Methane as an Ozone Precursor

Conclusions and Recommendations

Task Force on Hemispheric Transport of Air Pollution
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Conclusions and recommendations reported by Task Force

- Atmospheric methane concentration has more than doubled since pre-industrial times, indicating substantial growth in anthropogenic emissions. Major anthropogenic sources of methane include the energy (coal, oil, and natural gas), wastewater, solid waste, and agricultural (ruminants and rice) sectors. Without mitigation, global anthropogenic methane emissions are expected to continue to increase. Natural methane emissions are highly uncertain, and sensitive to changes in climate.
- Methane is a precursor to background tropospheric ozone and its growth since pre-industrial times has contributed to an increase in ozone globally. Future changes in methane emissions are expected to affect ground-level ozone concentrations, including in polluted regions.
- Since methane mitigation reduces global background ozone, it offers an opportunity to improve air quality globally, while also decreasing climate forcing. Mitigation efforts would complement ongoing local and regional ozone management. For example, models indicate that a 20% reduction in global anthropogenic methane emissions reduce surface ozone everywhere, globally averaged as ~1 ppbv, as well as decreasing climate forcing of both methane and ozone by approximately 0.15 W m^{-2}.
- Low-cost and cost-saving options are available to reduce methane emissions, as demonstrated through recent emission reductions in industrialized nations. Analyses of greenhouse gas reduction options suggest that roughly 20% of current global anthropogenic methane emissions can be reduced at low cost through global applications of currently identified measures (particularly in the oil, gas, and waste management sectors).
- Future research priorities should include: (1) assessing and reducing uncertainties in the ozone response to methane, through analyses such as multi-model intercomparisons and integration with observations, (2) identification of additional methane mitigation options and associated costs, (3) improved characterization of global methane emissions, (4) analyses of how future global change will affect the tropospheric ozone response to methane. The Task Force could benefit from ongoing research in the climate change and stratospheric ozone communities.

1. Characterizing the CH_4-O_3 relationship

- Observations indicate that global tropospheric O_3 concentrations have at least doubled over the past century.
- Global tropospheric chemistry models roughly reproduce this background increase and attribute it in part to anthropogenic increases in CH_4 emissions (also NO_x).
- Anthropogenic methane has long been recognized to contribute to tropospheric ozone (in the presence of NO_x). Because methane is long-lived and well-mixed in the troposphere, it affects the tropospheric ozone background, including in surface air.
- A number of global modeling studies suggest that O_3 responds roughly proportionally to changes in methane emissions; estimates of that relationship are fairly consistent.
  - A 20% decrease in anthropogenic CH_4 emissions is estimated to reduce surface O_3 by ~1 ppb (eventual or steady-state response).
  - Compiling results from these studies suggests that anthropogenic methane contributes ~50 Tg to the annual mean tropospheric O_3 burden, and ~5 ppb to surface O_3
- The global O_3 response appears to be largely independent of the CH_4 source location.
  - The spatial pattern of the O_3 response does depend on distributions of OH and NO_x.
- Ozone air quality benefits are realized gradually, due to the long lifetime of methane (roughly a decade), such that ~60% of the eventual (steady-state) response would be realized in 10 years, ~80% in 20 years, and ~90% in 30 years.

2. Methane budget and trends

- **Atmospheric methane concentrations have more than doubled since pre-industrial times, indicating substantial growth in anthropogenic emissions.**

- **Total methane emissions are ~600 Tg yr^{-1} (uncertainty ~25%) [IPCC TAR, 2001].**

- **Anthropogenic emissions contribute ~60% to total emissions [IPCC TAR, 2001].**
  - **Anthropogenic sectors include energy (coal, oil, and natural gas), wastewater, solid waste, and agriculture (ruminants and rice).**

- **The largest uncertainties are in the natural sector.**

- **The dominant methane sink is reaction with tropospheric OH (~30% uncertainty)**

- **Under business as usual assumptions, global anthropogenic CH_4 emissions are projected to grow 30-40% from 2000 to 2020.**

- **New methane emissions estimates and projections are forthcoming (e.g., IPCC AR-4).**

3. Methane mitigation for ozone management

- Methane mitigation offers a new opportunity for ozone management, which is best viewed as:
  - International in scope, as benefits are shared globally.
  - Complementary to ongoing local and regional controls on NO_x, NMVOC, and CO emissions.
- Technical measures are available to mitigate CH_4 emissions.
  - Low-cost and cost-saving options have been identified for the purpose of mitigating climate change.
  - Many industrialized nations have reduced emissions since 1990, demonstrating that cost-saving mitigation opportunities are available (by capturing methane to use as natural gas for energy).
  - These opportunities exist in several sectors, including energy (coal, oil, and natural gas), wastewater, solid waste, and agriculture (ruminants and rice), and in all world regions.
- A first study [West *et al*., 2006] finds that the global health benefits from decreasing ozone by reducing methane (~$240 per ton methane, or ~$12 per ton CO_2 eq.) can exceed the costs of a 20% reduction in global anthropogenic methane emissions.
  - Other benefits would accrue to natural ecosystems and agricultural productivity.
- Methane emission reductions also decrease radiative forcing of climate (from CH_4 and O_3), whereas NO_x controls cause a small net positive forcing.

4. Research needs

- More fully identify methane mitigation options and the associated costs and feasibility for global application, particularly for the large agricultural sector.
- Improve source characterization to better quantify methane emissions from both the anthropogenic and natural sectors.
  - Potential for new constraints from space-based observations
  - Measurements of many species (including isotopes) for sector apportionment
- Assess and reduce uncertainties in the tropospheric ozone response to methane
  - Multi-model intercomparison of the dependence of the tropospheric burden and surface ozone to methane.
  - Improve assessment of impacts at higher resolution, through linking global and regional models.
  - Improve constraints on OH and NO_x distributions through relevant measurements and integration with models.
  - Can the response of ozone to methane be directly observed in the atmosphere?
  - Improve understanding of observed trends in background surface ozone
- Advance understanding of effects of changes in methane on aerosols (for air quality and climate), and on stratospheric ozone (including any feedbacks to tropospheric ozone).
- Investigate the impact of global change (climate change and future emissions) on:
  - Methane lifetime
  - The CH_4-O_3 relationship (through changes in NO_x and OH)
  - Biogenic and methane hydrate emissions
- Consider how possible strategies to reduce methane for ozone air quality purposes might interact with current or future climate change strategies.
  - Consider the tropospheric ozone and health benefits of climate strategies.
  - Would consideration of tropospheric ozone benefits alter climate strategies?