WG2 Climate change and air pollution – a long term perspective

Long term is taken as 2020 and beyond. Decisions now determine emission patterns for the next 30 years and more, which depending on societal sector is the lifetime of investments made now.

Science Issues

1. Links between changes in short lived greenhouse gas and particulate matter emissions/concentrations and climate change (both ways)
2. Feedback from climate change on air quality (sulphur, nitrogen, volatile organic compounds, secondary species, heavy metals and persistent organic pollutants)
3. Will natural variability dominate over the climate change feedback on air quality over the next 1-2 decades?
4. Are changes in air quality arising from emission control measures larger than or less than the changes in air quality that may arise from climate change?
5. Will regional emission changes affect regional climate? Will air quality emission reduction policies lead to emission changes that counteract climate change policies?

1 Links between changes in short lived greenhouse gas and particulate matter emissions/concentrations and climate change (both ways) + nitrogen as a cycle

- Critical processes for air quality are determined by the structure of the planetary boundary layer. Stable planetary boundary layers are of particular significance in air quality and is not a main concern in regional or global climate models or even numerical prediction models.
- Climatological observations done by the meteorological services and air quality observations done by environmental agencies/institutions) are separated and this is counterproductive for the assessment of climate change/variability and air quality relationships. Some meteorological agencies like the Chinese Meteorological Agency now reorganises meteorological observations to merge with air quality observations.
- Particulate matter and ozone impact on local precipitation and surface temperature
- There is an under-exploitation of observed climate variability-air quality-relationships in the past as a training material for possible relationships between air climate and climate in the future.
- Ozone and particulate matter redistribution affects synoptic weather patterns (gradients in radiative forcing created by tropospheric particles and ozone will modify synoptic weather patterns). Example: Indian monsoon system modified by regional PM

  Recommendations
  - Explore the observations further: e.g. identify how particulate matter may impact on precipitation (local); integrate air quality-observations and meteorological observations to merge the information and evaluation capabilities
  - Use climatological observations to underpin air quality-climate change relationships (e.g. use the 40 years of global reanalysis data from ECMWF (ERA40 (1961-2001) to identify the impact of meteorological variability on air quality variability/trends)

2 Feedback from climate change on air quality (sulphur, nitrogen, volatile organic compounds, secondary species, heavy metals and persistent organic pollutants)

- There is evidence that trends in meteorological parameters due to climate change have an impact on air quality. Studies are being produced, but solid quantification of these processes is still lacking. The main meteorological parameters which will be affected are:
  - temperature;
  - precipitation regimes;
  - wind patterns.
- Changes in these parameters will have first order effects on processes such as:
  - natural (e.g. sea salt) and biogenic (e.g. volatile organic carbon) emissions;
  - removal rates of chemicals;
  - transport processes;
  - atmospheric chemistry (e.g. oxidising capacity).
- A wide range of secondary effects are also expected which will affect all major biogeochemical cycles. Also feedbacks on the climate system itself are to be expected. Adaptation measurements will also affect the whole loop.

Recommendations

- Implement monitoring and past data acquisition strategies to ensure comparable data-bases for analysis and interpretation.
- Methodologies which can be proposed to tackle these issues are twofold: off-line or on-line approaches:
  - reanalysis of past meteorological data in connection with air quality (past data only);
  - regional climate model ensembles linked to air quality (past and future data);
  - fully coupled climate-air quality models

3 Will natural variability dominate over climate change feedback on air quality in the coming decades?

- Based on model simulations using observed climate (ERA40):
  - Ozone concentrations in Europe varies up ~5% (relative to the standard deviation of the annual mean concentrations) due to variability in meteorology during 1979-2001. The year to year variability in annual ozone between 1979 and 2001 is -10% to + 10%; the extreme case 2003 show +20%, some grid values over 30%
  - SIA variability 5-30%. Year to year variability larger (> 20%).
  - Ozone trends -5 to +5% per decade (1979-2001) in different parts of Europe
  - SIA have increased 1-5% per decade over 1979-2001 due to climate change alone.
- CTM Simulations using meteorology from regional climate models
  - indicate that ozone will increase by 10-20% in summer in southern/central Europe during the coming 30 years just because of climate change
  - For SIA model studies indicate a larger increase in most of Europe during most seasons. Increase in Europe 10-30% over 30 years. (Year-to-year variability in emissions not accounted for).

Summarised

- On a decadal scale the climate change signal in the ozone and PM concentrations is comparable to or larger than the signal due to meteorological variability

4 Are changes in air quality arising from emission control measures larger than or less than the changes in air quality that may arise from climate change?

- Change in air quality, e.g. ozone, sulphates and nitrates observed during the last 50 year is shown to be significantly influenced by climate change. It is thus important to take into account when evaluating the actual effect of different control measures.
- For some parameters the climates change affects mainly the transport pattern and thus mainly change the “effect” pattern, while for others, like ozone, climate change increase the formation and thus the actual concentrations and thus the total effects.
- Several air quality components – ozone, black carbon and aerosols - are shown to have significant effect on the climate. These components have shorter lifetimes in the atmosphere than most of the greenhouse gases. Climate strategies for a short time horizon (a few years) counteracting rapid climate change should be coordinated with air quality measures as several of these components have considerable health effect.
- Methane is the one greenhouse gas with short life time that should be considered for climate abatement on a short time scale.
- Control measures concerning greenhouse gases and other climate relevant parameter for counteracting climate change will most certainly affect air quality not only due to climate change but even more as the same sources will be controlled, e.g. combustions sources.

Recommendations:

- Future revisions of international air quality legislation (e.g. the NEC Directive and the Gøteborg Protocol) has to take climate change into account in the goal setting.
- The science community has to quantify the air quality-climate change-relationships
- Climate change measures include important air quality parameters, so air quality measures and climate change measures have to be considered simultaneously.

5 Will regional emission changes affect regional climate? Will air quality emission reduction policies lead to emission changes that counteract climate change policies?

- If the global radiative forcing effect of anthropogenic aerosols is 1 – 1.5 W/m^2 as suggested by IPCC then the down wind effect of reducing emissions should be noticed in the regional climate. The magnitude and character of the climate change effect has to be analysed by regional air quality and climate models and observations in combination. The models need to include a sufficient description of the relevant air quality parameters.
- A large reduction in emissions of particulate matter and particulate matter precursors will most likely intensify climate change and thus on short time scale counteract climate change reduction policies (regionally very large increases in radiative forcing to be expected as aerosols burden declines, the current radiative forcings by particulate matter identified in connectiion with biomass burning over Amazonia and in the Indoex experiment).
- A targeted reduction in ozone precursors or black carbon can reduce regional warming.

Recommendation:

- Regional AQ need to be coupled with CC models to include AQ parameters and to interact such that AQ models can take into account CC and CC can take into account the effect of changing regional AQ fields.

General recommendations

- CLRTAP (EMEP) to account for ow climate change contribute to air quality changes and how air quality changes contribute to regional climate change.
- Integrate climate change and air quality communities (The climate change community has up to now focused on how weather elements and their probability density functions change with time and location as a consequence of increasing radiative forcings from greenhouse gas and particulate matter concentration changes. Further the climate change community has focused on the societal implications of the changed probability density functions of weather elements, but air quality has not been part of the picture up to now.) Tis is addressed to the science community; policy makers (the research community needs to have a good showcase); CLRTAP + UNFCCC (item for the next SBSTA meeting?)
- Joint assessment IPCC + global air quality-body (CLRTAP + others to make it global and rooted in the science plus policy arena) (Example to follow: The Montreal protocol technical body and IPCC together prepared a stratospheric ozone-climate assessment)
- Publish findings of air quality - climate change interlinkages in publications that are common ground to both air quality and climate change research communities (To: science community)
- Develop coupled climate-chemistry models in a stepped approach with time as base information evolve. As base information is meant e.g. dynamical description of two way fluxes between land and the atmosphere and between ocean and the atmosphere with appropriate resolution and accuracy. Another constraint on the pace of the coupled climate-chemistry model development is the evolution of resources like computer power, and the evolution and availability of observational material from in-situ and remote sensing instrumentation. To: science community, an important time post will be the next IPCC assessment (2009 start). This is also addressed to international research and coordination structures like IGBP and WCRP/WMO.
- Influence FP7: The work programme is renewed each year; in the coming summer for next year's call; expert meetings in the summer. To: CEC/CEC-experts and national delegates
- Emission estimates and scenarios: Harmonisation needs to go beyond 2020 which has been established through the Clean Air for Europe Thematic Strategy and needs to include the major greenhouse gases and air quality pollutants including particulate matter and its precursors, heavy metals and persistent organic pollutants. As climate models and air quality models are being coupled, the demand for resolution of emission estimates increases (0.1x0.1 degree?).