Indian Air Quality in 2030: Avoided Premature Mortality from Emissions Reductions Scenarios

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Poor air quality leads to livelihood and economic losses

- [$PM_{2.5}$]>>100 μg/m^3
- 580,000 to 1,000,000+ lives lost annually in India due to ambient $PM_{2.5}$ air pollution[1,2,3]
- 12,000 to 58,000 estimated lives lost to O_3 air pollution[1,3]
- Nearly $505-640 billion (USD) annual cost to India's economy[1,4]

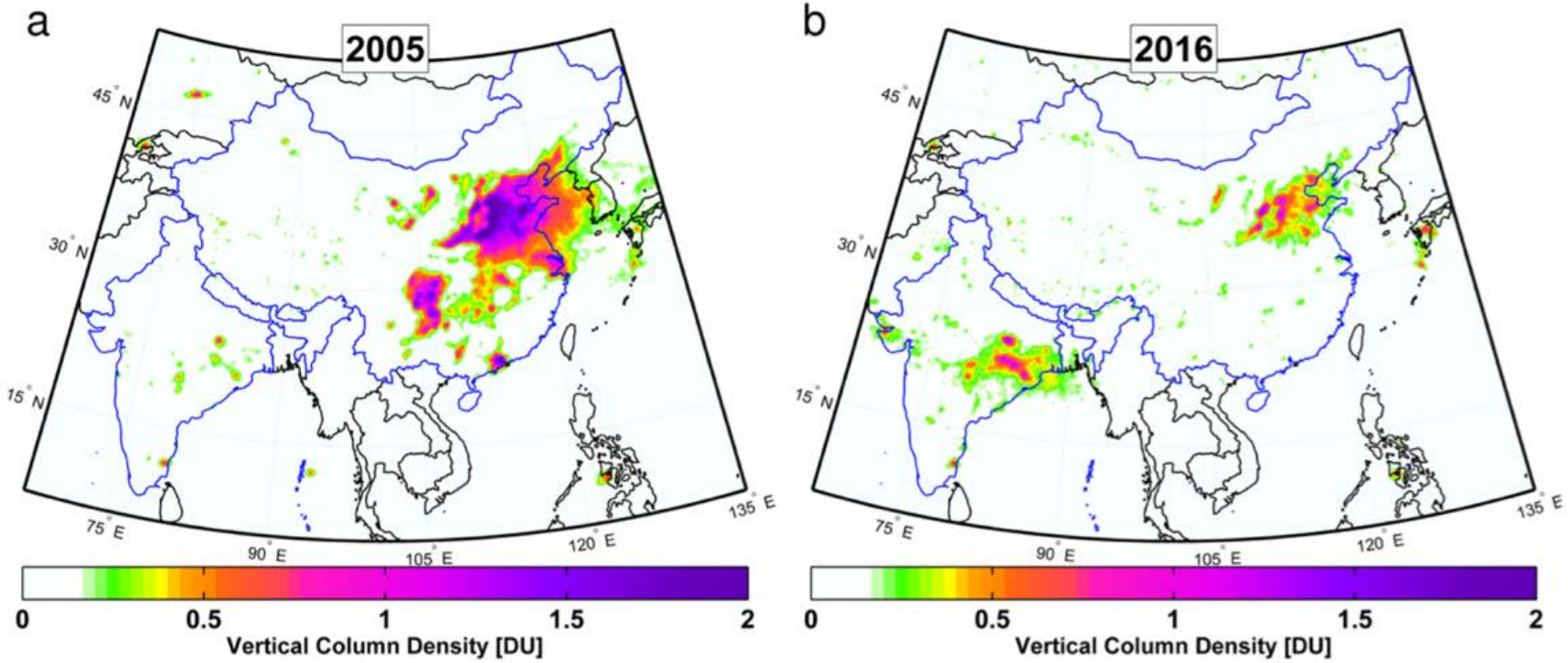

India Gate, Delhi


Presidential Palace, Delhi

Images from lonelyplanet.com

[1]Ghude et al., 2016
[2] Health Effects Institute, 2018
[3] Karambelas et al., 2018
[4] World Bank 2016

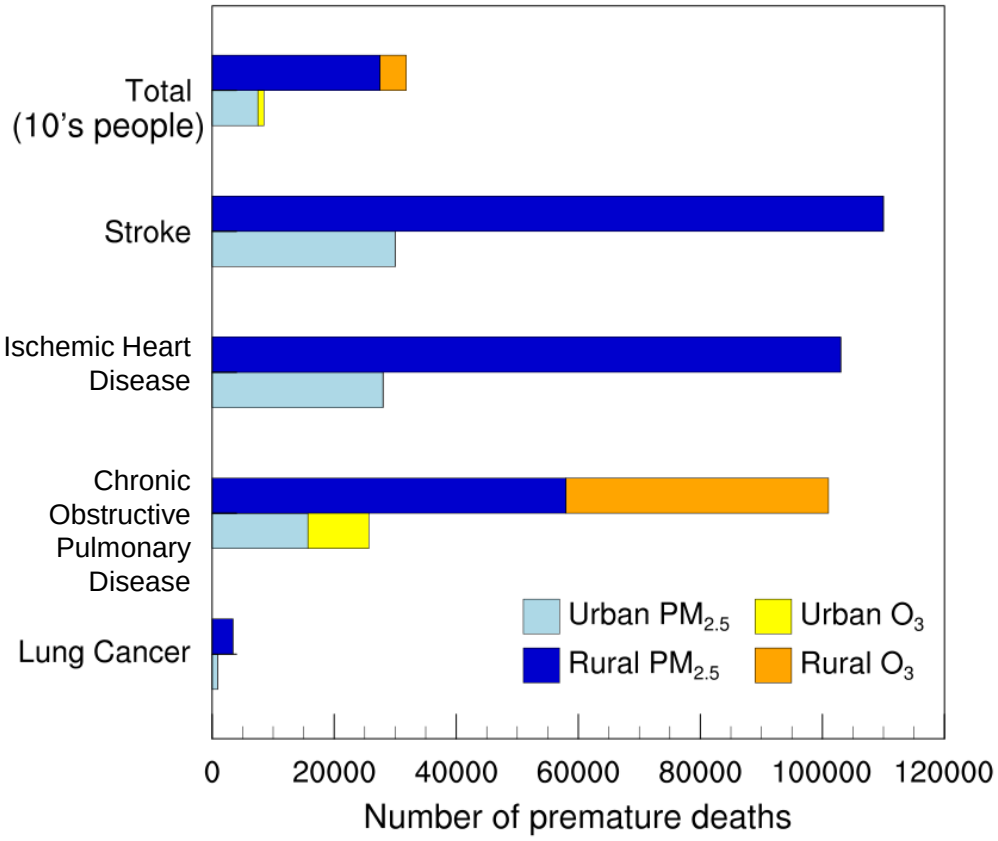
India's air quality has worsened while China's has improved



1 Dobson Unit (DU) = 2.69 x 10^{16} molecules cm^{-2}

Li et al., 2017 Scientific Reports

$PM_{2.5}$ and O_3 attributable mortality affects both urban and rural populations



Karambelas et al., (in press) ERL

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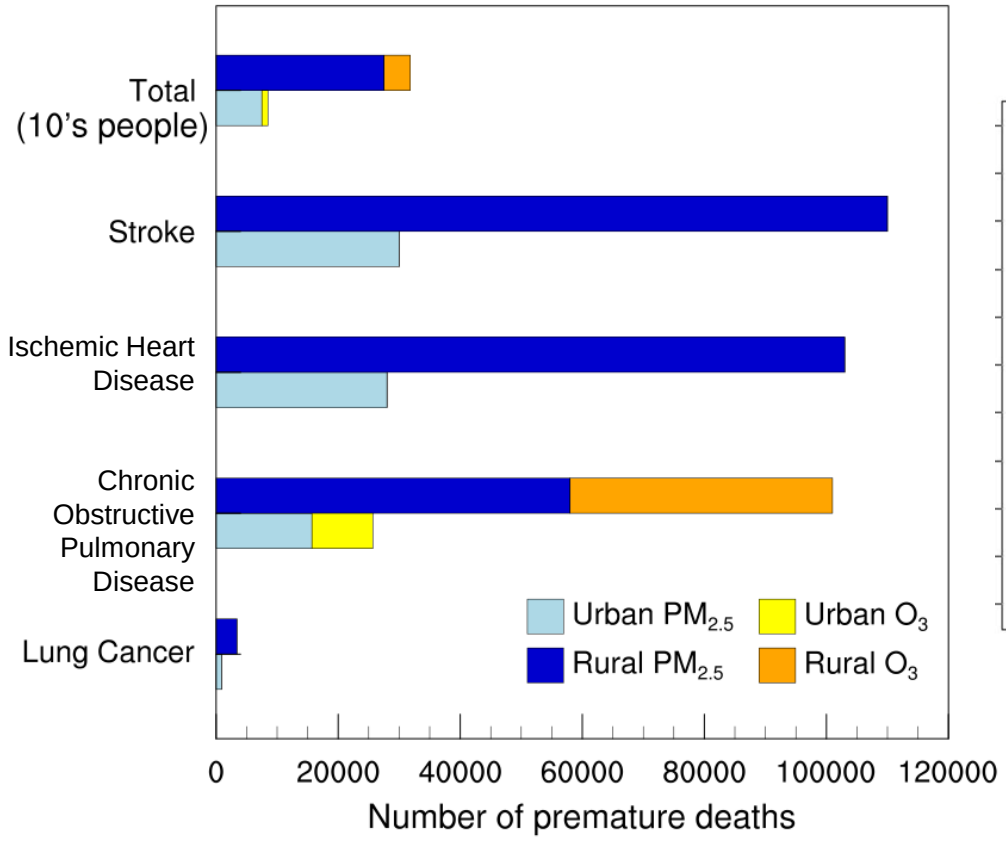

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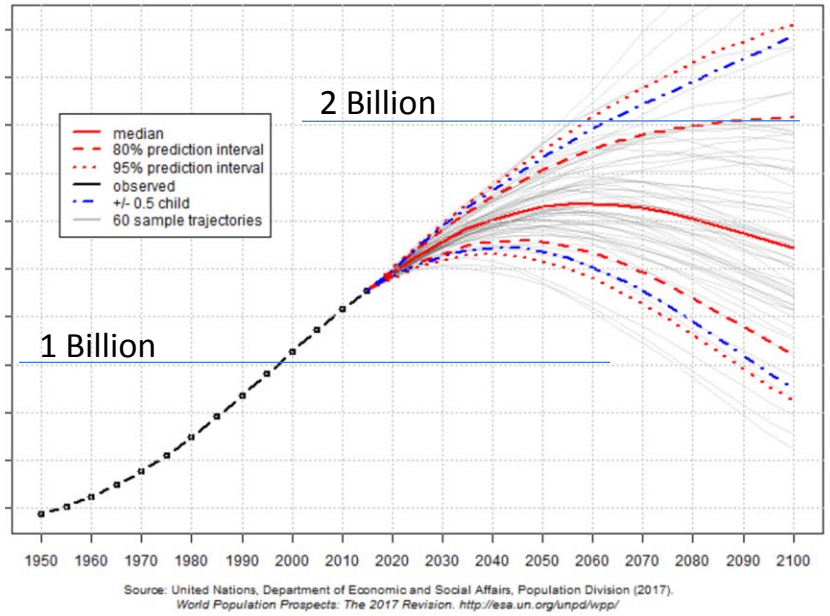
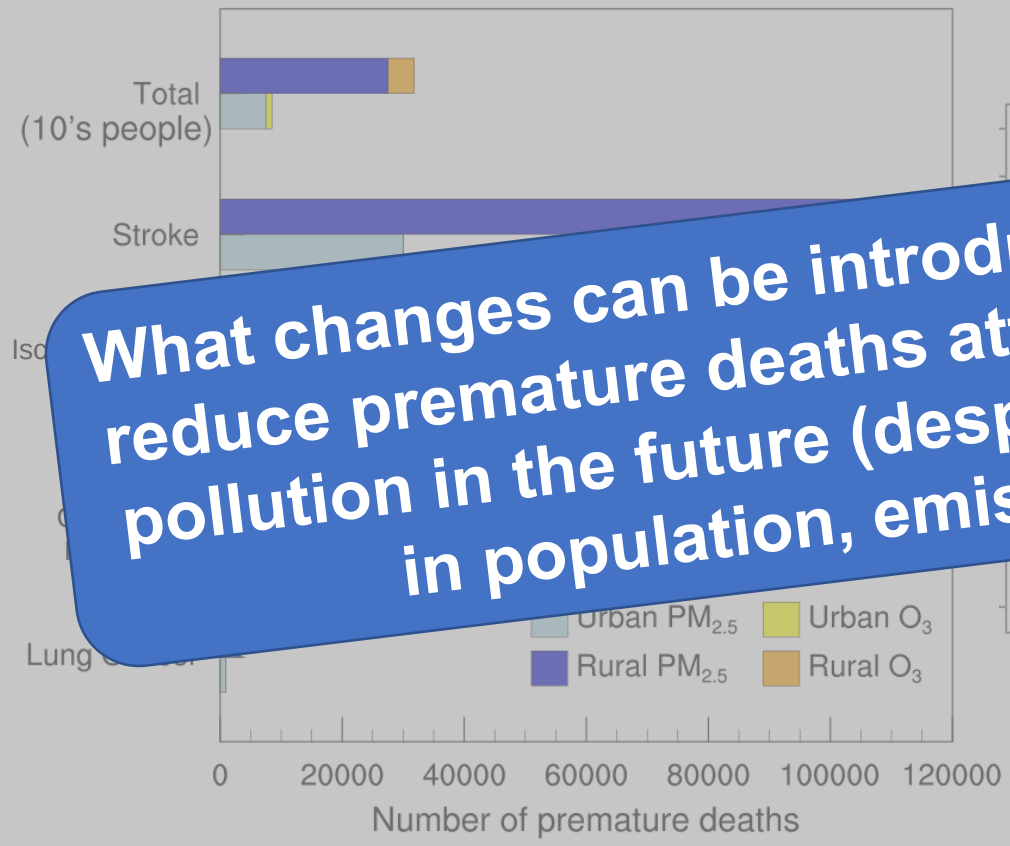
India, Total Population (billions)



UN Population Division

$PM_{2.5}$ and O_3 attributable mortality affects both urban and rural populations



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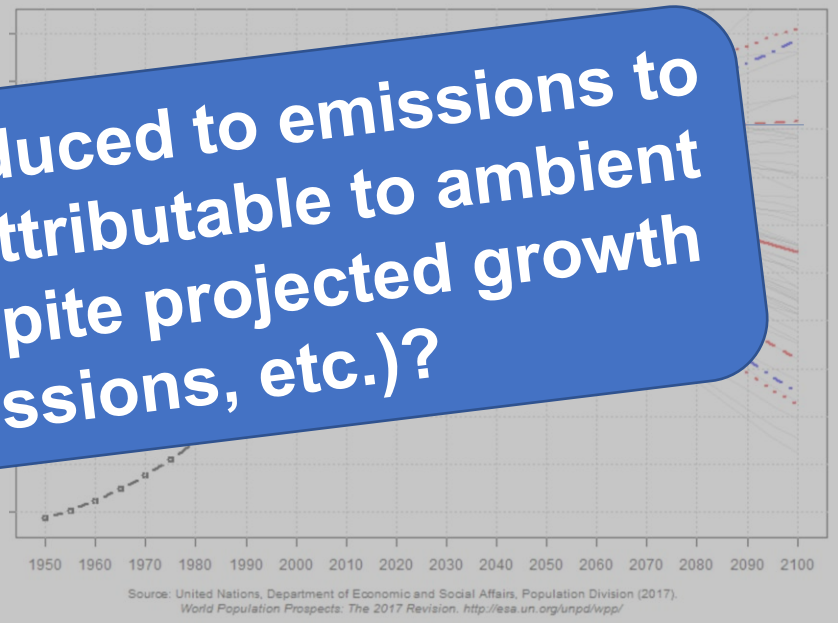
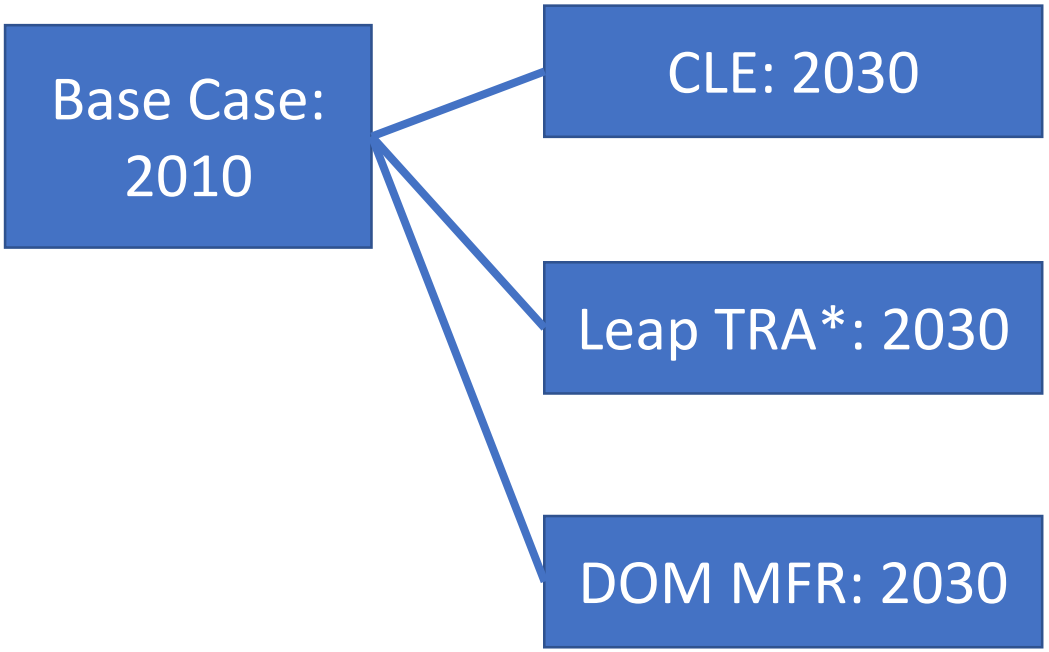
What changes can be introduced to emissions to reduce premature deaths attributable to ambient pollution in the future (despite projected growth in population, emissions, etc.)?

India, Total Population (billions)



UN Population Division

Assess implications on AQ and health from reduced emissions from transportation and residential combustion



Current Legislation (CLE) assumes current or forthcoming policies regulating anthropogenic emissions

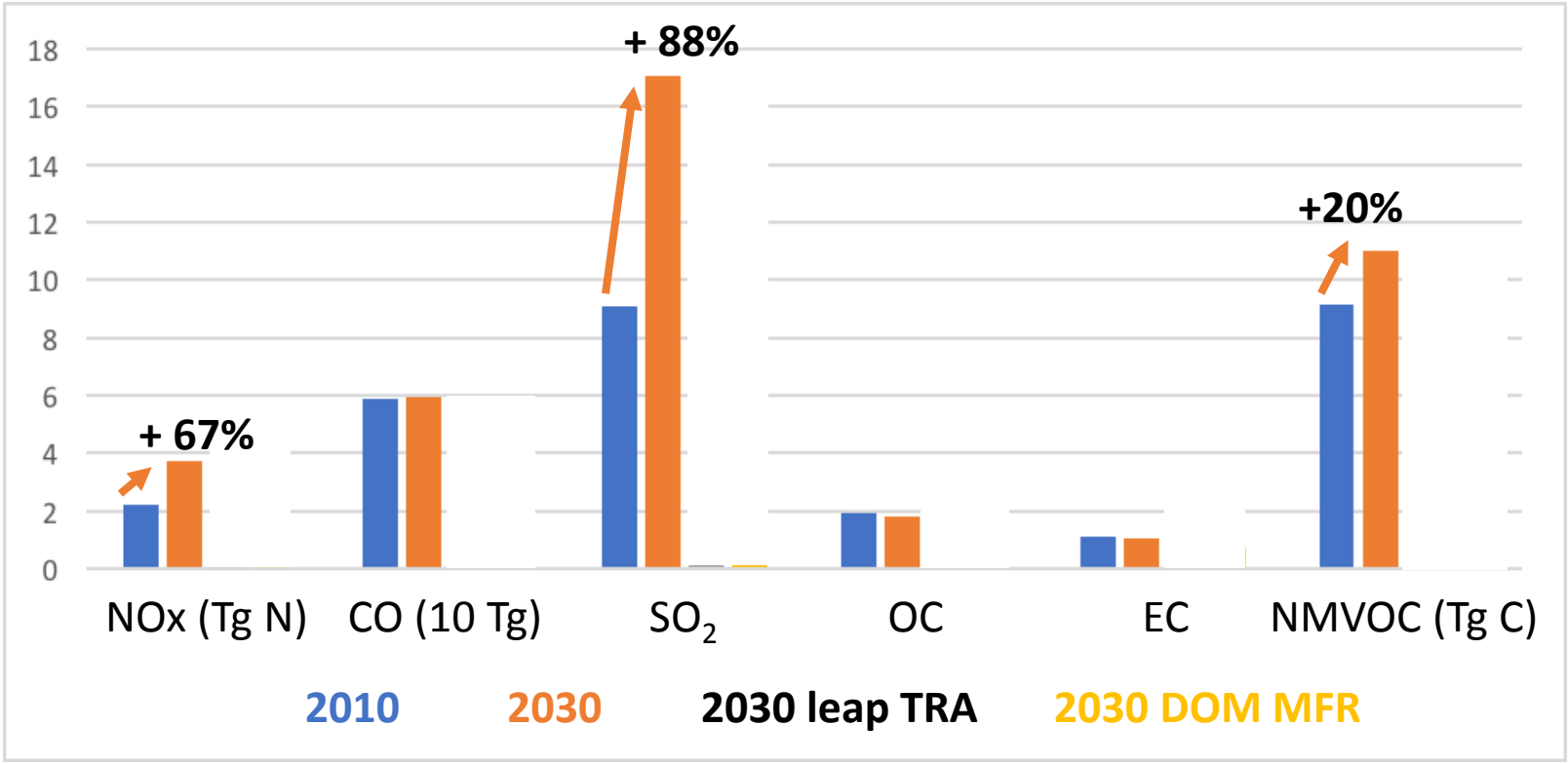
Leap TRA assumes ”leapfrog” technology of Euro V standard for all on-road motor vehicles in India

DOM MFR assumes maximum efficiency cookstoves in-use across all of India

GEOS-Chem v. 10.01 with HEMCO
Meteorology: GEOS-5 (2010)
Emissions: GAINS ECLIPSE v5a (2010, 2030)

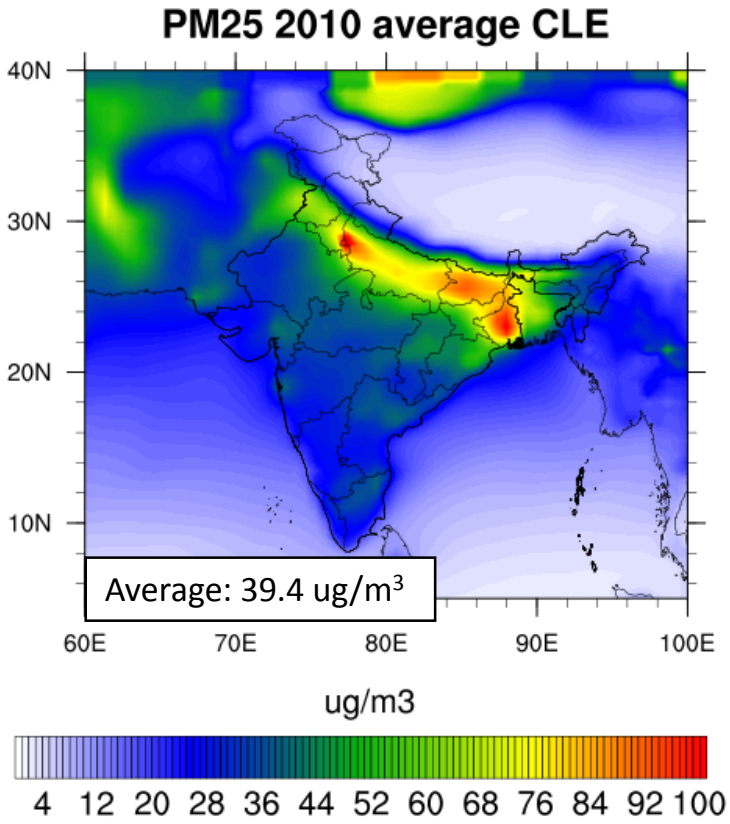
* This scenario was developed prior to recent discussions of legislation adapting Euro 6 standards

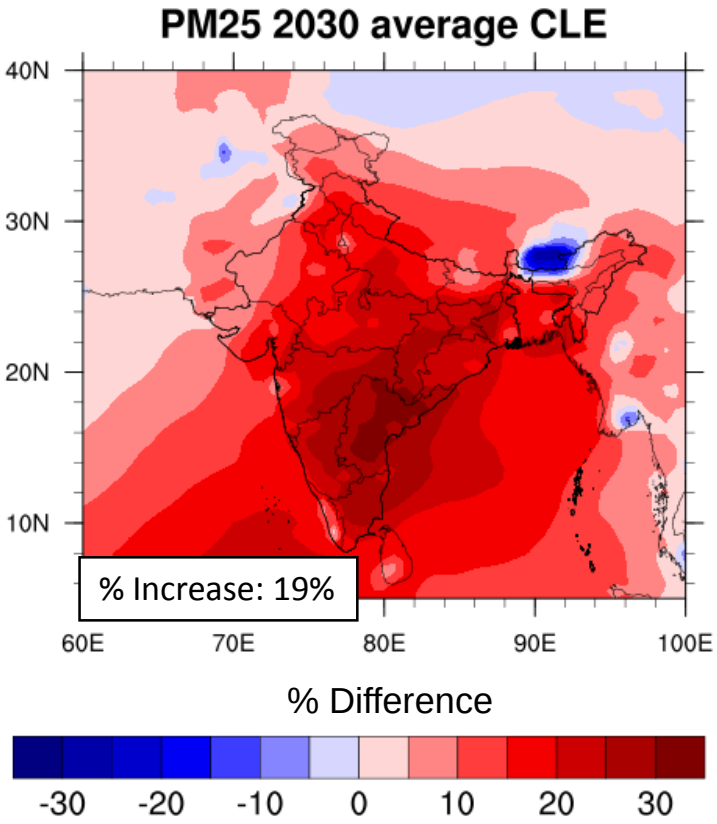
Emissions scenarios for 2010 and 2030 CLE* show significant increases in most gas-phase pollutants



* Current legislation at emissions inventory development

Growth in NO_2, SO_2, VOC emissions leads to major increases in ambient $PM_{2.5}$ concentrations

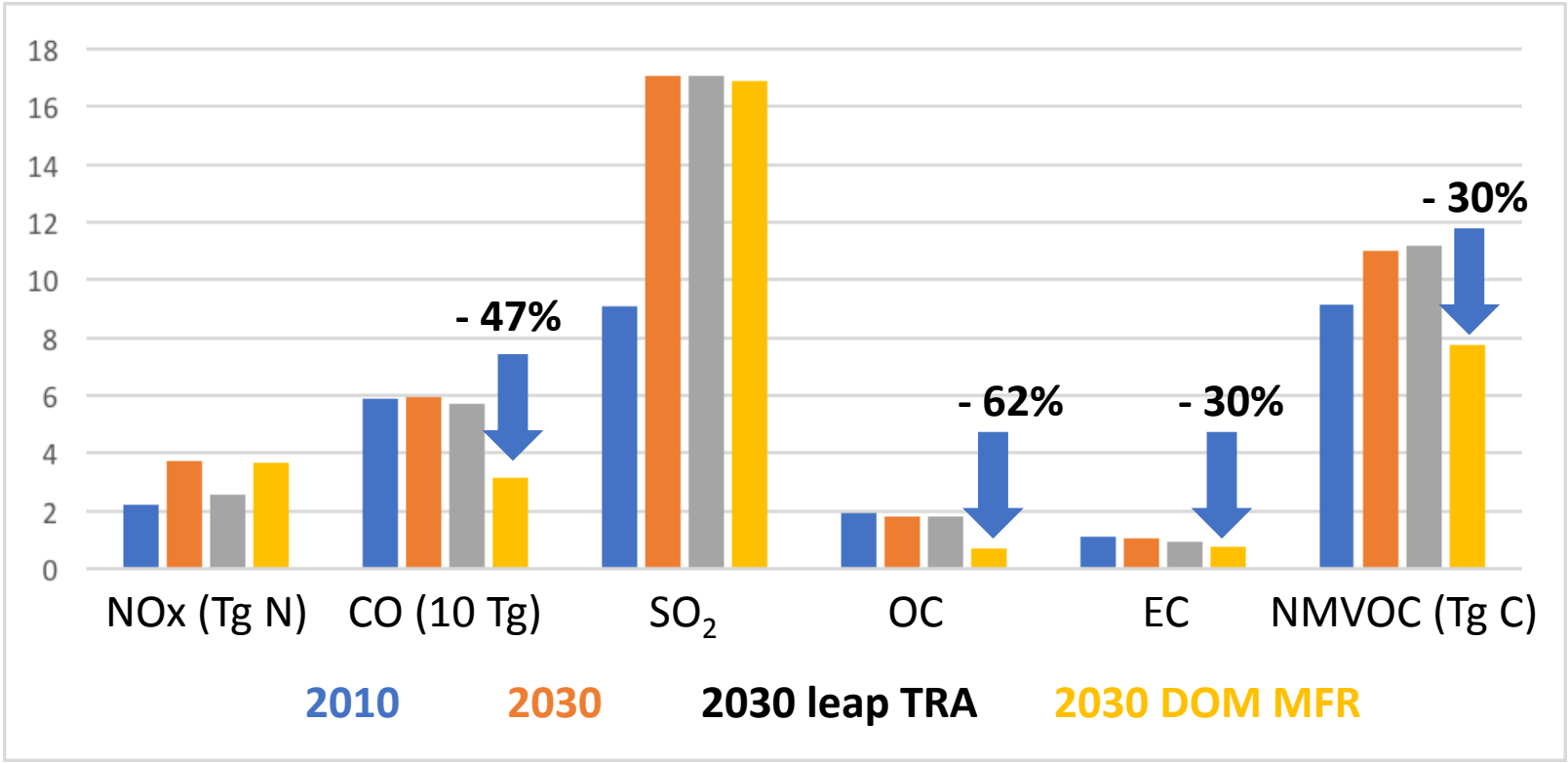




In 2030…

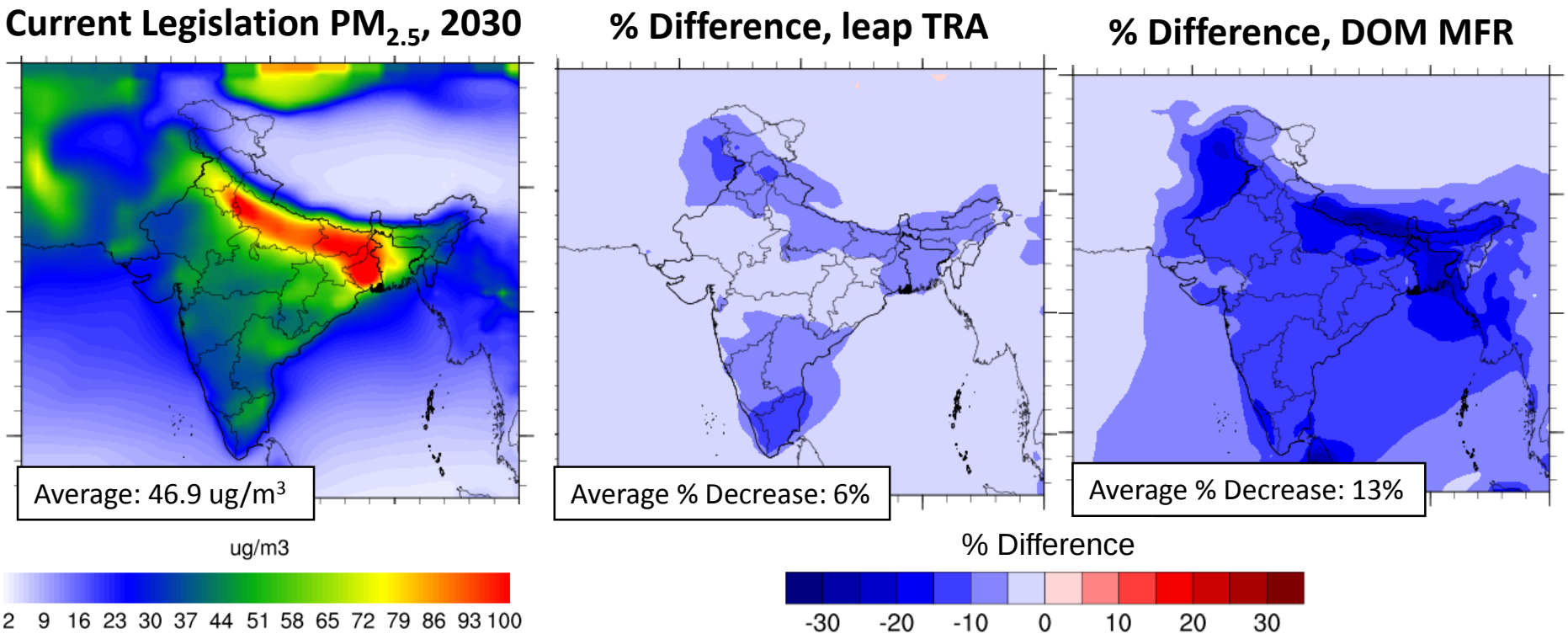
- Major increases in $PM_{2.5}$ over all, greatest in southern states
- Trying to understand the change in particulates in Bhutan is beyond the scope of this presentation

Greatest decline in emissions from DOM MFR scenario are for CO, VOCs, and primary particulates



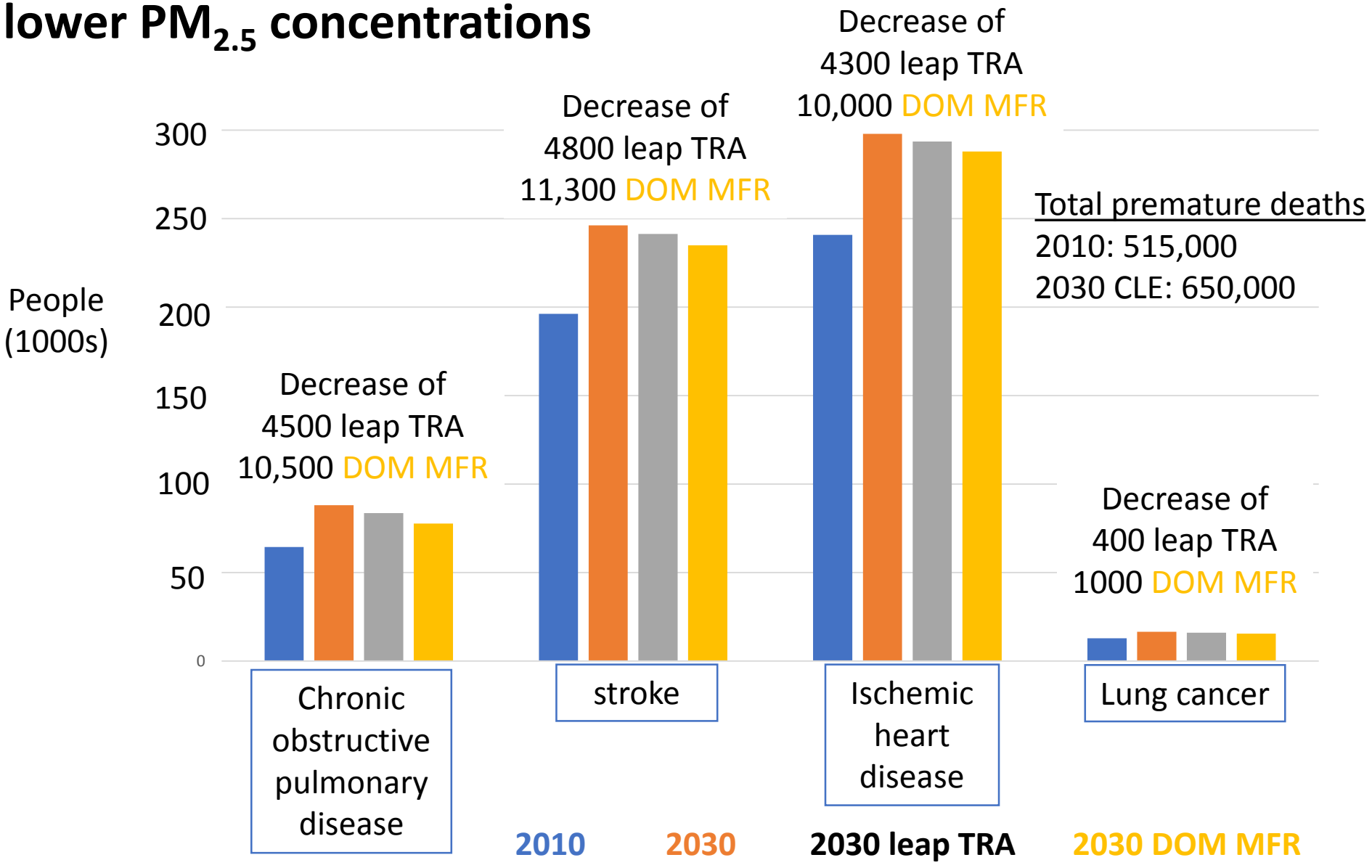
- Leap TRA major reductions on NO_X emissions

Reducing primary particles and secondary precursor gases in both scenarios reduces annual average $PM_{2.5}$



- Greatest changes to ambient $PM_{2.5}$ from residential combustion emissions reductions
- Largest magnitude of changes in IGP and southern states (corresponding with population density)

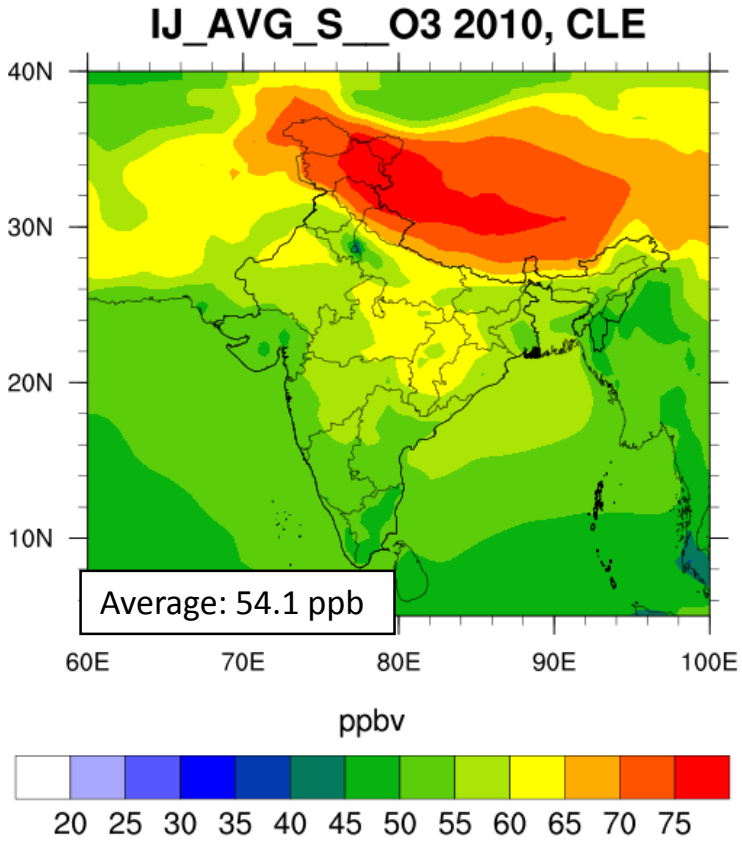
Scenarios mitigate 14,000-33,000 premature deaths because of lower $PM_{2.5}$ concentrations

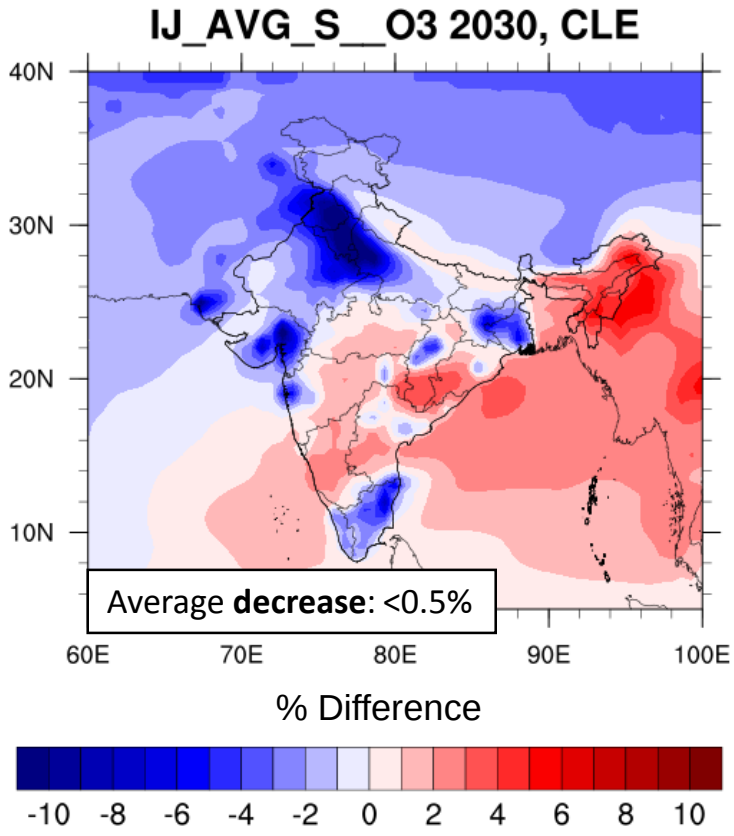


Reducing transportation and residential combustion emissions can reduce exposure and premature deaths

- Examined relevant and tractable emissions reductions scenarios
- Decreased residential combustion emissions elicited biggest response in ambient $PM_{2.5}$
- Results show that focusing on only one sector won't elicit major changes when coupled with population growth
- Limitation: results here do not account for urbanization growth and aging population

Growth in emissions between 2010 and 2030 leads to complex changes in surface O_3 concentrations

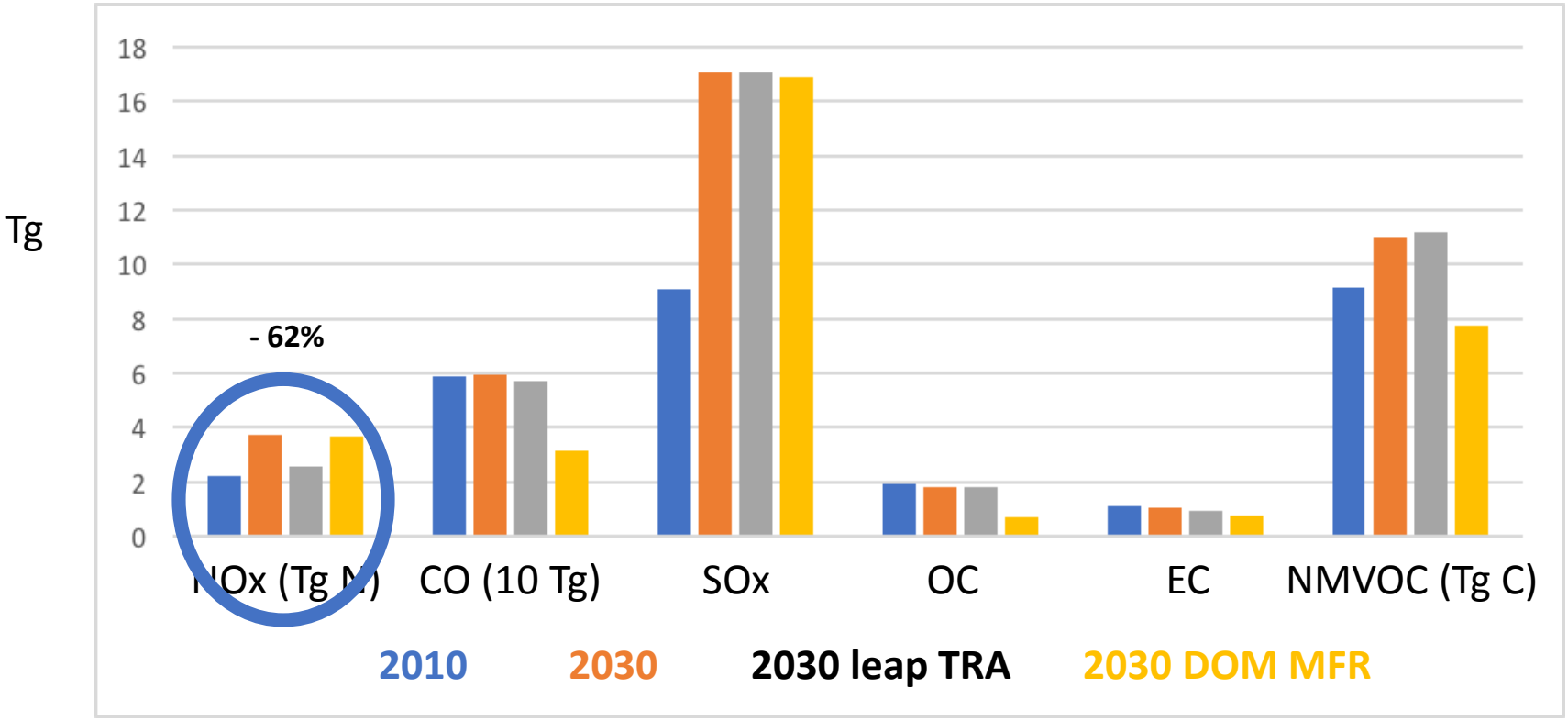




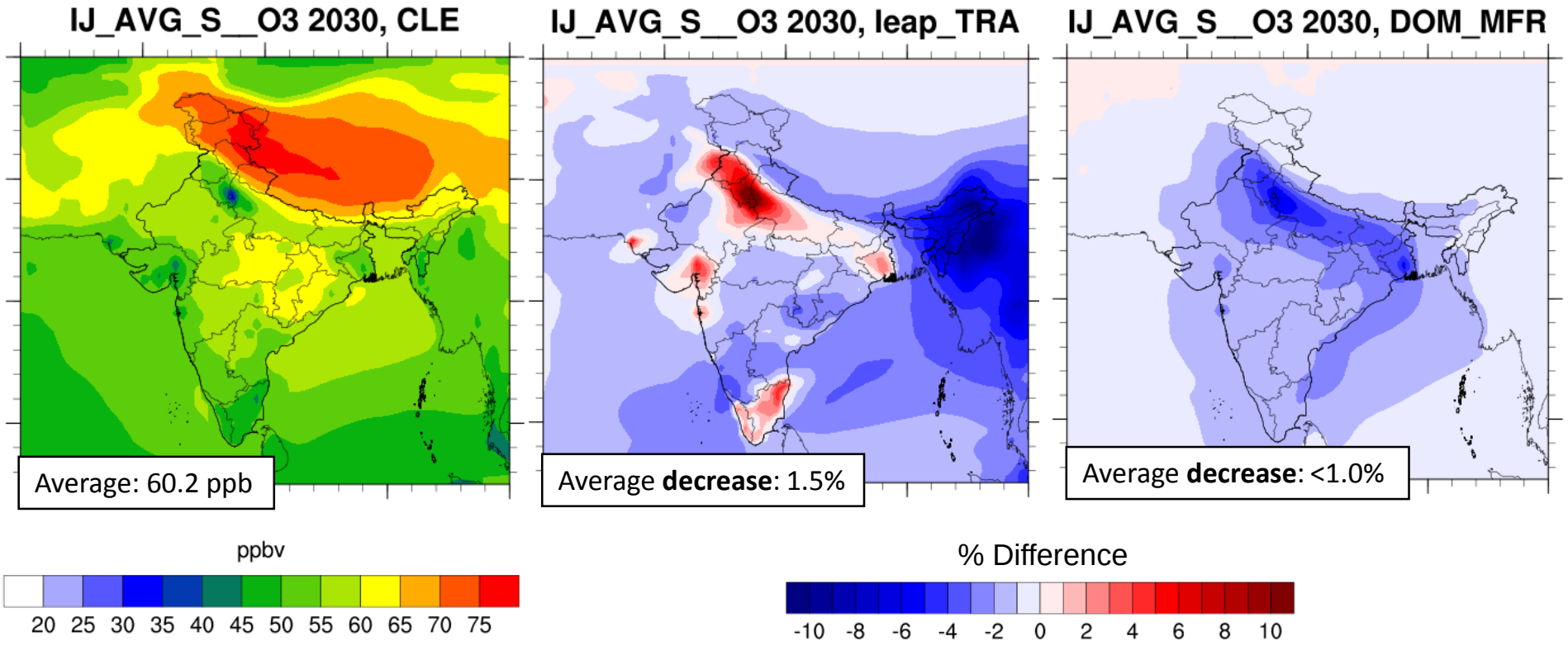
In 2030…

- Decreases in northwest and in cities due to increased NO_x emissions and titration
- Increases in rural regions that don't benefit from NO_x titration

Greatest decline in emissions from leap TRA (gray) scenario are for NO_x



Reducing transportation emissions can increase O_3 in cities, Reducing residential emissions decreases O_3 everywhere

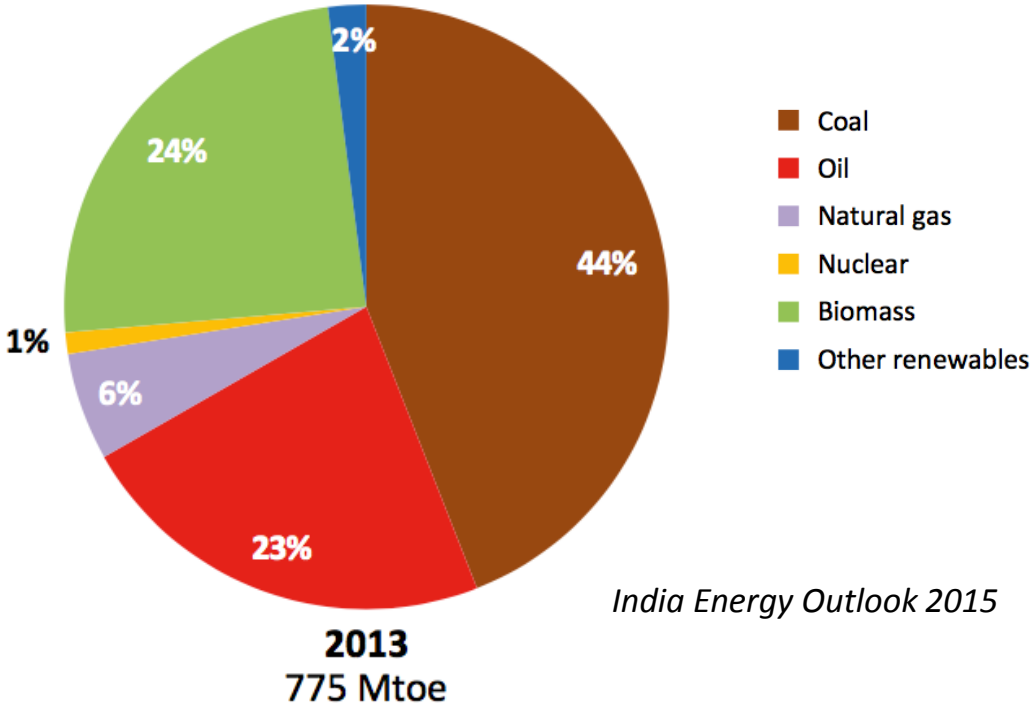


GEOS-Chem v.10.1

- Domain: nested India 0.5x0.667 degree (from Dylan Millet and Sree Chaliyakunnel, U. Minnesota)
- Emissions (HEMCO):
  - Anthropogenic: ECLIPSE v5a (2010 ,2030)
  - Biogenic: MEGAN
  - Biomass burning: GFED 4.1s and small agricultural fires from Tina Liu (Harvard)
- Meteorology: GEOS-5 (2010)
- Boundary conditions: global GEOS-Chem, GEOS-5 2x2.5 degree

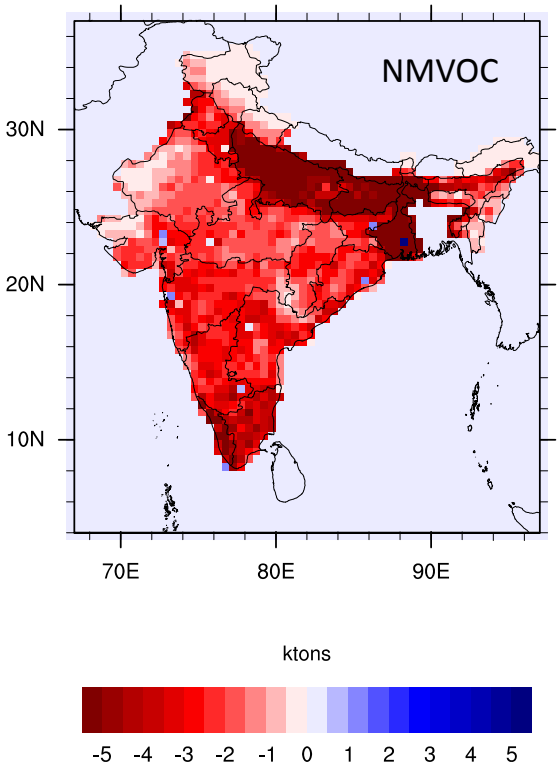
Energy in India

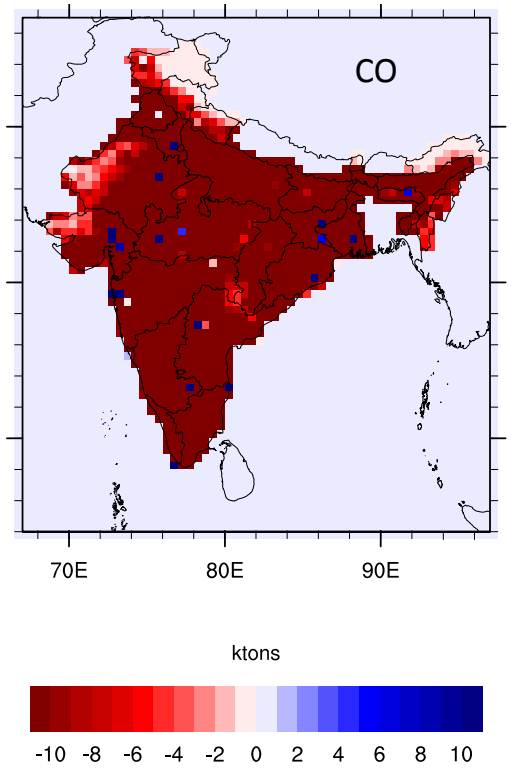
- Population of 1.25 billion
- 240 million people lack access to electricity, 800 million lack clean cooking fuels
- Coal-dominant energy mix
- 22.5 million passenger cars, 95 million two/three wheelers
- Low per capita consumption <1 ton of oil equivalent (vs. U.S. 7 toe)
- High energy inefficiency—leads to wasted fuel, more emissions

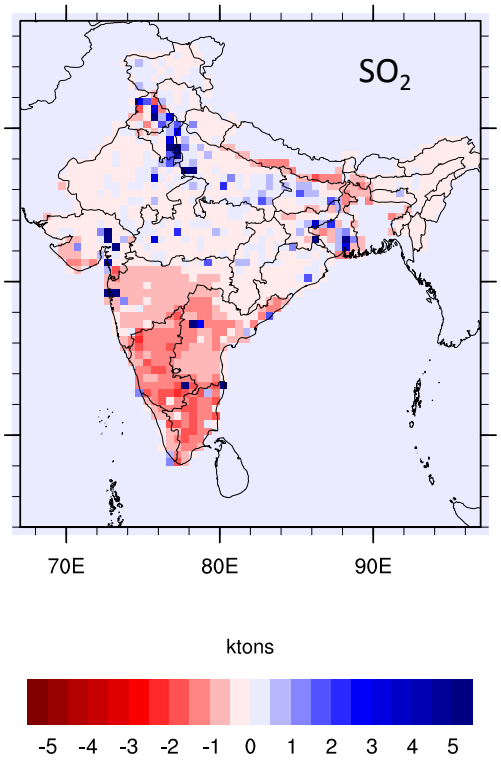


India Energy Outlook 2015

Changes in emissions due to DOM MFR







Changes in emissions due to leap TRA