Air Quality Modeling Using the NASA GEOS-5 Multispecies Data Assimilation System

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Air quality is a global problem

World Bank: ~$5 trillion in welfare losses in 2013

Up to 50% of crop yield can be lost to ozone pollution (e.g. VanDingenen, 2009)
GEOS-CF model produces near real-time air quality forecasts

GEOS-FP

GEOS-Chem

Ozone

Nitrogen Dioxide

Carbon Monoxide
Model has low bias compared to OMI NO$_2$ observations
Also low bias in (surface) carbon monoxide CO

![Graph showing CO concentration over time](image-url)
Toward an air quality modeling system in the NASA GEOS model

- GEOS-5 data assimilation system:
  - Weather
  - Aerosols

+ GEOS-Chem composition forecast model

+ Chemical data assimilation:
  - $O_3$, $NO_2$, $CO$, ...

Air Quality Modeling System
The GEOS chemical data assimilation system

- Based upon GEOS-ADAS (GSI)
- Joint assimilation of $\text{NO}_2$, CO, $\text{O}_3$
- Weakly coupled (no covariances)
- 6-hour assimilation window
Assimilate independent NO$_x$ scale factors for three layers

- Boundary layer
- Free troposphere
- Stratosphere

NO$_x$ scale factor
NO$_2$ assimilation reduces model-observation mismatch

Are we now overestimating NO$_2$ over polluted regions?
Impacts of ozone assimilation are primarily seen in stratosphere
CO: improved comparison against surface observations

Control (no assimilation)

With assimilation
Assimilation of NO$_2$ and CO exacerbates tropospheric ozone bias

- Improved diurnal cycle, but (background) ozone increases
Data assimilation system for tropospheric constituents

- Impacts of joint assimilation of $O_3$, $NO_2$ and $CO$:
  - ✔ Reduction of CO bias
  - ✔ Better spatiotemporal representation of $NO_2$
  - ✗ Further increase of tropospheric ozone

- Weak observational constraint in current configuration

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