Annual Rossby waves below the pycnocline in the Indian Ocean

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In-situ observations in the Indian Ocean had long been limited to sporadic ship observations, which hampered the progress of observational research of basin-wide circulation and variability. The implementation of Argo profiling float program since 2004 dramatically improved this situation, and now abundant in-situ observations obtained from Argo floats are available. This study uses the resulting temperature and salinity observations between the sea surface and 2000 m depth and float trajectories at 1000 m depth to examine annual variability in pressure and horizontal velocity. Annual variability below the pycnocline is large in amplitude in the Arabian Sea and between 10˚S and 20˚S in the South Indian Ocean. Wavenumbers were estimated by fitting a straight line to annual harmonic phase. Results showed that vertical wavenumber tends to decrease poleward in both hemispheres, and vertical wavelength is more than tripled from about 5,000 m at 5˚N/S to 16,000 m at 20˚N/S. The inverse radius of deformation squared (defined as f^2m^2/N^2) does not show clear dependence on latitude, because poleward increase in the magnitude of the Coriolis parameter (f) compensates for poleward decrease in vertical wavenumber (m), and Brunt-Väisälä frequency (N) varies little meridionally in the analysis domain. According to the dispersion relation of linear, quasi-geostrophic Rossby waves at a rest state, these meridional structures in m and deformation radius result in steeper angle of ray trajectory at a higher latitude in the longitude-depth plane. Energy estimated from in situ observations shows a consistent pattern with this expectation. The line of constant phase of annual pressure harmonic is steeper in angle at higher latitudes, which is also expected from the uniform deformation radius and constant N. This result indicates that energy penetrates deeper at higher latitudes.

Keywords: Indian Ocean, mid-depth, Linear, quasi-geostrophic Rossby waves

