Climate and Human Health:
Informing strategies for equity and well-being

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GLOBAL CHANGE

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EAPS

IDSS
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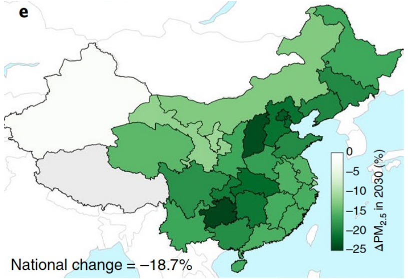
What we know: Climate policies benefit human health

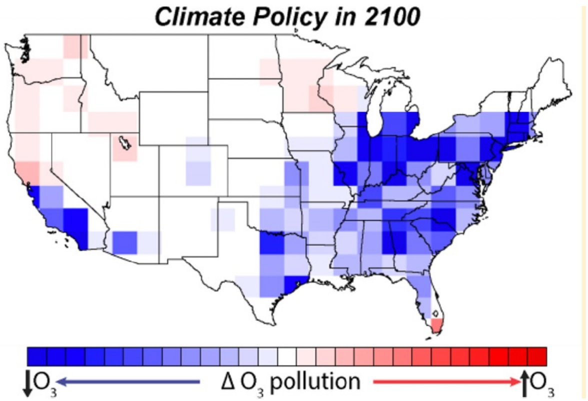
A major way in which they do so is by reducing air pollution and related mortalities.

In **China**, strict carbon policies by 2030 could **avoid 160,000 premature mortalities** from $PM_{2.5}$



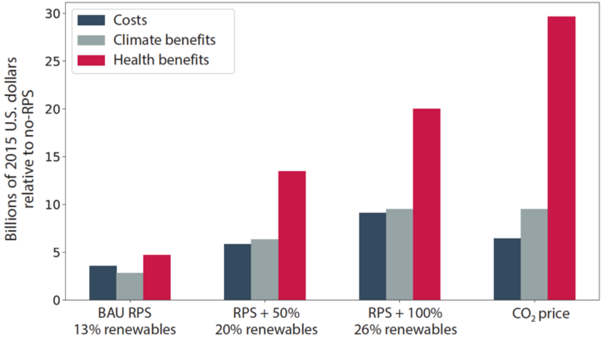
M. Li, D Zhang, C. T. Li, K. M. Mulvaney, N. E. Selin, and V. J. Karplus. 2018. "Air Quality Co-Benefits of Carbon Pricing in China." Nature Climate Change, 8:398-403.

Mitigating climate change **avoids future air pollution related mortality increases** in the US



F. Garcia-Menendez, R. K. Saari, E. Monier, and N. E. Selin. 2015. "U.S. air quality and health benefits from avoided climate change under greenhouse gas mitigation." Environmental Science and Technology, 49:7580–7588.

In the US, monetized **air pollution benefits from regional carbon policies exceed policy costs**



E. Dimanchev, S. Paltsev, M. Yuan, D. Rothenberg, C. Tessum, J. Marshall, and N. E. Selin. 2019. "Health co-benefits of sub-national renewable energy policy in the U.S." Environmental Research Letters, 14, 085012.

Beyond "Co-benefits"

- Previous work conceptually separated "direct" from "indirect" benefits, emphasizing "co-benefits" (including in our own paper titles!)
- This increasingly doesn't make sense in terms of how we think about climate action in a changed world:
  - Integrated problems require integrated solutions
  - Increasing focus on equity and justice: different stakeholders have different goals and priorities
- Need for new research, metrics, ways of thinking

Questions

- **What are the observed impacts** of climate and energy policies on air quality?
- **Who benefits and why?** Including assessment of environmental justice and equity
- **What strategies can promote well-being for the present and the future?**
  - What new methods and models are needed to evaluate options?

What are the observed impacts?

A natural experiment: China's energy and air pollution policies during the 11th Five-Year Plan (2006-2010). Firm-level data on energy use and emissions from iron and steel and cement plants.

Observed impacts are heterogeneous and depend on local responses to policy

"Ex Ante" **"Ex Post"**

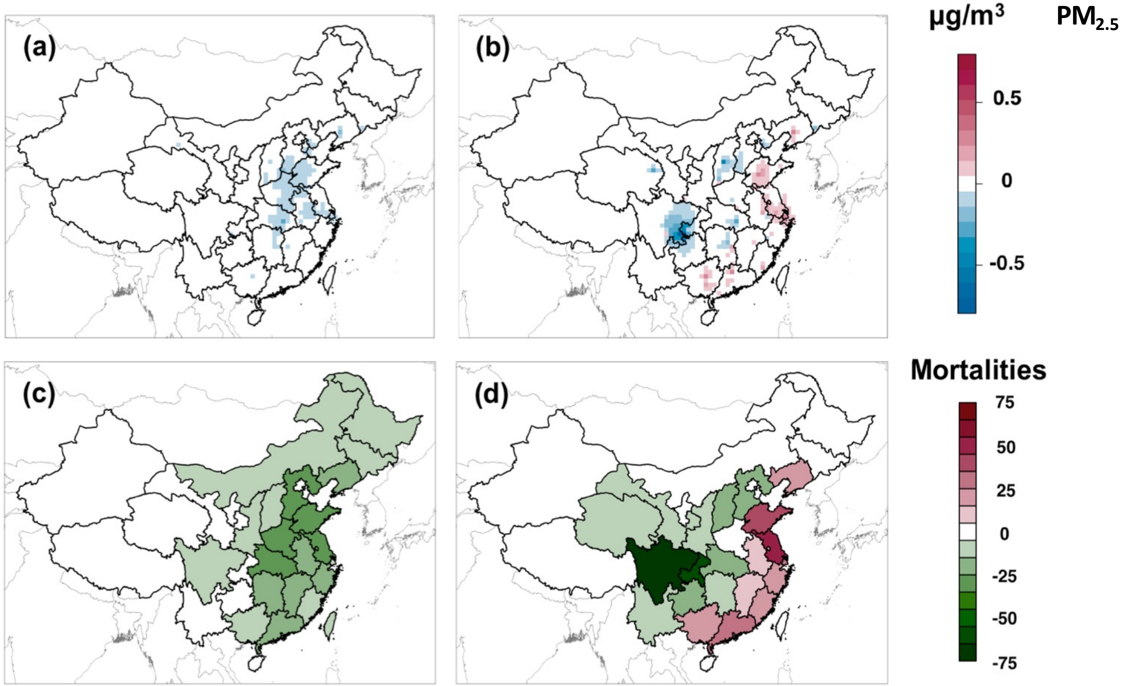
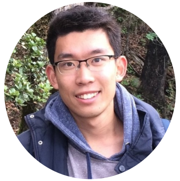


Figure 2. Impacts of the energy intensity policy on air quality (a,b) and human health (c,d) under ex ante and ex post scenarios. (a) and (c) show changes in $PM_{2.5}$ and associated mortalities, respectively, calculated ex ante, and (b) and (d) are calculated ex post. Air quality impacts are characterized as changes in annual average surface $PM_{2.5}$ concentration under policy relative to a counterfactual baseline (Unit: $\mu g/m^3$).

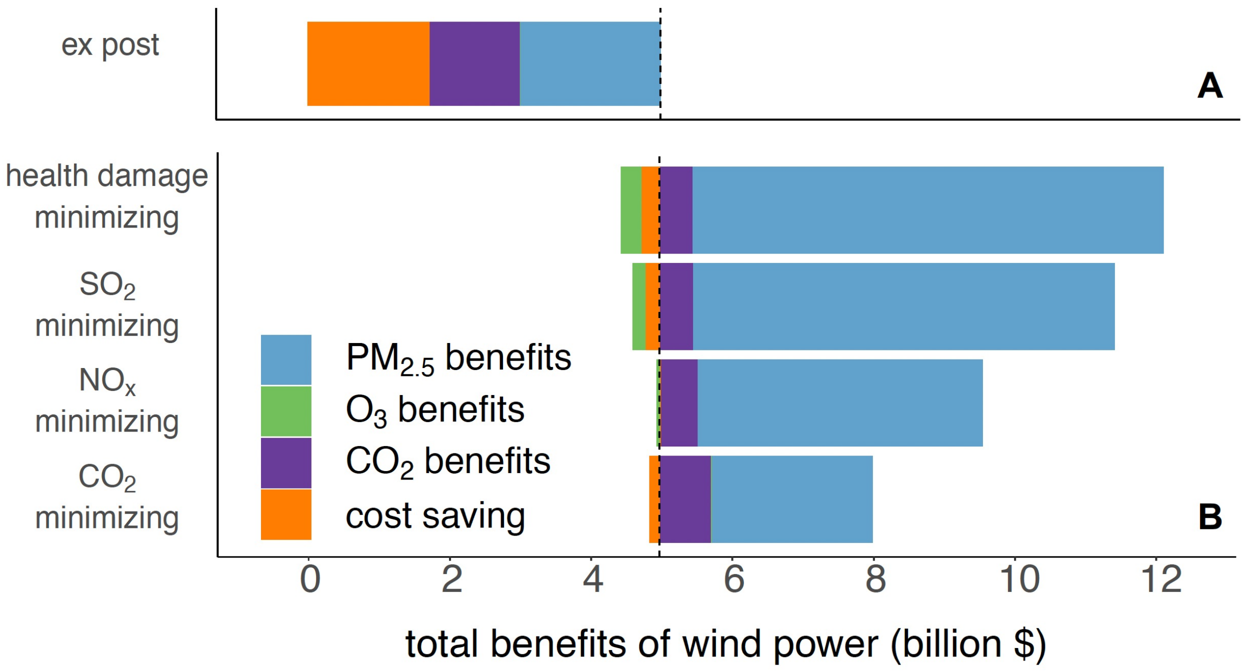
M. Qiu, Y. Weng, J. Cao, N. E. Selin and V. J. Karplus. 2020. "Improving evaluation of energy policies with multiple goals: Comparing ex ante and ex post approaches." Environmental Science & Technology 54(24):15584-15593.



Minghao Qiu, PhD MIT IDSS '21
Now postdoc, Stanford

What are the observed impacts?

Wind power in the US: regression approach to calculate unit-level benefits of wind power for air quality related health outcomes from 2011-2017

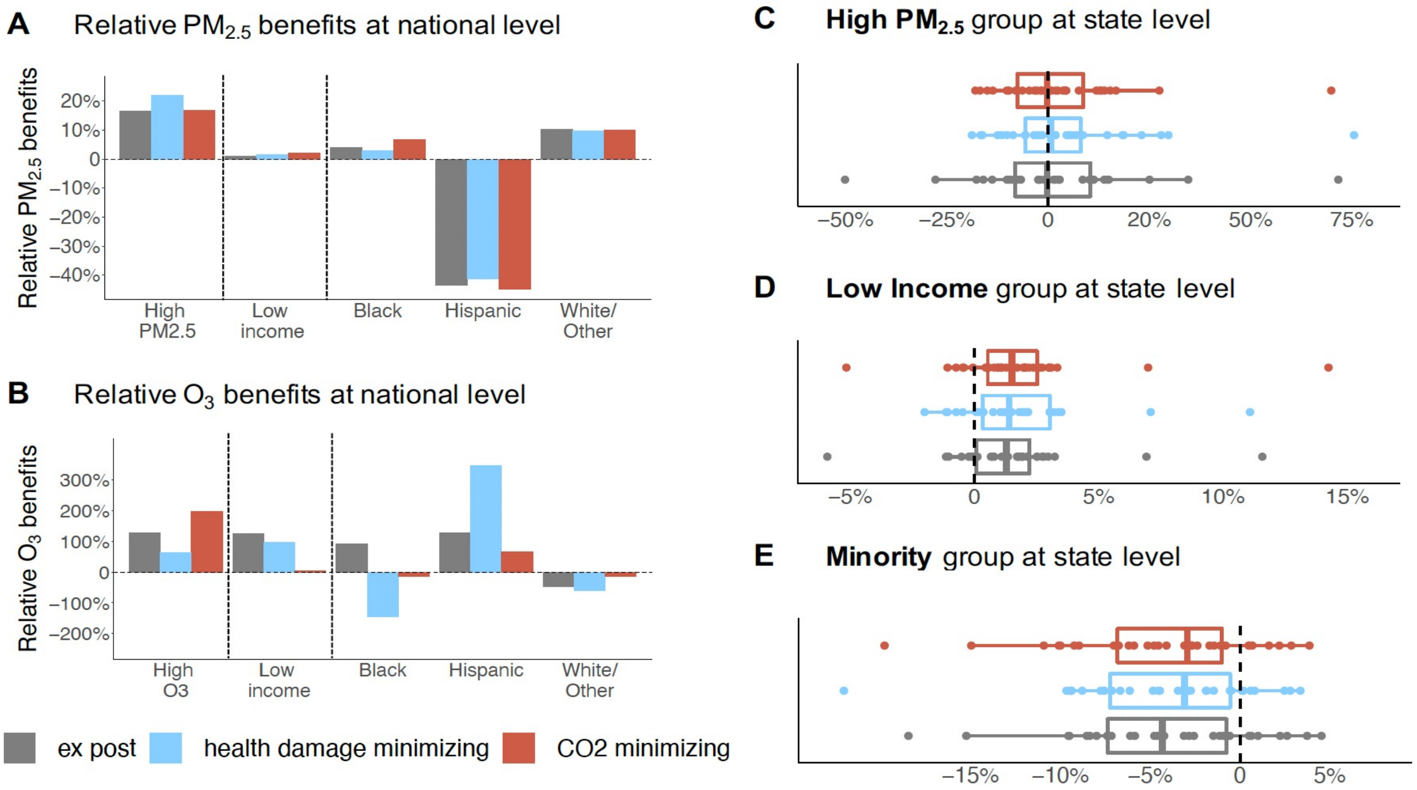


Large benefits, but different distributions could result in much larger benefits

M. Qiu, C. Zigler, N. E. Selin "Impacts of wind power on air quality, premature mortality and environmental justice in the US," in revision

Who benefits and why?

Wind power in the US: regression approach to calculate unit-level benefits of wind power for air quality related health outcomes from 2011-2017

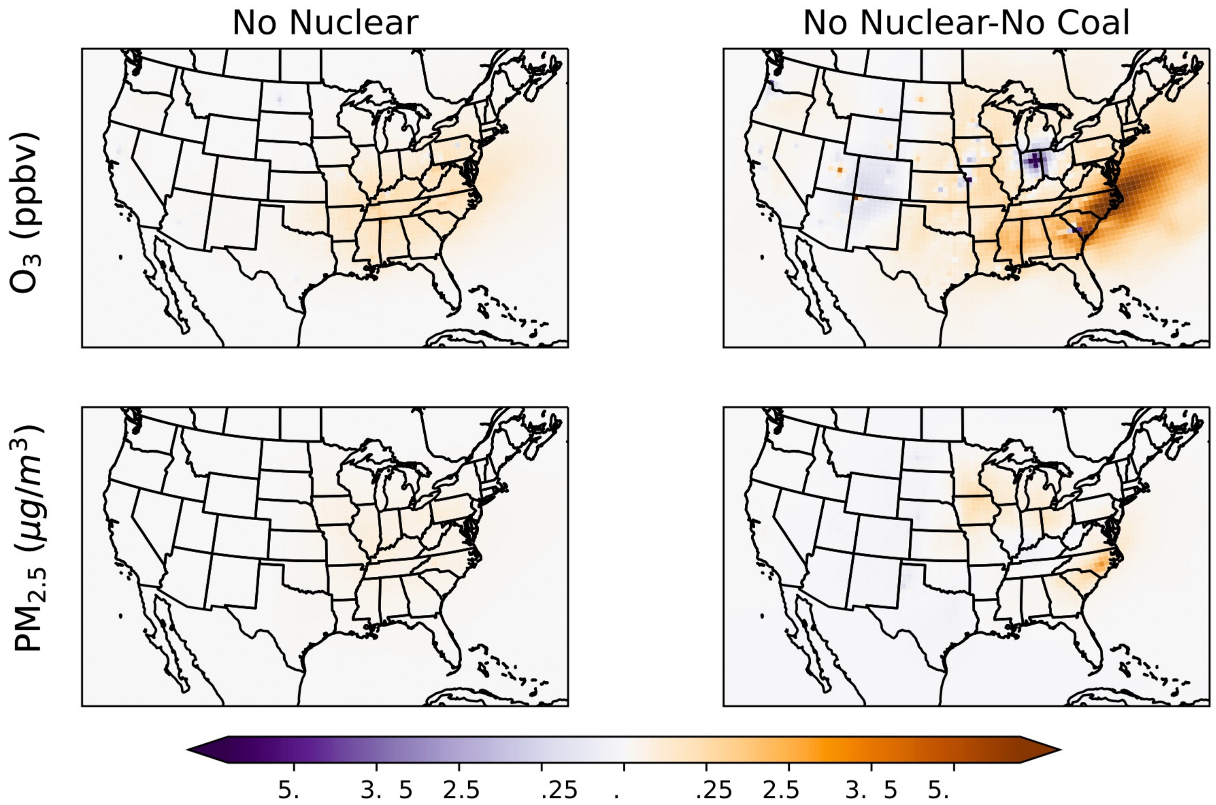


Maximizing overall benefits largely doesn't address disparities

Qiu et al. in revision

Who benefits and why?

Phase-out of nuclear energy and air quality impacts under current electricity system, and with simultaneous coal phase-out



Impacts depend strongly on baseline energy transition assumptions, and shift risks to different populations

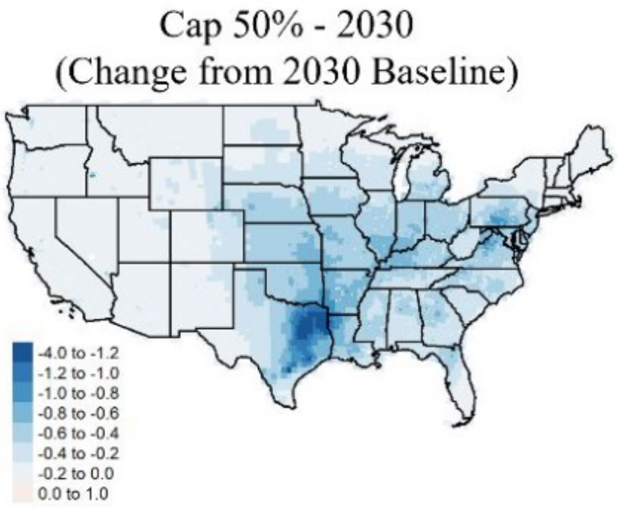
Accounting for mortality cost of carbon, right side has order of magnitude more mortalities over 21[st] century

Lyssa Freese,
PhD Candidate,
MIT EAPS

Who benefits and why?

National carbon cap and implications for air quality

PM2.5



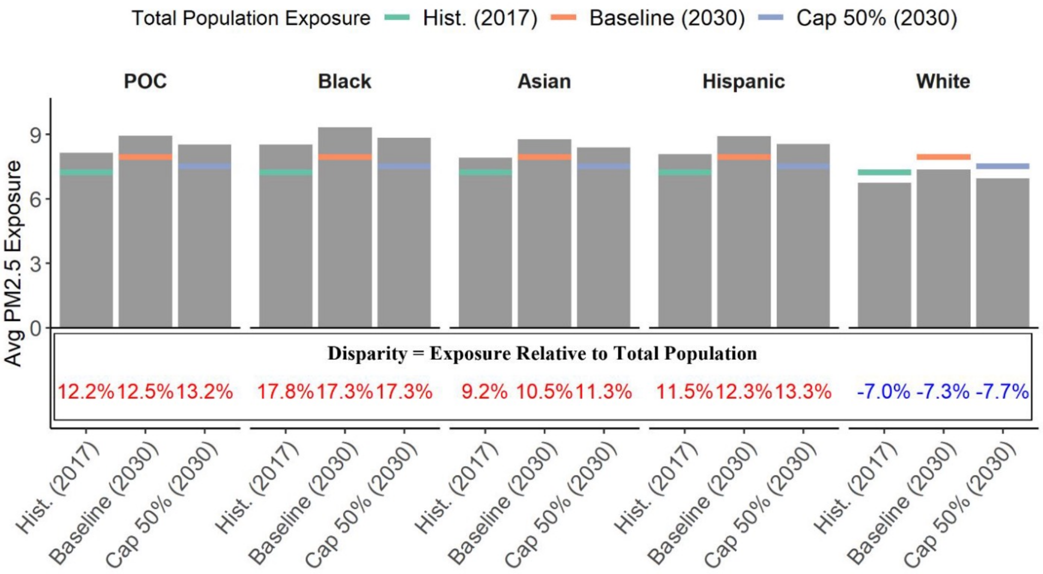


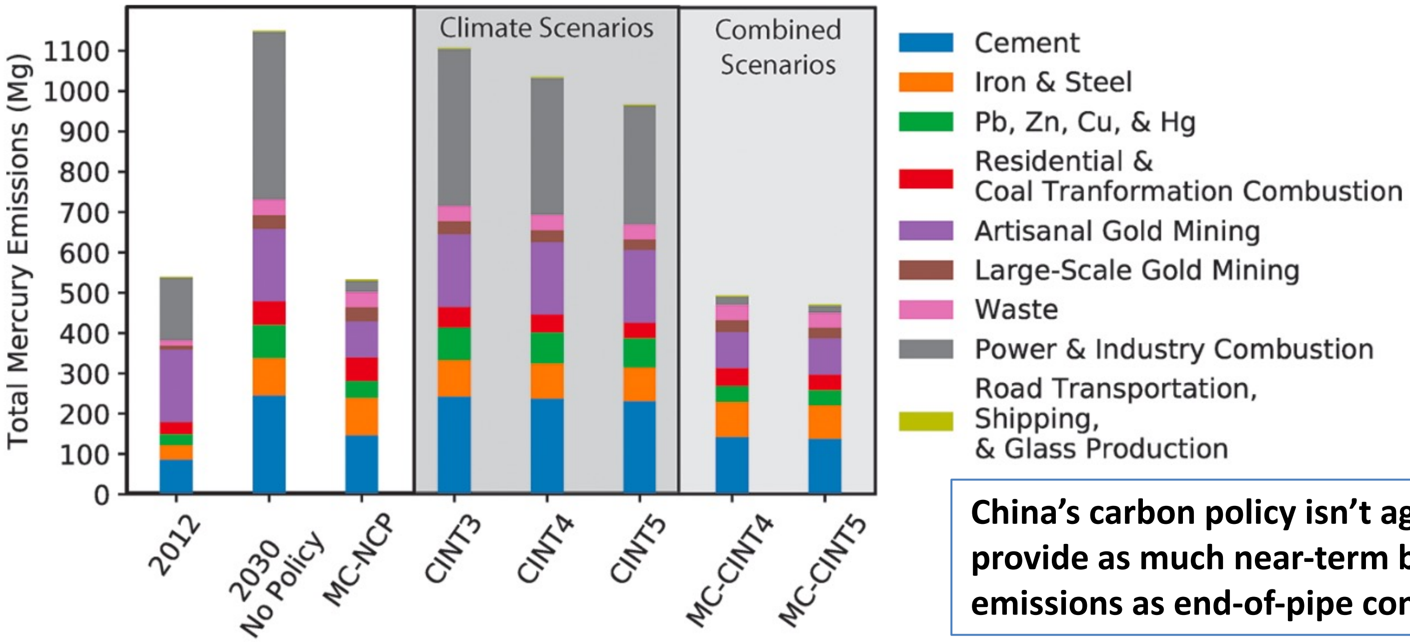
Figure 4. $PM_{2.5}$ exposure disparities by emissions source and race-ethnicity in 2017, Baseline (2030) and Cap 50% (2030).

Paul Picciano, Master's student in Technology and Policy

Carbon cap doesn't directly address air pollution disparities, but doesn't make them worse either

What strategies can promote present and future well-being?

Case of Chinese emissions under mercury policy (Minamata Convention) and climate strategies



Kathleen Mulvaney, M.S. in Technology and Policy (2017), now Rocky Mountain Institute

China's carbon policy isn't aggressive enough to provide as much near-term benefit in mercury emissions as end-of-pipe controls

K. M. Mulvaney, N. E. Selin, A. Giang, M. Muntean, C-T. Li, D. Zhang, H. Angot, C. P. Thackray, and V. J. Karplus. 2020. "Mercury benefits of climate policy in China: Addressing the Paris Agreement and the Minamata Convention Simultaneously." Environmental Science & Technology 54(3):1326-1335.

What strategies can promote present and future well-being?

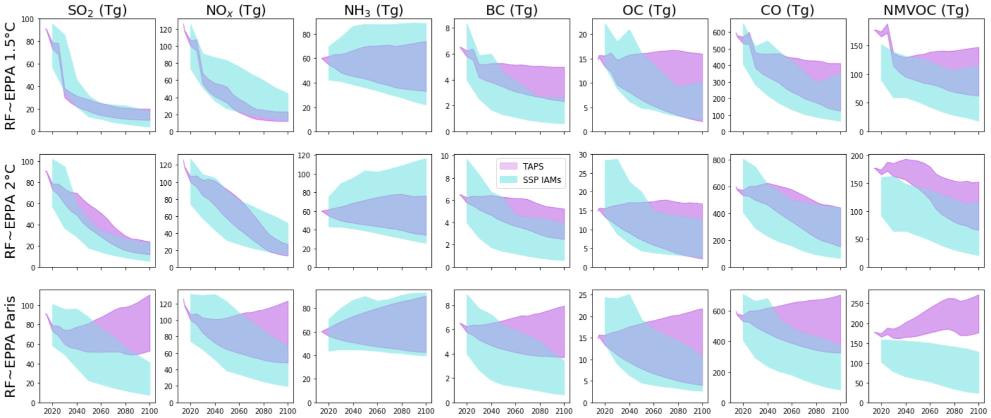
New models and methods

TAPS framework	
$E_{f,i,j,r,0}$	Best-practice global emissions inventory of anthropogenic air pollutants
$A_{f,i,j,r,t}$	Choice of climate policy scenarios → activity scaling from sector-specific fuel use
$f(\gamma_{f,i,j,r}t)$	Choice of emissions intensity trend → via pollution controls and innovation potential
Flexible air pollutant emissions scenarios	

This implementation
Community Emissions Data System (CEDS_GBD-MAPS), Global Fire Emissions Database (GFED 4.1s)
Economic Prediction and Policy Analysis (EPPA7) model: "Paris Forever", 2°C, and 1.5°C scenarios to 2100
Full-century trends based on the GAINS 4.01 scenarios: Current Legislation vs. Maximum Feasible Reductions
Range of long-term air pollutant emissions scenarios

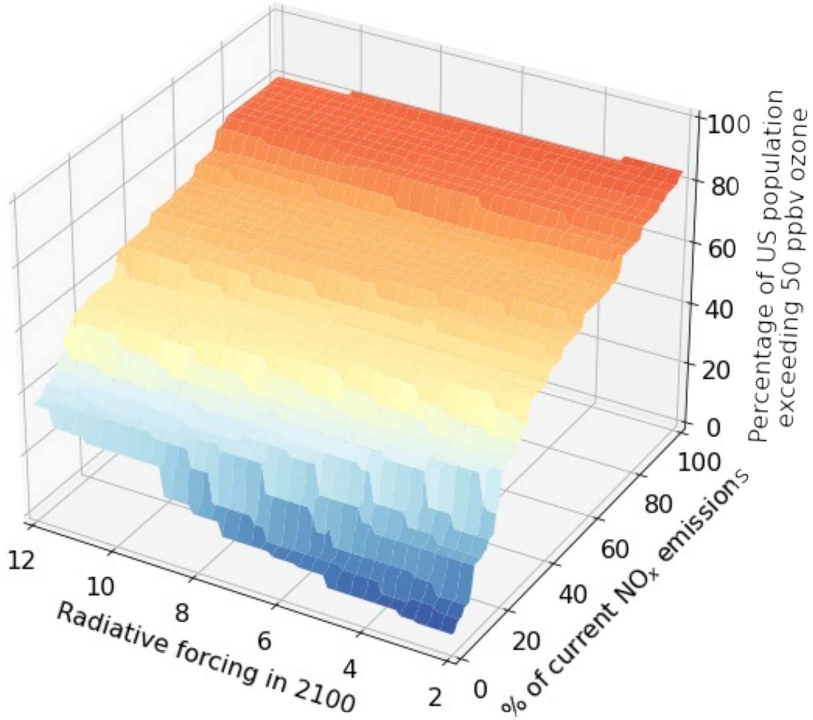
New TAPS model provides flexible global-scale scenario development for air quality

Will Atkinson, Master's student and Biogen Fellow, Technology and Policy Program



What strategies can promote present and future well-being?

New models and methods



Ensemble approach and new metrics can examine how interventions can achieve goals

Seb Eastham, Research Scientist

Summary

- **Evaluating** interventions shows that distributional impacts can drive critical health outcomes of policy strategies
- **Existing strategies** are a mixed bag for equity, but potential for greater policy impacts exists
- **New models and methods** can facilitate multi-dimensional assessment

Extensions to multiple indicators and outcomes relevant to sustainability