Task Force on Hemispheric Transport of Air Pollution

Past Assessments of Ozone Responses to Methane

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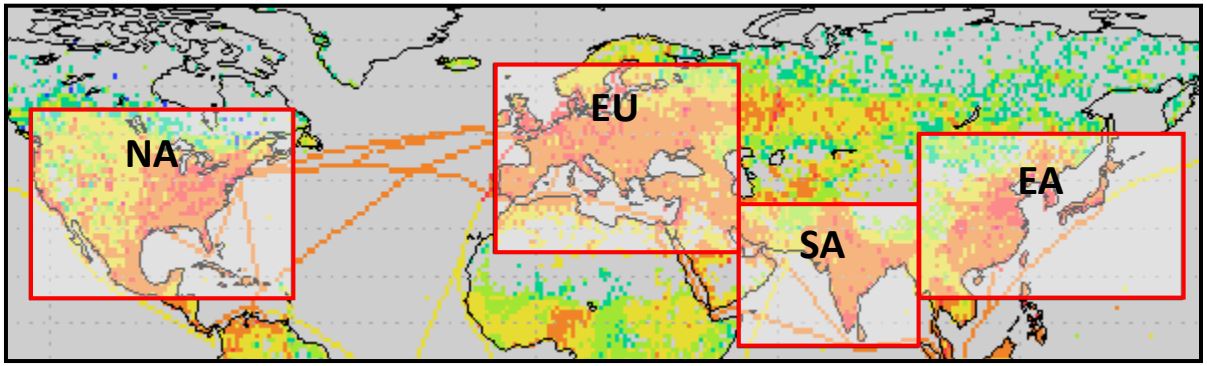
LRTAP Long-range Transboundary Air Pollution

Task Force on Hemispheric Transport of Air Pollution

Lancaster University

- HTAP Phase 1 SR studies for 2001



HTAP: Quantify impacts of major anthropogenic source regions on surface O_3 under 2001 conditions using 20% precursor emission changes, ~30 models contributed.

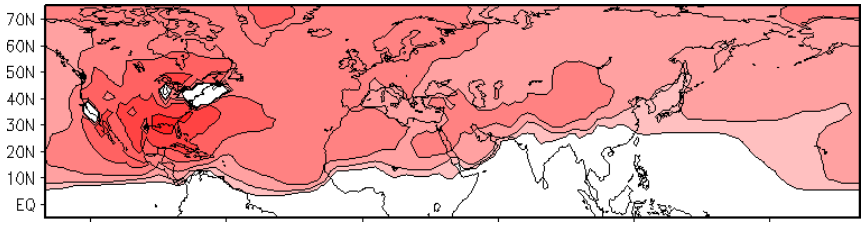
Fiore et al., 2009

- Model Runs
  - Control run (SR1), 20% reduced CH_4 run (SR2)
  - 20% reduced NO_x emissions over each region (SR3)
  - 20% reduced VOC emissions over each region (SR4)
  - 20% reduced CO emissions over each region (SR5)
  - 20% reduced NO_x/VOC/CO/aerosol emissions (SR6)
- Quantify current source-receptor relationships
- Parameterization: use relationships to explore O_3 trends

Parameterizing Surface O_3 Changes

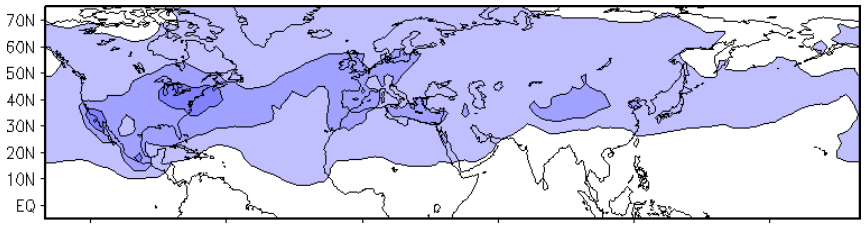
- Simple linear combination of emission perturbations
  - Decompose emission scenario by region and precursor
  - Scale contributions to ΔO_3 for each region and precursor
  - Sum to estimate ΔO_3 at any location or region
  - Determine anthropogenic contribution to O_3 changes

ΔO_3 due to 20% reduction in E_{NOx} over N. America



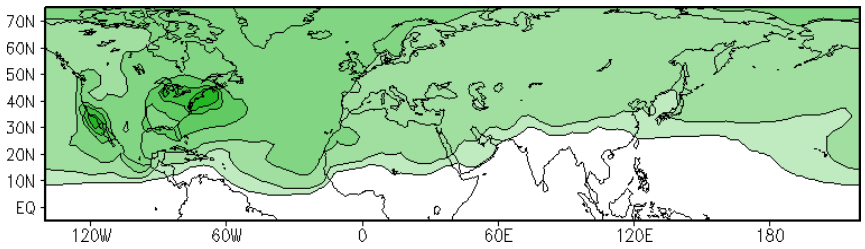
$$f_{NA,NOx} = \Delta E_{NOx}/0.2E_{NOx}$$

ΔO_3 due to 20% reduction in E_{CO} over N. America



$$f_{NA,CO} = \Delta E_{CO}/0.2E_{CO}$$

ΔO_3 due to 20% reduction in E_{VOC} over N. America



$$f_{NA,VOC} = \Delta E_{VOC}/0.2E_{VOC}$$

Parameterizing Surface O_3 Changes

- Simple linear combination of emission perturbations
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$$\Delta O_3(k) = \sum_{i=1}^{3}\sum_{j=1}^{5} f_{ij}\Delta O_3(i,j,k) + f_m \Delta O_{3m}(k)$$

O_3 response at location *k*

3 precursors NOx, CO, VOC

5 emission regions NA, EU, SA, EA, RoW

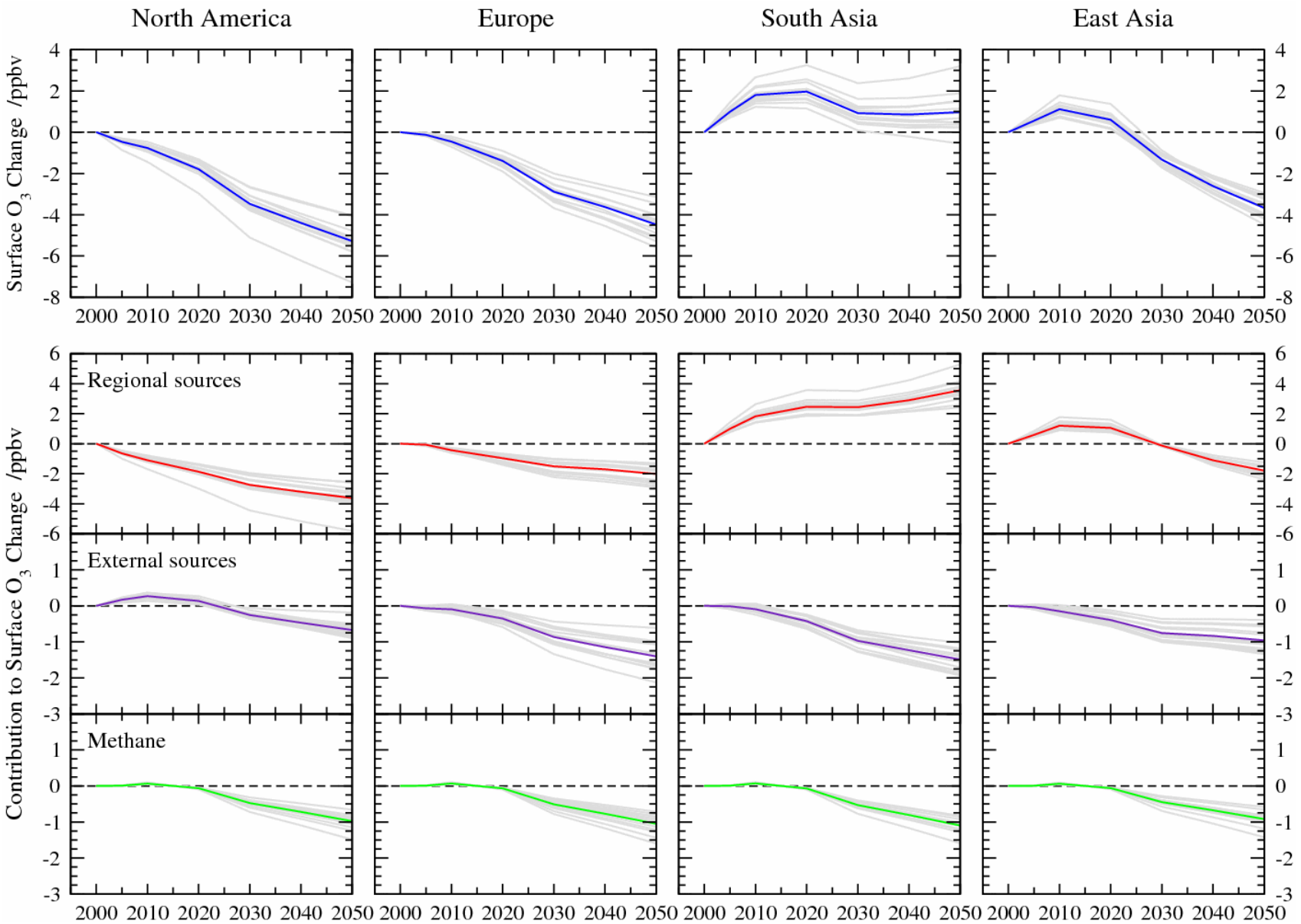
scale factor

HTAP O_3 response

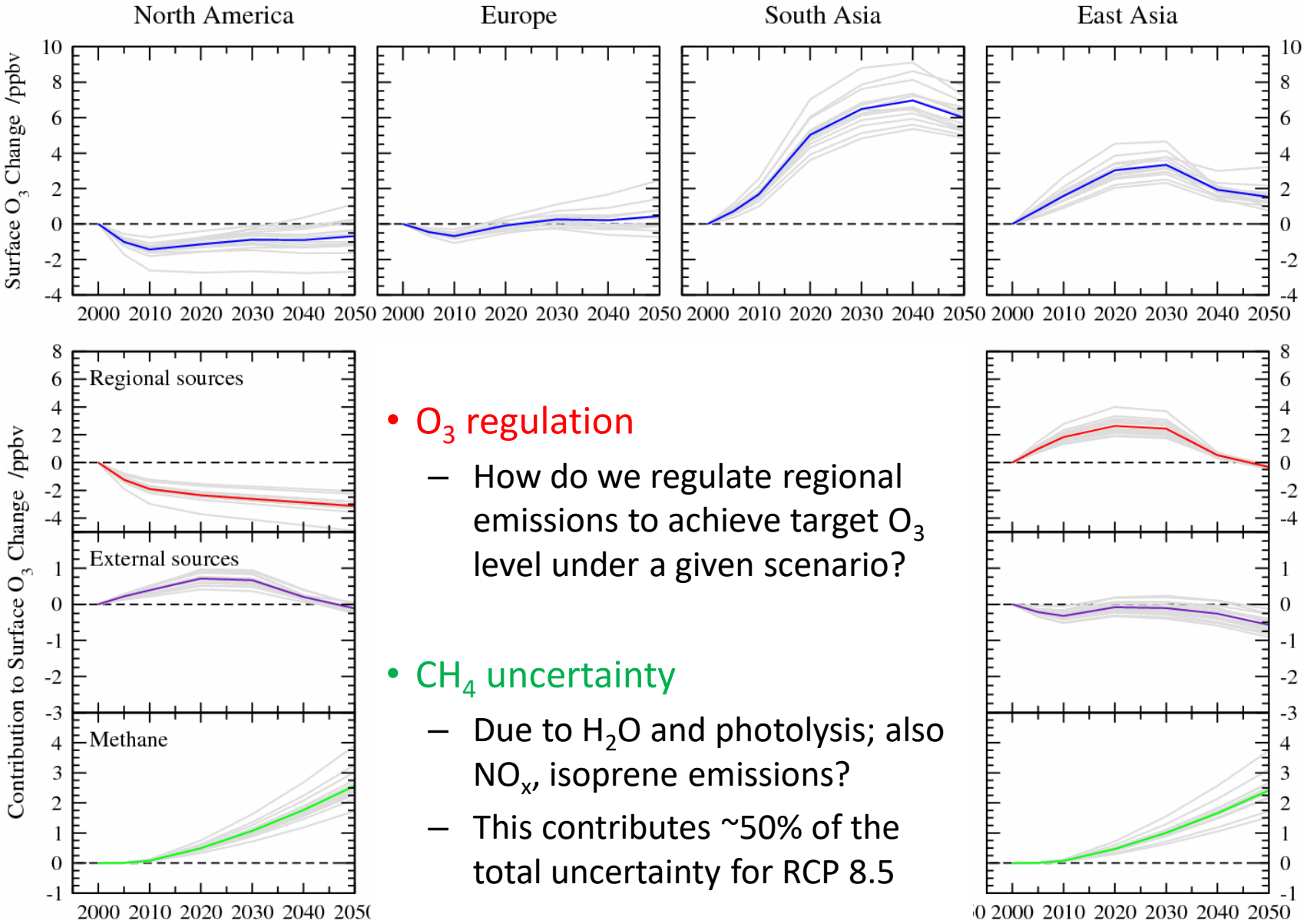
O_3 Response to CH_4 abundance

$f' = 0.95f + 0.05f^2$

Surface O_3 changes under RCP 2.6

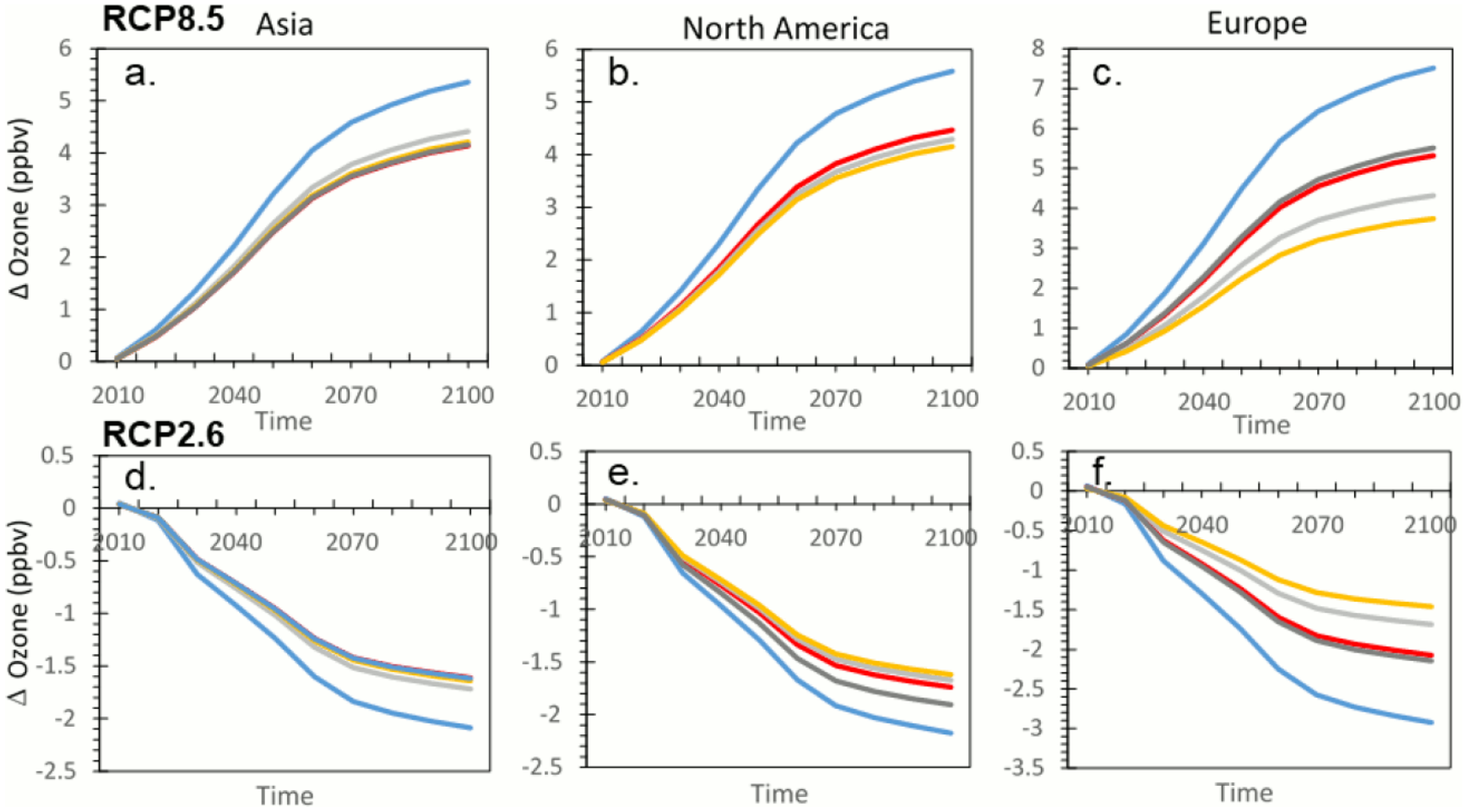


Surface O_3 changes under RCP 8.5



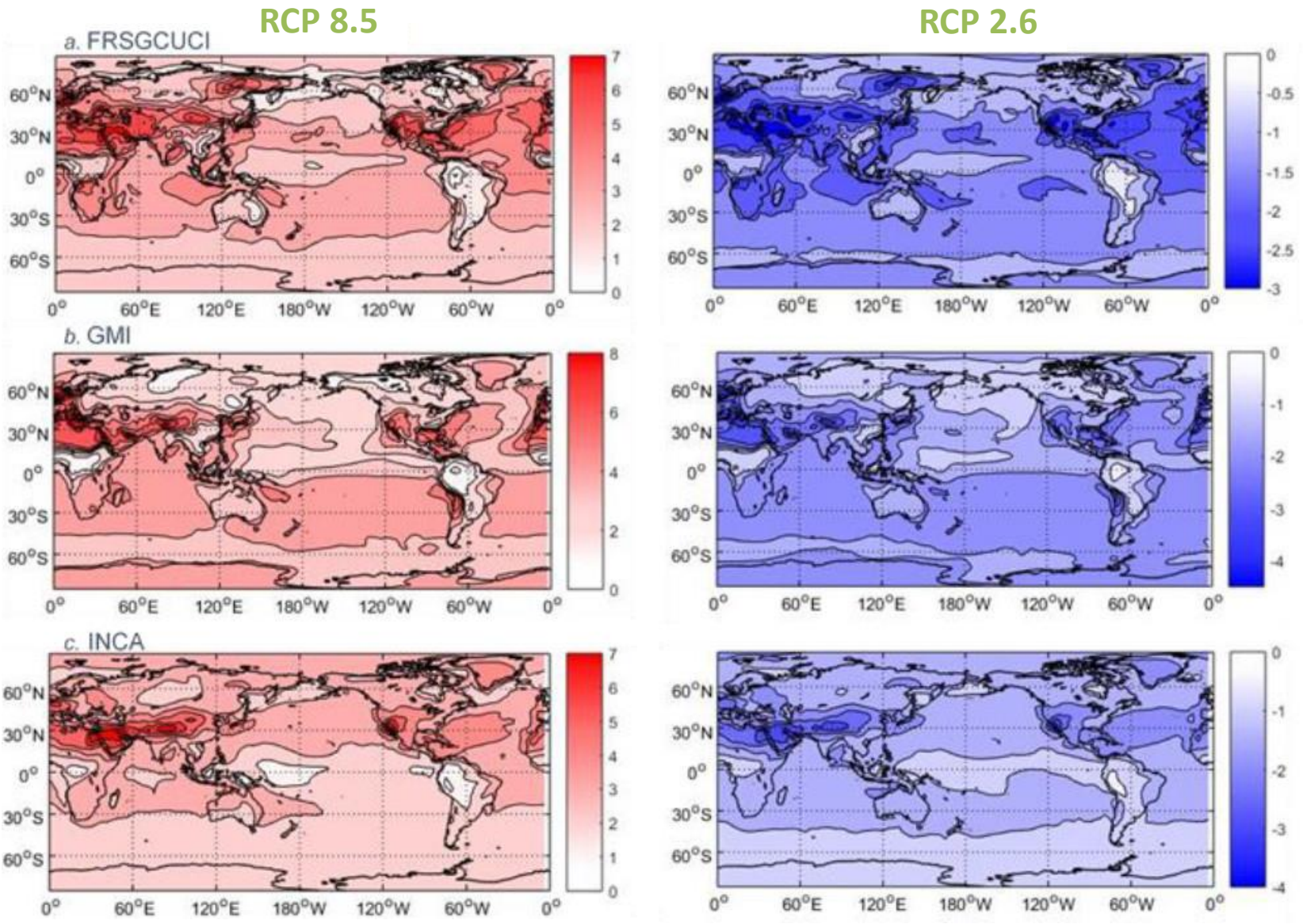
- O_3 regulation
  - How do we regulate regional emissions to achieve target O_3 level under a given scenario?
- CH_4 uncertainty
  - Due to H_2O and photolysis; also NO_x, isoprene emissions?
  - This contributes ~50% of the total uncertainty for RCP 8.5

Surface O_3 Changes due to CH_4 only

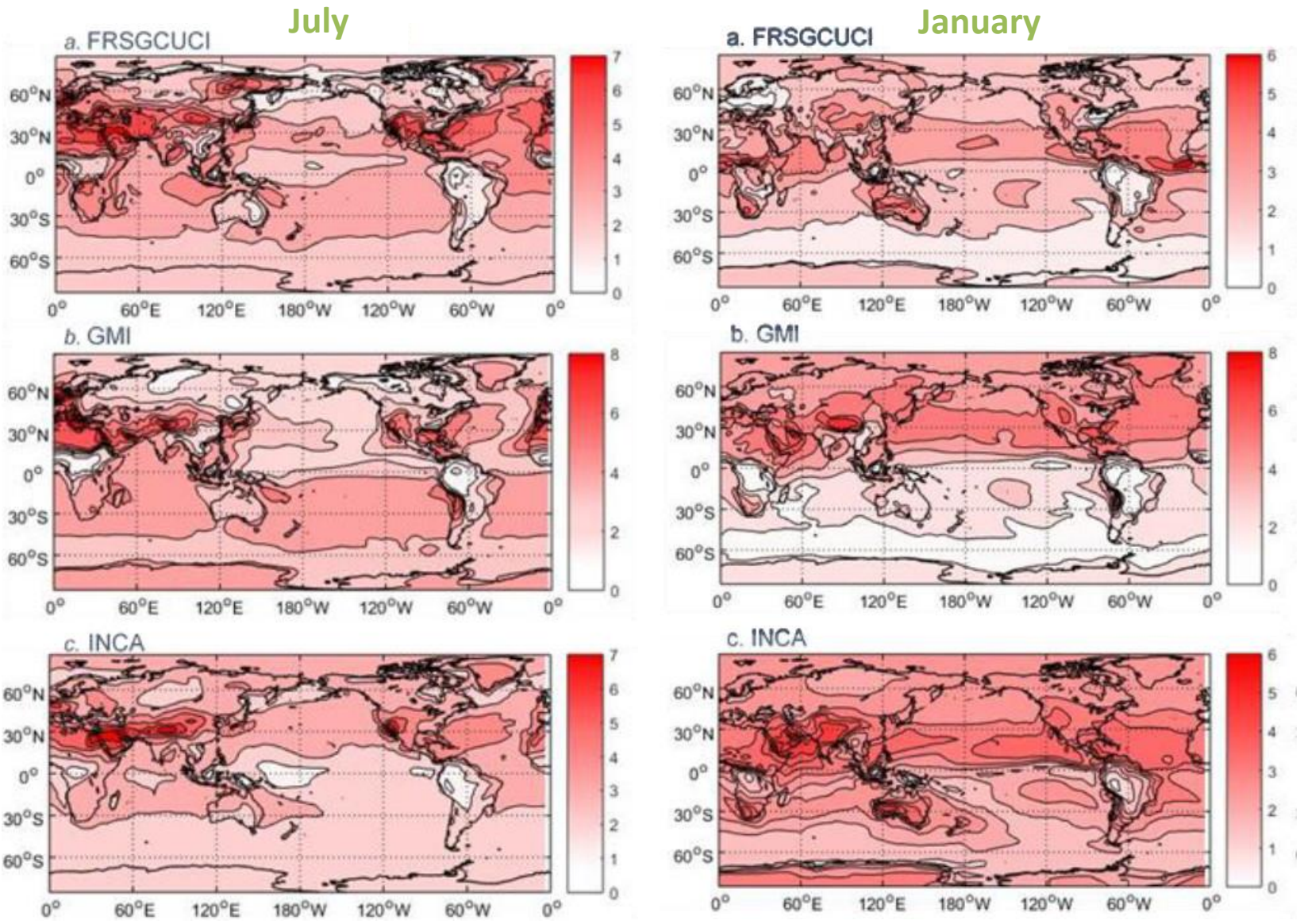


Results from 5 models: FRSGC/UCI, GMI, INCA, MOZECH, MOZART-GFDL

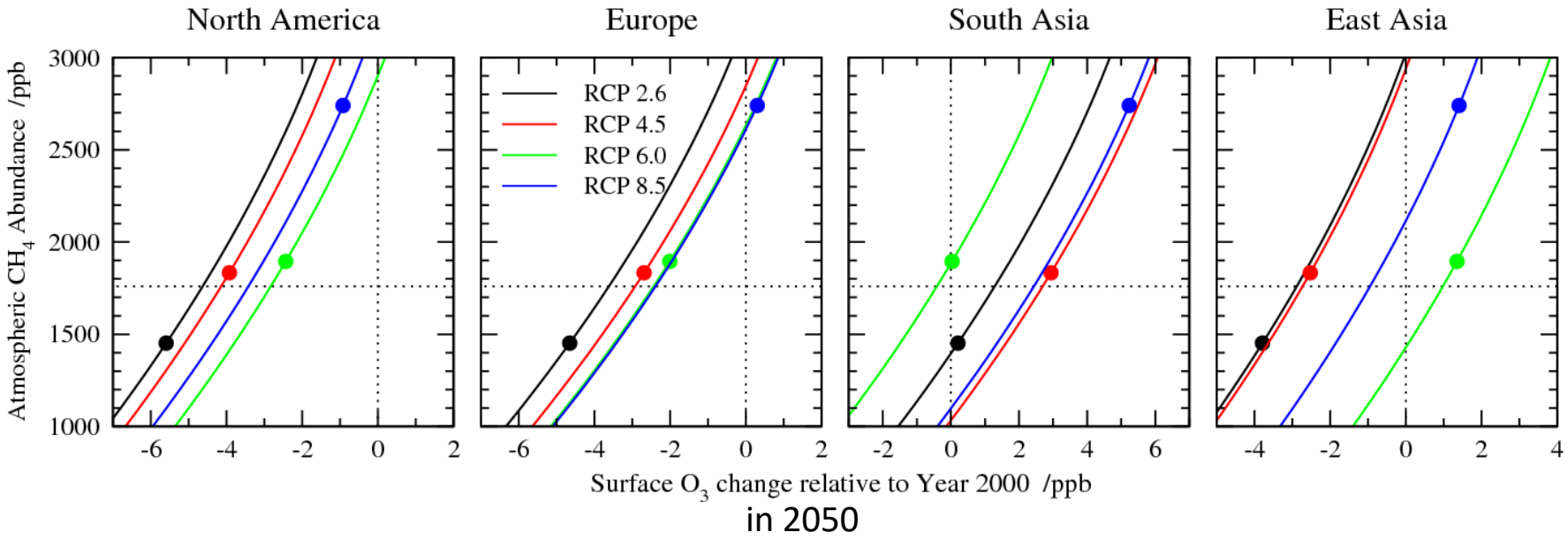
Surface O_3 impacts from CH_4 in 2100 (July)



Surface O_3 impacts from CH_4 in 2100 (RCP8.5)



Contribution of CH_4 Mitigation



- How would controlling CH_4 emissions affect surface O_3?
  - RCPs have O_3 precursor controls but big differences in CH_4 abundance
  - This accounts for most of the difference in O_3 between scenarios
    - 75% for N. America and Europe
  - Under future precursor emissions controls, limiting atmospheric CH_4 will become increasingly important…

Issues to take forward

- Regionality of O_3 responses to CH_4
  - Substantial differences between models
  - NO_x chemistry dependence (e.g., over Europe)

- Impacts of precursor changes on CH_4 impacts on O_3
  - Need to include these interactions in parameterization
  - Explore based on HTAP2 source regions?

- Quantify climate responses (see AerChemMIP)
- Include robust assessment of model uncertainty
- Work with emissions rather than concentrations (challenging)