Preliminary Ozone Results from the TF HTAP Model Intercomparison

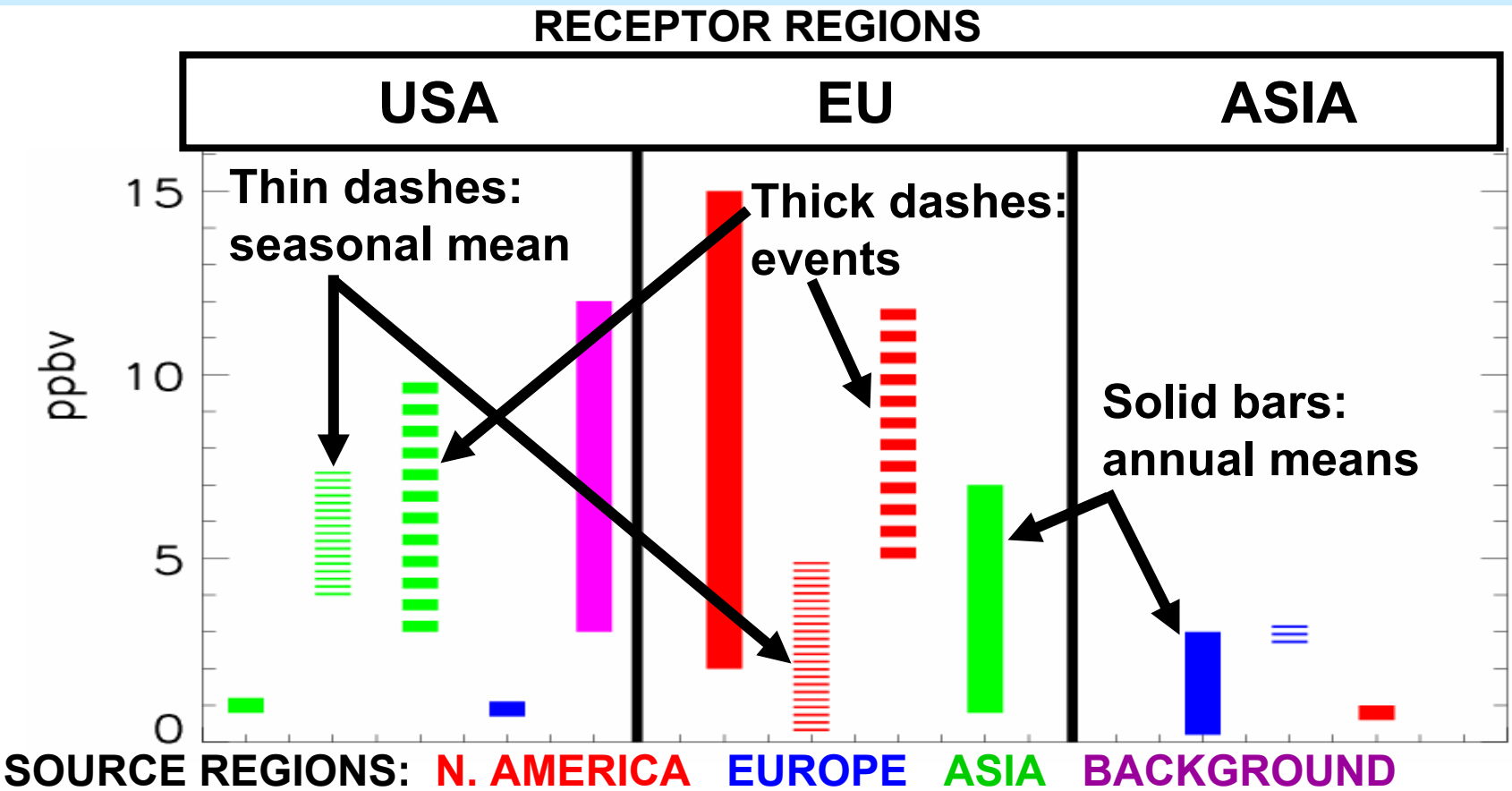
Arlene M. Fiore
(arlene.fiore@noaa.gov)

Kees Cuvelier, Frank Dentener (JRC)
and the HTAP Modeling Team

Task Force on Hemispheric Transport of Air Pollution

HTAP Observations Workshop, WMO, Geneva, January 25, 2007

Literature Estimates of Surface O_3 Enhancements at Northern Mid-latitudes from Hemispheric Transport



Estimates are from studies cited in current draft of Interim report Ch5 Section B, updated from tables in *Holloway et al.*, *ES&T*, 2003 and *Fiore et al.*, *EM*, 2003

Difficult to conduct meaningful assessment due to differences in: 1) methods 2) regional definitions 3) reported metrics

Overview of HTAP Model Intercomparison for Ozone

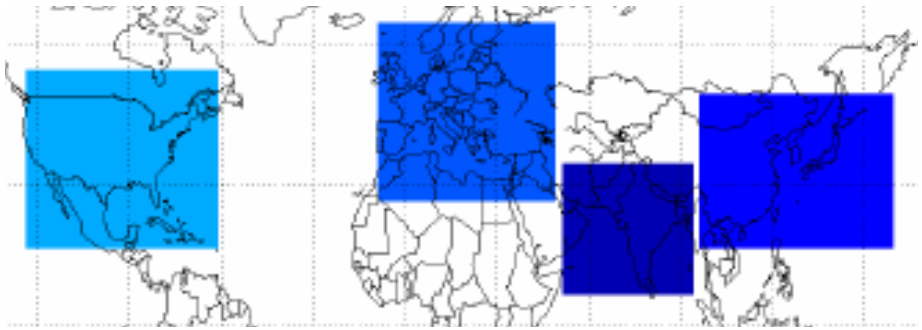
OBJECTIVES: Quantify source-receptor relationships for HTAP regions and assess uncertainties in these estimates

APPROACH: Conduct base simulation with 3-D models

- → horizontal resolution of 4°x5° or finer
- → 2001 meteorology
- → each group's best estimate for emissions in 2001
- → methane set to a uniform value of 1760 ppb

Conduct sensitivity simulations (17 total)

HTAP Source-Receptor Regions

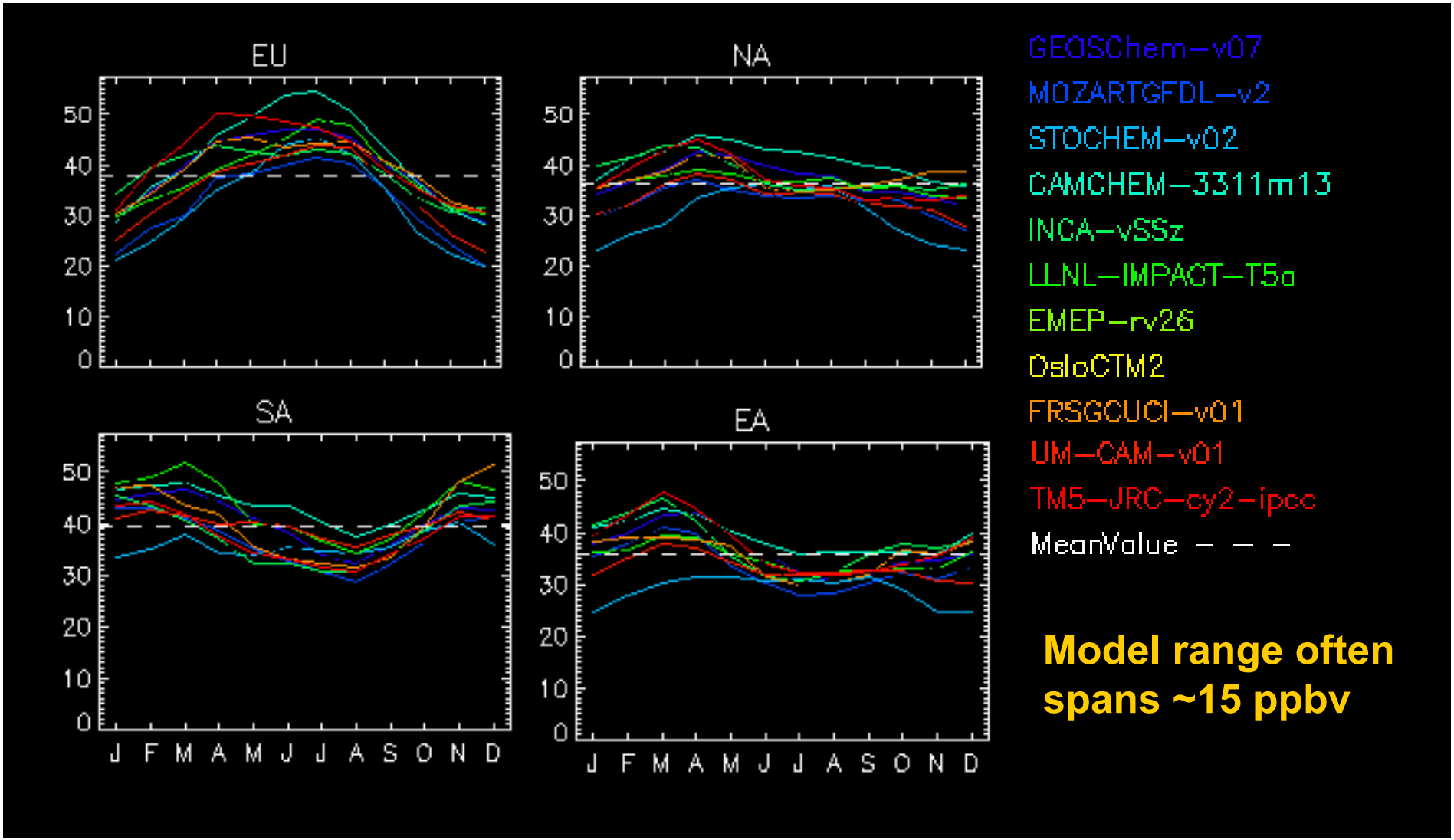


20% decreases in:

- ➢ anthrop. emis. in HTAP regions for NO_x, CO, NMVOC individually
- ➢ anthrop. emis. of all O_3 and aerosol precursors in HTAP regions
- ➢ global CH_4

~ 14 modeling groups have already delivered results for Experiment 1

Seasonal Cycles in Simulated Surface O_3 over HTAP Regions: Results from Individual Models



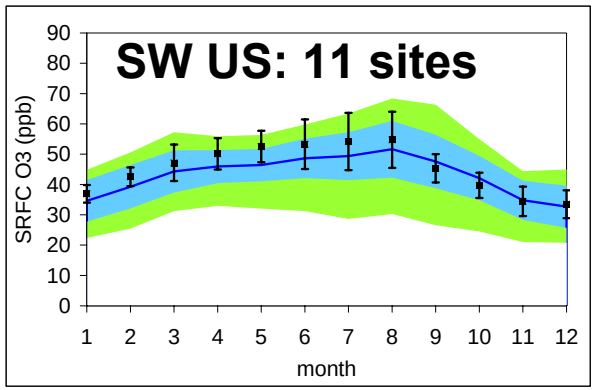
Model range often spans ~15 ppbv

Previous ACCENT Multi-model Surface O_3 vs. Observations in HTAP Regions: NA and EU

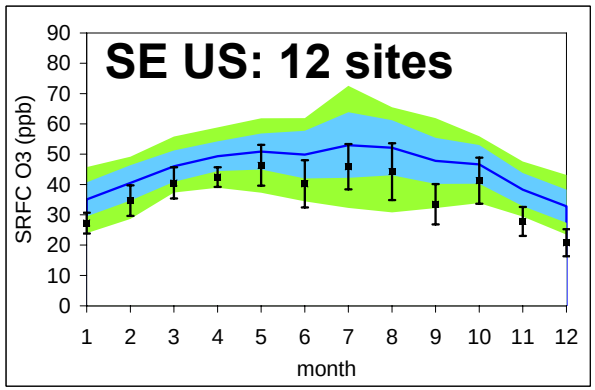
OBS Multi-model mean standard deviation range

North America

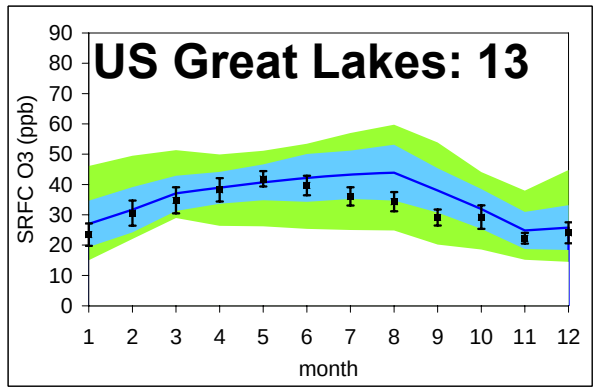
SW US



SE US

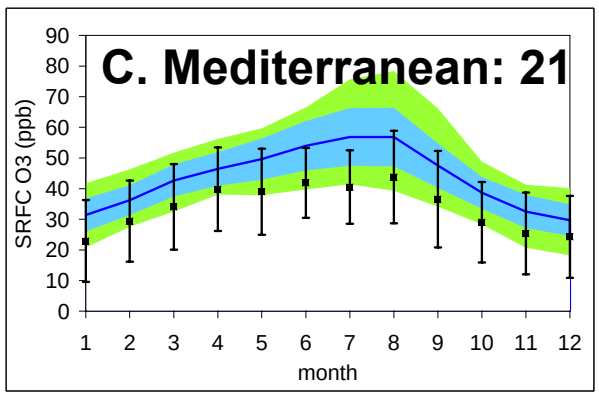


US Great Lakes

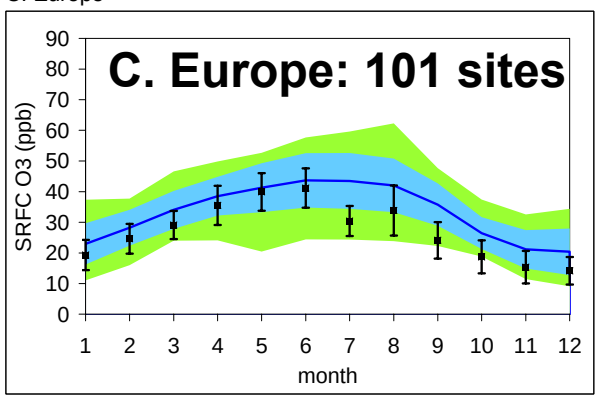


Europe and North Africa

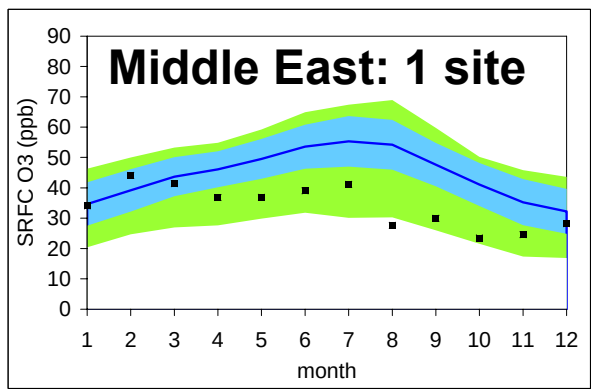
C. Mediterranean



C. Europe



Middle East



Ellingsen et al., in prep

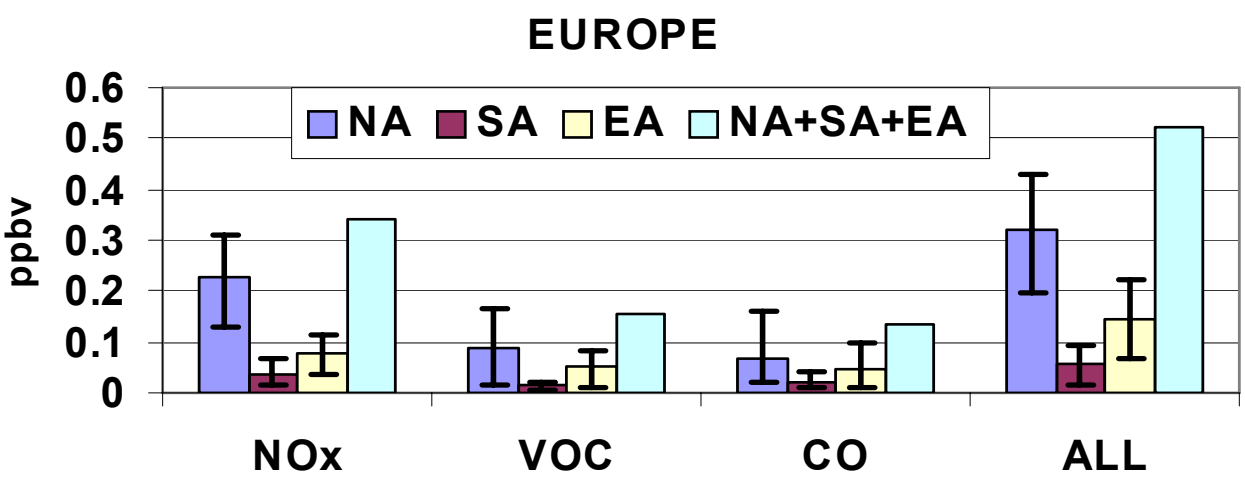
How Should We Test Models of Hemispheric O_3 Transport?

→ **Signatures of intercontinental transport in tracer correlations?**
→ **Observation-based estimates of HTAP?**

OBSERVATIONAL DATASETS FOR 2001

- Field campaigns (TRACE-P, ACE-Asia, PHOBEA-II, CONTRACE, STACCATO)
- Vertical profiles (e.g. sonde network, MOZAIC, long-term sites)
- Satellites
- Surface monitoring networks (CASTNet/AIRS; EMEP; EANET)
- Event-based analysis at sites where long-range transport has been detected?
- Others?

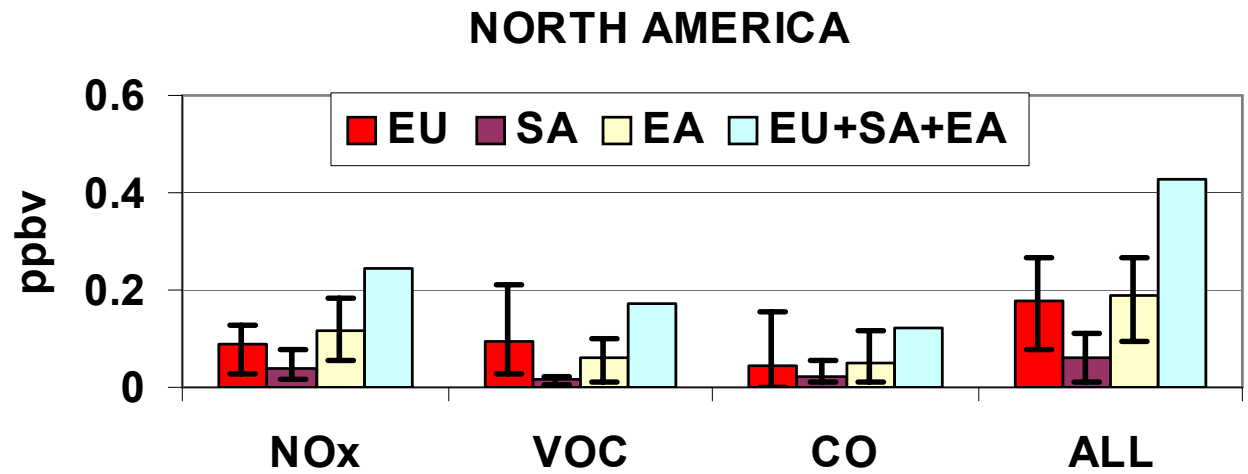
Annual Mean Surface O_3 Decrease in HTAP Receptor Regions from 20% Reductions of O_3 Precursors



Multi-model means indicate:

NA contributes most

EU→EU 0.5 0.4 0.1 1.0 ppbv (multi-model mean)

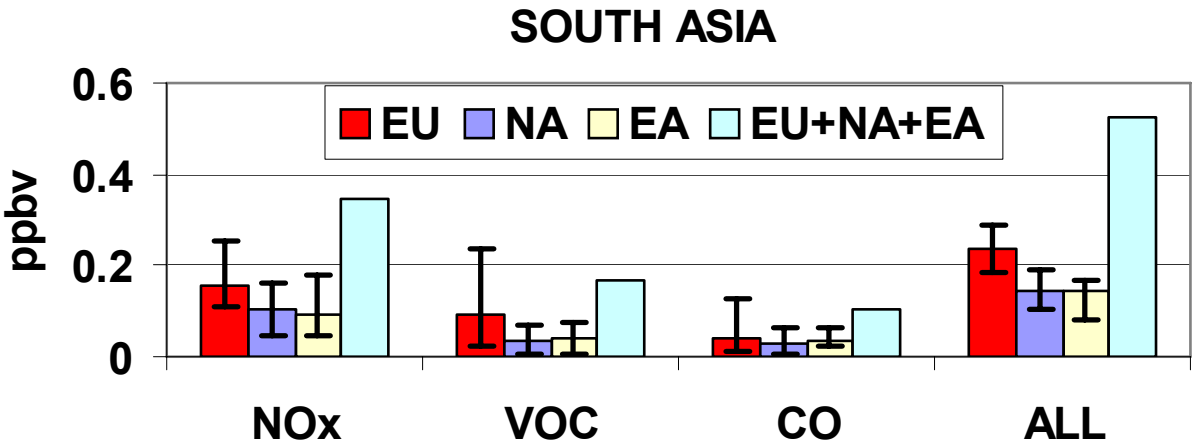


EA/EU contribute similarly

EU VOC at least as important as NO_x

NA→NA 0.8 0.2 0.2 1.1 ppbv

Annual Mean Surface O_3 Decrease in HTAP Receptor Regions from 20% Reductions of O_3 Precursors

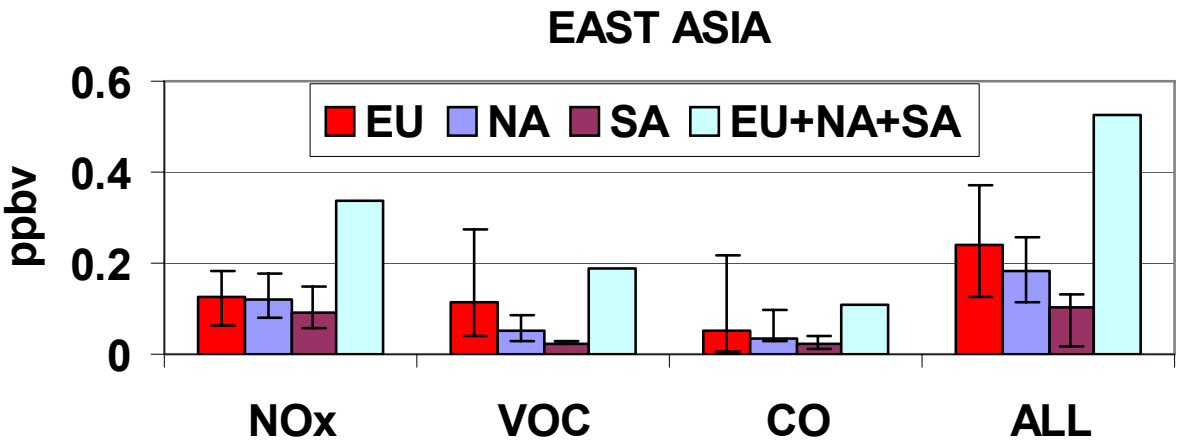


SA→SA 1.1 0.2 0.2 1.1 ppbv

Multi-model means indicate:

EU contributes most

EA contribution ≈ NA



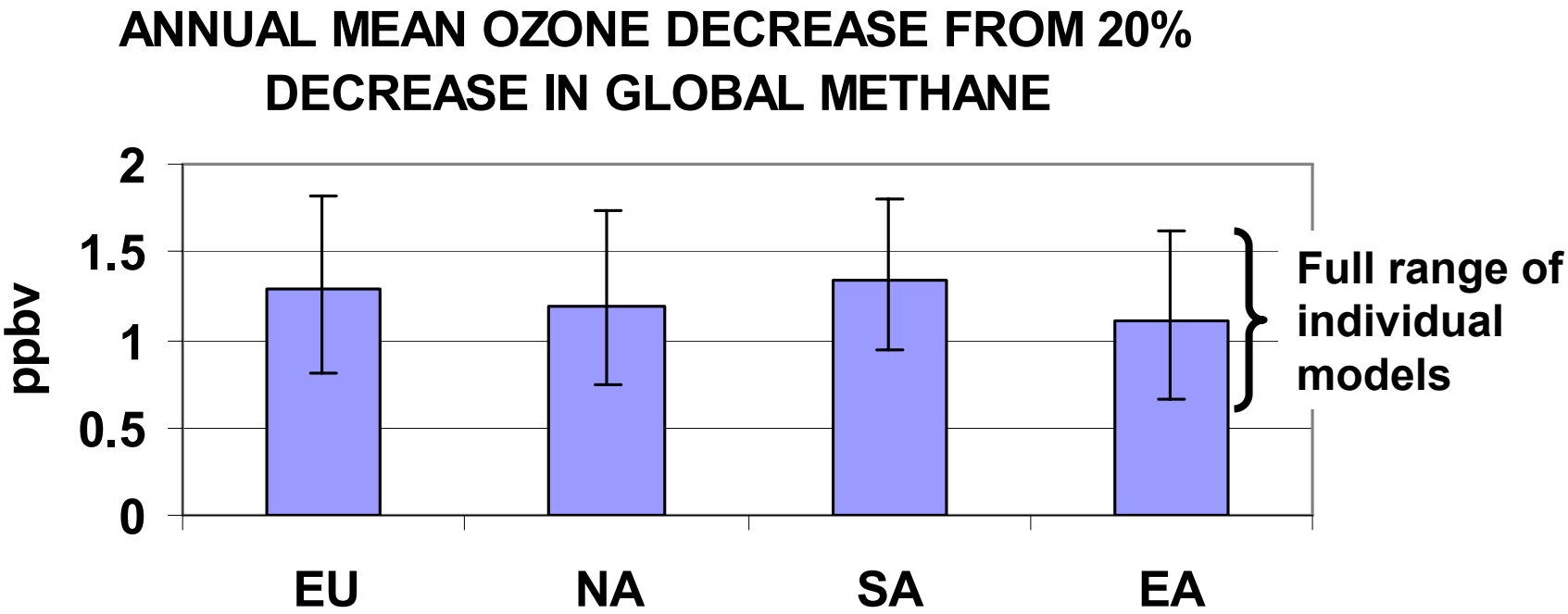
EA→EA 0.6 0.2 0.2 0.9 ppbv

EU and NA NO_x contribute similarly but stronger EU VOC influence

EU and NA > SA

Does response to 20% reductions scale linearly to other magnitudes?

Surface Ozone Decreases Similarly in all HTAP Regions When Global Methane is Reduced



→ 1 ppbv O_3 decrease over all NH receptor regions

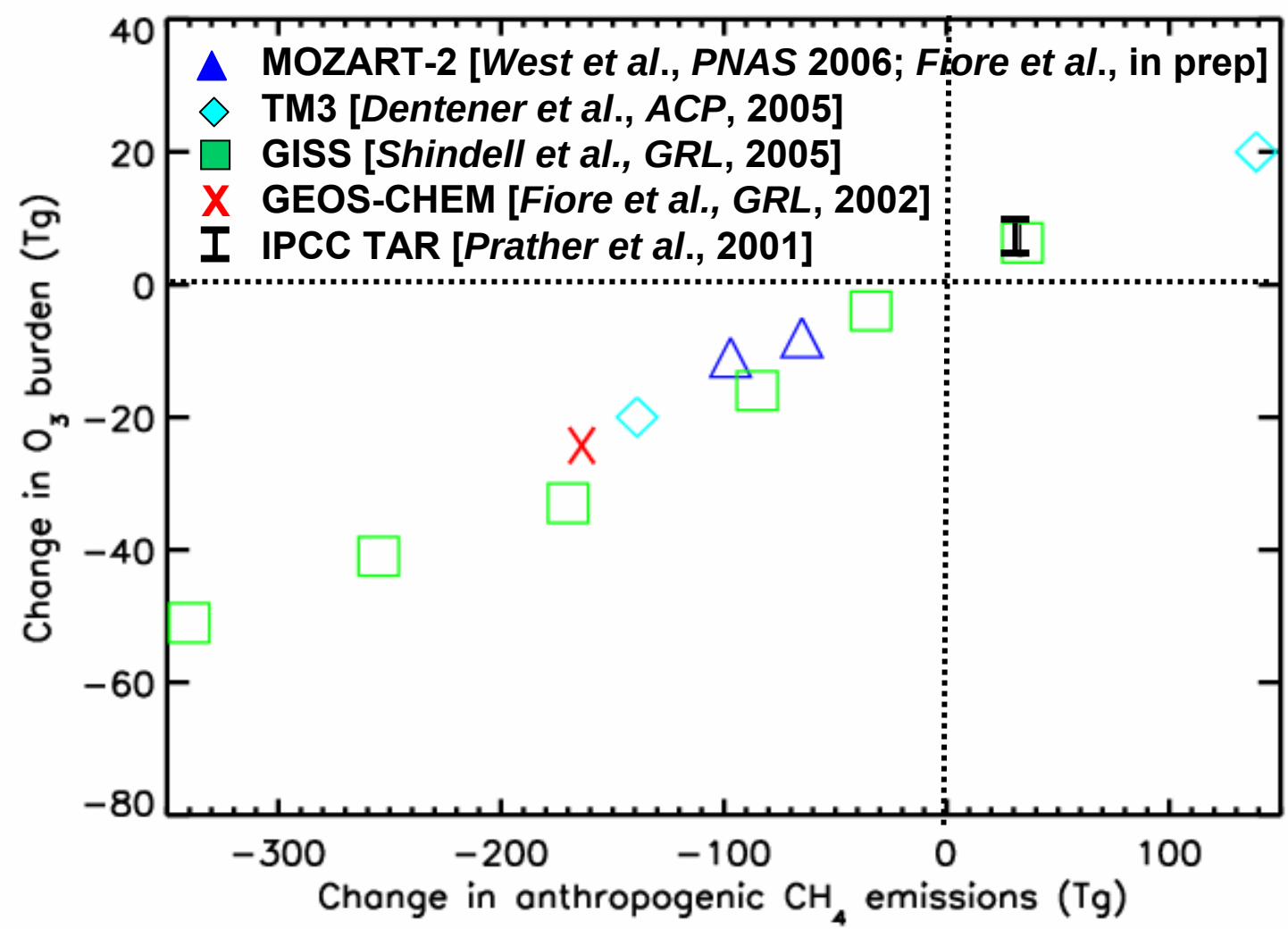
→ Consistent with prior studies

What causes the ~1 ppb range across individual models?

-- examine ozone production efficiency; NO_x:VOC ratios

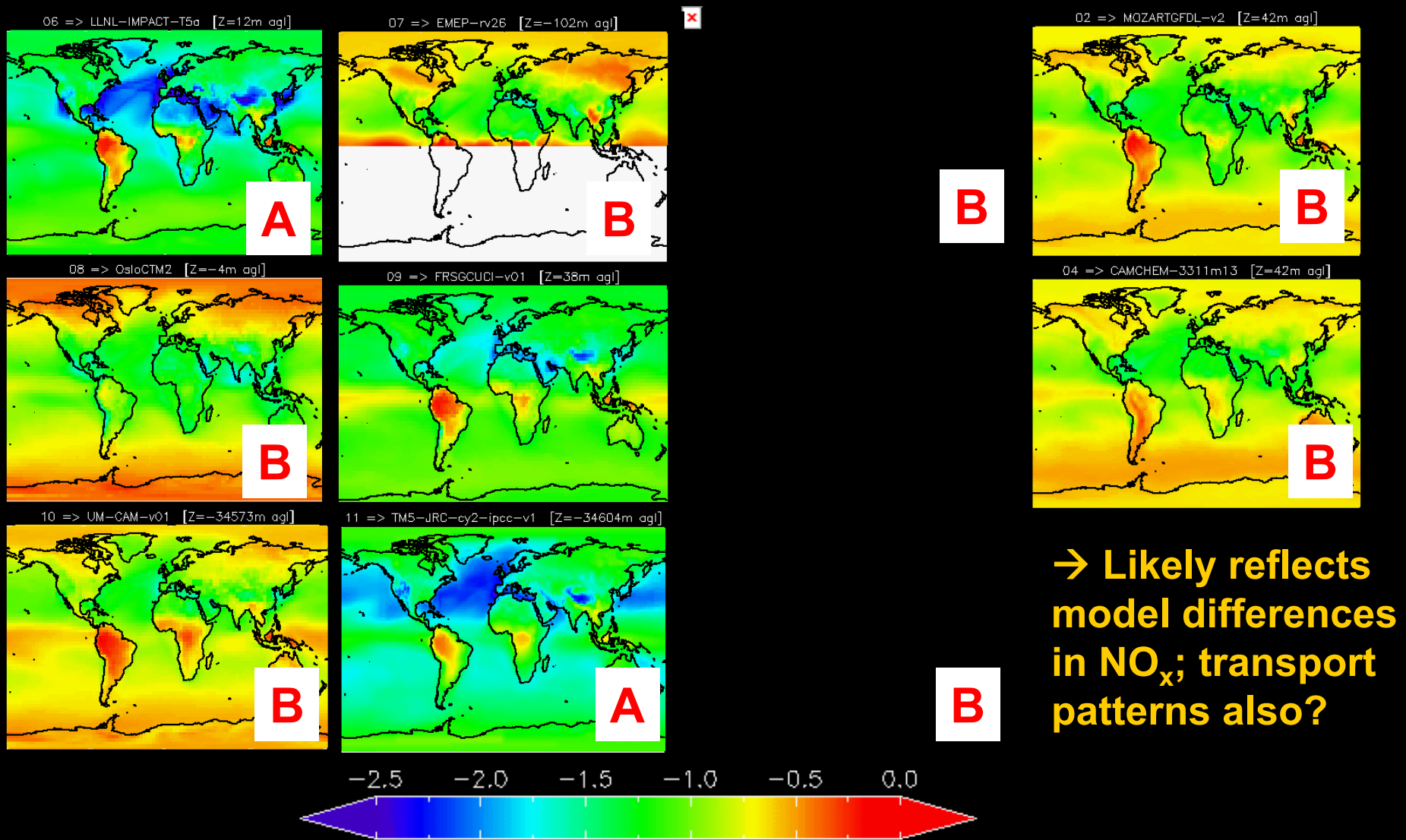
Is there seasonality in the response?

Tropospheric O_3 Responds Approximately Linearly to Anthropogenic CH_4 Emission Changes Across Models



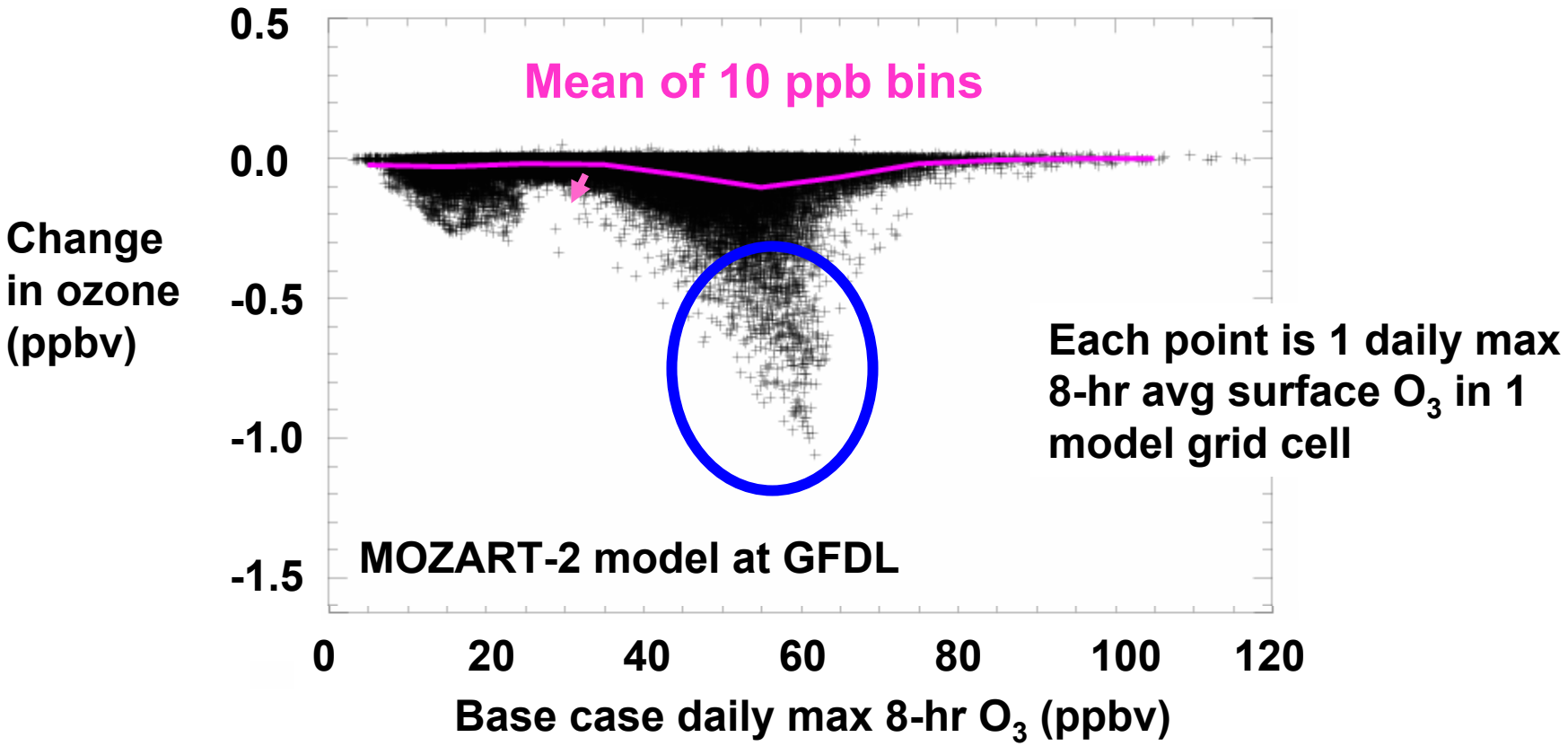
Anthropogenic CH_4 contributes ~50 Tg (~15%) to tropospheric O_3 burden
~5 ppbv to surface O_3

Annual Mean Surface O_3 Response to Global CH_4 Decrease of 20% in HTAP Models



→ Likely reflects model differences in NO_x; transport patterns also?

Example Analysis From One Model: Impact of a 20% Decrease in NA Anthropogenic NO_x to EA Surface O_3 (Jun 1 - Aug 31 2001)



Intercontinental influence typically largest near the middle of the overall O_3 distribution

→Consistent with prior work on intercontinental influence on O_3 in surface air over the United States [*Fiore et al*., 2002] and Europe [*Li et al*., 2002]

What Next?

- JRC will distribute a visualization tool
- Normalize by applied emissions perturbations
- Examine seasonality of hemispheric transport of O_3
- Impacts on deposition
- Any obvious dependence on horizontal resolution?
- Can we scale to reductions of different magnitude?
- Contribution to O_3 episodes, clean conditions, e.g. compare intercontinental contribution to O_3 at the 10^{th}, 50^{th}, 90^{th} percentiles of O_3 distribution for a given season

Preliminary (!) Conclusions on HTAP Source-Receptor Relationships

- Range of estimates narrows from that in the literature under a coherent modeling framework.
- 20% decreases of NO_x, NMVOC, CO individually in an HTAP region reduce annual mean surface O_3 over receptor regions by <0.2 ppbv.

  -- Largest contributions from NO_x everywhere, and European NMVOC
- 20% reductions of NO_x+NMVOC+CO in HTAP regions yield responses over the receptor regions that are ~20% of the decrease from equivalent reductions in domestic emissions.
- 20% reductions in global CH_4 abundances yield ~1 ppbv (0.7-1.8 range from individual models) decrease in annual mean surface O_3 over HTAP receptor regions.
- Reductions in individual O_3 precursors appear to be fairly additive (to within 20-30%).