Ocean response to short-period atmospheric and tidal forcings

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**The objectives of our investigation are to improve our knowledge of the response of the ocean at global and regional scales to tidal astronomical forcing and to short-term meteorological forcing (pressure and wind).
New improvements are expected for the long-period tides (semi-monthly and monthly), and for non-linear tides over continental shelves. Better understanding of inverse barometer corrections is also expected. At a more basic level, we will address the problems of global ocean tidal dissipation and non-linear interactions between tides and shelf waves.**

Objectives

The objectives of the proposed program are to further investigate the response of the ocean at global and regional scales to tidal astronomical forcing and to short-term meteorological forcing (pressure and wind).
New improvements for tidal and so-called inverse barometer corrections are expected from these studies, in the context of the one-centimeter challenge of the Jason-1 mission. At a more basic level, this program will address the problem of tidal dissipation, which is still an open scientific question, and non-linear interactions between tides and continental shelf waves.

Barotropic tides

Major improvements of our knowledge of ocean tides have been gained recently through analysis of TOPEX/POSEIDON data combined with numerical hydrodynamic models and data assimilation techniques [Le Provost, 2000]. However, comparisons with in-situ measurements seem to indicate that improvements in the accuracy of tidal predictions are still possible, especially over continental shelves and coastal areas [Lefèvre et al, 2000-a].

Hydrodynamic model improvements

The main directions of research are:
• analysis of the whole T/P, ERS and future Jason and ENVISAT data sets, along track, paying special attention to the continental shelves and near-coastal areas, including the determination of the major non-linear tidal constituents, which are significant over the major shelf areas all around the world;
• analysis of the whole set of in-situ tide gauge data available to date, with error bar estimates for model validation and data assimilation [after Ponchaut et al, 2000];
• new improvements to the CEFMO hydrodynamic model: a new refined grid (see figure 1), new bathymetry, new estimates of the loading and self-attraction, tuning of the bottom friction and parameterization of the sink of energy by internal tides;
• assimilation in the hydrodynamic model of results from analysis of new T/P+ERS+… altimeter satellite data, including the non-linear constituents;
• assimilation of in-situ coastal tide gauge data [Lefèvre et al, 2000-b];
• error bar estimates associated with the new solutions.
With this new series of tidal solutions, we expect to better describe how the barotropic tidal waves propagate from the deep ocean over the many continental shelves around the ocean basins. We will thus also improve our knowledge of how the energy is dissipated through bottom friction and tidal mixing. We will also enhance our capability to predict the tidal contributions to sea level variations and ocean currents, for corrections in altimetric data and other in-situ ocean measurement systems like ADCPs, profiling floats, and so on where space or time aliasing of the high-frequency tidal signal are critical [Lohmann et al, 2001].

Improvement of long-period components

Recent results from the analysis of the T/P data set and hydrodynamic model results lead us to think that the ocean response to semi-monthly and monthly tidal forcing is quite different from static equilibrium. Preliminary results obtained with the CEFMO model combined with in-situ data assimilation are already significant. These components will be further investigated.

Study of the limits of tide predictability

The harmonic and response tide prediction methods are based on the concept that the tidal constituents do not vary with time.

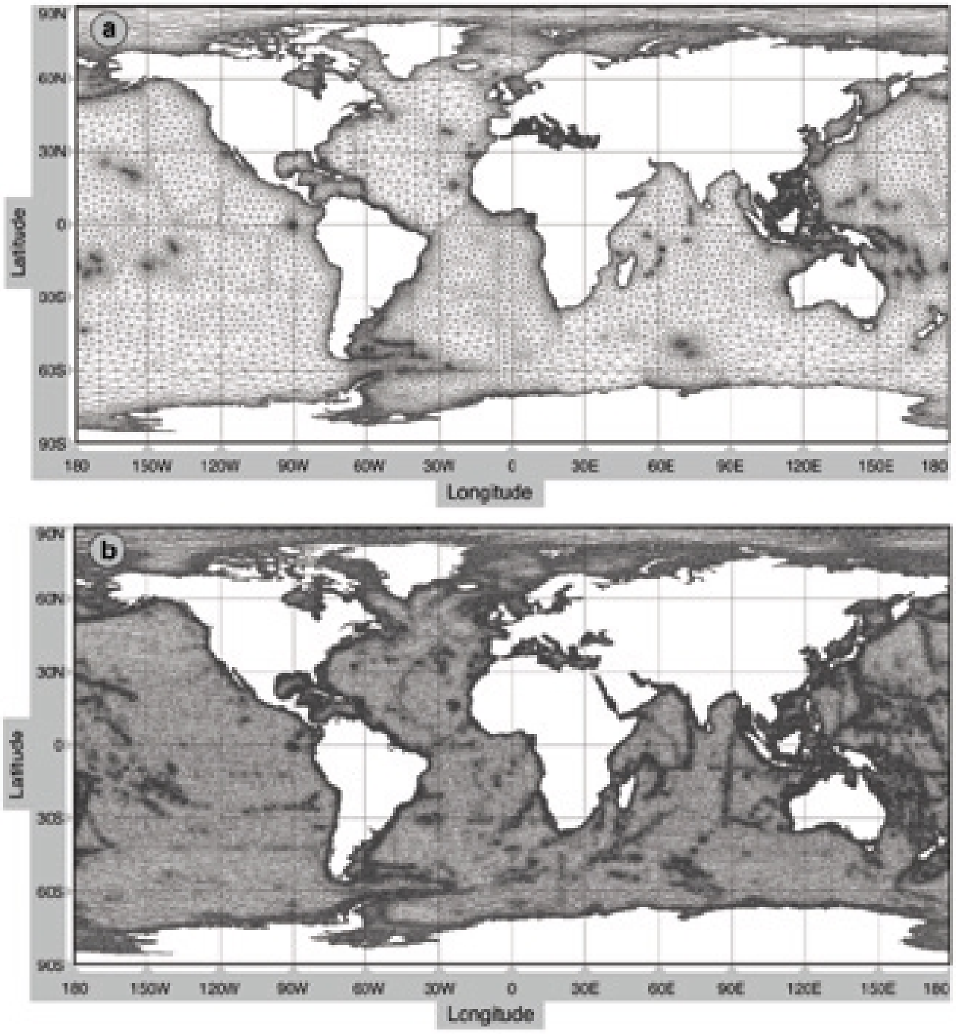

Figure 1: The Finite Element grids developed for this project: FES94 (a) and FES2000 (b).

This is certainly incorrect, at the level of accuracy we are now looking for. Non-linear interactions with meteorological forcing, or climate-related effects, also have to be considered: ice cover, interactions with western boundary currents, with storm surges, and so on. These questions will be investigated through analysis and correlation of both altimeter and in-situ observations together with meteorological forcing.

Baroclinic tides

Better description of the ocean tides over recent years, thanks in particular to precise satellite altimetry, has led us to revise our understanding of the role of internal tides in the ocean, both in terms of the tidal energy budget and of ocean mixing. The recent results obtained by Egbert and Ray [2000] suggest that up to 30% of the tidal energy input to the ocean by astronomical forcing is dissipated through internal tides. It has been demonstrated that it is possible to identify signatures of internal waves at the sea surface by along-track analysis of altimetric observations [Ray and Mitchum, 1997].
This subject will be further investigated, through along-track analysis of the altimeter signals and by improving our hydrodynamic model, in terms of parameterization of the transfer of energy from the barotropic mode to the baroclinic modes (internal waves). It is thus expected to identify the areas where internal tides are generated and dissipated (see figure 2 for preliminary results). This hopefully will help to advance our understanding of the global ocean tidal energy budget, and of the impact of the tides on global ocean mixing.

Topographic wave trapping

Topographic Rossby waves are common features over continental shelves and seamounts. Altimeter data have not been used, up to now, to identify the existence of these waves. Such features are visible in the diurnal and long-period solutions produced with our CEFMO model. A systematic check of these features and their existence in the altimeter data will be performed, by combining T/P and ERS, and in future Jason and ENVISAT data (paying particular attention to the period where, hopefully, T/P and Jason will operate simultaneously, thus doubling spatial resolution).

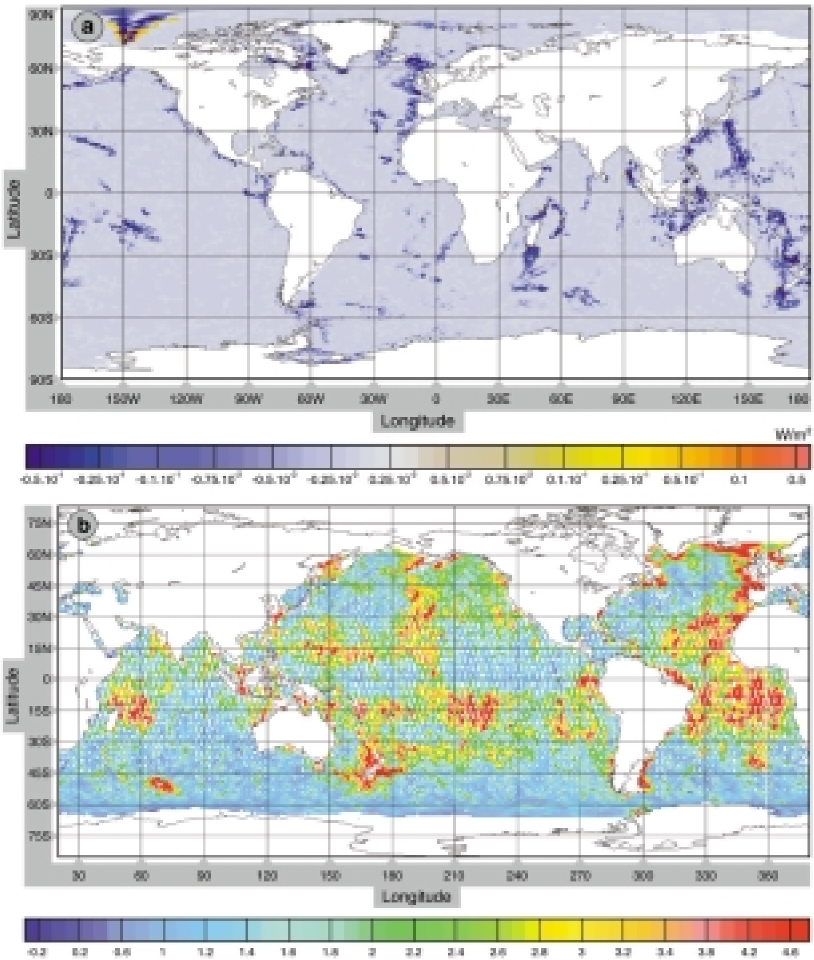

Figure 2: Location of barotropic to baroclinic tidal energy transfer (a) as parameterized in our hydrodynamic tidal model, and spatial extent of the coherent part of the internal tides (b) as identified in the tidal analysis of along-track T/P altimeter data, for the lunar tide M2.

Ocean response to pressure and wind forcing

The ocean does not strictly follow the inverse barometer response. This problem has been addressed by several authors within the SWT T/P. It is proposed here to further investigate the short-term response of the ocean to pressure and wind forcing, with the help of a time-stepping version of our finite element model. The flexibility of the finite element technique will allow us to increase the grid resolution over shelves and seamounts, and thus to better resolve the energy trapping and wave propagation processes over these topographic features. This part of the program will be pursued in collaboration with R. Ponte.

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