CCSP Synthesis and Assessment Product 2.4

SAP-2.4

Prospectus for

Trends in Emissions of Ozone-Depleting Substances, Ozone Layer Recovery, and Implications for Ultraviolet Radiation Exposure

U.S. Climate Change Science Program

Lead Agencies
National Oceanic and Atmospheric Administration

Contributing Agencies
National Aeronautics and Space Administration
U.S. Department of Agriculture
Environmental Protection Agency
National Science Foundation
Department of Defense

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Agency Leads

A.R. Ravishankara
National Oceanic and Atmospheric Administration
Michael J. Kurylo
National Aeronautics and Space Administration
Ken Vick
U.S. Department of Agriculture
Terry J. Keating
Environmental Protection Agency
Anne-Marie Schmoltner
National Science Foundation
Richard M. Bevilacqua
Department of Defense

For More Information

U.S. Climate Change Science Program
1717 Pennsylvania Avenue, NW, Suite 250
Washington, DC 20006 USA
+1.202.223.6262 (voice)
+1.202.223.3065 (fax)
http://www.climatescience.gov/

This prospectus has been prepared according to the *Guidelines for Producing Climate Change Science Program (CCSP) Synthesis and Assessment Products*. The prospectus was reviewed and approved by the CCSP Interagency Committee. The document describes the focus of this synthesis and assessment product, and the process that will be used to prepare it. The document does not express any regulatory policies of the United States or any of its agencies, or make any findings of fact that could serve as predicates for regulatory action.

Prospectus for Synthesis and Assessment Product 2.4

Trends in Emissions of Ozone-Depleting Substances, Ozone Layer Recovery, and Implications for Ultraviolet Radiation Exposure

1. Description of Topic, Audience, Intended Use, and Questions to be Addressed

1.1. Introduction

This prospectus has been prepared according to the *Guidelines for Producing Climate Change Science Program (CCSP) Synthesis and Assessment Products*. The prospectus has been reviewed and approved by the CCSP Interagency Committee. The document describes the focus of this synthesis and assessment product and the process that will produce it. The document does not express any regulatory policies of the United States or any of its agencies, or make any findings of fact that could serve as predicates for regulatory action. The Atmospheric Composition chapter of the *CCSP Strategic Plan* describes a vision to produce a synthesis and assessment product on "Trends in Emissions of Ozone-Depleting Substances, Ozone Layer Recovery, and Implications for Ultraviolet Radiation Exposure" (SAP 2.4). As part of CCSP Goal 2, SAP 2.4 will provide a synthesis and integration of the current knowledge of the stratospheric ozone layer, ozone-depleting substances, and ultraviolet radiation reaching the Earth's surface.

This product will contribute to and enhance the ongoing and iterative international process of producing and refining climate-related assessments and decision-support tools. For instance, SAP 2.4 will integrate findings from the Word Meteorological Organization (WMO) / United Nations Environment Programme (UNEP) 2006 assessment on the ozone layer, and the 2005 Special Report of the Intergovernmental Panel on Climate Change (IPCC) on *Safeguarding the Ozone Layer and the Global Climate System – Issues Related to Hydrofluorocarbons and Perfluorocarbons*. It will discuss these assessments in the context of the United States of America. SAP 4.2 will discuss ozone changes over North America, the contributions of the United States to ozone-depleting substances, and the UV changes due to the ozone layer changes over the North American continent. This synthesis and assessment product will take advantage of these thoroughly vetted scientific assessments to prepare a product that can be used to inform domestic and international decisionmakers in government and industry, scientists, and the public.

1.2. Topic and Content

SAP 2.4 will address key issues related to the stratospheric ozone layer, including its changes in the past and expected levels in the future. Also, it will take account of the current abundances and emissions of ozone-depleting substances. Further, it will synthesize the best available information on the past and future levels of UV radiation at the Earth's surface. Lastly, it will explore the interactions between climate change and stratospheric ozone changes. All of this will be carried out within a U.S. context to distill a regional assessment from the global assessments. More specifically, SAP 2.4 will:

- Quantify current information on sources, sinks, and abundances of ozone-depleting substances and associated uncertainties. It will quantify the atmospheric lifetimes, the

ozone depletion potentials, and global warming potentials of many important past, present, and future emissions.
- Discuss levels of ozone in various regions of the stratosphere, including the polar regions. It will pay special attention to the Antarctic ozone hole.
- Provide information on the past, current, and future levels of ultraviolet radiation.
- Provide an assessment of the impact of climate and compositional changes on the future of the ozone layer.
- Identify where research supported by CCSP agencies is critical for future assessments of the ozone layer.
- Describe how these findings relate to human activities, with a particular emphasis on the United States.

See Appendix A for more detail. Note that the report will cover the radiative forcing due to stratospheric ozone trends but will not extensively cover the impact of the trends on climate variability, or indirect impacts on climate change. A few impacts on climate will be noted and described qualitatively.

1.3. Audience

The audience for SAP 2.4 includes decisionmakers in the public (Federal, State, and local governments) and private realms (chemical industry, transportation and agriculture sectors, and climate policy and health-related interest groups), scientists, the international community, and the general public.

This broad audience is indicative of the diversity of stakeholder groups interested in knowledge of the stratospheric ozone layer, ozone-depleting substances, and UV radiation, and of how such knowledge might be used to inform decisions. The primary users of SAP 2.4 are intended to include, but are not limited to, officials involved in formulating climate and environmental policy, individuals responsible for managing emissions of ozone-depleting substances, and scientists involved in assessing and/or advancing the frontier of knowledge.

1.4. Intended Use

SAP 2.4 will be used (i) as a state-of-the-art assessment of knowledge of the stratospheric ozone layer, ozone-depleting substances, and UV radiation at the surface; (ii) to provide the scientific basis for decision support to guide management and policy decisions that affect the ozone layer and emissions of ozone-depleting substances; (iii) as a means of informing policymakers and the public concerning the general state of knowledge of the stratospheric ozone layer and emissions of ozone-depleting substances with respect to the contributions of and impacts on the United States; and (iv) to provide scientific information on the ozone layer to inform important stakeholder groups. Examples of these groups include the chemical industry that produces substitutes of ozone-depleting substances; sectors of the U.S. economy that request exemptions from emissions of substances banned by the Montreal Protocol and its Amendments; and the climate-science community. Senior managers and the general public may use the Executive Summary of SAP 2.4 to improve their overall understanding of what is known and unknown about the effects of U.S. emissions on the stratospheric ozone layer and UV radiation at the surface. It will also provide an estimate of the impacts of the ozone layer changes on the country.

1.5. Questions to be Addressed

Questions to be addressed by SAP 2.4 follow:
- What is the current state of the stratospheric ozone layer?
- What are the recorded changes in the emissions and concentrations of ozone-depleting substances?
- What do the observations indicate about the abundances and trends of stratospheric ozone?
- What is the trend in the occurrence, depth, duration, and extent of the Antarctic ozone hole?
- What is the state of ozone depletion in the Arctic region?
- When can one expect recovery of the global ozone layer and of the Antarctic ozone hole?

- What are the influences of climate change on the recovery of the ozone layer?
- How has surface UV radiation changed in the past and what is expected for the future?
- What are the various possible emissions scenarios that can be considered for any further policy actions on emissions of ozone-depleting gases?

These questions are starting points for producing SAP 2.4; they were developed by the proposed SAP 2.4 author team (see Section 3) and refined based on the deliberations for the two international assessments that were noted earlier. The draft outline of major sections of the report is included as Appendix A to this prospectus.

2. Contact Information for Responsible Individuals at Lead and Supporting Agencies

The lead agency for SAP 2.4 is the National Oceanic and Atmospheric Administration (NOAA), which is also responsible for ensuring compliance with the Office of Management and Budget's *Information Quality Bulletin for Peer Review* (<http://www.whitehouse.gov/omb/inforeg/peer2004/peer_bulletin.pdf>). Dr. Krisa Arzayus of NOAA is the point-of-contact for matters concerning Information Quality Act (IQA) compliance.

The individuals responsible for production of SAP 2.4 and acting as corresponding and lead authors are Drs. A.R. Ravishankara and Michael J. Kurylo. All agency leads are presented below:

Member Agency	Lead
NOAA	A.R. Ravishankara, (303) 497-5785 A.R.Ravishankara@noaa.gov
NASA	Michael J. Kurylo, (202) 358-0237
USDA	Ken Vick
EPA	Terry J. Keating
NSF	Anne-Marie Schmoltner
DoD	Richard M. Bevilacqua

3. Authors: Required Expertise of Authors and Biographical Information for Proposed Authors

In 2006, the authors for this SAP were chosen based on their expertise and participation in the international assessments from which this product will derive a great deal of information. The SAP 2.4 author team and roles follow:

- A.R. Ravishankara, NOAA — Overall Lead
- Michael J. Kurylo, NASA — Overall Lead
- Richard Bevilacqua, NRL/DoD — Scientific Content
- Jeff Cohen, USEPA — Scientific Content
- John Daniel, NOAA — Scientific Content
- Anne Douglass, NASA — Scientific Content
- David Fahey, NOAA — Scientific Content
- Jay Herman, NASA — Scientific Content
- Terry Keating, USEPA — Scientific Content
- Malcolm Ko, NASA — Scientific Content
- Stephen Montzka, NOAA — Scientific Content
- Paul Newman, NASA — Scientific Content
- V. Ramaswamy, NOAA — Scientific Content
- Anne-Marie Schmoltner, NSF — Scientific Content
- Ken Vick, USDA — Scientific Content

The SAP 2.4 author team will be responsible for organizing and outlining SAP 2.4 and for its final content and submission to NOAA. They will provide all the inputs to SAP 2.4 and will lead the overall synthesis and integration of the report. They will provide oversight and editorial review of individual chapters and will prepare any overview chapters and the Executive Summary. Their biographies are provided as Appendix B. Drs. Kurylo and Ravishankara will coordinate the SAP 2.4 author team's activity.

The responsibility for writing each individual chapter of SAP 2.4 has been assigned to one or more scientific experts in the topic area of the chapter; this person (or persons) will be designated the lead chapter author(s). These authors were chosen for their recognized expertise in various specific areas that are covered in the product. This is based on the quality and relevance of current publications

in the peer-reviewed literature pertaining to their chapter topics, past or present positions of leadership in the topic fields, and other documented experience and knowledge of high relevance. All authors will be listed in association with their contributions (e.g., chapters) in the final report.

Their biographies are provided in Appendix B. The SAP 2.4 contributing agency leads discussed the draft chapter outline and candidate chapter authors in their initial meeting held at NASA Goddard Space Flight Center in Maryland on May 22, 2006.

4. Stakeholder Interactions

A process for engaging important stakeholder groups and establishing an ongoing dialog with them is a priority activity. Stakeholder involvement is essential to ensure *transparency* (open access to information on SAP 2.4), *feedback on relevance* (review and comment on the process and verification that information produced by SAP 2.4 will be useful), and *credibility* (recognition by stakeholders of the scientific validity and independence of the SAP 2.4). These activities will be the responsibility of the author team.

As a first step in this process, the plan for this synthesis and assessment product was presented at the CCSP Workshop, "U.S. Climate Change Science Program: Climate Science in Support of Decision Making," held in Arlington, Virginia, during 14-16 November 2005, where it was well received. Further stakeholder input will be solicited through the public comment periods for this prospectus and for the draft final report. All comments submitted during the public reviews will be made publicly available and these comments will be carefully considered by the authors.

5. Drafting Process (Including Materials to be Used in Preparing the Product)

SAP 2.4 contributing agency leads have discussed the draft chapter outline (see Appendix A) in initial consultations with science, government, and other stakeholders. Additional venues for input will be explored; if found, they will be posted on the CCSP web site. It is anticipated that response to the web-posted prospectus will serve as the major input from the public.

The two international assessments, which were vetted by hundreds of scientists from around the world, form the basis of SAP 4.2.

All authors will be provided with NOAA's IQA guidelines as specified in the *Guidelines for Producing CCSP Synthesis and Assessment Products*, which will include compliance with the overall Office of Management and Budget guidelines—that is, *OMB Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by Federal Agencies and the Information Quality Bulletin for Peer Review*.

The authors of SAP 2.4 will be expected to emphasize accuracy and precision of numerical information, confidence levels, and characterization of uncertainties. SAP 2.4 will provide a clear discussion of uncertainties and how uncertainties may be reduced, preferably through a section of each chapter in which measurements, model results, or combinations of data and models occur. Whenever appropriate and possible, numerical values will be accompanied by measures of uncertainty (e.g., ± x units or percent). Where the uncertainty cannot be quantified, an explanation or justification will be given.

To ensure consistency and thoroughness in the treatment of uncertainties across all chapters of SAP 2.4, the author team will maintain regular oversight of overall data and information quality as presented in workshops and in draft text.

6. Review

NOAA will ensure that SAP 2.4 is reviewed at all stages as specified in the *Guidelines for Producing CCSP Synthesis and Assessment Products* and consistent with the

Information Quality Act and the *Information Quality Bulletin for Peer Review*; that comments and other feedback are provided to the SAP 2.4 author team for response; and that comments and responses are documented and made publicly available.

6.1. During Drafting Period

The SAP 2.4 author team will post on the CCSP web site the list of authors and draft versions of the outline, with a mechanism for providing comments through the web site. The SAP 2.4 author team will also establish a process and standards for ongoing information quality review.

6.2. Expert Review of First Draft

NOAA will coordinate a formal expert review through the National Research Council (NRC) of the U.S. National Academy of Sciences in 2007. This review will be conducted according to NRC policies and procedures.

6.3. Public Review of the Second Draft

After revision in response to the expert review, the second draft of SAP 2.4 will be released for public comment. The public comment period will last 45 days.

Following this comment period, the authors will prepare a third draft of the report, taking into consideration the comments submitted during the public comment period. The scientific judgment of the authors will determine responses to the technical comments. All comments submitted during the public comment period will be made publicly available.

The public comment period will begin after the NRC review and is expected to occur toward the end of 2007. The public will have the opportunity to access the NRC review of the report prior to the 45-day public review period.

6.4. CCSP and National Science and Technology Council Review of the Third Draft

Once the revisions to the second draft are complete, the SAP 2.4 author team will submit the third draft to NOAA. Once NOAA determines that the report conforms to CCSP and IQA guidelines, it will submit the draft product and a compilation of the comments received to the CCSP Interagency Committee.

If the CCSP Interagency Committee determines that further revision is necessary, their comments will be sent to NOAA to seek consideration and resolution by the SAP 2.4 author team. If needed, the NRC will be asked to review the revised draft.

After the CCSP Interagency Committee review determines that no further revisions are needed and NOAA certifies that the report has been prepared in conformance with the *Guidelines for Producing CCSP Synthesis and Assessment Products* and the Information Quality Act (including ensuring objectivity, utility, and integrity as defined in 67 FR 8452), the CCSP Interagency Committee will submit the report to the National Science and Technology Council (NSTC) for clearance.

Clearance will require the concurrence of all members of the Committee on Environment and Natural Resources. The CCSP Interagency Committee will be responsible for ensuring that comments generated during the NSTC review are addressed. They will consult with NOAA and the authors to develop an appropriate response. If the draft should need to be revised, the revisions will be written by the SAP 2.4 author team then routed through NOAA and the CCSP Interagency Committee to NSTC.

After clearance and prior to publication, the SAP 2.4 author team will be given the opportunity to examine the final report. If at this stage, or any earlier stage in this process, an individual author cannot accept the outcomes of the writing, review, and revision process, they will be accorded the opportunity to withdraw their name from the publication.

7. Related Activities, Including Other National and International Assessment Processes

SAP 2.4 will utilize, to the maximum extent possible, the information available from two international assessments: the WMO/UNEP 2006 assessment on the stratospheric ozone layer to be released in spring of 2007, and the IPCC Special Report on *Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons* published in 2005. When necessary, other existing data, programs, publications, and related activities in the United States or elsewhere will be used for input.

8. Communications: Proposed Method of Publication and Dissemination of the Product

Once NSTC clearance has been obtained, NOAA will coordinate publication, printing, and release of SAP 2.4. SAP 2.4 will be made available through the CCSP Office; it will also be made available electronically on both the CCSP and NOAA web sites. The published report will follow the standard format for all CCSP synthesis and assessment products.

The SAP 2.4 author team and other participants will publicize the process widely, with the dual purpose of disseminating information and encouraging key stakeholders to use the report as a tool to promote informed management and decisionmaking. A package of material will be created for all those involved in SAP 2.4 to use as they travel in their ongoing professional work.

9. Proposed Timeline

Activity	Months from Start	Estimated Completion Date
Planning the SAP product	0	Aug 2005
First presentation to stakeholders	3	Nov 2005
Establish author team	9	May 2006
Prospectus development	12	Aug 2006
CCSP posts for public review	15	Nov 2006
Public review period ends	16	Dec 2007
CCSP posts revised, final prospectus	17	Jan 2007
Submit first draft to NOAA	23	Jul 2007
Complete NRC review of first draft	26	Oct 2007
Deliver second draft to NOAA	27	Nov 2007
Post revised second draft for public review and comment	28	Dec 2007
Public comment period closes	29	Jan 2008
Deliver third draft to NOAA	30	Mar 2008
CCSP and NSTC review completed and SAP 2.4 released	32	Apr 2008

Appendix A. SAP 2.4 Chapter Structure and Outline

1. Introduction
(Kurylo, Ravishankara, and Schmoltner)
This section will introduce the material to be covered under SAP 2.4, with an emphasis on how the Montreal Protocol (together with its Amendments and Adjustments) has been effective in protecting the stratospheric ozone layer from further destruction by halocarbons and what its global and national implications are for changes in ultraviolet radiation exposure and climate change.

2. Current trends, mixing ratios, and emissions (ozone- & climate-related chemicals)
(Montzka, Vick, Cohen, Daniel)
This chapter will focus on a discussion of recent changes in the production, emission, and atmospheric burden of ozone-depleting substances (ODS) and long-lived replacements. The role of the Montreal Protocol in bringing about these changes will be highlighted. A discussion of banks (ODSs produced but not yet emitted), critical use exemptions, and other factors pertinent to the present and future atmospheric burden of halogens will be included. Recent changes in total atmospheric chlorine, bromine, and equivalent chlorine from these long-lived gases will be reviewed to allow a discussion of the relevance these changes have had or will have for the ozone layer. Finally, aggregate changes in the radiative forcing supplied by ODSs and their replacements will be reviewed to gauge the influence these changes might have had or will have on climate. The atmospheric abundances of the ozone-depleting gases as reported by NOAA and NASA to comply with the congressional mandate of the Clean Air Act, will be discussed.

3. Ozone & UV observations
(Herman, Newman, Bevilacqua, Keating)
This chapter will briefly review observations and current understanding and uncertainties in long-term trends in ozone and ground ultraviolet radiation levels. Because of fundamentally different properties and issues, the chapter will treat the polar regions separately from the low and mid-latitudes. For each of these main geographic regions, both total column and ozone profiles will be discussed. Total column ozone and the vertical profiles of ozone in the following regions will be examined: Mid- and low latitudes, polar Northern Hemisphere, and polar Southern Hemisphere (ozone hole). Ground-level ultraviolet radiation levels in the following regions will also be examined: Mid- and low latitudes, polar Northern Hemisphere, and polar Southern Hemisphere.

Each of these broad categories will be broken down into ground-based and satellite observations for well-established techniques.

4. How do climate change and stratospheric ozone loss interact?
(Fahey, Douglass, Schmoltner, and Ramaswamy)
This chapter will examine the coupling between ozone depletion from ODSs and changes to the earth's climate, including stratospheric temperatures changes during the past two decades, due in part to increased radiative forcing from growing greenhouse gas abundances. It will also examine the impact of cooler stratospheric temperatures on stratospheric ozone amounts. It will examine the influence of changed ozone abundance, particularly in southern polar regions, on circulation not only in the stratosphere but also in the troposphere. It will further explore the influence of changes in circulation caused by climate forcing, such as increases in the global transport of air from the troposphere to the stratosphere, on ozone concentrations. The projected future ozone amounts will be examined based on our current understanding of the coupling of stratospheric ozone to climate parameters. The chapter will emphasize the return to periods when ODSs concentrations decline to pre-1980 values and the changes in climate parameters in the next century.

5. The future & recovery

(Ko, Daniel, Herman, Newman, and Ramaswamy)

Using the emission scenarios from the WMO/UNEP ozone assessment, the corresponding concentrations of ODSs will be presented along with species specific contributions to Equivalent Effective Stratospheric Chlorine (EESC) and to instantaneous radiative forcing. These scenario results will be assessed to demonstrate the extent to which production- and emission-limiting actions can still affect the future evolution of ODSs. The expected responses in global ozone, Antarctic ozone, and UV at the surface will be discussed based on the EESC results. The possible implications of future climate changes will also be discussed.

Appendix B. Biographies of Authors of the SAP 2.4

Akkihebbal R. RAVISHANKARA
NOAA/ESRL/Chemical Sciences Division
325 Broadway
Boulder, CO 80305
Tel: (303) 497-5821; Fax: (303) 497-5822

EDUCATION

1975	Ph.D.	Physical Chemistry, University of Florida
1970	M.Sc.	Physical Chemistry, University of Mysore, India
1968	B.Sc.	Chemistry and Physics, University of Mysore, India

EMPLOYMENT HISTORY

National Oceanic and Atmospheric Administration

Acting Director, Chemical Sciences Division	2005-Present
Chief, Atmospheric Chemical Processes Program	1993-Present

RESEARCH INTERESTS

Climate and climate change; Regional air quality; Atmospheric chemistry; chemical kinetics; photochemistry; heterogeneous and multiphase chemistry; Aerosol formation and their chemical and optical properties; Measurement of atmospheric gas phase species; Measurement of atmospheric aerosols; Modeling of atmospheric processes.

SELECTED RECENT AWARDS

American Chemical Society's award on Creative Advances in Environmental Sciences	2005
Presidential Meritorious Rank Award	2005
Fellow of the Royal Society of Chemistry, UK (with title FRSC)	2004
Elected to U.S. National Academy of Sciences	2000
Polanyi Medal of Royal Society of Britain (Gas Kinetics Div.)	1998
Fellow, American Geophysical Union	1997

SELECTED PUBLICATIONS (related to the S&A product's topic)

1. Pulsed laser photolysis kinetics study of the $O(^3P)$ + ClO reaction, *J. Chem. Phys. 89*, 5670 (1988), J.M. Nicovich, P.H. Wine and **A. R. Ravishankara**.
2. Remote sensing observations of nighttime OClO column during the Airborne Antarctic Ozone Experiment, September 8, 1987, *J. Geophys. Res. 94*, 11405 (1989), A. Wahner, R.O. Jakoubek, G.H. Mount, **A. R. Ravishankara** and A.L. Schmeltekopf.
3. The rate coefficient for the termolecular channel of the self-reaction of ClO, *J. Phys. Chem. 94*, 4896 (1990), M. Trolier, R.L. Mauldin III and **A. R. Ravishankara**.
4. The reaction probabilities of $ClONO_2$ and N_2O_5 on polar stratospheric cloud materials, *J. Geophys. Res. 96,* 5081 (1991), D.R. Hanson and **A. R. Ravishankara**.
5. New measurement of the rate coefficient for the reaction of OH with methane, *Nature 350*, 406 (1991), G.L. Vaghjiani and **A. R. Ravishankara**.
6. Atmospheric lifetime of CHF_2Br, a proposed substitute for halons, *Science 252*, 693 (1991), R. Talukdar, A. Mellouki, T. Gierczak, J.B. Burkholder, S.A. McKeen and **A. R. Ravishankara**.
7. Atmospheric fate of CF_2H_2, CH_3CF_3, CHF_2CF_3, and CH_3CFCl_2: Rate coefficients for reactions with OH and UV absorption cross sections of CH_3CFCl_2, *J. Phys. Chem.95*, 5815 (1991), R. Talukdar, A. Mellouki, T. Gierczak, J.B. Burkholder, S.A. McKeen and **A. R. Ravishankara**.

8. The reaction probabilities of $ClONO_2$ and N_2O_5 on 40 and 75% sulfuric acid solutions, *J. Geophys. Res. 96*, 17,307 (1991), D.R. Hanson and **A. R. Ravishankara**.
9. The reaction probabilities of $ClONO_2$ and N_2O_5 on polar stratospheric cloud materials, *J. Geophys. Res. 96,* 5081 (1991), D.R. Hanson and **A. R. Ravishankara**.
10. New measurement of the rate coefficient for the reaction of OH with methane, *Nature 350*, 406 (1991), G.L. Vaghjiani and **A. R. Ravishankara**.
11. Atmospheric lifetime of CHF_2Br, a proposed substitute for halons, *Science 252*, 693 (1991), R. Talukdar, A. Mellouki, T. Gierczak, J.B. Burkholder, S.A. McKeen and **A. R. Ravishankara**.
12. Atmospheric fate of CF_2H_2, CH_3CF_3, CHF_2CF_3, and CH_3CFCl_2: Rate coefficients for reactions with OH and UV absorption cross sections of CH_3CFCl_2, *J. Phys. Chem.95*, 5815 (1991), R. Talukdar, A. Mellouki, T. Gierczak, J.B. Burkholder, S.A. McKeen and **A. R. Ravishankara**.
13. The reaction probabilities of $ClONO_2$ and N_2O_5 on 40 and 75% sulfuric acid solutions, *J. Geophys. Res. 96*, 17,307 (1991), D.R. Hanson and **A. R. Ravishankara**.
14. Atmospheric lifetimes of long-lived species, *Science*, *259*, 194-199 (1993), **A. R. Ravishankara**, S. Solomon, A.A. Turnipseed and R.F. Warren.
15. Do hydrofluorocarbons destroy stratospheric ozone?, *Science 263*, 71-75 (1994), **A. R. Ravishankara**, A.A. Turnipseed, N.R. Jensen, S. Barone, M. Mills, C.J. Howard and S. Solomon.
16. Heterogeneous reactions in sulfuric acid aerosols: A framework for model calculations, *J. Geophys. Res. 99*, 3615-3629 (1994), D.R. Hanson, **A. R. Ravishankara** and S. Solomon.
17. On the role of iodine in ozone depletion, *J. Geophys. Res. 99*, 20,491-20,499 (1994), S. Solomon, R.R. Garcia, and **A. R. Ravishankara**.
18. Difference in the reactivity of Type I polar stratospheric clouds depending on their phase, *Journal of Geophysical Research*, *101* (D2), 3885-3890, 1996, **A. R. Ravishankara** and D.R. Hanson.
19. Summer in the (polar) stratosphere, *Science, I*, 285, 208-210, 1999, D. W. Fahey and **A. R. Ravishankara**.
20. The atmospheric degradation of 1-bromoprpane ($CH_3CH_2CH_2Br$): The photochemistry of bromoacetone, *Geophys. Res. Lett.*, 29, OID: 10.1029/2002GL014712, J. B. Burkholder, M. K. Gilles, T. Gierczak, and **A. R. Ravishankara**.

PROFESSIONAL MEMBERSHIPS

American Chemical Society; American Geophysical Union; Royal Society of Chemistry; AAAS

Richard Michael Bevilacqua
Remote Sensing Division
Naval Research Laboratory, Code 7200
Washington, DC 20375
Tel: (202) 767-3391; Fax: (202) 404-7453

EDUCATION:
1972-76 B.A. Physics, Temple University, Philadelphia, PA
1976-78 M.S. Meteorology, Penn State University, University Park, PA
1978-82 Ph.D. Meteorology, Penn State University, University Park, PA

EMPLOYMENT HISTORY:
Oct 1982 - Oct 1984: NRC Postdoc at NRL
Oct 1984 - Jul 1985: Research Associate, S.F. Associates, Inc. (at NRL)
Jul 1985 - Feb. 1991: Research Physicist, NRL
Feb. 1991 - Feb. 1996: Head Middle Atmosphere Physics Section, NRL
March 1996 – May 2004: Head Remote Sensing Physics Branch, NRL
May 2004 – March 2006: Acting Superintendent Remote Sensing Division
March 2006 – present: Superintendent Remote Sensing Division

RESEARCH INTERESTS:
Dr. Bevilacqua's main research interests lie in remote sensing of the atmosphere, atmospheric retrieval methodologies, middle atmospheric water vapor, stratospheric polar ozone processes, and in the photochemistry and dynamics of the stratosphere. He has more than 25 years experience in the retrieval of atmospheric constituents from ground-based and space-based limb-viewing measurements, and in atmospheric science studies derived from these measurements. He has been the P.I of both the Polar Ozone and Aerosol Measurement (POAM) II and III satellite-based experiments, and project scientist for the shuttle-based Millimeter-wave Atmospheric Sounder (MAS) experiment. He is the author or coauthor of more than 100 refereed journal publications. Dr. Bevilacqua has spent his entire scientific career at the Naval Research Laboratory (NRL), and is currently Head of the NRL Remote Sensing Division.

SELECTED RECENT AWARDS:
NRL Alan Berman Research Publication Award: 1983, 1990, 1995, 1996, 1998, 2000,2002,2004, and 2005.
NASA SOLVE I Science Team Group Achievement Award: 2001
NASA SOLVE II Science Team Group Achievement Award: 2004.
UARS Team NASA Honor Group Achievement Award: 2006.
Selection into the Senior Executive Service (SES): 2006.

SELECTED PUBLICATIONS (RELATED TO ATMOSPHERIC COMPOSITION)
1) "Measurements of middle atmospheric water vapor from low latitudes and mid-latitudes in the Northern Hemisphere, 1995-1998," G.E. Nedoluha, R.M. Bevilacqua, R.M. Gomez, B.C. Hicks, J. Geophys. Res., 104, 19257-19266, 1999.
2) "Observations of boreal forest fire smoke in the stratosphere by POAM III, SAGE II, and lidar in 1998," M. Fromm, J. Alfred, K. Hoppel, J. Hornstein, R. Bevilacqua, E. Shettle, R. Servranckx, Z. Li, and B. Stocks, Geophys. Res. Lett., 27, 1407-1410, 2000.
3) "POAM III measurements of dehydration in the Antarctic lower stratosphere," G.E. Nedoluha, R.M. Bevilacqua, K.W. Hoppel, M. Daehler, E.P. Shettle, J.H. Hornstein, M.D. Fromm, J.D. Lumpe, J.E. Rosenfield, Geophys. Res. Lett., 27, 1683-1686, 2000.
4) "Stratospheric NOx enhancements in the southern hemisphere vortex in spring/summer of 2000," C. E. Randall, D.E. Siskind, and R.M. Bevilacqua, Geophys. Res. Lett., 28, 2385-2388, 2001.

5) "POAM III measurements of water vapor in the upper troposphere and lowermost stratosphere," G.E. Nedoluha, R.M. Bevilacqua, K.W. Hoppel, J.D. Lumpe, and H. Smit, J. Geophys. Res., 10.1029/2001JD000793, 2002.
6) "POAM III observations of Arctic ozone loss for the 1999/2000 winter," K.W. Hoppel, R.M. Bevilacqua, G.E. Nedoluha, C. Deniel, F. Lefevre, J.D. Lumpe, M.D. Fromm, J. Rosenfield, and M. Rex, J. Geophys. Res., 10.1029/2001JD000476, 2002.
7) "Observations and analysis of PSCs detected by POAM III during the 1999/2000 Northern Hemisphere winter," R.M. Bevilacqua, M.D. Fromm, J.M. Alfred, J.S. Hornstein, G.E. Nedoluha, K.W. Hoppel, J.D. Lumpe, C.E. Randall, E.P. Shettle. E/V. Browell, C. Butler, A. Dornbrack, and A.W. Strawa, J. Geophys. Res., 10.1029/2001JD00047, 2002.
8) "On the unexplained stratospheric ozone losses during cold Arctic Januaries," Rex, M, R.J. Salawitch, M.L. Santee, J.W. Waters, K. Hoppel, and R.M. Bevilacqua, Geophys. Res. Lett., 10.1029/2002GL016008, 2003.
9) "POAM III Observations of the Anomalous Ozone Hole, Hoppel, K., R.M. Bevilacqua, D. Allen, G. Nedoluha. C. Randall, Geophys. Res. Lett., 10.1029/2003GL016899, 2003.
10) "POAM measurements of PSCs and water vapor in the 2002 Antarctic vortex," G.E. Nedoluha, R.M. Bevilacqua, M.D. Fromm, K.W. Hoppel, and D.R Allen, Geophys. Res. Lett., 10.1029/2003GL017577, 2003.
11) "Unusual stratospheric transport and mixing during the 2002 Antarctic winter," Allen, D.R., R.M. Bevilacqua, G.E. Nedoluha, C.E. Randall, and G.L. Manney," Geophys. Res. Lett., 10.1029/2003GL017117, 2003.
12) "An evaluation of trends in middle atmospheric water vapor as measured by HALOE, WVMS, and POAM," Nedoluha, G.E., R.M. Bevilacqua, R.M. Gomez, B.C. Hicks, J.M. Russell, and B.J. Connor, J. Geophys. Res., 10.1029/2002JD003332, 2003.
13) "New directions: Eruptive transport to the stratosphere: Add fire-convection to volcanoes," Fromm, M.F, R.M. Bevilacqua, B. Stocks, and R. Servranckx, New Directions/Atmospheric Environment 38 (2004) 163-165.
14) "Reconstruction and simulation of stratospheric ozone distributions during the 2002 austral winter," Randall C.E., G.L. Manney, D.R. Allen. R.M. Bevilacqua, J. Hornstein, C. Trepte, W. Lahoz, J. Ajtec, G. Bodeker. JAS, 62 (3), 748-764, 2005.
15) "Pyro-cumulonimbus injection of smoke into the stratosphere: observations and impact of a super blowup in northwestern Canada on 3-4 August 1998," Fromm, M.D., R.M. Bevilacqua, R. Servranckx, J. Rosen, J. Thayer, J. Herman, D. Larko. J. Geophys. Res., 110 (D8): D08205, 2005.
16) "Fall vortex ozone as a predictor of springtime total ozone at high northern latitudes," S. R. Kawa, P. A. Newman, R. S. Stolarski, R. M. Bevilacqua, Atmos. Chem. Phys., 5, 1655-1663, 2005.
17) "A measurement/model comparison of ozone photochemical loss in the Antarctic ozone hole using POAM observations and the Match technique," Hoppel, K., R.M. Bevilacqua, T. Canty, R. Salawitch, M. Santee, J. Geophys. Res., 110, D19304, 2005.
18) "Reduced ozone loss at the upper edge of the Antarctic ozone hole during 2001-2004, Hoppel, K., G. Nedoluha, M. Fromm, D. Allen, R.M. Bevilacqua, J. Alfred, B. Johnson, and G. Konig-Langlo, Geophys. Res. Lett., 32, doi 10.1029/2005GL023968, 2005.
19) "Microphysical modeling of southern polar dehydration during the 1998 winter and comparison with POAM III observations," Benson C. M., K. Drdla, G. E. Nedoluha, E. P. Shettle, K. W. Hoppel, R. M. Bevilacqua J. Geophys. Res., 111, D07201, doi:10.1029/2005JD006506, 2006.
20) "Arctic winter 2005: implications for stratospheric ozone loss and climate change," M. Rex, and 33 authors including R.M. Bevilacqua, Geophys. Res. Lett., in press, 2006.

PROFESSIONAL MEMBERSHIPS
American Geophysical Union, Sigma XI

Jeff COHEN
US Environmental Protection Agency/Stratospheric Protection Division
1200 Pennsylvania Avenue
Washington DC 20460
Tel: (202) 343-9005 Fax: (202) 343-2363

EDUCATION

1980 M.Sc Public Health, University of North Carolina, Chapel Hill
1978 B.Sc. Biology, State University of New York, Albany
In progress M.Sc Environmental Engineering, George Washington University

EMPLOYMENT HISTORY

Environmental Protection Agency, Chief Alternatives and Emissions Reduction Branch	1999-Present
White House Energy Task Force	2004
University of Newcastle, Chemical Engineering Dept, Visiting Professor	2003
Environmental Protection Agency, Office of Drinking Water	1990-1998
Environmental Protection Agency, Region II, New York City	1994
Environmental Protection Agency, Office of Air Quality Planning & Standards	1981-1989
EPA, Office of Research & Development	1980-1981

RESEARCH INTERESTS

Stratospheric ozone, climate change, advanced energy technologies; risk assessment.

SELECTED RECENT AWARDS

EPA Science Award – lead biokinetic model	1996
EPA Gold medal – lead task force	1992

PROFESSIONAL MEMBERSHIPS

United Nations, Ozone Secretariat, Technical Options Committee; Board of Directors – Halon Alternatives Research Corporation

JOHN S. DANIEL
NOAA/ESRL/Chemical Sciences Division
325 Broadway, Boulder, Colorado, 80305
Tel: (303) 497-7622; email: john.s.daniel@noaa.gov

EDUCATION

1993 Ph.D., Atmospheric, Oceanic and Space Sciences; University of Michigan, Ann Arbor, Michigan

1989 B.A., Physics, *Magna cum Laude*, distinction in Physics, 1989; Carleton College,, Minnesota

EMPLOYMENT HISTORY

1996-present National Oceanic and Atmospheric Administration (NOAA), Aeronomy Laboratory and Chemical Sciences Division, Chemistry and Climate Processes Group, Boulder, Colorado

1993-1996 NOAA and Cooperative Institute for Research in Environmental Science, University of Colorado, Boulder, Research Associate

1989-1993 Research Assistant, University of Michigan, Ann Arbor

RESEARCH INTERESTS

Climate and climate change; stratospheric ozone depletion; modeling of atmospheric processes; cloud remote sensing; differential optical absorption spectroscopy

AWARDS

Presidential Early Career Award for Scientists and Engineers, 1996

Outstanding Graduate Student Award - Atmospheric, Oceanic and Space Science Department, University of Michigan, Ann Arbor, 1992

SELECTED PUBLICATIONS (relevant to ozone and climate)

1. Daniel, J. S. and G.J.M. Velders, Scientific Assessment of Ozone Depletion: 2006, lead-authors of chapter 8: Halocarbon Scenarios, Ozone Depletion Potentials, and Global Warming Potentials, in preparation, 2006.
2. Daniel, J. S., G. J. M. Velders, S. Solomon, M. McFarland, S. A. Montzka, Present and future sources and emissions of halocarbons: Towards new constraints, submitted to Journal of Geophysical Research, 2006.
3. IPCC/TEAP Special Report on Safeguarding the Ozone Layer and the Global Climate System: Issues related to Hydrofluorocarbons and Perfluorocarbons, contributing author of chapter 2: Chemical and Radiative Effects on HFCs, PFCs and their Possible Replacements, 2005.
4. Scientific Assessment of Ozone Depletion: 2002, contributor to "Twenty Questions and Answers about the Ozone Layer.
5. Scientific Assessment of Ozone Depletion: 2002, co-author of chapter 1: Controlled substances and other source gases,, 2002.
6. Climate Change 2001, contributor of chapter 4: Atmospheric chemistry and greenhouse gases, 2001.
7. Climate Change 2001, contributor of chapter 6: Radiative forcing of climate change, 2001.

8. Daniel, J.S., S. Solomon, R.W. Portmann, and R.R. Garcia, *Journal of Geophysical Research*, Stratospheric ozone destruction: The importance of bromine relative to chlorine, *Journal of Geophysical Research*, 104, 23,871-23,880, 1999.

9. Scientific Assessment of Ozone Depletion: 1998, co-author of chapter 10: Climate Change, 1999.

10. Scientific Assessment of Ozone Depletion: 1998, co-author of chapter 11: Scenarios for the Future Ozone Layer and Related Consequences, 1999.

11. Slaper, H., G.J.M. Velders, J.S. Daniel, F.R. de Gruijl, and J.C. van der Leun, Estimates of ozone depletion and skin cancer incidence to examine the Vienna Convention achievements, *Nature*, 384, 256-258, 1996.

12. Gierczak, T., R.K. Talukdar, J.B. Burkholder, R. Portmann, J.S. Daniel, S. Solomon, and A.R. Ravishankara, Atmospheric fate and greenhouse warming potentials of HFC 236fa and HFC 236ea, accepted by *Journal of Geophysical Research*, 101, 12,905-12,911, 1996.

13. Daniel, J.S., S.M. Schauffler, W.H. Pollock, S. Solomon, A. Weaver, E.L. Atlas, L.E. Heidt, R.R. Garcia, and J.F. Vedder, On the age of stratospheric air and inorganic chlorine and bromine release, *Journal of Geophysical Research*, 101, 16,757-16,770, 1996.

14. Solomon, S., and J.S. Daniel, Impact of the Montreal Protocol and its amendments on the rate of change of global radiative forcing, *Climate Change*, 32, 7-17, 1996.

15. Schauffler, S.M., W.H. Pollock, E.L. Atlas, L.E. Heidt, and J.S. Daniel, Atmospheric distributions of HCFC 141b, *Geophysical Research Letters,* 22, 819-822, 1995.

16. Daniel, J.S., S. Solomon, and D.L. Albritton, On the evaluation of halocarbon radiative forcing and global warming potentials, *Journal of Geophysical Research, 100*, 1271-1285, 1995.

17. Climate Change: 1994, contributor to chapter 5: Trace Gas Radiative Forcing Indices, 1995

18. Scientific Assessment of Ozone Depletion: 1994, contributor to chapter 13: Ozone Depletion Potentials, Global Warming Potentials, and Future Chlorine/Bromine Loading, 1995

Anne R. DOUGLASS
NASA Goddard Space Flight Center
Code 613.3
Greenbelt MD 20771
Tel: (301) 614-6028; Fax: (301) 614-5903

EDUCATION

1981	Ph.D.	Physics, Iowa State University
1975	M.S.	Physics, University of Minnesota
1971	B.A.	Physics, Trinity College Washington D.C.

EMPLOYMENT HISTORY

NASA Goddard Space Flight Center	1991-Present
Universities Space Research	1989-1990
Applied Research Corporation	1981-1989

RESEARCH INTERESTS

Atmospheric chemistry; stratospheric ozone; multi-dimensional modeling; chemistry and climate; numerical transport; modeling of atmospheric processes.

AWARDS

Fellow, American Meteorological Society	1998
Claire Booth Luce Women in Mathematics and Science	1993
NASA Group awards (1991,1993, 1994,1995,1998,2000,2005)	

SELECTED PUBLICATIONS (related to the S&A product's topic)

1. Comparison of Model Results Transporting the Odd Nitrogen Family with Results Transporting Separate Odd Nitrogen Species, **A. R. Douglass**, C. H. Jackman, and R. S. Stolarski, *J. Geophys. Res.,* 94, 9862-9872, 1989.
2. The Influence of Polar Heterogeneous Processes in Reactive Chlorine at Middle Latitudes: Three-Dimensional Model Implications, **A. R. Douglass**, R. B. Rood, J. A. Kaye, R. S. Stolarski, D. J. Allen, and E. M. Larson, *Geophys. Res. Lett.,* 18, 25-28, 1991.
3. Application of a Monotonic Upstream-Biased Transport Scheme to Three-Dimensional Constituent Transport Calculations, D. J. Allen, **A. R. Douglass**, R. B. Rood, and P. D. Guthrie, *Mon. Wea. Rev.,* 119, 2456-2464, 1991.
4. Thermodynamic Balance of Three Dimensional Stratospheric Winds Derived from a Data Assimilation Procedure, C. J. Weaver, **A. R. Douglass**, R. B. Rood, *J. Atmos. Sci.,* 50, 2987-2993, 1993.
5. Stratosphere-Troposphere Exchange, J. R. Holton, P. H. Haynes, **A. R. Douglass**, R. B. Rood, L. Pfister, *Rev. Geophys.,* 33, 403-439, 1995.
6. Interhemispheric Differences in Springtime Production of HCl and $ClONO_2$ in the Polar Vortices, **A. R. Douglass**, M. R. Schoeberl, R. S. Stolarski, J. W. Waters, J. M. Russell III, A. E. Roche, and S. T. Massie, *J. Geophys. Res.,* 100, 13,967-13,978, 1995.
7. A Three Dimensional Simulation of the Ozone Annual Cycle Using Winds from a Data Assimilation System, **A. R. Douglass**, C. J. Weaver, L. Coy, and R. Rood, *J. Geophys. Res.,* 101, 1463-1474, 1996.
8. A 3D Simulation of the Evolution of the Middle Latitude Winter Ozone in the Middle Stratosphere, **A. R. Douglass**, R. B. Rood, S. R. Kawa, and D. J. Allen, *J. Geophys. Res.,* 102, 19,217-19,232, 1997.
9. The CO_2 Seasonal Cycle as a Trace of Transport, S. E. Strahan, **A. R. Douglass**, J. E. Nielsen, and A. Boeing, *J. Geophys. Res.,* 103, 729-741, 1998.
10. Doubled CO_2 Effects on NO_y in a Coupled 2D Model, J. E. Rosenfield, and **A. R. Douglass**, *Geophys. Res. Lett.*, 25, 4381-4384, 1998.
11. Choosing Meteorological Input for the Global Modeling Initiative Assessment of High-Speed Aircraft, A**. R. Douglass**, *J. Geophys. Res.*, 104, 27,545-47,564, 1999.

12. Simulations of Water Vapor in the Lower Stratosphere and Upper Troposphere, A. Gettelman, J. R. Holton, and **A. R. Douglass**, *J. Geophys. Res.*, 106, 9003-9023, 2000.
13. Seasonal Variability of Middle-Latitude Ozone in the Lowermost Stratosphere Derived from Probability Distribution Functions, R. B. Rood, **A. R. Douglass**, M. C. Cerniglia, L. C. Sparling, and J. E. Nielsen, *J. Geophys. Res.*, 105, 17,793-17,805, 2000.
14. A simulation of bromoform's contribution to stratospheric bromine, J. E. Nielsen and **A. R. Douglass**, *J. Geophys. Res.,* 106, 8089-8100, 2001.
15. Estimating downward cross-tropopause ozone flux using column ozone and potential vorticity, M. A. Olsen, **A. R. Douglass** and M. R. Schoeberl, *J. Geophys. Res.,* 107, 4636, doi: 10.1029/2001JD002041, 2002.
16. The impact of increasing carbon dioxide on ozone recovery J.E. Rosenfield **A. R. Douglass**, D.B. Considine, *J. Geophys. Res.,* 107, 4049, 2002.
17. A comparison of the lower stratospheric age spectra derived from a general circulation model and two data assimilation systems, M. R. Schoeberl, **A. R. Douglass**, Zhengxin Zhu, Steven Pawson, *J. Geophys. Res.,* 108, 4113, doi: 10.1029/2002JD002652, 2003.
18. Evaluation of transport in the lower tropical stratosphere in a global chemistry and transport model, **A. R. Douglass**, M.R. Schoeberl, R. B. Rood and S. Pawson, *J. Geophys. Res.,* 108, 4259, 2002JD002696, 2003.
19. Evaluating the credibility of transport processes in simulations of ozone recovery using the Global modeling Initiative three-dimensional model, S. E. Strahan and **A. R. Douglass**, *J. Geophys. Res.,* 109, D05110, doi:10.1029/2003JD004238, 2004.
20. Radicals and reservoirs in the GMI chemistry and transport model: Comparison to measurements, **A. R. Douglass**, R. S. Stolarski, S. E. Strahan, and P. S. Connell, *J. Geophys. Res.*, 109, D16302, doi:10.1029/2004JD004632, 2004.
21. Stratosphere-troposphere exchange of mass and air, M. A. Olsen, M. R. Schoeberl, **A. R. Douglass**, *J. Geophys. Res.,* 109, Art. No. D24114, 2004.
22. Estimation of Stratospheric Age Spectrum from Chemical Tracers M. R. Schoeberl, **A. R. Douglass**, B. Polansky C. Boone, K. A. Walker, and P. Bernath, *J. Geophys. Res.,* 110, Art. No D21303, 2005.
23. Trends in stratospheric ozone: lessons learned from a 3D chemical transport model, R. S. Stolarski, **A. R. Douglass**, S. Steenrod, S. Pawson, *J. Atmos. Sci.,* 63, 1028-1041, 2006.

PROFESSIONAL MEMBERSHIPS

American Geophysical Union; American Meteorological Society, Association of Women in Science

DAVID W. FAHEY
National Oceanic and Atmospheric Administration (NOAA)
Earth System Research Laboratory/Chemical Sciences Division
325 Broadway CSD6
david.w.fahey@noaa.gov
Boulder, Colorado 80305 USA
303-497-5277

Specialized Professional Expertise

- Measurements of reactive nitrogen trace-gas species in the atmosphere involving catalysis, chemiluminescence detection, and ion-molecule reactions
- Design and construction of ground-based and aircraft instrumentation for atmospheric measurements of trace gases and aerosols
- Interpretation of observations of long-lived and reactive species and aerosols in the lower stratosphere and upper troposphere
- Evaluation of scientific results for international assessments of ozone depletion and climate change

Professional Experience

1981 - present	Research Physicist Meteorological Chemistry Group, NOAA Aeronomy Laboratory
1979 - 1981	National Research Council Postdoctoral Research Associate Ion Chemistry Program, NOAA Aeronomy Laboratory

Academic Background

B.S. (1975) in Physics, University of Wisconsin, Madison, Wisconsin
M.S. (1977) and Ph.D. (1979) in Physics, University of Missouri, Rolla, Missouri

Selected Professional Associations and Honors

Chair, Atmospheric Chemistry Gordon Research Conference, 4 – 9 September 2005, Big Sky, MT.
Fellow of the Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, Colorado, April 2003 - present.
Highly Cited Researcher, ISI Web of Knowledge (ISI-Thomson Scientific, Philadelphia, PA), 2002, one of the top 100 cited researchers in Geosciences between 1980 and 2000.
Fellow of the American Geophysical Union, 2002, for 'Elucidating the role of nitrogen oxides in the stratosphere via field measurements and interpretations.'
Recipient of the U. S. Department of Commerce Silver Medal for Meritorious Federal Service, December 1996, for 'Leadership in making the first direct measurements of supersonic aircraft emissions and analyzing the atmospheric implications.'
Recipient of the American Meteorological Society Henry G. Houghton Award, January 1996, for 'Outstanding contributions to our understanding of the ozone layer through airborne observations and theoretical analyses.'
Outstanding Scientific Paper Award, Office of Oceanic and Atmospheric Research, National Oceanic and Atmospheric Administration: 1995, 1997, 1998, 2002, 2005.

Selected Airborne Science Responsibilities

Co-Project Scientist for the NOAA Unmanned Aerial System (UAS) Flight Demonstration Project in April-November 2005 involving the Altair UAS of General Atomics Aeronautical Systems, Inc..
Co-Project Scientist for the NASA Aura Validation Experiment campaigns in January and October-November 2004 and June 2005 with the WB-57F high-altitude aircraft.
Project Scientist for the 1997 NASA Photochemistry of Ozone Loss in the Arctic Region in Summer (POLARIS) campaign with the ER-2 high-altitude aircraft.

Selected International Assessment Participation

Lead Author of Chapter 2, *Changes in Atmospheric Constituents and in Radiative Forcing*, in the Fourth Assessment Report, Working Group I, Intergovernmental Panel on Climate Change, 2007.

Lead Author of '*20 Questions and Answers about the Ozone Layer*,' Scientific Assessment of Ozone Depletion: 2002, Global Ozone Research and Monitoring Project – Report No, 47, World Meteorological Organization, Geneva, 2003.
Coordinating Lead Author of '*Aviation-produced aerosols and cloudiness*', Chapter 3, Aviation and the Global Atmosphere, Intergovernmental Panel on Climate Change, May 1999.

Selected Peer-Reviewed Publications

1. The observation of nitric acid-containing particles in the tropical lower stratosphere, P. J. Popp, T. P. Marcy, E. J. Jensen, B. Kärcher, D. W. Fahey, R. S. Gao, T. L. Thompson, K. H. Rosenlof, E. C. Richard, R. L. Herman, E. M. Weinstock, J. B. Smith, R. D. May, H Vömel, J. C. Wilson, A. J. Heymsfield, M. J. Mahoney, A. M. Thompson, *Atmospheric Chemistry Physics* 6, 601-611, 2006.
2. Nitric acid uptake on subtropical cirrus cloud particles , P. J. Popp, R. S. Gao, T. P. Marcy, D. W. Fahey, P. K. Hudson, T. L. Thompson, B. Kärcher, B. A. Ridley, A. J. Weinheimer, D. J. Knapp, D. D. Montzka, D. Baumgardner, T. J. Garrett, E. M. Weinstock, J. B. Smith, D. S. Sayres, J. V. Pittman, S. Dhaniyala, T. P. Bui, M. J. Mahoney, *Journal of Geophysical Research* 109 (D06302), doi:10.1029/2003JD004255, 2004.
3. Quantifying stratospheric ozone in the upper troposphere using in situ measurements of HCl, T. P. Marcy, D. W. Fahey, R. S. Gao, P. J. Popp, E. C. Richard, T. L. Thompson, K. H. Rosenlof, E. A. Ray, R. J. Salawitch, C. S. Atherton, D. J. Bergmann, B. A. Ridley, A. J. Weinheimer, M. Loewenstein, E. M. Weinstock, M. J. Mahoney, *Science* 304, 261-265, 2004.
4. Evidence that nitric acid increases relative humidity in low-temperature cirrus clouds, R. S. Gao, P. J. Popp, D. W. Fahey, T. P. Marcy, R. L. Herman, E. M. Weinstock, D. G. Baumgardner, T. J. Garrett, K. H. Rosenlof, T. L. Thompson, P. T. Bui, B. A. Ridley, S. C. Wofsy, O. B. Toon, M. A. Tolbert, B. Kärcher, Th. Peter, P. K. Hudson, A. J. Weinheimer, A. J. Heymsfield, *Science* 303, 516-520, 2004.
5. The detection of large HNO_3-containing particles in the winter Arctic stratosphere, D. W. Fahey, R. S. Gao, K. S. Carslaw, J. Kettleborough, P. J. Popp, M. J. Northway , J. C. Holecek, S. C. Ciciora, R. J. McLaughlin, T. L. Thompson, R. H. Winkler, D. G. Baumgardner, B. Gandrud, P. O. Wennberg, S. Dhaniyala, K. McKinney, Th. Peter, R. J. Salawitch, T. P. Bui, J. W. Elkins, C. R. Webster, E. L. Atlas, H. Jost, J. C. Wilson, R. L. Herman, A. Kleinböhl, M. von König, *Science* 291, 1026-1031, 2001.
6. Ozone destruction and production rates between spring and autumn in the Arctic stratosphere, D. W. Fahey, R. S. Gao, L. A. Del Negro, E. R. Keim, S. R. Kawa, R. J. Salawitch, P. O. Wennberg, T. F. Hanisco, E. J. Lanzendorf, K. K. Perkins, S. A. Lloyd, W. H. Swartz, M. H. Proffitt, J. J. Margitan, J. C. Wilson, R. M. Stimpfle, R. C. Cohen, C. T. McElroy, C.R. Webster, M. Loewenstein, J.W. Elkins, T.P. Bui, *Geophysical Research Letters* 27, 2605-2608, 2000.
7. Summer in the stratosphere, D. W. Fahey and A. R. Ravishankara, *Science* 285, 208-210, 1999.
   In situ observations of NO_y, O_3, and the NO_y/O_3 ratio in the lower stratosphere, D. W. Fahey, S. G. Donnelly, E. R. Keim, R. S. Gao, R. C. Wamsley, L. A. Del Negro, E. L. Woodbridge, M. H. Proffitt, K. H. Rosenlof, M. K. W. Ko, D. K. Weisenstein, C. J. Scott, C. Nevison, S. Solomon, K. R. Chan, *Geophysical Research Letters* 23, 1653-1656, 1996.
8. Emission measurements of the Concorde supersonic aircraft in the lower stratosphere, D. W. Fahey, E. R. Keim, K. A. Boering, C. A. Brock, J. C. Wilson, S. Anthony, T. F. Hanisco, P. O. Wennberg, R. C. Miake-Lye, R. J. Salawitch, N. Louisnard, E. L. Woodbridge, R. S. Gao, S. G. Donnelly, R. Wamsley, L. A. Del Negro, B. C. Daube, S. C. Wofsy, C. R. Webster, R. D. May, K. K. Kelly, M. Loewenstein, J. R. Podolske, K. R. Chan, *Science* 270, 70-74, 1995.
9. In situ measurements constraining the role of sulphate aerosols in mid-latitude ozone depletion, D. W. Fahey, S. R. Kawa, E. L. Woodbridge, P. Tin, J. C. Wilson, H. H. Jonsson, J. E. Dye, D. Baumgardner, S. Borrmann, D. W. Toohey, L. M. Avallone, M. H. Proffitt, J. Margitan, M. Loewenstein, J. R. Podolske, R. J. Salawitch, S. C. Wofsy, M. K. W. Ko, D. E. Anderson, M. R. Schoeberl, K. R. Chan, *Nature* 363, 509-514, 1993.
10. A diagnostic for denitrification in the winter polar stratospheres, D. W. Fahey, S. Solomon, S. R. Kawa, M. Loewenstein, J. R. Podolske, S. E. Strahan, K. R. Chan, *Nature* 345, 698-702, 1990.
11. Observations of denitrification and dehydration in the winter polar stratospheres, D. W. Fahey, K. K. Kelly, S. R. Kawa, A. F. Tuck, M. Loewenstein, K. R. Chan, L. E. Heidt, *Nature* 344, 321-324, 1990.

Jay R. HERMAN
Atmospheric Chemistry and Dynamics Branch
NASA Goddard Space Flight Center

PRESENT POSITION:	**Principal Investigator** UV, aerosols & Trace Gases for Aura Validation **Principal Investigator** L-2 SVIP Interferometer **Principal Investigator** Ocean Radiation
RESEARCH EXPERIENCE	Satellite Instrument Design, stratospheric chemistry and modeling, radiative transfer, atmospheric spectroscopy, UV solar flux measurements, ozone inversion algorithms, and long-term ozone trend analysis, volcanic aerosols, tropospheric trace gas detection, tropospheric ozone, physical oceanography.
EDUCATION:	1959 B.S. Clarkson College, Potsdam New York 1963 M.S. Pennsylvania State University 1965 PhD. Pennsylvania State University
AWARDS	Exceptional Service Performance Award, 1988 Group Achievement Award, 1989 Certificate of Outstanding Performance. 1991 Group Achievement Award, 1992-1993 Performance Award, 1994-1995 Scientific Achievement Award, 1994 Quality Increase Award, 1996 United Nations Environment Program, 1999 Performance Award, 1999, 2000 Special Act Award, 2001 Performance Award 2002 Special Act Award 2002

Recent Publications (2005 –2006)

1. Krotkov, P.K. Bhartia and **J.R.Herman**, Jim Slusser, Gwen, Scott, G. Labow T. F. Eck, and B. N. Holben, Aerosol UV absorption experiment (2002-04): 2. Absorption optical thickness and single scattering albedo, Opt. Eng., 44, 4, 041005, 2005
2. Vasilkov, A.P., **J.R. Herman**, Z. Ahmad, M. Kahru, and G. Mitchell, Assessment of the ultraviolet radiation field in ocean waters from space-based measurements and full radiative transfer calculations, Opt. Eng. **44**, 2863-2869, 2005.
3. Ahmad, Z. J.R. Herman, A. Vasilkov, N. Krotkov, M. Tzortziou, G. Mitchell, M. Kahru, Seasonal climatology of UV irradiances in the ocean, submitted, Applied Optics, 2004.
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12. Cede, Alexander, **Jay Herman**, Andreas Richter, Nickolay Krotkov and John Burrows, Measurements of Nitrogen Dioxide Total Column Amounts at Goddard Space Flight Center Using a Brewer Spectrometer in Direct Sun Mode, accepted, J. Geophys. Res., Vol. 111, D05304, doi:10.1029/2005JD006585, 2006.

Terry J. KEATING
US Environmental Protection Agency
Office of Air and Radiation
1200 Pennsylvania Avenue NW (MC 6103A)
Washington DC 20460
Tel: (202) 564-1174; Fax: (202) 564-1554

EDUCATION

1997	Ph.D.	Environmental Sciences and Engineering, University of North Carolina, Chapel Hill
1989	M.S.P.H.	Environmental Sciences and Engineering, University of North Carolina, Chapel Hill
1987	B.S.	Environmental Sciences, University of California, Riverside

EMPLOYMENT HISTORY

2003 – Present	Senior Environmental Scientist, US Environmental Protection Agency, Office of Air & Radiation, Washington, DC
2000 – 2003	Environmental Scientist, U.S. Environmental Protection Agency, Office of Air & Radiation, Washington, DC
1998 – 2000	American Association for the Advancement of Science Fellow at the U.S. Environmental Protection Agency, Office of Air and Radiation, Washington, DC
1997 – 1998	Global Environmental Assessment Project Fellow, Kennedy School of Government, Harvard University, Cambridge, MA
1991 – 1992	Air Quality Scientist, Warzyn, Inc, Pasadena, CA
1989 – 1991	Air Quality Scientist, AeroVironment, Inc., Monrovia, CA

SCIENTIFIC INTERESTS

Regional air quality; intercontinental transport of air pollutants; air quality and climate interactions; use of scientific information in environmental policy making.

CURRENT POSITION

Dr. Terry Keating is a senior environmental scientist with the Office of Air and Radiation (OAR) of the U.S. Environmental Protection Agency, where he advises senior management on scientific issues related to air quality management at the national and international level. Dr. Keating=s responsibilities include co-chairing the international Task Force on Hemispheric Transport of Air Pollutants under the Convention on Long Range Transboundary Air Pollution, as well as EPA's International Transport of Air Pollutants Working Group. Dr. Keating is also responsible for facilitating OAR cooperation with the EPA=s Global Change Research Program and the interagency Climate Change Science Program. In this role, he has led an effort to restructure EPA's UV monitoring and research program.

Malcolm K. W. KO
NASA Langley Research Center
MS 401, 21 Langley Blvd
Hampton, VA 23681-2199
Voice 757 864-8892; FAX 757 864-6326

EDUCATION

Ph.D	(Physics)	University of Pittsburgh, 1977
M.S.	(Physics)	California Institute of Technology, 1973
A.B.	(Physics)	Princeton University, 1971

EMPLOYMENT HISTORY

NASA LaRC Science Directorate, lead scientist	2005-Present
NASA LaRC Science Directorate, Branch Head	2002-2005
Atmospheric and Environmental Research Inc.	1978-2002

RESEARCH INTERESTS

the roles of dynamical transport and chemistry in trace gases' distributions; studies of stratospheric ozone distribution and its response to natural and anthropogenic activities such as emissions of halocarbons, operation of space shuttle and supersonic aircraft; change in radiative forcing and climate responses from greenhouse gases.

AWARDS

AGU Editor's Citation for Excellence in Refereeing: 1993 and 2000
NASA's Group Achievement Award to the POLARIS Project Team, 1998
Certificate of Appreciation in recognition of significant contributions towards the achievement of the NASA High Speed Research Program goals, 1999

SELECTED PUBLICATIONS (related to the S&A product's topic)

1. Ko, M.K.W., N.D. Sze and D.K. Weisenstein (1991) Use of satellite date to constrain model calculated atmospheric lifetimes for N_2O and the CFCs. *J. Geophys. Res.*, **96**, 7547-7552.
2. Weisenstein, D., M.K.W. Ko and N. D. Sze (1992) The chlorine budget of the present day atmosphere: A modeling study. *J. Geophys. Res.*, **97**, 2547-2559.
3. •Ko, M.K.W. et al., (1993) Atmospheric sulfur hexafluoride: Sources, sinks and greenhouse warming. *J. Geophys. Res.*, **98**, 10,499-10,507.
4. •Ko, M.K.W., N.D. Sze, G. Molnar, M.J. Prather (1993) Global Warming from chlorofluorocarbons and their alternatives: Time scales of chemistry and climate. *Atmos. Environ.*, **27A**, 581-587.
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6. Gunson, M.R., et al. (1994) Increase in levels of stratospheric chlorine and fluorine loading between 1985 and 1992. *Geophys. Res. Lett.*, **21**, 2,223-2,226.
7. Ko, M.K.W., et al. (1997), On the relation between stratospheric chlorine/bromine loading and short-lived tropospheric source gases, *J. Geophys. Res.* **102**, D21, 25507-25517.
8. •MacKay, R.M., M.K.W. Ko, S. Zhou, G. Molnar, R-L Shia, Y. Yang, (1997), An estimate of the climatic effect of ozone during the 1980s. *Journal of Climate*, **10**, 774-788.
9. Wamsley, P.R. et al. (1998), Distribution of halon-1211 in the upper troposphere and lower stratosphere and the 1994 total bromine budget, *J. Geophys. Res.* **103**, 1513-1526.

10. Kotamarthi, V.R., J. M. Rodriguez, M.K.W. Ko, T.K. Tromp, N-D. Sze (1998), Trifluoroacetic acid from the degradation of HCFC and HFCs: a three dimensional modeling study, *J. Geophys. Res.* **103**, 5747-5758.
11. Ko, M.K.W., N.D. Sze, C. Scott, J.M. Rodriguez, and D.K. Weisenstein, (1998) Ozone depletion potential of CH_3Br, *J. Geophys. Res.,* **103**, 28187-28195**.**
12. •Ko, M.K.W., R-L Shia, and N-D Sze, (1999), Atmospheric lifetime and global warming potential of HFC-245fa, *J. Geophys. Res.* **104**, 8173-8181.
13. Danilin, M.Y., M.K.W. Ko, and D.K. Weisenstein (2001) Global implication of ozone loss in the Space Shuttle wake, *J. Geophys. Res.,* **106**,D4, 3591-3601.
14. Ko, M.K.W. et al., [2003] Photochemical ozone budget during the BIBLE-A and B campaigns, *J. Geophys. Res.* 10.1029/2001JD000800, 24 December 2002

SELECTED INTERNATIONAL REPORTS

Ko, M.K.W., E.A. Jadin, D. Kley, and S. Wofsy [1992] "Predicted Aircraft Effects on Stratospheric Ozone" in *Scientific Assessment of Ozone Depletion: 1991*, World Meteorological Organization Global Ozone Research and Monitoring Project, report No. 25. Geneva, Switzerland.

Albritton, D.L., et al. (1992) *Methyl Bromide and the Ozone Layer: A Summary of Current Understanding*. Report to the United Nations Environment Programme on behalf of the Contracting Parties to the Montreal Protocol.

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Isaksen, I., et al. (1999), "Modeling the Chemical Composition of the Future Atmosphere," *in IPCC Special Report on Aviation and the Global Atmosphere*

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PROFESSIONAL MEMBERSHIPS

Member of American Geophysical Union; Member of American Meteorological Society

Michael J. KURYLO
NASA Headquarters
Science Mission Directorate
Earth Science Division
Washington, DC 20546
Tel: (202) 358-0237; Fax: (202) 358-2770

Education:

1966	B.S. (Chemistry) - Boston College, *magna cum lauda*
1969	Ph.D. (Physical Chemistry) - The Catholic University of America

Professional Experience:

1969 - 1971	National Research Council / National Bureau of Standards (NBS) Postdoctoral Research Associate
1971 - 2003	Research Chemist, Physical and Chemical Properties Division, Chemical Science and Technology Laboratory, National Institute of Standards and Technology (NIST - formerly NBS);
1987 - 2003	Inter-Agency detail from NIST to the National Aeronautics and Space Administration as Manager of NASA's Congressionally-mandated Upper Atmosphere Research Program;
2004 - present	Program Manager / Program Scientist for Atmospheric Composition in the Earth Science Division of NASA's Science Mission Directorate.

Research Interests:

Gas Phase Kinetics and Photochemistry, Atmospheric Chemistry, Environmental Chemistry, Stratospheric Ozone Depletion, Climate Change Research

Professional Memberships:

American Chemical Society; American Geophysical Union; American Physical Society; Sigma Xi, The Scientific Research Society

Selected Honors and Awards:

U.S. Dept. of Commerce Bronze Medal,	1983
U.S. Dept. of Commerce Silver Medal	1991
NASA Exceptional Service Medal	1996
Catholic University of America Alumni Achievement Award in the Field of Science	1996
United Nations Environment Programme Certificate of Recognition	1995, 1999
National Oceanic and Atmospheric Administration Environmental Hero Award	2000
NASA Ames Research Center Honor Award	2004

SELECTED PUBLICATIONS (related to the S&A product's topic)

1. M. J. Kurylo and W. Braun, "Flash Photolysis Resonance Fluorescence Study of the Reaction Cl + O_3 ® ClO + O_2 Over the Temperature Range 213-298 K," Chem. Phys. Lett. **37**, 232 (1976).
2. M. J. Kurylo, P. C. Anderson, and O. Klais, "Flash Photolysis Resonance Fluorescence Study of the Reaction OH + CH_3CCl_3 ® H_2O + CH_2CCl_3," Geophys. Res. Lett. **6**, 760 (1979).
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4. M. J. Kurylo, K. D. Cornett, and J. L. Murphy, "Temperature Dependence of the Rate Constant for

the Reaction of Hydroxyl Radicals with Nitric Acid," J. Geophys. Res. **87 C4**, 3081 (1982).
5. M. J. Kurylo, P. A. Ouellette, and A. H. Laufer, "Measurements of the Pressure Dependence of the HO_2 Radical Self Disproportionation Reaction at 298 K," J. Phys. Chem. **90**, 437 (1986).
6. M. J. Kurylo and P. A. Ouellette, "Rate Constants for the Reaction $HO_2 + NO_2 + N_2$ ® $HO_2NO_2 + N_2$: The Temperature Dependence of the Fall-Off Parameters," J. Phys. Chem. **91**, 3365 (1987).
7. M. J. Kurylo, "The Chemistry of Stratospheric Ozone: Its Response to Natural and Anthropogenic Influences," Int. J. Refrig. **13**, 62 (1990).
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9. T. J. Wallington, P. Dagaut, and M. J. Kurylo, "Kinetics and Mechanisms of the Gas Phase Reactions of Peroxy Radicals," Chem. Rev. **92**, 667 (1992).
10. Z. Zhang, R. D. Saini, M. J. Kurylo, and R. E. Huie, "Rate Constant for the Reaction of OH with CH_3Br," Geophys. Res. Lett., **19**, 2413 (1992).
11. S. A. Penkett, J. H. Butler, R. J. Cicerone, A. Golembek, M. J. Kurylo, J. S. Levine, M. J. Molina, R. Prinn, C. E. Reeves, J. M. Rodriguez, H. Singh, D. Toohey, and R. Weiss, "Methyl Bromide," Scientific Assessment of Ozone Depletion: 1994, World Meteorological Organization, Global Ozone Research and Monitoring Project Report No. 37, Chapter 10.
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13. V. L. Orkin, V. G. Khamaganov, A. G. Guschin, R. E. Huie, and M. J. Kurylo, "Atmospheric Fate of Chlorobromomethane: Rate Constant for the Reaction with OH, UV Spectrum, and Water Solubility, J. Phys. Chem., **101**, 174 (1997).
14. M. J. Kurylo, J. M. Rodriguez, M. O. Andreae, E. L. Atlas, D. R. Blake, J. H. Butler, S. Lal, D. J. Lary, P. M. Midgley, S. A. Montzka, P. C. Novelli, C. E. Reeves, P. G. Simmonds, L. P. Steele, W. T. Sturges, R. F. Weiss, and Y. Yokouichi, "Short-Lived Ozone-Related Compounds," Scientific Assessment of Ozone Depletion: 1998, World Meteorological Organization, Global Ozone Research and Monitoring Project Report No. 44, Chapter 2.
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16. S. N. Kozlov, V. L. Orkin, R. E. Huie, and M. J. Kurylo, "The OH Reactivity and UV Spectra of Propane, n-Propyl Bromide, and Isopropyl Bromide," J. Phys. Chem. A, **107**, 1333, (2003).
17. V. L. Orkin, A. G. Guschin, I. K. Larin, R. E. Huie, and M. J. Kurylo, "Measurements of the Infrared Absorption Cross Sections of Some Haloalkanes and Their Use in a Simplified Calculational Approach for Estimating Direct Global Warming Potentials," J. Photochem. and Photobiol. A, **157**, 211 (2003).
18. M. J. Kurylo and V. L. Orkin, "The Determination of Atmospheric Lifetimes via the Measurement of OH Radical Kinetics," Chem. Rev. **103**, 5049 (2003).
19. M. J. Kurylo (Chairman), "Report of the Sixth Meeting of the Ozone Research Managers of the Parties to the Vienna Convention for the Protection of the Ozone Layer," WMO Global Ozone Research and Monitoring Project, Report No. 48 (2005).

Stephen A. MONTZKA
NOAA/ESRL/Global Monitoring Division
325 Broadway
Boulder, CO 80305
Tel: (303) 497-6657; Fax: (303) 497-6290

EDUCATION

1988	Ph.D.	Analytical Chemistry, University of Colorado
1983	B.Sc.	Chemistry, summa cum laude, St. Lawrence University

EMPLOYMENT HISTORY

National Oceanic and Atmospheric Administration

Research Chemist, Global Monitoring Division	1991-Present
Post-Doctoral Fellow, National Research Council/NOAA	1989-1991

RESEARCH INTERESTS

Trace gases in the atmosphere, stratospheric ozone depletion, atmospheric chemistry, atmospheric oxidation processes, exchange of gases between the ocean or terrestrial ecosystems and the atmosphere, hazardous air pollutants.

SELECTED RECENT AWARDS

NOAA Research Employee of the Year	2000
US Department of Commerce Silver Medal Award	1997
NOAA Outstanding Scientific Paper of the Year Awards	1996, 1997, 1999, 2000, 2001

SELECTED PUBLICATIONS (related to the S&A product's topic)

1. When will the Antarctic ozone hole recover? P.A. Newman, E.R. Nash, S.R. Kawa, **S.A. Montzka,** S.M. Schauffler, *Geophys. Res. Lett.,* in press, 2006.

2. Urban/Industrial pollution for the New York City—Washington, D. C. corridor, 1996-1998: A study of the efficacy of the Montreal Protocol and other regulatory measures, D.H. Barnes, S.C. Wofsy, B.P. Fehlau, E.W. Gottlieb, J.W. Elkins, G.S. Dutton, **S.A. Montzka,** *J. Geophys. Res., 108(D6),* 4186, doi:10.1029/2001JD001117, 2003.

3. A decline in tropospheric organic bromine, **S.A. Montzka,** J.H. Butler, B.D. Hall, J.W. Elkins, D.J. Mondeel, *Geophys. Res. Lett., 30(15)*, 1826, doi:10.1029/2003GL017745, 2003.

4. Controlled substances and other source gases, Chapter 1 in *Scientific Assessment of Ozone Depletion: 2002, Global Ozone Research and Monitoring Project—Report No. 47*, **S.A. Montzka,** and P.J. Fraser (Lead Authors), J.H. Butler, D. Cunnold, J. Daniel, D. Derwent, P. Connell, S. Lal, A. McCulloch, D. Oram, C. Reeves, E. Sanhueza, P. Steele, G. J. M. Velders, R.F. Weiss, R. Zander, Geneva, 2003.

5. Chlorine budget and partitioning during the Stratospheric Aerosol and Gas Experiment (SAGE) III Ozone Loss and Validation Experiment (SOLVE), S.M. Schauffler, E.L. Atlas, S.G. Donnelly, A. Andrews, **S.A. Montzka,** J.W. Elkins, D.F. Hurst, P.A. Romashkin, V. Stroud, *J. Geophys. Res., 108(D5)*, 4173, doi:10.1029/2001JD002040, 2003.

6. Implications of methyl bromide supersaturations in the temperate North Atlantic Ocean, D.B. King, J.H. Butler, **S.A. Montzka,** S.A. Yvon-Lewis, and J.W. Elkins, *J. Geophys. Res., 105(D15)*, 19763-19769, 2000.

7. New observational constraints for atmospheric hydroxyl on global and hemispheric scales, **S.A. Montzka,** C.M. Spivakovsky, J.H. Butler, J.W. Elkins, L.T. Lock, and D.J. Mondeel, *Science, 288,* 500-503, 2000.

8. A twentieth century record of atmospheric halocarbons in polar firn air, J.H. Butler, M. Battle, M. Bender, **S.A. Montzka,** A.D. Clarke, E.S. Saltzman, C. Sucher, J. Severinghaus, J.W. Elkins, *Nature, 399,* 749-755, 1999.

9. Short-lived ozone-related compounds, M.J. Kurylo, J.M. Rodriquez, M.O. Andreae, E.L. Atlas, D.R. Blake, J.H. Butler, S. Lal, D.J. Lary, P.M. Midgley, **S.A. Montzka,** P.C. Novelli, C.E. Reeves, P.G. Simmonds, L.P. Steele, W.T. Sturges, R.F. Weiss, and Y. Yokouchi, Chapter 2 in *Scientific Assessment of Ozone Depletion: 1998, Global Ozone Research and Monitoring Project—Report No. 44,* World Meteorological Organization, Geneva, 1999.
10. Present and future trends in the atmospheric burden of ozone-depleting halogens, **S.A. Montzka,** J.H. Butler, J.W. Elkins, T.M. Thompson, A.D. Clarke, and L.T. Lock, *Nature, 398,* 690-694, 1999.
11. Growth and distribution of halons in the atmosphere, J.H. Butler, **S.A. Montzka,** A.D. Clarke, J.M. Lobert, J.W. Elkins, *J. Geophys. Res., 103,* 1503-1511, 1998.
12. The distribution of upper tropospheric and lower stratospheric halon-1211 and the 1994 total bromine budget, P.R. Wamsley, J.W. Elkins, D.W. Fahey, G.S. Dutton, C.M. Volk, R.C. Myers, **S.A. Montzka**, J.H. Butler, A.D. Clarke, P.J. Fraser, L.P. Steele, M.P. Lucarelli, E.L. Atlas, S.M. Schauffler, D.R. Blake, F.S. Rowland, R. M. Stimpfle, K. R. Chan, D. K. Weisenstein, and M. K. W. Ko, *J. Geophys. Res., 103,* 1513-1526, 1998.
13. Undersaturations of CH_3Br in the Southern Ocean, J.M. Lobert, S.A. Yvon, J.H. Butler, **S.A. Montzka,** and R.C. Myers, *Geophys. Res. Lett., 24*, 171-172, 1997.
14. Decline in the tropospheric abundance of halogen from halocarbons: Implications for stratospheric ozone depletion, **S.A. Montzka,** J.H. Butler, R.C. Myers, T.M. Thompson, T.H. Swanson, A.D. Clarke, L.T. Lock, J.W. Elkins, *Science, 272*, 1318-1322, 1996.
15. Observations of HFC-134a in the remote troposphere, **S.A. Montzka,** R.C. Myers, J.H. Butler, J.W. Elkins, L. Lock, A. Clarke, and A.H. Goldstein, *Geophys Res. Lett., 23*, 169-172, 1996.
16. A net sink for atmospheric methyl bromide in the East Pacific Ocean, J.M. Lobert, J.H. Butler, **S.A. Montzka,** L.S. Geller, R.C. Myers, and J.W. Elkins, *Science, 267*, 1002-1005, 1995.
17. Early trends in the global tropospheric abundance of hydrochlorofluorocarbon-141b and -142b, **S.A. Montzka,** R.C. Myers, J.H. Butler, and J.W. Elkins, *Geophys. Res. Lett.,* 21, 2483-2486, 1994.
18. Atmospheric measurements of HCFC-22 at the South Pole, **S.A. Montzka,,** R.C. Myers, J.H. Butler, J.W. Elkins, and S.O. Cummings, *Antarctic J. of the U.S., 28(5),* 267-269, 1994.
19. Global tropospheric distribution and calibration scale of HCFC-22, **S.A. Montzka,** R.C. Myers, J.H. Butler, J.W. Elkins, and S.O. Cummings, *Geophys Res. Lett., 20*, 703-706, 1993.
20. A decrease in the rates of atmospheric halon concentrations, J.H. Butler, J.W. Elkins, B.D. Hall, S.O. Cummings, and **S.A. Montzka**, *Nature, 359*, 403-405, 1992.

PROFESSIONAL MEMBERSHIPS

American Geophysical Union; AAAS

Paul A. NEWMAN
National Aeronautics and Space Administration
Goddard Space Flight Center
Atmospheric Chemistry and Dynamics Branch
Code 613.3
Greenbelt, MD, 20771
Tel: (301) 614-5985; Fax: (301) 614-5903
Email: Paul.A.Newman@nasa.gov

EDUCATION

1984	Ph.D.	Physics, Iowa State University
1978	B.Sc.	Physics, Seattle University

EMPLOYMENT HISTORY

NASA's Goddard Space Flight Center	1990-present
Universities Space Research Associates	1989-1990
Applied Research Corp., Landover, MD	1986-1989
National Research Council Postdoctoral Fellow	1984-1986

RESEARCH INTERESTS

Atmospheric dynamics; Atmospheric chemistry; Measurement of atmospheric gas phase species; Modeling of atmospheric processes.

SELECTED RECENT AWARDS

NASA Group Achievement Award (ASHOE/MAESA)	1995
NASA Group Achievement Award (POLARIS)	1998
NASA GSFC Special Act Award (SOLVE)	2000
GSFC Laboratory for Atmospheres Peer Award	2001
Arthur S. Flemming Award	2002
NASA Group Achievement Award (SOLVE II)	2005

SELECTED PUBLICATIONS (related to the S&A product's topic)

1. "Quantifying Denitrification and its Effect on Ozone Recovery," A. Tabazadeh, M. Santee, M. Danilin, H. Pumphrey, **P. A. Newman**, P. Hamill, J. Mergenthaler, *Science*, **288**, 1407-1411, 2000.
2. "Quantifying the Wave Driving of the Stratosphere," **P. A. Newman**, and E. R. Nash, *J. Geophys. Res.-Atmos.*, **105**, 12,485-12,497, 2000.
3. "What controls the temperature of the Arctic stratosphere during the spring**?" P. A. Newman**, E. R. Nash, J. E. Rosenfield, J. Geophys. Res , 106, 19999-20010, 2001.
4. "Severe and extensive denitrification in the 1999-2000 Arctic winter stratosphere," P. J. Popp, M. J. Northway, J. C. Holecek, R. S. Gao, D. W. Fahey, J. W. Elkins, D. F. Hurst, P. A. Romashkin, G. C. Toon, B. Sen, S. M. Schauffler, R. J. Salawitch, C. R. Webster, R. L. Herman, H. Jost, T. P. Bui, **P. A. Newman**, and L. R. Lait, Geophys. Res. Lett., 28, 2875-2878, 2001.
5. "Observational evidence for the role of denitrification in Arctic stratospheric ozone loss," R. S. Gao, E. C. Richard, P. J. Popp, G. C. Toon, D. F. Hurst, **P. A. Newman**, J. C. Holecek , M. J. Northway, D. W. Fahey, M. Y. Danilin, B. Sen, K. Aikin, P. A. Romashkin, J. W. Elkins, C. R. Webster, S. M. Schauffler, J. B. Greenblatt, C. T. McElroy, L. R. Lait, T. P. Bui, and D. Baumgardner, *Geophys. Res. Lett.*, ***28***, 2879-2882, 2001.

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10. "On the size of the Antarctic ozone hole," **Newman PA**, Kawa SR, Nash ER, Geophys. Res. Lett., 31 (21): Art. No. L21104, 2004
11. "Interannual variability of stratospheric trace gases: The role of extratropical wave driving," Ma J., D. W. Waugh, A. R. Douglass, S. R. Kawa, **P. A. Newman**, S. Pawson, R. S. Stolarski, S. J. Lin, Q. J. Roy. Met. Soc., 130, 2459-2474, 2004.
12. "The ozone hole of 2002 as measured by TOMS," Stolarski, R. S., R. D. McPeters, **P. A. Newman**, J. Atmos. Sci., 62, 716-720, 2005.
13. "The unusual Southern Hemisphere stratosphere winter of 2002," **Newman, P. A**., E. R. Nash, J. Atmos. Sci., 62, 614-628, 2005.
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16. "When will the Antarctic ozone hole recover?", **Newman, P. A**., E. R. Nash, S. R. Kawa, S. A. Montzka, S. M. Schauffler, Geophys. Res. Lett., in press, 2006.

PROFESSIONAL MEMBERSHIPS

American Geophysical Union; American Meteorological Society

Venkatachalam RAMASWAMY
NOAA/ Geophysical Fluid Dynamics Laboratory
Princeton University, Princeton, NJ 08542.
Tel: 609-452-6510; Fax: 609-987-5063

EDUCATION

1982	Ph.D. (Atmospheric Science), State University of New York at Albany, NY
1977	M.Sc. (Physics), University of Delhi (India)
1975	B. Sc. (Honours) Physics, University of Delhi (India)

EMPLOYMENT HISTORY

1985-1995	Research Scientist/ Scholar, Princeton University, and NOAA/ GFDL
1995-	Physical Scientist, NOAA/ GFDL, and Lecturer with rank of Professor, Atmospheric and Oceanic Sciences Program, Princeton University
2000-	NOAA/ GFDL Senior Scientist and Leader (Atmos. Physics and Chemistry Group).

RESEARCH INTERESTS

Atmospheric radiative processes. Radiative forcing of climate due to natural and anthropogenic agents, including long-lived greenhouse gases, ozone and aerosols. Cloud-climate interactions. Modeling of the global climate system and climate response to radiative forcings. Modeling of: stratosphere-troposphere interactions; ozone-climate linkages; stratospheric temperature changes. Diagnostic analyses of climate change using satellite and other observations and coupled atmosphere-ocean models.

AWARDS

American Meteorological Society, Henry G. Houghton Award - 1994.
WMO Norbert Gerbier-MUMM International Award – 1998, 2003.
Department of Commerce Gold Medal – 2002; Silver Medal – 2005.
Presidential Rank Award for Meritorious Senior Professional – 2005.
Fellow, American Meteorological Society – 2005.

COMMITTEES and PANELS

Coordinating Lead Author, Intergovernmental Panel on Climate Change (2001, 2007).
Lead Author/Co-author/Contributor, WMO-UNEP Scientific Assessment of Ozone Depletion (1999, 2002).
Coordinating Lead Author, Climate Change Science Program S&A Report 1.1 ("Temperature Trends in the Lower Atmosphere") (2006).
Vice-Chair, Joint Scientific Committee, World Climate Research Program (WCRP) (2006-).

SELECTED PUBLICATIONS

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Anne-Marie SCHMOLTNER

Division of Atmospheric Sciences
National Science Foundation
4201 Wilson Blvd. # 775
Arlington, VA 22230
Tel: (703) 292-4716; Fax: (703) 292-9022

EDUCATION

1989 Ph.D. in Chemistry, University of Vienna, Austria
1982 First Diploma, Chemistry, University of Vienna, Austria
1981 First Diploma, Mathematics, University of Vienna, Austria

EMPLOYMENT HISTORY

U.S. National Science Foundation	
Program Director, Atmospheric Chemistry Program	1998-Present
Associate Program Director, Atmospheric Chemistry Program	1995-1998
Universities Space Research Association	
Visiting Scientist	1994-1995
Cooperative Institute for Research in Environmental Sciences, University of Colorado and National Oceanic and Atmospheric Administration	
Research Associate	1992-1993
University of California, Berkeley	
Lecturer	1991
Universität Göttingen, Germany	
Postdoctoral Researcher	1989-1990

HONORS

Fulbright Scholarship, 1983-1985
Alexander von Humboldt Stipendium, Germany, 1990

SELECTED PUBLICATIONS

1. B. Sierk, A. Richter, A. Rozanov, Ch. von Savigny, A. M. Schmoltner, M. Buchwitz, H. Bovensmann, and J. P. Burrows, Retreival and Monitoring of Atmospheric Trace Gas Concentrations in Nadir and Limb Geometry Using the Space-Borne SCIAMACHY Instrument, Environmental Monitoring and Assessment (2006), DOI: 10.1007/s10661-005-9049-9.
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3. R. K. Talukdar, J. B. Burkholder, A. M. Schmoltner, J. M. Roberts, R. R. Wilson, and A. R. Ravishankara, Investigation of the loss processes for peroxyacetyl nitrate in the atmosphere: UV photolysis and reaction with OH, J. Geophys. Res., *100*, 14,163-14,173 (1995).
4. M. J. Kurylo, J. A. Kaye, R. F. Hampson, and A. M. Schmoltner, Editors, Present State of Knowledge of the Upper Atmosphere 1993: An Assessment Report, NASA Reference Publication 1337 (1994).
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10. A. M. Schmoltner, P. M. Chu, and Y. T. Lee, Crossed Molecular Beam Studies of the Reaction O(3P) + C2H2, J. Chem. Phys. 91, 5365-6373 (1989).
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12. A. M. Schmoltner, D. S. Anex, and Y. T. Lee, IR Multiphoton Dissociation of Anisole: Production and Dissociation of Phenoxy Radical, J. Phys. Chem, 96, 1236-1240 (1992).

PROFESSIONAL MEMBERSHIPS

American Chemical Society; American Geophysical Union; Association for Women in Science.

Kenneth W. VICK
US Department of Agriculture/ Agricultural Research Service (ARS)
5601 Sunnyside Avenue
Beltsville, Maryland 20705
301-504-5321

EDUCATION:

BS, Biology/Chemistry, 1964, Oakland City University, Oakland City Indiana
MS, Zoology, 1967, Oklahoma State University, Stillwater, Oklahoma
PhD, Entomology/Biochemistry, 1968, Oklahoma State University, Stillwater, Oklahoma

EMPLOYMENT HISTORY:
1968-1991, Research Entomologist, USDA/ARS, Gainesville, Florida
1991-1998, National Program Leader, National Program Staff, ARS, Beltsville, MD
1998-2006, Senior Nat. Prog. Leader, National Program Staff, ARS, Beltsville, MD

RESEARCH INTERESTS:

Leader of a research program for the Agricultural Research Service, the in-house research agency of the USDA. This program includes a $17 million research effort of more than 40 scientists at some 20 locations across the country to develop alternatives for the ozone depleting fumigant, methyl bromide. Methyl bromide is an important tool in agriculture to fumigate soil prior to planting and to disinfest stored commodities and structures. This is the largest methyl bromide alternatives program in the world and has made significant contributions to the decline in use of methyl bromide in the United States and the world.

AWARDS:

1988, U.S. Department of Agriculture Superior Service Award
1999, U.S. Department of Agriculture Superior Service Award
2002, U.S. Environmental Protection Service Bronze Medal for Commendable Service

PROFESSIONAL MEMBERSHIPS:

Ken Vick is a founding member of the Methyl Bromide Technical Options Committee (MBTOC) of the Montreal Protocol. MBTOC provides policy-relevant guidance and recommendations concerning the technical and economic availability of methyl bromide alternatives to the Parties of the Montreal Protocol. The committee is comprised of 38 scientists, technical experts and economists from over 20 countries. MBTOC publishes three reports each year updating the Parties and public about progress in methyl bromide alternatives, and giving recommendations concerning the critical use nominations made by Parties each year. MBTOC also publishes guidance documents and other reports as requested by the Parties. Additionally, MBTOC publishes a major assessment report every 4 years assessing all controlled and quarantine and pre-shipment uses of MB and all alternatives for those uses.