AN INVESTIGATION OF VERY LOW FREQUENCY SEA LEVEL CHANGE USING TOPEX/POSEIDON ALTIMETER DATA

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With 5 years of precise satellite altimeter data from TOPEX/POSEIDON, and the prospect of the continuation of this time series by Jason-1 into the next century, we now have a data set of sufficient length to begin studying very low frequency (VLF) sea level variations. The objective of this investigation is to obtain a better understanding of VLF sea level variations by analyzing TOPEX/POSEIDON and Jason-1 altimeter data using both advanced statistical analysis techniques and numerical ocean modeling.

The success of the TOPEX/POSEIDON (T/P) altimeter mission has created a revolution in oceanography. T/P truly provides “sea level to within an inch”, allowing entirely new types of oceanographic problems to be addressed that were impossible with previous missions. Among many accomplishments, T/P has provided measurements of global mean sea level variations at 10-day intervals with a precision of 4 mm, more than sufficient to detect the very low frequency (VLF) changes associated with climate change given a sufficiently long time series and accurate monitoring of the instrument calibration. More importantly, T/P makes it possible to geographically map the spatial variations of VLF sea level (Figure 1), and a better characterization and understanding of these patterns is still sought. It is difficult to detect the geographic “fingerprint” of long-term climate change signals using altimeter data from a single satellite mission, even T/P, because the mission length will probably be insufficient to easily differentiate these signals from interannual and decadal variations. Therefore, a multi-decadal time series of sea level derived from several both T/P and Jason-1 altimeter data will likely be required. Nevertheless, in the interim, the interannual to decadal VLF signals which T/P has detected over the last 5 years are of great interest in themselves because of what we can learn about short-term climate change. As the T/P mission generates a longer time series, much better separation of the interannual, decadal, and secular sea level signals will be possible. In addition, as we develop a better understanding of the interannual to decadal sea level variations, this will also help us identify the long-term climate change signals. Thus, it is the VLF sea level change currently being observed by T/P at interannual periods and longer which are the subject of this investigation.

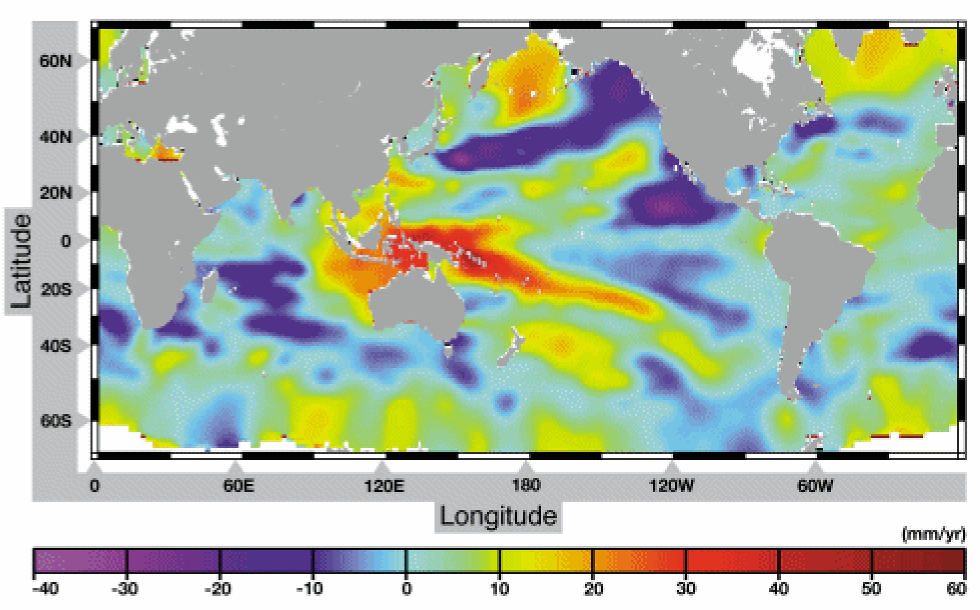

Figure 1

Secular rate of sea level change (in mm/yr) over 1993-mid1997 estimated by performing a least squares fit of annual, semi-annual, and secular terms to the T/P data at each geographic location.

The primary objective of this investigation is to obtain a better understanding of the factors contributing to the VLF sea level changes observed by T/P. The first part of our investigation considers the measurement/data analysis issues associated with accurately measuring VLF sea level change using satellite altimeter data. These issues include monitoring the altimeter calibration behavior, errors in the measurement corrections, and new data analysis techniques for extracting VLF changes. While the investigation will emphasize data from T/P and Jason-1, data from other missions (Geosat, ERS-1, ERS-2, Geosat Follow-On) will be considered in order to extend and corroborate the T/P sea level record if the larger measurement errors from these missions can be accommodated. We will employ the global tide gauge network to develop better estimates of the behavior of the T/P altimeter calibration, which will complement other on-going calibration studies (e.g. the Harvest platform). Tide gauge data are an important resource, not only for instrument calibration, but also for tying different altimeter missions together, and understanding the sea level variations observed in the relatively short altimetry record in the context of the tide gauge observations of sea level rise over the last century. With appropriate monitoring of the altimeter calibration, we can more confidently use statistical analysis techniques (e.g. filtering theory, principal component analysis, etc.) to extract and characterize the VLF sea level changes contained in the altimeter data records.

In the second part of our investigation, we turn to understanding the observed VLF sea level changes, which is important for studies of short-term climate change, and also has implications for uncovering the long-term climate change signal imbedded in the relatively short altimetry time series. We will compare the observed VLF sea level changes to various in situ measurements (e.g., SST , hydrography, tide gauges) and numerical ocean models (Semtner-Chervin, MOM2, etc.) in order to evaluate possible causes for the observed variations, such as changes in heat content, large scale ENSO responses, etc. We will also assimilate the altimeter data into a modified MOM2 ocean model in an attempt to simulate the observed VLF variations. If reasonable simulations are obtained, then we will have a powerful tool at our disposal for studying the factors driving the VLF changes.

Unquestionably, in explicitly focusing on the longest time scales possible, this proposal addresses a difficult objective given the relatively short time series of precise satellite-observed sea level. However, with 5 years of data in hand, and the prospect of the T/P doubling the length of its record, this is an excellent time to begin a study of VLF sea level changes. We have planned a comprehensive effort employing multi-mission satellite altimetry, tide gauge data, models of sea level change, and advanced statistical analysis techniques. This has an excellent chance of significantly advancing our understanding of VLF sea level change and its causes. Also, the team has been explicitly chosen in order to bring different areas of expertise to bear on the problem, including members with experience in geodesy and oceanography, and in data analysis and numerical modeling.