Meridional component of oceanic Rossby wave propagation

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Abstract

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A large meridional component of the Rossby wavenumber (hence, wave phase velocity) vector is an important intrinsic feature of the Rossby wave field. This component has been observed since at least the 70s using in situ data. Nevertheless, it is often ignored in altimeter-based studies (such as those using longitude-time plots of SSH variability), leading to an inaccurate interpretation of the wave field properties. In particular, the Rossby wave speed and wavelength determined based on the Hovmoler diagrams alone are greatly overestimated and thus appear as non-dispersive and propagating strictly westward.

The present work offers a detailed statistical analysis of SSH variations which avoids many difficulties inherent in the longitude-time plots and thus yields a more accurate and more detailed characterization of a Rossby wave field. Estimating 3D wavenumber-frequency spectra of SSH variability, we find that the meridional component of the wavenumber vector for baroclinic Rossby waves of all timescales in usually much greater than the zonal component, and the wave velocity vector often deviates from the zonal direction by more than 70 degree. Because of the shorter wavelength (yielding kL as high as 0.7, where L is the Rossby radius of deformation and k is the wavenumber modulus), Rossby waves are essentially dispersive. Another intrinsic feature confirmed by our 3D analysis is the directional wave dispersion leading to both poleward and equatorward refraction. As a result, a likely role of Rossby waves in ocean and climate dynamics is a cross-latitudinal exchange of physical and bio-geochemical quantities caused by waves' latitudinal displacements and subsequent transformations. In agreement with some earlier theoretical studies, we find that the propagation of Rossby waves across ocean basins from east to west is questionable.