Air Pollution and Health Co-Benefits of the Paris Agreement on Climate Change: Methodology and Preliminary Precursor Emissions Results

Kathleen M. Mulvaney[1*], Steven J. Smith[2,3], Haewon C. McJeon[2], J. Jason West[1]

[1]Department of Environmental Sciences and Engineering, University of North Carolina (UNC) at Chapel Hill, Chapel Hill, NC; [2]Joint Global Change Research Institute, Pacific Northwest National Lab, College Park, MD; [3]Department of Atmospheric and Oceanic Science, University of Maryland, College Park, MD; *Contact: katmm@live.unc.edu

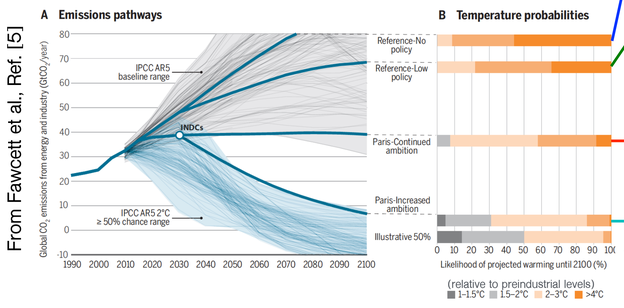
Research Questions

- How could the Nationally Determined Contributions (NDCs), pledges submitted by member countries under the Paris Agreement on climate change, impact global $PM_{2.5}$ and ozone concentrations, considering the impacts of a changing climate on air quality?
- Relative to a baseline scenario where less stringent policy is implemented, to what extent could the Paris Agreement reduce premature mortality from respiratory diseases, cardiopulmonary diseases, and lung cancer?
- How does the United States NDC impact air pollution and health co-benefits in other world regions? Conversely, how do NDCs from the rest of the world impact air pollution and health co-benefits in the United States?

Emissions Scenarios

Precursor emissions are calculated for two Reference and three Paris Agreement policy scenarios based on an analysis by Fawcett et al. [5] using the Global Change Assessment Model (GCAM). We harmonize the GCAM emissions with the 2015 Community Emissions Data System (CEDS) inventory [6] and grid them at 0.5˚x0.5˚ for use in CESM2.0.0.

From Fawcett et al., Ref. [5]



Reference-No-policy
No new policies impacting GHGs through 2100

Reference-Low-policy
Countries decrease CO_2 by 2%/yr/GDP (decarbonization rate) beginning 2030

Paris-Continued-ambition
Countries achieve NDCs by 2030, then continue at decarbonization rate required to achieve NDCs, minimum 2%/yr/GDP

Paris-Increased-ambition
Countries achieve NDCs by 2030, then continue at decarbonization rate required to achieve NDCs, minimum 5%/yr/GDP

Paris-No-US
Same as **Paris-Increased-ambition**, except US does not meet their NDC pledge

The Paris Agreement on climate change is an international, legally binding treaty [1]. The 197 member countries submit Nationally Determined Contributions (NDCs) every five years, which involve pledges to mitigate greenhouse gas emissions (GHGs) [2, 3]. Actions to mitigate GHGs that reduce energy system reliance on fossil fuels can achieve significant co-benefits, including reductions in other air pollutants that impact human health, such as ozone and particulate matter smaller than 2.5 microns ($PM_{2.5}$) [4].

Ozone, $PM_{2.5}$, and a Changing Climate

The CAM6 component of CESM2.0.0 with CAM-Chem chemistry calculates global ozone and $PM_{2.5}$ concentrations at a geographic resolution of 2.0˚x2.5˚ [7]. We will simulate full atmospheric dynamics, atmospheric chemistry, and land use, while using prescribed RCP ocean and ice data.

Ocean/Ice Data

Use RCP8.5 for:
Ref-No-policy
Ref-Low-policy

Use RCP4.5 for:
Paris-Cont-amb,
Paris-Inc-amb
Paris-No-US

Simulation Years

Ref-No-policy, Paris-Cont-amb -> 2015-2100 + 1 yr spinup
174 years total

Ref-Low-policy, Paris-Inc-amb, Paris-No-US -> 2030-2100
213 years total

Premature Mortality

We will evaluate change in premature mortality (ΔY) from chronic respiratory diseases, ischemic heart disease, stroke, chronic obstructive pulmonary disease, and lung cancer in each grid cell using the equation below. We will use scenarios of future baseline incidence and population data, and will consider present-day baseline incidence rates as a sensitivity analysis.

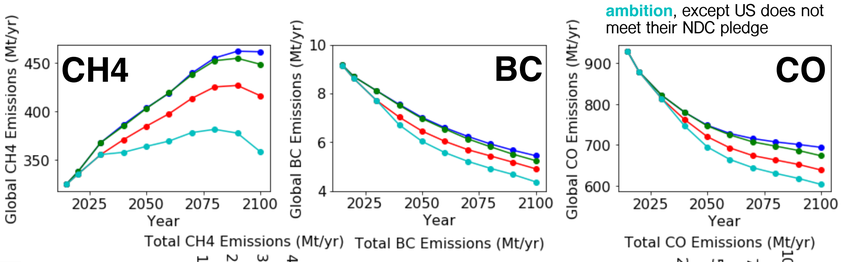
$$\Delta Y = Y_0 * Pop * AF$$

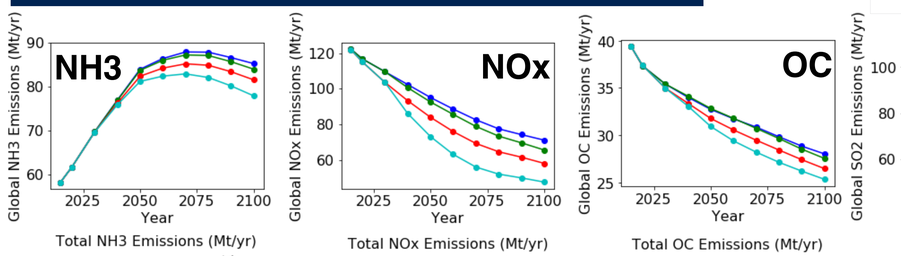
	Baseline Incidence	Population
Future	International Futures [10]	International Futures [10]
Present Day	Global Burden of Disease [8]	CIESEN SEDAC [9]

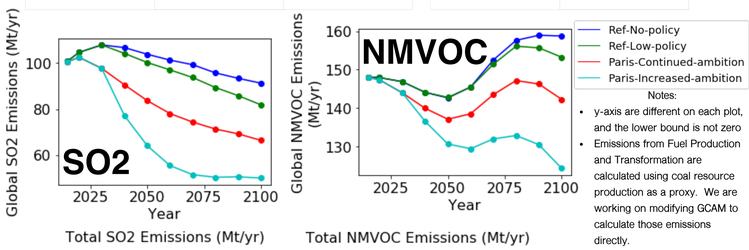
	Attributable Fraction
Ozone	Jerrett et al. [11]
$PM_{2.5}$	Burnett et al. [12]

Preliminary Global Precursor Emissions Results

Full Time Series by Policy Scenario

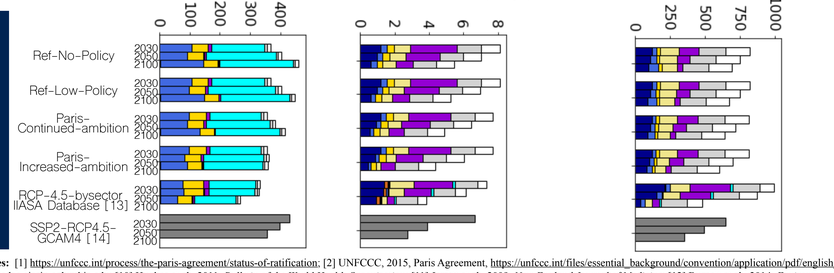


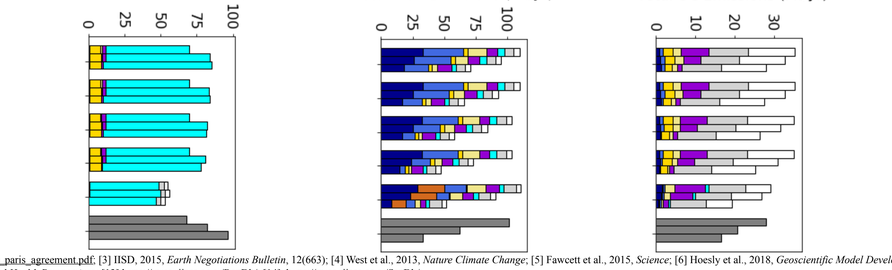


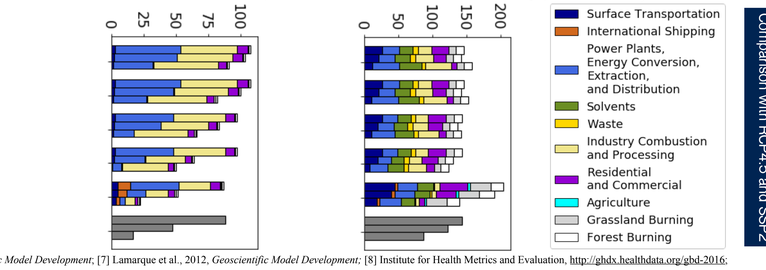


Full Time Series by Policy Scenario

Emissions by Sector and Comparison with RCP4.5 and SSP2







Emissions by Sector and Comparison with RCP4.5 and SSP2

References: [1] https://unfccc.int/process/the-paris-agreement/status-of-ratification; [2] UNFCCC, 2015, Paris Agreement, https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf; [3] IISD, 2015, *Earth Negotiations Bulletin*, 12(663); [4] West et al., 2013, *Nature Climate Change*; [5] Fawcett et al., 2015, *Science*; [6] Hoesly et al., 2018, *Geoscientific Model Development*; [7] Lamarque et al., 2012, *Geoscientific Model Development*; [8] Institute for Health Metrics and Evaluation, http://ghdx.healthdata.org/gbd-2016; [9] http://sedac.ciesin.columbia.edu; [10] Hughes et al., 2011, *Bulletin of the World Health Organization*; [11] Jerrett et al., 2009, *New England Journal of Medicine*; [12] Burnett et al., 2014, *Environmental Health Perspectives*; [13] https://tntcat.iiasa.ac.at/RcpDb/; [14] https://tntcat.iiasa.ac.at/SspDb/

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