# Written Public Comments on the *Strategic Plan for the U.S. Climate Change Science Program* Chapter 3: Climate Quality Observations, Monitoring, and Data Management (pp 26-37)

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Page 26, Chapter 3: The chapter is inconsistent with regard to what is meant by "climate" - in some parts of the chapter, the term seems to include atmospheric composition, emissions, land use, et al., while in other parts the term seems to be limited to meteorological phenomena.

**ROBERT M. CUSHMAN, ORNL**

Page 26, Chapter 3: The IRI and partners can help build international constituency for climate observation systems, but it is very important that ‘next generation’ of climate observing systems also embrace the range of observations for the long historical record. These time series data are critical to the analysis of climate, and for the validation of climate models. Further, in addition to observations of trends and extremes, the characterization of year-to-year variability remains very important. Climate observing systems must inform over a range of time scales, not just the long-term trends.

The report would benefit from a clearer distinction of information types needed for advancement. For example, data that supports cross-disciplinary analysis and data that support the decision making process itself are not anticipated to be the same kind of information resources. It is a huge undertaking to advance a climate observing system – what are the priorities in placement of system components for the monitoring of physical and social systems implicated in connecting science and policy, at the time scales of use to the decision process? The report has a stronger emphasis on longer-term changes than interannual variability, whereas the observing systems need to support analysis, decision opportunities, and decision validation across a range of time scales. Further, the challenge of presenting data for cross-disciplinary analysis is significant, and presents a challenge. IRI and partners are already working this problem to different degrees. Information resource development needs to build on ongoing work.

**IRI, ZEBIAK AND STAFF**

Page 26, Chapter 3: The development and validation of spatially explicit remote sensing methods are a focus of the US strategic plan [page 9 line 13f; page 15, line 12f; page 19, line 25f], are especially important in the context of accelerating our understanding and monitoring capabilities in the near term of the CCRI. Although remote sensing methods quantify land coverage and vegetation index (NDVI) of plant ecosystems these methods are about 2 orders of magnitude insensitive to estimate the changes in fluxes associated with the functioning biomass. This sensitivity gap is especially large when it comes to anticipating the future consequences in terms of fluxes in response to periodic stress experiences in vegetation.

Remote sensing methods that indicate the functional state of vegetation, not merely whether it is green of standing dead, are needed to serve predictive models, especially in the context of compliance in a carbon credits trading context. We need the capability to detect effects within days [page 5, line 35] and reliably monitor such changes that may be reversible within weeks to serve the understanding of the time scales of adaptation processes [page 8, line 18].

**CHARLES B. OSMOND, COLUMBIA UNIVERSITY**

Page 26, Chapter 3: Please note that on page 26, fourth talking point in the first box under Chapter 3, mention is made of "...response of biological and ecological systems to climate variability and change". This is good. However, there is an imbalance with regard the ecosystems selected as examples: there are no examples from freshwater or marine ecosystems, nor any comments on the impact that climate variability has on living marine resources. I think that here and elsewhere, that when choosing examples, the drafters of this document should strive for a balance between terrestrial, freshwater and marine ecosystems.

**BILL PETERSON, NOAA/FISHERIES**

Page 26, Chapter 3: This chapter falls far short of defining the issues and research directions associated with climate observations. Much of the material that ought to be here is included in Chapter 12. I suspect that is because of the politics of the CCRI, rather than on the basis of any real scientific separation. This is unfortunate. If it is truly necessary, then the separation of topics between Chapters 3 and 12 should be clearly articulated for the reader.

The chapter is heavily biased towards monitoring the atmospheric state, e. g., the distribution of temperature and humidity, and the ocean state, e. g., sea surface temperature. While these state variables are certainly important for climate, they are only *half* of the issue. If we are to understand climate change, we need to understand the transfer of energy within the system. This includes the radiation fluxes in and out at the top of atmosphere and the exchange of energy between the atmosphere and ocean and atmosphere and land surfaces. These energy fluxes drive the changes in atmospheric and ocean state; observations of them are crucial to our understanding of current and future climate change.

The role of clouds in influencing climate is acknowledged in several places in the following chapters, but this chapter makes no reference to observations of cloud properties as an integral part of the climate observation strategy. There are many issues here that need to be addressed. For example, the advent of automated weather observations in the US and other developed countries has actually degraded our ground-based cloud observation data set. Do satellite observations make up for that loss? Will they in the future?

The chapter is very uneven in terms of the depth at which many issues are addressed. It has the appearance of being a compilation of several lists supplied by multiple parties, with little thought given to the partition of depth vs. breadth in those lists. Another important factor is the difference between ocean and atmosphere re-analysis. Ocean science here is much less advanced and the observational network has been much poorer. Also, the reanalysis really is largely relevant to the ocean mixed layer (I think). Some distinctions need to be drawn regarding which statements apply to the atmosphere and which to the ocean.

The chapter (and the larger document) provides very little guidance on priority. It is easy to generate the long lists. It is much more difficult to articulate a strategy for how these should be prioritized. Nowhere is this more difficult than in the field of climate observations due to the large costs implicit in the items in this list. From my perspective, this chapter needs to be thoroughly rewritten with a careful assessment of what is needed for a climate observing system and what we actually have in place. (As one of the panelists put it, you can't repair a system that has never worked.) Then the document needs to offer two choices. Either the US government puts a lot more money into the system and we actually get a climate observing system, or we have the same resources and we limp along as we have. It is not honest to pretend that we can have a climate observing system given the available resources. Finally, this chapter also needs to recognize that while we can do some things to improve some parts of the climate observing system in the short term, most of what we need to do will require long-term commitment and the fruits will not be realized for many years. It is not reasonable to assume that we can make substantive changes in climate observations in a two-year period.

**THOMAS ACKERMAN, PNNL**

Page 26, Chapter 3: Upgrading the Global Observational System" is mandatory - the first step that must be achieved is addressed, but is not sufficient. The first step focuses on the near term (i.e. 2 to 4 years) and on fixing deteriorated classical observing systems. Step two needs to address the use of new technologies for better, higher accuracy, more frequent observational data from ground systems. Satellite systems are addressed in the plan as it exists, but complementary ground-based facilities are not - questions exist as to what instruments, how many, in what areas, and communications capabilities need to be addressed, and are ignored. Continuously operating instruments that embody promising approaches from FTIR, Raman Lidar, DIAL Lidar, and passive microwave to cloud radar come to mind. 2. "Regional Observational Networks" is a concept that is needed, but is not addressed. What will be the strategy to achieve the necessary observational networks in key regions - what order; what instruments, what distribution; how will these questions be answered; and, that is the end desirable capability. 3. "Accuracy" and "Precision" requirements for climate observations are DIFFERENT than for weather observations. This is a change that is not well appreciated or understood. Part of the national strategy document needs to address how to identify requirements to be achieved and then how to achieve observational data of sufficient accuracy and precision. This may well involve improved classical instrumentation or a specifically designed "CLIMATE NETWORK" that is part of the World Weather Watch, but produces much more accurate and precise data.

**Comments on Chapter 3**

I hope these comments are useful - this is an important plan and it needs to credible and feasible. IT CANNOT DO EVERYTHING and that needs to be made clear. Thank you for the opportunity to comment.

**TED CRESS, PNNL**

Page 26, Chapter 3: This is a very comprehensive and general introduction to all aspects of climate change. However, in reading, or rather, wading through this exhaustive list of every possible aspect of climate change research, it occurs to me that a few important things are lost in the shuffle:

UNCERTAINTY: What level of certainty do we need to determine that human caused alteration of our climate system has occurred and is occurring? A similar question is raised on page 26 line 17 in the box, but is not answered by the subsequent discussion on page 27. We have achieved a certain degree of certainty on this front (66-90%, IPCC, 2001), and need to decide at what confidence level (90-95%?) we will be confident enough to consider the question answered and move on to the next step. CCSP is spending hundreds of millions of dollars toward this endpoint, yet no endpoint has been decided upon (e.g., page 72, line 23).

**NATIONAL PARK SERVICE**

Page 26, Chapter 3: It seems that long-term monitoring of atmospheric gases should be included in with Observations, Monitoring, and Data Management (Chapter 3). Perhaps it is a cross-cutting issue that should be mentioned *explicitly* as such in both Chapters 3 and 5, no matter how it is handled. Documenting chemical records is something that is important to understanding atmospheric composition and chemistry, but obtaining long-term records is a matter of conducting high-quality observations and managing the data from those observations. Many of the criteria for long-term observations and data management apply to the greenhouse gases as well. They certainly will form an important part of an observational network.

**NOAA/CMDL**

Page 26, Chapter 3: One absolutely essential feature of long-term high quality observations is that the observing program must be intimately tied to research to maintain quality control. Separating research from what is sometimes called "routine observations" is an open invitation to a gradually degrading performance in instances where the levels of precision and accuracy necessary for climate change are difficult to achieve. Having scientists abreast of such observations, trying to answer specific questions at hand with the data, provides the incentive to maintain the precision and accuracy necessary. This should be mentioned in these chapters.

**NOAA/CMDL**

Page 26, Chapter 3: The draft (p. 26) initially raises the question of how did "global climate change over the past fifty years and beyond," and what "level of confidence" exists for this data "in attributing change to natural and human causes." We are concerned that the draft seems, by this question, to focus on only "fifty years" of data. Additionally, under the heading "Products and Payoffs" (p. 28), the draft refers to "50 years and beyond." We think 50 years is too brief a period on which to focus and note that the IPCC assessments cover a longer period, generally 100 years. Further, the draft discusses the need to incorporate historical data as far back as 150 years to better understand climate variability (p. 27):

> Many individuals in many countries have gathered climate system variables using many different instrument types during the past 150 years to document climate system variability. In order to document and understand change from a historical perspective, we need to develop global, comprehensive, integrated, quality-controlled databases of climate system variables based on historical or modern measurements, and to provide the user community with open and easy access to these databases. We need to integrate these records as far into the past as is practical to reduce uncertainties in the climate trend estimates of individual parameters.

**FANG/HOLDSWORTH, EDISON ELECTRIC INSTITUTE**

Page 26, Chapter 3: 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 26, Chapter 3: The AASC has a strong interest and considerable expertise in the issues discussed in Chapter 3 including the US climate network (particularly the Cooperative Observer Network), data quality, climate monitoring, and making the climate record accessible to users. Some examples of this include active involvement with the Climate Database Modernization Project at NCDC, reconstructing climate extremes from historical accounts, developing and applying quality-control procedures to climate data, and working extensively at the state and regional level with users of climate information. Rather than building a new infrastructure to address the issues discussed in this chapter, it would be more effective to build on the existing network of climate expertise of the state and regional climate centers.

## Comments on Chapter 3

**AASC, ROGER PIELKE, SR.**

Page 26, Chapter 3: First Overview Comment: This chapter contains excellent suggestions for improving our new (monitoring) observations and comparing them to the instrumental record of the past. However, the instrumental record only extends 50-150 years into the past and this period completely overlaps the period during which anthropogenic climate change is believed to have taken place. A much longer record of climate variability is needed to answer three of this chapter's five questions: 1. How did the global climate change over the past fifty years and beyond, and what level of confidence do these data provide in attributing change to natural and human causes? 2. What is the current state of the climate, how does it compare with the past, and how can observations be improved to better initialize models for prediction? 4. How do we improve observations of biological and ecological systems to understand their response to climate variability and change? Only through the paleoclimatic record can we understand the full range of natural variability and have the ability to separate anthropogenic changes from natural variability. These records are barely mentioned in this chapter, and need a more prominent presence. Paleoclimatic and paleoenvironmental records have the ability to measure past changes in the climate system, often at subannual resolutions, and at the same time provide records of environmental responses to climate. Through paleoclimatic observations, we can generate multi-century and longer records in one to a few years. This gives us the only way to implement "retrospective" monitoring that extends our climate records back in time, while new monitoring and observing systems extend our record forward. The plan needs to consider these key, cost effective data sets.

**C. MARK EAKIN, NOAA/NCDC**

Page 26, Chapter 3: First Overview Comment: At the Dec 3, Observations and Monitoring Systems breakout session, a gentleman from the House Committee on Science made the statement that there really is not a monitoring plan within the Strategic Plan. I concur. As presently written, Chapter 3 is really a statement of need.

Second Overview Comment: In reality, an operational global climate observing system (GCOS) does not exist. Further, some existing operational monitoring systems, including NPOESS and some other weather parameter systems, are considered to not provide climate quality measurements. This is a big issue owing to the resource level required to operate and maintain these systems. A priority should be to make resources available to transition these operational systems to climate quality.

Third Overview Comment: All operational climate measurement systems require independent verification. For remote observations, this means ground touching. For in situ systems, this means comparison with near by sensors or perhaps, a different sensor technology.

Recommendation: A climate change panel should be sanctioned by the recognized community and given the charge to define climate quality standards for all desired parameters. I suspect this has already been done over the years. With those standards in place, the panel should then recognize existing operational systems that meet those standards. These existing sustainable systems become the backbone of the Global Climate Observing System (GCOS). Owing to the intensive resource requirements to maintain these existing sustainable systems, logic dictates that partnerships be created when and where required to densify the existing capability. Instead of creating new and independent infrastructure to satisfy data gap needs, the community should enhance the existing capability through partnerships. In the U.S., base funds should be made available to help partners fill these data gap needs. Once again, a panel sanctioned by the recognized climate change community would manage this process.

With this section, I would like to suggest why the NOAA/NOS real-time monitoring infrastructure should be recognized as the climate reference network for *in situ* U.S. coastal physical oceanographic measurements. This operational and sustained infrastructure includes both the National Water Level Observation Network (NWLON) and Physical Oceanographic Real-Time System (PORTS®) Program. The NWLON (water levels coupled with marine meteorology) is probably the best example of an existing system that is *in situ*, sustainable (over 150 years), National in coverage (175 locations), disseminates in near real-time (hourly), operational (24x7 quality control, field support, base funded, etc.), and includes integrated communications and data management. PORTS®, now with 10 sites, integrates any number of water level, current, wind, or other user specified measurements from multiple platforms within a specific harbor or estuary to provide the maritime transportation and resource management communities with accurate real-time information. Each PORTS® site is equipped with a commercial communications service that provides reliable real-time delivery of data. Quality controlled, current profile, time series now exist in excess of 10 years length from the oldest PORTS® sites.

NWLON water level measurements, along with measurements from up to 11 ancillary user specified plug-in sensors, are transmitted to headquarters hourly via GOES satellite. NOS quality controls both NWLON and PORTS® data on a 24 hours/day, 7 days/week (24X7) basis through the Continuous Operational Real-Time Monitoring System (CORMS), that is a staffed, centralized, quality control and decision support system. In addition, the NOS Ocean Systems Test and Evaluation Program (OSTEP) facilitates the transition of new sensor technology to an operational status and ensures that the instruments used to support NOAA's mission are safe, reliable, and provide measurements with known accuracy. The National PORTS® Database provides users with access to all quality controlled PORTS® data and information. Water level data and most meteorological data are available from the NWLON database.

NOAA is very interested in any and all potential coastal observations because these are viewed as opportunities that may lead to a densification and enhancement of the present NOAA coastal observation network that will allow NOAA to better satisfy traditional and emerging mission requirements. The goal is to work with partners to ensure that new data meet National standards to allow integration of the data into NOAA product lines.

**JOSEPH WELCH, NOAA**

## Comments on Chapter 3

Page 26, Chapter 3: The chapter puts a lot of emphasis on improving observations in the future. This is useful in the long term, but will not contribute meaningfully to narrowing uncertainties in the next 2-5 years. More emphasis should be placed on improving our knowledge of the past record through data archeology (for the instrumental record), creation of additional paleoclimate proxy data, and improved analysis of this data. Such work has a better prospect of short-term results.

Section 3 overstates the importance of surface-troposphere temperature differences in our understanding of climate change. The section should be careful not to lend credibility to the idea that the surface may not really be warming. An explicit statement in this section that the surface warming appears to be real, as supported by the information in the White Paper and the NRC's 2000 report, and as made in the Introduction to the CCSP, would help to clarify this.
**MELISSA FREE, NOAA ARL**

Page 26, Chapter 3: The overview discussion is fine, but the specific recommendations on observing systems are disconnected from the science issues. For example, are surface buoys and VOS measurements the best way to improve model estimate of air/sea fluxes? Maybe we could get better model performance if we worked to exploit satellite-based microwave radiometers, which are now revolutionizing studies of air/sea fluxes. But the point is not this specific measurement; rather the entire set of recommendations focuses on repairing or improving existing networks. We need a thorough, quantitative analysis of data needs based on model experiments and fundamental data analysis. We have not done this, and we continue to resist attempts to make these linkages between observations and modeling/analysis. For example, what are the sampling and measurement errors of the observed fields? Will the proposed observing systems reduce these errors? How do suites of observing systems work together? We tend to view observing systems as largely standalone systems. Are models prepared to assimilate these observations? Many measurements must be made over decades to understand processes, not just for monitoring. Ocean processes are a classic example where the inherent time scales are long.

Paleoclimate data is relegated to a very small role in the CCSP. Yet it is the only climate-scale data set that encompasses a wide range of climatic forcings. The Ocean Drilling Program is a critical component of this observing system but little is said about its role or about the need to improve paleoproxies. For example, the paleo record in the Southern Ocean leads to contradictory interpretations regarding the role of iron during the Last Glacial Maximum. Additional cores in specific regions could resolve this issue and provide a rigorous test of climate models.

There is an implicit assumption that if we simply make data available, policymakers will be able to make informed decisions. This will not happen simply because the science community wishes it would. In fact, decisionmakers are overwhelmed with information. We need to go the next step and deliver services, not data products. Such an approach requires close involvement between scientists who can add value and data producers.

Moreover, a new class of "brokers" who can move information and requirements between the climate community and those would use its services is needed.

**MARK R. ABBOTT, OREGON STATE UNIVERSITY**

Page 26, Chapter 3: Reconstructing the past 50 years of climate change is far too short. Several thousand years is the minimum requirement and longer is even better. For instance, ocean records show that the North Atlantic has been freshening continuously for more than the last 40 years. Longer records are needed to see if this is natural or anthropogenic. Historical records cannot be used to produce longer records, so geological investigations must be invoked. The research needs section completely omits geological research.

**WILLIAM B. CURRY, WOODS HOLE OCEANOGRAPHIC INSTITUTION**

Page 26, Chapter 3: Comprehensive Observations of Water Vapor, Clouds, and Aerosols

This chapter is focused primarily on surface-based and upper air sounding stations traditionally used by weather services. The objective is to transform this network into one that provides verifiable, climate quality, observations. The chapter addresses a problem that has needed attention for many years.

At the same time, there are other long-standing observational and monitoring problems that need attention. The proposed observational enhancements miss an opportunity to make headway on the water vapor and cloud feedback problem. With regard to temperature, water vapor, clouds, and aerosols, satellite observations should be analyzed in conjunction with surface observations. Improving surface observing capabilities, particularly capabilities devoted to water vapor, clouds, and aerosols, and distributing these capabilities globally, could lead to substantial payoffs in unraveling the myriad of feedbacks and interactions.

Past, present, and future satellite observations will prove crucial to learning how water vapor, clouds, and aerosols are varying. One can expect that a credible climatology of high quality satellite observations could begin with the TIROS-N series of satellites, at the start of the 80's. With the trends that will be seen in the coming decades, looking back from 2020 from TIROS-N to NPOESS, one should clearly be able to detect and characterize some of the regional changes that are bound to occur. But, the past data needs to be calibrated, using surface targets. It must be reanalyzed. For example, cloud properties are only crudely treated in existing archives. Much is to be gained by analyzing HIRS and MSU data in conjunction with AVHRR data. The same types of analyses should be followed through on NPOESS. Much is also to be gained in wedding the analysis of polar orbiter data to geosynchronous data. Such projects, however, require substantial dedication of resources and manpower, none of which the community has yet seen.

Satellite, enhanced surface-based, and conventional weather observations should serve as testbeds for model development. Here is where true coordination is needed: the development of climate data in conjunction with the development of climate models.

Water vapor, clouds, aerosols, should be assimilated in existing models that are used in prediction. Building models to perform the assimilation not only advances the climate modeling capability, but will help to define the observing system.

Undertaking such projects will require a core of dedicated and talented researchers who are given substantial financial support for software, computer power, data analysis, and model development. Where is the manpower to come from? It certainly doesn't exist now. The existing community is aware of all of the problems mentioned in the document, but is hard-pressed isolating and making headway on only a fraction of what seems to be called for. More workers are needed.

It's not only that more talent is needed, but the talent needs direction in order to accomplish some of the tasks addressed above, e.g., working out the calibration of historical satellite observations, reanalyzing the satellite observations with current, state-of-the-art algorithms, making the outcome of the analyses and the original data streams available to the community, creating climate models with assimilation capabilities, and using models to assess the capabilities of existing observation systems, etc. Such work can be undertaken only by a federal agency with whatever expertise can be mustered from the academic community and other government agencies. The model to follow is the NASA Science Team—a core of federal agency scientists focused on a mission with a group of other federal and academic scientists working in collaboration.
**JIM COAKLEY, OREGON STATE UNIVERSITY**

Page 26, Chapter 3: The instrumental record, and existing ecological observations, only extend 50-150 years into the past, and this period completely overlaps the period during which anthropogenic climate change is believed to have taken place. A much longer record of climate variability is needed to answer key questions posed in this chapter:
1. How did the global climate change over the past fifty years and beyond, and what level of confidence do these data provide in attributing change to natural and human causes?
2. What is the current state of the climate, how does it compare with the past, and how can observations be improved to better initialize models for prediction?
4. How do we improve observations of biological and ecological systems to understand their response to climate variability and change?

We already use coral skeletons to generate past (paleoclimatic) records of both natural and anthropogenic climate and we may soon be able to use them to reveal the impact of past climate on important ecosystems. These paleoclimatic and paleoenvironmental records have the ability to measure past changes in the climate system at subannual resolutions and at the same time provide records of environmental responses to climate. Through coral paleoclimatic observations, we can generate multi-century records in one to a few years.
**C. MARK EAKIN, NOAA/NCDC**

Page 26, Chapter 3: Chapter 3 describes a truly impressive series of climate related environmental measurements and observations. Our concern lies in the geographic

coverage of these measurements and observations. Currently virtually all the satellite and *in situ* measurements either being made or planned to be made are either land or ocean based and there are virtually no plans for significant efforts to be made to collect data relevant to the shelf and coastal marine environments. Not only is this transition zone between land and ocean highly important economically and socially for a significant proportion of the world's population, but it is also likely to be one of the most sensitive regions to climate change, as is evident by the recent alarming increases to the severity and extent of mass coral bleaching. It is also likely to be the region that will have most climate change related ecosystem impacts do to the ever-present anthropogenic stresses that make these systems more vulnerable to the changing climate. We fear that the main reason for the omission of these measurements and observations is one of practicality, since this is also one of the hardest regions to remotely sense and one of the harshest environments for *in situ* instrumentation. However we feel that this region of the world is far too important to ignore and needs to be included in the overall climate monitoring network. There are a number of agencies around the world with relevant expertise in this field, one of the more obvious agencies that could help in this endeavor is NOAA (in particular NOAA NESDIS and OAR who jointly run the Coral Reef Watch program).
**WILLIAM SKIRVING, NOAA/NESDIS; ALAN E. STRONG, NOAA/NESDIS; KAREN H. KOLTES, DOI**

Page 26, Chapter 3: Question from workshop panelist regarding the utility of remote sensing of sea surface temperatures to predict coral bleaching: "So what...how does a manager do anything once warm water develops?"

Response of Billy Causey, NOAA's Reef Manager, Florida Keys National Marine Sanctuary : "First I notify all the dive shops that a bleaching event is likely to develop over the next few weeks. I tell them that with the corals under stress, it is wise to encourage their clients to stay away from (don't touch) the corals, thereby keeping other compounding stresses to a minimum. We have learned, interestingly, that once a bleaching event begins to develop visibly, typically several weeks after the early warning is issued (satellite/CREWS), these dive shops want to understand the science that's behind the bleaching and we have a great opportunity for educating them, their clients, etc. -- enormous outreach opens up!"

"The ability to predict these events has given us incredible credibility in the local community .... and not just the science community. It gives people a sense that their tax dollars going to research money has real use and is being put to good use. It also gives them a way to relate to the research and monitoring that is going on in the field."
**ALAN E. STRONG, NOAA/NESDIS, WILLIAM SKIRVING, NOAA/NESDIS, BILLY CAUSEY, NOAA/NOS**

Page 26, Chapter 3: First Overview Comment: The focus of this chapter on the quality of climate observations is good and appreciated. This emphasis is critical to being able to develop sound assessments of the impact of climate on biological systems.

## Comments on Chapter 3

Second Overview Comment:  Section 4, dealing with observations of biological and ecological systems, raises important issues but appears to be rather vague as to exactly what types of biological and ecological data are needed and whether managed ecosystems including agriculture, agroforestry, grazing lands, and urban ecosystems will be considered along with natural ecosystems.  Managed ecosystems will probably be more resilient to climate change than natural ecosystems and may provide options to help mitigate some of the adverse effects of climate change.  In general, managed ecosystems seem to be under represented in the entire document which is disappointing since they are the ecosystems that humans are most able to manipulate in order to mitigate or adapt to climate change.

Third Overview Comment: While it is very commendable to try and coordinate climate observing and monitoring networks, it would be a shame if the effort stopped with just the climate data.  It is equally important to bring together all related data including biodiversity surveys, soil carbon data, results from $CO_2$ flux networks, etc. so that a complete picture of ecosystem responses to climate change can be obtained.

Fourth Overview Comment:  In general, Chapter 3 addresses the effects of a changing climate on ecosystems.  It does not, however, sufficiently address the effect of a changing climate on *managed ecosystems* (agricultural crops, domestic animal production, and forestry) which is probably most significant to the comfort and survival of a healthy human population.

Fifth Overview Comment: Because of possible critical problems associated with production of food, fiber, and forest products and changing climate, this reviewer feels more emphasis should be put specifically on the association of climate change with these systems and not so much on the general term of biological systems including discussion, research needs, and potential benefits and payoffs.
**STEVEN R. SHAFER, USDA-ARS**

Page 26, Chapter 3: The introduction and to a lesser degree chapter three are somewhat dismissive of previous and ongoing efforts. Of particular note are global observation networks. The U.S. should not try and reinvent the wheel but instead work to strengthen and expand existing networks, notably GCOS, GTOS, and GOOS. The US certainly must take a leading role, but it must act as an international collaborator to effectively expand and develop the networks in data sparse areas beyond the US such as most of the Arctic. The U.S. must also act internationally and collaboratively to rescue important past data collections.  This is generally addressed on page 29 lines 11-17, but it needs to be expanded with specifics such as describing which agencies would take the lead in coordinating U.S. efforts in global networks and some specific steps or recommendations on how the U.S. could better integrate with existing programs and networks.

**Second Overview Comment:**  Chapter three addresses both data collection (monitoring) and data management and these topics get rather confused. The monitoring section addresses broad issues but then mentions specific parameters as precise "research needs". The detailed parameters should be addressed in the discipline specific chapters and the monitoring chapter should spell out more of the political and logistical needs to enhance the quantity and quality of data coming from these networks. The chapter does describe the need for better interoperability or "bundling" of data, but this could be expanded.

**Third Overview Comment:** Data management should be a separate chapter, if for no other reason than to give it greater prominence. It will be very difficult to answer the questions that are poised without rigorous and comprehensive data management. Some specifics:

- The document should more clearly emphasize the need for *consistent* long-term time series.
- It should amplify the need for comprehensive data documentation adequate for scientists and policy makers to use the data 100 years from now.
- It should affirm the importance of active scientific involvement in data management to ensure 1 and 2 are achieved and to ensure continual refinement and improvement of data (e.g., through reprocessing).
- It is not enough to say that "adequate support for federal depository centers" (page 35 line 38) is required. The chapter must emphasize that data management needs, and scientific involvement in data management, must also be addressed at the research initiative or even grant level.

**MARK PARSONS, NATIONAL SNOW AND ICE DATA CENTER, UNIVERSITY OF COLORADO**

Page 26, Chapter 3:
**First Overview Comment:** The emphasis of question 1 regarding data archeology and continuing quality assurance needs to be focused more on the continuing efforts of the National Climatic Data Center (NCDC) and its Regional Climate Center (RCC) and State Climatologist Office (SCO) partners. The Climate Database Modernization Project at NCDC should be extended, with an increasing focus on data quality assurance after initial digitization of observations from $18^{th}$ to $20^{th}$ Century historical records. Extending bonafide climatological observations to 150+ year time series is of critical importance, and resources are needed to properly quality control these data.

**Second Overview Comment:** Question 2 covers the realm of real-time climate monitoring quite well. However, the U.S. Climate Reference Network and U.S. Cooperative Observer Network Modernization are not strongly represented in this initiative, in deference to global scale observational networks and satellites. While the latter are important, we should start by increasing our commitment to our own climate observation networks, which are presently deteriorating more rapidly than they are being replaced. NCDC and Regional Climate Center efforts are underway to create real-time assessments of the health of observational networks and to improve real-time climate system monitoring in cooperation with the National Weather Service, but need resources to improve this situation more rapidly.

**Third Overview Comment:** The goal of Question 5, to make the climate record more accessible, is the most important aspect of the Chapter 3 initiatives. Unfortunately, it seems to be demanding a fixed “one-size-fits-all” solution to providing data as diverse as tree rings and satellite imagery. Setting standards to make data accessible is good, and raw data should be available in a standard format, but there is much more to data accessibility. In regards to surface climate observations, a tripartite system exists in the U.S., consisting of the National Climatic Data Center (NCDC), Regional Climate Centers (RCCs), and State Climatologist Offices (SCO). This system is pursuing a goal in line with NOAA/NESDIS policies to develop a uniform system to provide raw climate data through NCDC, and formatted and derived climate information through a system that will be used by NCDC, the RCCs, and SCOs. Most users of climate data in the public and private sectors prefer that data are provided in a format suitable to their needs; a flexible system is required to meet their varied needs. A distributed system with multiple entry nodes but synchronized data is a solution in keeping with the pattern of the best system designs presently used. It would be anachronistic to expect all data to conform to one data set accessed from one location, setting up a single point of failure. In addition, the regional and state levels have local connections to users in their regions and states through the RCCs and SCOs that allow for better government service, and also provide conduits for stakeholder feedback. The present NCDC/RCC/SCO system would work better and reach more people with increased permanent resources, but it should nevertheless be recognized in Chapter 3.

**MICHAEL A. PALECKI AND JAMES R. ANGEL, ILLINOIS STATE WATER SURVEY**

Page 26, Chapter 3: Overview Comments on Chapter 3: Climate Observations etc. Several chapters (e. g. Chapter 6, page 78, Chapter 2, page 23 etc.) of the strategy plan emphasize the need for "regional test beds" and enhanced observing systems is emphasized. Chapter 3 however lacks regional specificity. We suggest that CCRI objectives of near-term reduction of key uncertainties and support for decision-makers might best be achieved through a regional test bed coupled to associated model-based analyses, incorporating the characteristics suggested on p27 lines 29-30, p28 lines 1 and 18-19, p31 lines 5-6 and 24-26, p33 lines 6-15 and 27-28, p34 lines 39-41, and p36 lines 1-2. The current global approach implied throughout Chapter 3 seems too diffuse to yield either practical near-term products or useful lessons toward achieving the payoffs suggested on p37. While overall observational improvements are admittedly essential, we believe that a demonstration of the effectiveness of an integrated observational/monitoring/data management/modeling project on a regional scale, would provide more impetus to national and international efforts than relatively minor adjustments to the many loosely coordinated ongoing programs.

We suggest that a high-latitude US region such as Alaska is suitable for such a "test bed" or "enterprise", given that:

- climate change in the region is expected to have global impact;
- its biological and ecological effects have already been documented in the region, in both marine and terrestrial ecosystems;
- yet there remain many uncertainties which could be reduced by an intergrated observational /modeling effort;
- the SEARCH science plan provides a basis for implementation; and

- existing facilities, observational systems, LTER sites, process studies and model comparisons could be readily integrated to achieve the objective.

**WELLER, ET AL, UNIVERSITY OF ALASKA FAIRBANKS**

Page 26, Chapter 3: (The following is the text version of the powerpoint presentation I gave at the meeting.)

**1. Improving international coordination**

· Crucial that the US response is closely coordinated with the international community.

· Additional support for observations especially in developing countries is crucial.

· Needs to be better, more objective assessments of the incremental benefits of adding observations using assimilation and models.

· Importance of the Integrated Global Observation Strategy as an organizing framework for satellite and in situ observations.  Needs to become a System.

  Links the space agencies through CEOS and the key international groups responsible for observations (WMO, UNESCO, UNEP, FAO, ICSU)

**2.  Improving international organizations**

· Support the global observing systems as organizations

  We need more than „international coordination and commitment‰ ˆ we need national commitments to support them.

· Raise the status of the global observing systems within their UN international organizations and amongst nations to make them work.

  It‚s wrong to talk about „repairing‰ something that has never worked.

· Highly inadequate international coordinating mechanisms especially for terrestrial climate observations.

  Absence of an international technical commission such as that established for oceans - joint body for oceanography and marine meteorology (JCOMM)

**3.  Land Observations**

· Land observations are essential to assess the impact of climate change on ecosystems and to understand ecosystems as forcing functions

· Operational terrestrial observations of land cover and ecosystem functioning are often inadequate.

· Need to support & link existing terrestrial in situ observations

· Requirements have been formulated in detail in several planning documents.

e.g., Terrestrial Carbon Observations; Global Observations of Forest Cover /Global Observations of Landcover Dynamics; Terrestrial Observations Panel for Climate

· In terms of products and payoffs we need to recognize the value of ecosystem services and how potentially these may be improved and worsened.

· Validation of products from space observations.

**4. Observations in themselves are not enough**

· Focus is needed on the products to be generated.

· Requires an end-to-end approach from observations to products and their use.

· Absence of a single critical component can prevent creation of the record

· Major example is land cover, where there are still no funded program to generate global land cover change products which are crucially needed and have been recommended for several years.

Despite having the observatory (Landsat), the acquisition strategies needed, the archives and the information systems.

**5. Accessibility of climate record**

· High priority for information accessibility

· Integrating distributed information systems nationally has improved

e.g., the Earth Science Information Partnership Federation (<http://www.esipfed.org>http://www.esipfed.org), but need to encourage this internationally as well.

· Obtaining data, products and records is usually much easier through the US than through international partners. US should work with international partners to improve access.

· Access to data is hindered by multiple interfaces to meta-data as well as the data themselves

· Too much emphasis in the report on architecture of heterogeneous systems: emphasis should be on interfaces and linking and the standards and protocols needed to achieve them. Authors should consult NASA materials associated with New-DISS and SEEDS.

· Needs to be explicit tracking of information so that conclusions can be tracked to the information and observations on which they were based.

**JOHN TOWNSHEND, UNIVERSITY OF MARYLAND**

Page 26: What about human systems?

**ANN FISHER, PENN STATE UNIVERSITY**

Page 26, Chapter 3: First Overview Comment: The first two questions do not appear answerable within the 2-4 year time frame of the CCRI and should be refocused on methodology. The work described under each question seems entirely reasonable and will certainly be relevant to the Fourth Assessment Report of the IPCC in 2007. The exact CCRI questions should be rephrased and focused less on yet-another review of recent climate history and the human role in it, and more on the development of useful data and datasets.

Second Overview Comment: The third question, which focuses on ecosystem impacts appears to posit a much greater understanding of ecosystems than we currently possess. It suggests that we will identify ecosystems that are either vulnerable or resilient to climate change when in fact we know very little about the vulnerability and resilience of any ecosystem. One could argue that beyond the most obvious cases of tidal wetlands and permafrost, we have little to guide us in assessing the relative resilience of ecosystems to environmental change. While data are always needed, a more productive first step in guiding this assessment would be a more synthetic and systematic approach, perhaps using workshops or congresses, focused on describing the salient features of different ecosystems across the United States.

Third Overview Comment: California would be excellent laboratory for studying the responses of biological and ecological systems to climate variability and change. The state is the most diverse in the nation along both rainfall and elevational gradients. The state has already conducted preliminary assessments of the ecosystems most vulnerable to climate change. State government has an active research program related to ecological effects and large state departments with considerable knowledge and expertise.

Fourth Overview Comment: This section correctly identifies the need for improving long-term records of climate parameters (e.g. temperature, precipitation) and climate proxies (e.g. paleothermometry, palynology), but it does not adequately emphasize the need to reassess the siting and spatial coverage of these observations. Recent research has shown that the underlying assumptions on which some long-term observing programs are based are no longer generally accepted by the global research community. Similarly, observing biases in space-based sensors due to inherent physical limitations or spatially variable validity of assumptions in interpretive algorithms need to be fully reviewed. This is especially true for comparing measurements over land and ocean.
Finally, and most significant, this section's focus on meteorological measurements fails to recognize the need for enhanced, <u>continuous</u> surface and airborne observations of gases and aerosols. The current practice of massive "snapshot" field programs entails an unacceptable risk of unrepresentative sampling and failure to observe infrequent but

significant events. Furthermore, the very variability that you seek to understand (e.g. effects of ENSO cycles, the northern annular oscillation, or even random variation) appears as uncertainty in such programs, rather than being a focus of understanding. We in the air pollution community have learned this lesson through bitter experience, and fervently hope that the global atmospheric community can avoid replicating our learning curve.

**CALIFORNIA AIR RESOURCES BOARD**

Page 26, Chapter 3: 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 26, Chapter 3: In general, Chapter 3 addresses the effects of a changing climate on ecosystems. It does not, however, sufficiently address the effect of a changing climate on *managed ecosystems* (agricultural crops, domestic animal production, and forestry) which is probably most significant to the comfort and survival of a healthy human population.

**Second Overview Comment:** Because of possible critical problems associated with production of food, fiber, and forest products and changing climate, this reviewer feels more emphasis should be put specifically on the association of climate change with these systems and not so much on the general term of biological systems including discussion, research needs, and potential benefits and payoffs.

**LOWRY A. HARPER, USDA-ARS**

Page 26, Chapter 3: Chapter 3 would be much stronger if it discussed not just the requirements for observations, but the need for careful and innovative data analysis. The chapter needs to include at least a page on how analysts greatly contribute to advancing our understanding. We could do little without them.

Section 3 regarding surface and tropospheric temperature trends would benefit from major revision to follow the key comments made at the workshop: in particular, the emphasis should be on understanding the vertical structure of atmospheric processes, and on a better understanding of the links between boundary layer, global energy cycle, global water cycle, and circulation. As it stands, the focus on a set of observations of a particular anomaly (some of which has already been shown to be related to errors in calibration and interpretation) is not a balanced discussion of the state of the science. This section needs a major revision.

**SUSAN SOLOMON, NOAA**

Page 26, Chapter 3: In order to understand and respond to the five questions, please consider utilizing NOAA's Cooperative Weather Observer network, the nation's largest and oldest weather network. It was established in 1890 to formalize the collection of meteorological observations and record climate conditions across the U.S.. Today, more than 11,000 Cooperative Weather Observers donate more than one million hours each year to collect daily hydrometeorological data. Please see July, 2002 NOAA Magazine article on the COOP Program at:
http://www.noaanews.noaa.gov/magazine/stories/mag45.htm or

## Comments on Chapter 3

http://www.noaanews.noaa.gov/ then click to July 2002 edition.
**ANDY HORVITZ, NOAA/NWS**

Page 26, Chapter 3: The focus of this chapter on the quality of climate observations is good and appreciated. This emphasis is critical to being able to develop sound assessments of the impact of climate on biological systems.
**JERRY L. HATFIELD, USDA-ARS**

Page 26, Chapter 3:
1.How did the global climate vary and change over the past fifty years and beyond, what were the climate forcings over the past 50 years and beyond, and what level of confidence do these data provide in attributing change to natural and human causes? **[To do attribution requires the forcings as well as state variables, and both detection and attribution require signal to noise analysis, which means variability must be fully taken into account.]**

2. What is the current state of the climate, how does it compare with the past, and how can observations be improved to better initialize models for prediction?

2a. How can we improve analyses of observations into globally gridded products?

**2b. How can we ensure that future observations can be compared with past?**

**[Should also deal with analysis of observations, including four dimensional data assimilation]**

3. How real are the differences in surface and tropospheric temperature trends? [Suggest rewording to:]
What is the vertical structure of climate change in the atmosphere, and how well do models reproduce it?

4. How do we improve observations of biological and ecological systems to understand their response and feedback to climate variability and change?

5. How accessible is the climate record? [Change to:]
How do we make the climate record more accessible?

Some nice discussion but not followed up with items in "Research Needs".

1. "go beyond observations to include the processing and support system that leads to reliable and useful products"
No item on analysis and four-dimensional data assimilation
Does include "Reanalyses"
Does not deal with variability, forcings, full fields needed for understanding causes, relationships and feedbacks. (**Attribution**)

2. Discusses scientific stewardship: monitoring performance of system and taking corrective actions.
No item on required infrastructure.

## Comments on Chapter 3

Deals only with baseline networks.
Does not deal with synthesis, esp. satellite and in situ (for ocean).
Does not deal with understanding.

3. Satellite vs surface: This is dealt with further below.

Overall comment:

**We do NOT have an adequate Climate Observing System!**

Instead we rely on an eclectic mix of observations taken for other purposes. But we can not create an observing system just for Climate! Observations MUST serve multiple purposes.
In the United States multiple **Federal Agencies** make observations for all sorts of purposes. Many could be useful for climate (with a bit more care). However:
**Coordination among agencies should be a high priority.**
Building knowledge of just what observations are made (as done for the UNFCCC in preparation for the 2nd adequacy report) is a key first step to better management.

In addition, real time knowledge of how the observing system is **performing** is essential. Along with the wherewithal to **fix** problems promptly.

I strongly urge these items be added in the sections.
**KEVIN TRENBERTH, NCAR**

Page 26, Chapter 3: The protocols and procedures for climate quality remote sensing could be initiated in the next 2-4 years. Little mention to ensure this.

Where is the interaction between these observations and the models?

Where is the research to determine what observations are most important and research on how best to initialize models with these observations?
**ANTONIO J. BUSALACCHI, EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER (ESSIC), U. MARYLAND**

Page 26, Chapter 3: I like the title of Chapter 3 which lists the very relevant issues of quality observations, monitoring and data management. Unfortunately, all of this is not adequately discussed in the text or reflected in the research needs.
**LYDIA DÜMENIL GATES, LBL**

Page 26, Chapter 3: **Observing Principles are Incomplete.** Need to add the 10 satellite climate observing principles adopted by the international GCOS (Global Climate Observing System). They are:

- Rigorous station keeping should be maintained to minimize orbital drift.
- Overlapping observations should be ensured for a period sufficient to determine inter-satellite biases.

- Satellites should be replaced within their projected operational lifetime (rather than on failure) to ensure continuity (or in-orbit replacements should be maintained).
- Rigorous pre-launch instrument characterization and calibration should be ensured.
- Adequate on-board calibration and means to monitor instrument characteristics in space should be ensured.
- Development and operational production of priority climate products should be ensured.
- Systems needed to facilitate user access to climate products, metadata and raw data, including key data for delayed-mode analysis, should be established and maintained.
- Continuing use of still-functioning baseline instruments on otherwise de-commissioned satellites should be considered.
- The need for complementary in-situ baseline observations for satellite measurements should be appropriately recognized.
- Network performance monitoring systems to identify both random errors and time-dependent biases in satellite observations should be established.

To solve this oversight: add to Pg 29, Line 26:
*"The CCRI will achieve these objectives by adhering to the 10 climate observation principles in the recent NRC report on climate observing systems, as well as to the 10 climate observational principles for satellite data that were adopted by the GCOS."*
**BRUCE WIELICKI, NASA LANGLEY RESEARCH CENTER**

Page 26, Chapter 3: **Missing a 21st Climate Observation Principle: Independent Climate Quality observations are required for each climate parameter: 3 are optimal, 2 are the absolute minimum.** Why? Because any surprise in the climate system will immediately need independent confirmation. This will happen often. The observations should be made with different observing types of instrumentation to assure independence. For some climate parameters this already exists: SST is measured from space by infrared imagers, microwave imagers, and infrared sounders, as well as by surface buoys. This gives 4 independent observation systems to resolve discrepancies and assure accurate error analysis. Others like broadband solar reflected radiation currently have only one climate quality estimate (CERES on EOS and ERB on NPOESS). Note that surface observations must have sufficient time and space sampling to count as one of the climate observing systems. There is a corollary to this principle: the algorithm and processing system software or code used to process the data will have errors. All codes of significant size have errors. The way to discover and eliminate these is to produce at least 2 different groups produce climate products for each climate instrument data set. A good example of how important this is has been demonstrated in the MSU atmospheric temperature record. Separate analyses by Christy et al. and Wentz have shown that significant (and yet unresolved) errors are still present in one or the other of these data sets. Again, there are several SST and surface air temperature analysis data sets: all of which have been key to determining confidence and accuracy bounds. We should think of this as code and algorithm calibration. NIST calibration standards represent an excellent example of why multiple measurements are required when high accuracy (e.g. climate) data is at stake. NIST follows instrument design, modeling, calibration, and validation in the laboratory to derive an error budget for each standard. Many other countries in Europe and other parts of the world do the same. When the standards are compared in a round-robin, typically the differences in the national standards are larger than the predicted error bounds (NIST, personal communication at the NIST/NPOESS/NASA Climate Calibration Workshop, Nov 2002). The conclusion is that since most climate quality measurements push the bounds of even NIST calibration accuracy, climate data sets must be provided by more than one instrument type to discover the true uncertainty. Hence the minimum of 2 instrument types. The ideal of 3 is to more definitively and quickly determine which measurement is the outlier. To provide this guidance, add the following paragraph at pg29, line 27 (just before research needs):

*"After consideration of the climate data accuracy challenge, we recommend following the experience of NIST in determining the accuracy of calibration standards. Each climate parameter should be measured by a minimum of 2 independent instrument approaches, and ideally 3. NIST and other nation's standard bureaus typically find during intercomparison of their independent results, that standards accuracy is less than they had predicted. Since climate accuracy requirements typically approach or exceed NIST standards, climate observations require a similar approach. Independent observations are needed to confirm surprising climate results, which are inevitable considering our current state of knowledge. Independent measurements are also required to attain a high degree of confidence when basing critical policy decisions on the climate record and its assessment of climate model performance. In addition, since the algorithm software used to analyze the climate data record will have errors: these will be discovered and corrected by comparing at least two independent analyses of each climate record. A recent example of why this is critical is the Wentz vs. Christy et al. analysis o the MSU satellite air temperature record. In total, a minimum of 4 data sets would be provided for each climate variable: 2 independent measurement types each with 2 independent groups providing climate data products. Several key climate variables such as SST (buoys, infrared satellite, microwave satellite), air temperature, water vapor, and surface wind speed already meet this critical independent measurement and analysis standard. Many others such as aerosol, cloud, and radiation budget do not. Since these later parameters are the largest uncertainties in radiative forcing and feedback, these and all key climate variables will be evaluated in light of the need for independent climate observations. "*

**BRUCE WIELICKI, NASA LANGLEY RESEARCH CENTER**

Page 26, Chapter 3: **Weather data is not necessarily good climate data. NPOESS is a good example of why key climate requirements either need to be added to NPOESS, or achieved with an independent climate observing system.** This result is coming out of a recent NIST/NPOESS/NASA workshop on climate quality calibration. Examples of needed improvements include:

- ability to make deep space lunar calibration for high spatial resolution imager solar reflectance wavelength bands (0.3 through 3 micron wavelength), and to use deep space to validate zero level of thermal infrared satellite data. This ability is already designed into the NASA Aqua spacecraft that is the basis for the NPOESS spacecraft. SeaWIFS does this manuever routinely (every 2 weeks) for lunar calibration. ERBS and TRMM spacecaft performed the manuever for zero level validation 5 to 6 times during mission life.

- ability to launch replacement spacecraft before instrument failure, and to turn the replacement on for sufficient overlap period to intercalibrate with the prior instrument. This will eliminate most of the data gap and climate record risk.
- require determination of a set of climate data record (CDR) requirements for NPOESS: accuracy and stability of measurement over nominal 7 year instrument lifetime.
- since calibration and characterization often happen near the end of the instrument build cycle: cost over-runs and schedule delays often eliminate climate quality calibration and characterization. These requirements must become CRITICAL NPOESS requirements in order to assure they are achieved despite shedule delays and cost over-runs.

This consideration of NPOESS and its potential role in the climate observation system suggest adding the following text to RESEARCH NEEDS: page 29, line 33:

"Assess the ability of the NPOESS weather satellite system to meet climate data record requirements and plan other options for these data if NPOESS cannot meet the requirements."

**BRUCE WIELICKI, NASA LANGLEY RESEARCH CENTER**

Page 26, Chapter 3: **We currently have no climate observing system.** Instead we have pieces of research and weather observing systems which were not designed to be a climate observing system, and do not meet its requirements. This is a major risk to achieving solid recommendations to policy makers. The argument over the MSU air temperature record versus radiosondes is a classic example of this problem: neither system was designed as a climate observing system. We desperately need to build such a system. NASA's Earth Observing System(EOS) , the DOE Atmospheric Radiation Measurement (ARM) surface sites, NASA's Aeronet aerosol surface network, the international Baseline Surface Radiation Network (BSRN), all are prototypes that demonstrate such a system is possible. But only some of the capabilities are being transferred from EOS to NPOESS and some are likely to have critical data gaps in the transition to NPOESS. ARM, BSRN, and Aeronet have no long-term climate data acquisition plans, and sites are often ad-hoc or very few. These and other systems need to be transitioned with research accuracy and operational continuity into a climate observing system. These are just some of the aerosol, cloud, and radiation data examples. There will be others in oceans, land, and ecosystems. The document does a good job of discussing surface and atmosphere air temperature and water vapor, but does not mention aerosol, cloud, or radiation networks: key to understanding climate forcing and feedback.

Add at Page 29, Line 40 under Research Needs:
"Stabilize and extend the current prototype aerosol (Aeronet), cloud (ARM), and radiation (BSRN) surface networks into all major climate zones to provide critical

surface-based climate observations of these key forcing and feedback climate parameters."
**BRUCE WIELICKI, NASA LANGLEY RESEARCH CENTER**

Page 26, line 4 Box Why is a fifty year timeframe selected? We have climatological data of 30 year averages, 40 year reanalyses, 100 year instrumented records?
**LYDIA DÜMENIL GATES, LBL**

Page 26, lines 6-7: So far, the CCRI has not provided any money, and even if the requested amounts are provided it is not providing much money given the challenge. A more circumspect statement is needed.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 26, Line 17: Question 1 targets the past 50 years. This seems far too short. "and beyond" is added, but "50" stands out and I fail to understand what drove its use. Sustained warming initiated in the 1920s and in the 1970s. Clearly, a solid view of the pre-industrial background is needed. International efforts to understand the recent climate in the southern high latitudes are focussed on a 200-year history of climate as a minimum. The CCSP text itself (page 27, line 16) states "150 years". I see nothing but trouble in the use of 50 years in this question.
**R.BINDSCHADLER/NASA**

Page 26, Line 17: Question 1 (between line 17 and 18) is a time frame much too short for meaningful investigation of long-term change. It is imperative that the paleoclimate record be considered when looking at change. The really dramatic shifts in global temperature came over very short periods and that is only evident from looking at a millennial scale.
**STELLA M. COAKLEY, OREGON STATE UNIVERSITY**

Page 26, Line 17: Question 1 in the box. What is so special about the past 50 years, other than it being a nice round number? The quality of the existing observational record should dictate the period under analysis, and this varies depending on the variable of interest. Just because we can run reanalysis models for the past fifty years doesn't mean that we can understand all climate changes equally well during that period. I'd suggest softening this to simply call for examination of climate changes for the longest period possible, depending on the utility of available data.
**DIAN SEIDEL, NOAA/ARL**

Page 26, line 19ff and p. 27, l. 33: In the text for Question 1. the issue of attribution needs more text and more detail instead of ...more can be done...
**LYDIA DÜMENIL GATES, LBL**

Page 27 under Research Needs (or possibly expand the first bullet on the top of Page 30): This chapter appears to be the best place to mention sea level rise measurements with existing tide gage stations. Some of these gages, such as the one at the Golden Gate in California, have long measurement records. But we are not sure how much of the apparent change in average sea level is ocean rise and how much is tectonic change or settlement. It is essential that an accurate determination of the vertical stability of such gages (or at least a goodly sample of them) be made, checking for long term vertical movement of the datum. Tools may now be available by use of highly precise space geodetic techniques, which can measure very small changes in vertical elevation. The measurements, if feasible, will probably take a period of several years. This would then give us confidence in the actual rise of sea level at a number of locations. The National Geodetic Survey does this kind of work.

**MAURICE ROOS, STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES. ALSO SUBMITTED FOR USGCRP GLOBAL WATER CYCLE SCIENCE STEERING GROUP**

Page 27, lines 1-3. This sentence represents a prime example of the perspective (incorrect in my view) from which this chapter was written. The implication is that climate is an initial condition problem just like weather forecasting. This is simply not true and flies in the face of what we know about predictability in complex dynamical systems. The information contained in the initial atmospheric conditions is lost within days; the information contained within the ocean has a longer time constant in some cases, such as tropical ocean sea surface temperature, but this time constant is still only months to a year. Climate is a boundary value problem where the boundary values are complex specifications of external forcing (e. g., solar variability) and internal forcing such as atmospheric composition (e. g., greenhouse gases and aerosol production). While the specification of the initial state is important, I strongly doubt that it is “key to meeting the complex challenge of predicting future climate”. I would agree that an improved initial state, particularly of the ocean, may help the short range climate forecasting problem (ENSO, for example), but even that has not been completely demonstrated. There is no evidence of what I am aware that shows the initial condition has any influence of time scales beyond 5 to 10 years.

**THOMAS ACKERMAN, PNNL**

Page 27, line 3. Observations are not generally 'input to climate models'; they provide tests of climate model but are not input.

**SUSAN SOLOMON, NOAA**

Page 27, line 3: Observed data are NOT “essential input to climate model”—that phrasing misrepresents how climate models work (note that the season-interannual models do require observations to be initialized, but that is not being indicated as the basis for improving the observation system). Instead, climate models need the observational data (and it need not all be global, but can come from intensives study of particular regions or processes) to help test their parameterizations and overall performance. The future projections of these models (so change “predicting” to “projecting” later in the sentence) are based primarily on the boundary conditions—not the internal conditions of the atmosphere.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

## Comments on Chapter 3

Page 27, line 8: Just to note that balloons and aircraft are generally considered “in situ” as well.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 27, line 8: Demands of instruments accuracy are much higher for the climate change monitoring than that for weather prediction. Instrument calibrations need to be stable for long time of periods for climate change monitoring. For example, the required instrument stability change (or repeatability) of radiation budget monitoring is less than 1 W m^-2 or 1% over the lifetime of instruments. Our understanding of accuracy of the instruments used for weather prediction is not that good (5\% accuracy of radiation measurements is usually good for weather prediction). Therefore, we cannot use data collected for weather prediction purpose for the climate change analysis. We need a different set of instruments of which calibration is well understood for climate change analysis.
**SEIJI KATO, HAMPTON UNIVERSITY**

Page 27, Insert end of sentence on line 9:
This may change, however, with the next generation of weather satellites associated with NPOESS, the National Polar-orbiting Operational Environmental Satellite System, where a replacement policy of launching on failure is anticipated.  Such a policy will no longer allow a period of measurement redundancy to ensure consistency, and will thus require that increased attention be paid to the instrument calibration and its reference to national and international standards.
**NIST, HRATCH SEMERJIAN**

Page 27, Line 10: suggest changing "centennial climate changes" to  "centennial (and longer-scale) climate changes" to capture some of the lower-frequency Milankovitch variations
**ROBERT M. CUSHMAN, ORNL**

Page 27, Lines 11-13: Just as lines 17-19 call for “global, comprehensive, integrated, quality-controlled databases of climate system variables based on historical or modern measurements”, we need similar records from paleoclimatic proxies. While such a database is maintained and made available by NOAA, we lack a comprehensive system to develop spatial networks of paleoclimatic data. Centennial to millennial reconstructions of climate have had to rely on irregularly distributed paleodata, often too sparse to truly reconstruct climate patterns. Greater resources need to be applied to developing proxy records using a network approach.  Additionally, many more records are needed from many parts of the world, including the tropics and the Southern Hemisphere. Finally, climate change and direct human threats already threaten many of these sources with loss before we can generate the records. Lines 11-13 need to call for a “global, comprehensive, integrated, quality-controlled network of paleoclimatic data - a Global Paleoclimatic Observing System”.
**C. MARK EAKIN, NOAA/NCDC**

Page 27, line 15: Change “gathered” to “observed” as we are not just interested in the assembly of information.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 27, Line 16: suggest changing "the past 150 years" to "the past 300 years" - version 1 of the Global Historical Climatology Network (http://cdiac.ornl.gov/epubs/ndp/ndp041/ndp041.html) includes station data as far back as 1697

**ROBERT M. CUSHMAN, ORNL**

Page 27, Line 17 and Page 26, Line 10 Chapter 3 Climate Quality Observations, Monitoring and Data Management addresses the need for “global, comprehensive, integrated, quality-controlled databases of climate system variables” and recognizes that an observational system needs to “include the processing and support system that leads to reliable and useful products.” Although this is an obvious point, it does bear emphasizing given the past history and current state of the data and information systems that have accompanied observational programs. Thus the need for recovering data that are not presently in an accessible archive as part of the CCSP is also particularly important. The need for advanced data and information systems that link distributed archives are really just beginning to make their way into the Earth sciences, and should be a priority under the CCSP. In general, the CCSP plan and the scientific community could probably benefit from making cyberinfrastructure issues more prominent. We need research at the interface between computer and Earth sciences, to get the most out of emerging and existing data.

**ROGER C. BALES, UNIVERSITY OF ARIZONA**

Page 27 line 18: [Comment: It is important to stress the difference between improved calibration and quality controlled. To many people quality-controlled data means that out of range data and instrument failure periods are eliminated. This is not good enough for climate quality data.]

**BILL PORCH, LANL**

Page 27, Line 18: suggest changing "quality-controlled databases" to "quality controlled, and documented databases" - without information on instrument changes, time-of-observation changes, station moves, etc., long-term trend analysis is jeopardized

**ROBERT M. CUSHMAN, ORNL**

Page 27, line 19: Change “or” to and as we are not advocating one or the other, but both.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 27, lines 22-23: The statement here is very misleading: NWP-style assimilation of data is **NOT THE ONLY** data analysis tool, it is not even the best tool when we are trying to develop understanding. This statement should be revised to indicate that, in scientific research, there are several forms of data analysis: (1) basic measurement analysis, since usually the actual measurement requires some “retrieval” procedure to transform it into the physical quantity needed (especially for remote sensing measurements), (2) various ways to combine separate, disparate measurements into more complete, consistent and homogeneous descriptions of the system’s space-time variations (assimilation is just one way to do this), (3) various diagnostic calculations where combinations of separate measurements are used to derive other relationships among the physical variables that are indicative of processes, and (4) analysis of all of these forms of data products to understand how the climate works.

Item 4: This whole section needs to be re-worded to indicate that work needs to **begin** on this whole set of topics: there is no way that this question will be answered in 2-4 years! Maybe this whole set of questions should be part of GCRP, not CCRI. If there are some key long-lead items that must be started now, they are a proper part of CCRI.
**WILLIAM B. ROSSOW, NASA GODDARD INSTITUTE FOR SPACE STUDIES**

Page 27, line 22ff. It must be noted that the reanalyses are primarily useful for measures of atmospheric temperature and circulation, with some limited applicability to atmospheric water vapor. The measurements of water vapor in the upper troposphere prior to obtaining satellite radiances are of marginal utility. Reanalysis cloud fields are simply the result of the cloud parameterizations used in the particular model and thus are no better than the parameterizations themselves. Since these parameterizations do an often uncertain job of generating clouds and cloud properties, the generated cloud fields are of limited value. Similar statements can be made about the other terms in the energy budget such as surface fluxes.
**THOMAS ACKERMAN, PNNL**

Page 27, Modify at the end of line 25:
Such a strategy will fail unless the approach and the standards used to calibrate the sensor together with the validation record are well documented.
**NIST, HRATCH SEMERJIAN**

Page 27, lines 23-25: The model-based reanalyses have NOT been particularly successful for assessment of long-term climate change due to a variety of problems. We should not rely too heavily on future reanalyses as a basis for narrowing uncertainties.
**MELISSA FREE, NOAA ARL**

Page 27, line 28: To what does “This” refer?
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 27, line 31-33: this seems to be needlessly criticizing the IPCC for being disorganized and slow in informing "climate-related policy" - how will CCRI improve on that aspect of IPCC? the suggestions of data mining and reanalysis are intriguing, but not a major shift from what's already being done.
**PHILIP MOTE ON BEHALF OF THE CLIMATE IMPACTS GROUP, UNIVERSITY OF WASHINGTON**

Page 27, lines 31-35: These lines state that much of the information generated by the Intergovernmental Panel on Climate Change is "not routinely updated and integrated into a clear, comprehensive assessment, nor is it combined into a convenient format for policymakers." This is a bizarre statement. The 2001 IPCC TAR is the latest update on a

research effort that started in 1988. The Summary for Policy Makers (SPM) of the 2001 IPCC TAR presents the major findings of the report in a clear and convenient format.
**ESTHER MECKING, STANFORD UNIVERSITY, BURKE MOUNTAIN ACADEMY**

Page 27, line 31-35. The discussion of IPCC would be more accurate if it drew the distinction between assessment and research planning. IPCC assesses research, which is a process that must occur on a slower time scale than the research planning and timely updating that are the goals highlighted here. It is not correct that IPCC does not put material into convenient formats for policymakers -- IPCC explicitly produces short summaries, both technical summaries and summaries for policymakers that have certainly been of use in many applications. I suggest the following rewording: " The Intergovernmental Panel on Climate Change (IPCC) assesses climate changes and variations on a time scale of about five years, but IPCC does not do research, nor does it attempt to provide interim fast-response information. IPCC's goals address a broad and global community, while the US research program can be tailored to US needs. Routine updates on rapid time scales would provide additional information of complementary benefit to policymakers."
**SUSAN SOLOMON, NOAA**

Page 27, line 33: Change "policy" to "development and evaluation of policy options" or something similar. The phrasing here makes it sound as if the observations will be gathered and tilted toward particular policies.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 27, lines 34-35: Is the phrase "not routinely updated and integrated into a clear comprehensive assessment" intended as an insult to the IPCC—sounds that way. Phrasing should be changed. And what does the phrase "convenient format for policymakers" mean, and the implicit notion that just seeing a clearer summary of the observations will change the minds of policymakers needs to be expunged, as there is no indication that this is what is holding up the decisions of policymakers (if there really is, please indicate it).
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 27, Line 37: Add the following bullet to research needs:

- To establish the future historical record develop a new generation of stable, robust, and inexpensive sensors which are accurate, easily calibrated to national and international standards, and not prone to calibration drifts or shifts.

**NIST, HRATCH SEMERJIAN**

Page 27, lines 37-42: Not mentioned in Chapter 3 under Question 2 is the possibility of obtaining records of data from nature. Specifically, this would include polar firn and polar firn air, which recently has been useful in documenting 20$^{th}$ century trends of numerous atmospheric trace gases, but it also should include analyses of sediments in areas of high deposition, glacial ice, particularly in the mid-latitudes, and chemical analyses of trees (i.e., tree-ring analyses). We should be open to the introduction of new

data or measurement of additional indicators from repositories of past environmental information.
**NOAA/CMDL**

Page 27, lines 38-41. While these are fine statements, the reality of the climate record is such that we are quite unlikely to achieve quantitatively useful global climate records by data archaeology. There are useful tasks that can be accomplished primarily on a regional basis. Calling this out as a key research strategy, however, promises much more than can be delivered.
**THOMAS ACKERMAN, PNNL**

Page 27, Lines 38-39: We strongly endorse data archeology/mining but this should not be confined to specific events. What is an "event/trend " depends on the nature of the problem and may be identified differently according to that. This activity requires resources that are often lacking because grant reviewers want to see science problems, not data rescue.
**ROGER BARRY, NSIDC**

Page 27, Line 38: archeology is a vague term. Is it redundant with "mining"?
**JAMES BONTA, USDA-ARS**

Page 27, Lines 38-41 (Research Needs): *Perform data archaeology and mining for specific climate related events and trends using rehabilitated records. Begin to reanalyze historical records to improve data fidelity so they are more useful for improved long-term climate records*. NOS tidal records are some of the oldest geophysical records in existence (over 150 years). In addition to these records, concurrent records of water density, surface temperature, and air temperature (late 1800s through 1994) are now being digitized. Digital marine meteorological (wind speed and direction, barometric pressure, and air/water temperature) exist at these sites since 1995. Tidal current measurements are available from as early as 1890. These are acquired to maintain the adequacy of NOAA's Tidal Current Prediction Tables. The first PORTS® installation was established in Tampa Bay, Florida, in 1992.

The climate community has been using the data sets provided by NOS for decades in applied and basic research activities. These include, (1) estimating global sea level variations on decadal-to-centennial time scales, including estimating trends and accelerations due to global warming; (2) characterizing seasonal-to-interannual events such as "el Nino"; (3) studying recurrence frequencies and magnitudes of storm events; and 4) most recently, verification and calibration of the various satellite altimeter missions.
**JOSEPH WELCH, NOAA**

Page 27, line 39: What is a rehabilitated historical record? Longer, higher quality, more agreement with other contemporaneaous variables?
**LYDIA DÜMENIL GATES, LBL**

Page 27, lines 40-41. What does this mean? I found this statement unclear.
**SUSAN SOLOMON, NOAA**

Page 27, line 41: Change "improved long-term records" to "study of the long-term climate" to make more sense.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 27, Line 42: Add a third bullet: "Fund the collection of proxy climate records to contribute to a Global Paleoclimatic Observing System".
**C. MARK EAKIN, NOAA/NCDC**

Page 27 line 42: Improve methods for screening of urban heat island, land-use including regional water vapor and aerosol effects.

Improve factory calibration services to include before and after calibration results to adjust instrument drifts.

Develop as many on-site calibration tests (on site comparisons) as possible to insure data quality.
**BILL PORCH, LANL**

Page 28, line 2. Atmospheric reanalyses have proven to be very useful tools and I expect this to be true of ocean reanalyses also. However, it is unlikely that they can be usefully extended back beyond about 1950. A useful reanalysis depends critically on the quality and quantity of assimilated data. The data prior to the mid part of the last century is inadequate on both counts.
**THOMAS ACKERMAN, PNNL**

Page 28, line 3: It would be helpful to indicate what might be expected of this assessment—is it of how the system is working, of the results, etc.—and if of the results, this would best be done as part of an overall integrated assessment. Really, I think the word "evaluation" might better be used here to avoid confusion.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 28, Line 4: This is your justification for the bullet above. Improved collection of proxy records is necessary to reach beyond the historical instrumental record.
**C. MARK EAKIN, NOAA/NCDC**

Page 28, Line 6: Should read "from historical and paleoclimatic data"
**C. MARK EAKIN, NOAA/NCDC**

Page 28, L7 - Question - It has not been shown that initial conditions are important for climate projections longer than 1 year. Longer projections are mainly a boundry value problem, not an initial value problem as in weather forecasting.
**RONALD STOUFFER, GFDL/NOAA**

## Comments on Chapter 3

Page 28, lines 8ff **(15-S)** (This is a general comment on the section about question 2, “What is the current state of climate...”): I believe that a paragraph would be useful in this section to point out the differing needs for observations for climate research and for initializing weather forecast models. There are large overlaps, of course, but climate has its own requirements, and these shouldn’t get confused with NWP needs. In particular, the initialization issues that NWP has are strong drivers of much of the observational planning for that purpose, while, as pointed out in this section, complete coverage (in terms of processes and so on – not only winds, temps, water; but also radiation, surface characteristics, the oceans below the surface) is a strong driver for climate. I’ll be glad to draft something if this seems appropriate to add (although I’m sure that others could do a better job). I believe that such an addition here would pay off particularly in Chapter 12, first section (Page 132ff.).

**HP HANSON, LANL**

Page 28, line 9. There is no such thing as the global climate observing network.

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

Page 28, line 9ff: In the discussion of Question 2 it needs to be clearly stated what the purpose of longterm monitoring is as opposed to establishing the state of the climate system (atmosphere, land, ocean and bio-geochemical aspects). What are the relevant required networks of observations in time and space? What bio-geochemistry data will be required to initialize fully integrated carbon cycle models and vegetation? Please cross-reference. This is an area that would benefit from a discussion of what quality levels are required, how these can be established and what relevant climate information would be appreciated by the users (cf. p. 146, l. 1-3). GCOS et al. are mentioned and some guidance may be taken from the documents of the associated programs.

**LYDIA DÜMENIL GATES, LBL**

Page 28, line 8ff Is the current state of the climate the characterization of present-day climate? What is the meaning of "past" in this text? Sometimes it is suggested that past , i.e. paleo-climates are compared with present-day climate. this could be 400 or 100,000 years?.Why is the initialization of models an issue here? Is it because of the poor knowledge that we have of the present state of the ocean including its surface flux exchange with the atmosphere that leads to long spin-up times for coupled model simulations and the necesssity of flux correction? Please add text.

**LYDIA DÜMENIL GATES, LBL**

Page 28, Line 11: suggest changing "mean state" to "mean state (which is itself based on recent observations, e.g., the preceding three decades such as 1961-1990)"

**ROBERT M. CUSHMAN, ORNL**

Page 28, Lines 13-14: question the sentence "The future state of the climate is predicted by starting from the present state of the climate" - I believe that some climate models spin up de novo

## Comments on Chapter 3

**ROBERT M. CUSHMAN, ORNL**

Page 28, line 13ff. Once again, this chapter seems to see climate prediction as analogous to weather prediction, that is, dependent solely on initial conditions. The importance of climate observations lies in understanding climate sensitivity and climate history, not in climate forecasting.

**THOMAS ACKERMAN, PNNL**

Page 28, lines 13-14: This statement is INCORRECT unless it is referring to seasonal-interannual forecasts—that this statement is included suggests a fundamental lack of understanding about why observations are needed for long-term climate studies, or brings to the fore the problem of this plan not separately addressing seasonal-interannual and long-term climate prognostication. Long-term projections (not predictions) of climate do not begin with the state of the present climate, but most often begin with conditions typical of 1860 or 1900 and simulate the 20$^{th}$ century as well so that an evaluation of performance can be done. I know of no simulations really starting from the present state (some start from the present state of atmospheric composition, but with an atmosphere-ocean state from a previous run starting at earlier time), and doing so would require great care to ensure proper account is taken of lag effects.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 28, lines 20-25: **General comments**: This section was not written by someone with a broad perspective on where most climate records, particularly for oceans, have come from.

Climate relevant data sets come from records of well over 100 years duration, not fifty-year or so.

Background info: The world's ocean shipping and fishing/whaling industries have provided the longest ocean data series, which internationally coordinated records were brought together initially through the efforts of Mathew Fontaine Maury – in the 1850s. Since that time, there have been several efforts to collate a larger data set, but the best effort has been that initiated by Dr. Joseph Fletcher, ex-Director of NSF Polar Programs, and ESSA/NOAA Environmental Research Labs, in the Comprehensive Ocean and Atmosphere data Set – or COADS, maintained at NOAA's National Data Center in Boulder, CO. Recent initiatives brought the data set entries from ship logs as far back as the late 17$^{th}$ century.

Meanwhile, the most densely collected ocean observation sets derived from the Cold War era, and as an importantexample, the most data-rich period of observation and reporting from the equator northward in the Pacific Ocean, was when the US oceanic fishing fleets were recruited into the observing system. These efforts extended the EASTROPAC data set, as well Pacific-wide records as the US fleets expanded their fishing activities. Analogously, Japan's cooperative ocean observation set was also replete with observations from high seas fishing activities, and when entered into the COADS, in the early 1990s, nearly doubled the ocean observation set for the recent fifty years, and expanded the global coverage dramatically.

**Thus, the lines 20-25 should include a short note to the effect that:**
The re-establishment of the cooperative ocean observation programs that have degraded in recent decades, due to numerous poor decisions within agencies, and general separation of ocean going cultures from science observing systems, is imperative, if in situ calibrations and instrumental observations are to reach their maximum utility.
Gary D. Sharp, Center for Climate/Ocean Resources Study

**Followed by complete description of new option – as follows:**
A second, more recent source of valuable ocean observations is available through the various 'animal tagging' projects, now reaching Global Status, as techniques and tools have evolved rapidly. The Tag-A-Giant project, led by Dr. Barbara Block and her associates, has led the field through their focus on oceanic fishes, particularly the Atlantic bluefin tuna, whose migrations include the entire North Atlantic and Mediterranean Sea. They have evolved and thoroughly tested archival tags that allow observations to be taken periodically; at intervals from 20 seconds to minutes between data collection events. For example, depth, temperature, time, and light levels have been archived every two minutes for up to and over four years for individual fishes, whose travels include sun-up – sundown dives to over 800 meters, and trans-Atlantic migrations from the Carolinas, to western Spain, into the Mediterranean, into the Gulf of Mexico, and as far north as the Flemish Cap and eastward to the English Channel. Similar records exist for large fishes and marine mammals for the North Pacific Ocean, and from Antarctica into the Southern and Indian Oceans. Shorter-term deployment records abound.

The most important recent innovation was the development of the archival pop-off tag, which is deployed on individuals, and is preset to release on specific dates. The tags then float to the surface, and radio-transmit the contents of their archive to satellite systems that in turn transmit these values to ground stations where they are held for relay to the initiating research labs, where they are geolocated using the light level data, and related SST observations from remote sensing systems.

These animal-based research activities have been cloned, and applied around the world. Along with several independent research activities where ocean observations have been made over variously tracked species, it is known that the animal's travels and diving behaviors, differ by species, and a diverse set of animal deployments provide very useful information o ocean dynamics, on all time and space scales. Both types of activities have recovered archival instruments initially deployed on marine mammals, large fishes, and oceanic birds. Large marine mammals, turtles, and sharks have been carrying radio-transmitter devices that deliver ocean observations (T-D) daily, via satellites, that also allow geolocation to relatively high resolutions. Particularly productive have been the studies of Antarctic and North Pacific seals and large migratory seabirds, both of which have been deployed using similar technologies for over a decade. All together, these animal-ported observation tools are more prone to cover large areas, thoroughly, and consistently, than the usual shipping-lane tracks that dominate the ocean records to date.

All of these records can be compared to, and added into the array of conventional observational data from the conventional physical oceanography's toolkit, and used to assess both regional and temporal scale transitions and dynamics. These records would be of particular interest to ocean modelers, particularly those whose efforts include understanding daily-scale upper ocean dynamics, down through the thermocline, into the deeper ocean.

The Sloan Foundation's Census of Marine Life (CoML) project has recently initiated a North Pacific archival tagging program, Tagging of Pacific Predators (TOPP), that is nearing it's final testing stages, and planning it's next, more coordinated release of 4000 or so animals, comprising a dozen or so wide-ranging species, from near the Equator to Alaska. Preliminary tests and tracks have proven that much of the Pacific basin will be sampled, and both coastal and open ocean observations will be useful in ongoing ocean monitoring and modeling projects.

The second bit of good news is that the GLOBAL GLOBEC Program has just blessed the CLIOTOP project, the Climate, Oceanography Tagging of Predators project, put forward by staff of the French Institute for Research and Development, IRD, involving efforts to coordinate all such studies in all of the major ocean basins, with the CLIOTOP project administered by diverse participants. The coordination of activities and results will be handled by the IRD staff stationed in the Seychelles, where a major new effort is being focused by the recently converged French researchers from previous similar efforts, i.e., Fr, Polynesia's ECOTAP, and related projects in the Atlantic and Indian Oceans. The Seychelles Fishing Authority has promoted and implemented ocean observations amongst its fishing fleets since its inception, in the late 1970s, and hence more than doubled the observation set in the region.

**RESEARCH NEEDS:**
The various TOP projects are in the final planning stages for the development of a generic TOOLKIT for delivery of animal observation data sets into the world ocean atmosphere archives. As well, the integration and analysis TOOLKIT is being finalized, using existing Global Data Management techniques, and integration systems. The integrated data-shopping capability will be central to further use in both analysis of the integrated observations, validation and verification of the diverse quality observation types, and eventual analysis of animal behavior and responses to environmental changes, visualization TOOLKIT.

**PRODUCTS AND PAYOFFS:**
In general, these TOP approaches will enhance the existing ocean observing systems, planned or ongoing, and provide considerable insights to more than only Climate Change, particularly as the various species involved are notoriously responsive to seasonal and climate level signals, and give nearly instantaneous insights into unique changes – as they occur, through general behavioral shifts, and group responses. Also, the funding levels, in contrast to ocean-going research programs and high-tech oceanic bouy system maintenance, is much more defensible, and likely for renewal, and sustained applications

in economically important fisheries management and coastal ocean monitoring are more likely to receive continued support, while providing valuable climate-related information for both physicists, and living resources managers. Along with all these particular species studies, there is tremendous public interest. The wide range of insights that will evolve will provide a long needed information core for related public education options.

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

Page 28, line 22 insert as below:

Balloons, flux towers, and samplers. The complex and varying measurements made by these sensing need to be interrelated by reference to international standards traceable to the SI units.

**NIST, HRATCH SEMERJIAN**

Page 28, line 23: I would suggest saying "brought up to the best available technology and methodology." Of course, care must be taken in doing so to address continuity issues.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 28, line 28: Change "the fact" to "being introduced" as facts are pretty hard to come by.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 28, lines 29-36: An example would help some readers.

**ANN FISHER, PENN STATE UNIVERSITY**

Page 28, line 38: I am pleased to see this absolute assurance about what the CCRI will do, but really suspect it is likely to be more wishful thinking than reality, and would suggest more caveated wording. Accomplishing this will require much more money than the CCRI has so far proposed.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 28, line 39 modify as below:

initiatives to provide a more definitive observational foundation tied to national and international standards for determining the current state

**NIST, HRATCH SEMERJIAN**

Page 29, line 2: What are "upper air atmospheric measurements"—is there any other upper air? And is this really the case?

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 29, Line 6: "disappointing results" - Is the problem funding or poor science or what?

**RONALD STOUFFER, GFDL/NOAA**

Page 29, Lines 8-9: Change to "Over land, the great spatial heterogeneity requires more measurement sites." (It does not require extremely detailed measurements).

**STELLA M. COAKLEY, OREGON STATE UNIVERSITY**

Page 29, line 12ff. While not wanting to disparage the great deal of work that has gone into the Global Observing Systems studies, these systems are again predicated on observing the state of the system and fail to address the energy flow in the climate system.

**THOMAS ACKERMAN, PNNL**

Page 29, lines 15-17: The status of the G3OS is assessed in the GCOS Second Adequacy Report for SBSTA/UN FCC now in draft form, Dec 2002 (URL: http://www.wmo.ch/web/gcos/adequacy/Adequacy_Summary.htm). This document should be the basis for assessing observing system needs. Implementation needs to be geared to the particularities of the variables of interest. For terrestrial variables there are no established networks in some cases (e.g. frozen ground); in others (e.g. glaciers) the networks are woefully inadequate due to sustained funding cuts in the observing programs and absence of resources to assemble data bases. Only 40% of the estimated 160,000 world glaciers are even minimally documented in the World Glacier Inventory and many errors are known to exist. The locational accuracy assigned the individual glaciers (for earlier national security reasons) does not allow most of them to be identified unambiguously. Mass balance records needed to assess change in sea level and water resources are available for only about 60 small glaciers poorly distributed in space. There are no centralized archives for global snow depth and water equivalent, nor for freshwater freeze/break up, both GCOS Variables. Projects designed to remedy these situations are seldom, if ever, funded except as short term research projects. Data rescue is likewise piecemeal.

**ROGER BARRY, NSIDC**

Page 29, line 16ff. The full implementation of the G3OS will require a massive infusion of resources, which at this time is simply not evident in the US system. This plan needs to take a realistic perspective. Either the US has to allocate significant new resources to this issue (much larger budget amounts than are currently being discussed) or we have to accept the fact that our climate observing network will continue to decay.

**THOMAS ACKERMAN, PNNL**

Page 29, lines 22-26: This really applies to seasonal-interannual predictions and not to long-term projections. It would really help if there were a differentiation of needs indicated.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 29 line 28 to p. 30, line 29: The list is very incomplete. See Second GCOS Adequacy Assessment (Draft) Report, Dec 2002. (URL: http://www.wmo.ch/web/gcos/adequacy/Adequacy_Summary.htm)

**ROGER BARRY, NSIDC**

Page 29, starting on line 28: Not acknowledged in the list of "Research Needs" are observations of anthropogenic forcing agents other than carbon dioxide, ozone, and aerosols. A broader list of gases and albedo changes should be included. Reference to

these other forcing agents is made later in the report, e.g., on page 61, and albedo is discussed in Chapter 8.
**NOAA/CMDL**

page 29, line 29 There is no mention of the need for next-generation sensors and data products. All of the recommendations revolve around improvement of existing networks.
**MARK R. ABBOTT, OREGON STATE UNIVERSITY**

Page 29, line 29: This is a really ambitious objective, if it is what CCRI is thinking it will do for "all" networks.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 29, lines 29-42: Where is the satellite component?
**ANTONIO J. BUSALACCHI, EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER (ESSIC), U. MARYLAND**

Page 29, lines 34-36: What specifically is meant by "improve atmospheric column observations..."? In breakout group 15 Tom Karl mentioned a vastly improved in situ sounding system, dedicated to climate. This recognition that the existing operational radiosonde network doesn't serve climate needs is crucial, but it is not explicitly reflected in the plan. The implication, on lines 3-6 of page 29, that the GUAN would be adequate if the stations reported regularly should be discarded.
**DIAN SEIDEL, NOAA/ARL**

Page 29, line 35: Suggest changing "repairing" to "fully implementing"
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 29, line 37-39. This research need is much more specific than the others in the group and lacks any supporting documentation. Why is the Asia Pacific area more important climatically than Africa? I doubt there is any real justification for that statement.
**THOMAS ACKERMAN, PNNL**

Page 29, line 37: Aerosols and ozone relevance and location iof measurement needs in Asia not supported by text above. Lydia Dümenil Gates, LBL cross-reference to p. 72, l. 4-5.
**LYDIA DÜMENIL GATES, LBL**

Page 29, lines 37-39: GAW stations don't measure emissions, but rather concentrations. It would be useful to add some discussion to this section about how the GAW program fits into the goals of the CCSP, which would explain why improvements to the GAW network are vital to climate observations. That discussion could also include an evaluation of other enhancements to the GAW network that would help to meet CCSP goals. For example, measurements of black carbon at GAW sites would fill a major gap in the current global aerosol climatology.

## Comments on Chapter 3

**NOAA/CMDL**

The World Meteorological Organization (WMO) should be listed along with the other organizations in lines 30 - 33 on page 157.

**NOAA/CMDL**

Need for explicit mention of important greenhouse gases and other involved gases in Chapter 3 and Chapter 5. Granted, the measurement of some of these gases is mentioned in Chapter 5 (Atmospheric Composition), but this should be clearly cross-referenced between the two.

There are some gases listed in the Kyoto Protocol as potentially significant greenhouse gases that are alluded to in the document, but not mentioned explicitly (e.g., p.61, 64, research questions) and elsewhere. They are the perfluorocarbons, (PFC's), the hydrofluorocarbons (HFC's), and sulfur hexafluoride ($SF_6$). These are extremely strong greenhouse gases with atmospheric lifetimes of thousands of years. At present they are low in atmospheric concentration and some have yet to be emitted, but once emitted, they remain and accumulate in the atmosphere, as some already are doing. We need more than the study of the properties of these gases (e.g., p.64, lines 13-14); we need to be monitoring their atmospheric burden starting now. Although many are substitutes for the ozone-depleting CFC's, they do not fall under the umbrella of ozone-depleting gases (p.63-64) because they do not deplete ozone.

**NOAA/CMDL**

Short-lived, ozone-depleting gases should be mentioned explicitly and should be referenced to the upcoming Scientific Assessment of Ozone Depletion, 2003. Some of these gases are anthropogenic and some are naturally produced. The fluxes into the atmosphere of many of these gases, which emanate from the ocean and are very high, will be affected by certain elements of global change, namely temperature, windspeed, convection, mixed layer depth and stability, etc. An entire chapter of the 2003 Scientific Assessment of Ozone Depletion is devoted to short-lived, halogenated gases. Today, we have little clue as to their behavior, yet they may already contribute significantly to regulating stratospheric $O_3$. These gases also affect the chemistry of the marine boundary layer and changing their fluxes will alter that chemistry, which in turn affects the lifetimes of a number of greenhouse gases. They are an important and historically neglected element of climate change.

**NOAA/CMDL**

Where do we put sulfur? Some sulfur measurements (e.g., COS) may be more relevant to Observations and Monitoring (Chapter 3 or 5) and some (e.g., $SO_2$, DMS) are more related to aerosol and cloud formation (Chapter 2 or 5). In any case, we do not want sulfurous compounds to slip through the cracks. All sulfurous gases of moderate to long lifetime should be monitored so that we can obtain a picture of their spatial and temporal distributions. Chapters 3 and 5 seem the best place for this.

**NOAA/CMDL**

**Comments on Chapter 3**

The chlorofluorocarbons (CFCs) are noted in the document, mainly with respect to ozone-depletion (p. 59, line 2, p. 63-65, Question 4), but they are significant greenhouse gases in their own right (currently ~15% of greenhouse forcing from gases) and should be noted as such. Today, their concentrations in the atmosphere are falling, but they are falling slowly because of their ~50-100 year lifetimes. By current projections, when $CO_2$ in the atmosphere has doubled in concentration, the CFCs will still be around in significant amounts. We do not know what that amount will be, because we are still somewhat unsure of the release rates of these gases from their current reservoirs.
**NOAA/CMDL**

It is good that other important greenhouse gases are noted in Question 2 (p. 61), but we don't feel that it is right to refer to $N_2O$ and $CH_4$ as "chemically active", as they have atmospheric lifetimes of ~150 and ~10 years respectively.
**NOAA/CMDL**

We also would argue that tropospheric ozone is not the "third-most influential greenhouse gas" in the climate system (p. 61, lines14-16), but rather $N_2O$ (which is mentioned along with $CH_4$ in the text here). There is little evidence that tropospheric ozone has been increasing in the atmosphere over the past half-century, while $N_2O$ has been increasing for the past century at a relative rate of about half that of $CO_2$. The natural and anthropogenic sources and the sinks of $N_2O$ and $CH_4$ are diverse, complex, and sensitive to climate, which makes these especially important gases to study.
**NOAA/CMDL**

Water is the subject of an entire chapter on Hydrology (Chapter 7), its measurement is discussed in the chapter on Observations (Chapter 3), and it is mentioned as a greenhouse gas in Atmospheric Composition (Chapter 5, p. 61, p 62, lines 23-25). However, it is important that long-term measurements of stratospheric water vapor, which has been increasing over the latter part of the 20$^{th}$ century and which affects stratospheric ozone and contributes to stratospheric cooling, continue. This is a potential, perhaps already occurring, feedback of climate change on ozone depletion and its significance is high. This probably belongs in Chapter 5 or Chapter 3 if certain revisions in the document are made, or both, with cross-referencing.
**NOAA/CMDL**

Page 29, lines 38-39. There should be more discussion of GAW and the reasons for this recommendation should be clarified.
**SUSAN SOLOMON, NOAA**

Page 29, line 41: The term "freshwater" has not been defined, and is really a derived quantity. Most readers will be quite confused, and perhaps wonder why, if this is the case, the world is so short of drinking water.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 30, line 9-11. Do the fluxes in question here include radiative fluxes? If so, that should be explicitly noted because the typical strategy has been to ignore them. There are

new radiometer systems that could be deployed to get accurate fluxes, but we are again limited by resources.
**THOMAS ACKERMAN, PNNL**

Page 30, lines 12-13: This is not yet a routine satellite observation, if at all.
**ANTONIO J. BUSALACCHI, EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER (ESSIC), U. MARYLAND**

Page 30 line14: Improve calibration and spatial coverage of water vapor measurements (Tower, Microwave Radiometers, and GPS Satellite water vapor measurements).
**BILL PORCH, LANL**

Page 30, line 16: This is jargon, please explain.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 30, lines 17-18: Does this not depend on the situation, the type of changes, etc. This again seems rather like jargon.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 30, Lines 17-18: Estimating "the number of years a climate record is required ... to recognize a climate trend and/or variation" is a function of the magnitude of trend sought and the permissible type I and II errors - who will specify these?
**ROBERT M. CUSHMAN, ORNL**

Page 30, line 23: What does "integrated estimates" mean? There are many types of stakeholders and they want many types of information. It would be helpful to have up-to-date estimates of climatic change, but I would be very careful about indicating that they are "integrated" and would not refer to them as "estimates". People want to see the observations.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 30, Line 31: Overview comment on Section 3. For a short-term research plan, this section makes more sense than the prior two. It is a specific question that can be attacked directly and its resolution would certainly damp some of the rhetoric currently going on in the global warming arena.
**THOMAS ACKERMAN, PNNL**

Page 30, Line 31: Overall comments Chapter 3.3
As a panelist for this section I summarized the state of the art of the observing elements that contribute to this problem, and I suggest the whole framework for this section should be broadened to include the questions as follows:

Surface Temperatures
Land: thermometers; surface air T
Ocean: thermometers; sea surface T
Plus IR satellite patterns

## Comments on Chapter 3

Coverage:
Increases over time (poor 1800s, better after 1950)
Global after 1982 with satellite
No Antarctica pre-IGY (1957)
Poor southern oceans

Biases:
Changes in observing practices
Land use/urbanization effects

Advantages:
- Long record
- Many independent measurements
- Several independent analyses
- Many cross checks (NH vs SH; rural vs urban; global vs land-based vs SST vs Marine Air T)

Disadvantages:
- Mostly less than global coverage
- Coverage changes with time

Assessment:Trends robust; may be slightly underestimated owing to under-representation of southern oceans and Antarctica

<u>Radiosonde Temperatures</u>
Thermisters, balloon borne, transmitted

Coverage:
Begin mid-1940s
At best twice daily
Changed to 00,12 UTC July 1957
Marginal before 1964
Good vertical resolution

Biases:
- Many changes in instrumentation, observing methods
- - Not designed for climate monitoring
- - Poor, no documentation of changes
- - Known biases in some brands, radiation effects
- - Many suspected biases not known

Advantages:
- Each sounding uses new instrument
- - Dozens of instrument types
- - Few groups, independent analyses

- - Prospects to improve record

Disadvantages:
- Dozens of instruments, not calibrated
- - Biases change, often unknown
- - Spotty, non-global coverage
- - Inadequately exploited to date

Assessment:
Tropospheric temperature record reasonably well established for extratropics of NH after 1964. Coverage inadequate and discontinuities serious elsewhere.

<u>Satellite Temperatures (Microwave Sounder)</u>
Oxygen emits microwave radiation, measured by MSU; proportional to T. Retrieval to get 2LT record combines off-nadir and nadir footprints.

Coverage:
Global over several days
Began December 1978
2 or 4 times per day
(1 or 2 satellites)
Obs times vary with satellite and orbit drift
Very broad vertical layers

Biases:
9+ different satellites/instruments
Orbital decay affects retrieval
East-west orbital drift aliases diurnal cycle onto trends
Instrument calibration
Solar heating of platform
Retrieval amplifies noise

Advantages:
Measurement: excellent long term stability
Global, fairly uniform, coverage
Biases OK if adequate satellite overlap
Millions of observations (beats down noise)

Disadvantages:
Signal includes 20% from surface (land)
Contamination by precipitation-sized ice
Biases change, not reduced by averaging
Continuity across satellites: NOAA 9
Was one group (mainly) processing data
2nd group results differ for trends.

## Comments on Chapter 3

Assessment:
Excellent for spatial coverage, interannual variability, but suspect for trends

Satellite based observations

- Satellites typically last 3-5 years and have to be replaced
- Orbits decay
- Equator crossing times change
- New satellite orbits differ
- Instrument calibrations drift and can be changed by launch
- Interference can occur from other instruments

- Need is for stable orbits
- May require boosters
- Need sufficient sampling of diurnal cycle
- Launch on schedule, not on failure, to ensure overlap
- Calibrations required
- Ground truth validation required

Lonnie Thompson's tropical ice cores in Africa, southern Asia and South America have clearly shown melting and ablation coincident with the time of the satellite record. These should be added as part of the record.

There are good physical reasons why the surface and satellite records should differ: they do not measure the same thing. Also, phenomena such as surface wintertime inversions and trade wind inversions isolate the troposphere from the surface.

Chapter 3.3:

- Does not deal fully with vertical structure of atmosphere.
- Issues include the forcings (volcanoes, GHGs, aerosols, ENSO, ozone depletion) and response of atmosphere to these.
- Need to be able to simulate observed record within bounds of predictability. Can then take it apart. For the past 20 years, two exceptional El Niño events and two major volcanic eruptions means that specified SSTs are required, not coupled models.
- There is no reliable baseline against which to reference measurements.
- Radiosonde records can be improved using reanalysis feedback files.

I suggest the following questions should be highlighted in this section.
Key issues suggested revised title: What is the vertical structure of climate change in the atmosphere, and how well do models reproduce it?

Surface vs low troposphere
- How do they co-vary regionally?
-Is the trade wind inversion at the right level in models and does it vary as observed?
- Are wintertime surface inversions over mid-latitude continents simulated, and how do they show up in the satellite record?
-Are warmings found in tropical glaciers present in radiosonde and satellite records?

- Is static stability in models maintained correctly? (relates to sub-grid scale parameterization of convection and mixing)

Tropopause
- Is the tropopause simulated at the correct level with the annual cycle and are changes over time and with ENSO replicated?

Lower stratosphere
- How well is ozone and its heating simulated?
- Is transition of warming near surface to cooling in stratosphere with changes at right level in models?

Forcings:
Greenhouse gases, stratospheric ozone depletion, tropospheric aerosols (scattering, absorbing, CCN), volcanic/stratospheric aerosols, clouds, water vapor.

- Is the observed warming in the lower stratosphere with volcanic eruptions simulated?
-What is the greenhouse effect of the aerosol and the heating?
- Is the vertical profile different in regions with absorbing aerosols?
- How much of that is because of no rain vs the aerosol effects?
- Why do the cooling effects of ozone depletion appear to penetrate into upper troposphere and is this modeled?
- Do changes in clouds, from aerosols or climate change, affect vertical temperature profiles, and are they simulated?
-Can we detect the changes in the troposphere and lower stratosphere and attribute to forcings?
- It is NOT just greenhouse gas forcing expectations that should be compared with observed!

**KEVIN TRENBERTH, NCAR**

Page 30, Line 32 – Page 32, Line 36 – The lack of significant warming in the free troposphere undermines the credibility of the general circulation models. This is an area where real world data and analyses need to help refine models rather than simply relying on forecasts that come from models that do not reflect what is happening in the atmosphere. Consequently, this should be a high priority issue. In attempting to determine the reason for the discrepancies between the surface and tropospheric temperature measurements, the role of the urban-heat island effect also needs to be freshly re-examined. It should not be assumed that present attempts to filter out this effect are necessarily valid.

**GEORGE WOLFF, PH.D., GENERAL MOTORS**

Page 30, Line 32:

The Community Climate Systems Model (CCSM) Advisory Board (CAB) wishes to avail itself of the opportunity to comment on the modeling aspects of the draft *Strategic Plan for the Climate Change Science Program*. By way of identification, the CAB consists of scientists (listed above) active in various aspects of climate modeling. It advises the CCSM Scientific Steering Committee, the Director of NCAR and President of UCAR, and the Program Managers at NSF and DOE on strategic aspects of climate modeling, and on coordination of CCSM activities with other climate modeling efforts within the U.S. and abroad. The CAB also generally tries to improve climate modeling strategies and associated infrastructure within the US, especially at the highest end of global climate modeling, by discussing these aspects of climate modeling at its annual meeting designed for this purpose.

In recent years the CCSM has been in the forefront of climate modeling in the U.S. and has led in the development of a modeling strategy that develops and runs global climate models in collaboration with a large community of climate scientists located in universities and in other modeling centers. The CAB was therefore delighted to see the pivotal role of the CCSM within NCAR recognized in the "Two Centers" strategy for IPCC assessments in the CCRI part of the document. Focusing additional resources on two climate modeling Centers will indeed accelerate progress on climate modeling for assessments, but it should be noted in the document that this, by itself, is not enough.

In particular, the community that forms an integral part of the CCSM must stay healthy. While the CCSM can participate in a "Two Centers" strategy, the strength of the CCSM comes substantially from the network of collaboration implemented through the CCSM working groups, through which a large proportion of the university community participates in building, testing, revising and applying the model. If support to this broad community were not commensurate with the centralized support, the CCSM would be weakened substantially. Further the other contributing climate modeling centers must not be put at a disadvantage by the focus on the "Two Centers" strategy.

Indeed the health of climate modeling ultimately depends on the health of the entire climate enterprise--observations, data assimilation, diagnostics, education and training, and climate operations across the scales of climate variability and climate change. Climate modeling, through its synthesis of all aspects of climate knowledge, reflects the accumulated wisdom of the climate enterprise.

The CAB also supports the Common Modeling Infrastructure which it should be noted has been made concrete in a NASA funded program, Earth System Modeling Framework (ESMF) in which several national modeling centers, NCAR and GFDL, as well as NCEP and NASA/GSFC, are playing a major role.

Finally, the CAB notes that while the CCSM activity has been increasingly successful in meeting the challenges to the U.S. climate modeling effort as raised in recent NRC reports (e.g. NRC, 1998; NRC 2001), two important issues remain to be addressed in a meaningful way: improved access to high-end computing by the U.S. climate modeling community and development of a sustained global climate observing system (NRC, 1999). Both of these issues were at the forefront of the December 3-5, 2002 U.S. Climate Change Science Workshop, and both issues need much greater attention in the *Strategic Plan for the Climate Change Science Program.*

**References:**

NRC, 1998: **Capacity of U.S. Climate Modeling to Support Climate Change Assessment Activities**. National Academy Press, 78 pp.

NRC, 1999: **Adequacy of Climate Observing Systems**. National Academy Press, 66 pp.

NRC, 2001: **Improving the Effectiveness of U.S. Climate Modeling.** National Academy Press, 128 pp.

**COMMUNITY CLIMATE SYSTEMS MODEL ADVISORY BOARD (CAB)**

Page 30 line 40-page 31 lines 1-3: The sentence overstates the impact of the issue. No credible evidence questions the existence of surface warming. The significant uncertainty is limited to upper-air temperatures and the ability of models to reproduce changes in those temperatures.

**MELISSA FREE, NOAA ARL**

Page 30 lines 26-30: This is poorly worded. The word "is" should be changed to "could be", or the whole three last sentences combined into one list of possible explanations, as: "The failure of models to simulate the observed differential warming may arise from model inadequacies, missing or inaccurately specified external forcings, or errors in the observations."

**MELISSA FREE, NOAA ARL**

Page 30, Line 40-Page 31, Line 1: Statement way too strong. Recently much of these discrepancies have been reduced.

**RONALD STOUFFER, GFDL/NOAA**

Page 30, last few lines and page 31, top few lines. These statements are too strong. The data are subject to large uncertainties, error bars are very large, and as they stand they do not "call into question both our understanding of the causes of any change....". They do raise interesting questions about circulation, water cycle, energy cycle, and other factors, and they raise interesting questions about calibration and accuracy. This should be restated to be more balanced.

**SUSAN SOLOMON, NOAA**

Page 31, line 6: The phrase "projected inaccurately in climate models" suggests a really biased perspective. There have been quite a number of cases where the observations are inaccurate, biased, or miscalibrated, etc. (and the Wentz et al. Studies seem about to point out another case), and models and analyses help to point these situations out. This can be corrected by dropping the word "inaccurately".

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 31, lines 12-14: Well, of course there are in the stratosphere—this is a ridiculous variable to include in this list. With regard to the surface-troposphere difference, the NRC (2000) report called for the analyses to be redone from scratch by a different group, and interestingly, this other group is getting a different result. It is not at all clear that the science is "very likely" to be understood yet.

## Comments on Chapter 3

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 31, Line 16: suggest changing "IPCC and NRC" to "IPCC (2001) and NRC (2000)" to avoid confusion

**ROBERT M. CUSHMAN, ORNL**

Page 31, Lines 18 & 20: To what part(s) of the world do "estimates of tropospheric temperature trends" and "the satellite record" refer - global? regional? zonal? Some of the preceding text refers to the tropics and sub-tropics.

Page 31, Lines 21-22: Is the "0.1oC per decade" warming significant? The question arises because this warming is contrasted with a "statistically insignificant trend" in another data set. For both, the significance level should be specified.

**ROBERT M. CUSHMAN, ORNL**

Page 31, L24-30 - This needs rewritten. It is unclear. What difference is in view? The surface record and the upper air record or satellite and surface records or both. This paragraph does not reflect what was discussed at Washington meeting in December.

**RONALD STOUFFER, GFDL/NOAA**

Page 31, line 26-30: To suggest, by having the possibility in a different sentence, that shortcomings in the data are some sort of alternative explanation seems to fail to indicate that there are indications that the Christy data set may well be miscalibrated. That observed data or analyses of it could be wrong would seem as likely as the other explanations that are given much more prominent mention. These two sentences should be reworked to be better balanced.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 31 line 27. is due to a combination of inadequate model physics and missing ...

**CHRISTY, UNIVERSITY OF ALABAMA IN HUNTSVILLE**

Page 31, line 30. Insert as below (The fact that such a statement is made attests to the needs for more attention to standards and calibration):

…are not trivially small. Improving the calibration, characterization, and robustness of our environmental monitoring sensors and establishing the traceability of the measurements to national and international standards will aid the decoupling of model and observational errors.

**NIST, HRATCH SEMERJIAN**

Page 31, line 30: There is really no more basis for saying that the “truth could lie somewhere in the middle” than that it could lie at one end or the other—the statement is really useless.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 31, lines 32 and beyond: Similar to previous section, what is the strategy to do this?

## Comments on Chapter 3

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

Page 31, Line 32: RESEARCH NEEDS
1. include careful organizing and formatting of data for scientists to access (especially radiosonde data)

2. I think specific mention of the NOAA effort to homogenize radiosonde data (Lanzante, Seidel etc.) as needing permanent support and that an updated and upgraded product is likely achievable in 2-4 years. Also recognize that The Met Office (UK) has a parallel and independent radiosonde effort underway which will help determine overall confidence in everyone's results. US collaborative activities should be supported with The Met Office.

3. Some type of operational research support for those who produce climate records from satellite data but who do not work in government labs (e.g. UAH, RSS) is needed.

4. Rectify the discontinuities in the NCEP pressure level temperatures. Since the Reanalyses will forever undergo upgrading, this should be a permanent (i.e. climate aspect) role for NOAA. In particular in the next 2-4 years the 100 hPa temperature problems should be fixed.

5. Expand the quality climate record upward above 30 hPa with new instrumentation (Good balloons, Lidar, Rockets, GPS etc.) This is achievable in 2-4 years.

6. Develop a cost-effective system for remotely determining the fine-scale structure of the vertical atmosphere so the vast areas of the tropics and oceans may be monitored (unmanned balloon stations, unmanned profilers etc.) This is key to resolving the direction of atmospheric temperature trends.

**CHRISTY, UNIVERSITY OF ALABAMA IN HUNTSVILLE**

Page 31, lines 39-40: The needed metadata goes beyond information about types of radiosondes used. All changes in procedures and equipment are potentially important and should be documented.

**MELISSA FREE, NOAA ARL**

Page 31, Insert between lines 40 and 41 the following bullets:

- More effort needs to be made to establish the traceability of environmental measurements to international standards.

- Attention needs to be directed at the design of environmental sensors to ensure through characterization their ability to perform the desired measurements, to establish that they can be accurately calibrated against national and international standards, and to guarantee through rigorous testing that they can maintain their calibration over long periods of time.

- o Develop comprehensive laboratory data sets of atmospheric gas, aerosol, and surface optical and radiative properties to independently test and validate the performance of the radiative transfer components in climate models.

**NIST, HRATCH SEMERJIAN**

Page 31, line 41. I strongly endorse this statement and would in fact go somewhat further. We need systematic comparisons of radiosondes with more sophisticated ground-based and in situ instrumentation continuing into the future. Research within the Atmospheric Radiation Measurement Program has shown that radiosonde measurements vary from batch to batch. This is more of a problem for water vapor than temperature, but is true for both.

**THOMAS ACKERMAN, PNNL**

Page 31, Lines 41-43: As the Strategic Plan states, the need for more meteorological and hydrological measurements is important for effective monitoring of climate change. We are extremely interested in collaborating on this effort. Regional climate models for the western United States suggest more pronounced warming in high elevations in the Sierra Nevada. Unfortunately, there is a lack of monitoring stations in high elevations and in other key areas in the state. In order to obtain better measurements of climate quality in the future, the Commission, in collaboration with the California Department of Water Resources, is funding the installation of a limited number of monitoring stations in key transects in California.

**CALIFORNIA ENERGY COMMISSION**

Page 32, lines 1-11: Another useful form of research is work to improve understanding of the differences between upper-air climate datasets from different sources and of the reasons for those differences- this is similar to, but broader than, "updates, adjustments", etc.

**MELISSA FREE, NOAA/ARL**

Page 32, line 2. This type of statement needs to be connected back to the discussions in the previous sections. If one is going to have a climate observing system, then it is crucial that the system have the requisite measurement accuracy. But that accuracy can only be maintained by a vigorous program of calibration and inter-comparison. The biggest problem with the proposed NPOESS climate monitoring approach is insufficient attention paid to and resources for calibration and comparison. If the need for this is so clear in a specific case, then surely it must hold for the entire monitoring system.

**THOMAS ACKERMAN, PNNL**

Page 32, top bullet reword second sentence, line 2, as follows:

- o Calibration issues and traceability to national and international standards need to be a priority in the development of satellites, particularly with new operational satellites (NPOESS) potentially functioning under a "launch on failure" mode which will eliminate the critical overlap in satellite records.

**NIST, HRATCH SEMERJIAN**

## Comments on Chapter 3

Page 32, line 10. I don't know what this means. I guess it is an attempt to say that we need to have calibrated, accurate measurements but we don't want to pay very much for them. There is no way to implement the real GCOS vision without resources. Implying that some "cost effective" solution can be found simply does not make sense. We know how to do the problem, we just don't have the resources.
**THOMAS ACKERMAN, PNNL**

Page 32 line12: Improve quantification of boundary layer clouds trends and effects on the global temperature record.
**BILL PORCH -LOS ALAMOS NATIONAL LAB**

Page 32, line 17. Maybe this is correct, but the first order of business is to decide what the trends really are.
**THOMAS ACKERMAN, PNNL**

Page 32, lines 20-22: The usefulness of new model reanalysis results in assessing time-dependent biases is dubious, since the input to the reanalysis consists of the same observations whose biases are to be assessed, and the models' representation of the real atmosphere has important shortcomings.
**MELISSA FREE, NOAA/ARL**

Page 32, line 25: It is easy to say an improved international network is needed, but how? What is the strategy to do this in an international context? This is supposed to be a strategy document.
**ANTONIO J. BUSALACCHI, EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER (ESSIC), U. MARYLAND**

Page 32, lines 26-27: The regions of greatest importance are not really known with enough certainty to provide a basis for selecting locations of new network stations. The existing coverage is weaker in the tropics than in the Northern Hemisphere extratropics. This is the real reason for adding stations in the tropics.
**MELISSA FREE, NOAA ARL**

Page 32, lines 28-30: There is no basis in the preceding text for mention of precipitation and surface pressure here- the section is about temperature only.
**MELISSA FREE, NOAA ARL**

Page 32, lines 25-36: The "Products and Payoffs" section emphasizes future observations, which, while nice, will not have any effect on uncertainties in the next 2-5 years. The needed product in the short term is better data records for the past rather than improved systems for the future.
**MELISSA FREE, NOAA ARL**

Page 32 line 33: Indicate where the "GCOS climate monitoring principles" (mentioned on line 33) can be found.

## Comments on Chapter 3

**CLAIRE L. PARKINSON, NASA GODDARD SPACE FLIGHT CENTER**

Page 33, top: How do the intended meanings differ for “biological” and “ecological”?

**ANN FISHER, PENN STATE UNIVERSITY**

Page 33. The response of biological and ecological systems to climate change requires historical documentation on time scales of a 1000 years or longer. These reconstructions will require geological studies. The historical (human observed) records will be too short and too incomplete. Only geological proxy reconstructions will show how rapidly ecosystems responded to climate changes in the past, particularly abrupt climate changes, and provide useful insight to future ecosystem response.

**WILLIAM B. CURRY, WOODS HOLE OCEANOGRAPHIC INSTITUTION**

Page 33: Very nice extension of the atmosphere/ocean research to ecosystems.

**LYDIA DÜMENIL GATES, LBL**

Page 33, Line 1, dealing with observations of biological and ecological systems, raises important issues but appears to be rather vague as to exactly what types of biological and ecological data are needed and whether managed ecosystems including agriculture, agroforestry, grazing lands, and urban ecosystems will be considered along with natural ecosystems. Managed ecosystems will probably be more resilient to climate change than natural ecosystems and may provide options to help mitigate some of the adverse effects of climate change. In general, managed ecosystems seem to be under represented in the entire document which is disappointing since they are the ecosystems that humans are most able to manipulate in order to mitigate or adapt to climate change.

While it is very commendable to try and coordinate climate observing and monitoring networks, it would be a shame if the effort stopped with just the climate data. It is equally important to bring together all related data including biodiversity surveys, soil carbon data, results from $CO_2$ flux networks, etc. so that a complete picture of ecosystem responses to climate change can be obtained.

**R. HOWARD SKINNER, USDA-ARS**

Page 33: How do we improve observation of biological and ecological systems to understand their response to climate variability and change?

**General Comments:** The entire contents of this section was well written and to the point, BUT…

It was written by terrestrial ecologists, with little or no concern for the larger, and more complex aquatic ecosystems, and their interactions – and in particular their continuity from the highest mountain tops, to the deepest oceans, via the water cycle, and the downstream consequences from the highest mountain tops, through their subject ecosystems, into the oceans. **This is not a state of the art commentary.**

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

Page 33-35: Question 4 (page 33-35) regarding monitoring ecological systems is extremely important. While documentation of changes in radiation balance and temperature trends are important to the scientific community, ecosystem responses define the consequences of global change that matter most to the public. It must remain a prominent part of the research agenda for the next decade. Developing a rigorous and comprehensive monitoring program of ecosystem response should be considered one of the highest priorities for the CCSP. An important short-term objective, appropriate for the CCRI, will be to define and design such a monitoring program. If coupled with ecosystem-scale manipulative experiments (Chapter 10), a monitoring program could provide critical benchmarks for evaluating the consequences of global change for the next several decades. Another short-term objective important to the establishment of such a program would be a research initiative to develop non-invasive, real-time monitoring capability of critical ecosystem processes and data management, computer modeling and visualization schemes to makes use of extensive data streams. Activities in this area should be coordinated with chapter 10.
**RICHARD NORBY, ORNL**

Page 33, line 3 **Add in front:**
This section is focused on the local to regional scale issues of Climate Change. The interconnections of these scales is recognized, and the usual intermediary is the water cycle, via seasonal atmospheric patterns, and delimited by watersheds that are scaled from meters, to subcontinents, hence difficult to generalize. The downstream flows from various sources, at all scales, tend to end up either back in the atmosphere - via evaporation/sublimation - or stream, river, and undersea aquifer deliveries into various basins, some closed, others, more dynamic and open to the oceans.

We will limit this section to only within-watershed subject matter, or somewhat broader 'ecotypes' – defined as we progress. This is by no means the broader view of ecosystems, since we cannot delimit the many data series and observational studies, bounded by an infinite variety of arbitrary and historical decisions.
**GARY D. SHARP, CENTER FOR CLIMATE/OCEAN RESOURCES STUDY**

Page 33, line 5 ff: **(16-E)** Please consider expanding this long list of ecosystem responses into bullets. It makes it much easier to read that way.
**HP HANSON, LANL**

Page 33, lines 3, 36, 38; also p. 34 line 4 and several other places: **(17-S)** "Environmental" is used here in the sense of "climate" (or weather) – but "environmental change" includes ecosystem change. To distinguish these, I'd suggest that "physical environmental" or just "climate" or "climatic" be used in these and analogous instances. In Chapter 6, this issue is resolved by calling them "climate elements"; this could be the solution here as well.
**HP HANSON, LANL**

Page 33, Line 10: Should read “and coral bleaching”. Actually, The CCSP plan suffers from a strong terrestrial bias when discussing ecosystems. The IPCC report includes numerous marine examples that should be included here.
**C. MARK EAKIN, NOAA/NCDC**

Page 33, lines 11-12: There are always possibilities remaining—this type of phrasing really is exhibiting a bias towards requiring virtual certainty before agreeing to a potential outcome that is negative. The phrasing should indicate that global warming appears to be the more likely explanation. Phrasing such as this just again points out the need for this plan to have an up-front discussion about the meaning of uncertainty and the lexicon used, as there is a mixing of what is typically used by policymakers and the carefully caveated approaches of the scientific community.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 33, lines 14-16: "... attribution of the causes of biological and ecological changes to climatic change or variability is extremely difficult. Moreover, because many ecosystem-environment interactions play out over long periods - ultimately involving evolutionary changes and adaptations without ecosystems - long periods of studies are needed . . ." I strongly agree that changes in species ranges and other ecological phenomena cannot be attributed to climate change without a much better understanding of regional climate histories and non-climate factors driving ecological changes. There is an increasing tendency to blame all ecological changes on changing climate, even though change is the one known constant of ecology, and even when local temperature stations record no warming or cooling trends, and finally, even when other change factors (e.g., tourism and changes in land use in adjacent areas) are far more likely to be responsible. I suggest the authors use this section of the Strategic Plan to warn against the natural tendency of scientists and advocates to attribute to climate change a wide range of phenomena in order to qualify for research grants under the climate change science research initiative, as well as to increase the odds of having their findings appear in popular magazines and academic journals. The USCCSP must be alert to this problem, which is akin to "mission creep" in other government agencies, and reject funding requests for research projects that are likely to be only tangentially relevant to climate change. As part of its commitment to credible fact finding, the USCCSP should consider funding critical analysis of claims that ecological phenomena provide evidence of "global warming." –
**JOSEPH L. BAST, THE HEARTLAND INSTITUTE**

Page 33, line 22: The response of biological and ecological systems to climate changes larger than those that have occurred in response to recent climate change is also relevant. In particular, the recent changes in the terrestrial biosphere to both climate and carbon dioxide (that can be observed by satellite remote sensing and atmospheric measurements) are largely physiological. We have not yet realized the changes in vegetation composition and structure that would likely have strong feedback to the rest of the climate system as suggested by the longer-term paleoenvironmental record.
**PATRICK J. BARTLEIN, DEPT. GEOGRAPHY, UNIV. OREGON**

Page 33, Lines 22-28: Prioritization of what systems to look at is urgently needed; as this reads, one has to be prepared to look at all systems and that is not possible. Key organisms should be chosen that are representative of different systems, e.g. some animal species, some plant species (of different types), invertebrate species, plant and animal pathogens, where data already exists. These studies should be expanded.
**STELLA M. COAKLEY, OREGON STATE UNIVERSITY**

Page 33 Line 30: The section associated with Question 4 on improving observations of biological and ecological systems to understand responses to climate is important but vague. 'Early effects' and 'indicator systems' are not defined. The draft suggests that systems subject to rapid change will be targeted, however, I am not aware of broad scientific agreement on which systems they might be.
**PAUL HANSON, ORNL**

Page 33, Line 33: Paleoclimatic and paleoecological data should be used to understand how ecosystems have responded to past changes, as keys to potential changes in the future.
**C. MARK EAKIN, NOAA/NCDC**

Page 33, lines 36-37: The wording here is a bit awkward, though it is helpful to have the possible criteria listed.
**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 33, Lines 36-38: As mentioned here, it will indeed be important to (1) target for research ecosystems that are subject to most rapid and extensive environmental changes and/or sensitivity to environmental changes. In addition, it is also critical to consider **(2)** the socio-economic importance of the sensitive/impacted ecosystem to national and international stakeholders, **(3)** the potential of the system to provide historical data on climate change and ecosystem responses, and **(4)** the extent of pre-existing capacity and mechanisms already in place for the study of that system (such that doing an interdisciplinary assessment that integrates climate with other layered stressors can be done with greatest efficiency and maximum results).

Coral reefs qualify in all of the above respects as a critical focal research system for comprehensive monitoring, modeling, assessment and management of the impacts of climate change on ecosystem components, processes, and services. **(1)** Coral reefs appear to be the first ecosystem showing global-scale degradation with a clearly demonstrated linkage to climate change (increasing sea surface temperatures and variability). Coral bleaching has been clearly demonstrated to result from climatic effects and may already be serving as one of the earliest and strongest indicators of the impact of climate change on marine organisms.

Quoting from the IGOS Coral Reef Sub-Theme (Draft), Arthur Dahl and Alan E. Strong (Eds.), Integrated Global Observing Strategy (IGOS) Committee, Submitted 2002: "Coral reefs are . . . now a significant coastal ecosystem under major threat. Widespread episodes of coral bleaching and mortality are being reported from around the world. The combination of local stresses from overfishing, physical destruction, coastal pollution and sedimentation, together with the growing threat from climate change, may result in permanent degradation of the coral reef ecosystem at a planetary scale. In fact, coral reefs may be the first major biological system to respond to human impacts at this scale.…Coral reefs appear to be the first major ecosystem type to show rapid degradation at a global scale due to human impacts."

**(2)** Coral reefs are a high priority focal ecosystem because of their great economic and cultural value both nationally and internationally. Coral reefs provide food from fisheries, serve as coastal protection structures, contribute major income and foreign exchange earnings from tourism, provide novel pharmaceutical compounds, and serve as repositories for some of the greatest biological diversity in the world.

**(3)** Corals themselves are recorders of both climate information and ecosystem responses. We already use coral skeletons to generate past (paleoclimatic) records of both natural and anthropogenic climate and we may soon be able to use them to reveal the impact of past climate on an important ecosystem. More work is needed to exploit multi-century coral records to understand natural variability such as El Niño and the Pacific Decadal Oscillation, and to use these records to separate natural from anthropogenic climate change.

**(4)** As a system that has been demonstrated to be highly sensitive to climate change, coral reefs are already the focus of concentrated study with respect to their responses to climate change variables. The U.S. Coral Reef Task Force is implementing an initiative to better coordinate monitoring, modeling, research, and assessment of coral reefs with respect to climate change – coordination will involve information-sharing and collaboration among not only Agencies but also among national and international non-governmental organizations that are active in this area of research. The initiative is being pursued by NOAA, which is active in remote sensing and modeling, the Department of Interior, which is active in targeted monitoring and research, and EPA, which is active in organizing stakeholder-driven, integrative environmental assessments.
**JORDAN M. WEST, USEPA/ORD, ALAN E. STRONG, NOAA/NESDIS, WILLIAM SKIRVING, NOAA/NESDIS, C. MARK EAKIN, NOAA/NCDC, KAREN H. KOLTES, DEPARTMENT OF THE INTERIOR**

Page, 34, line 2. Need to consider adding a research need that would address the diversity of agricultural systems and the sensitivity of each system to climate change.
**JERRY L. HATFIELD, USDA-ARS NATIONAL SOIL TILTH LABORATORY**

Page, 34, line 2. Need to consider adding a research need that would address the diversity of agricultural systems and the sensitivity of each system to climate change.
**STEVEN R. SHAFER, USDA-ARS**

Page 34, Lines 3-4: An essential first step is a synthesis of knowledge regarding the structure and function of American ecosystems at some level of generality with an explicit focus on likely routes by which climate change would impact them. While data are important, it is not clear that we would know now which variables to monitor across all ecosystems. California riverine systems may be very sensitive to climate change via changes in seasonality of precipitation, reflected in the annual hydrograph, while the sensitivity of California's Great Basin ecosystems may result from exotic invasions and be reflected therefore in floristics. The administration might charge the Ecological Society of America with facilitating that type of synthetic work from which conclusions regarding vulnerability or resilience might be more reasonably drawn.

**CALIFORNIA RESOURCES AGENCY**

Page 34, Line 3: ... and quantitative observations of natural and managed ecosystem state variables ...

**LOWRY A. HARPER, USDA-ARS**

Page 34, Line 5: Identifying natural and managed ecosystems ...

**LOWRY A. HARPER, USDA-ARS**

Page 34, line 5; A research need is to identify the resilient ecosystems; however, there needs to be an emphasis in the research need on the time scale. The food security issue that comes from intraseasonal variation in precipitation and temperature could overwhelm the long-term trends in impact.

**JERRY L. HATFIELD, USDA-ARS NATIONAL SOIL TILTH LABORATORY**

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**STEVEN R. SHAFER, USDA-ARS**

Page 34, Line 6: Interfaces between natural and managed ecosystems (ecotones) ...

**LOWRY A. HARPER, USDA-ARS**

Page 34, Line 8: Ecosystems experiencing the most rapid environmental changes, or that may experience the most rapid changes in the near future, such as ecosystems located at high latitudes, high elevations, and arid to semi-arid areas.

**LOWRY A. HARPER, USDA-ARS**

Page 34 Lines 8-10: Where is the evidence showing that high latitude and high elevation systems are the most prone to change? Certainly this has been hypothesized, but I'm not certain we should be ready to ignore other systems.

**PAUL HANSON, ORNL**

Page 34, Line 10-11. Coastal ecosystems need study also because large quantities of harvestable living marine resources come from these regions, both in the form of naturally produced resources as well as those which are cultured. Thus, we need research on how both natural and cultivated populations will respond to a warmer ocean, to one with a altered seasonal cycles of growth, one with different nutrient regimes and with radically different levels of productivity.

Changes in the physical forcing of coastal ecosystems will also impact our nation's estuaries bays in ways that we can only guess. More work is needed on the degree to which coastal waters serve as a boundary condition for estuaries and bays.
**BILL PETERSON, NOAA/FISHERIES**

Page 34, Lines 11-12: Add "Identification of agricultural systems especially vulnerable to environmental change; identify those factors likely to impact these systems under change, specifically insects, weeds, and plant pathogens and monitor them."
**STELLA M. COAKLEY, OREGON STATE UNIVERSITY**

Page 34 Lines 17-19: A comprehensive report of ecosystems potentially affected by environmental change, promised under Products and Payoffs, will not be useful until scenarios for study are agreed to. Without boundaries to the scenarios for change, almost any system might be found to be subject to potential impacts (good or bad).
**PAUL HANSON, ORNL**

Page 34, lines 17-24: Where are the links to climate variability?
**ANTONIO J. BUSALACCHI, EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER (ESSIC), U. MARYLAND**

Page 34, Line 17: ... describing natural and managed ecosystems that will potentially...
**LOWRY A. HARPER, USDA-ARS**

Page 34, Line 17: ... describing natural and managed ecosystems that will potentially...
**STEVEN R. SHAFER, USDA-ARS**

Page 34, Line24: ... leaf area and duration, and terrestrial (both natural and managed) and marine ecosystem ...
**LOWRY A. HARPER, USDA-ARS**

Page 34, Line24: ... leaf area and duration, and terrestrial (both natural and managed) and marine ecosystem ...
**STEVEN R. SHAFER, USDA-ARS**

Page 34, Line 26: "Global to regional datasets linking pre-instrumental climate changes with their correlated ecosystem changes."
**C. MARK EAKIN, NOAA/NCDC**

Page 34 Line 27-29: The presence of clouds limits the temporal resolution of space-based remote sensing products leading to periodic rather than continuous data streams from space. I am concerned that gradual changes in seasonal phenomenon may be missed. To capture and verify near-term rates of change, observational systems should strive to attain daily rather than weekly to bi-weekly resolution.

## Comments on Chapter 3

**PAUL HANSON, ORNL**

Page 34, lines 32-33: It seems impractical to promise a report (or perhaps more correctly an assessment) on an annual basis when there are likely to be fluctuations that cause year-to-year variations that obscure long-term trends. And why the phrase “attributable (or attributed)”—what does this mean?

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 34, lines 35-37: These are really important, in this chapter and throughout the plan.

**ANN FISHER, PENN STATE UNIVERSITY**

Page 34, lines 36-37: How would trends be distinguished from interannual to decadal variability?

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

Page 35, lines 1-2: Can and is already being done.

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

Page 35, Line 2: ...analyses of how both natural and managed ecosystem responses in turn ...

**LOWRY A. HARPER, USDA-ARS**

Page 35, Line 2: ...analyses of how both natural and managed ecosystem responses in turn ...

**STEVEN R. SHAFER, USDA-ARS**

Page 35, Line 3: This data section is very weak. There are a number of efforts underway to improve data distribution schemes. This section needs modified to reflect the efforts of Earth System Grid (ESG), PRISM and NOAA Operational Model Archive and Distribution System (NOMADS). Providing data to other users is difficult and costly.

**RONALD STOUFFER, GFDL/NOAA**

Page 35, Line 5: Question 5 is all about the accessibility of the climate record yet ice cores, the undeniable Rosetta Stone of paleoclimate, are not mentioned at all! There has yet to be an ice core drilled anywhere on the planet that has not reaped huge dividends in understanding of the climate record. I would argue that deep-sea cores, with limited temporal resolution have reached a point of diminishing returns, while ice cores, with their exceptional temporal resolution and ability to provide a host of information on atmospheric composition, temperature, and transport tendencies are still bearing exciting fruit.

**R.BINDSCHADLER/NASA**

## Comments on Chapter 3

Page 35, Line 5: Section 5.Starts off good, but ends weakly. Nonetheless has the potential to help self-organize CCRI.

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

Page 35, line 21: What do these words mean? This is jargon to me, certainly to others.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 35, Line 23 The section in chapter 3 on "How accessible is the climate record" should also link with the decision support chapter. There are a number of decision makers who already have the ability to use climate information but do not have access to that information in a usable form. The plan should acknowledge both researchers and decision makers as the users of climate information, with differing information needs. The research needs part of this section seems to focus on providing coordination and giving guidance. In fact, there are real infrastructure needs, for information systems that will do data archiving, data delivery, data analysis; and will develop better ways of doing these. Likewise, the products section should include these items.

**ROGER C. BALES, UNIVERSITY OF ARIZONA**

Page 35, insert at the end of line 28.

The meaning of data for such stewardship should be broadly encompassing to include the calibration, validation, and characterization record of the instrument. The standards used in the calibration must be able to be tracked for generations, and such a process is simplified by establishing traceability to national and international measurement standards based on the SI system of units.

**NIST, HRATCH SEMERJIAN**

Page 35, lines 30-35: This is really overstating things. The decision process is much more complex than having an accurate data set, as is the validation of models. It can well be that data from earlier that is not continuous and data from situations that is not complete can also be very useful. To have the science stated with such uncertainty and then have the value of this type of contribution indicated with such certainty is really striking. I would also note that what is proposed has proven quite hard to do in the past.

**MICHAEL MACCRACKEN, LLNL (RETIRED)**

Page 35, Lines 30-33, and 38-39: *A continuous and complete data record for the observational instrument series or network of stations, including history and metadata (information about the data set), provides the details necessary to support a high degree of confidence in the data employed by the scientific research community in forecast and prediction modeling...Adequate support for safeguarding by federal depository centers will ensure long-term access*. One aspect of NWLON products is that they have legal applications and associated certification and liability. The NWLON tide and water level datums are typically tied into geodetic datums and the National Spatial Reference System. There are increasing efforts to precisely tie-in every station using GPS and several stations are co-located near CORS locations. This provides a national picture linking water-derived datum and land derived datum reference systems. The long time series, many of which are near or longer than one century in length, can be analyzed by the climate community in complete context because they are not a set of disjointed time series on different datums.

**JOSEPH WELCH, NOAA**

Page 35 line36: The goal of instrument quality records should be more than specifying generic instrument accuracies, but rather the accuracy of a particular instrument over a specified time range based on calibration and calibration test (on site comparison) records.

**BILL PORCH, LANL**

Page 35, Line 37: suggest expanding "accessible" to "accessible at the lowest possible cost (e.g., no more than the marginal cost of filling a request)" to be consistent with the "Bromley Principles" and to provide the greatest possible benefit from the investment of tax dollars in global-change research and monitoring

**ROBERT M. CUSHMAN, ORNL**

Page 35, Lines 38-39: "Adequate support" will not "ensure" long-term access of data, without wise planning and oversight; funding is a necessary, but not sufficient, condition for success

**ROBERT M. CUSHMAN, ORNL**

Page 36, Lines 3-14: Listed in this section should include the payoffs to managed ecosystems, (food, fiber, and forest products) from research and information used to better sequester carbon or to understand how not to produce GHGs which are naturally produced in these systems (ex: enteric emissions, denitrification, and human or animal waste management).

**LOWRY A. HARPER, USDA-ARS**

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**STEVEN R. SHAFER, USDA-ARS**

Page 36, Line 11: suggest changing "high-quality" to "high quality and well-documented"

**ROBERT M. CUSHMAN, ORNL**

Page 36, Line 19: suggest changing "i.e." to "e.g." - the programs that are listed are good examples, but there are others

**ROBERT M. CUSHMAN, ORNL**

Page.36 lines 28-30: Data management plans need to be funded at all stages of data processing and archiving. Within NSF a few programs have proactively endorsed this: these include Office of Polar Programs Arctic System Science (ARCSS) through the

ARCSS Data Coordination Center (URL: http://nsidc.org/arcss/) and the Antarctic Glaciological Data Center (URL: http://nsidc.org/agdc/). These efforts should be expanded to many other agency programs where they are lacking. NASA has a good record of responsible data management in its EOSDIS DAACs, but agency commitments for Long term archiving are still uncertain. Planning for NPOESS data is also slow in these respects.

**ROGER BARRY, NSIDC**

Page 36, second bullet ending on line 30 append at the end:
…to include the validation and calibration record.

**NIST, HRATCH SEMERJIAN**

Page 36, lines 31-33: The difficulty in doing this is underestimated throughout the document

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

Page 36, Lines 31-33: *Develop a cross-agency mechanism to coordinate implementation of the climate observing system, identify where efficiencies could be gained, and support leveraged activities*. The PORTS® model is an example of the NOS innovative business approach. PORTS® is a highly leveraged program that requires local partners, via terms of formal partnership agreements, to provide funding for (1) design and installation costs, including the procurement of all equipment and contractor support, (2) local operating and maintenance costs, including repair and preventive maintenance for all locally resident instrumentation and computer equipment, (3) telephone lines and communications equipment costs for local distribution of PORTS® information, (4) spare parts and supplies, and (5) other desired value-added services as they become available such as environmental information forecasting. NOS provides the integrated monitoring infrastructure (quality control, communications, data management, research and development, systems engineering, existing platforms) to enable the individual sites to operate within the NOS developed PORTS® National Standards. In addition, NOS installs the systems, using local partner funds, in partnership with private sector contractors.

**JOSEPH WELCH, NOAA**

Page 37, Line 12 add:
…can locate the data, information, calibration and validation record, models….

**NIST, HRATCH SEMERJIAN**