Improving surface $PM_{2.5}$ **forecast** using an ensemble of satellite data, chemistry transport model outputs, and surface observations

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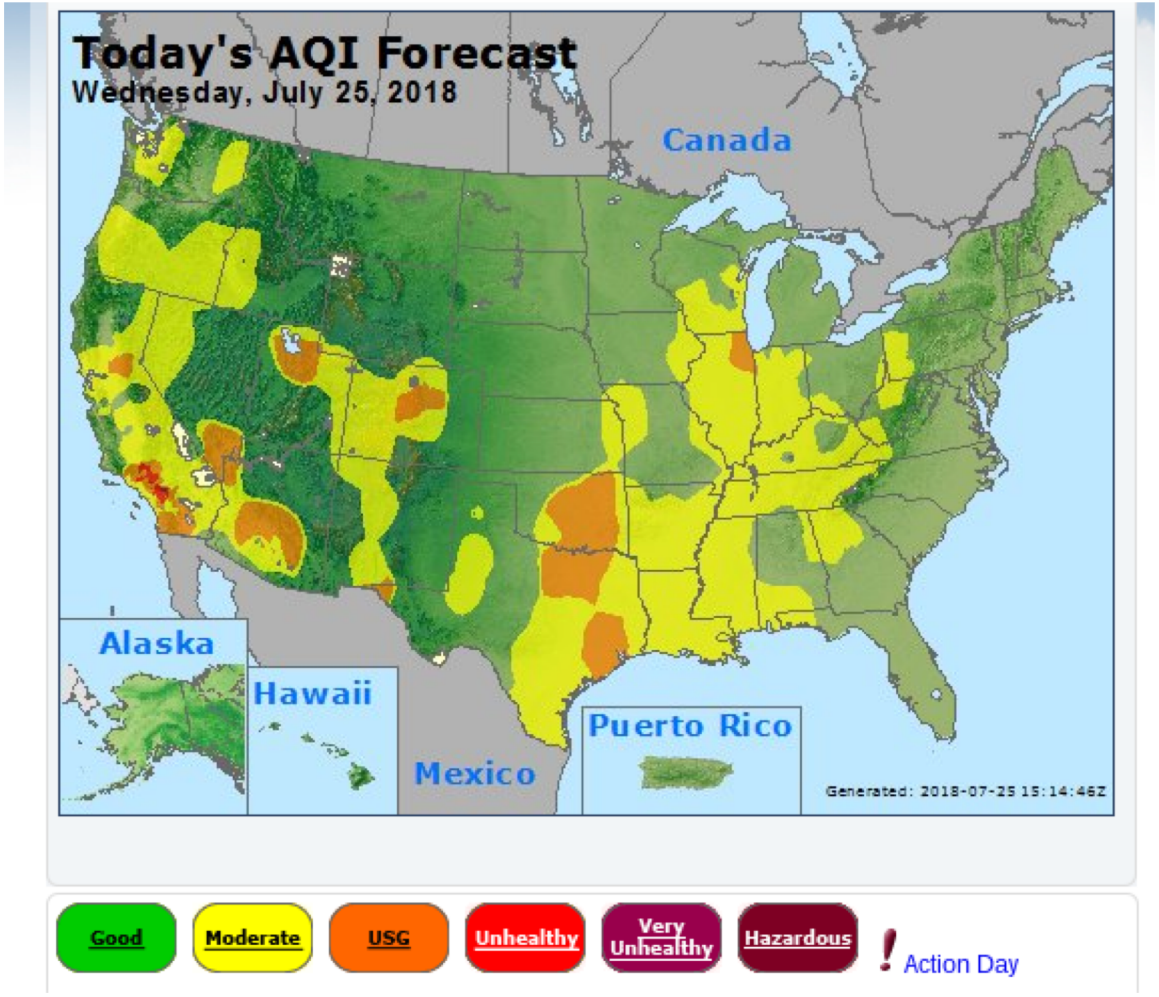
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

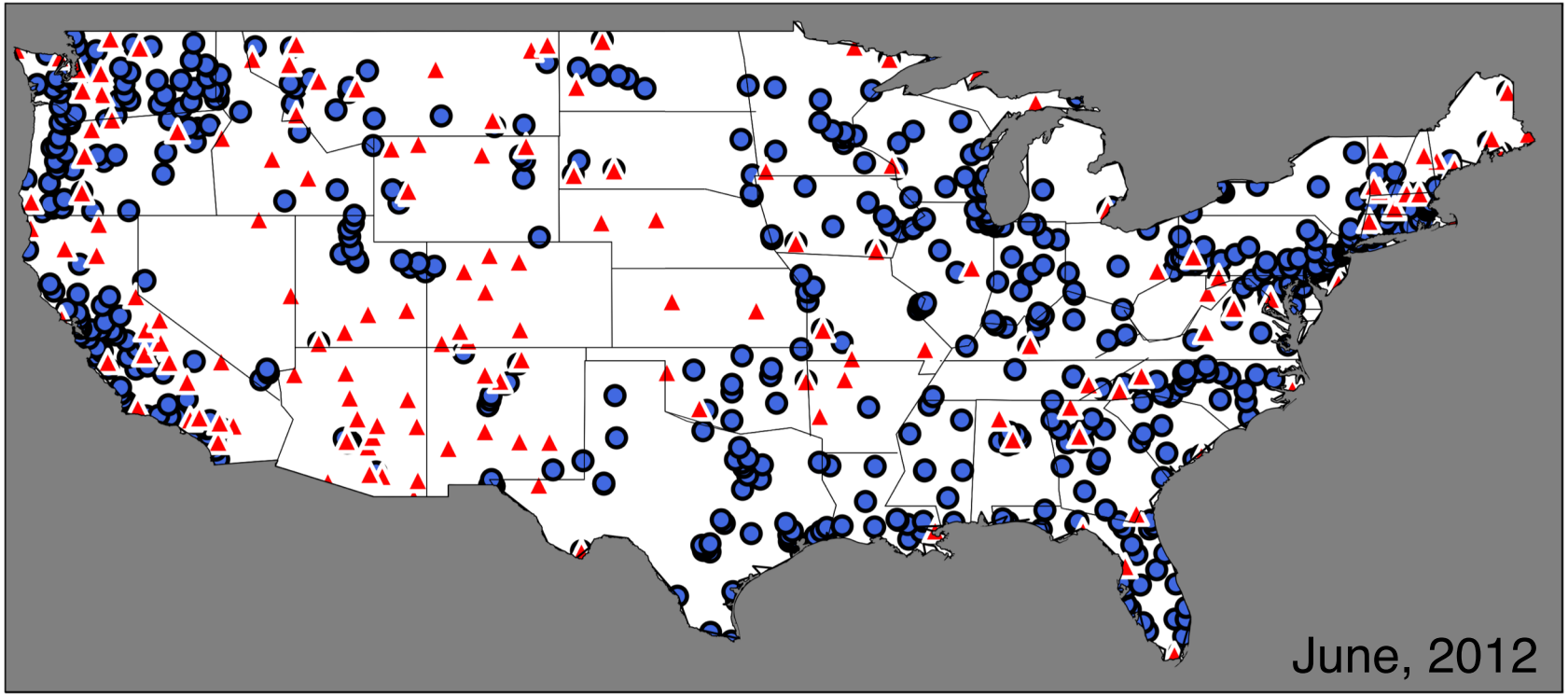
The current U.S. Air Quality forecasting



- Today and tomorrow forecasts
- Forecasts are made for major MSAs (metropolitan statistical areas): typically for cities with over 350k in population

AirNow

Uneven distribution of ground $PM_{2.5}$ measurements

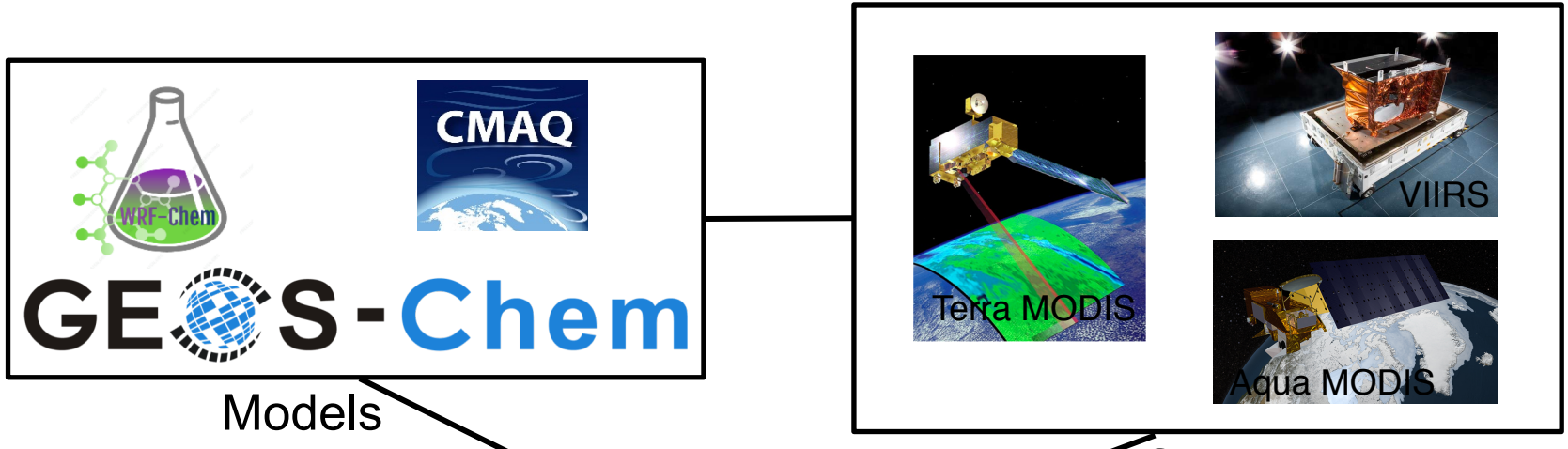


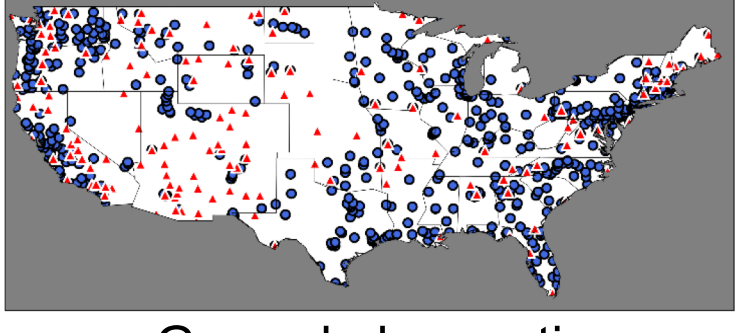
Blue: ~ 600 ground stations providing near real-time **hourly** $PM_{2.5}$ mass, in support of the EPA AIRNow program.

Red: ~150 stations as part of the IMPROVE network. Measure **daily** $PM_{2.5}$ mass every 3rd day.

Objective: Improve $PM_{2.5}$ forecast in the rural

A multi-model, multi-AOD approach



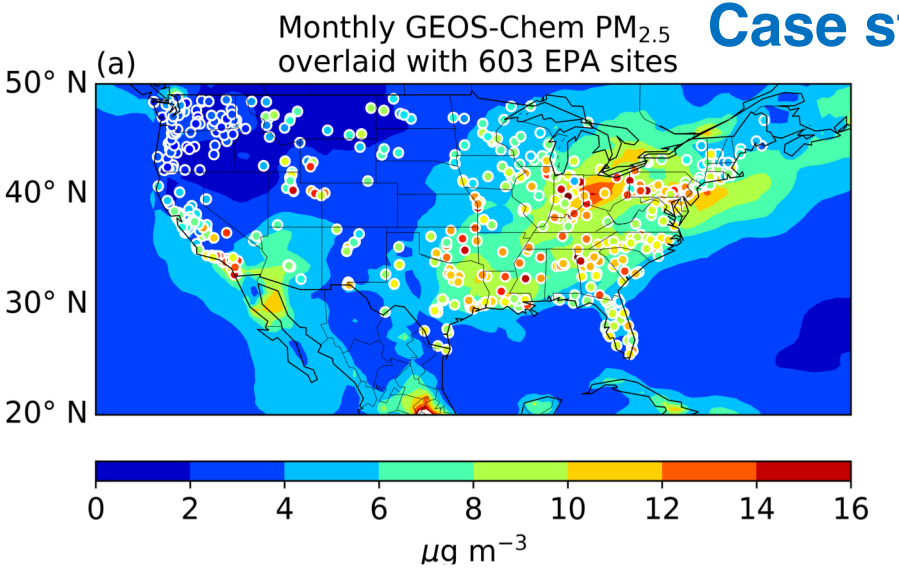


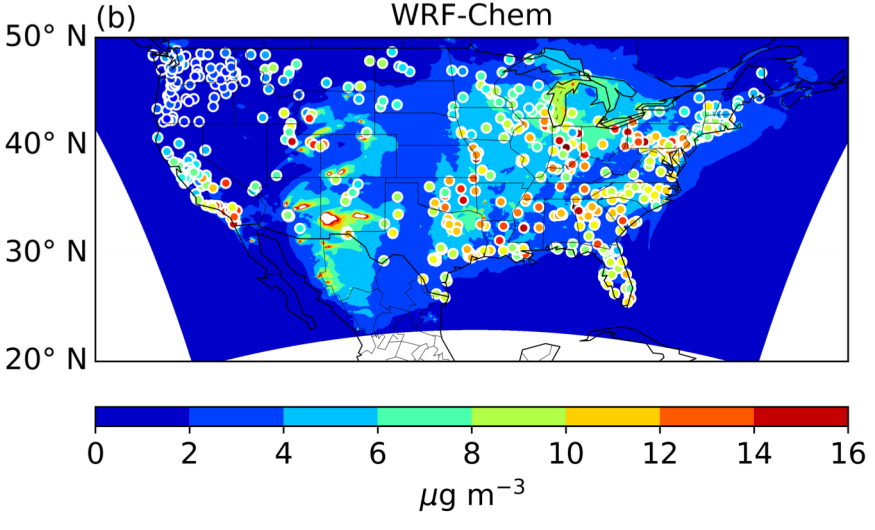
Ground observations

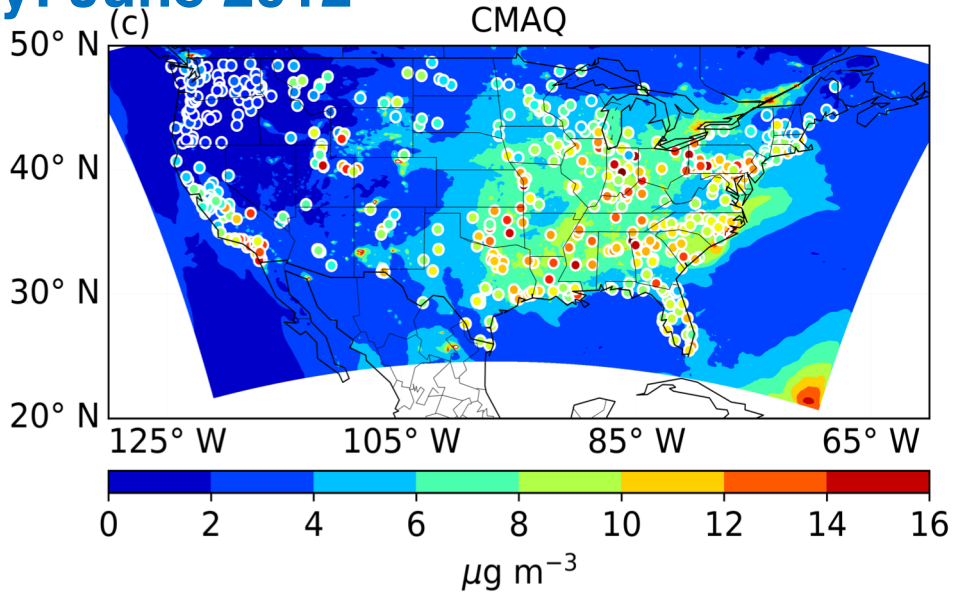
(https://www.epa.gov/cmaq;
https://ruc.noaa.gov/wrf/wrf-chem/;
http://acmg.seas.harvard.edu/geos/;
https://www.epa.gov/aqs;
http://vista.cira.colostate.edu/Improve/)

(https://podaac.jpl.nasa.gov/Terra;
https://aqua.nasa.gov/content/about-aqua;
https://jointmission.gsfc.nasa.gov/viirs.html)

Case study: June 2012





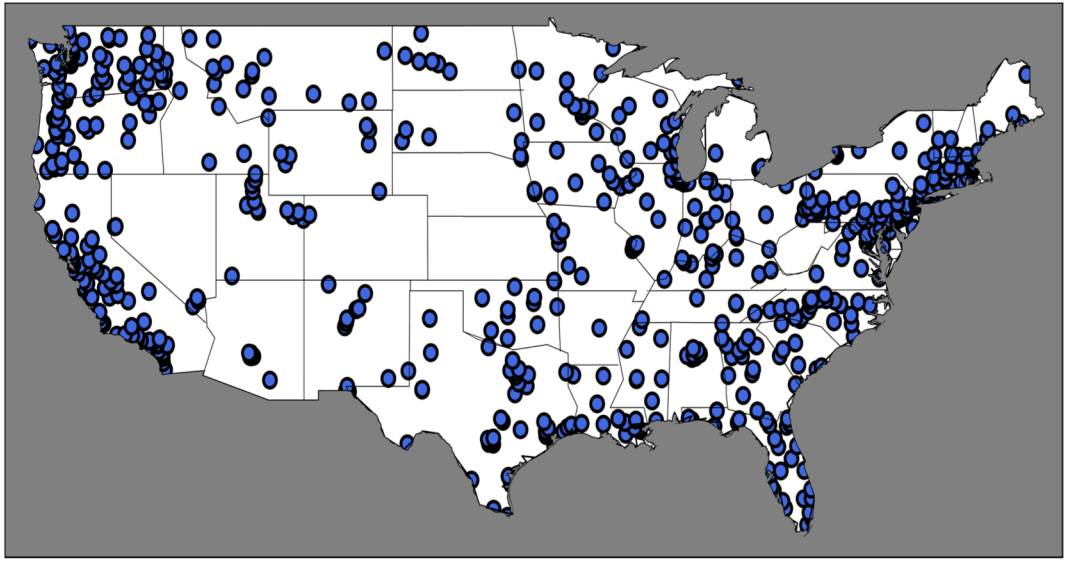


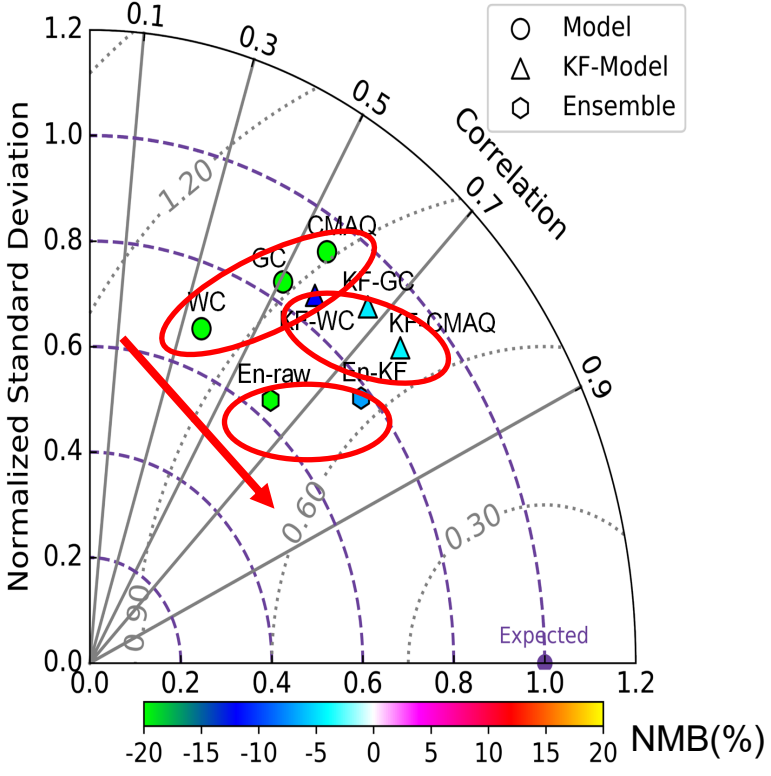
Models underestimate the ground observations

Monthly EPA: 8.80 ± 3.65 $\mu g\ m^{-3}$
Monthly GC: 6.61 ± 3.28 $\mu g\ m^{-3}$ (-25%)
Monthly WC: 4.54 ± 2.18 $\mu g\ m^{-3}$ (-48%)
Monthly CMAQ: 6.94 ± 3.30 $\mu g\ m^{-3}$(-21%)

Step I: Bias correction

Kalman filter (KF)

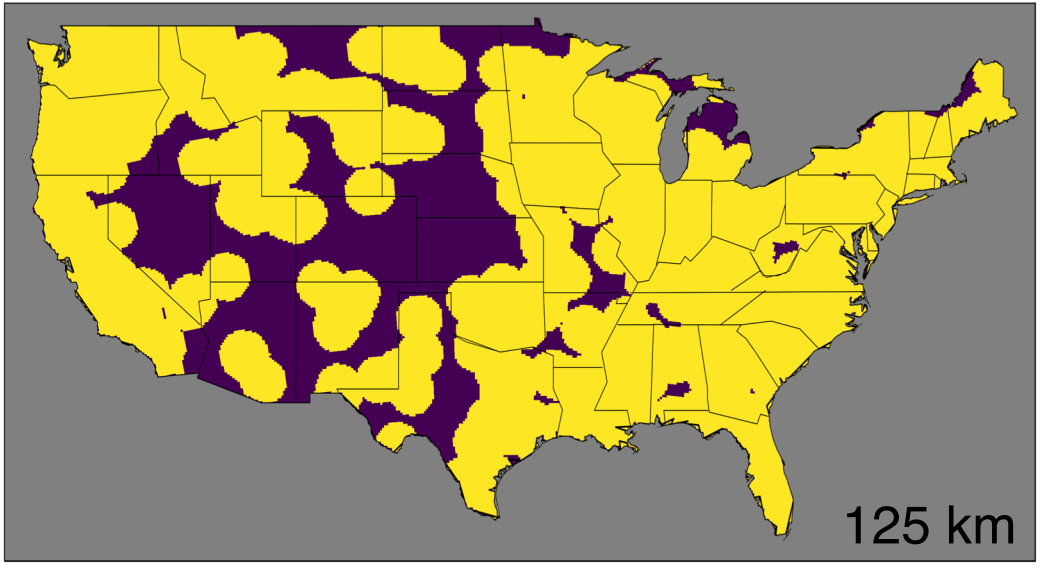




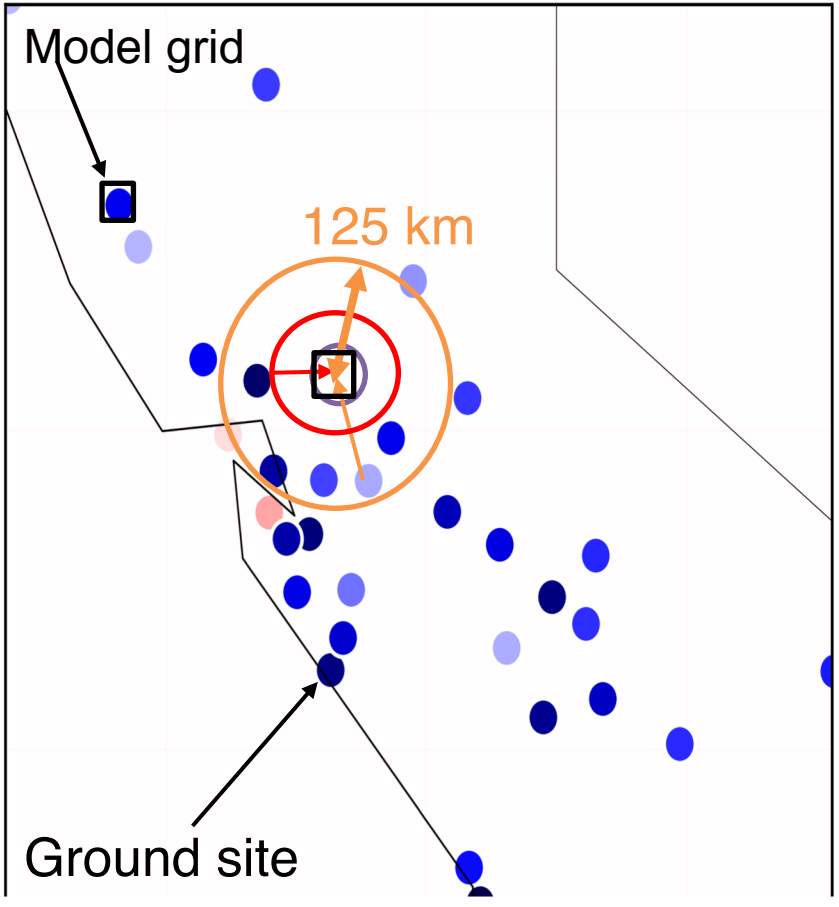
Ensemble KF provides the best performance

Step II: Bias propagation

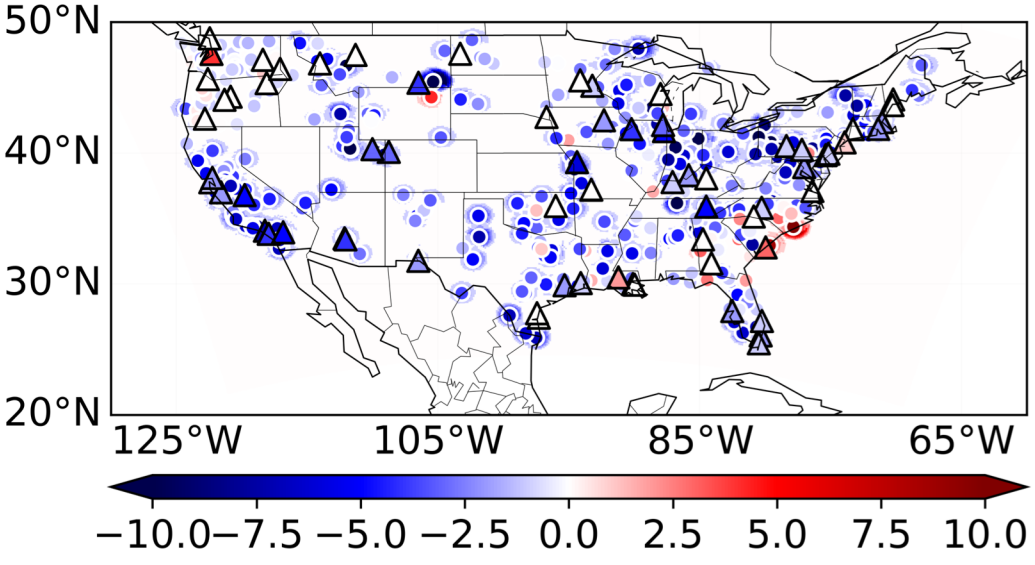
Successive correction method (SCM), < 125 km



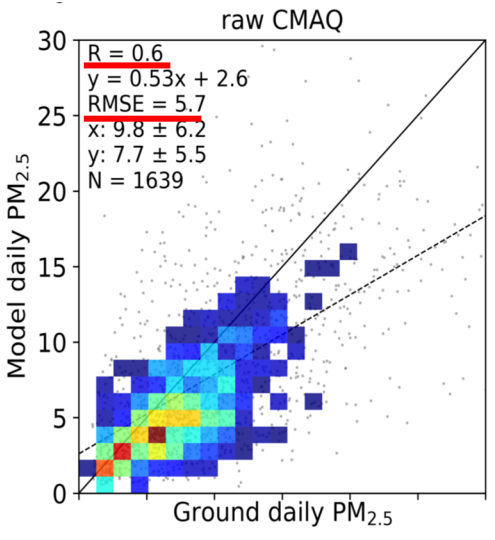
Yellow: covered areas through SCM
Purple: not covered



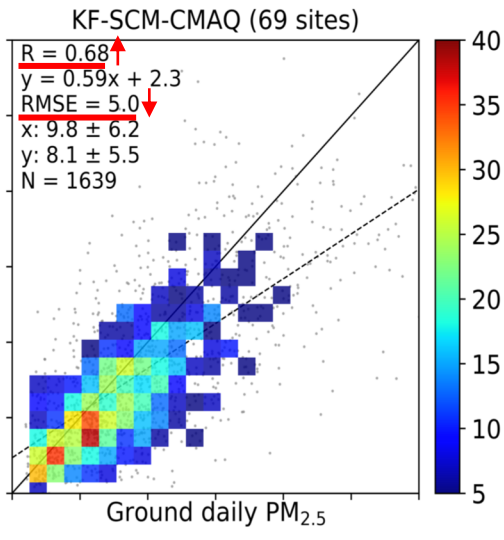
Step II: SCM evaluation



Raw CMAQ

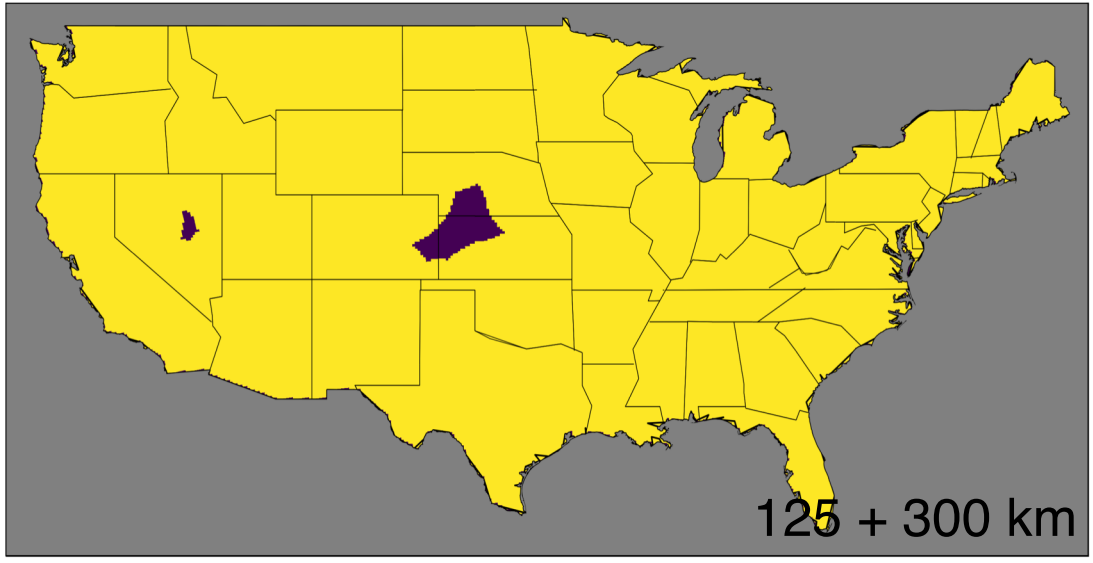


SCM CMAQ

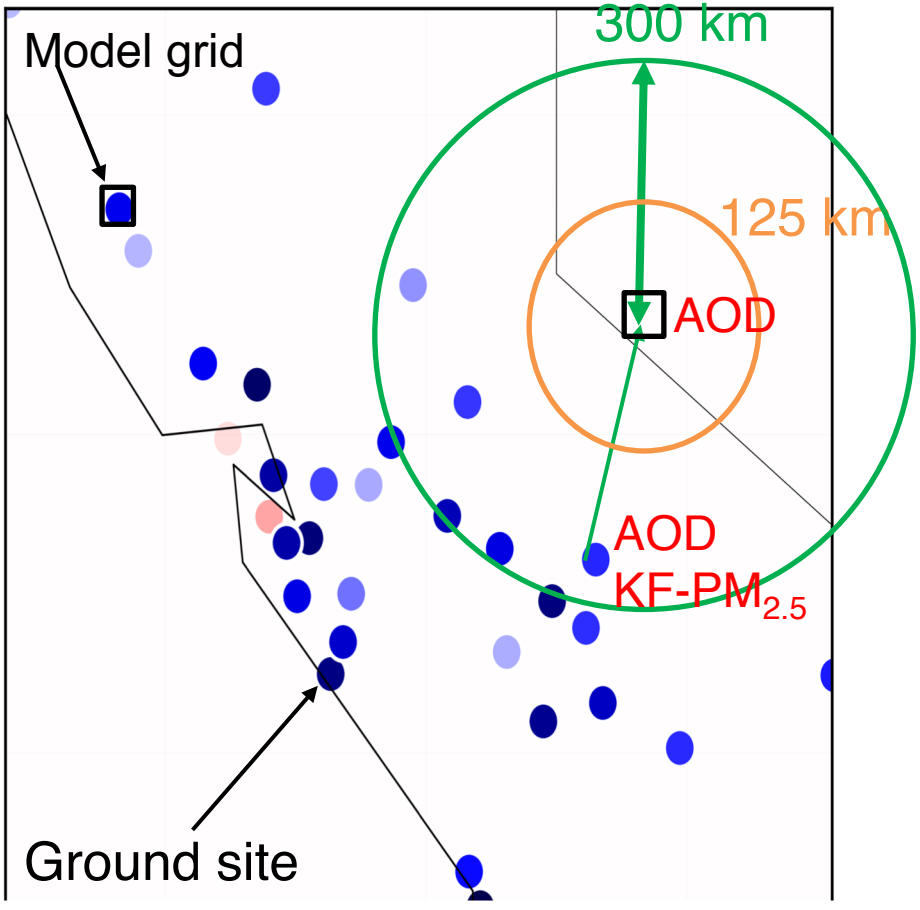


SCM could help improve correlation and reduce RMSE

Step III: Combine AOD spatial pattern & station-based bias for $PM_{2.5}$ estimate at 125 – 300 km

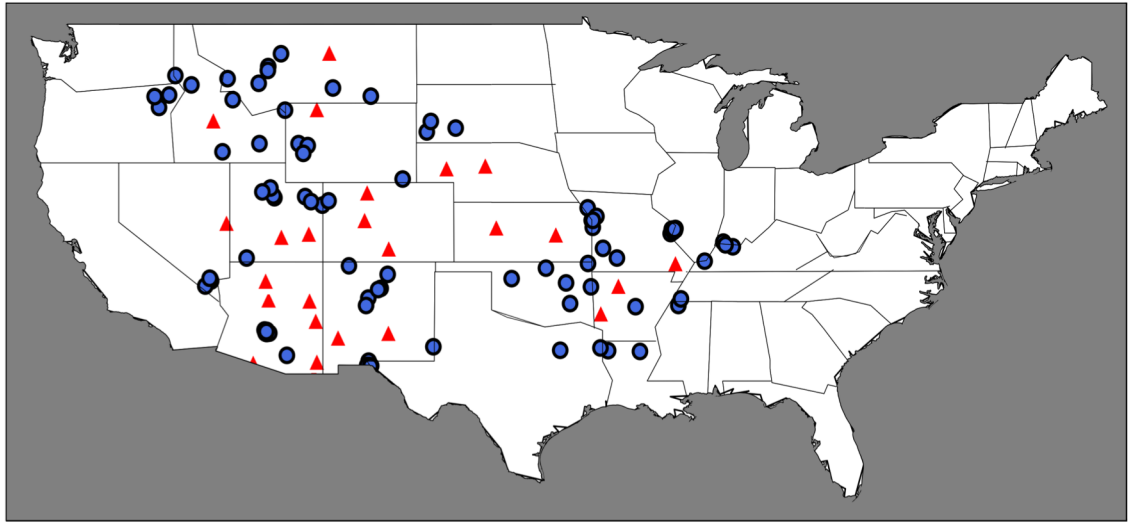


Yellow: covered areas through SCM + AOD
Purple: not covered

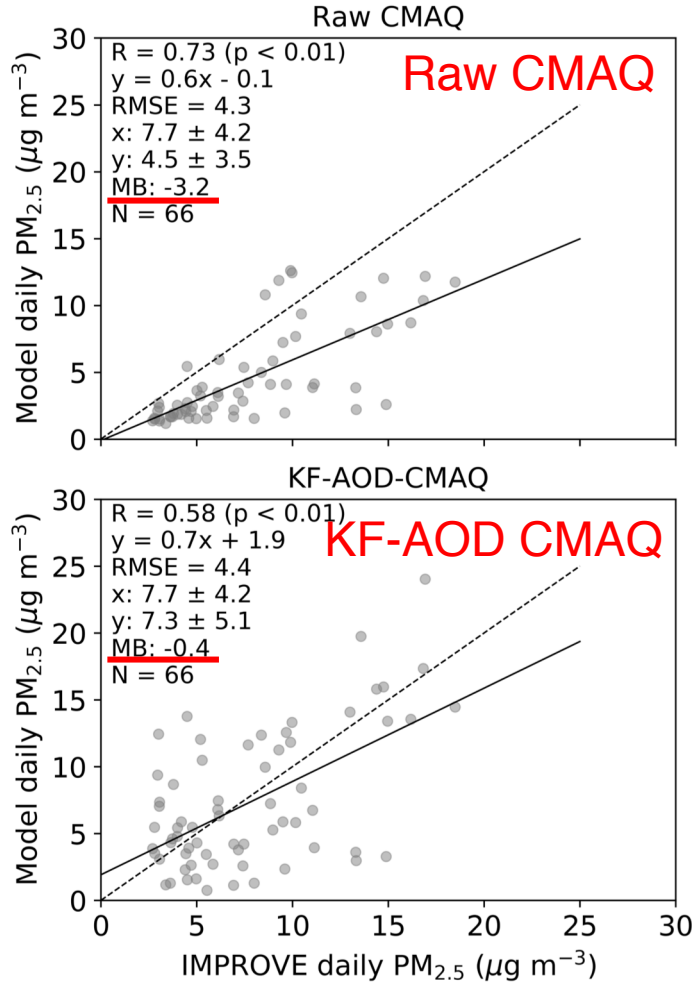


Step III: preliminary results

26 IMPROVE sites
that do not have EPA sites within 125 km



Using AOD spatial pattern and improved $PM_{2.5}$ estimate at the surface station to scale $PM_{2.5}$ in rural areas is promising



Summary

- Kalman filter could reduce individual model forecast bias and ensemble KF provides the best model performance
- Bias propagation using SCM within 125 km could improve model simulated $PM_{2.5}$
- Using AOD spatial pattern and station-based bias info to scale $PM_{2.5}$ in rural areas shows promising results

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