Comparison of Aerosol Measurements from ASCENT Yellowstone Site with IMPROVE Data

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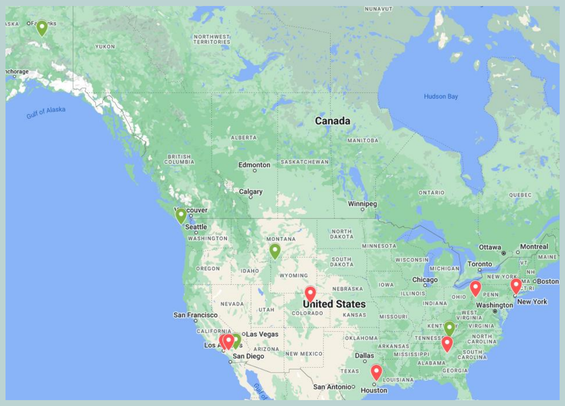
Introduction

- PM2.5 aerosol mass composition are essential to a better understanding on the pollutant sources, air quality, health impacts, and cloud processing.
- The filter based Interagency Monitoring of Protected Visual Environments (IMPROVE) network has been measuring aerosol mass and composition for decades at hundreds of remote and urban site (Malm, 1994).
- The Atmospheric Science and Chemistry mEasurement NeTwork (ASCENT) is a newly deployed (from 2023), comprehensive, real-time, long-term measurement network in the U.S., with higher time-resolution.
- This work compared the ASCENT measurement with IMPROVE data, and validate the ASCENT Yellowstone measurement.

ASCENT Network and Instruments



ASCENT Network

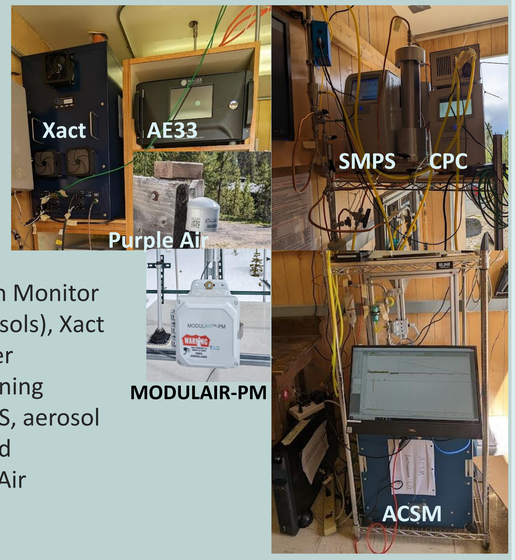
A total of 12 sites is established across the U.S., including remote/background, an urban sites.

ASCENT Instruments

Each ASCENT site will be equipped with a set of aerosol instruments for real-time measurements of fine aerosol chemical composition and properties:

Aerosol Chemical Speciation Monitor (ACSM, non-refractory aerosols), Xact (trace metals), Aethalometer (black/brown carbon), Scanning Mobility Particle Sizer (SMPS, aerosol number size distribution and concentration), and Purple Air sensor.

Yellowstone Site



Equations

1) Xact soil (dust)= 2.20*Al + 2.49*Si + 1.63*Ca +2.42*Fe + 1.94*Ti
   (Hand et al., 2019)
2) ACSM PM2.5 mass = Org + SO4 + NO3 + NH4 + Chl
3) ASCENT PM2.5 mass = ACSM PM2.5 mass + BC mass + Xact soil mass
3) Particle density for SMPS:
   OrgDensity = (12+H:C+16*O:C)/(7+5*H:C+4.15*O:C)
   Volume = (SO4+NH4+NO3)/1.75 + Chl/1.52 +Org/OrgDensity + BC/1.80
   Density = (ACSM Mass + BC Mass)/Volume

References

Hand, J. L., Prenni, A. J., Schichtel, B. A., Malm, W. C. and Chow, J. C.: Trends in remote PM2.5 residual mass across the United States: Implications for aerosol mass reconstruction in the IMPROVE network, Atmos. Environ., 203, 141–152, doi:10.1016/j.atmosenv.2019.01.049, 2019.

Malm, W. C., Sisler, J. F., Huffman, D., Eldred, R. A. and Cahill, T. A.: Spatial and seasonal trends in particle concentration and optical extinction in the United States, J. Geophys. Res., 99(D1), 1347–1370, doi:10.1029/93JD02916, 1994.

Acknowledgements

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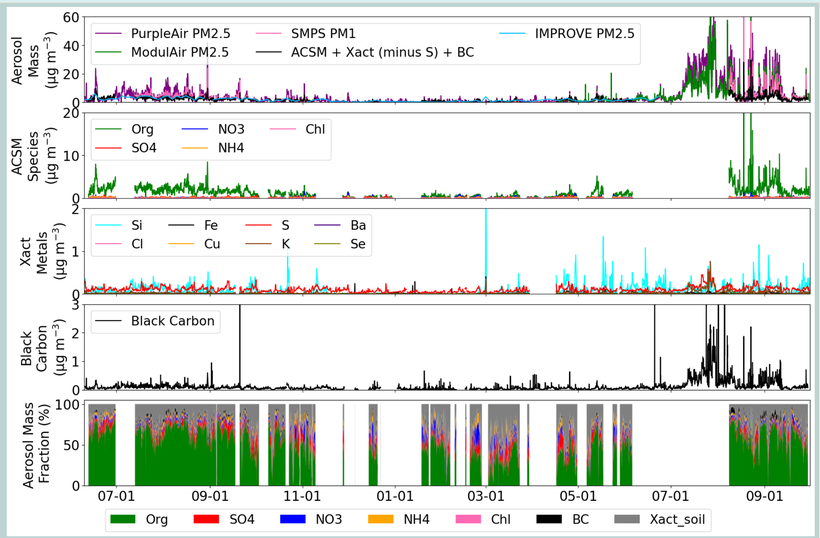
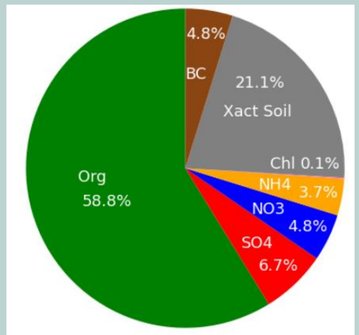
Overview of Yellowstone Site

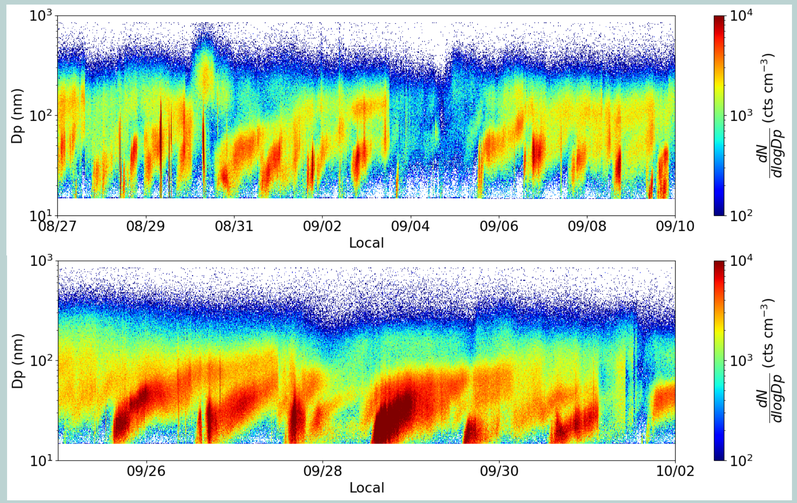


The main instruments at Yellowstone site were deployed in June 2023, the MODULAIR was installed in April 2024. The IMPROVE composition data and PM data are available until Dec. 2023 and Jun. 2024, respectively.



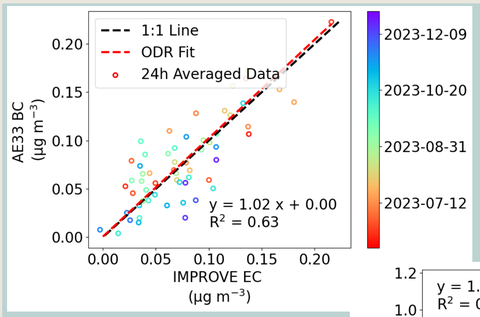
Averaged composition:

The largest source at Yellowstone is organic (58.8%, 1.31 μg m^{-3}), and the second largest is soil (21.1%, 0.47 μg m^{-3}).



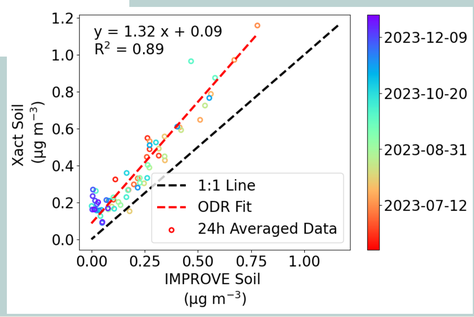
Frequent new particle formations were observed in Fall, 2023.

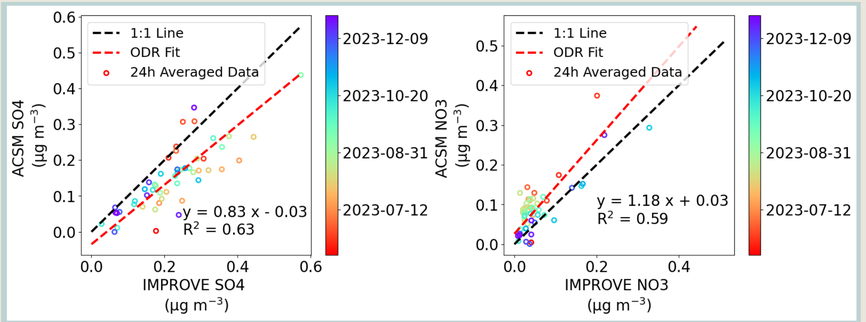
Comparison with IMPROVE



The comparison between AE33 BC and IMPROVE EC are scattered, but the ODR fit overlap with the 1:1 line.

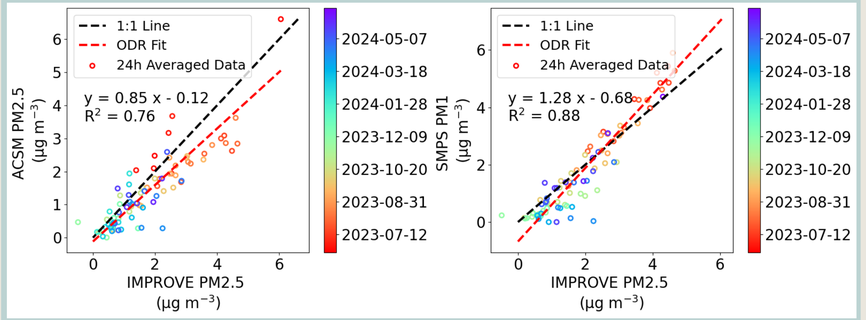
Xact soil is 32% higher than the IMPROVE soil.





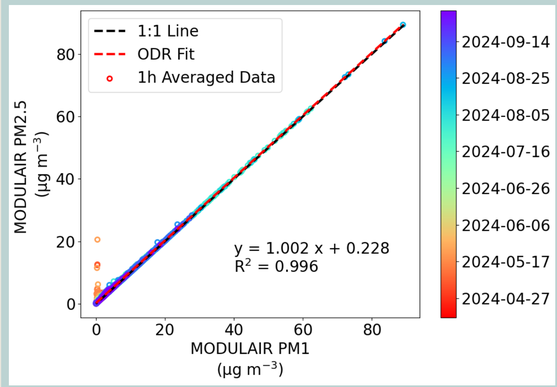
Compare with IMPROVE, ACSM underestimates SO4, because ACSM can only measure non-refractory particles.

IMPROVE may underestimates NO3 when they evaporate from the filter.



ACSM PM2.5 is less than IMPROVE PM2.5 : caused by refractory aerosol.

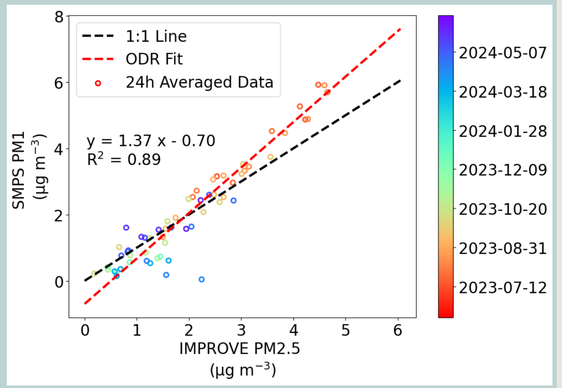
SMPS PM1 is larger than IMPROVE PM2.5: (a) Some particle evaporate from the filter; (b) Yellowstone measured a lot fine dust (submicron).

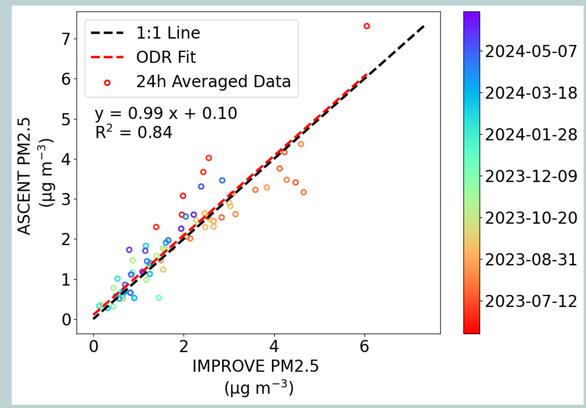


MODULAIR PM1 matches MODULAIR PM2.5:

It proves that Yellowstone doesn't have much super micron particles.

However, SMPS PM1 is 37% higher than the IMPROVE PM2.5, which need to be further investigated.





Although ASCENT Yellowstone site overestimates soil and NO3 and underestimates SO4, the overall quantification of PM2.5 from the ASCENT Yellowstone site matches IMPROVE PM2.5. This comparison validates the ASCENT measurement, but ASCENT can provide measurements with higher time resolution.