# World Data System Position Statement*

### *Science and the Road to Transformation: Opportunities in the post-2015 global climate regime*

The World Data System (WDS) promotes the documentation, long-term archiving and curation of observations for global change science. These datasets are diverse, spanning the physical, chemical, biological, economic and human sciences. The data sources range from remotely-sensed records to in-situ measurements, and cover timespans from the recent decades, the post-industrial historic record to palaeoenvironmental archives.

Observations have played a key role in advancing our understanding of anthropogenic climate change. Remotely-sensed data provide time series of information about changes in an ever-increasing range of variables, allowing us to monitor the impacts of climate change on the natural environment. They have been important, for example, in establishing the decline in seasonal sea-ice thickness and extent in the Arctic and the accompanying decline in the snow cover in the northern high latitudes during recent decades. Perhaps more importantly, remotely-sensed data have demonstrated the impact of recent climate changes on the terrestrial biosphere including a significant greening and associated change in the length of the growing season over large parts of the world in recent decades.

Remotely-sensed data must be complemented by ground observations, partly because ground observations are required for calibration and validation of the satellite products. However, ground observations have a more important role to play because they can provide a longer, continuous and self-consistent record of climate changes and the impact of these changes on the environment. The in-situ sampling of atmospheric composition since the 1950's is the single most powerful record of anthropogenic impact on the Earth System—yet these measurements exist largely due to the vision of a single scientist and the growth of this monitoring network was largely ad hoc. The lack of atmospheric sampling from key regions of the world, such as Africa, speaks volumes about the lack of global coordination of climate change research. The decline in the number of meteorological stations and stream gauges in some regions, and the tendency for these data to be treated as revenue sources, also argues for a failure in global coordination of vital scientific resources.

Historical and satellite-era data are important for detection and attribution of anthropogenic climate change. However, the changes in forcing and response since the pre-industrial era are small compared to the changes that are likely to occur over the 21$^{st}$ century. Palaeodata have a key role to play here because they provide evidence of how the Earth System has responded to changes in forcing both as large and as fast as those expected in the future. Ice-core records provide well-resolved records of climate and atmospheric composition over multiple glacial-interglacial cycles—transitions that are as large though of longer duration as the projected 21$^{st}$ century changes. These records also document very large climate changes on the decadal to centennial timescale that is relevant to the next century, the so-called Dangaard-Oeschger cycles of the glacial intervals. Past climates do not provide direct analogues for the future— but palaeoclimate information demonstrates what the climate system can do, allows us to quantify the magnitude of feedbacks in the climate system, and provides an ideal out-of-sample test of the ability of state-of-the-art climate models to simulate large climate changes.

The diversity of observations needed to monitor and understand climate changes already pose a significant challenge; the need to integrate these observations with modelling perhaps an even greater challenge. The key to improving our ability to make reliable climate projections, well-informed estimates of climate impacts and, most importantly, information to inform management for sustainability, is integration: integration across scientific disciplines, integration across different approaches, and integration across temporal and spatial scales. Understanding how the biosphere will respond to and affects climate, for example, requires inputs from agronomists, plant physiologists, ecologists, as well as the biophysicists who have traditionally been responsible for implementing biosphere feedbacks in Earth System models. But, as the current debate about the velocity of climate change and potentially dangerous impacts on biodiversity illustrates, it is also important to integrate observations and understanding of biospheric changes on longer, palaeoclimate timescales. The last Assessment Report of the Intergovernmental Panel on Climate Change indicated that tree species were likely to be highly susceptible to future climate changes whereas small mammals were less susceptible because of their ability to migrate; the record of the past glacial-interglacial cycle demonstrates the opposite. In a similar fashion, there is an urgent need for the expertise from multiple science disciplines and from the end-user modelling community to be used more explicitly to ensure that the ongoing development of remotely-sensed products is maximally useful for monitoring, analysis and model-development.

There are a number of research priority areas that need to be addressed with some urgency and will require a high level of integration across disciplines, across temporal and spatial scales, and between data analysis and modelling. These include:

1) How interannual to decadal variability in climate will change as the mean climate state changes? In particular what will happen to climate modes such as the El Nino-Southern Oscillation or the North Atlantic Oscillation as climate warms?
2) What is the likelihood of changes in the incidence and magnitude of extreme events? How will changes in extremes affect the natural environment, the biosphere, and society?
3) Is the biosphere resilient to climate change or not? What are the mechanisms that produce resilience in different groups of organisms?
4) What is the magnitude of earth-system feedbacks on climate? What are the timescales on which these feedbacks operate?

These are not open-ended questions. There is no doubt that they could be answered and that they will improve our capacity to deal with future climate and environmental changes. However, they will require a focused and comprehensive scientific collaboration in order to reach well-constrained answers quickly.

Changes in the organization and funding of global-change science could help to improve scientific integration, but these changes must be supported by changes in the availability, accessibility and usefulness of observations. This is partly an issue of improving documentation and increasingly the speed at which observations become widely and freely available. But there also needs to be a step-change in the range of services provided by data archives and data-service organizations. A dialogue between practitioners, scientists and the data service providers is required to ensure that optimal use of precious data resources. WDS is committed to promoting such a step-change and to supporting the data archive and data-service organizations whose existence is vital to global-change science.

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