

## **Designing the Climate Observing Systems of the Future**

### **Discussion Summary – December 14, 2015, San Francisco**

**Chairs:** Betsy Weatherhead, U. Colorado, Bruce Wielicki, NASA Langley, V. Ramaswamy, NOAA GFDL

**Attendees:** Mark Abbott, Tom Ackerman, Guy Brasseur, Lori Bruhwiler, Tony Busalacci, Dave Carlson, Chris Clack, Jason English, Dave Fahey, Steve Fine, Norm Loeb, Julie Morris, Steve Po-Chedley, Diane Stanitski, Graeme Stephens, Tim Stryker, Byron Tapley, Anne Thompson, Don Wuebbles

#### **1) Introduction: Purpose and background**

Betsy and Bruce informed those present of the converging efforts to significantly improve the climate observing system in an efficient and effective manner. Prior to the meeting, a white paper was circulated to the attendees that summarized what Betsy and Bruce presented at the USGCRP meeting in September, 2015. The powerpoints from the USGCRP presentation were also circulated just before the meeting started. The scope of the activities encompassed all observing systems: satellite, in situ, and ground based. Some key points in this discussion of observing systems of the future are 1) we can do a considerably better job of planning our observing systems by identifying key climate questions first and developing hypotheses that require observations; 2) we can evaluate proposed observing systems to assure that they can address the specific hypotheses; and 3) there is financial justification for significantly expanding the current climate science budget.

Guy Brasseur commented on how the efforts of this group would be a direct complement, building from the WCRP Grand Challenges. He made the point that while we may be talking about improving observing systems, it would be impossible to remove this from the discussion of improving climate science; this was a point that was reiterated several times in the meeting. Dave Carlson indicated that some new grand challenges were being considered by WCRP: carbon fluxes and seasonal/decadal prediction. Graeme Stephens stressed that planning of observing systems should not be exclusively focused on trends. There was some agreement that addressing monitoring the Earth, advancing understanding of climate processes and improving projections captured the primary goals of Earth observations.

There was some additional discussion on how this group's efforts interfaced with other ongoing efforts, including GCOS, the Decadal Survey, and NOAA's NOSIA 2 efforts. There was general consensus that this group could add vision to the future observing systems and could, potentially, help focus and prioritize future observation options.

#### **2) The current climate observing system: is it designed, sustained and sufficient?**

Bruce Wielicki led a discussion on the current observing system. There was general agreement that the current observing system was inadequate to address many of the science questions which are important to advancing climate science. Tom Ackerman made the point that the current system was in a state of decline and that if significant action weren't taken, our ability to observe the Earth would be worse in the future and not better. Ram reported that at least two countries indicated last week in Paris that they were planning to launch carbon observing satellites. He further indicated that there was an energy and motivation to observe the Earth in a serious manner that has not occurred in recent times, offering a unique opportunity for better planning for observations.

### **3) How can we evaluate climate observing systems?**

Betsy opened the discussion with the idea that many of the current Climate Observing System Simulation Experiments (Climate OSSEs) are quiet activities often led by PIs of particular instruments. Techniques and results were shared at the discretion of the PIs and likely do not offer a robust, unbiased analysis of the proposed system. She further reported that in discussing climate OSSEs over the past five months with climate scientists, there was strong resonance with the idea that future observing systems needed to be evaluated honestly and independently to assure that we are able to address specific climate hypotheses. There was strong agreement among the attendees that this was an area that needed to be addressed regardless of the size of observational budgets.

Lori Bruhwiler shared some of her success in using Climate OSSEs to identify observational needs to be able to identify regional carbon fluxes. Some of the key points of this discussion were that climate OSSEs were an evolving effort and that the best results were obtained by national and international coordination. This paralleled some of Jason English' comments on his experience with weather OSSEs, although the approaches and metrics for evaluation for the two types of OSSEs were quite different.

Byron Tapley indicated that this critical evaluation would not be easy but needed to be done; others strongly agreed with this point. Tim Stryker asked the question of whether this sort of evaluation had been performed on existing observing systems, and all seemed to agree that the effort that had taken place was inadequate. Both Graeme Stephens and Tom Ackerman indicated that the previously proposed observing systems should be used to analyze whether a proposed systems actually lived up to their claims once funded. A scheduled evaluation of systems after they are operational would be illuminating and might prevent some of the over-inflation of promised capabilities that currently occurs. Graeme indicated that this sort of evaluation occurs at every stage for smaller observing efforts, but seems absent for the larger efforts. Tom Ackerman further indicated that the de-scoping challenge—where systems go over-budget during development and certain capabilities must be dropped would benefit from critical analyses of capabilities.

### **4) Economic value of addressing climate questions?**

Bruce reported on the analyses that he had carried out and published with an economist that indicated that improving our understanding of climate change had direct economic value. Their efforts indicated that each year of increased understanding of climate change resulted in an estimated global financial value of \$650 billion. His initial efforts have proven to be very useful to decision makers. However, there are considerable challenges in getting more of this work funded and even finding appropriate areas for publication were difficult. Tom Ackerman indicated that this work would be more powerful coming from outside of the climate community.

### **5) Next steps nationally and internationally**

Ram outlined some of the next steps that this group could take to help the planning of future climate observations. He stressed continuing to work appropriately with the national and international efforts on climate observations, including GCOS, WCRP, the Decadal Survey and NOCIA-2. Our best contribution may be to help focus and synthesize these activities. With respect to Climate OSSEs, he suggested that we needed to develop scientific robustness in how we design climate OSSEs. He encouraged USGCRP to address these issues, including the evaluation of economic value. Ram

reiterated that there was momentum on these issues now and that perhaps we could focus on whether the current observing system is adequate to identify whether we are on the appropriate trajectories to avoid reaching a 2 degree increase. Jason English indicated that more clarity is needed on what is meant by Climate OSSEs and OSEs as well as appropriate metrics of success.

Some of the discussion focused on the need to understand climate extremes better, which is the third of WCRP's five grand challenges. Ram pointed out that there is very likely a good correlation between a warming world and the occurrence of extremes. Also, there tends to be a more ready acceptance of the value of scientific information concerning extremes. This is an active area of research between the weather and climate communities, often relying on weather observations which may change in quality or extent in the coming years. It was agreed the current observing system was in a state of decay and that we could not count on existing observing capabilities of the future being as good as the current observing capabilities unless action is taken quickly.

Other discussion points identified the Arctic as a key area needing work. Lori Bruhwiler pointed out that with new leadership in the Arctic Monitoring Assessment Program, there were opportunities to advance observations, leveraging international interest in this area. Byron stressed the importance to start by evaluating the current systems. Diane Stanitski pointed out that the GCOS implementation plan was open for input. Julie Morris also pointed out that the USGCRP strategic plan was also open for comments. Tom Ackerman questioned the effectiveness of USGCRP in its 25 years in existence. Julie pointed out that some of USGCRPs successes at coordinating the agencies may not be fully visible. Betsy shared her vision that this group was far beyond responding to the USGCRP's request for information: when there is scientific consensus in the important next step, this consensus is powerful in its own right.

Bruce indicated that we are looking for colleagues who agree with the general concepts discussed to help improve and sign on to the white paper. The white paper with appropriate signatories will help indicate to decision makers where there is scientific consensus on the importance of appropriate observing systems for the future.

## **6) Wrap-up**

Betsy shared her strongest impressions from the meeting with the attendees and asked for changes by email. These summary points were themes that recurred throughout the meeting or points where there appeared to be the most consensus:

- 1) The current observing system is inadequate for addressing the multiple climate questions and is in a state of decay; trends, processes and projections are all important and currently observationally limited.
- 2) All climate observations (satellite, in situ and ground based) need to be considered in terms of how they support specific science questions or hypotheses.
- 3) While we discussed climate observations, it is not possible to separate improving climate observations from improving climate science.
- 4) We need to be able to evaluate observing systems in a practical and honest manner; this will require intensive effort and international collaborations.

- 5) The economic value of improving our climate understanding by one year is currently estimated at \$650 billion. We owe it to society to give the something better than what we have.
- 6) Consensus on these issues needs to be built both nationally and internationally through continued interactions with the appropriate groups.
- 7) A critical examination of current observing capabilities would be a useful and appropriate starting point for a critical examination of future observing systems.
- 8) There is a momentum and global interest in improving our understanding of climate. It is the responsibility of the scientific community to give thoughtful, coordinated advice on critically needed observing systems and science priorities.