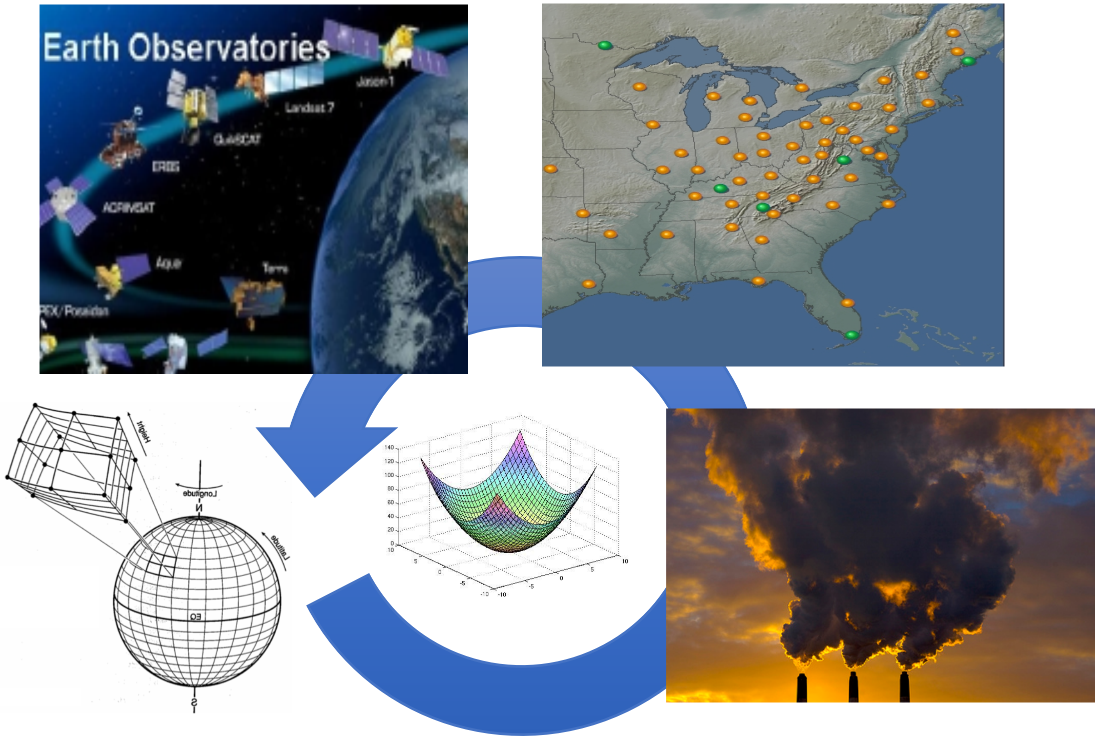
Air quality / GHG co-benefits: opportunities for a constellation of earth observations and stakeholders



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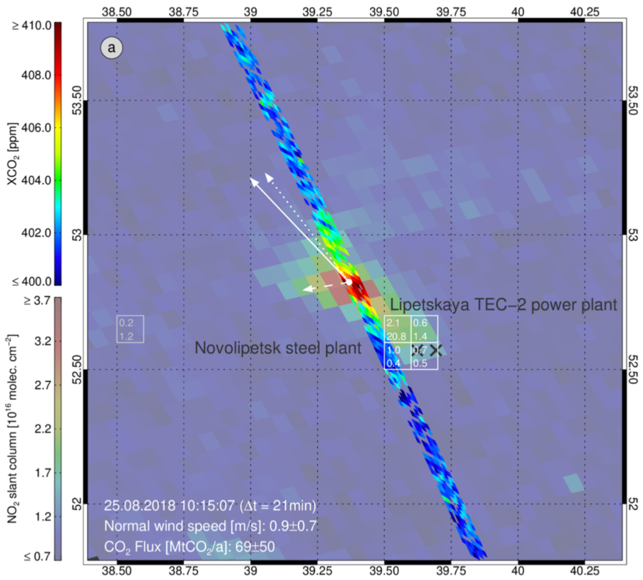
Types of AQ/GHG co-benefits

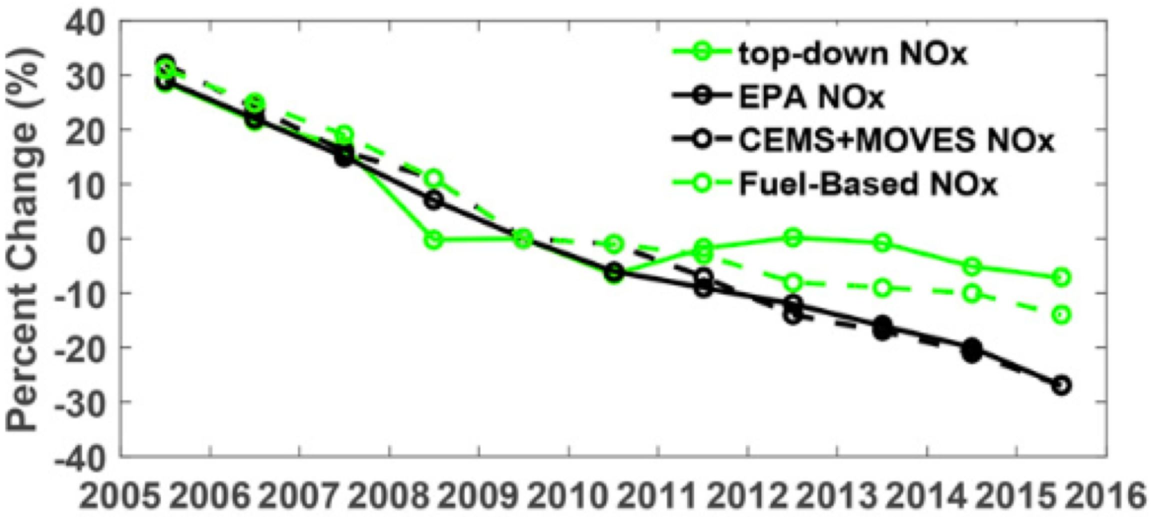
Co-benefits of AQ measurements for constraining ff CO_2 emissions: e.g., talks from Arellano, Miyazaki, plume analysis of Reuter et al. (2019).



Reuter et al., ACPD, 2019

Challenges being / to be addressed:

- mixes of small point sources, area sources
- NO_x/CO_2 ratios are changing or not well known
- NO_x controls turned off when the price is right
- Urban biosphere contributions to city plumes can be significant e.g. 20% in LA based on ^{14}C, (Lehman, Miller)



Benefits of GHG measurements to AQ emissions? e.g., NH_3 / CH_4….

Types of AQ/GHG co-benefits

What are some other “co-benefits” besides understanding emissions?

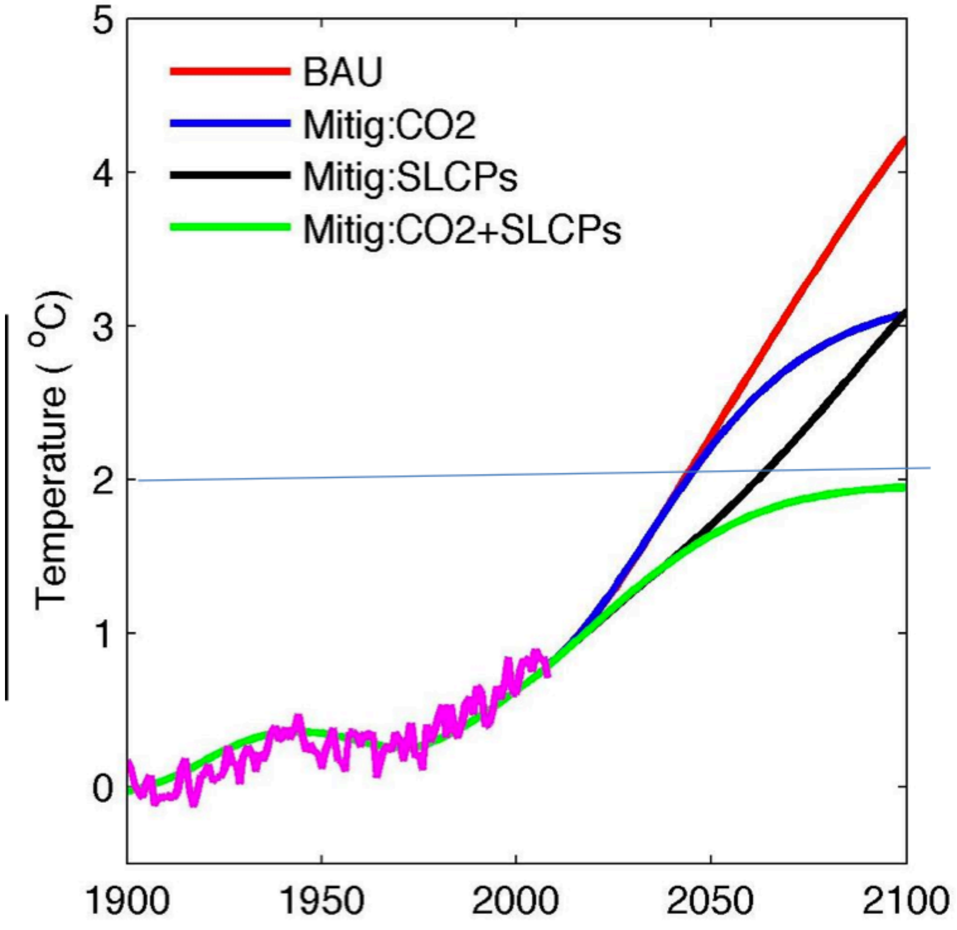
- engaging stakeholders (e.g., C40 cities, GUAPO,CCAC) who are interested in the co-benefits of AQ or GHG emission control strategies

- evaluating the effectiveness of such policies being adopted at the city to national scale

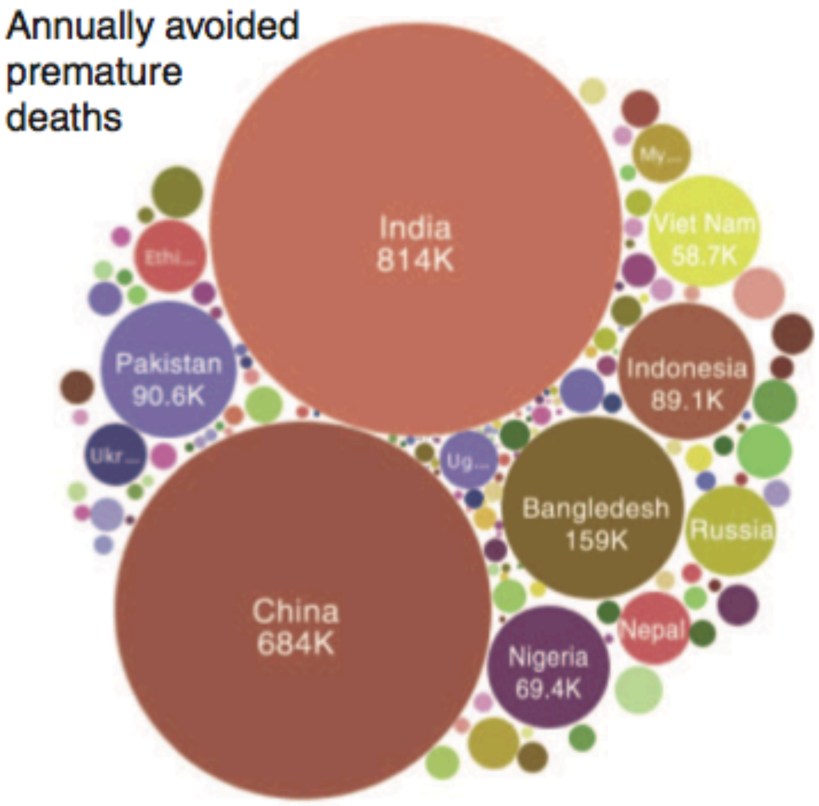
- designing new strategies that maximize co-benefits

Climate and health co-benefits of short-lived climate pollutants (SLCPs)

SLCPs = **CH_4**, **BC**, OC, CO, VOCs, NO_x, SO_2, NH_3, (HFCs)



Ramanathan and Xu, 2010; Hu et al., 2013
Ramanathan and Carmichael, 2008

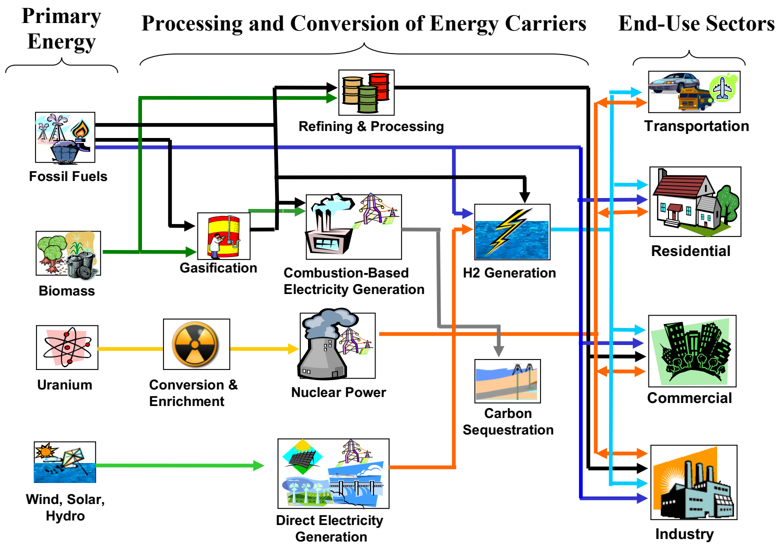


UNEP 2011; Shindell et al., 2012

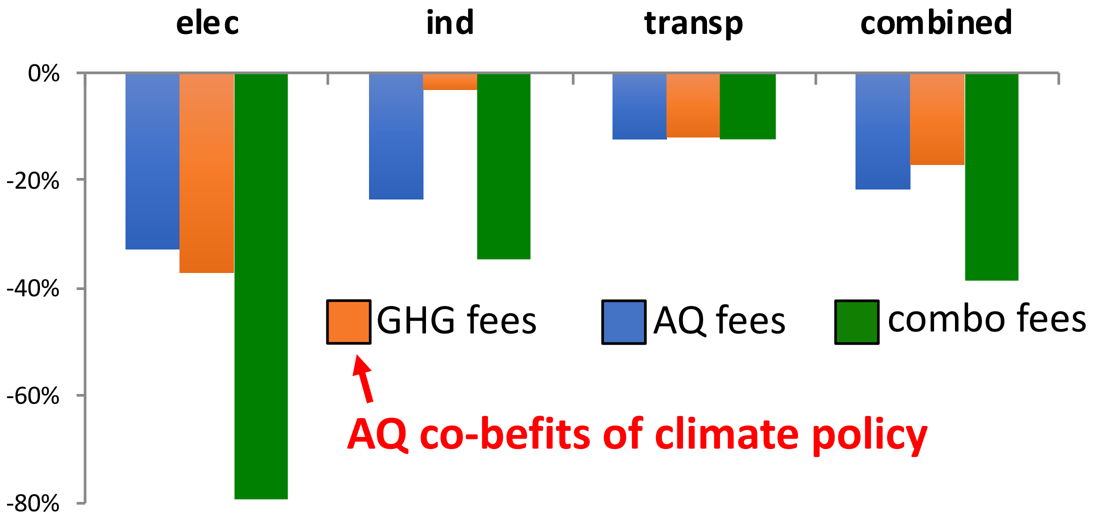
Air quality / GHG co-benefits in the US

Brown et al. (2017):

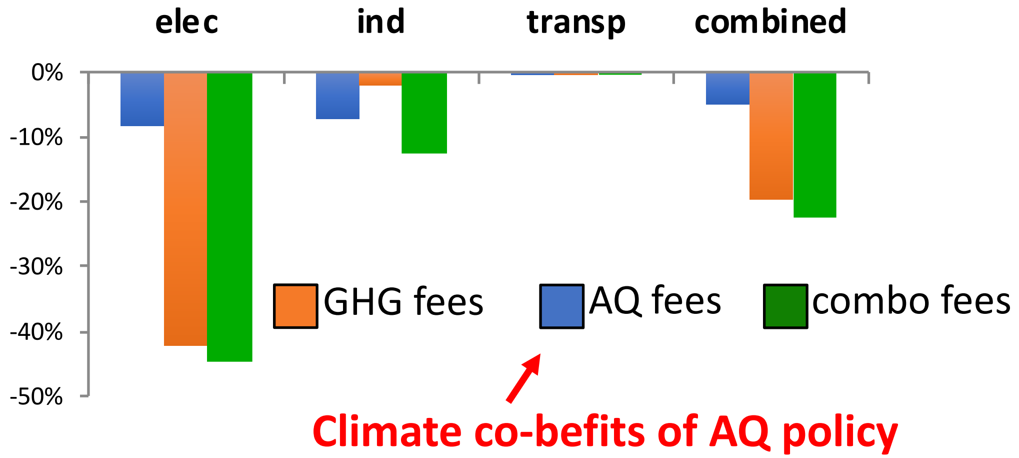
- EPA - MARKAL energy system model, 13 regions
- Baseline (BAU) scenario including current policies and energy demand projections
- Implement emission fees according to external damage:
  - $PM_{2.5}$ and O_3 mortality impacts (Muller et al., 2011; NRC 2010; Fann et al., 2009, 2012)
  - CO_2 (SCC 2013)
- Estimate NO_x and CO_2 emissions in 2045:



2045 NO_x: (fees – BAU) /BAU



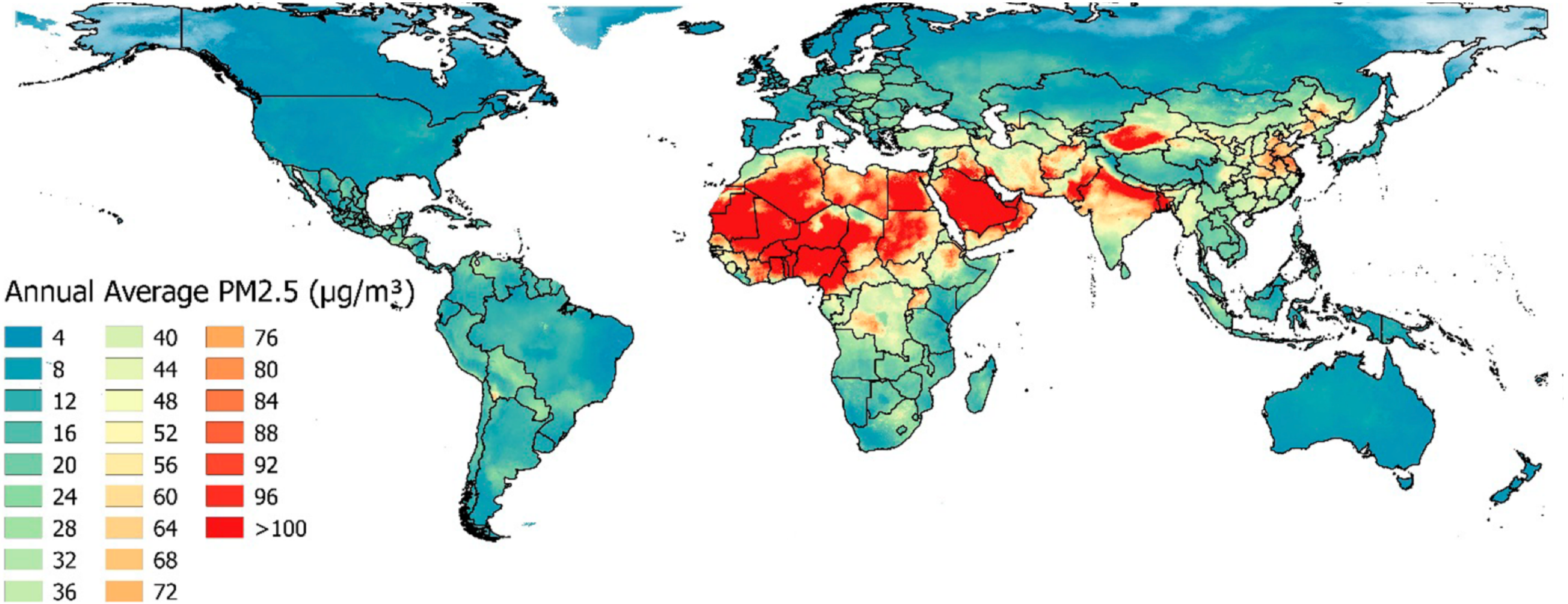
2045 CO_2: (fees – BAU) /BAU



Air quality / GHG connections in cities world wide

Anenberg et al. (submitted): compare $PM_{2.5}$ health impacts, CO_2 emissions, carbon footprint, and GDP in cities world-wide using globally consistent datasets and methods

$PM_{2.5}$ from Shaddick et al. (2018): hierarchical Bayesian synthesis of satellite-derived products, surface obs, geostatistical info



Of the 250 largest cities, only 8% < WHO guideline of 10 μg/m³ (all in USA, Canada, Australia and Brazil)

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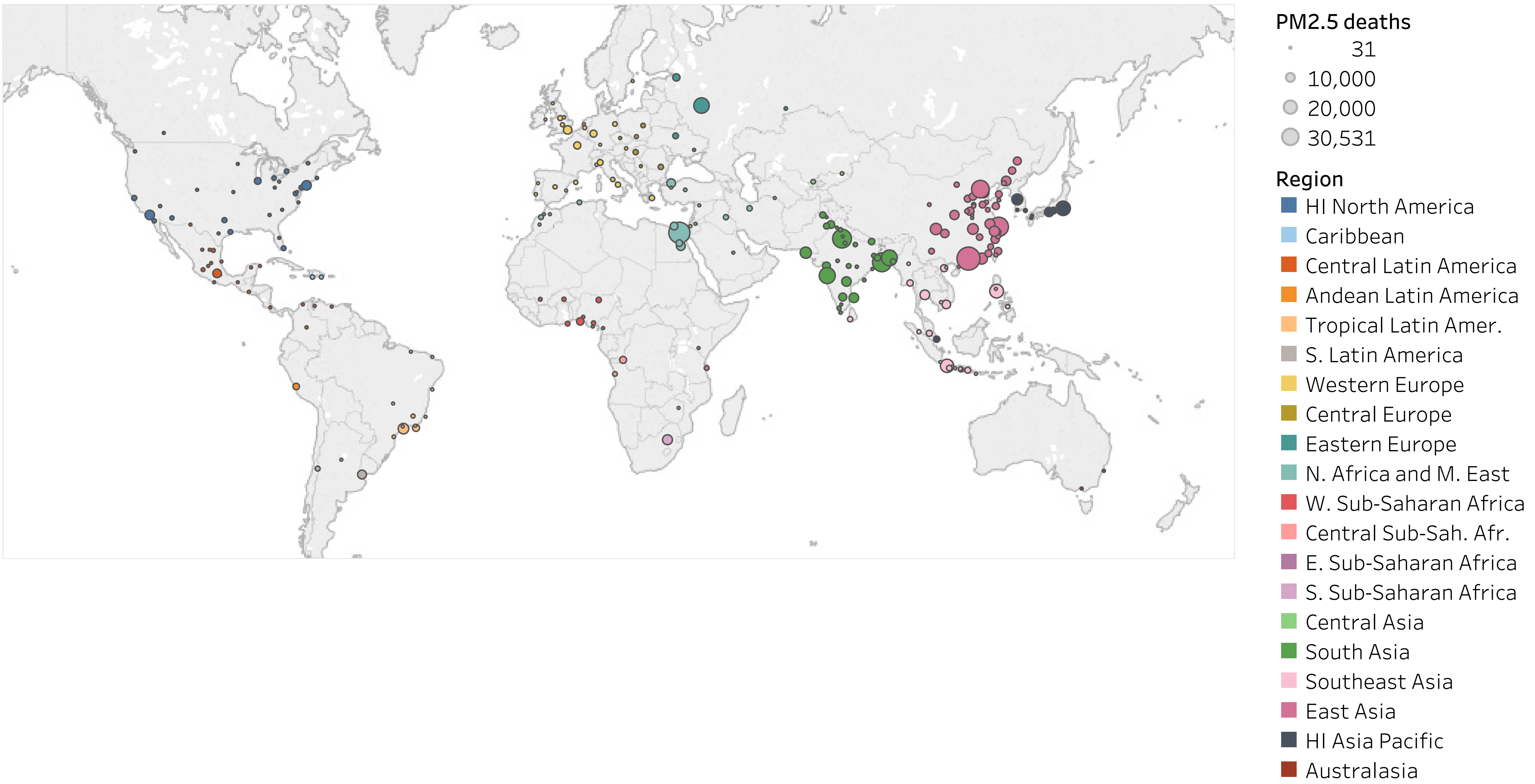
Health impacts calculated following Global Burden of Disease (GBD) methods (Cohen et al, 2017)

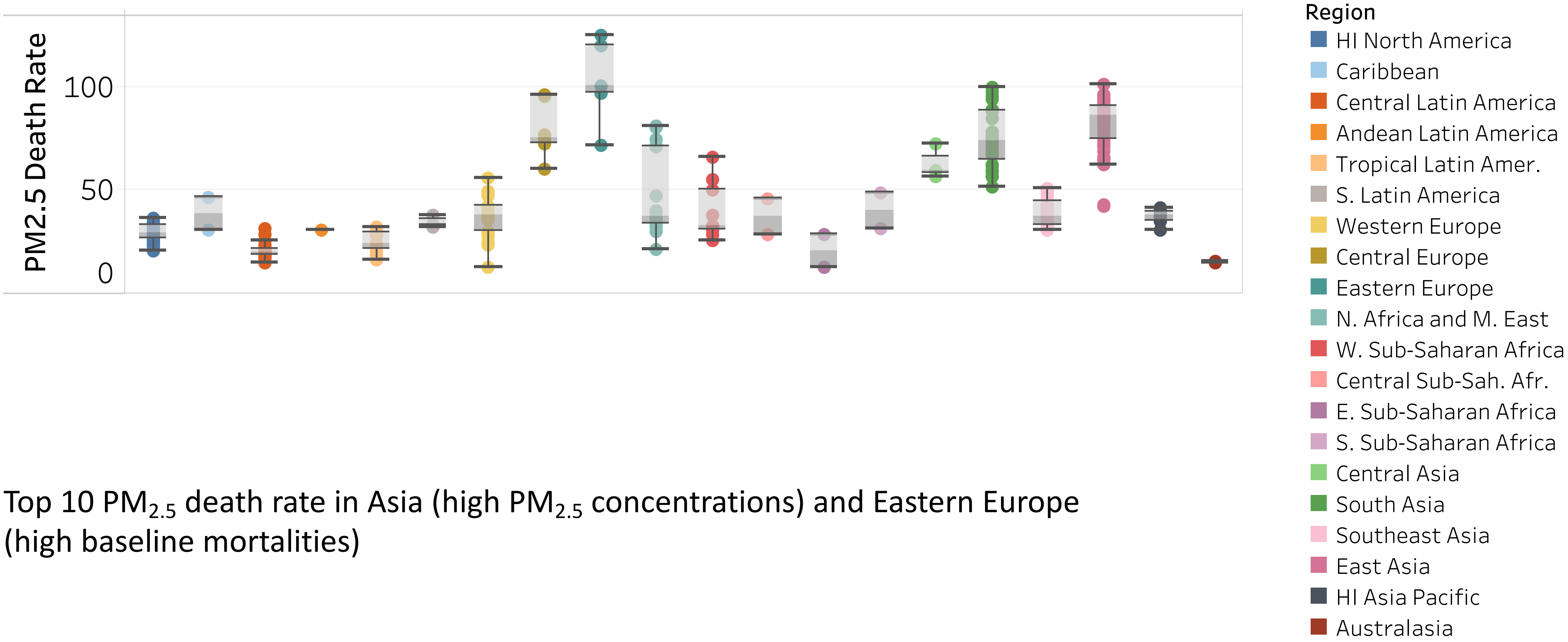
- Regional mortality rates, IER concentration-response relationships
- 4.1 (2.3 – 6.1) million premature deaths globally
- stroke (20%), IHD (39%), COPD (19%), lung cancer (7%), and lower respiratory infections (16%)
- cities defined as broader metropolitan regions (GHS-SMOD)

City ff CO_2 emissions from ODIAC for 2016

$PM_{2.5}$ associated premature deaths in cities worldwide (Anenberg et al., submitted)



$PM_{2.5}$ associated premature deaths in cities worldwide (Anenberg et al., submitted)

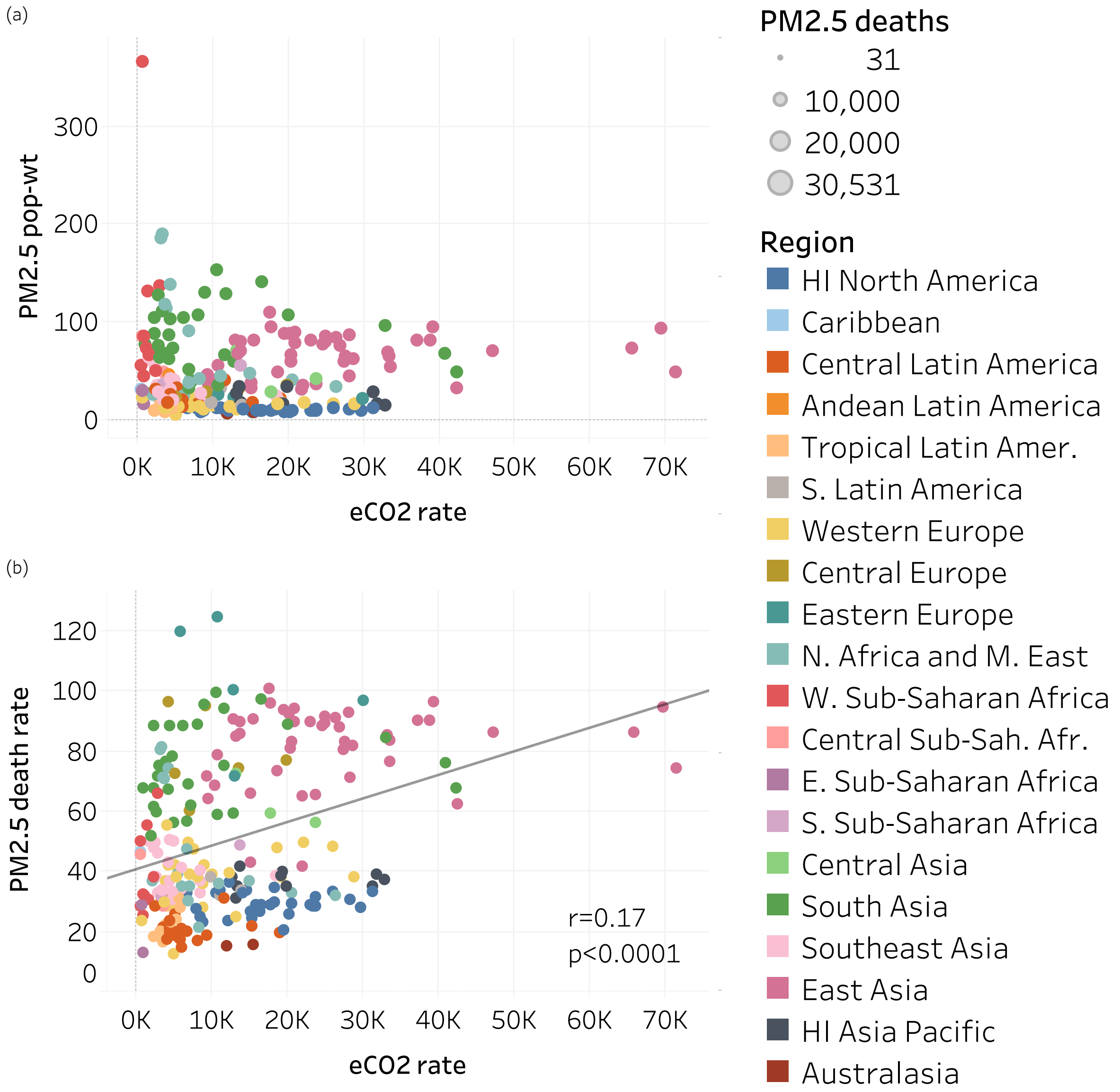


Top 10 $PM_{2.5}$ death rate in Asia (high $PM_{2.5}$ concentrations) and Eastern Europe (high baseline mortalities)

$PM_{2.5}$ associated premature deaths in cities worldwide (Anenberg et al., submitted)

What is the connection between $PM_{2.5}$ and CO_2?

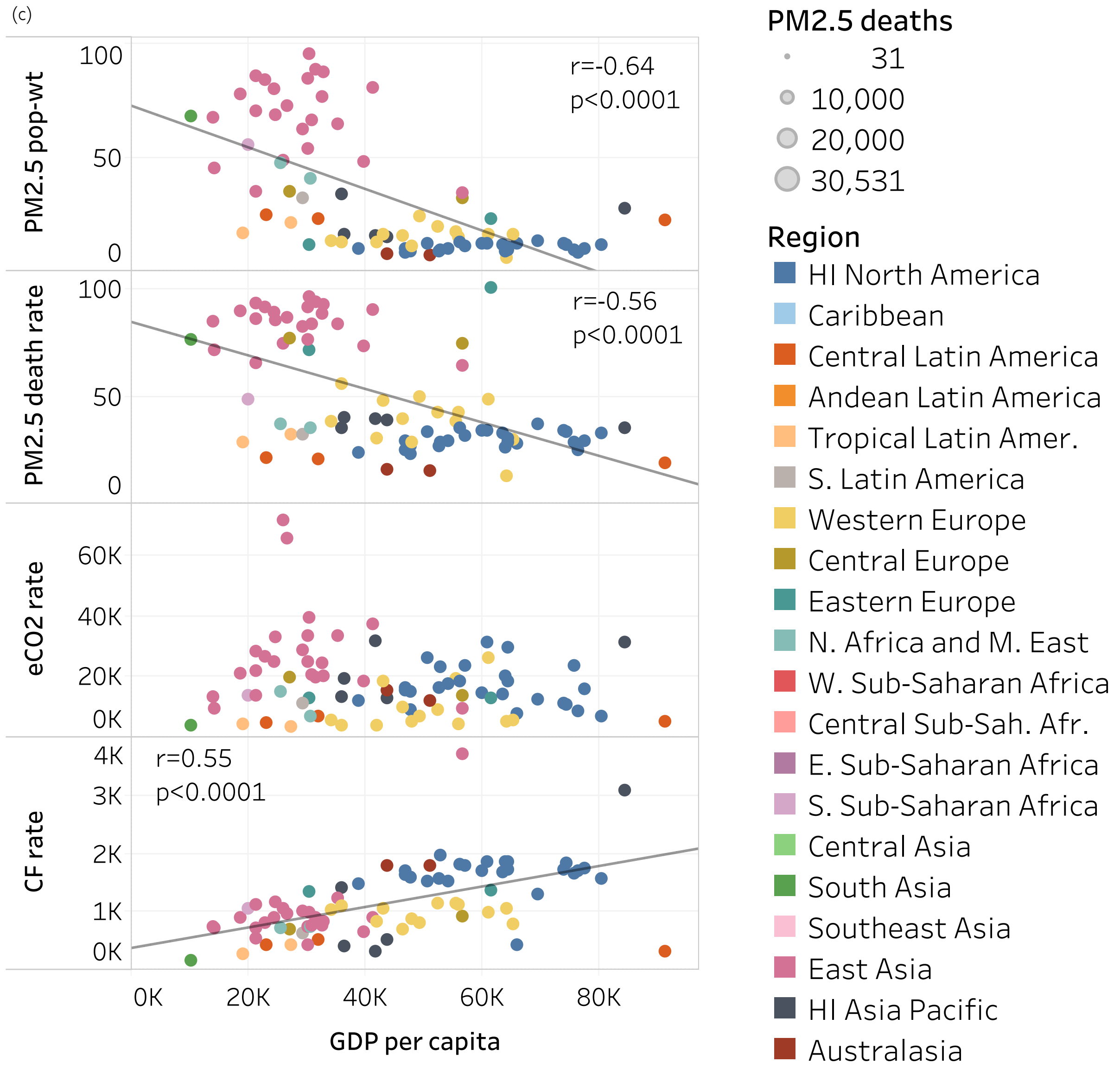
- no correlation of $PM_{2.5}$ with eCO_2 rate
- Slight correlation of $PM_{2.5}$ death rate with eCO_2 rate



$PM_{2.5}$ associated premature deaths in cities worldwide (Anenberg et al., submitted)

Consider trends compared to GDP per capita

- Richer countries are reducing air pollution
- Little relationship between GDP and eCO_2 per capita
- Richer countries still have largest carbon footprint (CF)
- "Reducing" $PM_{2.5}$ without reducing CF can mean shifting rather than reducing net AQ burden
- Within regions the trends are not as clear



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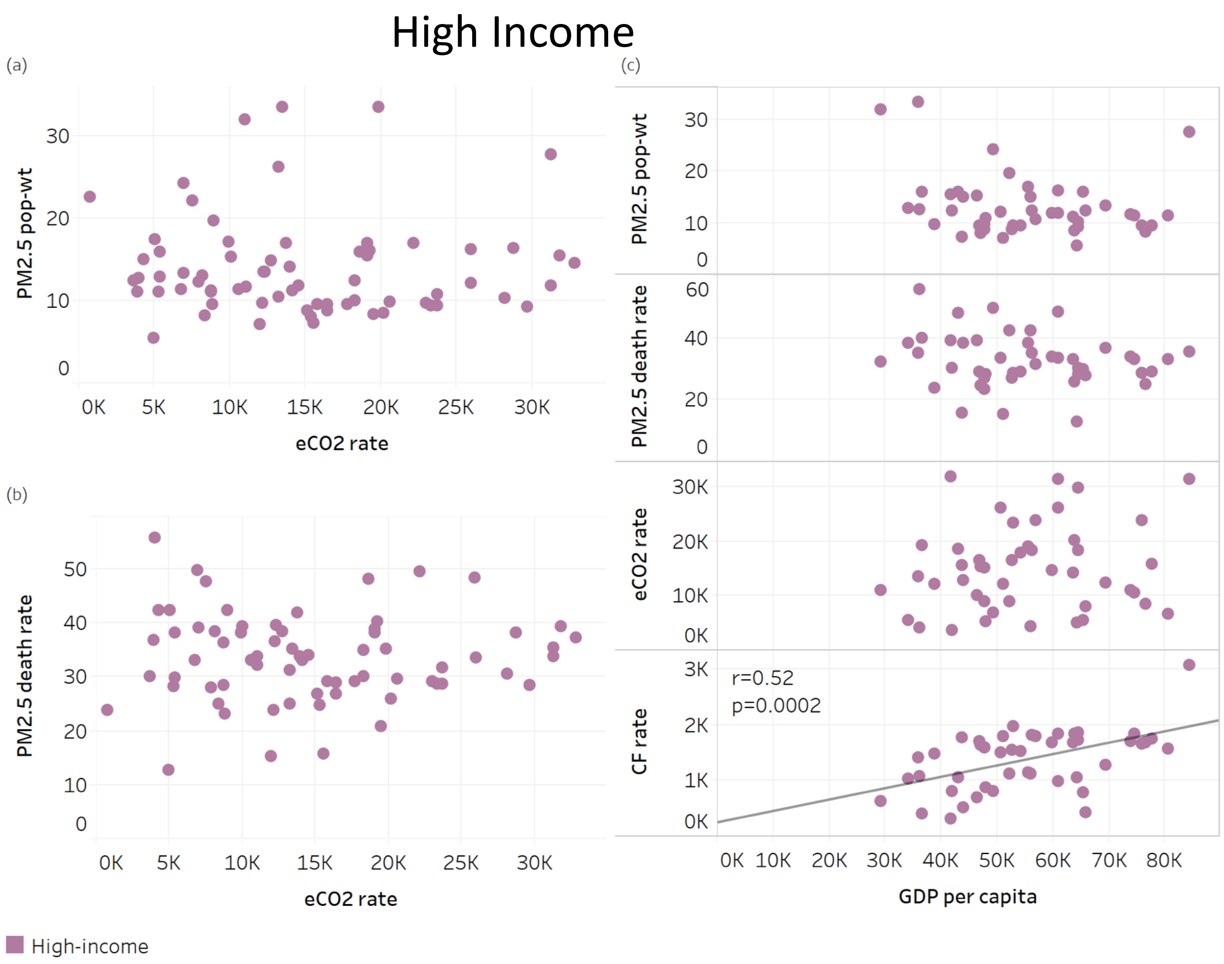
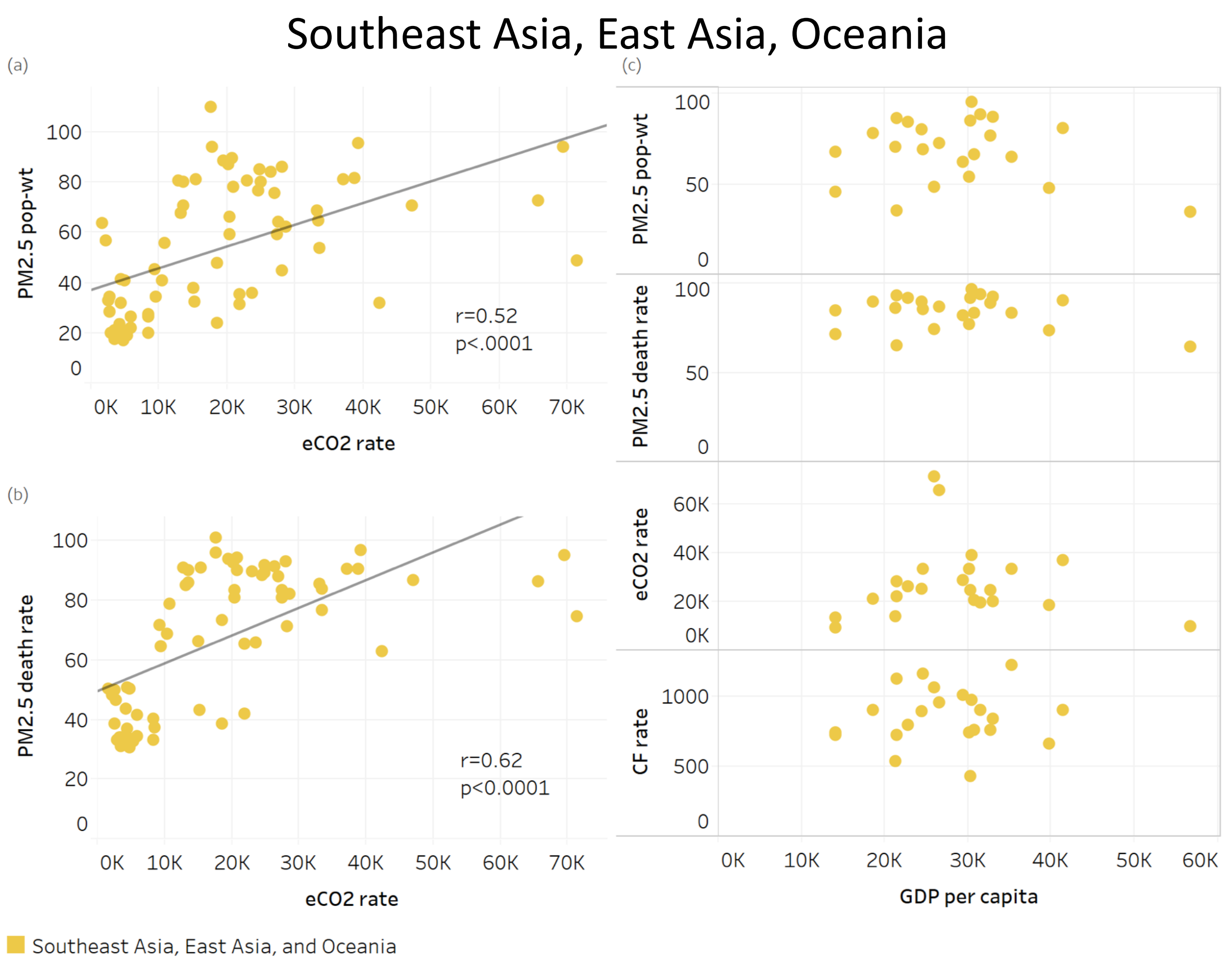


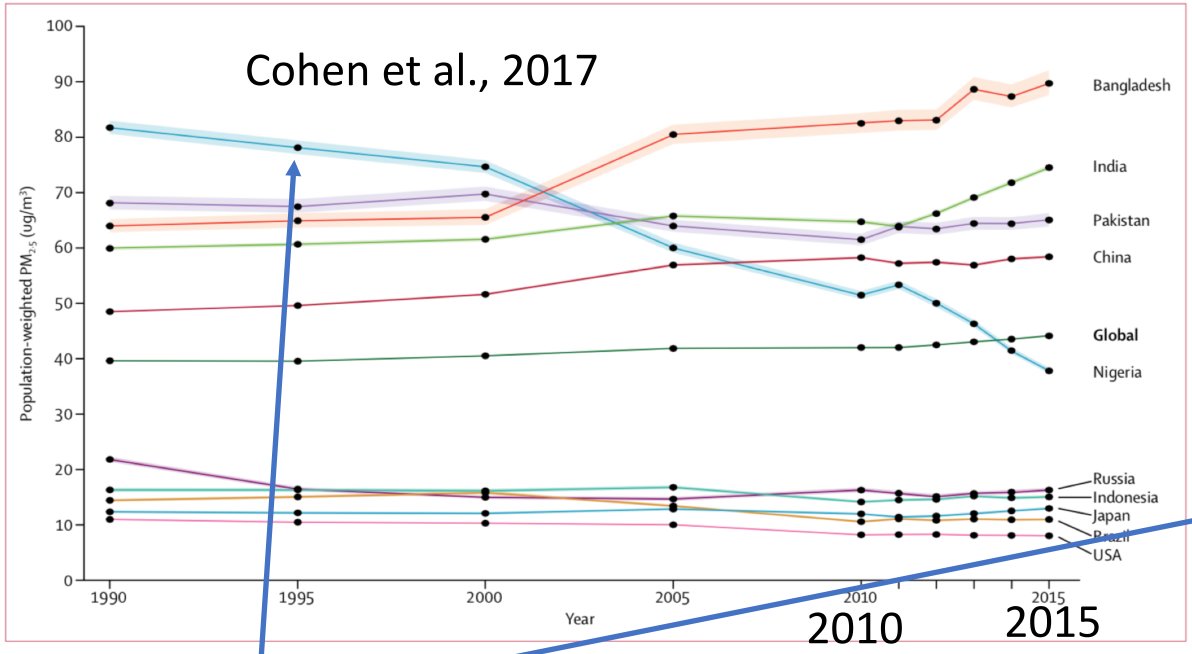


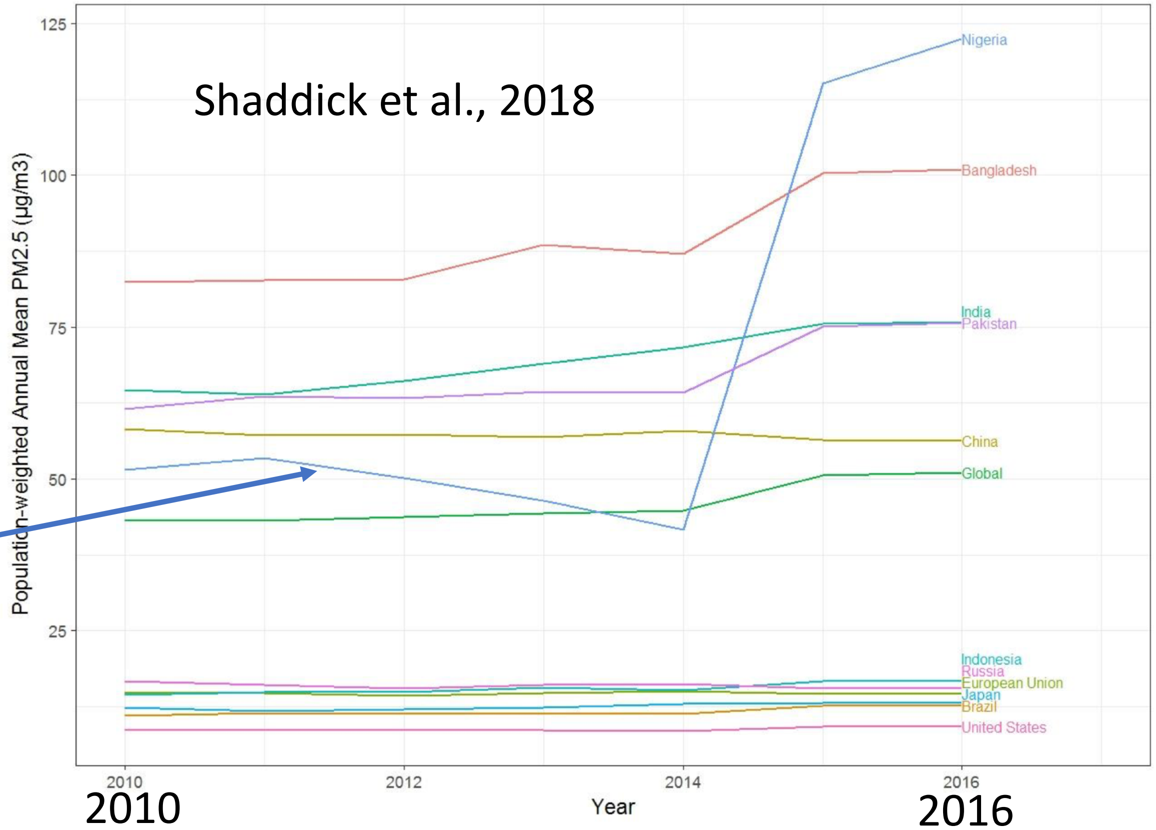
Routinely Taking Stock of Air Pollution:
Global Burden of Disease (GBD) and the NCD countdown

Non communicable disease (NCD) countdown:

- Sustainable Development Goal 3.4, is 33% reduction, in the probability of dying between 30 years and 70 years of age from cancers, cardiovascular diseases, chronic respiratory diseases, and diabetes by 2030 relative to 2010 (Bennett et al., 2018).

GBD assessment now being conducted annually:





Nigeria

Summary

- Air quality touted as an incentive for reducing CO_2 emissions (e.g., Vandyck et al., 2018: AQ co-benefits may counterbalance costs to meet Paris Agreement).

- AQ control policies that employ end-of-pipe technologies haven't helped reduce eCO_2 rate

- Low-carbon development presents an opportunity for co-benefits that has yet to be widely realized

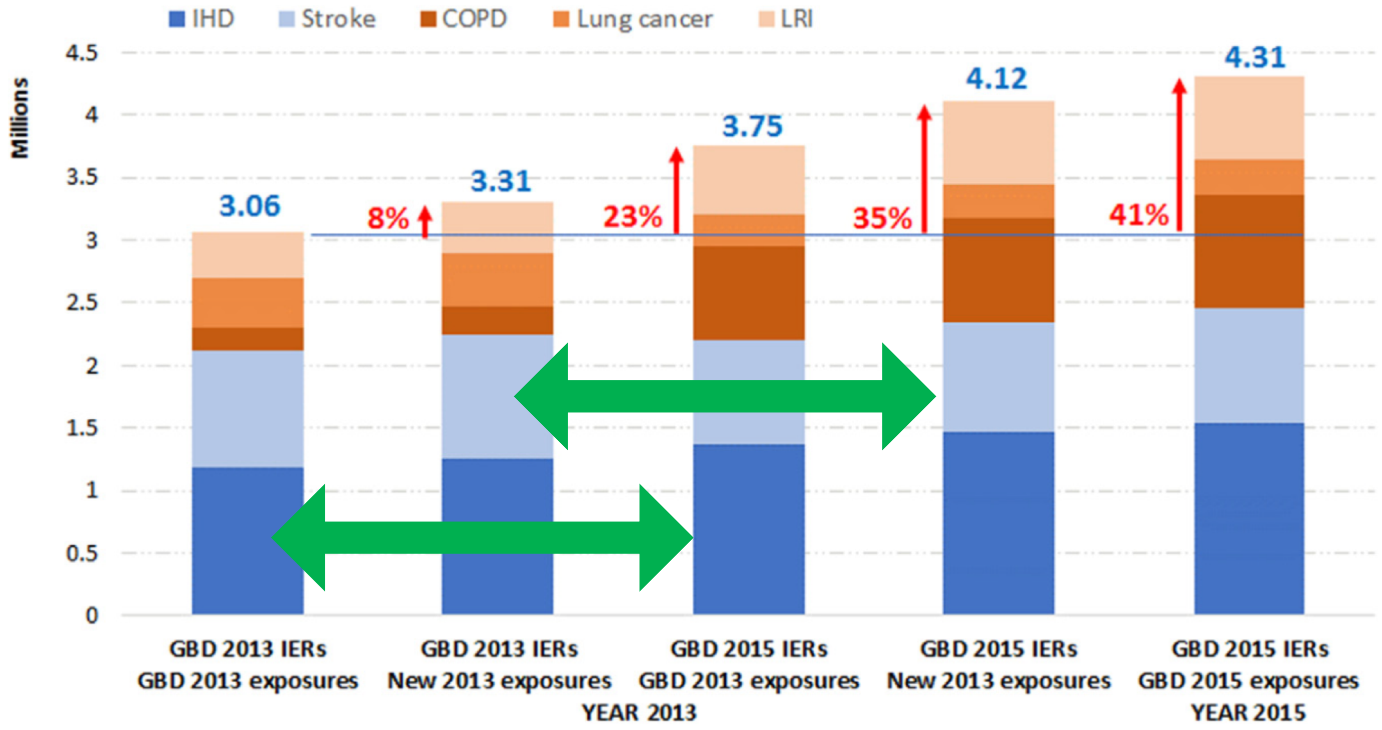
- These estimates have many sources of uncertainty that benefit from an observing constellation:
  - city-to-national scale CO_2 emissions
  - city-to-national scale surface $PM_{2.5}$ estimates (and associated sources)

- The paucity of data in a large number of cities / countries means that nearly anything we can provide now will at least be helpful

Thanks!

GBD

Comparison of GBD ambient AQ health impacts across the years (Ostro et al., 2018)



Large differences associated with updates to IERs

$PM_{2.5}$ associated premature deaths in cities worldwide (Anenberg et al., submitted)

- Air quality touted as an incentive for reducing CO2 emissions
- AQ control policies that employ end-of-pipe technologies don't help reduce eCO2
- Low-carbon development presents an opportunity for co-benefits that has yet to be widely realized

- This disconnect presents a challenge to multi-species systems for improving CO2 flux estimations through e.g. trace-gas assimilation
  - Trends in AQ constituents alone may not be associated with changes to ff CO2 (especially if consider these emissions just being exported to another part of the world)
  - A constellation is required to understand these tradeoffs

- Connections and opportunities
  - The AQ equivalent of the stocktank assessment is the annual GBD assessment of air quality health burden

$PM_{2.5}$ associated premature deaths in cities worldwide (Anenberg et al., submitted)