WAVE-INDUCED DEEP EQUATORIAL OCEAN CIRCULATION

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ABSTRACT

In the Pacific and Atlantic oceans, a complex equatorial current structure is found below the thermocline. The currents are zonal with typical speeds from 5 to 20 cm s^{-1} and extend as deep as 2500 m. The structure can be divided into two overlapping parts: the Tall Equatorial Jets (TEJs), with large vertical scale and alternating with latitude, and the Equatorial Deep Jets (EDJs), centered on the equator and alternating in the vertical with a wavelength of several hundred meters.

This circulation poses a computational and a theoretical challenge. First, state-of-the-art high-resolution regional models and Ocean General Circulation Models (OGCMs) typically produce a rather weak, inaccurate and incomplete picture of the circulation. Second, the most promising existing theory, based on the rectification of intraseasonal Yanai waves, cannot account for the basin-wide presence of the TEJs.

In the present study, using idealized numerical simulations and analytical solutions, we demonstrate that the TEJs could result from a rectification of a beam of monthly-periodic Yanai waves that is generated in the eastern part of the basin by instabilities of the swift equatorial surface currents.

For weak Yanai wave amplitude, currents resembling the TEJs are obtained, but only within the beam. They are the mean Eulerian flow, which cancels the Stokes drift of the Yanai waves, yielding a zero-mean Lagrangian flow: the water parcels conserve their potential vorticity (PV) and are stationary over a wave cycle. With stronger amplitude, the Yanai waves become unstable, and lose their energy to small vertical scales where it is dissipated. The resulting vertical decay of the Yanai waves provides a source of PV, allowing water parcels to move meridionally within the beam. This process results in TEJs with a mean Lagrangian zonal flow extending to the west of the beam.