Coupled Rossby Waves on Annual to Interannual Timescales

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Extended Abstract

Here we summarize three separate studies examining coupled Rossby wave activity over the Indian and Pacific oceans on three different periodscales (White, 1999a, 1999b, 1999c). Collectively these studies examine annual and interannual variability in TOPEX-Poseidon sea level height (SLH) and National Centers for Environmental Prediction sea surface temperature (SST) and meridional surface wind (MSW) from 1993 to 1999. In White (1999c) these data were examined for coupled Rossby waves in the annual cycle over the tropical and subtropical Indo-Pacific ocean from 6° to 26° latitude (see **Panel 1a**). In White (1999a) these same data were examined for coupled Rossby waves on biennial timescales over the tropical Pacific ocean from 10° to 22° latitude (see **Panel 2a**). In White (1999b) again these same data were examined for coupled Rossby waves on interannual timescales over the tropical and subtropical South Indian ocean from 10°S to 26°S (see **Panel 3a**).

Zonal wavenumber-frequency spectra of monthly SLH, SST, and MSW differences and anomalies yielded peak spectral energy density for westward traveling waves of annual and interannual period in all three variables (not shown). In order to focus on the particular periodscale of interest we band passed the time records for annual and interannual variability. In order to focus on propagation we computed the difference between these band pass filtered spectral estimates in both east and west quadrants, yielding the "propagation" wavenumber-frequency spectrum (**Panels 1b**, **2b**, **3b**). In each study the propagation spectra for SLH, SST and MSW residuals and anomalies were similar to one another. Propagation spectra for annual variability are displayed in **Panel 1b** for latitude bands 6° to 26° latitude in the tropical Indo-Pacific ocean. Propagation spectra for biennial variability are displayed in **Panel 2b** for latitude bands 10° to 22° latitude in the tropical Pacific ocean. And propagation spectra for interannual variability are for the latitude band 10°S to 26°S in the South Indian ocean. At each latitude significant peak spectral energy density for all three variables are in close proximity to one another, with the center of shared spectral energy density estimated by the solid circle. This indicates the presence of coupled waves that share westward phase propagation among all three variables. Notice the difference between zonal wavenumbers and frequencies of these shared spectral peaks and those indicated by the theoretical Rossby wave dispersion relation (Killworth *et al.*, 1997).

Animation sequences and time-longitude diagrams of covarying SLH, SST, and MSW differences and anomalies are displayed in **Panels 1c**, **2c**, **3c**, characterized by westward phase propagation across the Indian and Pacific oceans in fixed phase with one another. Alignment of the variables can be intermittent or confined either to the western or eastern ocean but they begin to tell a consistent story among the three studies. By examining the phase relationships relative to dashed reference lines overlain on **Panels 1c**, **2c**, **3c**, we find warm (cool) SST differences and anomalies approximately overlying or displaced to the west of high (low) SLH differences; and we find poleward (equatorward) MSW differences and anomalies approximately overlying or displaced to the east of warm (cool) SST anomalies. These phase relationships are indicative of the dynamics relating ocean to atmosphere and allow simple coupled models to be constructed that explain the characteristics of the coupled Rossby waves (White *et al.*, 1998; White, 1999a, 1999b, 1999c). Moreover, in the animation sequences in **Panels 1c** and **3c**, each variable can be seen to display a beta refraction pattern characteristic of oceanic Rossby waves; that is, their alignment is in the northeast-southwest (southeast-northwest) direction in the northern (southern) hemisphere. But here the beta refraction patterns of the coupled Rossby waves are much weaker than those expected of free oceanic Rossby waves.

The reason beta refraction patterns of the coupled Rossby waves are weaker than those expected of free oceanic Rossby waves is because the meridional decrease in westward phase speed with latitude is less than expected of free Rossby waves (see **Panels 1d**, **2d**, **3d**). In each of the three studies the westward phase speed for coupled Rossby waves was observed to be less than expected of free Rossby waves in the tropical oceans and often greater than expected of free Rossby waves in the extratropical oceans.

References

Killworth, P.D., *et.al*, 1997. The speed of observed and theoretical long extra-tropical planetary waves. *J. Phys.Oceanogr.*, 27, 1946-1966.
White, W.B., 1999a.Tropical coupled Rossby waves in the Pacific ocean-atmosphere system. *J. Phys. Oceanogr.*, (in press).
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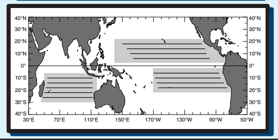
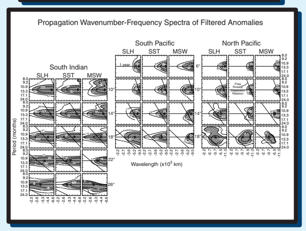
Annual

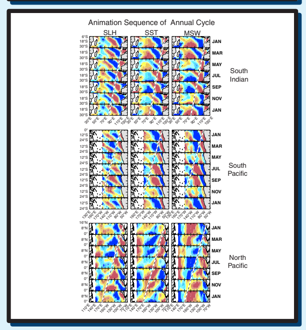
1a



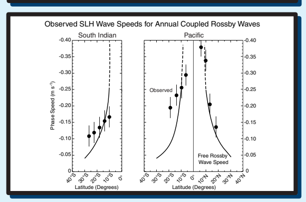
1b



1c

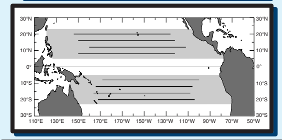


1d

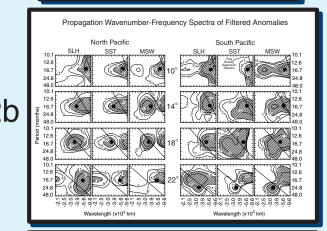


Biennial

2a



2b



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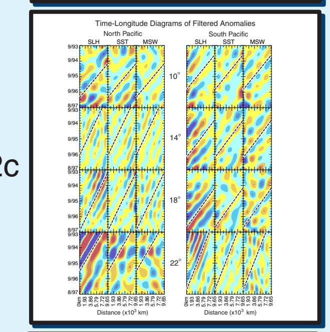
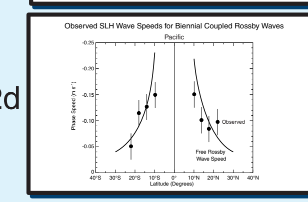
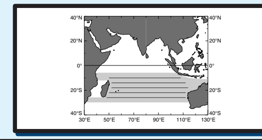


2d

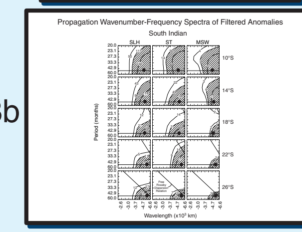


Interannual

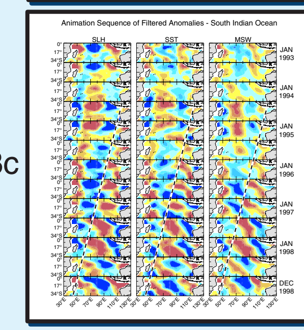
3a



3b



3c



3d