“The need of TPJ accuracy to make further progress in understanding ENSO”

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Introduction

Since 1992, our objective has been to use **Sea Level (SL) data** in **Intermediate Coupled Models (ICMs)** of the tropical Pacific Ocean/Atmosphere system to make progress in **understanding El Nino Southern Oscillation (ENSO)**.

ICMs are anomaly models in which the mean states of the ocean and atmosphere are prescribed to observed values. ICMs simulate more realistic ENSOs than any Coupled General Circulation Model (CGCM) of the IPCC community because the mean states simulated by CGCMs differ too much from the observed mean states (Dewitte et al, 2007).

Our mean states are derived from observations averaged over the Jan 1980-to-Dec 1996 period. For SL data prior to October 1992, we use the surface dynamic topography relative to 400dbar (courtesy of N. Smith, BRMC) starting January 1980 as a proxy to SL. In addition to “SL” anomalies between 1980-1996, the BRMC data set provides the mean SL anomaly surface for Oct 1992-Dec 1996 (Fig1a) which we add to **TOPEX/Poseidon-Jason (TPJ) data**. Because the SL variations observed by TPJ are more accurate than the BRMC “SL”, we also correct the latter by the ratio displayed in Fig1b.

All our work on ENSO shows that a SL reference mean surface over at least two decades is needed to detect and understand coupled processes that matter for the actual evolution of El Nino/La Nina events.

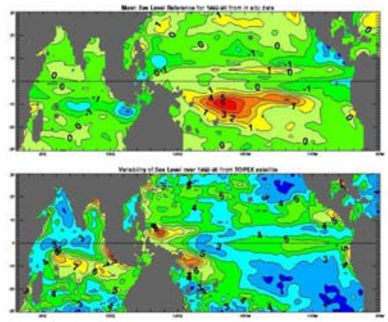


Figure1: *Maps of Sea Level in cm. Top map is the mean SL anomaly reference derived from BRMC dynamic topography. Bottom map is the RMS variability of TPJ (its ratio with the variability of the BRMC dynamic topography over 1992-2000 is used to correct the latter (see Florenchie + Perigaud, 2002).*

Example 1: Impact of O(1cm) change due to Mean Equatorial Sea Level on ENSO

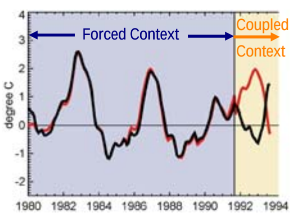


Figure2a: *NINO3 SST indices simulated in forced followed by coupled contexts. The two experiments differ by O(1cm) mean equatorial sea level (see text)*

The model is integrated in a FORCED context (forced by wind data) before being integrated in a COUPLED context (no data) for forecast.

Two different sets of experiments (FORCED followed by COUPLED) are performed. They differ only by O(1cm) in the Mean Equatorial Sea Level reference (see Fig1) used for the SL data assimilated in the model during the wind-FORCED period of the experiment.

⇒ Fig2a-b display the Sea Surface Temperature (SST) Nino3 indices simulated by 2 examples of such experiments. For all experiments, the **O(1cm) SL change impact on ENSO is negligible during FORCED simulations**, whereas **it is large during FORECASTS** (coupled context).

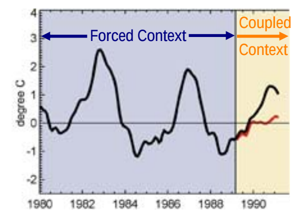


Figure2b: *NINO3 SST indices simulated in forced followed by coupled contexts. The two experiments differ by O(1cm) mean equatorial sea level (see text)*

Example 2: Impact of O(1cm) change due to ITF correction on ENSO

Here, SL data are used to correct the conditions at the western boundary of the model.

♦ Standard experiments (black) do not allow variations of the Indonesian Throughflow (ITF).
♦ Experiments with ITF (red) consist in correcting the Rossby transport across 3°N-8°N at 130°E with the variations estimated from TPJ SL and wind data.

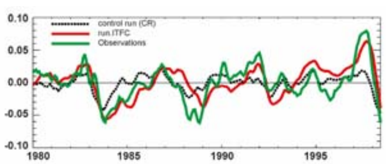


Figure3a: *Time series of Basin averaged SL in the Equatorial Pacific. Black is the standard model experiment without ITF. Red is model SL with ITF corrections. Green is TPJ+BRMC data. Unit is m.*

⇒ For **FORCED** experiments (Fig3a), the ITF impact on the equatorial sea level changes is O(1cm) and its **impact on the Nino3 SST index is negligible**

⇒ But for **COUPLED** experiments (Fig3bc), the ITF correction **impact on the predicted ENSO indices is very large**.

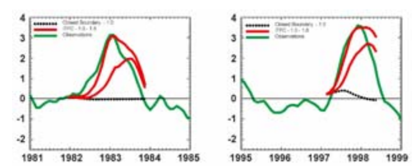


Figure3b-c: *NINO3 SST indices simulated in coupled contexts without ITF (black) or with ITF values prescribed at the western boundary of the model (red). Green is Reynolds observed SSTs.*

Example 3: Impact of O(1cm) change due to Off Equatorial Sea Level on ENSO

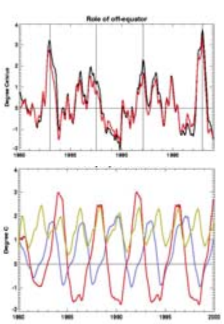


Figure4: *Time series of NINO3 SST indices simulated by model*

(4a: top) in FORCED context. Black is the standard model experiment with Rossby meridional modes from 1-20. Red is model with Rossby meridional modes from 1-5.

(4b: bottom) in COUPLED context. Blue with Rossby meridional modes from 1-20, Red is with modes from 1-5 , Yellow is with modes 1-7.

Here, we test the role of the off-equator.

At each time step of the model integration, SL is projected onto Rossby meridional modes from 1 to 20. In the standard experiments (black), all 20 modes are allowed.The off-equator is filtered out (red) by allowing only modes 1 to 5.

⇒ In **FORCED experiments** (Fig4a), meridional modes 6 to 20 **change the equatorial SL by O(1cm)** and the SST Nino3 by O(0.1°C).

⇒ By contrast (Fig4b), the off-equator impact on the **SST Nino3 indices simulated in a COUPLED context is large**. Results are very sensitive to the number of meridional modes filtered out and to other model parameters.

SL data are then used to correct the conditions in the off-equatorial bands of the model. As illustrated in Fig4c, the SL variations North of the equator differ significantly from those in the South (by contrast to models which tend to simulate symmetric Rossby waves).

⇒ In “**Almost data-free**” experiments (Fig4d), the only data assimilated in the model are the Rossby modes 6 to 20 of the SL data. These experiments simulate a succession of warm and cold events which growths, peaks, decays and reversals are independent of the number of meridional modes larger than 10 and of model parameters.

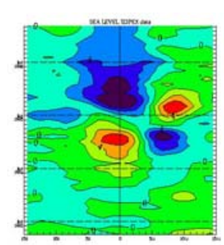


Figure 4c: *Latitude-Time Hovmoeller diagram of basin zonally averaged SL observed from TPJ.*

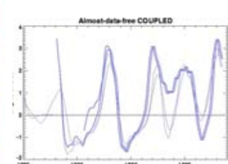
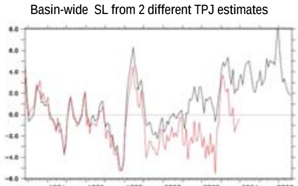


Figure 4d: *Time series of NINO3 SST indices simulated by model which off-equatorial SL is controlled by the meridional Rossby modes higher than 5 (these modes are derived from SL data). Several experiments controlled by the same SL data are tested for different initial conditions and model parameters.*

Conclusion: We Need TPJ accuracy and continuation for Jason Future Missions

Figure5: Time series of basin zonally averaged SL from TPJ estimates available at the PODAAC or AVISO websites. Red correspond to the data which were last downloaded in June 2004. Black correspond to the time series (first downloaded in July 2005) updated with our most recent download in early March 2007.



“Almost-Data Free” experiments demonstrate that ENSO is indeed sensitive to O(1cm) Changes in the basin-averaged Equatorial Pacific. The TPJ estimates downloaded from websites before and after 2005 do differ by O(5 cm) since ~2001. This big difference does lead to different solutions on how the Indian/Pacific oceans/atmosphere interact. Therefore, there is still a lot to understand on this question with TPJ accuracy needed from now-on.