Preliminary evaluations of Jason-1 sea level anomalies and TAO-TRITON dynamic height anomalies in the tropical Pacific Ocean

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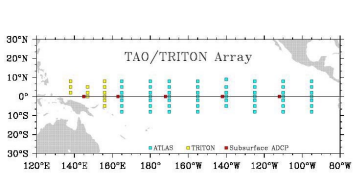
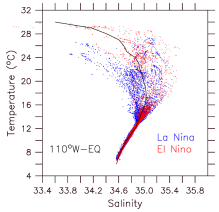
Abstract. Cross validation between TOPEX/Poseidon and Jason-1 radar measurements will certainly insure that calibration and correction procedures will be very similar for both missions, but it is important to consider an independent source of information to evaluate their accuracy. In the tropics, changes in the upper heat content and sea level variations are closely related and in-situ measurements from the TAO/TRITON array of moorings will be used as a basis to validate the preliminary measurements of Jason-1 at the scale of the equatorial Pacific Ocean (8°N-8°S from 137°E to 80°W). Eleven temperature sensors from the surface down to 500 meters allow to determine the heat storage changes. However, altimetric data must be compared to dynamic height anomalies that are a function of both temperature and salinity fields. The salinity effect in sea level variations is only partially taken into account through a climatological T-S relationship that could not consider the upper layers. In consequence, the present approach tries to estimate the salinity variability along the upper water column by using statistical relationships with any given temperature profile. In practise, The Jason-1 data has been processed by the CTO at LEGOS. The anomalies are computed using the same reference as TOPEX/Poseidon data. The daily TAO/TRITON temperature profiles and sea surface salinity are used to estimate the salinity variability at depth. Then, dynamic height anomalies (DHA) are computed using the observed temperature and reconstructed salinity profiles relative to 500 db. In this study DHA are computed locally at each of the 70 TAO/TRITON mooring sites. A selection procedure is applied to co-localize the Jason-1 data based on decorrelation scales of 5° in longitude and 3° in latitude centered on a TAO/TRITON site. The DHA from TAO/TRITON array are averaged over a time window centered on each Jason -1 10-days cycle. Preliminary comparisons for cycles 8 and 9 show a good agreement and future comparisons between in-situ estimates and altimetric anomalies from Jason-1 and TOPEX/Poseidon missions will be conducted. Such comparisons will allow determining if the accuracy of present altimetric products is sufficient or not to determine the role of the salinity field in sea level variations, and ultimately, in climate forecasting of ENSO.





Methodology :

Along with temperature, salinity determines the ocean mass, and therefore influences the ocean dynamics. The vertical structures of temperature and salinity are thus required to determine their concurrent signature in surface dynamic height anomalies (DHA). The sea level variability deduced from altimetric observations may be compared closely to the DHA variability because barotropic contributions are known to be small in the tropics. Moored instrument platforms with eleven temperature sensors from the surface down to 500 meters have allowed the determination of heat storage changes at the scale of the equatorial Pacific Ocean (10°N-10°S from 137°E to 80°W) since the end of 1994 when the entire TAO/TRITON array of 70 moorings was completed (McPhaden, 1995). However, there is evidence that specific salinity variability in the western Pacific Ocean could be crucial during an El Niño or La Niña (e.g., Maes, 1998, 2000). The familiar practice of estimating the salinity field from a climatological T-S relationship (e.g., Busalacchi et al., 1994) is not satisfactory at the present accuracy of altimetric missions (e.g., Picaut et al., 1995). Therefore recourse is made to an indirect estimate of the salinity variability using a more sophisticated statistical relationship that allows the determination of a corresponding salinity profile from any given temperature profile (Maes and Behringer, 2000). Sea Surface Salinity data are also used by the method when they are available.

Results :

Comparisons per cycle show an overall good agreement between the DHA and the Jason-1 SLA. The systematic mean difference of order 10 cm noted by several other investigators is found over the entire tropical Pacific Ocean.

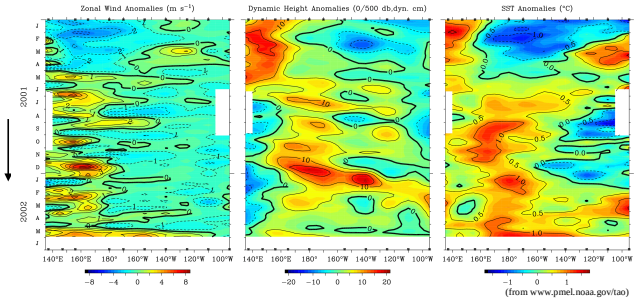
Cycle 004 provides a nice comparison characterized by differences equal to or lower than 4 cm over the entire 4°N-4°S equatorial band. The positive anomaly in DHA in the east Pacific resulting from the Kelvin wave excited in December 2001 is present but the amplitude seems underestimated. The most important differences are localized in the central and western Pacific in the region of the inter-tropical convergence zone.

The comparison for cycle 011 shows more pronounced differences and the same features apply for cycle 010 and cycle 012. These different cycles show some negative anomalies along 110°W and as a consequence, negative SLA anomalies penetrate too far in the central and western Pacific compared to the TAO/TRITON DHA.

Mean and RMS differences over the entire tropical Pacific Ocean are basically stable from cycle 005 to cycle 013 (05/03-14/05). The order of magnitude of the RMS difference is about 4 cm. This result is encouraging as it is lower than the signals for most of the physical processes characterizing the thermal and haline variability of the tropical Pacific Ocean.

Climatic context

Jason-1 was launched in December 2001, at a time when a number of scientists thought that the necessary conditions were in place for the initiation of an El Niño in 2002. Since 1998, moderate to weak La Niña conditions have resulted in the piling up of warm water in the western equatorial Pacific. Over this region, Westerly Wind Events (WWEs) have been frequent since boreal summer 2001, and in December 2001 a prominent WWE excited an equatorial Kelvin wave, which propagated across the equatorial basin and induced a surface warming in the east by March 2002. Unexpectedly, upper ocean conditions in the equatorial Pacific Ocean have returned to normal over the last two months, but another surprise may be in store as the result of an extensive new WWE in the equatorial basin since mid-May. The combination of TOPEX/Poseidon and Jason-1 should be useful in elucidating these interesting features, but prior to doing so, it is essential to validate Jason-1 with data from the 70 TAO/TRITON moored buoys of the ENSO observing system.



(from www.pmel.noaa.gov/tao)

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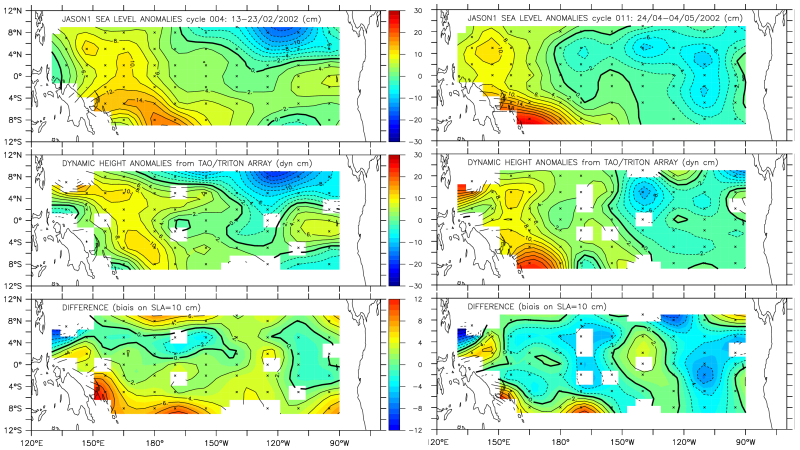
Comparisons for cycle 004 and cycle 011

Processing :

1. Jason-1 sea level anomalies have been processed by the Centre de Topographie des Océans (CTO) at LEGOS. The anomalies are computed using the same reference as TOPEX/Poseidon data.
2. The daily TAO/TRITON temperature profiles and sea surface salinity are used to estimate the salinity variability at depth. Then, DHA are computed using the observed temperature and reconstructed salinity profiles relative to 500 db. In this study, DHA are computed locally at each of the mooring sites.
3. A selection procedure is applied to co-localize the Jason-1 data centered on each TAO/TRITON site using decorrelation scales of 5° in longitude and 3° in latitude. The DHA from TAO/TRITON array are averaged over a time window centered on each Jason-1 10-day cycle.



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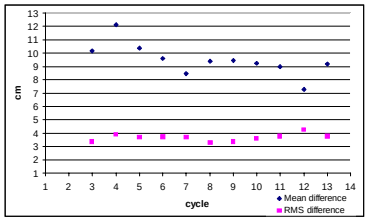
Differences in the Tropical Pacific Ocean

Mean sea level difference and RMS difference per cycle over the entire TAO/TRITON array



Conclusions and Perspectives :

1. Despite the preliminary status of the Jason-1 IGDR, this first comparison study is very encouraging as the RMS differences over the tropical Pacific Ocean are remarkably stable over the first cycles.
2. Our validation method would need to be repeated when the corrections applied to the Jason-1 data are fully developed and comparable to those applied to the TOPEX/Poseidon data.
3. The present validation method using a reconstructed salinity variability should be an improvement compared to a validation using a simple T-S relationship. Conversely, TOPEX/Poseidon and Jason-1 data can provide useful information on the salinity variability within the tropical Pacific Ocean. The combination of TOPEX/Poseidon, Jason-1 and reconstructed salinity profiles should result in a better understanding of El Niño and La Niña.