Ocean circulation, height systems and gravity field studies based on Jason-1 altimetry

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This article summarizes the activities in the field of satellite altimetry at the Delft Institute of Earth-Oriented Space Research (DEOS). It is a logical next step forwards from earlier science plans for TOPEX/POSEIDON (T/P) and ERS discussing new challenges for geodetic and oceanographic studies based on Jason-1 altimetry.
Our research concerns both the stationary and variable components of sea level, and the calibration and validation of altimeter systems.

Introduction

The Jason-1 mission is a valuable follow-on to the high-precision, along-track ocean topography measurements provided by TOPEX/ POSEIDON. It will ensure a smooth transition from T/P sea level observations to the Jason series.
In this article, we discuss several issues affecting this transition problem. We assume the T/P ground track pattern will be continued and that after a calibration period, the existing T/P measurements will start an interleaving pattern. We highlight some recent results and prospects for Jason altimetry.

Tides

DEOS has been involved in the assimilation of T/P altimeter data into a regional non-linear tide-resolving hydrodynamical model for the South China Sea region extending north to south from Taiwan to the Indonesian Archipelago and west to east from the Andaman Sea to the Philippines. This is a very complex region in hydrological terms and the question is how much information is obtained from T/P compared to existing tide gauges. Moreover, the purpose of the hydrodynamical model is to obtain boundary conditions for locally nested models in the Hong Kong area, which are in turn used, for instance, in environmental pollution studies. Initially, we relied on crossover data from the T/P satellite including in-situ tide gauge data representative of the shallow areas. The combination of coastal gauges and altimeter data in an adjoint assimilation scheme proved useful, although the T/P crossovers miss many tidal details. Along-track observation of the tides would be more useful in this area, yet in this case the observation quality generally deteriorates. Also, internal tides have been identified in the Sulu-Celebes region and the Andaman Sea, as is apparent from the band pattern shown in figure 1. Extended measurements by Jason-1 will help to strengthen the in-situ estimation of along-track ocean tide components. Interleaving the existing T/P ground tracks helps to increase the spatial sampling pattern to meet the needs of the model area.

Western boundary current variability

All western parts of the oceans show increased levels of surface topography changes after repeated observations. The mechanism that causes this surface variability is an eddy formation process in a turbulent fluid motion. Observing western boundary current variability is one of our on-going activities where we study in detail intra- and inter-annual variations, and the eddy shedding mechanisms [Nerem et al, 1994].

A long-term objective is to determine decadal variability in the climate system. A key element in this system is the global ocean circulation in which the Agulhas region is thought to be a major link. Jason-1 altimetry will provide fresh insight into these results.

Gravity field related

Dedicated satellite gravity missions play an important role in linking Earth's gravity field and satellite altimetry and in better separating geoid undulations from dynamic topography. Right now, the CHAMP mission is obtaining useful data. Later this year NASA will launch the GRACE mission, which is currently planned for a period of five years and will enable the observation of the low-to-medium-resolution part of the gravity field, both static and variable.
Additionally, in 2004 ESA will launch the high-resolution gravity gradiometer mission GOCE, for which we have high expectations. Knowledge of an improved gravity field will help us to test the assumption that a stationary reference surface coinciding with the mean sea level or geoid needs to be determined from altimeter data itself. This becomes important when ocean currents are computed from slopes of the sea level relative to the reference surface.
Observation of temporal gravity variations will help us to study a wider range of geophysical phenomena partially related to global hydrology.

Calibration and Validation

Precise orbit determination (POD) of satellites is a traditional research activity at DEOS. These POD activities mainly concern calibrating the ERS missions [Scharroo and Visser, 1998]. However, we are also interested in the new possibilities offered by altimetry for orbit and gravity field improvement, and on orbit improvement of other low Earth orbit satellites within the scope of gravity research missions. Recently DEOS started building a consistent calibrated and validated altimeter data base [Schrama et al, 2000] (http://www.deos.tudelft.nl/altim/rads) and insertion of Jason-1 observations into this database will improve the accuracy of sea level variation estimates at global and local scales.

At regional scales, the combination of T/P and ERS data and/or in-situ data has already demonstrated the ability to separate T/P instrument drift from sea level change. Synergies between Jason-1 and existing altimeter missions and other in-situ ocean monitoring techniques could solve the calibration problem globally.

Moreover, proper phasing of Jason-1's orbit with respect to T/P's orbit enhances sampling characteristics and, therefore, enhances resolution. Inter-satellite calibration with respect to T/P and ERS-2 or other new altimeters like ENVISAT or GFO and in-situ observation by a network of independent tide gauges will play a significant role in all these studies.

As stated earlier, DEOS' goal is to continue its altimetry-related research and with Jason-1 we will definitely solve some more important pieces of the hydrological puzzle.

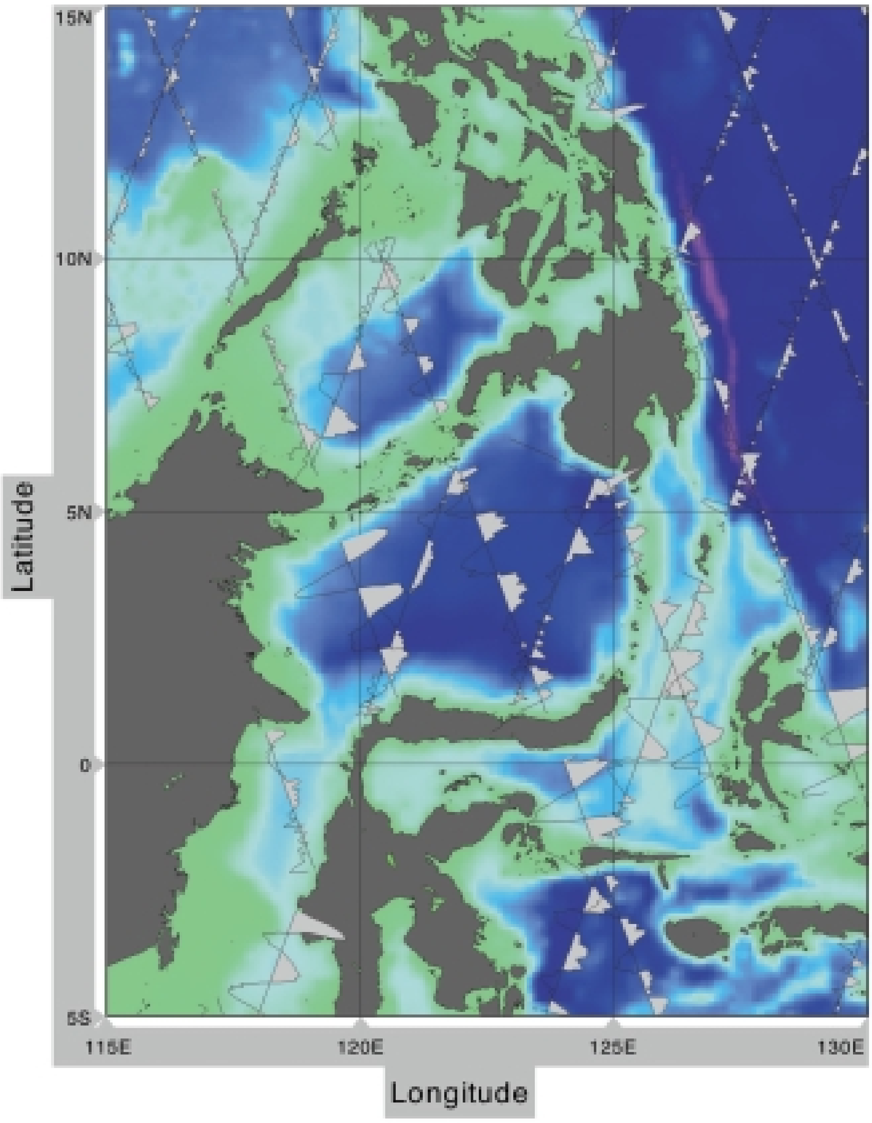

Figure 1: Amplitude of internal waves in the Sulu Celebes region observed by high-pass filtering along-track T/P data at the twice daily M2 frequency.

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