Aerosol source attributions and source-receptor relationships across the Northern Hemisphere

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1. Objectives

- Examine the transport of aerosols, including anthropogenic, dust, and biomass burning, from source regions to downwind regions
- Assess the emission and transport impacts on regional and global air quality, ecosystems, public health, and climate
- Provide information on potential emission mitigation options

2. Approaches

- Hemispheric transport of air pollution (HTAP) is a UN TF HTAP coordinated international assessment activity to assess these objectives. Initial results of two HTAP2 models (GOCART and GEOS-5) are used in this analysis.
- Measurements from satellite, aircraft and ground networks are used to evaluate the models.
- Investigating aerosol source attributions and source-receptor relations across the Northern Hemisphere from surface concentration and column-wise perspective.
- Response to extra-regional emission reduction (RERER or R) is calculated as

\[ R_i = \frac{\Delta C_{\text{reg}}}{\Delta C_{\text{glo}}} \]

For each region \( i \), \( R_i \) is the regional concentration change due to the extra-regional emission reduction relative to that due to the global emission reduction (regional + extra regional)

3. Model set up

- Emissions:
  - Anthropogenic: HTAP2, 0.1x0.1 deg, 4 sectors (energy, industry, residential, transportation)
  - Biomass burning: GFED v3 (recommended)
  - Volcanic: HTAP2/AeroCom-MAP (Thomas Diehl)
  - Dust and sea salt: Model calculated
- High priority runs:
  - BASE, 2008-2010
  - 20% reduction of anthropogenic emissions in GLO, NAM, EUR, EAS, SAS, RBU, and MDE
  - Zero-out dust emissions in NAF, CAS, EAS, MDE
  - 20% reduction of global fire emissions

4. Model Evaluation

Surface BC, OC, SO4, Duf concentration from IMPROVE network

BC vertical profile from the HIPPO aircraft campaign

AOD and AAOD from satellites and AERONET

5. In the Arctic – where are the carbonaceous aerosols from?

6. Response to Extra-Regional Emission Reduction (RERER)

- The lower the \( R_i \), the less sensitive the amount within a region to the extra-regional emission reduction (or the more sensitive to the emission reduction within its own region)

Surface concentration – GOCART anthropogenic

AOD – GOCART anthropogenic

7. Conclusions

- GOCART and GEOS-5 model simulated aerosol mass and AOD are in general consistent measurements.
- Compared with in-situ measurements, the model does not have systematic bias of surface BC concentrations in the US, but it significantly overestimates BC concentrations at the remote free troposphere.
- The surface concentrations of BC over the NH polluted regions are predominantly from their own regional pollution sources, while the source attribution for surface POM is quite different between NAM/EUR and SAS/EAS, as the former more influence by extra-regional or other sources
- Column-wise, there is also a sharp difference between NAM/EUR and SAS/EAS, as the former generally overwhelmed by the extra-regional or other sources
- The results imply that the long-range transport of carbonaceous aerosol can significantly alter the regional climate and weather