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

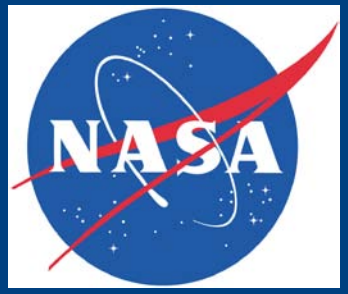
Meiyun Lin[1] (*mlin26@wisc.edu*)

Tracey Holloway[1], Greg R. Carmichael[2], Arlene M. Fiore[3]

[1]Center for Sustainability and the Global Environment (SAGE), Univ. of Wisconsin-Madison

[2]Center for Global and Regional Environmental Research, Univ. of Iowa

[3]NOAA Geophysical Fluid Dynamics Laboratory (GFDL)

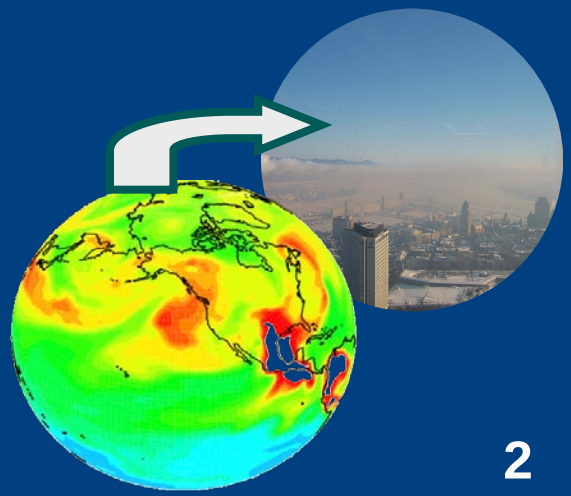


HTAP Incentives for Considering Regional Processes

- 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



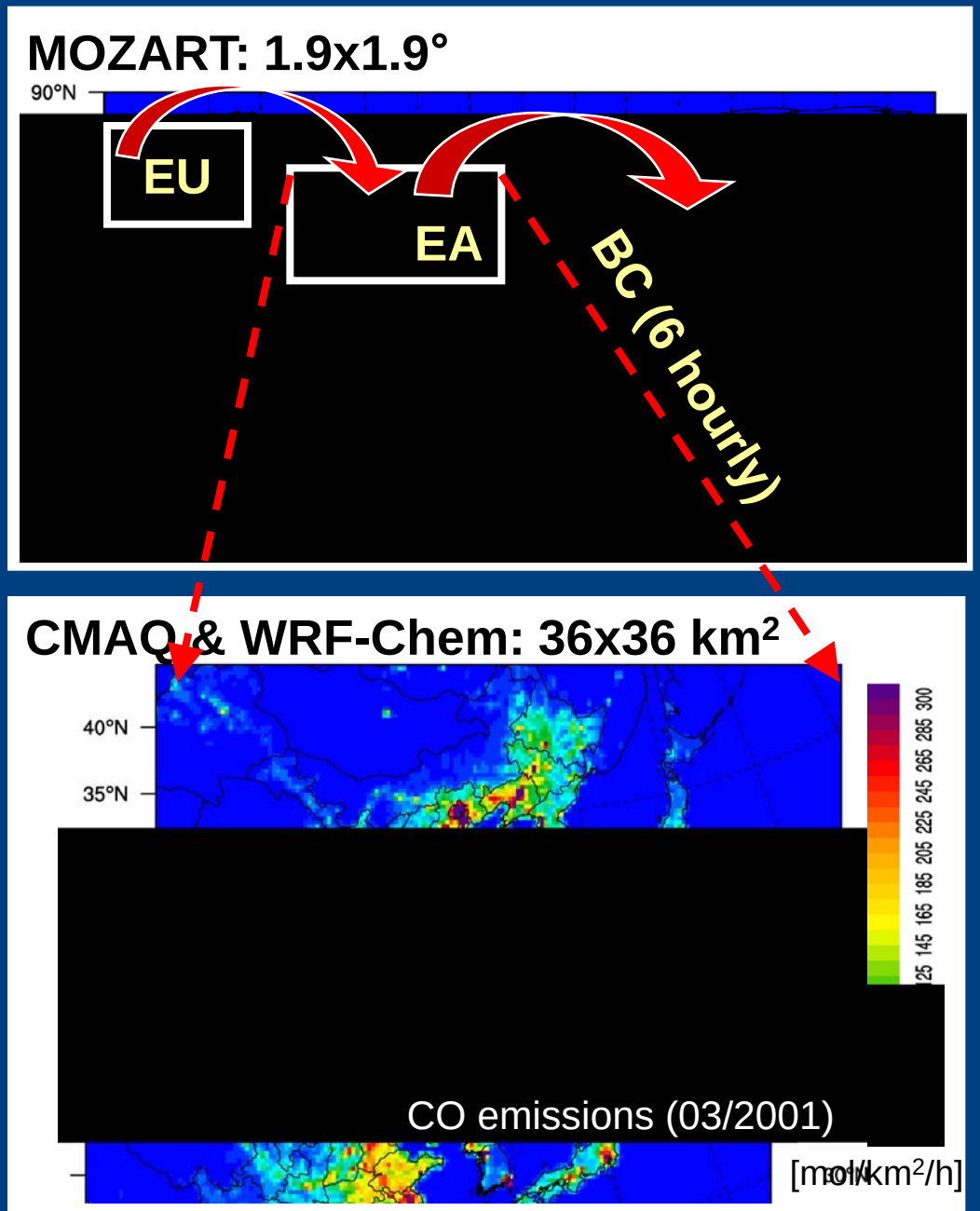
Coupling regional and global models

- 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

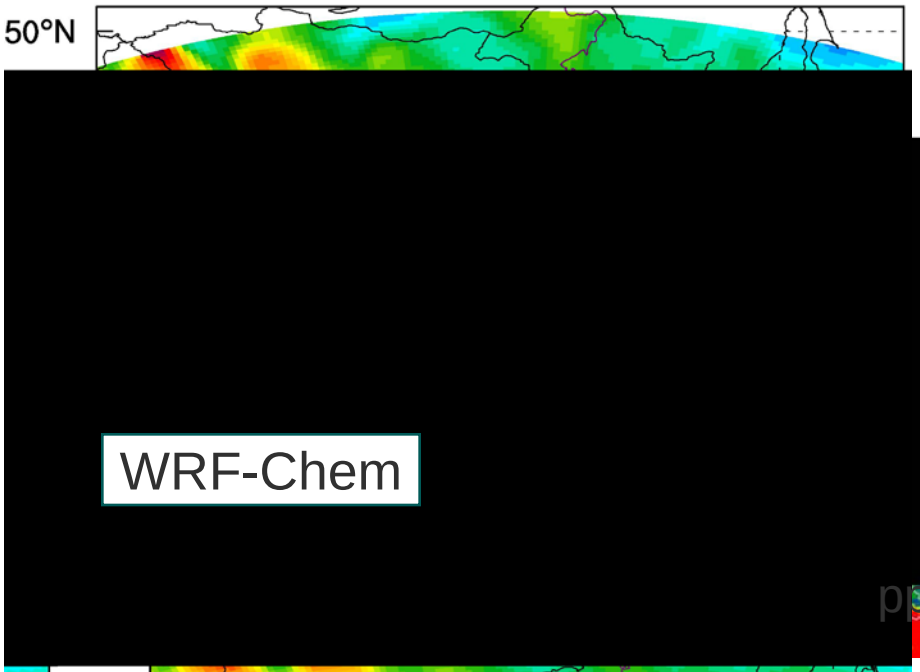


Outstanding Questions:

- 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

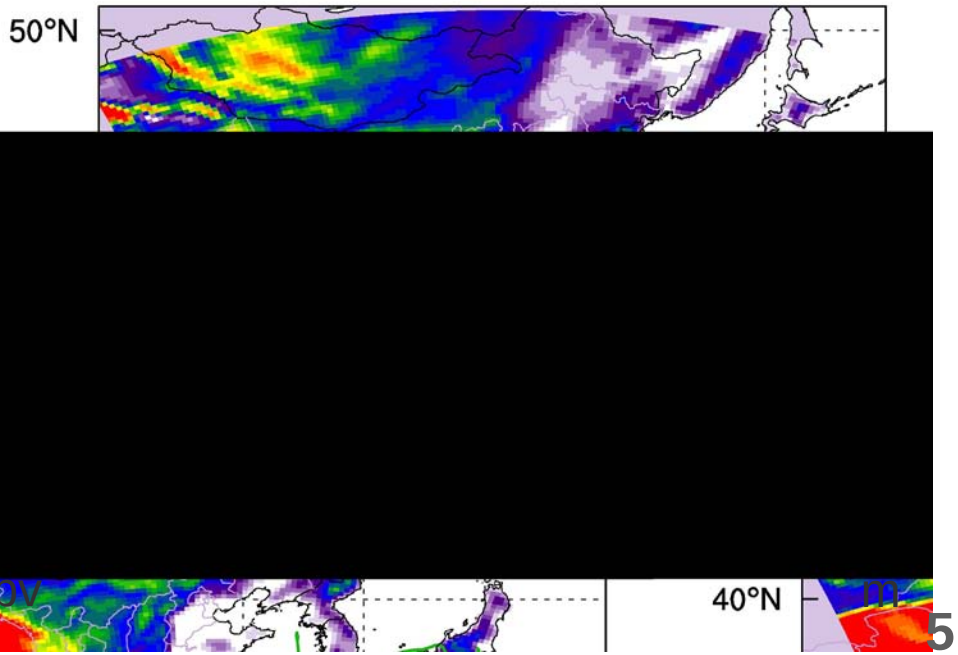
5 * 20% EU→ EA surface ozone



WRF-Chem

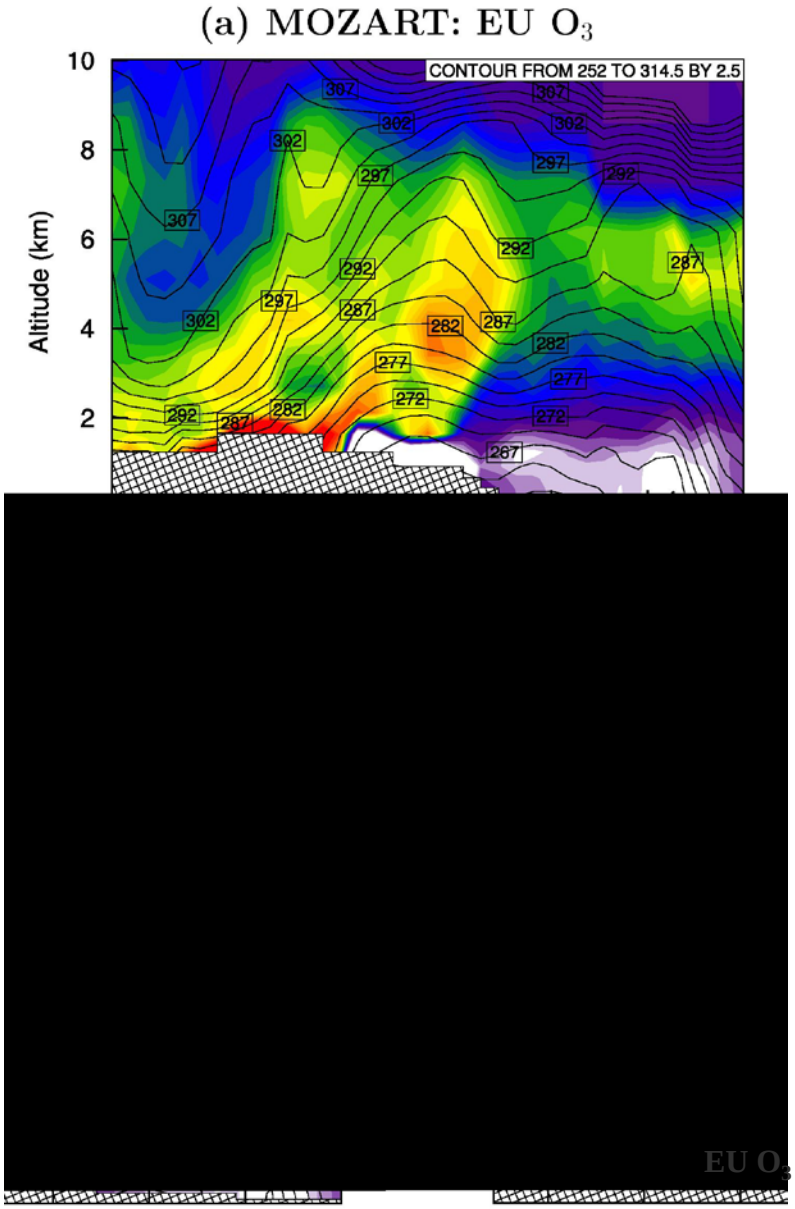
- High over mountains
- Low over megacities

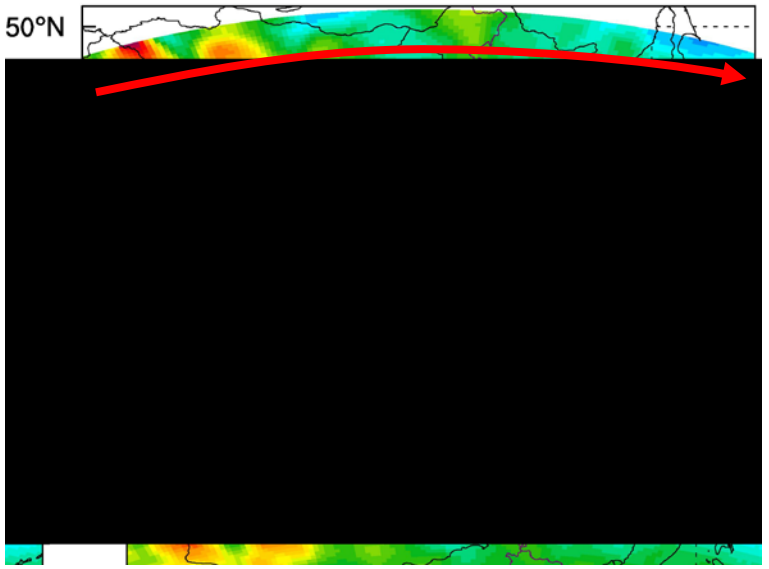
Terrain Height



Vertical profile of EU inflow

-- along 45N during a cold front sweeping over EA --





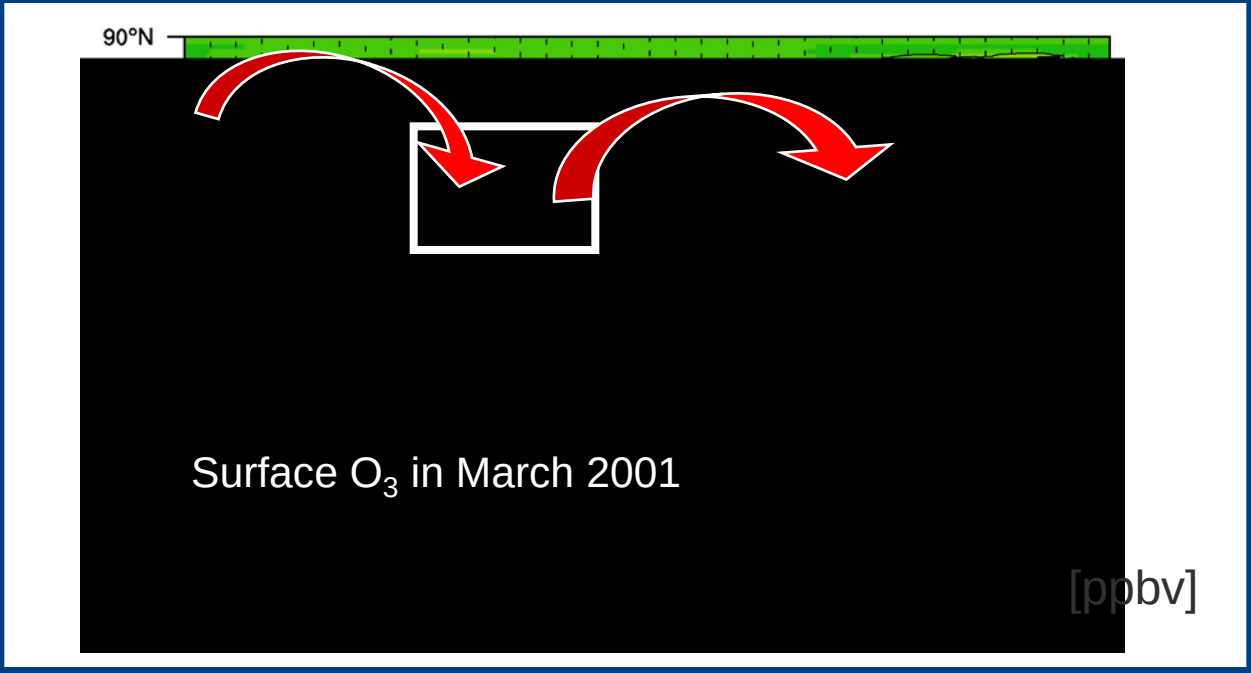
- Pollutants are transported in the BL and lower FT more efficiently in WRF-Chem
- Orographic forcing might play an important role

Summary on Pollution Import

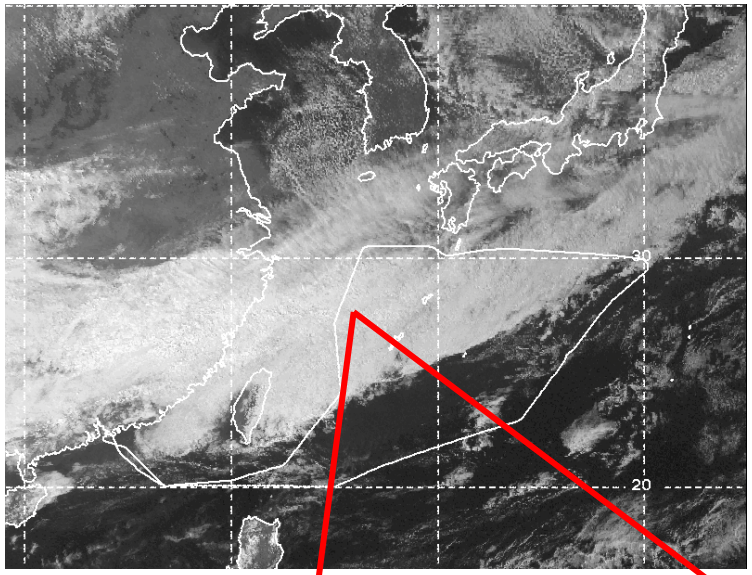
- Impacts of HTAP on surface ozone vary greatly within a receptor region depending on local topography and atmospheric constituents
- Entrainment of upper BT & lower FT air

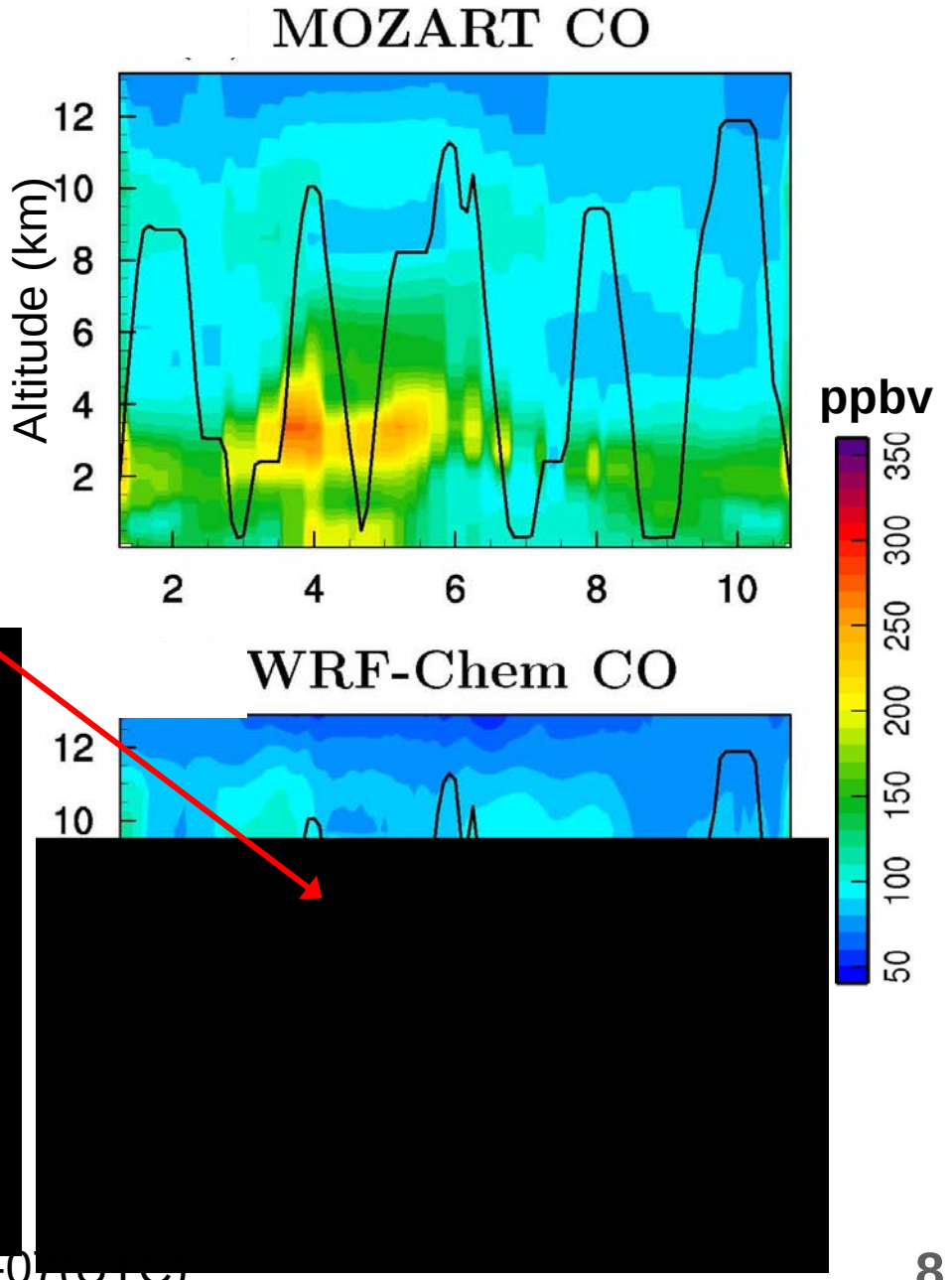
  → high HTAP signal at the mountain top
- Mixing with strong NO_x emissions at megacities

  → weakened enhancement on surface ozone



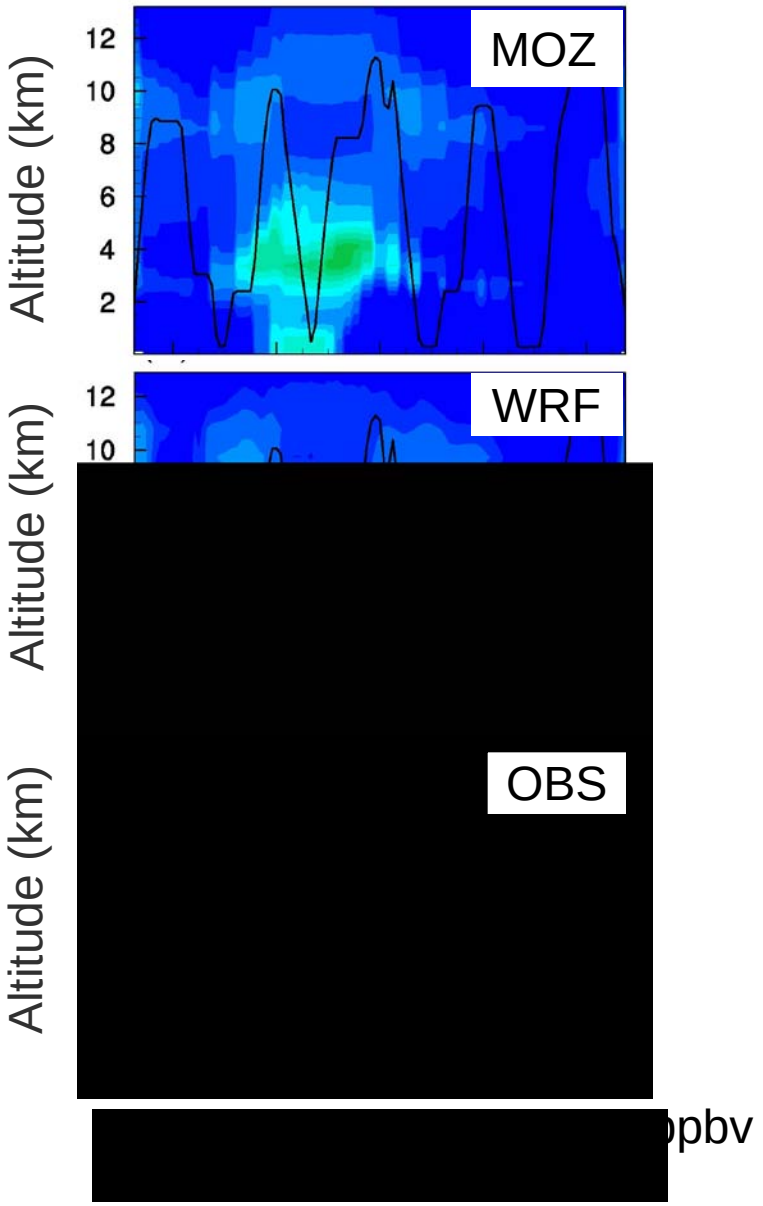
Episodic frontal outflow --Comparison with TRACE-P



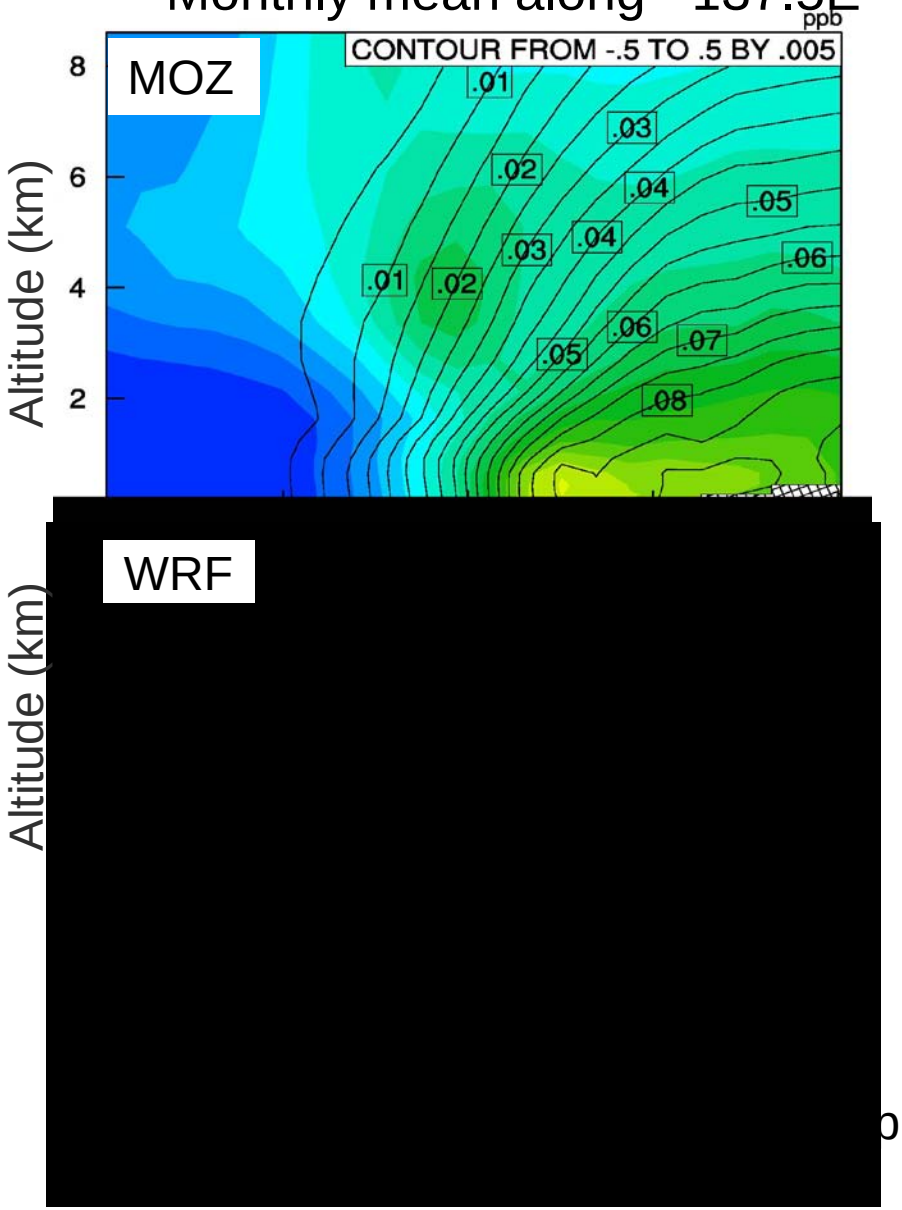


Vertical profiles of PAN

Episodic (07/03)

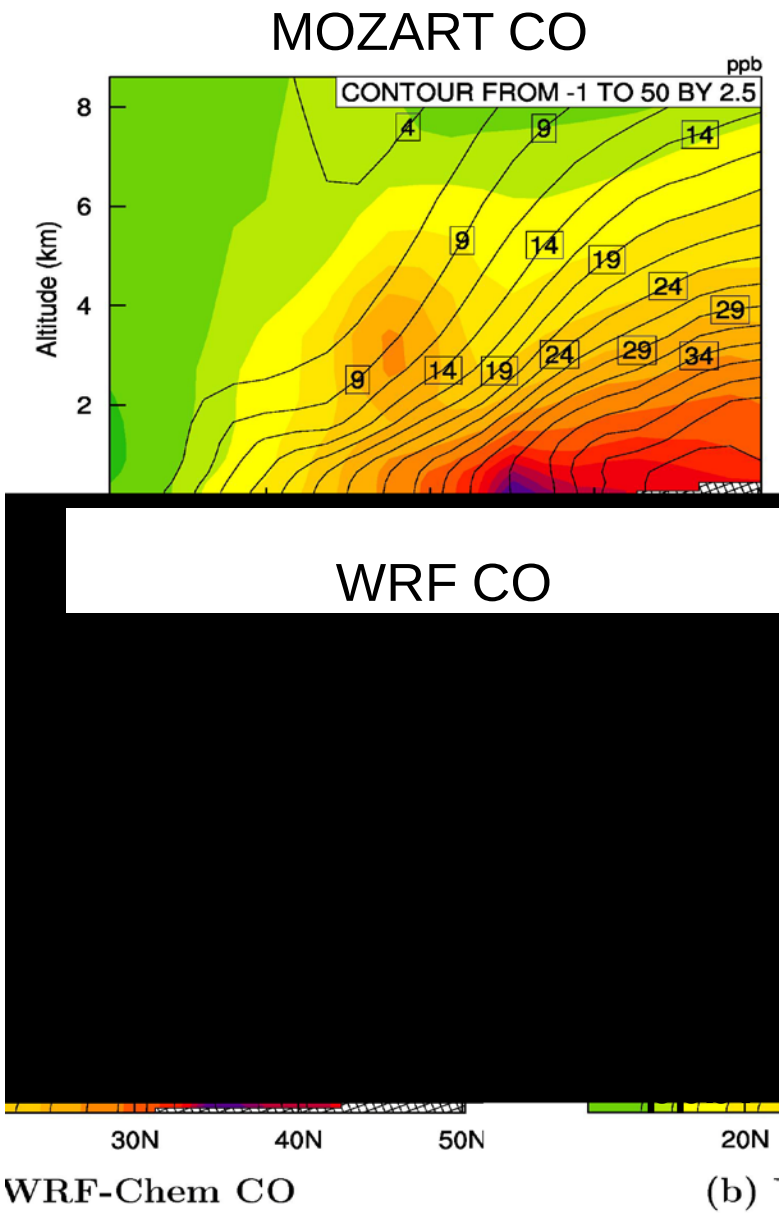


Monthly mean along ~137.5E



Summary on pollution export

Monthly mean conc. along 137.5E



- 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

Meiyun Lin
(*mlin26@wisc.edu*)