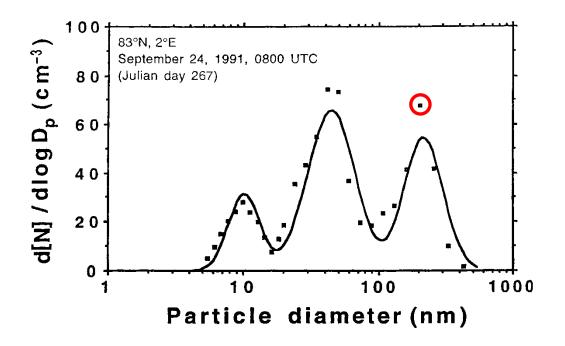
Lecture 18. Aerosol measurements and

online datasets



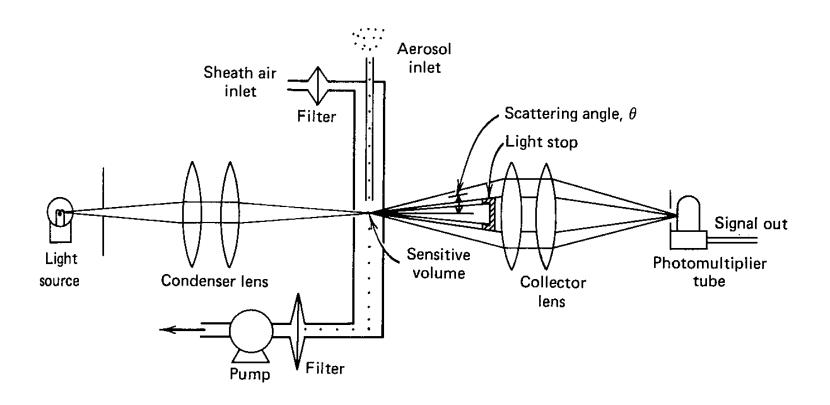
Example of size distribution (Number size distribution with three log-normal modes measured in the Arctic (y-axis linear):



O How do we measure particle number and particle size?



Optical Particle Counter (OPC): $^{\sim}$ 100 nm to 5 μ m



size limits defined by Mie scattering, which are used to interpret integrated scattered intensity.

Condensation Particle Counter

Saturate an aerosol with water or alcohol vapor

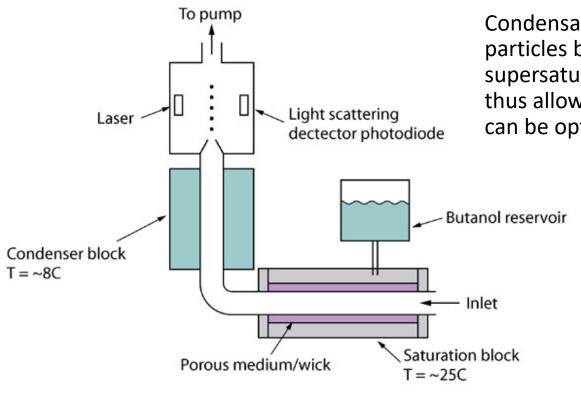
Cool by adiabatic expansion or flow through a cold tube

Nuclei will grow to \sim 10 μ m

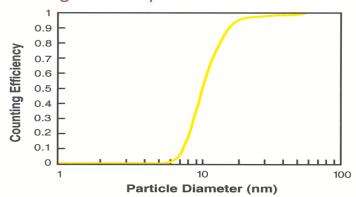
Every nuclei grows to a droplet

Measure the number of droplets with an e.g. single particle optical counter

Condensation Particle Counter (CPC): ~1.5 nm to 0.5 μm



Counting efficiency curve: TSI model 3010



Condensation Particle Counters (CPCs) detects particles by exposing them to a region that is supersaturated with vapor (usually butanol), thus allowing particles to grow to a size that can be optically detected.

Water-based CPC:

A possible term paper project: Apply what you have learned in the class to analyze/understand the operation of CPC?

Functioning:

The aerosol flow is saturated with butanol in a slightly heated saturator.

The the temperature of the butanol-aerosol mixture is decreased by 17-27°C in the condenser of the CPC.

Here, the butanol become supersaturated and condenses onto the particles.

The particles grow to droplets of several µm in diameter.

The droplet flow is focused in a nozzle and introduced into a counting optic.

The droplets pass a laser beam, and each single particle creates a light pulse.

Pulses with an amplitude above a certain threshold are counted.

The particle number concentration can be calculated by knowing the aerosol flow rate.

DMA - Differential Mobility Analyzer

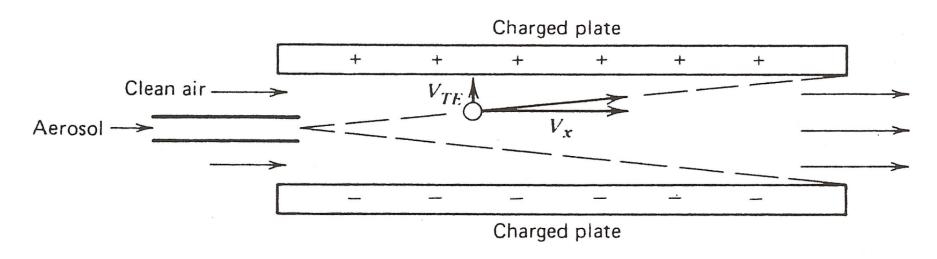


FIGURE 15.10 Diagram of a simple electrical mobility analyzer.

A charged particle will be pushed in the direction of V_{TE} by the electric field E between the two plates.

DMA - Differential Mobility Analyzer

Stokes Drag on a particle

 $F_d = 3 \pi \eta V d / Cf$

 η = viscosity of air

V = transverse velocity (going from plate to plate)

d = diameter of the particle

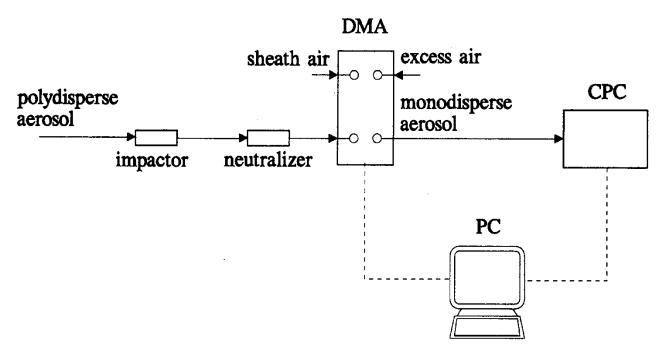
Cf = 1 + (mean free path of particle) / d (correction factor)

Electric force on a particle with charge Q in electric field E is QE

Equate the two forces, solve for $V = Q E Cf / 3 \pi \eta d$

V = Q E B where B is called the Mobility

DMA + CPC = Scanning Mobility Particle Sizer (SMPS) or Differential Mobility Particle Sizer (DMPS)



DMPS:

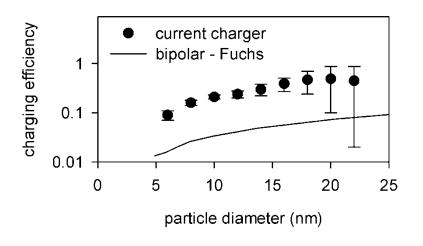
- A pre-impactor removes all particles larger than the upper diameter of the size range to be measured
- The particles are brought in the bipolar charge equilibrium in the bipolar diffusion charger.
- A computer program sets stepwise the voltage for each selected mobility bin.
- After a certain waiting time, the CPC measures the number concentration for each mobility bin.
- The result is a mobility distribution.
- The number size distribution must be calculated from the mobility distribution by a computer inversion routine.

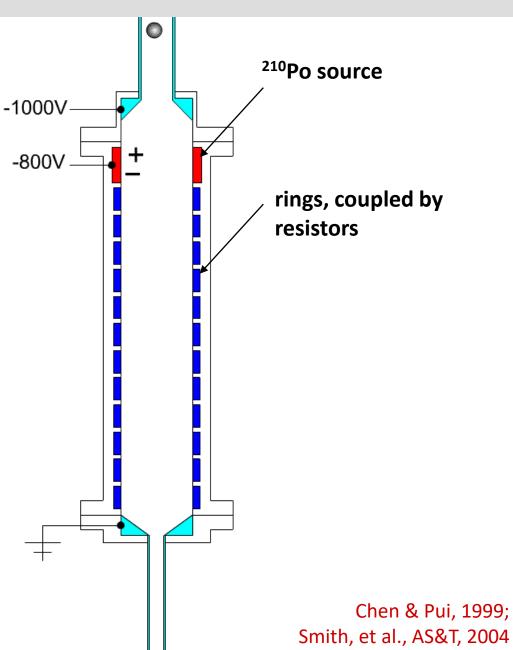
Unipolar charger

An efficient ambient nanoparticle charger

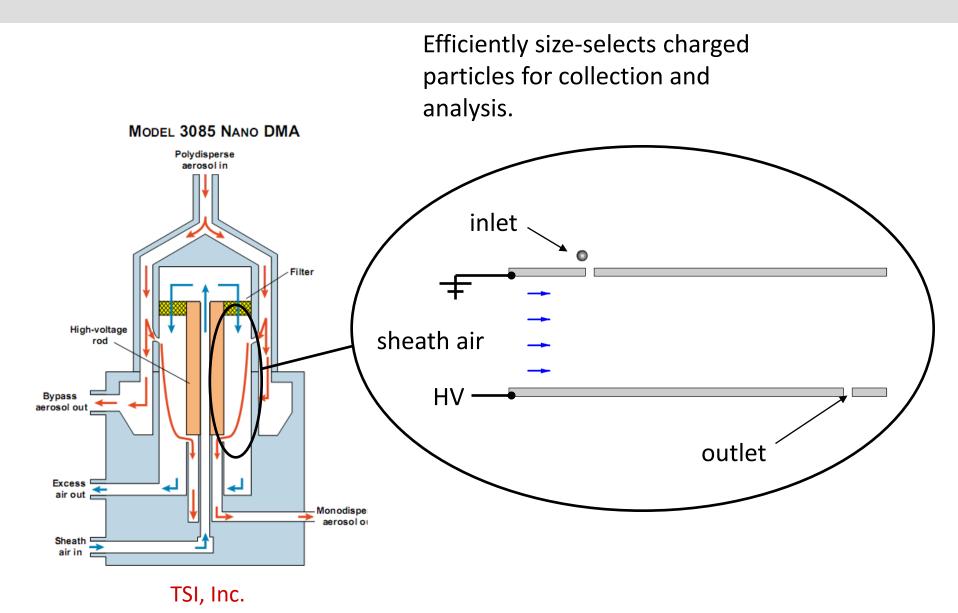
~x10 more efficient than bipolar chargers for sub-20nm particles.

Voltages turned off for particles >20nm due to multiple charging.

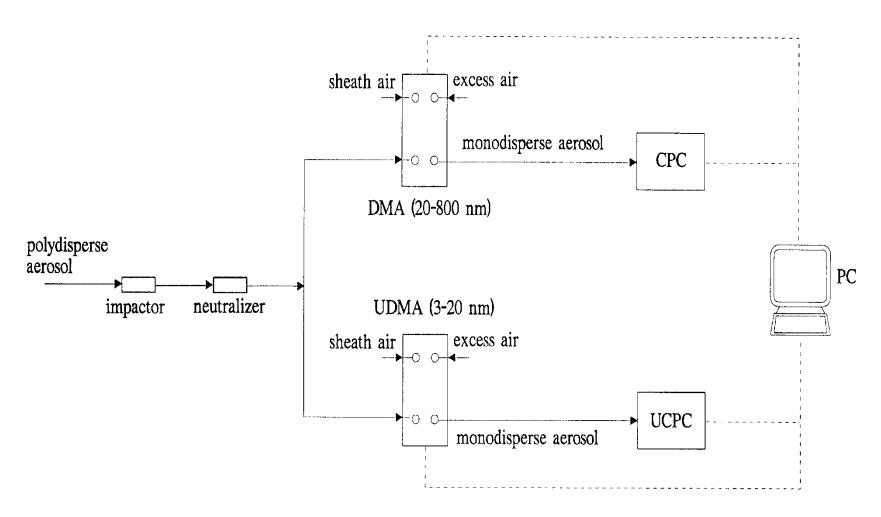




Differential Mobility Analyzer (shown below, a "Nano DMA")



Twin Differential Mobility Particle Sizer (TDMPS)



A combination of two electrical mobility spectrometers allows to measure the size distribution of the entire submicrometer size range.

Tandem Differential Mobility Analyzer (TDMA)

A TDMA is a system where two DMAs are applied in series.

A TDMA can measure the mixing state of a defined particle size in terms of a certain aerosol parameter.

The first DMA selects a monodisperse aerosol out of the entire aerosol population.

The monodisperse aerosol is modified in a conditioner

The new size spectrum is determined with the second DMA

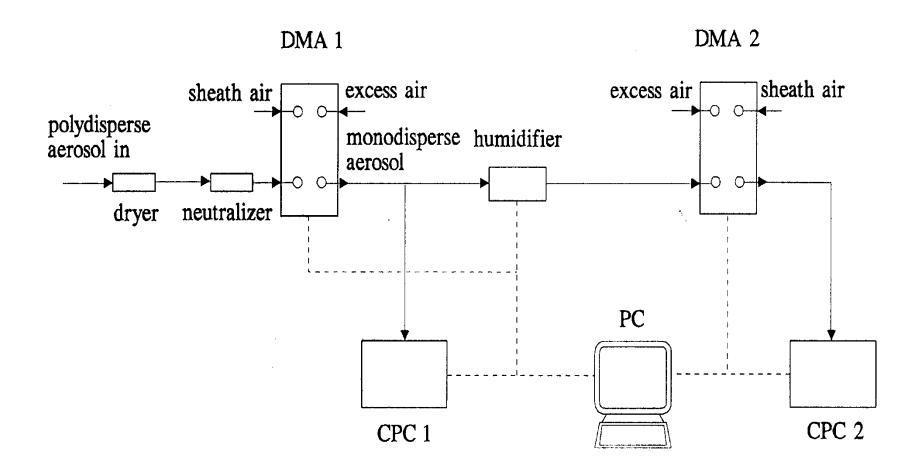
Applications:

Bipolar charge distribution

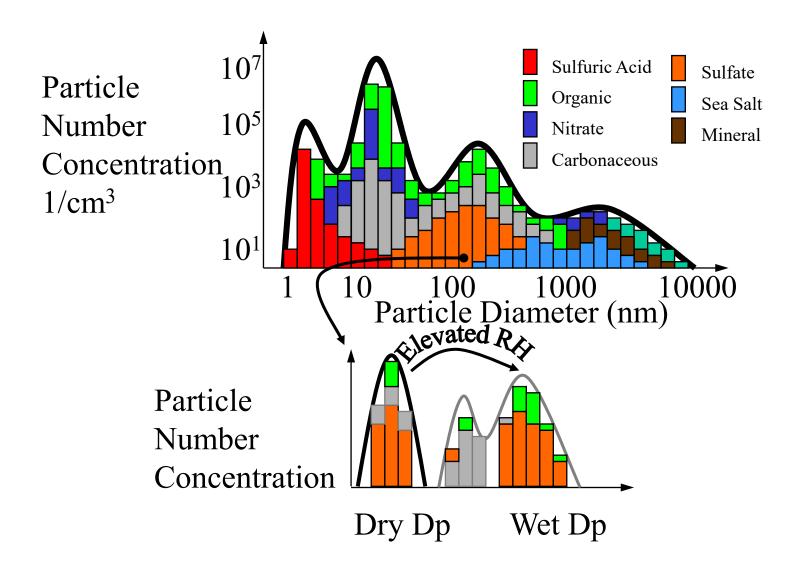
Hygroscopicity

Volatility

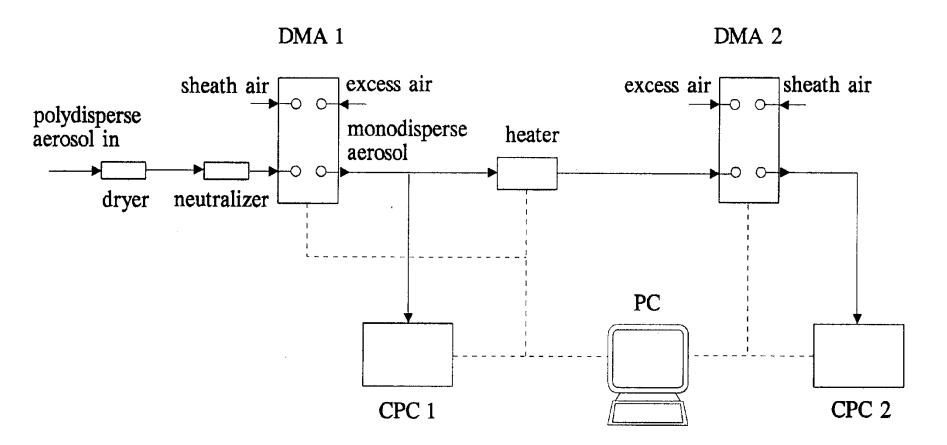
Hygroscopicity-Tandem-Differential-Mobility-Analyzer (HTDMA)



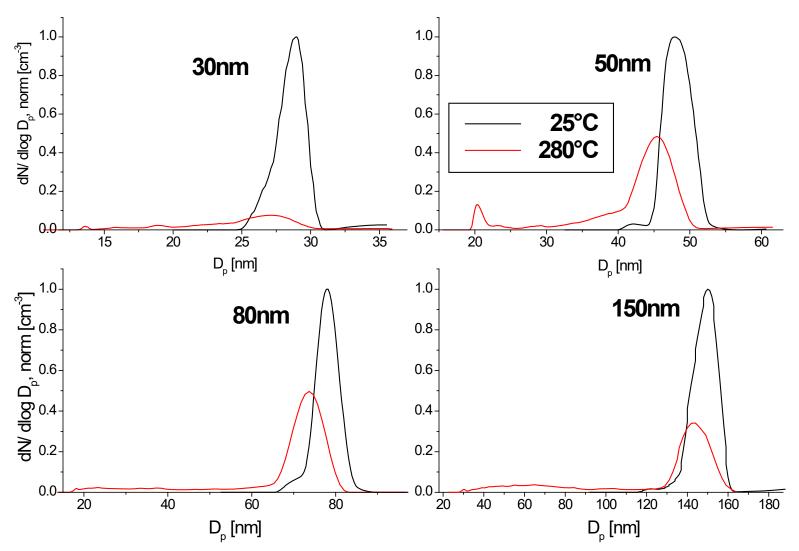
Examples of HTDMA measurement



Volatility-Tandem-Differential-Mobility-Analyzer (VTDMA)

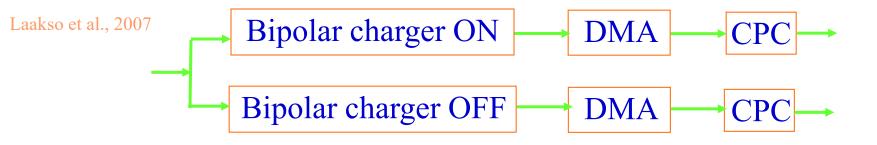


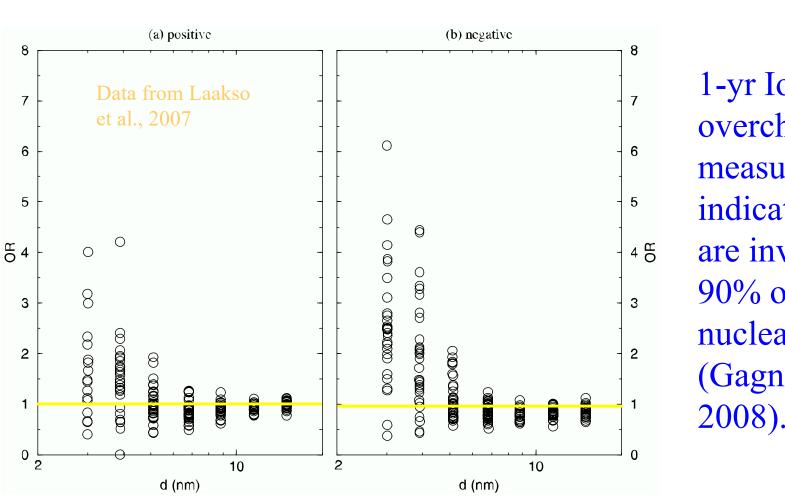
Examples of VTDMA measurements:



Volatility spectra of 30, 50, 80, and 150 nm particles measured near a freeway for 280°C in comparison to 25°C.

Ion-DMPS: Detecting charging state of ultrafine particles

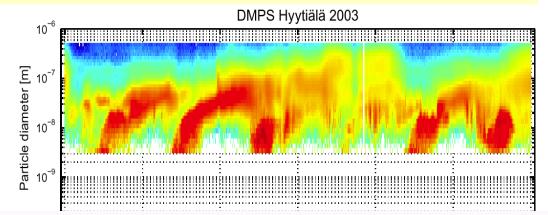




1-yr Ion-DMPS overcharging ratio measurements indicate that ions are involved in ~ 90% of the nucleation events. (Gagné et al.,

Multiple-instrument characterizations of nucleation events in boreal forests (Hyytiälä, Finland)

Differential/Scanning Mobility Particle Sizer (DMPS/SMPS)



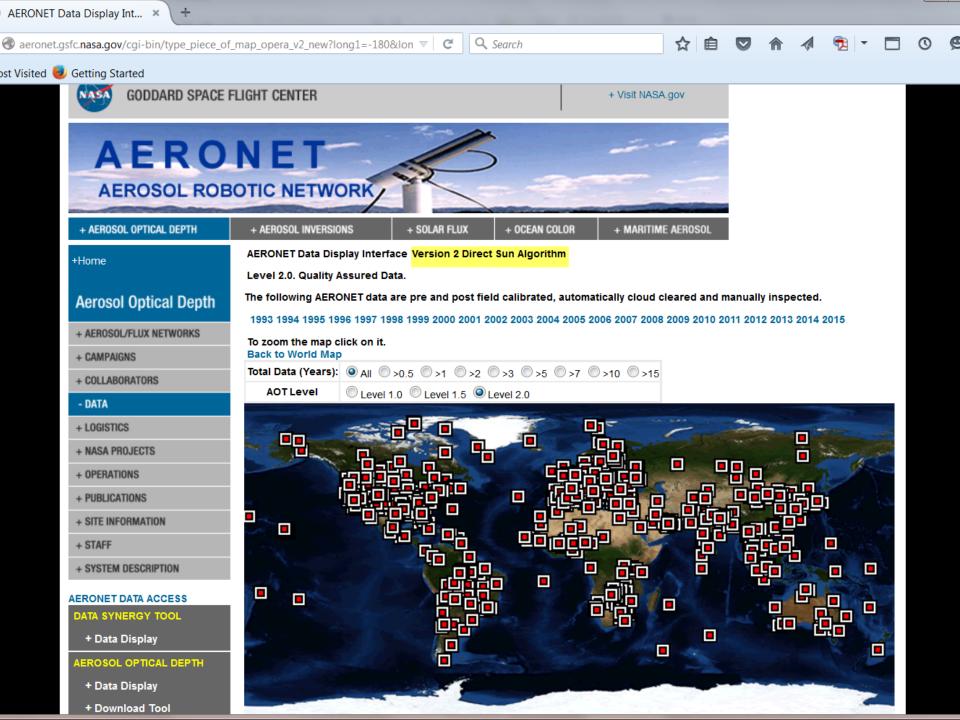
Based on 3 years (2003-2006) of continuous measurements of ion mobility spectrum, Hirsikko et al (2007) concluded that ions are involved in more than 90% of the particle formation days that can be clearly identified.

Air Ion Spectrometer AIS: negative air ion size distribution at Hyytiälä (27.-29.3.2004) 10 nm 3 nm 1 nm 10 nm 1 nm

Online datasets: Particle optical properties, mass

and number concentrations, and size

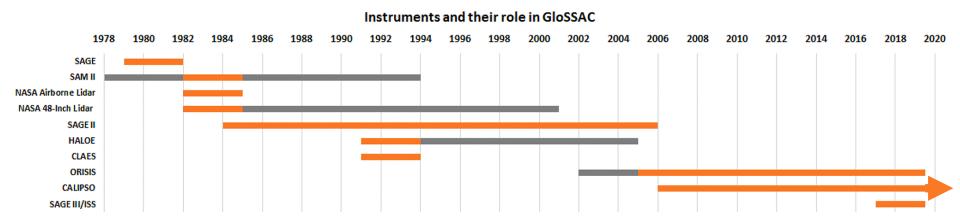
distributions



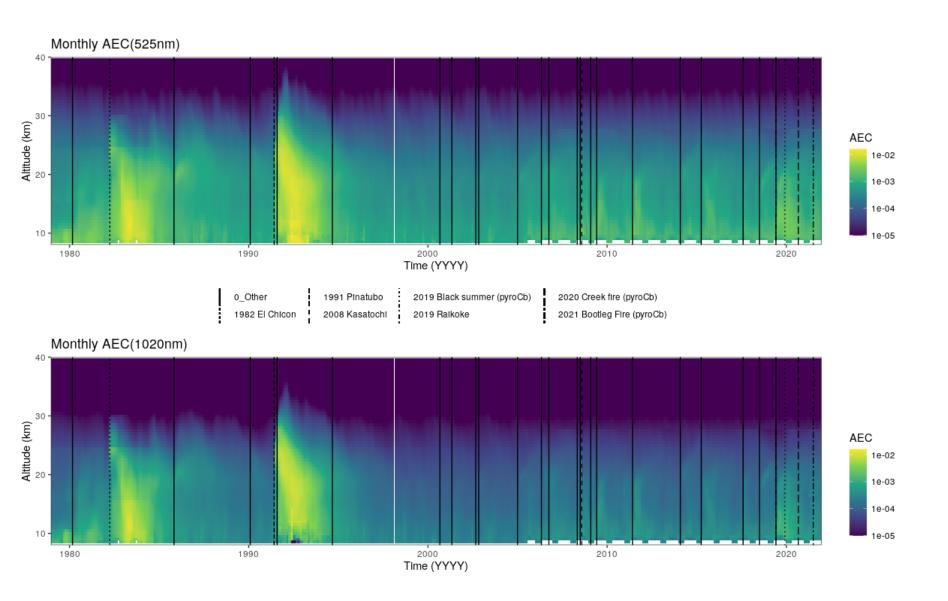
The Global Space-based Stratospheric Aerosol Climatology, or GloSSAC, is a 40-year climatology of stratospheric aerosol properties focused on extinction coefficient measurements by the Stratospheric Aerosol and Gas Experiment (SAGE) series of instruments through mid-2005 and on the Optical Spectrograph and InfraRed Imager System (OSIRIS) and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) data thereafter. Data from other space instruments and from ground-based, air and balloon borne instruments to fill in key gaps in the data set. The end result is a global and gap-free data set focused on aerosol extinction coefficient at 525 and 1020 nm and other parameters on an 'as available' basis.

GloSSAC

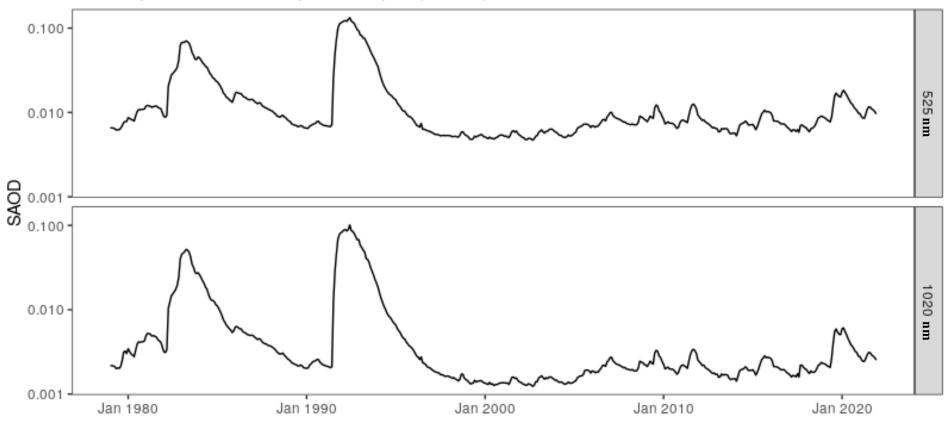
- Global Satellite-based Stratospheric Aerosol Climatology
- 43-year climatology of stratospheric aerosol properties focused on extinction coefficient (525 & 1020 nm)



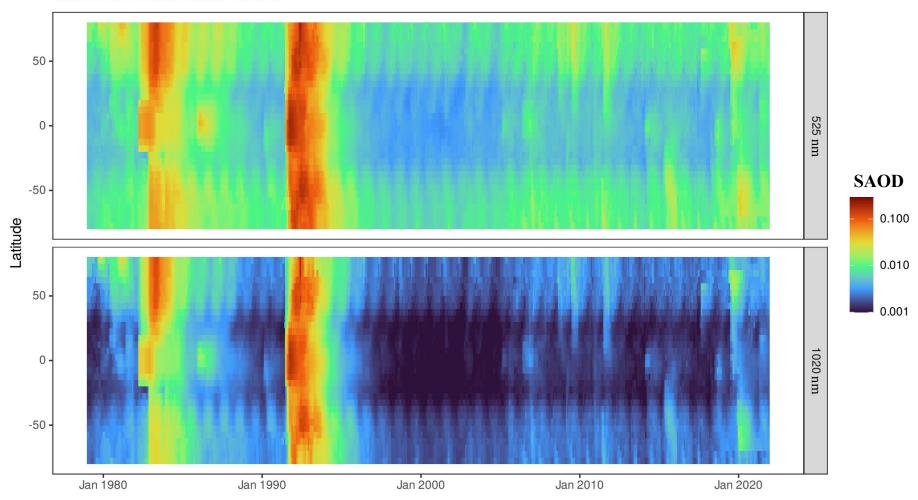
Adapted from: Kovilakam, M., Thomason, L. W., Ernest, N., Rieger, L., Bourassa, A., and Millán, L.: The Global Space-based Stratospheric Aerosol Climatology (version 2.0): 1979–2018, Earth Syst. Sci. Data, 12, 2607–2634, https://doi.org/10.5194/essd-12-2607-2020, 2020.



Stratospheric Aerosol Optical Depth (SAOD)



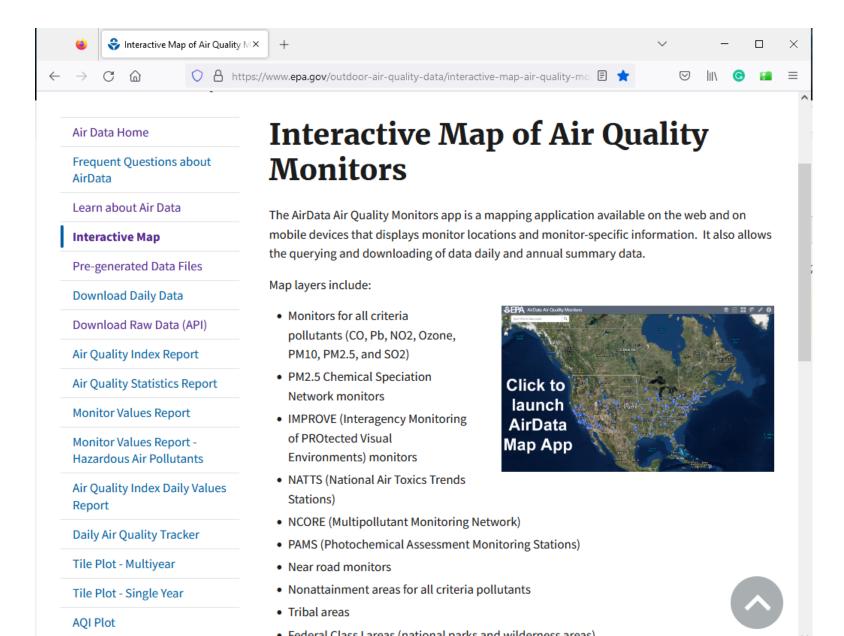
GloSSAC: Zonal mean SAOD



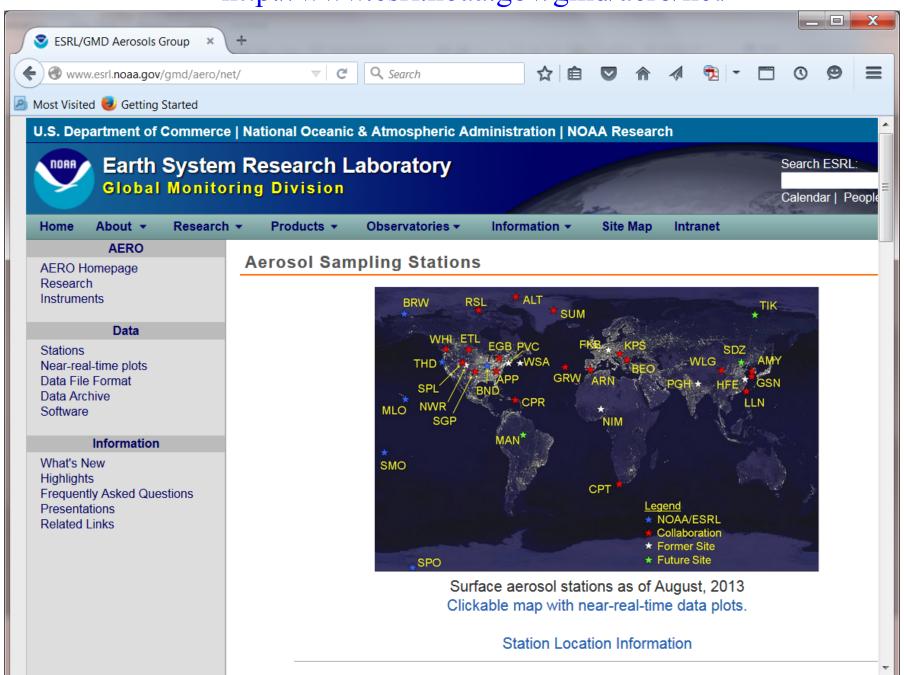
EPA Air Data: Air Quality Data Collected at Outdoor Monitors

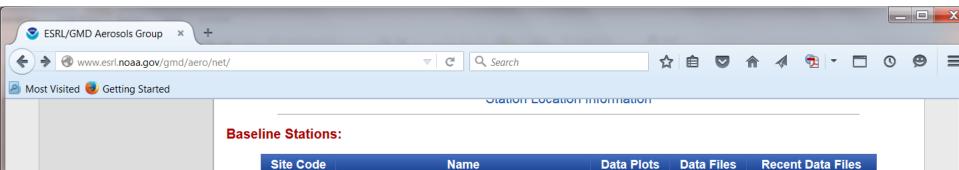
Across the US

https://www.epa.gov/outdoor-air-quality-data



http://www.esrl.noaa.gov/gmd/aero/net/





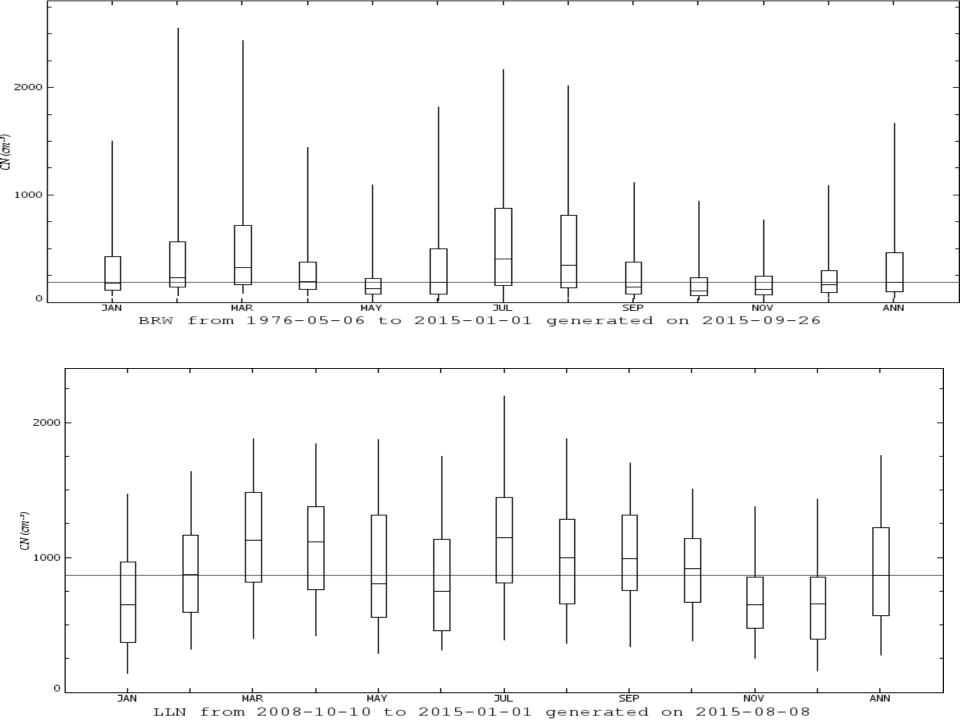
Site Code	Name	Data Plots	Data Files	Recent Data Files
BRW	Barrow, Alaska, USA	BRW-plots	BRW-data	Recent Data Files
MLO	Mauna Loa Observatory, Hawaii, USA	MLO-plots	MLO-data	Recent Data Files
SMO	American Samoa	SMO-plots	SMO-data	Recent Data Files
SPO	South Pole Observatory	SPO-plots	SPO-data	Recent Data Files

Regional stations:

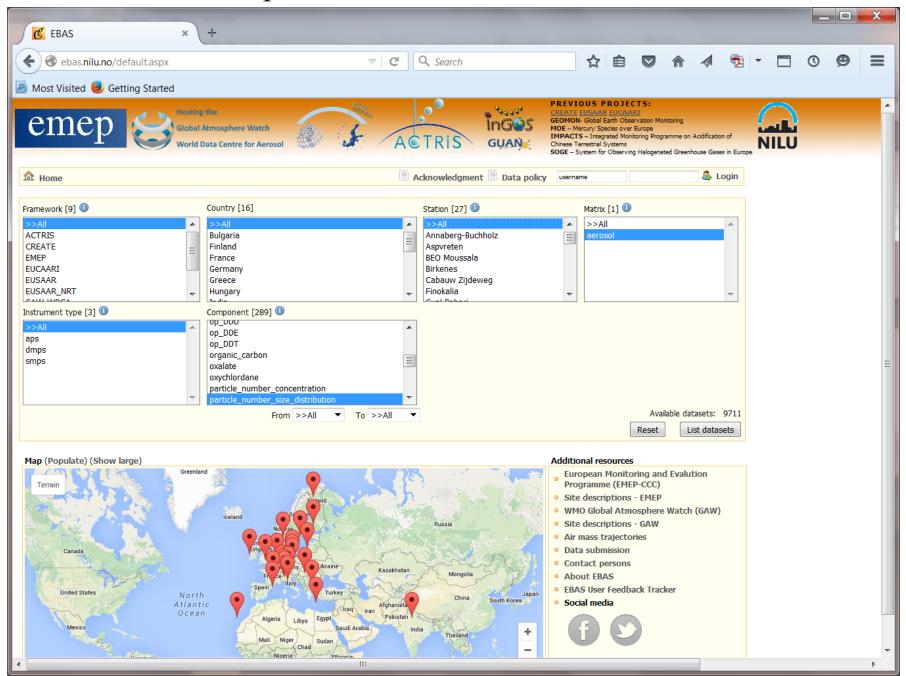
Site Code	Name	Data Plots	Data Files	Recent Data Files
BND	Bondville, Illinois, USA	BND-plots	BND-data	Recent Data Files
LAB	Laboratory data	LAB-plots	LAB-data	Recent Data Files
SUM	Summit, Greenland	SUM-plots	SUM-data	Recent Data Files
THD	Trinidad Head, California, USA	THD-plots	THD-data	Recent Data Files

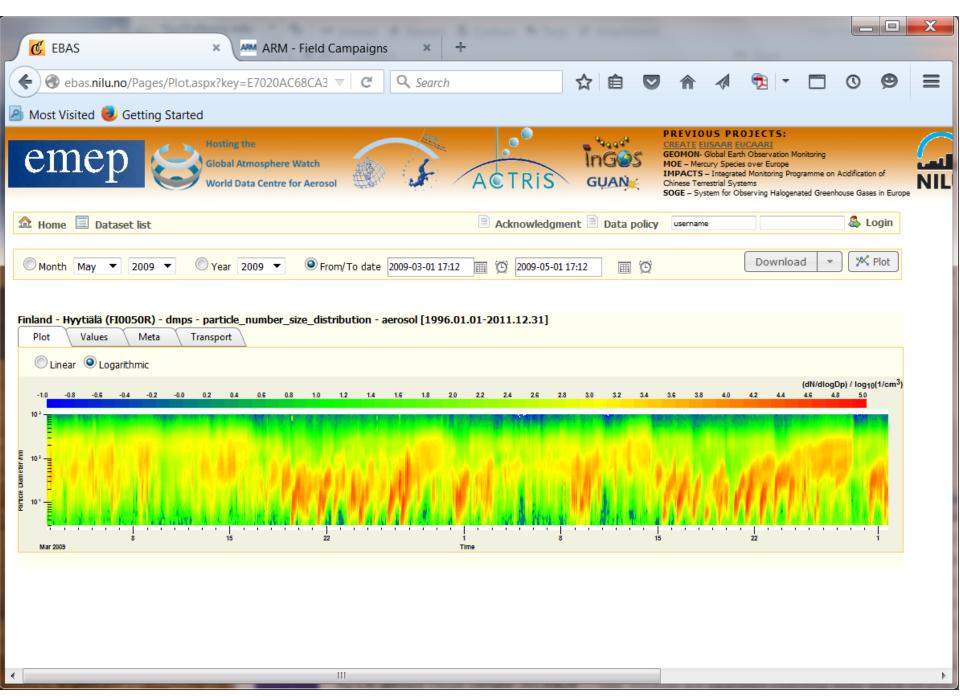
Mobile and cooperative platforms:

Site Code	Name	Data Plots	Data Files	Recent Data Files
ALT	Alert, Canada (cooperative with Environment Canada)	ALT-plots	ALT-data	Recent Data Files
AMF	ARM mobile facility, different location every year	AMF-plots	AMF-data	Recent Data Files
AMY	Anmyeon-do, South Korea	AMY-plots	AMY-data	Recent Data Files
APP	Appalachian State University, Boone, North Carolina, USA	APP-plots	APP-data	Recent Data Files
ARN	El Arenosillo, Spain	ARN-plots	ARN-data	Recent Data Files
BEO	Moussala, Bulgaria	BEO-plots	BEO-data	Recent Data Files

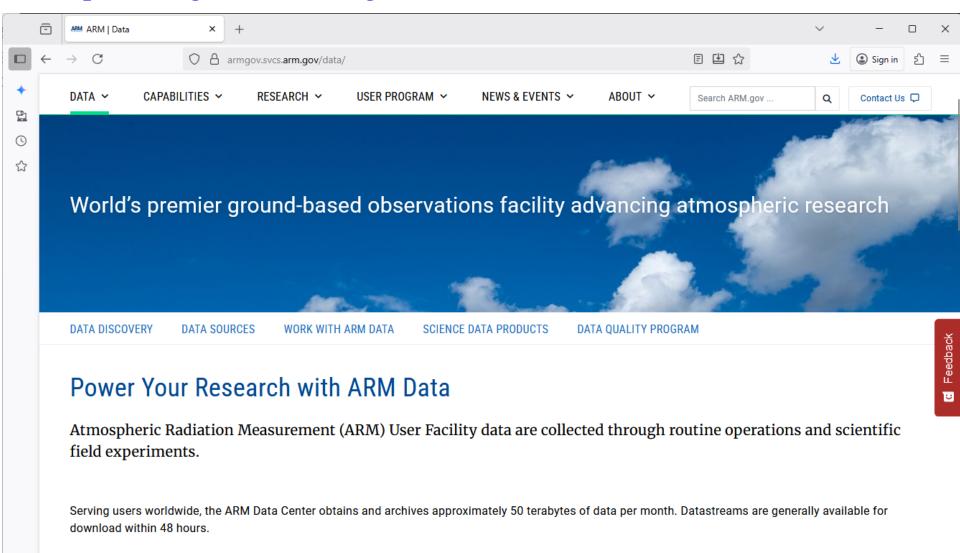


https://ebas-data.nilu.no/





https://armgov.svcs.arm.gov/data/



Access the Data

All data obtained through ARM are monitored for quality and made available free of charge through the ARM Data Center via Data Discovery.

ARM USER PROFILE

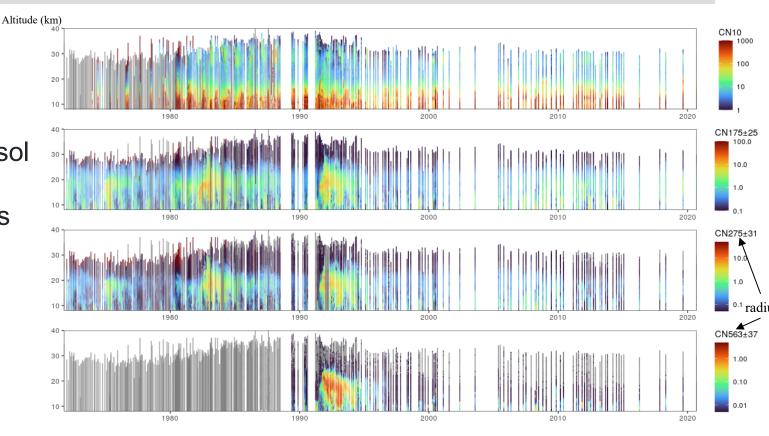
in-situ balloonborne size resolved aerosol concentration measurements

https://dataverse.arcc.uwyo.edu/dataset.xhtml?persistentId=doi:10.15786/wyoscholar/9897

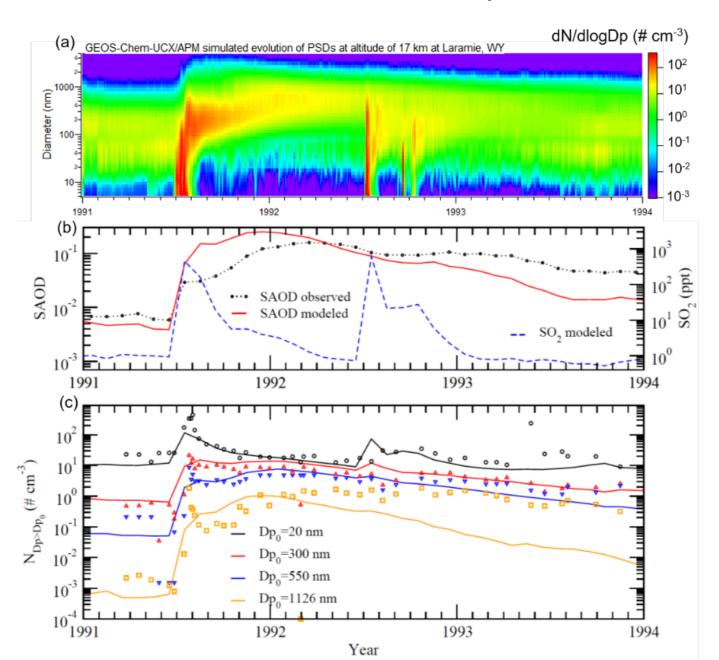
Laramie Balloon Data

In-situ balloon borne size resolved aerosol concentration measurements

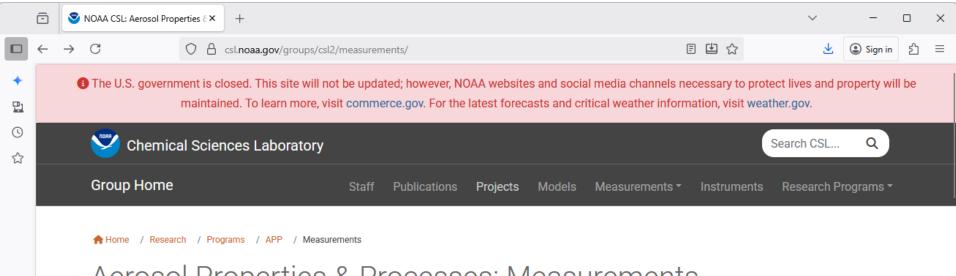
(Deshler et al., 2005, 2018)



Model-observation comparisons



Various field measurements, such as



Aerosol Properties & Processes: Measurements

Aerosol properties and processes research relies on measurements of the chemical, physical, and optical properties of aerosol particles from aircraft, ships, and ground sites as well as in the laboratory. By combining these with gas-phase and other measurements, we learn about the sources, sinks, and radiative properties of these particles.

The NOAA WP-3D is used in many of our field campaigns, and group participating field projects have used the NOAA R/V Ronald H. Brown. Data archived from our major NOAA field campaigns, with instruments on aircraft and ship research platforms, are available with the Tropospheric Chemistry research group (Collaborative Field Campaigns):



Campaign	Season	All Platforms	Location	Purpose
FIREX-AQ 2019	Summer	NOAA Twin Otter	western US	Understand impact of North American fire emissions on air quality.
FIREX FireLab 2016	Fall	USDA Fire Lab	western US	Understand impact of North American fire emissions on air quality.
SONGNEX 2015	Spring	NOAA WP-3D	western US	Study emissions of western US oil and shale gas basins.
SENEX 2013	Summer	NOAA WP-3D	Nashville, TN	Study interactions between natural and anthropogenic emissions and affects on climate change and air quality.

Various satellite data, such as

