MEASURING PRECIPITATION FROM SPACE

ADVANCES IN GLOBAL CHANGE RESEARCH

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EURAINSAT and the Future

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V. Levizzani
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The community also felt that it was time to put together the amount of knowledge, technology and vision that is available in the field for the benefit of students, professionals and decision makers. More than 20 years have passed since the last book on this subject was printed. Many satellite missions have been launched in between while, at the same time, scientists have made substantial progresses towards transforming satellite rainfall "estimates" into real "measurements" and to produce operational rainfall products readily available for a wide field of applications ranging from climate research and numerical weather prediction to hydrology and agriculture.

This book represents a significant effort and each one of the authors did not spare herself or himself in providing top class material, most of the time contributing results and ideas that were worth publishing in peer reviewed journals. The result is a book, which not only photographs the state of the art of the discipline, but also projects it into the future.

Several people and organizations need to be warmly thanked and it would be difficult to do it one by one. However, we feel it is appropriate to say at least a few "thank you's" that will enclose almost all the others.

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Bologna, Reading, and Monterey, 13 October 2006

Vincenzo Levizzani, Peter Bauer and F. Joseph Turk

PREFACE

Since the last two decades, awareness by the international community of the threats hanging over the planet has increased significantly. Progress in sciences and technologies made it possible to improve our inventory of the state of the environment; evidence was given that rapid changes are occurring across the globe. At present, the complex dynamics of planet Earth and its multidimensional and interrelated processes are at the heart of current scientific investigations. In this context, it is primordial for Europe to further strengthen its capacity to understand, detect, and forecast global change.

Detailed process studies and modeling relies permanently on the availability of systematic observations of atmospheric, terrestrial, and oceanic parameters including those of climate. Such a comprehensive observing capability includes large panoply of instruments on various platforms such as ground stations, ships, buoys, floats, ocean profilers, unmanned autonomous underwater and airborne vehicles, balloons, aircraft and satellites. Among these platforms, it is worth noting the unsurpassed coverage brought by Low Earth Orbiting (LEO) and Geostationary (GEO) satellites. Since about three decades, satellites are transmitting homogeneous measurements of many variables characterizing environmental processes and changes.

As part of its 5th Framework program for European research and technological development (1998–2002), the European Commission has been supporting a portfolio of 26 research projects in the field of generic Earth observation technologies for the environment. The related 240 research and user organizations have cooperated and delivered innovative processing, modeling, and integration techniques. They have demonstrated elements of future monitoring systems and assessed the strengths and limitations of current space missions.

Among these 26 European projects, EURAINSAT has successfully explored the real-time exploitation of data from both LEO and GEO satellites for rainfall estimation and subsequent assimilation into numerical weather prediction models. EURAINSAT has not only promoted the use of SEVIRI data from the recently declared operational METEOSAT-8 satellite, it has also prepared the scientific ground for the multilateral Global Precipitation Measurement (GPM) constellation to be launched in the period 2007-2008. The project, which was presented on the occasion of the Flood Media Event organized by the European Commission on 13 October 2003, builds upon several European research projects addressing the issue of precipitation such as EUROTRMM, MUSIC, and MEFFE. The project also opens new collaboration perspectives at European and global levels. It is thus a privilege to introduce this book presenting state of the art in the field of measuring precipitation from space.

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Section 1

Climate Monitoring

1

EUROPEAN COMMISSION RESEARCH FOR GLOBAL CLIMATE CHANGE STUDIES: TOWARDS IMPROVED WATER OBSERVATIONS AND FORECASTING CAPABILITY

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Abstract Improved forecasting at the local, regional and global scales of the interrelated Earth system processes requires, as a prerequisite, a comprehensive global observing strategy susceptible to support the progressive establishment of a global science of integration. This paper concentrates on climate change research and observations, including the key parameters of the global water cycle. Reference is made to the related European research program in the field of "Global Change and Ecosystems" (thematic sub-priority 1.6.3. of the 6th research Framework Programme of the European Union, 2002–2006).

Keywords Earth system, global change, water, floods, global observations, forecasting, European research, 6th Framework Programme

1 INTRODUCTION

Looking at our global environment, water is often mentioned to be the resource challenge of this century. Water must satisfy the need of all forms of life, starting with the rising water demand by a world's population that has tripled during the 20th century. Sustainable management of water resources has to consider the increasing imbalance between the geographical and seasonal demand for, and availability of, water. It has to cope with pollution and waste of water, also where it is in abundant supply. The European Union (EU) is pursuing a common water policy since a number of years. The Water Directive of the European Parliament and of the European Council establishes

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a framework for the Community action in the field of water policy. This EU Directive calls notably for integration and coordination of river basin management across national borders. It also calls for an improved management of the hydrological extremes of floods and droughts.

Water management and more generally sustainable development rely heavily on the improved understanding of the multidimensional mechanisms of the water cycle and their interactions with other climate-related processes. This paper concentrates on climate change research and observations, including the key parameters of the global water cycle.

2 WATER CYCLE AND PRECIPITATION

The global water cycle includes many components, mainly atmospheric water vapor, cloud cover, precipitation, surface and subsurface runoff, soil moisture, groundwater, oceans, snow, glaciers, and ice sheets. These components – that illustrate water in its various phases – are affected by a number of physical, chemical, biological, and human-induced processes that play a key role in the Earth's climate.

Precipitation is unanimously recognized as one of the most central variables of the global water cycle, mainly because of its direct significance for the availability of water for drinking and the agriculture, but also because of its impacts on, for instance, runoff over land, soil moisture, floods, stream flow, ocean salinity or atmospheric circulation through associated latent heating. To date, precipitation data are recorded from various remote and in situ instruments (mainly rain gauges, rain radars, and microwave, visible or infrared sensors) based on various platforms (mainly ground-based, airborne or space-borne). However, the fact that water cycle dynamics occur at a wide variety of spatial and time-scales makes them very challenging to observe, understand, and predict. Precipitation is characterized by various regimes. Moreover, determination of precipitation inputs and regimes requires ideal observation of the vertical hydrometeor structure, especially with respect to droplet size, shape, and temperature. Existing instruments and new emerging sensing technologies have each their own advantages but also limitations with respect to spatial sampling and resolution, spatial coverage, temporal coverage, cost of purchase and operation, calibration, accuracy, and consistency of the retrievals, etc. To date, the quantification of adequate precipitation products is hampered by a lack of long-term, stable and high quality observational data and a lack of integration among the various available observation data sources.

The observation challenge is a prerequisite for our understanding of the water cycle and its interactions with the climate system at the local, regional, and global scales. Moreover, further research is also required in order to reduce current limitations of the climate models in their ability to simulate aspects of the water cycle such as precipitation amounts and frequency on seasonal and longer time-scales, not only at very large grid scales, but also at lower scales such as catchment scales. At weather time-scales, new optimized near-real-time assimilation schemes and increased lead-time of weather forecasts open the perspective for improved flood warning. Better forecasts also rely on stronger interdiscipline linkages. Meteorologists and hydrologists, for example, could further expand intelligent coupling of numerical weather forecast models with runoff models.

3 TESTS AND APPLICATIONS

Nowadays, more and more evidence is accumulated that weather and climate are characterized by chaotic aspects that could be inherited from a nonlinear behavior of the internal dynamics of the Earth system. The scientific community is step-by-step investigating the occurrence and amplitude of climate change with respect to changes in the forcings and feedbacks patterns of the Earth system. There is a consensus to categorize water vapor among the largest forcing agents and to group the processes involving water in its three phases among the most important feedback mechanisms that amplify or damp climate perturbations. This is notably true for the water vapor-cloud-radiation feedback.

Scientists who have studied long-term climatological data confirm increases in the frequency of extreme events – such as extreme temperatures or exceptional intensity of precipitations – decreases in sea level rise and seasonal and perennial snow and ice. In its Third Assessment Report 2001 the Intergovernmental Panel on Climate Change (IPCC) forecasts warmer climates, owing to more frequent and more intense hydrological extremes.

Observed climate trends and projected scenarios raise the urgency to address several key scientific questions. To what extent is the global water cycle intensifying? What is the level of interactions between variations in the water cycle and other biogeophysical cycles? More particularly, is the observed increase in extreme events linked to climate change? Is this the result of natural variability or is it caused by human pressure on the environment, or both? One should consider the numerous interconnected factors at play. Climate change is likely to have an incremental effect. Human pressure (for instance, on the atmospheric composition) interferes with the natural flows of energy. More directly, human activities influence the hydrological cycle at various scale, notably through changes in land use, land cover including deforestation, irrigation and drainage, extended pavement, etc.

4 RESEARCH STRATEGY

Quantitative answers to the above questions require a comprehensive and integrated research strategy that builds upon ongoing disciplinary research on parts of the Earth system, but progressively evolves towards addressing interrelations between the dynamics of the Earth system as a whole. Such an