TF HTAP Multi-model Estimates of Intercontinental Source-Receptor Relationships for Ozone Pollution

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LRTAP Long-range Transboundary Air Pollution

Task Force on Hemispheric Transport of Air Pollution

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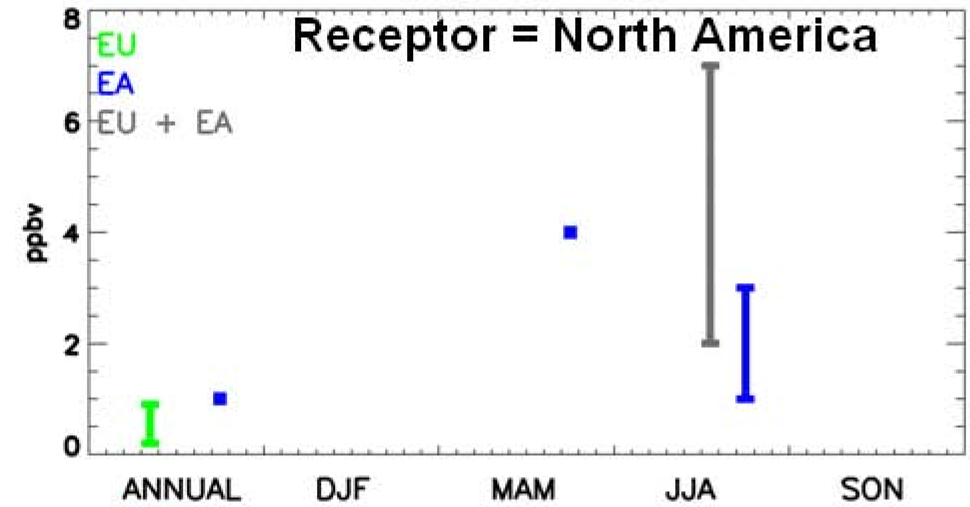
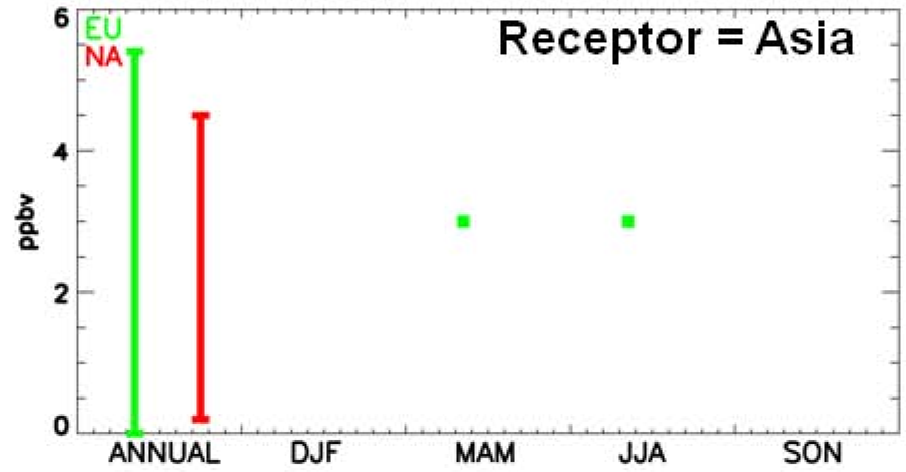
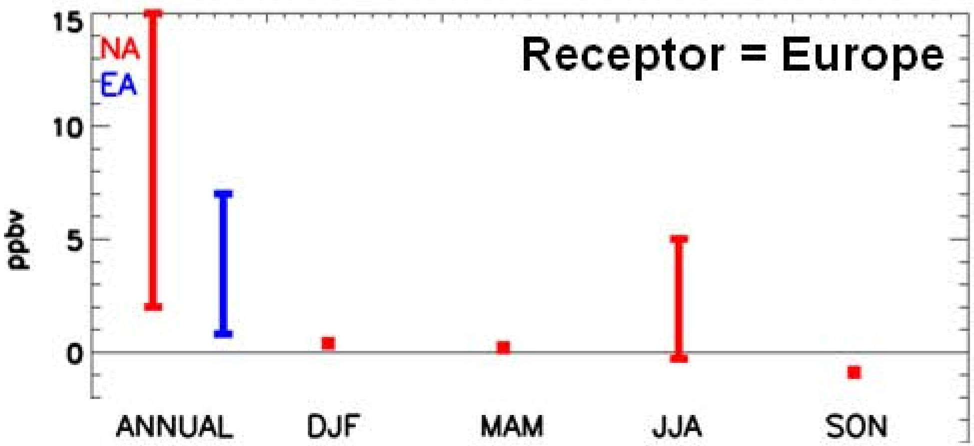
Wide range in prior estimates of intercontinental surface ozone source-receptor (S-R) relationships







Assessment hindered by different:

1) **methods**
2) **regional definitions**
3) **reported metrics**
4) **years (meteorology)**

→ **Adopt a multi-model approach**
→ **Consistency across models**
→ **Examine all seasons**

Estimates are from studies cited in TF HTAP [2007] Ch5, plus new work [*Holloway et al.*, 2008; *Duncan et al.*, 2008; *Lin et al.*, 2008]

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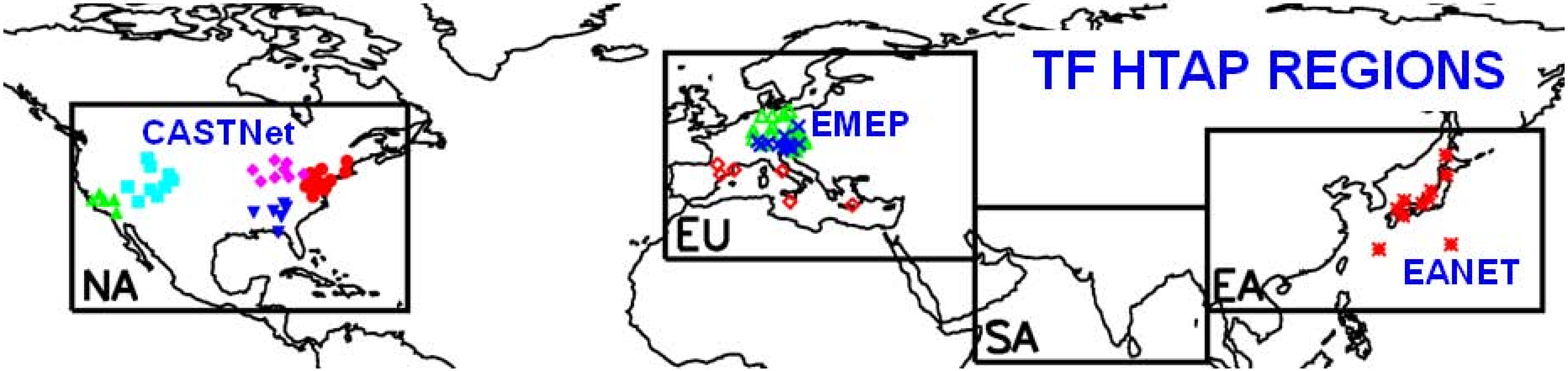
Objective: Quantify & assess uncertainties in N. mid-latitude S-R relationships for ozone



BASE SIMULATION (21 models):

→ horizontal resolution of 5°x5° or finer
→ 2001 meteorology
→ each group's best estimate for 2001 emissions
→ methane set to 1760 ppb

SENSITIVITY SIMULATIONS (13-18 models):

→ -20% regional anthrop. NO_x, CO, NMVOC emissions, individually + all together (=16 simulations)
→ -20% global methane (to 1408 ppb)

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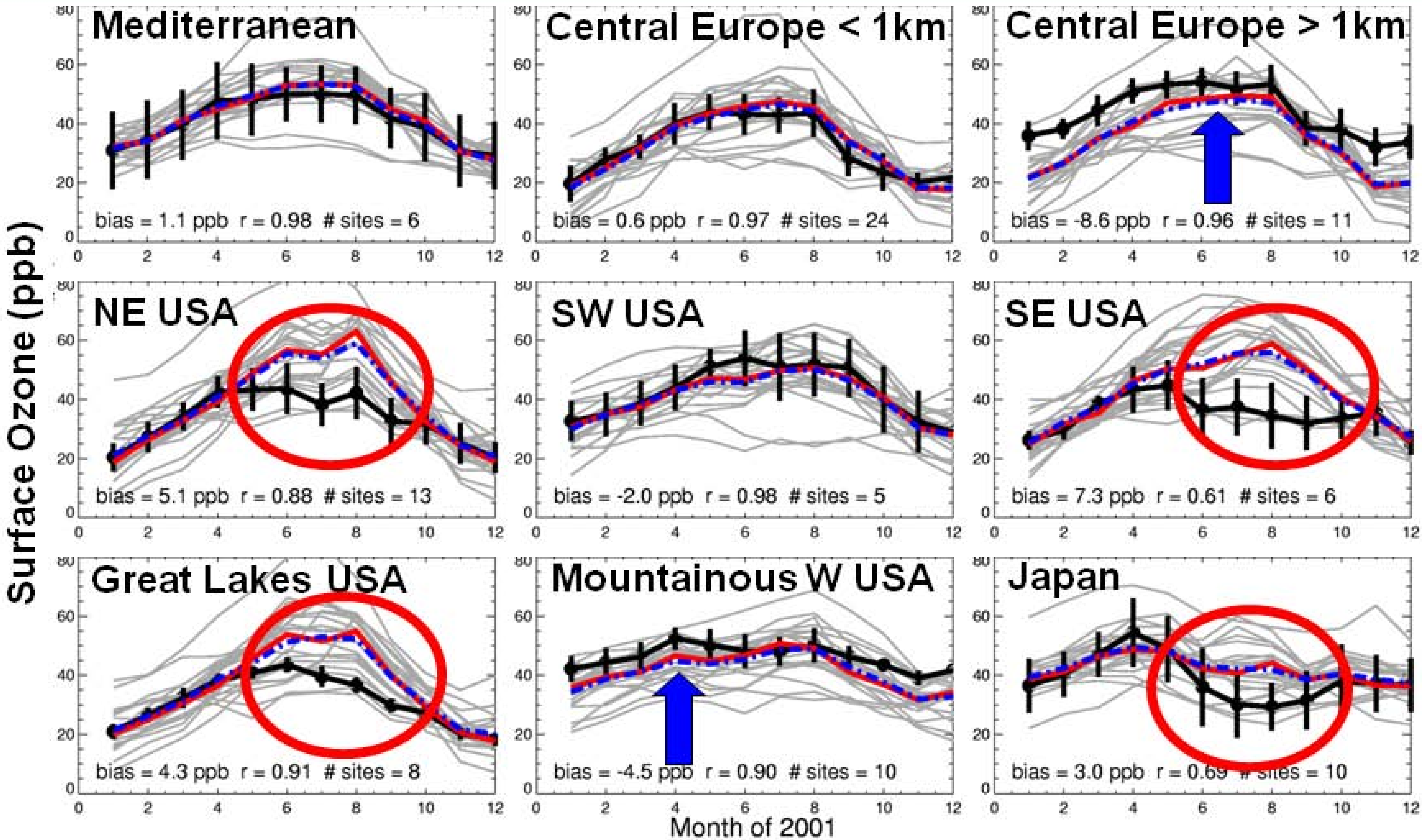
Large inter-model range; multi-model mean generally captures observed monthly mean surface O_3



→ Many models biased low at altitude, high over EUS+Japan in summer

→ Good springtime/late fall simulation

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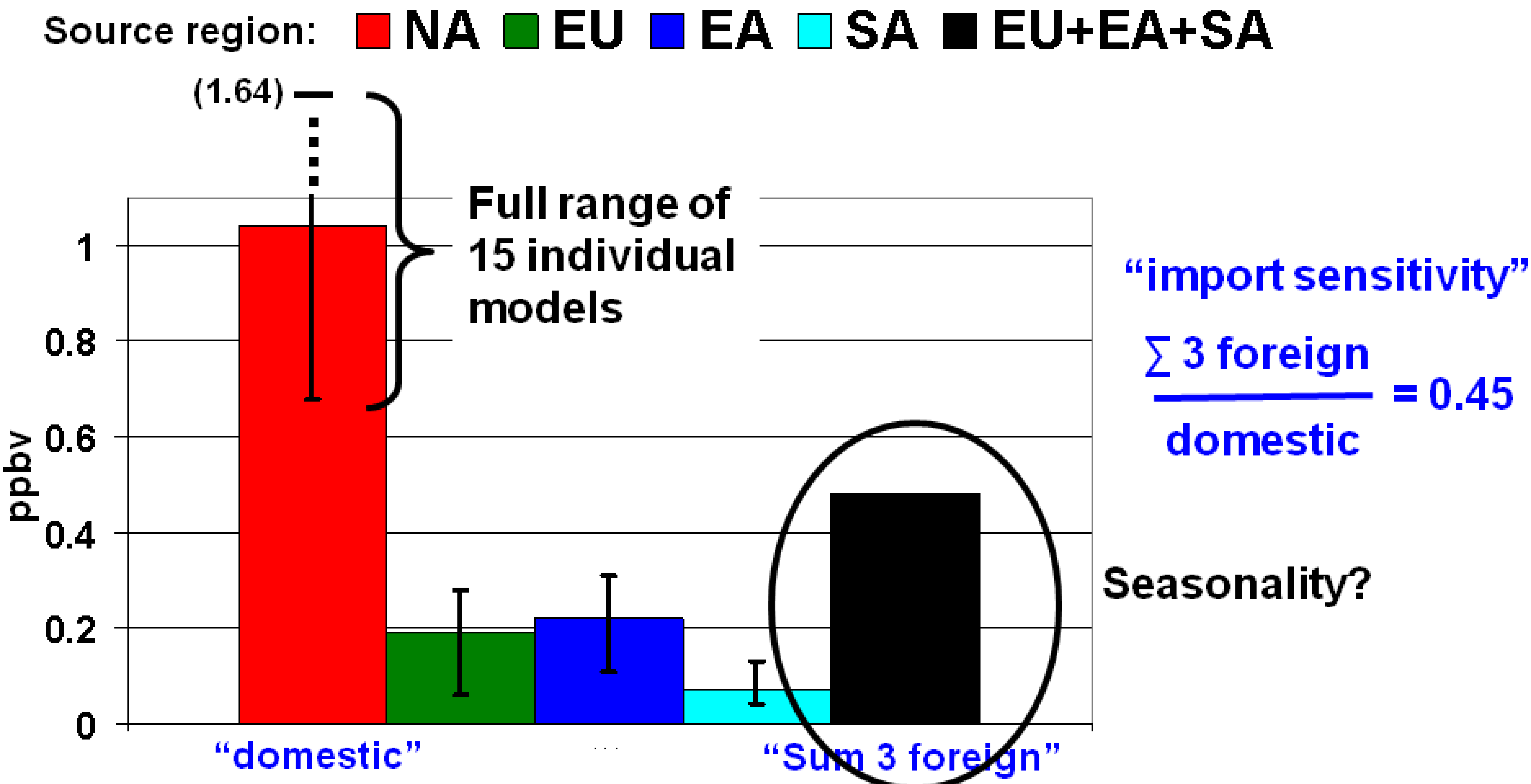
North America as a receptor of ozone pollution: Annual mean foreign vs. domestic influences

Annual mean surface O_3 decrease from -20% NOx+CO+NMVOC regional anthrop. emissions



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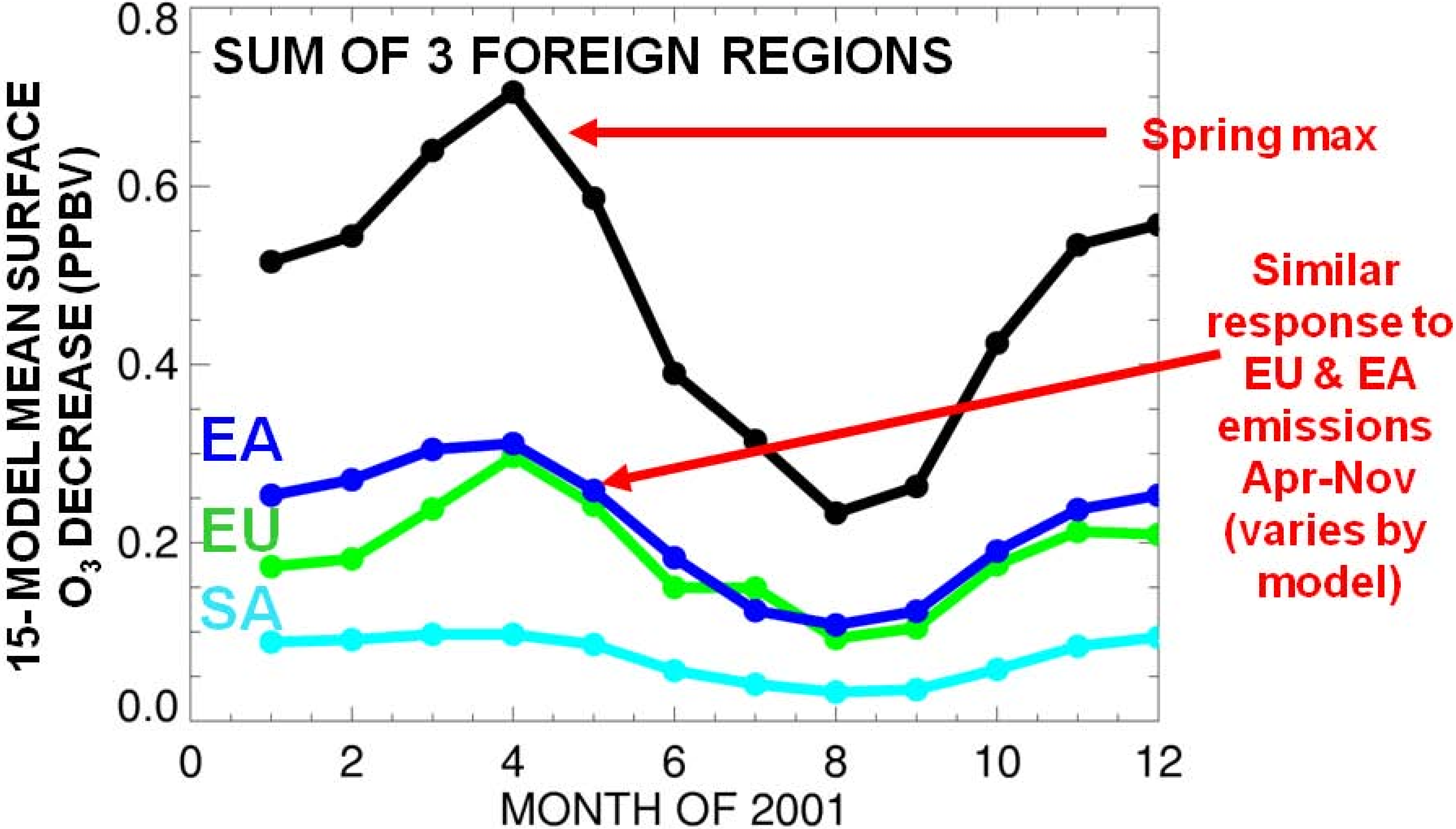
North America as a receptor of ozone pollution: Seasonality of response to -20% foreign anthrop. emissions



Spring (fall) max due to longer O_3 lifetime, efficient transport

[e.g., Wang et al., 1998; Wild and Akimoto, 2001; Stohl et al., 2002; TF HTAP 2007]

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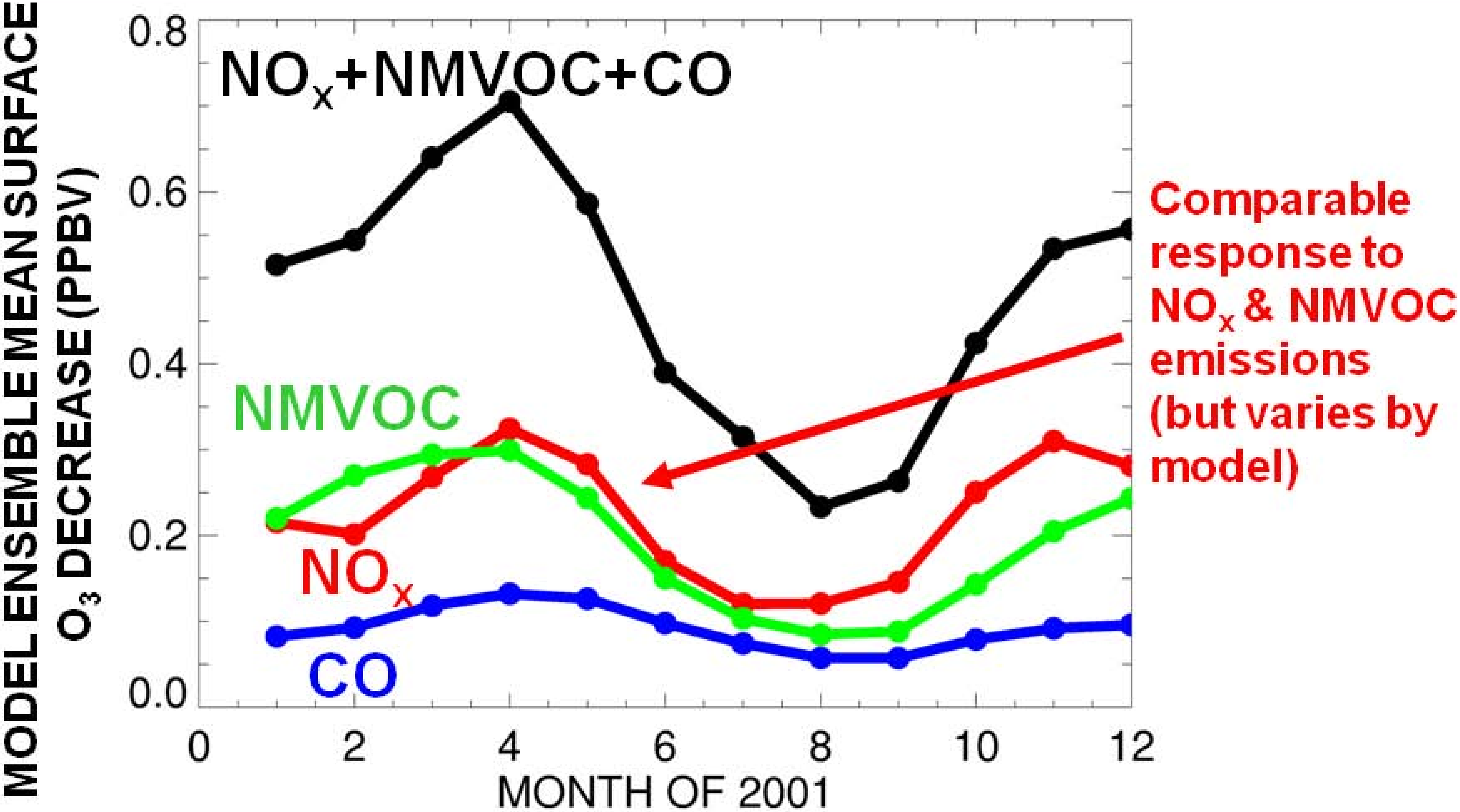
North America as a receptor of ozone pollution: Seasonality of response to -20% foreign anthrop. emissions



Wide range in EU anthrop. NMVOC inventories → large uncertainty in the estimated response of NA O_3

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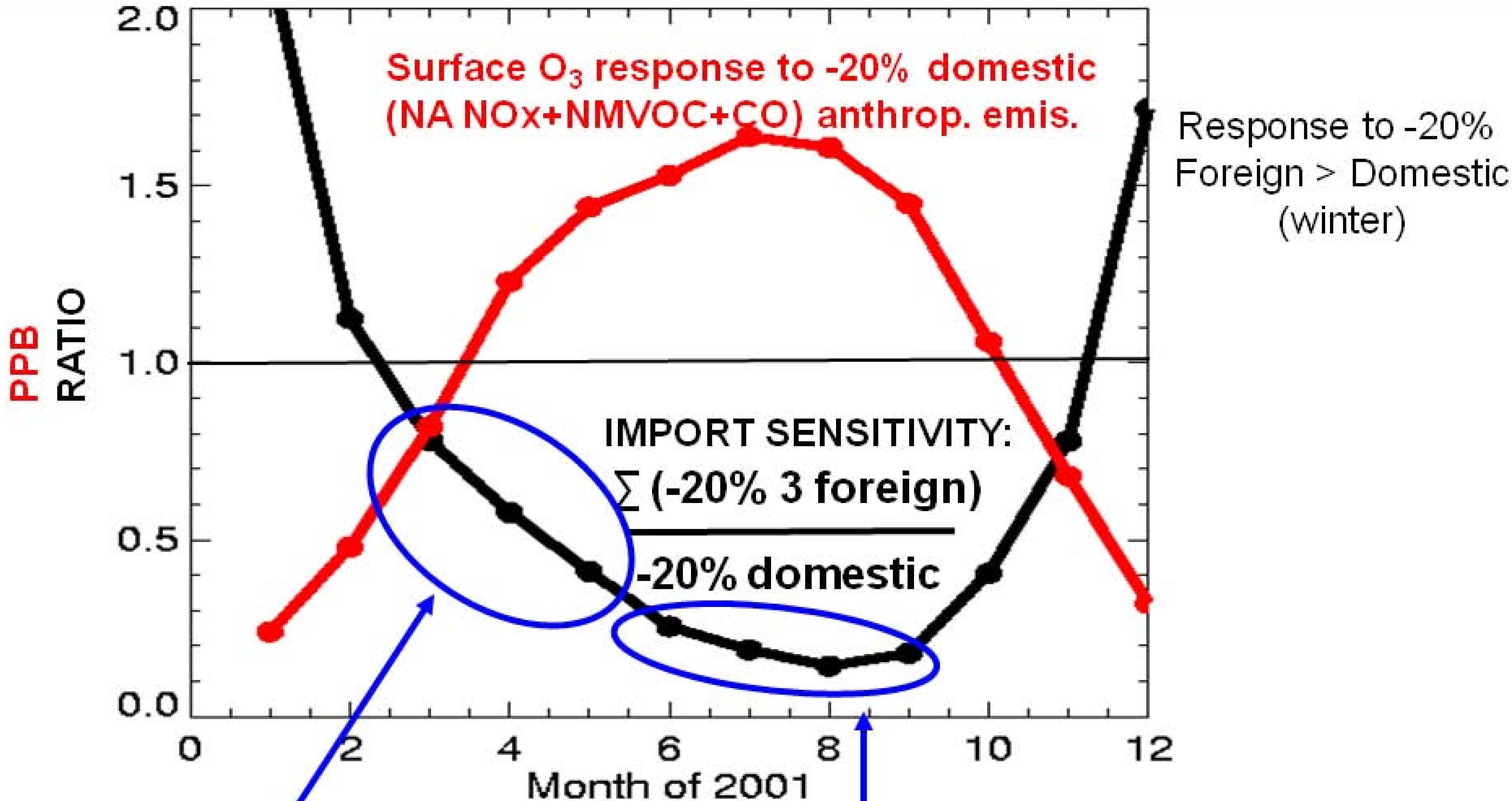
North America as a receptor of ozone pollution: Seasonality in "import sensitivity"



0.4-0.8 during spring "high transport season"

~0.2 when domestic O_3 production peaks in summer

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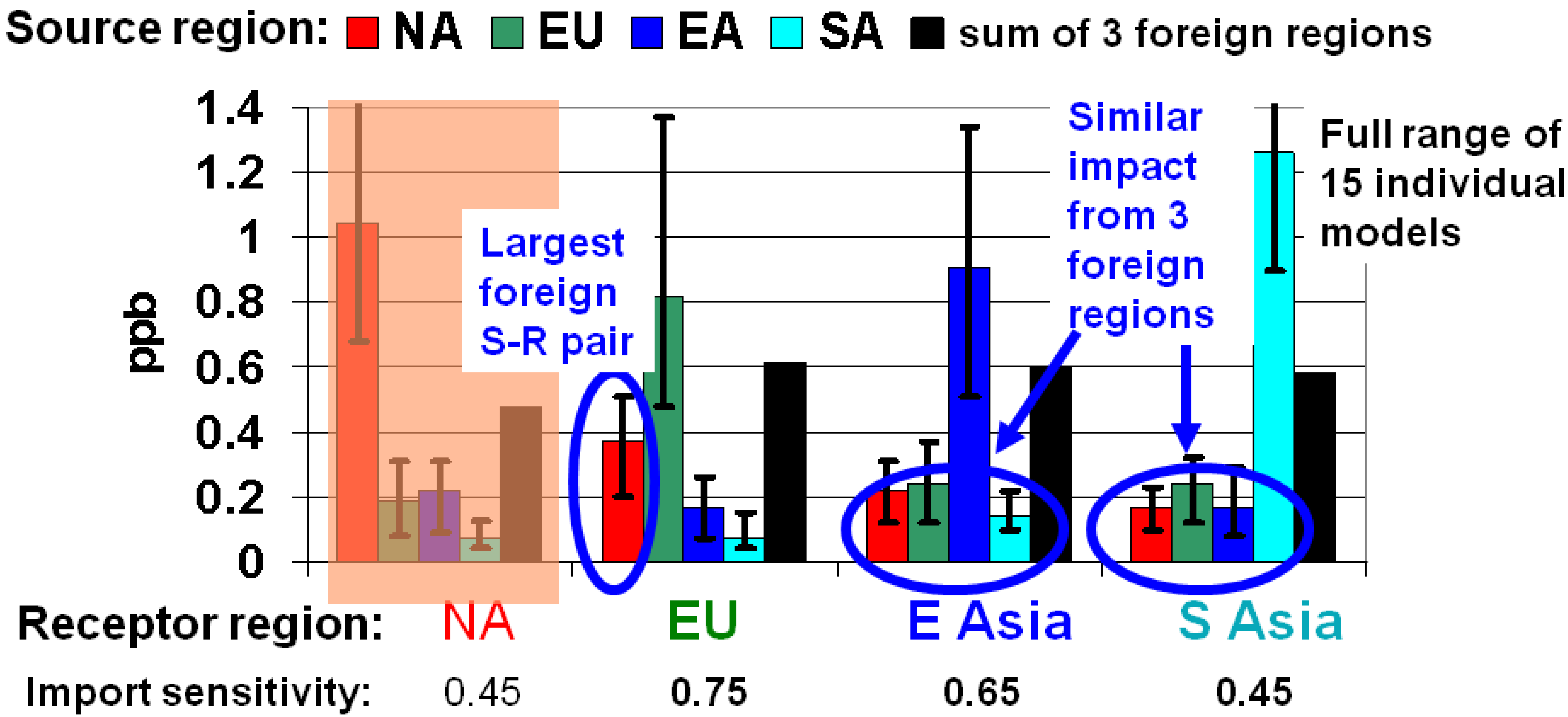
Estimates of S-R relationships for surface O_3 pollution

Annual mean surface O_3 decrease from -20% NOx+CO+NMVOC regional anthrop. emissions



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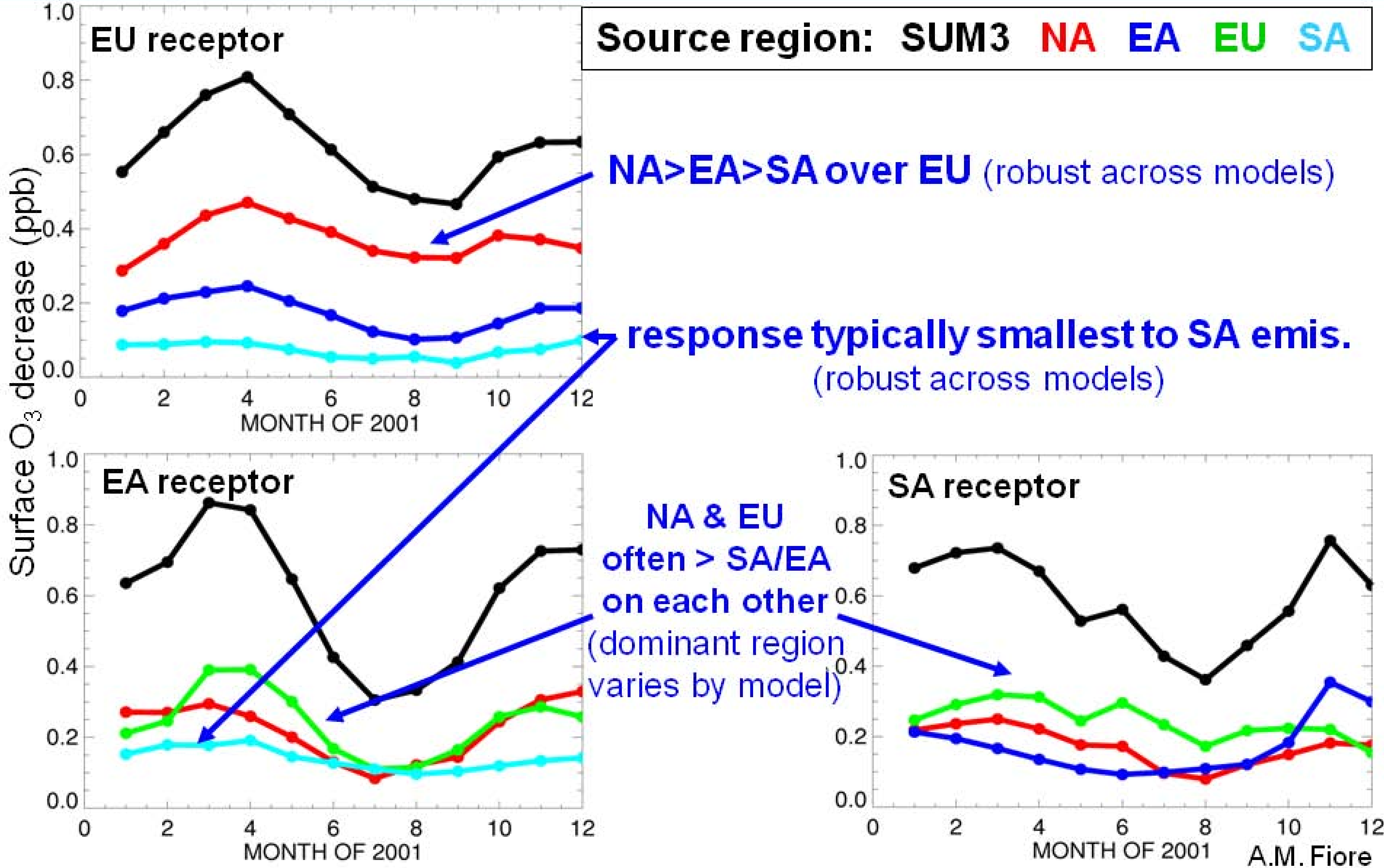
Surface O_3 response to decreases in foreign anthropogenic emissions of O_3 precursors



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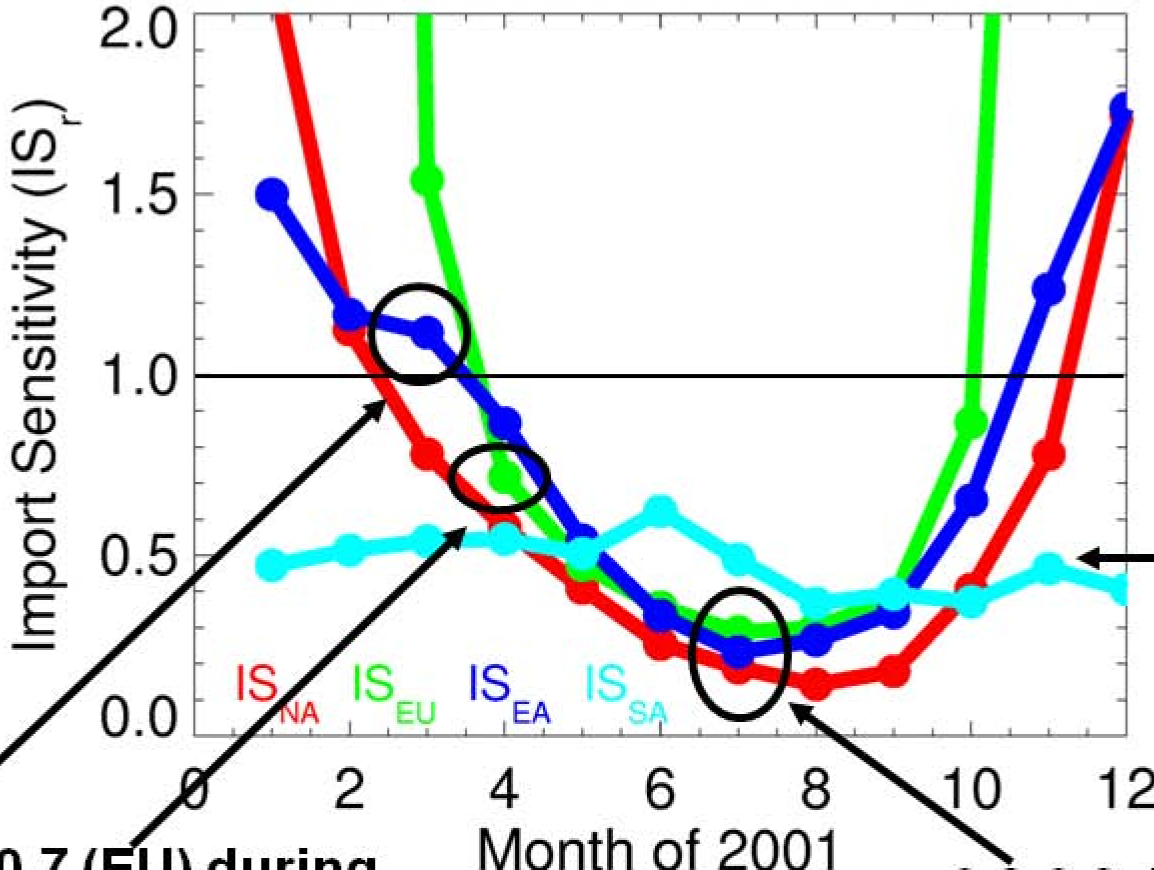
Monthly mean import sensitivities



SA fairly constant ~0.5

1.1 (EA), 0.7 (EU) during month with max response to foreign emissions

0.2-0.3 during month of max response to domestic emissions

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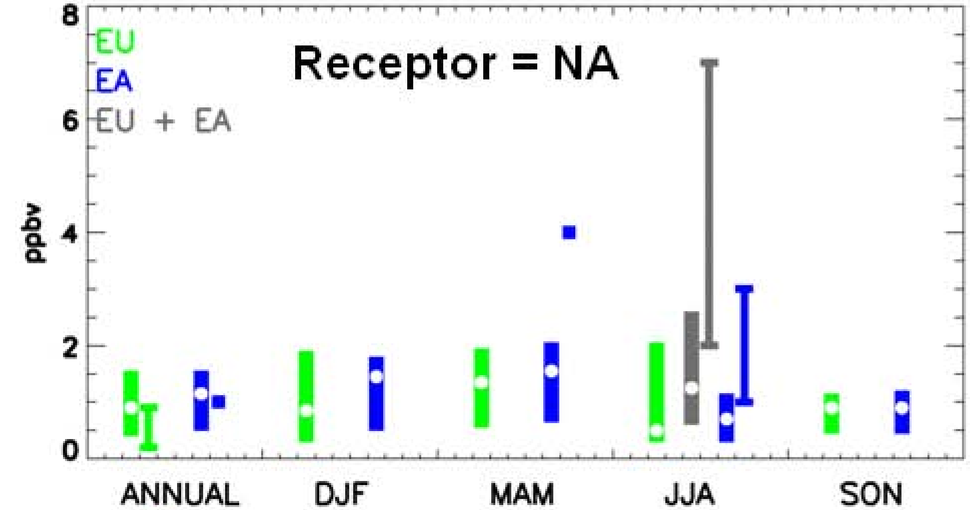
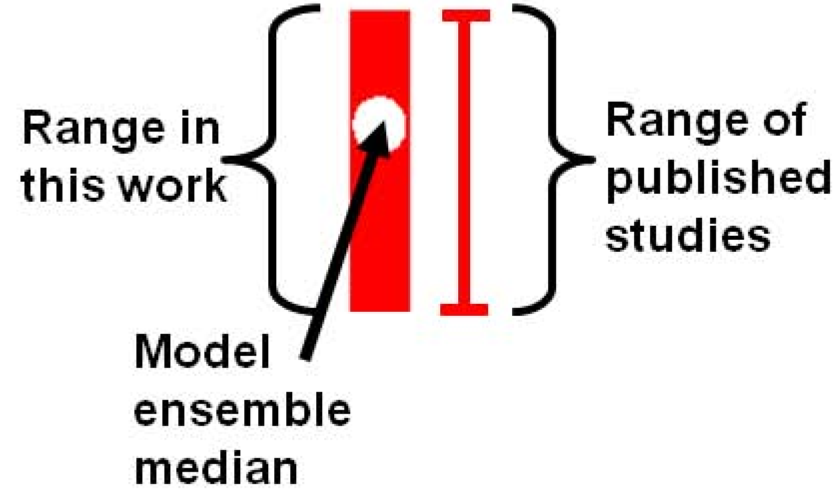
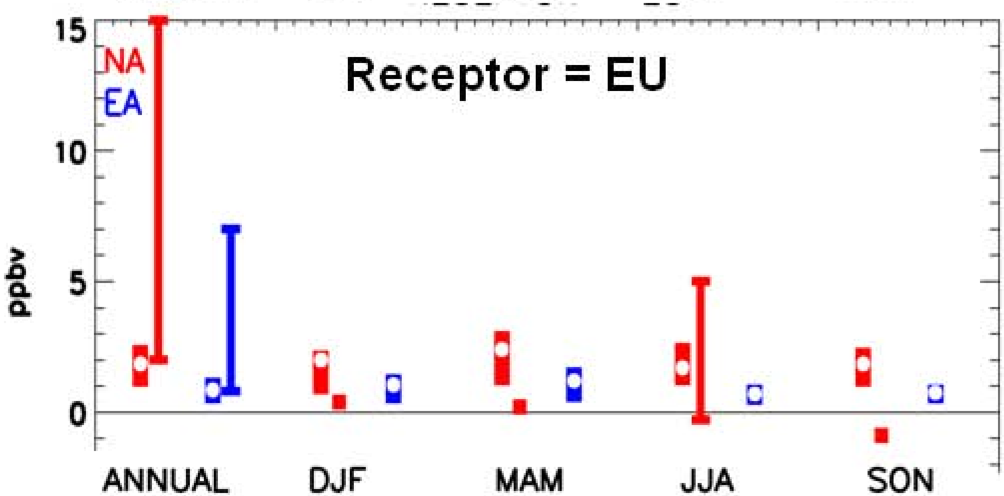
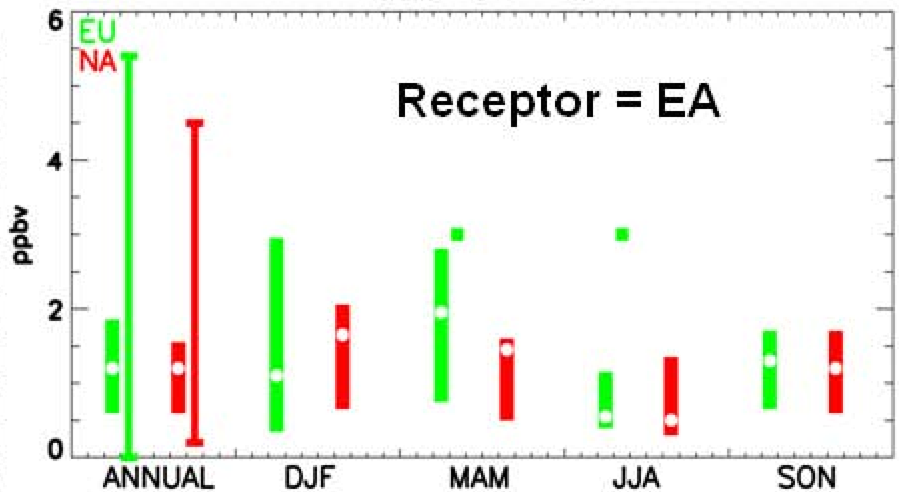
Range of estimated S-R relationships narrows from that in the literature with consistently applied HTAP approach

Assume linearity, scale response to -20% to 100% to estimate total contribution









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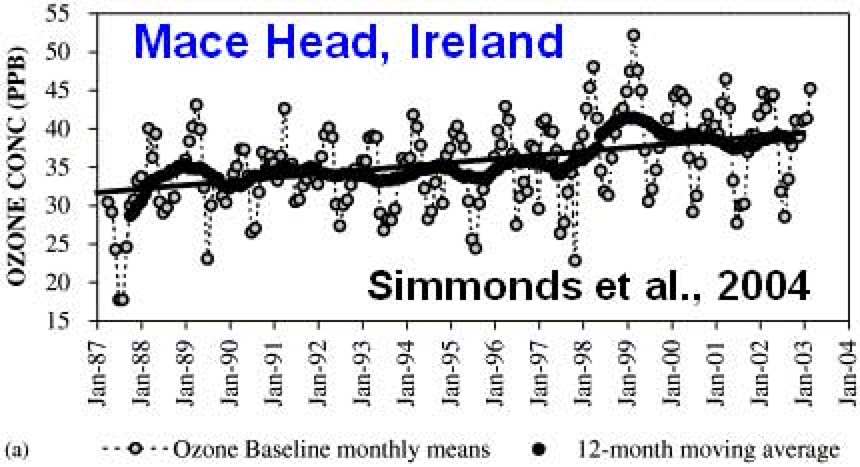
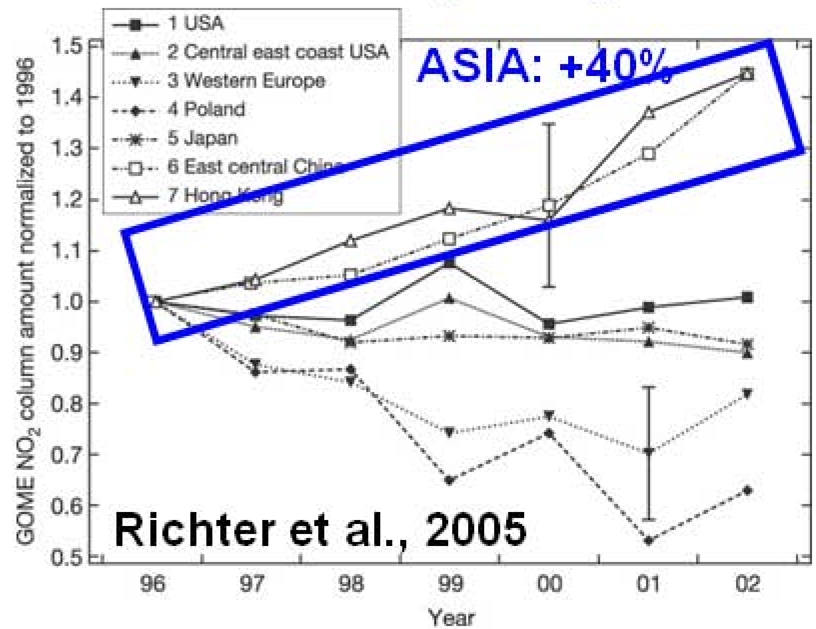
Apply S-R relationships to address hypothesis of rising background O_3 driven by increasing Asian emissions

OBSERVED: +0.1-0.5 ppb yr^{-1} in background surface O_3 [TF HTAP, 2007]



SPACE-BASED NO_2 → NO_x EMISSIONS



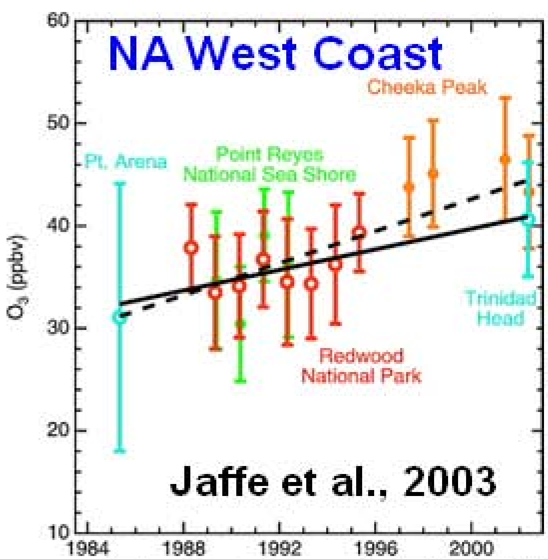


Fig 3.6 from TF HTAP [2007]

Assuming +10% yr^{-1} Asian emissions, our results imply an O_3 increase over NA and EU of at most 0.15 ppb yr^{-1}

OUR CAVEATS:

-- assumes SA+EA, + other emissions follow NO_x

-- continental-avg vs. "west coast" obs

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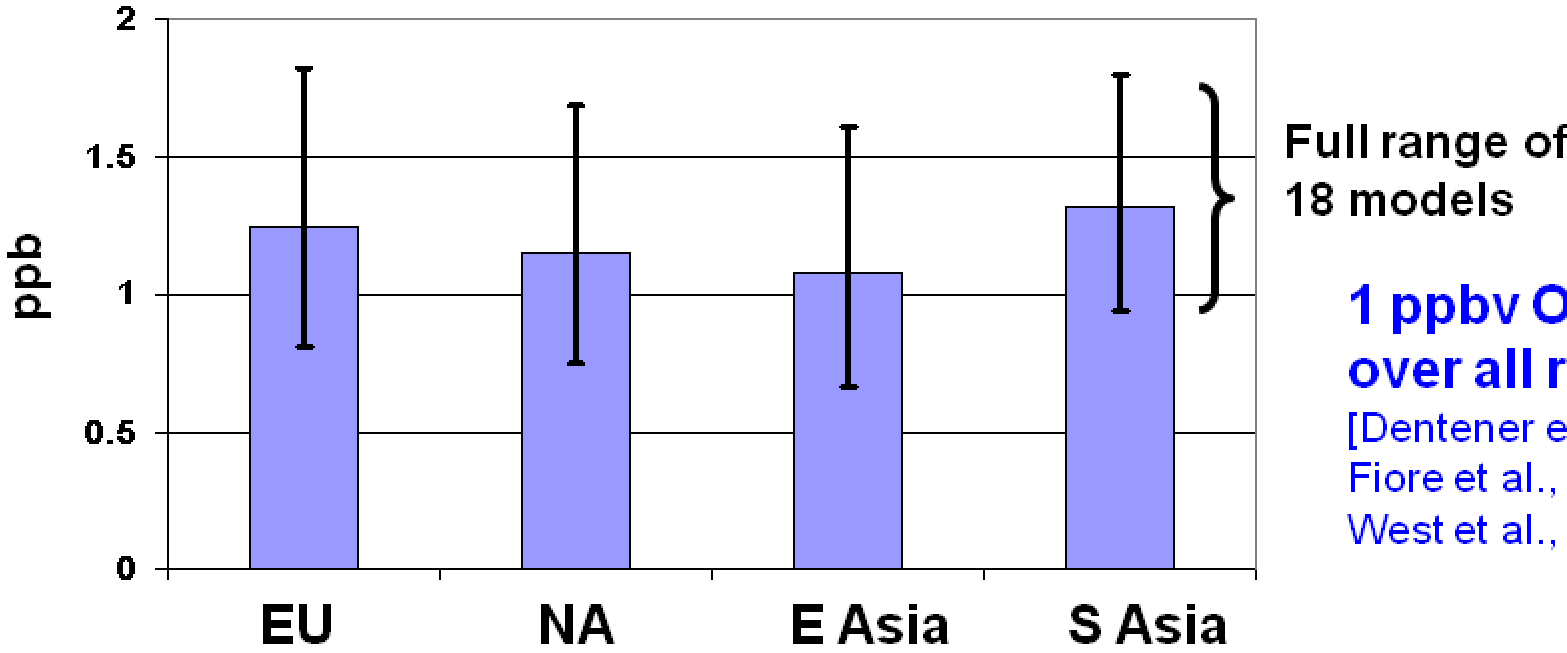
Surface ozone response to -20% global [CH_4]: similar decrease over all regions



1 ppbv O_3 decrease over all regions
[Dentener et al.,2005; Fiore et al., 2002, 2008; West et al., 2007]

Estimate O_3 response to -20% regional CH_4 anthrop. emissions to compare with O_3 response to NOx+NMVOC+CO:

(1) -20% global [CH_4] ≈ -25% global anthrop. CH_4 emissions
(2) Anthrop. CH_4 emis. inventory [Olivier et al., 2005] for regional emissions
(3) Scale O_3 response (linear with anthrop. CH_4 emissions [Fiore et al., 2008])

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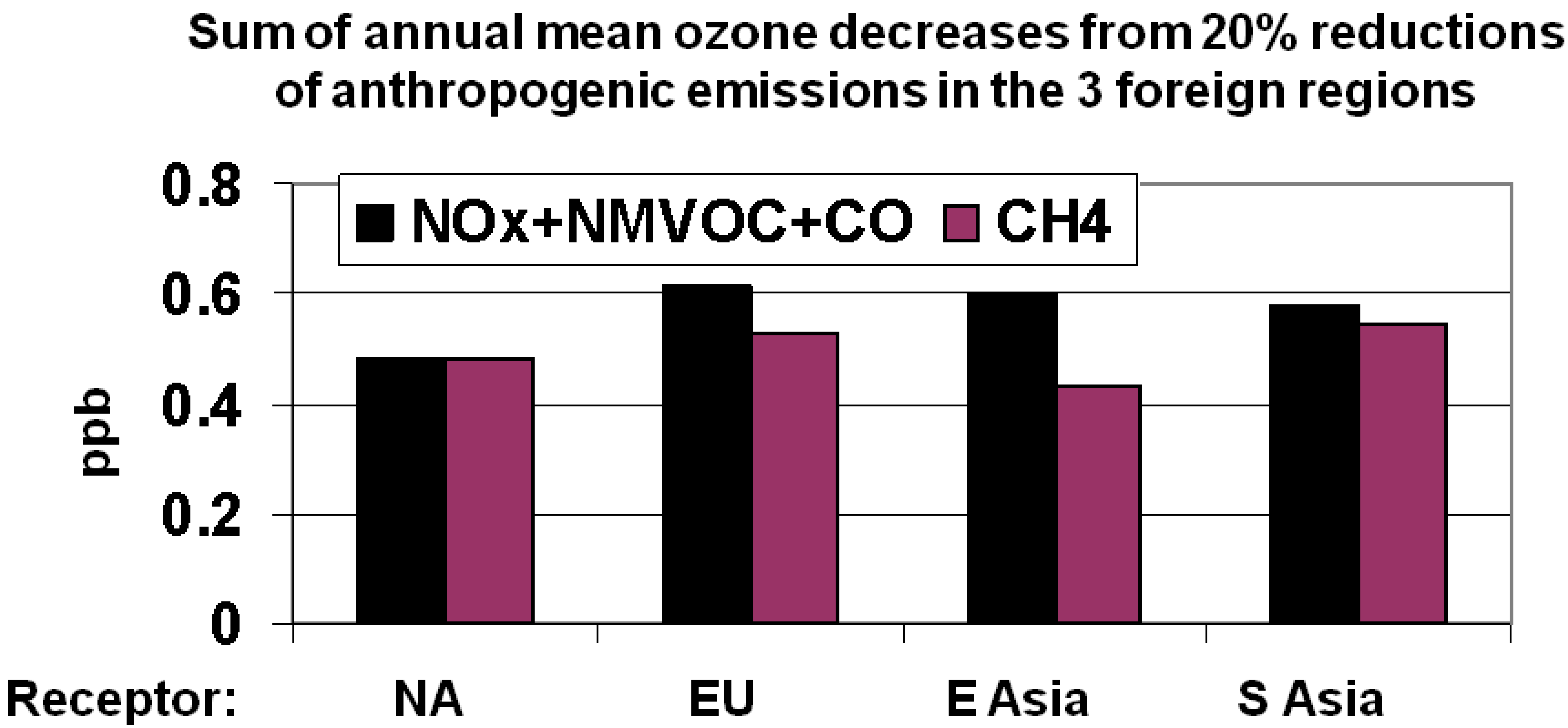
Comparable annual mean surface O_3 response to -20% foreign anthropogenic emissions of CH_4 vs. NO_x+NMVOC+CO



(Uses CH_4 simulation + anthrop. CH_4 emission inventory [*Olivier et al.*, 2005] to estimate O_3 response to -20% regional anthrop. CH_4 emissions)

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Areas needing additional analysis
(*studies underway)

- Relevance to air quality objectives*
  - Variability within HTAP regions
  - Assess simulation of metrics used to determine compliance
- Scalability of results (non-linearities)*
- Process-based evaluation*
  - Relative contributions from transport, emissions, chemistry to uncertainties
- Summertime bias (EUS*)
- NMVOC inventories / reactivity mix (esp. EU)
- Changes in SR relationships
  - Interannual
  - Future (emissions, climate)

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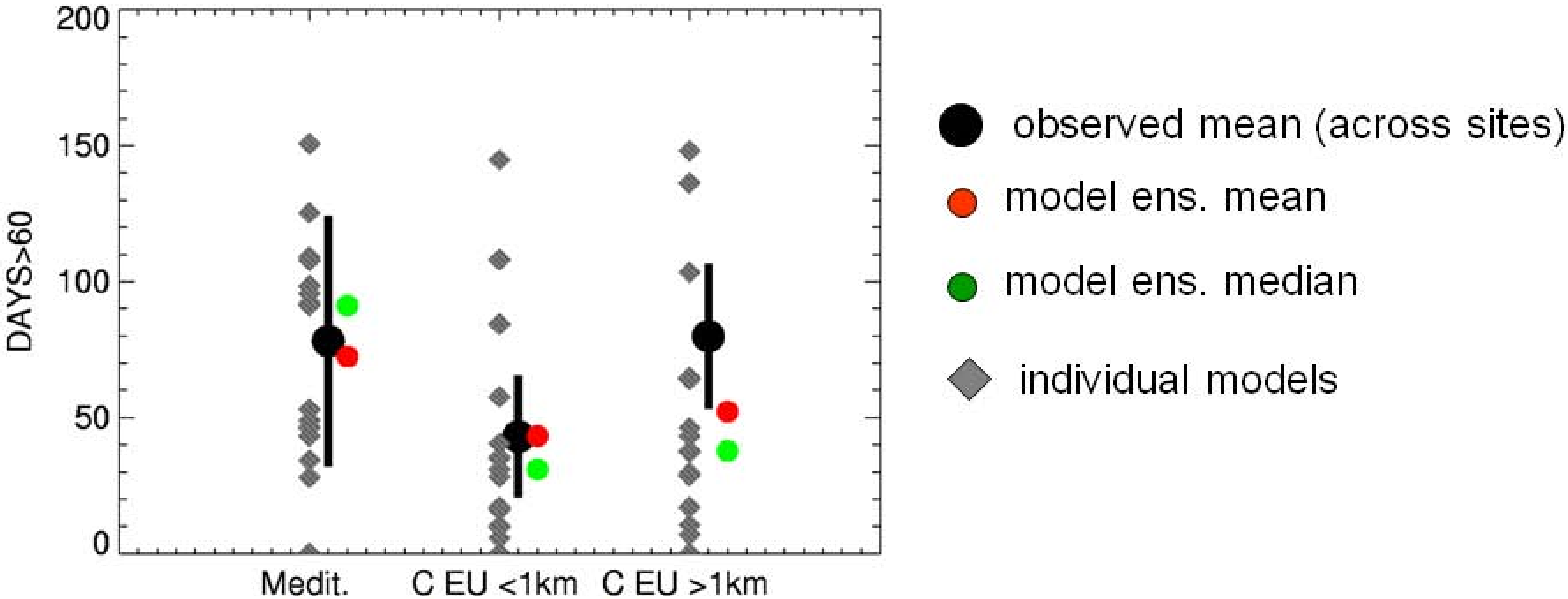
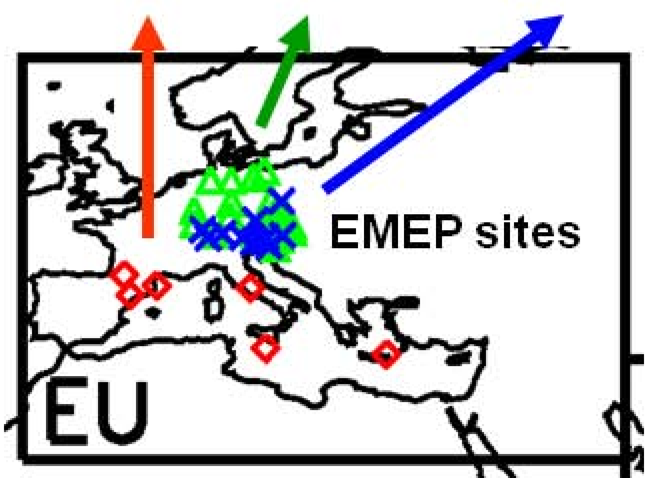
Simulated vs. observed DAYS>60 over Europe





→**Model ensemble mean close to observed except for low bias at high-altitude sites**

→**Ensemble mean results consistent with evaluation for monthly mean results.**

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Conclusions: Intercontinental S-R Relationships for O_3

Benchmark for future: Robust estimates + key areas of uncertainty

- Robust: NA→EU largest; SA→others smallest;
  NA/EU often > SA/EA on each other
- Uncertainty on relative roles of EU/EA → NA; NOx/NMVOC →NA
- Model ensemble mean overestimate vs. obs in summer EUS and Japan

Estimated "import sensitivities"

- Over EA/NA/EU, response to "ALL" foreign vs. domestic anthrop. emis.
  = 0.6-1.1 during month of max response to foreign emissions
  = 0.2-0.3 during month of max response to domestic emissions
- Over SA =0.45 (max response to foreign+domestic); little seasonality

Reported emis. trends + SR estimates → low end of observed surface O_3 trends

Reducing equivalent % of CH_4 yields an O_3 decrease similar to that achieved with NOx+NMVOC+CO over foreign regions (0.4-0.6 ppb for 20% reductions)

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