

Air Quality Nowcasting and Forecasting in Alaska Using Low-Cost Sensors and Satellites

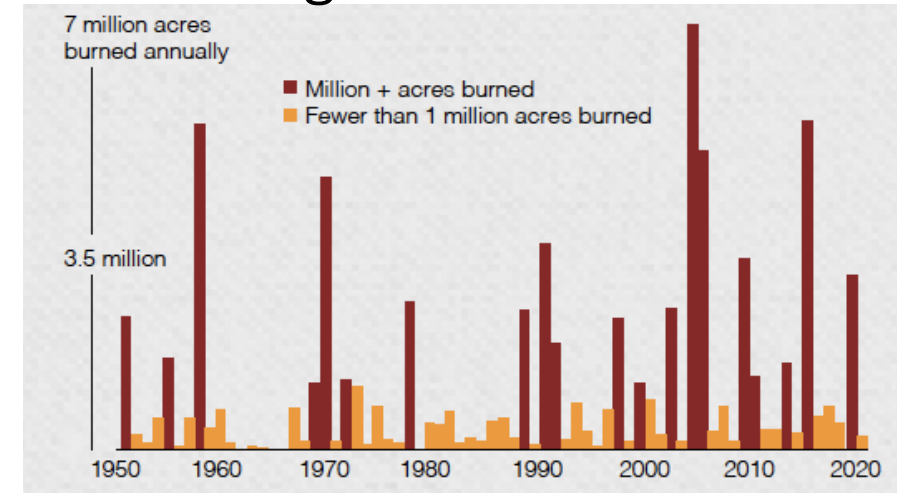
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Jun Wang (University of Iowa)



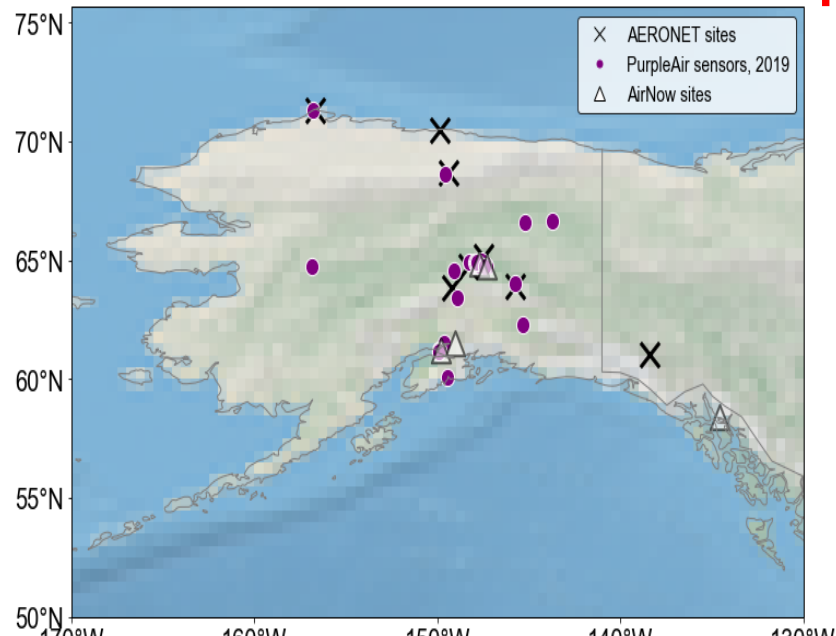
Wildfire accounts for majority of PM2.5 pollution in Alaska summer, and it will get a lot worse...



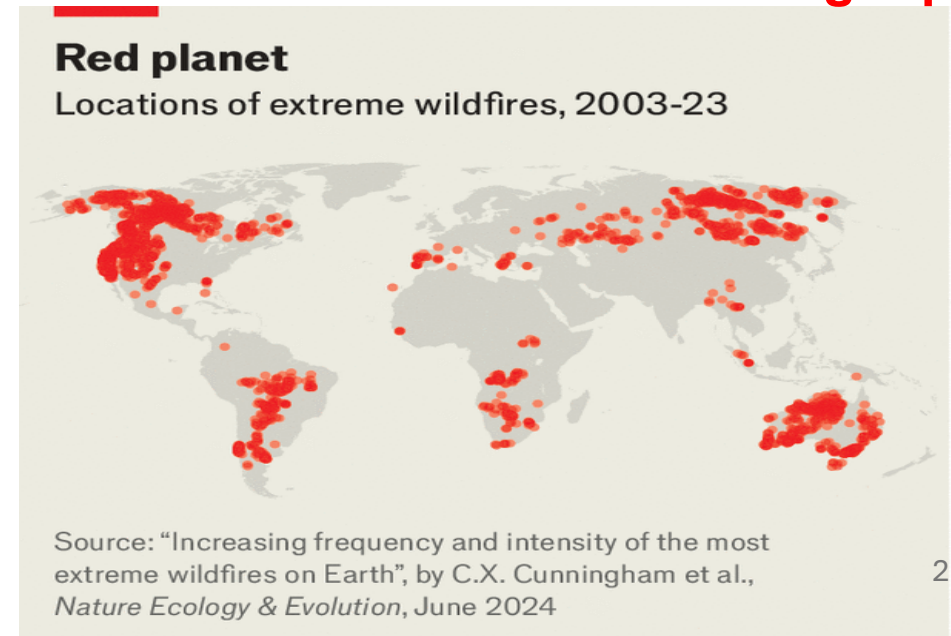
Burning area in Alaska



Ground-based measurements are sparse in Alaska



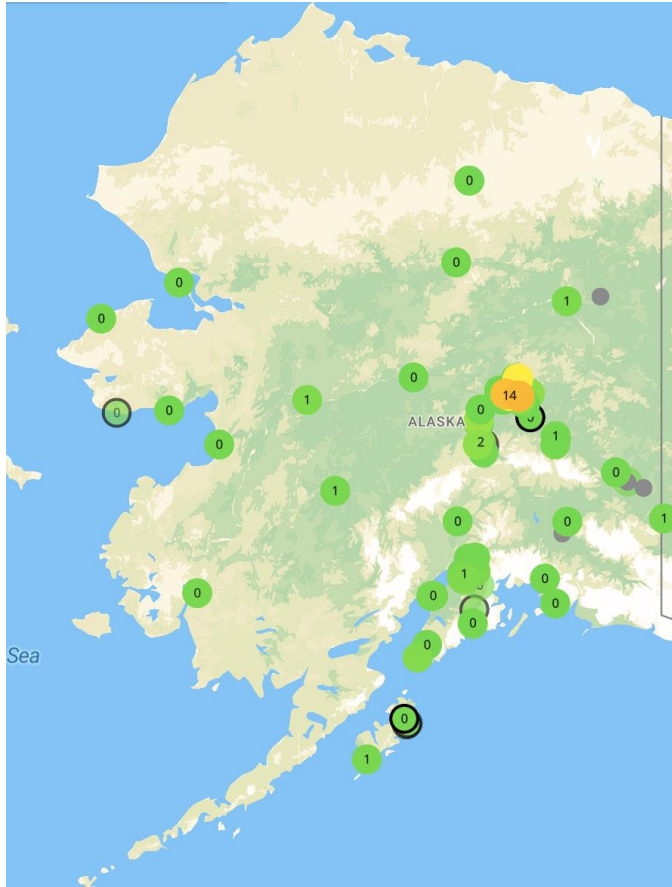
Extreme wildfires are increasing rapidly



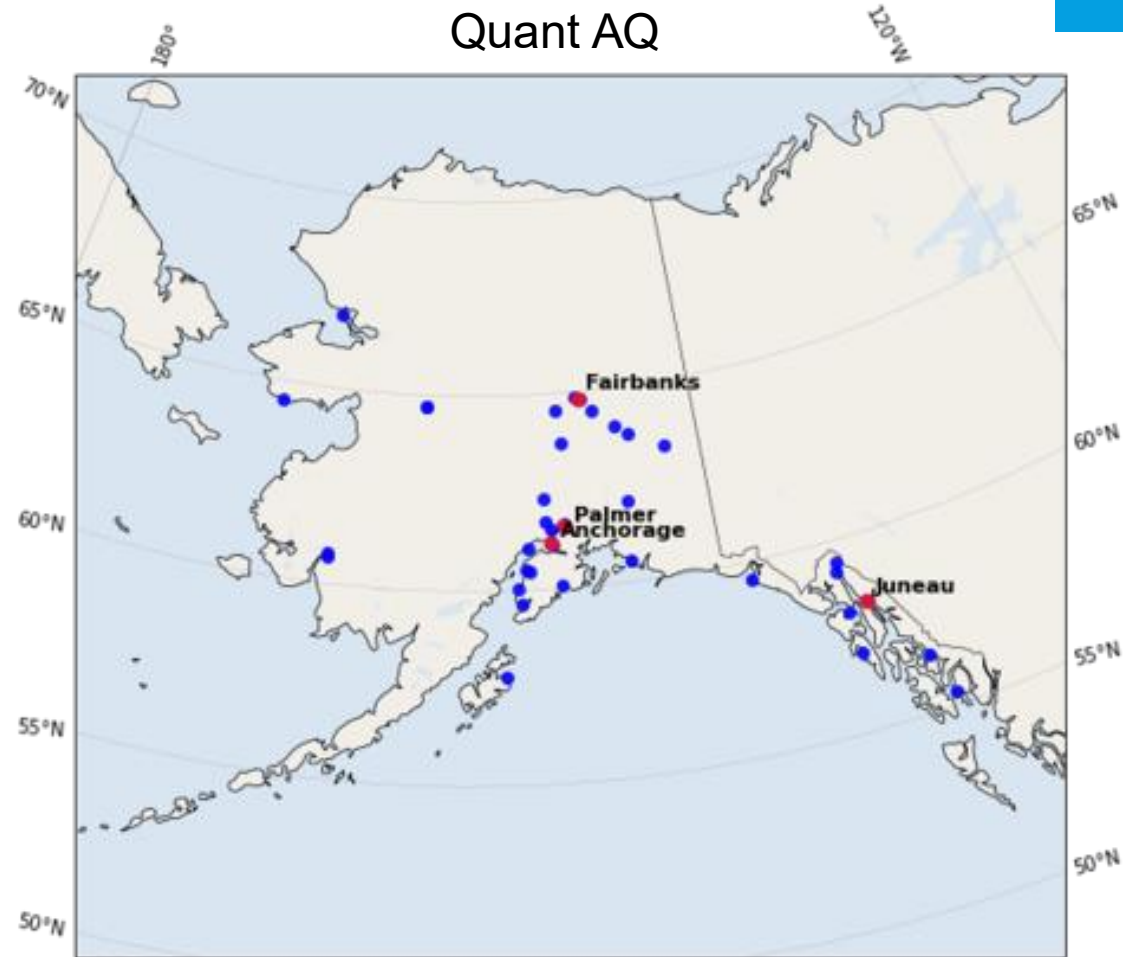
Low-cost sensor networks in Alaska



Purple Air Map in AK

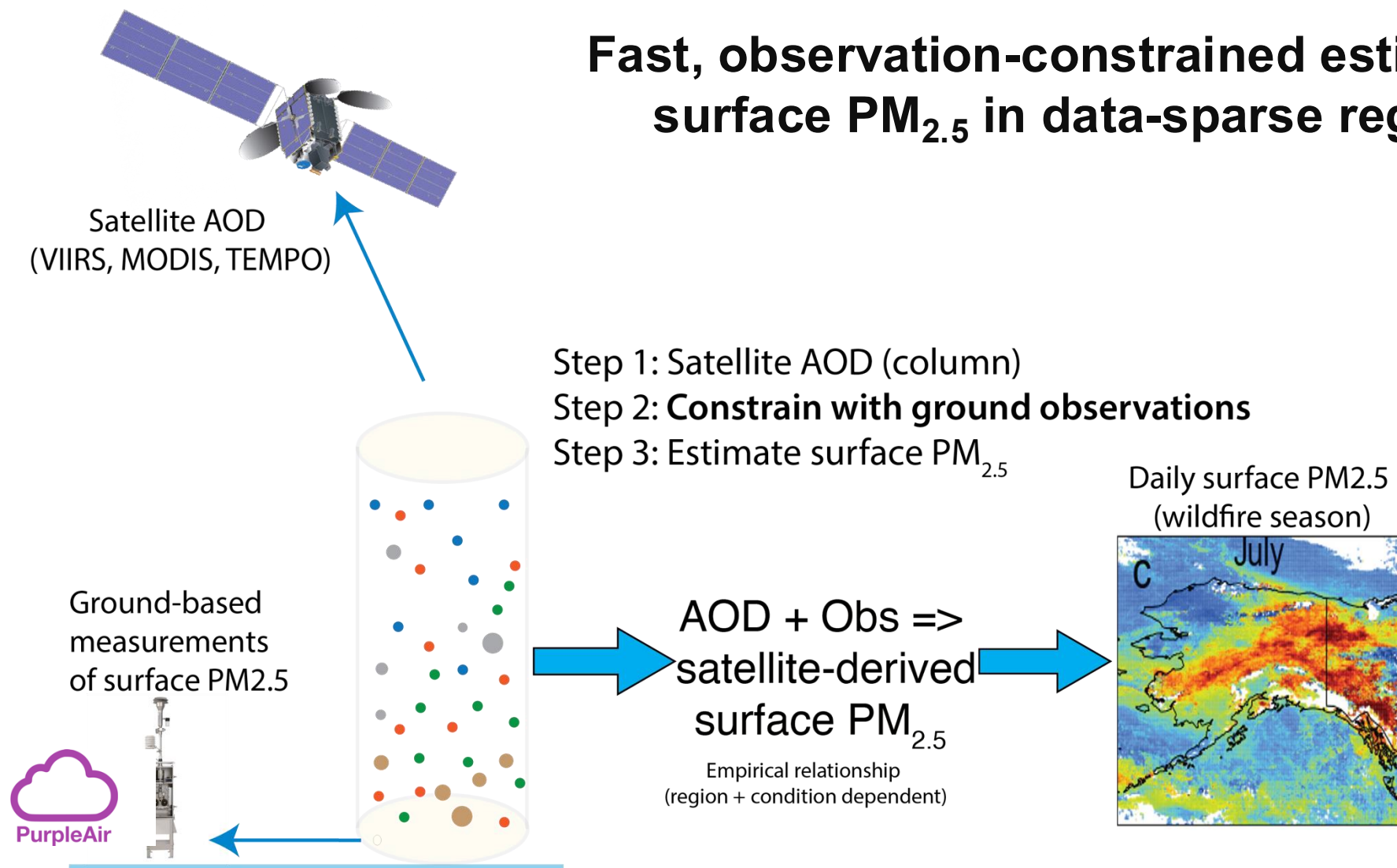


Quant AQ



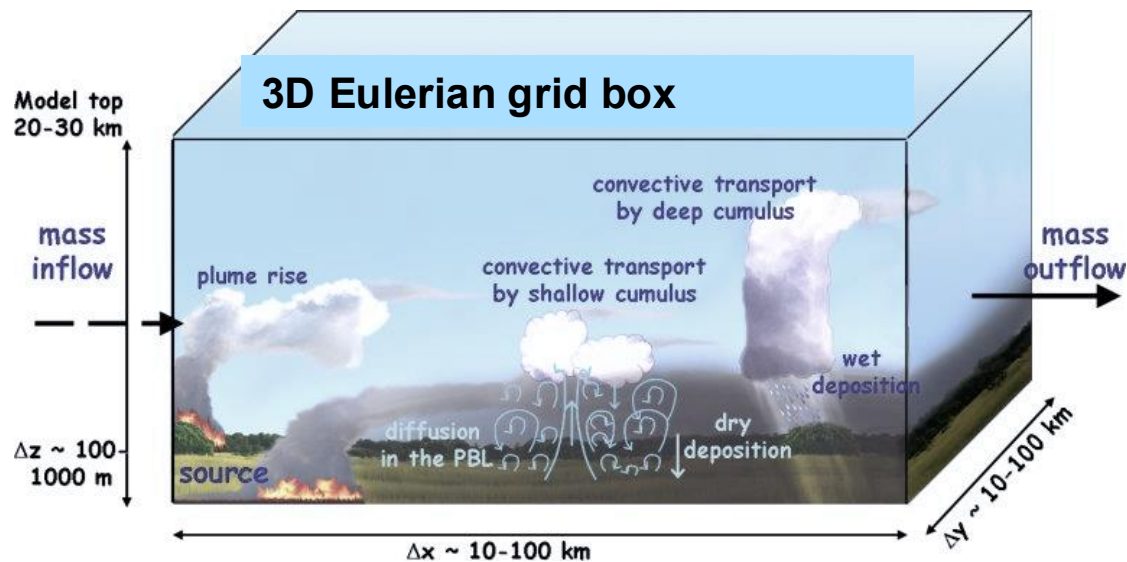
(Data provided by Alaska DEC)

Estimating surface PM_{2.5} from satellite observations in data-sparse regions



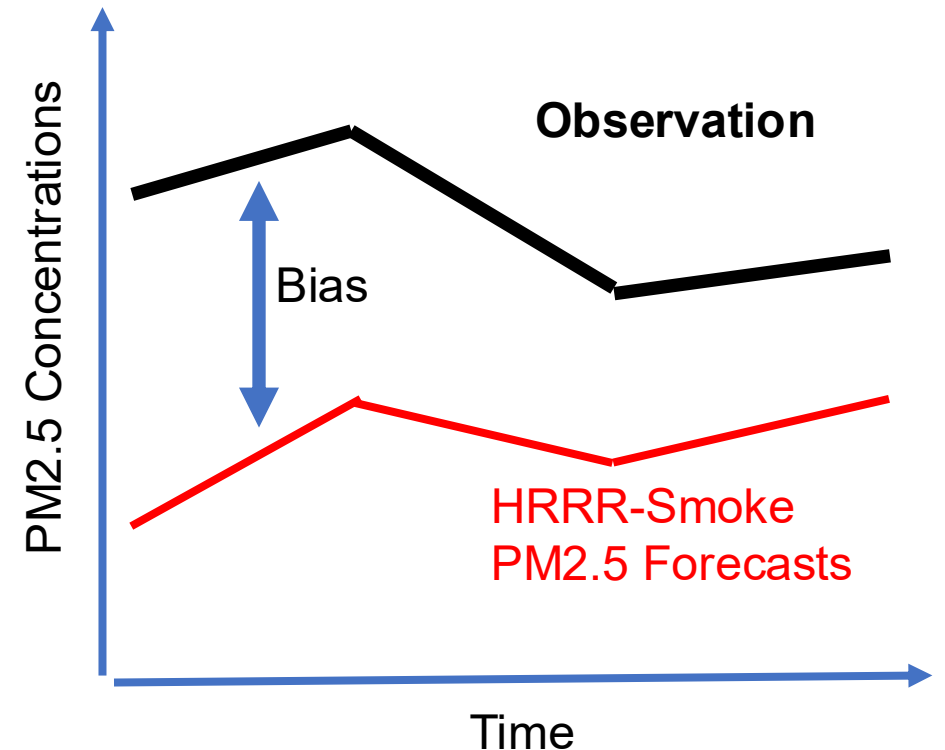
Models systematically underestimate surface PM_{2.5} during wildfire events

HRRR-smoke model (3 km x 3 km)



- **Inadequate smoke–meteorology interactions**
- Missing fire emissions (FRP detection)

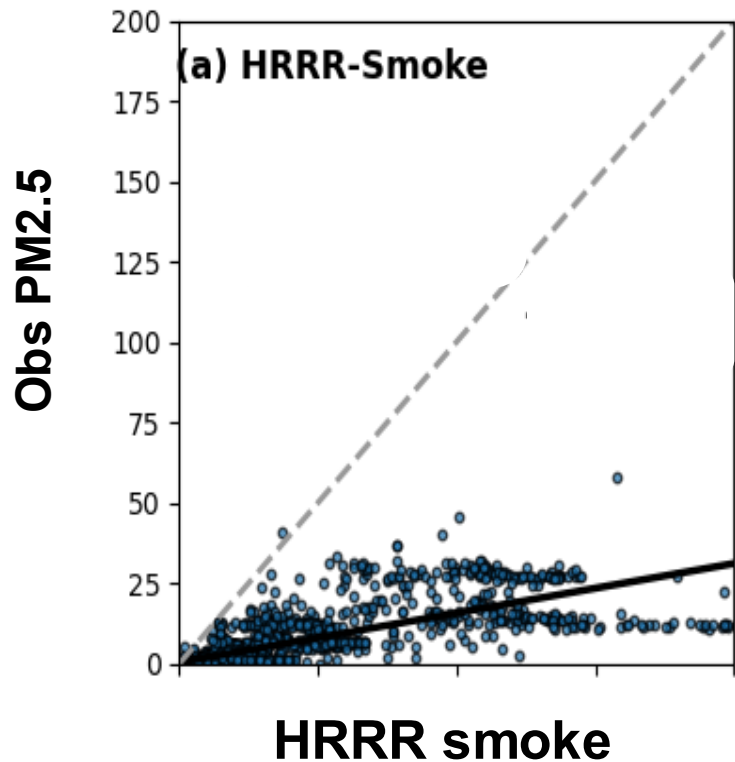
Model underestimates surface PM_{2.5} by a factor of 5.



(Dong et al., ES&T Air, 2026)

Machine learning substantially reduces PM_{2.5} underestimation

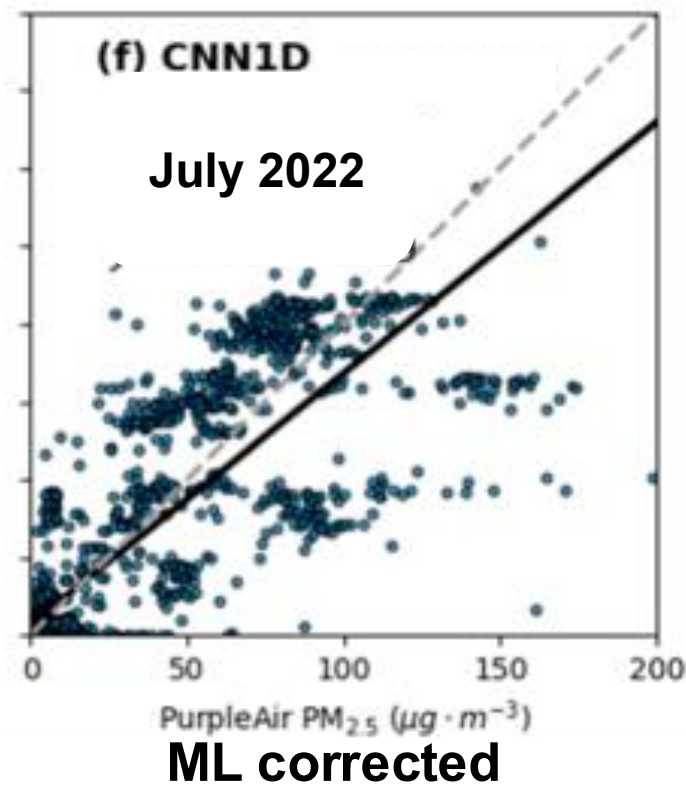
up to 5x underestimate



bias correction



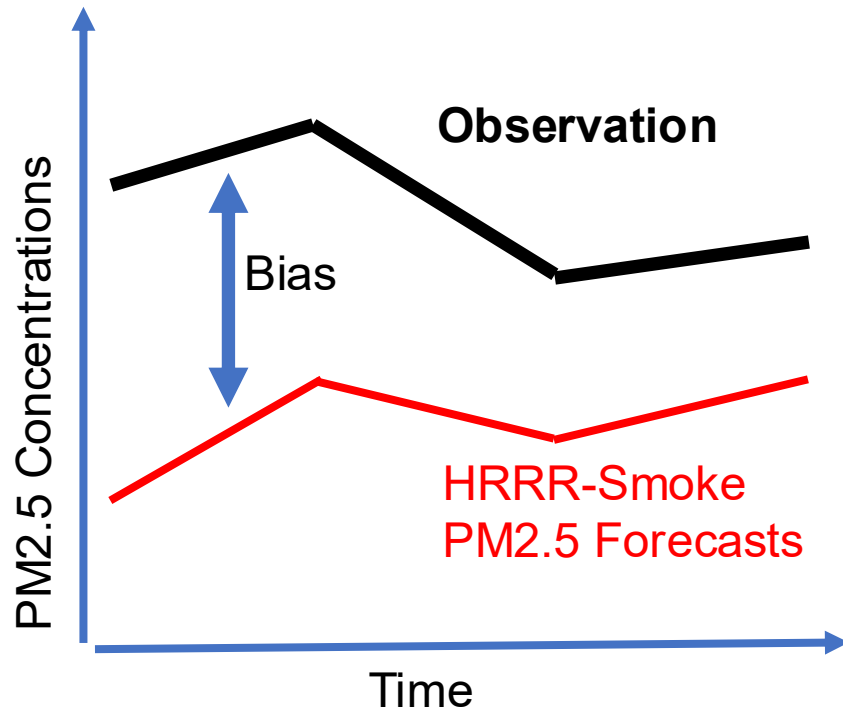
Bias reduced to 20%



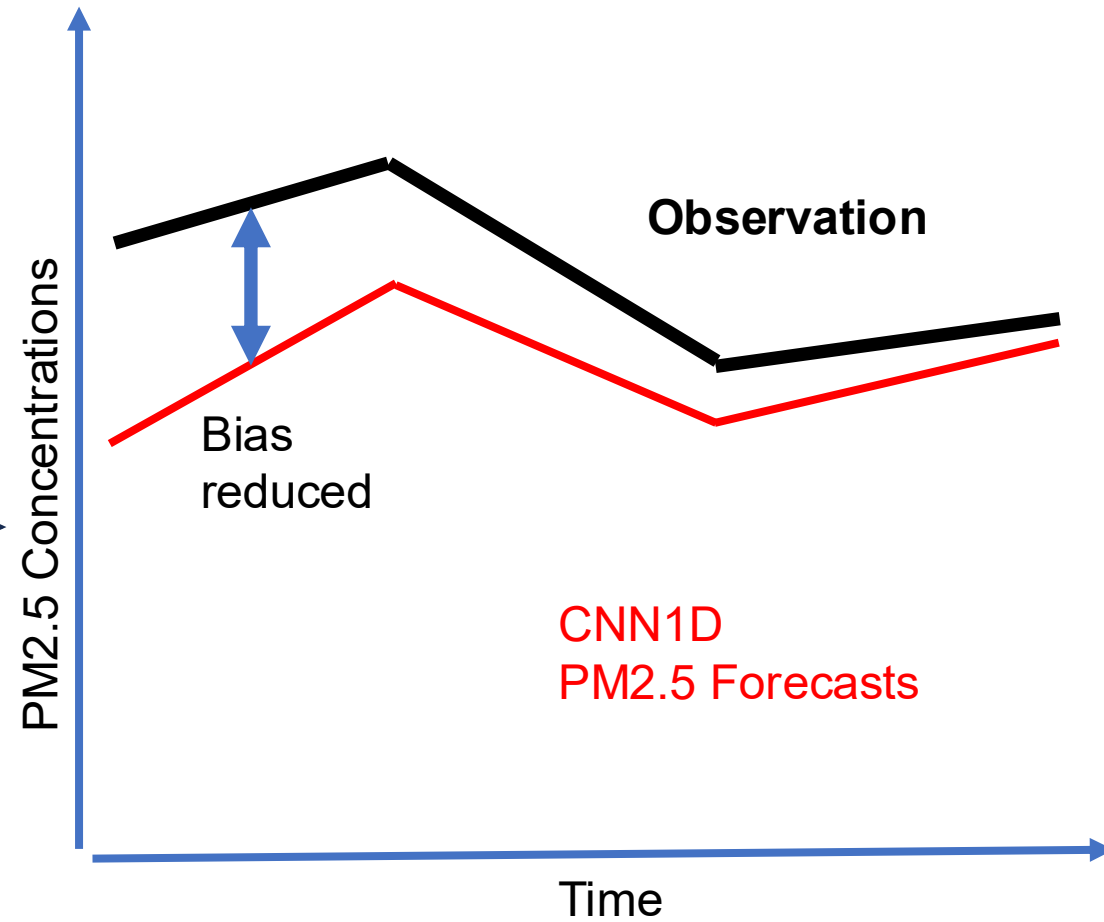
- ML reduces large PM_{2.5} underestimation in smoke events.
- Predictor ranking shows **column smoke better explains observed surface PM_{2.5} than surface smoke.**
- **Indicates misrepresentation of mixing processes.**

Machine learning to correct model bias using observations

Up to 5x underestimation of surface PM2.5.



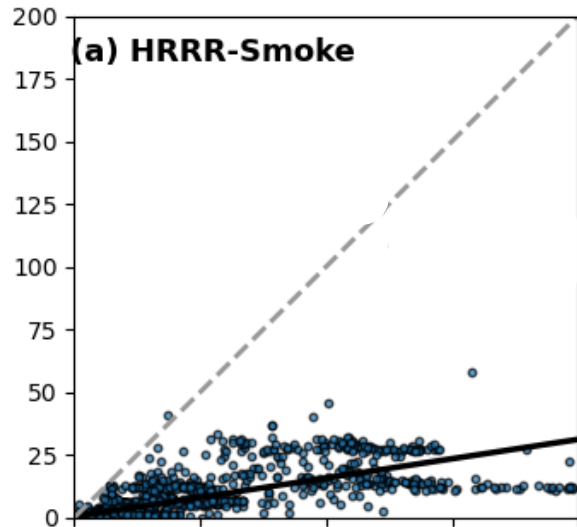
bias correction



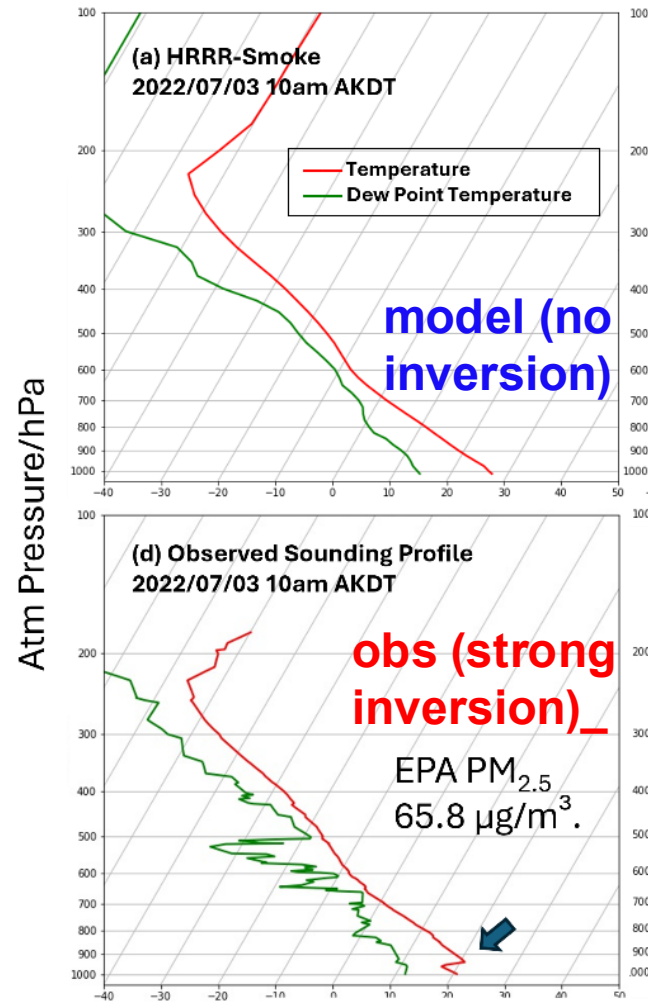
ML improves forecasts by learning missing physical processes from observations

Missing smoke–meteorology feedback explains large PM_{2.5} underestimate

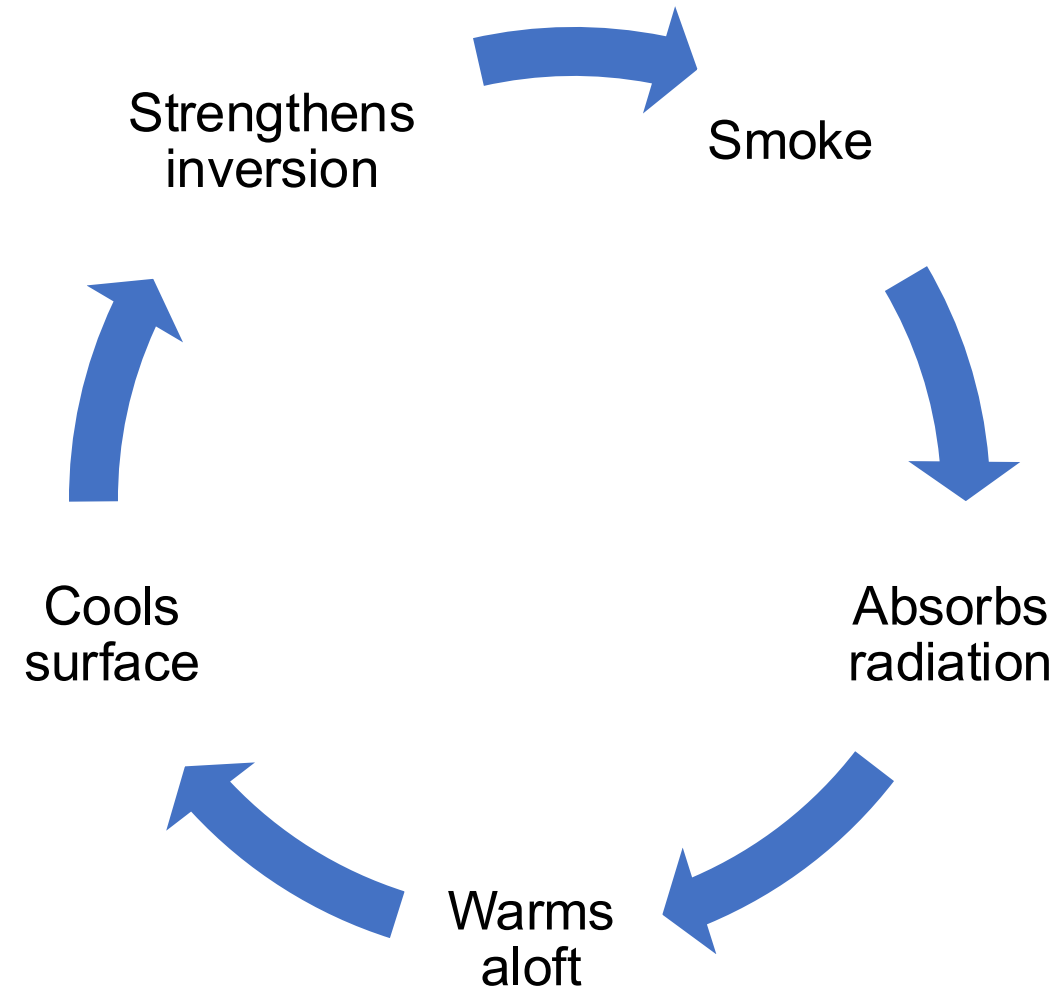
up to 5x underestimate



temperature profile



Model fails to represent this feedback

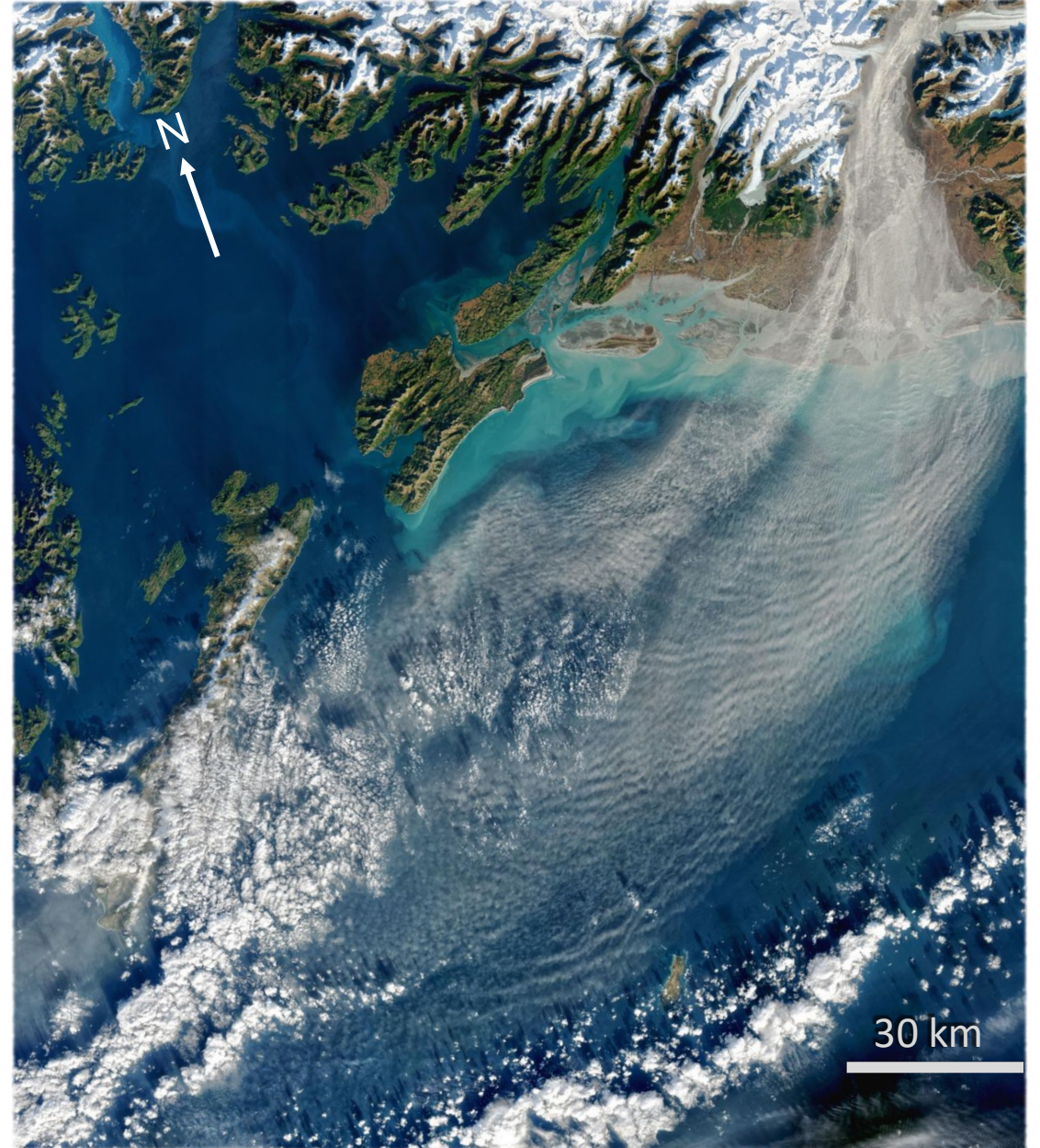


This missing feedback leads to large PM_{2.5} underestimate. (Dong et al., 2026, ES&T Air)

High latitude dust is another challenge for air quality and climate

Dust cloud at Copper River Valley, Alaska

Glacier dust provides nutrient to the ocean phytoplankton

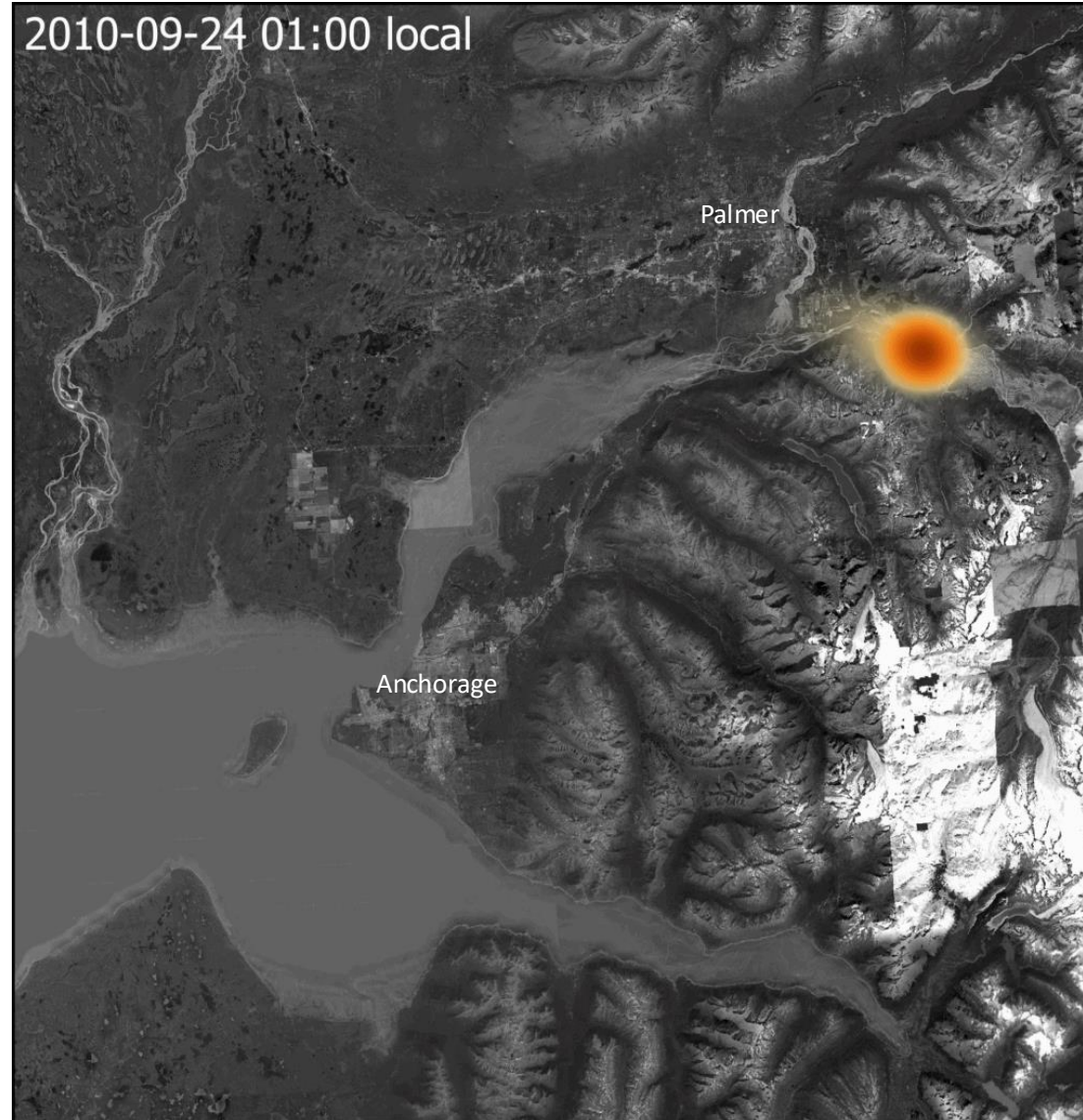


Modelling dust dispersion

FLEXPART-WRF

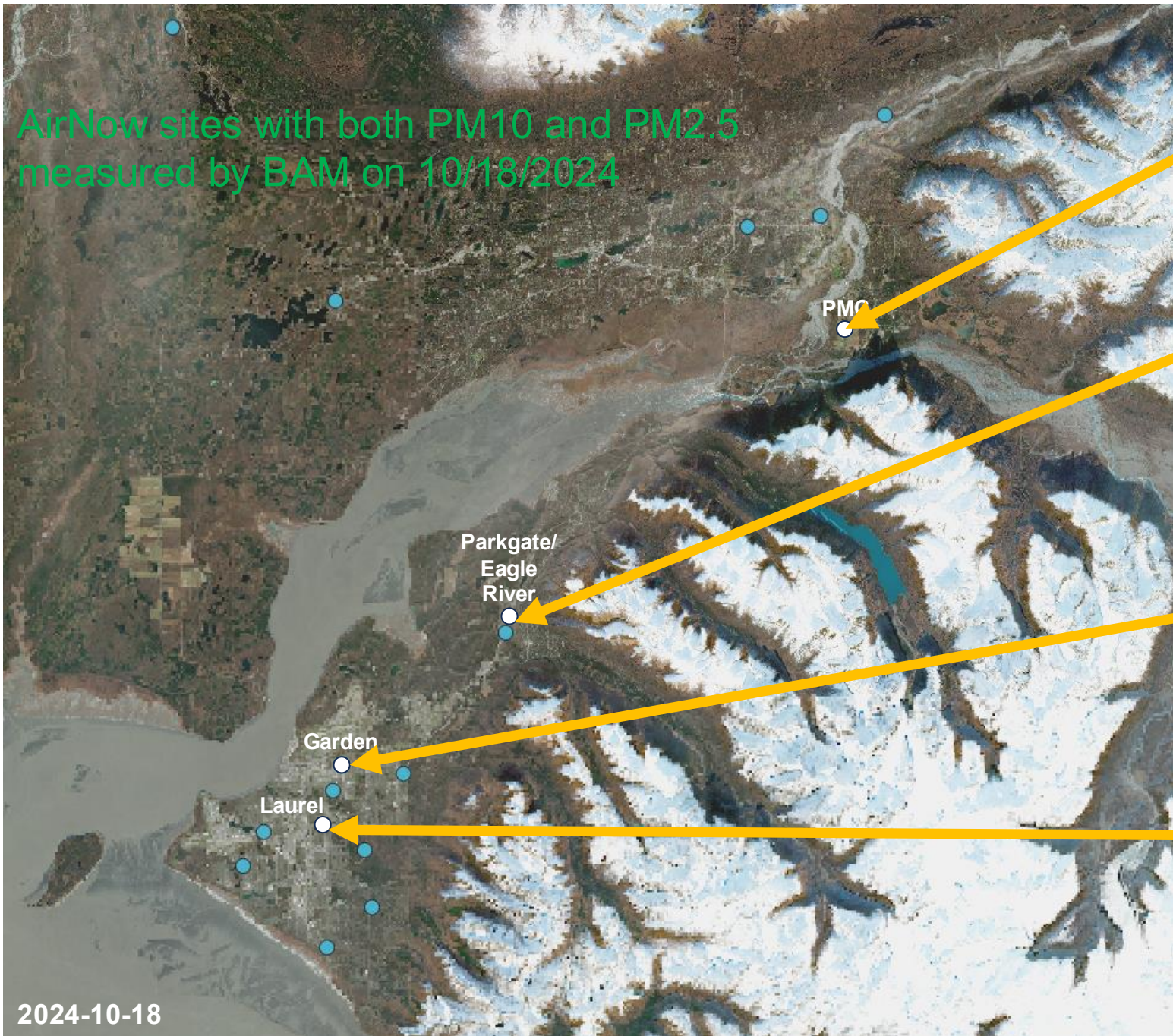
- Known dust event from surface monitoring
- How does dispersion affect population exposure?

e.g. one source location

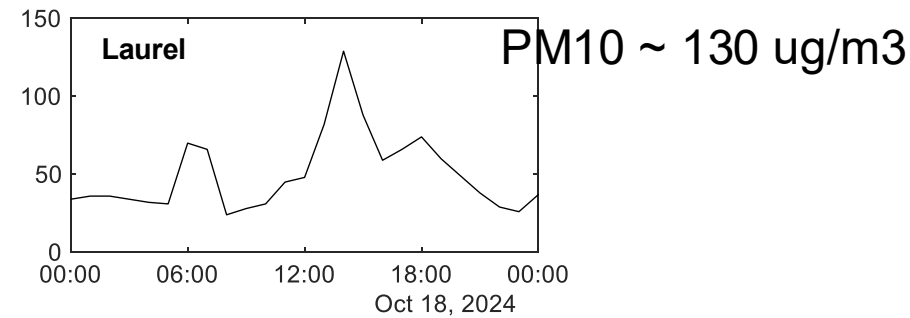
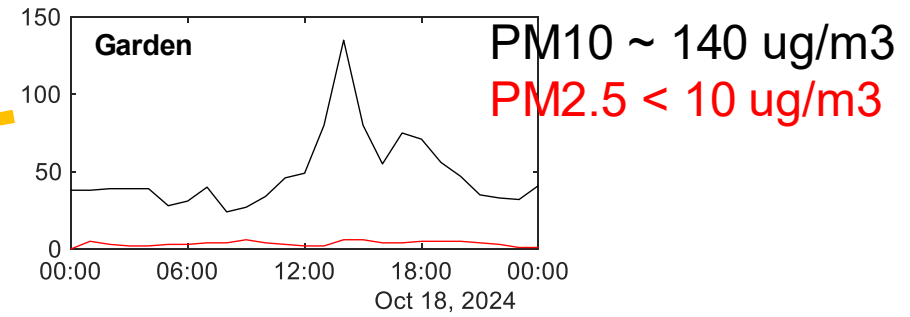
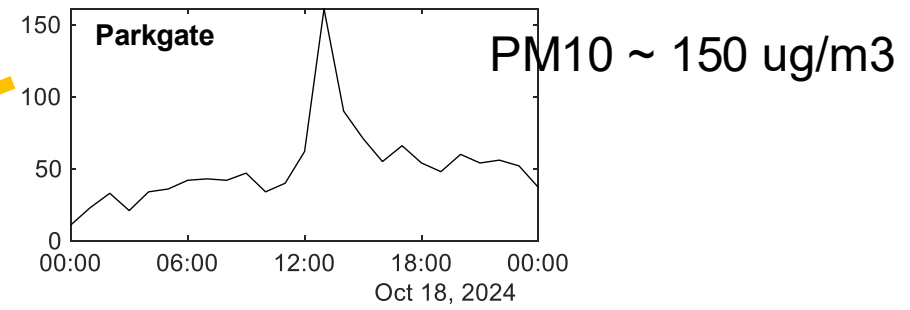
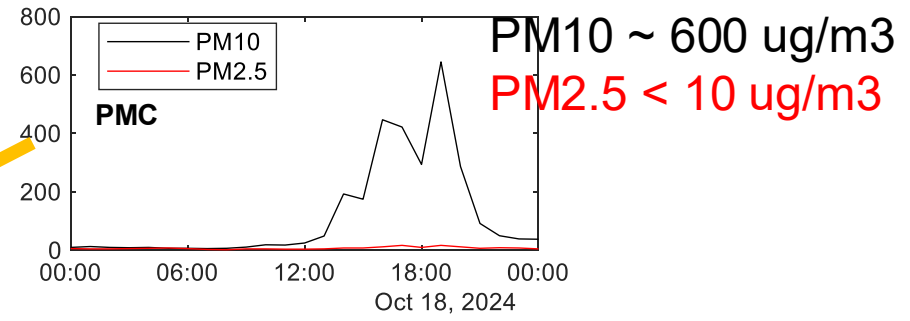


See Daniel Bellamy's poster

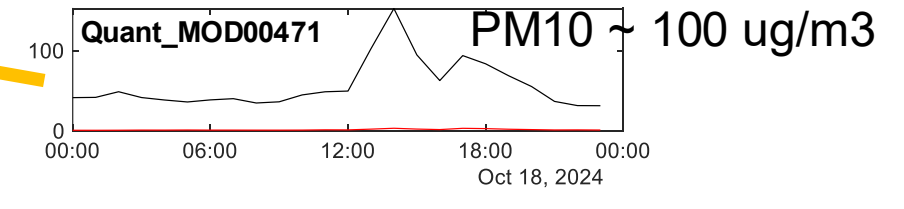
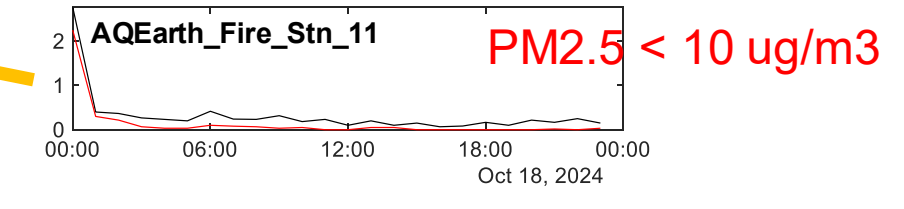
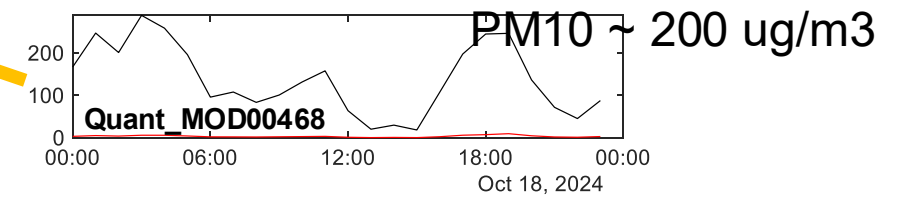
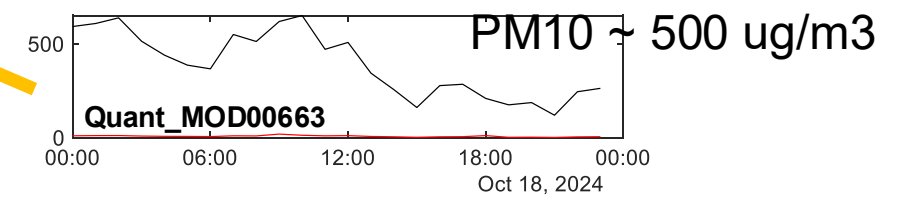
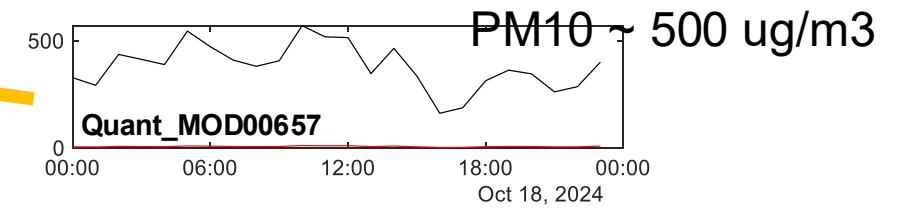
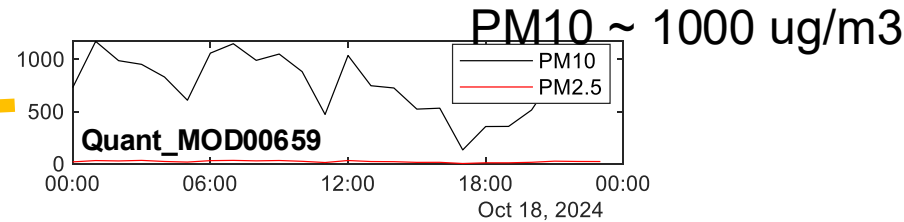
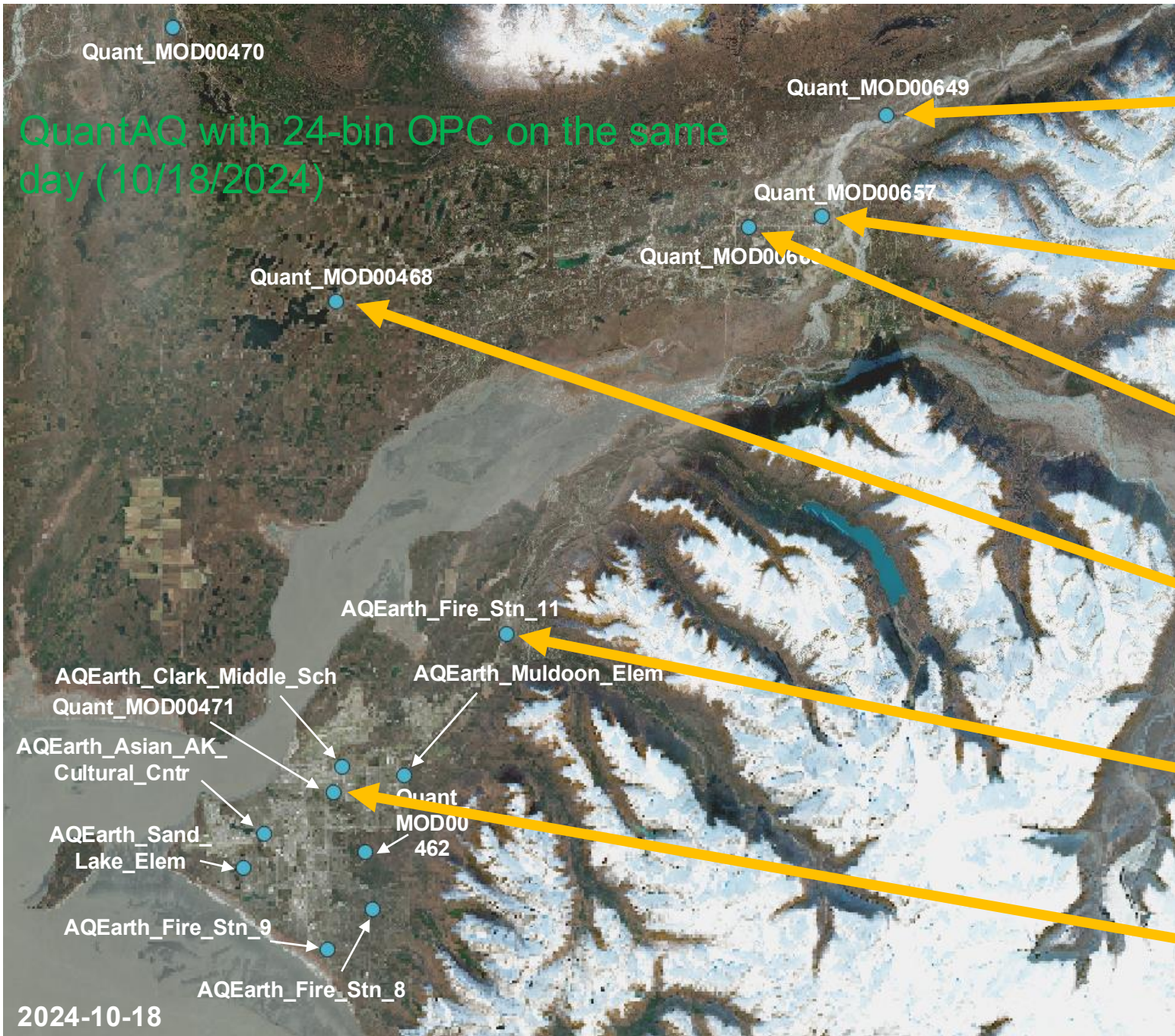
AirNow sites with both PM10 and PM2.5 measured by BAM on 10/18/2024



2024-10-18



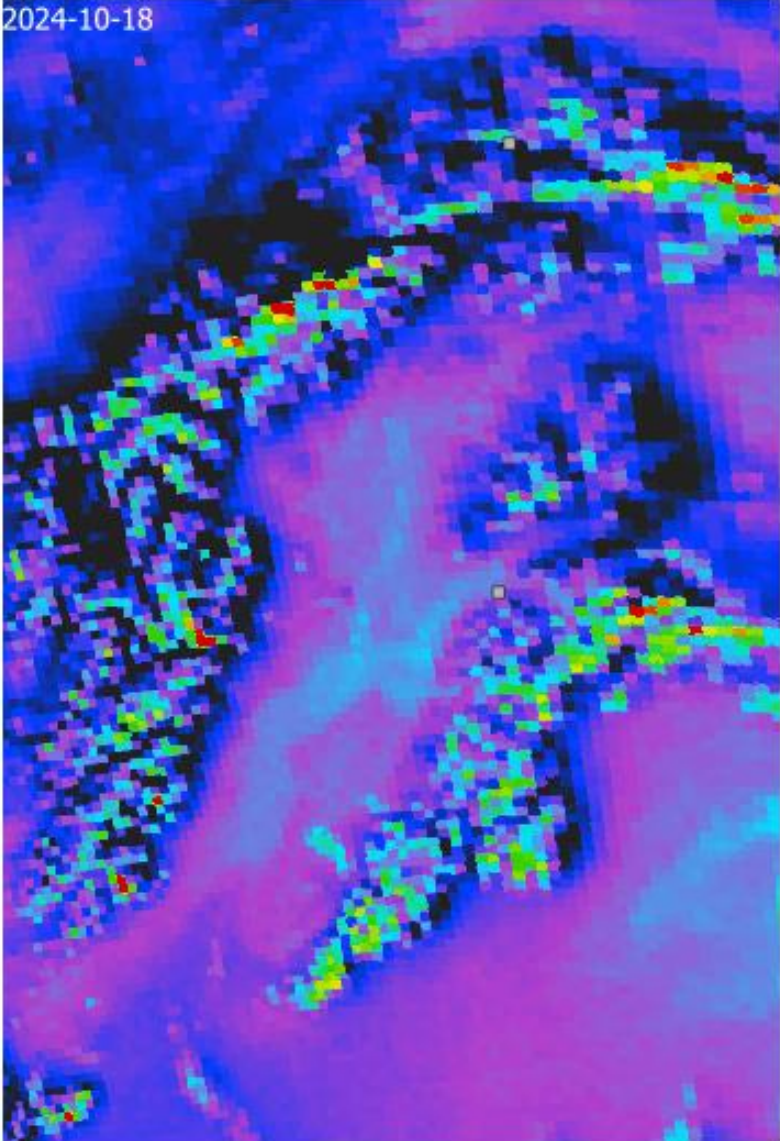
QuantAQ with 24-bin OPC on the same day (10/18/2024)



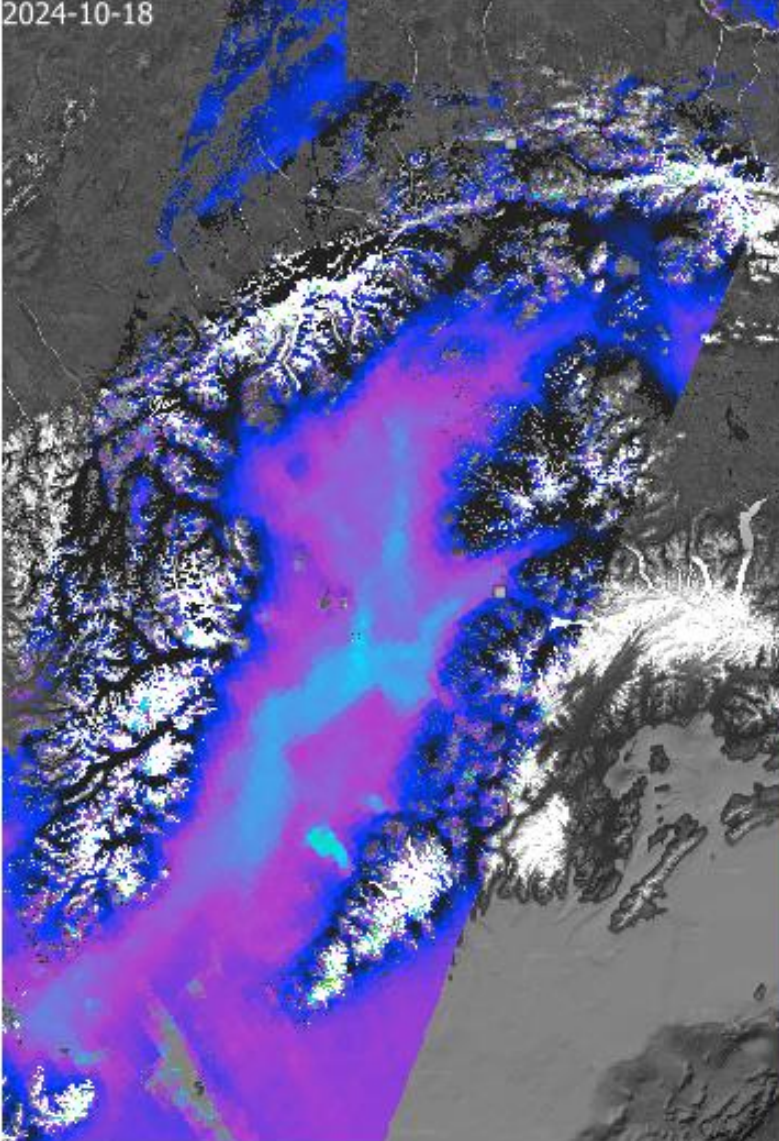
2024-10-18

Same event seen by TROPOMI Aerosol Index product

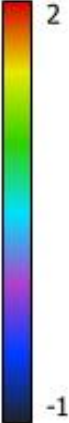
Sentinel-5P AER AI
2024-10-18



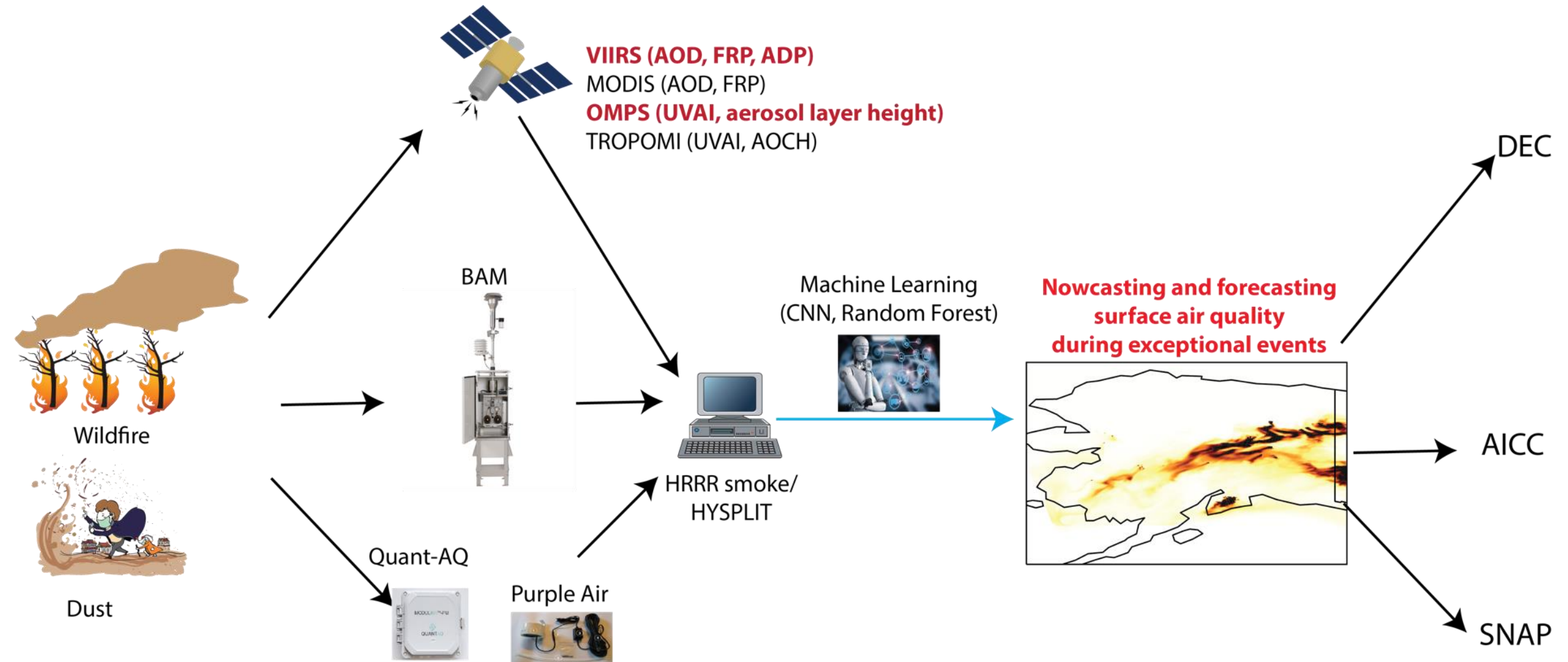
Sentinel-5P AER AI - masking derived from Sentinel-2
2024-10-18



Aerosol
Index



Develop reliable air quality nowcast and forecast for Alaska



1. Direct broadcast from VIIRS for near-real-time nowcast.
2. Reconcile discrepancies between low-cost sensor network and regulatory measurements.