Co-benefits of mitigating global greenhouse gas emissions for future air quality and human health

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Co-benefits - Background

Reducing GHG emissions also reduces co-emitted air pollutants

- Air quality and health co-benefits shown to be substantial compared to GHG abatement costs.

  "$2-175 / ton CO_2 … all studies agree that monetized health benefits make up a substantial fraction of mitigation costs." IPCC AR4

  "$2-196 / ton CO_2, and the highest co-benefits found in developing countries. These values, although of a similar order of magnitude to abatement cost estimates, are only rarely included in integrated assessments of climate policy." Nemet et al. (2010)

- Most studies have focused locally or regionally.
- Tend not to analyze future scenarios.
- None has been global, using an atmospheric model.

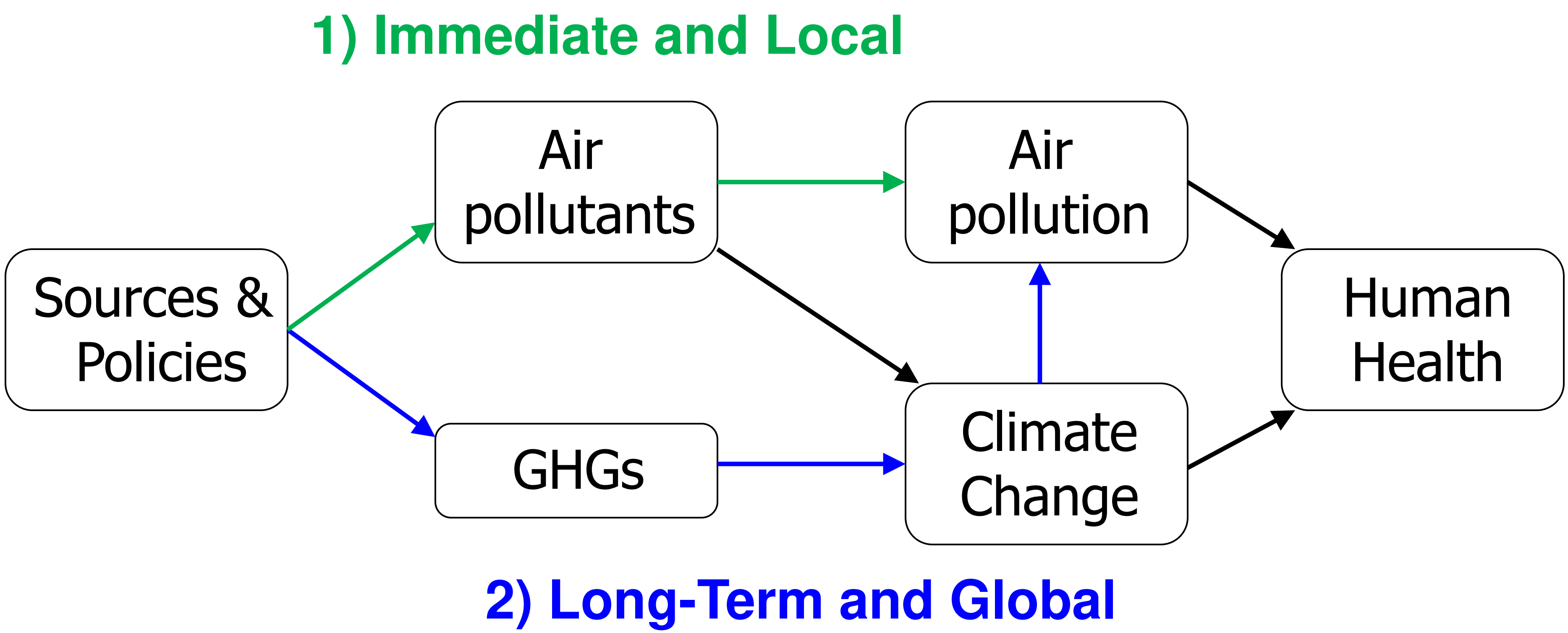
Effect of Climate Change on Future Air Quality

- Influences via changes in photochemical rates, biogenic emissions, horizontal and vertical transport, H_2O, partitioning of semi-volatiles, rainfall (stagnation), etc.
- Climate change shown to increase O_3 in US and Europe, but the O_3 background will decrease.
- Climate change will also affect PM, but those influences are less clear.

  (Weaver et al., 2009; Jacob and Winner, 2009; Fiore et al., 2012)
- Emphasis on meteorological downscaling.
- Tend not to analyze future emissions scenarios.
- Only two studies estimate global effects of climate change on future health from air pollution (West et al., 2007; Selin et al., 2009)

** Now an opportunity to reinterpret this literature as an air quality (health) co-benefit of reduced GHG emissions.

Co-benefits of GHG Mitigation for Air Quality



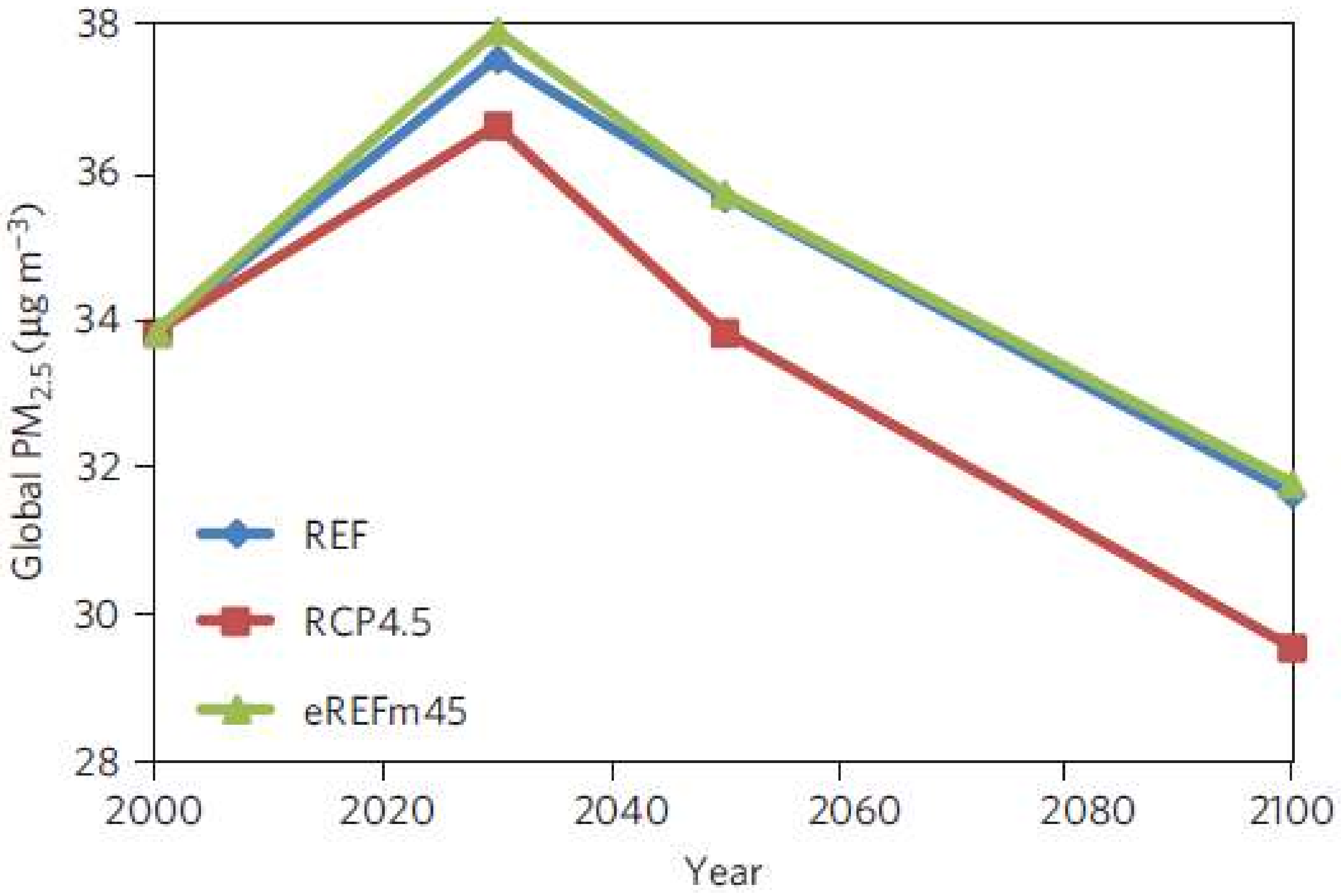
Objective: Analyze global co-benefits for air quality and human health via both mechanisms, in scenarios to 2100.

Approach

Years	Emissions GCAM	Meteorology GFDL AM3	Name
2000	2000	2000	2000
2030, 2050, 2100	GCAM Reference	RCP8.5	REF
	RCP4.5	RCP4.5	RCP4.5
	GCAM Reference	RCP4.5	eREFm45

- Use the GCAM reference for emissions rather than RCP8.5, for consistency with RCP4.5.
- Simulations conducted in MOZART-4.
  - 2° x 2.5° horizontal resolution.
  - 5 meteorology years for each case.
  - Fixed methane concentrations.
  - Compares well with ACCMIP RCP4.5

Results – $PM_{2.5}$ Concentration

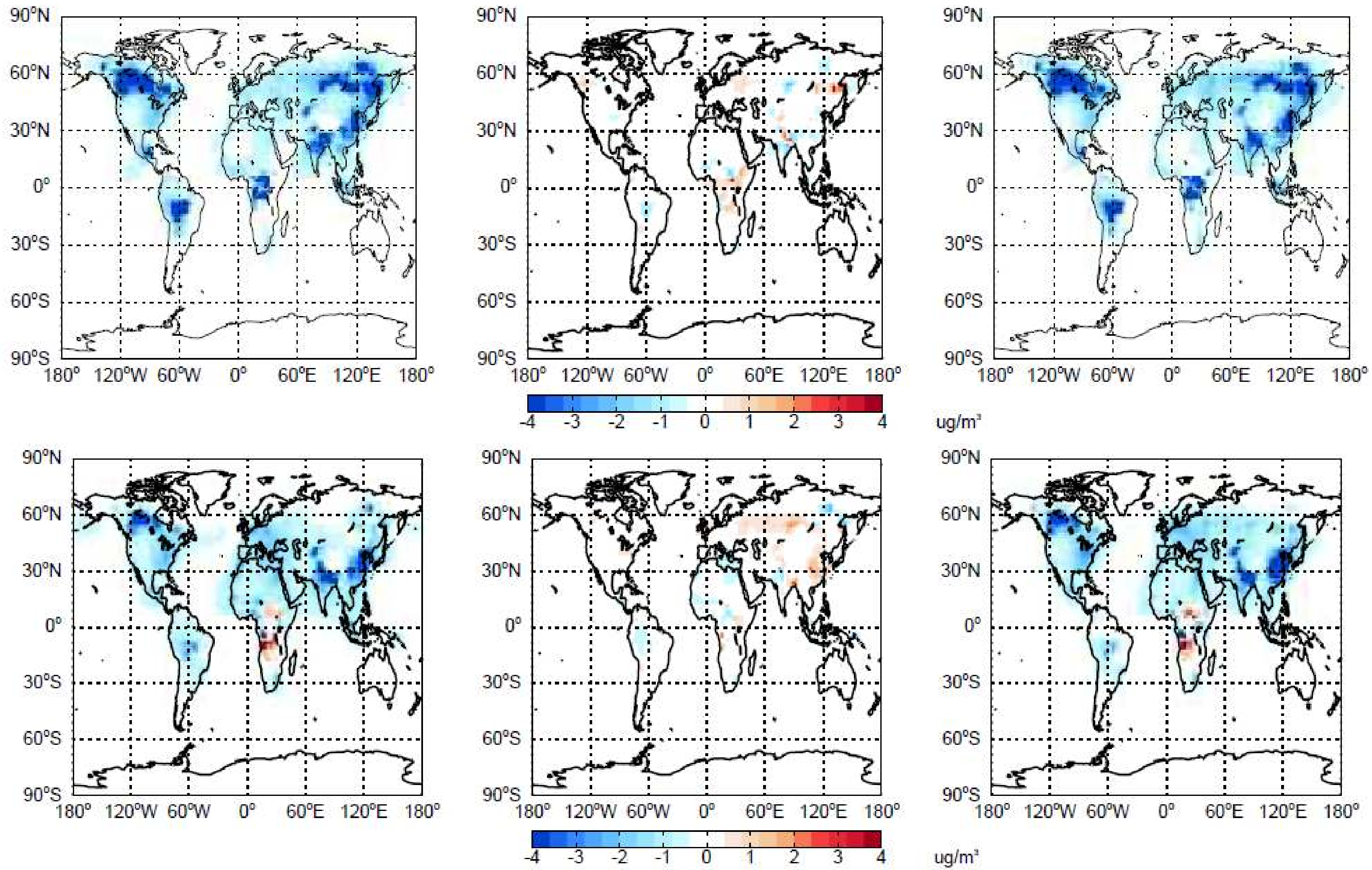


Global population-weighted, annual average $PM_{2.5}$

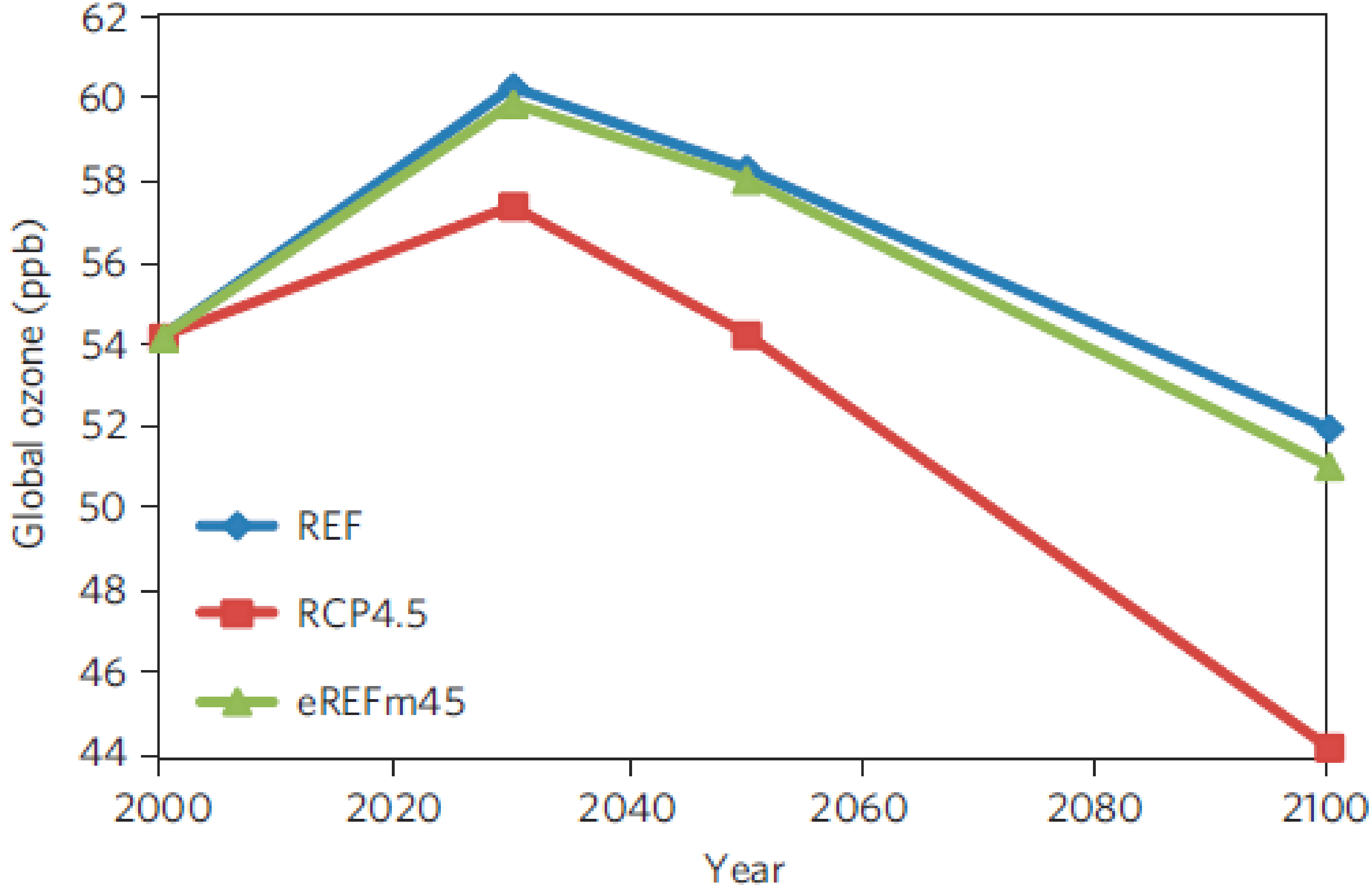
Results – $PM_{2.5}$ Concentration

Annual average $PM_{2.5}$

	Total change RCP4.5 - REF	Meteorology eREFm45 - REF	Emissions RCP4.5 – eREFm45
2050			
2100			



Results – Ozone Concentration



Global population-weighted,
max. 6 month average of 1 hr. daily max ozone

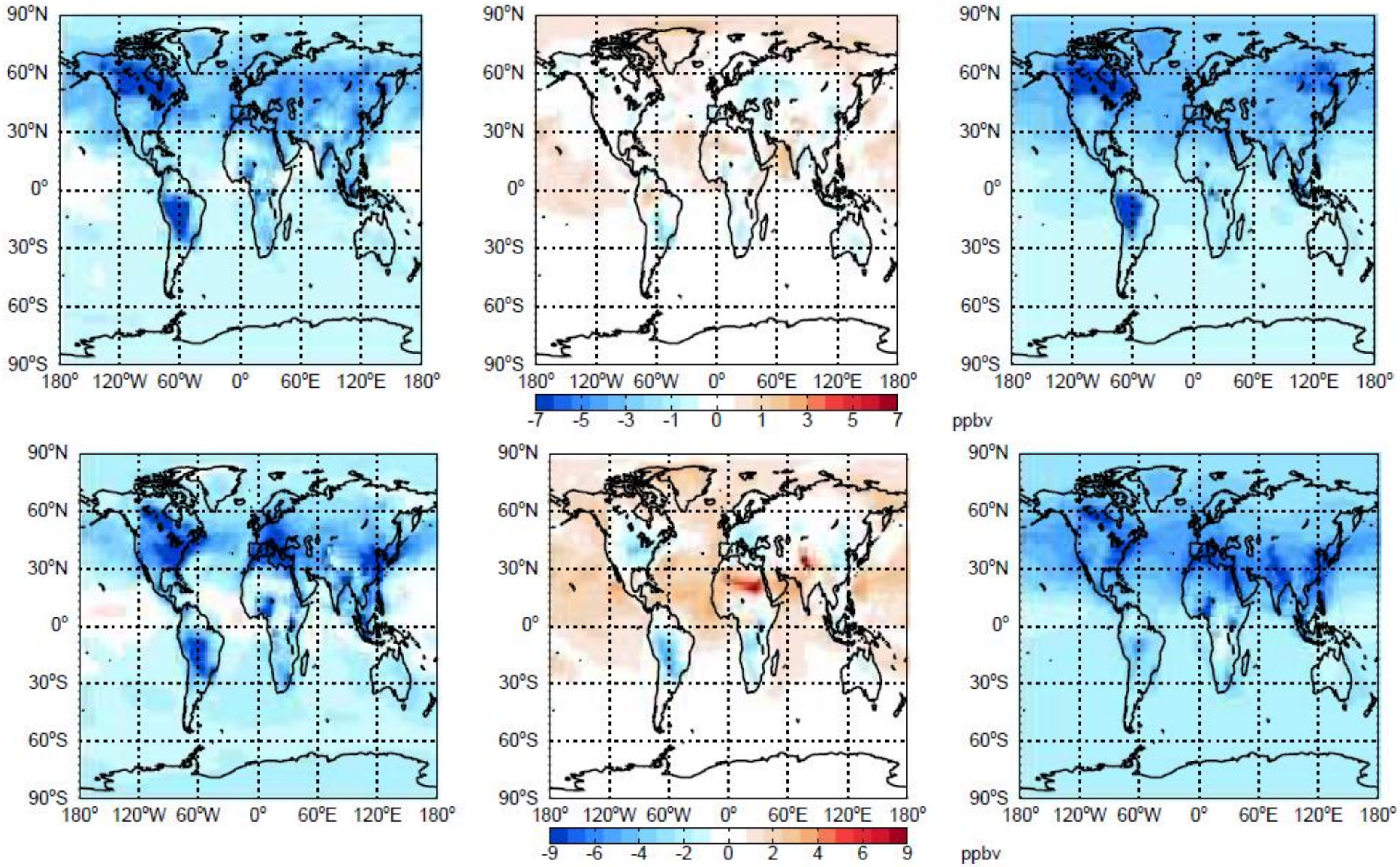
Results – Ozone Concentration

Max. 6 month average of 1 hr. daily max ozone

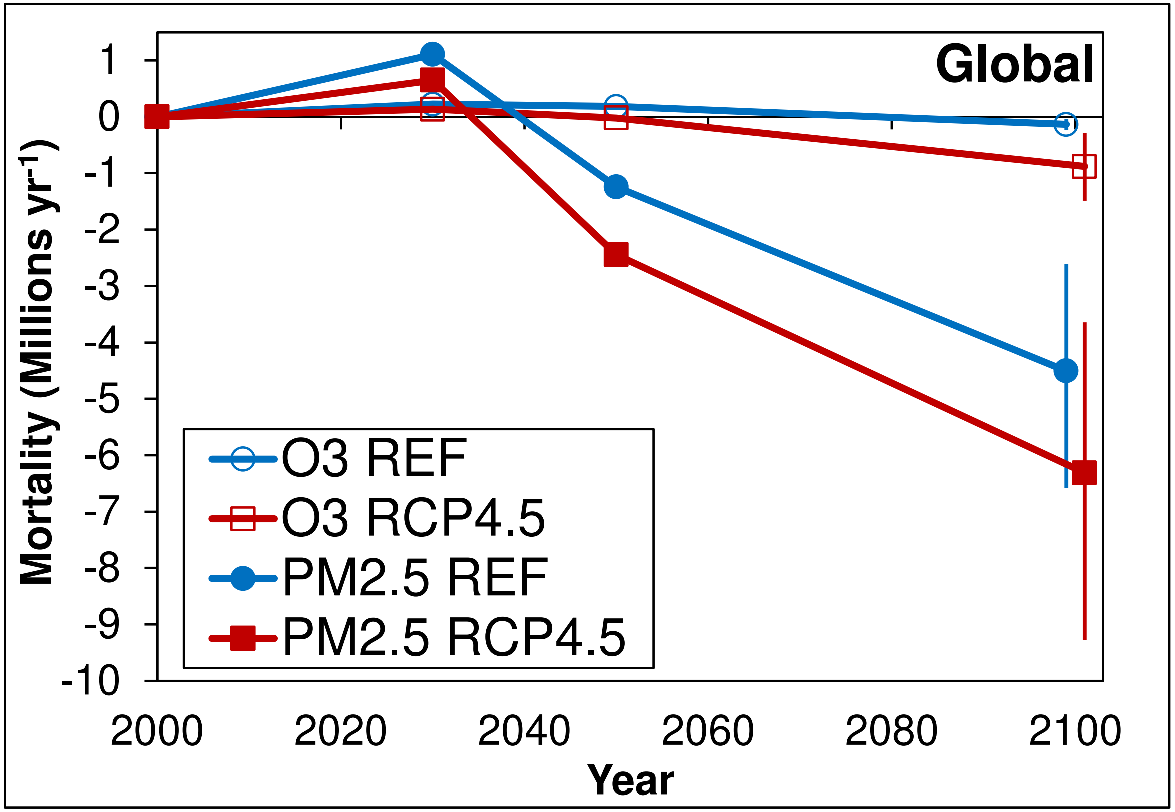
Total change RCP4.5 - REF | Meteorology eREFm45 - REF | Emissions RCP4.5 - eREFm45

2050

2100



Results – Global Premature Mortality



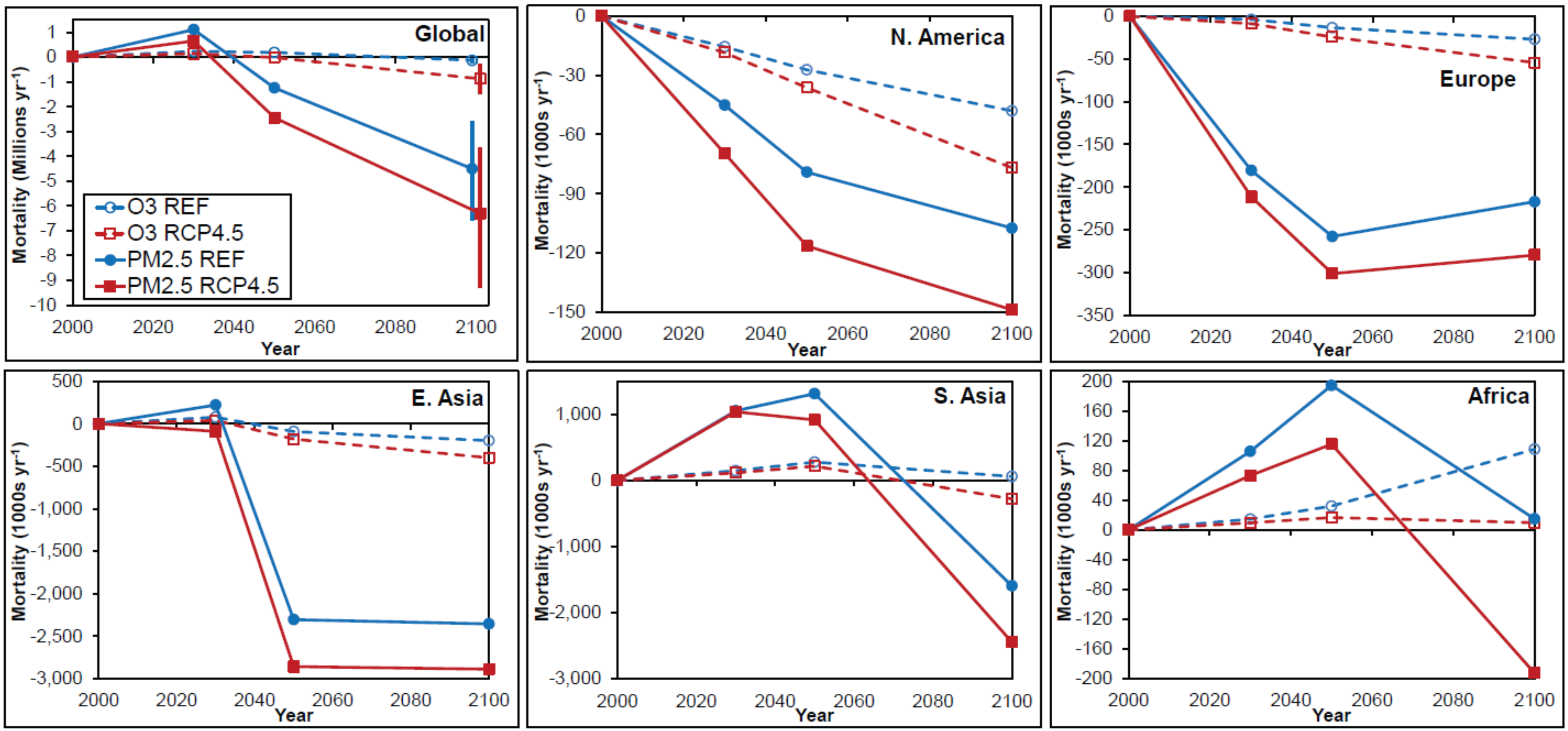
Projection of global population and baseline mortality rates from International Futures.

$PM_{2.5}$ co-benefits
(CPD + lung cancer mortality)
2030: 0.4±0.2
2050: 1.1±0.5
2100: 1.5±0.6

Ozone co-benefits
(respiratory mortality)
2030: 0.09±0.06
2050: 0.2±0.1
2100: 0.7±0.5

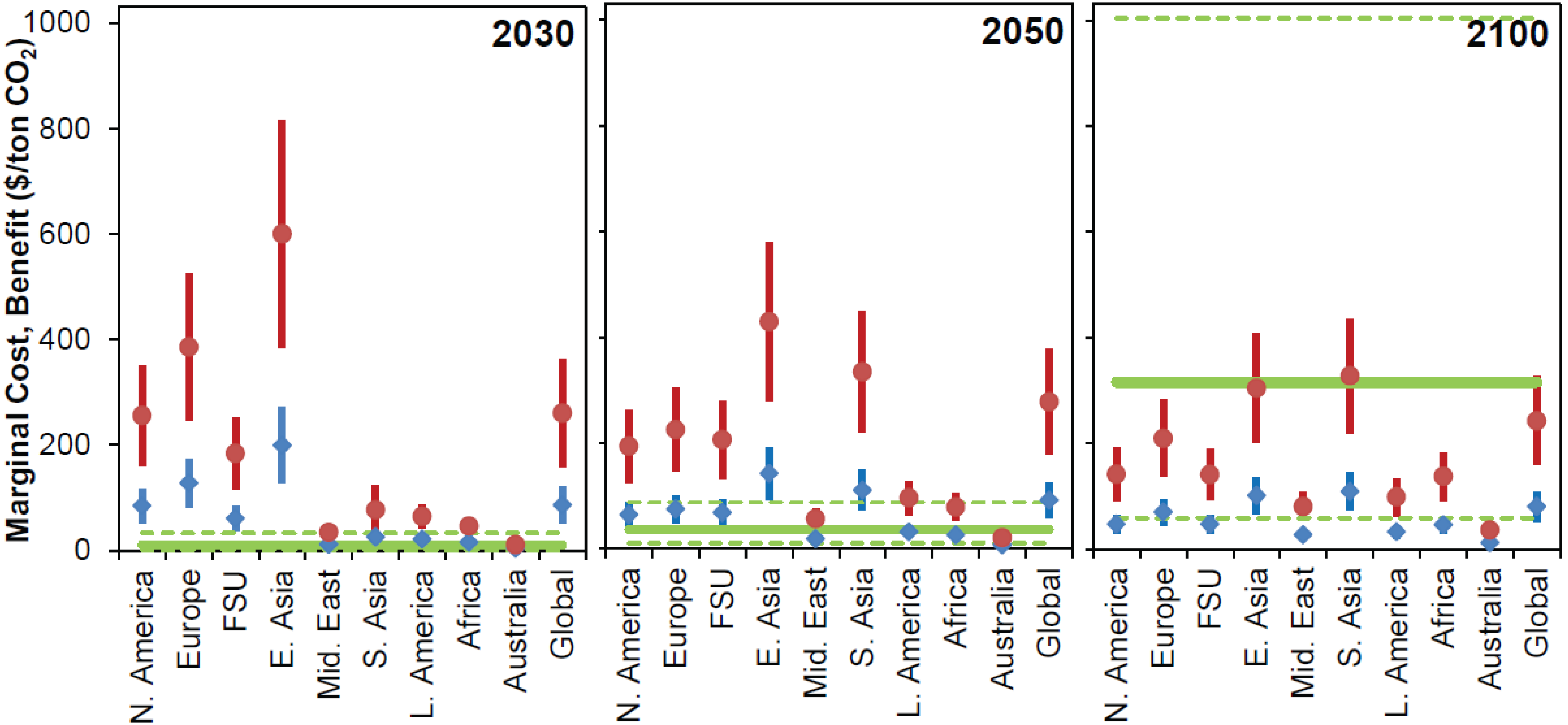
West et al. (2013)

Results – Global Premature Mortality



West et al. (2013)

Results – Valuation of Avoided Mortality



Red: High valuation (2030 global mean $3.6 million)
Blue: Low valuation (2030 global mean $1.2 million)
Green: Median and range of global C price (13 models)

West et al. (2013)

Monetized Co-benefits

- Global average: \$50-380 / ton CO_2
- US and Western Europe: \$30-600 / ton CO_2
- China: \$70-840 / ton CO_2
- India: -\$20-400 / ton CO_2
- Higher than previous estimates: \$2-196 / ton CO_2

  - Use future scenarios where population, susceptibility to air pollution, and economies grow.

  - Account for chronic mortality influences of ozone as well as $PM_{2.5}$.

  - Account for global transport, and long-term influences via methane.

Major uncertainties

- Only adults >30 years accounted for. (low bias)
- Co-benefits of GHG mitigation would be greater had the reference scenario not assumed decreased air pollution.
- RCP emissions do not include primary inorganics (fly ash). (low bias for $PM_{2.5}$)
- Coarse grid resolution for air pollution exposure. (low bias for $PM_{2.5}$)
- Applying concentration-response functions from the present-day US, globally and into the future.

Alternate approach to co-benefits: the value of avoided air pollution controls.

Co-benefits: conclusions

- Global abatement of GHG emissions brings substantial air quality and human health co-benefits.
- Global GHG mitigation (RCP4.5 relative to REF) causes 0.5±0.2 million avoided deaths in 2030, 1.3±0.5 in 2050, and 2.2±0.8 in 2100.
- Global average monetized co-benefits are $50-380 / ton CO_2
  - Greater than previous estimates
  - Greater than abatement costs in 2030 and 2050.
- The direct co-benefits from air pollutant emission reductions exceed those via slowing climate change.

West, J. J., S. J. Smith, R. A. Silva, V. Naik, Y. Zhang, Z. Adelman, M. M. Fry, S. Anenberg, L. W. Horowitz, and J.-F. Lamarque (2013) Co-benefits of global greenhouse gas mitigation for future air quality and human health, *Nature Climate Change*, 3, 885-889.

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UNC Climate Health and Air Quality Lab
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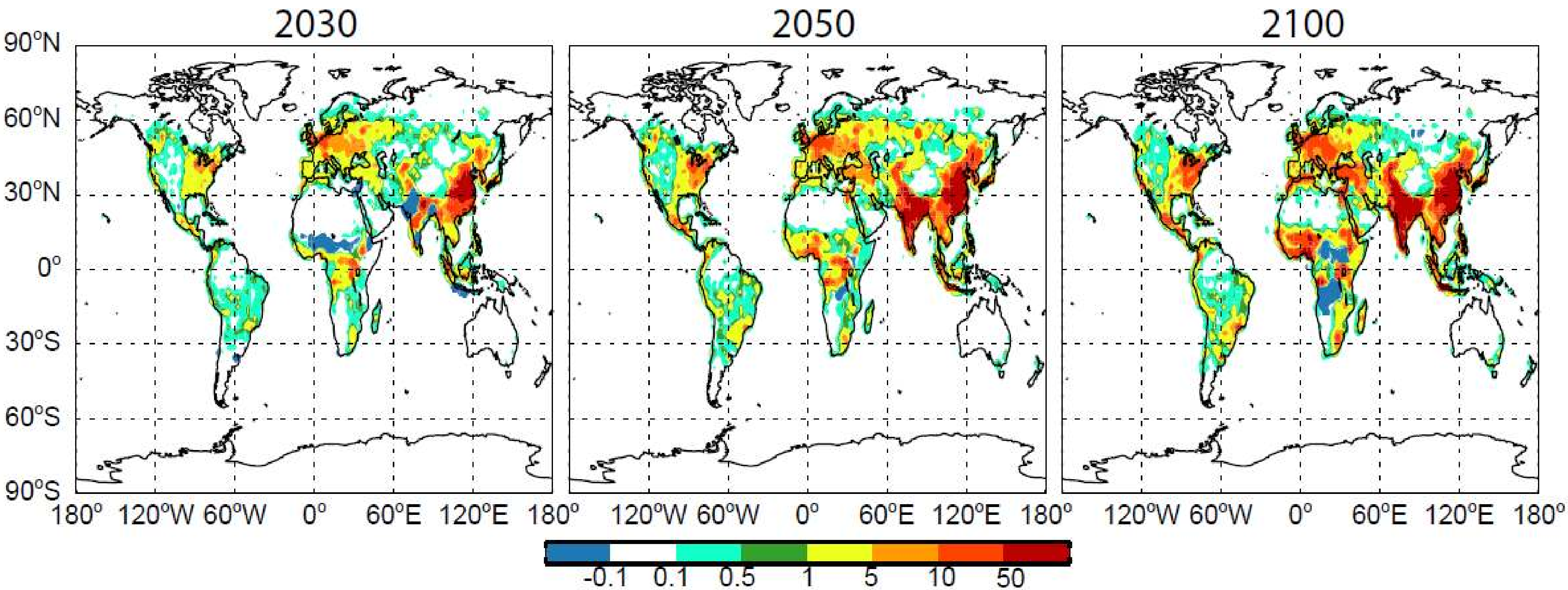
Results – Global Premature Mortality



Avoided deaths per year, from ozone (respiratory) and $PM_{2.5}$ (CPD + lung cancer)