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Climate Change Science

Part III of VI: Critical Omissions for Critical Emissions

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Any comprehensive treatment of the global warming problem must take into account important gaps in scientific knowledge.

Full recommendations, page 4.

Summary: The atmospheric concentrations of several non-carbon dioxide greenhouse gases are rising and making an increasing contribution to global warming. The most important of these gases include methane, nitrous oxide and ground level ozone. For example, Nitrous oxide is two hundred times more pernicious a greenhouse agent than carbon dioxide. Yet, while its rising concentration since the start of the industrial revolution indicates a man-

made source, nearly thirty percent of its origins remain unidentified. In China, rural-to-urban migration accompanying economic modernization will result in huge greenhouse gas emissions. Critical to forecasting these and predicting their consequences are demographic and intra-country emissions statistics and modeling. More research on non-carbon dioxide greenhouse gasses is needed to develop the best overall policies for regulating emissions. ❖

IGCC is a multicampus research unit of the University of California, established in 1983 to conduct original research and inform public policy debate on the means of managing conflict and promoting cooperation in international relations.

Policy Briefs provide recommendations based on the work of UC faculty and participants in institute programs.

Authors' views are their own.

IT IS WELL KNOWN THAT MOST warming in the Earth's atmosphere comes from the infra-red activity of carbon dioxide. However, in the past decade other gasses' greenhouse capacities have gained in importance. The atmospheric concentrations of several non-carbon dioxide greenhouse gases are rising and making an increasing contribution to global warming. The most important of these gases include methane, nitrous oxide and ground level ozone.

Ultimately, development of a successful greenhouse gas regulation policy must include all greenhouse gases. However, unlike carbon dioxide or the hydroflourocarbines responsible for damage to the earth's atmospheric ozone layer, there is a real problem in that sources for significant amounts of these remain unidentified. Part of this discussion will focus upon the role of molecules other than carbon dioxide as greenhouse agents, and the obstacles associated with mitigation of their emissions.

Nitrous Oxide Sources

For example, nitrous oxide is a greenhouse agent two hundred times more effective on a per-molecule basis than carbon dioxide. In addition, following its decomposition in the upper atmosphere, nitrous oxide is a major agent in stratospheric ozone depletion. It has a greater than 100 year atmospheric lifetime, with an annual increase between approximately one and two percent.

The observation of large increases in nitrous oxide concentration since the onset of the industrial age indicate a man-made source. However, In spite of more than several decades of high quality global concentration measurements and modeling efforts, nearly 30

per cent of nitrous oxide's anthropogenic origins remain unidentified.

With an atmospheric lifetime of approximately 130 years, even after sources are identified and eliminated by appropriate restrictions, it will be decades before there is a noticeable decline in the atmospheric concentration of nitrous oxide. In order to develop the best decisions for regulation of greenhouse gas emissions, identification of those sources is imperative. At a recent international conference on nitrous oxide held in Japan, there was a clear consensus that this remains one of greatest challenges in reducing greenhouse gas emissions.

Methane Sinks

We also have limited understanding of the sources and sinks for other important greenhouse gases, like methane, another agent with significant heating capacity. While its atmospheric lifetime is significantly shorter than nitrous oxide (approximately a decade), its radiative forcing capacity and global warming capability is larger. With the onset of the industrial age, methane has exhibited dramatic concentration increases and presently maintains an observable annual increase.

Traveling Aerosols

Aerosol particles created as by-products of human activities are emitted into the atmosphere where they act as important climate modifiers. For example, these particles help to form clouds, which play an enormous role in the heat balance of the atmosphere (see Policy Brief 12-2: *Predicting 21st Century Climate*).

Furthermore, these particles are small, respirable, and interact with human lung tissue. Most recently, it has been recognized that chemical interactions on the surfaces of these particles, particularly in highly polluted areas, create new, and

THE IGCC CLIMATE CHANGE PROGRAM

is a University of California system-wide initiative that brings leading climate scientists directly in touch with key national and international policy-makers. Bringing objective, timely scientific expertise directly to bear in ongoing negotiations, IGCC sent a delegation of eminent climate change scientists to the November, 1998 (fourth) meeting of the Conference of the Parties (COP-4) of the United Nations Framework Convention on Climate Change (UNFCCC), held in Buenos Aires, Argentina. Through three panel presentations on abrupt climate change, carbon sinks, and the science-policy interface, UC scientists advised UN national delegations, intergovernmental organizations, industry representatives, environmental agencies, and international media about current, relevant implications of recent research.

IGCC was the only academic organization with a substantial presence at the conference, where there were otherwise few scientists. According to Michael Molitor, IGCC Climate Change Program Coordinator, "Our fundamental understanding of the climate system is evolving rapidly. There are some basic scientific assumptions that underlie the Kyoto protocol negotiating process that need to be reexamined in light of recent advances." The importance of these latest discoveries was not lost on UN delegates. Thereafter, on 10-11 May 1999, IGCC Climate Change Program held briefings for policymakers in the nation's capitol. IGCC's delegation comprised:

Sandra BROWN, Winrock International

Richard CARSON, IGCC

Michael MOLITOR, IGCC

Stephan RAHMSTORF, Potsdam Institute for Climate Impact Research

Jayant SATHAYE, Lawrence Berkeley National Laboratory

Stephen SCHNEIDER, Stanford University

Jeff SEVERINGHAUS, Scripps Institution of Oceanography, UCSD

Lisa SHAFFER, Scripps Institution of Oceanography, UCSD

Robert SHELTON, UC Office of the President

Richard SOMERVILLE, Scripps Institution of Oceanography, UCSD

Mark THIEMENS, UCSD Center for Environmental Research and Training

Susan TRUMBORE, UC Irvine

Ray WEISS, Scripps Institution of Oceanography, UCSD

toxic chemicals which may enter human tissue following lung deposition.

An equally disturbing aspect involves the long-range transport of aerosols. It is becoming quite clear that there is a measurable impact of aerosols upon the United States. As the result of an exhaustive multi-national measurement campaign, it is now known that the transit time from the Indian sub continent directly to California takes less than a week. Also directly observable is the impact of emissions from China on the western United States and further into the continent. Careful documentation of the extent and predicted growth of this interaction is relevant not only to the health and air quality of the western continent, but to the increased role of these particles in global climate.

Conclusions

The largest amount of human driven climatic warming currently results from the addition of carbon dioxide to the atmosphere. However, contributions to warming from non-carbon dioxide greenhouse gases are nearly as great in magnitude.

One of the greatest scientific issues concerning these non-carbon dioxide gases is the inability to identify all of the sources that are emitting these gases into the atmosphere. Any response to global warming will need to account for this problem. The situation is exacerbated by the long lifetime of these gases, in some cases, in excess of a thousand years.

Particles in the atmosphere are transported over long distances and play an important role in the climate system. Recent scientific data indicates that aerosols

produced as a by-product of fossil fuel combustion in Asia are being transported in the atmosphere to the west coast of the United States in a matter of days.

Any comprehensive treatment of the global warming problem must take into account these important gaps in our scientific knowledge.



Mark H. THIEMENS is dean of natural sciences, professor of atmospheric chemistry in the department of chemistry and biochemistry, and director of the Center for Environmental Research and Training at UC San Diego. His research focuses on the measurements of stable isotopes in atmospheric species by ground and rocket sampling; physical chemistry of isotope effects; studies of solar system formation; and nucleosynthesis. His extensive research sampling concentrates on studying the global impact of many important atmospheric species, including carbon dioxide, nitrous oxide, carbon monoxide, ozone and sulfate. He was recently awarded the U.S. Department of Energy's Ernest O. Lawrence Award for Advances in Science based on his outstanding contributions in the field of

atomic energy. Thiemens received his Ph.D. from Florida State University in 1977. He was a post-doctoral research fellow at the Enrico Fermi Institute for Nuclear Studies at the University of Chicago, and a visiting professor and Humboldt Fellow at the Institute for Physical Chemistry, University of Gottingen.

This is the third of a six-part series titled Climate Change Science. See also PB 12-1: Bridging Science to Policy by Richard Carson; PB 12-2: Predicting 21st Century Climate by Richard C.J. Somerville; PB 12-4: Soil Carbon Sinks by Susan Trumbore; PB 12-5: Abrupt Climate Change by Jeff Severinghaus; and PB 12-6: Practical Implementation by Michael Molitor.

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How to fill non-carbon dioxide greenhouse gaps:

1. Identify nitrous oxide sources.
2. Identify methane sources and sinks.
3. Measure the extent and predict the growth of aerosol transport.
4. Assess climate and health interactions.

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