Air quality forecasts using the NASA GEOS model

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Air quality is a global problem

- 1 of every 9 death is related to air pollution (WHO)
- $5$ Trillion in welfare losses every year (World Bank)
- Locally up to 50% crop loss due to ozone
Need global models to fill gaps in observations

Tropospheric Ozone Assessment Report TOAR (Schulz et al., 2017)
GEOS composition forecasting system (GEOS-CF)

GEOS - CF
- 1-day analysis
- 5-day forecast
- 0.25° resolution
- Aerosols
- Reactive gases

GEOS - FP

GEOS - Chem

Running since March 2017 – still in test / evaluation mode
GEOS-CF surface ozone

2017-10-01 00:30 UTC
Contributors to air pollution

- **Aerosols**
  - Particulate matter:
    - Organic Carbon
    - Black Carbon
    - Sea salt
    - Nitrate
    - Sulfate
    - Dust

- **Reactive gases**
  - Ozone
  - Nitrogen dioxide
  - Carbon monoxide
  - Volatile organic compounds:
    - Formaldehyde
    - Benzene / Toluene
    - And many more!

GOCART

GEOS-Chem

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High resolution critical to resolve features relevant to air quality

Denver, CO

CO [ppmv]

June 2014

(obs) 200km 12km@200km 12km
Global evaluation of NO$_2$: comparison against surface observations

North America

Europe

Asia

Southern Hemisphere

https://openaq.org
Local evaluation of NO$_2$: good temporal correlation with surface observations (where available)
High bias in surface ozone, but diurnal cycle is well captured

0.25 degrees

2 degrees
Will new chemistry mechanism reduce ozone bias?

v11-02d: updated halogen chemistry

Currently implemented

Fig. 3 Modelled ("HAL") and observed median diel mixing ratio at Weybourne of O$_3$, NO$_y$, NO$_x$ and CO during the observational period. Shaded regions give 25th and 75th percentiles.

Fig. 4 Probability distribution function of observed and modelled O$_3$ mixing ratios at selected UK AURN background sites (N = 63) for the observation period (29th June to 1st August 2015). Modelled values are shown for the simulation with halogens ("HAL"), without halogens ("NOHAL"), and with halogens only within the European domain ("HAL-LOCAL").

Sherwen et al., 2017, Faraday Discuss.
Application: Health Air Quality Index (HAQI)

- HAQI is a function of $O_3$, $NO_2$, and $PM_{2.5}$ (e.g. Stieb et al., 2008)
NYU and UNICEF will use GEOS-CF to refine HAQI for children.
Summary

• GEOS-CF produces daily global air quality forecasts at 25km horizontal resolution

• Output available to public in early 2018

Under development:

• 2-5 year simulation to collect statistics

• Assimilation system for trace gases (O₃, NO₂, CO)

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