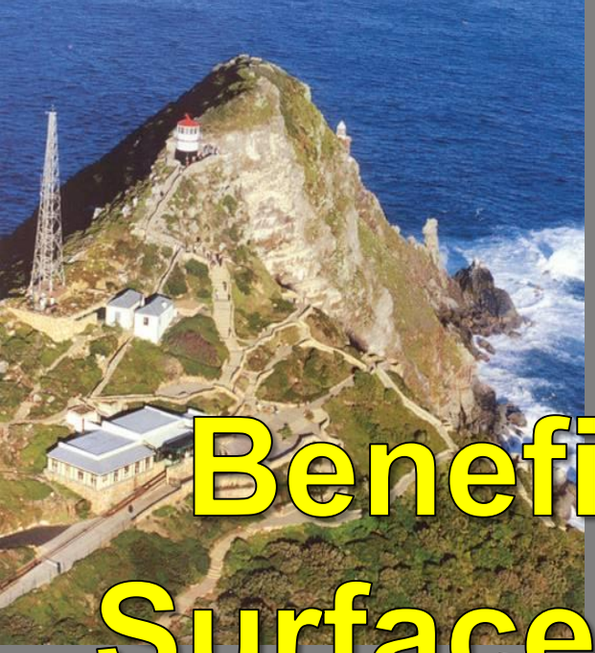


Benefits of a Collaborative Global Surface Aerosol Monitoring Network

John Ogren, Betsy Andrews, Anne Jefferson, and Patrick Sheridan

NOAA/ESRL Global Monitoring Division, Boulder, CO USA

And many collaborating scientists!

Outline of Talk

- Evolution of the NOAA/ESRL surface aerosol network over the years
- Science!
- Collaboration – why, how, what, how much

NOAA Baseline Aerosol Monitoring Network (circa 1985)

Mission: To detect changes (i.e., trends, cycles) in the long-term global aerosol background

Strategy: To conduct aerosol measurements at four Baseline Observatories. Stations are far removed from human activities ➔ global background aerosols

GMD Aerosol Program (circa 2010)

The goals of the current monitoring program are:

• characterize means, variability and trends of climate-forcing properties of different types of aerosols on regional scales

•understand factors controlling regional aerosol properties

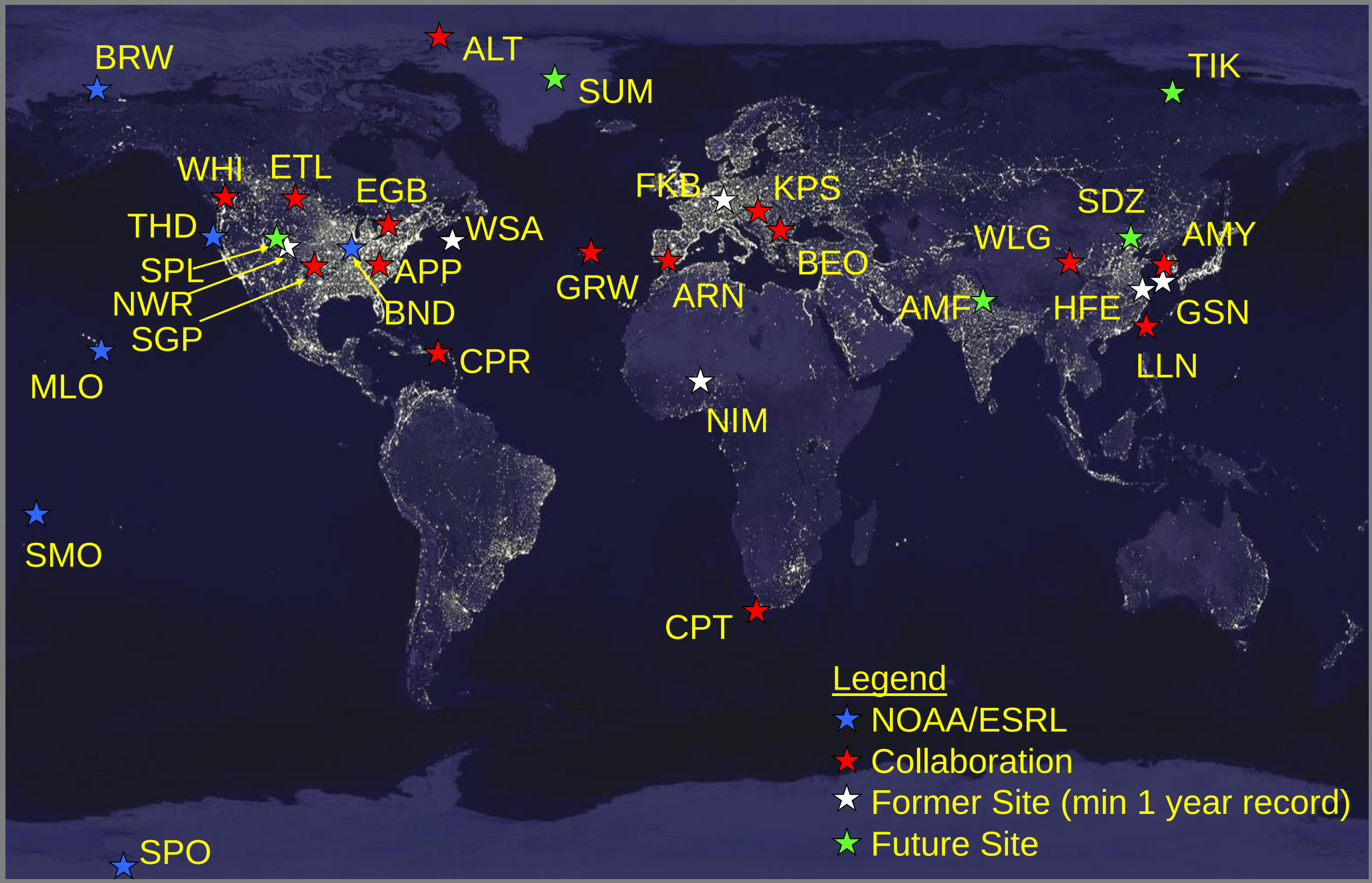
•provide ground-truth for satellite measurements

•provide key aerosol parameters for global-scale models

→Need regional aerosol monitoring stations all over the globe sampling different types of aerosols

Question: How to accomplish this given funding realities?

NOAA/ESRL Collaborative Global Aerosol Monitoring Network in 2010 (21 active stations)



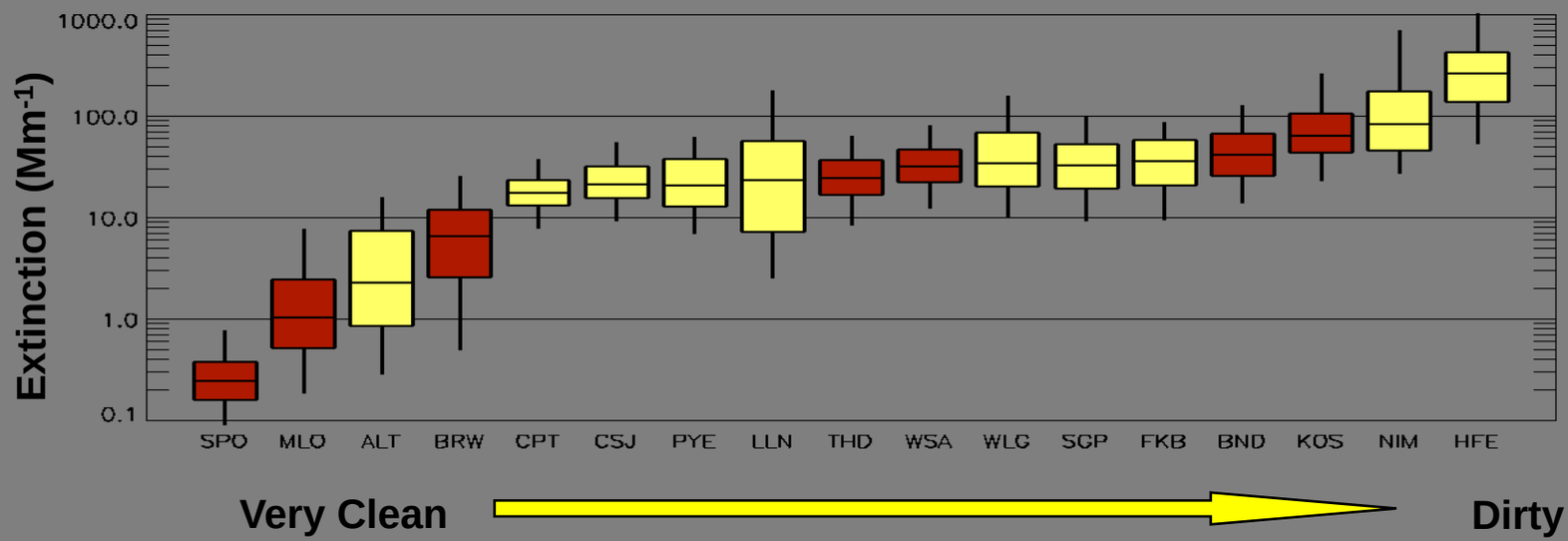
Basic NOAA Aerosol Rack System at Mauna Loa, Hawaii

Common, core design at NOAA and collaborative stations

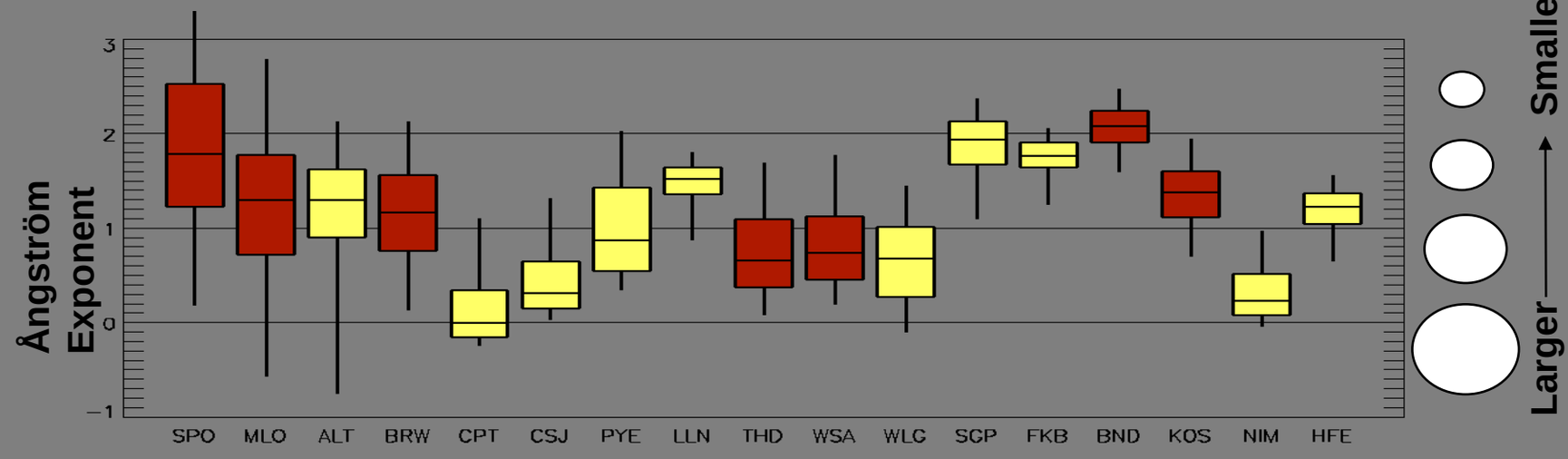
- Provides size- and RH-controlled measurements of aerosol
  - total light scattering (3 λ)
  - backward light scattering (3 λ)
  - light absorption (3 λ)
  - number concentration

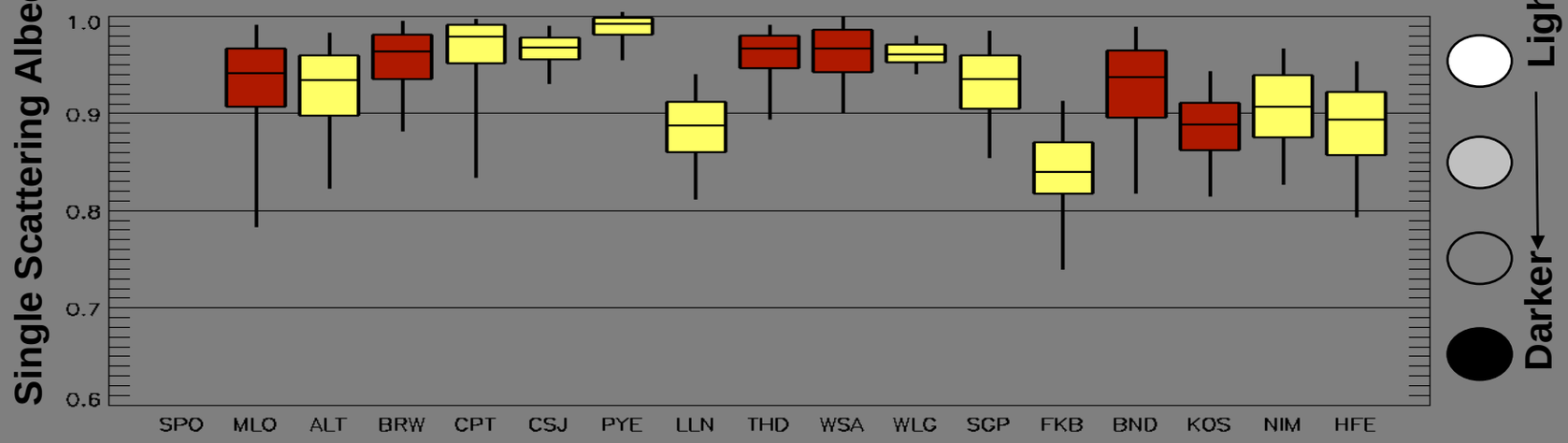
- Can calculate important aerosol and aerosol radiative forcing parameters:
  - single scattering albedo
  - asymmetry parameter
  - Ångström exponent

Variations in Aerosol Amount and Type

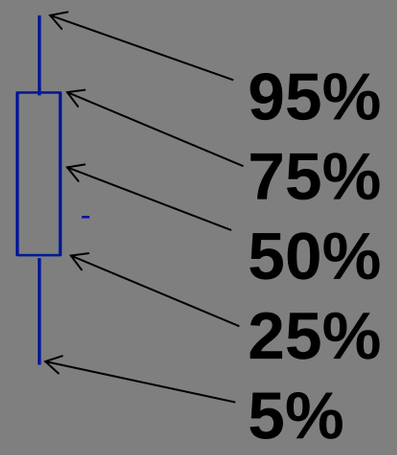


Very Clean → Dirty





Percentiles

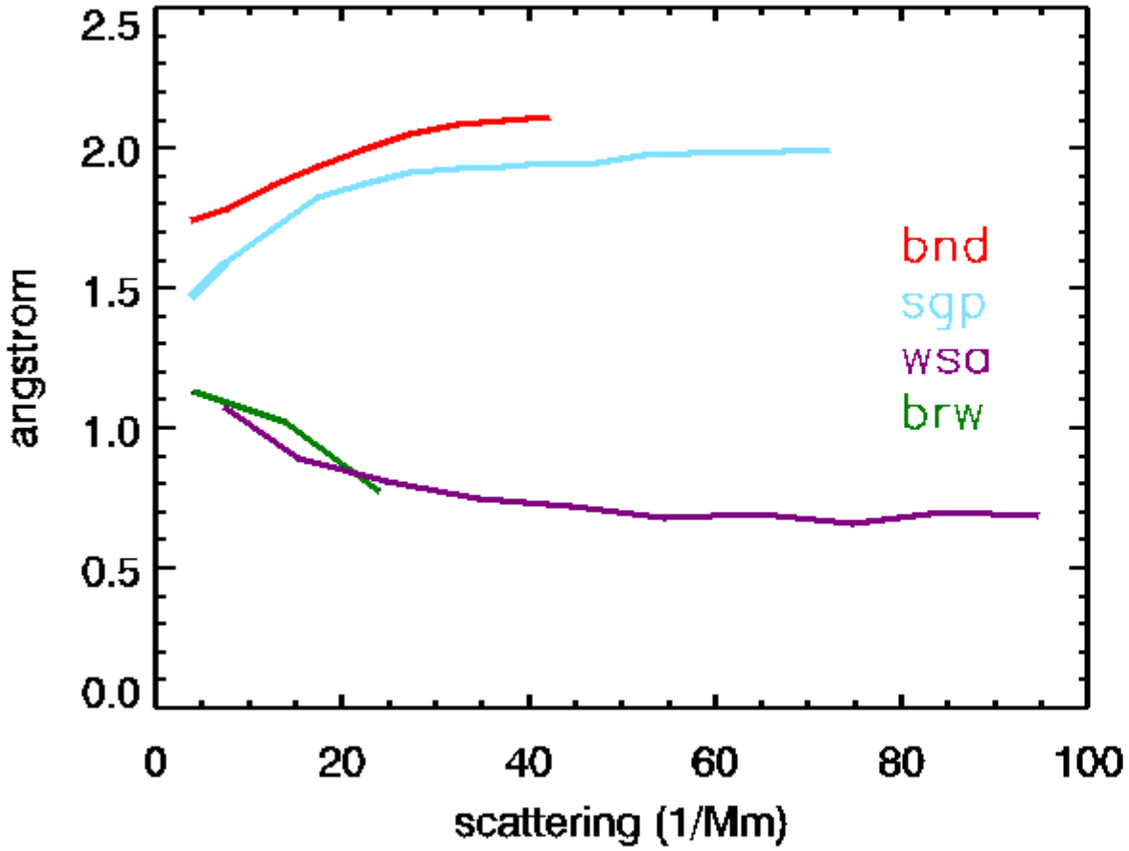


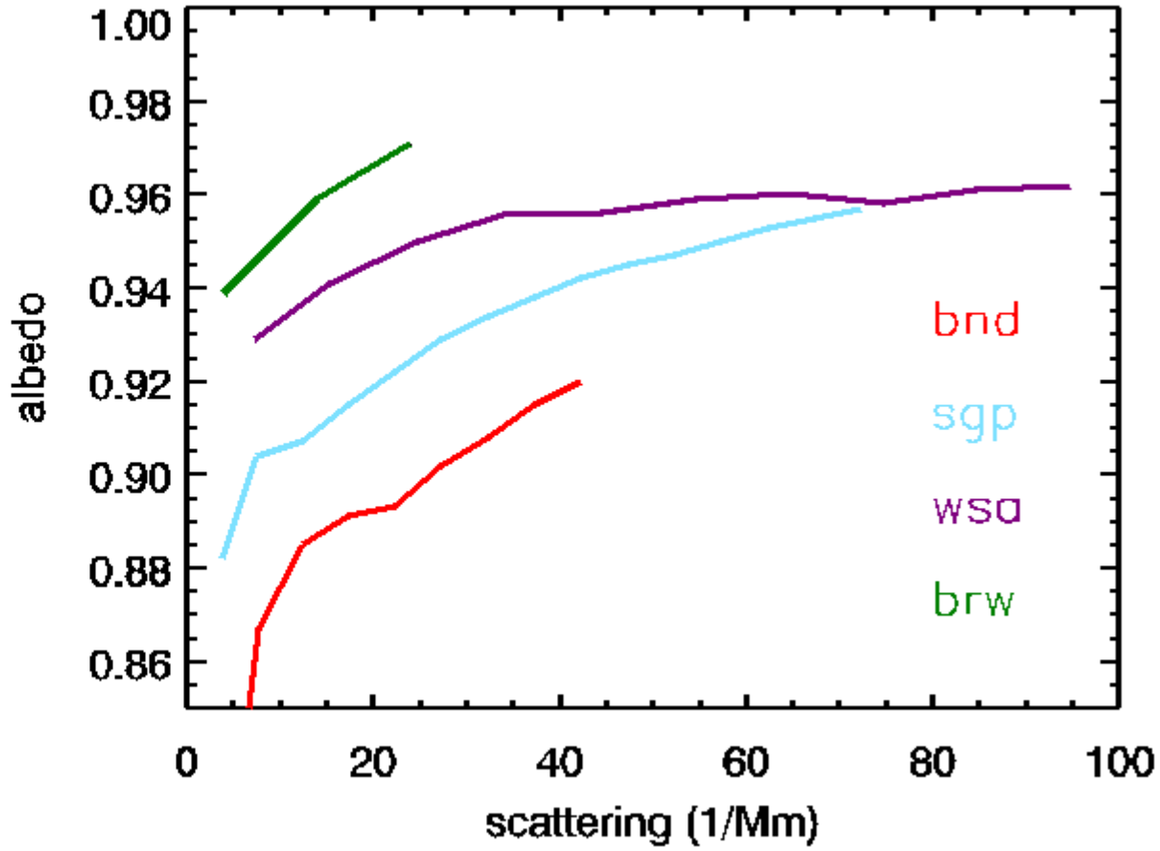
Comparisons of this type are valid when:

→similar measurements at the various sites

→sampling/measurement/data processing differences among sites are understood

Is Systematic Variability Related to Scavenging?



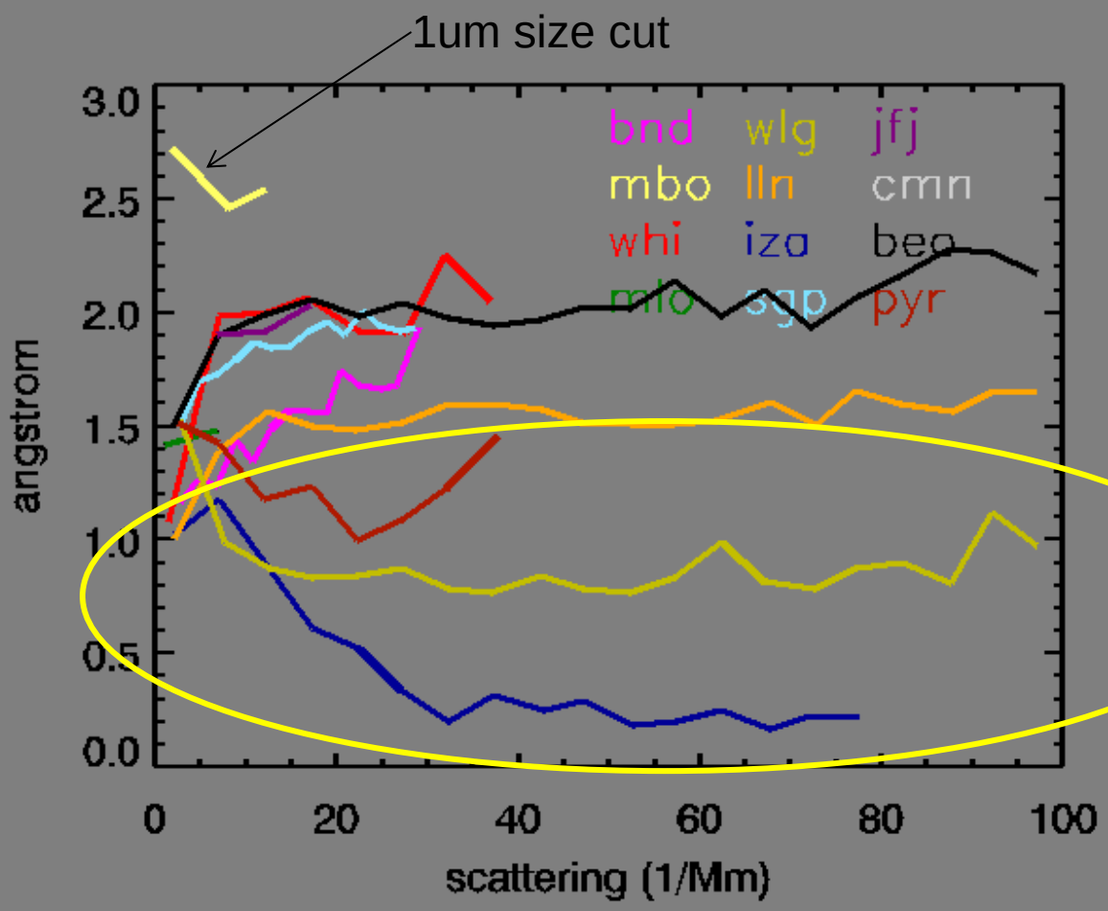


The relationship between Angstrom exponent and scattering appears to be a function of the type of aerosol – WSA and BND are marine sites; BND and SGP are rural continental sites.

Data from a wide range of places show similar behavior: the lowest single-scattering albedos and occur under the cleanest conditions for that site.

Free Troposphere Studies

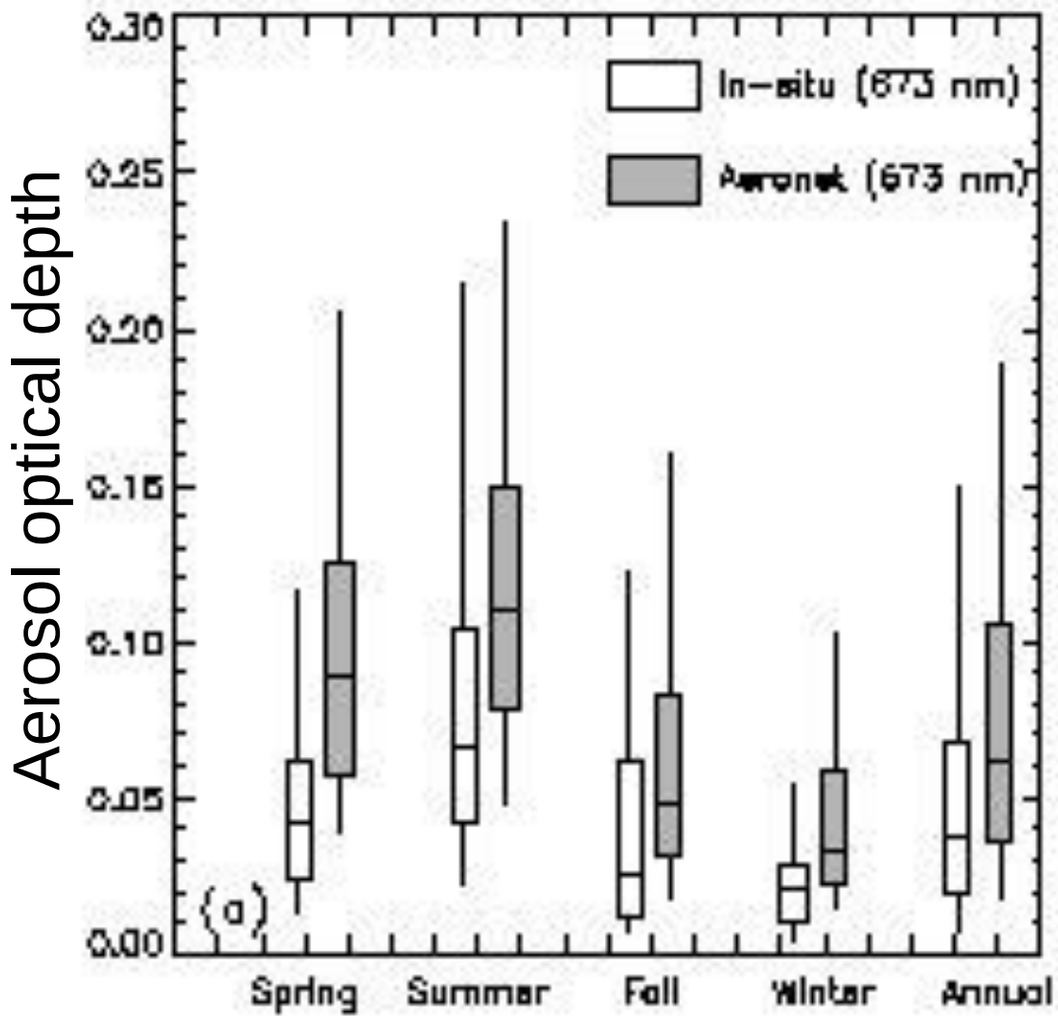
Sites between 2.2 and 5.1 km

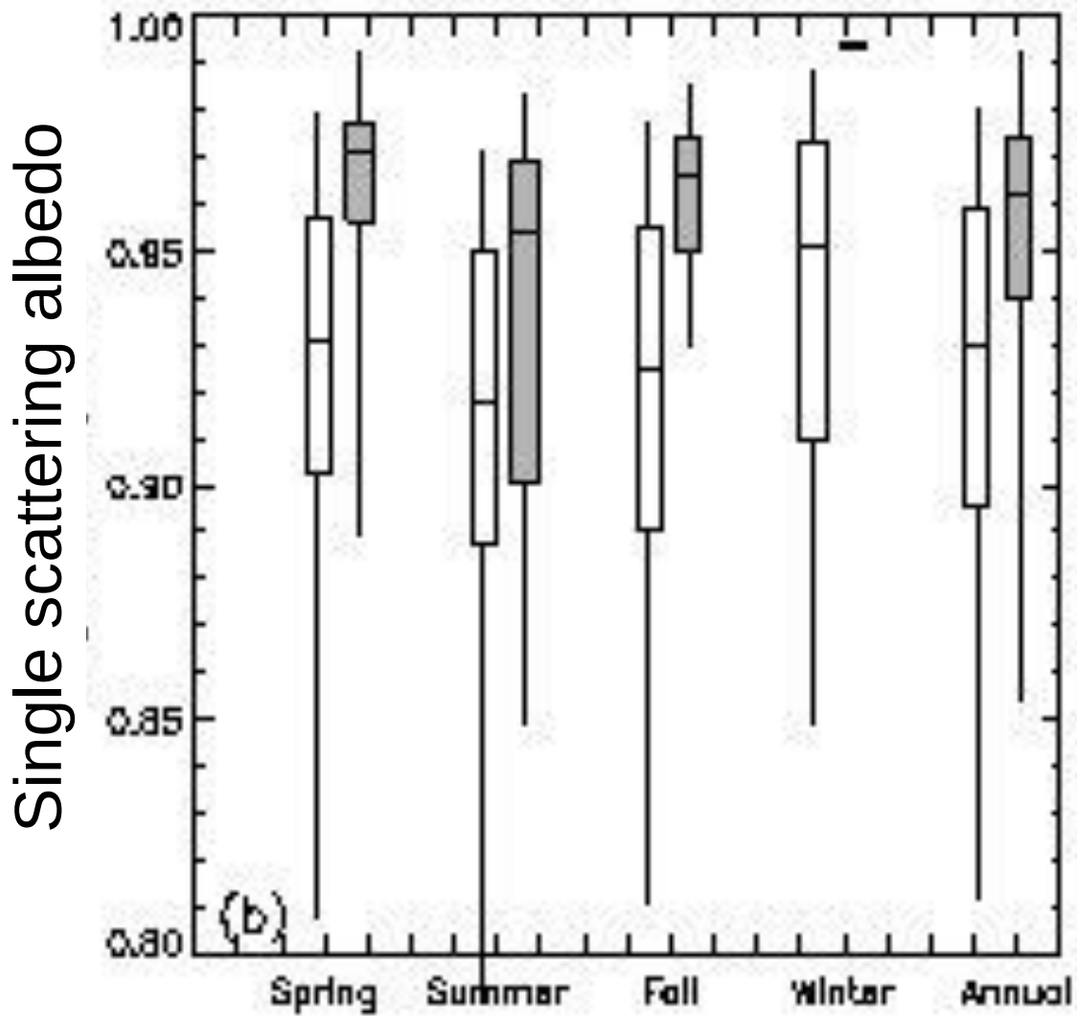


Aerosol type influences relationship between Angstrom exponent and amount (scattering)

These three sites (IZA, WLG, PYR) impacted by dust.

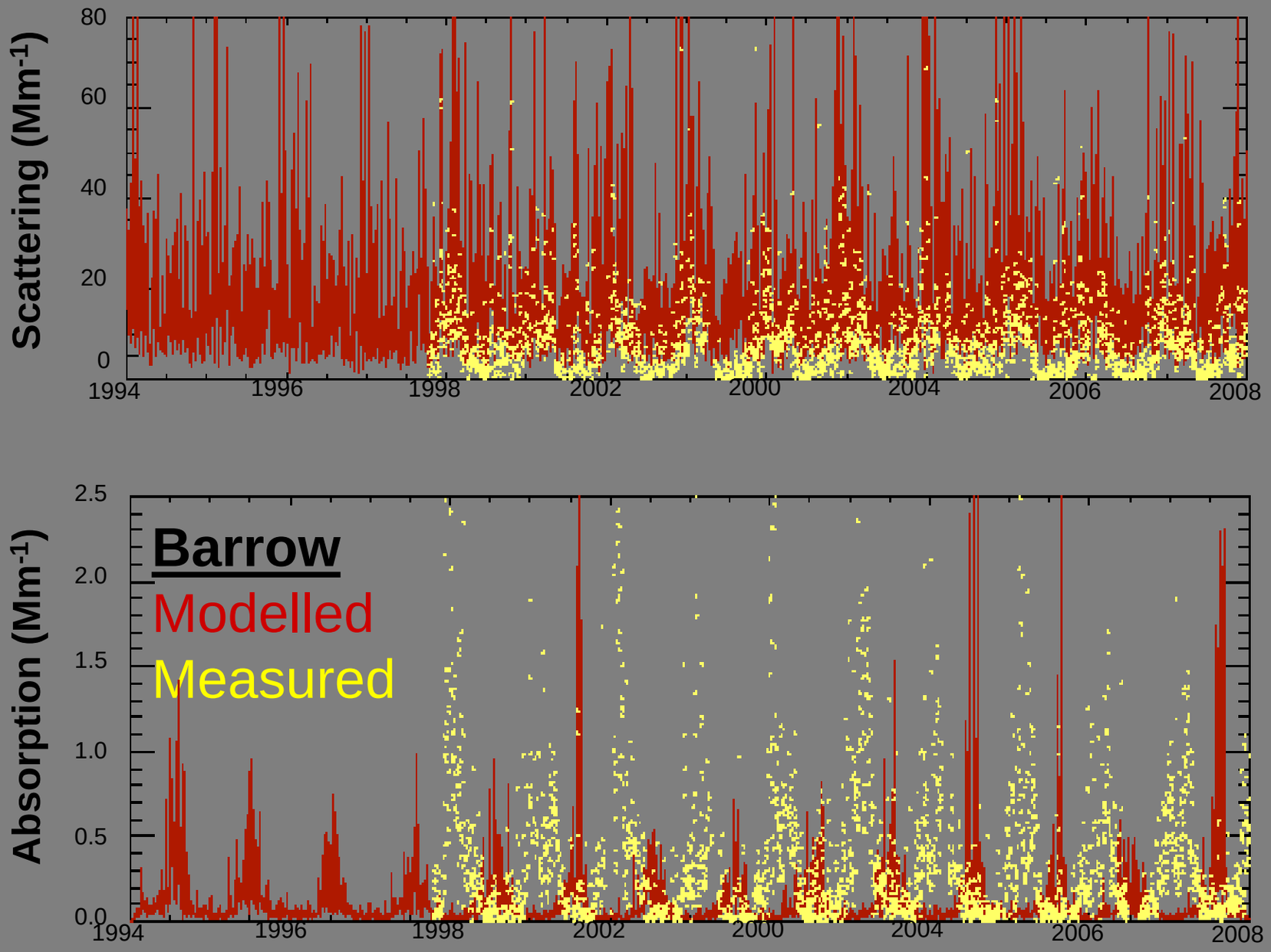
Free Troposphere Studies





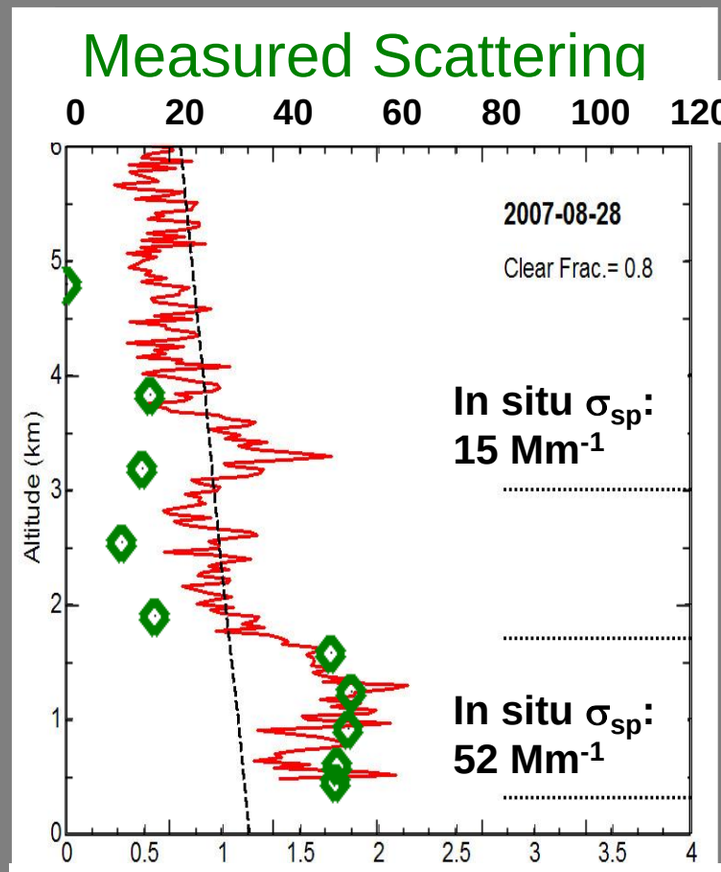
Validation Studies

Model validation



Model results differ from measurements:
--source strength/timing
--transformation and removal mechanisms
--transport

Satellite validation



CALIPSO
Attenuated Backscatter

Satellite/in-situ comparisons
–different sensitivities
–different resolution (x,y,z,t)

A Collaborative Global Aerosol Monitoring Network Model

NOAA/ESRL Approach:

- Find partners with scientific interest in long-term aerosol measurements (university researchers, other government agencies, other countries, etc.)

- Provide partners with:
  - proven designs for aerosol sampling infrastructure (e.g., characterized inlet systems)
  - standardized support hardware, as funding allows (e.g., racks, modular components for sample conditioning and data acquisition, housekeeping data sensors)
  - standardized operating procedures (ops manuals, checklists, etc)
  - GMD-developed and supported software for data acquisition, visualization, processing, editing, and archiving
  - Annual training and strategy sessions
  - Technical assistance in station operation

Collaboration Details

Collaborator supplies…

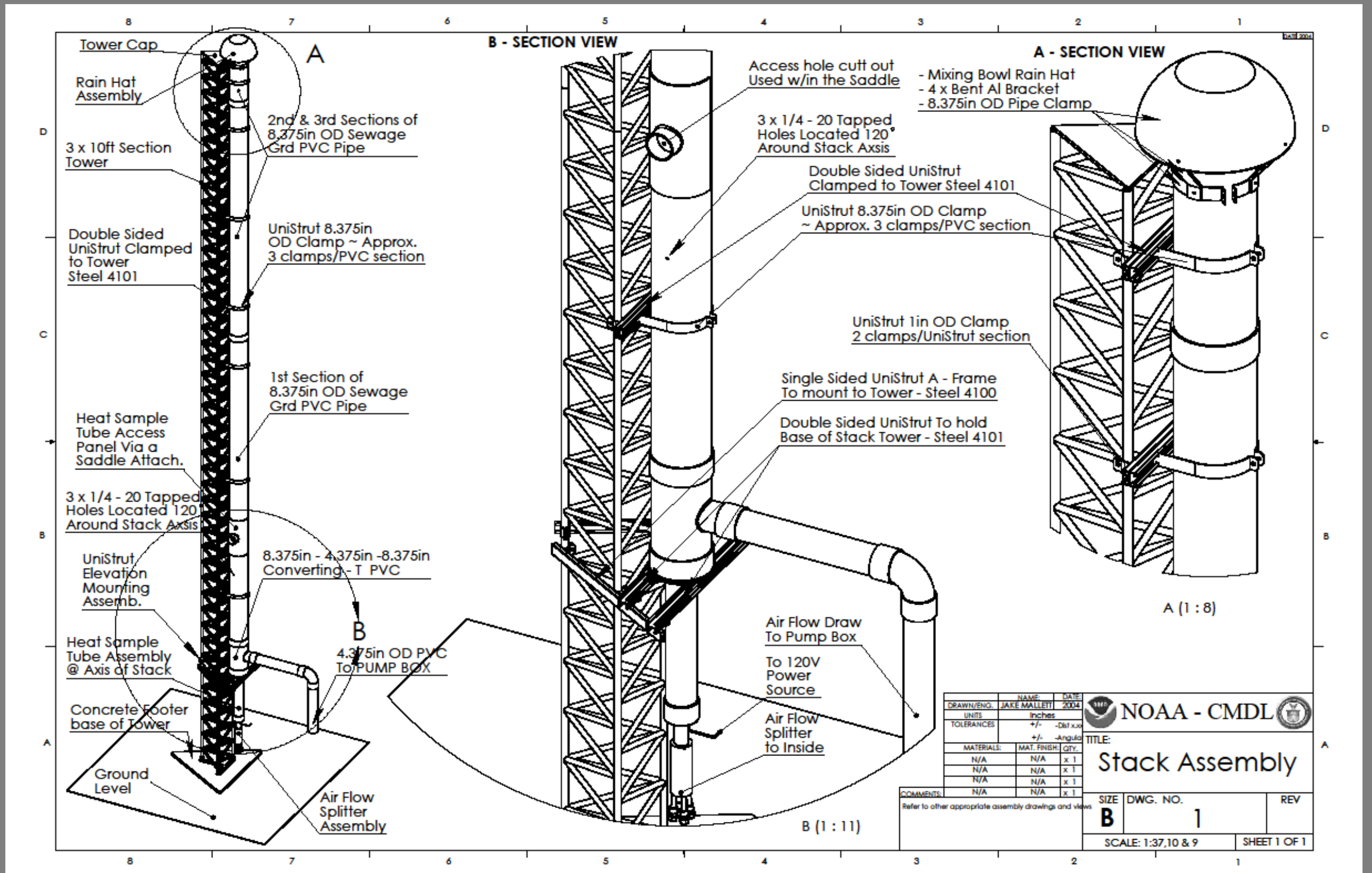
- **Commitment to long-term site operation**
- **Most of the equipment (i.e., major instrument systems)**
- **Station technicians for daily system checks, maintenance, troubleshooting, etc.**
- **Long-term station operation costs (site, power, internet, etc.)**
- **Data quality checking and editing**

Result: A long-term, cooperative program with shared data access, making atmospheric measurements that are directly comparable with the other stations in the network and following established aerosol sampling protocols (e.g., NOAA, GAW)

NOAA/ESRL supplies…

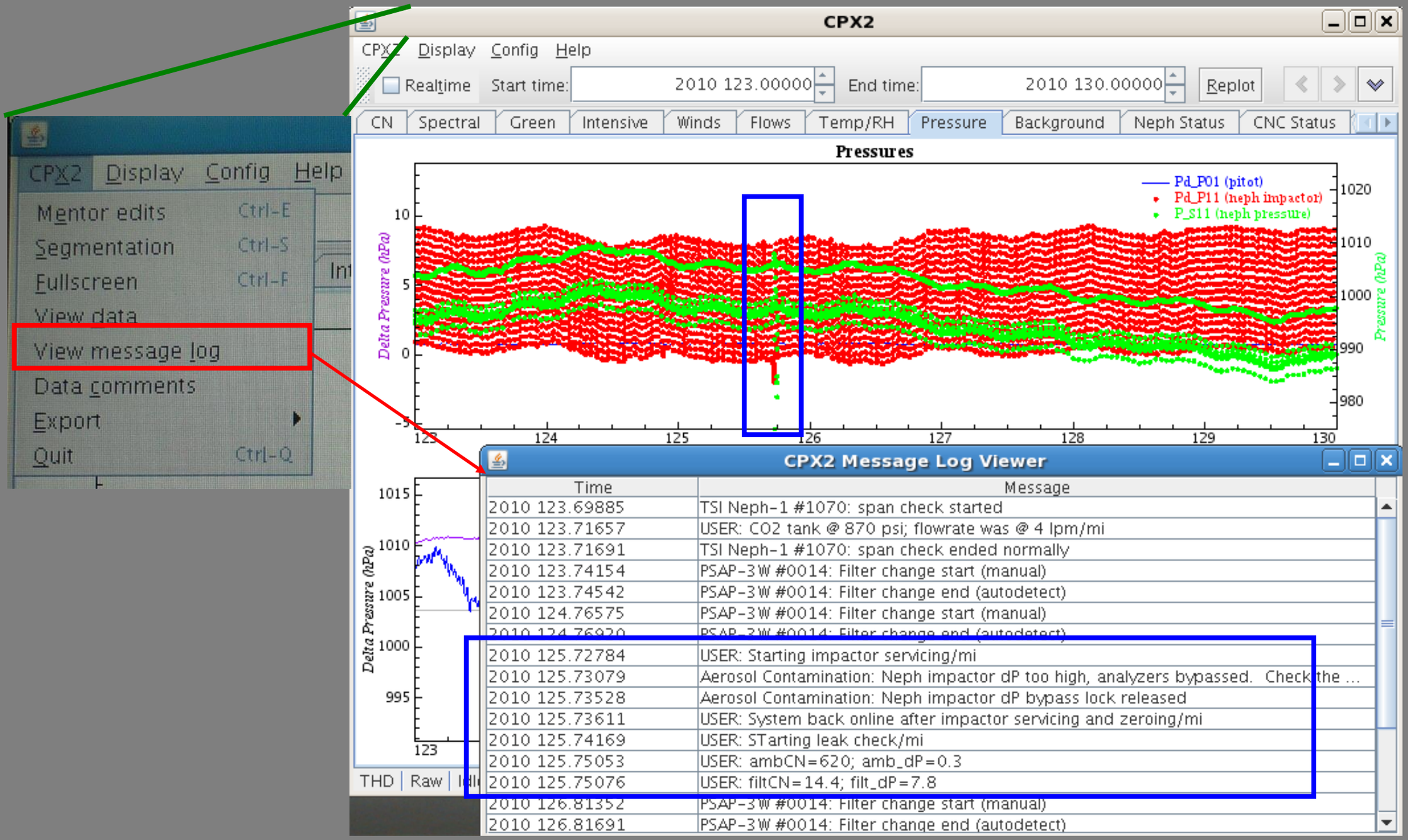
- **Site visit(s), design assistance**
- **Initial installation assistance and instrument calibrations**
- **Some equipment (e.g., support hardware)**
- **Training (hardware, software, data editing, etc.)**
- **Automated data processing, including all known corrections for the measurements**
- **Data visualization and editing software**
- **Future assistance and troubleshooting support**

Provide Engineering Drawings to Collaborators



ftp://ftp.cmdl.noaa.gov/aerosol/doc/drawings

Data Visualization/Data Editing Software



Time and cost *_estimates_* Basic aerosol system

Installation costs (~185K):

50K NOAA labor and set-up
(includes several trips to site for installation and operations training)

25K Non-instrument system parts (e.g., pumpbox, controllers, etc)

110K Instruments (includes nephelometer, PSAP, CN)

Note: our data acquisition and editing software is freely available on the web. If you have a spare computer and any of the instruments for which we've developed modules you could start logging data now. However, it's the ancillary items (inlet, sample conditioning, etc.) which help create a consistent data set.

Post-installation time commitment (provided by collaborators):

→site visit at least 1x/week for instrument maintenance (2-4 h of active time)
→daily data inspection (10 min active time) (not at site)
→weekly data editing (30 min active time) (not at site)
→troubleshooting (with NOAA help) as needed

Summary of NOAA Collaboration Benefits

- Collaborations benefit both NOAA and collaborators
- Improved data quality across network stations
- Ensure measurement comparability
- Economies of time and scale – no need to reinvent the wheel!

  - Proven design of sample inlet and sample conditioning system
  - Construction and fabrication drawings are provided
  - Dedicated data acquisition/control system for all instruments
  - A single time stamp for all recorded measurements
  - Easy to use data visualization/data editing tools
  - Known corrections to measurements are automatically and consistently applied
  - Raw and final data are archived at NOAA and collaborator's institute
  - Final raw and processed data can be automatically translated into proper format for ingest into GAW/WDCA data archive.

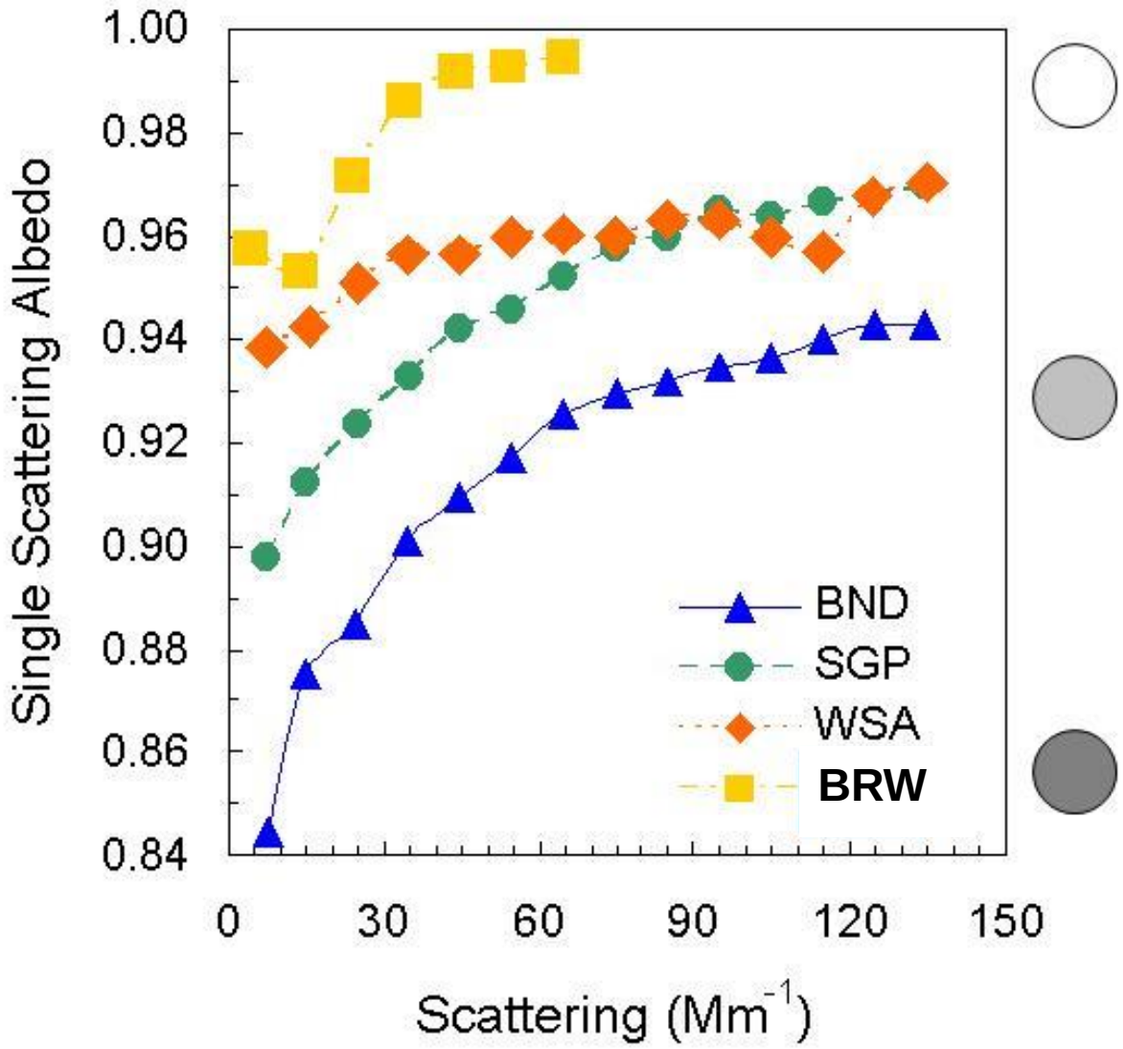
Collaborators

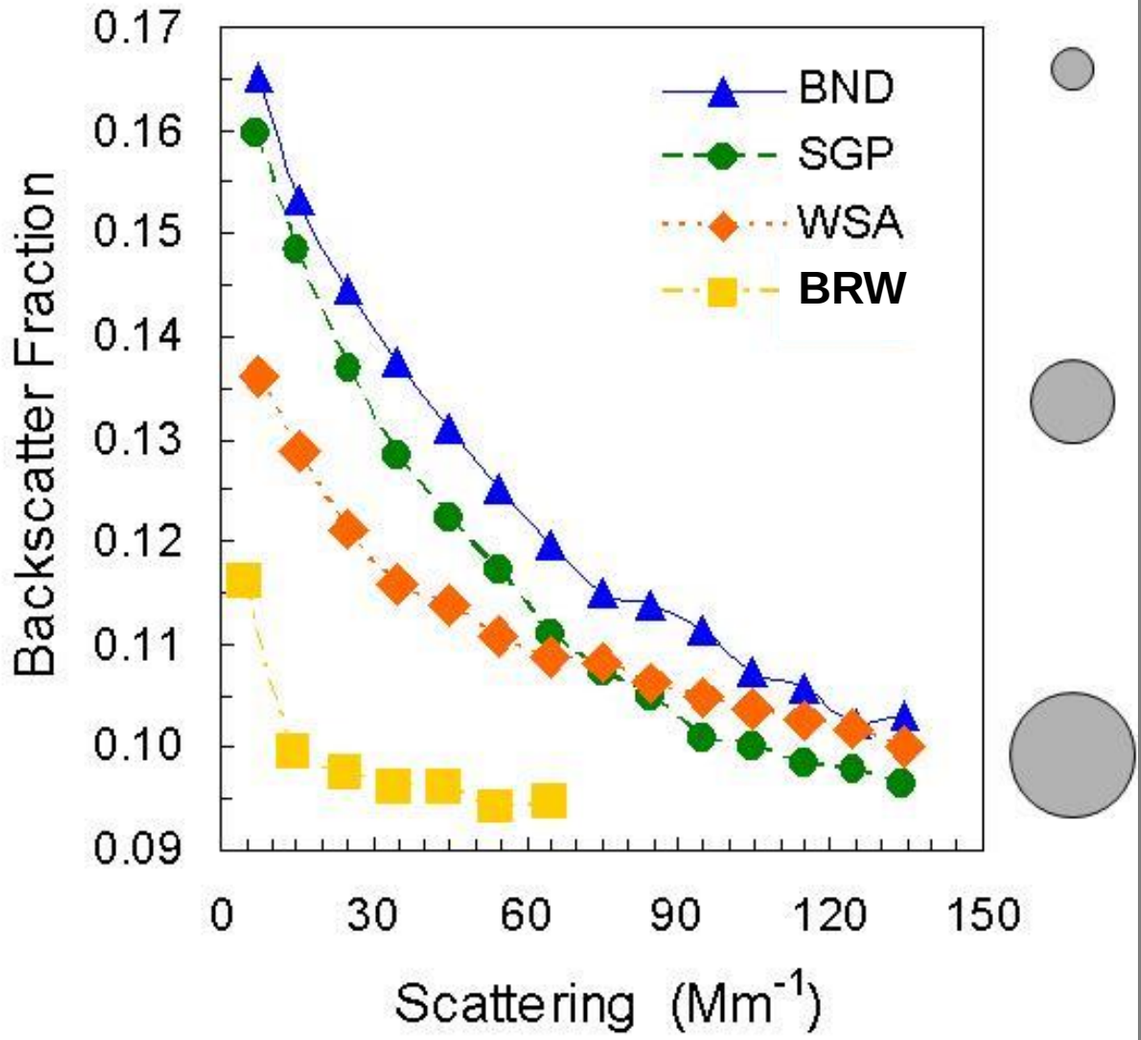
- **DOE Atmospheric Radiation Measurement Program (SGP, NIM, FKB, HFE, GRW, SPL, AMF (India))**
- **Environment Canada (WSA, ALT, ETL, EGB, WHI)**
- **WMO Global Atmosphere Watch Program (CPT, WLG)**
- **China Meteorological Administration (WLG, SDZ)**
- **South African Weather Service (CPT)**
- **University of Puerto Rico (CPR)**
- **University of Pannonia, Hungary (KPS)**
- **Taiwan Environmental Protection Agency (LLN)**
- **Taiwan National Central University (LLN)**
- **Bulgarian Academy of Sciences (BEO)**
- **Appalachian State University, North Carolina (APP)**
- **Instituto Nacional de Tecnica Aeroespacial (ARN)**
- **Korea Meteorological Administration (GSN, AMY)**
- **NOAA SEARCH Program (TIK)**
- **Roshydromet (TIK)**

Past sites
Present sites
Future sites


Thank you!

Is Systematic Variability Related to Scavenging?





(Delene and Ogren, 2002)

Surface and aircraft data from a wide range of places show similar behavior: the lowest single-scattering albedos and highest backscatter fractions occur under the cleanest conditions for that site.

Need for standardization of sampling methods, data acquisition, data processing, data QC editing, etc.

Standardization Issues (a few of many):

- Minimum inlet height above ground or canopy?
- Sampling line sizes, materials, pickoffs, and flow rates optimized to promote maximum passing efficiency for particles of interest?
- RH control?
- Particle size cuts?
- Measurement observation frequency?
- Has a common, non-drifting time stamp been applied to all instruments?
- Measurements reported at what conditions (e.g., instrument, ambient, standard)?
- What instrument corrections been applied?
- Have editing strategies been discussed for consistency between different users?

Data Acquisition/Instrument Control Software

ftp://ftp.cmdl.noaa.gov/aerosol/etc/cpd/cpdlive.iso

NOAA/GAW Aerosol Data Flow

Field data system

NOAA server

ftp

ssh + VNC

ssh + VNC

ftp

ssh + rsync

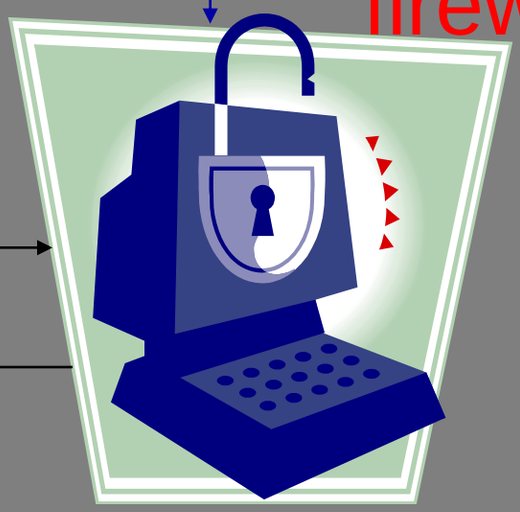
firewall

WDCA archive

ftp

ssh + NX

sftp



World Data Center for Aerosols

Site operator

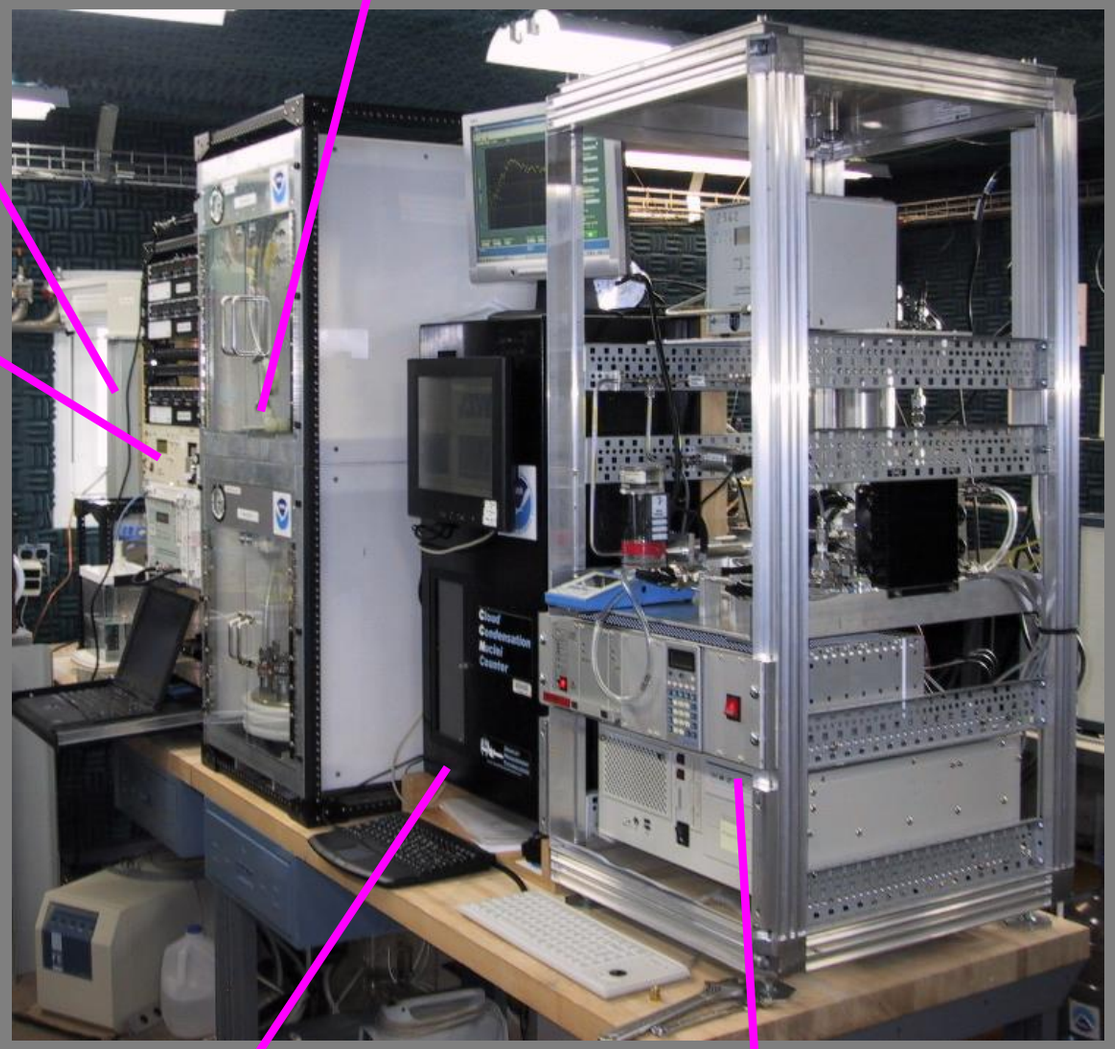
GAW workstation at NOAA

Expanded aerosol sampling system (Barrow, AK)

Nephelometers and humidograph system
Scattering, backscattering, hygroscopicity (f(RH))

Aerosol chemistry
Inorganic ions and organics

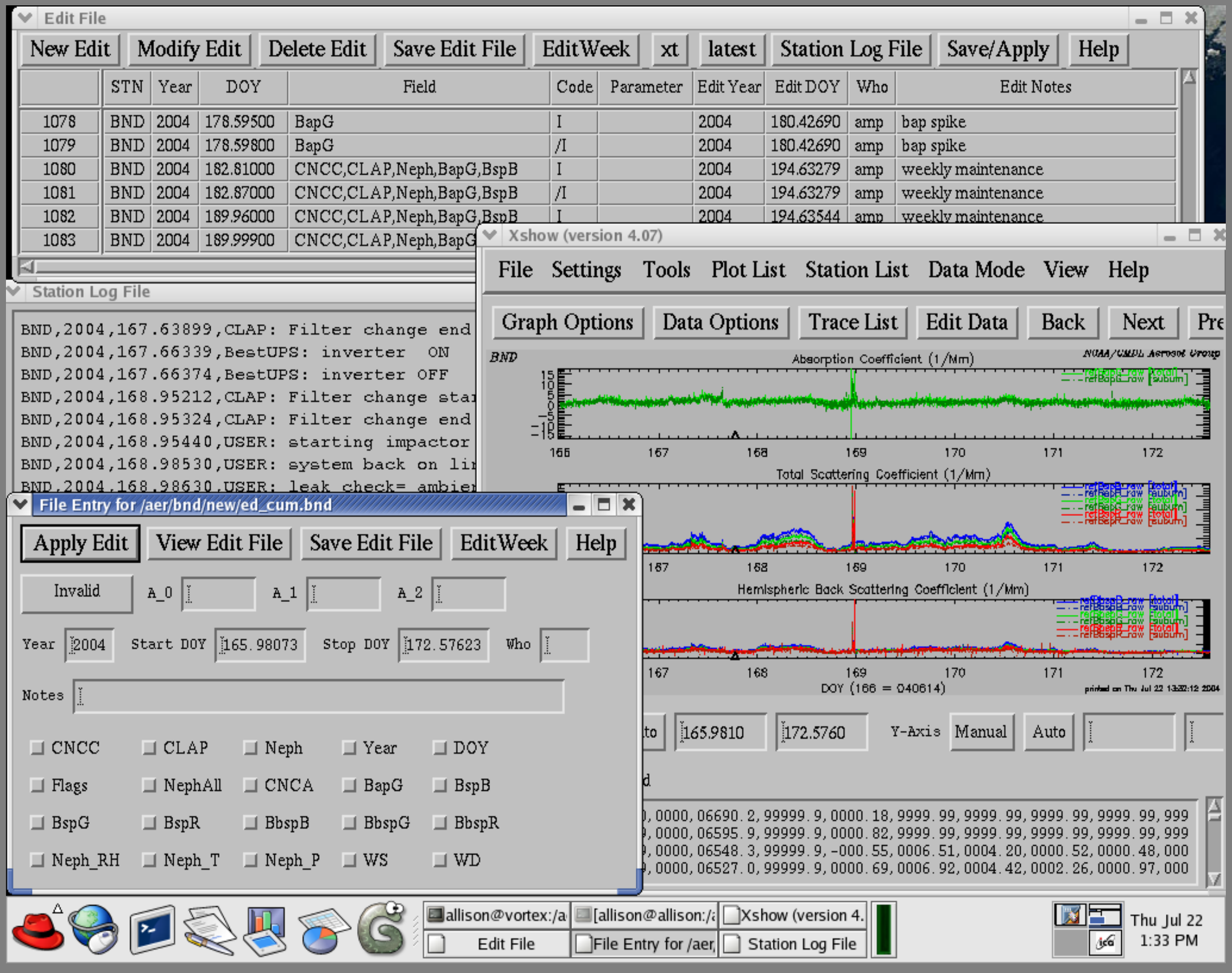
PSAP and CPC
Absorption and N_{CN}



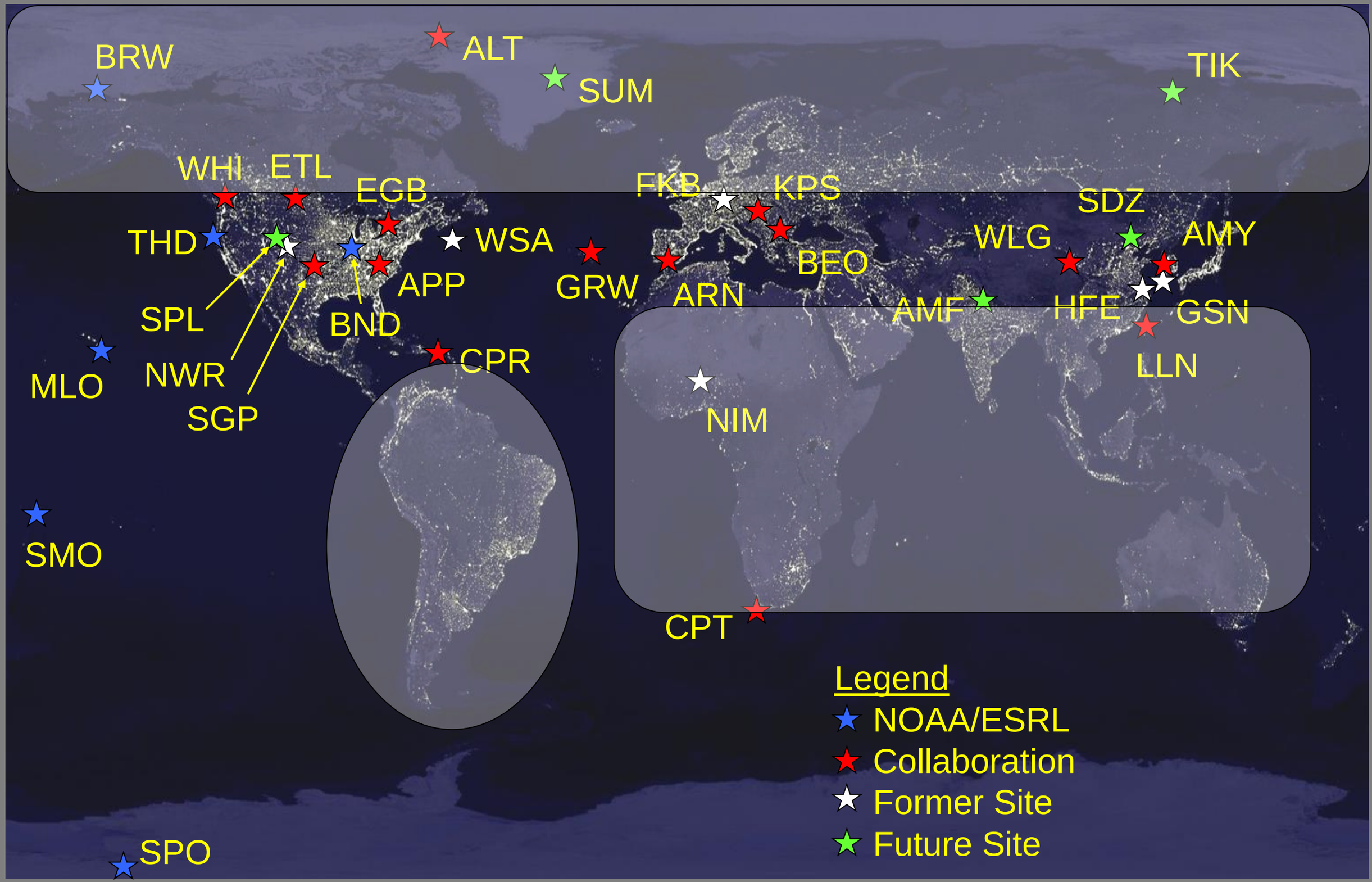
Cloud condensation nuclei counter
N_{CCN} as f(SS)

Aerosol size distribution

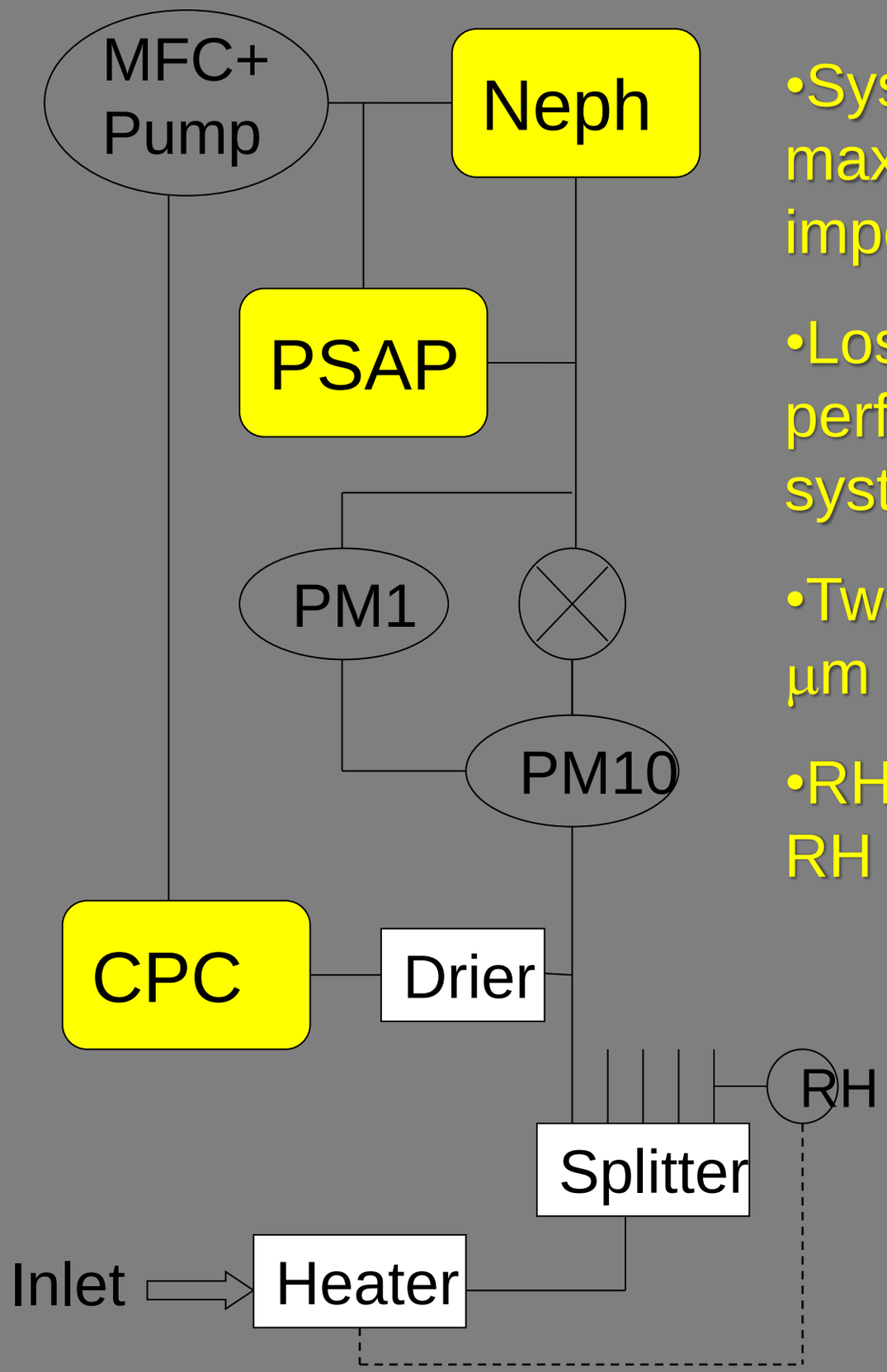
Data Visualization/Data Editing Software



Network Gaps

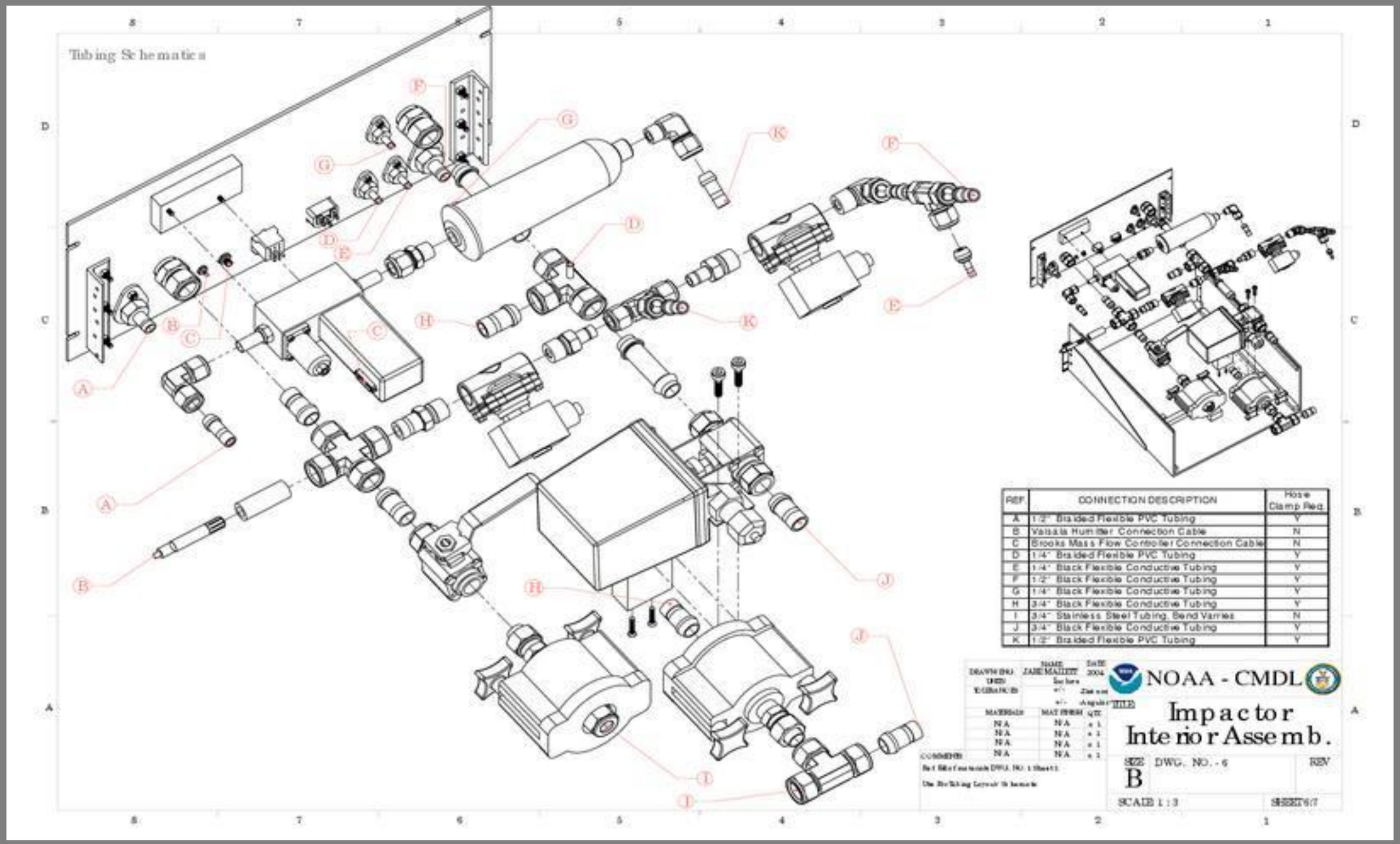


NOAA Basic Aerosol Sampling System



- System flow rates are designed to maximize passing efficiency of optically important particles.
- Loss calculations have been performed for all parts of the inlet system
- Two size cuts: Dp < 1 μm and Dp < 10 μm
- RH control to keep a low and stable RH in the system

Construction Schematic (example)



REF	CONNECTION DESCRIPTION	Hose Clamp Req.
A	1/2" Braided Flexible PVC Tubing	Y
B	Vaisala Humitter Connection Cable	N
C	Brooks Mass Flow Controller Connection Cable	N
D	1/4" Braided Flexible PVC Tubing	Y
E	1/4" Black Flexible Conductive Tubing	Y
F	1/2" Black Flexible Conductive Tubing	Y
G	1/4" Black Flexible Conductive Tubing	Y
H	3/4" Black Flexible Conductive Tubing	Y
I	3/4" Stainless Steel Tubing, Bend Varries	N
J	3/4" Black Flexible Conductive Tubing	Y
K	1/2" Braided Flexible PVC Tubing	Y

ftp://ftp.cmdl.noaa.gov/aerosol/doc/drawings