APPLICATION OF ALTIMETRY MEASUREMENTS TO OBSERVATIONAL AND MODELING STUDIES OF LOW-FREQUENCY UPPER OCEAN MASS AND HEAT CIRCULATION IN THE TROPICAL PACIFIC

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A team of investigators at NASA/GSFC-ESSIC/UMD (A. Busalacchi, R. Murtugudde), NOAA/PMEL (M. McPhaden, D. Moore), ORSTOM (J. Picaut, T. Delcroix, L. Gourdeau, Y. du Penhoat), and LEGI/Grenoble (J. Verron) is focusing on the utilization of satellite altimetry data in support of monitoring, prediction, and process studies of interannual variability in the tropical Pacific Ocean with an extension to the Indian Ocean.

The team activities during the TOPEX/POSEIDON Extended Mission (TPEM) will focus on:

- seasonal-to-interannual (i.e., ENSO) variability in the tropical Pacific,
- the variability of the Indo-Pacific warm pool system,
- assimilation and impact assessment of altimetry data and TOGA TAO dynamic topography into ocean and coupled ocean-atmosphere prediction models,
- analyses of inverted barometer effect at low latitudes, and of equatorial wave dynamics via the joint analyses of T/P and TOGA TAO observations.

Several of these research topics represent a broadening of our use of altimeter data beyond our accomplishments during the pre-launch phase and three-year Prime Mission, and are in direct support of the CLIVAR/GOALS program. During the primary phase of the T/P mission this collection of investigators was responsible for approximately 28 publications specific to the utilization of altimeter data in studies of the tropical Pacific Ocean circulation.

Original objectives and accomplishments to date

The purpose of our original T/P project was to describe the seasonal and interannual transports of upper ocean mass and heat in the tropical Pacific, and to understand the mechanisms responsible for these transports. The original approach relied on the complementary nature of altimetry data, in situ data, and ocean model outputs in order to estimate the accuracy of the altimetry data in the tropical Pacific, and identify the dominant processes intrinsic to mechanisms of ENSO. A brief list of our accomplishments can be categorized into:

1. validation-representation of low-frequency zonal geostrophic currents at the equator [Picaut et al., 1990], sea surface topography and geostrophic current field comparisons based on various data sources [Delcroix et al., 1994; Busalacchi et al., 1994], and the

only open ocean validation of T/P data with surface-to-bottom in situ data [Picaut et al., 1995],
2. ENSO mechanisms- evidence of first baroclinic mode equatorial waves [Delcroix et al., 1991] and their role in ENSO [Picaut and Delcroix, 1995], ENSO related zonal displacement of the warm pool [Picaut et al., 1996], interannual variations of sea surface topography and deficiencies of wind products for modeling studies [Busalacchi et al., 1990], and
3. assimilation and prediction studies- review of assimilation methodologies, development of assimilation techniques [Verron et al., 1997; Hackert et al., 1996], enhancement of ENSO forecast skill through assimilation [Chen et al., 1995], reduction of computational burden via a reduced state space Kalman Filter [Cane et al., 1995]. The role of the Indonesian throughflow in the interannual variability of the Indo-Pacific warmpool and the use of T/P data for monitoring the Indonesian throughflow are reported in [Murtugudde et al., 1997].

New avenues of research and approach

In addition to continuing the general areas of research from the original project, we are interested in pursuing several new topics of research. Decadal variability of ENSO, connections between the tropical Pacific, the mid-latitude Pacific, and the tropical Indian Ocean, their potential implications for the skill and lead time of dynamical model-based ENSO forecast schemes have raised our interest in the light of the extended warming during the 1990s. Compared to our original project, our objectives have not changed significantly. We will continue our efforts in analyzing in situ data, altimeter data, and ocean model solutions together with data assimilation efforts in stand-alone and coupled models for the interannual variability in the tropical Pacific Ocean. A host of scientific questions will be addressed with this comprehensive approach. What are the reasons for the decadal shifts in the amplitudes of seasonal cycle in thermocline depth and dynamic height? Are similar decadal scale changes reflected in existing altimeter data? Does the interannual or decadal variation in the Indonesian throughflow play any role in the upper ocean heat content and thermocline variability in the Pacific and hence ENSO dynamics? How do potential decadal scale changes in the seasonal character of the tropical Pacific wind forcing manifest themselves as decadal changes in sea level and SST? What is the nature of meridional exchanges of mass and heat to high latitudes during 1991-1995? What are the effects of interannual variability of the Indian Ocean on the Indo-Pacific warm pool?

In addition to the analyses of data in seeking answers to the above questions, we will make extensive use of various data sources in multiple assimilation activities. The first activity with a sigma coordinate ocean GCM is part of an assimilation technique development effort which will also lead to the best possible 4-dimensional view of the COARE domain. The second aspect of our assimilation into stand-alone ocean models will support diagnostic and process oriented studies. The third aspect of the assimilation studies will be targeted toward coupled ocean-atmosphere prediction models. It is anticipated that through these analyses of altimeter data, in situ data, assimilation fields, and model simulations we will develop a better understanding of the processes involved in the development of ENSO events, and in particular the potential role that upper ocean heat and mass exchange with higher latitude plays in setting the time scale between events. We also expect to demonstrate the utility of model-based ocean analyses of altimeter data for climate studies.

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