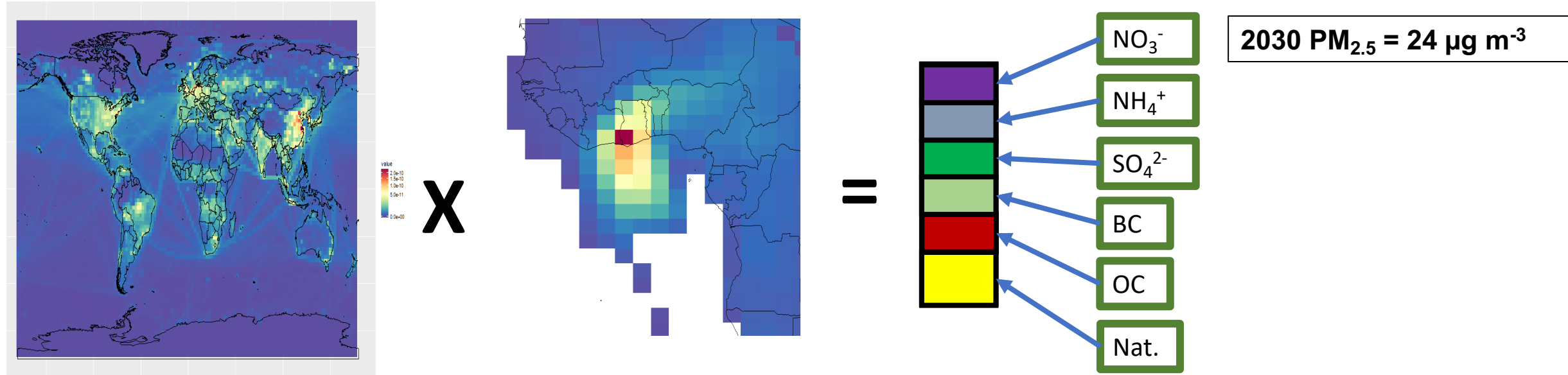


Use of satellite-informed $\text{PM}_{2.5}$ concentrations in an international integrated assessment tool (LEAP-IBC)

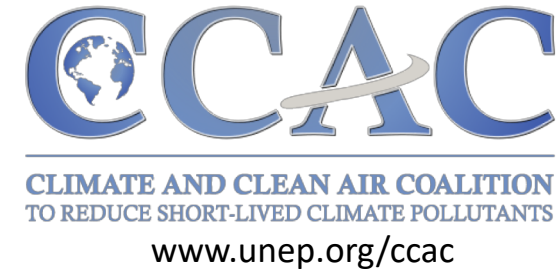


Daven. K. Henze¹, Christopher S. Malley², Johan C.I. Kuylenstierna², Harry W. Vallack², Kevin Hicks², Yanko Davila¹, Susan C. Anenberg³, Rob Pinder⁴, Sara Terry⁴, Amanda CurryBrown⁴, Neal Fann⁴, Elsa Lefevre⁵, Charlie Heaps⁶, Stefani Penn⁷, Henry Roman⁷, James Neumann⁷, Eloise Marais⁸, Forrest Lacey⁹, Patrick Kinney¹⁰

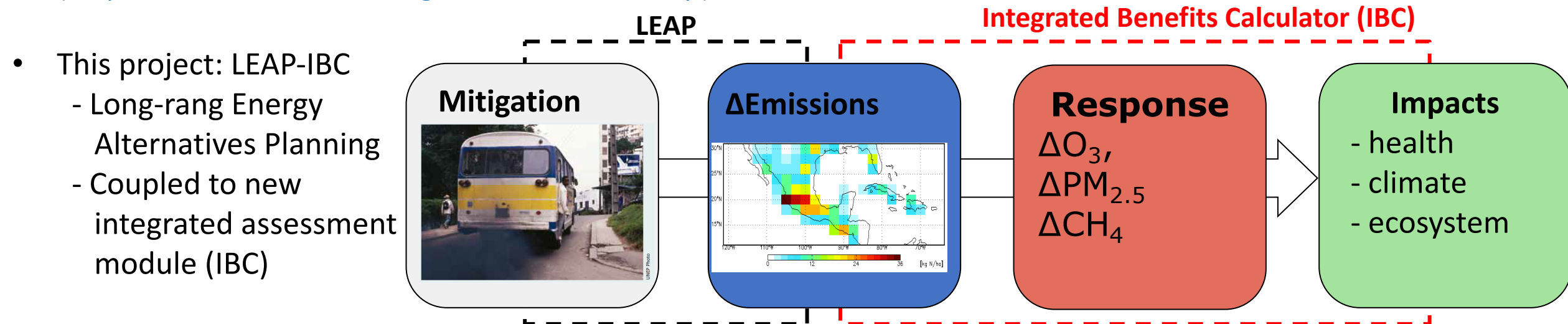
Funding from NASA, CCAC, and US EPA. Views presented here do not necessarily reflect those of the EPA.

(1) University of Colorado, Boulder, CO, USA (2) Stockholm Environment Institute, Environment Department, University of York, York, United Kingdom (3) Environmental and Occupational Health, George Washington University, Washington D.C., USA (4) US EPA, Research Triangle Park, NC, USA (5) Climate & Clean Air Coalition (CCAC) Secretariat, Paris, France (6) Stockholm Environment Institute, Boston, MA, USA (7) Industrial Economics, Cambridge, MA, USA (8) University of Birmingham, Birmingham, UK (9) NCAR, Boulder, USA (10) Boston University, Boston, USA

Climate and Clean Air Coalition (CCAC)



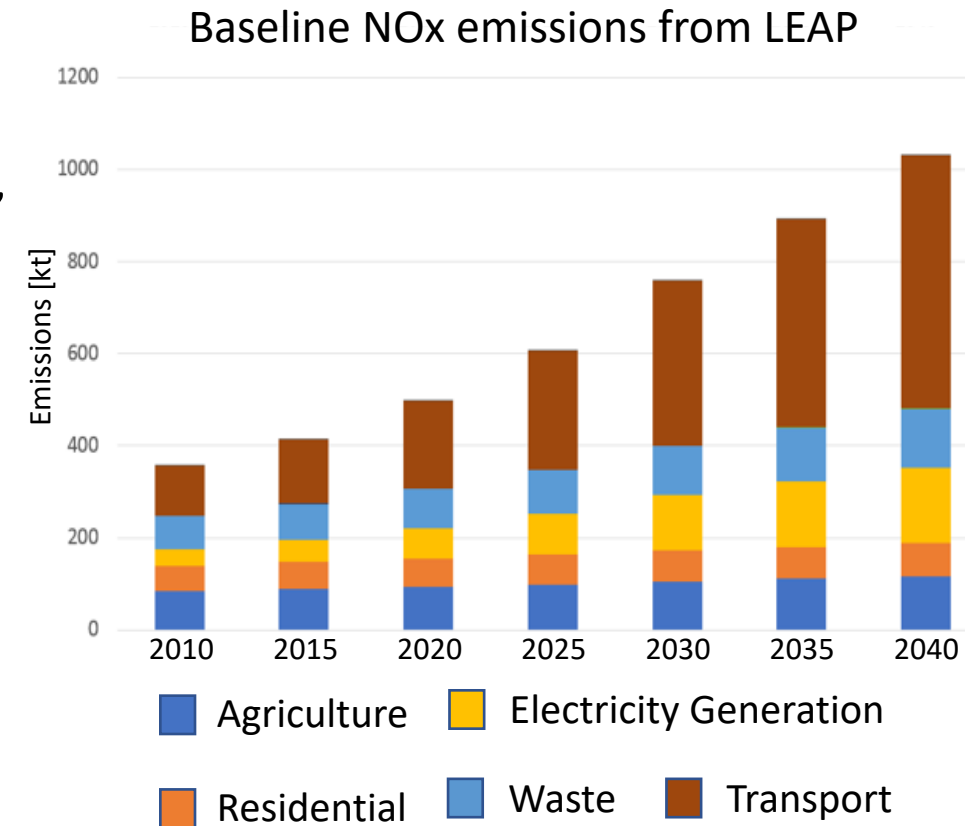
- Initiated in 2012 as part of UN Environmental Programme (UNEP), funding sources include US Department of State: now 61 countries, 71 NGOs, 93 actors
- Leads multiple initiatives on reducing SLCP emissions (BC, OC, SO₂, NO_x, CH₄, CO, NH₃, NMVOC) from particular sectors, assessments, and capacity building
- Short Lived Climate Pollutant (SLCP) National Action Plan (SNAP) Toolkits – provide countries a means of evaluating the impacts of SLCP emission reduction strategies (<http://new.ccacoalition.org/en/initiatives/snap>)



LEAP-IBC (Kuylenstierna et al., in prep; Nakarmi et al., submitted) used by 25 CCAC member nations (Peru, Colombia, Mexico, Chile, Ghana, Bangladesh, Togo, Nigeria,...)

Using the LEAP-IBC tool to assess air quality and climate co-benefits of emission reduction strategies for Bangladesh

- Bangladesh: CCAC founding member member, high air pollution health burden, sensitive to climate change (e.g., Goyal and Canning, 2017; Khan et al., 2019; Karim et al., 2008).
- Nationally Determined Contribution (NDC)
 - Bangladesh's commitment to UNFCCC for reducing GHG
 - Targets: renewable energy, improved brick kilns, efficiency, road transport fuel efficiency, ...
- National Short-Lived Climate Pollutant (SLCP) Action Plan
 - Targets: SLCP rich actions (rice parboiling, crop residues,...)
 - Those with GHG reductions treated as part of NDC
 - Additional targets comprise "SLCP Action"
- Mitigation efforts implemented in LEAP to generate emissions for several scenarios: baseline, NDC (3), and SLCP action

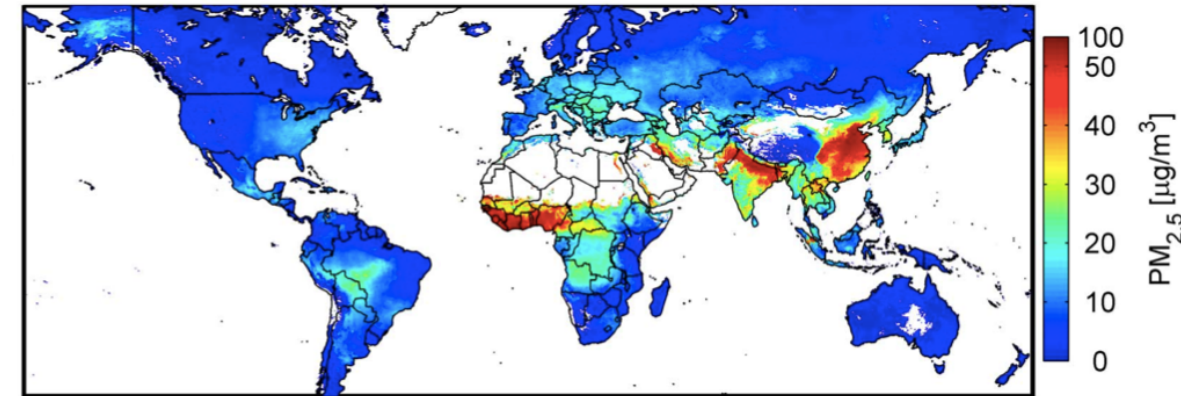


(Kuylenstierna et al., in prep)

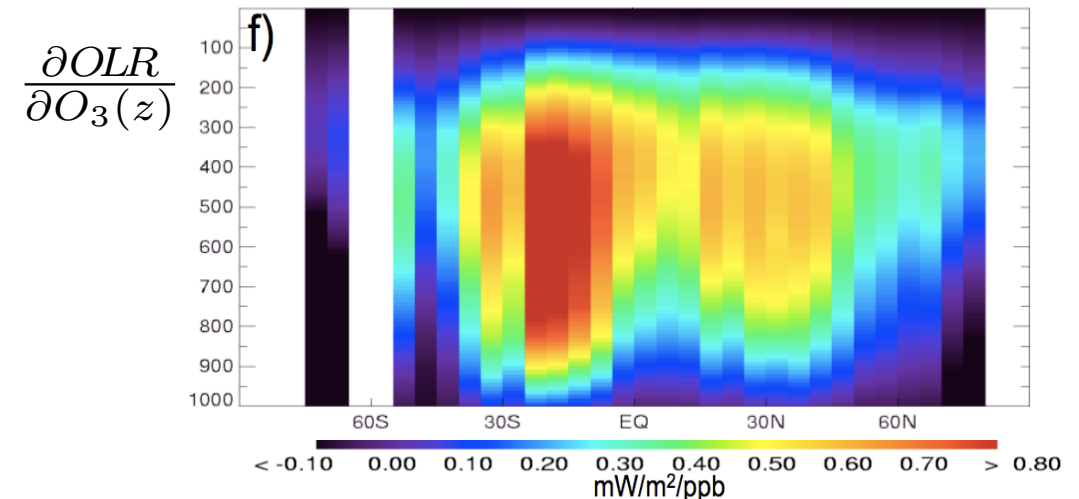
Remote sensing and earth system models in the Integrated Benefits Calculator

- PM_{2.5} health impacts
 - Coarse models underestimate exposure by 10-30% (Punger and West, 2013; Li et al., 2015).
 - Downscale and bias correct with **AOD-derived PM_{2.5}**
 - provides a globally consistent PM_{2.5} estimate
- Climate impacts
 - Regional radiative forcing of SLCPs:
 - **O₃: TES IRK**
 - CH₄, aerosols: modeled
 - Radiative forcing → ΔT from NASA GISS climate model
 - Transient ΔT calculated for both short-lived species (aerosol, O₃, CH₄) and CO₂
- Source apportionment: GEOS-Chem adjoint model
 - impact-per-emission from each species, sector, location
 - approach best suited for evaluating multiple spatially heterogeneous emissions scenarios, when the spatial distribution of the impacts is not of interest.

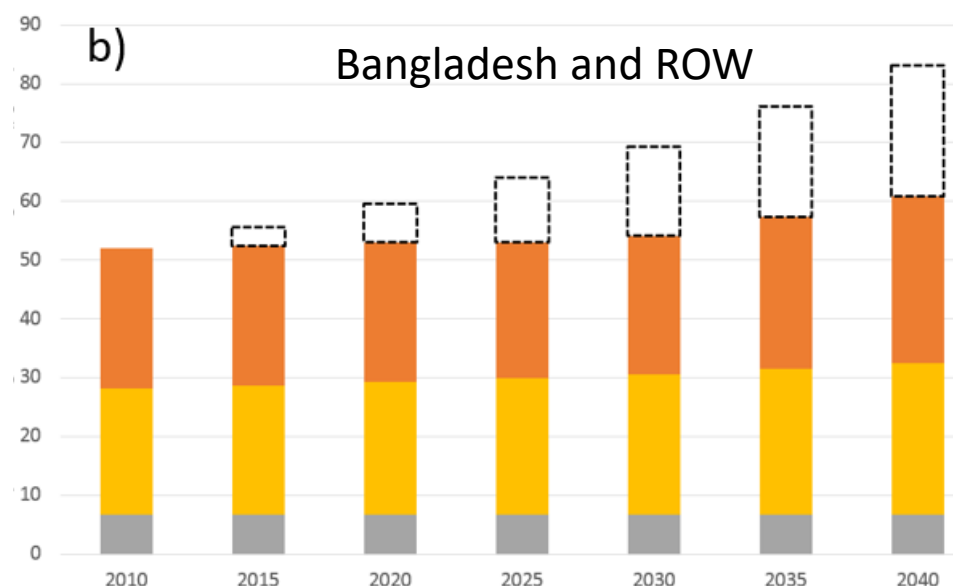
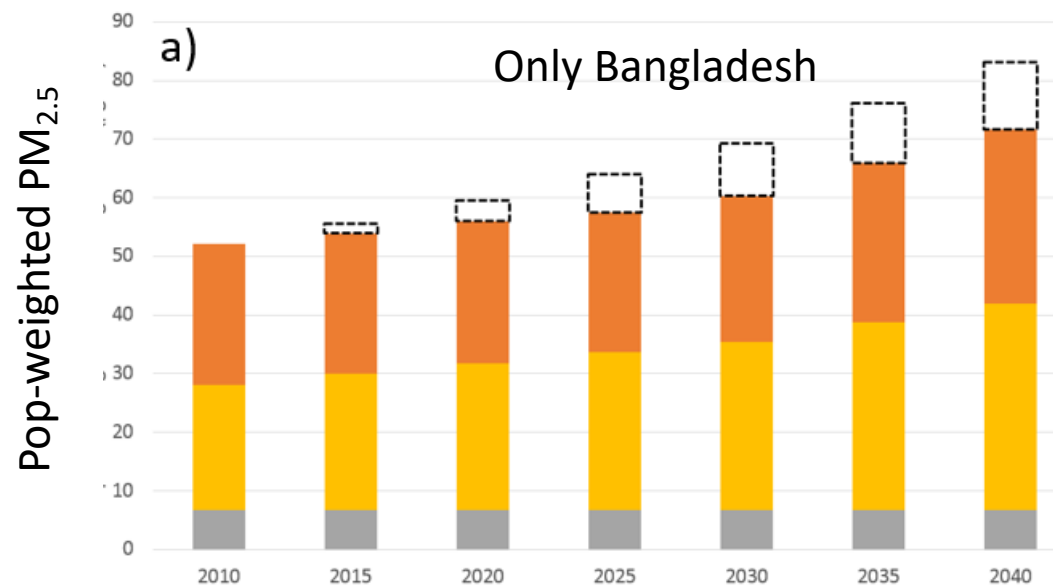
0.1° x 0.1° PM_{2.5} from van Donkelaar et al. (2016)



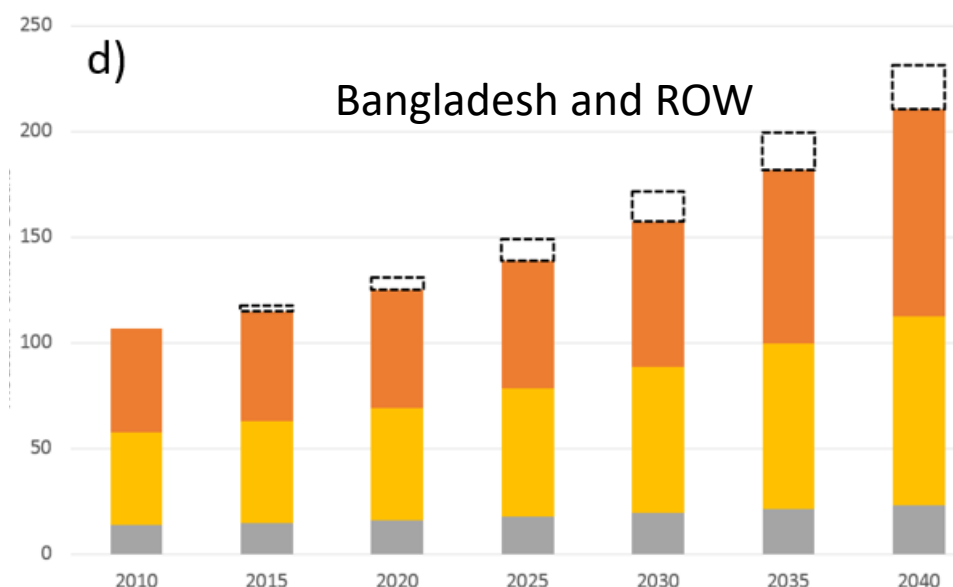
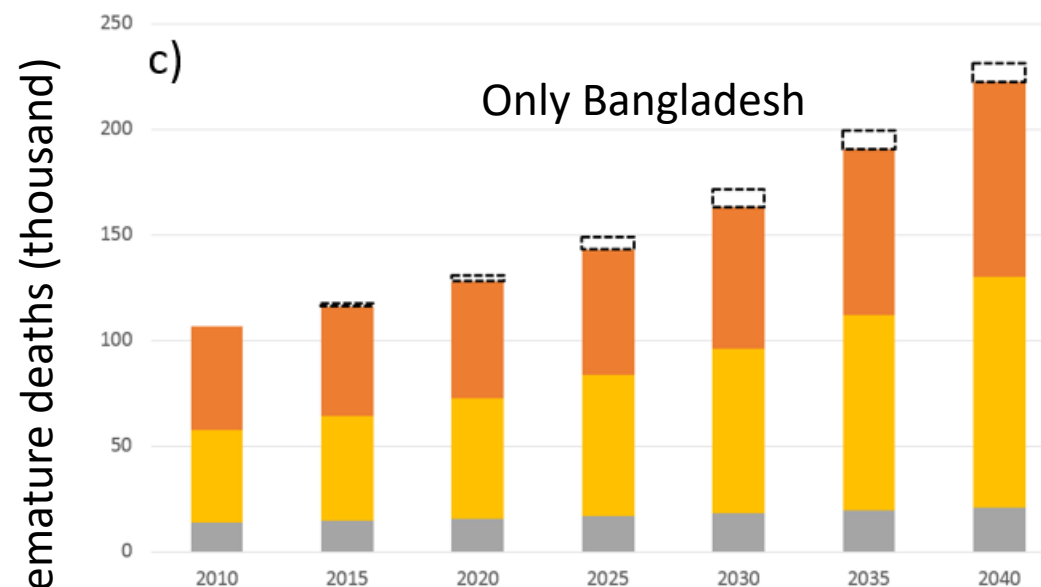
TES Instantaneous Radiative Kernels (Worden et al., 2008)



LEAP-IBC application for Bangladesh: Most comprehensive scenario



- 10 ug/m3 alone
- 20 ug/m3 in concert with global initiatives



- ~10,000 avoided deaths, 60% of which from SLCP mitigation

- ~20,000 in concert with global initiatives

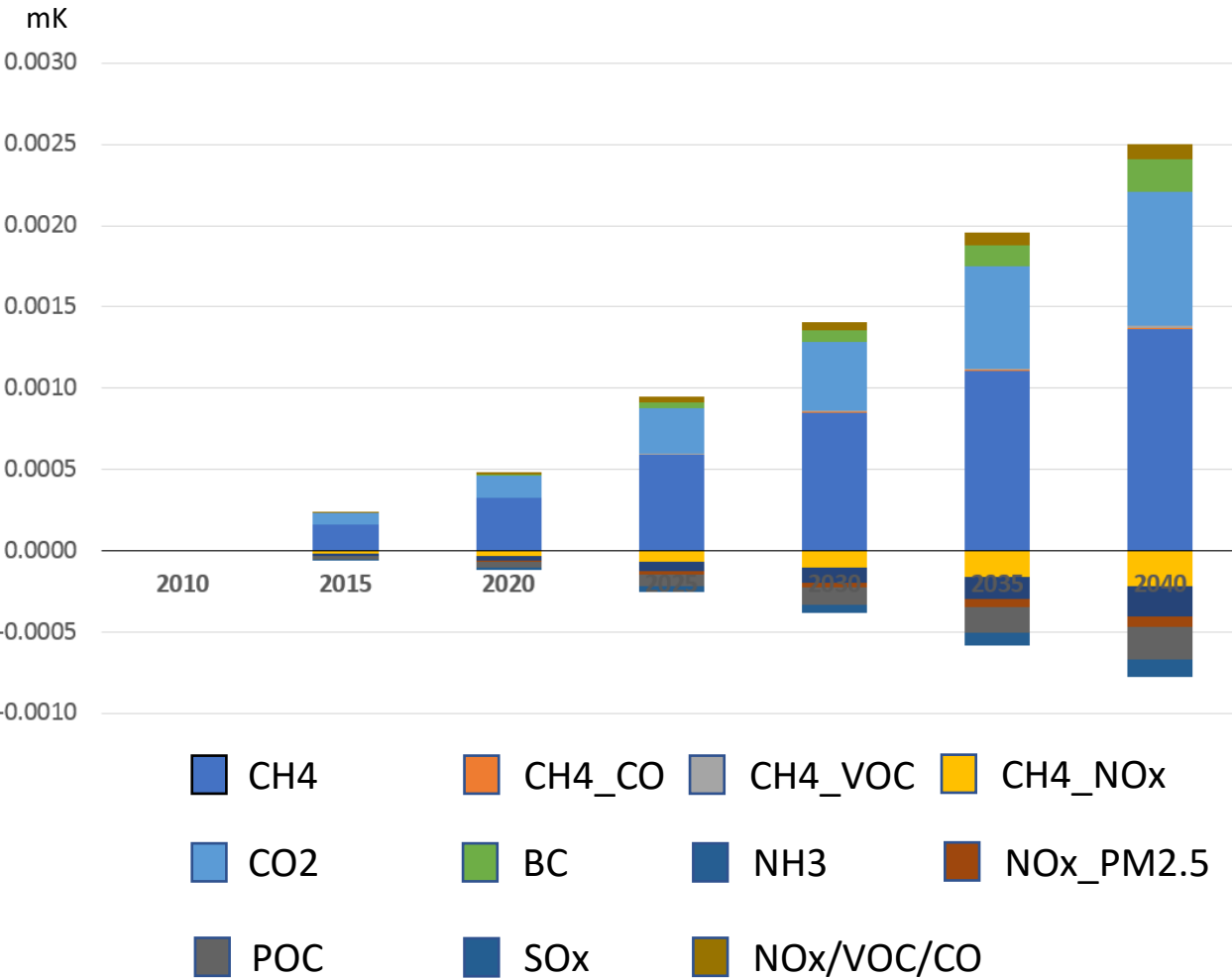
- Total burden rises from pop growth

■ From Natural Background ■ From Rest of World Emissions ■ From National Emissions □ Avoided vs. Baseline

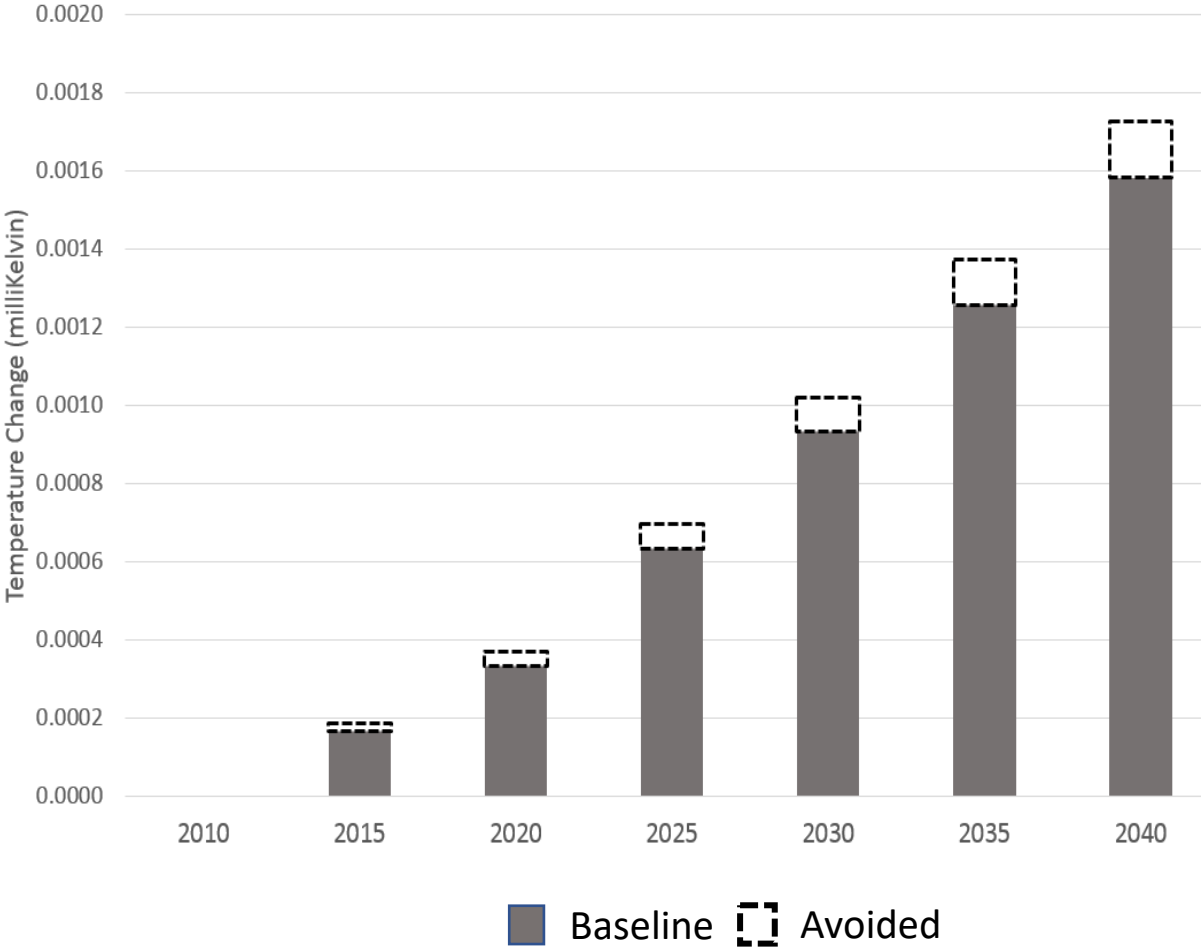
LEAP-IBC application for Bangladesh: Most comprehensive scenario

Impacts on global mean surface temperature of emissions in Bangladesh:

Baseline by species



Baseline vs NDC+SLCP



(Kuylenstierna et al., in prep)



Year 3 Progress Update, PI Henze, Co-I's Anenberg, Kinney

Supporting health impact assessment tools using remote sensing and earth system models

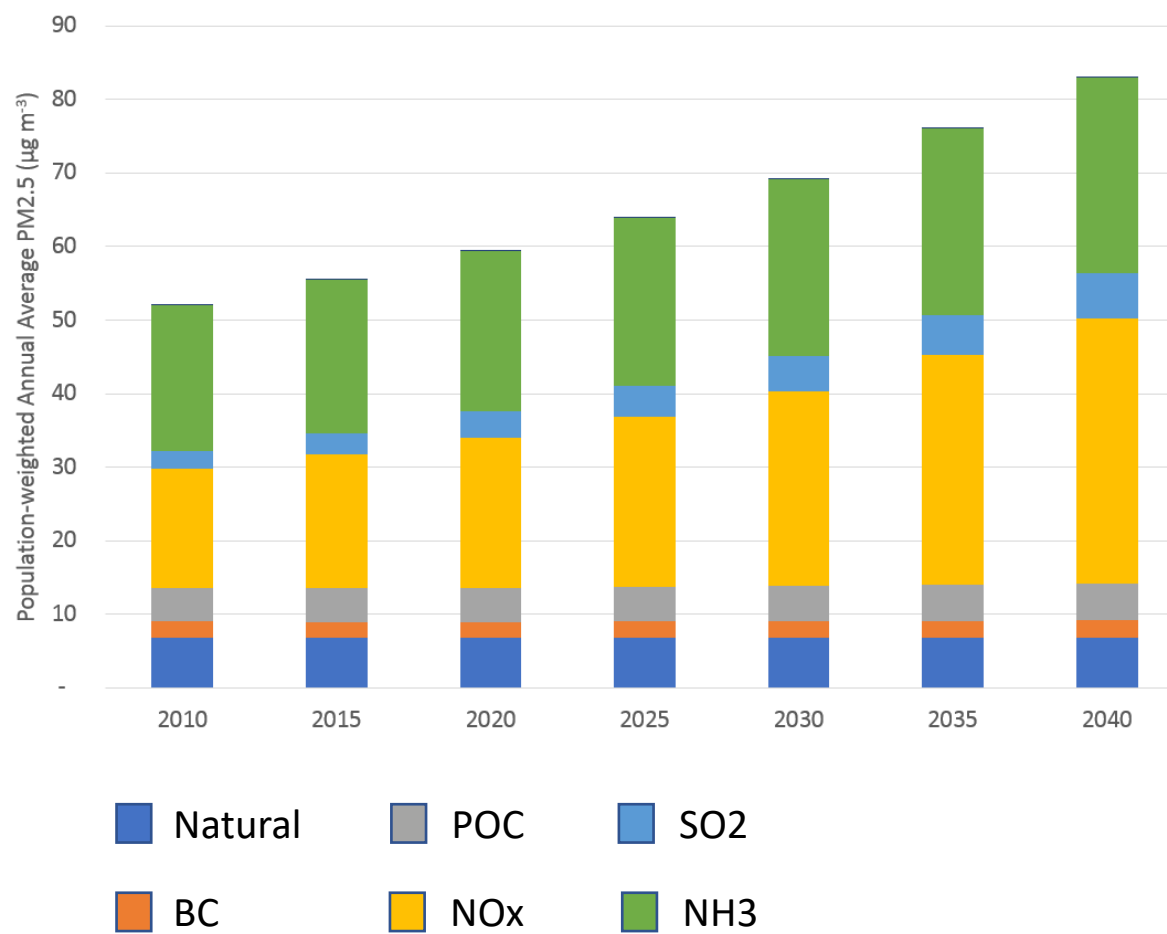
- Source-receptor (SR) coefficients for $PM_{2.5}$ and O_3 to CCAC impact toolkit (LEAP-IBC)
 - $PM_{2.5}$ SR coefficients for all countries in Asia, Africa, Caribbean, Central & South America.
 - O_3 coefficients for each CCAC member nation
 - LEAP-IBC used in 25 countries, with manuscripts on application in Nepal (Nakarmi et al., submitted) and Bangladesh (Kuylenstierna et al., in prep)
 - Impacts of cookstoves (Lacey et al., 2017) and fugitive diesel NO_x (Anenberg et al., 2017)
- High-resolution SR calculations for urban regions
 - In progress for Africa, West Africa
- Expand health impacts
 - Global burden of ambient air pollution on asthma (Anenberg et al., 2018)

Tiger Team Participation

- Hi-Res $PM_{2.5}$ (Kinney, Freedman)
 - Health impacts of different $PM_{2.5}$ estimates (**Anenberg**)
 - Low-cost monitors deployed in NYC, Boston, SF (**Kinney**)
- NO_x constraints (Pierce, Tong)
 - US July 2011 0.5×0.667 NO_x emissions, comparison to CMAQ DA (Pierce) & retrieval impact (SP vs DOMINO)
- SIPs (Fiore)
 - Contribute to / review technical guidance documents
 - NO_2 trends from OMI (Zhang et al., PNAS, 2018)
 - Review of background O_3 (Jaffe et al., 2018) and satellite $PM_{2.5}$ (Diao et al, submitted.)
- Trends (Duncan, West) / Background O_3 (Neu) / Regional Haze (Fiore)
 - SO_2 and NO_x emission from OMI (two submitted by Qu et al., working towards O_3 and $PM_{2.5}$ impacts)
 - O_3 source apportionment in Yuma, Az (Qu et al., in prep)
- Long-range pollution transport (AQAST TT)
 - Contributed to 6 papers in ACP special issue
- Fires (O'Neill): **Kinney** Co-I. Indicators: **Anenberg** **PI**

LEAP-IBC application for Bangladesh: Baseline results

Pop-weighted PM_{2.5} (primary carbonaceous and secondary inorganic) in Bangladesh from global emissions



>50% from ROW

Impacts on global mean surface temperature of emissions in Bangladesh

