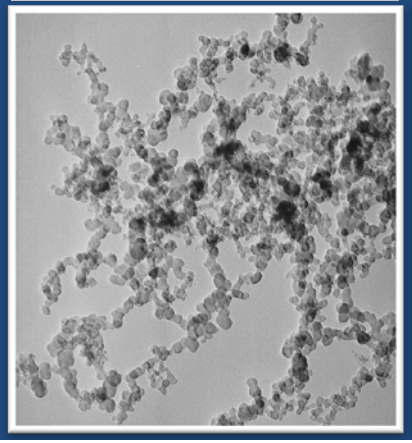
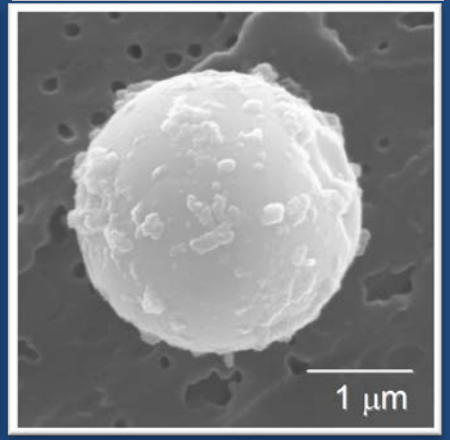
Contact: lhr@che.utexas.edu
https://faculty.engr.utexas.edu/hr-group

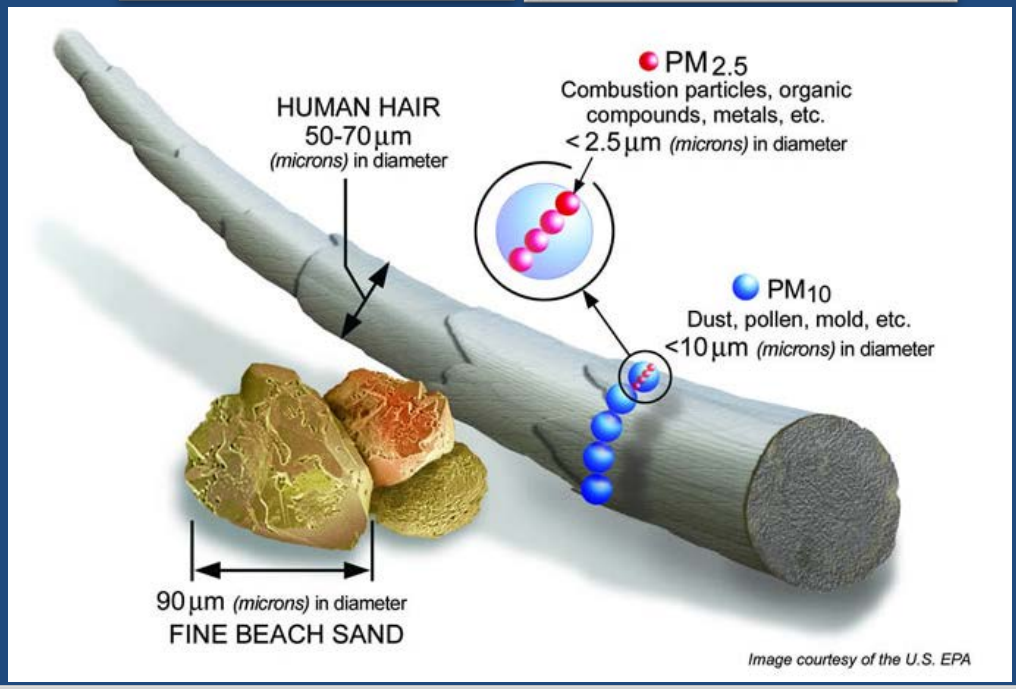

Jeff Bean
Dongyu (Simon) Wang
Cameron Faxon
Lea Hildebrandt Ruiz
Puneet Chhabra
Surya Dhulipala

Atmospheric Particles ("Aerosols")

Small Suspended Particles

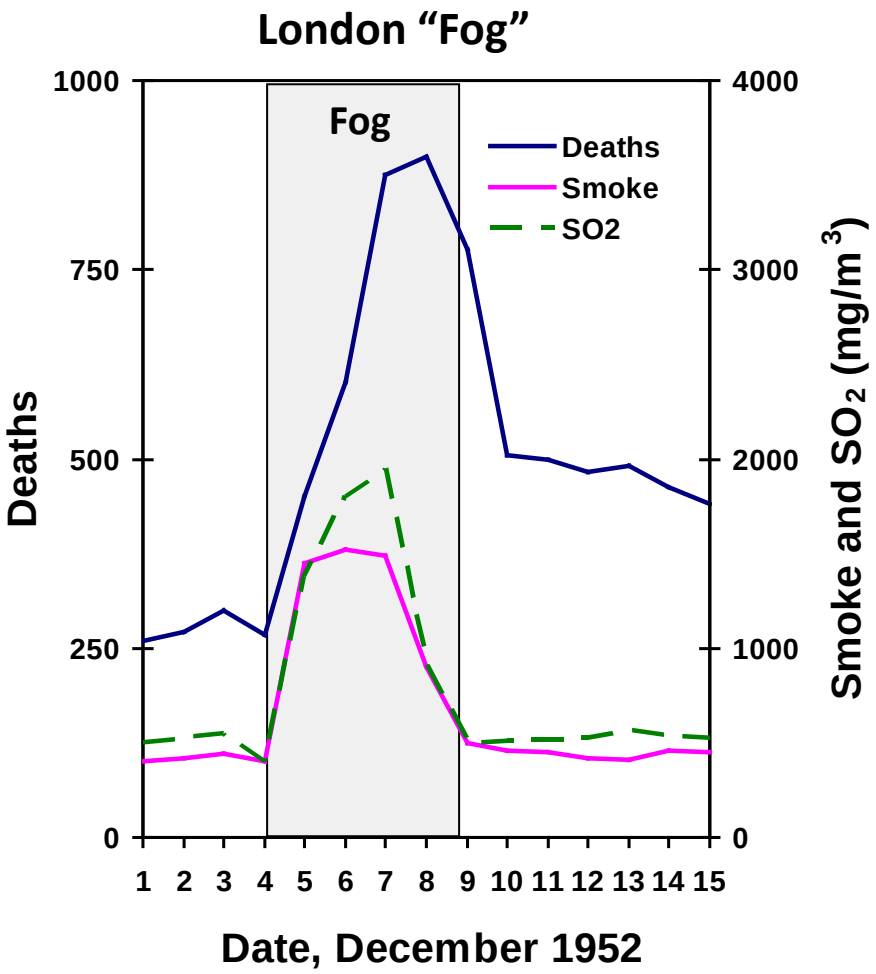
- 10^4-10^5 particles cm^{-3}
- 1000s compounds
- few nm to 10s µm
- complex shapes
- multiphase
- many sources

Diesel Soot	Coal Combustion
	



Adverse Health Effects of Particles

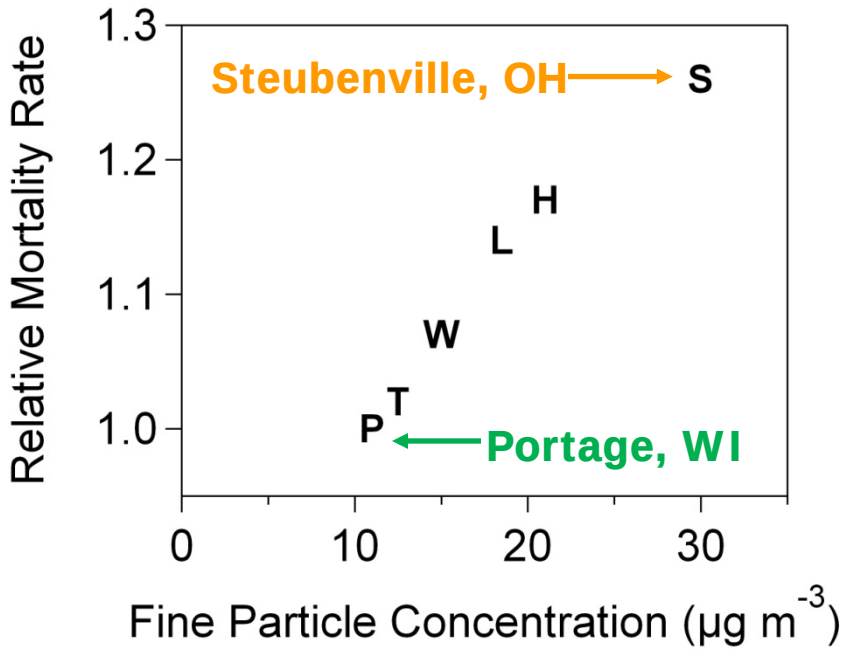
Severe Pollution Episodes



Source: Beaver, 1954

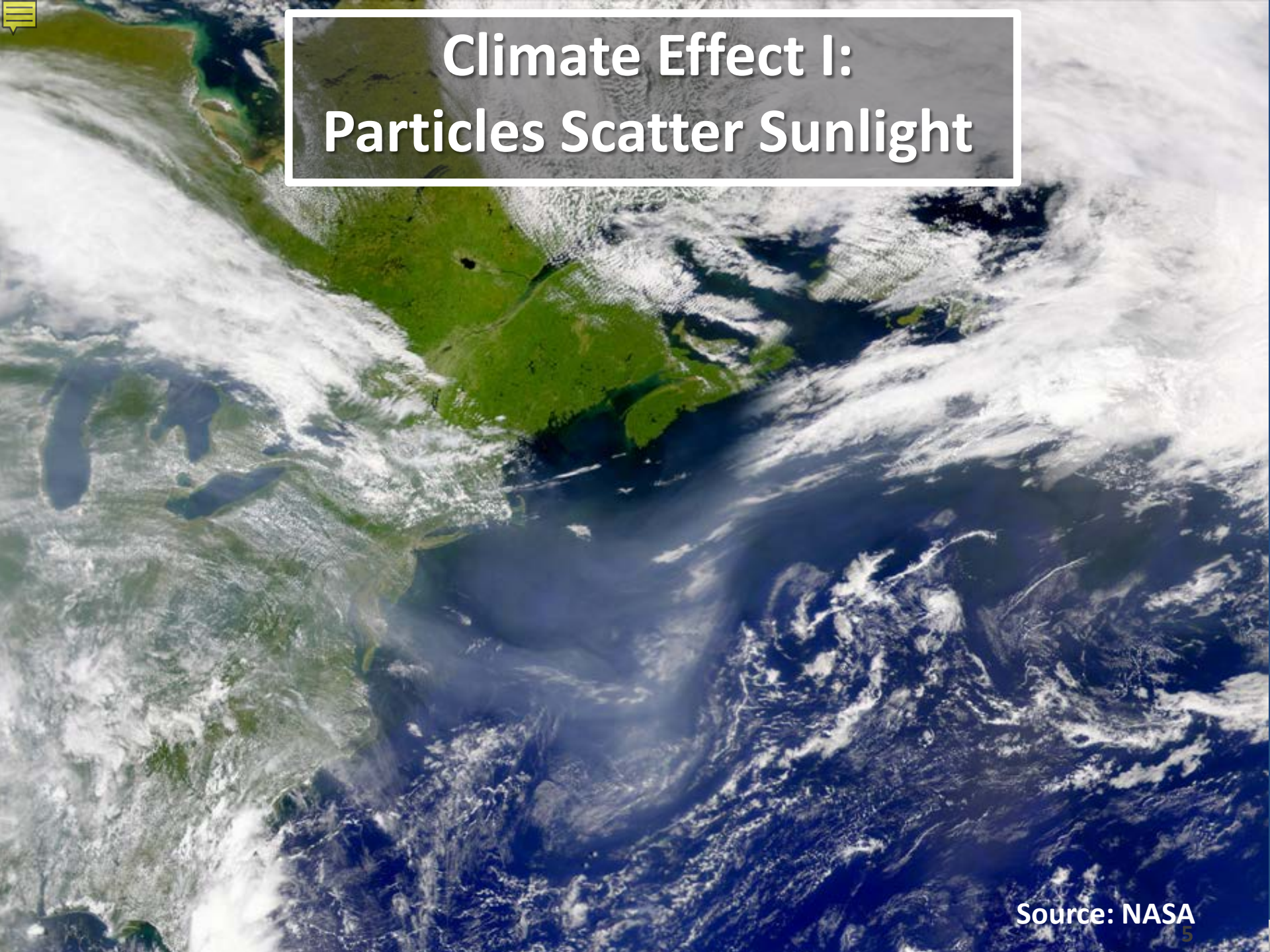
Moderate Concentrations

Epidemiology data from the Six-Cities Study



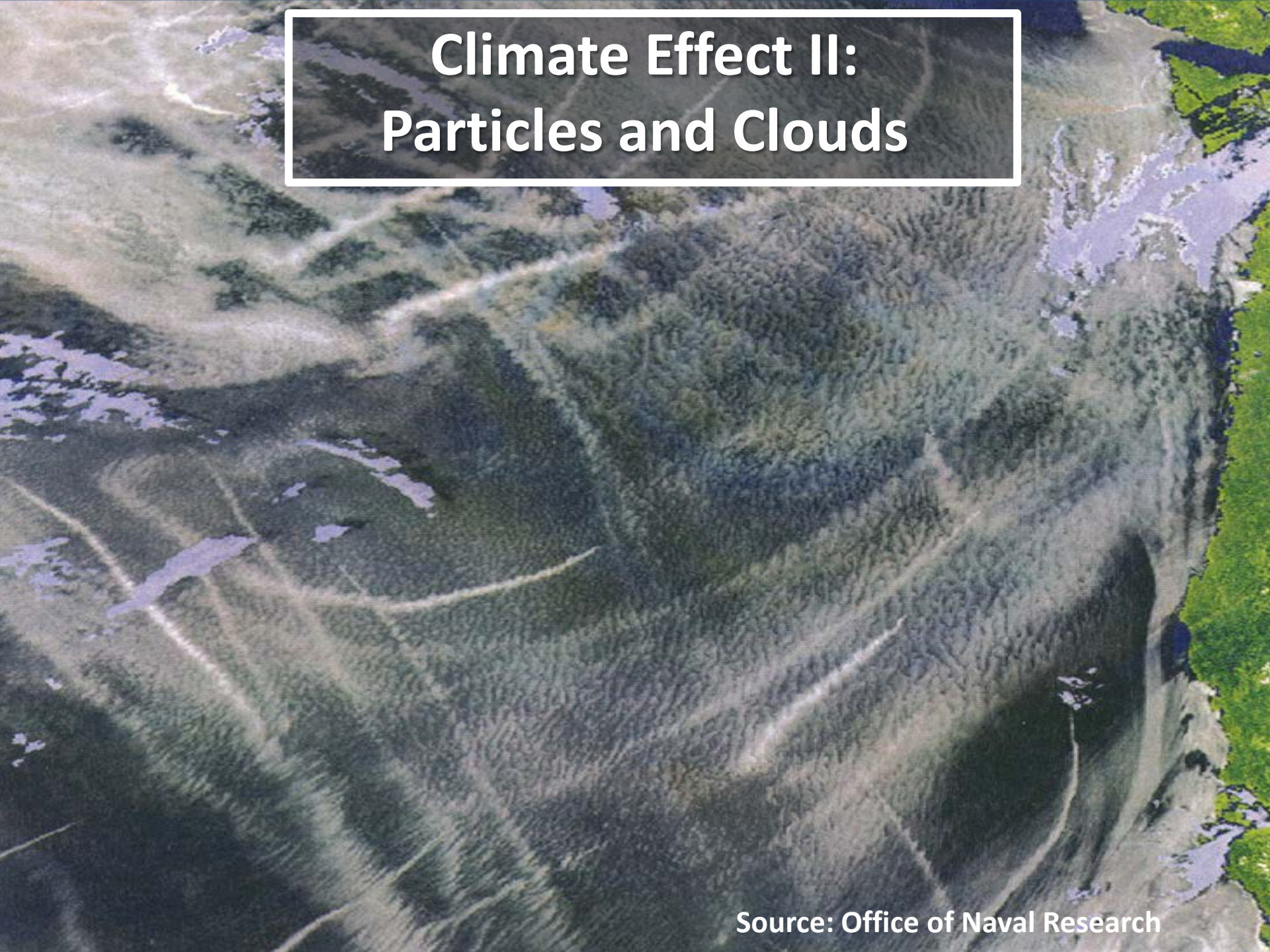
Source: Dockery *et al.*, 1993

Climate Effect I: Particles Scatter Sunlight



Source: NASA

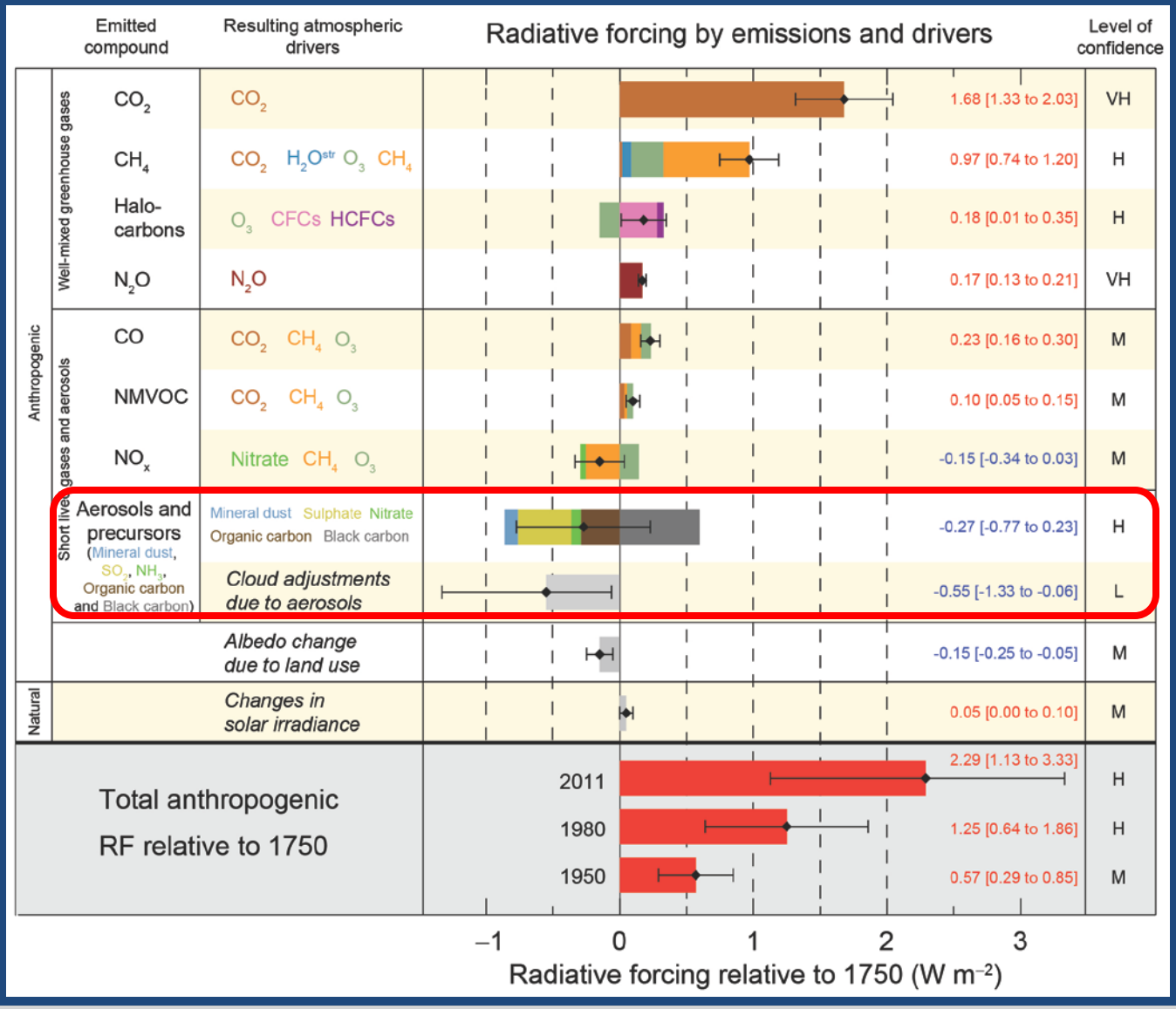
Climate Effect II: Particles and Clouds



Source: Office of Naval Research

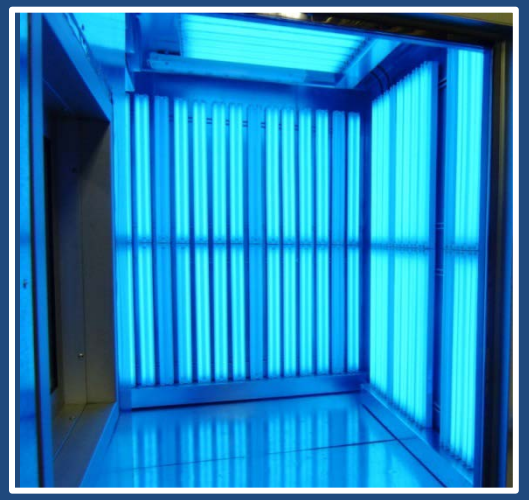
Climate Effects Highly Uncertain

Intergovernmental Panel on Climate Change (IPCC) 2014 Report

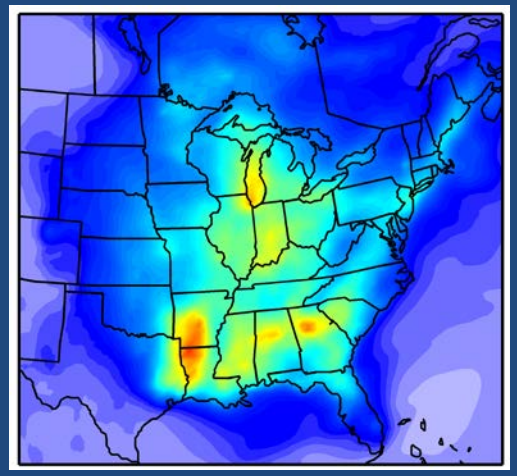


Research methods

Ambient measurements



Laboratory chamber experiments



Computer modeling

Environmental Chamber Experiments

HR-ToF-CIMS

Clean air

Compressed air

Clean air generator

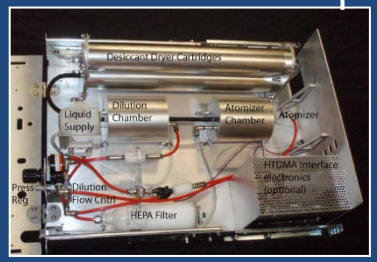
Temperature control

10 m^3 Teflon Reactor

oxidant precursor

Aerosol Chemical Speciation Monitor

NO_2, NO_x. O_3 monitors

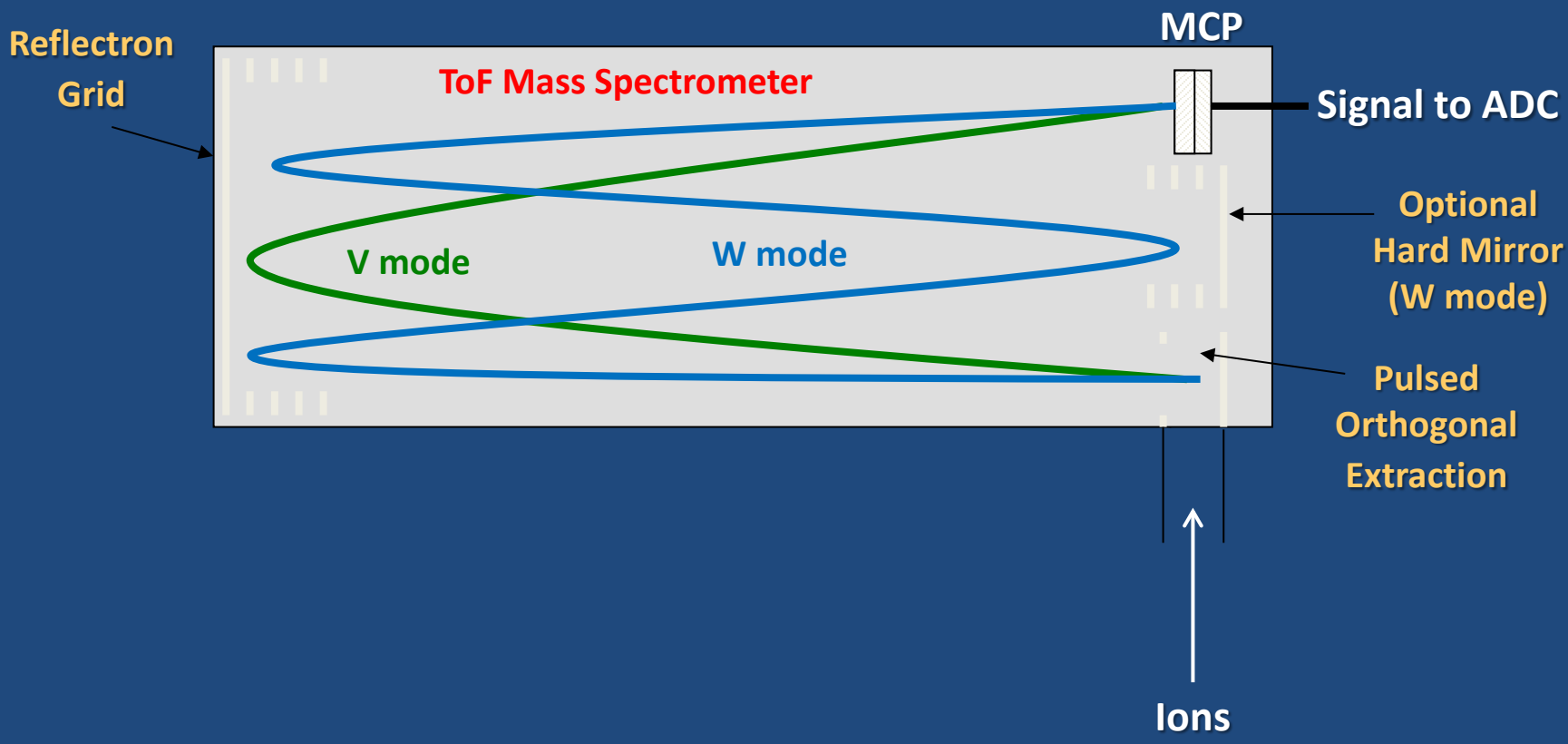


Aerosol generator

Scanning Electrical Mobility System

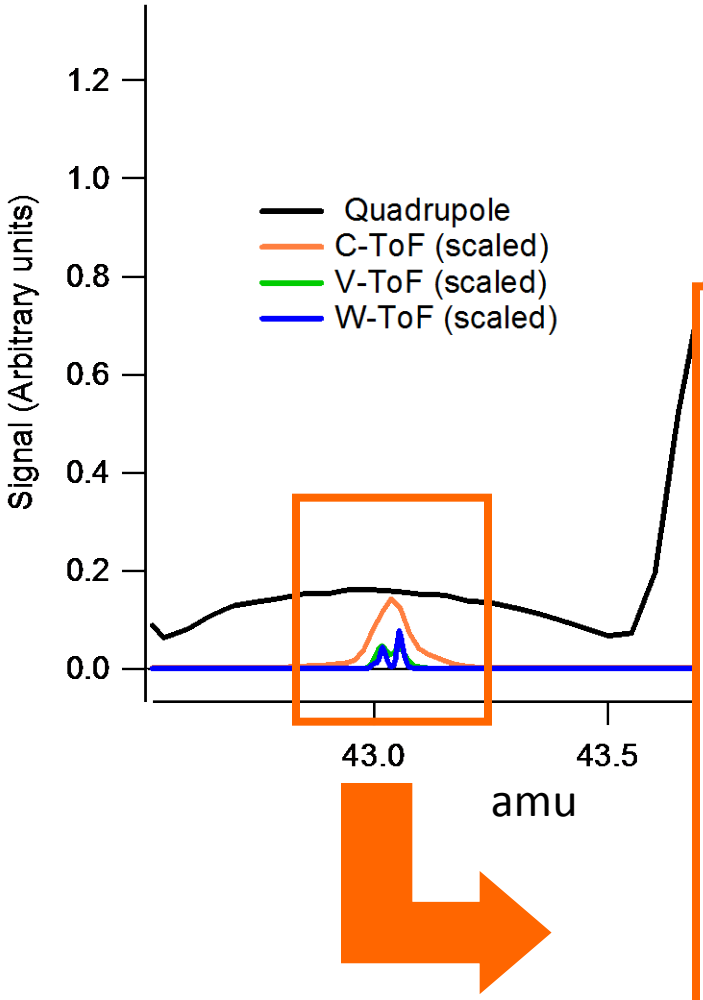
Cl_2, NO

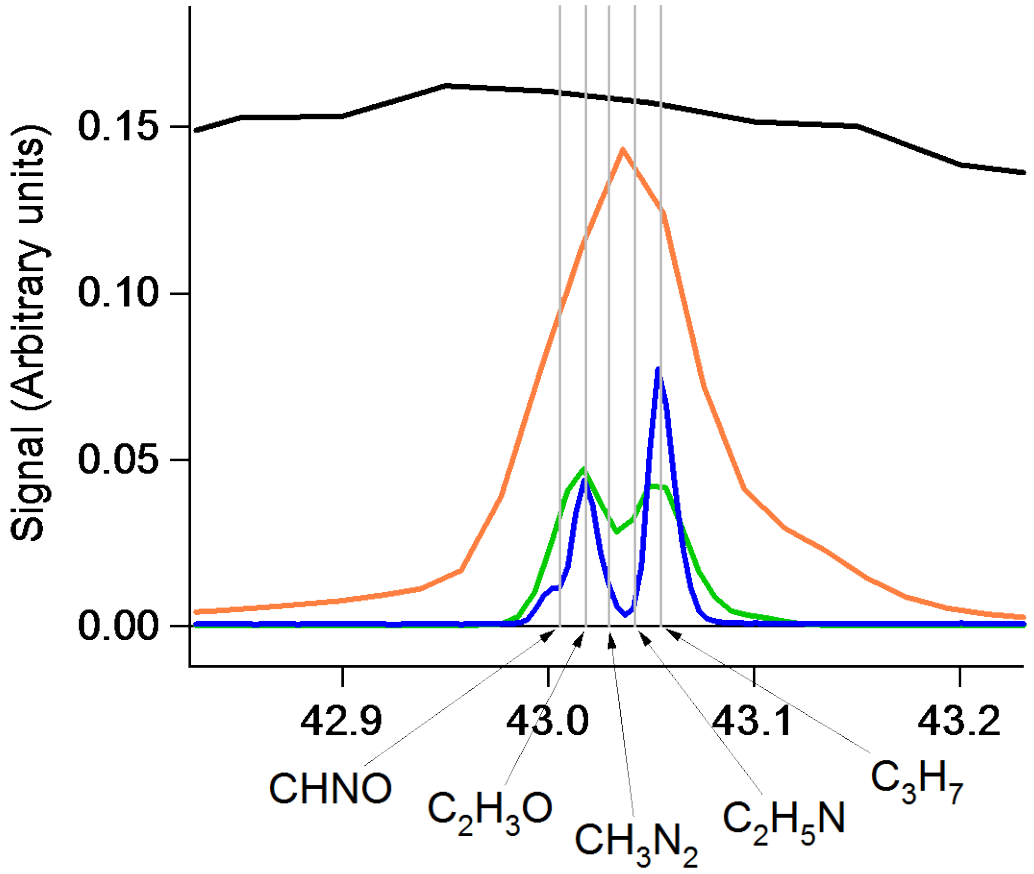
High Resolution Time-of-Flight (HRToF) Mass Spectrometer



DeCarlo et al. *Anal. Chem.*, 2006.

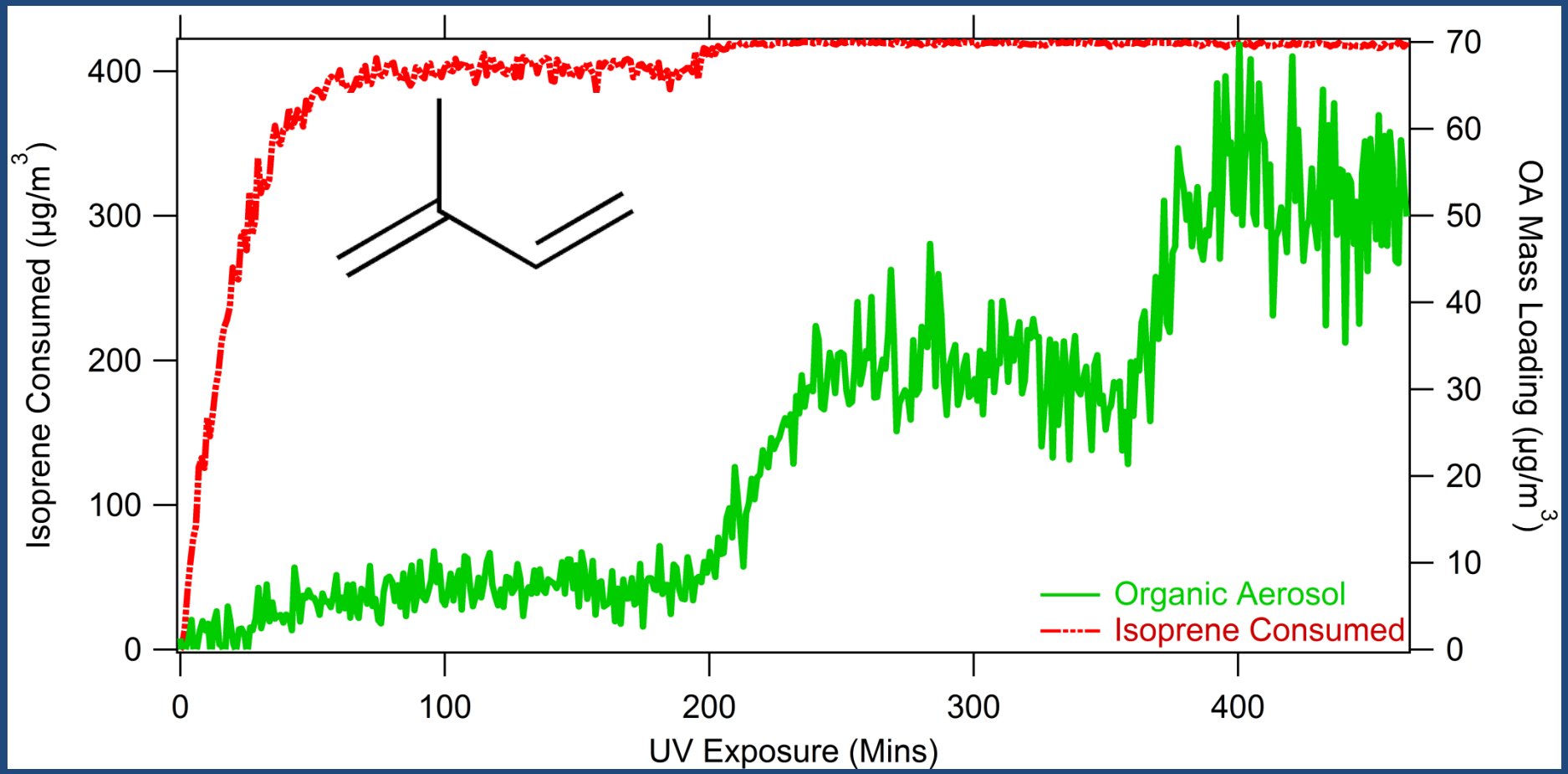
Mass Spectra Comparison





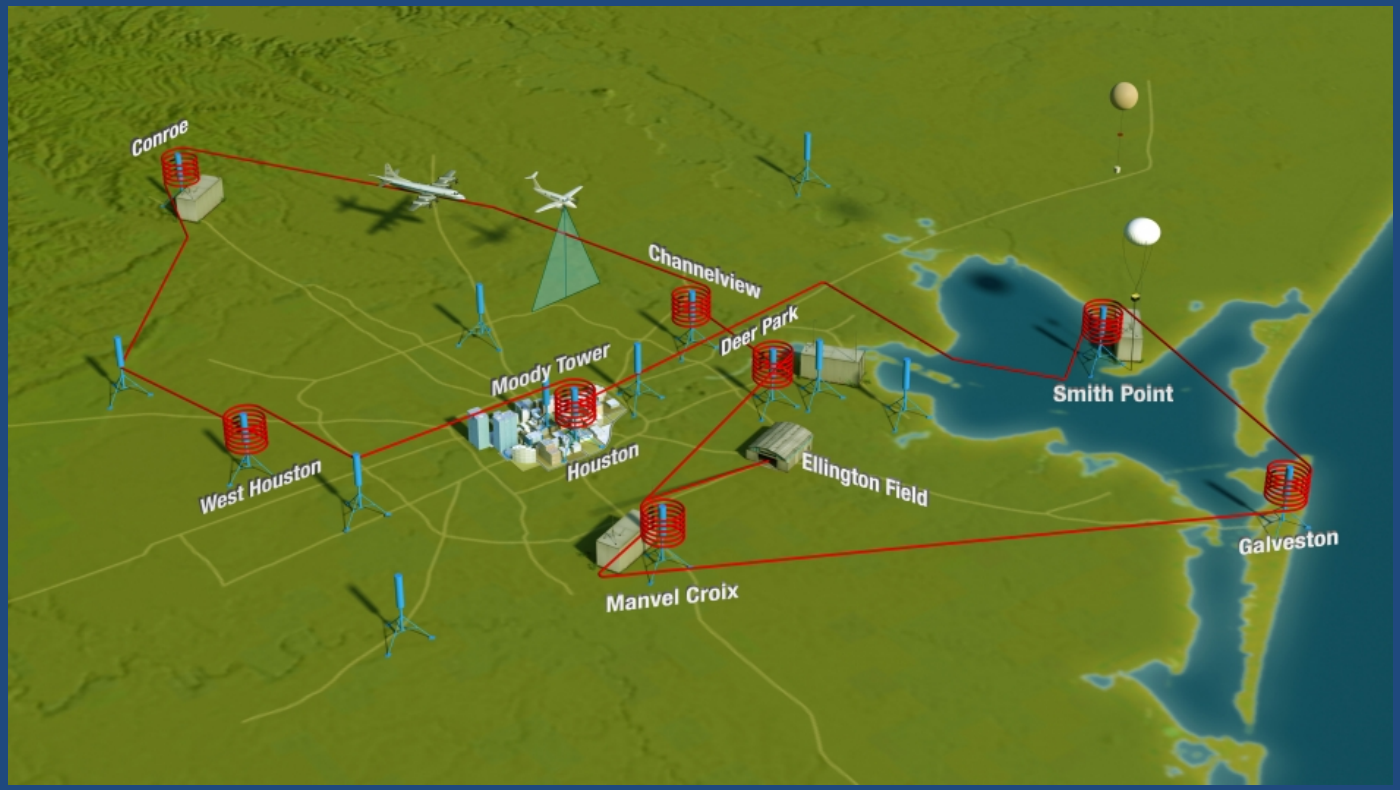
DeCarlo et al. *Anal. Chem.*, 2006.

Isoprene + Cl = Organic Aerosol

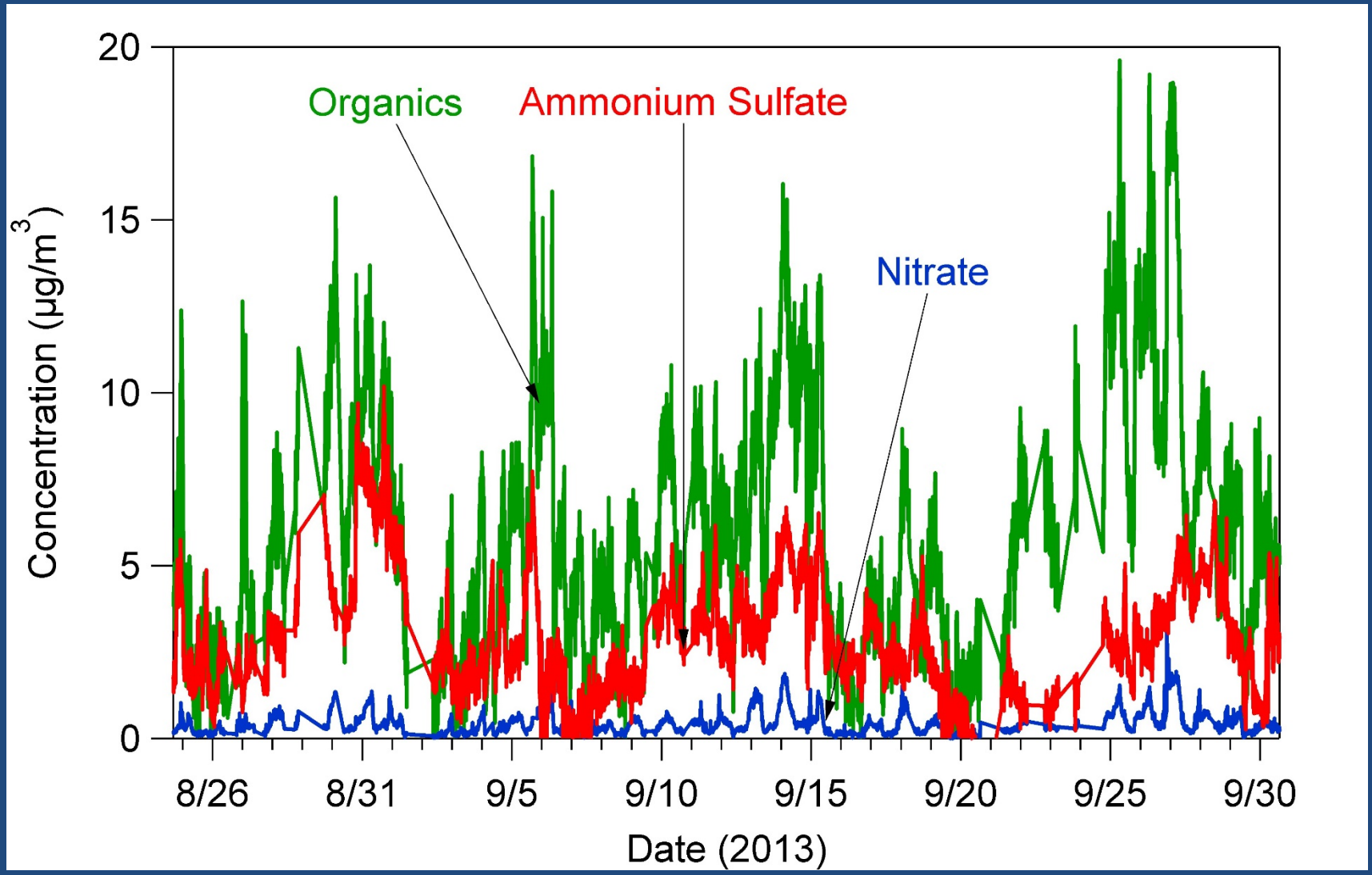


Ambient Measurements

- DISCOVER-AQ: a four-year campaign to improve the use of satellites to monitor ground-level air quality.
- September 2013: deployment in Houston, TX region.

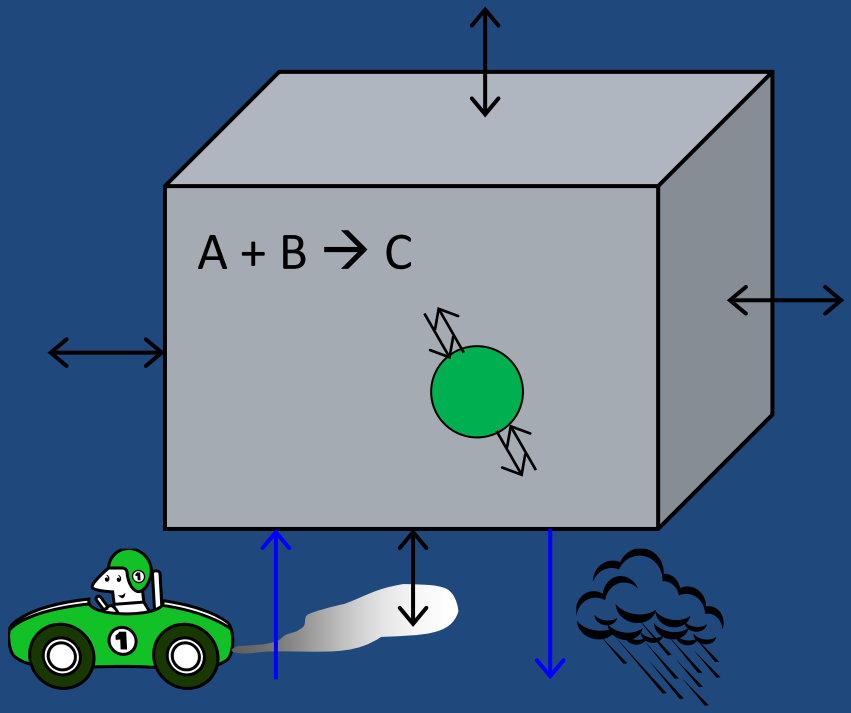


1 month of Particle Composition Data

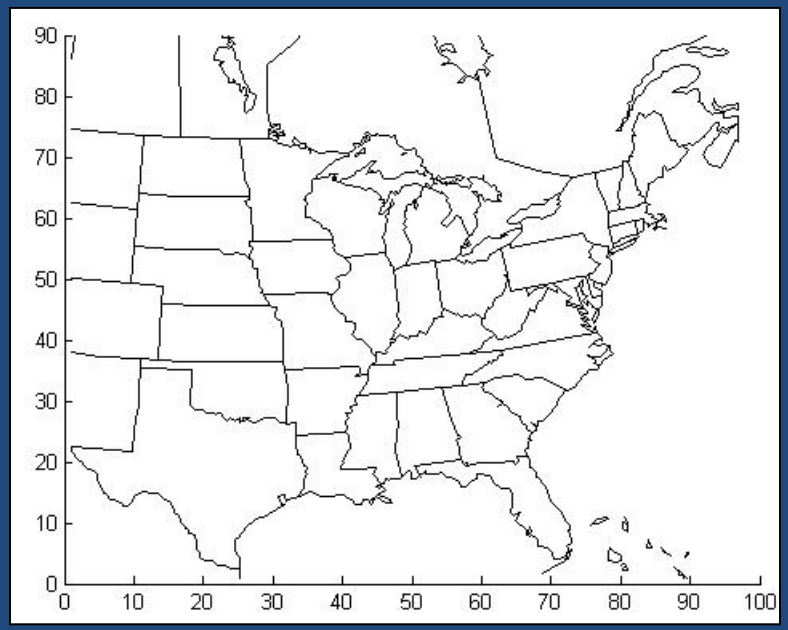


Computer Modeling

Box modeling:
Mass balance on a CSTR



Chemical transport modeling
e.g. Houston, Texas, "Eastern US"



Box could be:
- environmental chamber
- a city / region

Split up domain into boxes

Opportunities for new Ph.D. Students

- Air quality near major roadways
- Air quality impacts of hydraulic fracturing activity
- Indoor air quality in UT Austin buildings
- Energy, air quality and climate
- Biomass combustion and effects on air quality
- Vapor pressure and molecular identity of organic aerosol components

All using new, state-of the art equipment in laboratory experiments and ambient measurements.

Atmospheric Physicochemical Processes
The Course

ChE 384 Fall 2015

Topics:

- Formation of tropospheric ozone
- Motion of single particles
- Condensational growth and coagulation rates
- Classical nucleation rates
- Gas-particle partitioning of (in)organic species
- Water uptake by non-ideal solutions
- Activation of aerosols into cloud droplets
- Light scattering by aerosol and cloud particles
- Measurement and modeling techniques