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Designing the Climate Observing System of the Future

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Climate observations remain a serious challenge for current and future Earth observations. The number of essential climate variables to measure and monitor is $\sim$ 50, about 10 times the number for weather observations. Observing the critical small decadal changes in those variables commonly requires 10 times the accuracy of weather observations. Maintaining very high accuracy continuous global observations over many decades provides a third challenge. As a result, the world lacks a designed, complete, and rigorous climate observing system. Such a system would include global long term high accuracy monitoring of the 50 essential climate variables, as well as much more detailed observations of poorly understood climate processes such as aerosols, clouds, carbon cycle, ocean and ice sheet dynamics. It would provide independent observations to allow confirmation of surprising results and independent analysis to discover and resolve observational system shortcomings. While progress has been made (e.g. WCRP GCOS, NASA Earth Observing System, Copernicus) very serious shortcomings remain (Trenberth et al. 2013).

Given the magnitude of the task, what is the appropriate level of investment? What would the economic value of such a system be? Recent estimates based on narrowing uncertainty in climate sensitivity suggest a value of \$10 to \$20 Trillion U.S. dollars in net present value at a typical discount rate of 3%. The cost to provide such an advanced climate observing system might require tripling current investments of \$4 Billion per year, for 30 years or longer. But compared to its value, such an observing system would provide a return on investment of 50:1 to 100:1, much higher than typical societal investments. How would such a system be designed? Several concepts have recently been suggested including the use of Quantified Science Objectives based on key IPCC uncertainties, climate model and process model Observing System Simulation Experiments (OSSEs) to improve the understanding of the relationship between observations and their ability to achieve a quantified science objective, and the required Quality of the observation especially for rigorous monitoring of critical long term trends (NASEM 2015, 2018). These concepts are in addition to traditional use of measures of technical readiness, risk, and cost.

The need, value, and methods for designing such an observing system have been described in a recently published paper (Weatherhead et al. 2017, AGU Earth's Future). This presentation will summarize that paper as well as interpret the need in terms of the recent U.S. Academy of Sciences Decadal Survey released in January 2018. The Decadal Survey set of quantified climate science objectives allows a measure of how short we remain of the required observations. In most cases, the technology exists, but the resources to apply it do not. How do climate scientists better communicate this need to society as well as the large return on investment it represents? What is the right amount to invest? The goal of this paper is to prompt such discussion.