Comparing Global Emissions of CEDS, CAMS, and ECLIPSEv6b and Their Effects on Air Quality and Human Health Using CESM CAM6-Chem

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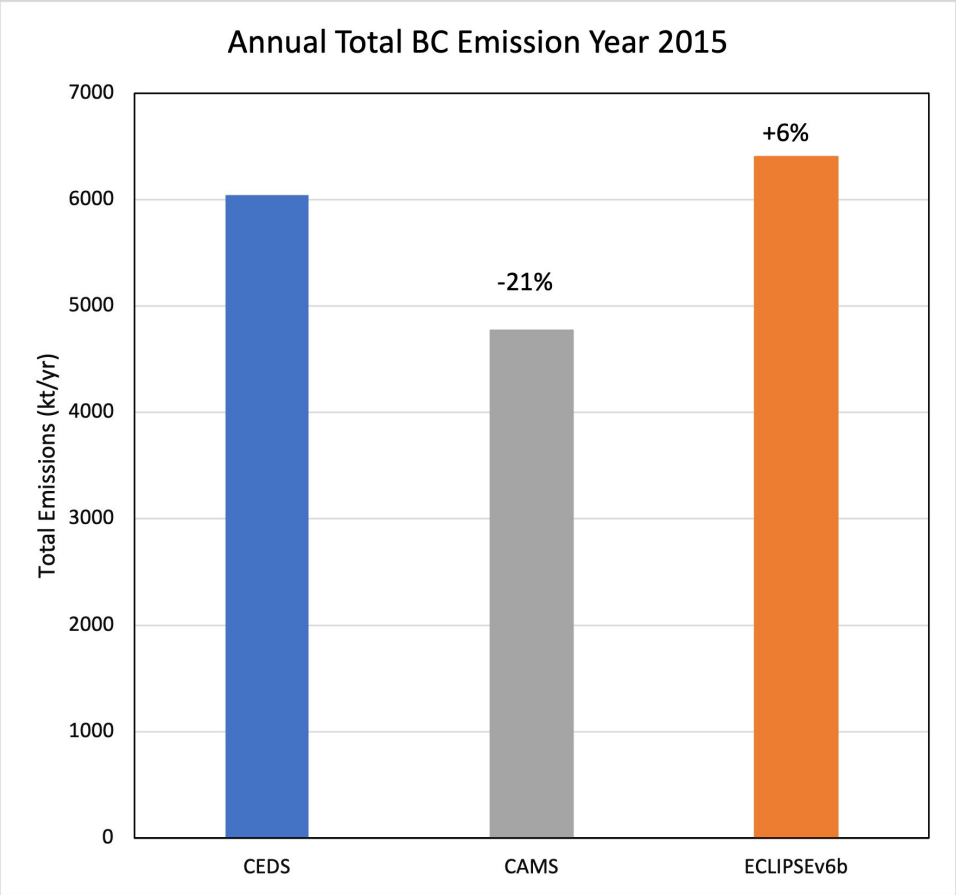
Motivations and Hypotheses



An inter-comparison of global annual total emissions of BC for the year 2015 from CEDS (blue), CAMS (gray) and ECLIPSEv6b (orange). Units: kt specie/yr

CEDS: Community Emissions Data System
CAMS: Copernicus Atmosphere Monitoring Service
ECLIPSEv6b: Evaluating the Climate and Air Quality Impacts of Short-Lived Pollutants version 6b

- We assume that there exist uncertainties in global anthropogenic emission inventories for trace gases and aerosols in three commonly used global anthropogenic emissions inventories, which are CEDS, CAMS and ECLIPSEv6b, respectively.

- In addition, we assume that the uncertainties among the emission inventories ultimately lead to different impacts on air quality and human health.

Scientific Questions

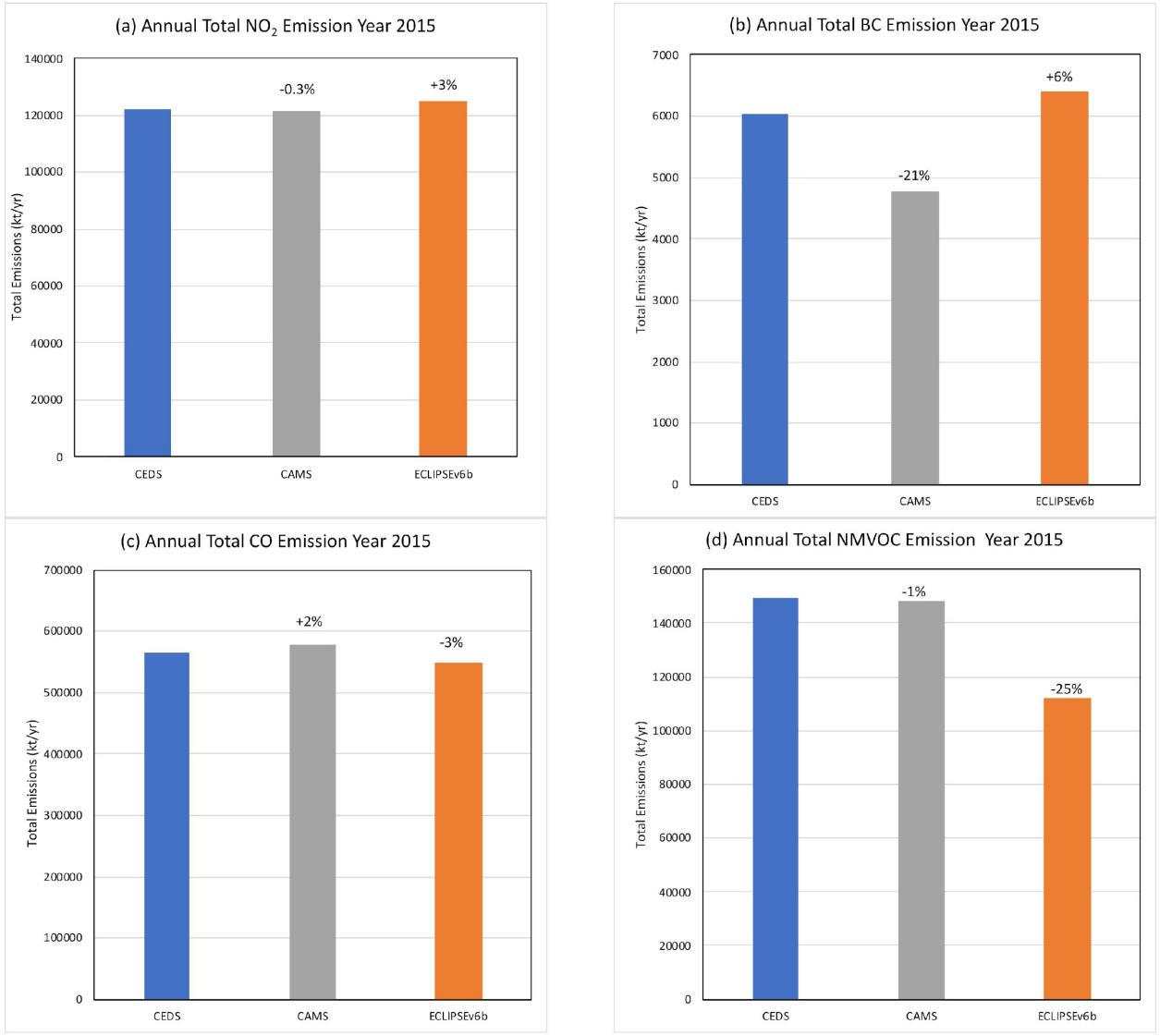
- What are the drivers of regional and global differences in the global anthropogenic emission inventories for trace gases and aerosols among **CEDS**, **CAMS** and **ECLIPSEv6b**?
- What are the regional and global air quality and human health impacts resulting from the application of different anthropogenic emission inventories?
- What are the implications for air quality management and air pollution mitigation strategies attributable to the uncertainties of global anthropogenic emissions?

CAM6-Chem Model Configurations

Cases	Anthropogenic Emission Inventory	CAM6-Chem Resolution	Simulation Period
Case 1	CEDS	0.9° x 1.25°	01/01/2014 - 01/01/2016
Case 2	CAMS	0.9° x 1.25°	01/01/2014 - 01/01/2016
Case 3	ECLIPSEv6b	0.9° x 1.25°	01/01/2014 - 01/01/2016
Case 4	OFF	0.9° x 1.25°	01/01/2014 - 01/01/2016

The differences between the Case 1/2/3 and the Case 4 will be the net air quality and human health impacts for each anthropogenic emission inventory.

Intercomparisons of global annual total emissions

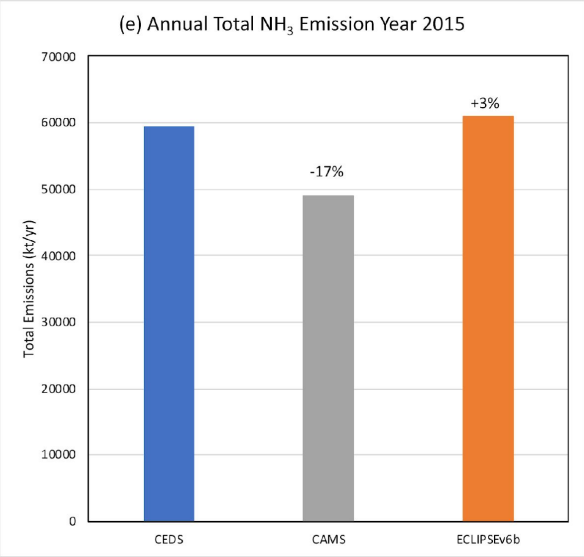


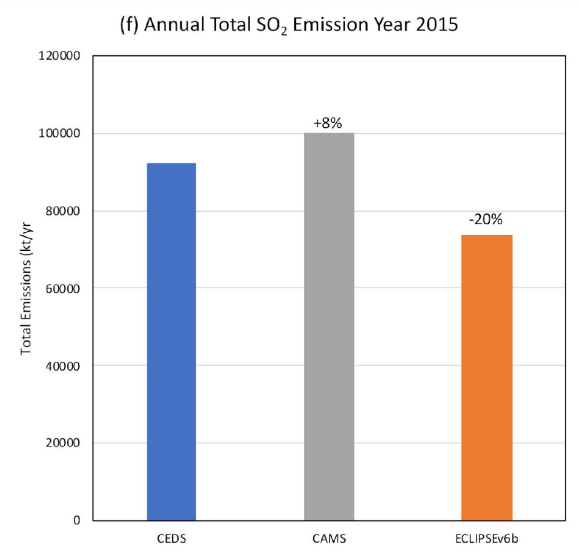
An inter-comparison of global annual total emissions of (a) NO_2, (b) BC, (c) CO, (d) NMVOCs for the year 2015 from CEDS (blue), CAMS (gray) and ECLIPSEv6b (orange). Units: kt specie/yr

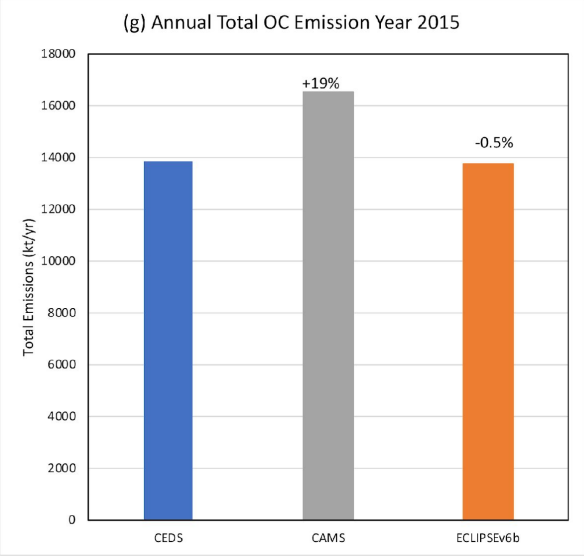
NOTE: We use CEDS as baseline to find percentage difference between inventories

- Global annual total emissions of NO_2 and CO are consistent among CEDS, CAMS and ECLIPSEv6b;
- Compared with CEDS, global annual total emissions of BC from CAMS in 2015 were 21% lower;
- For ECLIPSEv6b, global annual total emissions of BC and NMVOCs in 2015 were 6% higher, and 25% lower, than that from CEDS.

Intercomparisons of global annual total emissions



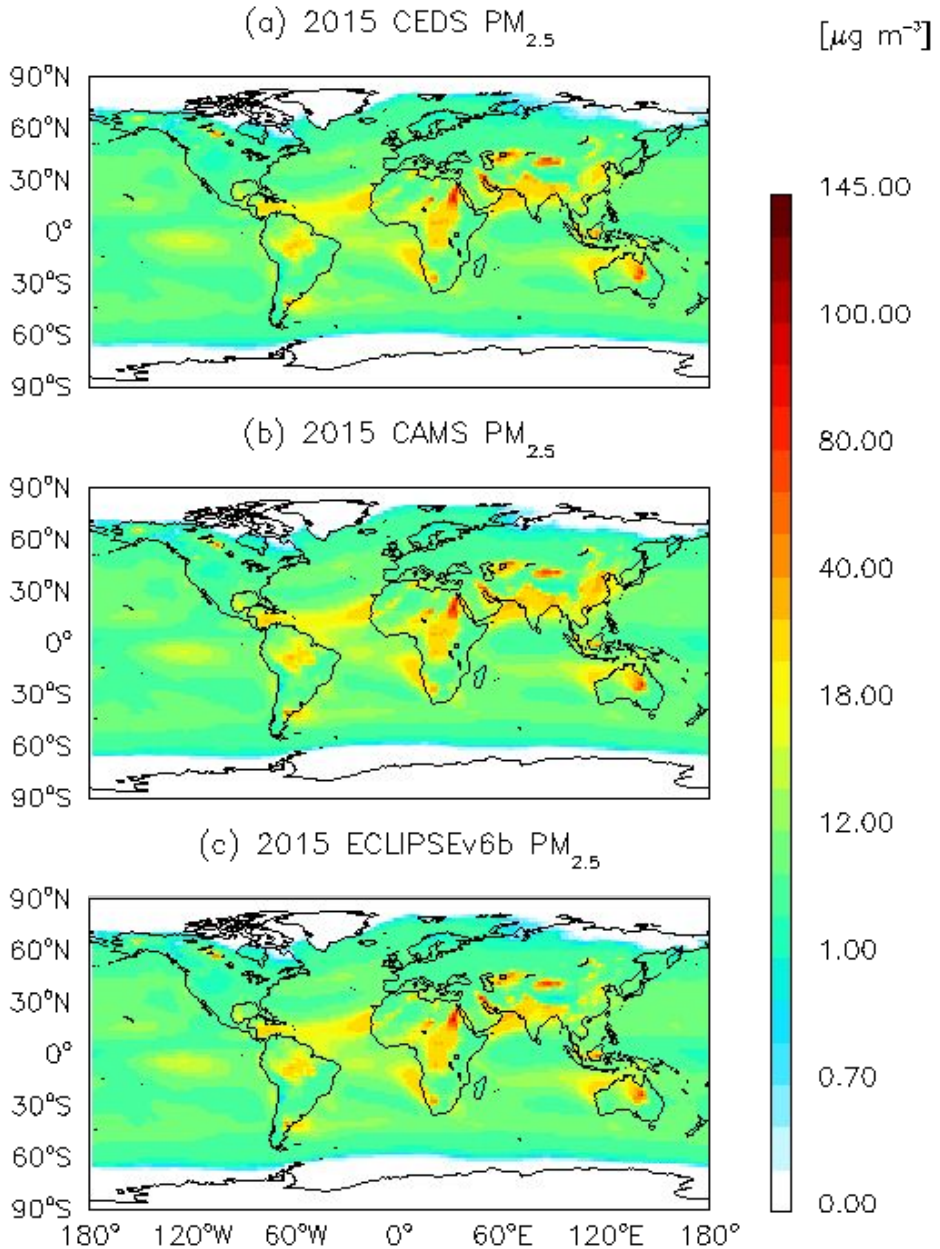


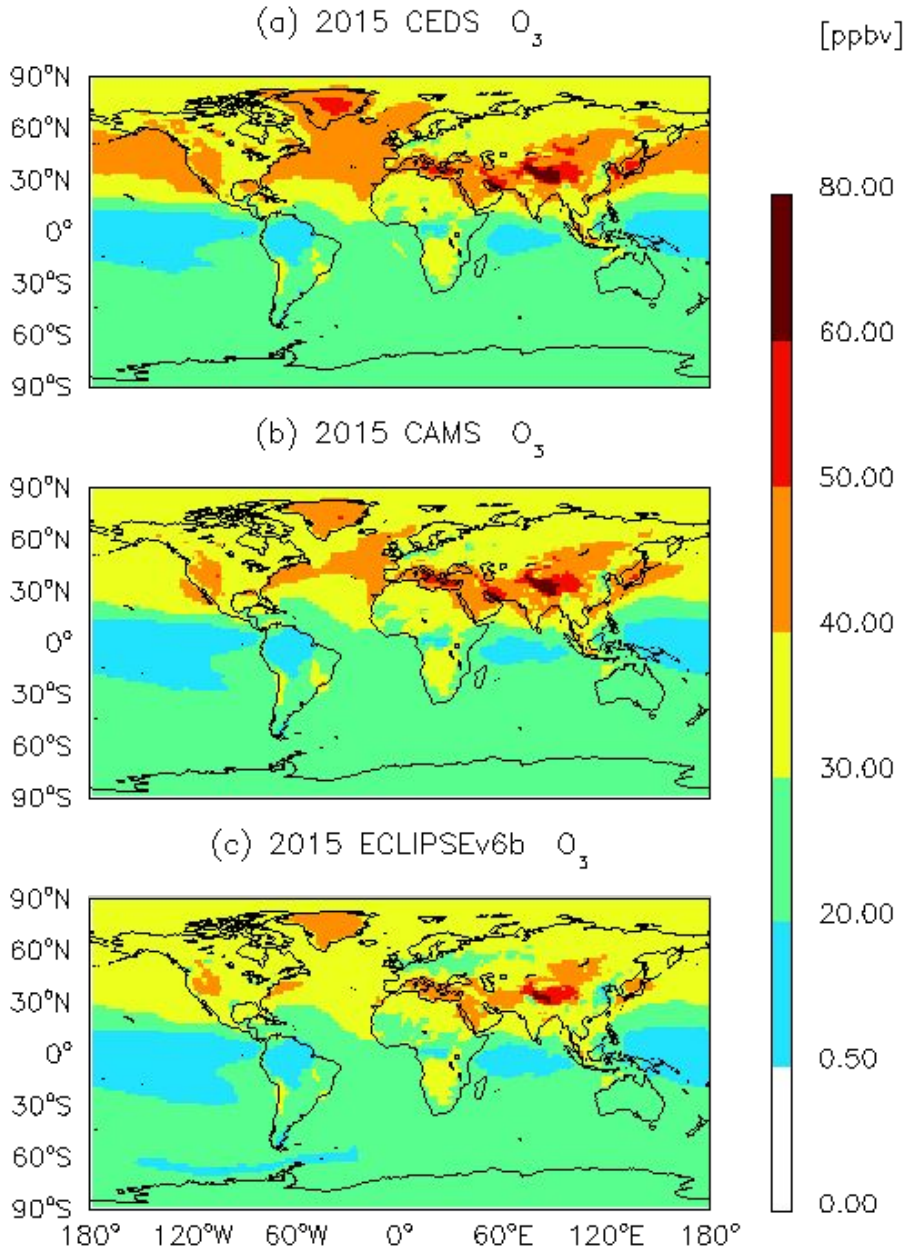


An inter-comparison of global annual total emissions of (e) NH_3, (f) SO_2 and (g) OC for the year 2015 from CEDS (blue), CAMS (gray) and ECLIPSEv6b (orange). Units: kt specie/yr

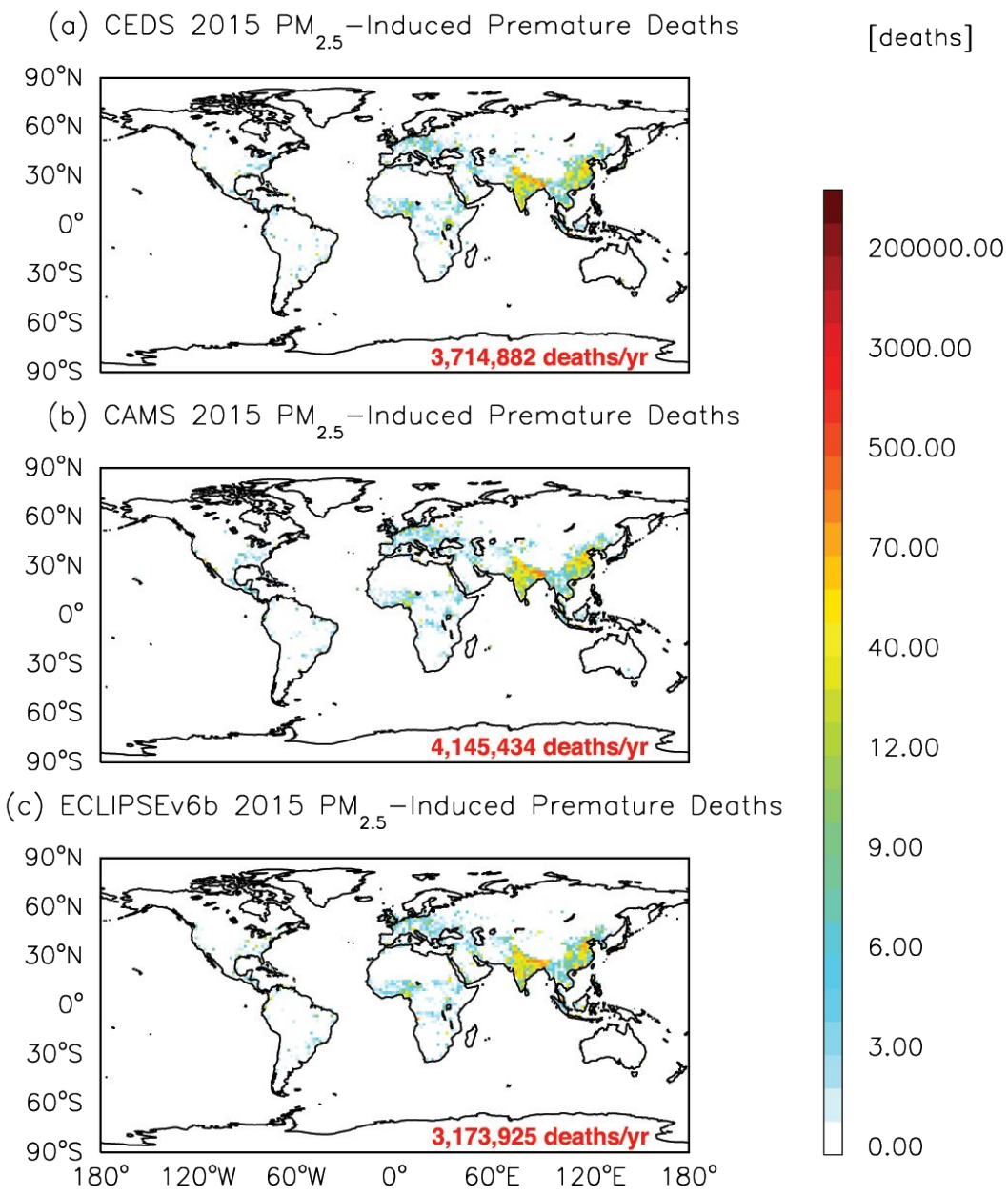
- Global annual total emissions of SO_2 and OC from CAMS for the year 2015 were 8% and 19% higher, with NH_3 17% lower, than those from CEDS, respectively;
- We found large discrepancies between ECLIPSEv6b and CEDS for SO_2, with global annual total emissions of SO_2 from ECLIPSEv6b in 2015 20% lower, compared with that from CEDS.

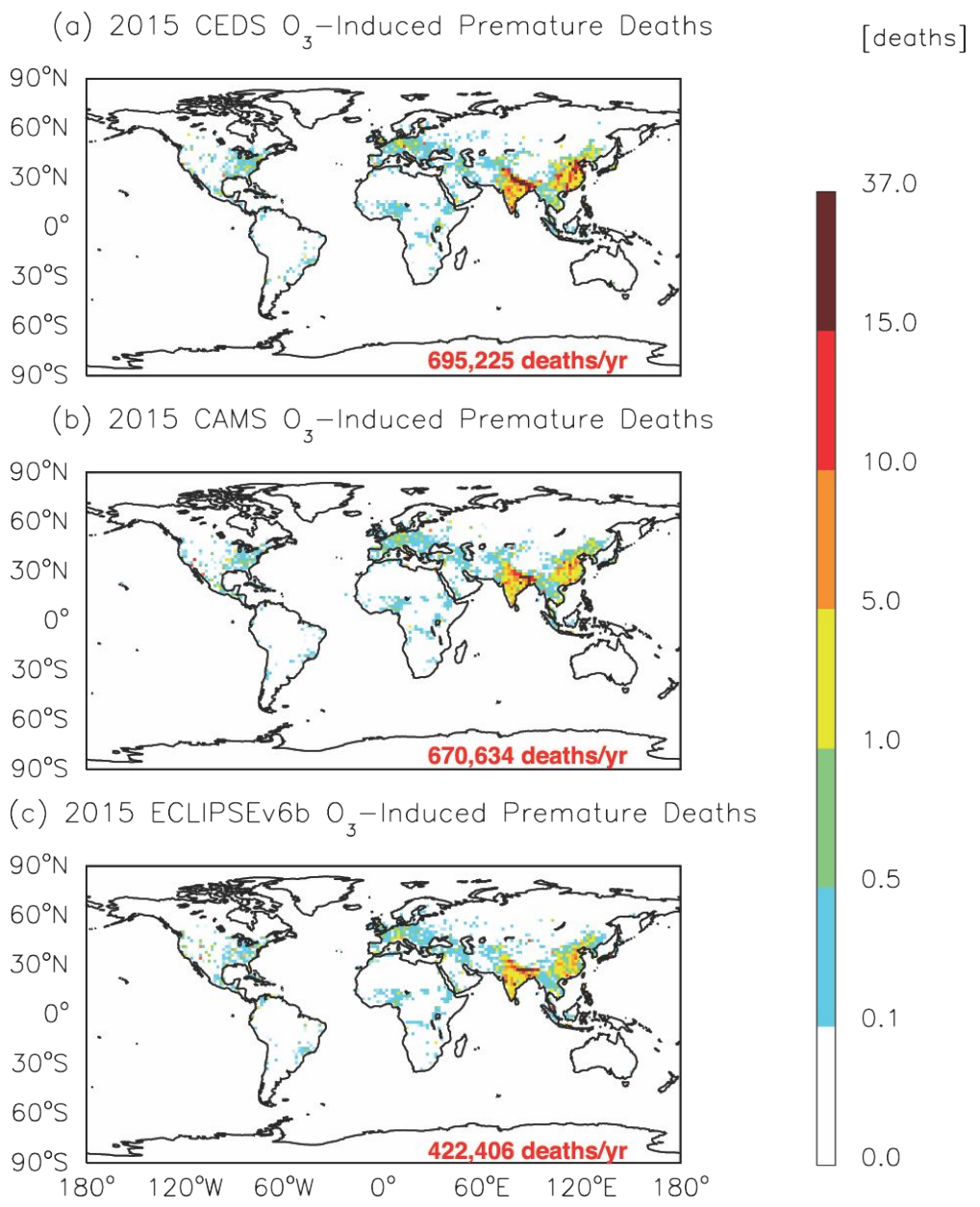
Global annual mean surface concentrations of $PM_{2.5}$ and O_3 in 2015 for (a) CEDS, (b) CAMS and (c) ECLIPSEv6b



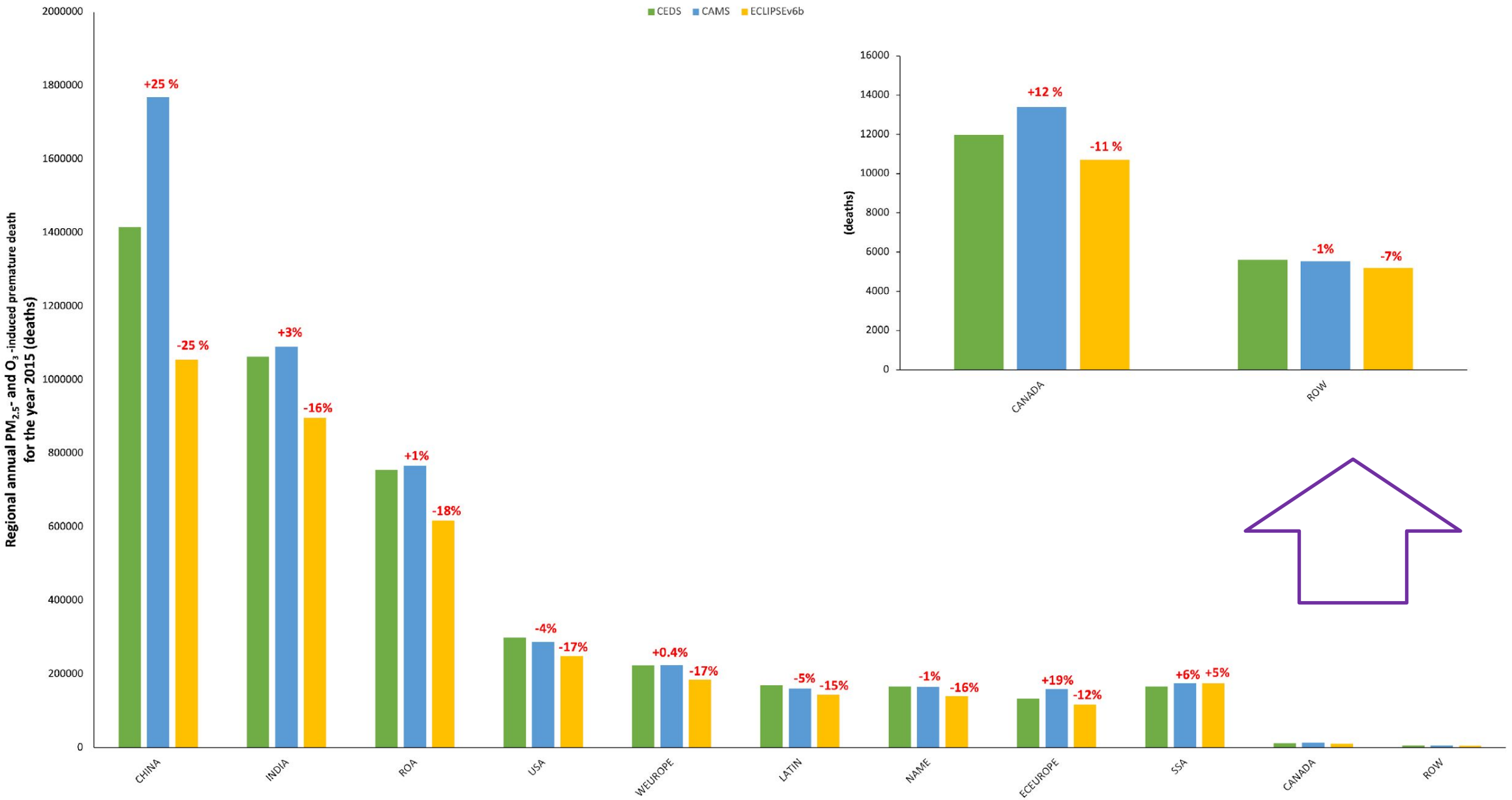


Impacts on Human Health





Regional comparisons of the combined $PM_{2.5}$- and O_3-Induced premature deaths



Summary and Conclusions

- Global annual total emissions of NO_2 and CO are consistent among CEDS, CAMS and ECLIPSEv6b. However, global annual total emissions of OC and SO_2 from CAMS in 2015 were 19% and 8% higher, with BC and NH_3 21% and 17% lower than that from CEDS, respectively.
- For ECLIPSEv6b, compared with CEDS, global annual total emissions of NMVOCs and SO_2 in 2015 were 25% and 20% lower.
- The combined global annual $PM_{2.5}$ and O_3 induced premature deaths for the year 2015 for CEDS, CAMS and ECLIPSEv6b were 4.41, 4.82, and 3.59 millions, respectively. The drivers of the discrepancies were mainly caused by the regional differences over Asia, particularly from China and India.
- When compared with CEDS, global annual total $PM_{2.5}$- and O_3-induced premature deaths from CAMS over China in 2015 were 25% higher. However, ECLIPSEv6b showed 25% lower relative to that from CEDS.

Acknowledgements

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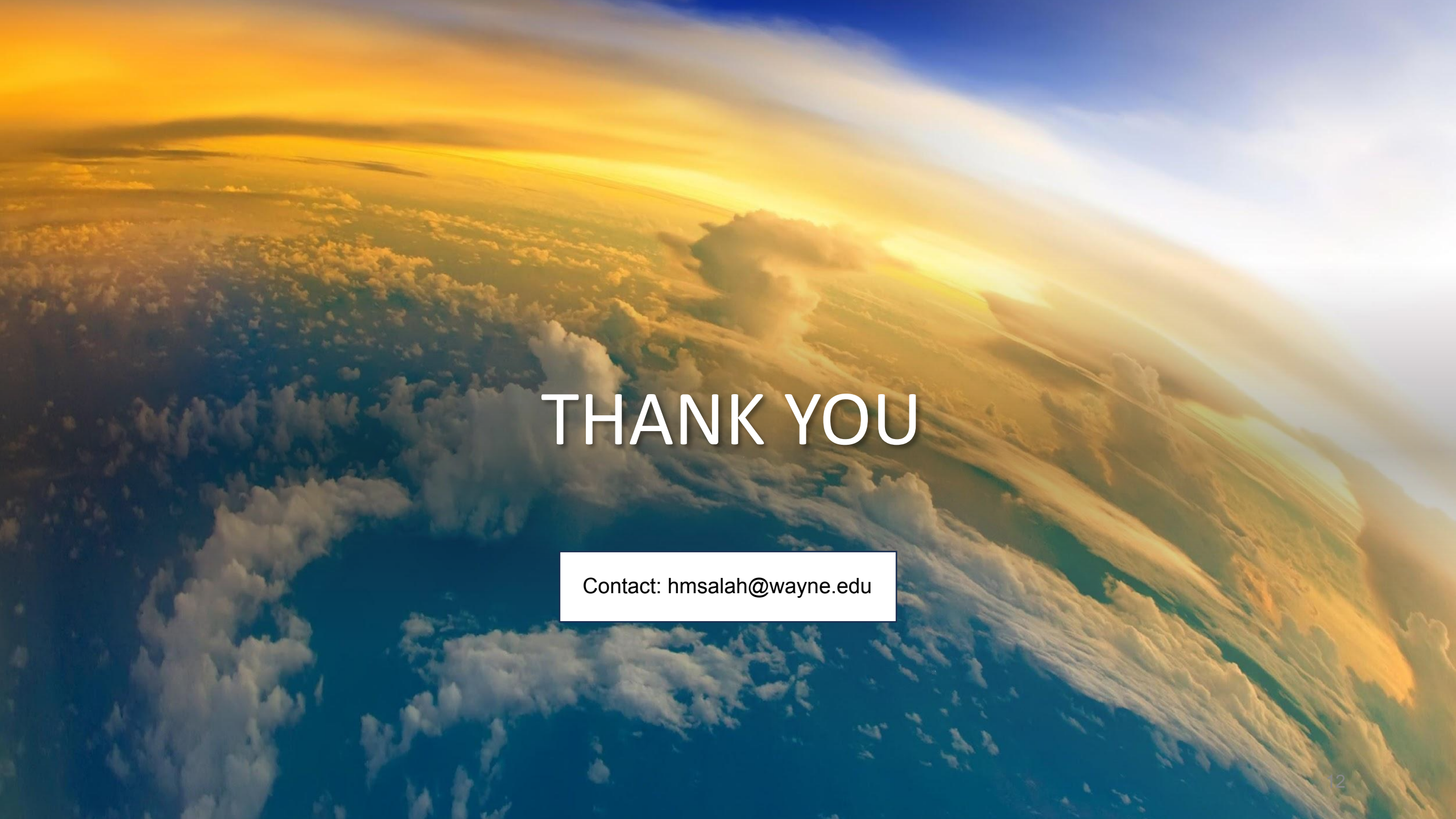
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Emissions Inventory

- **Community Emissions Data System (CEDS):**
  - Data set uses *Coupled Model Intercomparison Project Phase 6 (CMIP6)* (Hoesly et al., 2018)
- **Copernicus Atmosphere Monitoring Service (CAMS):**
  - Using *CAMS-GLOB-ANTH v5.1*
    - Combination of CEDS and Emissions Database for Global Atmospheric Research version 5 (EDGARv5) (Soulie et al., 2022)

- **Evaluating the Climate and Air Quality Impacts of Short-Lived Pollutants version 6b (ECLIPSEv6b):**
  - Global emissions (for both historical and near-future times) are available in 5 five-year increments and include 160 country regions (Stohl et al., 2015)

Pacific Northwest NATIONAL LABORATORY

Atmosphere Monitoring Service atmosphere.copernicus.eu

International Institute for Applied Systems Analysis IIASA www.iiasa.ac.at

Inventories

- **CEDS:**
  - Updated CEDS dataset that contains historical anthropogenic emission from 1750 to the year 2019 from Pacific Northwest National Laboratory (PNNL)
    - Re-gridded to **0.9° x 1.25°** to be consistent with CAM6-Chem model resolutions
    - Summation of all sectors is included in total pollution emissions for year 2015
- **CAMS:**
  - Using CAMS Global Anthropogenic emissions (**CAMS-GLOB_ANTH**)
    - For NMVOCs inventory each individual emission calculated separately to find a summation of NMVOCs
    - NO to NO_2 for consistency
    - Summation of all sectors is included in total pollution emissions for year 2015
- **ECLIPSEv6b**
  - **Regridded** to **0.5° x 0.5°** longitude-latitude
  - The temporal distribution ranges from 1990 to 2030 in five-year intervals, 2040, and 2050

Inventory Intercomparisons of Global

	NO_2	BC	CO	NMVOC	NH_3	SO_2	OC
CEDS	121860	6041	565480	149557	59404	92057	13855
CAMS	121473	4772	578126	148307	49097	99724	16541
ECLIPSEv6b	124991	6399	548397	112034	60986	73381	13790

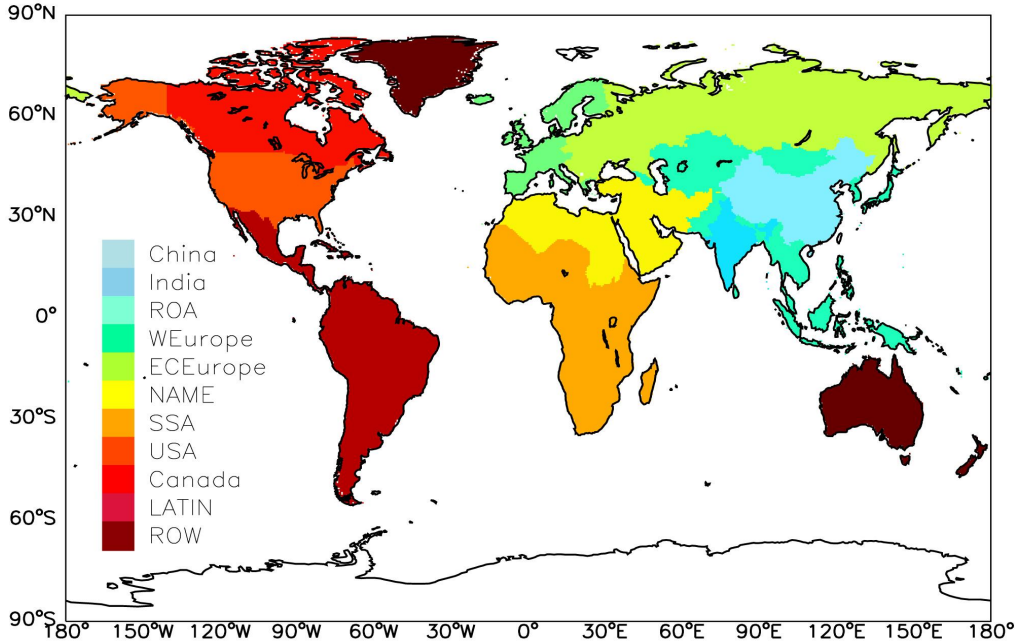
Global Annual Total Emissions of various species for the year 2015 from CEDS, CAMS and ECLIPSEv6b. Units: Kilo tons (kt) specie per year

Human Health Impacts

$$M_{i,j,h,a} = POP_{i,j,a} \times BMR_{i,j,h,a} \times \left[{(HR_{i,j,h,a} - 1)} / {HR_{i,j,h,a}} \right]$$

- POP is the gridded population density for each age group in each grid cell
- Premature deaths are calculated using the Baseline Mortality Rate (BMR), the gridded population density, and the HR associated with exposure to $PM_{2.5}$ and O_3
- Hazard Ratio (HR) functions attributed to the Global Exposure Mortality Model (GEMM) (Burnett et al., 2018)(Huang et al., 2021)
  - HR functions are derived based on cohort studies conducted in 16 countries worldwide
  - Investigates association between long term exposure to ambient PM2.5 and noncommunicable diseases (NCDs) and lower respiratory infections (LRIs).

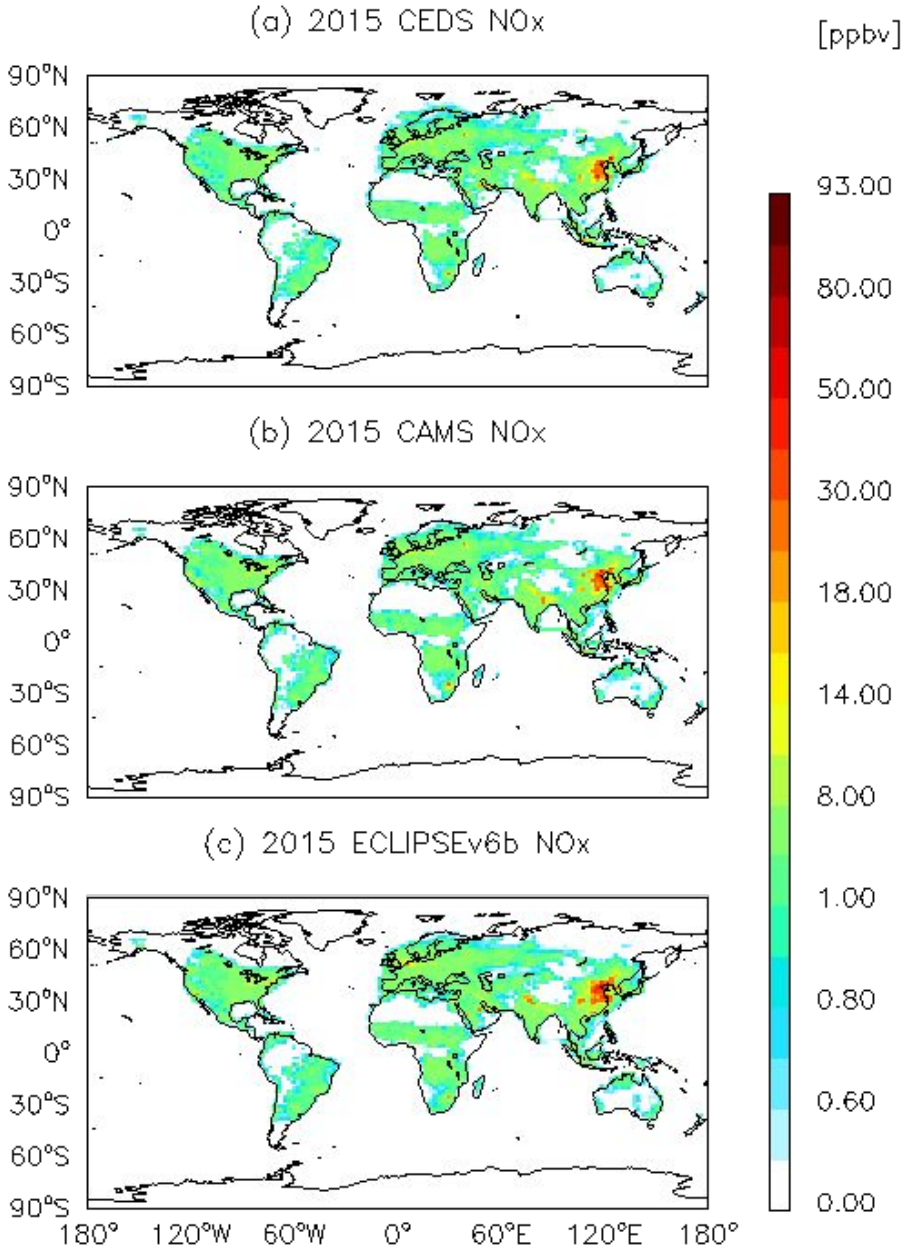
$$HR_{i,j} = exp^{(\eta \Delta Y_{i,j})} \quad \Delta Y_{i,j} = \max(0, Y_{i,j} - 26.7)$$

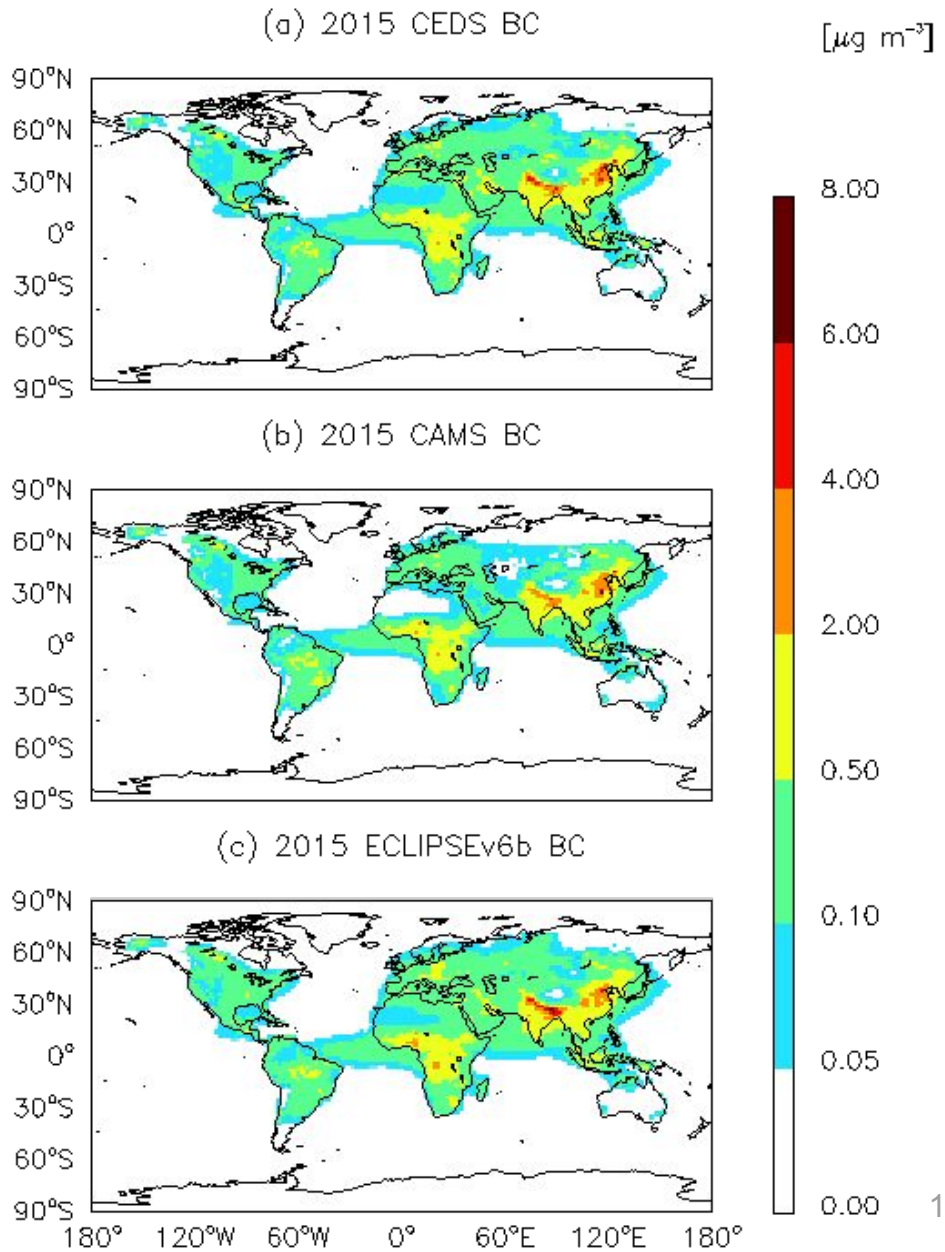


CTRL-NO_ANTH= *Human Health Impacts due to anthropogenic sources*

11 defined regions adapted from (Huang et. al,2020):
ROA = rest of Asia; **WEurope** = western Europe; **ECEurope** = eastern and central Europe; **NAME** = northern Africa and the Middle East; **SSA** = sub-Saharan Africa; **LATIN** = Latin America; **ROW** = rest of the world

Global annual mean surface concentrations for the year 2015 for (a) CEDS, (b) CAMS and (c) ECLIPSEv6b





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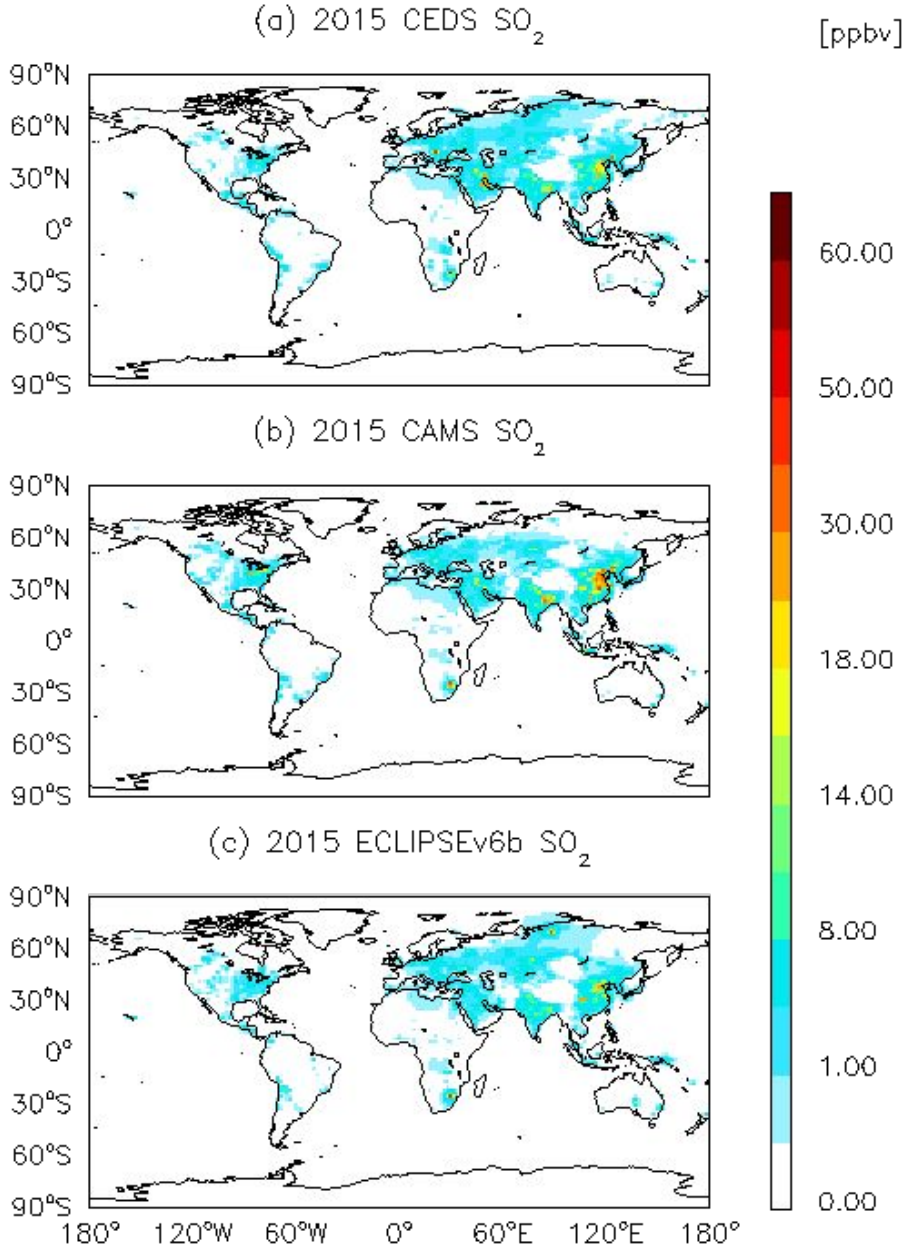

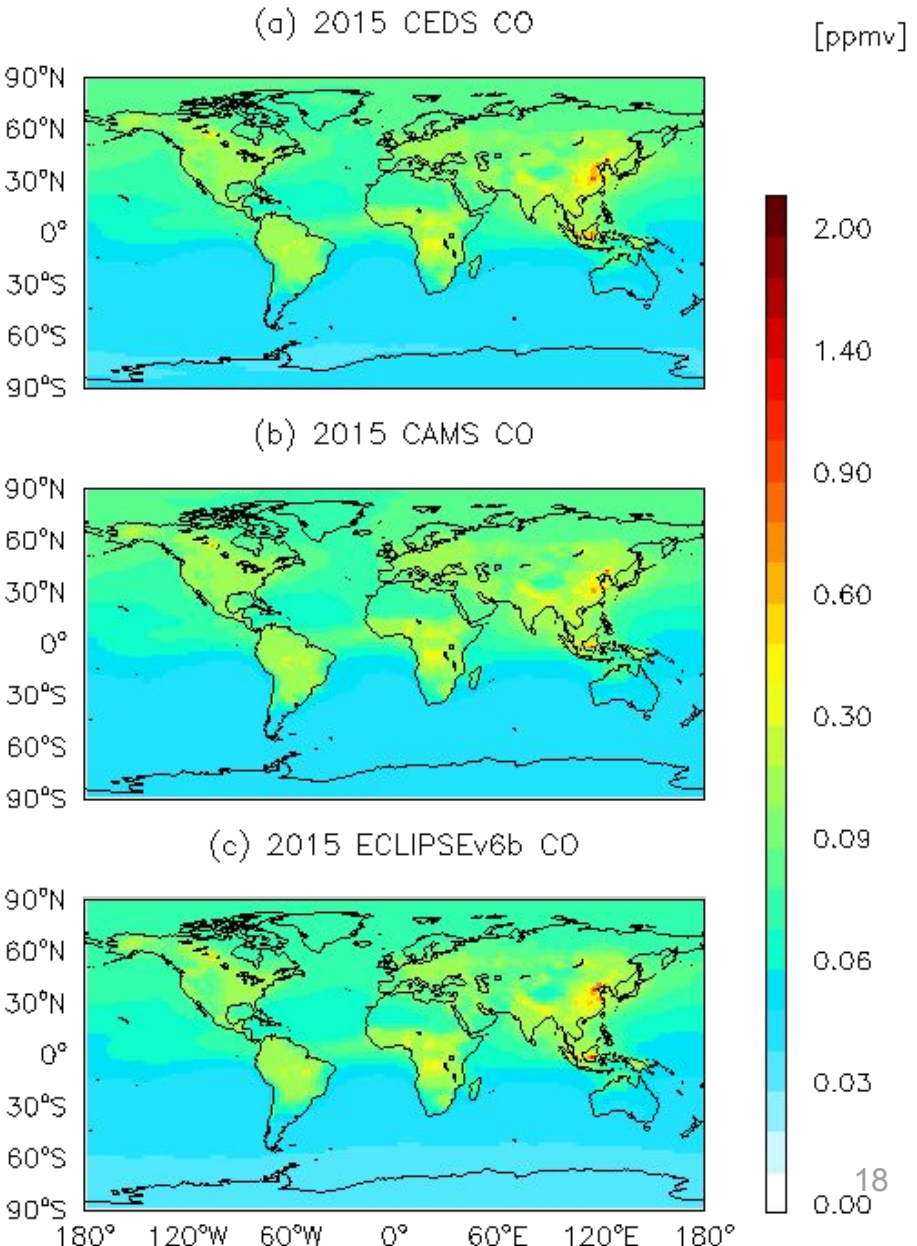

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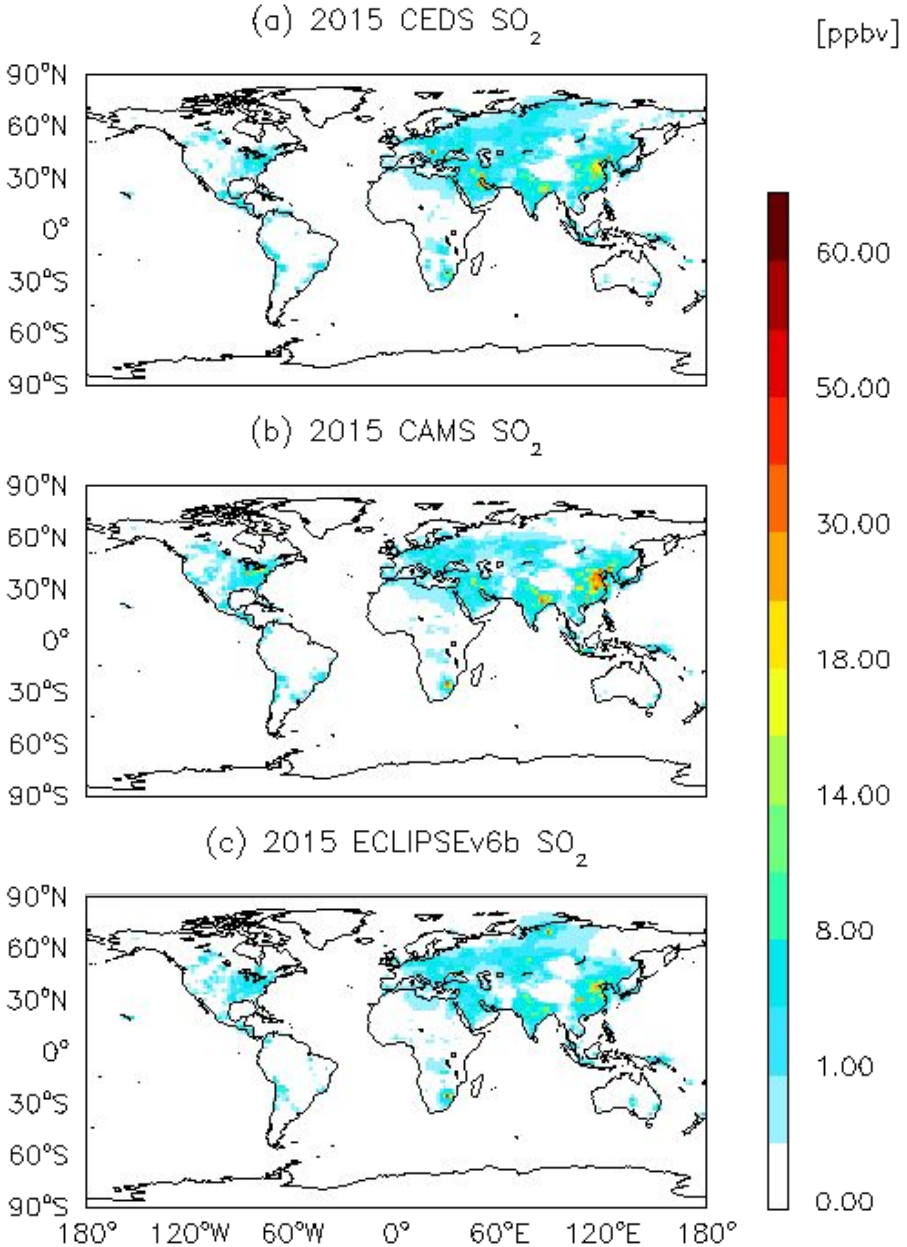

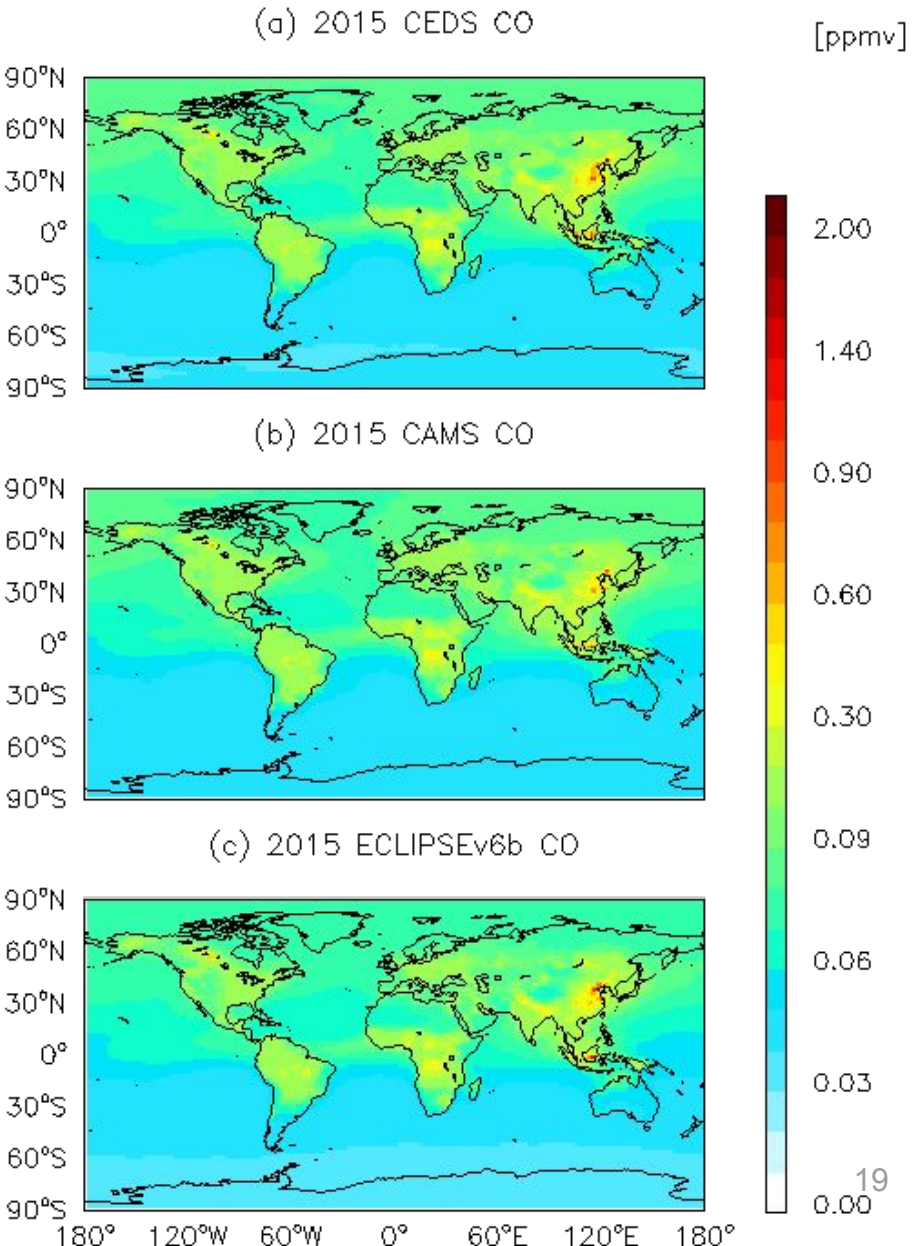

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