The Need for New Research to Address the Impacts of Aviation on Climate Change

Statement of

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Good morning Mr. Chairman and members of the Committee.

My name is Don Wuebbles. I am a Professor of Atmospheric Sciences and Director of the School of Earth, Society, and Environment at the University of Illinois at Urbana-Champaign.

Thank you for the invitation to testify today about the need for a new research agenda in the U.S. for understanding the impacts of aviation on the Earths' climate system. In June 2006, I organized and chaired a workshop on the impacts of aviation on climate change that was developed in particular coordination with the Federal Aviation Administration. This workshop was sponsored jointly by the U.S. Next Generation Air Transportation System (NGATS) Joint Planning and Development Office Environmental Integrated Product Team JPDO/EIPT and Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER) Centre of Excellence. The resulting findings from the international panel of experts participating in that workshop are the basis for my statement.

A 2004 report to Congress from the PARTNER Center for Excellence at MIT indicated that the most serious long-term environmental issue facing the aviation industry may be the effects of aircraft emissions on climate – both because of potential impacts and also the lack of understanding of the issues. Projections from industry and from governmental organizations, including the FAA, suggest that over the next two decades, the demand for aviation could grow to about three times its present level. This projected growth will likely result in [higher aviation emissions of various pollutants and associated] increased impacts from aviation on the environment, and human health and welfare. [These effects are dependent upon a variety of factors (such as the size and mix of the operational fleet necessary to meet the stated demand as well as mitigation steps such as new technological advances, more efficient operational procedures, market based options and regulatory intervention).] One of the most important concerns is the potential impact of emissions on the climate. Once released at cruise altitudes [within the upper troposphere and lower stratosphere], the aircraft effluents interact with the background atmosphere

and undergo complex processes, resulting in potential impacts on the Earth's climate system.

Our workshop examined the current state of scientific knowledge about the effects of aviation on climate, identified key uncertainties and gaps, and determined further research needs. I will describe some of our findings and what is still unclear. But the bottom line is that because of the potentially serious implications of aviation effluents on our planet, further research and funding for that research are imperative.

In agreement with earlier studies [e.g., the 1999 assessment by the international science community through the Intergovernmental Panel on Climate Change (IPCC)], the workshop concluded that the major ways that aviation can affect climate are the direct effects from aircraft emissions of the important greenhouse gas carbon dioxide (CO_2) (and, to a much lesser extent, water vapor), the indirect forcing on climate resulting from changes in the atmospheric distributions and concentrations of ozone and methane as a primary consequence of aircraft nitrogen oxide emissions, the direct effects (and indirect effects on clouds) from emitted aerosols and aerosol precursors, and the climate effects associated with contrails and cirrus cloud formation.

Aviation contributes about 2% of the global human-related emissions of carbon dioxide. As a result of policies to reduce other human-related emissions, this percentage could increase in the future. The climate effects from aviation emissions of carbon dioxide are much better known than the effects from other emissions. This workshop agreed with prior assessments that the level of scientific understanding to estimate climate response due to aviation emissions other than carbon dioxide ranges from fair to very poor.

The potential importance of aircraft nitrogen oxide emissions on the atmospheric concentrations of ozone is well recognized. Aviation perturbed ozone levels can also affect the amounts of methane, another important greenhouse gas. However, the workshop determined that important uncertainties remain in our understanding of these effects. The workshop recommended new detailed intercomparisons of current models of atmospheric physics and chemistry relative to the existing database of measurements of key atmospheric gases and particles. Also, participants recommended expanding the analysis of the wealth of data already measured from aircraft and satellite platforms with a focus on the atmospheric regions perturbed by impacts of aviation emissions. In the longer term, there is a need for new field campaigns to better understand the physical and chemical processes in these regions.

The estimates of climate impacts due to contrail and contrail-induced formation of high-altitude cirrus clouds are especially uncertain. Contrails form if ambient air along the flight track is colder and moister than a threshold based on known thermodynamic parameters that are not well characterized at cruise altitudes. Early contrail evolution depends, in poorly understood ways, on aircraft and engine emission parameters. In ice-supersaturated air masses, contrails can organize themselves in regional-scale clusters that add significantly to the natural high cloud cover and have the potential, albeit with large uncertainties, for a relatively large effect on climate. Factors controlling the climate

effects of cirrus clouds and contrail-cirrus (e.g., ice crystal habit, vertical profiles of ice water content, effective radius) are poorly constrained by existing observations. The extent of global distribution of supersaturation at cruise altitudes has not been adequately verified to enable its reliable prediction.

Workshop participants discussed many uncertainties and knowledge gaps related to aircraft emissions of aerosols, their role in plume evolution, interaction with the background atmosphere and the formation of high altitude cirrus clouds. The magnitude of the atmospheric impact depends on details of plume processing and on the relative ability of background aerosol particles to act as ice-forming nuclei. It was also noted that models do not adequately treat the radiative properties of cirrus, thus limiting their abilities to study contrail-cirrus cloud interactions. Large uncertainties also exist as to how properties of ambient aerosols are perturbed in the presence of jet engine emissions under various atmospheric conditions and aircraft configurations.

The workshop recommended new carefully coordinated regional-scale measurement campaigns to measure the factors affecting the growth, decay, and trajectories of contrail ice particle populations, and to define the abundance and properties of ambient aerosols as well as gaseous aerosol precursor concentrations. Process studies that explore the role of emitted aerosol particles, and how volatile aerosols interact with each other and with background aerosols, are required to understand the effect of emitted aerosol particles on cloudiness. Laboratory measurements are also urgently needed to develop improved aerosol-related parameterizations of heterogeneous ice nucleation for use in atmospheric models.

The Workshop also found that much better approaches are needed for comparing relative effects of all aviation emissions on climate, particularly to place these effects on a common scale for assessing the overall climate impact, and to quantify the potential trade-offs on the climate impact due to changes in aircraft technology, aircraft operations and various policy scenarios. For example, should aviation emphasize increased energy efficiency, thus reducing emissions of carbon dioxide, or policies to reduce formation of contrails and effects on cirrus clouds? There is no published study that utilizes the current understanding of the impact of aviation emissions on atmospheric composition to examine the possible choices, dependencies, and problems for evaluating aviation trade-offs. This is an important consideration for national and international policy – some in Europe are advocating action without adequate analysis – which could lead to bad unintended consequences.

Conclusions

As a key conclusion, the workshop participants acknowledged an urgent need for aviation-focused research activities to address the uncertainties and gaps in the understanding of current and projected impacts of aviation on climate and to develop metrics to better characterize these impacts. This effort will entail coordination with existing and planned climate research programs within government agencies, and could be organized through expansion of such programs or by totally new activities. The

workshop participants indicated that such efforts should include strong and continuing interactions among the science and aviation communities as well as among policy makers to develop well-informed decisions. The next steps required include further ranking and prioritizing of identified research needs; creating a research roadmap with associated roles and responsibilities of various participating agencies and stakeholders; and identifying resources needed to implement the roadmap.

The FAA has already taken some steps to make resources available – there is funding allocated to these efforts in the FY08 President's Budget starting in FY09. However, one agency cannot do it alone – this should be a focus for the U.S. Climate Change Science Program. We need better science-based understanding of the impacts of aviation emissions on climate change. We need improved metrics, measurement techniques, and modeling capability to quantify and predict impacts and to understand inter-relationships of aviation environmental factors. This is not a "science project" – the need is immediate. Decisions, with broad policy implications, such as the European Emissions Trading Scheme are being made without a firm understanding of the underlying science. We need scientific focus and resources in the U.S. to pursue aviation climate impact research – to put us in a position to make smart decisions for the NextGen aviation system and to allow us to shape the international debate within the International Civil Aviation Organization and other fora.

Biography for Donald J. Wuebbles

Don Wuebbles is Executive Coordinator (Director) of the new School of Earth, Society, and Environment at the University of Illinois. He is also a Professor in the Department of Atmospheric Sciences as well as in the Department of Electrical and Computer Engineering. Dr. Wuebbles was Head of the Department of Atmospheric Sciences from 1994 until 2006 before accepting the new position. He was also the first Director of the Environmental Council at the University of Illinois, from 1996 until August 1999; as Director, he was responsible for oversight and development of all educational and research programs at the University of Illinois relating to the environment. Don earned his B.S. (1970) and M.S. (1972) degrees in Electrical Engineering from the University of Illinois. He received his Ph.D. in Atmospheric Sciences from the University of California at Davis in 1983. Don spent many years as a research scientist and group leader at the Lawrence Livermore National Laboratory before returning to the University of Illinois in 1994. He is the author of about 400 scientific articles, most of which relate to atmospheric chemistry and global climate change as affected by both human activities and natural phenomena. His research emphasizes the development and use of mathematical models of the atmosphere to study the chemical and physical processes that determine atmospheric structure, aimed primarily towards improving our understanding of the impacts that man-made and natural trace gases may be having on the Earth's climate and on tropospheric and stratospheric chemistry. He has been a lead author on various national and international assessments related to these issues, including chairing a recent international workshop on the potential impacts of aviation on climate.