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Using models for OSSEs to guide measurement strategies

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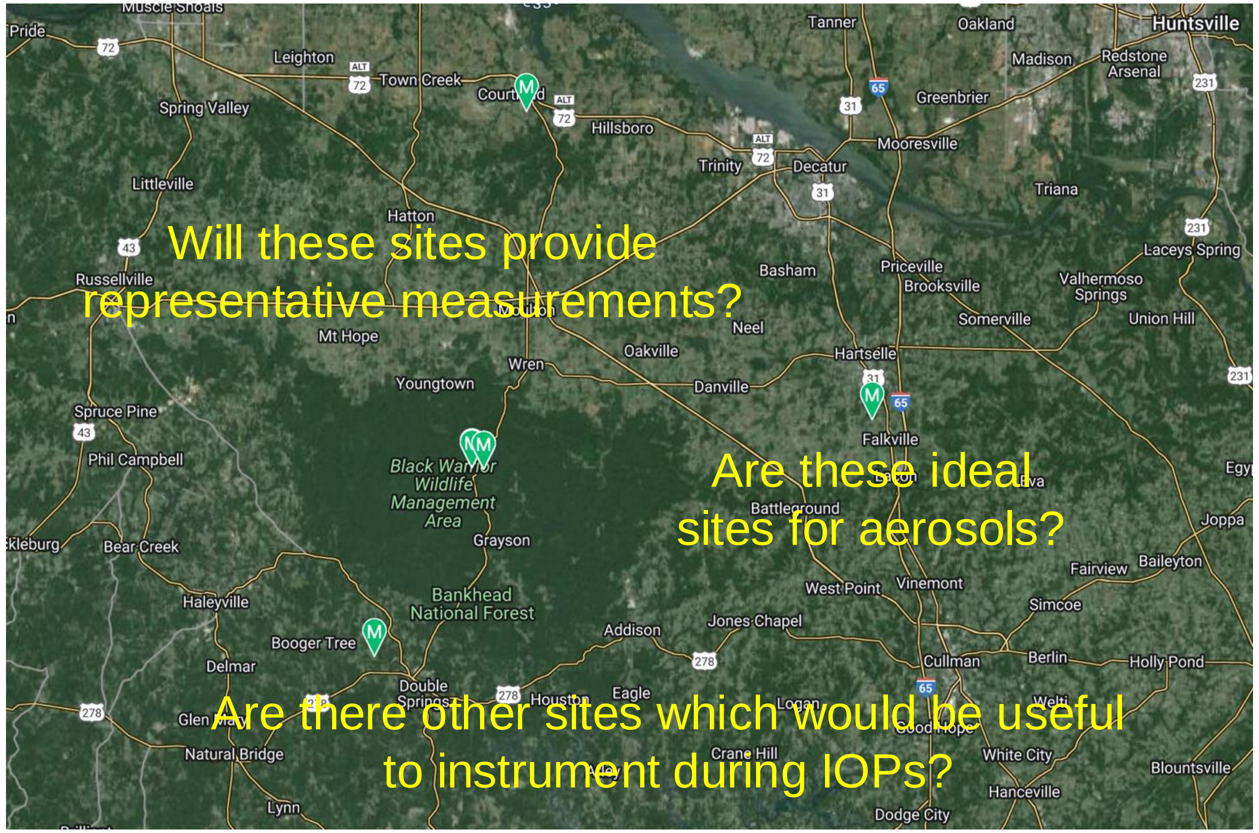
Integrated Cloud, Land-Surface, & Aerosol System Study ICLASS

ASR Atmospheric System Research

Spatial Variability of Aerosols and OSSEs

- An observing system simulation experiment (OSSE) is a model experiment used to evaluate the value of a new observing system when actual observational data are not available.
- OSSEs have been performed to determine whether a new observing system will add value to numerical weather prediction and analysis; to make decisions for a new observing system or network; and to investigate the behavior of data assimilation systems and thereby optimally tune these systems in an environment where the "truth" and hence the system's behavior is known (Zeng et al. BAMS 2020).



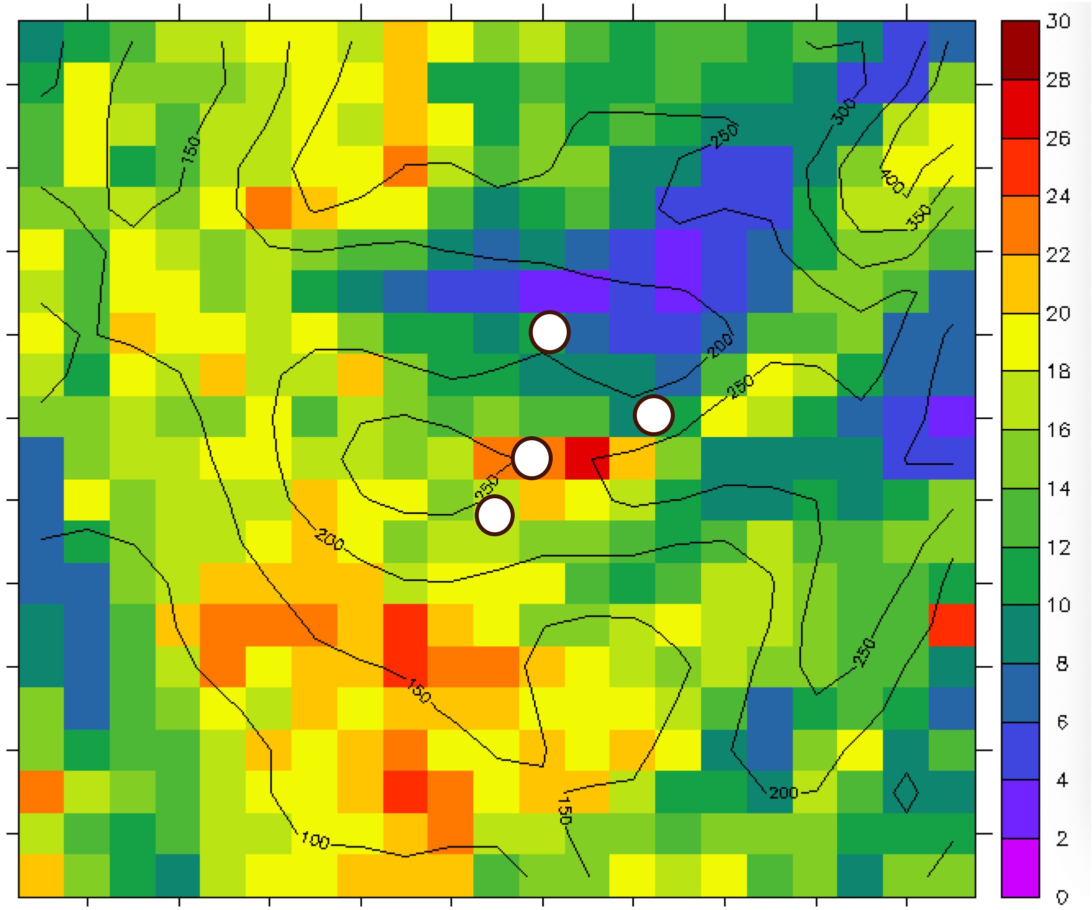
- Use BNF as a case.

What’s Available to Help?

- WRF-Chem has been providing daily air quality forecasts for the past several years
  https://www.acom.ucar.edu/firex-aq/forecast.shtml
- Δx = 12 km for CONUS
- NEI2014, MEGAN, and FINN for emissions
- MOZCART chemistry (GOCART-like aerosols, bulk)
- CO tracers (for source attribution)
- 21 x 21 grid extracted at every hour for SGP and BNF since August 2023, mostly 2D surface variables but some 3D variables saved
- ~3 Gb per month

Other operational U.S. air quality models with aerosols include RAP-Chem, NOAA CMAQ

Simulated isoprene concentrations

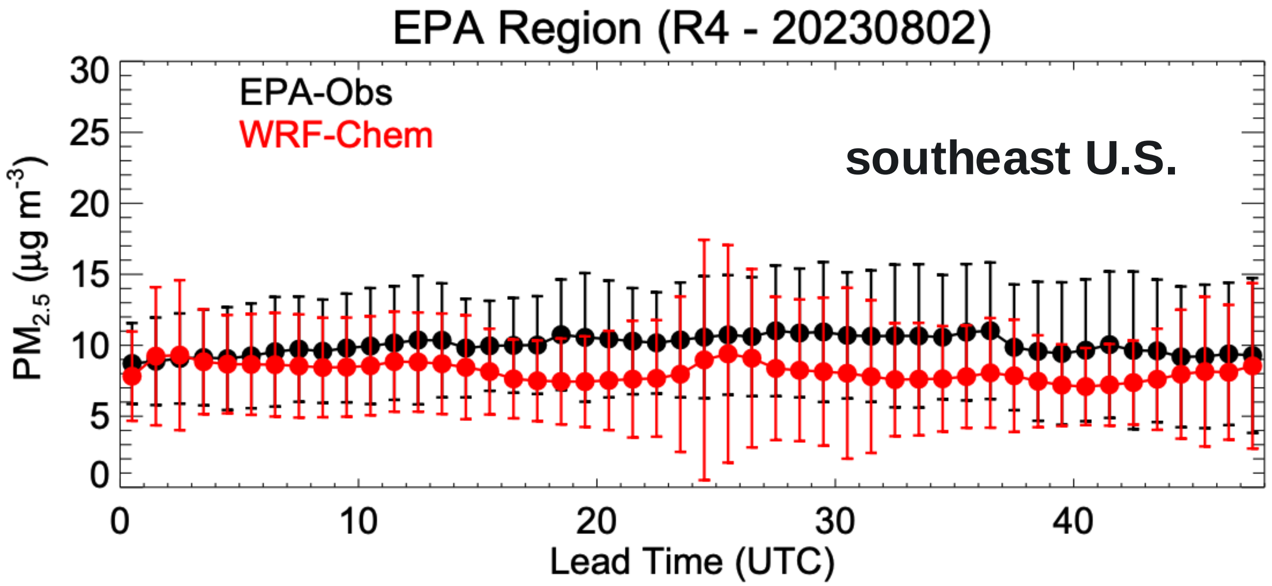


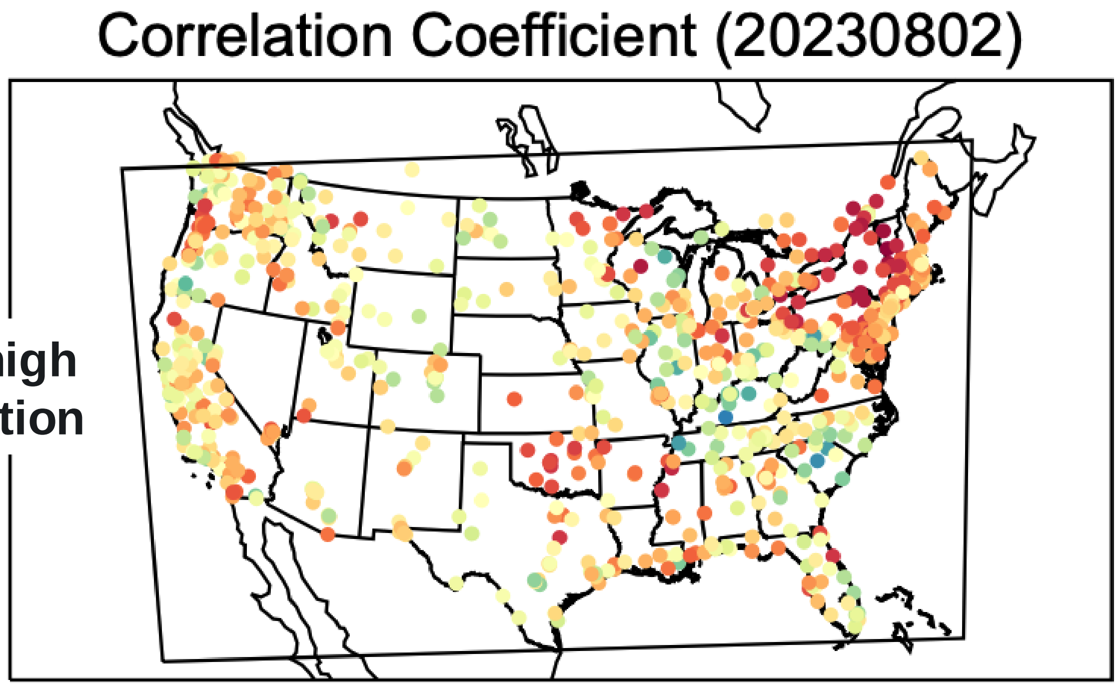
Relatively few EPA monitors in this region

Variables Saved

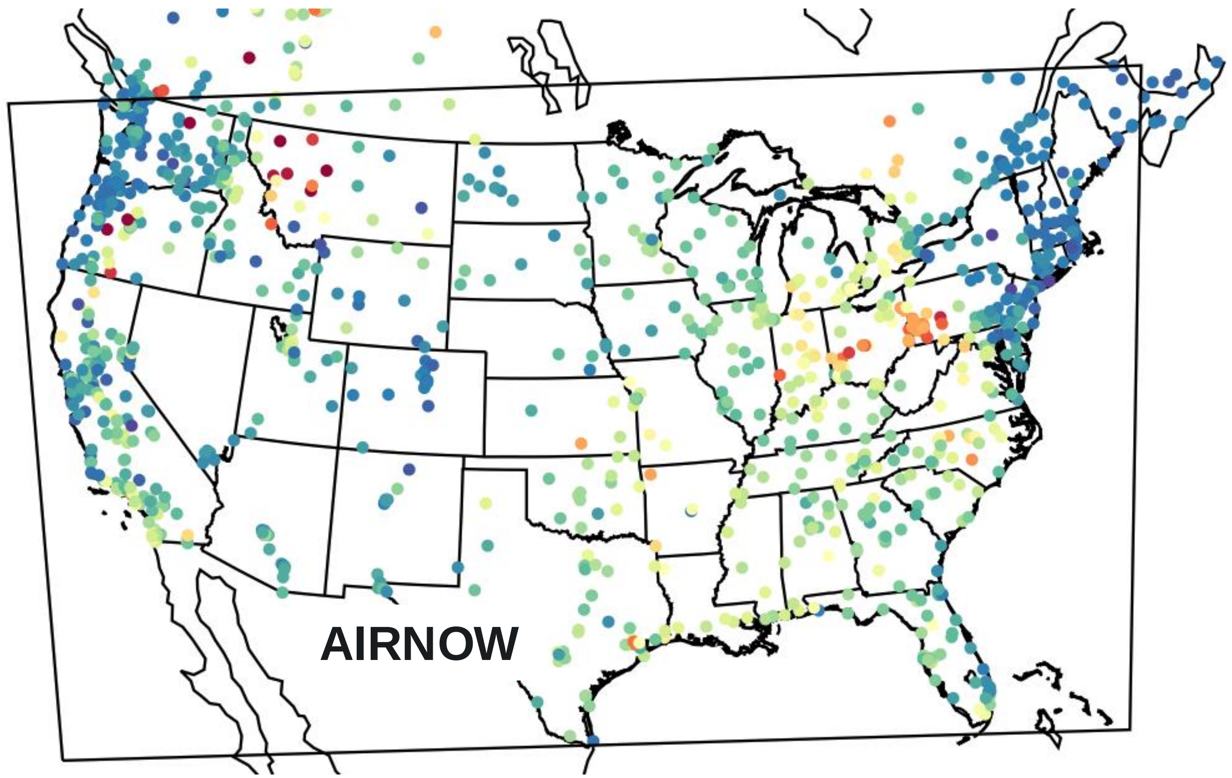
- **Gases - 2D surface**: ACET, ALD, BIGALK, BIGENE, C2H4, C2H6, C3H8, CH3CHO, CH4, CO, HCHO, HO2, HO, ISOPR, NO2, NO, O3, PAN, TOL
- **Gases - 3D:** c2h6, ch4, co, co_anth, co_fire, co_asia, co_bdry, co_brdy_fire, co_chem, hcho, hcn, hno3, h2o5, nh3, no, no2, o3 ,pan
- **Aerosol - 2D surface:** BC1, BC2, DUST1-5, OC1, OC2, PM10, PM2_5, SEAS1-4, SO2
- **Aerosol - 3D:** PM10, PM2_5
- **Optical properties - 2D surface:** AOD300, 400, 550, 600, 999; SSA300, 400, 600, 999
- **Optical properties - 3D:** BSCOEF2-4, EXTAER1-5, EXTCOF55, PHOTR2-3
- **Meteorology - 2D:** CFRACT, CLDFRA, PBLH, Q2, T2, RAINC, RAINNC, RAINSH, SWDOWN, U10, V10
- **Meteorology - 3D:** P, PB, PH, PHB, PSFC, QCLOUD, QVAPOR, T, U, V, W

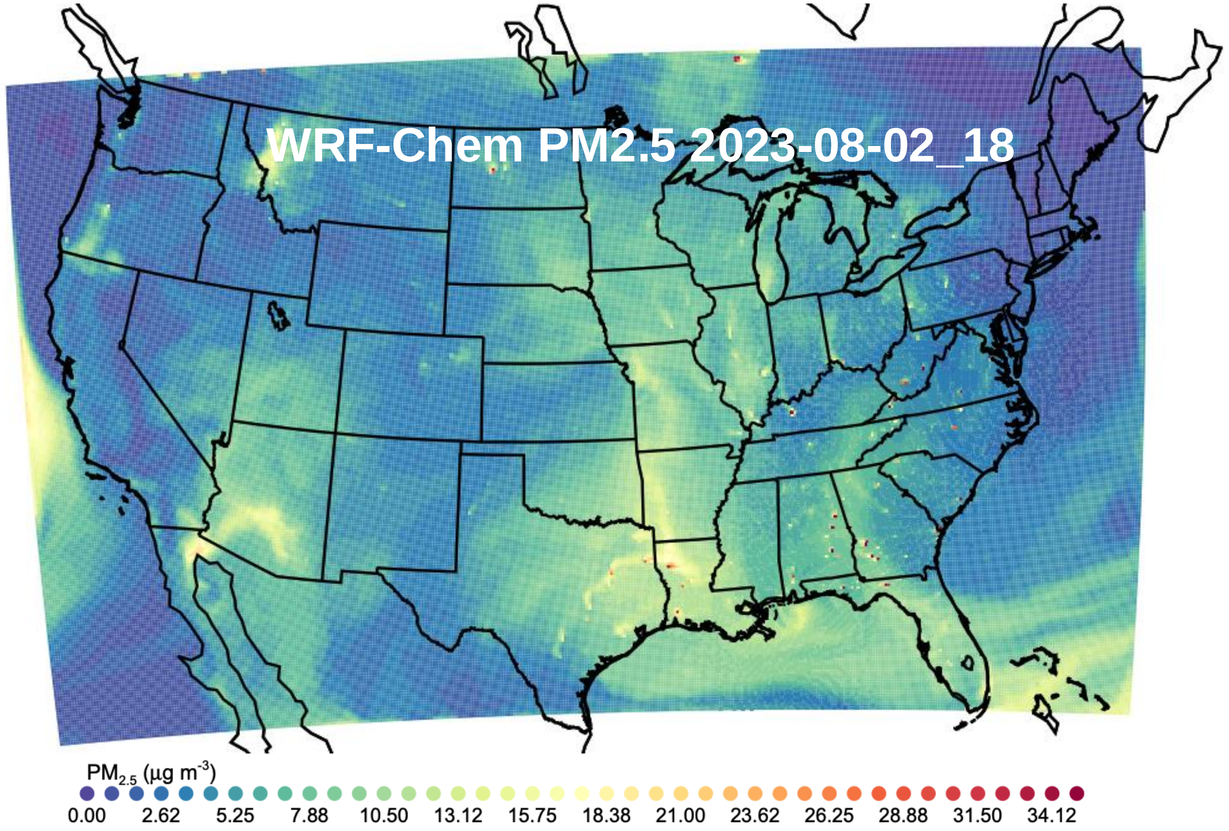
Model Evaluation



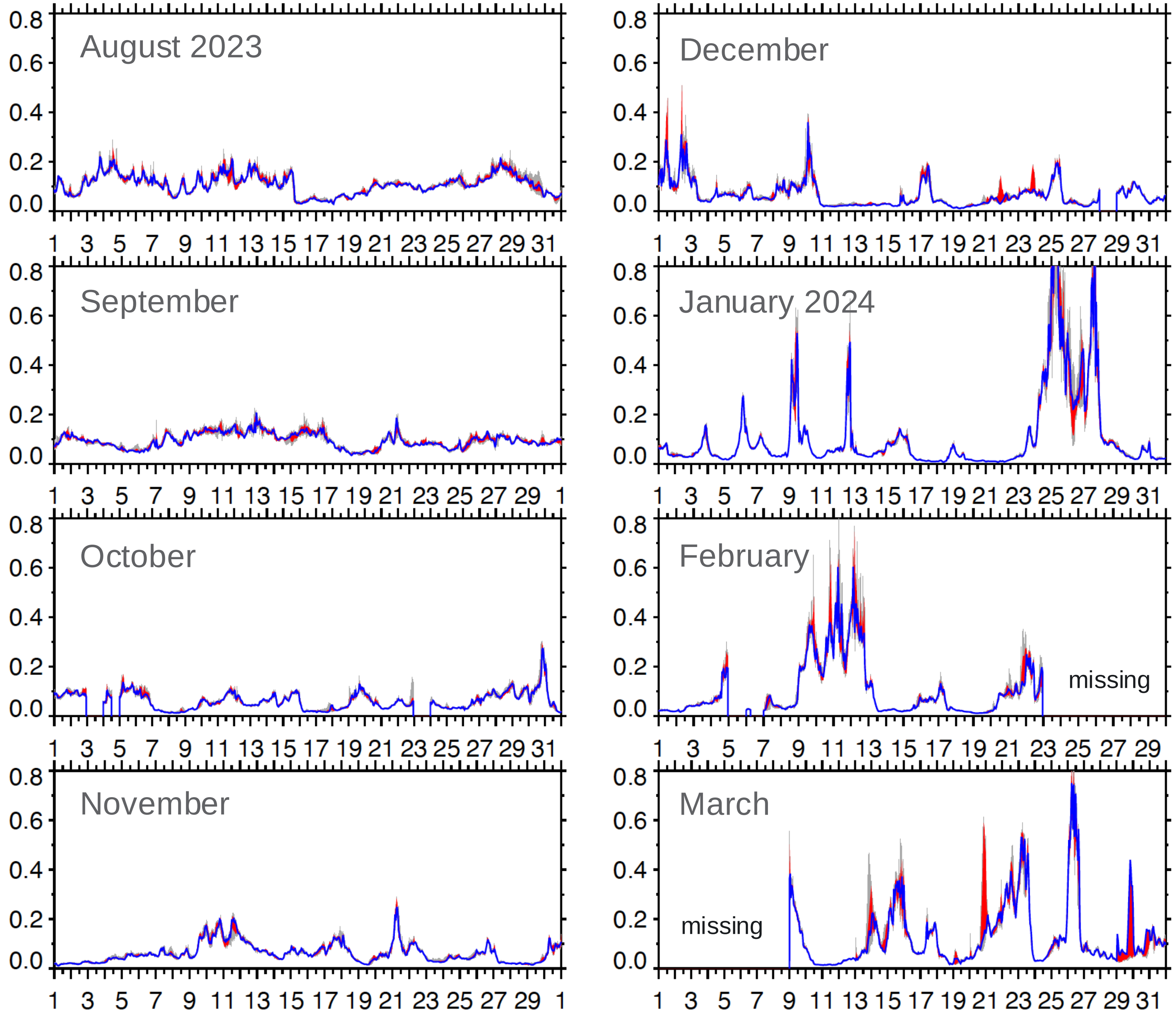


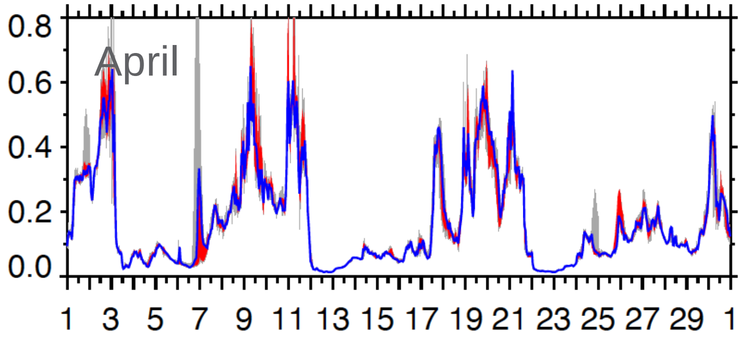
red = high correlation



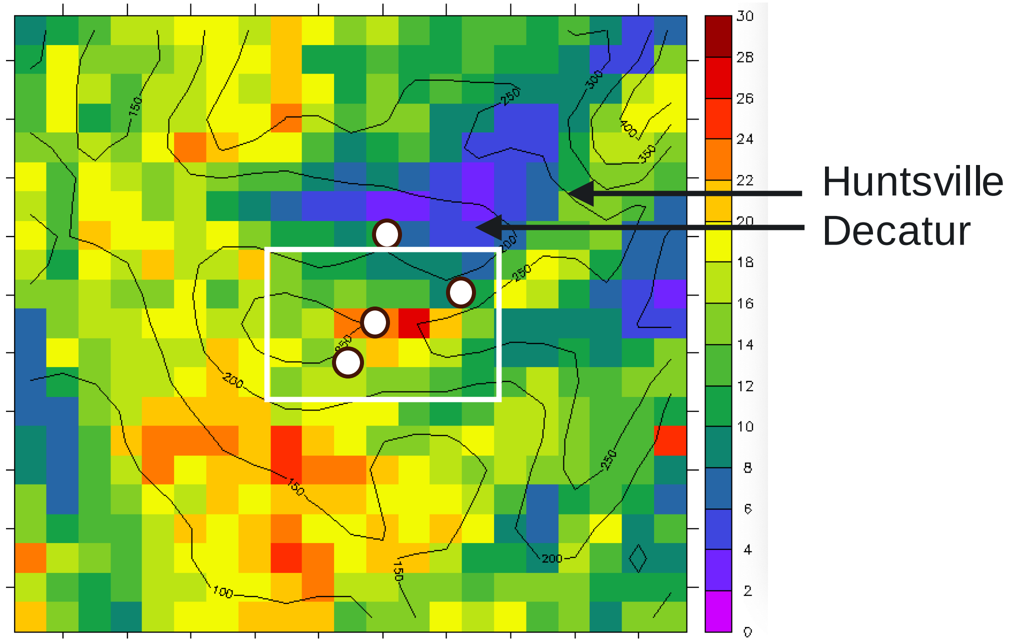


AOD Variability





main site
range from supplemental sites
range within 7 x 5 cells around main site



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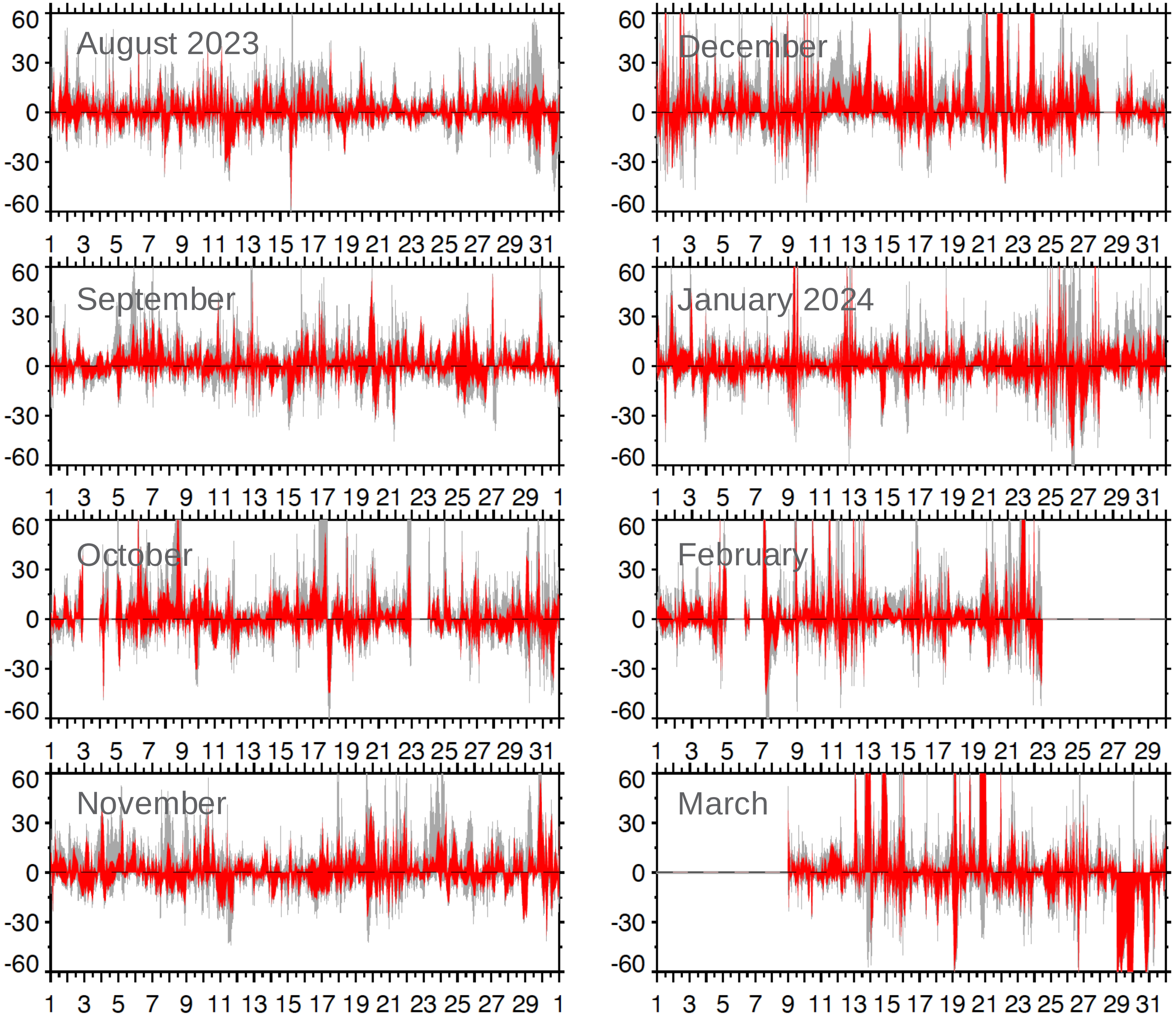
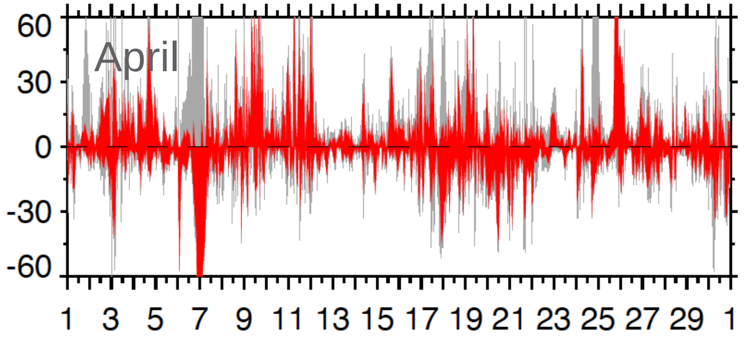
AOD Variability (% Difference)





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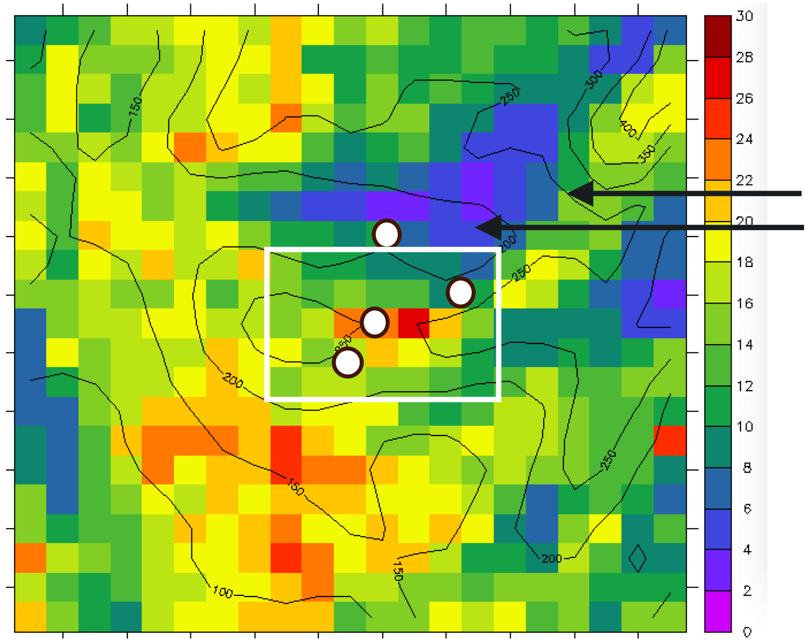
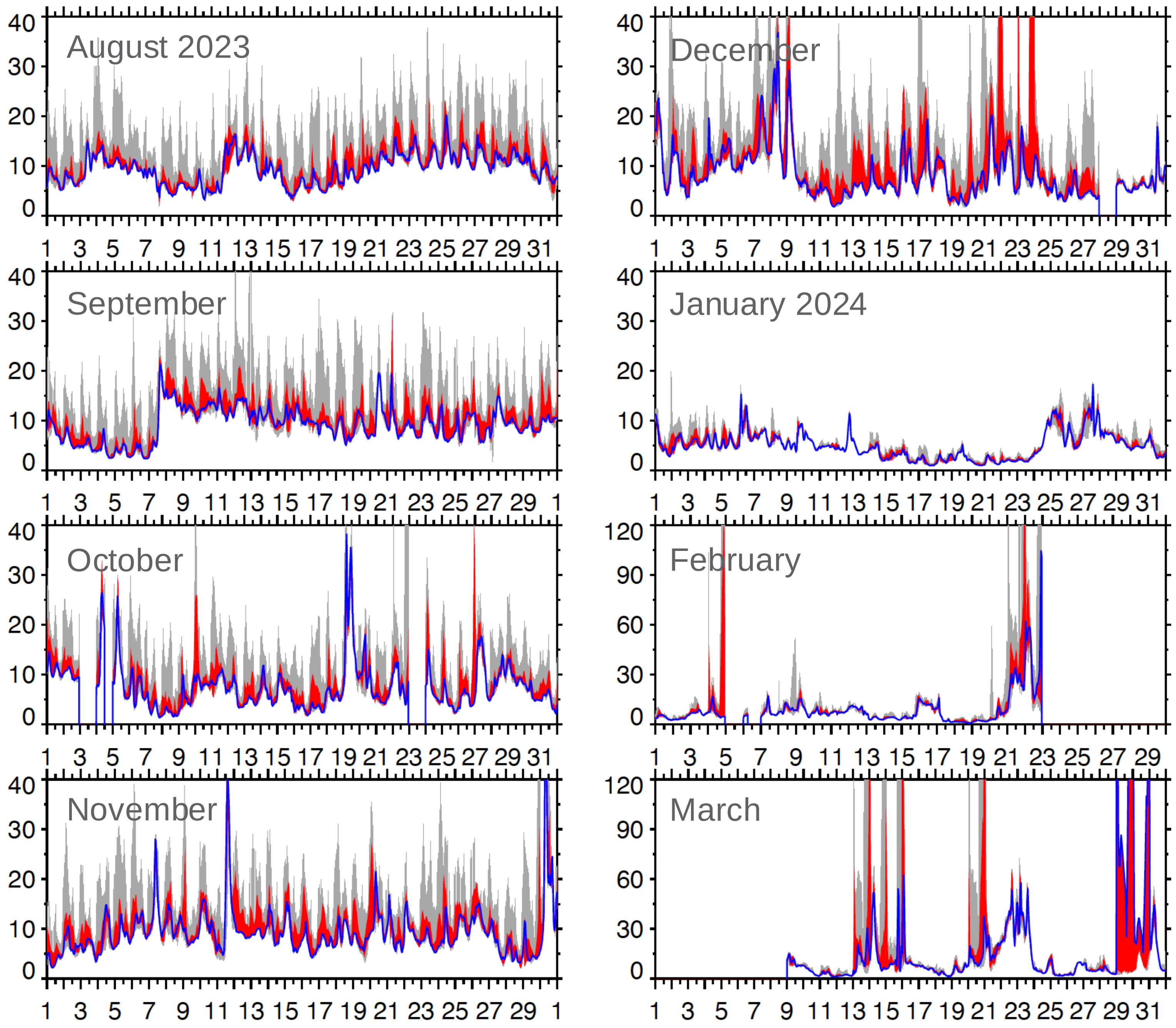
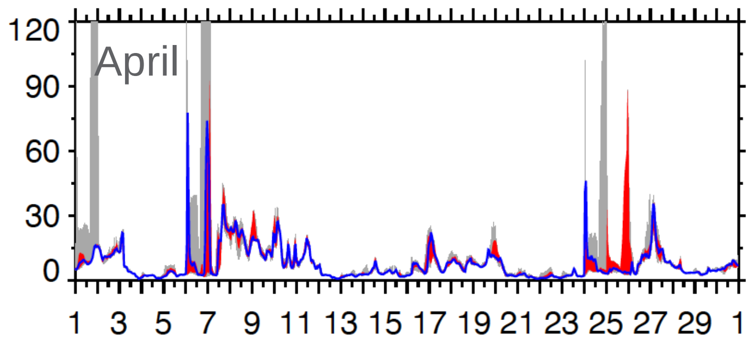


PM2.5 Variability





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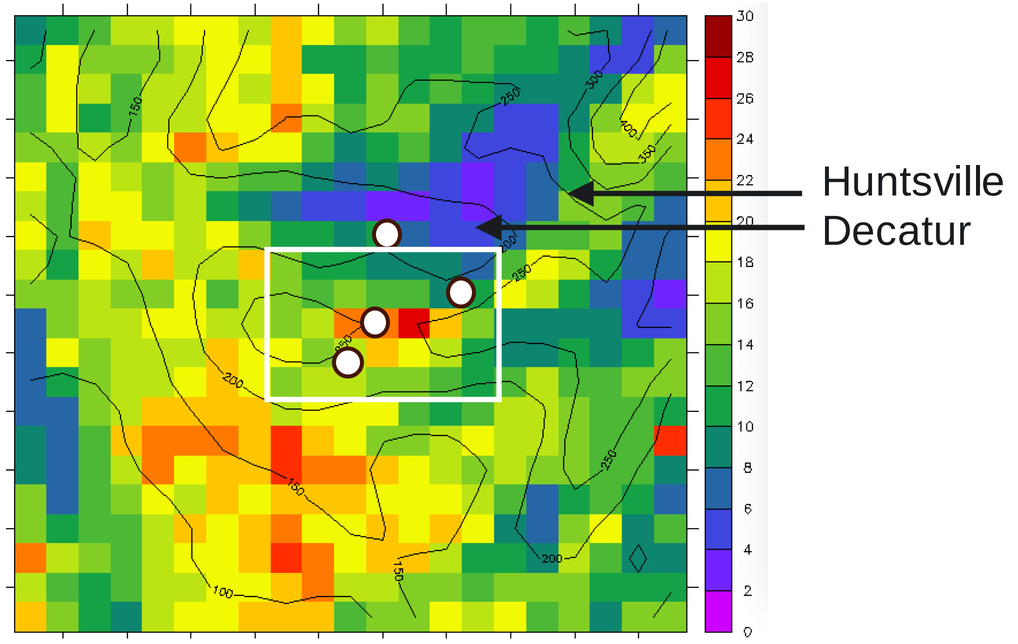
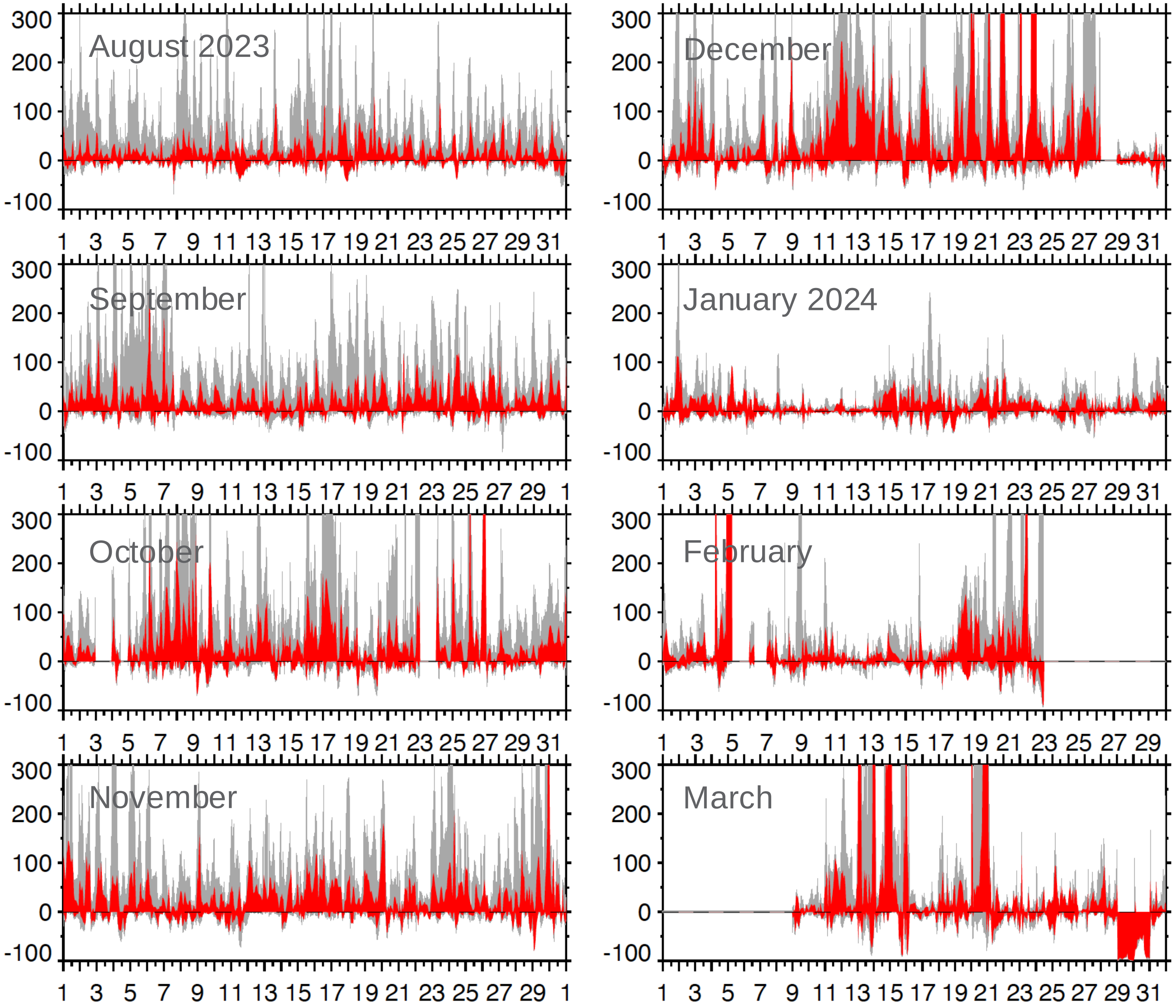
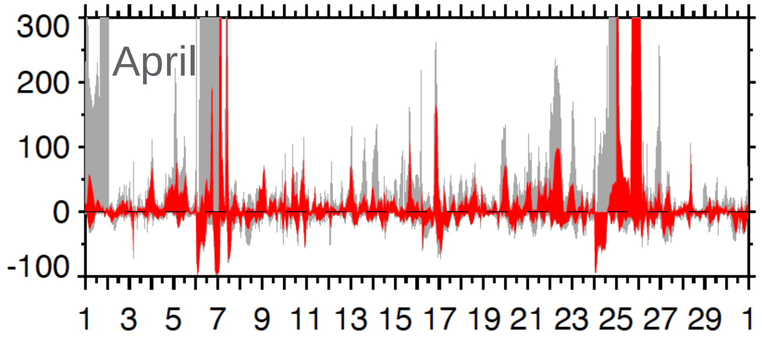


PM2.5 Variability (% Difference)





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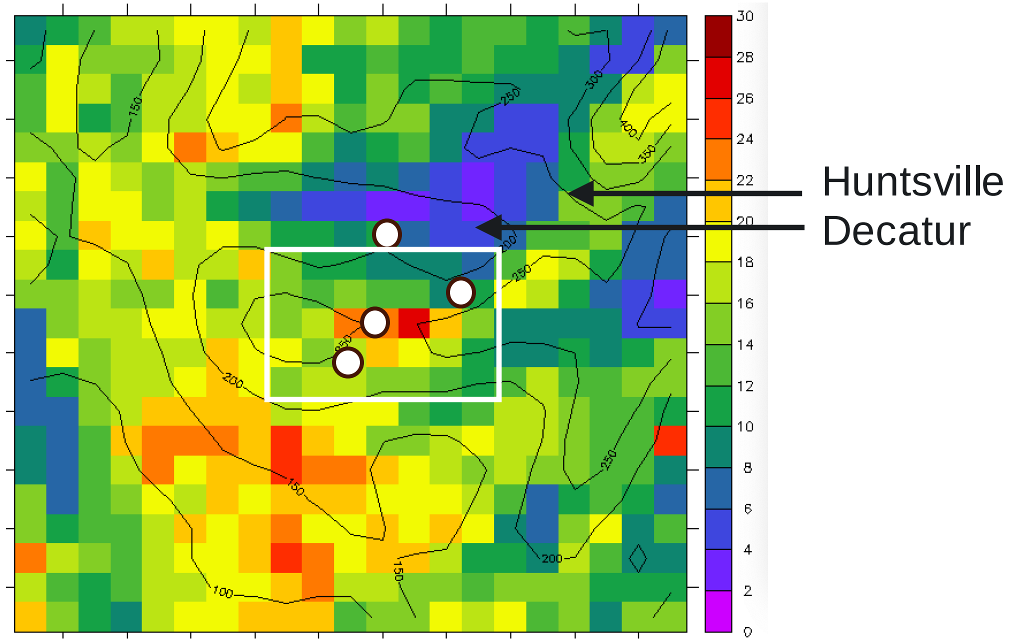
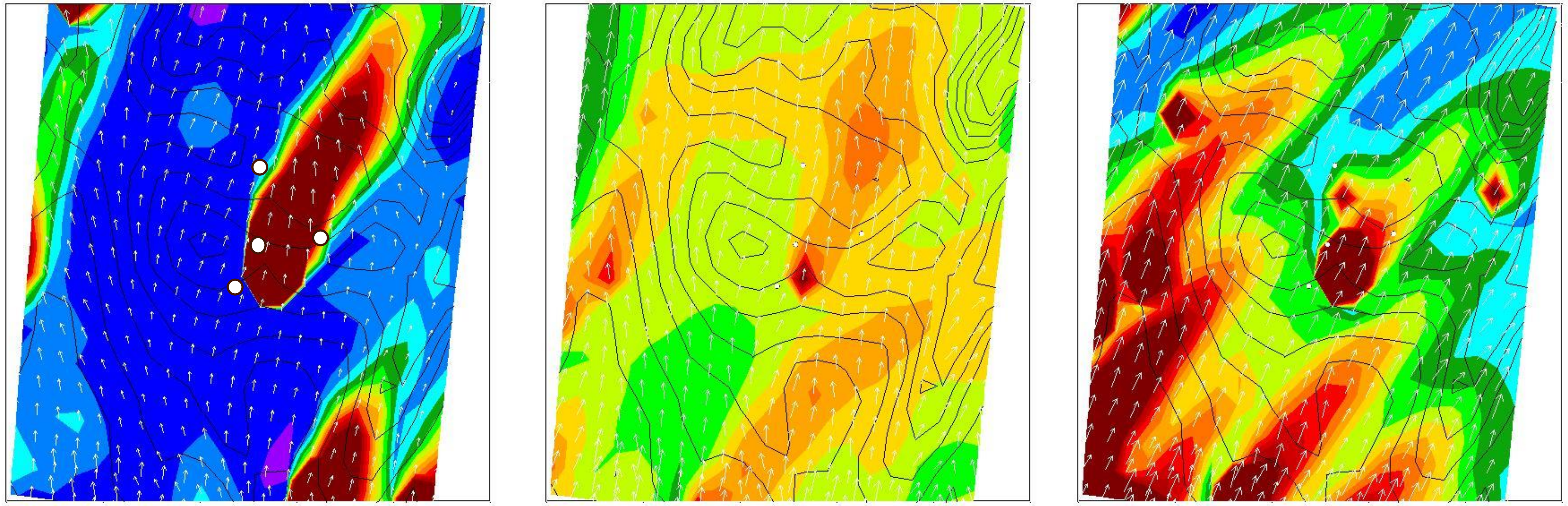


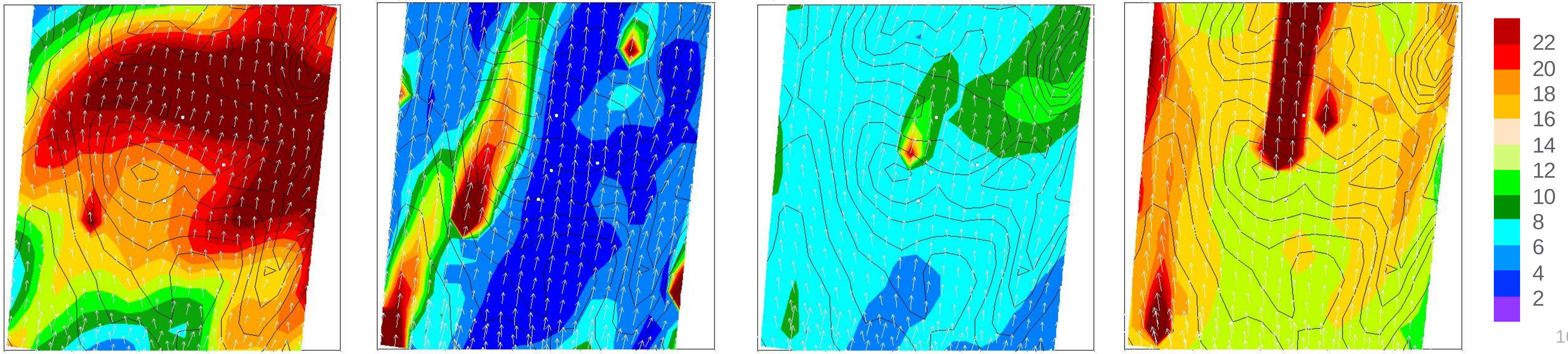
Example Spatial PM2.5 Variability

March 30 00 UTC | March 30 12 UTC | March 31 00 UTC

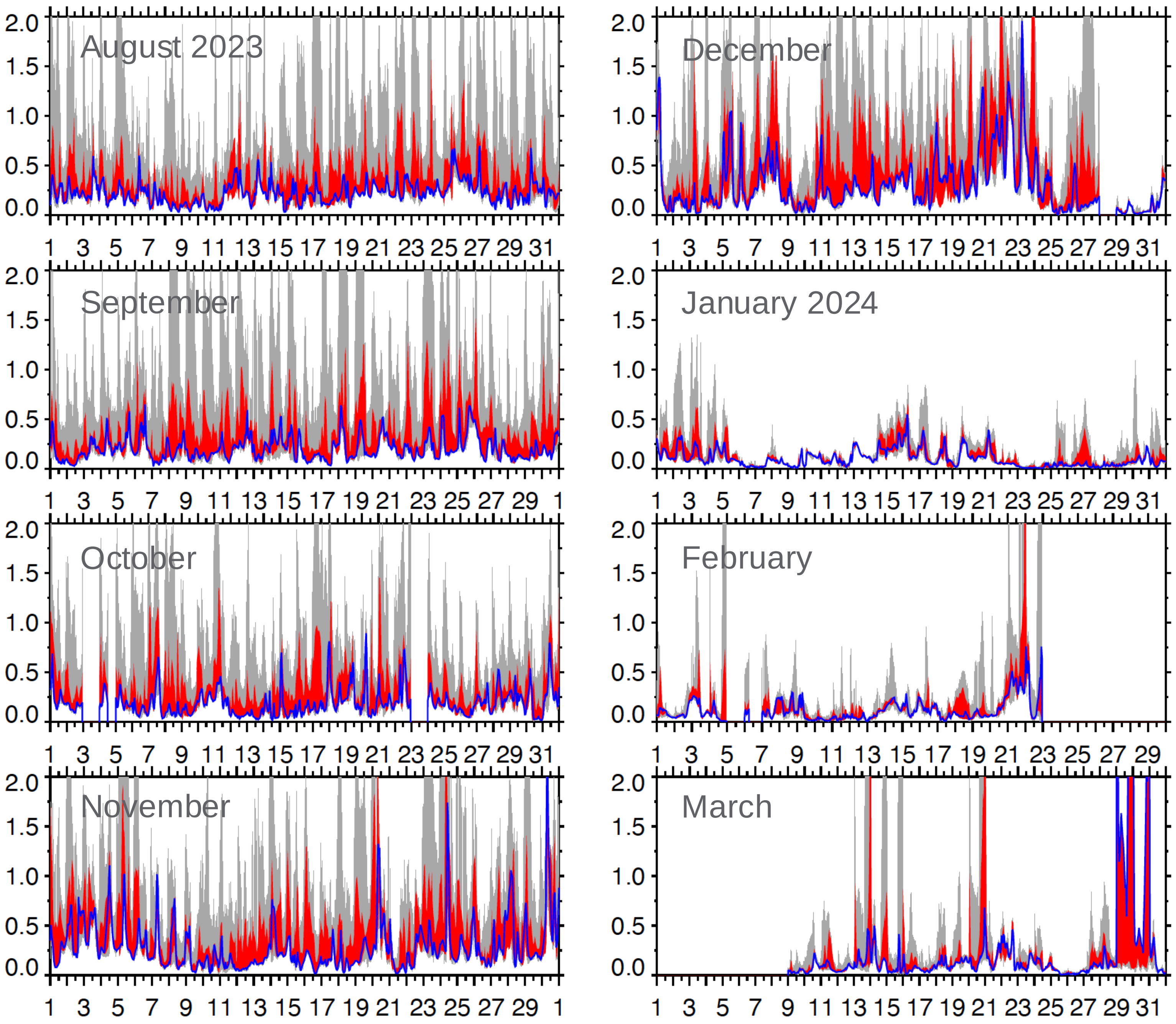


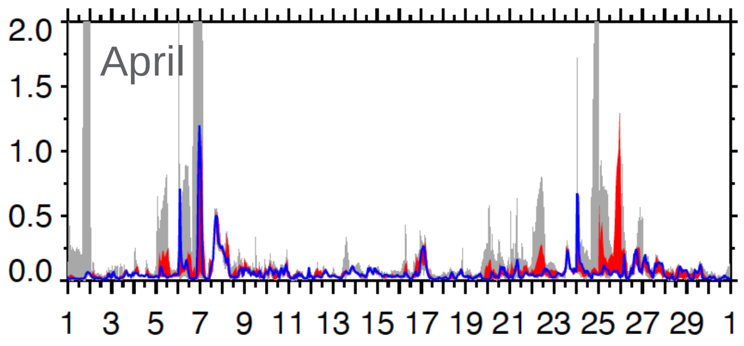
- Period when local fires produce large variability
- Some plumes pass through network
- Δx = 12 km over-estimates impact of fires on network

March 31 12 UTC | April 1 00 UTC | April 1 12 UTC | April 2 00 UTC



SO_2 Variability





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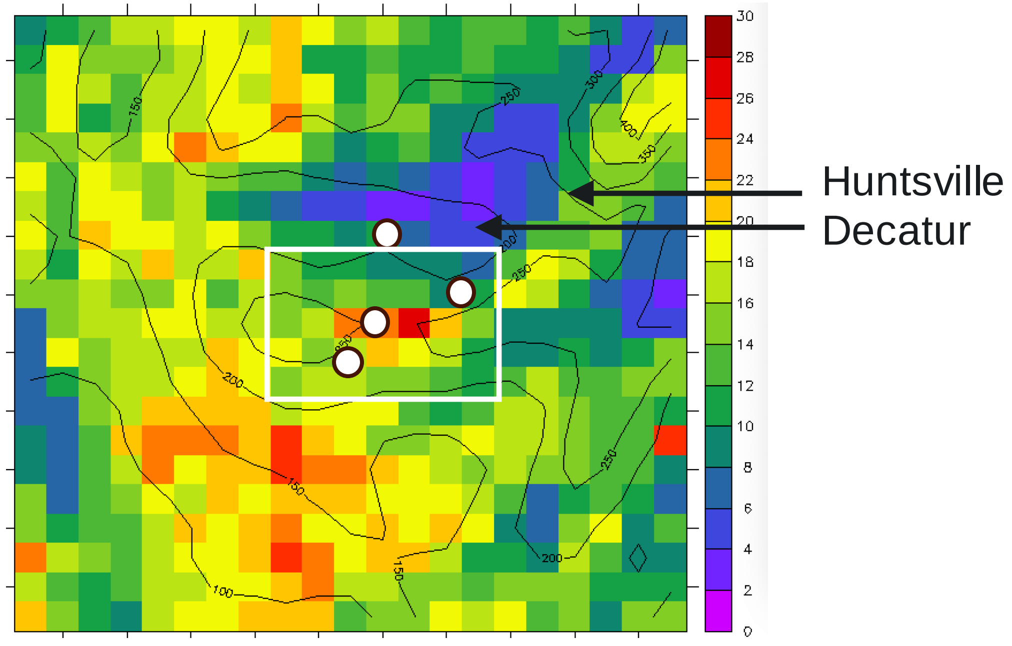
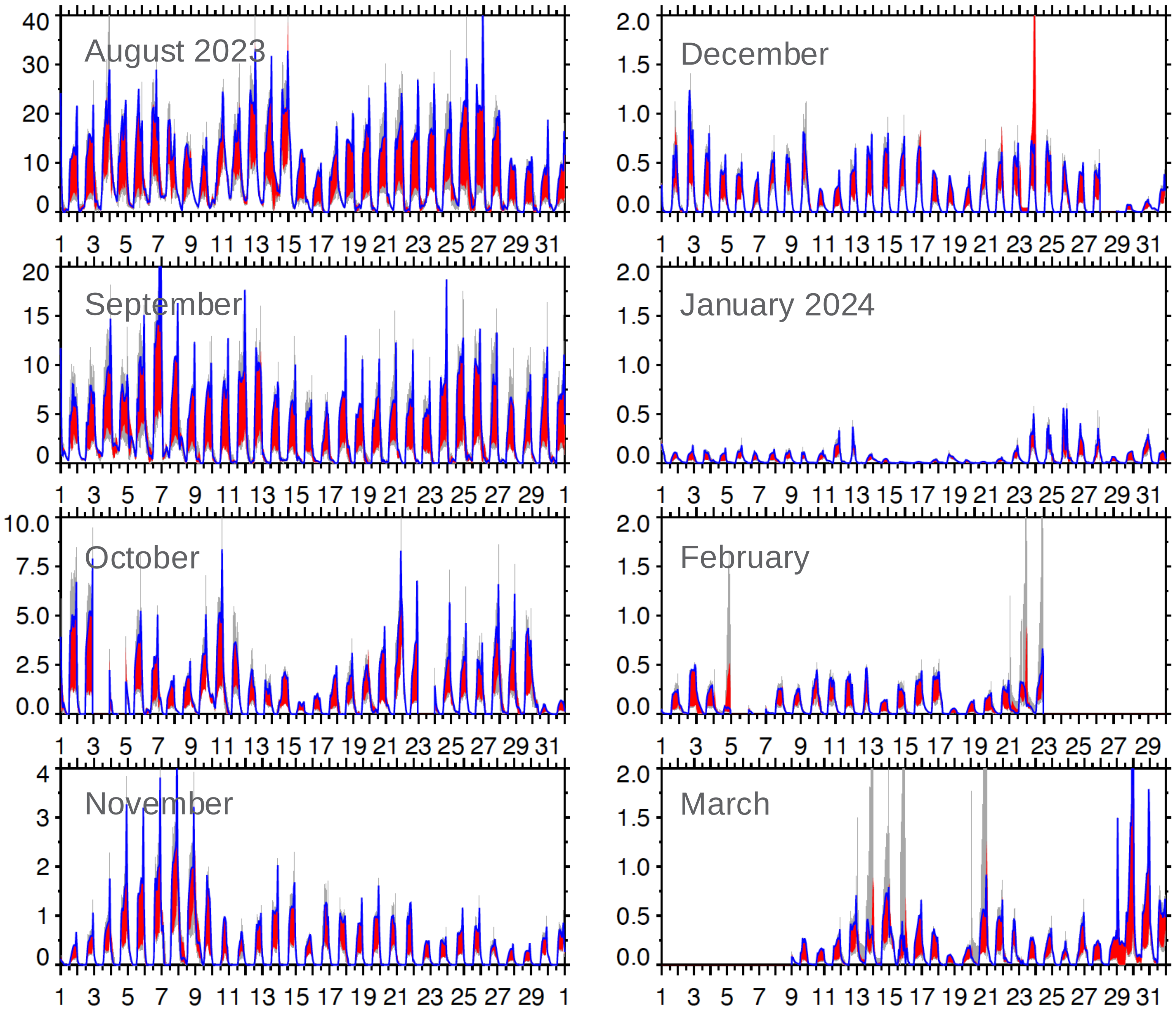
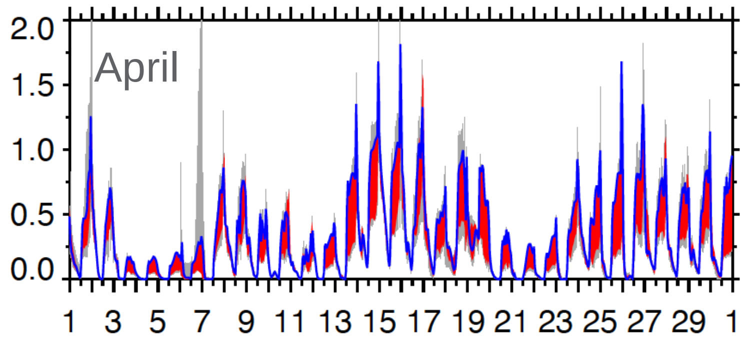


Isoprene





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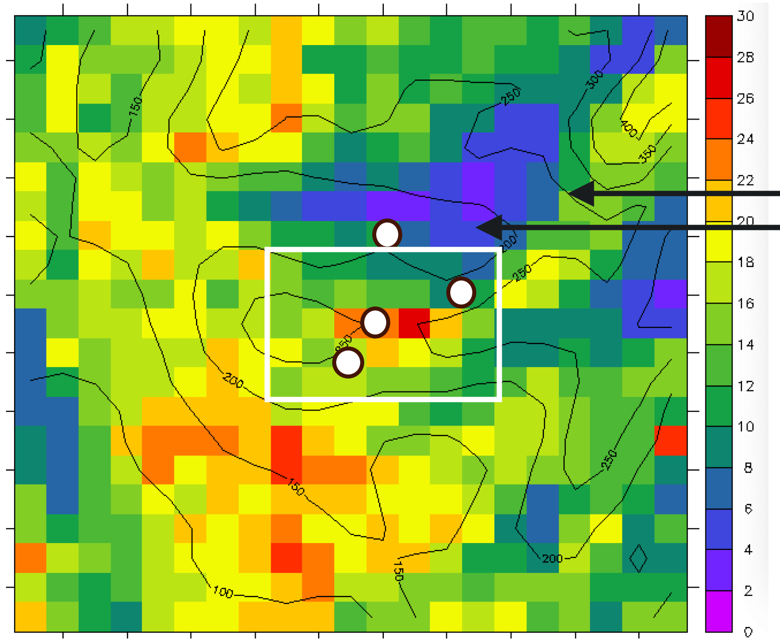
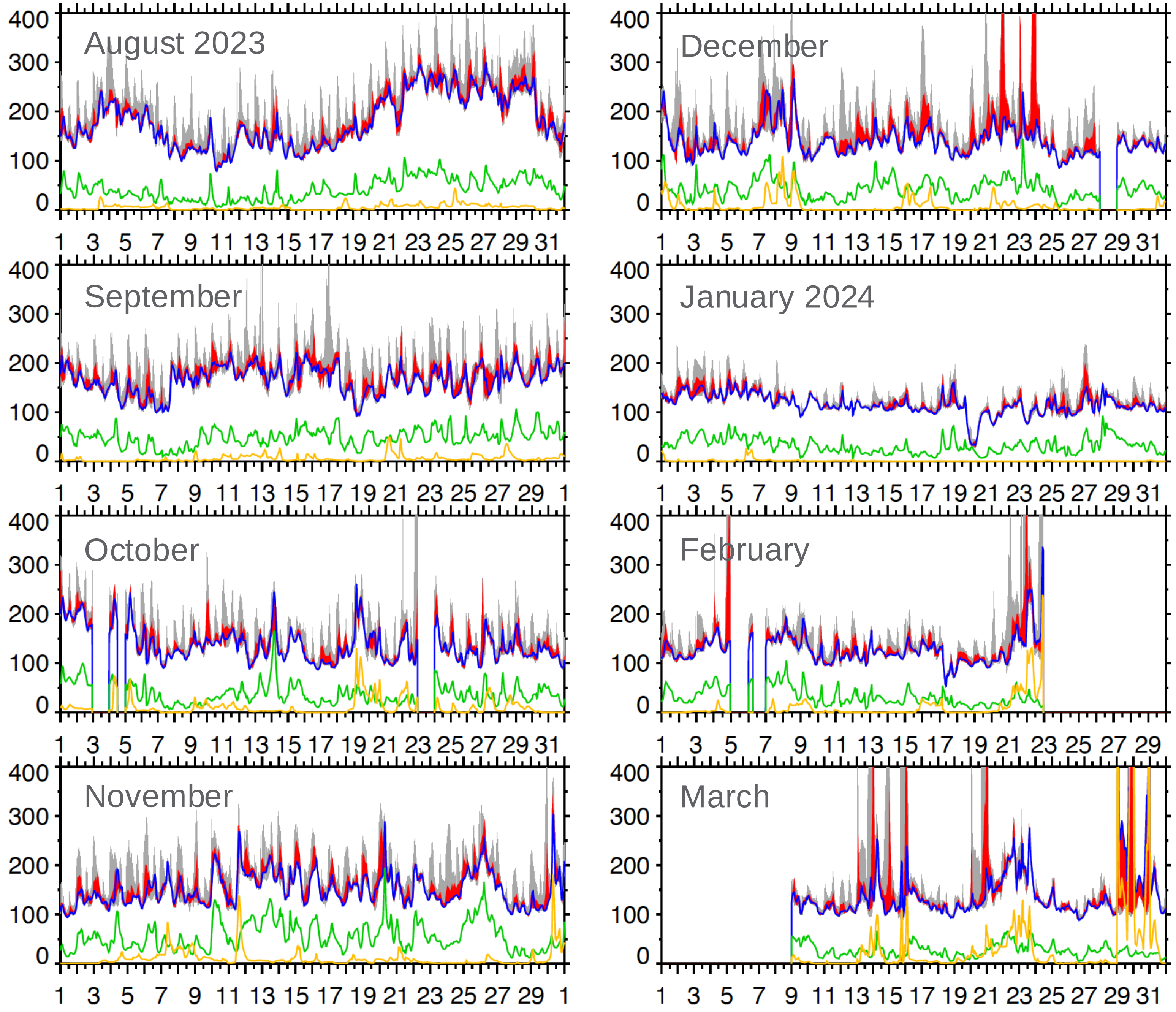


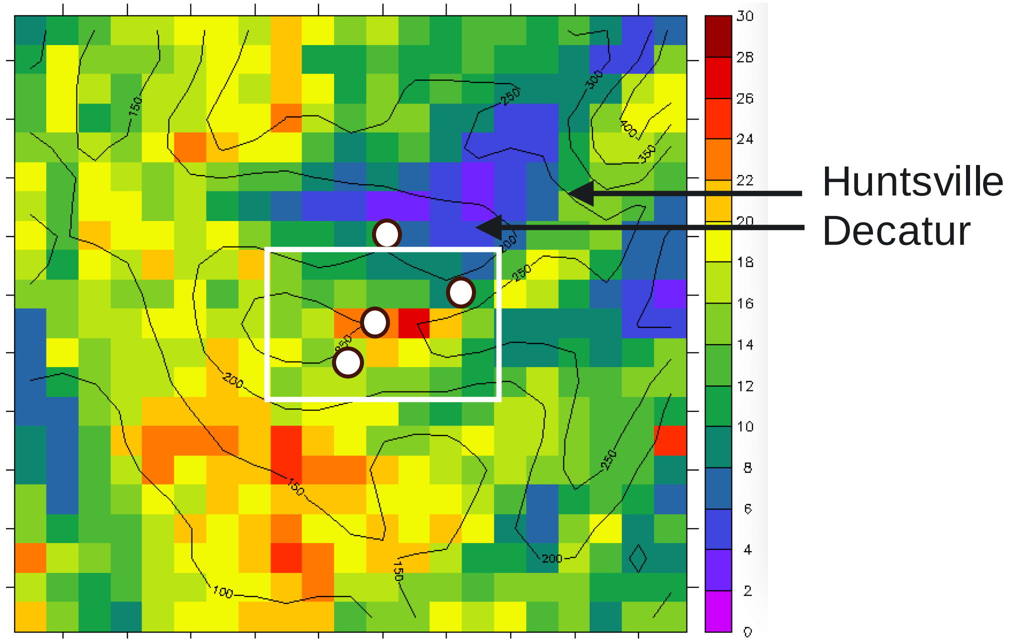
Huntsville

Decatur

CO



main site
range from supplemental sites
range within 7 x 5 cells around main site
main site anthropogenic CO
main site fire CO



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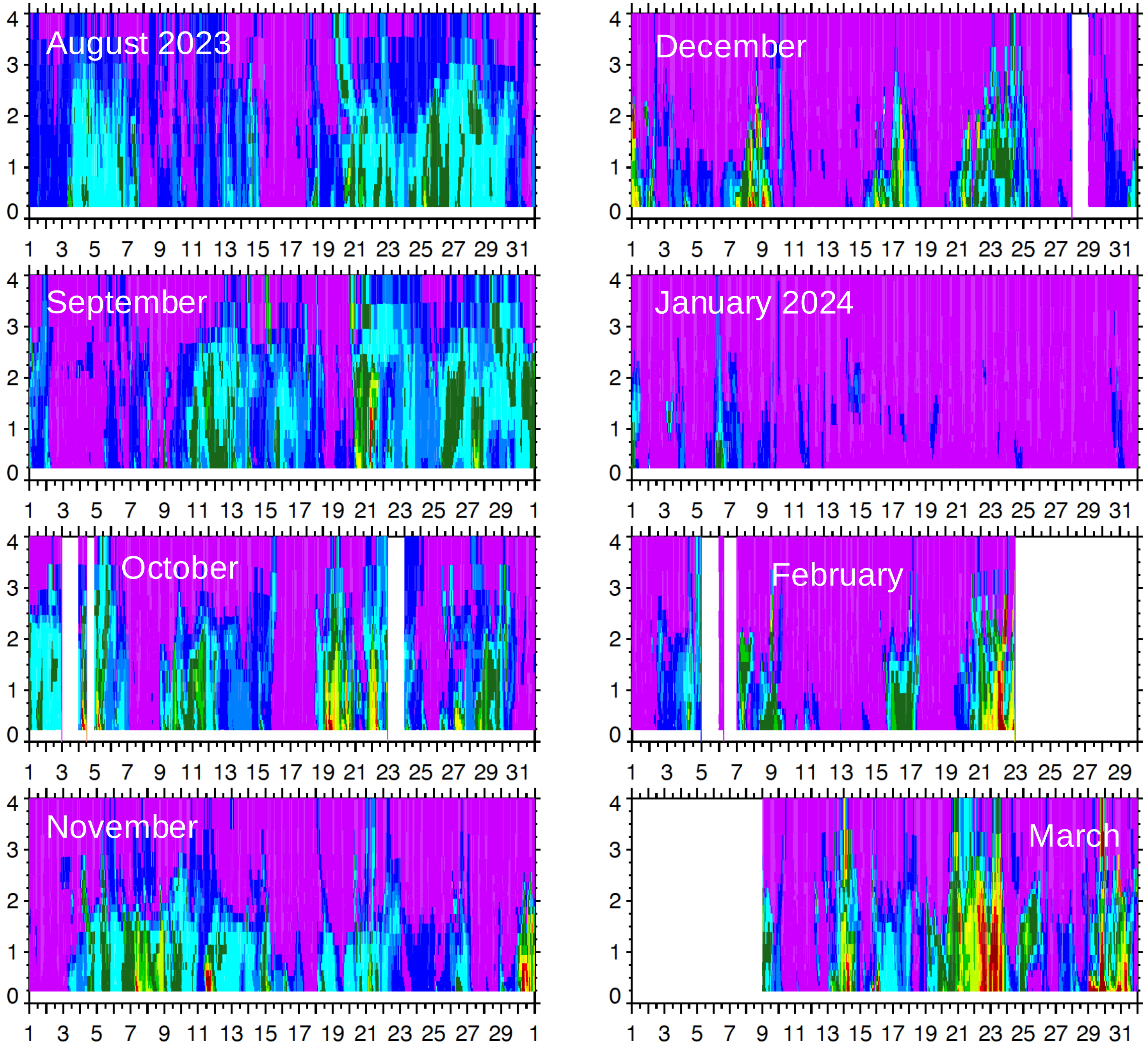
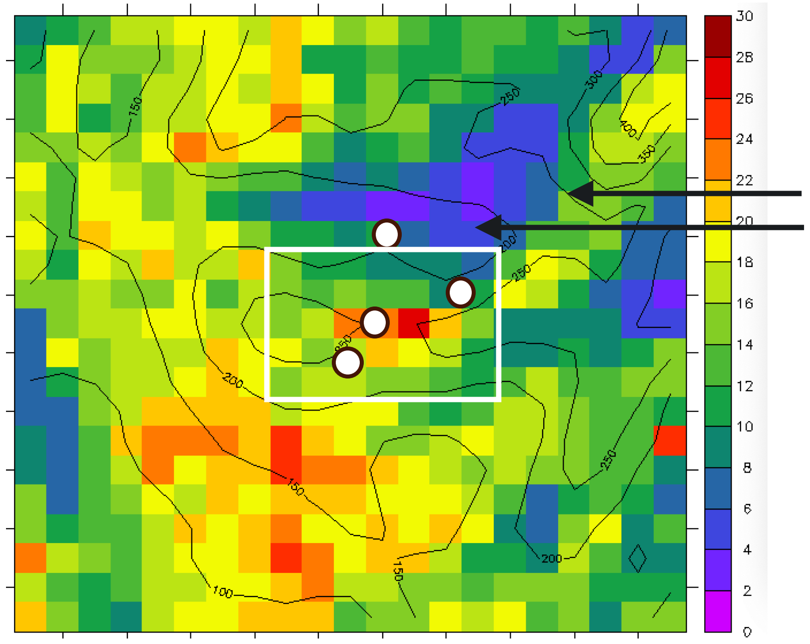
Vertical Profiles of CO from Fires



profiles at the main site



Implications

- Aerosols and their precursors are highly variable around BNF, and the amount of spatial variability is seasonally dependent.
  - *Anthropogenic point sources, biogenic emissions, fires (particularly local prescribed)*
- Some species are more variable than others (e.g., AOD vs SO_2)
- Main site will likely have largest local biogenic influence
- This analysis just scratches the surface

- Possible activities:
  - *Sample at other grid cells?*
  - *Correlate species with wind direction?*
  - *Examine variability aloft?*
  - *Continue to archive simulations through the BNF lifetime?*