Connecting air quality and health with management: Progress from the UNC HAQAST Team

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Year 3 Progress Update, PI West

Global Mapping of Ozone Surface Concentration for Global Burden of Disease

- A first global map has been delivered and used in GBD 2017, another will be delivered next month for GBD 2019.
- 2 papers (Chang, GMD).

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

- Completing analysis of emissions from GCAM and planning to start simulations this summer.

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

Mapping pollutant concentrations, and analyzing health impacts.

Tiger Team: Global indicators

Global indicators of surface ozone.

Total 4 papers published, many more in preparation.

Mapping Global Surface Ozone Concentrations

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

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, Stephanie Cleland, Elyssa Collins (UNC), Owen Cooper, Kai-Lan Chang (U Colorado & NOAA)

TOAR
tropospheric ozone assessment report

ccmi
chemistry-climate model initiative

Geoscientific
Model Development
Open Access
EGU

A new method (M[3]Fusion v1) for combining observations and multiple model output for an improved estimate of the global surface ozone distribution

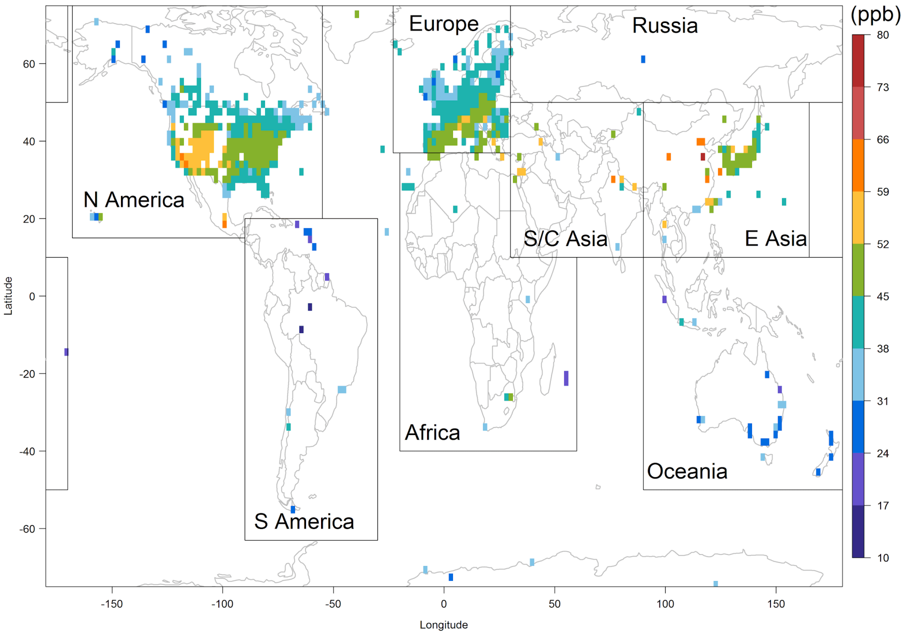
Kai-Lan Chang[1,2,3], Owen R. Cooper[2,3], J. Jason West[4], Marc L. Serre[4], Martin G. Schultz[5], Meiyun Lin[6,7], Virginie Marécal[8], Béatrice Josse[8], Makoto Deushi[9], Kengo Sudo[10,11], Junhua Liu[12,13], and Christoph A. Keller[12,13,14]

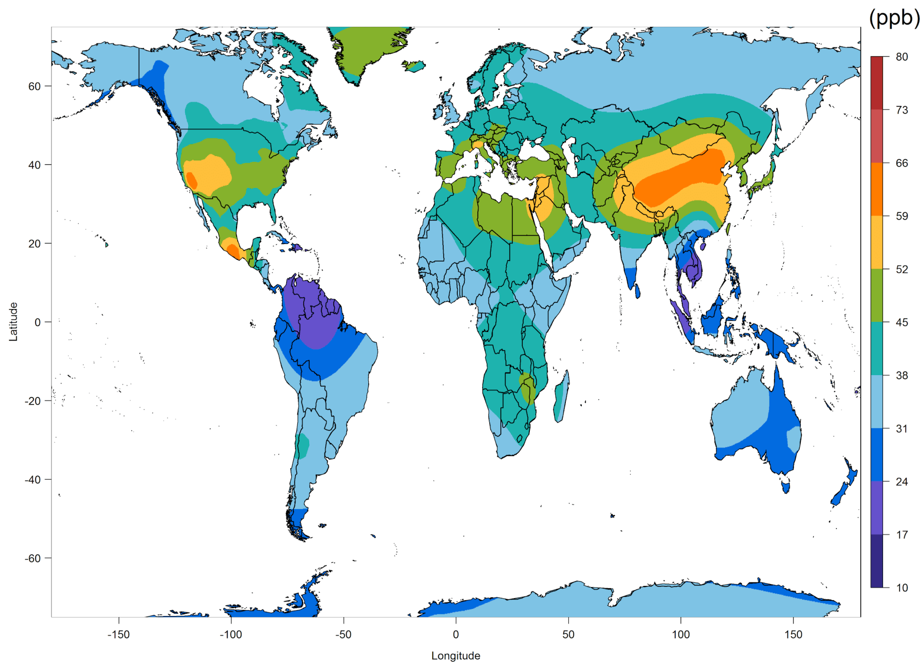
Ozone metric: 2008-2014 average of 6-month average 8-hr. daily maximum surface ozone concentration

Mapping Global Surface Ozone Concentrations for GBD 2017

Step 1 – Spatial interpolation of TOAR measurements

4801 sites, averaged within 2°x2° grid cells



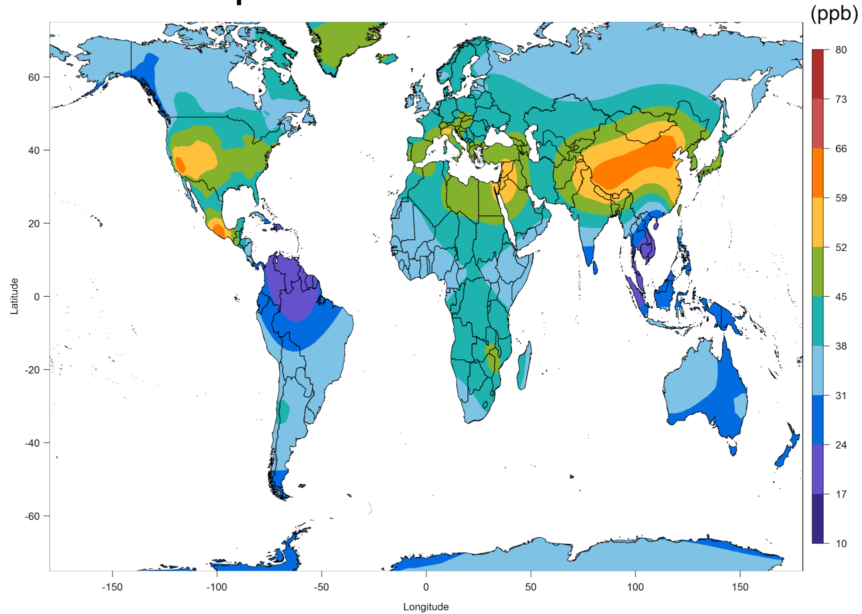


Mapping Global Surface Ozone Concentrations for GBD 2017

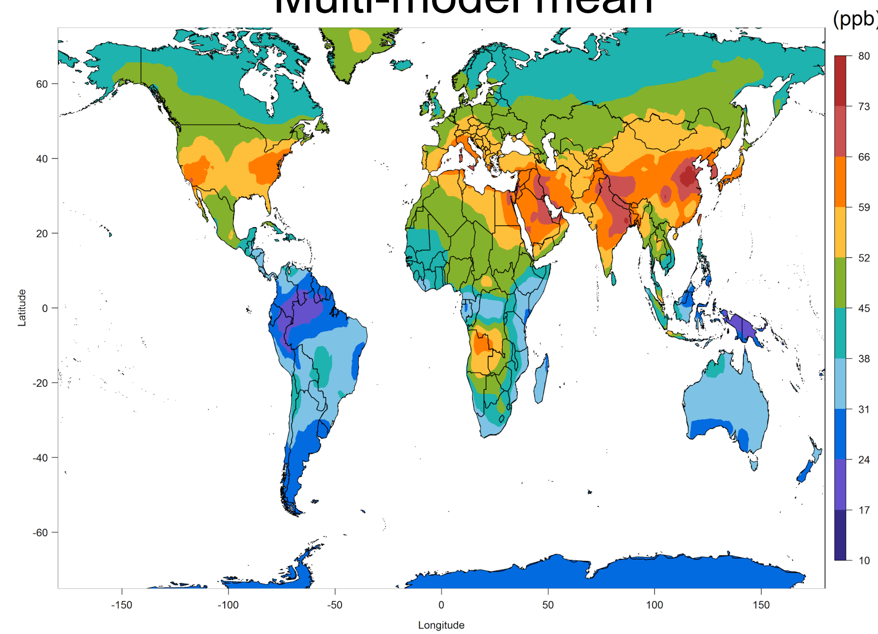
Step 2 – Evaluate each model with respect to observations

Model ID	Group	Resolution	Meteorological Forcing†	References
CHASER (MIROC-ESM)	Nagoya University; Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan	2.8° × 2.8°	C2	Sudo et al. (2002a, b); Watanabe et al. (2011)
GEOSCCM	NASA Goddard Space Flight Center, USA	2.5° × 2°	C2	Oman et al. (2011)
GFDL-AM3	NOAA Geophysical Fluid Dynamics Laboratory, USA	2° × 2°	C1SD	Lin et al. (2012, 2014, 2017)
G5NR-Chem	NASA Goddard Space Flight Center, USA	0.125° × 0.125°	*	Hu et al. (2018)
MOCAGE	Centre National de Recherches Météorologiques; Météo France, France	2° × 2°	C2	Josse et al. (2004); Teyssèdre et al. (2007)
MRI-ESM1r1	Meteorological Research Institute, Japan	2.8° × 2.8°	C2	Adachi et al. (2013)

Interpolated observations



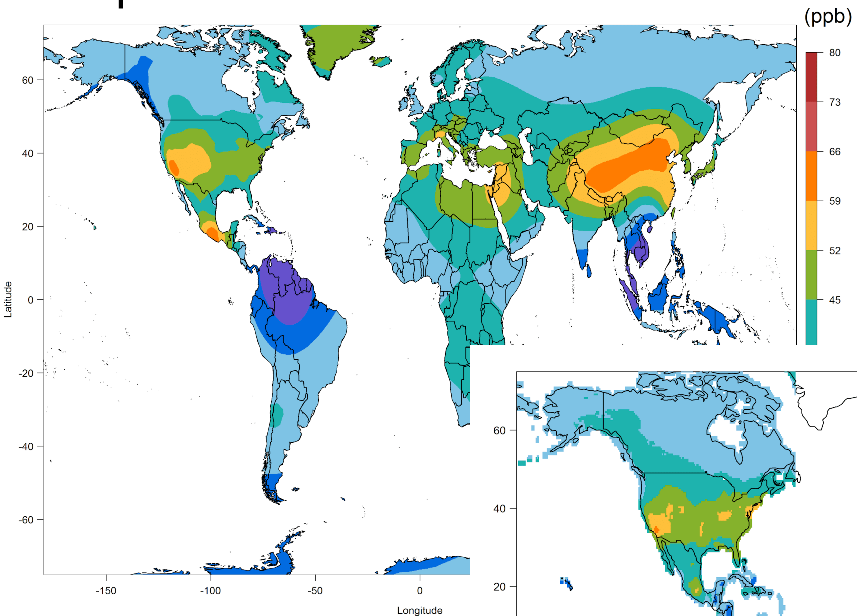
Multi-model mean



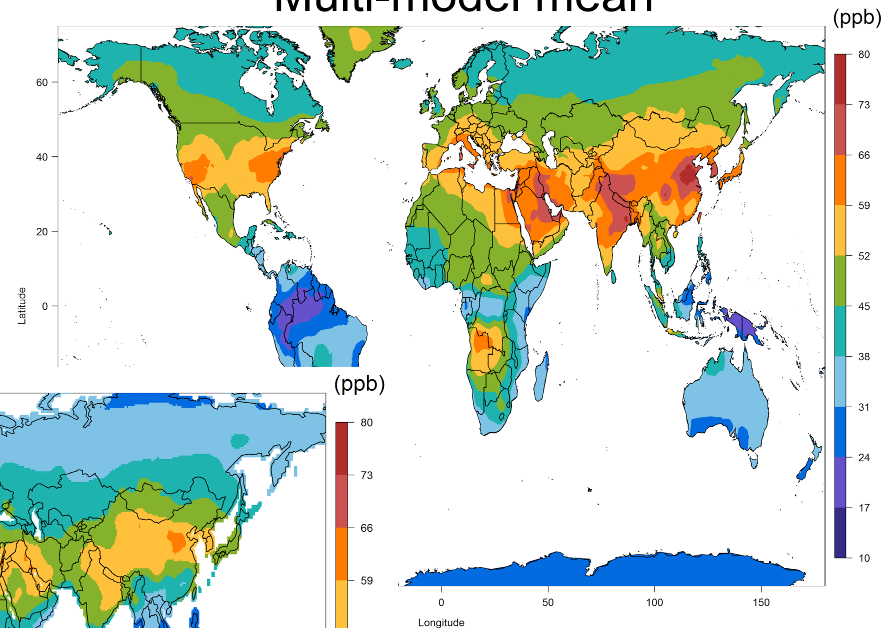
Mapping Global Surface Ozone Concentrations for GBD 2017

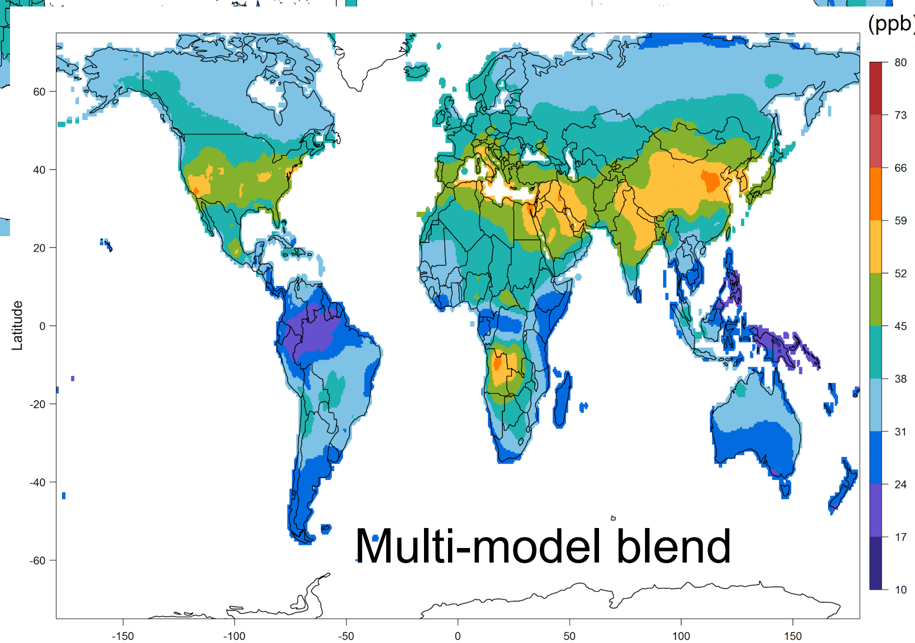
Step 3 – Find the linear combination of models in each world region that minimizes error with respect to the interpolated measurement surface

Interpolated observations



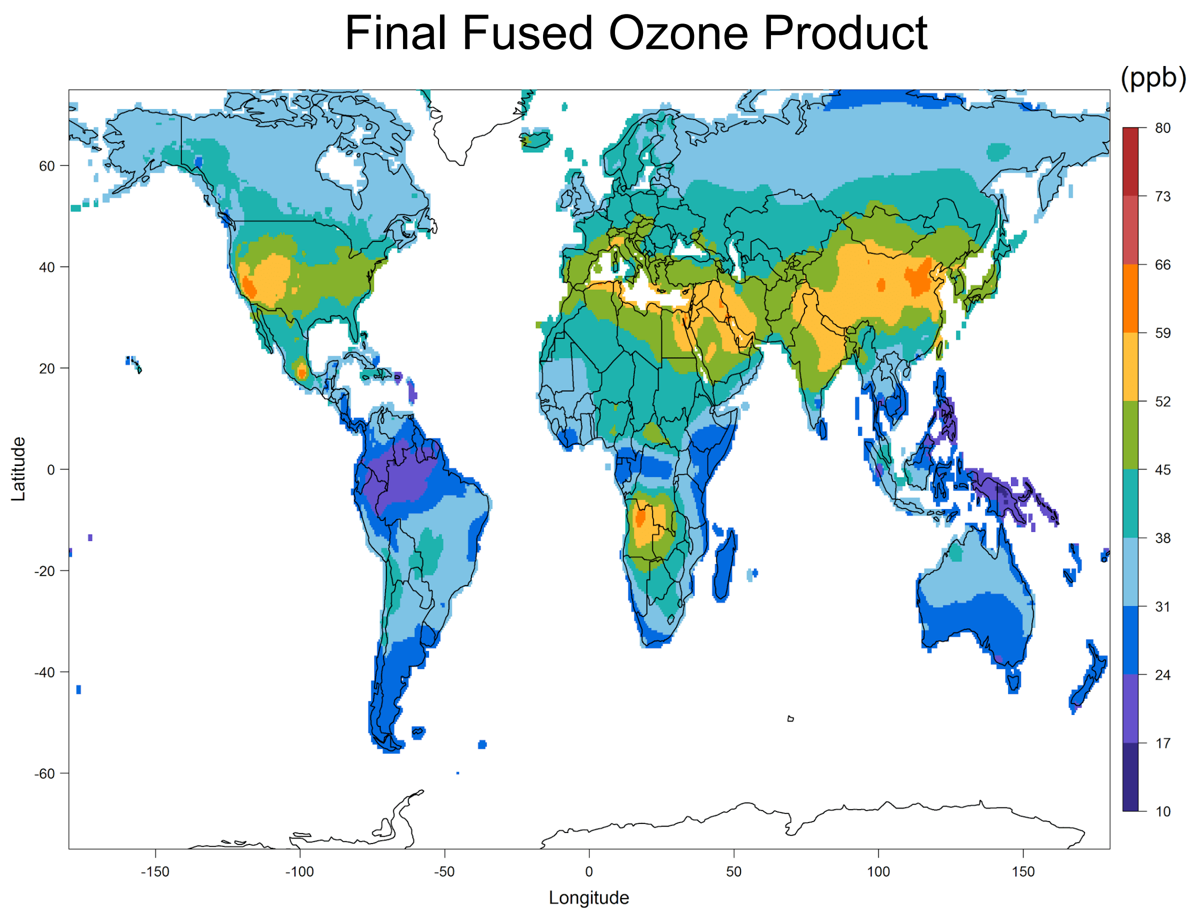
Multi-model mean





Mapping Global Surface Ozone Concentrations for GBD 2017

Step 4 – Bias correct within 2° of observation sites (using interpolated surface)



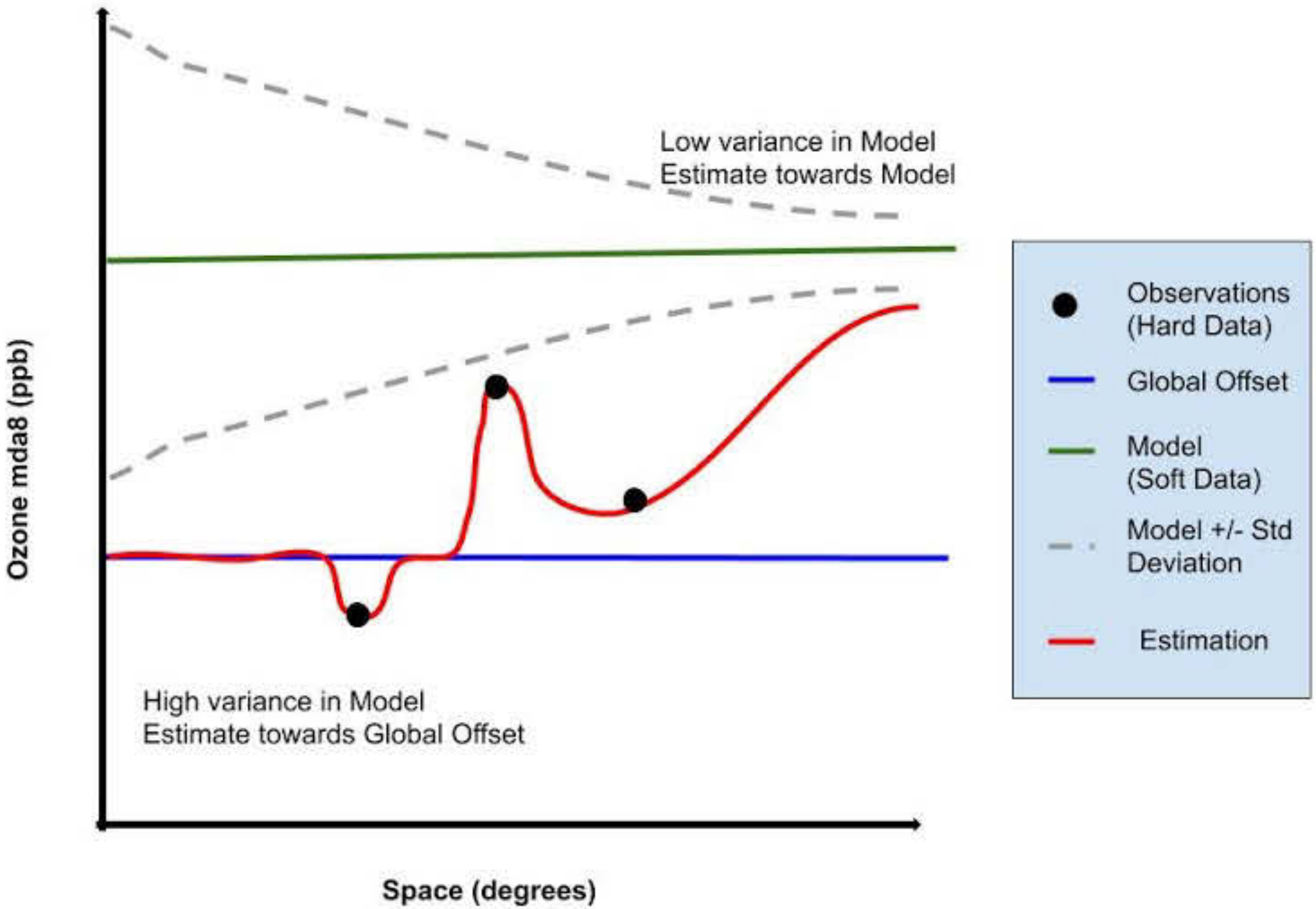
- GBD 2017 – 470,000 (180,000 – 770,000) deaths globally

Global Ozone Mapping for GBD 2019

- Produce ozone maps for all years from 1990 to 2017.
- Perform a new data fusion with observations using Bayesian Maximum Entropy method.
- Add new observations from China and elsewhere, updated models.
- Add fine spatial structure using NASA G5NR (0.125°).

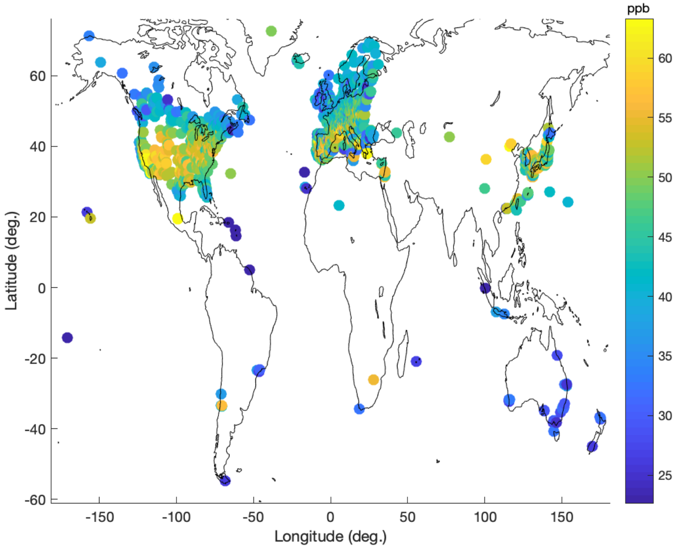
- New maps have nearly been completed for 1990 to 2010.
- See poster by Jacob Becker and Marissa DeLang

Bayesian Maximum Entropy Methods

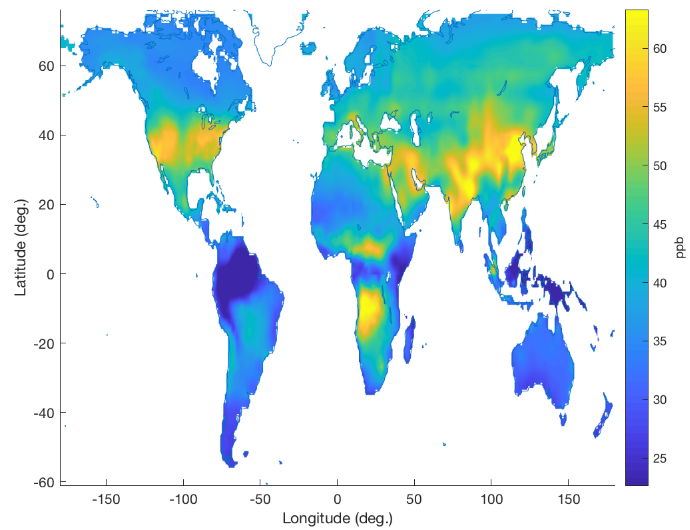


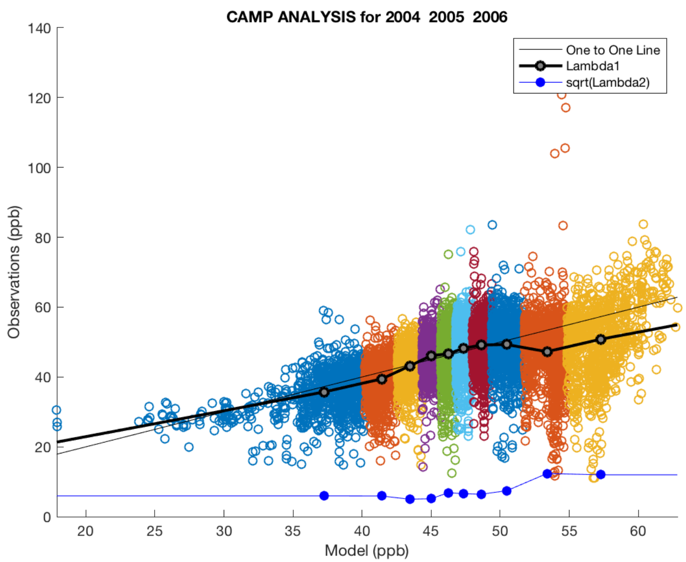
Global Ozone Mapping for GBD 2019

Observations for 2005

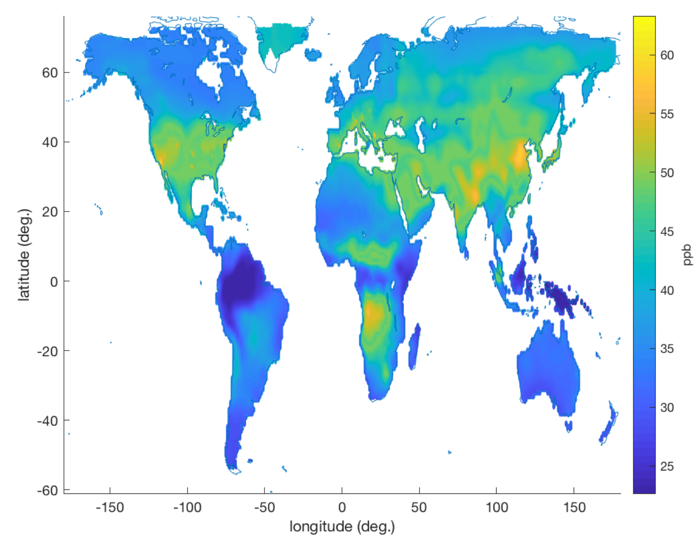


M^3Fusion for 2005





BME Estimate for 2005



MAPPING THE AIR QUALITY & HEALTH IMPACTS OF THE 2017 CALIFORNIA WILDFIRES

UNC
GILLINGS SCHOOL OF GLOBAL PUBLIC HEALTH
DEPARTMENT OF ENVIRONMENTAL SCIENCES AND ENGINEERING

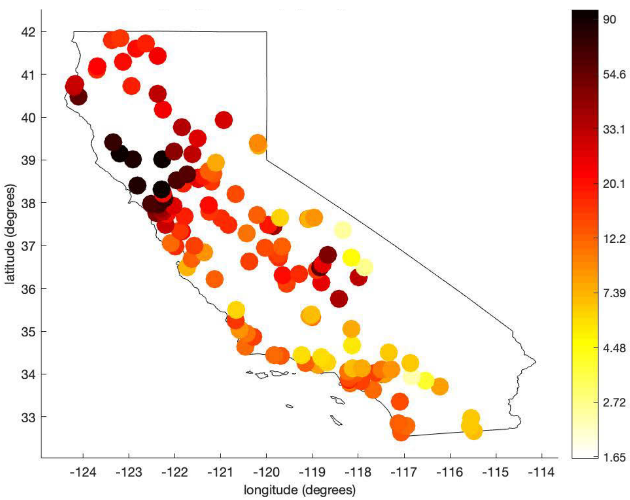
Stephanie Cleland, Marc Serre, Jacob Becker, Marissa DeLang, & Jason West

Goal 1: Map $PM_{2.5}$ during the Oct. 2017 wildfires, fusing together observed & modeled $PM_{2.5}$ concentrations

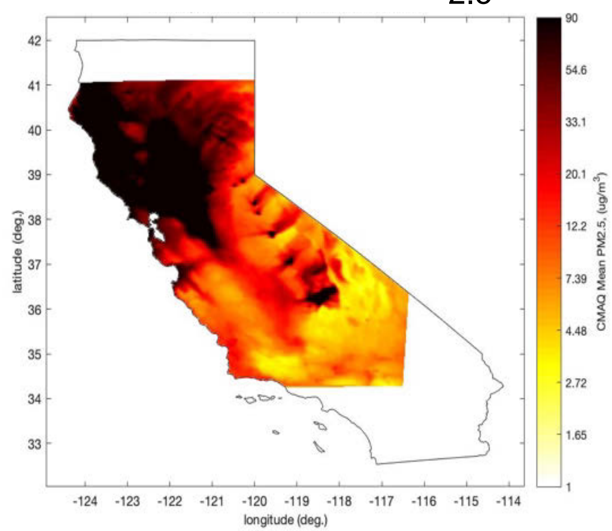
- Surface observation data from both FRM/FEM & temporary monitoring stations

- Model data from BAAQMD CMAQ run

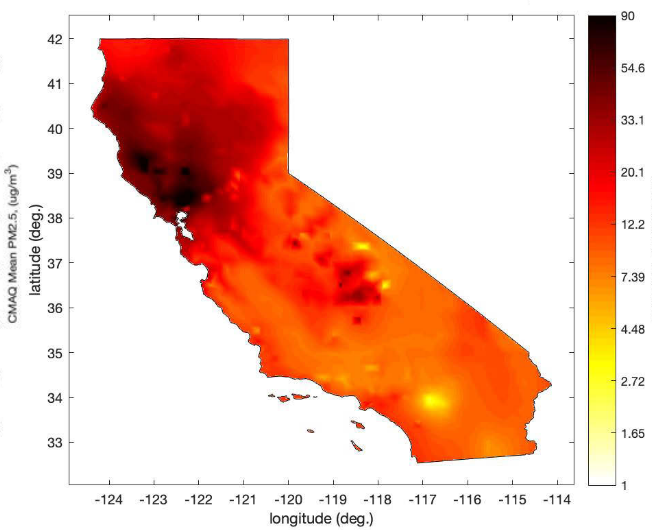
Observed $PM_{2.5}$



CMAQ Model $PM_{2.5}$



BME Data Fusion



maps for Oct. 10, 2017, 24-hr average $PM_{2.5}$

MAPPING THE AIR QUALITY & HEALTH IMPACTS OF THE 2017 CALIFORNIA WILDFIRES

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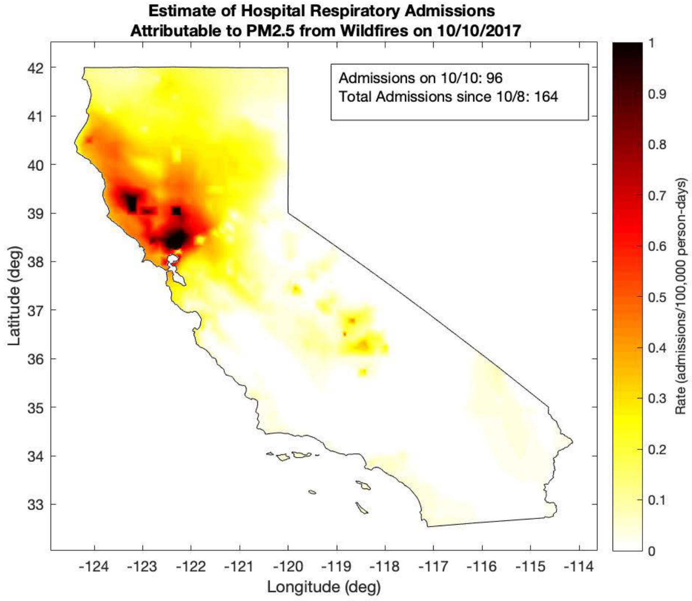
Goal 2: Use the $PM_{2.5}$ map to **estimate the acute health impact of the Oct. 2017 wildfires**, specifically the attributable respiratory hospital admissions

Future work will extend this approach to more health endpoints and pollutants.



- See poster by Stephanie Cleland

UNC GILLINGS SCHOOL OF GLOBAL PUBLIC HEALTH

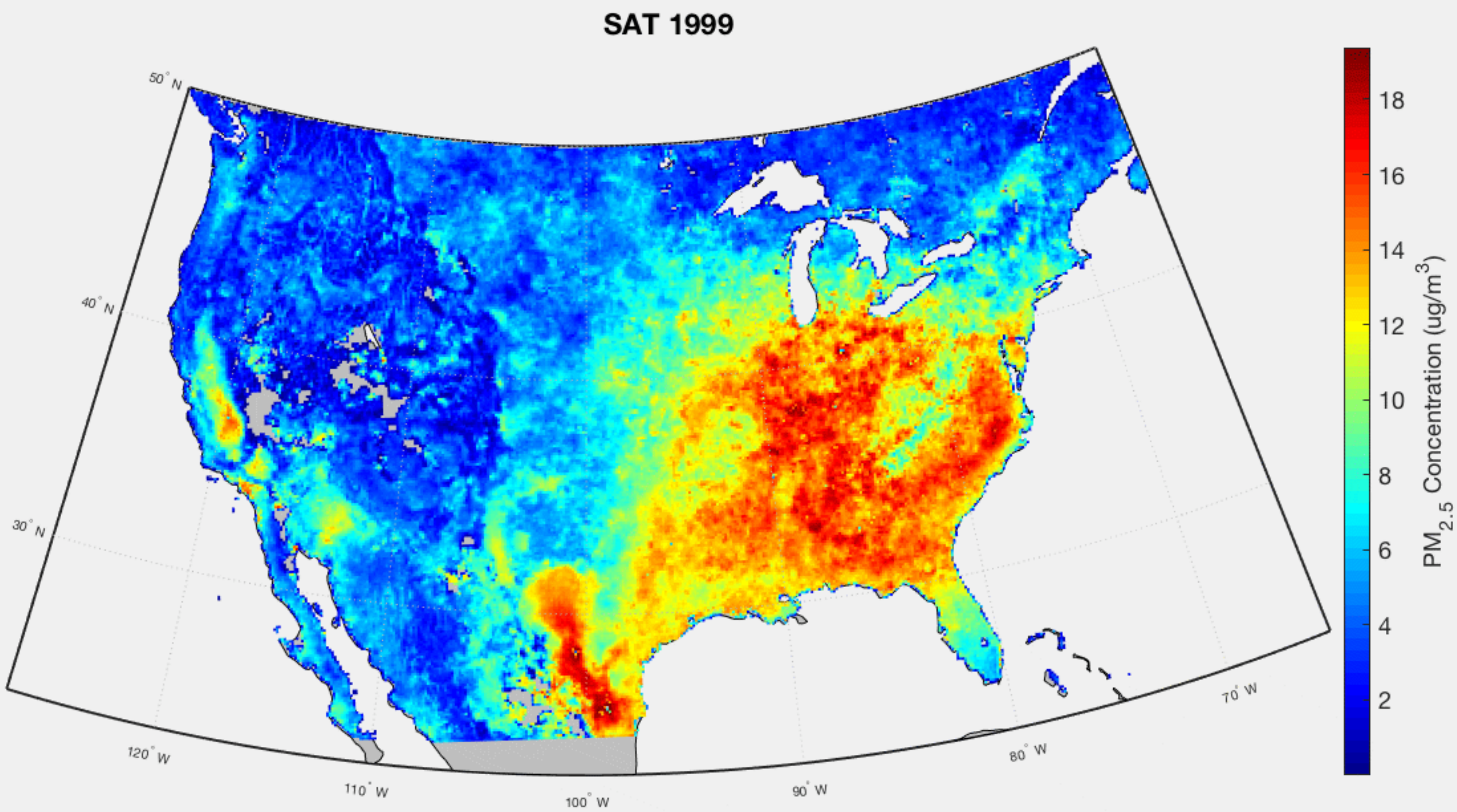
Health Benefits of Decreases in $PM_{2.5}$ and Ozone in the United States, 1990-2015

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

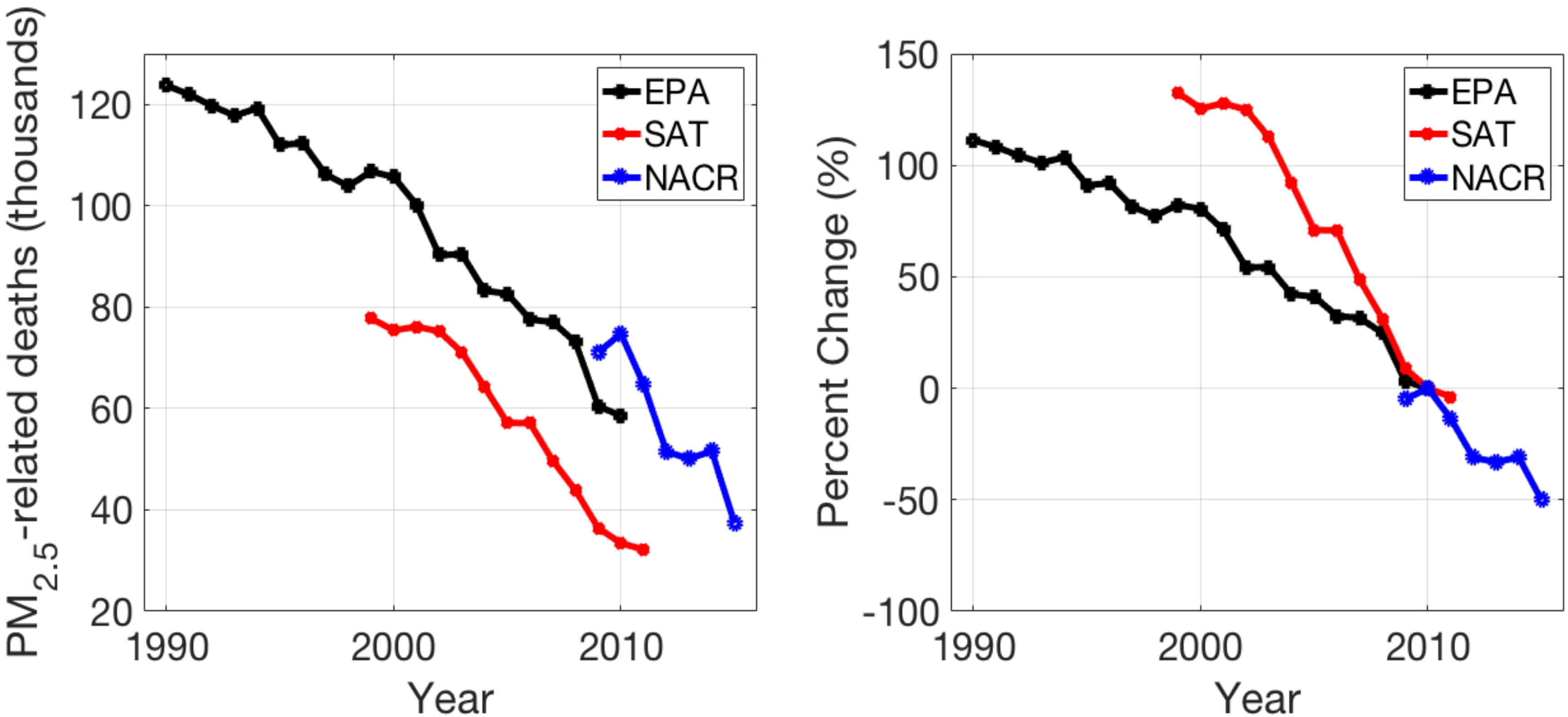
* Air pollutant datasets:
    - A 21-year CMAQ simulation (1990-2011) **EPA**
    - The North American Chemical Reanalysis (2009-2015) **NACR**
    - N. America $PM_{2.5}$ satellite-derived data combined with a model and surface observations (1999-2012) **SAT**

* 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)

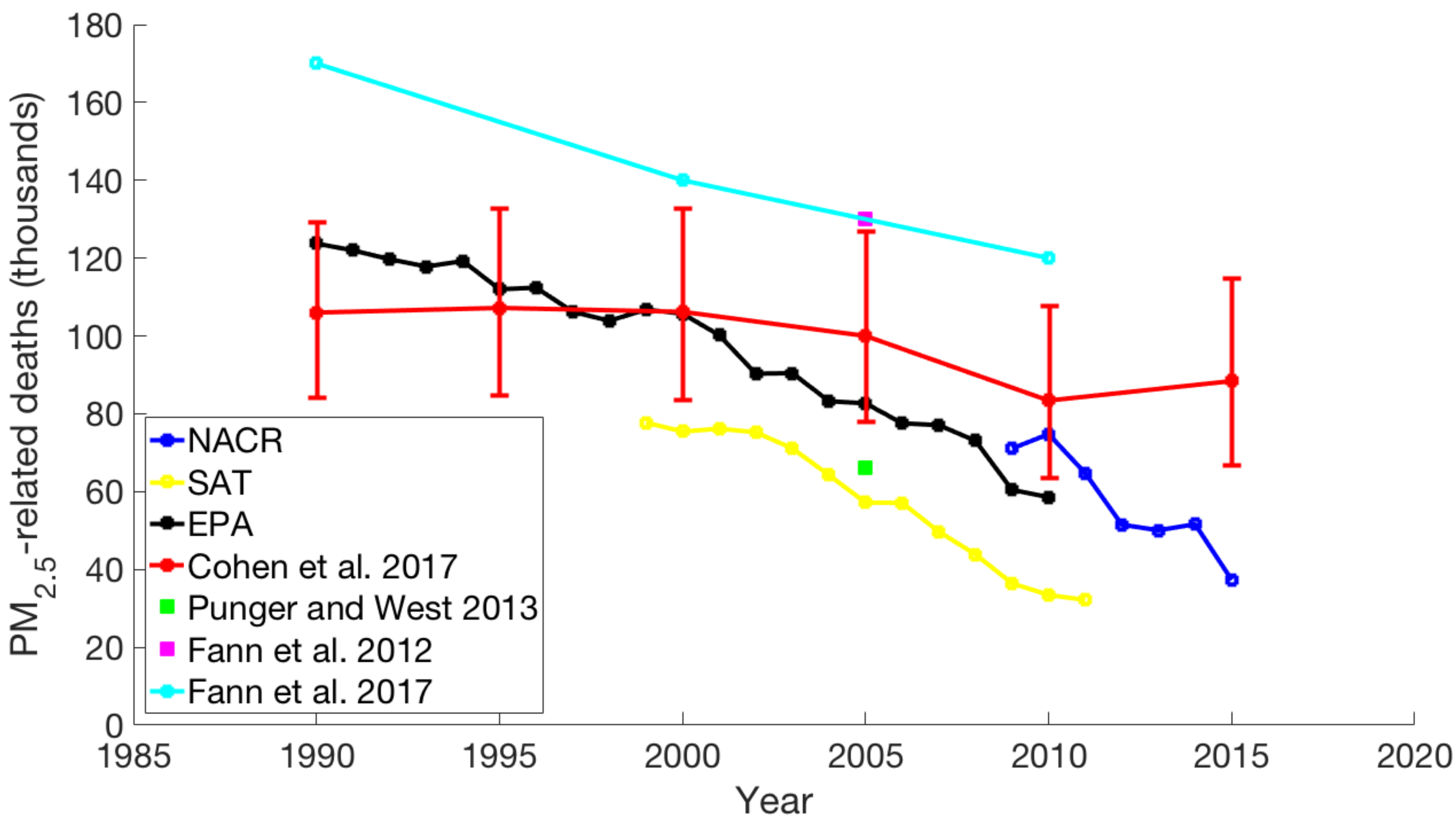


US $PM_{2.5}$-related deaths



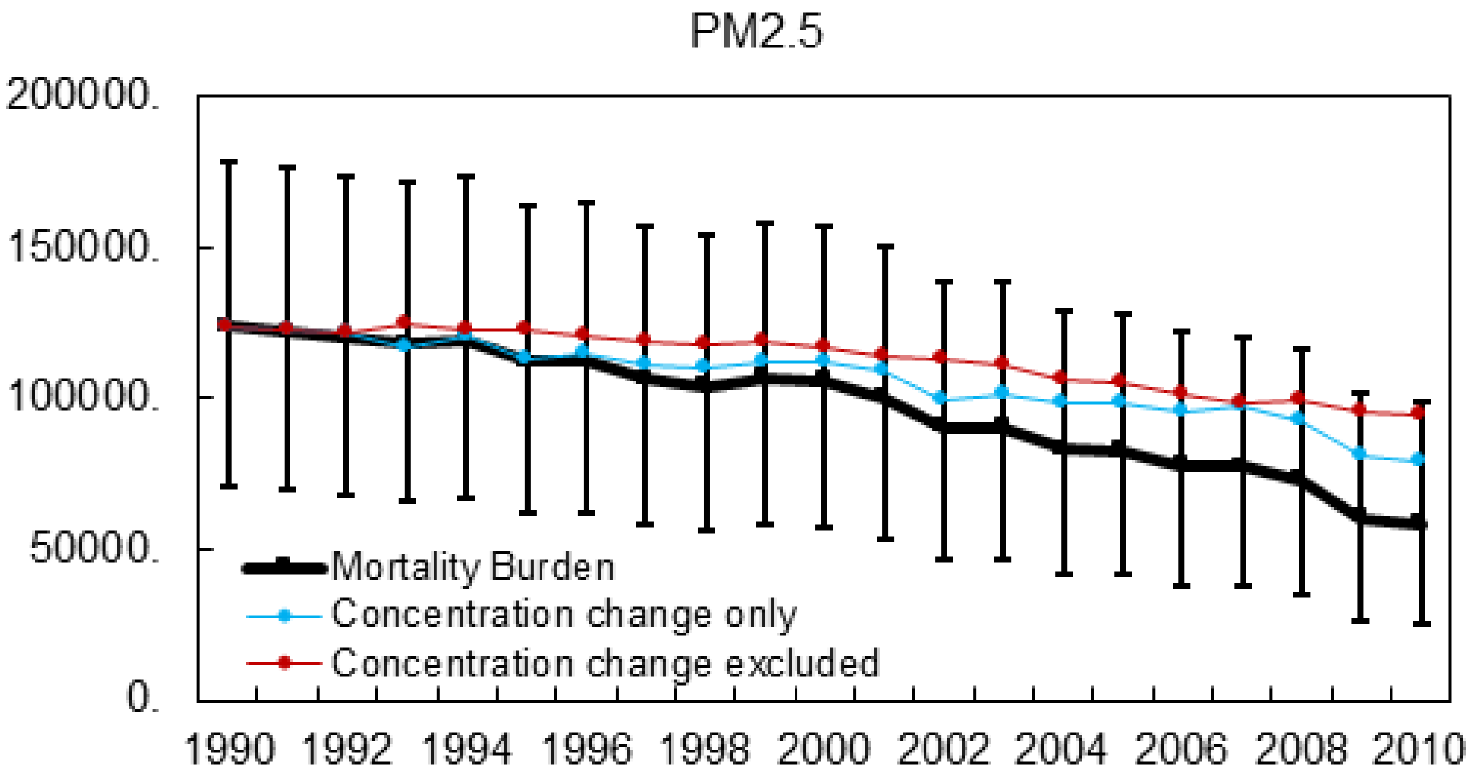
Zhang, ACP 2018; Nawaz, in prep.

Comparison with Other Studies ($PM_{2.5}$)



Zhang, ACP 2018; Nawaz, in prep.

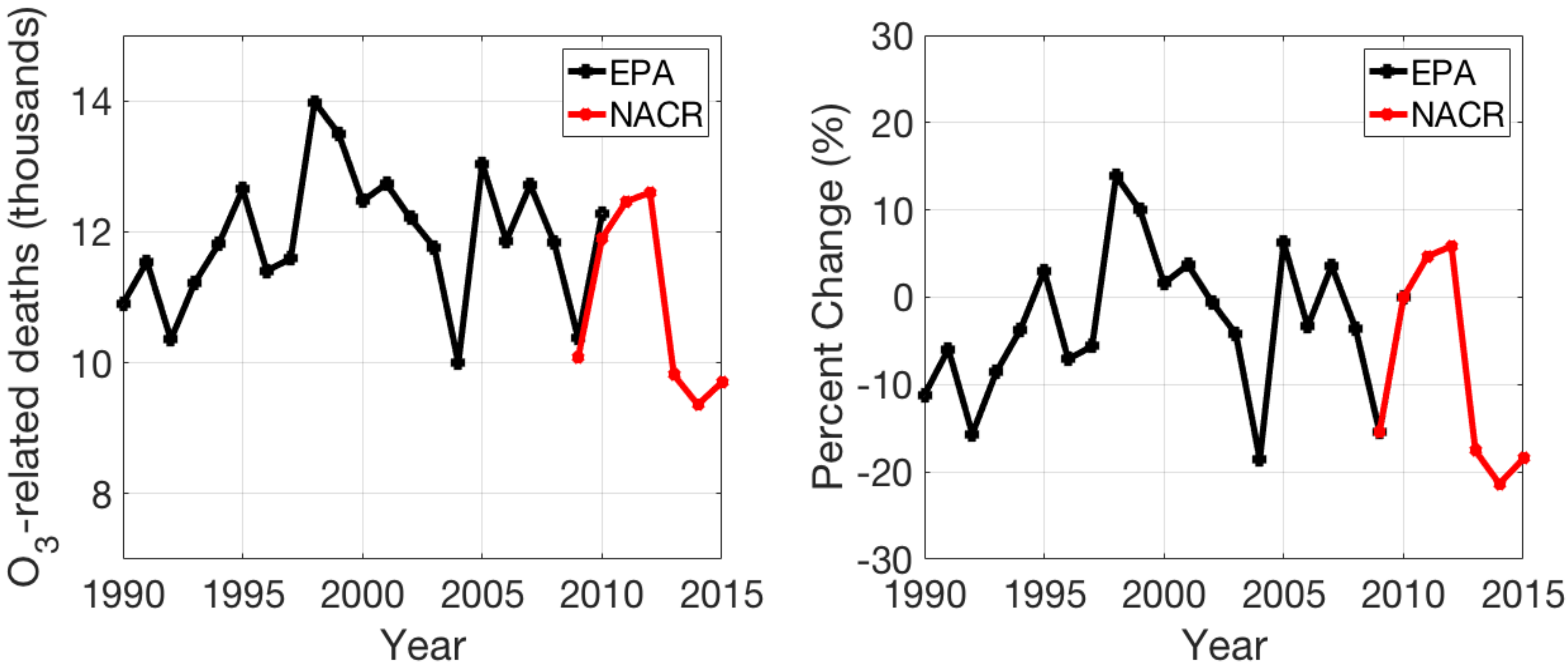
$PM_{2.5}$ Mortality Burden (EPA)



- $PM_{2.5}$ 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**.

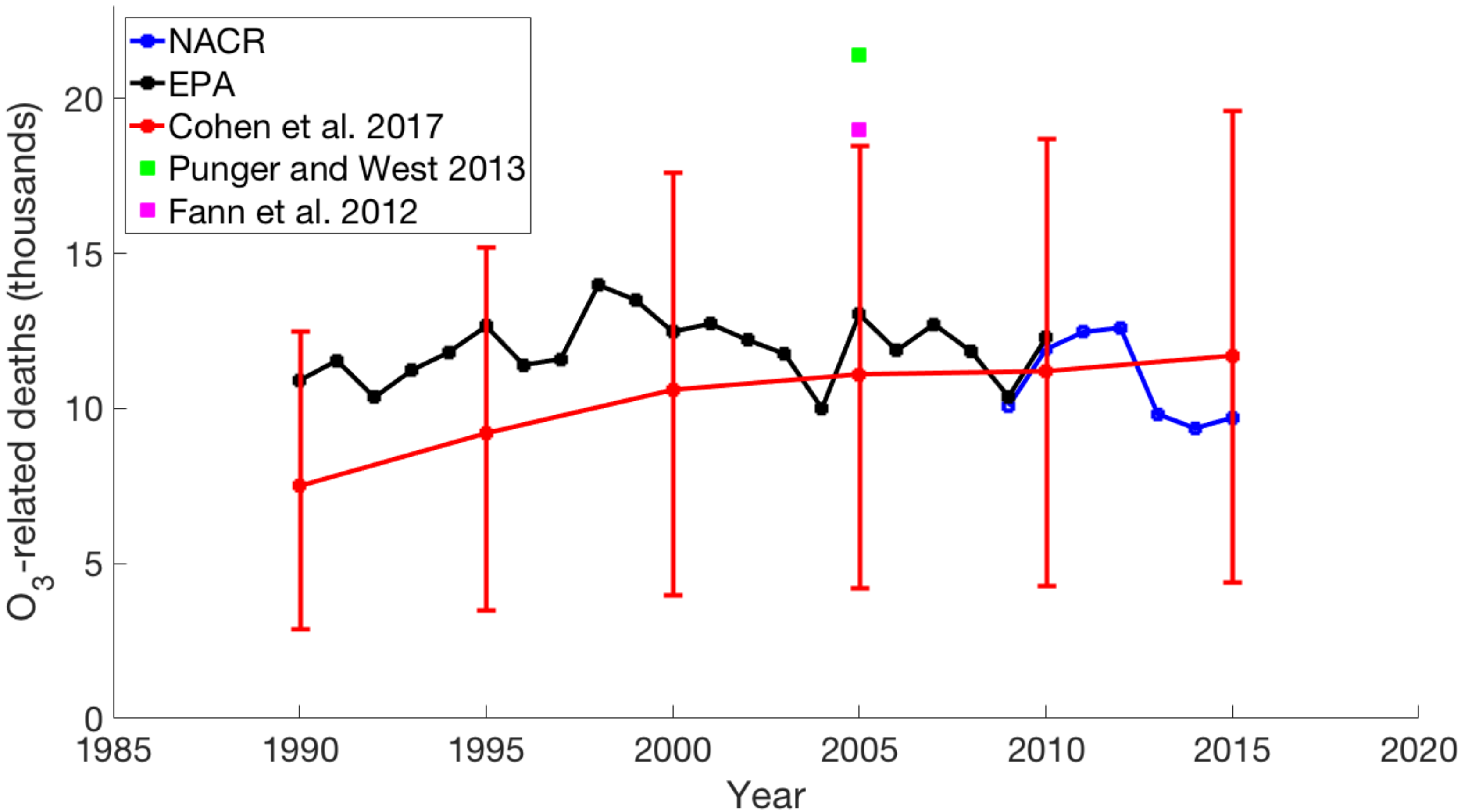
Zhang, ACP 2018

US O_3-related deaths



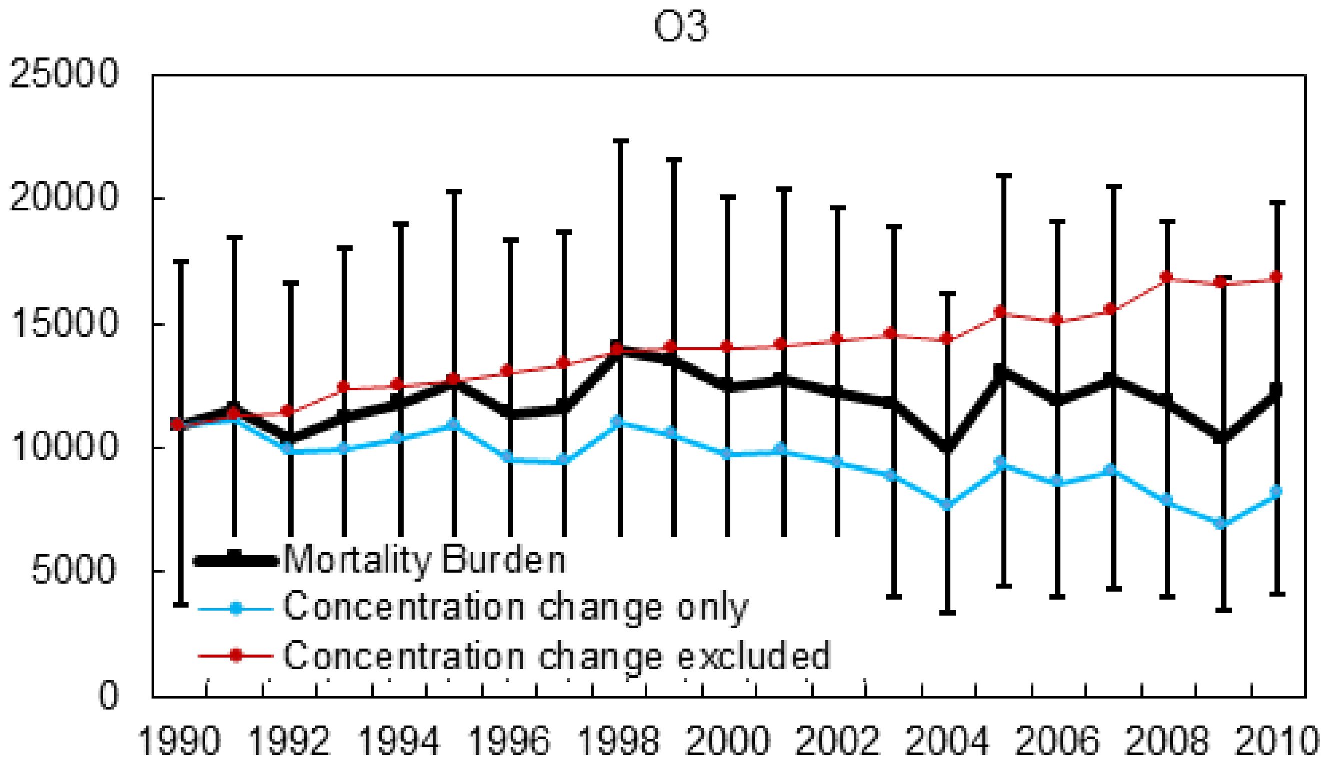
Zhang, ACP 2018; Nawaz, in prep.

Comparison with Other Studies (O_3)



Zhang, ACP 2018; Nawaz, in prep.

O_3 Mortality Burden (EPA)



- 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

Global burden of disease of air pollution (2017)

Global Deaths per Year

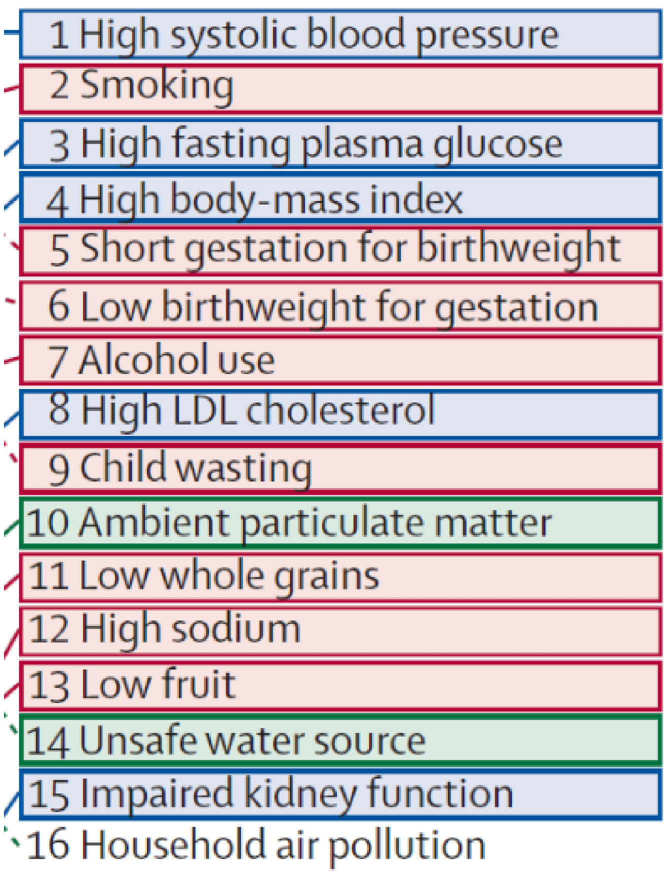
Ambient $PM_{2.5}$ pollution: **2.9 (2.5 – 3.4) million**

Ambient ozone pollution: **0.47 (0.18 – 0.77) million**

1 in 19 deaths globally!

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