Structure and evolution of the tropical synoptic-scale waves in the Indian Ocean-Maritime Continent region

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This study investigates the dominant structure, characteristics, and origins of the tropical synoptic-scale waves (TSWs) in the Indian Ocean-Maritime continent region during austral summer. An extended empirical orthogonal function-based composite analysis is performed on 2-8-day filtered atmospheric circulation fields during December-February 1979/80-2015/16. The analysis results reveal the structure and evolution of the TSWs and associated extratropical-tropical interactions. The composite wave pattern exhibits a modified mixed Rossby-gravity wave-like structure over the Indian Ocean and a tropical depression-type wave-like structure over the Maritime continent. They form a wave train which is trapped in the mean monsoon westerly flow coupling with deep convection in the Indian Ocean intertropical convergence zone. The TSWs propagate westward from the Maritime Continent into the western Indian Ocean. Zonal wavelengths are about 6000-7000 km over the Indian Ocean and is about 3000-4000 km over the Maritime Continent. The westward phase speed is estimated to be about 8-12 m/s. Eastward amplification of wave troughs and ridges of the wave train due to group propagation occurs along the mean monsoon westerly flow. The eastward group speed is estimated to be 7m/s. A dispersive wave energy flux (WEF) formulation derived by Aiki et al. (2017, PEPS) is used to diagnose the eastward amplification of the waves along the mean monsoon westerly flow. The new WEF vectors are considered to be useful to assess energy dispersion characteristics of various types of waves in the tropics. The WEF diagnostics verify that wave energy propagation facilitates the eastward development of the synoptic-scale wave train, suggesting that the mean monsoon westerly flow acts as a tropical waveguide. Extratropical forcing mechanisms responsible for the development of the TSWs are explored. Two types of extratropical forcing of the TSWs are identified over the southwest Indian Ocean. One type is direct propagation of midlatitude synoptic-scale waves toward the tropics that induces the growth of the tropical waves through the Rossby wave energy dispersion from the subtropics into the tropics. The other type is meridional wind surges originated in the midlatitude that could intensify the TSW troughs and ridges. The surges are induced by the baroclinic development of the midlatitude synoptic-scale waves. The self-organizing map (SOM) technique is used to classify the TSW patterns. The SOM-based composite analysis successfully detects various types of the southerly and northerly wind surges which force the TSWs in the Indian Ocean--western Pacific region.

Keywords: Tropical synoptic-scale waves , Extratropical-tropical interaction, Wave energy dispersion, Asian-Australian monsoon

