HAQAST Research at UNC

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Global Mapping of Ozone Surface Concentration for Global Burden of Disease

- A first global map has been delivered to the GBD team and used in GBD 2017.
- 1 paper submitted (Chang, GMD).

Global Air Quality and Health Co-benefits of the Paris Agreement Pledges

- Analyzing emissions from GCAM to start simulations this spring.

Tiger Team: Efficacy of Environmental Regulations in the Eastern US

- Trends in US air pollution-related deaths since 1990
- 1 paper published (Zhang, ACP), 1 in preparation.

Tiger Team: California fires

- Analyzing health impacts of fires

Tiger Team: Global indicators

- Global indicators of surface ozone.
Goal: Estimate global surface ozone concentrations by statistically fusing global ozone observations and an ensemble of global models.

Ozone metric: 2008-2014 average of 6-month average 8-hr. daily maximum surface ozone concentration.

Stakeholder partners: Global Burden of Disease Assessment – Michael Brauer (UBC), Rick Burnett (Health Canada), Bryan Hubbell (EPA).

Team: Jason West, Marc Serre, Marissa Delang, Jacob Becker, Elyssa Collins (UNC), Owen Cooper, Kai-Lan Chang (NOAA).
A new method (M³Fusion-v1) for combining observations and multiple model output for an improved estimate of the global surface ozone distribution

Kai-Lan Chang¹,², Owen R. Cooper²,³, J. Jason West⁴, Marc L. Serre⁴, Martin G. Schultz⁵, Meiyun Lin⁶,⁷, Virginie Marécal⁸, Béatrice Josse⁸, Makoto Deushi⁹, Kengo Sudo¹⁰,¹¹, Junhua Liu¹²,¹³, and Christoph A. Keller¹²,¹³,¹⁴
Mapping Global Surface Ozone Concentrations

Step 1 – Spatial interpolation of TOAR measurements

4801 sites, averaged within 2°x2° grid cells
Step 2 – Evaluate each model with respect to observations

<table>
<thead>
<tr>
<th>Model ID</th>
<th>Group</th>
<th>Resolution</th>
<th>Meteorological Forcing</th>
<th>References</th>
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<tr>
<td>CHASER</td>
<td>Nagoya University; Japan Agency for Marine-Earth</td>
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<td>C2</td>
<td>Sudo et al. (2002a, b); Watanabe et al. (2011)</td>
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<td>(MIROC-ESM)</td>
<td>Science and Technology (JAMSTEC), Japan</td>
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<td>GEOSCCM</td>
<td>NASA Goddard Space Flight Center, USA</td>
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<td>Oman et al. (2011)</td>
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<td>Lin et al. (2012, 2014, 2017)</td>
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<td>NASA Goddard Space Flight Center, USA</td>
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<td>Hu et al. (2018)</td>
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<td>MOCAGE</td>
<td>Centre National de Recherches Météorologiques; Météo France, France</td>
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<td>Meteorological Research Institute, Japan</td>
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<td>C2</td>
<td>Adachi et al. (2013)</td>
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</tbody>
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Interpolated observations

Multi-model mean
Mapping Global Surface Ozone Concentrations

Step 3 – Find the linear combination of models in each world region that minimizes error with respect to the interpolated measurement surface

Interpolated observations

Multi-model mean

Multi-model blend
Step 4 – Bias correct within 2° of observation sites (using interpolated surface)
Global burden of disease of air pollution (2017)

Global Deaths per Year

- Ambient PM$_{2.5}$ pollution: $2.9$ (2.5 – 3.4) million
  - 1 in 19 deaths globally!
- Ambient ozone pollution: $0.47$ (0.18 – 0.77) million
- Household air pollution from solid fuels: $1.6$ (1.4 – 1.9) million
  - 1 in 45 deaths globally!

Ambient PM$_{2.5}$ pollution is the 8$^{th}$ leading risk factor for death globally.

Burnett et al. (PNAS, 2018) estimate 8.9 (7.5-10.3) million deaths from PM$_{2.5}$ in 2015.

GBD 2017 Team, *Lancet*, 2018
Global Ozone Mapping: Moving Forward

Step 1 – Spatial interpolation of TOAR measurements
Step 2 – Evaluate each model with respect to observations
Step 3 – Find the linear combination of models in each world region that minimizes error with respect to the interpolated measurement surface
Step 4 – Bias correct within 2° of observation sites (using interpolated surface)
Global Ozone Mapping: Moving Forward

Step 1 – Spatial interpolation of TOAR measurements
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Next steps

1 – Perform a new data fusion with observations using Bayesian Maximum Entropy method.
2 – Add fine spatial structure using NASA G5NR (0.125°).
3 – Add new observations from China and elsewhere, updated models.
**Health Benefits of Decreases in PM$_{2.5}$ and Ozone in the United States, 1990-2015**

Omar Nawaz, Yuqiang Zhang, Daniel Q. Tong, Aaron van Donkelaar, Randall Martin, J. Jason West

* Air pollutant datasets:
  - A 21-year CMAQ simulation (1990-2011) **EPA**
  - N. America PM$_{2.5}$ satellite-derived data combined with a model and surface observations (1999-2012) **SAT**

* We use annual county-level population and baseline cause-specific mortality rates from the CDC to assess air pollution mortality in each year.
Trends in PM$_{2.5}$ (SAT)
US PM$_{2.5}$-related deaths

Zhang, ACP 2018; Nawaz, in prep.
Comparison with Other Studies (PM$_{2.5}$)

Zhang, ACP 2018; Nawaz, in prep.
- PM$_{2.5}$ mortality decreased by 53% from 123,700 (70,800-178,100) deaths in 1990 to 58,600 (24,900-98,500) in 2010.
- Without the decrease in PM$_{2.5}$ since 1990, the burden would have only decreased by 24%.
- PM$_{2.5}$ reductions since 1990 have decreased deaths in 2010 by about 35,800.
US $O_3$-related deaths

Zhang, ACP 2018; Nawaz, in prep.
Comparison with Other Studies ($O_3$)

Zhang, ACP 2018; Nawaz, in prep.
- Ozone mortality increased by 13% from 10,900 (3,700-17,500) deaths in 1990 to 12,300 (4,100-19,800) in 2010.
- Without the decrease in ozone since 1990, the burden would have increased by 55%.
- Ozone reductions since 1990 have decreased deaths in 2010 by about 4,600.

Zhang, ACP 2018
In the US, air pollution kills:

- 109,000 (2017 from GBD), 1 in 25 US deaths
- 47,000 (2015 our work), 1 in 58 US deaths

Diabetes: 80,000
Influenza & pneumonia: 52,000
All suicides: 45,000
All transportation accidents: 43,000
Breast cancer: 42,000
All gun shootings: 39,000
Prostate cancer: 30,000
Parkinson’s: 30,000
Leukemia: 23,000
HIV AIDS: 6,000

2016 data from CDC