Near real-time temperature and salinity profiles in the Indian Ocean derived from TOPEX/POSEIDON altimetry

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Abstract

The purpose of this paper is to show the potential of satellite altimetry in understanding the upper ocean temperature (T) and salinity (S) variability in the tropical Indian Ocean using a combination of TOPEX/Poseidon (T/P) derived sea-level anomalies, Reynold's sea surface temperature (SST), and monthly climatological T and S data (World Ocean Atlas, 1998). This new technique allows extension of altimetric surface information to derive the T and S information down to a depth of 1000 m. The accuracies of derived T and S profiles are evaluated using the World Ocean Circulation Experiment (WOCE) hydrographic data along Transindian Ocean Sections I1 and I3. This technique yields a difference of ~0.9°C or less between synthetic and observed (I1 section) temperature over most of the section, and a salinity difference of ~ 0.5 in the top 200 m and negligible difference beyond 200 m depth. The time series of synthetic T and S profiles constructed for the WOCE I1 and I3 sections shows the usefulness of this technique in obtaining information on the time variability of the water mass structure, currents, eddies, and propagating signals without having to carry out repeated hydrographic observations.

Methodology

We have adopted the technique developed by Shi et al. [2003] to derive the T, S profiles in the tropical Indian Ocean (30°N-30°S). Following this technique, quasi real-time T and S profiles were derived for the upper 1000 m water column for each 1° x 1° square during the period of 1993 –2000 using T/P sea surface height (SSH) anomalies, monthly climatological T and S profiles from the World Ocean Atlas 1998 (WOA 98).

Results

One of the advantages of this approach in estimating the T and S profiles is that it can be used to estimate the continuous temperature and salinity profiles in areas of sparse hydrographic data. The WOCE I1 section is the northernmost of the zonal sections carried out during the WOCE Indian Ocean Expedition during August 29-September 28, 1995 and September 30-October 16, 1995. It crossed the southern boundaries of both the Bay of Bengal (I1e) in the east (along 10°N latitude) and the Arabian Sea (I1w) in the west (along 8.5°N latitude), with 158 continuous profiles of temperature, salinity and oxygen versus pressure. Figure 1 displays a comparison between the observed temperature and salinity sections for WOCE I1 in the Arabian Sea and Bay of Bengal and the synthetic temperature and salinity sections derived using the method described above. A glance at the observed T and S WOCE I1 sections (Figure 1, top panel) and synthetic T and S sections (Figure 1 middle panel) shows that they are quite similar. In the Arabian Sea, on both temperature sections, the isotherms slope upward to the east below the mixed layer. In addition, the strong uplift of the isotherms along the western boundary associated with the northeastward flowing Somali Current is clearly evident. The upper mixed layer is shallow in the eastern Arabian Sea and deepened in the western Arabian Sea along both sections. In both sections, SSTs in excess of 28°C are seen to the east of 62° E. Visual inspection shows that in the deeper layers, these two sections are also in close agreement. In both sections, the depression of the isotherms in the upper part of the water column associated with the "Great Whirl" is observed at ~57° E (although it is more obvious in the observed section). Within the Bay of Bengal, both sections show a mixed layer that is significantly shallower than the Arabian Sea. The thermocline deepens from west to east in the Bay of Bengal with the shallowest mixed layer found at ~85° E. In addition, both sections display a deepening of the isotherms along the east coast of Sri Lanka associated with the southwesterly flowing East Indian Coastal Current. Figure 1 (bottom panel) shows the errors of the T and S estimations. The largest errors in the T and S estimation are found at the depth of thermocline. Maximum temperature errors reach ~ 1.2°C, while the maximum error in salinity reaches ~ 0.5. Taking into account the limitations of the data used to construct the synthetic temperature and salinity fields, it appears that the technique used to construct these fields works quite well.

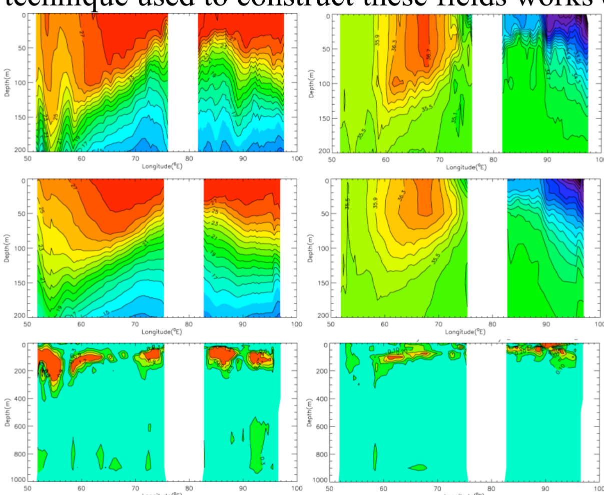

Figure 1. Comparison of (top panel) *in situ* temperature and salinity profiles along WOCE section I1, (middle panel) T/P derived temperature and salinity profiles, (bottom panel) the difference between *insitu* and T/P altimetry derived temperature and salinity profiles. Please note that top two panels are plotted to 200 m depth, whereas the bottom panel to 1000 m depth.

Conclusions

In this paper we have shown the methodology to separate out thermal (T) and salinity (S) signals from the satellite altimetric (T/P) SSH anomalies, and further applied this technique to the tropical Indian Ocean to derive near real-time T, S profiles in the upper 1000 m. This technique show that the generation of synthetic T and S profiles may be useful in studying the variability in the upper ocean, water mass structure and eddies without the need of repeat hydrographic section. This approach has only been tested in the Indian Ocean; further research is still required to see its applicability to other oceans.

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References

Shi, W., B. Subrahmanyam , J.Morrison, Estimation of heat and Salt storage variability in the Indian Ocean from Topex/Poseidon altimetry, *J. Geophys. Res.*, 108 (C7), 3214, doi:10.1029/2001JC001244, 2003.