A Five Year Review:
Climatology of Aerosol Optical Properties from Storm Peak Laboratory

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Storm Peak Laboratory

DRI Desert Research Institute

Storm Peak Laboratory

Located on Steamboat Springs Ski Resort

Elevation: 3220 m Pressure: ~ 690 mb

In cloud ~25% of time in winter

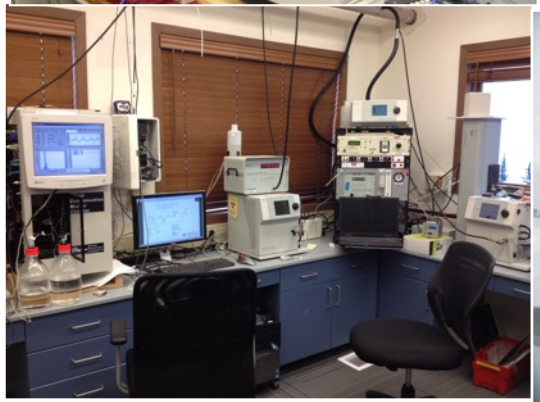
Mixed Phase Clouds

9 Person Bunkhouse, Full Kitchen

Facility and Guest Instruments

Wet Chemistry Lab

DRI
Desert Research Institute

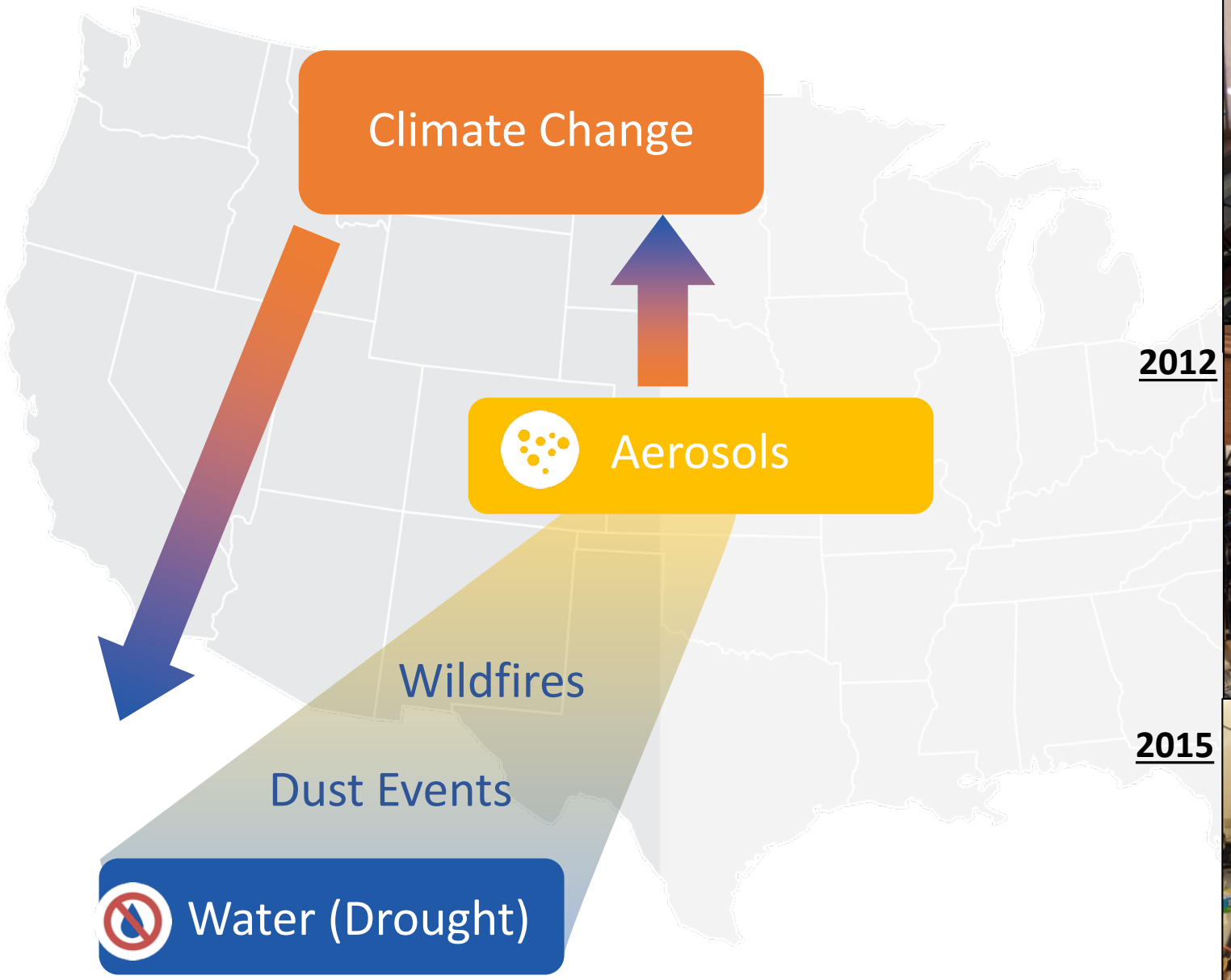


2011 Established as GMD Aerosol Group and WMO Global Atmospheric Watch Regional Station

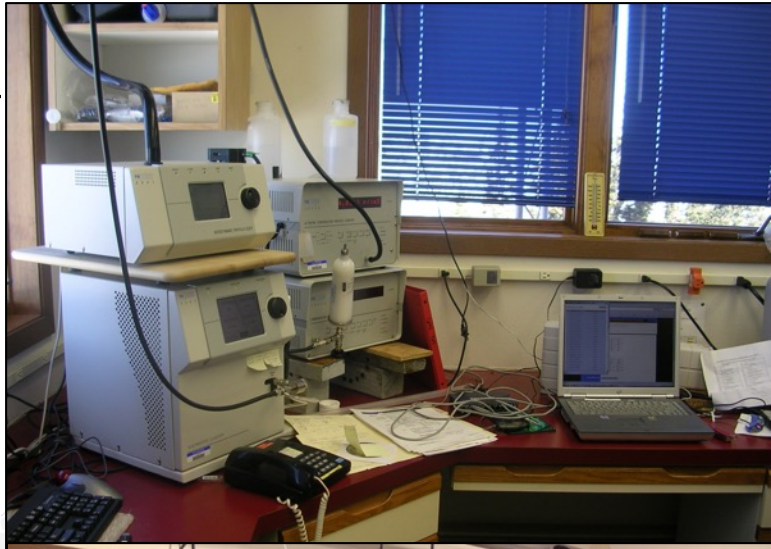
Annual Site visits included Calibration and Improvements

DRI Long Term Instrumentation:
CPC, UCPC, PSAP, CLAP, Neph
SMPS, APS, CCN-C
UV/VIS MFRSR, MET
NCAR CO2
O_3, SO_2, NO_X
SSP-100, CIP, PIP

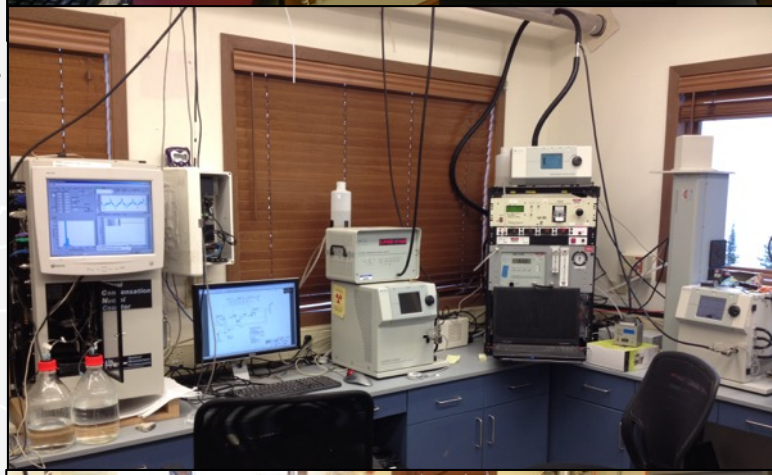
SPL Science Framework



2006



2012

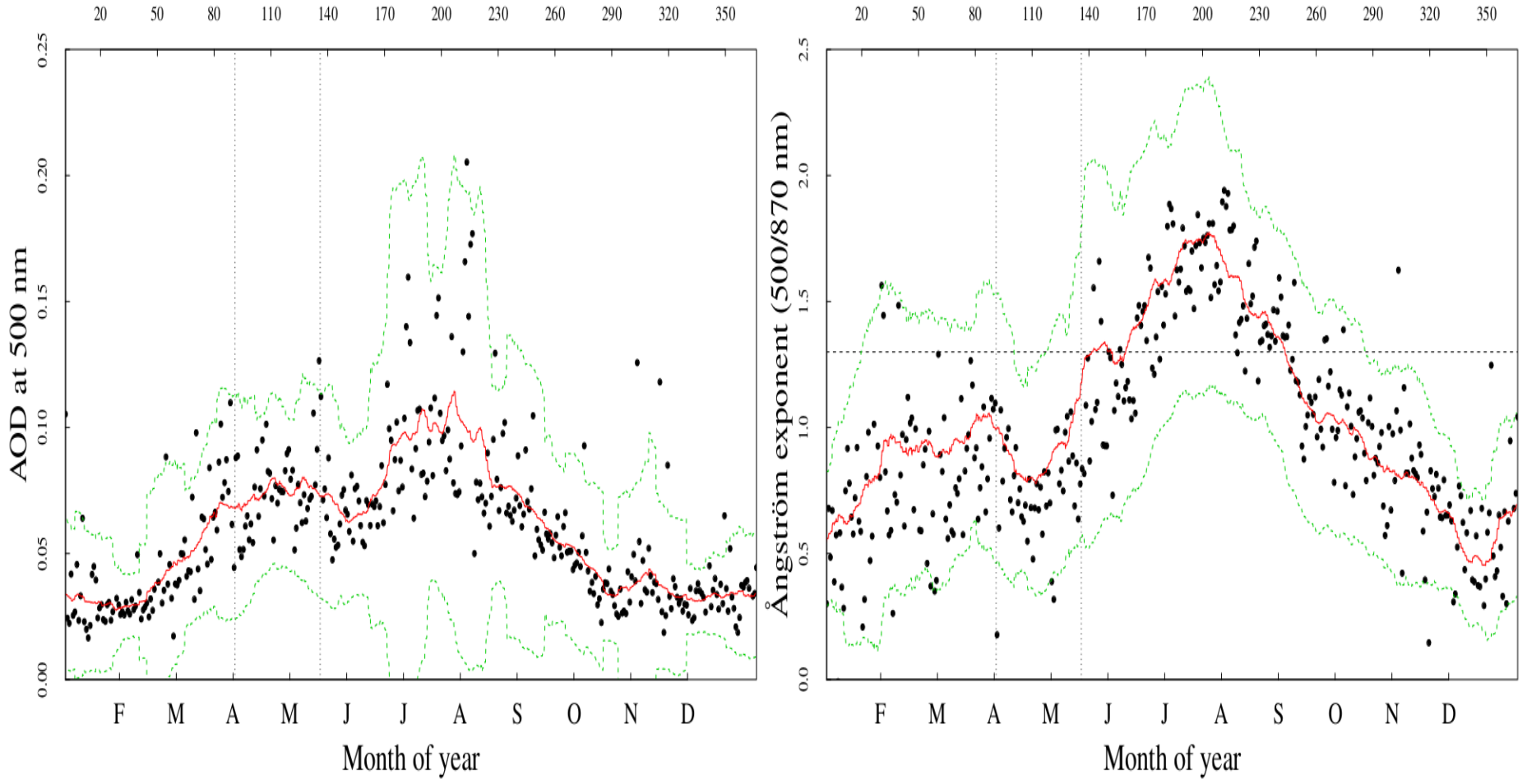


2015

Contributions of dust and biomass burning to aerosols at a Colorado mountain-top site

A. G. Hallar[1], R. Petersen[1], E. Andrews[2,3], J. Michalsky[2,3], I. B. McCubbin[1], and J. A. Ogren[2]

Atmospheric Chemistry and Physics
Atmos. Chem. Phys., 15, 13665–13679, 2015
www.atmos-chem-phys.net/15/13665/2015/
doi:10.5194/acp-15-13665-2015



- Summer fire signal strong in both in situ and AOD
- Spring dust signal weaker in situ than AOD
- Work enabled by cloud screening algorithm & student mentoring program with NOAA GMD Radiation Group.

Used α>1.3 to separate combustion sources from dust (Clarke and Kapustin, 2010; *Science*)

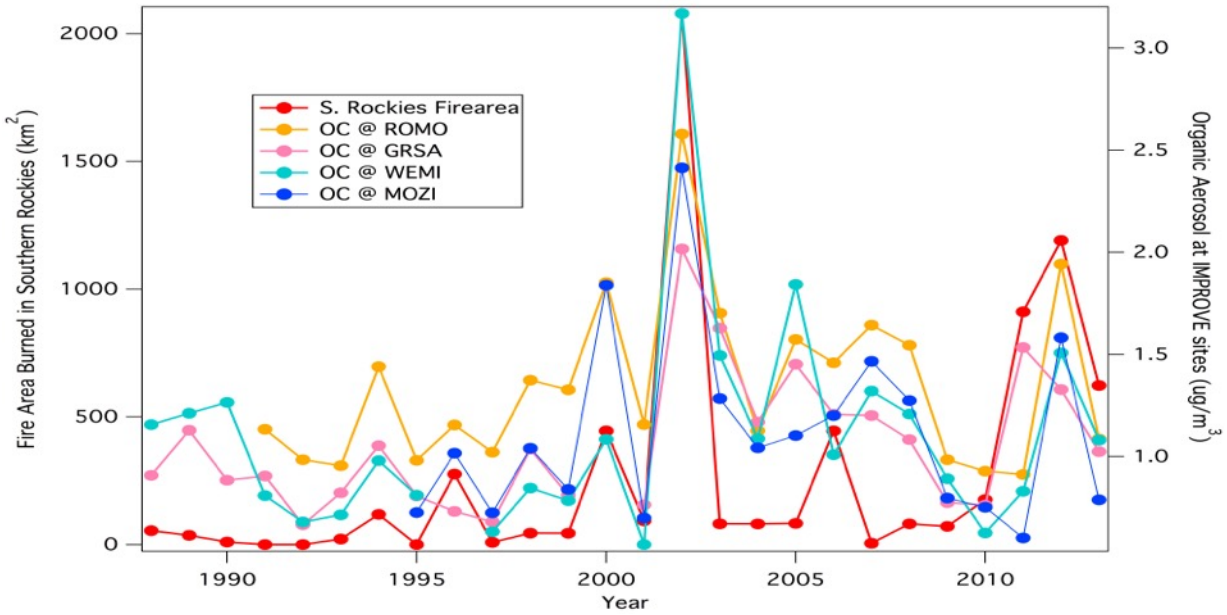
Link between Aerosol Loading and Fire Area

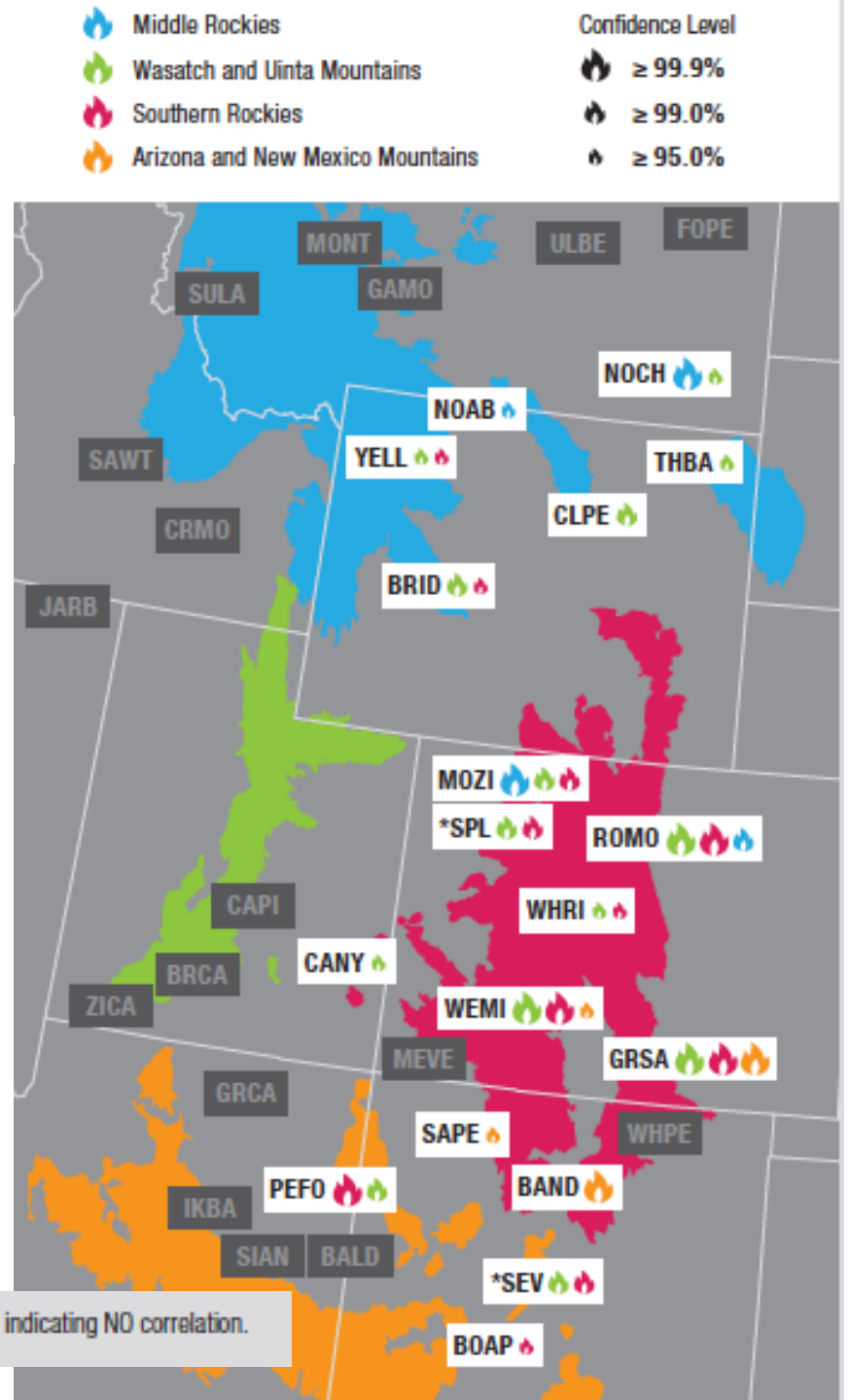
Impacts of increasing aridity and wildfires on aerosol loading in the intermountain Western US

A Gannet Hallar[1,2,3], Noah P Molotch[4,5], Jenny L Hand[6], Ben Livneh[7,8], Ian B McCubbin[3,5], Ross Petersen[1,3], Joseph Michalsky[7,9], Douglas Lowenthal[1,2] and Kenneth E Kunkel[10]

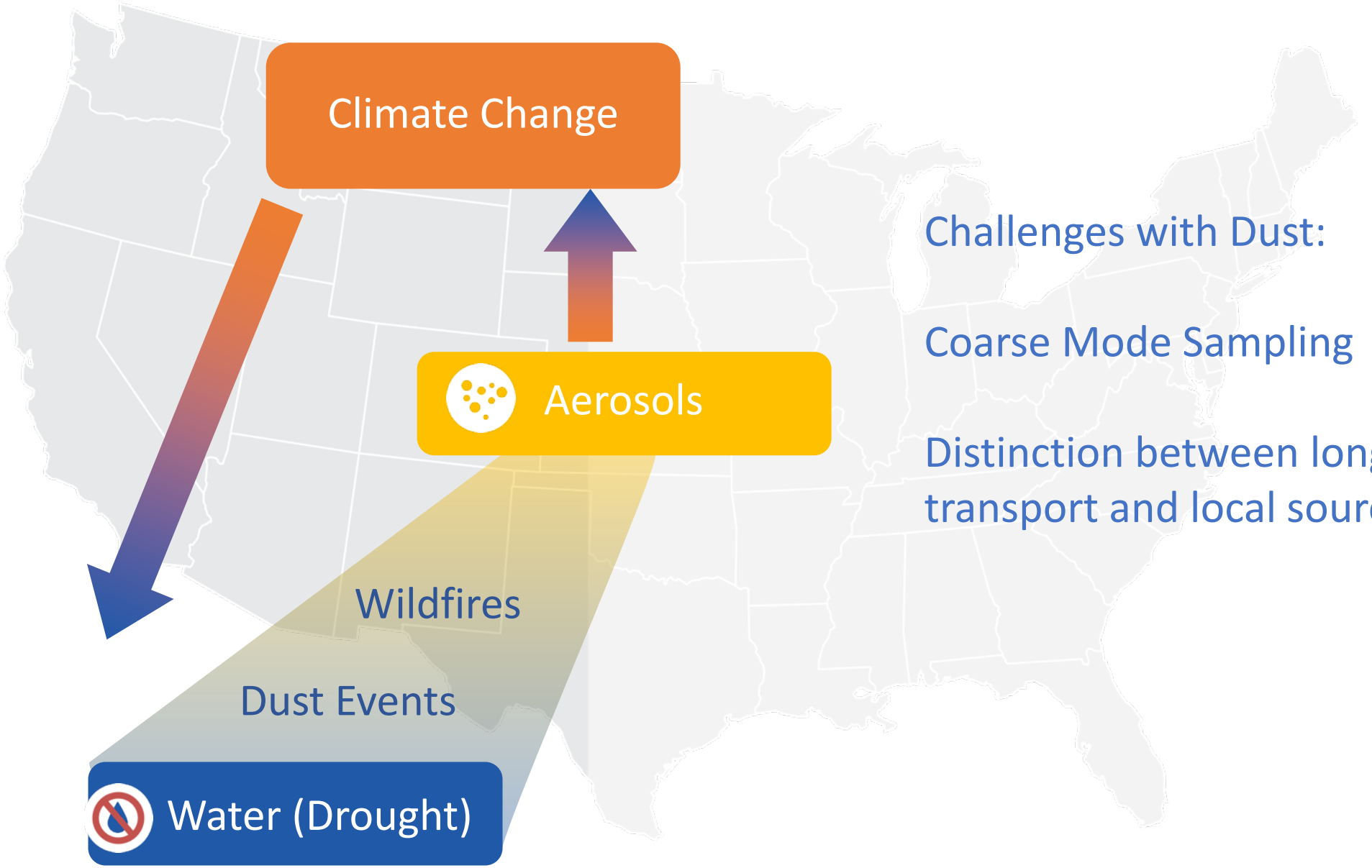
Environ. Res. Lett. **12** (2017) 014006

- GCMs predicted a fire area increase of 2.69 times
  - Increasing summer OC by 46% by 2050
- From the data presented we expect an increase in:
  - OC of 24±3% and 34±3% for Southern Rockies & Wasatch/Uinta Mts. by 2050





SPL Science Framework



Challenges with Dust:

Coarse Mode Sampling

Distinction between long range transport and local sources

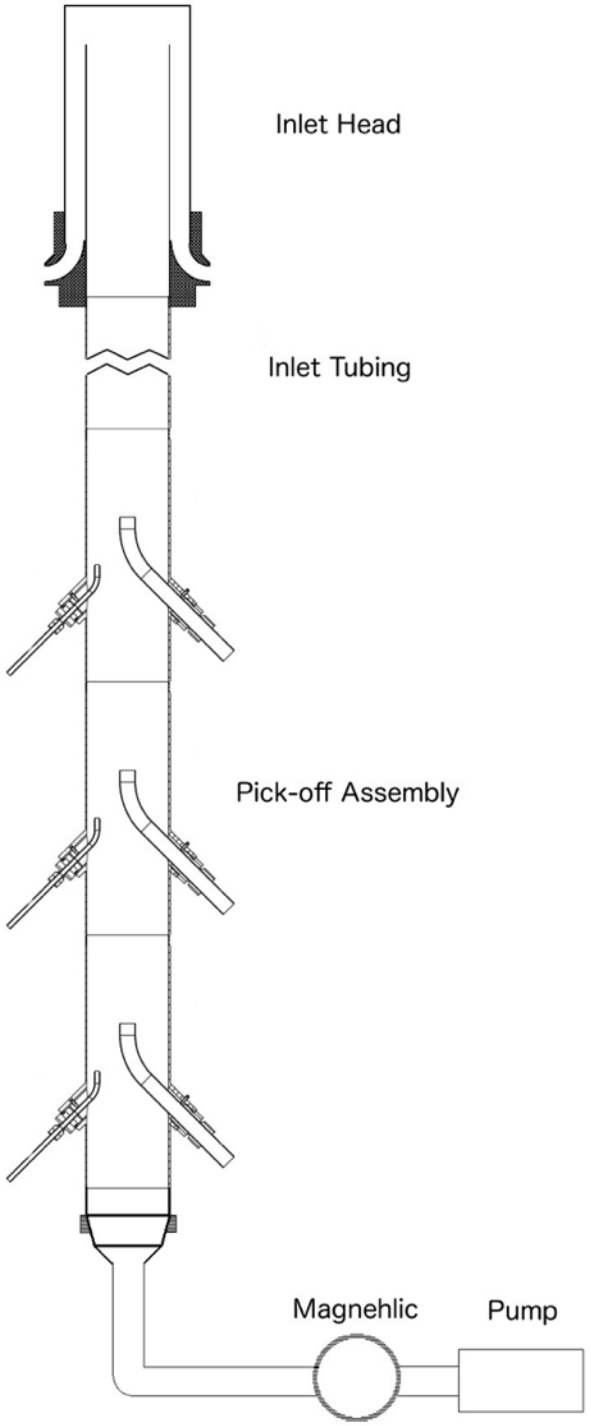
New Standard Ground Based Aerosol Inlet and Sampling Manifold System:

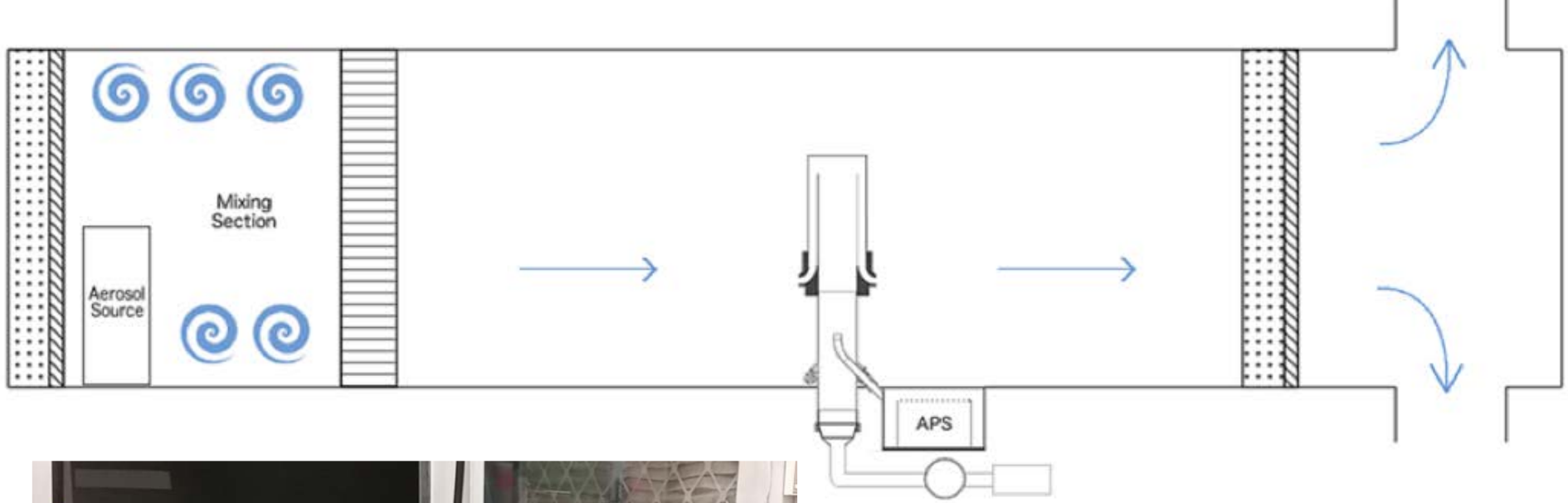
Initial Funding from NSF, and now supported by USTAR.

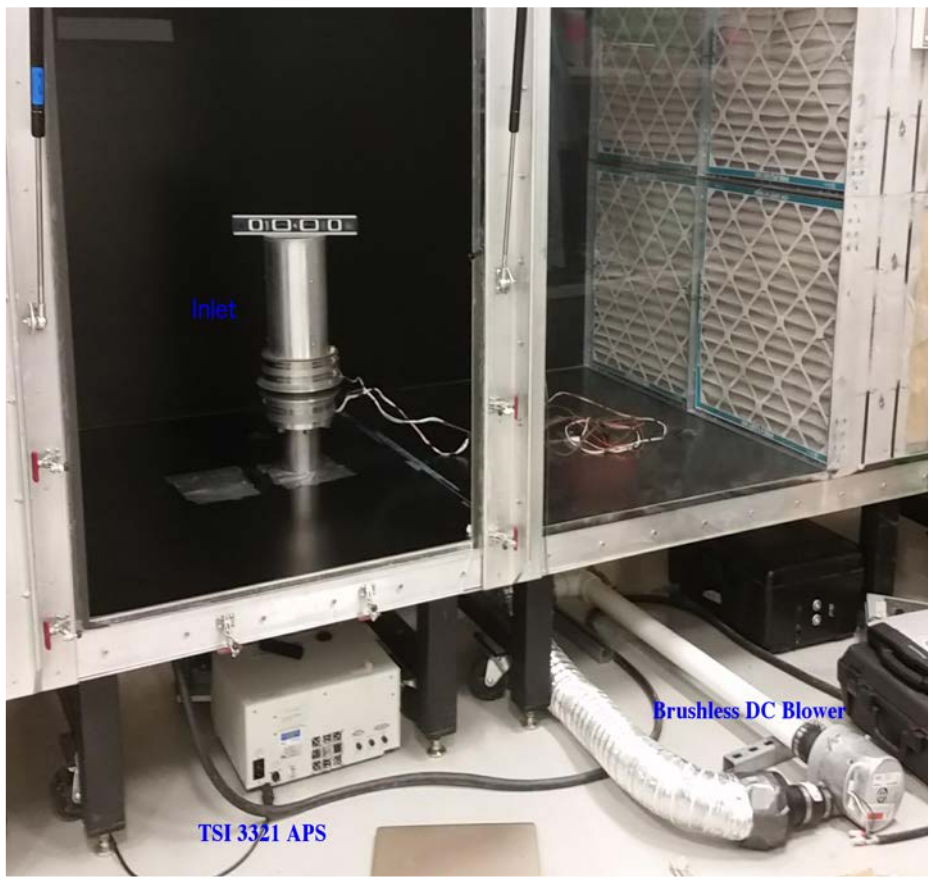
Designed in close Collaboration with NOAA Aerosol Group (J. Ogren)

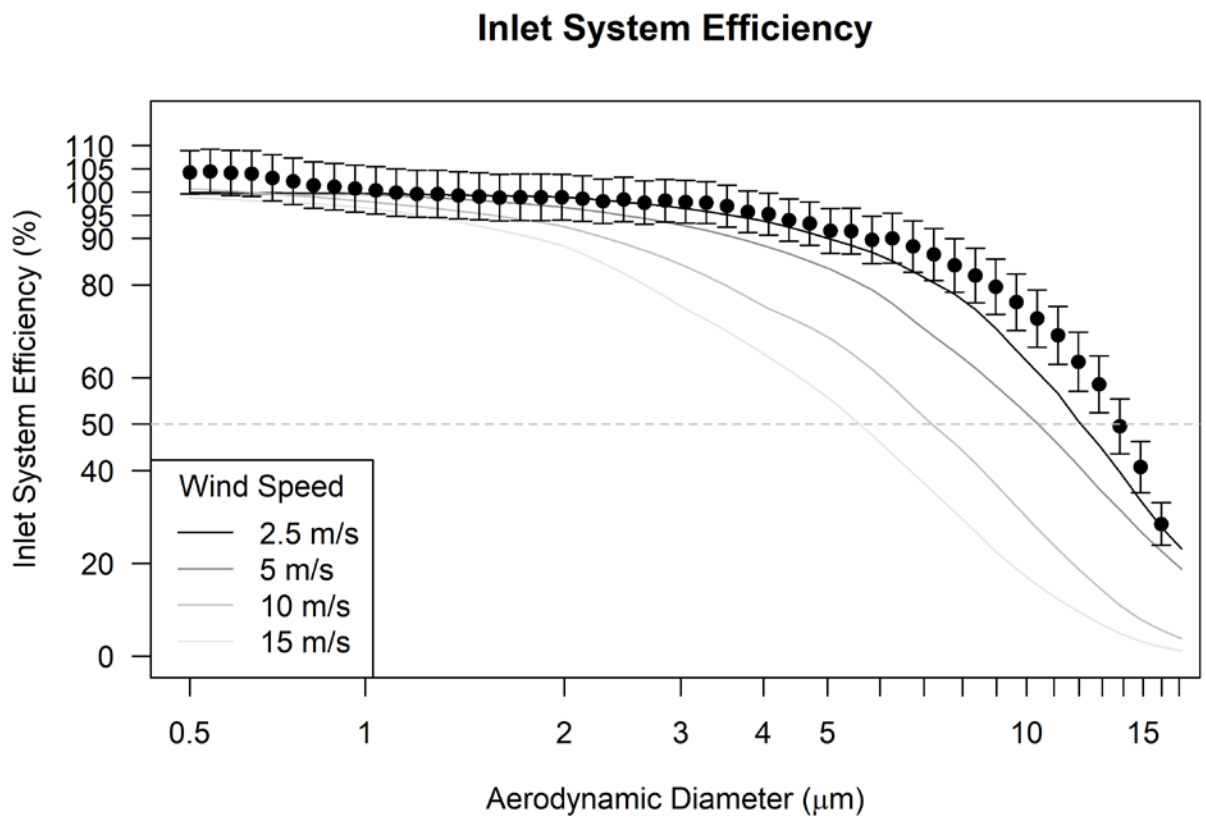
- ✓ Design
- ✓ Simulations
- ✓ Manufacturing (BMI)
- ✓ Installation
- ✓ Comparison to Prior System
- ✓ Wind Tunnel Verification

Completed!




Mixing
Section
Aerosol
Source
APS


Inlet
Brushless DC Blower
TSI 3321 APS

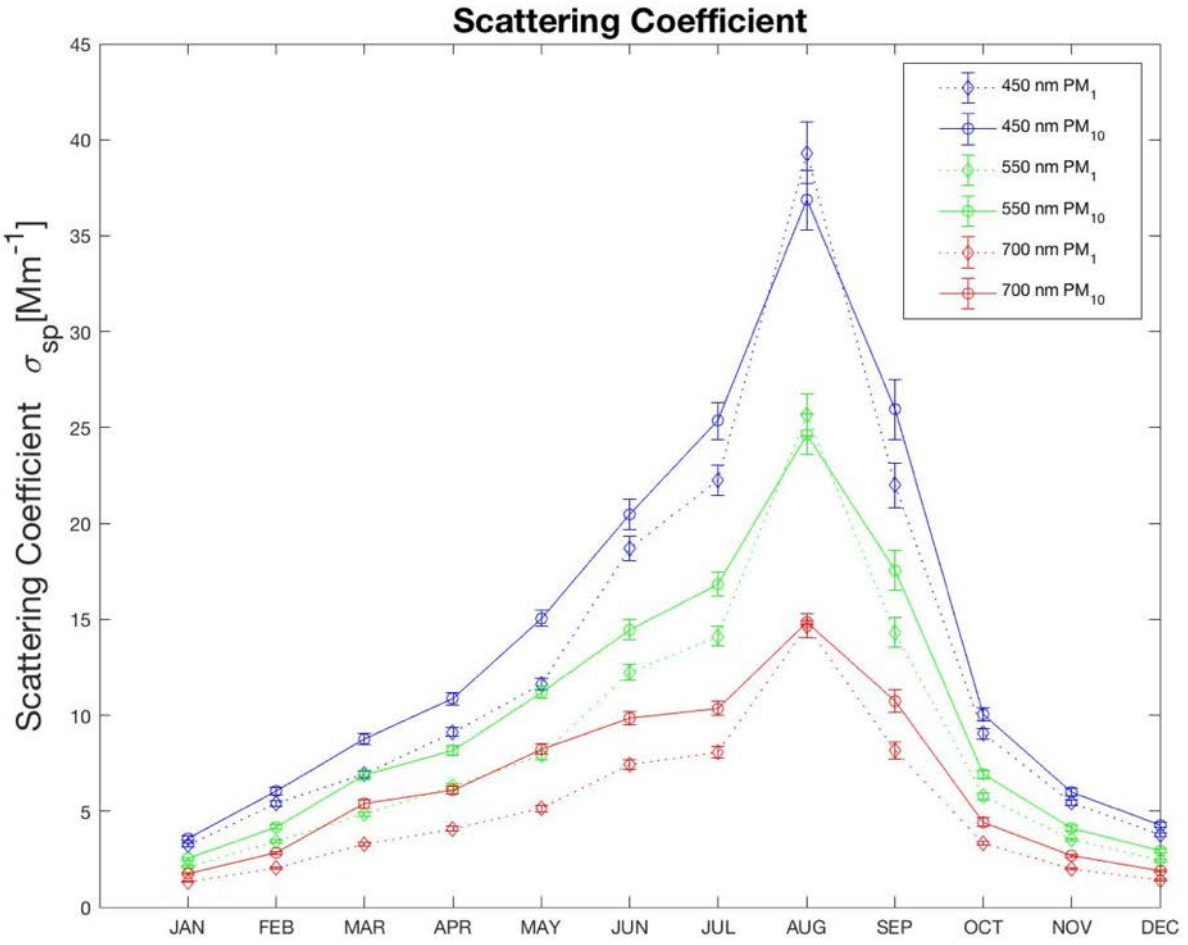

Inlet System Efficiency
Inlet System Efficiency (%)
110
105
100
95
90
80
60
50
40
20
0
Wind Speed
2.5 m/s
5 m/s
10 m/s
15 m/s
0.5
1
2
3
4
5
10
15
Aerodynamic Diameter (μm)

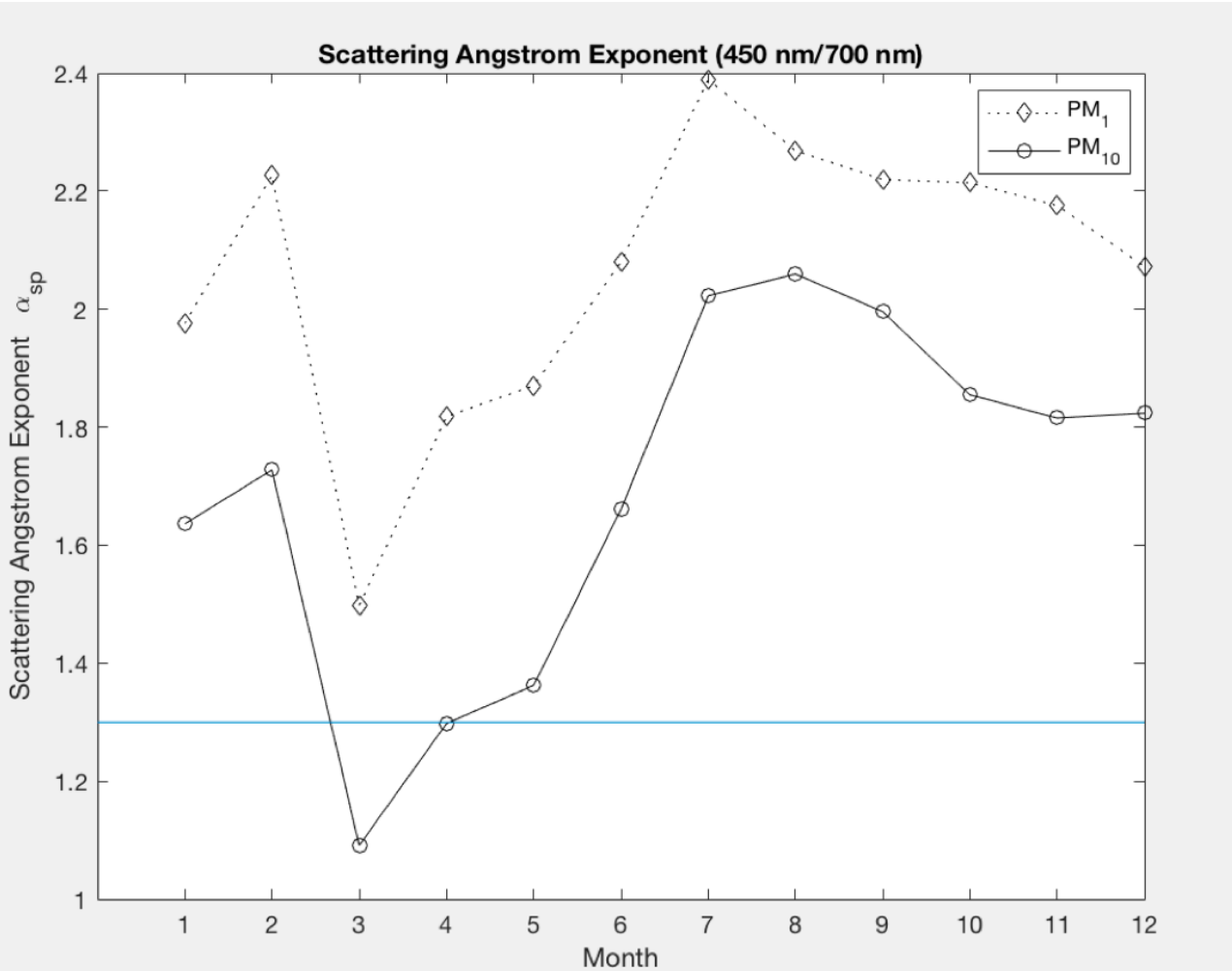
Seasonality of Aerosols at SPL 2011 – 2016

GMD system allowing continuous measurements

Confirms clear seasonality of dust in spring and fire signal in summer

Expands the climatology of dust events from the prior intermittent APS data via Nephelometer





Increase Accessibility to SPL Data due to GMD

Use of SPL Aerosol Concentration Data (from 1998-2017) after inputting into the GMD Aerosol database in 2012

Evaluation of Nucleation Parameterization

Makkonen, R., et al. (2014), Evaluation of Aerosol Number Concentrations in NorESM with Improved Nucleation Parameterization, *Atmos. Chem. Phys.,* 14.10, 5127-5152.

Yu, F., G. Luo, A. G. Hallar (2016), Vertical Profiles and Seasonal Variations of Key Parameters Controlling Particle Formation and Growth at Storm Peak Laboratory, *Aerosol and Air Quality Research*, 16(3), 900-908, doi:10.4209/aaqr.2015.05.0341

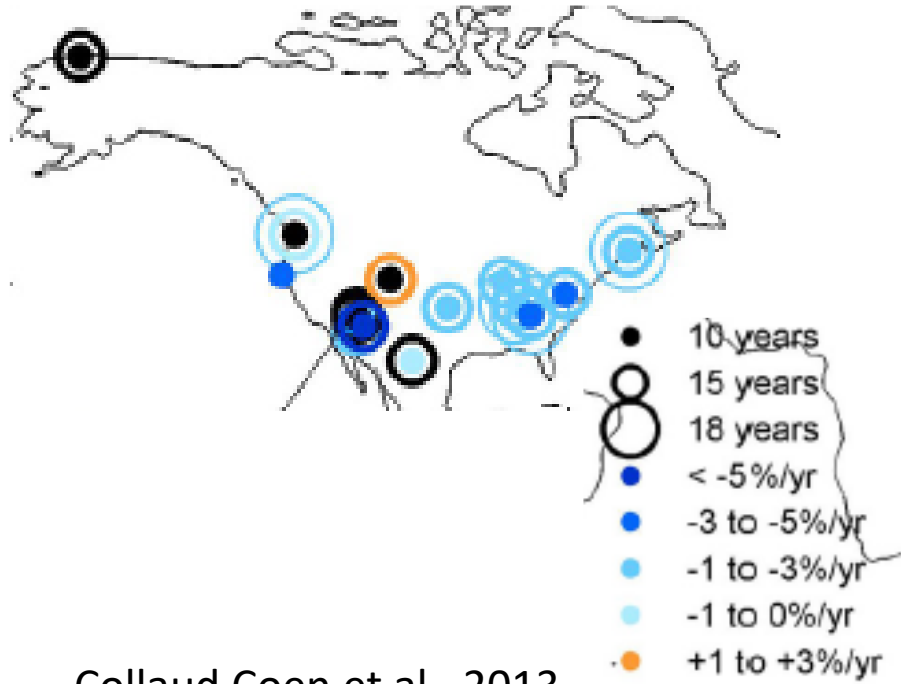
Yu, F., et al. (2015), Spring and Summer Contrast in New Particle Formation Over Nine Forest Areas in North America, *Atmos. Chemistry and Physics*, acp-2015-453.

Yu, F. and A. G. Hallar (2014), Difference in Particle Formation at a Mountain-top Location During the Spring and Summer: Implications for the Role of Sulfuric Acid and Organics in Nucleation, J. of Geophysical Research, 119, 21, 12,246 12,255.

Trend Analysis:

Asmi, A. et al., (2013), Aerosol Decadal Trends – Part 2: In-situ Aerosol Particle Number Concentrations at GAW and ACTRIS Stations, Atmos. Chem. Phys., 13, 895-916, doi:10.5194/acp-13-895-2013.

Trend in Aerosol Scattering



Collaud Coen et al., 2013

Acknowledgements to Derek Hageman

Conclusions

2011 Storm Peak Lab became GMD Regional Aerosol Station

- Improved existing station measurements: CPC, UCPC, Size distribution, CCN
- Added Aerosol Optical properties to SPL
- Resulted in regular calibration & standard QA/QC procedures
- GMD provided critical input for the design, build, installation and verification of new aerosol inlet
- GMD database allowed for all present and past data from SPL to become part of WMO record
    - Resulted in more publications
    - Allowed for data to be used in validating GCMs

Collaboration with GMD Radiation Group has allowed for:

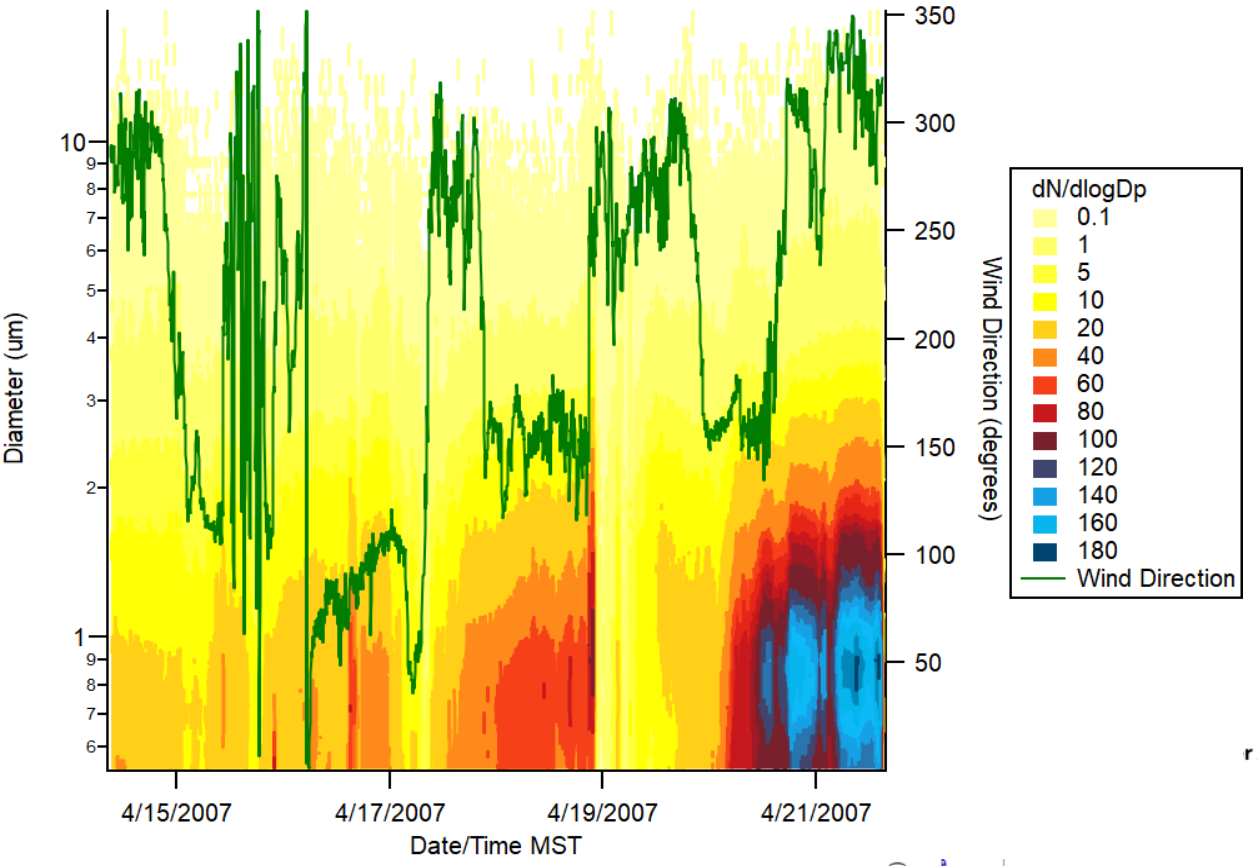
- AOD product from SPL
- Provided technical assistance with installation of MFRSR at the U. of Utah

Acknowledgements

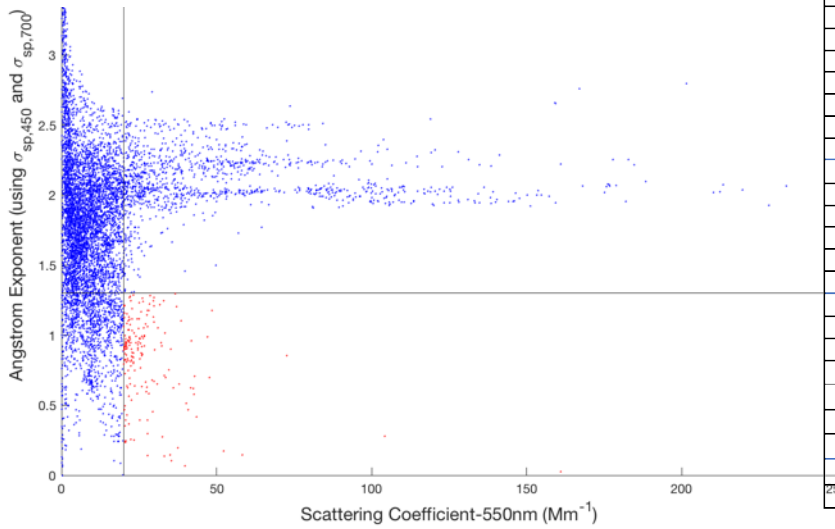
Storm Peak Laboratory/DRI:
Doug Lowenthal, Melanie Wetzel, P. Tyson Atkins, Randy Borys, Joe Messina

USDA/CSU UV- B Monitoring & Research Program

NOAA GMD
John Ogren, Betsy Andrews, Derek Hagman, Pat Sheridan, Joe Michalsky



r Angstrom v. Scattering Coefficient



Clear Impact of dust at surface in Spring
Suggest Local Sources
Climatology of dust using Nephelometer and APS in preparation (A. Lambert)

Start Time (MST)	End Time (MST)	APS	Nephelometer
2007/04/04 00:00	2007/04/05 00:00	X	
2007/04/16	2007/04/17	X	
2007/04/18	2007/04/19 00:00	X	
2007/04/20	2007/04/20	X	
2008/04/01	2008/04/04	X	
2008/04/08	2008/04/09	X	
2008/04/25	2008/04/27	X	
2008/04/28 06:00	2008/05/01 03:00	X	
2010/04/13 00:00	2010/04/13 08:00	X	
2010/05/09 16:00	2010/05/10 08:00	X	
2010/05/22 22:00	2010/05/24 12:00	X	
2010/05/28/23:00	2010/05/29 12:00	X	
2011/03/17 14:00	2011/03/21 21:00	X	X
2011/04/08 02:00	2011/04/10 05:00	X	X
2011/04/15 14:00	2011/04/17 04:00	X	X
2011/05/08 07:00	2011/05/09 11:00		X
2011/05/29 21:00	2011/05/30 04:00		X
2011/06/05 05:00	2011/06/05 09:00		X
2011/06/06 22:00	2011/06/07 07:00		X
2012/03/06 21:00	2012/03/07 16:00		X
2012/03/12 14:00	2012/03/12 21:00		X
2012/03/27 19:00	2012/03/29 04:00		X
2012/04/06 10:00	2012/04/06 15:00		X
2012/04/07 17:00	2012/04/09 02:00		X
2012/04/30 15:00	2012/05/02 11:00		X
2012/05/22 22:00	2012/05/23 04:00		X
2012/05/25 11:00	2012/05/26 03:00	X	X
2012/05/26 19:00	2012/05/27 01:00	X	X
2012/06/06 00:00	2012/06/06 18:00		X
2012/06/19 10:00	2012/06/20 01:00		X
2013/04/08 00:00	2013/04/08 17:00		X
2013/04/16 06:00	2013/04/16 13:00		X
2013/04/26 05:00	2013/04/26 20:00		X
2013/04/27 04:00	2013/04/28 11:00		X
2013/05/23 23:00	2013/05/24 12:00		X
2013/06/27 05:00	2013/05/24 12:00		X
2014/04/26 00:00	2014/04/26 04:00		X
2014/05/07 02:00	2014/05/07 20:00		X
2014/05/10 09:00	2014/05/10 12:00		X
2014/05/18 15:00	2014/05/20 11:00		X
2014/05/21 00:00	2014/05/21 06:00		X
2014/06/14 02:00	2014/06/14 06:00		X
2014/06/16 22:00	2014/06/17 05:00		X
2015/03/31 20:00	2015/04/01 06:00		X
2015/04/07 22:00	2015/04/08 02:00		X