

# MEETING SUMMARIES

## CLIMATE SYMPOSIUM 2014

### Findings and Recommendations

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The Climate Symposium 2014, organized by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and the World Climate Research Programme (WCRP), with support from the European Commission (EC), European Space Agency (ESA), and other agencies, took place in Darmstadt, Germany, from 13 to 17 October 2014. Around 500 participants from 49 countries attended the event and represented over 200 organizations. Another 500 individuals participated remotely via “live streaming.”

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#### CLIMATE SYMPOSIUM 2014

**WHAT:** The Climate Symposium 2014, organized by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and the World Climate Research Programme (WCRP), was entitled “Climate Research and Earth Observation from Space—Climate Information for Decision Making.” Session topics revolved around the six Grand Science Challenges of the WCRP and addressed the specific need for, and role of, climate observations from space. Based on the presentations and discussions at the symposium, the Science Programme Committee identified main findings and recommendations, which are presented in this summary.

**WHEN:** 13–17 October 2014

**WHERE:** Darmstadt, Germany

The symposium was entitled “Climate Research and Earth Observation from Space—Climate Information for Decision Making” and was organized around the six Grand Science Challenges of the WCRP—namely,

- Clouds, Circulation and Climate Sensitivity;
- The Changing Water Cycle;
- Cryosphere in a Warming World;
- Ocean Circulation and Regional Sea Level Rise;
- Prediction and Attribution of Extremes: From Climate to Weather; and
- Regional Climate Variability and Change: Enabling Climate Services.

During the opening session of the symposium, these Grand Science Challenges were placed within the context of the recently completed Intergovernmental Panel on Climate Change (IPCC) assessments by T. Stocker, cochair of IPCC Working Group One. Following this scene-setting session, the subsequent sessions were devoted to the Grand Science Challenges, addressing the specific need for, and role of, climate observations from space. A roundtable discussion focused on the role of science-based climate information for decision makers. This session benefited greatly from the perspectives of high-level representatives from the energy, transport, commercial real estate, and insurance sectors, who described how they use climate information for their decision making. Early career scientists participated actively in the symposium and reported daily on oral and poster sessions. Several of the early career scientists were awarded special prizes for the quality and innovative aspects of their poster presentations.

The symposium concluded with a presentation of findings and recommendations emerging from the Grand Science Challenges sessions and a final roundtable session with space agencies and sponsors of Earth observations and research. This session was moderated by the Global Climate Observing System (GCOS) and the participants shared plans and priorities of their respective organizations for Earth observations during the coming decade. The participants also discussed the architecture for climate monitoring from space and how it can meet the observation needs emerging from the symposium.

Based on the presentations and discussions, the Science Programme Committee identified the following main findings and recommendations, which are organized according to the following themes: i) research and process understanding, ii) observations, and iii) coordination and integration of observations.

## RESEARCH AND PROCESS UNDERSTANDING.

- 1) The role of atmospheric water and circulation, and their coupling, emerges as a common uncertainty across several of the Grand Science Challenges. Progress on Grand Science Challenges will require improved understanding of underlying processes based on observations of water vapor, clouds, and winds, especially in the lower troposphere, and at a higher vertical resolution than is available from the current sensors.
- 2) Much progress has been made in closing the global sea level budget, but open questions

remain concerning regional and coastal sea level change, which is greatly affected by regional circulation and associated processes. Specific challenges include understanding the processes and feedbacks contributing to changes in circulation and sea level, as well as predicting changes in regional circulation and regional sea level.

- 3) Understanding circulation changes and the processes driving climate sensitivity requires coincident observations of clouds and their environment, as well as better estimates of the components of the surface energy balance. Spaceborne observations of winds and circulation such as atmospheric motion vectors, scatterometer winds, and future lidar winds need to be exploited for this purpose and need to be enhanced.
- 4) Greater confidence in climate projections requires improved process understanding and better representation of key aspects of the climate system. Such aspects include i) large-scale atmospheric circulation and processes that control low-level clouds, ii) measurements to examine short-term variability of key components, iii) the energy budget (moist static energy profiles, atmospheric heating, surface fluxes) to guide the use of observations to constrain circulation, and iv) land sinks of CO<sub>2</sub>, which still are largely inferred as a residual; thus, better measurements should focus on identifying processes responsible for midlatitude terrestrial carbon sinks.

## OBSERVATIONS.

- 5) There is an unequivocal need for sustained long-term space-based observing systems provided by operational satellites that are primarily used for weather observations. It is recommended that “science theme” oriented space missions proposed by the research agencies derive benefits from the core observations produced by these operational meteorological satellites.
- 6) Accuracy is an important attribute of a climate observing system and helps to advance our understanding of physical processes in Earth’s climate system. A climate-reference mission (e.g., a hyperspectral infrared mission) could provide accurate anchor measurements for other observations.
- 7) Constellations of different satellites provide powerful observations that assist in the evaluation of changes in water vapor, cloud formation–dissipation, and convective processes, as well as their relationship to atmospheric circulation. Notably, active remote sensing [e.g., *CloudSat* and

the *Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)*] has revolutionized our understanding of processes involving clouds, precipitation, aerosols, and their detailed vertical structure. Therefore, the continuity of the active remote sensing records needs to be maintained.

- 8) Sustained and improved observations of rain, snow, soil moisture, evapotranspiration, and their variability are needed to understand the changes in the water cycle and to help in closing the surface energy and water balance. Those observations are also essential for capturing the intensity and frequency of precipitation and their extremes, as well as land–atmosphere feedbacks relevant to water and temperature related extremes.
- 9) Space-based observations of the cryosphere need to deliver both area and volume measurements in order to narrow down uncertainties in the mass balance and changes. The results help us to better formulate ice sheet modeling.
- 10) Understanding ocean circulation and regional sea level rise calls for a sustained combination of in situ (e.g., floats, tide gauges, coastal observations) and space-based measurements of the ocean surface topography (high-precision altimetry) and changes in the gravity field [e.g., the Gravity Recovery and Climate Experiment (GRACE)]. Consideration should be given to expanding the measurements of Argo profiling floats in terms of geographical coverage (e.g., the Indonesian region, Arctic), in deeper parts of the ocean, and under sea ice to better understand ocean circulation.
- 11) Global navigation satellite system (GNSS) radio occultation observations have very desirable properties (e.g., stability, homogeneity, high vertical resolution in the free troposphere and stratosphere), which has resulted in improvements in our understanding of atmospheric variability and the detection of climate change. It is important that their continuity is ensured with optimum global coverage.
- 12) To enhance the value of existing observation records for climate research and applications, operational and research space agencies should put a sustained effort into reprocessing and reanalyzing existing archived data to produce temporally homogeneous products that can be used to study climate variability and change.

- 13) The mapping capabilities and global coverage of spaceborne observations are essential for observing the frequency and intensity of extreme events and for improving our understanding and attribution of causes.

## **COORDINATION AND INTEGRATION OF OBSERVATIONS.**

- 14) The potential of combining multisensor/satellite operational and research missions should be considered to address science questions across multiple Grand Science Challenges, noting that i) the continuation of the high-precision ocean altimetry measurements, expected from the Sentinel-6/Jason-CS mission to be launched in the next decade, is a top priority, and ii) high-priority research missions such as GRACE, active atmospheric sounding (*CloudSat* and *CALIPSO*), and the Global Precipitation Mission need to continue beyond their original missions to consolidate our understanding of key climate processes.
- 15) The broad range of scientific challenges and priorities formulated by the research community for space-based observations can only be fulfilled through international cooperation. The architecture for climate monitoring from space coordinated by the Committee for Earth Observation Satellites and the Coordination Group for Meteorological Satellites (CEOS–CGMS) Working Group on Climate appears to be an appropriate framework for such international cooperation.
- 16) There is a need for an integrated observational approach that is strategically designed to be cost effective and sustained over decades, yet remains targeted on key challenges and promotes the fusion of theory, models, and observations. Where relevant, this approach should also address the linkage to societal benefits, as this could facilitate greater support and funding for such observation systems.

The full program and presentations from the Climate Symposium are available at [www.theclimatesymposium2014.com](http://www.theclimatesymposium2014.com).

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