Aerosol Properties and Their Impact on Climate

Preliminary Prospectus for Synthesis and Assessment Product 2.3

Lead Agency: National Aeronautics and Space Administration (NASA)
Supporting Agency: National Oceanic and Atmospheric Administration (NOAA)

Contents

1. Overview: Description, Audience, Intended Use, and Questions to be Addressed.

1.1 Introduction

In the Strategic Plan for the U.S. Climate Change Science Program (CCSP), issued in July 2003), 21 Synthesis and Assessment Products (SAPs) were identified to be produced over a 4-year time frame (2004-2008). These products are to be prepared through processes that are open and public, encouraging stakeholder participation in order to promote a consensus about the knowledge base for climate change decision support. In line with the Atmospheric Composition Chapter and Goal 2 of CCSP Strategic Plan, "Improve quantification of the forces bringing about changes in the Earth's Climate and related systems", Synthesis and Assessment Product (SAP) 2.3 will provide a synthesis and integration of the current knowledge of the climate-relevant impacts of anthropogenic aerosols.

This prospectus describes the focus and implementation plan for developing and producing Climate Change Science Program (CCSP) Synthesis and Assessment Product 2.3, "*Aerosol Properties and Their Impact on Climate*". This prospectus has been prepared according to the Guidelines for Producing Climate Change Science Program Synthesis and Assessment Products and will be reviewed and approved by the CCSP Interagency Committee . This prospectus 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.

1.2 The Topic

Recent research has demonstrated that atmospheric particles (aerosols) can cause a net cooling or warming within the climate system, depending upon their physical and chemical characteristics. Sulfate-based aerosols, for example, tend to cool, whereas black carbon (soot) aerosols, tend to warm the system. In addition to these direct effects, aerosols can also have indirect effects on the balance of incoming and outgoing radiation by their influence on cloud properties, distribution, and persistence. When climate models include the effects of sulfate aerosols, the simulation of global mean surface temperatures is improved. One of the largest uncertainties about the net impact of aerosols on climate is the diverse warming and cooling influences of the very complex mixture of aerosol types and their spatial distributions. Further, the poorly understood impact of aerosols on the formation of both water droplets and ice crystals in clouds also results in large uncertainties in the ability to project climate changes. Thus, aerosols impact climate by interacting directly by scattering and absorbing solar radiation but also indirectly by modifying cloud properties. More detail is needed globally to describe the scattering and absorbing optical properties of aerosols from regional sources and how these aerosols impact other regions of the globe

Anthropogenic aerosol emissions since the beginning of the industrial era have continuously increased along with increases in greenhouse gases (GHGs) but the effects on climate are not as definitive as those due to GHGs. While non-absorbing particles such as sulfates counteract the influence of GHGs by reflecting more solar energy back into space (thus reducing heating by the atmosphere), increasing emissions of carbonaceous particles that are more absorbing add to the uncertainty in aerosol forcing. The problem is particularly severe with the rapid industrialization of large developing areas of the world, particularly in Asia from where bulk of aerosol and GHG emissions are anticipated in the coming decades. A substantial fraction of the uncertainty in radiative forcing of climate is due to the uncertainties associated with the effects (direct and indirect) of aerosols on the climate system.

For example, large errors in an estimate of the indirect effect of aerosols on climate were anticipated even when the interaction of aerosols with cloud fields was thought to be simpler – namely the first indirect effect or the Twomey effect. Here, stack or automobile emissions consisting of very small – submicron – particles interacted with clouds, and by acting as ‘cloud condensation nuclei’ can lead to an increase in number of cloud droplets. If the total amount of liquid in the cloud remains the same, then the effective radius of the droplets is reduced, and clouds with smaller droplets are brighter. Quantification of this effect is a major field of activity [3] and is a difficult task given the stochastic nature of the clouds, cloud layering and the emission sources.

The uncertainty in aerosol climate forcing makes it impossible for us to understand the sensitivity of the climate system based on the observed temperature record. If aerosol cooling has been large, then the warming we have already received implies a large climate sensitivity. If aerosol forcing has been small, then most of the greenhouse gas warming has not been counteracted, and climate sensitivity is smaller. Understanding the actual aerosol influence is therefore necessary for us to know how sensitive the climate will be in the future to continued anthropogenic influence.

1.3 Questions to be Addressed

There have been increased efforts to determine the aerosol direct impact from remote sensing, surface based observations, and in situ field campaigns (1, 2). A primary topic to be addressed in this report is to assess our current state of understanding of anthropogenic aerosol climate forcing from the observational perspective, primarily the direct component, but also the indirect component.

The observations themselves are often used in conjunction with aerosol models of the climate system, to help understand the aerosol components that make up the total aerosol optical depth. These models can also be used to assess the radiative impact of the different aerosol types. Thus the interaction of observational techniques with aerosol modeling will be a prime component of the subjects reviewed.

Aerosol climate forcing is included in global climate models as part of their simulations of the last century. All models run for the latest IPCC (AR4) report included at least some aerosol component. A second focus of this report is to review the quality of the aerosol composition and forcing used in these models compared with data that is being obtained from observations and from aerosol models (3). The accuracy of the aerosol forcing included will help indicate whether the models have been able to reproduce the observed temperature changes with the proper climate sensitivity.

Based in part on the above discussion, an outline for the proposed report is provided in Appendix A1.

1.4 Audience and Intended Use

Aerosol interaction with shortwave (SW) radiation is a major source of uncertainty impacting two areas of research – climate prediction and remote sensing. Thus policy makers and policy analysts both within and outside the US government and worldwide, interested in these two areas are the most likely target audience. The organizations include (but are not limited to) Climate Change Science Program, Climate Change Technology Program, National Science Technology Council (NSTC), Interagency working group on Earth Observations, U. S. Weather Research Program, other inter-agency committees and US military. International agencies such as those connected with the United Nations (IPCC, World Meteorological Organization etc) are also intended audience.

2. Contact Information:

Lead Agency: National Aeronautics and Space Administration (NASA)
Supporting Agency: National Oceanic and Atmospheric Administration (NOAA)

Key Contact
NASA (Lead)
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3. Lead Authors

The following individuals have been nominated as potential lead.

Lead	**Agency**
Mian Chin	NASA
Philip L. DeCola	NASA
Graham Feingold	NOAA
Rangasayi N. Halthore	NASA
Patricia.K.Quinn	NOAA
Lorraine A. Remer	NASA
David Rind	NASA

Appendix A2 also contains a list of other potential authors whose expertise is highly relevant to the subject of this study.

4. Stakeholder Interactions

Stakeholder input will be solicited through the public comment period for this prospectus and the public comment period for the draft report. All comments submitted during the public reviews will be made publicly available and these comments will be carefully considered by the authors.
Stakeholder involvement is essential to ensure *transparency* – open access to information on the SAP 2.3; *feedback on relevance* – review and comment on the SAP 2.3 process and verification that information produced by the SAP 2.3 will be useful; and *credibility* – recognition by the stakeholders of the scientific validity and independence of the SAP 2.3.
The process of drafting and incorporating public comment will comply with the rules set forth in the Federal Advisory Committee Act and NASA's general IQA guidelines for peer review from the Office of Management and Budget.

5. Drafting

The lead author will convene a meeting of potential authors to contribute to each section of the proposed draft. Since the turnaround time is limited, it may be necessary to bring together few authors to contribute larger portions of the draft.

6. Review

The *Guidelines for Producing CCSP Synthesis and Assessment Products* provide guidelines for soliciting reviews. These involve expert peer review, a public comments period, and a final review and approval by the CCSP interagency committee and the National Science and Technology Council (NSTC) via the Committee on Environment and Natural Resources Research (CENR).
The expert peer review will be conducted in accordance with NASA's requirements for peer review and general guidelines from the Office of Management and Budget.
Immediately following expert review, the lead authors will produce the second draft of the report by incorporating comments and suggestions from the reviewers, as the lead authors deem appropriate. Following this expert review process, the second draft will be released for a 45-days public comments period. The authors will prepare a third draft, taking into consideration the comments submitted during the public comments period. The scientific judgment of the lead and supporting authors will determine responses to the comments. The public comments received along with the responses to these comments, will be posted on the CCSP web site.

Following clearance by NASA, the third draft of the product will be submitted concurrently to the CCSP Interagency Committee and the CENR for final review and approval. If the concurrent CCSP Interagency Committee/CENR review further revision is necessary, the comments will be sent to the lead agency for consideration and resolution by lead authors.

7. Communication: Proposed Method of Publication and Dissemination of the Product

Hardcopies of the product will be published using the standard format for all CCSP synthesis and assessment products. The final product and the comments received during the expert review and the public comment period will be posted on the CCSP web site. Once the document has been cleared by the NSTC process, the product will be prepared for both web and hardcopy dissemination. The number of hardcopies and the distribution process will be determined as part of the development of this product.

8. Proposed Timeline (subject to change)

November 07	Final prospectus completed
November 07	First draft of the report completed
December 07	Expert review of first draft report completed
Dec 07/Jan 08	Public Comments
March 08	Submission for final CCSP/CENR clearance

References

http://www.atmos-chem-phys.net/6/1657/2006/acp-6-1657-2006.pdf
http://www.atmos-chem-phys.net/6/613/2006/acp-6-613-2006.pdf
http://www.atmos-chem-phys.net/6/3391/2006/acp-6-3391-2006.pdf

Appendix A1. Proposed Content of the Report.

ASSESSMENT OF THE CURRENT STATE OF UNDERSTANDING OF THE INFLUENCE OF AEROSOLS ON 20TH CENTURY CLIMATE CHANGE AND THUS CLIMATE SENSITIVITY

1. INTRODUCTION
    - A. Definition of aerosols
    - B. Potential influence of aerosols on the climate system
        - a. Direct Effect
        - b. Indirect Effect
        - c. Semi-direct Effect
    - C. Aerosol observations (brief introduction)
        - a. Remote sensing
        - b. Field campaigns
        - c. Surface observations
    - D. Modeling of aerosols
        - a. Aerosol models
        - b. Aerosols in climate models
    - E. Plan for this report
2. UNDERSTANDING AEROSOL FORCING FROM OBSERVATIONS
    - A. Introduction on obtaining aerosol forcing from observations
    - B. Observational techniques
    - C. Method of combining observations and models
    - D. Results for the Direct Effect of aerosol forcing
    - E. Indirect Effects
    - F. Additional Considerations
3. AEROSOLS IN CLIMATE MODELS
    - A. Introduction discussing aerosol impacts in AR4 simulations
    - B. Comparison of aerosol direct effects with observations
        - a. GISS GCM
        - b. GFDL GCM
        - c. General model intercomparisons
        - d. Additional considerations
    - C. Comparison of Aerosol Indirect Effects in models
        - a. Aerosol effects on clouds and radiation
        - b. Aerosol effects on precipitation
    - D. Impacts of aerosols on model climate simulations
    - E. Implications of comparisons of modeled and observed aerosols for climate simulations
4. THE WAY FORWARD
    - A. Improvements already introduced into aerosol models
    - B. Improvements planned for future aerosol models
    - C. Improvements possible in current climate models
    - D. Improvements possible in future climate models
    - E. Trade-off between increased aerosol complexity and climate model resolution
    - F. What can we really expect to know and when will we know it

Appendix A2. Additional Proposed Collaborators

1. Aerosol Chemistry/ Composition
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2. Aerosol Remote Sensing
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