The life-cycle of annual waves in the Indian Ocean as identified by a seamless diagnosis for the energy flux

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The role of synoptic-scale waves in tropical-extratropical interactions has been little investigated in terms of the transfers of wave energy, owing to the lack of an appropriate diagnosis scheme in previous studies. A recent theoretical study has derived a seamless scheme that is able to identify the direction of group velocity for both gravity and planetary waves at all latitudes. This new scheme has been used in the present study to provide a first-ever energetic view for the life-cycle of annual waves in the Indian Ocean in a set of shallow-water model experiments with climatological wind forcing. The new scheme is able to show, in particular for the second baroclinic mode, eastward energy fluxes associated with equatorial Kelvin waves (KWs) whose signal are found to span the full zonal extent of the tropical Indian Ocean. For the first and third baroclinic modes, eastward signals at the equator are found to appear in the western and eastern parts of the basin, respectively. Concerning the low-pass filtered time evolution the energy flux, eastward signals associated with equatorial KWs are found to culminate when zonal currents change direction (four times per year) according to monsoon winds. Waves in the tropical and subtropical regions are connected each other at the zonal boundaries of the Indian Ocean that has been viewed, for the first time in the history of geophysical fluid dynamics, in terms of the circulation of wave energy. Near the eastern boundary of the Indian Ocean, the incoming signals of equatorial KW bifurcate polewards along the coasts of Bay of Bengal and Australia and then transmit midlatitude Rossby waves, forming a basin-scale cyclonic energy circulation in each hemisphere. Near the western boundary of the Indian Ocean, the seasonal variations of both the Somali jet and the east African coastal current are found to yield equatorward energy fluxes along the African coast, forming a localized cyclonic energy circulation in each hemisphere. These results for the analysis of climatological annual waves provide a basis for the analysis of waves with interannual variations in a future study to better understand, for example, tropical-extratropical interactions during the Indian Ocean Dipole mode.

Keywords: tropical-extratropical interactions, seasonal variations analysis, wave energy circulation

