Air Pollution as Climate Forcing: A Second Workshop

April 4-6, 2005 at East-West Center, Honolulu
Sponsored by Hewlett Foundation & Columbia University Earth Institute
Local Host: International Center for Climate and Society, University of Hawaii

Workshop Rationale

It is widely recognized that global warming is occurring and that human-made climate forcing agents are at least partly responsible. Climate forcings include changes of long-lived greenhouse gases, especially CO_2, but also short-lived air pollutants such as aerosols (fine particles), tropospheric ozone (O_3), and its precursor methane (CH_4). Short-lived air pollutants have inhomogeneous spatial distributions with both regional and global climate effects.

Actions to address air pollution and climate forcing agents are being taken separately at all levels of government, in industry, and by consumers. Successes in reducing pollutants and climate forcing have been achieved in many ways, and even multilateral accords are usually preceded by actions of consumers, industry and government organizations. Discussions about potential actions to reduce air pollution and climate change should be informed about the full range of effects and current scientific understanding. Such knowledge may influence strategic choices.

Workshop Purpose

Our goal is to communicate current knowledge about linkages between the air pollution controls and climate mitigation. We aim to illuminate the role of air pollutants as climate forcing agents, make the discussion of health and other impacts more composition-specific, quantify the potential of technologies to address both health and climate forcings, and estimate costs and benefits of alternative approaches.

The workshop focuses on the two major air pollutants that are also climate forcings: (1) aerosols, and (2) the greenhouse gases controlled by air pollution, i.e., tropospheric ozone (O_3) and methane (CH_4). Their climate effects must be measured against those of the dominant climate forcing, CO_2. Cost/benefit implications are a key criterion for assessing alternatives.

We will ask what would be required to halt and reverse the growth of these pollutants, what impact this would have on climate change, what contributions technologies can make to reducing these pollutants including carbon dioxide, what the air quality benefits would be for human health and the environment, and how cost/benefit considerations might affect choices among alternative technologies.

Specific Topics

1a. Methane: Is it feasible to achieve a global warming success story with CH_4, i.e., to achieve a real world scenario with decreasing CH_4? What actions would be most effective for that purpose?

1b. Ozone: Is it feasible to halt the growth of global tropospheric O_3 or even achieve a reduction? What actions would be most effective for that purpose?

2. Black Carbon/Soot: Is it feasible to reduce soot emissions enough to alleviate the global warming surge expected to accompany reduction of anthropogenic sulfate aerosols?

3. Nitrogen: Do we understand 'nitrogen' emissions and resulting climate forcings (via nitrate aerosols, cloud effects, O_3 and CO_2) well enough to offer advice on controls to minimize climate change?

4. Human Health and Agricultural Effects: Can we differentiate the effects of specific aerosols and gases on human health? Can we quantify economic impacts of specific pollutants, i.e., make a "bar graph" equivalent to that for climate forcings?

5. Technology: Can technologies achieve absolute reduction of pollutants, given expected economic growth and development? Are there real world case studies providing useful guidance?

6. Cost/Benefit: Can we estimate costs & benefits of candidate technologies or actions to reduce pollutants? Does inclusion of a GHG benefit (specified via \$/ton of CO_2) alter the sign of cost – benefit?

Air Pollution as Climate Forcing: Alternative Scenarios – Their Benefits and Costs

Goal is to Quantify: 1. Current Trends, 2. Moderate Action, and 3. Strong Action Scenarios

Agenda

March 30, 2005

Monday, April 4: Science Sessions

8:45 **Lorenz Magaard** (Director, International Center for Climate and Society, and Chair, Department of Oceanography, University of Hawaii): Welcoming Remarks

1. Causes of Changing Air Quality and Climate [co-chairs: Yunfeng Luo and Jim Hansen]

8:50 **Michael Prather** (Univ. Cal. at Irvine): Current Understanding & Relevant Issues
9:20 **David Hofmann** (NOAA): Recent CH_4 Data and Analysis re Sources
9:40 **Xiao-Ye Zhang** (CMA): EC/OC Emissions and Aerosol/Gas Observations in China
10:00 **Dina Kruger** (EPA) & **Dennis Tirpak**: Potential for Reduction of Methane Sources
10:25 **Jason West** (Princeton): Methane Control for Ozone Air Quality Purposes
10:45 **Open Discussion**

10:50 Coffee Break/Discussion

2. Aerosol/Gas Emissions & Atmospheric Amounts [co-chairs: T.S. Panwar & Tami Bond]

11:10 **David Streets** (Argonne Natl. Lab.): Current Understanding & Relevant Issues
11:35 **T.S. Panwar** (TERI): Emission Inventories and Air Quality in India
11:55 **Yunfeng Luo** (China NSF): Aerosol Forcing over China and Regional Climate Change
12:15 **Dorothy Koch** (Yale Univ.): Aerosol Climate Forcings vs. Source Region & Sector
12:30 **Tami Bond** (Univ Illinois): From Action to Forcing: A Solution-Centered View
12:50 **Open Discussion**

1:00 Lunch Break

3. Human Health Effects of Pollutants [co-chairs: Dan Greenbaum and Tong Zhu]

2:00 **Dan Greenbaum** (Health Effects Inst.): Current Understanding & Relevant Issues
2:45 **Tong Zhu** (Peking Univ.): Health Effects of Air Pollution in China
3:10 **Praveen Amar** (NESCAUM): Valuation of Health Benefits from Mercury Pollution Control
3:30 **Student/Post-Doc Poster Introductions**

3:50 Discussion/Coffee Break

4. Regional and Agricultural Impacts of Pollutants [co-chairs: L. Emberson & M. Agrawal]

4:10 **Lisa Emberson** (York University): Assessing the Global Impact of Air Pollution on Agriculture
4:40 **Madhoolika Agrawal** (Banarus Univ.): Impacts of Pollution on Crops in South Asia
5:00 **Surabi Menon** (LBNL): Regional Climate Impacts of Air Pollutants
5:20 **Open Discussion**

5:45 Bus Leaves for Aquarium

Evening reception at the Aquarium

6:00-8:30 PM 2777 Kalakaua Avenue (Spouses Welcome)

Tuesday, April 5: Alternative Technologies

1. Mobile Sources [co-chairs: Axel Friedrich & Tang Dagang]

8:45 **Michael Walsh**: Overview, Alternatives, Issues
9:15 **R.K. Bose** (TERI): Potential Transportation Pathways in India
9:35 **He Kebin**: Potential Transportation Pathway in China
9:55 **Richard Corey** (CARB): Climate Forcings from Mobile Air Conditioning Systems
10:15 **K.G. Duleep**: Prospects for Hybrids, Diesel, and Hydrogen Vehicles
10:35 **Mark Delucchi** (UC Davis): Potential of Fuels for Reducing Emissions

10:55 Coffee Break/Discussion

2. Power Generation [co-chairs: P.K. Dadhich and Armond Cohen]

11:15 **Armond Cohen** (CATF) & **Steve Brick** (Wisc. EC): Overview, Alternatives, Issues
11:45 **P.K. Dadhich** (TERI): Potential Power Sector Scenarios for India
12:05 **Edward Rubin** (Carnegie Mellon Un.): CO_2 Sequestration Options, Costs and Impacts
12:25 **David Hawkins** (NRDC): Integrated Strategy for Fossil Generation Reduction
12:45 **Open Discussion**

1:00 Lunch Break

3. Energy Efficiency

2:00 **Art Rosenfeld** (CEC): Lessons from California & Cooperation with Annex 2 Countries
2:25 **Axel Friedrich**: Potential of Improved Efficiency in Different Energy Use Sectors
2:45 **Curtis Moore**: Ten Steps to Zero – An Analysis of the Potential of Energy Efficiency
3:05 **Adam Chambers** (NREL): Role of Energy Efficiency & Renewable Energy in Reducing Emissions
3:25 **Open Discussion**

3:35 Coffee Break/Discussion

4. Household Energy and Emissions of Gases and Aerosols [co-chairs: K. Smith & D. Greenbaum]

3:55 **Kirk Smith** (UC Berkeley): Overview, Alternatives, Issues
4:25 **T.S. Panwar** (TERI): Biofuel Emissions in India
4:40 **Rufus Edwards** (UC Irvine): Assessment of Residential Sector Emissions and Incorporation into Trading Mechanisms
5:00 **Health/Agriculture Panel Discussion:** Speciation (which constituents cause problems?) and Valuation (what are the costs to society?). Can we hazard bar-graphs of impact vs pollutant, why not?
Panel: Dan Greenbaum, Kirk Smith, Lisa Emberson, Madhoolka Agrawal

Open Discussion

5:45 Bus Leaves for Hotel

Wednesday, April 6: Integrated Assessment and Panel Discussions

1. Integrated Assessment [co-chairs: Denise Mauzerall and Marcus Amann]

8:45 **Denise Mauzerall** (Princeton University): Integrated Assessment with Valuation
9:10 **Markus Amann** (IIASA): Integrated View of Air Pollution and Climate Change
9:35 **Steve Smith** (PNNL): Integrated View of Air Pollution and Climate Changes
10:00 **Ben DeAngelo** (EPA): BC/OC Role in Integrated Assessments
10:20 **Open Discussion**

10:30 Coffee Break/Discussion

2. Cost/Benefits of Technologies and Efficiencies [co-chairs: Michael Holland and Axel Friedrich]

10:50 **Michael Holland**: Quantifying Health and Environmental Impacts
11:15 **Joseph Spadaro**: Application of RiskPoll Model to Europe and Developing Countries
11:40 **Mark Delucchi**: Social Costs of Mobile Source Pollutants

2b. Scenarios Reconsidered: Current Trends, Moderate Action, and Strong Action Scenarios

11:55 **Bart Croes, Michael Walsh, R.K. Bose**: Mobile Source Scenarios for Climate Forcings
12:15 **Armond Cohen, P.K. Dadhich**: Power Generation Scenarios for Climate Forcings
12:35 **Eric Redman**: Practical Advice on Strategies to Slow Human-Made Climate Forcing
12:50 **Open Discussion**

1:00 Lunch Break

3. Real-World Case Studies [co-chairs: Adrian Fernandez and Ken Colburn]

2:00 **Adrian Fernandez**: Air Quality and Climate Considerations in Mexico
2:20 **Ken Colburn**: Strategies and Reality in Northeast States
2:40 **Tim Wallington**: Business Perspective on Potential Pollution Reductions
3:00 **Ellen Baum**: Incorporating BC, CH_4, and N_2O into State Climate Stabilization Planning
3:20 **Peter Flachsbart**: Integrated Planning to Mitigate Emissions of Air Pollutants and GHGs
3:35 **Open Discussion**: Overcoming Practical Barriers to Pollution Reduction and Climate Control

4. Panel Discussions Summarizing Understanding of Workshop *"Specific Objectives"*

Format allows brief presentations and includes proposed synthesis by panel leader. Volunteers solicited.

3:45 **Panel 1: Non-CO_2 Greenhouse Gases:** Can further increase of non-CO_2 GHG climate forcing be halted or even reversed? This is the sum of three problems CH_4 + O_3, N_2O, trace gases (esp. HFC-134a).

Panel Leader: Drew Shindell, others Michael Prather, Markus Amann, Richard Corey, Tim Wallington

4:25 **Panel 2: Soot and Sulfate:** Can reduced soot emissions counteract the warming effects of reducing sulfates? What are the most effective actions in that direction?

Panel leader: Ellie Highwood, others Jim Hansen, Xiao-Ye Zhang, Ben DeAngelo, Tami Bond

5:00 **Open Discussion**

Air Pollution as Climate Forcing: A Second Workshop (April 4-6, 2005)
Goals and Limitations

March 30, 2005

We draft specific workshop goals, to help organize the agenda and identify needed participation. These are ambitious and include uncommon topics.

Goals

1. Quantitative relationships for emissions → effective climate forcings.

Air quality cannot be included in the climate discussion without a prescription for how to relate pollutant emissions* to climate change. A straw-man exists for the portion: atmospheric composition → effective global** climate forcing. We need quantitative results for emissions → atmospheric composition. This will differ with location; places of principal interest are the United States, Europe, Southeast Asia (China/India).

*Principal emissions that affect both human health and climate are aerosols, ozone, and their precursors. However, when the costs (damage) of air pollution and the benefits of alternative technologies and energy efficiency are totaled, the benefits of reductions of all pollutants, including, e.g., CO_2 and mercury, should be incorporated. The benefit of reduced global climate forcing can be included for all terms via a $/ton value on CO_2 and the emission forcing relationship.

**The fact that regional climate change due to regional pollution may exceed global effects is not a constraint. The regional climate effect of regional pollution is an additive term that can be included when the impacts are quantified. The workshop will include a review of the status of understanding of regional pollution effects on regional climate.

2. Composition specificity of pollution and climate effects.

Goal is to relate health effects to aerosol composition, not simply to PM2.5. Some of the pollution effects on climate have a clear dependence on pollutant composition. Knowledge of composition-specific emissions by sector and technology is needed to identify sources warranting targeted emission reductions.

3. Quantify economic benefits of reduced pollution, as input to a cost/benefit discussion.

We will attempt only simple cost/benefit tabulations, as opposed to a sophisticated economic discussion. Important terms (on either side of the equation) that are difficult to quantify should be noted and bounded, if possible. Impacts that cannot be quantified, e.g., pollution effects on natural vegetation, should be noted as an unquantified effect.

4. Greenhouse gases (GHGs) should be included in the cost/benefit discussion.

This can be via a specified $/ton of CO_2 on all GHG emission reductions. This is not a "co-benefits" discussion in either direction. It is simply the addition of two terms on the benefits side of the equation (short-lived pollutants and long-lived GHGs). The relation to be obtained in 1 above will allow an equivalent global climate valuation on non-CO_2 climate forcings.

5. Spirit of Cooperation.

The discussions are positive and ecumenical, with no intent to cast blame for growth of relevant atmospheric constituents, but rather with a helpful spirit in which we try to identify and quantify opportunities and benefits of reducing local pollution and global climate forcings.

These ambitious goals need to be counterbalanced by limitations on objectives and the use of simplifying assumptions and approximations that help make the tasks feasible.

Limitations

6. Limited time for discussion of end-use efficiency.

Improved end-use efficiencies may be the most effective way to reduce both short-lived pollutants and CO_2 emissions. Efficiency probably could obviate the need for new power plants in the U.S. for a couple of decades, allowing time for clean technologies to be developed and demonstrated. Adequate discussion of efficiency would require its own conference. Although we can devote only one session to this topic, we will emphasize its importance. Also end-use efficiency will be implicitly included via cost benefit comparisons of alternative technologies.

7. Straw-men approximations.

Approximations are required to reach an endpoint in the calculations. Approximations should be clearly stated and replaceable when better methods are practical. For example, aerosols in a first approximation may be treated as externally mixed, although even in this case the crucial aerosol absorption term can be adjusted to give the proper magnitude of absorption for realistic aerosol mixing.

8. Principal (representative or dominant) components.

Where necessary we can restrict quantitative discussion to representative or dominant components of the system. For example, when global data is not available or practical to deal with, we can restrict considerations to principal contributions such as U.S. + Europe + China + India, possibly with global estimates obtained by scaling up these components appropriately.

9. 25 and 50 year projection points.

Rather than detailed transient simulations, we can restrict comparison of the present (say year 2000) with two points in the future, one of them being 25 years from now (2030). The other could be 2100, as per the IPCC approach. That is necessary for IPCC purposes, because of the long climate response time, but it is difficult to say much about technology then. Therefore a more practical second point is 50 years (2050 or 2055). Considerations requiring a transient calculation can assume linear change of atmospheric composition between the three time points.

10. Outdoor biomass burning.

Biomass burning is a major global source of aerosol and gas pollution. This workshop will not focus on outdoor biomass burning. However, in estimating the potential for reductions of ambient atmospheric loadings of aerosol and gaseous pollutants it is essential to know the fraction of the load that derives from outdoor biomass burning. Thus we must at least deal with biomass burning in emission inventories.