"A Near-Uniform Basin-Wide Oscillation of the Japan/East Sea"

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Introduction

Satellite altimetry reveals a prominent basin-wide oscillation of sea level in the Japan/East Sea (Figure 1) that is nearly uniform in amplitude and phase across the entire basin. The fluctuation has amplitudes as large as 10cm and periods ranging from 20-days and longer. The nature of this oscillation is examined using a 1/4°-resolution global ocean general circulation model.

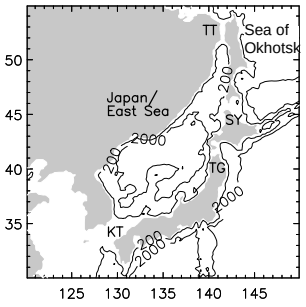

Fig 1: Bathymetry of the Japan/East Sea (JES) (m) and its straits; Korea/Tsushima (KT), Tsugaru (TG), Soya (SY), and Tartarsky (TT).

Observed Variability

While seasonal variability is commonly large-scale, a basin-wide coherence is peculiar for higher frequencies. We, therefore, focus here on the non-seasonal component of sea level variability. The mean seasonal cycle from 1993 to 2001 is computed and subtracted from TOPEX/POSEIDON (T/P) observations. The resulting basin-average sea level across the Japan/East Sea (JES) (Figure 2) varies with an amplitude as large as 10 cm with prominent periods ranging from a few weeks to several months. (There is also a weaker interannual component.) The spatial structure of the first Empirical Orthogonal Function (EOF; Figure 3) is nearly uniform across the basin and accounts for 38% of the observed non-seasonal variability.

1/4° Model

The 1/4° model (simulation) successfully resolves much of the observed variability. The model's JES basin-averaged sea level is comparable to that of T/P (Figure 2, correlation is 0.56), and the model's first EOF (Figure 3) is also similar to that of T/P accounting for 78% of the model variability. The larger fraction of variance the model EOF explains of its fluctuation compared to that of T/P's EOF, may be due to the model's lack of small-scale variability and/or the observation's (3-day maps) inaccuracy in resolving higher frequency oscillations. Given the skill, the model provides a suitable means to analyze the nature of the observed sea level variability.

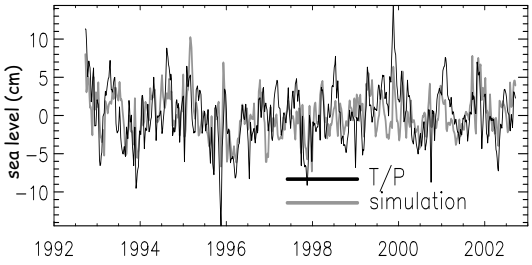

Fig 2: Basin-mean non-seasonal Japan/East Sea sea level from T/P and simulation.

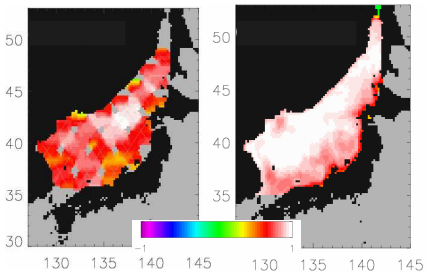

Fig 3: First EOF of non-Seasonal Japan/East Sea sea level variability; T/P (left), model (right)

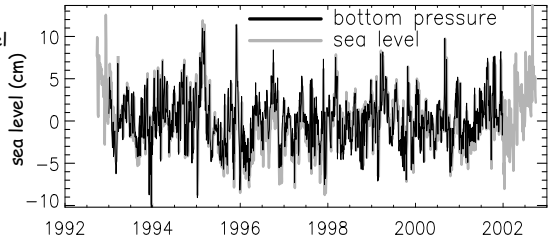

Fig 4: Basin-mean Japan/East Sea simulated sea level and simulated bottom pressure

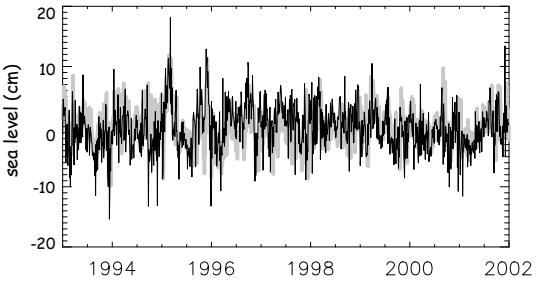

Fig 5: Sea level produced by simulation (gray) and implied by simulated transports through the straits

Nature of the Oscillation

The non-seasonal basin-wide JES sea level changes are barotropic in nature and controlled by the mass transports through the straits of the JES, as evidenced by the consistency among the simulated time series of sea level, bottom pressure, and sea level inferred from the transports through the straits (Figures 4 and 5).

Wind forcing at the Straits

Non-seasonal winds in the vicinity of the Korea/Tsushima (KT) and Soya (SY) Straits correlate most strongly with the simulated basin-mean sea level (Figure 6). When the non-seasonal vector winds near the KT and SY Strait are suppressed, the energy in the simulated non-seasonal sea level is reduced by 50 to 80% (Figure 7). These results suggest that the winds around the straits dominantly determine the non-seasonal variations of simulated JES sea level, and that the wind around the SY Strait have significant impacts. The basin-wide sea level response is linear with respect to wind as evidenced by barotropic simulations with forcing applied at individual straits (Figure 8).

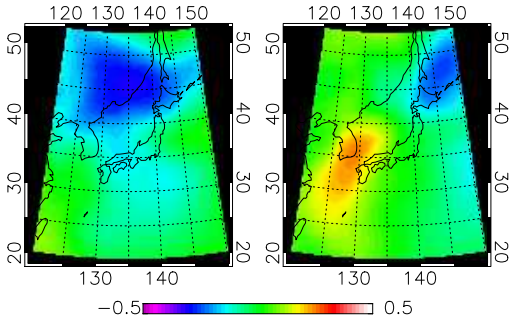

Fig 6: Correlation between basin-mean non-seasonal JES sea level and non-seasonal zonal (left) and meridional (right) winds.

Conclusion

A prominent near-uniform basin-wide fluctuation of sea level is found in the Japan/East Sea (JES). The fluctuation, similar to that recently identified in the Mediterranean Sea (Fukumori et al., 2007, *J. Phys. Oceanogr.*, **37**, 338-358), is barotropic in nature and is controlled by locally wind-driven transport through the straits (Korea/Tsushima and Soya Straits) that connect the semi-enclosed sea to the open ocean.

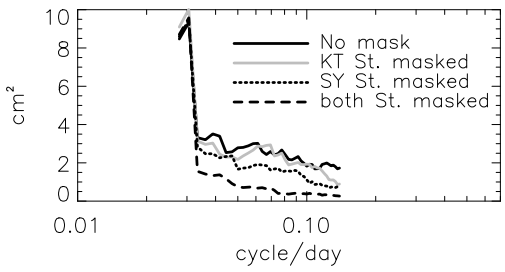

Fig 7: Variance preserving spectra of basin-mean JES sea level for 1993, with the winds over the KT, SY, or both straits masked with mean seasonal winds. No mask refers to the simulation with the original winds.

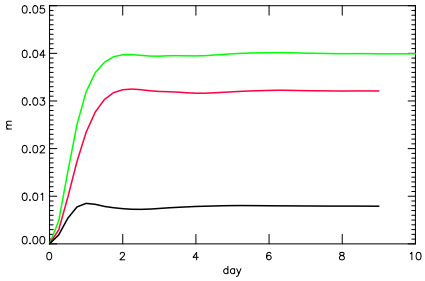

Fig 8: Sea level response from barotropic experiments with time-invariant constant winds at the KT Strait (red), the SY Strait (black), and simultaneously at both straits (green).