The Influences of Sumatra Island and Synoptic Features on Tropical Cyclone Formation in the Indian Ocean: A Numerical Study

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Abstract

Sitting across the Equator with a northwest-southeast orientation and steep terrain, the Island of Sumatra can exert significant influences on low-level prevailing flow near the Maritime Continent. Under an easterly flow regime, in particular, lee vortex (or vortices) tends to form to the west of the island, and some of them may subsequently develop into a tropical cyclone (TC) in the Indian Ocean (OI). This study, therefore, investigate the roles of the Sumatra Island and other migratory tropical disturbances on the formation of TCs using a cloud resolving model.

A total of four cases in the northern IO during the Year of Tropical Convection (YOTC) period were selected for analysis and two of them (TCs Nisha and Ward) for simulation using the Cloud-Resolving Storm Simulator (CReSS) with a horizontal grid spacing of 4 km (i.e., the control experiments). Sensitivity tests with the Sumatra topography removed were also performed. The results indicate that when the pre-TC vortices remain stationary at the leeside of Sumatra at their early stage, they are indeed slightly stronger with a clearer circulation due to the blocking effect of Sumatra on the prevailing northeasterly flow. However, the island's terrain is not a deciding factor on TC formation in these events, as the vortices without the terrain also eventually reach TC status, just at a slightly later time. In addition, westerly wind burst at low latitudes along the equator and migratory disturbances, typically from tropical convection or the ranments of a TC that move westward from the South China Sea (SCS), are also common factors to provide enhance vorticity and moisture, and thus appear important. An examination on all TC cases in northern IO after monsoon in 2008 and 2009 suggests that all their pre-TC vortices evolve in a similar environment with positive horizontal wind shear and advection of vorticity and moisture from the SCS. During the period of TC Ward, another TC (Cleo) also formed in the southern IO, to the southwest of Sumatra, so that it is also examined. It is suggested that the deflection of equatorial westerly wind into a northwesterly flow by the Sumatra terrain (on the windward side) does contribute to the vortex circulation there and is thus also helpful in the formation of TC Cleo later.

Keywords: tropical cyclone, lee vortex, Sumatra, Indian Ocean, topographic effect, cloud-resolving model