The time series of the Leeuwin Current transport from satellite altimeter measurements

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Abstract

The time series of the net baroclinic volume transport is estimated from Topex/Posidon (T/P) and Jason-1 satellite altimeter data in the Leeuwin Current (LC) region (24°S to 33°S and 111°E to 115°E). The data used are altimeter-derived sea level anomalies (SLAs) along three ascending tracks offshore of Western Australia from 1993 to 2008, the ocean mean dynamic topography from CSIRO’s Atlas of Regional Seas (CARS); climatology, and CSIRO’s RV Franklin hydrographic measurements. We first infer the subsurface temperature and salinity structure from altimeter-derived SLAs using a model developed from historical in-situ observations of CARS, and then we compute the baroclinic transport along each altimeter track. The hydrographic sections from the RV Franklin cruises are used for validation. The time series of transport across each altimeter track, representing the flow of the LC, show a range of complex temporal signals during 1993-2008.

Introduction

Hydrographic and current observations suggest that the LC transports fresher and warmer tropical waters along the west Australian coast when its poleward flow is maximum during May–June (Cresswell and Golding, 1980; Smith et al., 1991). Estimates of the volume transports of the LC have been published during the last two decades (e.g., Feng et al., 2003). However, previous transport estimates may only represent a local (e.g., Feng et al., 2003) or short period estimate (e.g., Smith et al., 1991; Frezzotti et al., 2005). Therefore, it is necessary to examine the long period of the volume transport and its seasonal, annual and interannual variations in the LC.  

Methods

Instead of estimating the time series of the volume transport by an empirical relation between the transport obtained from oceanic in-situ data and altimetry SLAs (e.g., Zhu et al., 2004; Rintoul et al., 2002), our method directly infers the relation between the transport obtained from oceanic in-situ data and altimetry data using a multiple linear regression technique. The baroclinic transport is then estimated from the historic height inferred from the synthetic SLAs (LSHs).

This method allows the influence of the variable topography with depth to be included in the estimate of volume transport. The baroclinic transport is referred a ‘level of no motion’ (2000 m).

Comparison between RV Franklin and synthetic data

Figure 3 (right) shows the CTD salinity (PSU, top left) and temperature (°C, bottom left) from RV Franklin 2000 transect I. Synthetic salinity (PSU, top right) and temperature (°C, bottom right) from altimetry SLAs and CARS. The RV Franklin data along transect I were collected between 23-24 November 2000 while SLAs of track a101 were measured on 28 November 2000. Considering a 5-day difference between T/P and in-situ data, vertical profiles of synthetic salinity and temperature in Fig. 3 agree with observations along transect I.

In addition, we investigated the spatial pattern in layer 0-10 dB of the correlation between the synthetic surface salinity and temperature with observed surface salinity and temperature. The correlations are 0.58 and 0.72 respectively, suggesting that the synthetic surface salinity and temperature are compatible with the in-situ CTD observations.

Time series of net transports (top left Figures)

Figures 4, 5 and 6 (left) show the 15-year time series of net transport across the LC from January 1993 to January 2008 with a 10-day interval. The transport across a177 indicates a poleward flow with a mean of 2.22 Sv, while the mean net transports are -0.13 Sv for a101 and 0.42 Sv for a253 respectively. The estimated transports across the LC lattice grid and show a rich spectrum of frequencies from seasonal to interannual, and an annual cycle as well.

Seasonal and interannual variability of net transports (left bottom Figures)

To isolate the different timescales, the net transports are analysed with the wavelet transform. The wavelet power spectra, global wavelet spectra and average transport variance are shown in left Figures 7, 8 and 9. The wavelet power is normalised and thus measures the deviations from the reference spectrum. In general, for the net transports across three tracks, the power is broadly distributed, with peaks in the 1-2-yr band in common. For track a101, the power appears high in bands of 0.5-2-yr and 4-yr during 2000-2006 and 1994-2002, respectively. The 5% significance level indicates that 2000-2007 contains interannual higher transport variance, while 1993-1999 is a period of lower transport variance. The wavelet spectrum for transport across track 177 shows the highest power in a 2-4-yr band during 1995-2004.

Discussions and conclusions

The time series of the LC flow across three altimeter tracks has been, for the first time to our knowledge, constructed using nearly 15-years of altimeter-derived sea level anomalies and CARS. The net LC flow across these tracks offshore of WA shows a range of temporal signals from seasonal to interannual.

Both the seasonal and interannual variations of the LC obviously appears to be very variable depending on the location. The LC flow across tracks a101 and a177 has a 0.5-yr cycle with basically southward in summer and northward in winter. It flows poleward across a253 in most months, but has smaller net transports than tracks a101 and a177 at the interannual timescale. It results from wavelet analysis suggest that the power is broadly distributed with peaks in the 1-2-yr band in common across the tracks. The wavelet spectrum for transport across track 177 also shows the highest power in a 2-4-yr band during 1995-2004.

Further study is necessary to investigate the relationship between transport estimates and ENSO events, as well as comparison between synthetic in-situ data.

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References