LRTAP
Long-range Transboundary Air Pollution

Task Force on Hemispheric Transport of Air Pollution

Interaction between climate and air pollution on the Hemispheric Scale

Frank Dentener, EC, JRC
Terry Keating, US EPA

www.htap.org

Key Messages:

1. Air pollution impacts climate and climate impacts air pollution- both on the regional and hemispheric/global scales.

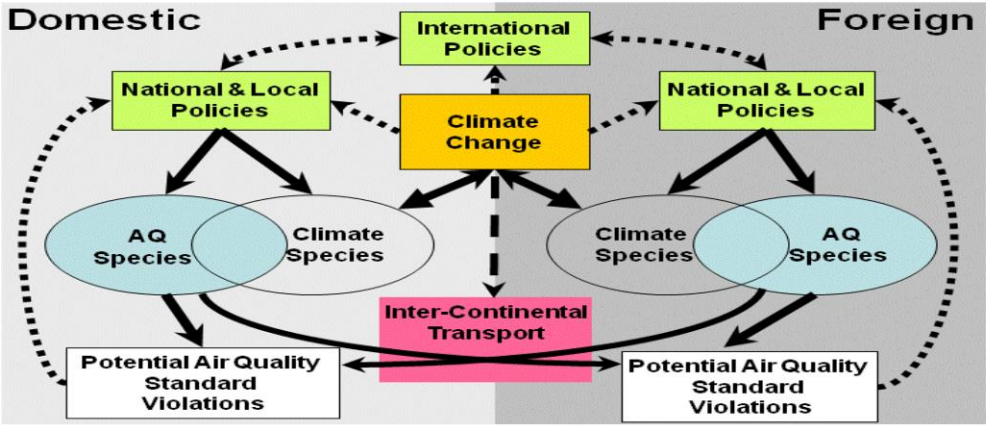
2. Climate impacts on regional air pollution – through changes in meteorology and emissions in the region itself, and through changes in meteorology+chemistry elsewhere. Changes in transport patterns (winds) are of some importance for long-range transport, but changes in land-use related emissions and sinks, strat-trop exchange of ozone, large scale temperature/precipitation/oxidant changes are probably of larger importance, depending on the component. [e.g. PM, vs. O_3, vs Hg]
=>Need to take stock of most recent insights.

3. Past and current HTAP analyses provide useful information on the regional aspects of radiative forcing associated with anthropogenic emissions, but more comprehensive air pollution-climate change interaction analysis will be performed in CMIP6/AerChemMIP ("IPCC AR6") and come available in the coming years. There are many metrics and analysis methods that could be used.
=>Careful phrasing of policy questions of regional importance may guide some of the analysis.

4. Air pollution scenarios follow the SSPs Shared Socio-economic Pathways- using some of the concepts used in the HTAP(GAINS) scenarios. The range is wider than the often critized 'RCPs'. If ambitious climate policies will be implemented, it will have e.g. beneficial aspects for various types of air pollution, including aerosol, O_3 and CH_4.
=>One source of alternative scenarios; but regionally alternative scenorias not readily available.

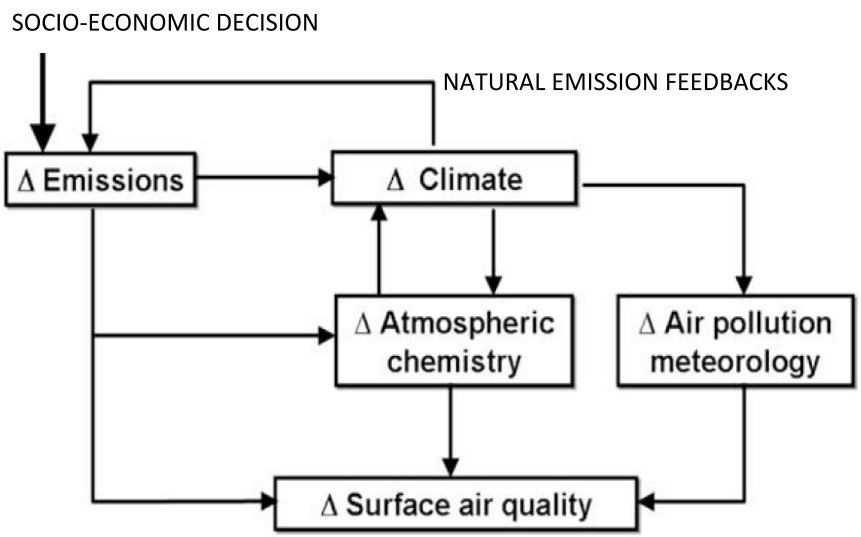
5. Continuous exchange with other communities – global, regional climate modellers remains necessary. Getting the numbers and uncertainties to well defined questions.
=>Dedicated workshop taking stock of progress in climate modelling community?

1. Air pollution impacts climate and climate impacts air pollution.



HTAP1:
Climate Change and Hemispheric Transport share the international dimensions

Chemistry-climate feedback



Adapted from Jacob and Winner, Atmos. Env, 2009

- **Δclimate would also include impacts on cryosphere, vegetation, oceans->AP**
- **The same climate impacts that play a role in Europe are also found elsewhere, and partly seen also downwind- changing boundary conditions/inflow**
- **The impacts of European/North American SLCP emissions is partly on Europe (NA) itself, but to a large extent also exported.**
- **For ozone: there is some compensation between local increases and large scale decreases driven by H_2O under climate change**

What came out of HTAP1? Analysis of RF and derived parameters for 'big' regions.

Split radiative forcing from Fry et al, and Yu et al. into 4 latitude bands

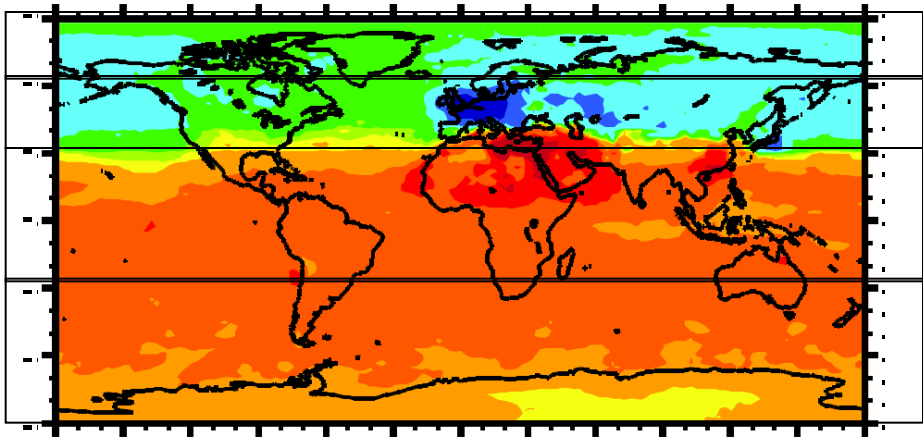
Use Shindell and Faluvegi matrix to calculate surface temperature changes in these bands

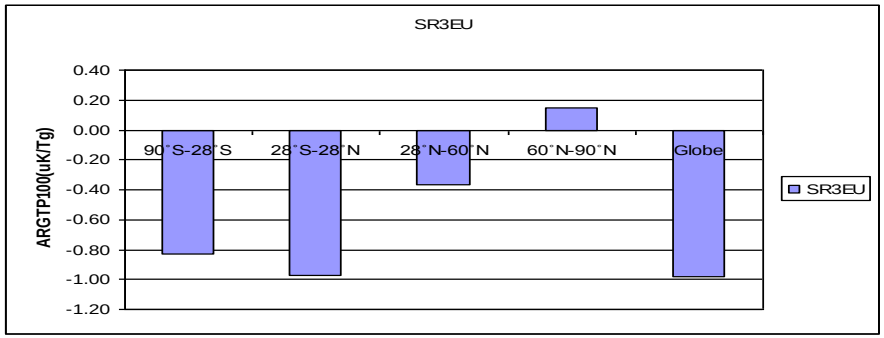
E.g. EU NO_X emissions cool globally, but warm Arctic

Collins et al. (2013) looked at a number of other climate metrics. BC particularly sensitive to BC emissions in South Asia

HTAP2 coordinated experiments have some additional potential to provide information on spatial extent of specific regions. Limited use for more advanced climate metrics that involve climate modelling.

Radiative forcing





S. Hem Tropics N. Mid -lat Arctic Global

ECLIPSE project

HTAP-like experiments in ECLIPSE

Radiative Forcing

Europe, China and Rest of World.

Summer, Winter

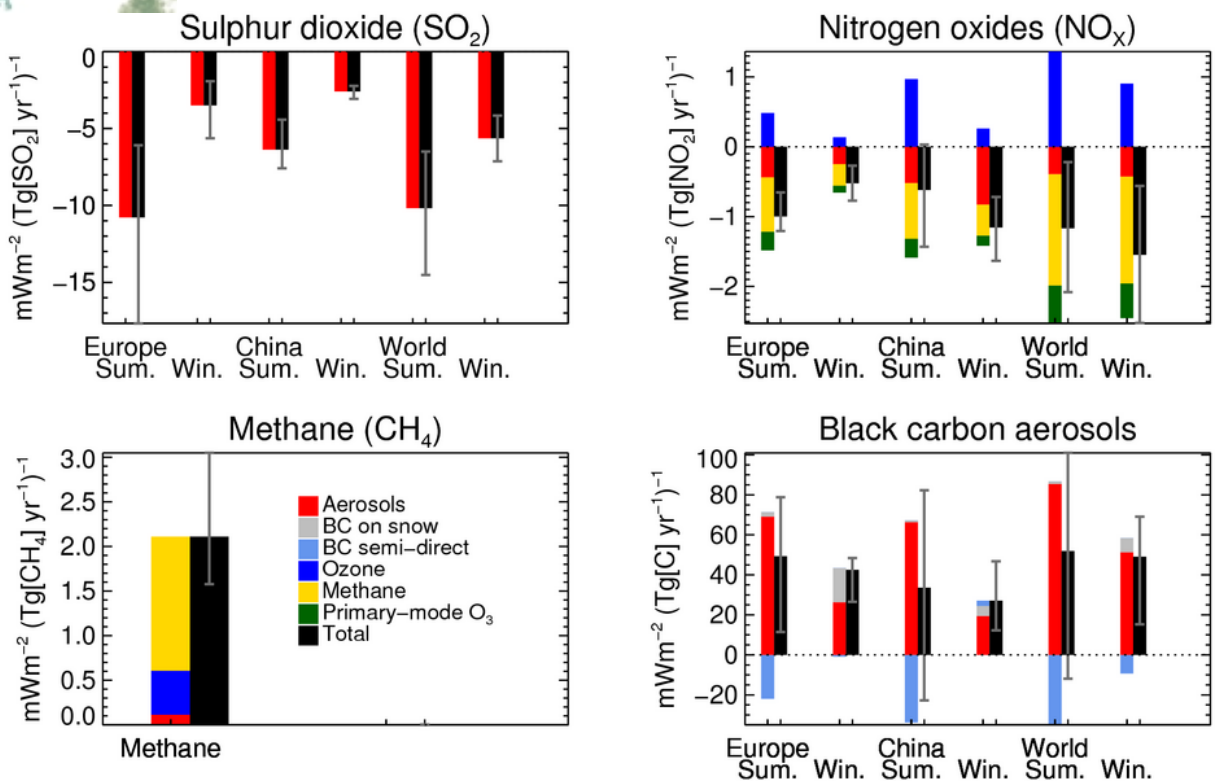
Also OC, NH_3, CO, VOC (not shown).

Used in ECLIPSE to design climate-beneficial AQ controls

Challenges:

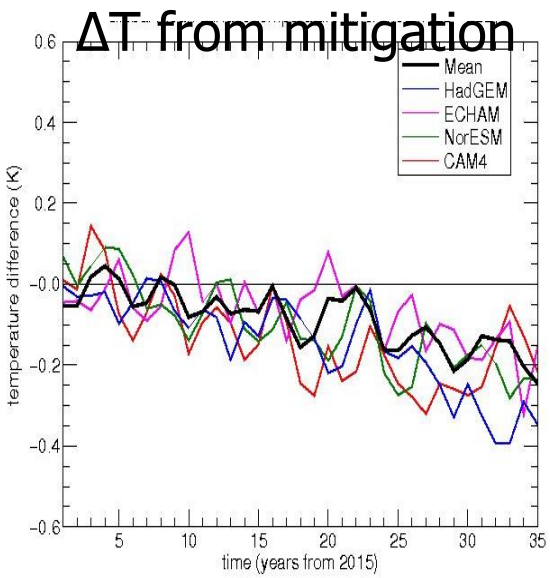
How to connect these to HTAP2?

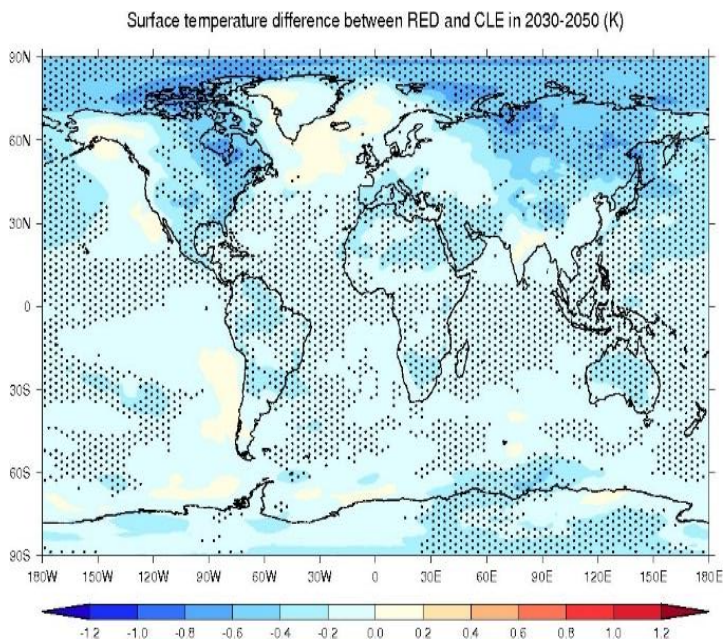
Narrowing error bars.



Quantification of larger scale climate impacts (T, RF, GWP, GTP, precipitation, snow albedo, direct/indirect effects) due the emissions specific regions remain very uncertain- reducing these uncertainties will take a lot of time.

Climate modelling of additional mitigation measures





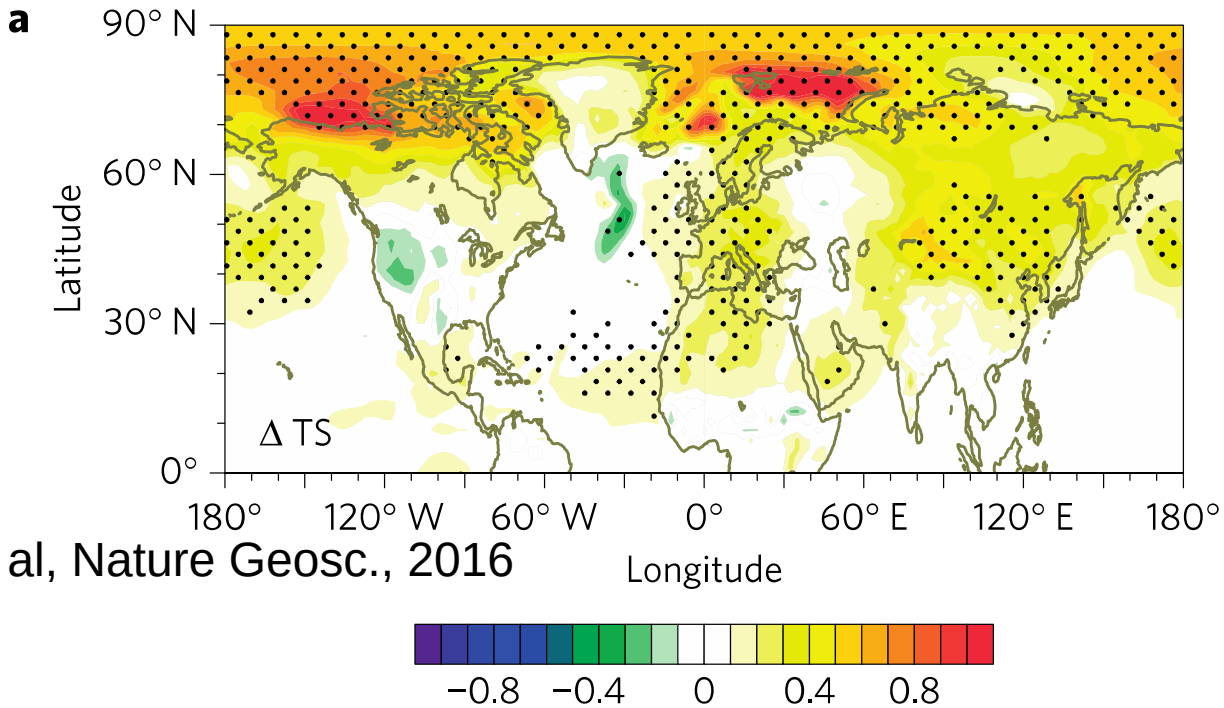
Comparison of 'Current legislation' AQ policy with additional mitigation measures

- Mitigation successfully reduces climate change
- Climate still warms, but less
- Most of the effect seems to come from CH_4 measures
- Net effect of non-CH_4 measures is small

Should we look at this again?

How robust is this?

Pegasos project:
Climate effects of sulfur emission reductions in Europe: 1980-2005



Acosta Navarro et al, Nature Geosc., 2016

Effect of reduced European sulfate (SO_2 + SO_4) emissions on different climate variables. NorESM calculations in multiple ensemble runs for 1980-2005. Fully coupled Ocean-Atmosphere model- includes short and long term feedbacks.

Questions/caveats:
Simplified approach: e.g. didn't include NH_4NO_3, interactive oxidants.
Are results consistent with more simple climate metrics?
Would other models find the same? Do we need more of this?

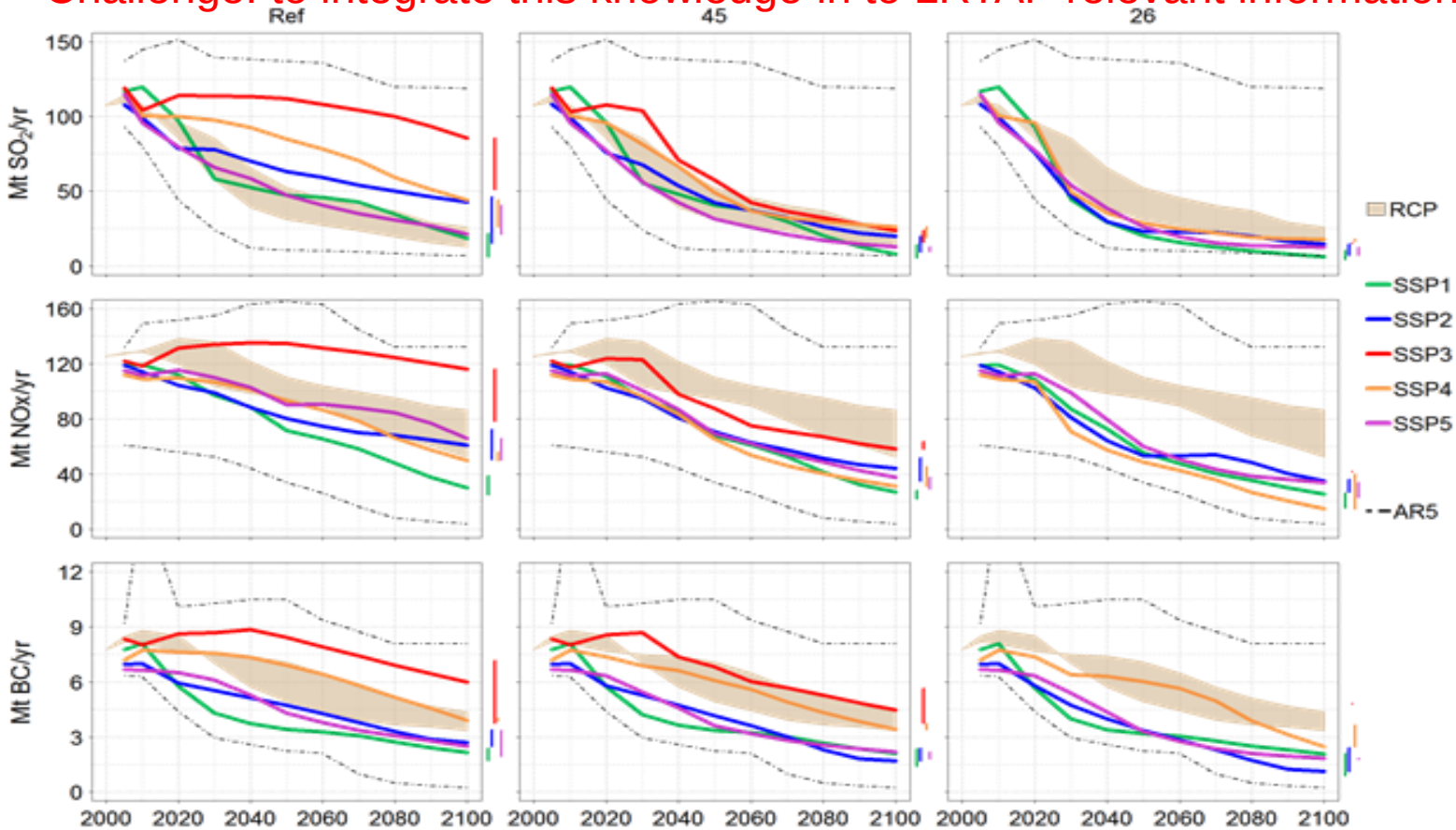
Impact of Climate Change on Extreme Air Pollution Events:

Findings from a series of U.S. EPA research grants

- Extreme Value Theory has been used to predict 1-year summertime ozone MDA8 "**return levels**." For the eastern U.S., return levels were shown to be related to regional NOx emissions. (PI Fiore)
- **Analysis techniques** have been developed to rapidly scan ensembles of climate models to identify regional scale pollution events and gauge changes in frequency and duration. (PI Fiore)
- The **sensitivity of pollution to meteorology** can differ significantly with pollutant levels, for example 95th percentile O_3 concentrations are ~50% more sensitive to temperature than 50th percentile ozone**.** This behavior in O_3-T is not uniformly reproduced by global models, and appears to be more strongly influenced by dynamics than by chemistry. (PI Heald)
- There is considerable uncertainty about the effect of **drought on ozone** due to uncertainties in land cover characterizations, soil moisture conditions, and the relationship between biogenic emissions and water availability. (PI Allen)
- **Observed monthly mean ozone** concentrations in the southeastern United States were **higher in October than July in 2010**. Analysis suggests that this is due to dry and warm weather conditions, which enhance photochemical production, air stagnation, fire emissions, and biogenic emissions, as well as increases secondary organic aerosol formation. (PI Wang)

Challenge: taking stock of North American/European Climate Air Pollution Research

- SSPs (Shared Socio-economic Pathways) Air pollution scenarios follow some of the concepts used in HTAP(GAINS) scenarios. The range is wider than the often criticized 'RCPs'.
- If ambitious climate policies will be implemented, it will have e.g. beneficial aspects for various types of air pollution, including aerosol, O_3 and CH_4.
- Linkage to Sustainable Development Goals
- Challenge: to integrate this knowledge in to LRTAP relevant information



Presented by Shilpa Rao, Potsdam, 2016; submitted to GEC; 2016.