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FORUM

Measuring Progress of the Global Sea Level Observing System

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Sea level is such a fundamental parameter in the sciences of oceanography, geophysics, and climate change, that in the mid-1980s, the Intergovernmental Oceanographic Commission (IOC) established the Global Sea Level Observing System (GLOSS). GLOSS was to improve the quantity and quality of data provided to the Permanent Service for Mean Sea Level (PSMSL), and thereby, data for input to studies of long-term sea level change by the Intergovernmental Panel on Climate Change (IPCC). It would also provide the key data needed for international programs, such as the World Ocean Circulation Experiment (WOCE) and later, the Climate Variability and Predictability Programme (CLIVAR).

GLOSS is now one of the main observation components of the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) of IOC and the World Meteorological Organization (WMO). Progress and deficiencies in GLOSS were presented in July to the 22nd IOC Assembly at UNESCO in Paris and are contained in the GLOSS Assessment Report (GAR) [*IOC*, 2003a].

The status of the program is presented in the GAR in different ways, but one important measure is its success in achieving its originally stated objective of improving data flow to the PSMSL which, prior to GLOSS, had received data from countries for many years, but on a rather ad hoc basis. Figure 1 shows the status of each of the 290 stations of the GLOSS Core Network as of October 2003, defined in terms of the latest data available at the PSMSL. Only about two-thirds of the stations exist and deliver data regularly. This situation has persisted for a number of years, and we believe that without new initiatives, there is little chance of further overall improvement, and indeed, there could be a deterioration in the provision of sea level data as equipment malfunctions and is not replaced.

We must be careful, though, not to present a completely pessimistic report; the overall status has increased from approximately one-third to two-thirds during the 1990s, and there has been definite progress by many countries in the provision of the relatively new "fast" (quasi-real-time) data stream (Figure 2). Fast data are required for deep-ocean and coastal numerical model assimilation and validation projects—for example, the Global Ocean Data Assimilation Experiment (GODAE)—and for a range of "operational oceanography."

The overall GLOSS status is better than two-thirds if one considers that, at some sites, environmental conditions such as sea ice mean that gauges capable of delivering true sea level data cannot be operated, but the stations are equipped with pressure transducers that can supply useful subsurface pressure data for oceanographic studies. Nevertheless, a large part of the remaining one-third comes from the stations that have no gauge, or a broken one, or from some difficulty in data from the gauge getting through to data centers.

GLOSS is a program that depends on the active participation of a large number of states, including many developing countries. So why do some of these countries not make better efforts to meet their internationally agreed upon responsibilities to GLOSS? Of course, a lack of funds for hardware, maintenance, and staff is the most obvious problem. However, in some countries, there are reasons that are harder to identify. These could be because appropriate national contacts do not exist or have insufficient technical expertise. Or they may have positions that carry insufficient authority to organize others to conduct the work, or have little interest outside of their immediate national responsibilities. In addition, in some countries, there are national security and cost recovery concerns that inhibit data exchange.

It is clear that progress in GLOSS cannot be made rapidly without either significant, simultaneous investment over the next few years by a number of countries that have not invested so far, or a more coordinated approach led by the IOC in cooperation with other international organizations. From our experience of the program during the last decade, we have little expectation that the former will happen. Therefore, the GAR included a proposal for the latter costing \$3.5 million, which would install almost 100 new GLOSS stations world-

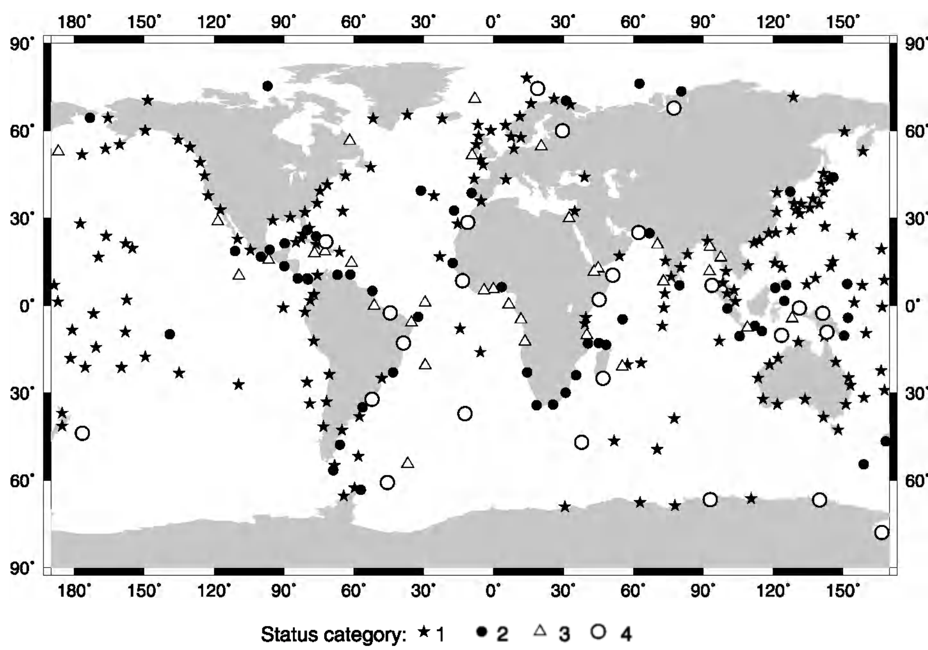

Fig. 1. The status of stations in the Global Sea Level Observing System Core Network is defined by the latest data available at the Permanent Service for Mean Sea Level. Status category 1: Latest data 1999 or later; Category 2: 1989 to 1998; Category 3: Before 1989; Category 4: No data. Totals: 176, 56, 33, and 25, respectively.

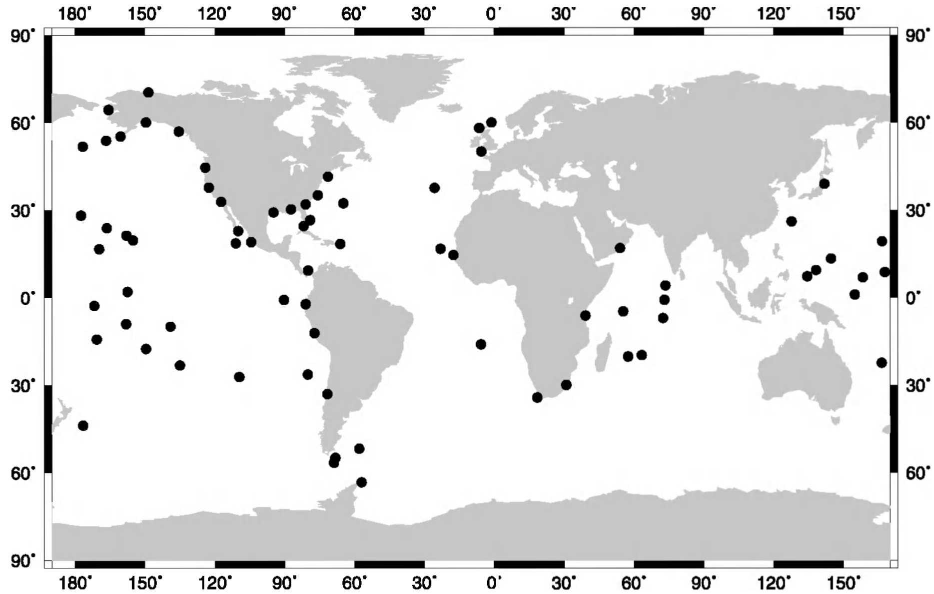

Fig. 2. The 73 sites of the GCN are shown for which data are received at the Global Sea Level Observing System Fast Centre at the University of Hawaii Sea Level Center, either in near-real- time (within a few hours) or with a delay of up to 1 week, which is still an acceptable lag for deep-ocean modeling. Twenty-four additional non-GCN sites are also regularly delivering data to the Global Sea Level Observing System Fast Centre in this "fast" mode. (Figure taken from IOC *[2003a].)*

wide. In addition, it would provide training to make use of data locally, and thereby convince countries of the value of ongoing measurements from national perspectives. It should improve the operational status of GLOSS measured by the "delayed mode" streams by at least 30%, and should approximately double the effective number of sites available in "fast" mode. As a result, the international community should gain access to information from a wider, "kick-started" network than would be possible by waiting for GLOSS to evolve as originally intended.

This proposal was approved by the Assembly unanimously, but the "victory" was a hollow one, in that the Assembly itself has no resources of this magnitude for funding. So where is the money to come from?

As a start, proposals for GLOSS in Africa and South America have been submitted to major funding agencies. The need for similar proposals has been identified for other regions (for example, the Middle East and Southeast Asia), but they need respected "regional champions" to take them forward energetically. These proposals take notice of the fact that GLOSS has attempted to be two programs at once; namely, the "ocean/climate" and "coastal" halves. For many years, the balance of interest in the program has been tilted more to the "ocean/climate" half. However, with the identification of the coastal requirements for the Global Ocean Observing System (GOOS), that balance may be restored. Sea level is recognized as a key Coastal GOOS parameter [*IOC*, 2003b], and the installation of relatively inexpensive sea level stations is seen as a way to broaden the ownership of GOOS among coastal states.

In summary, we believe that, while many countries will continue to recognize the importance of the GLOSS program as originally proposed, and will have the funds to maintain their national contributions toward it, the future for sea level recording in a large part of the world will depend increasingly on effective articulation of the benefits from the coastal, as well as the ocean/climate perspective. In addition, if the traditional GLOSS organizational model of nations contributing to a global program has failed in some way, then the regional approach needs to be investigated more thoroughly. That implies countries working together on a regional basis more effectively than before. Also, local sea level experts will need to come forward to design the optimum sea level networks in their regions and make a strong case for funding them.

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BOOK REVIEWS

Waves in the Ocean and the Atmosphere: Introduction to Wave Dynamics

JOSEPH PEDLOSKY

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Anyone who has stood on a ship or a beach will recognize that wave motions are an essential element of the ocean environment. And in its deeps, along its margins and across its basins, the ocean seethes with a wide spectrum of slow-moving interior waves that are invisible to the casual eye of the surface observer. Their influence may ultimately be felt across the globe, on land as well as at sea, for years, decades, or centuries. The winds that buffet a land-locked observer may seem less like waves and more akin to the continuous rush of water through a pipe or down a river channel. However, viewed from a broader perspective, even the ever-changing weather patterns of the Earth's atmosphere have their own particular wave dynamics.

With *Waves in the Ocean and the Atmosphere: Introduction to Wave Dynamics*, leading geophysical fluid dynamicist Joseph Pedlosky provides an accessible and authoritative theoretical introduction to the wide variety of wave motions that occur in the planetary fluid environment. This is a fine book, tailor-made for graduate teaching, but also suitable for use as a desk reference for the basic elements of oceanic and atmospheric wave dynamics. The oceanographic perspective is emphasized. Aside from a few, largely cosmetic typographical errors, the only disappointment is that it does not go on a little longer: chapters on acoustic waves, tides, coastal-trapped ocean waves, and some pointers toward the many fascinating phenomena of nonlinear wave dynamics would have been welcome extensions, and one can hope that they may be added to a future edition.

As is noted in the preface, this text was developed from the author's own course notes, and its pedagogical heritage is consciously preserved in the presentation and organization. The chapters are labeled "Lectures" and each is a brief, focused episode