Quantifying pollution inflow and outflow over East Asia through coupling regional and global models

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HTAP Incentives for Considering Regional Processes

- Regional to urban scale processes affect pollutant inflow to receptor regions
  - Urban chemistry
  - Mountain entrainment
  - PBL top entrainment and mixing

- Synoptic to turbulent scale processes affect pollutant outflow from emissions source regions
  - Mid-latitude frontal activities and deep convection
  - Boundary layer mixing and venting
  - Mountain-valley wind systems

- Aid in global model evaluation and development
Coupling regional and global models

• Past work for HTAP/2001 with CMAQ & MOZART-GFDL
  - Sulfur & reactive nitrogen
    Lin et al. (2008a), AE
    Lin et al. (2008b), AE
  - Ozone & its precursors
    Holloway et al. (2007), AE
    Lin et al. (2009), ACP

• Current work for HTAP/2001 with WRF-Chem & MOZART-GFDL

• Future work for 2005/2006 with WRF-Chem & MOZART-NCAR
Outstanding Questions:

- How do regional processes affect imported pollutants; how do predicted S/R relationships vary within a region?

- How sensitive are the predictions of pollution export to resolution-dependent processes?

- What fine-scale transport & chemistry processes are responsible for the discrepancies between regional and global models?
European Inflow

5 * 20% EU → EA surface ozone

WRF-Chem
- High over mountains
- Low over megacities

MOZART

Terrain Height
Vertical profile of EU inflow
-- along 45N during a cold front sweeping over EA --

- Pollutants are transported in the BL and lower FT more efficiently in WRF-Chem
- Orographic forcing might play an important role
Summary on Pollution Import

- Impacts of HTAP on surface ozone vary greatly within a receptor region depending on local topography and atmospheric constituents.
- Entrainment of upper BT & lower FT air → high HTAP signal at the mountain top.
- Mixing with strong NO$_x$ emissions at megacities → weakened enhancement on surface ozone.

Surface O$_3$ in March 2001
Episodic frontal outflow -- Comparison with TRACE-P

2001-03-07 (UTC)
Vertical profiles of PAN

Episodic (07/03)

Monthly mean along ~137.5E

Altitude (km)

MOZ

WRF

OBS

ppbv
Summary on pollution export

- WRF-Chem successfully simulates the timing, location, and magnitude of frontal outflow; MOZART places outflow too low, too weak

- Treatment of convective transport and resolution of orographic features may be responsible for MOZART biases

- Our results suggest that MOZART (and perhaps other HTAP global models) might underestimate Asian outflow to free troposphere
Conclusions

- Regional models highlight the importance of fine-scale processes in determining HTAP import and export.
- The regional WRF-Chem model suggests less impacts of HTAP on surface ozone, in particular at megacities.
- The regional WRF-Chem model also suggests greater pollution export than the global MOZART model, in particular during convective transport.

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