Written Public Comments on the
Strategic Plan for the U.S. Climate Change Science Program
Chapter 5: Atmospheric Composition (pp 58-67)
Comments Submitted 11 November 2002 through 18 January 2003
Collation dated 21 January 2003

Page 58, Chapter 5: First Overview Comment: Measurements are the key to improving climate understanding. Current generations of general circulation models (GCMs) employ far too much parameterization and depend on numerous basic input values that are poorly known. We believe that special emphasis is needed on the following areas:

1) Establishing a spatially representative, continuous, long-term aerosol sampling network.
2) Enhancing mid-latitude research to take advantage of the ongoing "experiments" in long term land cover change, vegetation change, and evolving industrialization to better understand the consequences of future human development in tropical and subtropical regions. The current tropical emphasis of global research, focusing on recent acceleration of human modification, should be complemented by retrospective analysis of the effects of past human impacts in Europe, southwest Asia, and North America.

-CALIFORNIA AIR RESOURCES BOARD

Page 58, Chapter 5: First Overview Comment: This chapter does adequately address what we expect to be key non-linaerities in atmospheric composition, the carbon cycle and the climate system for the coming years. One area in which we expect significant non-linearities is in how the carbon and nitrogen cycles interact with one another and the oxygen cycle. For example, rising levels of surface ozone, generated by NOx and VOX and VOC emissions, significantly impact crop productivity and compromise terrestrial carbon uptake, and subsequent emissions of CH4 , NOx and N2O. N deposition, a product of the accelerating N cycle has potential non-linear impacts on the carbon cycle and trace gas emissions. Both N deposition, and the processes that generate it and surface ozone concentrations have significant interactions resulting from the interactions of emissions, chemistry and transport. These biogeochemical interactions are a key component of Question 2, Chapter 2.

Second Overview Comment: The impact of changes in the global nitrogen cycle is not included in the current document. Increases in NOx emissions influence tropospheric ozone, nitrate aerosol formation and N deposition. Increases in ammonia emissions impact sulfate and nitrate aerosol formation, and N deposition. Increases in N2O emissions impact stratospheric ozone levels. The change in these emissions, over the last 150 year is proportionally greater than the change in carbon dioxide emissions.

BETH HOLLAND, NCAR

Page 58, Chapter 5: First Overview Comment: Trace gas emissions and sinks are difficult to measure under field conditions especially for those gases such as isoprene that are so rapidly degraded after emission. Laboratory studies in environments that selectively exclude differing wavebands of UV and other radiation components that promote oxidative reactions are needed for process level evaluation of fluxes and products.

OSMOND, COLUMBIA UNIVERSITY

Page 58, Chapter 5: Another example of redundant research focuses on the contribution of aerosols to climate change. In Chapter 5 one main question is, "What aerosols are contributing factors to climate change and what is their relative contribution to climate change?" This has already been extensively studied by the IPCC, as well as the EPA. (See the EPA's *Inventory of U.S. Greenhouse Emissions and Sinks: 1990-2000*.)

CHRISTINE CORWIN, BLUEWATER NETWORK

Page 58, Chapter 5: Efforts to use point or column measurements of atmospheric composition to constrain surface fluxes of trace gases is very dependent on the proper representation of atmospheric transport. Although great strides have been made in this area, it is still important to recognize that vertical transport occurs by sub-grid-scale atmospheric events that can't be explicitly represented in GCM's. These are poorly constrained by theory or observation. Experimental campaigns are needed to test and develop transport parameterizations - especially aircraft studies of transport of surface derived tracers in convective storms. The products and payoffs would include: 1) improved analytical framework for establishing sources and sinks of trace gases including CO_2, VOC's and CH_4; 2) improved strategies for sampling the atmosphere.

JOE BERRY, CARNEGIE INSTITUTION.

Page 58, Chapter 5: First Overview Comment: The term uncertainty is utilized without any clear definition of the term. As this is the main theme of much of the report, it portrays an incorrect image of climate science that everything is uncertain and that no one can or should act until the uncertainty levels are diminished. It then goes on to lay out a high risk strategy of waiting until an unknown day for uncertainties to be reduced before any action can be taken. The risks are high as the lifetime of greenhouse gases in the atmosphere is long and mitigation efforts will not take immediate effect, unlike some other pollutants. This also ignores decades of research by US institutions and others that have reduced uncertainty levels on a wide range of climate issues. A guide to the uncertainty levels is clearly included in the IPCC's Third Assessment Report.
We would therefore strongly recommend that the report and the research efforts around it not revolve around reducing uncertainties per se, but rather provide new and useful information for policymakers. Finally, to infer that policymakers must have 100% certainty before taking any decisions is not consistent with the current situation. As the report notes, there are many uncertainties surrounding terrorism, but the government is not waiting for 100% certainty before taking preventative measures such as increasing security in airports.

JENNIFER MORGAN, WORLD WILDLIFE FUND

Page 58, Chapter 5: Overview Comments on Chapters 5, 6, and 7 based on my Panel Presentation

Comments on Chapter 5

Emphasize exploitation of recent and ongoing programs to demonstrate capability to bridge gap between "Research Needs" and "Products and Payoffs" -- especially for 2-4 year horizon -- e.g., ARM Program, including use by GCIP

Acknowledge gulf that exists between (a) obtaining improved understanding of climate system and (b) having society benefit from this new knowledge -- requirements include substantial "impact data sets", extensive interactions with potential users of mitigation information, and long-term collaboration with social scientists, economists, etc.

Need for greatly enhanced resources if desired progress is to occur -- qualified scientists and institutional funding -- e.g., where are needed people with interdisciplinary expertise?; level of funding of NOAA Laboratories in last 20 years has halved their capability to contribute

PETER LAMB, THE UNIVERSITY OF OKLAHOMA

Page 58, Chapter 5: Aerosol research could benefit from research to understand past aerosol variability and its effect on climate. Glacial periods are characterized by significantly higher dust concentrations in ice cores, which must mean that the atmosphere was much dustier.

WILLIAM B. CURRY, WOODS HOLE OCEANOGRAPHIC INSTITUTION

Page 58, Chapter 5: Comments on Part I, and Part II, Chapter 5 (Climate Change). Two key "big-picture" questions face climate scientists. 1) Are the climate changes we are now observing on Earth a result of anthropogenic impact, or a manifestation of natural climate variability? 2) Can we expect patterns of future climate change to be orderly and predictable, or are there some "wild-cards" in the climate system that could yield unpredictable and potentially catastrophic consequences? Whichever way we answer these questions will have major impact on policy decisions.

These questions will likely never be answered by monitoring our modern climate as it evolves. The draft plan could highlight a major opportunity to address these issues, by examining and understanding past variations in the Earth system in the geologic record. The scientific community has steadily improved their ability to quantify and understand past climate changes on scales and with precision that will inform policy decisions. The ability of models to address paleoclimatic data has also improved greatly. But the current draft strategic plan effectively ignores the opportunities presented by paleoclimatic, paleoceanographic, and paleoecologic data and modeling. Paleo data will help put changes we observe through monitoring into the perspective of what is possible within our complex Earth system. Existing geologic data suggests that this system is capable of some truly dramatic behaviors on very short timescales, especially because of coupled ocean-atmosphere interactions, and these must be of concern to any policy making body.

I suggest that the planning group add some key scientists who have appropriate expertise in the field of paleoclimatology, paleoceanography, and paleoecology to their ranks, so that these issues can be dealt with as part of an integrated plan for understanding climate change. These experts should represent the broad reach of the field. It would be a mistake to think that all of the relevant effects of climate change could be studied in a record of the past few thousand years. In fact, studies of climate processes of appropriate scale can be addressed throughout geologic history. For example, the best evidence for dramatic changes in North Atlantic Deep Water formation, a concern for the future, comes from studies of the last glacial episode. Evidence for catastrophic greenhouse warming associated with methane degassing comes from the distant past, some 50 million years ago. Both of these observations have motivated more detailed studies of modern processes, which benefited from the revolutionary idea that the systems are subject to massive change. These sorts of impacts remain on the menu of possible effects on Earth in the future, and thus must be understood in detail, so that the processes they represent can be considered in predictive models.

Certainly the understanding of natural climate variability, as represented in the geologic record, will be an important part of any study of future climate change. Not dealing with this issue will leave the report, and any future studies, open to criticism that climate changes we observe are just natural oscillations, and thus not of major concern. This result would be a disservice to scientists, policymakers, and the public.

ALAN MIX, OREGON STATE UNIVERSITY

Page 58, Chapter 5: A document like this can sometimes promise everything under the sun (motherhood & apple pie, etc.) or say so little it has no real teeth. This draft, however, walks the middle ground fairly well.

DOE, CYNTHIA ATHERTON

Page 58, Chapter 5: This chapter is clearly a highly distilled summary of very substantial research programs in this area. The most useful comments from us would be to identify research issues that receive inadequate or excessive emphasis, but we didn't see any. The primary area of research for two of us is aerosols. Aerosol issues are emphasized both in Chapter 5 and 2, and we think this emphasis is appropriate.

DOE, RICHARD C. EASTER, ELAINE CHAPMAN, RAHUL ZAVERI

Page 58, Chapter 5:

This chapter is clearly a highly distilled summary of very substantial research programs in this area. The most useful comments from us would be to identify research issues that receive inadequate or excessive emphasis, but we didn't see any. The primary area of research for two of us is aerosols. Aerosol issues are emphasized both in Chapter 5 and 2, and we think this emphasis is appropriate.

DOE, RICHARD C. EASTER, ELAINE CHAPMAN, RAHUL ZAVERI, PACIFIC NORTHWEST NATIONAL LABORATORY

Pae 58, Chapter 5:

Two questions that I feel need to be addressed in the atmospheric composition chapter are (1) How will the many feedbacks of ecosystems that are brought upon by climate change impact regional and global atmospheric chemistry? and (2) How do interactions between the biogeochemical cycles of the macronutrients (e.g., C, N) affect climate change?

On a global scale the majority of hydrocarbons that are precursors to ozone and aerosol formation are emitted by vegetation. Reductions in the reactivity of hydrocarbons from anthropogenic sources has limited the production of ozone in urban areas but has increased ozone production in rural areas. Increased exposure of ecosystems to ozone and other oxidants will diminish plant productivity. Increased deposition of N may have a fertilization effect. Changes in temperature and precipitation levels brought upon by climate change will affect the viability of vegetation in various regions. These changes will have a profound effect on trace gas emissions and consequently, both regional and global atmospheric chemistry.

One of the research needs to answer question 5 includes building and evaluating models that couple biogeochemical systems with decision making frameworks. I feel that we need to build and evaluate models that couple the biogeochemical cycles of elements, in particular C and N. A lot of research has already gone into studies of the C cycle while ignoring the impacts from the biogeochemical cycles of other macronutrients. It appears that we forget that the molecular composition of a plant also includes N. I don't know if this research need belongs in the atmospheric composition chapter (although the interaction of the C and N cycles has a major impact on atmospheric composition) but I do feel it needs to be in the document.

DOE, PAUL DOSKEY

Page 58, Chapter 5: The emphasis on quantifying the roles of both regional (aerosols, clouds) and global forcing (GHGs) agents in the earth's radiative budget and climate change. It aims to develop linkages between climate change, air pollution, and recovery of the ozone layer. It also has a strong commitment to national and international partnerships.

The tremendous value of the approach developed in Chapter 5 is illustrated by the enormously valuable INDOEX Expedition, that discovered the extensive Southeast Asian brown haze above the Indian Ocean, that absorbs a large fraction of the solar radiation in the atmosphere radically altering the thermal structure to suppress rainfall which in tern enhances pollutant residence times. This Asian haze intercepts solar radiation weakens the hydrological cycle, and may have strong impact on the fresh and clean water supply. It also illustrates that as we do more climate research we could uncover new and important feedback and linkages between air-pollution, climate, and water resources. (Ramanathan, Crutzen, Kiehl and Rosenfeld, Aerosols, Climate, and the Hydrological Cycle, Science 7 Dec 2001, 294, 2119). This data in turn should be fed into global coupled ocean-atmosphere models, to achieve more confidence in assessments.

Our understanding of aerosols is probably the weakest link and global aerosol distribution is rightly the first product to focus on under Question 1. However, additional focus on understanding radiative impact of absorptive aerosols (e.g soot/black C) is needed. In addition the source of the high carbonaceous aerosols in the clean marine boundary layer found during INDOEX should be identified. Development of more robust models to calculate optical properties of complex multi-component aerosols (internal or external mixtures) needs to be included in (1). In addition mechanisms for gas to particle conversion need to be investigated. This will require more laboratory investigations and the technology has advanced enough that we can do this well.

Much more is known about the global source term for CO2 than its sink term. While there are uncertainties in CH4, and N2O budgets and future projections of their growth terms their current forcing should be well known. Their monitoring should be valuable. The CFCs are declining and their budgets are well constrained. Monitoring tropospheric ozone extensively and understanding its formation mechanism have been subject to much study that must made more extensive and systematic to produce meaningful trend data.

Here are some monitoring priorities that could help sift us through the uncertainties and policy variables:

1. Aerosols (in particular soot and carbonaceous aerosols) in key areas (urban, above oceans). Their fate and transport over long distance, e.g. from Asia to Western US needs to be evaluated particularly related to toxics like Hg etc..

2. Ozone and its precursors (NOx, HCs) particularly in out-flow regions of extensive fires, powerplant/urban plumes, study of high-pollution urban areas (Houston, Mexico, Shanghai), long range transport 3. Methane, Carbon Monoxide

4. Nitrous Oxide

5. I want to stress the need to monitor other atmospheric gases at a global network to develop source relations and mechanistic inferences. Examples should include (1) Acetonitrile (measure fire activity) (2) Hydrogen (related to formaldehyde and hence isoprene and auto exhaust, this may be a good data to harness if we shift to a hydrogen economy, and need to tackle its leak etc.). This is a very weak element in the current plan and needs to be developed further.

6. Isotopic information on trace gases should be utlilized to constrain their budgets.

Again the atmospheric composition section should try to gain mechanistic information, as much as it wants to gather better observational data. Particularly missing in the draft is a focussed drive to monitor, detect or understand any potential changes in global OH levels which feedback into numerous chemical constituents in our atmosphere.

DOE, MANVENDRA DUBEY

Page 58, Chapter 5: Overview comment 1: The questions, research needs, products and payoffs all are common climate science issues. The text reads like many climate science white papers/science plans/proposals etc. that we have all seen. I find no glaring factual scientific errors in the text, but the main intent appears to be to put any kind of assessment/recommendation off for 4-6 years.

Overview comment 2: The needs to be an increased level of quantitative guidelines in this document. As it stands, many chemicals, processes, aerosols and dynamical couplings are mentioned with some level of detail on what needs to be known to what level for a policy decision to be made.

Overview comment 3: The role of feedbacks in the climate system needs to be enhanced. While many view these feedbacks as a natural part of climate model development, many researchers are more confined in their scope.

Overview comment 4: Again, I am bothered by the continual reference to 2006 and the many references to time scales like (2-4 years) and (4-6 years). I find no objective criteria that resulted in the selection of these time intervals.

Overview comment 5: While many researchers, and the population in general, may have not been actively aware of the couplings between ozone depletion and greenhouse buildup that results in warming, much research has been done on these couplings. This needs to be made clearer in the document. As it reads now, Questions 5 could be interpreted as a lack of understanding with regard to how global warming will occur.

DOE, DAVID ERICKSON

Page 58, Chapter 5: I would like to point out that the Atmospheric Composition section eludes to natural emissions and sources of important greenhouse gases and aerosols but does not really indicate the importance of the emissions of isoprene and monoterpene hydrocarbons. I did a check and isoprene, monoterpenes, and natural hydrocarbons are not mentioned in the entire document. Note that I have sent in a comment to the Carbon Cycle Chapter which I also commented on as a reviewer noting that these naturally occurring compounds as well as a number of other trace gas species, including organic alcohols, acids, and larger compounds (diterpenes, sesquiterpenes, etc.) and their oxidation products are important in regional and global scale issues.

The emissions of natural hydrocarbons are quite large and are connected strongly to the biosphere and the species distributions in the forest, savannah, tropical, and other ecosystems. We also know that they can play important roles in determining the atmospheric composition of the troposphere on regional and global scales. Indeed their presence in areas where there are anthropogenic emissions of air pollutants such as nitrogen oxides and sulfur dioxide, can lead to increased levels of regional ozone and fine aerosols that are important in radiative balance considerations.

These compounds emission rates will be affected by the health of the plants, precipitation, nutrient levels, temperature, light intensity, and the distribution of the species. I think that this addressed in the atmospheric composition section under Question 2. Note that the additional questions in this section address methane and N_2O which are directly emitted greenhouse gases, and also the nitrogen oxide natural and anthropogenic sources, but does not mention the natural volatile hydrocarbons. I think this needs to be addressed here or separately.

Comments on Chapter 5

The role of natural hydrocarbons will also be involved with feedbacks that are tied to ozone and other air pollutants that can interact with the ecosystems in either positive (e.g. fertilization) or negative (e.g. ozone stress, drought, etc.) ways. This is eluded to in the most general of ways in this document.

Note: The emissions will be impacted by ozone causing reduction in the photosynthetic activity and growth of the plants. The most abundant of these natural hydrocarbons is isoprene (a hemiterpene). Isoprene oxidation will enhance the levels of hydrogen peroxide formation and sulfur dioxide oxidation to sulfate aerosols (see . J.S. Gaffney, G.E. Streit, W.D. Spall, and J.H. Hall, "Beyond Acid Rain: Do Soluble Oxidants and Organic Toxins Interact with SO_2 and NO_x to increase ecosystem effects?" Feature Article in *Environ. Sci. Tech.* **21** (6) 519-524 (1987)), and monoterpene reactions with ozone will produce fine secondary organic aerosols. Isoprene has also been clearly connected with enhanced ozone production in areas where anthropogenic nitrogen oxides are high. The Southern Oxidant Study (SOS) clearly demonstrated the importance of natural isoprene emissions on the observed increased ozone levels in urban and regional areas in the Southeastern United States, where deciduous forests are an abundant source of this compound.

Ozone is a potent plant phytotoxin. Increased tropospheric ozone (a greenhouse gas) levels will lead to the stomatal resistance being increased leading to reduced uptake of carbon dioxide, less water emitted through evapotranspiration, and less emission of volatile organic carbon (i.e. isoprene) from the plants. Carbon sequestration under ozone exposures have been shown to reduce carbon uptake in FACE experiments even at moderate levels based in research performed under the DOE PER program (Dave Karnovsky). At 60 ppb levels carbon dioxide uptake even under high carbon dioxide exposure was reduced significantly due to this interaction.

This type of feedback is not really addressed in this document. It would be nice to see this addressed and linked to the Atmospheric Composition section (Chapter 5). I will be sending them a similar comment.

I suggest that there might be additional questions added to the Chapter that addresses this, and offer two possibilities.

Will changes in climate (i.e. changes in temperature and precipitation) lead to significant changes the emission of natural hydrocarbons that may have feedbacks in the secondary production of regional ozone, aerosols, and other radiatively important species?

What are the feedbacks between carbon dioxide uptake, water vapor and natural hydrocarbon release rates, and exposures to higher levels of ozone and other oxidants due to anthropogenic emissions of nitrogen oxides?

I have suggested similar questions to the Carbon Cycle Chapter 9 group. There are obvious links to evapotranspiration reduction due to ozone impacting plants that should be examined in the Water Cycle chapter as well.

I note that this document is attempting to look at methane and N_2O, which is long over due, and would comment, that there are a lot of other key species that are also potentially important greenhouse gases (acetone, MEK, for example) and should be explored. These compounds are not at the same magnitude of carbon dioxide in terms of mass, but their chemical properties can act to substantially impact the atmosphere in significant ways due to their reactivity and catalytic abilities. Similar to the CFC's, if the transformation products from the oxidation of these compounds have IR absorbances in window regions their increases in the atmosphere may be quite important.

DOE, JEFFREY S. GAFFNEY

Page 58, Chapter 5: Trends in the oxidative capacity of the atmosphere need to be assessed using global models of atmospheric chemistry, included as part of comprehensive Earth Systems Models. Changes in the oxidative capacity of the atmosphere will affect the rate of future climate change.

Linking high resolution local/regional scale chemistry models with global scale models to assess the role of megacities on global atmospheric chemistry needs to addressed given the potentially substantial impact of megacities on the chemistry of the atmosphere.

Models of atmospheric chemistry need be included in studies aimed at determining the long term trends in the carbon cycle and climate, particularly with respect to predicting CH4 and tropospheric O3 concentrations. Our understanding of air/sea trace gas interactions and their influence on O3 atmospheric chemistry and climate needs to be improved.

DOE, JOHN TAYLOR

Page 58, Chapter 5: The illustrative questions posed as the framework for this chapter are good ones that must be addressed if we are to progress toward a reasonable method of quantifying the effects of climate change. There are a number of sources which are not addressed in this chapter related to agricultural production. Some include enteric methane emissions from both domestic and wild animals. These emissions are 'energy drains' on the animals and research into methods to reduce these emissions would reduce a significant percentage of anthropogenic emissions (and a payoff of increased animal feed and forage efficiency conversion). Other areas are human and animal solid waste and excreted waste management. A better understanding of these facets should be a research question included.

STEVEN R. SHAFER, USDA-ARS

Page 58, Chapter 5 (Cross-cutting issues with Chapters 5,6,7)
Overview:
The draft strategic plan, particularly Part 2 describing the US Global Change Research Program (GCRP), has a number of strengths that are relatively well articulated. In particular, Chapters 5, 6 and 7 all describe a broad, ambitious program of field experiments, laboratory studies, remote sensing missions and model investigations that quite reasonably follows on the achievements of the last decade in the GCRP.

Comments on Chapter 5

The three chapters, all of which describe elements of the GCRP, have a number of common questions and a number of common research needs and strategies. Among the common questions are the following:

a. How can we best make use of coupling of models, e.g., climate and pollution models, to understand the regional and local effects of climate change?

b. What is the sensitivity of each element of the climate system to feedbacks? For example, how does the feedback between climate and cloud amount, structure and composition affect the system response to changes in forcing?

c. How can the baseline variability of the climate system be characterized?

d. What are the consequences of change in each area of inquiry and how can these be effectively communicated outside the research community?

Among the common research needs and strategies are the following:

a. Uncertainties identified and quantified in the preceding decade of GCRP research must be reduced.

b. The re-assimilation of existing observations offers the best methodology for refining baseline climate variability estimates and identifying and quantifying trends.

c. Regional climate modeling is a promising strategy that can be applied to provide information about the regional characteristics of climate change.

d. Data sets are growing in size, diversity and potential applications, so there is a great need for frameworks to support the integration of these diverse and voluminous data sets.

The linkages among the three chapters appear to have been an afterthought. While each chapter (or section) ends with a sentence naming other chapters that may be linked, these links have not been articulated or even outlined.

The two parts of the CCSP, namely CCRI and GCRP, are distinct and weakly related in the draft strategic plan.

Suggestions:

1. There are several gaps in the scientific basis for and the research plan to implement the CCSP program. By this I mean basic questions that are asked (science gaps) and ways and means of addressing these questions (research gaps). Suggestions for eliminating the science gaps include:

a. Linkages among program elements should be given much higher priority in the planning process.

b. A much more serious and profound consideration of how the CCRI and GCRP parts of the plan will work together scientifically is needed.

c. A much stronger emphasis on predictability is needed throughout the document. Predictability provides a context for assessing the reliability of model results, e.g., seasonal to interannual climate variations like El Nino and the Southern Oscillation. Predictability can also serve to provide policy guidance by identifying and quantifying what can be predicted and what cannot.

d. Climate variability and predictability should be cast in a probabilistic framework. It is widely recognized that climate variability is a probabilistic problem, at least on the shorter climatic time scales. A probabilistic framework provides a context for quantifying uncertainty, and it provides a link to stakeholders who already have the ability to quantify risk (costs and benefits).

e. The importance (and hence the visibility) of the water cycle should be elevated in the draft strategic plan. Water is inherently important for climate, humans and ecosystems, and changes in the water cycle are the principal modes in which humans and ecosystems will "experience" changes in climate. Also, the draft strategic plan ask new questions. Rather than focusing on water vapor feedback (well known for over a century), the plan should question assumptions such as the assumption in current climate models that relative humidity remains constant under climate change.

f. The plan should characterize the predictability of regional climate (and regional climate change) as an open question. Regional climate modeling is widely applied (almost ubiquitous) in the draft strategic plan, but despite a growing body of work that supports the hypothesis, there is, to date, no definitive demonstration that regional climate models can uniquely characterize the regional climate.

2. Suggestions for how to eliminate the research gaps in the draft strategic plan include the following:

a. Uncertainty enters from many sources: incomplete, inaccurate and inexact observations; incomplete and inaccurate climate models; and the probabilistic aspects of climate variability. The draft plan addresses the first two of these sources, but not the third. The plan should include multiple, comparable observations, a multi-model approach to bracket the observations, and multiple model realizations (ensembles of model integrations) to estimate the uncertainty.

b. There needs to be a more robust scientific rationale for coupling models. Bigger, more complex models are not necessarily better, and they may be much worse. Possible elements of a rationale for coupling models could include

(1) identifying coupled modes of variability or

(2) potentially important feedbacks. For example, coupling a climate model with an atmospheric chemistry model and a pollution transport model may be needed to simulate feedbacks between climate and

aerosols, but such models are extremely sensitive to things that individual components do poorly, like simulation of aerosol-scavenging precipitation.

b. The plan should include specific descriptions for how to quantify feedbacks. For example, consider the problem of the feedback between clouds and climate. The plan needs to explore ways to incorporate and quantify the effects of cloud microphysics on radiation and precipitation. It also needs to be inclusive of alternative methodologies such as embedded cloud-resolving models.

c. Because the report relies heavily on reanalysis, i.e., re-assimilation of historic observational data sets, the plan should include scietific "vetting" of and reports to stakeholders on what reanalysis data can be used for and what such data cannot be used for. It is also necessary to include data assimilation and observing system simulation in the planning for the Climate Process Teams, not just for strategic deployment of observing system assets, but also for assessment of reliability and uncertainty.

d. The plan should recognize and explicitly describe the scope, maturity and level of readiness of its different parts. For example, there is a high degree of readiness for quantifying the sensitivity to feedbacks through controlled experiments, but there is a low degree of readiness for the study of abrupt climate change in a modeling context or for the study of catchment-scale water quality issues in the climate context.

e. There are clearly scientific, technical and cultural barriers between the diverse modeling communities that are represented in the draft strategic plan. For example, there has been practically no interaction previously between the climate and pollution modeling communities. The plan should recognize that these barriers exist and define processes to overcome them.

f. The plan should include the goal of establishing the legitimacy of downscaling. A full suite of methodologies, including statistical models, nested dynamical models, and ultra-high resolution global models, is needed in order to validate the hypothesis that regional climate models can be sed to address the regional climate change problem.

1. There are two minor "language" issues that need to be resolved throughout the draft strategic plan.

    a. There needs to be a scientifically defensible process for defining terms, such as "key variables" and "key regions".

    b. The level of specificity needs to be more homogeneous. Overly-specific language should be made more general. For example, "GIS" is mentioned in several places as a data integration framework, but it should be removed in favor of "a suite of data integration tools and procedures". Likewise, overly-vague language should be amplified. For example, where the "natural mechanisms for abrupt climate change" are mentioned, specific examples from the recent NAS report such as the collapse of the thermohaline circulation and Arctic Ocean "flushing" should be mentioned.

Omissions: There are several missing linkages among these three program elements. For example, the following pairs of subject areas are obviously linked in scientific terms, but those linkages are not described anywhere in the draft strategic plan:

a. The water cycle and the energy cycle are closely related, because of the latent energy transports associated with phase changes of water and because of the radiative effects of water vapor and clouds. This linkage has been explicitly recognized in the international and national GEWEX programs, but is of relatively low visibility in the draft strategic plan.

b. The energy cycle and the carbon cycle are closely linked through the radiative effect of carbon dioxide and through the role that carbon dioxide plays in the life cycle of terrestrial vegetation and the latter's role in the energy budget of the land surface.

c. Aerosols are closely linked in both direct and indirect ways and in both supplementary and complementary ways. The direct and indirect radiative and cloud effects of aerosols of different types are described in the draft strategic plan, but there is no recognition that aerosols may have an effect on the time scale of precipitation formation or that precipitation scavenges aerosols from the troposphere.

d. The linkage between clouds and precipitation and water vapor may seem obvious, but the relationship has an implication for how climate variability is closely related to the water cycle.

2. The question of how predictability of climate variations may change in a changing climate is missing. While we have very good estimates of the predictability of weather, and we are beginning to achieve estimates of the predictability of seasonal climate variations, we have very little understanding and no quantitative measures of how different that predictability will be as the climate changes.

James Kinter, Center for Ocean-Land-Atmosphere Studies

Page 58, Chapter 5: To study the feedback between the regional pollution and global climate change using modeling tool, the global emission source functions of chemical species are the bases of modeling studies from global to local scale. The emphasis on the global emission estimation of major greenhouse gases and precursor gases of tropospheric ozone should be added as “Research Needs” in Question 2 (page 61) or Question 3 (page 62).

A.L. WILLIAMS, H.C. HUANG, M. CAUGHEY, ILLINOIS STATE WATER SURVEY

Page 58, Chapter 5:

- Consider water vapor and aerosols in the context of the hydrological cycle in order to build more effective links to Chapters 6 (climate variability and change) and 7 (the water cycle).

- In this chapter and throughout the Plan, review the document for consistency between research questions and research needs (e.g., water vapor is listed in the questions for Chapter 5 but not discussed in the research needs section of this chapter).

- Regional air quality issues provide an important link with the discussion of climate in Chapter 6 for example: (1) the connections between ENSO-related drought and fires with haze and air quality; and (2) the links between dust, haze and cloud condensation nuclei with feedbacks to climate.

- Be sure to include recognition of the important role that assessment processes and reports have played in the past and will continue to play in the future.

EILEEN L. SHEA, EAST-WEST CENTER

PAGE 58, CHAPTER 5:

Comments fall primarily in four areas: the leadership (accomplishments/contributions) role of U.S. science; the importance of stakeholder engagement; focus of the program; and balancing near-term and long-term goals. The comments do not impact the overall scope of the program, but they may alter the focus of implementation plans.

<u>Leadership</u>

U.S. research has played a dominate role in advancing understanding of the global environment and providing guidance for policy to protect the environment. An important part of the U.S. role has been leadership in the international assessments (IPCC and stratospheric ozone) that provide the foundation for international agreements on environmental issues. The strategy outlined in Chapter 5 provides the basis for continued leadership in the advancing the understanding in atmospheric composition. However, there should be specific reference to scientific leadership in international assessments including linking the timelines for specific accomplishments of the program to timelines of the assessments.

<u>Stakeholder engagement</u>

Stakeholder engagement can enhance the program focus and increase cooperation in addressing environmental issues. As an example, cooperation on R&D on CFC alternatives focused government research on the compounds being evaluated by industry and increased the value of the government research as a basis for decisions and increased the pace of developing the alternatives required for ozone layer protection. Also, cooperation in understanding stratospheric ozone depletion science resulted in better industry understanding of the basis for policy decisions and greater cooperation in addressing the problem, again increasing the pace of actions to protect the ozone layer.

Engaging stakeholders in the design (e.g., this meeting) and implementation of the climate change science program can provide similar benefits. Two areas (both would be addressed under Question 5) where stakeholder engagement could be particularly important are determining the mechanism for potential health impacts of particulate matter and the mechanism of transport of persistent organic pollutants.

Program Focus

Two aspects of the influence of aviation on atmospheric composition should be added to the program.

On page 61, lines 29 and 30, there is an illustrative research question on understanding the NO_x budget. There should be some specific mention of the importance of understanding NO_x budget in the upper troposphere and the relative role of aviation in that budget. The impact of persistent contrails on radiative forcing and the potential role of these contrails in cirrus cloud formation as a specific focus area in Question 1.

In Question 1 there should be specific mention of the need for additional research on the influence of aerosols on tropospheric chemistry. The role of aerosols in tropospheric chemistry is only beginning to be explored and much more work is needed. Also, in Question 5 there is a need for increased focus of the effect of aerosol composition on human and ecosystem impacts. Particulate matter (PM) regulations are moving forward without the required scientific understanding. As a result, costly actions could be taken with little health and environmental benefit.

The focus on the ozone depletion "end game" contained in Question 4 should be retained in the final strategy document. The landmark Montreal Protocol owes its success to a solid scientific basis and a lack of continued advancements in the scientific understanding required to answer questions from the policy community could undermine that success. Continued work is needed to verify the effectiveness of the Protocol; e.g., monitoring concentrations of ODSs and the recovery of stratospheric ozone. Additional work is needed to answer some difficult questions being posed by policymakers, e.g. what is the stratospheric ozone impact of anthropogenic methyl bromide and very short-lived ozone depleting substances and what is the relationship of climate change and ozone depletion. As example of the ongoing attention to these issues by policy-makers, Parties to the UNFCCC have recently requested an IPCC report: "Relationship between efforts to protect the stratospheric ozone layer and efforts to safeguard the global climate system: issues related to HFCs and PFCs." The reputation of the scientific community and the commitment of policymakers to rely on science as a basis for decisions will be impacted by how scientists respond in this "end game."

Balancing near-term and long-term goals

Clearly there is a need for the type of results focused research described in Chapter 5 of this plan. However, there must also be a continuation and enhancement of the research that provides the basis for such results oriented programs. Since CCRI is meant to be more near term results focused to support decisions, Chapter 5 should have more of a long-term/advancing basic understanding focus.

MACK MCFARLAND, DUPONT

Page 58, Chapter 5: See general comment #3 about other greenhouse gases. Also, while the attention to water vapor on page 62 is laudable, it is generally considered part of the climate response, not a primary greenhouse gas. With a fuller list of questions about other gases (there are plenty in IPCC chapter 4) there won't be as much need for filling out this section with a mention of water vapor. instead it could fit into a slightly reworded question 5.

PHILIP MOTE ON BEHALF OF THE CLIMATE IMPACTS GROUP, UNIVERSITY OF WASHINGTON

Page 58, Chapter 5: Two questions that I feel need to be addressed in the atmospheric composition chapter are (1) How will the many feedbacks of ecosystems that are brought upon by climate change impact regional and global atmospheric chemistry? and (2) How do interactions between the biogeochemical cycles of the macronutrients (e.g., C, N) affect climate change?

On a global scale the majority of hydrocarbons that are precursors to ozone and aerosol formation are emitted by vegetation. Reductions in the reactivity of hydrocarbons from anthropogenic sources has limited the production of ozone in urban areas but has increased ozone production in rural areas. Increased exposure of ecosystems to ozone and other oxidants will diminish plant productivity. Increased deposition of N may have a fertilization effect. Changes in temperature and precipitation levels brought upon by climate change will affect the viability of vegetation in various regions. These changes will have a profound effect on trace gas emissions and consequently, both regional and global atmospheric chemistry.

One of the research needs to answer question 5 includes building and evaluating models that couple biogeochemical systems with decision making frameworks. I feel that we need to build and evaluate models that couple the biogeochemical cycles of elements, in particular C and N. A lot of research has already gone into studies of the C cycle while ignoring the impacts from the biogeochemical cycles of other macronutrients. It appears that we forget that the molecular composition of a plant also includes N. I don't know if this research need belongs in the atmospheric composition chapter (although the interaction of the C and N cycles has a major impact on atmospheric composition) but I do feel it needs to be in the document.

PAUL V. DOSKEY, ARGONNE NATIONAL LABORATORY

Page 58, Chapter 5: The illustrative questions posed as the framework for this chapter are good ones that must be addressed if we are to progress toward a reasonable method of quantifying the effects of climate change. There are a number of sources which are not addressed in this chapter related to agricultural production. Some include enteric methane emissions from both domestic and wild animals. These emissions are Œenergy drains, on the animals and research into methods to reduce these emissions would reduce a significant percentage of anthropogenic emissions (and a payoff of increased animal feed and forage efficiency conversion). Other areas are human and animal solid waste and excreted waste management. A better understanding of these facets should be a research question included.

LOWRY A. HARPER, USDA-ARS, WATKINSVILLE, GA.

Page 58, Chapter 5: Links to ecosystems and DMS need improvement. Same goes for aerosols and cloud microphysics.

ANTONIO J. BUSALACCHI, EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER (ESSIC),
U. Maryland

[duplicate comment deleted in space below]

Comments on Chapter 5

[duplicate comment deleted in space above]

[duplicate comment deleted in space below]

Comments on Chapter 5

[duplicate comment deleted in space below]

[duplicate comment deleted in space above]

[duplicate comment deleted in space above]

Page 58, Chapter 5: The Draft Strategic Plan for the Climate Change Science Program focuses on the status quo (current research programs within the various agencies) and is short on specifics. In particular, inter-agency coordination of research on clearly posed and prioritized scientific questions is missing. But, rather than just being critical, it may be helpful to offer a specific example of the sort of broader integrative effort that is needed. Inasmuch as I work on aerosol forcing of climate, I will use that topic as my example.

The case in point is the longstanding overdependence on model calculations for quantifying climate forcing by anthropogenic aerosols. (Climate forcings are imposed changes in the Earth's energy balance and are the key metric for understanding the causes of climate change. Aerosol forcings are the dominant source of uncertainty in total, industrial-era forcing.) The joint U.S./French lidar satellite CALIPSO, in orbit with EOS, CLOUDSAT and other platforms, is intended to provide an observational basis as an alternative to pure modelling approaches. Objective number one of CALIPSO is to attain this observational basis and thereby reduce uncertainties associated with aerosol forcings. However, the CALIPSO lidar and EOS instruments (e.g., CERES, MODIS and MISR) alone or in combination cannot provide a complete data base. What is missing are in-situ observations of chemical microphysical and optical properties that are needed to obviate gross assumptions in the retrieval of information from the satellite instruments. For example, without in-situ chemical data it will be very difficult to differentiate between natural and anthropogenic aerosols. What is needed, therefore, is a program of in-situ measurements COORDINATED with the satellite observations. Current observations, e.g., the ordinary air pollution monitoring data, cannot be used because they are performed at fixed sites, are over inappropriate averaging times and seldom have the needed combination of variables. The preferred approach would involve a dedicated aircraft for making in-situ observations along the CALIPSO/EOS/CLOUDSAT ground track, flying perhaps a few times a week for the entire duration of the CALIPSO mission. One such aircraft in the EASTERN U.S., along with others in other countries would provide the needed data, to be taken at the same time as the satellite observations. Considerable effort has been expended to insure simultaneity of satellite observations, and the same is needed for the in-situ observations.

It is my considered opinion that the hundreds of millions of dollars already being spent on satellite retrieval of aerosol information will have been spent in less than optimal ways if the in-situ information (that would cost only a few or perhaps 10 million) is not made available.

I attach a paper that I wrote explaining in more detail what is needed.

I have sent a few visual aids to Stephen Schwartz for use at the meeting.

ROBERT CHARLSON, UNIVERSITY OF WASHINGTON, SEATTLE

Page 58, Line 3: +; Q1: add word
… climate-relevant physical, chemical, and radiative properties .

NIST

Page 58, Line 3-5 ˆ Question 5 is a central important issue and should be retained in any subsequent iterations.

BETH HOLLAND, NCAR

Page 58, Line 3, The 5 questions seem reasonable to me. Perhaps add 'what anthropogenic processes are causing the increases/changes in atmospheric trace gas/aerosols concentrations?'

DOE, DAVID ERICKSON

Page 58, line 7 - page 59 line 9. I concur in the three bullets and endorse the "shared atmosphere" concept and the concept that the long removal times of certain compounds may have implications for all countries and populations, and for future generations. I am pleased to see these concepts in the present report. I support as well the need for national and international partnerships (page 59, lines 26-27). This shared atmosphere concept is at variance with the call for studies of North American sources and sinks in Sections 2.2 and 3.3.

The several questions in the box, page 58, are not suitable for this document for a variety of reasons. the questions are poorly phrased (e.g., Question 1 asks "What are the ... properties... of aerosols?" Question 2 asks "What is the current skill for simulating GHG budgets?", etc.) These questions should be restated as quantitative requirements.
Elaborating on question 1, which reads: "What are the climate-relevant chemical and radiative [presumably the question should read optical, not radiative; optical deals with the interaction of radiation and matter; radiative requires specification of the particular atmospheric situation, solar zenith angle, surface reflectance, and the like, which are not aerosol properties but properties of the system in which aerosols are present] properties, and spatial and temporal distributions, of human-caused and naturally occurring aerosols?" Is the question to be answered simply by an enumeration of the properties: Mass loading, composition, size distribution, shape, size-dependent composition, light scattering coefficient, light absorption coefficient, single scattering albedo, phase function, and the like; relative humidity dependence of the above; degree of homogeneity within a size class? I doubt that such an enumeration of properties is what the author had in mind by the question. So the question probably means "Specify the values of these chemical and optical properties." But this then gives rise to the question where and

when? But clearly there is no way to do that either. For all times and places, including the future for prospective emission scenarios.

So what does the question mean? Really it should be a task or objective, in which case it should read:

> Develop the capability (1) to characterize, for aerosols in the present atmosphere, the chemical, microphysical, and optical properties pertinent to radiative forcing of climate change and to influencing the hydrological cycle; (2) to understand the processes responsible for these properties, as a function of location and time; (3) to represent this understanding in chemical/microphysical aerosol models; and (4) to demonstrate that understanding by comparison of model with observation do an accuracy such that the influences of aerosols on radiation (direct and indirect radiative effects) and on clouds and precipitation can be calculated to a specified uncertainty in W m-2 or other climatically relevant units.

A similar examination and restatement must be made for each of the questions in the Box, page 58.

SCHWARTZ, BROOKHAVEN NAT'L LAB

[duplicate comment deleted from the space below]

[duplicate comment deleted from the space above]

[duplicate comment deleted from the space below]

[duplicate comment deleted from the space above]

Page 58, Lines 8-20: Agriculture, including the important biogeochemistry driving trace gas emissions, is not currently represented in most climate system models, thus failing to capture important global sources of the trace gases discussed. Furthermore, agriculture has been one of the key forces driving the increases in N gas emissions.

BETH HOLLAND, NCAR

Page 58, line 17 to Page 59, line 1: There is only one atmospheric CO_2 concentration, for all practical purposes. The text should not imply that there are multiple growth rates.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Comments on Chapter 5

Page 59ff: ***Given the overall present uncertainty in radiative forcing over the industrial era, the statement that "When climate models incorporate [positive and negative forcing by aerosols] they simulate the observed trends much better" (page 59, line 37) cannot be scientifically justified.***

No justification is given for the selection of illustrative research questions page 60. Are these the most important issues or just a random list?. The questions are unacceptably vague and too open-ended for a Strategic Plan. The plan must specify the level of understanding that is required, and this requires quantitative research questions.

Closely related is concern over the phrasing of the questions: Questions 1-3 (page 60, line 8 *ff*) all are sub-questions to a more general task that might read something like:

> Develop understanding and model-based representation of the processes governing the loading and properties of anthropogenic and natural aerosols, and their spatial and temporal distribution, and their dependence on sources of particles and precursors and on controlling variables, sufficient for calculating the direct and indirect radiative forcing of these aerosols to an uncertainty of __ W m^{-2} locally and of __ W m^{-2} in the global and annual average.

Likewise consider bullet 4 (page 60, line 14) "How do aerosols affect a cloud's radiative properties and ability to generate precipitation?" Much better something such as the following.

> Develop understanding and capability to represent in models the influences of anthropogenic aerosols on the radiative properties of clouds and on precipitation development. This capability must be sufficient to describe these influences, relative to the preindustrial base case, to an uncertainty of __ W m^{-2} in the global and annual average and __ W m^{-2} locally and instantaneously."

This task is phrased in terms of required understanding of the effects of anthropogenic aerosols. Undoubtedly, however, developing this understanding will require understanding of both the base case preindustrial aerosol and the anthropogenically influenced aerosol in order to meaningfully evaluate the difference.

The research needs (really they are activities) are by and large on target, but again the expected outcomes are weakly stated (e.g., "provide better data"; these needs should be requirement driven. The diagnostic model estimates activity lines 24-25 might be questioned.

The Products and Payoffs (page 60) are weakly stated and not driven by requirements.

One must be cautious about the suggestion that the relatively short atmospheric residence times of aerosols may give rise to potential options for changing radiative forcing within a few decades, in contrast to the longer response times associated with CO_2 (page 60, line 36). Trade-offs must consider the integrated warming potential of the aerosols versus CO_2 and the cost per integrated warming potential. This is a legitimate subject for examination but should be readily answerable to good initial approximation from knowledge already at hand.

Little is said in this section about the approach (and nothing about the magnitude of effort) that will be required in characterizing aerosol loading and chemical and microphysical properties as a function of location and time, developing understanding of the controlling processes, and development and testing of chemical-microphysical aerosol models that can accurately represent these processes, all of which must be considered necessary outcomes of this activity. This effort will be a substantial undertaking and will require substantial resources. In addition to the field experiments, laboratory studies, and model development and testing noted on page 60, line 23, one must add characterization of aerosol distributions by satellite borne instruments and the associated correlative measurements.

SCHWARTZ, BROOKHAVEN NAT'L LAB

Page 59: Question 1 (Aerosols and their effects, pp. 59 - 61). I agree that this is a very high priority as aerosols apparently have large effects on the earth-atmosphere climate system with very high uncertainty. Under "Products and Payoffs" it is unclear what the listed times represent (e.g., "Improved description of the global distributions of aerosols (2-4 years)"). While our understanding of these issues will certainly be improved within the listed time span, it is unreasonable to think that we will have resolved the major uncertainties for a given topic. Some of these topics have been studied for a decade or more already; while our knowledge now is enormous compared to what we knew before, there are still very large uncertainties.

SOIL SCIENCE SOCIETY OF AMERICA, ANASTASIO

Page 59: The atmosphere can be a forcing-agent "reservoir" for long-term 5 changes. The long removal times of some compounds, such as CO_2 (>100 years) and 6

"100 years" is often quoted as the removal time of CO_2, but this is a great underestimate. In fact, it takes more like 700 years to remove the first 80% of added CO_2 from the atmosphere, and several thousand years to remove the rest (see. e.g. the paper by David Archer in Geophysical Research Letters -- "Multiple Time Scales for removal..."). The long term persistence of CO_2 is one of the things that makes prompt action to control CO_2 emissions important. We can't afford to wait for catastrophe to happen before taking action. By then it will be too late.

RAYMOND PIERREHUMBERT, THE UNIVERSITY OF CHICAGO

Page 59-61: Again on pages 59-61, the links of aerosols to the hydrologic cycle should be highlighted much more than they presently are.

SUSAN SOLOMON, NOAA

Page 59, Line 3, Perhaps the impact of legislation actually having a positive environmental impact (with regard to the CFCs) should be strengthened.

DOE, DAVID ERICKSON-OAK RIDGE NAT'L LAB

Page 59, Line 7, The long time scales of CO_2 etc. does not mean 'virtually irreversible'. That section needs to be recast.

DOE, DAVID ERICKSON-OAK RIDGE NAT'L LAB

Page 59, Lines 26-27: Emphasis should also be placed on research partnerships at the regional and local levels because greenhouse gas emissions and our subsequent responses often occur at local and regional scales (e.g. at state levels). For example, the California Energy Commission (CEC) is engaged in a variety of research activities related to climate change. The CEC has funded projects that use economic and theoretical models, in conjunction with regional climate models, in order to assess the impacts of climate change on the state of California. The CEC is also funding research that explores potential sources and sinks of carbon in the state, and that develops new remote sensing technologies for more efficient environmental monitoring capabilities. Likewise, the CEC prepares and updates inventories on greenhouse gas emissions in California. Atmospheric research partnerships will be (and have been) important at the state and regional levels and we hope that the CCSP's Strategic Plan will take this into account.

-CALIFORNIA ENERGY COMMISSION

Page.59; line 33 +: add word
… climate-relevant <u>physical</u>, chemical, and radiative properties .

NIST

Page 59, Line 33: Aerosols
Aerosols are a main focus of the CCRI (Chapter 2, Question 1). There is no discussion of how the USGCRP and CCRI aerosol research are coordinated under CCSP.

Question 1 and its "Illustrative Research Questions" do not include any mention of aerosol precursors. If one is going to study the sources of atmospheric aerosols, one also has to get a better handle on the sources of SO2, DMS, anthropogenic and biogenic VOCs that oxidize to organic aerosols, etc. Precursor source emissions is not a mature, finished field, and further work on global emissions inventories of such gases is definitely needed.

There should be a clear statement that size-related chemical composition information on aerosol emissions is needed. The current wording could be interpreted as getting size information, and separately getting chemical information on the bulk aerosol.

References to aerosol indirect forcing: "How do aerosols affect a cloud's radiative properties and ability to generate precipitation?" and "An improved estimate of the indirect climate effects of aerosols ...". Most of the progress in this area (excepting perhaps the ice nucleating properties of aerosols) will result from improvement in our understanding of and ability to model cloud microphysics and dynamics, which is addressed in water cycle research (Chapter 7). Instead, maybe the questions "How do different aerosols act as cloud condensation and ice nuclei?" and "How does chemical aging (heterogeneous chemistry) change the hygroscopic, nucleating, and optical properties of aerosols?" should be posed here.

In "Research Needs," we suggest slightly modifying line 23 to "...will involve field observations and closure experiments, some laboratory studies..."

Second bullet under Products and Payoffs, "...will yield potential options for changing radiative forcing within a few decades..." This stood out because it alludes to short time-scale fixes to global warming. We thought it inappropriate to bring up these types of policy options in this chapter.

Fifth bullet under Products and Payoffs, "Better understanding and description of uncertainties about the physical and chemical processes that form ...". This seems to emphasize uncertainties, but understanding of the processes themselves is important. We suggest "Better understanding and description of the physical and chemical processes that form, transform, and remove particles during long-range atmospheric transport, and their uncertainties".

DOE, RICHARD C. EASTER, ELAINE CHAPMAN, RAHUL ZAVERI, PACIFIC NORTHWEST NATIONAL LABORATORY

[duplicate comment deleted in space below]

[duplicate comment deleted in space above]

Page 59, line 35ff: This summary of the State of Knowledge is woefully incomplete if it is to stand-alone. If instead, it is to be a summary of the IPCC's review of this field, then this needs to be stated and an indication given that the IPCC findings are the baseline science.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 59, lines 36-37: To be helpful to the reader, it should indicate that some types of aerosols can cause a "cooling influence" or a "warming influence." Whether cooling or warming actually results depends on many additional things.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 59, Line 36 – Page 61, line 5 - We support the proposed intensive efforts to better understand the role of aerosols and clouds in climate change. Two key elements of uncertainty are the magnitude of the forcing of black carbon (BC) and the emissions inventory. Current estimates of the total forcing of carbonaceous aerosols range from negative to positive. The relative contributions from on-road and off road diesel-powered vehicles and gasoline-powered vehicles are not known with any precision.

GEORGE WOLFF, PH.D., GENERAL MOTORS

Page 59, line 37 and following: It really comes across as biased when this plan seems to focus so much on soot aerosols and their role, so accepting Jim Hansen's work on this, but then seems to indicate that everything else that he has done is uncertain. Here the phrasing seems to ignore that the aerosols containing soot often include organics and other light colored aerosols, etc. This notion of Jim's is likely the shakiest of what he has done; yet, it is accepted with little questioning or comment about other interpretations and limitations.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 60, line 1: Should say "the net impact"

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 60, line 4: Should say, "project" rather than "predict."

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 60; line 12: add word

… modify their physical, chemical, and radiative properties .

Note: aerosol size and morphology underlie radiative properties as well as heterogeneous chemistry.

NIST

Page 60, line 18: **(29-E)** "A series ...is focusing..."

HP HANSON, LANL

Page 60, line 23: Remove "some" from "some laboratory studies" as it belittles laboratory studies.

NIST, HRATCH SEMERJIAN

Page 60, Line 23: delete "some laboratory studies, and", and add at after model development:

*, and the development of laboratory-scale, well-controlled test beds that benchmark aerosol formation processes and interactions with environmental constituents for sub-grid model development.

NIST

Page 60, line 26: Should say "impacts"—plural.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 60, Line 28 - additive an additional illustrative research question:

- Can accurate laboratory model atmospheric aerosol systems be developed for measurements of optical properties to constrain the radiative properties used in climate models?

NIST, HRATCH SEMERJIAN

Page 60, Line 28: Uncertainties in direct and indirect radiative forcings (in W m^{-2}) from aerosols remain unacceptably large (factor of 2-3). Due to the chemical and morphological complexity of aerosols, an assessment of aerosol forcing uncertainty has little utility unless specific aerosols components that contribute significantly to overall aerosol forcing are identified and quantified. Chemically-specific aerosol-forcing information will lead to an assessment of the comparative forcing strengths with uncertainties of anthropogenic aerosols vs. those of natural aerosols. Variation in forcing necessarily derives from variation in the absorption and scattering efficiencies of the chemical components in aerosols at both short and long wavelengths and from variation in particle size, morphology, aggregation, etc. Therefore, an inventory of variabilities in aerosol forcing must include variations due to effects of chemical/isotopic composition and particle structure.

An assessment of the contributions to forcing uncertainty from chemical components found in individual aerosols and particle types must address the question of how much uncertainty derives from phenomenological variation and how much derives from sampling and measurement processes. Efforts must be made to assess measurement uncertainty using robust experimental design strategies for aerosol species that significantly impact total forcing uncertainty, thereby quantifying contributions from natural variation. In addition, efforts must be made to assess long-term measurement consistency, with respect to bias and imprecision, for historical collections of aerosol chemical measurements.

Three types of standards are needed:
1. Protocols for sampling and measurement must be established and historical variations with respect to these standard protocols must be assessed.
2. Reference materials of accurately known chemical composition must be made available to support instrument calibration, and compositional differences between these and other reference materials used historically must be assessed.
3. Use robust standard mathematical procedures to transform historical data for consistency with current and future measurements.

NIST

Page 60, Line 29: Products and Payoffs: To achieve more accurate analysis of climate model projections -

We might need to mention that this includes imbedding the atmospheric chemistry models within the general circulation models OR coupling atmospheric chemistry models and general circulation models.

DOE, CYNTHIA ATHERTON-LAWRENCE LIVERMORE NAT'L LAB

Page 60, line 30: There should be some indication that this effort will be undertaken in cooperation with other countries—this sort of sounds like we are going to do this all on our own. Also, this will take many measurements in many places over quite some time in order to get a result that is not quite uncertain. This needs to be indicated.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 60, line 31ff: This activity will take a lot of effort—and only "may" yield (not "will yield") potential options.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 60, Line 33, Where do the 2-4 year time estimates come from?

DOE, DAVID ERICKSON-OAK RIDGE NAT'L LAB

Page 60, lines 39-41: It is likely to take much more than 2-4 years to accomplish this. I would note that the IPCC summarizes the work of others, so what would be required for the IPCC adopt this result in place of others when it does its assessment in 2007 will take a great deal of work.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 61: Chemically active Greenhouse Gases
Focus on CH_4, N_2O and O_3 is appropriate given their forcings. The uncertainty in forcing by tropospheric ozone (see Figure) is due predominantly to uncertainty in the amount by which ozone concentrations are enhanced in the present atmosphere over the preindustrial atmosphere. I concur in the implication that CFCs are sufficiently well understood, but attention may need to be paid to HCFCs. Water vapor (lines 18, 33) should not be included here; water vapor is much more appropriately considered a part of the climate system, not a radiative forcing agent.
The requirements should all be stated more quantitatively, e.g., given that the normalized forcing of methane is __ W $m.^{-2}$ per ppb, then the influences affecting the budget must be known to __ ppb per year. Such requirements will focus the research and readily lead to weighting effort directed to the several gases according to their radiative influence. This analysis will also allow comparison of effort with that directed to other forcing agents.
The research needs (page 62) are activities, not requirements. Again the requirements should be specified in ppb related to radiative forcing.

SCHWARTZ, BROOKHAVEN NAT'L LAB

Page 61-62: Question 2 (Budgets of greenhouse gases, pp 61 - 62). I am surprised that there is little mention of CO_2 in this section, given its dominant role in anthropogenic warming and the important remaining uncertainties in its budget. Similarly, there is mention of CH_4, but not CO_2, in the discussion of linkages on page 66. There must be a plethora of CO_2-related linkages.

SOIL SCIENCE SOCIETY OF AMERICA, ANASTASIO

Page 61, Line 1: There is a need to measure the radiative properties of aerosols. Is the US going to pursue this research?

RONALD STOUFFER, GFDL/NOAA

Page 61; line 2: add phrase
… processes, <u>and underlying properties</u>, that form transform .

NIST

Page 61, Line 4: Characterization of the impact of human activities and natural sources on global aerosol distributions

Is it clear to the reader that the regional differences in these aerosol distributions can make profound differences?

DOE, CYNTHIA ATHERTON-LAWRENCE LIVERMORE NATIONAL LABORATORY

Page 61, Line 4: Page 61, Line 4, I see the research questions as being reasonable in the text of Question 2. They are rather standard climate science questions. Question 2 asks 'what is the current quantitative skill'. The text does not answer that question.

DOE, DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

[16]

[DUPLICATE COMMENT HAS BEEN DELETED FROM SPACE BELOW]

[32]

Page 61, Line 6: The scope of this question should be defined in the State of Knowledge paragraph. The two most important greenhouse gases (water vapor and CO2) are addressed in Chapters 7 and 9 and are outside this scope. The discussion of water vapor under this question (and chapter) seems inappropriate, as improvements of our understanding of it will result primarily from water cycle research (Chapter 7). The research questions for water vapor are very different from those involving the long-lived gases (CH4, N2O, CFCs).

DOE, RICHARD C. EASTER, ELAINE CHAPMAN, RAHUL ZAVERI, PACIFIC NORTHWEST NATIONAL LABORATORY

Page 61, line 9: **(30-EP)** This sentence isn't constructed quite properly. It reads "The increasing concentrations...are the primary gases that are forcing agents..." I'd suggest removing "gases that are" to get:

> The increasing concentrations of atmospheric constituents that absorb infrared radiation, such as CO_2 (see Chapter 8), methane (CH_4), tropospheric ozone, nitrous oxide (N_2O), and the chlorofluorocarbons (CFCs), are the primary forcing agents of global climate change.

There is also the question of whether this statement is appropriate, given some of the questions raised in previous chapters. If it's more appropriate to soften this rather extreme (from some points of view) asssertion, substitute “are implicated as” for “are the primary”.

HP HANSON, LANL

Page 61, line 9ff: It would have been helpful to the reader to define greenhouse gases earlier in the plan. Also, again, this state of knowledge is woefully incomplete—the text should indicate that the IPCC is the baseline.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 61, line 14: Another example to include should be transmission and leakage of natural gas.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 61, lines19-20: This statement about the problems in understanding water vapor needs context—it is only problematic for some purposes, and perhaps some people. Making a general statement here in the state of knowledge section is uncalled for.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 61, line 26ff: What is really wanted is more certainty in the estimates and understanding. The way these questions are phrased, it sounds as if nothing is known, and this is simply false.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 61, Line 29: Volatile Organic Compounds (VOCs) and nitrogen oxides (NOx) are the major precursor gases of tropospheric ozone. This bullet should add “volatile organic compounds” after the nitrogen oxides.

A.L. WILLIAMS, H.C. HUANG, M. CAUGHEY, ILLINOIS STATE WATER SURVEY

Pages 62-63. Could benefit from more discussion of regional forcings (e.g., due to tropospheric ozone) and the possibility of regional climate responses.

SUSAN SOLOMON, NOAA

Page 62: ***None of the three illustrative research questions seems to have any bearing on the climate change considerations under consideration here. Unless some strong connection can be demonstrated to climate change issues, activities directed to this question should not be included in a Climate Change Science Program..***

It is not clear what place chemical exposures in food producing areas in proximity to large urban areas has in this program.

The contributions of urban areas, megacities to sources of radiation-influencing atmospheric trace substances are important in consideration of the budgets of these substances but examination of the sources of such materials should be justified in terms of budget studies, and not whether the sources are in megacities.

The question of pollution import to North America (page 63, line 3-4) has no place in this program.

Comments on Chapter 5

The survey of vertically resolved tropospheric ozone and precursors should be justified in terms of the need to characterize ozone as a greenhouse gas (section 5.2) and not in the context of air quality.
The vulnerability of ecosystems to urban growth (page 63, lines 26-27) likewise seems to be an inappropriate extension of climate change research beyond its usual definition, especially in a situation of limited funding for climate change research.

SCHWARTZ, BROOKHAVEN NAT'L LAB

Page 62-63: Question 3 (Regional/Global interactions, pp. 62 - 63).
The second Illustrative Research Question (p. 63) states "How do the primary and secondary pollutants from the world's megacities contribute to global atmospheric composition?" This should be broadened to include not just "megacities" but also large-scale, non-urban emissions, such as burning of forest and peat bogs in Indonesia, Asian dust mixed with urban pollution, and African dust and biomass emissions.

I felt that Questions 4 and 5 are important issues and that they were addressed well.

SOIL SCIENCE SOCIETY OF AMERICA, ANASTASIO

[duplicate comment deleted from the space below]

Page 62, Line 5: Satellite maybe able to detect the occurrences of lighting globally but it can't detect all surface source functions such as the nitrogen oxides from automobile exhaustion. Aircraft, balloon, and ground-based campaign should be added as part of measurement methods.

A.L. WILLIAMS, H.C. HUANG, M. CAUGHEY, ILLINOIS STATE WATER SURVEY

Page 62; line 15: insert

Laboratory studies and data evaluation to extend and expand the highly successful database for stratospheric modeling into the troposphere, thereby allowing the development of reliable predictive models.

NIST

Page 62, line 17: Please indicate how one can do "observationally assessed" ranges of projections going out 100 years—one observationally assesses the past.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 62, line 19: This seems to imply that the CCRI will go it alone on developing a suite of scenarios rather than be part of the overall IPCC effort. This would be foolish and not productive internationally. If such an assessment is to be done by the US alone, then there need to be some general rules set about such efforts to ensure their credibility.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 62, lines 23-25: I would hope that the ultimate assessment being mentioned is the IPCC assessment—or will there also be a separate CCRI assessment on this topic as well.

MICHAEL MACCRACKEN, LLNL (RETIRED)

[duplicate comment deleted from the space below]

Page 62, Line 26: The Illustrative Research Questions could be expanded to include a host of questions on the impact of changing climate and weather patterns on air quality and economic activities (e.g., change in number of days with ozone excedances due to changes in ventilation, stability, cloudiness; changes in acid deposition patterns, etc.)

The first Illustrative Research Question (impact of large urban areas on nearby food producing areas) seems inappropriate. It is more of a regional issue than a global-regional interaction issue.

DOE, RICHARD C. EASTER, ELAINE CHAPMAN, RAHUL ZAVERI, PACIFIC NORTHWEST NATIONAL LABORATORY

Page 62, Line 26, Question 3 is very important and deserves significant attention. However, this critical scientific research field should not be allowed to deflect attention from the basic issue of increasing atmospheric CO2 concentrations. In the long term, fossil fuel CO2 is the main climate change driver.

DOE, DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 62, line 29ff: This is a really woefully incomplete summary of the State of Knowledge. Again, cite the IPCC or other sources—this is simply insulting to the reader.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 62, line 31: Change "pristine" to "supposedly pristine"—this is really poorly stated. Changes in atmospheric composition will of course occur over Greenland, and elsewhere—the notion of pristine in the time of human activities is what is absurd.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 62, Line 37 and Page 63, Line 26: Why is food-production the only emphasis of regional pollution impacts on ecosystems? The impacts of climate change/regional air-pollution on water resources, human health, and human societal activities should be considered. The regional air pollution is a result of local activities and long-range transport of chemical species. Food production region away from large urban areas may also be affected by urban growth. Why limited to within "proximity" of larger urban area?

A.L. WILLIAMS, H.C. HUANG, M. CAUGHEY, ILLINOIS STATE WATER SURVEY

Page 63: Stratospheric Ozone

The Plan is correct in noting that stratospheric ozone remains a concern to the nations of the world. However as with local and regional air pollution ***it seems hard to justify further research into the chemical processes of stratospheric ozone depletion, compliance with Montreal Protocols, and the like in a climate change research program.***

It might be appropriate within a Climate Change Science Program that there be a research element directed to examining couplings between climate change and stratospheric ozone. Such a program element should be tightly focused and not a broad survey of recovery of the ozone layer in response to the Montreal Protocols.

The radiative forcing properties of CFC replacement compounds (page 64, line 13) are appropriate to this Program; logically research directed to this question belongs in program element 5.2, (chemically active GHGs). ***Examination of their ozone depleting influences has no place in this program.***

SCHWARTZ, BROOKHAVEN NAT'L LAB

Pages 63-65. Discussion of ozone changes could benefit from bringing in the possible linkages of the stratosphere to the climate system, highlighted by recent work of Baldwin and Dunkerton among others. That work has opened up a whole new area of stratosphere/surface climate interactions that will surely require future work.

SUSAN SOLOMON, NOAA

Page 63-65: The relationship between greenhouse gases and stratospheric ozone depletion is certainly a timely scientific issue, but it is also one with important policy implications. What are the best ways of optimizing mitigation policies to minimize effects on stratospheric ozone? Furthermore, given that increases in tropospheric temperatures contribute to stratospheric cooling, which in turn enhances stratospheric ozone depletion, isn't the minimization of stratospheric ozone depletion an ancillary benefit of greenhouse gas mitigation? These issues need to be explored and communicated to policy-makers, as many national decision-makers are likely unaware of this interaction between greenhouse gases/climate change and ozone depletion/recovery.

VICKI ARROYO AND BENJAMIN PRESTON, PEW CENTER ON GLOBAL CLIMATE CHANGE

Page 63, Line 6: While it's wonderful to characterize the world's impact on North America, we are also studying North America's impact downwind - for example, ITCT, INTEX-NA, etc.

Although bullet 4 addresses this, I wonder if we sound a bit provincial by putting as bullet #1 the need to characterize everyone else's impact on North America?

DOE, CYNTHIA ATHERTON-LAWRENCE LIVERMORE NATIONAL LABORATORY

Page 63, line 8: Change "or" to "and" as all sorts of platforms will be needed.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 63, line 11ff: All of these are really major, long term, international tasks. There needs to be some indication somewhere that all this will be undertaken as part of an international effort.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 63, Line 11. This bullet should be generalized to include other sources in addition to pollution, and should include studies of vertical transport. I suggest: "Characterize sources and sinks for trace gases at the planetary surface and how these mix horizontally and vertically into the global atmosphere, with an initial emphasis on North America.

JOE BERRY, CARNEGIE INSTITUTE

Page 63, line 14, change to read:

- Establish baseline observations of atmospheric composition of North America and globally traceable to national and international gas composition standards, as maintained by the National Metrology Institutes (NMI's).

NIST, HRATCH SEMERJIAN

Page 63; line 18: insert
Characterize the key chemical and thermodynamic quantities that govern the temperature-dependent partitioning among soil, water, and atmospheric distributions of pollutant species.

NIST

Page 63: line 20: insert
Through intensive laboratory studies, develop a more complete understanding of the atmospheric degradation of pollutants and their impact on regional and global air quality.

NIST

Page 63, Line 21: Description of the changes in the impacts of global tropospheric ozone on radiative forcing over the past decade brought about by clean air regulations -

Is this product realistic???

Are our satellite products this good right now that we can look at the previous ten years? And see a clear and distinctive signal and be able to trace it to clean air regulations?

In terms of modeling, we certainly don't have (at least on a global scale!) emissions scenarios that vary year-to-year for 1992 - 2002.

DOE, CYNTHIA ATHERTON-LAWRENCE LIVERMORE NATIONAL LABORATORY

Page 63, lines 22-27: This is really an inadequate way to do this—seems to give a few short-term payoffs, and then says nothing about what happens next.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 63, lines 26-27: How does this derive from the research needs?

ANTONIO J. BUSALACCHI, EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER (ESSIC), U. MARYLAND

Page 63, lines 26-27: Is it as important or more important to look at the impacts on unmanaged ecosystems?

ANN FISHER, PENN STATE UNIVERSITY

Page 63, Lines 26-27: Chapter 5 indicates that an assessment of the vulnerability of ecosystems to urban growth, with emphasis on food production will be conducted. However, atmospheric deposition is known to be a major source of nutrients (particularly nitrogen) and toxins (e.g., mercury and pesticides) to aquatic, estuarine, and marine ecosystems, and nutrient loading in particular is known to be a major driver of aquatic eutrophication. Furthermore, factors such as tropospheric ozone may impact food production, but also affect U.S. carbon storage and human health. Thus, from a U.S. perspective, there appear to be more pressing issues related to ecosystem impacts associated with atmospheric composition and air quality than food production.

VICKI ARROYO AND BENJAMIN PRESTON, PEW CENTER ON GLOBAL CLIMATE CHANGE

Page 63, Line 27, Again, 4-6 years is a long time. These numbers need to be referenced to some quantitative estimate.

DOE, DAVID ERICKSON-OAK RIDGE NATIONAL LABORATORY

Page 63, Line 28: This question is outside of our areas of expertise. However, we were wondering if aircraft emissions should be mentioned here.

DOE, RICHARD C. EASTER, ELAINE CHAPMAN, RAHUL ZAVERI, PACIFIC NORTHWEST NATIONAL LABORATORY

Page 63, lines 31-32: It is nice to have a statement that agrees with the prevailing scientific consensus, even though there are those who would comment that uncertainties of various types exist. It would have been useful to have this statement much further forward in the report, indicating the types of things we have learned.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 63, line 38: The nations of the world took action on ozone even though there were uncertainties remaining. It would be useful to be using this as an example for the consideration of taking action on climate change.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 64, lines 1-5: It would seem appropriate to be mentioning that the increasing concentration of CO is affecting the recovery of the ozone layer. It would also be appropriate to be citing the WMO/UNEP series of assessments as providing the baseline set of what we know.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 64, "Research Needs": This section assumes ozone itself is adequately monitored. In fact, ozone profile changes, like temperature and humidity profile changes, are not very well monitored. The ozonesonde network is adequate only in the northern hemisphere midlatidude regions, so we have a serious observational deficiency. Furthermore, as far as I know, there is only one retired US scientist (Jim Angell) performing regular analyses of global in situ ozone measurements, and a few others looking at the data irregularly. Other international efforts are also irregular analyses, often done for the quadrennial ozone assessments. Should Dr Angell decide to quit his effort, the US would have precious little information on ozone changes from in situ observations, which are our main source of information on profile changes. The ozone profile changes (as distinct from changes in column-integrated amounts) are associated with radiative forcing changes. So there is a need for a better global ozone profile observing system and a better US ozone monitoring effort.

DIAN SEIDEL, NOAA AIR RESOURCES LABORATORY (R/ARL)

Page 64, Line 5: Ozone may not fully recover for decades.

DOE, DAVID ERICKSON-OAK RIDGE NAT'L LAB

Page 64, Lines 8-10: This illustrative research question addresses changes in CO_2 and N_2O on ozone-related processes. Shouldn't methane be considered here as well?

VICKI ARROYO AND BENJAMIN PRESTON, PEW CENTER ON GLOBAL CLIMATE CHANGE

Page 64, lines 11-12: and vice versa

ANTONIO J. BUSALACCHI, EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER (ESSIC),
U. Maryland

Page 64, line 12: This should indicate that it is referring to unusually cold winters in the stratosphere, I believe.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 64, line 34: What does "attributing" mean here. Perhaps say, "explaining"

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 64, lines 31-33: What types of assessments are being considered here? Prepared on what basis and with whom? What are the kinds of if-then questions that would be addressed?

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 64, line 36: It is interesting that mention can be made of an international assessment about pollutant transport, but doing one on climate change and its impacts is apparently forbidden.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 65: Couplings among climate change, air pollution and ozone layer depletion
This section seems open ended and not focused. A study such as the examination of multiple stresses of climate change, ozone layer depletion, and regional air quality on humans and ecosystems (page 65, line 21) lacks the rigor and need for quantitative understanding that should be the hallmark of this Program.

SCHWARTZ, BROOKHAVEN NAT'L LAB

Pages 65-66, Key Linkages: There is a natural synergy between air pollution and global change programs that needs to be utilized. The two disciplines have historically addressed similar phenomena at opposite ends of the spatial scale; the evolving emphasis on regional air quality (e.g. the U.S. programs on Regional Haze and large scale ozone transport) and the need to refine the spatial scale of climate understanding have blurred the boundaries between these fields.

Coordinated research and monitoring of meteorology, gases, and aerosols at various spatial scales is essential to proper understanding of the behavior of emission sources and pollutant sinks, and will enable better interpretation of the necessarily sparse global monitoring data. Moreover, a dialog among modelers working at various scales is desperately needed, as each modeling community can learn from the other and use each others data products to enhance their own work.

-CALIFORNIA AIR RESOURCES BOARD

Page 65, line 3 through page 66, line 9: Question 5 ("What are the couplings among climate change, air pollution, and ozone layer depletion …?") appropriately recognizes the importance and complexity of interactions between GHGs and other air pollutants such as sulfur dioxide emissions. State air quality control officials are responsible for developing plans to control criteria pollutants and, frequently, to address state GHG emissions as well. Further, many actions that help mitigate criteria air emissions, such as increasing energy efficiency and reducing peak summer electricity demand, are also effective strategies for reducing GHG emissions. It therefore is critical for state air agencies to have access to the best current understanding of interactions among these substances so that they can develop harmonized control policies. States should be considered important participants in the proposed research and product development discussed in this section.

KENNETH A. COLBURN, NORTHEAST STATES FOR COORDINATED AIR USE MANAGEMENT (NESCAUM).

Page 65, Line 3: The Plan is correct in noting that stratospheric ozone remains a concern to the nations of the world. However as with local and regional air pollution ***it seems hard to justify further research into the chemical processes of stratospheric ozone depletion, compliance with Montreal Protocols, and the like in a climate change research program.***

It might be appropriate within a Climate Change Science Program that there be a research element directed to examining couplings between climate change and stratospheric ozone. Such a program element should be tightly focused and not a broad survey of recovery of the ozone layer in response to the Montreal Protocols.

The radiative forcing properties of CFC replacement compounds (page 64, line 13) are appropriate to this Program; logically research directed to this question belongs in program element 5.2, (chemically active GHGs). ***Examination of their ozone depleting influences has no place in this program.***

DOE, STEPHEN SCHWARTZ-BROOKHAVEN NAT'L LAB

Page 65, Line 3: This section seems open ended and not focused. A study such as the examination of multiple stresses of climate change, ozone layer depletion, and regional air quality on humans and ecosystems (page 65, line 21) lacks the rigor and need for quantitative understanding that should be the hallmark of this Program.

DOE, STEPHEN E. SCHWARTZ, BROOKHAVEN NATIONAL LABORATORY

Page 65, Line 3: The writing here is much less specific than for the other questions. This may be because the issue of interactions between climate change, urban/regional air quality, and stratospheric ozone is relatively new compared to the other questions. If this is the case, this "newness" should be noted explicitly under the State of Knowledge paragraph.

"What are the multiple stresses that climate change, ozone layer depletion, and regional air quality exert on humans and ecosystems", and "Synthesize the understanding of the impacts of multiple stresses on humans ... and ecosystems ...". These issues belong in Chapters 10 and 11. The issue for this chapter is how climate change, air pollution, and stratospheric ozone interact. Only the linkage of this interaction to human and ecosystem issues needs to be noted here.

DOE, RICHARD C. EASTER, ELAINE CHAPMAN, RAHUL ZAVERI, PACIFIC NORTHWEST NATIONAL LABORATORY

Page 65, lines 25-33: The Question 5 is more narrow than these research needs.

ANTONIO J. BUSALACCHI, EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER (ESSIC), U. MARYLAND

Page 66, line 3: Again, will this be an international report or a national report. Should this not be done under international auspices?

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 66, lines 8-9: What sort of assessments are envisioned here? What does "multiple-issue integrated assessments" mean? How might they be done? This is entirely too vague.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 66, lines 25-27: NACIP is not otherwise explained, and needs to be described.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 66, lines 33-38: It would really be appropriate for the whole plan to indicate up front that there will be extensive coordination with international WMO and UNEP programs.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 67, line 1ff: Why is there no mention made of the Ozone Assessments that summarize that field of effort. Simply citing the IPCC here is also inadequate unless there is an affirmative statement somewhere that it represents the baseline of scientific understanding.

MICHAEL MACCRACKEN, LLNL (RETIRED)