Potential New Directions for CMAQ Post-Processing: Probabilistic AQ Forecasts

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Current KFAN Post-Processing System:

At each AirNOW observation site $x$

- Forecast $F_x$
  - Find Analog Forecasts
  - Find corresponding AirNOW Observations
  - Calculate weighted ensemble mean of observations, ANENS

- Apply KF to ANENS, KFAN
  - Apply Large Forecast Error correction
  - Calculate bias ($F_x - KFAN$)

Over entire CMAQ grid

- Interpolate biases from AirNOW sites to every CMAQ gridpoint
  - Add interpolated bias to rawCMAQ forecast

*Operational later this autumn for PM2.5 and ozone*
Large Forecast Error Correction

Algorithm works because it can find good analogs
Large Forecast Error Correction

Problem occurs because we are always working with short training data sets.

Reason why the correction works is because CMAQ has some skill at predicting these extreme (forest fire) events.
Large Forecast Error Correction

![Graph showing PM 2.5 data for August 2017 with lines for KFAN_new analog method and KFAN_old analog method.]

- KFAN_new analog method
- KFAN_old analog method

Legend:
- PM 2.5
- 06Z
- 905 sites
- August 2017

Graph shows a comparison of PM 2.5 levels over the days of August 2017, with specific methods indicating how forecast errors can be corrected.
Modifications for Probabilistic Forecasts:

At each AirNOW observation site $x$

1. Forecast $F_x$
2. Find Analog Forecasts
3. Find corresponding AirNOW Observations
4. Calculate weighted ensemble mean of observations, ANENS
5. Apply KF to ANENS, KFAN
6. Apply Large Forecast Error Algorithm
7. Calculate bias ($F_x - KFAN$)

Over entire CMAQ grid

1. Interpolate biases from AirNOW sites to every CMAQ gridpoint
2. Add interpolated bias to raw CMAQ forecast
3. Apply Large Forecast Error Algorithm
4. Interpolate biases from to CMAQ grid and add to raw CMAQ forecast
5. Calculate probability forecast, $n/10$
10 Member Ensemble, Ozone
Ozone Exceedance Probability Maps

$O_3 > 50$ ppbv

$O_3 > 70$ ppbv
Regional Probability Ozone Exceedance Map
$O_3 > 70$ ppbv
Spread-Skill Correlations
PM2.5 Exceedance Probability Maps
Summary

- New Large Forecast Error Correction scheme adds skill to all ranges of PM2.5 and ozone forecasts, but most importantly for high concentration events.
- Probabilistic forecasts for ozone (and PM2.5) can be made from the existing analog ensemble.
- These forecasts have skill as shown by reliability diagrams.
- The spread of the ensemble members is moderately correlated with forecast skill, allowing for time-series of point or regional forecasts of forecast uncertainty.
- *Would these forecasts be useful?*
Spread-Skill Relationship

Comparison of correlation over time and space for different regions:

- Western North
- Eastern North
- Western South
- Eastern South

Graphs show the correlation over forecast hours for July-August 2017, with 1 Hour MAX spread-skill relationship.