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Role of the Convective Scheme in Modeling Initiation and Intensification of Tropical Depressions over the North Atlantic

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Modifications of the large-scale environment related to intraseasonal (MJO) and interannual (ENSO) time-scale variability or to global climate warming may have important impacts on the tropical cyclonic activity. This sensitivity of tropical cyclones (TC) on environmental changes can now be studied using General Circulation Models (GCM). Before doing sensitivity studies with a GCM, it is interesting to assess the representation of the TC activity for different configurations (resolution, parameterization) of the GCM in present climate conditions and to trace possible causes of bias in TC number, location or strength. A possible approach to do this assessment is to separate initiation and intensification processes. By using either GCM output, or meteorological analysis combined to TC observation databases, it is possible to study the condition of formation of tropical depressions vortices (TDV) at an early stage and their possible intensification into a TC (say the Tropical Storm stage).

We use the LMDZ GCM to study the sensitivity of TDV characteristics to different entrainment and closure formulations of the convective scheme. The study focuses on the Tropical North Atlantic using the "zoom" capability of the LMDZ GCM. The horizontal resolution of the model is set to 0.75° over a large region of the North Atlantic and West Africa. The GCM is free to run in this region and is tied to ERA-Interim reanalysis outside that region, with intermediate relaxation times in-between. We use the Tiedtke convective scheme with entrainment and closure based on the moisture convergence, or with an entrainment based on the relative humidity of the environment, and additionally a closure based on CAPE. Each configuration is run for 10 years between 2000 and 2009 with prescribed SST.

In summary, the convective entrainment based on the relative humidity in the environment deepens the TDV in LMDZ, resulting in more TDV and TC. The convective closure mitigates this tendency and improves the realism of the TC activity. With the original Tiedtke scheme, too many TDV were initiated over southern West Africa. In ERA-I, many North Atlantic TDV are initiated south of the Hoggar Mountain, but not in LMDZ probably because of a lack of sustainability of the TDV over dry continental areas. Many TC in LMDZ are issued from TDV having different origins compared to ERA-I and different origins depending on the configuration of the convective scheme. This should be taken into account in climate sensitivity studies.