Using Jason-1 and TOPEX/POSEIDON data for seasonal climate prediction studies

P. Rogel, E. Maisonnave
(CERFACS, France)

The goal of this project is to develop and use tools to optimally combine altimeter observations, other oceanographic data and numerical climate models. The results will be used to show practically how global ocean observations help to improve tropical and European climate prediction over periods of a few seasons, using coupled ocean-atmosphere models.

Climate prediction and the ocean

In recent years, there has been an increasing interest in investigating the potential for predicting climate a few seasons ahead [Palmer and Anderson, 1994]. By climate, we mean here the average of the weather (temperature, precipitation, and so on) over a month or over a season, and over relatively large regions. Climate anomalies, though very different from day-to-day changes in the weather, can be perceived by populations—for example when a very hot or dry season occurs, or vice versa—but such anomalies can have huge impacts on agriculture, food security, water management, energy, and many other areas. [ECMWF, 1999]

It is now recognized that a large variety of such anomalies are linked to the well-known El Niño phenomenon, which occurs primarily in the tropical Pacific region [Trenberth et al., 1998]. This phenomenon is strongly coupled with the ocean and the atmosphere, meaning that anomalies occur simultaneously in both media and strengthen each other. In this sense, observation of the tropical ocean certainly improves our ability to forecast both El Niño and its teleconnected climate anomalies. Moreover, recent results show that some areas, where climate connections with El Niño are not clearly established (such as the North-Atlantic-Europe region) can be influenced, at least partially, by the ocean at these timescales [Drévillon et al., 2001].

The project reported here aims to make optimal use of ocean observations to improve climate prediction. The spatial and temporal distribution of Jason-1 altimeter data covering all the oceans, and their high accuracy, make them well suited to this goal. The period of more than ten years covered by TOPEX/POSEIDON and Jason-1 will allow a thorough examination of their usefulness in this field.

Data assimilation

Ocean circulation numerical models have attained a high degree of realism that allows them to factor in real observations. Data assimilation techniques to optimally combine observations and models exist, mostly derived from meteorology. These techniques are geared towards determining a great number of variables from a relatively sparse and irregular set of observations [Fukomori, 2001].

Altimeter data from Jason-1 will play a key role in obtaining a better description of the subsurface ocean structure (see figure 1, obtained with TOPEX/POSEIDON data). But the full potential of these data will be unlocked when used in combination with in-situ data. Indeed, altimeter data are geographically and temporally complementary to data collected from ships, buoys or floaters.

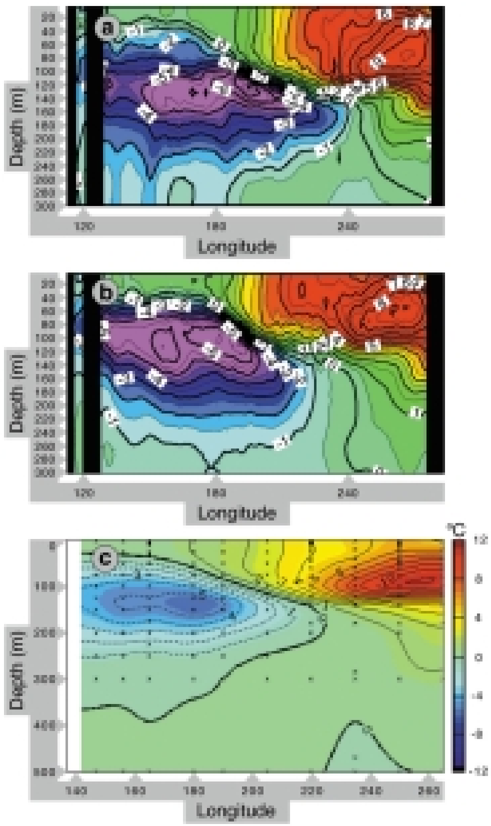

Figure 1: Impact of the assimilation of TOPEX/POSEIDON data on the vertical temperature anomaly structure of the tropical Pacific along the equator, during the 1997 El Niño peak (December). Model (a) is without assimilation, (b) with assimilation, and (c) temperature observation from the Tropical Atmosphere Ocean buoys.

This project will develop schemes to take into account most types of ocean observation data through variational methods that minimize discrepancies with respect to the model estimate. A key point of such methods is the statistical estimation of model prediction errors, and of the interdependence of these errors between variables. CERFACS is developing tools to better handle these methods using numerical models [Lagarde et al., 2001].

Ocean-atmosphere prediction

Data assimilation methods thus give us estimates of the ocean state that are as close as possible to the truth. Similarly, meteorological centers provide estimates of the atmosphere's state. To be able to make seasonal predictions, we also need a coupled ocean-atmosphere model. We will use a model developed at Météo-France (atmosphere), the French scientific research center CNRS (ocean), and CERFACS (coupler).

Given the long timescale of seasonal range with respect to atmospheric deterministic predictability, which is no more than a few weeks, ensembles of forecasts are needed to investigate how robust predicted anomalies are despite the chaotic behavior of the atmosphere. A critical point here is to create a broad variety of small forecast ensembles. Indeed, the computational cost of a large enough sample of predictions easily reaches hundreds of years of simulation [Palmer and Anderson, 1994]. The development of ensemble techniques for prediction is part of the project.

Besides the development of techniques already mentioned, the main goals of this project are first to investigate how the prediction of El Niño events (see figure 2 for an example of such experiments during the TOPEX/POSEIDON period) can be improved by the use of altimeter data and other observations, and second the impact of such data on the climate predictability of the European climate.

Acknowledgements

Project participants other than the authors will be E. Machu, S. Ricci, A. Weaver, A. Piacentini, O. Thual, and L. Terray, from CERFACS.

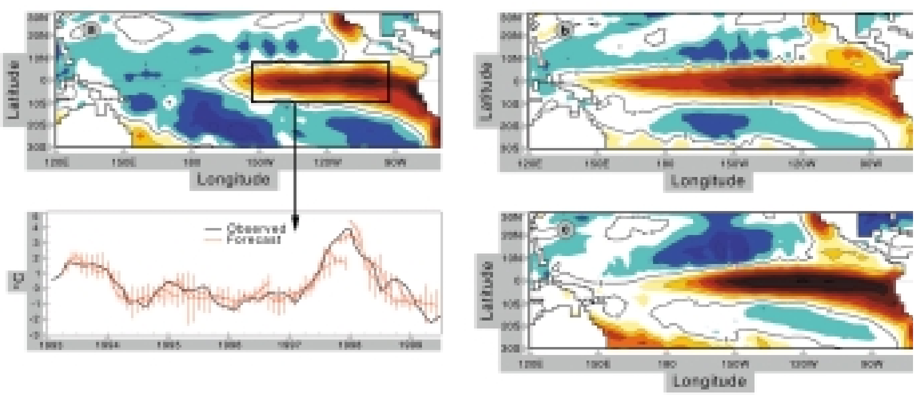

Figure 2: Example prediction of tropical ocean temperature anomalies over the TOPEX/POSEIDON period at CERFACS. Series of five six-month predictions, using a coupled ocean-atmosphere model, were carried out every three months. They show the model's ability to predict the 1997 El Niño event. (a) shows observations, (b) six-month and (c) three-month forecasts.

References

ECMWF proceedings of the workshop on applications of seasonal forecasting, 14-15 June 1999, ECMWF, 1999.

Drévillon M., L. Terray, P. Rogel and C. Cassou, 2001: Mid-latitude Atlantic SST influence on European winter climate variability in the NCEP reanalysis, to appear *in Climate Dynamics*.

Fukomori I., 2001: Data assimilation by models, in *Satellite altimetry and earth sciences*, L.L. Fu and A. Cazenave editors, Academic Press.

Lagarde T., A. Piacentini and O. Thual, 2001: A new representation of data assimilation methods: the PALM flow-charting approach, to appear in *Q. J. R. Meteorol.* Soc..

Palmer T.N., and D.L.T. Anderson, 1994: The prospect for seasonal forecasting - a review paper, *Q. J. R. Meteorol.* Soc., 120, 755-793.

Trenberth K.E., G.W. Branstator, D. Karoly, A. Kumar, N.C. Lau and C. Ropolewski, 1998: Progress during TOGA in understanding and modeling global teleconnections associated with tropical sea surface temperatures, *J. Geophys. Res.*, 103, 14291-14324.

Corresponding author:
Philippe Rogel
CERFACS
42, av. Coriolis
31400 Toulouse - France
E-mail: rogel@cerfacs.fr