Simulating High-Resolution Atlantic Tropical Cyclones using GEM: Part II

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In a previous paper (Caron et al., 2008), we discussed Atlantic tropical cyclone (TC) activity over a 26-year period as simulated by the Global Environmental Multiscale (GEM) model (Zadra et al., 2008) using observed sea surface temperatures. GEM has the ability to run in variable resolution so that the region of interest can be integrated at high-resolution while the rest of the globe is run at lower resolution, typical of today's global climate models (GCMs). For this experiment, the high-resolution region (0.3°) was chosen to extend from the Eastern Pacific to the Arabian Sea in order to cover the whole tropical Atlantic as well as the entire Sahel region where the African Easterly waves, precursors of a large portion of Atlantic TCs, are formed (figure 1).

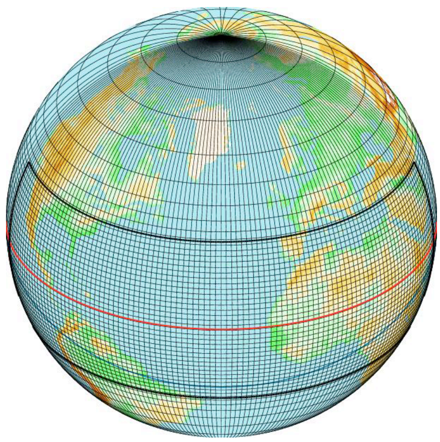

Figure 1: Variable-resolution grid used in this study.

We showed that GEM managed to capture TC intra-annual variability, with maximum activity in September, yet produced too many storms overall with respect to observations for the given period. Also, the storms produced by GEM had the tendency to be too weak in comparison with their observed counterpart: based on the maximum wind speed produced during their entire lifetime, no storm stronger than category 1 on the Saffir-Simpson scale was detected ($\sim 145\ km\ h^{-1}$). Here, we extend the study period to 2006 and follow up on these issues.

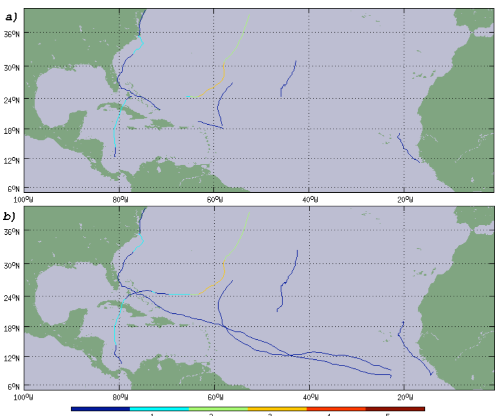

Figure 2: Same hurricane season as seen by a) the previous tracking procedure and b) the current tracking procedure. The scale represents TC intensities as measured by the Saffir-Simpson scale based on minimum central pressure.

When tracking TCs, we followed the scheme suggested by Walsh et al. (2007). As such, a storm is detected if it fulfills the following conditions for a 24h period:

- a minimum pressure in the center.
- surface winds of at least 17 $m\ s^{-1}$ (65 $km\ h^{-1}$) in the vicinity of the center.
- a warm core in the mid- to upper-troposphere.

No standard algorithm yet exists for identifying a warm core, and various definitions have been used in different studies (Walsh et al., 2007). In Caron et al. (2008), a warm core was positively identified if 1) the mean temperature in a 2° radius around the storm center at 500 hPa and 250 hPa was 1°C greater than the temperature at a 5° radius at the same levels, and 2) the low-level (850 hPa) wind was higher than the upper-level (250 hPa) wind. This technique is very efficient for discarding false-positives, but because of its stringent nature, has the disadvantage of double counting the storms that weaken (and therefore are no longer detected) and later re-intensify.

In order to address this issue, we modified the tracking procedure such that it is now performed in multiple steps. The first step has already been described above. The second step consists of running the tracking procedure a second time, but changing the surface wind threshold to 10 $m\ s^{-1}$ as well as ignor-

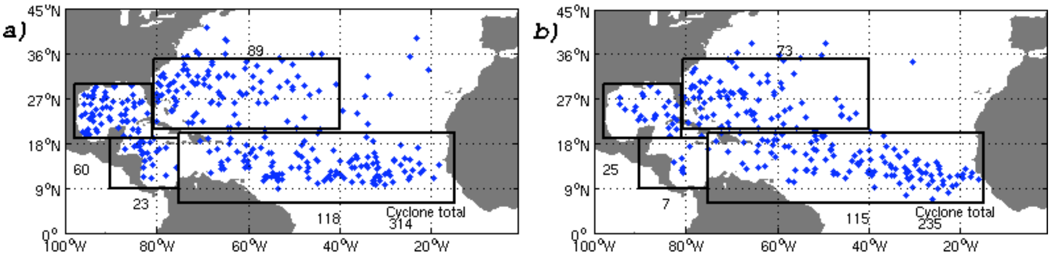

Figure 3: Cyclogenesis location a) observed and b) simulated by GEM for the 1979-2006 period.

ing the difference in temperature in the mid- and upper-troposphere. The comparison between lower and upper wind however, remains. Because more tracks are detected with the second tracking procedure, we then compare both sets of tracks, retaining only those detected using both the more permissive and the more stringent conditions. The different results between the two techniques can be seen in figure 2, which compares the same hurricane season using the previous and current method. The new technique has the added benefit of tracing a storm back to its origin. When compared to observations for the 1979-2006 period (figure 3), TC activity is fairly realistically represented over the entire basin, except in the Gulf of Mexico and the Caribbean Sea, where the number of TCs is too low. The reason for this is currently under investigation.

As mentioned above, based on maximum wind speed, GEM does not simulate storms stronger than category 1 on the Saffir-Simpson scale. However, since there is a relatively good correspondence between the central pressure of a storm and its maximum wind speed, storm intensity can also be estimated using the minimum central pressure. Doing so in our 28-year simulation leads do a different intensity distribution: low-intensity storms are still over-represented, but now storms up to category 4 ($\sim$ 945 hPa) are present.

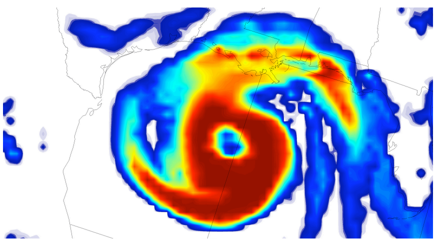

Figure 4: Cloud cover of a strong GEM simulated category 3 (on Saffir-Simpson scale) hurricane in the Gulf of Mexico.

It thus appears that the observed relation between maximum wind speed and minimum central pressure does not hold in GEM. This situation is not unique to GEM and has been observed in other simulations as well (Knutson et al., 2007). The reason for deficiency is not yet clear, but it has been hypothesized that the model misrepresentation of the drag coefficient for very high wind speed could be responsible (Knutson). We are planning to run some tests in that regard where the drag coefficient would be adjusted for hurricane strength wind speed.

Finally, it is worth mentioning that in Caron et al. (2008), we stated that ”0.3° appears insufficient resolution for eye development”. This appears to be incorrect, as the most powerful storms simulated do show the presence of an eye. Figure 4 shows a strong category 3 that reached a central pressure of $\sim$ 950 hPa in the Gulf of Mexico. An eye is clearly visible in the cloud cover, with strong ascending motion in the eyewall and descending motion in the eye itself (not shown).

References:

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