Tropical cyclone characteristics in response to the different cumulus convective activity in a high-resolution climate model

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Abstract

Importance of cumulus entrainment for realistic tropical cyclone simulation is investigated by diversifying the maximum-allowed convective cloud scale in a high-resolution (quarter-degree) climate model. We select the hurricane season of year 2005 and 2006, the very active and inactive hurricane year on record for Atlantic, respectively, for our experiments. The NASA / Goddard Earth Observing System version 5 (GEOS5) model is used for this study. Various tropical cyclone characteristics in response to the different cumulus convective activity are investigated including storm and hurricane numbers in each year, intensity, track, and 3-dimensional hurricane structure.

Results show that increase in minimum entrainment rate suppresses cumulus convective activity, resulting in convective precipitation decrease over the tropical storm genesis region whereas increase in large-scale precipitation. Larger total cloudiness is observed in the atmosphere when larger minimum entrainment threshold is applied. Associated latent heat and evaporative flux are also increased. Moist static energy profile over the storm genesis region demonstrates that suppression of the fast cumulus convective process facilitates maintenance of unstable atmospheric condition especially over lower troposphere, providing more favorable condition for tropical storm genesis.

The number of storms and hurricanes detected for year 2005 and 2006 is 25 and 13, respectively, which is close to observation (29 and 10, IBTrACS). 3-dimensional structure of strong hurricane shows the maximum lower-level wind speed around ~60 m/s and SLP minimum down to ~955mb. Radius of maximum wind, low-level vorticity, vertical div/con profile, and horizontal compactness of hurricane center are very reliable in the model at quarter-degree resolution.