Written Public Comments on the *Strategic Plan for the U.S. Climate Change Science Program* Chapter 12: Grand Challenges in Modeling, Observations, and Information Systems (p 131-147)

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Pages 131-143: Chapter 12 does include priorities for the U.S. Global Change Research Program (USGCRP) research elements. However, the priorities are described without any sort of ranking, making the prioritization little more than a summary. As stated earlier, the President wants the U.S. Climate Change Research Initiative (CCRI) to “study areas of scientific uncertainty and identify priority areas of scientific uncertainty and identify priority areas where investments can make a difference.”

Establishing real priorities for the separate research elements, as well as for the linkage between those elements, could save time and resources. However, flexibility must also be built into the priorities to allow for new information to shape possible changes in the prioritization.

Second Overview Comment (pp. 131- 37): The draft frequently refers to “the next decade” as though the time frame for all the “Products and Payoffs” for the research elements will be completed within that time frame. However, “Human Contributions and Responses to Environmental Change” does not include any time frames for its “Products and Payoffs,” while other elements, like “Water Cycle,” have time frames for its “Products and Payoffs” that can range as high as 15 years.

While the next decade will be an important time for many of the research elements, not all of the expected products are anticipated to be finished in that time frame. However, by focusing on that time frame, the draft raises expectations that the research elements will be completed within that period. Again, time and resources can be saved by establishing appropriate timetables for all work and then including that information when prioritizing the work.
FANG/HOLDSWORTH-EDISON ELECTRIC INSTITUTE.

Page 131, Chapter 12: 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 131, Chapter 12: **First Overview Comment:** General comment that may apply to this chapter and the rest of the document. There seemed to be a disconnect between Climatological data requirements and the requirements that the next generation sensors and system of operational polar orbiting spacecraft (i.e., NPOESS) will be able to meet. One participant's question about this in the Grand Challenges breakout group and suggestion that a more detailed table in the appendix of the specific requirements needed for climatological research and development might be needed, seemed to go unanswered. I just wanted to make sure this potential addition was captured and looked into in the event there is an appropriate place for that clarification in the document.

Second Overview Comment: General question for this observations section as well. There does not seem to be a lot of attention given to solar physics and measurements other than a mention in the very beginning of the document referencing the influence of the radiative output of the sun on the biosphere and weather/climate patterns. While the variations in the 11-year cycle of the sun may not be great, there are some definite long-term trends that cycle through and change in absolute amplitude and these may need to be more thoroughly addressed in this document (though the data may already be fed into the long-term models currently being worked).

N. MICHAEL SIMPSON, NOAA/NESDIS/OSO

Page 131, Chapter 12: We support the plan's strategy of assigning responsibility and adequate resources for the IPCC assessments to GFDL and NCAR. But climate research and prediction involve much more than IPCC assessments, and the nation's climate research program demands more tha a "two-center" strategy. The USGCRP part of the document needs its own research plan and its own modeling strategy. A more comprehensive national modeling strategy should be laid out in Chapter 12, replacing the woefully inadequate discussion in the second section of that chapter.

Modeling is critical to the goals of Chapter 6, and is virtually ignored in Chapter 12. Chapter 4 alludes to some work needed to improve models for CCRI activities, but no such plan is advanced in Chapter 12.

The overall picture presented in the CCSP draft plan is one in which models are acknowledged to be the key tools for predicting the future, and for asking "If...then.." policy questions. This is a remarkable change in the attitude of the scientific community towards models. Not so very long ago, models were abstract tools which were tested against known theoretical questions, and from which little was expected or believed. I am not convinced that we are as mature as the report seems to indicate, and I believe that a significant investment in continued development and improvement in models will continue for quite some time.

The USGCRP plans essentially neglect the need to strengthen US climate modeling capability. The USGCRP focus appears to focus on combining more and more component models (p 139, lines 4-19) into a more comprehensive system model. This reflects an attitude that a) the component models are in fine shape and b) that coupling them is a relatively simple matter.

The next paragraph discusses some research activities in climate modeling, with "areas of research emphasis would include model development, computational science, and data assimilation." (p 139, lines 28-29)

While it is good to see the specific call for a common modeling infrastructure in the CCRI plan, it should be as much a part of USGCRP as CCRI. More particularly, the ESMF effort underway should be mentioned. As an *Earth System* framework, ESMF embraces the needs of a wide variety of modeling groups, including weather prediction, climate modeling, climate forecasting, hydrological modeling and more. It will be particularly helpful for modelers throughout the US to have a common framework on which to base their own efforts.

U.S. CLIVAR SCIENTIFIC STEERING COMMITTEE

Page 131, Chapter 12: First Overview Comment: Transport of long-lived radiatively active trace gases, photochemically active trace gases, and aerosols remains a key uncertainties in determining the time and space scales by which changes in atmospheric composition, and the carbon cycle impact the climate system. The impact of these interactions will differ significantly depending on the global location. For example, surface emissions of aerosols, NOx, and VOCs have been shown to have a much greater impact on ozone formation when emitted in tropical regions. The vertical distribution together with aerosol composition determines the radiative impact. Nor is upper troposphere/lower stratosphere exchange well characterized. Because it is a sub-grid scale process, vertical transport is poorly represented in one of the key tools we use to assess climate change, climate system models and GCMs. Experimental campaigns are needed to develop, test and refine transport parameterizations˜particularly aircraft studies of compounds that can be used as tracers of surface emissions, and their behavior in deep convective cells. Studies at both temperate and tropical latitudes are needed to improve our analytical framework for estimating the sources and sinks of CO_2, N_2O, CH_4, O_3, aerosols, NOx, CO and VOCs. Such a series of studies will require considerable resources and cooperation amongst several communities. By focusing on transport rather than aerosols,Chapter 12, the issue could be one that cuts across chapters, and comes closer to evaluating air pollution as a climate forcing. If not included in Chapter 2, then it should be included in Chapter 12 as a cross-cutting issue

BETH HOLLAND, NCAR

Page 131, Chapter 12: he three elements of, observation, modeling and data management are not sufficient. The program must draw on and hopefully contribute to the store of fundamental knowledge. Experimental research leading to hypothesis testing needs to be included in this grand synthesis.

Comments on Chapter 12

JOE BERRY, CARNEGIE INSTITUTION.

Page 131, Chapter 12: We have a number of concerns with this chapter. The chapter relies heavily on satellite observations, but we should be realistic about what satellites can and cannot do. Improvements in some areas go far beyond the 2-4 year horizon we supposedly are to focus upon. For example, in the second bullet on p. 133 (lines 3-5), the emphasis should be upon discovery and improving understanding rather than "validat(ing) the new space-borne measurement capabilities" with aircraft and balloon observations. *[Tans 303-497-6678 – Butler, Dutton, Hofmann, Ogren, Schnell; NOAA/CMDL]*

NOAA/CMDL

Page 131, Chapter 12: "The approaches outlined in chapter 12 provide a reasonable framework for the collection and interpretation of observational data gathering and storage within information systems, such as the modeling of carbon and water cycles. However, more specifically-targeted modeling efforts to include the costs of global climate change are needed. As is done in Environmental Protection Agency risk assessments, the value of a human life, as well as the values of animal species should be quantified in a series of alternative action plans, ranging from no action to reduce greenhouse gas emissions to action beyond the requirements of the Kyoto protocol. The economic costs and benefits for the implementation of each alternative plan should be determined within the bounds of uncertainty; Monte Carlo simulation of model parameter uncertainty has been shown to be valuable in this regard.

"To be an effective tool in guiding research and action, the Climate Change Research Initiative must not seek to resolve all uncertainties in the myriad geologic, atmospheric, hydrologic, and biologic factors that are causative and reflective of climate change. Instead, reasonable estimates of these factors should be used within a cost-benefit modeling framework to evaluate alternative plans to moderate the effects of global warming. The best means to reduce uncertainty in these factors should also be defined. As uncertainty is reduced, the cost-benefit model will provide improved guidance for action alternatives."

CRISPIN PIERCE, UNIVERSITY OF WASHINGTON

Page 131, Chapter 12: First Overview Comment: I believe that something should be said in the required observations set about mapping the ocean floor. These data are required to make accurate forecasts of global climate change, because seafloor topography and roughness control the circulation and mixing of heat through the ocean, and only 0.1% of the deep ocean has been mapped in enough detail so far. There are satellite methods through which the sea floor can be mapped, and far faster and cheaper than can be done by ships.

STEVEN JAYNE, WOODS HOLE OCEANOGRAPHIC INSTITUTE

Page 131, Chapter 12: The chapter spells out a strong observational/modeling effort for or climate system. However, new modeling efforts should approach questions on a regional scale to create more usable models, which is not discussed in the chapter.

In addition, the chapter doesn't include discussion of modeling changes in human drivers, such as modeling energy demand and supply or changes in land use. These models are a key part of the predictive power of climate models and must be strengthened to improve the certainty of climate modeling. Incorporating modeling of human drivers may require an additional section in this chapter.

DEPARTMENT OF TRANSPORTATION, LAWSON

Page 131, Chapter 12: Under observational priorities, water cycle, four bullets outline excellent priorities for long-term measurements. One important gap that should be made explicitly is the synergy between satellite and ground-based observations, and between observations and modeling. Consider the following for the second through fourth bullets. - Develop and implement more-accurate global measurements of precipitation, continental soil moisture, soil freezing/thawing and snow accumulation by integrating space-based measurements with existing ground-based networks; and where possible, implement the new ground-based networks that are needed to augment/compliment the space-based measurements. - Maintain and expand surface-based operational measurements of precipitation, continental soil moisture, soil freezing/thawing, snow accumulation, river discharge, groundwater levels, water chemistry, land-atmosphere exchanges and other hydrologic variables. Develop and maintain: i) accurate, regionally specific models to spatially interpolate these measurements, and ii) the data and information systems needed to make this information widely and conveniently available. - Develop and implement systematic regional hydrologic, climate and radiation test beds, and advanced technologies involving ground-based remote sensing. Colocate and integrate these long-term test beds with complimentary ecosystem, carbon cycling and other climatic research.

ROGER C. BALES, UNIVERSITY OF ARIZONA

Page 131, Chapter 12: Many of the comments made regarding earlier chapters are relevant here and I will not repeat them. However, much is made of the "research to operations" transition. I think there is some confusion here. Operations refers to specific, well-defined products and services that must be delivered within a constrained budget and fixed schedule. However, to achieve these goals, much infrastructure must be developed such as stable observation systems, continuous data acquisition, production, and access, as well as other "operational" services. Many of these services are also necessary for climate and long-term systematic measurements. However, this does not mean that climate products are operational. There remains a strong component of research in climate data products. Note that weather products are produced in an environment where there are many value-added service providers such as the Weather Channel, Accu Weather, etc. This is not the case in climate. Rather the science community is the dominant value-added service provider. Careful reprocessing, data set characterization, fusion of multiple products, etc. is a science task, and adds value to the system.

If we begin to focus on services rather than just data products, then it becomes clear that there is not a transition from research to operations. Instead there is an integration and coordination of these two elements to deliver a service. Moreover, the requirement for technology infusion can also be considered in this context.

As data sets become massive, the value of data becomes essentially zero. What is important are the metadata that describe the data, algorithms, etc. If one cannot locate the granule of interest or understand how the product was made, then it is of no value. This is recognized in the information technology community: data are useless, metadata are priceless. There is little discussion relative to this concept. For example, metadata will require an understanding of the users (especially of the services, not just the data), and we need to start now with quantitative user modeling.

MARK R. ABBOTT, OREGON STATE UNIVERSITY

Page 131, Chapter 12: The term “grand challenges” is used here to attempt to group observations, modeling and information systems needs, which presumably overlap for each science area. In my opinion, the term “grand challenges” is somewhat inappropriate, and should be reserved for climate change science issues that are currently intractable and must be solved in order to address the key science and applications goals of the CCSP. An example of what might be a true “grand challenge” in this sense I the prediction of subsurface water fluxes and pathways, given that subsurface parameters and fluxes are not readily observable, and knowledge of the pathway is critical for questions such as carbon fluxes and storages as well as nutrient cycles. A problem of a similar magnitude would be that of predicting clouds, and all their interactions with aerosols, radiation, etc.

I would like to see the Water Cycle-related observation and modeling priorities map more explicitly to the questions in Chapter 7, as well as to the key areas in Chapter 2. In particular, under Observational Priorities, the regional testbeds should be able to support analyses of linked water, energy, carbon, and nutrient budgets as well as interactions between cloud processes and aerosols from the water table to the tropopause. Similarly, under the modeling priorities, as stated above, a true “grand challenge” is explicitly predicting the subsurface pathway of water, which has consequences for the linkages between the water, carbon and nutrient budgets as well as itself being a fundamental predictability problem in water cycle science. What seems to be missing as a “grand challenge” is the issue of integrating observations and modeling (i.e. data assimilation), including quantifying the uncertainties (errors) in both observations and modeling. This must be a major emphasis of the CCSP given the key role current and future observations (such as NASA’s EOS missions) will have for monitoring and modeling the climate system.

CHRISTA PETERS-LIDARD, USGCRP GLOBAL WATER CYCLE SCIENCE STEERING GROUP

Page 131, Chapter 12: The plan would benefit from a consolidated table of observational and product requirements, with links to chapters. There are many products which have multiple uses within the CCSP. For instance, satellite observations of fires can be used to:

Model trace gas and aerosol emissions (Chapter 5 Atmospheric Composition and Chapter 9 Carbon Cycle).

Identify areas undergoing rapid land cover change (Chapter 8 Land Use/Land Cover Change).

Assess climate change impacts on the frequency of extreme events (Chapter 6 Climate Variability and Change).

Represent a major feedback process with climate in terrestrial ecosystems (Chapter 10 Ecosystems).

NOAA-NESDIS, ELVIDGE

Page 131, Chapter 12: The establishment of a global climate and ocean observation system should be pursued as a top priority.

GEORGE WOLFF, PH.D., GENERAL MOTORS

Page 131, Chapter 12: First Overview Comment: The first overview comment on Chapter 6 applies equally here. The chapter does not recognize that the system of interest (i.e., the climate system) is itself undergoing change and acquiring momentum and that time matters if we are going to apply our research results to the system of interest to alter it in desirable ways.

Second Overview Comment: The second overview comment on Chapter 6 applies equally here. For instance, the text on page 138, lines 20–25 assumes that deterministic models produce orderly results, so testing models against past climate data should be easy and straight-forward. Not necessarily so. Some deterministic models, especially those with feedbacks, yield wildly different results for small changes in model parameters and initial conditions, and robust values for model parameters and initial conditions that avoid this sensitive condition may not exist (and if they do, they may not properly characterize the climate system).

DAVID L. WAGGER, PH.D., SELF

Page 131 et seq: The treatment of grand challenges seems overly technocratic and naïve to me, because we know all too painfully that even simple and uncontested knowledge about things like flood danger and coastal hazards is not being put to use. Spending vast efforts on refining the estimate of the speed of the run-away car is not a good idea if it prevents the occupants from working on finding the emergency brake. Ever more refined knowledge without prospects for application is an uncomfortable prospect. Yet, the grand challenge of working place by place and program by program, subsidy and investment by subsidy and investment, is the most important one. (See IPCC Working Group II, chapter on water resources, in regard to the quality of current adaptations to current conditions, let alone future or changed conditions; also, see Liverman, D., et al., 1998, People and Pixels: Linking Remote Sensing and Social Science, National Academy Press.)

WIENER, INDIVIDUAL COMMENTATOR

Page 131, Chapter 12: A cross-cutting issue not mentioned in this chapter is the effort required to combine the best observational data sets into gridded data sets for use in initializing and forcing climate models. This includes identifying and removing biases in reanalysis datasets, alternative model-independent methods for filling in sparse data and rapid inclusion of new and improved data into these datasets. Extending such data sets to other diagnostic fields for model/data comparison would also be useful.

PHILIP JONES, LOS ALAMOS NATIONAL LABORATORY

Page 131, Chapter 12: The presentation of requirements and unmet needs for climate data management (split between Chapter 3 and Chapter 12) contains most of the important thoughts and conclusions somewhere. In particular, Chapter 12 makes the important point that "Much of the technology required to make this vision a reality exists already" -- i.e. that the inadequacies of data accessibility today are not a result of inadequate technology. However (owing to the nature of the document) the solutions to the data accessibility problems are cast as "Research needs". In casting them thusly the Strategic Climate Science Plan has to a large extent missed the mark with respect to data accessibility concerns. The Plan's recommendations run the risk of perpetuating the causes of the community's current frustrations with data management, rather than solving them.

The current lack of integrated data and information management infrastructure for climate science is chiefly a challenge for community building and cooperation, rather than for research and new technology development. Most of the pieces needed to build an effective, integrated data distribution service exist today, though they are not used broadly or consistently enough to fulfill their potential. The solution to this problem lies in three areas:

1. broad usage of interoperability frameworks. This class of solution allows the community to rise above many of the historical issues of data location, data set size, and file format incompatibility. A prominent example today is the OPeNDAP framework;
2. the need for the community to agreed upon a standards process. The standards process is a step removed from the standard, itself. It refers to the formalized steps that need to be taken to ensure that a standard has been carefully crafted and publicly reviewed, and that awareness of the standard is broad. Our community does not suffer from a lack of standards, it suffers from i) a lack of agreement upon which of many standards to use and ii) an overly narrow focus in the crafting of the standards. Both of these problems can be addressed by the creation of a suitable community standards process; and
3. adoption of and adherence to broad community policies regarding responsible data stewardship. The most powerful tool to address this problem is the purse. Groups that receive funding to create data sets need to be held accountable by the funding source for i) timely accessibility of the data, either through interoperability frameworks, or through submission of data to a data-serving organization in a recognized standard format; and ii) completeness of metadata -- as well (of course) as the scientifically essential issue of quality control.

None of the preceding is intended to suggest that there is a paucity of genuine information technology research topics that would benefit climate research. That is certainly not the case and some discussion of topics such as scientific data mining and advanced scientific visualization do appropriately belong under Grand Challenges. However, the advances in data management that will most profoundly benefit climate research are in the area of infrastructure building, rather than information technology research..

STEVE HANKIN, CHAIRMAN, DATA MANAGEMENT AND COMMUNICATIONS STEERING COMMITTEE, US INTEGRATED OCEAN OBSERVING SYSTEM

Page 131, Chapter 12: As presented, the CCSP is a sprawling research program plan that accurately reflects the divergent range of R&D required to adequately understand future climate change assumes. Such a presentation is unusual although, in that all research components are provided the same level of priority

The chapter is well intended and serves as a valuable integration exercise to crosscut research agendas of the preceding chapters on the major science elements of the CCSP. I foresee clerical issues that will require considerable efforts to track and incorporate changes from the science chapters resulting from the comment process and workshop.

I find the vagueness of many of the ideas presented in the text to be disturbing. It implies that the scientific community knows little about how to resolve many of these issues. Nothing could be further from the truth. Most, if not all, of these challenges have been identified and documented in national reports. This information needs to be included in this chapter. For example, the presentation should include specific task (parallel to other chapters) about how linkages will be achieved; it should take advance of the various NRC reports and USGCRP reports on data and information systems. Current discussions in this chapter on known scientific challenges and how technology can and will provide solutions is unnecessarily vague.

Overview Comment 3: Section 3 on Data and Information Management is particularly troublesome. Over the next five years, the CCSP will focus on standards and formatting. What is new? These are necessary tasks that have been on the table for the last 5-10 years. What promise is the CCSP making on the next 5 years? How will things need to change to make this happen?

Overview Comment 4: Section 3 on Data and Information Management. The CCSP states that tailored portals will be developed that will be affected "as funding is available…" This is not the place or time to imply that such activities will be undertaken if and only if there is available funds. One could imply that data management is a second-class effort in the CCSP. These activities need to be made requirements of the CCSP not discretionary elements that most likely will not be funded. Data management and assimilation are urgent needs of the CCSRI and should be given priority status along with the other research topics.

Overview Comment 5: It is critically important that the topics of modeling, observations, and information systems be given a highly visible level of treatment in the CCSP. The existing chapter could be a major step toward addressing these issues. The section on observations nicely meets this goal and adequately addresses and integrates topics described in other sections of the CCSP on observations. However, the sections on modeling and data and information management are largely superficial and do not make a convincing case for goals adequately described in other chapters in the CCSP. In particular, the section on data management needs a major overall and needs to put forth a viable program plan that is consistent with advanced technology capabilities and the objectives and requirements of the CCSP. What is presented now is not particularly convincing nor is it an accurate reflection of where we are today. Recent and planned advances in data and information technologies could go a long way in providing near-term assistance in implementing the CCSP.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 131, Chapter 12: While there is nothing objectionable in this chapter regarding modeling, it does not contain the overview or summary of the needed modeling research that I had expected to find. In reading other chapters of the draft, however, I found the expected material on modeling research and improvement. It would seem appropriate to at least summarize these research needs in chapter 12, along with the recommendations regarding modeling made in connection with “applied climate modeling” in Chapter 4 and under “climate variability and change” in Chapter 6.

I believe Chapter 12 should address the need for a model-neutral facility or group to carry out sustained and comprehensive testing, diagnosis and validation of global climate models.

W. L. GATES, LLNL

Page 131, Chapter 12: The primary focus of my review is on CHAPTER 12 dealing with the Grand Challenges in Modeling, Observations and Information Systems. The plan is consistent with past programmatic direction in that it responds to and adopts the objectives of the 1990 Global Change Research Act. It has a sustained commitment to modeling and the gathering and use of observations (p. 131). It discusses some of the modeling grand challenges and many of the infrastructure challenges for information management of climate observational and model data. Infrastructure issues for high-end computing in the support of model development activities are not discussed at all. To carry out the development of climate models and to assimilate new climate data from satellites and other sources to produce refinements on the models and improved understanding of climate processes and interactions requires a serious commitment to high-end computing. Computing power on the scale of the Japanese Earth Simulator will be required to achieve predictive capability on regional scales. I did not find this in the plan.

JOHN DRAKE, OAK RIDGE NATIONAL LABORATORY

Page 131, Chapter 12: First overview comment (Part 1 Observations)
There is no mention of independent analysis of observational data. Particularly with indirect measurements such as satellite observations, the path from a measurement to an interpretable climate field is not straightforward. An example in case is recent lower

troposphere temperature trends as inferred from microwave sounding unit (MSU) measurements. Satellite measured irradiances must be corrected for instrument temperature, orbital decay, cross-platform calibrations and other effects. This data has been analyzed only twice, with two conflicting results. Christy and Spencer find that globally averaged lower troposphere temperature trends are essentially zero. Conversely, Mears, Schabel and Wentz find that this trend is about 0.1K per decade. The implication for both policy makers and climate model diagnosticians is enormous. Either the planet has warmed in the last two decades or it has not. The Strategic Plan must address this sort of issue by directing not only the greater accumulation of observations but that uncertainties in this data be quantified in a realistic sense.

Second overview comment (Part 2 Modeling): The Strategic Plan fails to mention the need to provide policy makers estimates of our uncertainty in future climate change predictions. There are multiple sources of our uncertainty. Some are internal to the climate system, a result of the chaotic behavior of the ocean and atmosphere. Some are the result of observational deficiencies. The recently discovered haze in the tropical ocean is evidence of what we have not seen. Yet other sources of uncertainty are related to our uncertainty in future human activities. I.e. will society significantly alter its fossil fuel consumption? However, the largest single source of uncertainty in future climate change prediction comes from deficiencies in the climate models themselves. This is most clearly seen by examining predictions of different models. For a given future scenario, the range of predictions is far greater between the world's leading models than it is for a given model subject to any plausible future scenario or any varying set of initial conditions. Climate model intercomparison has long taught us the folly of relying on a single model for something this important. In the paragraph starting at line 33, page 139, a prediction capability is outlined. However, the Strategic Plan fails to mention the importance of multi-model ensemble prediction. This is the most effective way to quantify our uncertainty about what we do not know.

Third overview comment (Part 2 Modeling): The plan makes only passing mention to the 'high-end' computing platforms that are needed to usefully predict future climate possibilities. In fact, to perform century scale coupled ocean-atmosphere GCM simulations at the resolution required for regional climate change prediction (~10km) will require Petaflop supercomputers running at reasonable fractions of their rated peak speeds. Current US scientific computing is severely hampered by architecture design, such that sustained computational performance rarely exceeds 10% of the machine's rated peak speed. The Strategic Plan should reinforce the need to maintain the leading role of US in the supercomputer industry, both for climate change prediction needs as well as for a general strategic plan for US technological development.

MICHAEL WEHNER, LAWRENCE BERKELEY NATIONAL LABORATORY

Page 131, Chapter 12: The modeling section of this chapter has much in common with chapter 4, section 3 on "Applied Climate Modeling". They both reach the same conclusion: that there should be two parallel efforts, one devoted primarily to research and involving a large community of "hundreds" of people. The other would retain a research component but would primarily be responsible for production-mode predictions on demand. Chapter 4 identifies these efforts as the NCAR CCSM and the GFDL modeling project, respectively. Chapter 12 refrains from making such identification.

Like much of the rest of the document, the writers of this chapter seem to have a reluctance to mention by name ongoing programs that are addressing specific issues that are called out for attention. I don't know if this was a policy adopted for this document, but neglecting to mention relevant programs will leave many readers with the misimpression that nothing is yet being done on those topics. Examples are given below.

ROBERT MALONE, LOS ALAMOS NATIONAL LABORATORY

Page 131, Chapter 12: 1: There are indeed significant Grand challenges in climate prediction. However, simply saying that projections of global change are unusable for decision-making is erroneous. While there are large uncertainties in the global climate system, there is a large base of understanding. Putting informed decisions off for decades would have been a disaster for environmental concerns such as CFCs, dioxin and other chemicals that harmed the environment.

Overview comment 2: The overall message that more climate research needs to be done is admirable, but a more clear focus on how one can translate present-day state of the knowledge to informed policy decisions needs to be done now.

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

Overview comment 4: The details of how the flow of information described in the linkages sections needs to be more fully fleshed out. As it sits now, several different communities are identified, but no clear plan is delineated on how to actually have the required information move between these communities.

DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 131, Chapter 12: **A truly global observing system must be satellite-based.** Although the older conventional weather observing system has important roles to play (maintaining the established longer data records, anchoring the satellite observations, improving interpretation of specific aspects of processes), the "grand challenge" is to improve the satellite system, not to improve the conventional observing network. The REAL CHALLENGE is that we need more than just a collection of satellite measurements for climate research; we need **globally integrated data products** that must come from the **combined and coordinated analysis** of the measurements from the **whole constellation of satellites**. To achieve this requires something that the current satellite programs do **not** provide: methods and their application that combine observations from multiple instruments on the same satellite and combine observations from multiple satellites into single, comprehensive global data products. To establish long satellite records also requires that there be a clearly defined program for conducting the work needed to transform well-tested research data analysis methodologies into operational data analysis systems.

Page 131, Chapter 12: Grand Challenges in Modeling, Observations, and Information begins to set the stage for the program. However it is odd that it comes so late in the document. The chapter starts off with a bang but then ends with a whimper as there is not too much substance. If crafted appropriately it has the potential for guiding/organizing strategy and implementation

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

Page 131, Chapter 12: The chapter has little or no focus, no priorities and contains nothing that really constitutes a Grand Challenge. I SUGGEST IT BE REPLACED WITH SOMETHING ALONG THE LINES GIVEN BELOW.

Constitute a new chapter to appear up near the front of the Plan. This chapter would concentrate on describing how the "Challenge Projects' would be handled by CCRI, and be the focus of the entire CCRI. These Projects would identify the key questions that need to be answered for decision makers. The new chapter would indicate how the appropriate groups and resources could be pulled together to answer the key questions. Such 'Challenge Projects' would be rather short in duration, but pull together needed components from within the overall program to give concrete, specific answers. The Challenge Projects might often be rather applied in content, but still draw scientists, engineers, etc as required. IF DONE PROPERLY, THE CHALLENGE PROJECTS WOULD BE THE HEART AND SOUL OF THE CCRI. They would infuse the program with new challenges and problems, eventually affecting all aspects of the program. By addressing new questions and needs as they arise, the CCRI would constantly be reinvented. The Challenge Project would also be the pay off needed to justify continued CCRI support.

Perhaps the best way to introduce the new Chapter would be through an example. Describe the setup and functions of a project we want to get going right now, e.g. impacts of global warming on water resources in the United States.

BARNETT, UC SAN DIEGO

Page 131, Chapter 12: This Chapter does not show a unified approach. It is clearly divided in three parts written in different styles. If the part on observations is taken as guidance, then the modelling and data management parts should define priorities and challenges and a strategy to achieve well defined goals. The sequence in the title should reflect the sections as they are discussed. Format: The section on modeling does not a have a special heading on Challenges. Scientific contents: Two challenges are defined on p. 139, but they amount to managerial or infrastructural challenges rather than to scientific challenges. Focussing on the example of ENSO forecasting confuses the reader about the longterm global change issues discussed elsewhere in the document. There is overlap and confusion with regard to Chapter 4 and text will have to be rearranged and deleted. In general there is not always enough text in the body of the document to substantiate the requests made in Chapter 12. Chapter 12 may fulfill the role of a summary, but should most importantly define priorities and challenges for instrument development, observation networks, modeling and data archiving and management, taking into consideration costs, benefits, importance for decision making and pathways of present and future international cooperation.

LYDIA DÜMENIL GATES, LBL

Page 131, Chapter 12: Odd placement. Does not come across as integrating. Reads as an afterthought. Where are the Grand Challenges?

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

Pages 131-137: In specific on challenges and needs for data, we are currently badly underfunding the boring and unexciting but still critically needed SNOTEL and stream gauge networks in the U.S., let alone expanding and optimizing their use. These may offer little glamour, but they are wanted and unavoidably important.

Similarly, there is a serious need for better snow science, under current conditions as well as in anticipation of future conditions. The suite of concerns in weather sequences and rates of sublimation, evaporative and soil infiltration losses, and other factors mediating the transformation from precipitation to useful stream flow is only abstractly understood in many places, and warrants far more investigation.

WIENER, INDIVIDUAL COMMENTATOR

Page 131, lines 9-11: This is an interesting admission—those research activities cannot meet the objective. Are not these other activities part and parcel of the 7 elements—it has sure sounded as if they are and these sections just pull things together.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 131, line 13 'Cannot be met' is inaccurate. The preponderance of evidence requires action, not decades long delay.

DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 131, line 14:
capabilities, and sustained commitment to observations, accurate and transparent calibration and validation, and data information systems.

NIST, HRATCH SEMERJIAN

Page 131, line 26: What does this sentence mean—which activities. And does being the highest priority mean that they get all the dollars they need independent of the other activities. It would really seem that this plan needs to provide a balance among approaches and elements of the program, and to have a section describing this.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 131, lines 26-30. Agree with the emphasis on the importance of reliance amongst agencies and recognizing that some agency resources are focused on other needs.

Recommend going a step further and ensuring the strategy included a process for allocating responsibilities and safeguards for ensuring partners live up to their responsibilities, even when faced with competing agency priorities.

DEPARTMENT OF TRANSPORTATION, LAWSON

Page 132, comment on bullet starting on line 36 on discussing "establishment of a linkage… between surface and space-borne sensors by performing regular whole-atmosphere column measurements from the ground and especially suborbital platforms":

In principle, the difference between a ground and satellite measurements of a surface phenomena, such as ocean color, is due in large part to the intervening atmosphere. Disagreement between the two measurements, after correction for the atmospheric effects through radiative transfer models, is used to "vicariously" calibrate the satellite measurements. The reliability of such a vicarious calibration demands on the match between the spectral responses of the ground and satellite sensors, which is often poor. Proper instrument characterization, calibration, and stability can minimize or remove the need for such vicarious calibration.

NIST, HRATCH SEMERJIAN

Page 132-138: The *Draft Strategic Plan* recognizes the observing system challenges raised by such reports as the NRC (1999) report *Adequacy of Climate Observing Systems* as well as the UNFCCC (1998) *Report on the Adequacy of the Global Climate Observing Systems* (GCOS). The U.S. and international network of climate observing systems currently has multiple deficiencies including:

- Spatial heterogeneity and sampling biases among global observing networks
- Poor reporting from the GCOS Observing Systems (see Chapter 3 of the *Draft Strategic Plan*)
- Corruption of the U.S. Automated Surface Observing System
- Corruption of the U.S. Cooperative Weather Observer Network
- Additional problems with observations for sea level, evapotranspiration, lake levels, etc.

In addition to existing problems in U.S. and global observing systems, many systems have experienced a decline in station number and/or reporting in recent years, just as the demand for climate information has increased. Examples include:

- The Global Historical Climatology Network (GHCN)
- The U.S. Historical Climatology Network (USHCN)
- The Comprehensive Aerological Reference Data Set (CARDS)
- The Comprehensive Ocean/Atmosphere Data (COADS)
- Global and U.S. radiosonde networks
- USGS gauging stations

These declines have occurred in concert with the proliferation of valuable space-based observing systems, which are capable of more robust measurements of some climate variables. Yet space-based systems remain inadequate for addressing many observing duties. Chapter 12 (in conjunction with Chapter 3) of the *Draft Strategic Plan* emphasizes the near-term strategy of the stabilization and maintenance of U.S. and global observing systems (as recommend by the NRC) to address the deficiencies and declines noted above. For example, efforts under the CCRI (Chapter 3) would address time-of-observation biases in observing systems, facilitate repairs of GCOS networks to improve reporting, and provide additional capacity to monitor aerosols, the surface ocean, sea-level, and sea-ice distribution. Meanwhile, Chapter 12 indicates that the GCRP will similarly pursue stabilization of observing systems, address deficiencies, engage in data integration among multiple systems, and pursue timely data reanalysis. This is certainly an appropriate beginning, but it seems clear that over the long-term, more ambitious targets must be set, and a pathway must be laid for reaching those targets. The pursuit of observing systems that provide true global coverage of the oceans, land, and atmosphere will require substantial upgrades and new investment in observing systems. Although the *Draft Strategic Plan* outlines a fairly clear near-term strategy for climate observations, the long-term strategy remains rather vague. Even the table in Chapter 12, which lists CCSP observational priorities, frequently refers to the maintenance and/or continuation of existing observations. However, it seems clear that the current system, even if well maintained, is not sufficient for current or future needs. Given that observations of the climate and other environmental systems is a fundamental requirement for climate change research, it would seem prudent to develop a long-term strategy for investment in and development of observing systems.

The climate change community has historically acted as a ‘free-rider’ with respect to climate observing systems. Many observing systems were not developed for long-term monitoring of the global climate and are, in fact, inadequate for this task. Conflicts over funding and research priorities further challenge the stability of observing systems for climate change research. The climate change community clearly needs stable observing platforms that can be utilized for long-term climate monitoring without risk of program interruption. If dedicated systems cannot be acquired, more thought needs to be given to the balanced use of existing assets to ensure they are used to address multiple research priorities in an efficient manner. These issues are raised in the *Draft Strategic Plan*, but it is unclear the extent to which they will or can be addressed.

There is a need for enhanced observing systems for both ecosystems and public health (see 2001 NRC report *Under the Weather*, as well as Chapters 3 and 10 of the *Draft Strategic Plan*). The United States has a long-history of ecological monitoring, but efforts have rarely been truly national or global in scale, and long-term responses to climate are seldom the major consideration of existing monitoring programs (with the notable exception of the Long-Term Ecological Research program). The observation priorities identified in Chapter 12 for ecosystems appear to simply be supportive of carbon cycle observations, such as the observation of changes in primary productivity (via remote sensing) and forest measurements. This is a fairly limited set of observations with respect to ecosystems that does not reflect the informational needs raised in Chapters 3 and 10 (e.g., observation systems for ecological indicators). Similarly there appear to be no observation priorities for public health listed in Chapter 12, although such needs have been identified by the NRC (i.e., *Under the Weather*) and are mentioned in Chapter 11 as well. Granted, the establishment and maintenance of long-term ecological and public health observing networks to assess potential responses to climate and environmental change represents a significant undertaking. As with many of the challenges faced by U.S. climate change research infrastructure, the question is whether or not the CCSP has the resources and funding available to make meaningful gains in this area (see comments re: Chapter 15).

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

Page 132, Line 2: **Insert text** "… observations from instrumental, satellite, and paleoclimatic sources."

U.S. CLIVAR SCIENTIFIC STEERING COMMITTEE

Page 132, Lines 12-22: The second paragraph on page 132 (lines 12-22) is vague in its intent. It is not clear what the "high-quality, global data" referred to in this paragraph are. It certainly cannot be documenting atmospheric trends, because all of the satellite measurements mentioned here may have global coverage but are weak on long-term trends. Only by conducting high-precision, accurate, globally dispersed, ground-based measurements can we obtain reliable temporal trends of the most important gases driving climate change. Long-term, *in situ* measurements of CO_2 and other greenhouse gases are the ultimate descriptors of the driving force behind much of the change observed today. The maintenance and quality control of these measurements should be at the top of the list for Observational Priorities. *[Butler 303-497-6898 – Dutton, Hofmann, Ogren, Schnell, Tans; NOAA/CMDL]*

NOAA/CMDL

Page 132, lines 14-19: The report lists a number of existing ocean-oriented observing systems, both satellite-based (Topex, QuikScat, SeaWifs) and in-situ (TAO, Argo), but the list of "remaining challenges" beginning in line 24 does not mention any presently unmet oceanic data requirements. I propose to add satellites capable of measuring surface salinity as one specific observing system that will fill important data needs. Making SSS measurements from space probably qualifies as a Grand Challenge.

RAINER BLECK, LOS ALAMOS NATIONAL LABORATORY

Page 132, lines 16-17: The phrase "are not far behind" is a bit strange—what does this mean?

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 132, lines 18-21: Add the World Ocean Circulation Experiment (WOCE) to the list.

ROBERT MALONE, LOS ALAMOS NATIONAL LABORATORY

Page 132, line 20, the DOE Atmospheric Radiation Measurement (ARM) program should be mentioned. What is missing from the observational priorities is an emphasis on improving theory through the use of the observational data. We are currently inundated with data that is not able being adequately analyzed and used to improve the science. The

Comments on Chapter 12

ARM program was specifically designed to improve the radiation theory and modeling. A much stronger program to assimilate data may require an operational emphasis within the CCRI as well as feeds from the observational program of the USGCRP.

JOHN DRAKE, OAK RIDGE NATIONAL LABORATORY

Page 132, Line 22: **Add to end of paragraph** "The global database of paleoclimate information has expanded and focused on questions critical to global change, including abrupt change, the past millennium of global temperature, and ENSO variability."

U.S. CLIVAR SCIENTIFIC STEERING COMMITTEE

Page 132, line 24-40, The description of the observational program is reasonably complete.

DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 132, Line 26: **Add to bulleted section**:

• Complete the characterization of decade to century scale climate variability and abrupt climate change during the current interglacial (last 10,000 years), including mechanisms.

U.S. CLIVAR SCIENTIFIC STEERING COMMITTEE

Page 132, Line 30: "Implementation of a global, comprehensive, integrated, quality-controlled network of paleoclimatic data -- a Global Paleoclimatic Observing System -- to provide a multi-century record of natural variability against which monitoring data may be compared."

C. MARK EAKIN, NOAA/NATIONAL CLIMATIC DATA CENTER

Page 132, line 34-35 – A point well taken and extremely important to observational systems. I might expand a little to bring home the point that the systems is not fixed and that we should anticipate change.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 132, line 34 Bullet needs to be rephrased.

JOHN DRAKE, OAK RIDGE NATIONAL LABORATORY

Page 132, lines 34-35: This is really vague and not an advance over what the program has done in the past.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 133, Line 1: page 133, line 1 How will explorer-class satellites help? This is obviously a programmatic need from NASA. Three-five year missions will answer some questions but few of these will help with the climate problem. We need more long-term systematic measurements where we can resolve the inherent climate variability.

MARK R. ABBOTT, OREGON STATE UNIVERSITY

Page 133, Bullet on line 6-7 append:

observing systems and underlying measurement science and physical and chemical data infrastructure.

Comments on Chapter 12

NIST, HRATCH SEMERJIAN

Page 133, line 15: **(46-E)** Another verb: " A range...is identified..."

HP HANSON, LANL

Page 133, line 19. between end and start of sentence insert new sentence: Also, measurement reliability, accuracy, validation, and long-term continuity are paramount, necessitating careful attention to instrument or sensor characterization, calibration, and stability.

NIST, HRATCH SEMERJIAN

Page 133, line 25: add the following text: "Unlike weather prediction models, which can be evaluated and validated by comparing predictions with what is actually observed to happen a short time later, climate models cannot be evaluated effectively through predictions of future climate. Therefore, it is important to have good 'observations' of past conditions with which to initialize, force, and ultimately validate climate models. This can be done either for the recent past, for which some historical data may be available, or for the distance past – paleoclimate. While this subject may not belong under 'Observations' because very different methods must be used to extract information about past climatic conditions, it is important nonetheless that attention be drawn to the need for reliable data on past climates."

ROBERT MALONE, LOS ALAMOS NATIONAL LABORATORY

Page 134, Are the topics in the box (ie. the Chapter title) prioritized in some way? This needs to be made clearer.

DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 134: Develop and maintain the continuity and consistency of climate-quality observations of atmospheric temperature, water vapor, and clouds by operational environmental satellites.

Special attention should be given to microwave mid and upper tropospheric water vapor satellites like SSM/T2. This data is under-utilized, hard to get at and the analysis of the data is woefully underfunded.

RAYMOND PIERREHUMBERT, THE UNIVERSITY OF CHICAGO

Page 134, the observational priorities for atmospheric composition and water cycle need to stress the common link with radiation and clouds through the "moist physics." On land use priorities there is a need to address regional level surveys of land use change and what the drivers are behind it. We need to separate human induced and natural variability in the observational record on the regional scale. This will require assembly of historical records and inventories as well as flux measurement on a regional scale.

JOHN DRAKE, OAK RIDGE NATIONAL LABORATORY

Page 134, Chapter 6: Depth of penetrating radiation

Comments on Chapter 12

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

Page 134, Chapter 6: Climate Variability in Change This chapter should explicitly state how paleoclimate data (from tree rings, ice cores, ocean and lake sediments) can contribute to understanding natural climate variability on decade to century time scales, and explicitly suggest a cross agency research initiative. The paleoclimate community has done a wonderful job demonstrating proof of concept, showing that these records can contribute to the key climate questions. Despite the readiness of the research community, the funding has fallen short of what is needed. Compared to other, expensive aspects, a small investment here can have a big impact.

DAVID ANDERSON, NOAA PALEOCLIMATOLOGY PROGRAM

Page 134, Chapter 6 bullet # 1: And ìmodern and pre-instrumentalî to read ìÖ modern and pre-instrumental observations of temperatureÖî.

C. MARK EAKIN, NOAA/NATIONAL CLIMATIC DATA CENTER

Page 134, Box: **Add to bullets under “Chapter 6” heading**:

- Expanding and improving the database of paleoclimate information relevant to climate change over the coming century, particularly those that address key uncertainties such as abrupt change, ENSO, extreme events, and climate sensitivity.
- Develop improved linkages between instrumental and satellite observation networks and paleoclimatic reconstructions, so that quantities important for paleoclimate calibrations are routinely measured.

U.S. CLIVAR SCIENTIFIC STEERING COMMITTEE

Page 134-135, Table. Recommend priorities also include developing enhanced measurement techniques specifically focused on climate change.

DEPARTMENT OF TRANSPORTATION, LAWSON

Pages 134-135: There are no observational priorities noted here for Human Contributions and Responses. To some extent this absence reinforces my suspicions regarding the solipsism of the chapter, but nonetheless human health certainly has observational requirements!

CALIFORNIA RESOURCES AGENCY

Page 134: Observational Priorities: The same issues pertain to this summary section as I mentioned in previous comments on the inadequacies of in situ atmospheric profile observations.

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

Page 134-35, "observational priorities" boxes: Strangely enough, there is no mention of oceanic freshwater observing needs under "Water Cycle". Under "Climate Variability", I would add monitoring (via deep hydrography) the strength of the Atlantic Conveyor Belt. Jochem Marotzke is proposing to get into this business with a repeat zonal section at

26.5N. Sounds like an excellent idea. Another Grand Challenge, at least money-wise! (See also p. 137, line 16, and p. 139, line 4.)

RAINER BLECK, LOS ALAMOS NATIONAL LABORATORY

Page 135, line 2. What is the specific NRC reference?

DEPARTMENT OF TRANSPORTATION, LAWSON

Page 135, end of box: The current draft of Chapter 11 calls for field studies for its Questions 2 and 4.

ANN FISHER, PENN STATE UNIVERSITY

Page 135, lines 2-4: The NRC provided this list as a way of organizing the research effort (and I was there and really was the one proposing they do something like this). This does not mean that these are the only attributes that are especially important for society. Things like humidity and heat index, air and water quality, presence of snow and sea ice, and lots more variables are also important, depending on the situation. The text should be generalized to recognize this.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 135, line 2-13 – This point should be made elsewhere and not rehashed here. Delete lines.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 135, line 8: **(47-ES)** "Variables" here might be another opportunity to use "climate elements – although because it refers to the previous list, which includes ecosystems, this needs careful consideration. It's just that "variables" is weak.

HP HANSON, LANL

Page 135, Line 11, The assessment of the 'vulnerability and resilience' to change is important, but actions to decrease the level and rate of climate change would also be beneficial.

DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 136, Are the topics called out in the box already prioritized?

DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 136: Readiness to be used is a criterion I would add. Does the information have application for a given sector or place? Social readiness is not the same as scientific readiness, and deserves its own consideration since work might be important for one or the other, or both. With better cooperation and co-development of the understanding of what is used and useful for a given case, readiness for use can be understood far more than it is presently. There may be a lot of pleasant surprises waiting, when we know what people can use and find that we can supply it.

WIENER, INDIVIDUAL COMMENTATOR

Page 136, line 2, comment:

The use of the word accuracy is confusing since for long-term measurements precision is often more critical.

Changing "accuracy" to "accuracy and precision" would be better.

NIST, HRATCH SEMERJIAN

Page 136, line 4, modify as below:
Careful calibration against accepted national and international standards and overlapping….

NIST, HRATCH SEMERJIAN

Page 136, Table. Recommend the extent to which a program enhances the workforce focused on climate change research also be included as a criterion.

DEPARTMENT OF TRANSPORTATION, LAWSON

Page 136, line 6ff: Is the order of these important. If so, benefit to society should be first!

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 136, lines 8-14 – Good point but what should we do. Need a sentence or two here describing the needed tasks.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 136, lines 10-11: **(48-E)** Non-parallel construction. Change line 11 to read "...rather than creating new systems."

HP HANSON, LANL

Page 136, line 13: Is it clear that doing something in an operational sense always is more cost effective?

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 137, Line 10: **Add paragraph**:
"A fundamental challenge to the observational program required to understand global change is that instrumental and satellite records span short time scales relative to the needs of the program. An observational program for global change must provide information on decade-century modes of variability, the likelihood of occurrence of abrupt changes, the relationship of extreme events to changes in mean state, and the sensitivity of climate elements and effects to changing forcings. Paleoclimate observations address these core questions over the seasonal-century time scales most relevant to global change, and need to be integrated into a global climate observing system. Collecting this information is particularly urgent in many cases where rare annually resolved records are under imminent threat of destruction. Old-growth trees, long-lived corals, and high-elevation glaciers are dying and disappearing rapidly; rescue sampling in climatically important regions should be a high priority."

U.S. CLIVAR SCIENTIFIC STEERING COMMITTEE

Page, 137, line 11-19 – A very good and important point presented without substance. What countries? What programs? What assistance is needed? What do we want to see happen?

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 137, lines 12-19. Agree with the importance of engaging the international community. However, I do not believe the strategy addressed How to engage the international scientific community in the program. Not obvious what their role is in the overall strategy.

DEPARTMENT OF TRANSPORTATION, LAWSON

Page 137, Lines 20-29: Since at least four of the main chapters (water, carbon, land cover and ecosystems) cover topics within which both states and regional organization have an operational presence, the program should include a bullet regarding collaboration with those entities.

CALIFORNIA RESOURCES AGENCY

Page 137, line 22: **(49-E)** A non-italicized "in situ" – all others I've seen are italicized (although I may have missed some other roman ones).

HP HANSON, LANL

Page 137, lines 28-29. How are the near term objectives to be accomplished? Need specificity to implement.

DEPARTMENT OF TRANSPORTATION, LAWSON

Page 137, lines 30-39: The plan needs to be more specific about which observations need "stabilization" and which need "improvements". Reasonable people might disagree on this, and it makes a lot of difference in our ability to monitor the climate system.

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

Page 137, Line 35: Add ìproxy records of pre-instrumental climateî.

C. MARK EAKIN, NOAA/NATIONAL CLIMATIC DATA CENTER

Page 137, line 40ff: **(50-S)** Here is a place where the suggestion above in comment 15 will pay off. The differing needs of a NWP initialization network (the "operational" observations) make the augmentation discussed in this bullet necessary for climate purposes. Leveraging climate benefits from NWP investments, however, is clearly desirable and can be emphasized more fully in the document, here and with respect to comment 15.

HP HANSON, LANL

Page 138: The major omission in the modeling section is something dealing with high-end climate modeling. This deserves a section to itself to balance the overly detailed discussion of the following Information Management section. There is nothing on the development of new methods that provide the building blocks of models or the investigation of new processes and feedbacks. In other words, the statement on p. 138, line 31 needs to be elaborated.

JOHN DRAKE, OAK RIDGE NATIONAL LABORATORY

Page 138: Modeling is one of the most important components of the CCSP. 20 As I noted in an earlier comment, it is not enough to focus on high-end computer modelling using existing styles of Fortran codes at a few national centers. It is equally important to fund a diversity of centers at universities, and to foster innovation in model flexibility by finding ways to accelerate the adoption of modern software engineering techniques in the climate science community.

RAYMOND PIERREHUMBERT, THE UNIVERSITY OF CHICAGO

Page 138: The current organizational structure of the US modeling effort has not fully supported the product- 33 driven modeling that 34

True, but in providing more support for product-driven modelling we must be careful not to destroy scientific innovation and the capability for tackling interesting and novel scientific questions. Many researchers in European modelling centers have complained about product-driven modelling stifling potentially more productive scientific research.

RAYMOND PIERREHUMBERT, THE UNIVERSITY OF CHICAGO

Page 138-143: The *Draft Strategic Plan* outlines a very ambitious plan for expanding modeling capability for climate and global change research. Although a broad range of research endeavors are identified that would undoubtedly improve the quality of climate change modeling, it seems questionable whether or not the CCSP will be able to achieve significant expansion of the modeling workload. The support for the high-end climate modeling centers under the CCRI (Chapter 4) is noted, yet these are still only two centers that have other responsibilities than to the CCSP. Also, the *Draft Strategic Plan* does not indicate whether the short-term support of the GFDL and CCSM modeling centers is sufficient to address the long-term needs of the U.S. climate change research community.

Many of the modeling efforts outlined in Chapter 12 are unrelated to GCMs, such as models for subsurface hydrology, land use projections, carbon cycle, ecosystem responses, and integrated assessment. It doesn't appear that the enhancement of modeling capabilities outlined in Chapter 4 for the CCRI includes support for these other modeling needs. Presumably facilitating all of these efforts would necessitate a significant ramping up of environmental modeling in general. The budget for the CCSP, at least over the near term, would not appear to deviate significantly from the past budget of the GCRP, save the additional $40 million dedicated to the CCRI activities (see comments re: Chapter 15), which may in fact be diverted from the GCRP and therefore not represent new funds. Given the multitude of modeling priorities outlined for the CCRI and the GCRP, it is questionable that sufficient resources will be available to truly fulfill the broad range of modeling needs proposed in the *Draft Strategic Plan*. As with the observational priorities, it would be helpful to have some reasonable indication of which of these priorities will actually be achieved and when.

Comments on Chapter 12

As noted in our comments on Chapter 4 of the *Draft Strategic Plan*, the characteristics of the two high-end climate models that have been selected for CCSP support raise questions as to whether they are sufficient for generating a comprehensive understanding of climate change and its implications. The extreme climate sensitivities of the GFDL and CCSM GCMs prevent their outputs from being representative of the maximum likelihood response of the climate system to various forcings (natural and anthropogenic). Although it is undoubtedly important to understand the range of uncertainty associated with climate projections, it would seem to be prudent to support a model that is capable of representing the central tendency of the climate system.

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

Page 138, The high end computational resources for integrated fully coupled biogeochemically complete climate predictions are Grand Challenge.

DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 138, Line 16: **Add to bullets**:

• Identify and develop paleoclimate resources that are in imminent danger of loss, and that are likely to provide significant information on key climate systems and questions.

U.S. CLIVAR SCIENTIFIC STEERING COMMITTEE

Page 138, line 20ff: It is not clear how this effort is coupled to the CCRI effort.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 138, line 33 that the current organizational structure of the US modeling effort has not supported product-driven modeling. This will be important to establish a national strategy and to address mitigation questions in a consistent manner. The Grand part of the challenges we face makes it impossible for individual groups to address.

JOHN DRAKE, OAK RIDGE NATIONAL LABORATORY

Page 138, lines 33-35: NESCAUM strongly supports the observation that the U.S. modeling effort to date "has not fully supported the product-driven modeling that is especially important for making climate model information more usable and applicable to the broader global change research community," and reiterates the need for products to support regional efforts by states to address climate change.

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

Pages 139-140: This chapter reaches the same conclusions as Chapter 4 regarding the need for two distinct modeling efforts, one research-oriented with "perhaps hundreds of external contributors" and the other a "quasi-operational" modeling facility capable of producing high quality results as needed by the assessment community. However, for some reason, Chapter 12 stops short of identifying the two efforts as the NCAR Community Climate System Model (CCSM) and the GFDL climate model, respectively, as Chapter 4 does. The reason for this omission is unclear. Hopefully this does not indicate that the CCRI (Chapter 4) and the USGCRP (Chapter 12) are going to end up with divergent approaches to modeling.

ROBERT MALONE, LOS ALAMOS NATIONAL LABORATORY

Page 139, line 3: **(51-S)** I think I understand that "dedicated capability" as used here means "big supercomputers," but I'm not certain – others may be even less certain. If it does mean this, I'd add "computational" before capability. (If it doesn't, what does it mean?)

HP HANSON, LANL

Page 139, line 5 Modeling Priorities:
Add: The impacts of climate change have the most relevance if they are assessed on a regional basis. High-resolution regional coupled models are available now and have been used successfully in regional impact assessments but should be developed further and used.

WELLER, ET AL, UNIVERSITY OF ALASKA FAIRBANKS

Page 139, line 6, The role of feedbacks in the climate system needs to be made stronger here.

DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 139, line 6: Does "in the next decade" mean after 2010?

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 139, lines 9-16: As discussed above, NESCAUM strongly supports the proposed focus on improving climate modeling at the regional level, especially for predictive applications. Nothing the CCSP can do is more important.

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

Page 139, Lines 10-12: While we completely concur with the conclusion that modeling needs are quite pronounced at the regional scales where decisions are actually made, we see no details thereafter about how CCSP will meet that important need. In fact this section of the chapter lacks any discussion about implementation. We suggest that the CCSP bring regional collaboration and provision of expanded computing facilities to the fore in its implementation.

CALIFORNIA RESOURCES AGENCY

Page 139, Line 19: "on demand" - Who determines this?

RONALD STOUFFER, GFDL/NOAA

Page 139, line 19-43 and lines 1-12 on page 140 –Jargon is being used to describe a fairly straightforward thought, i.e., line 27 "product driven", "line 35 "quasi-operational", line 20 on page 139 and line 1 on page 140 "discovery-driven research". I think a reader would be most appreciative of language that is void of jargon. It distracts from the very good points that are being made.

Comments on Chapter 12

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 139, lines 23-43: As mentioned later and in previous chapters, the research component of this strategy will rely on a supported software framework and agreements on Interfaces to be able to incorporate new research codes/packages. However, care must be taken to also support new methods and algorithms that may require more drastic changes in model design.

PHILIP JONES, LOS ALAMOS NATIONAL LABORATORY

Page 139, line 25: "knowledge" is really only useful when it has been well tested—one has to be careful in the transfer of information into a model.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 139, line 27 , The model products are made available to the larger community. For example the PCM and CCSM model out put is available to anyone who wants it.

DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 139, Line 33-43: What is really be described here? Who determines the demand? If the runs make no sense, this could waste lots of people and computer time. It is very difficult to seperate the signal from the noise for small differences in forcing.

RONALD STOUFFER, GFDL/NOAA

Page 139, line 33: Need to change "prediction" to "simulation"

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 139, lines 33-35: There is no discussion about which model or models the operational entity might run. It is really essential that the US not consider any single model "the answer" but consider what it is doing as part of the international effort to create a consensus of model results. Choosing one model and suggesting it is right would be very unscientific.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 140, lines 5-9: As mentioned here, a common software framework will be required for the strategies outlined in previous paragraphs. While this paragraph mentions substantial and continuing investment in hardware, it is equally important that substantial and continuing investment in the software framework and standards development exists.

PHILIP JONES, LOS ALAMOS NATIONAL LABORATORY

Page 140, line 5ff: There needs to be a link discussed to the broader set of modeling groups (GISS, CSU, UCLA, etc.).

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 140, line 6: In connection with the "common modeling framework", it should be mentioned that the NASA High-Performance Computing and Communication program is funding a three-year project to develop and deploy an Earth System Modeling Framework (ESMF). ESMF is a multi-agency, multi-institution effort based at NCAR. If

ESMF reaches its goals, it will be adopted in all the major US climate models and component models, making interchange of component models and even subcomponents of models easy.

ROBERT MALONE, LOS ALAMOS NATIONAL LABORATORY

Page 140, Line 11: Typo

JOHN DRAKE, OAK RIDGE NATIONAL LABORATORY

Page 141: The only ocean work asked for (relative to oceans and Chapter 6) is: “Models of the full three-dimensional circulation of the global ocean:”

This statement is confusing and mis-leading. We have models of the three-dimensional circulation of the global ocean in many forms and can run these for many thousands of years of simulation. By “full” do we mean “eddy-resolving”? If so, then why not say so? Some have suggested that full includes representation of every physical process in complete detail – but this is impossible without resolving the molecular level (and even then some other purist would disagree).

The problem here is defining the spatial and time scales that should be resolved to provide a solution that has comparable uncertainty to the AGCM to which it is coupled. No matter how fine a resolution OCGM we run, the climate problem requires coupled models. I have always considered that the ocean component must require between 50 and 200% of the time required by the AGCM (certainly on the same order of magnitude). If we increase computing power by 100,000-fold, we can increase resolution by a factor of 10 and increase the number of ensemble members (or length of runs) by 10. While welcome, these changes are not revolutionary – we will still recognize the models and techniques, and we will still not be accurately representing the dynamics of each eddy and filament, let alone the diapycnal mixing processes associated with internal wave variability, interaction with topography, deep density currents, etc.

U.S. CLIVAR SCIENTIFIC STEERING COMMITTEE

Page 141, Line 1: Chapt. 12, Section 3 "Data and Information Management", paragraph 2, opening sentence:
"This vision can only be achieved by harnessing advanced technologies ..." is misleading and would be better stated as
"This vision can only be achieved by effective use of technologies and a commitment to evolve the solutions as the infrastructure of the Internet evolves."

Steve Hankin, NOAA/PMEL

Pages 141-143, Table. Need to ensure the economic portions of the models are pursued in all areas – this should ensure the focus on product driven models.

DEPARTMENT OF TRANSPORTATION, LAWSON

Page 141, "modeling priorities" box: I am suspicious of the new cloud parameterizations that are supposed to result from the use of cloud resolving models and field studies. The weather services have worked on this problem for years and have elevated convective cloud parameterization in mesoscale models to an art form. It may not be wise to promise something "new" in this area.

RAINER BLECK, LOS ALAMOS NATIONAL LABORATORY

Page 141: In the Climate variability priorities on p 141, I'd suggest the need to understand regional variability and to link this with the development of high resolution atmospheric models capable of simulating extreme events as related to climate. Two other key priorities I do not see mentioned are the improved modeling of boundary layer interactions with cloulds and the elimination of model bias.

JOHN DRAKE, OAK RIDGE NATIONAL LABORATORY

Page 141, Box (that continues onto following pages): **(52-E)** It would make this easier to read if all of the bullets in all of the headings were constructed in parallel. As it stands, the atmospheric composition priorities are activities ("carry out" etc.) while the climate variability ones and all the others are product-like ("estimates", "predictions", "knowledge", etc.). This is a minor word-smithing exercise for someone.

HP HANSON, LANL

Page 141,: Dust deposition models, role of data assimilation, ensemble and probabilistic forecasts, reanalyses, study of extreme events.

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

Page 141: The bulleted item under "Climate Variability and Change" (Chapter 6) that lists "Models of the full three-dimensional circulation of the global ocean" as a priority is misleading. Virtually all present-day coupled climate models employ three-dimensional ocean general circulation models. Certainly the NCAR and GFDL models do.

ROBERT MALONE, LOS ALAMOS NATIONAL LABORATORY

Page 141, line 1: In the fifth bullet of the second item (and elsewhere), it needs to be indicated that, of course, uncertainties will still exist—there will still be uncertainties.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 142, the land use priorities I would suggest that modeling land use change and ecosystem adaptation to climate change through the use of interactive land models is a priority.

JOHN DRAKE, OAK RIDGE NATIONAL LABORATORY

Pages 142-143: the carry-over item is a case of abstraction to excess, for example of my complaints. This calls for about half the university library.

WIENER, INDIVIDUAL COMMENTATOR

Page 142 et seq: The missing issue here is the potential great benefit from specification of metadata standards to assure usefulness of archived data sets, and comparability. The need is not to impose standards and exclude information, but to make it very easy to use good judgement on how anyone should or should not use a given set of data. This is not a recommendation of control or editing, but rather a recommendation of pressure to expose and pressure to explain.

WIENER, INDIVIDUAL COMMENTATOR

Page 143-146: The *Draft Strategic Plan* articulates an interesting vision for data management and access, but a review of the deliverables indicates that this vision will remain unfulfilled at least over the near future. This is unfortunate, particularly since Chapter 12 indicates that the continual emergence of advanced technologies for information management could potentially enable innovative approaches to climate change data management. The only near-term deliverables appear to be the development of metadata for climate data sets, the potential for data portals to enhance data access (with actual development dependent on funding), data rescue and stewardship, data integration, and the development of a more robust multi-agency data management network. A number of comments in Chapter 12 indicate that the CCSP has yet to determine what improvements in data management it expects to implement over the long-term. Granted, we recognize that advanced data management and information delivery tools may appear to a certain extent to be luxury items, subordinate to the needs of basic research. However, a sub-standard data management infrastructure ultimately compromises both climate observation and climate modeling efforts.

We can make several suggestions for the enhancement of data access and management. Chapter 12 indicates that data will be housed in multiple locations. This, however, is clearly a problem with respect to enhancing data access. If individuals are to spend more time viewing and working with data and less time looking for data, then a centralized repository is necessary, or at least a well-maintained central portal. Furthermore, data management must include not only climate data sets (inputs), but also the results of modeling efforts (outputs) if the needs of multiple stakeholders are to be satisfied. Accordingly, data needs to be made available in different forms, as the needs of a climate researcher are different from those of a resource manager, which are different from those of a national decision-maker.

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

Page 143, line 1ff: **(53-S)** No changes suggested here; rather a comment: When I first saw that there was a “data management” grand challenge section, I was cynical (“Oh, yeah, the data crowd got their licks in...”), but this is exceptional. Kudos.

HP HANSON, LANL

Page 143 L9 - "sensitivity analysis" - Of what? To what?

RONALD STOUFFER, GFDL/NOAA

Page 143L13-14 - "leading to significantly reduced uncertainties in climate projections" - I doubt this will happen on the time scales of this report. See the lack of the reduction in the range of climate sensitivity in 1995 and 2001 reports. The models improved BUT the range did not reduce.

Comments on Chapter 12

Ronald Stouffer, GFDL/NOAA

Page. 143, lines 18-20: An "integrated assessment model" of climate change mitigation options will have to address a large number of issues, some physical and some economical (e.g., what does it cost if we do nothing?). However, demanding that such a model include the "costs of control" may be asking too much. In how many cases can these costs be objectively determined? Why does industry employ an army of lobbyists if these costs are known on a case-by-case basis? I suggest that "costs of control" be stricken from this sentence.

RAINER BLECK, LOS ALAMOS NATIONAL LABORATORY

Page 143, Line 22: Data section is very weak. There are a number of efforts underway to improve data distribution schemes. This section needs modified with the efforts of Earth System Grid (ESG), PRISM and NOAA Operational Model Archive and Distribution System (NOMADS). Distributing data to other users is a very difficult and costly task.

Ronald Stouffer, GFDL/NOAA

Page 143, line 24-34 – Points made on access are well taken. However, access is only a part of the problems faced by the research community. In fact, it is the interrelated need of access and assured content that is the biggest challenge facing the research and assessment community. Perhaps some thoughts should be included on this interplay between access and content. At a minimum, content should be given equal billing.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 143, lines 28-34: This vision of providing a uniform user interface to permit transparent access to diverse data sets resident at multiple centers is a worthy goal. It should be mentioned here that this is already being pursued by the Earth System Grid (ESG) project funded by the DOE Scientific Discovery through Advanced Computing (SciDAC) program.

ROBERT MALONE, LOS ALAMOS NATIONAL LABORATORY

Page 143, Line 28: **Data and Information Management**
The various ocean and atmospheric research data sets reside in local and agency data bases, with some having entered the Master Environmental Library – in response to similar needs, back in the 1990s. Today's increasing data sources, from satellites, in situ instrumental packages, and now living organisms outfitted with sensors, archival devices, and radio-transmitters, has made data integration a major dilemma – unless some common ground is chosen. Given the rather broader focus of Climate Change Data sets, and their longer-term requirements, it is presumed that all the environmental data sets should be made generally available, and contribute to realistic Climate Records from Globally distributed sources.

At present there is an over-representation of northern hemisphere, urbanized, or land-use affected historical records. This is at the heart of the controversy over the likely magnitude(s) of Global Change due to natural and anthropogenic sources. Certainly, existing GCMs use pared down, temporal and spatially smoothed data sets, and in that sense, provide little of direct use to local, regional decision makers, hence provide little but fodder for debate regarding ‘uncertainty’.

The near-term research focus of ecological researchers allows reasonably large scale monitoring, using local and regional records, of both physical measures and ecological indicator species. The lengths of some of the local ecological indicator records far exceed those of any instrumental records, and provide widespread insights into the timing and causes of local and regional climate changes. The ongoing enhancements of variably-scaleable GIS data management and integrative data visualization techniques, that allow overlay mapping of time series and an array of observation types, will provide the greatest utility to analysts, and public education efforts. **Continue with line 1 of page 144.**

GARY D. SHARP, CENTER FOR CLIMATE/OCEAN RESOURCES STUDY

Page 143, line 30-34 –The vision in on the mark. Wordsmithing and editing is needed. For example, the “CCSP system” is mentioned. What is the CCSP system? Perhaps the vision should be written for users and not for developers.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 144, the distinction between model output (data) and observational data should be made explicit. The high-end modeling centers are producing petabytes of output that presents a major IM challenge. The observational stream is also growing rapidly. But the need is not only to increase access and longevity of the data in electronic form, but to develop appropriate analysis tools and products and to make these available.

IN GENERAL, THIS LAST SECTION SHOULD TONE DOWN THE DATA GRID EMPHASIS AND TALK MORE ABOUT ASPECTS OF CLIMATE DATA ANALYSIS LIKE DETECTION AND ATTRIBUTION, FACTOR ANALYSIS, ETC. JOHN DRAKE, OAK RIDGE NATIONAL LABORATORY

Page 144(?):Several other multi-Agency distributed data access projects have been initiated in the US including the NOAA Operational Model Archive and Distribution System (NOMADS). NOMADS is a grass roots effort that includes some of the Nations top scientists collaborating to access and provide fundamental research on high volume climate data from around the world. This bottom up approach provides format independent access to climate models and observations in heterogeneous formats, and was initiated due to the lack of systematic approaches for data access, climate model evaluation, and for fundamental long term research. In the US today, there exists no long-term archive for climate and weather models. Further, as supercomputers increase the temporal and spatial resolution of models, and demands for on-line access to large-array data increase, current communication technologies and data management techniques are inadequate. It is clear that it is no longer sufficient for any one national center or laboratory to develop its data services alone. Both researchers and policy makers alike now expect our national data assets to be easily accessible and interoperable with each other, regardless of their physical location. As a result, an effective interagency distributed data service requires coordination of data infrastructure and management extending beyond traditional organizational boundaries.

A new paradigm for sharing data among climate and weather modelers is evolving. It takes advantage of the Internet and relatively inexpensive computer hardware. In this new framework, such as the NOMADS, scientists put their data unto a computer on the Internet. Software running on the computer allows outside users to see not only their local data but also data on other computers running this same software. The scientific community is a vast intellectual resource. One that goes largely untapped. Each time a researcher wants to perform a climate or weather model experiment he must develop, or obtain computer software to read the data, re-format if necessary, and then develop highly specialized skills to interpret both the model it self but also the results of his experiment.

The fundamental issue that this science program seeks to address is how CCRI can organize its distributed climate and weather models and data into a cohesive presence and perform real-time and retrospective climate change detection and model analysis and inter-comparisons.

GLENN K. RUTLEDGE- NOAA/NCDC/SCIENTIFIC SERVICES DIVISION

Page 144, line 2 – "…interoperability between heterogeneous systems…" Recast in understandable language.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 144, line 3: The issue of "quality control/quality assurance" is so important that it deserves more attention in this section.

ROBERT MALONE, LOS ALAMOS NATIONAL LABORATORY

Page 144, line 5 and line 39 Is a "common collective" consistent with "distributed data and information system"? I think it is but you may want to make the point that they are consistent with each other.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 144, line 7, The distinction between large satellite data generated quantities and large GCM output flows needs to be made clearer.

DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 144, Line 30: This is not true. The IPCC has provided integrated information to policymakers. Furthermore, policymakers are not going to want to analysis data. It is important to allow free and easy data access. How to provide the data so that it is free and easy to obtain is an active area of research.

RONALD STOUFFER, GFDL/NOAA

Page 144, line 33, insert the following:

Comments on Chapter 12

This inconsistency in calibration can be eliminated by ensuring that all calibrations are relative to accepted national and international standards preferably tied to the SI system of units and by making needed improvements in sensors stability and in in-flight calibration.

NIST, HRATCH SEMERJIAN

Page 144, lines 35-36: This sentence should be indicating that there is a need to avoid this situation—data need to be preserved/archived.

Michael MacCracken, LLNL (retired)

Page 145, line 1-8 – What about quality assurance issues that can only be resolved by working with the PI's? This concept should be included.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 145, Line 12: RESEARCH NEEDS

Start the sentence with "Building on the decade-long efforts to create the Master Environmental Library (MEL) system, expand the current data management infrastructure,… Etc.

GARY D. SHARP, CENTER FOR CLIMATE/OCEAN RESOURCES STUDY

Page 145, lines 12-17: These are noble goals, but will funding be forthcoming to implement them? Scientists involved in data management need to be assured of appropriate rewards and recognition that has often been lacking in the conventional research-based recognition system. The educational system also needs to address training in data analysis and management and related techniques (e.g. GIS and remote sensing).

ROGER BARRY, NSIDC

Page 145, line 18-36 – First bullet, the second sub-bullet on identifying and using socioeconomic data that may need to be georeferenced and made compatible on temporal and special time scales puzzles me. How does this link to the leading bullet? The last sub-bullet on including foreign involvement is good but does seem to be consistent with the lead bullet's message of expanding the CCSP. Do we not now work with other international organizations? We do. "Expand " is not the right concept.

In the second bullet, what is the "framework' mentioned?

In the last two bullets, add implementation actions to expand the activity from identification activities only.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 145, Line 29, The exact methods to convey the germane climate science to policy makers needs to be expounded upon.

DAVID ERICKSON, OAK RIDGE NATIONAL LABORATORY

Page 146, lines 1,3: **(54-ES)** Are “beginning to identify...” and “beginning to solicit” really “products”? Maybe some re-wording can make this less fuzzy. Also, the bullets in this list need to be made parallel.

HP HANSON, LANL

Page 146, line 1-11 – In my opinion, the first two bullets are just wrong. There have been innumerable workshops and meetings that have identified users of climate information. The issue is not identification. It is how to develop an R&D program that is response to users other than climate change researchers. Using the word “beginning” to lead these bullets is a red flag in and of itself, especially considering the amount of money invested in the USGCRP over the last 10 years. We are beyond “beginning”, we should be doing something productive.

The major message of the last bullet is not new and has been documented numerous times before. The challenge is to take this information and figure out how the CCSP will deliver the requested information. For example, the water resources community has consistently requested climate projections at 1 km and very short time steps. We know this now. We knew this in 1985! How we deliver the information is the question.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 146 line 3; **Insert:** Begin to trade climate information and solicit the climate information requirements from the users.

GARY D. SHARP, CENTER FOR CLIMATE/OCEAN RESOURCES STUDY

Page 146, lines 13-23: In addition to adopting standards for metadata and data formats at the various data repositories, it will be necessary to reach agreement on the tools (and user interface) to be used for data extraction, analysis, and visualization. Currently, each site has their own tools for these purposes.

ROBERT MALONE, LOS ALAMOS NATIONAL LABORATORY

Page 146, line 18 – Repeating my general comment from above-- the CCSP states that tailored portals will be developed that will be affected “as funding is available…” This is not the place or time to defer these efforts to discretionary activities of the CCSP. Need to make these efforts requirements of the CCSP. Data management and assimilation are needed and should be given priority status with other research topics.

MIKE FARRELL, OAK RIDGE NATIONAL LABORATORY

Page 146, lines 26-35. Agree with the importance of linkages between stakeholders – but the strategy omits a plan for achieving those linkages.

DEPARTMENT OF TRANSPORTATION, LAWSON