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THE FUTURE OF OCEANOGRAPHY FROM SPACE

INTRODUCTION TO THE SPECIAL ISSUE

In this special issue of *Oceanography* we explore a number of different science drivers for the future of oceanography from space. Given all the developments in remote sensing over the last few decades, this area is rich for inquiry, and we do not presume to provide a comprehensive overview in this single issue. Likely, there will be follow-on issues covering more science and different aspects of remote sensing in greater detail. We hope these papers will stimulate robust community conversation about oceanography from space that will lead to such follow up in *Oceanography*.

The idea for this special issue emerged in late 2008. Given the successes in remote sensing of temperature, sea surface height, surface vector winds, time-varying gravity, and ocean color, in addition to emergent capabilities in surface salinity, it seemed the right time to determine the next challenges in oceanography using satellites. The space oceanography community had provided more than 100 technical ideas for the 2007 US National Research Council decadal survey published under the title *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond* (see http://www.nap.edu/catalog.php?record_id=11820) to set the direction for US satellite development in the field of Earth science. Precisely what science drivers can and should guide satellite oceanography development remains an open question. Here, author teams address questions in oceanography where satellite measurements play a key role and will likely underpin future developments. The idea for this special issue was NOT to have papers about specific satellite missions. It was to articulate areas of scientific inquiry that fuel development of next-generation satellite missions.

There is no single best order to either present or read the articles in this special issue. We (the guest editors) have arranged the papers in a comfortable "cover-to-cover" reading order that appealed to us. To describe the 11 articles, it is somewhat easier to group them differently. A couple of the papers focus on air-sea interaction, several cover aspects of ocean circulation, a number review aspects of variability and change in the ocean, and a couple illustrate the relationship between technology development and ocean science. These categories are applied arbitrarily and only to get you, the reader, through this introduction to the papers.

In the last decade, joint analysis of different satellite data sets has opened up the study of air-sea interaction and the estimation of air-sea fluxes. Chelton and Xie examine the coupled interaction of ocean and atmosphere at oceanic mesoscales. The modification of the near-surface boundary layer as air flows over oceanic temperature gradients leads to modification of the wind field with profound implications for both oceanic and atmospheric circulation. Their work is tremendous motivation for development of both high-resolution ocean-atmosphere coupled models and a remote-sensing capability that more comprehensively samples the planetary boundary layer. Bourassa et al. look at the air-sea fluxes inferred from remote sensing that are essential for development of high-quality global climate analyses. In order to make estimates of air-sea fluxes globally, with reasonable and quantified uncertainty, a more cunning synthesis of satellite and in situ

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technologies is envisioned. Proposed future systems, which use improved instrumentation and collocate observations of winds, temperatures, and humidities, will improve the accuracy beyond current capabilities.

Several papers in this issue take on the future of ocean circulation studies. Fu et al. examine eddy dynamics**.** Eddies are a ubiquitous characteristic of the general ocean circulation but are not yet fully resolved in satellite observations. They set the scientific stage for the next generation of satellite altimetry that promises much higher spatial and temporal resolution of ocean surface topography. Lee et al. address basin-scale circulation changes associated with climate variability. Various modes of ocean and climate variability are described in a way that illustrates requirements for sustained global ocean observing systems. Dohan and Maximemko take on the subject of ocean surface currents and their derivation from a variety of satellite and in situ data sets. These analyses are used in a variety of scientific and practical applications.

A number of papers in this issue address profound changes in the ocean that will be emerging over the coming decades. Willis et al. look at global sea level rise and the complex array of space and in situ measurements required to advance our scientific understanding of this phenomenon. Satellite altimetry and the incredible ongoing developments in its accuracy emerged as an essential monitoring tool for sea level variability. Yoder et al. take on the enormous field of change in marine ecosystems and biogeochemistry as determined through ocean color radiometry. Remote sensing has provided evidence of large-scale change in ocean productivity and is increasingly capable of differentiating ecosystems in the open ocean. The issue of ocean acidification is touched on, but we refer readers to the December 2009 special issue of *Oceanography* on "Ocean Biogeochemistry in the High-CO_2 World" for a full treatment of this issue (see http://tos.org/oceanography/issues/issue_archive/22_4.html). Large modifications to coral reef ecosystems are also occurring as result of global climate change. Eakin et al. examine the issue of coral reefs and the role of remote sensing in addressing our understanding of shifts in these diverse ecosystems. Similarly, Kwok and Sulsky examine a specific and critical aspect of change—that of Arctic Ocean sea ice thickness. The dramatic decline in summer Arctic sea ice extent over recent decades has been front-page news. This article makes us more familiar with the profound changes in sea ice thickness and total ice volume that have occurred.

Two papers in this issue very clearly illustrate how technical developments in remote sensing open up new avenues of scientific inquiry. The advent of precision L-band radiometry to make estimates of ocean surface salinity is one such area. Lagerloef et al. look at the ocean's role in the global water cycle. The field of salinity remote sensing is just emerging and our capability to monitor the water cycle over the ocean will improve significantly over the next decade as a result of technology developments in satellite oceanography. Freeman et al. more generally describe technology advances in the field of satellite oceanography. They illustrate the close relationship between technical advancements by the developers of satellite sensors and scientific progress in oceanography.

We hope that you enjoy this issue of *Oceanography* as much as we enjoyed serving as guest editors. The diversity of talent and energy on display in these articles inspired us throughout the last year.