Urban Air Pollution, Tropospheric Chemistry, and Climate Change: An Integrated Modeling Study

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Linking Urban Pollution, Tropospheric Chemistry and Climate Change

- Impact of urban air pollution on global tropospheric chemistry and climate (e.g., tropospheric $O_3$ and $NO_x$ budgets, radiative forcing by $O_3$ and aerosols);
- Impact of future climate change on urban air pollution and tropospheric chemistry (e.g., effects of clouds, UV, precipitation, $H_2O$, and temperature on reaction rates);
- Interaction between urban/tropospheric chemistry and climate under various emissions policies;
- Anthropogenic aerosols' impact on human health;
- Impact of air pollution and climate change on natural ecosystems
Integrated Modelling Study

- Climate-chemistry interactions require models with integrated components of atmosphere, ocean, tropospheric chemistry, emissions (policy and non-policy), and ecosystem;

- Integration time: $\geq 10$ years for tropospheric chemistry studies (primarily due to $\text{CH}_4$ and $\text{O}_3$ simulation as well as aerosol forcing assessment), $\geq 100$ years for tropospheric chemistry and climate interaction studies;

- Subgrid scale nature of urban and fast tropospheric chemistry as well as lightning production of certain chemical species in current global models with resolution coarser than $\sim 100$ km requires adequate parameterizations for relevant processes;

- Data base (measurement and emissions);

- Computational efficiency (parallel, esp. distributed memory computing)
MIT Interactive Chemistry-Climate Model

Atmospheric Chemistry Model
- 25 Chemical species
- 4 Aerosol groups
- Advection, convection, and mixing
- Gaseous and aqueous reactions
- Wet and dry deposition

Urban Air Pollution Model
- Natural Emission Model
- Ocean Carbon Model
- EPPA and Emission Preprocessor

Terrestrial Ecosystem Model
- NPP, NEP, soil carbon pool

Climate Model
- MIT 2DLO, NCAR CCM/CSM, MIT AIM/OGCM
- Circulation and state of atmosphere
- Land and ocean
- Clouds and Precipitation
- Radiation

Concentrations of chemicals
- Winds, T, H2O, precipitation and radiative fluxes
Urban Air Pollution Model and Global Chemistry Model
Projected Future Increases of Emissions
(Emissions/Emissions of 1995; MIT EPPA)
Summary

- Integrated models are needed for linking urban air pollution, tropospheric chemistry, and climate; required integration time varies from 10 - 100 years depending on the given topics;

- Adequate parameterizations of urban scale air chemistry and other subgrid scale chemical processes in global models are critical to modeling results;

- Future black carbon emissions may increase according to the MIT EPPA Model;

- Modeled radiative forcing of aerosols is highly uncertain, multiple year integrations with uncertainty analyses are needed for assessment;

- Policy and health issues related to urban air pollution and anthropogenic emissions of aerosols need to be explored and inclusion of interaction between tropospheric chemistry and climate change is important.