1.1 COMPONENTS OF A CLIMATE OBSERVING SYSTEM

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1. INTRODUCTION

There is compelling evidence that the climate is changing. We can argue about the degree, nature and cause of the climate variations and whether there is in fact a change, but the only way to settle these arguments is with solid information. This requires improved global observations of the state variables and the forcings, the means to process these and understand them, and the ability to set them in a coherent physical (and chemical and biological) framework with models. Meanwhile, the information that helps settle these arguments and reduce uncertainties is also extremely valuable for many other practical applications for business, industry, government, and the general public. The implications are given for the climate observing system. Note the word "system" means a comprehensive approach that includes:

• Climate observations from both space-based and in situ platforms that are taken in ways that address climate needs and adhere to the ten principles outlined by the NRC (1999).
• A global telecommunications network and satellite data telemetry capacity to enable data and products to be disseminated.
• A climate observations analysis capability that produces global and regional analyses of various products for the atmosphere, oceans, land surface and hydrology, and the cryosphere that lead to reliable and useful products.
• Four dimensional data assimilation capabilities that process the multivariate data in a physically consistent framework to enable production of the analyses, not just for the atmosphere but also for the oceans, land surface and so on.
• Global climate models that encompass all parts of the climate system and which are utilized in data assimilation and in making ensemble predictions.
• A climate observation oversight and monitoring center that tracks the performance of the observations, the gathering of the data, and the processing system.

2. A REVITALIZED OBSERVING SYSTEM

President Bush outlined the Administration's Climate Policy on June 11, 2000. This followed the release of a report by the National Academy of Sciences on "Climate Change Science". The new policy recognizes that climate is changing and emphasizes the uncertainties that exist.

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It calls for the establishment of a US Climate Change Research Initiative "to study areas of uncertainty and identify priority areas where investments can make a difference." It also provides for "new resources to build climate observation systems and calls on other developed countries to provide matching funds, to help build climate observations in developing countries". The recommendations outlined here were developed as input to this initiative.

The IPCC Third Assessment Report (IPCC, 2001) concludes "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities." Hence the IPCC suggests that not only has climate change outside the realm of natural variability been detected, but also that it is most likely due to human influences. It follows that climate change will continue and will only become more significant. Therefore, regardless of whether or not the rate of human-induced climate change can be slowed, there is a compelling case for: *Improved description of changes as they happen and reliable predictions of climate for several planning horizons into the future, ranging from seasons to decades.* Further there is a need for much more than "what if" scenarios-driven projections of future climate, such as produced by IPCC. Instead climate prediction as an initial value problem is crucial. Necessarily this means addressing not just average conditions over a given place and time interval, but also the variability and extremes. The need for a revitalized climate observing system is clear, and there are also implications for modeling and climate research.

3. CLIMATE MONITORING AND DATA RECORDS

Climate monitoring requires a long-term commitment to quality and stability. Many of the climate-related signals are small and are obscured by variability on short-time scales; if natural changes are conflated with variability in the observing system, then climate research and detection of climate change become more problematic. Second, there must be an active program of research and analysis utilizing climate data sets. This will ensure the data are state-of-the-art and continue to meet climate research requirements. Third, climate observations will continue to require a blend of both monitoring and process-oriented observing systems. Fourth, observing strategies should be developed in light of quantifiable requirements to reduce uncertainty in climate models. Fifth, climate research and monitoring requires an integrated strategy of land/ocean/atmosphere observations, including both in situ and remote sensing platforms, and modeling and analysis. Sixth, in situ data from all parts of the globe are essential and often can only be garnered within a strong international framework through the United Nations.

A major effort is required to produce satisfactory climate data records from operational data. Over the past decade a number of basic principles have been developed for the delivery of long-term data with minimal space- and time-dependent biases (NRC, 1999):

- Management of Network Change: Assess how and the extent to which a proposed change could influence the existing and future climatology.
- Parallel Testing: Operate the old system simultaneously with the replacement system.
- Metadata: Fully document each observing system and its operating procedures.
- Data Quality and Continuity: Assess data quality and homogeneity as a part of routine operation procedures.
- Integrated Environmental Assessment: Anticipate the use of data in the development of environmental assessments.
- Historical Significance: Maintain operation of observing systems that have provided homogeneous data sets over a period of many decades to a century or more.
- Complementary Data: Give the highest priority in the design and implementation of new sites or instrumentation within an observing system to data-poor regions, poorly observed variables, regions sensitive to change, and key measurements with inadequate temporal resolution.
- Climate Requirements: Give network designers, operators, and instrument engineer's climate monitoring requirements at the outset of network design.
- Continuity of Purpose: Maintain a stable, long-term commitment to the observations, and develop a transition plan from serving research needs to serving operational purposes.
- Data and Metadata Access: Develop data management systems that facilitate access, use, and interpretation of data and data products by users.

4. EXAMPLE: SATELLITE OBSERVATIONS

The US operates an extensive space-based, remote sensing observation program for elements of the atmosphere, ocean, terrestrial systems, and climate forcings. The typical lifetime of a satellite is three to five years. Replacement satellite missions often have a somewhat different orbit and different time-of-day sampling. Orbits tend to decay unless continually boosted, and the time of observations is apt to drift on sun synchronous satellites. Instrumental calibration can be altered by the launch and the space environment, and measurements may be affected by other instruments and the platform, requiring constant calibration. All of these are issues for climate monitoring. Hence for space-based platforms, climate monitoring requirements are more stringent than weather requirements.

As a consequence the following recommendations result. (i) Satellites intended for monitoring should be launched into stable orbits designed to minimize drift in time of observation to within 2 hours over the lifetime of the satellite, or boosters are required to stabilize the orbit. (ii) Sufficient satellites should be operating to enable the diurnal cycle to be adequately sampled. (iii) Satellites should be launched on schedule, rather than on failure of the previous mission, as is the case today, to ensure overlap of measurements which is essential for the climate record. This aspect has substantial cost implications. (iv) All instruments must be calibrated and an extensive ground truth validation should be sustained.

5. OVERALL RECOMMENDATIONS

We do not have a climate observing system at present, but rather we rely on an eclectic mix of observations, mostly taken for other purposes. It is not practicable to attempt to develop an climate observing system ab initio. However, the climate scientific community has developed a set of climate monitoring principles, which if applied to observations taken for other purposes, could meet many of the climate observational needs. Adding a number of new or enhanced observations, analysis of the observations into products, implementation of an oversight facility to monitor and rectify problems in the system itself, and attention to management, access and archival of the data would provide an exceptionally valuable resource that can be used for climate and other multiple purposes. In particular, the system can be used for tracking climate variations and change and climate forcings, testing and improving models, initializing models for predictions, and generally for addressing all the needs that emerge when the climate is in a state of change, so that past records are no longer a good guide to the future. To develop a climate observing system that satisfies these attributes clearly calls for a comprehensive approach and a solid US commitment to a long-term process.

Therefore, the highest priority recommendation is to establish an organization with responsibilities for operational climate monitoring and prediction. Essential infrastructure has to be established to ensure the integrity and continuity of the observations, their analysis into products, and links to modeling and research activities. The need is for systematic, objective, continuous observations of both state variables and forcings of the climate system. In particular, the organization should provide a central facility with oversight of the health of the observing system and resources to build and sustain a climate observing system operating under the ten guideline principles. It should have strong links and users of the data, as well as those responsible for the observations. It should ensure free and open access to data, archival and stewardship of the data, and foster reanalysis and reprocessing of the data. It would have a new management structure, authority, and infrastructure and should be responsible for a line of products for use in all aspects of climate, and oversight of management of the data. However, while central oversight is essential, the various activities themselves need not be centralized.

References

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