IMPROVEMENT OF THE MODELING OF THE TROPICAL PACIFIC OCEAN THROUGH THE ASSIMILATION OF TOPEX/POSEIDON ALTIMETER DATA

L. GOURDEAU[1], J. VERRON[2], T. DELCROIX[3], and A.J. BUSALACCHI[4]

(1) LEGOS, Toulouse, France, (2) LEGI, Grenoble, France, (3) IRD, Nouméa, New-Caledonia, (4) NASA/GSFC, Greenbelt, USA

1. INTRODUCTION

TOPEX/POSEIDON sea level anomaly data, from October 1992 to October 1996, have been assimilated into the Gent & Cane's primitive equation model [1989] of the equatorial Pacific ocean. The assimilation scheme is based on the extended Kalman filter where the error covariances are defined and propagated in a reduced basis [Cane at al. ,1996; Verron et al., 1999]. We give evidence of the benefiting impact of TOPEX/POSEIDON data on the subsurface model flow by confronting them with independent in situ data. The mechanism responsible for the 1992-96 Warm Pool filling up and depletion is investigated. The findings are believed of main interest for understanding ENSO.

2. THE GENT & CANE MODEL AND THE SEEK FILTER

The assimilation method used is the SEEK filter in which the reduced basis is fixed (see Pham et al. [1998]; Verron et al. [1999]). The reduced basis are determined through an EOF analysis of a free model run. 15 EOFs (90% of the 4 years signal variance) are retained. Error specifications are detailed in Gourdeau et al. [1999]. The Topex/Poseidon data are assimilated along track every three days. The dimension of the observation vector is about 5000. The OGCM used is the reduced gravity, primitive equation, σ coordinate model of Gent & Cane [1989]. The model is forced by the monthly interannual FSU wind stress and heat flux from the Seager at al. [1988] formulation. The grid spacing is of 0.3° in latitude at the equator and 1° in longitude. There are nine layers in the vertical. The dimension of the model state vector is about 425000.

2. INDEPENDANT VALIDATION

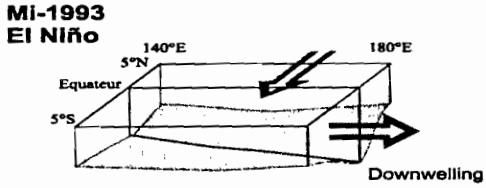
We focus here on how the sea level information assimilated is able to constraint the subsurface model flow, and in particular the equatorial zonal velocity. Velocity measurements are only available along the equator at a few TAO moorings instrumented with ADCP and/or current meters at different depths. They are compared to the simulated velocities by the way of correlation (Fig. 1). With the free model, the correlation is low with no spatial coherency. In contrast, with the assimilation, the correlation is high everywhere else in and above the Equatorial Under Current (EUC) and goes up to 0.7. Below the EUC, the current is slow and so the correlation may not be very significant.

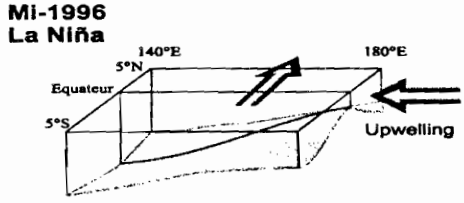
(a) (b)

Fig.1: Maps of correlation between the TAO zonal velocity and the modeled zonal velocity without (a) and with (b) assimilation for the longitude-depth section at the equator.

3. THE 1992-96 WARM POOL FILLING UP AND DEPLETION

The warm pool replenishment and depletion is of main interest for ENSO understanding. Time series of Upper Layer Volume in the warm pool were estimated either using the modeled temperature field or the velocity fields. The ULV changes deduced from the zonal and meridional transports have similar amplitude but are in phase opposition and it is the sum of both transports that mirrors the temperature derived ULV. Same analysis using the fields from the model without assimilation gives a different diagnosis, it reflects a weakness of the model and/or the use of inadequate forcing functions whose effects are compensated by assimilation. The scenario of the warm pool depletion during El Niño events is described below as an input flow at the north and an output flow at the east; opposite transports explain the replenishment of the warm pool during Niña events.





4 - CONCLUSION

Assimilation of TOPEX/POSEIDON data by the SEEK filter is able to constraint partly the subsurface model flow. Details about independent validation can be found in Gourdeau et al. [1999]. Using the assimilating simulations, the mechanism responsible for the 1992-96 warm pool replenishment and depletion is investigated as it is of main interest for understanding ENSO. The volume changes in the warm pool calculated with the temperature fields are in phase with those calculated from the zonal transport across the warm pool but with one-half the amplitude. It is the addition of the effects of both zonal and meridional transports that balance the volume changes in the warm pool.

REFERENCES:

[Cane 96] M.A. Cane, A. Kaplan, R.N. Miller, B. Tang, E.C. Hackert and A.J. Busalacchi: Mapping tropical Pacific sea level: Data assimilation via a reduced state Kalman filter. *J. Geophys. Res.*, 101, C10, 22,599-22,617, 1996.

[Gent 89] P.R. Gent and M.A. Cane: A reduced gravity primitive equation model of the upper equatorial ocean. *J. Comp. phys.*, 81 (2), 444-480, 1989.

[Gourdeau 99] L. Gourdeau, J. Verron, T. Delcroix, A.J. Busalacchi and R. Murtugudde: Assimilation of Topex/Poseidon altimetric data in a primitive equation model of the tropical Pacific ocean, during the 1992-1996 ENSO period, submitted at *J.Geophys. Res*, 1999.

[Pham 98] D.T. Pham, J. Verron and M.C. Roubaud: A singular evolutive extended Kalman filter for data assimilation in oceanography, *J. Mar. Syst.*, 16, 323-340, 1998.

[Seager 88] R. Seager, S.E. Zebiak and M.A. Cane: A model of the tropical Pacific sea surface temperature climatology, *J. Geophys. Res.*, 93, 1265-1280, 1988.

[Verron 99] J. Verron, L. Gourdeau, D.T. Pham, R. Murtugudde and A .J. Busalacchi: An extended kalman filter to assimilate satellite altimeter data into a non-linear numerical model of the tropical Pacific ocean: method and validation, *J. Geophys. Res.*, 104, 5441-5458, 1999.

Gourdeau L., Verron J., Descroix T., Busalacchi Antonio. (1999).

Improvement of the modeling of the Tropical Pacific ocean through the assimilation of TOPEX/POSEIDON altimeter data.

In : OCEANOBS 99 : conférence internationale sur le système d'observation de l'océan pour le climat : 2 = OCEANOBS 99 : international conference on the ocean observing system for climate : 2. Toulouse : CNES, non paginé

OCEANOBS 99 : Conférence Internationale, Saint-Raphaël (FRA), 1999/10/18-22.