P1.32 WESTERN NORTH PACIFIC “TROPICAL CYCLOGENESIS” IN AN AGCM

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1. Introduction

Atmospheric General Circulation Models (AGCMS) produce tropical storms whose statistical distributions in space and time are similar to observed ones. Low model resolution causes the model storms' intensities to be weaker, and spatial scales larger than in observed storms (see e.g. Bengtsson et al. (1982)). Here Western North Pacific model tropical storms are studied in a 13-member ensemble of low-resolution ECHAM4.5 AGCM simulations forced by observed sea surface temperature (1979–1995). Tropical storms are detected by a basin and model-dependent algorithm and then tracked using the low-level vorticity (Camargo and Zebiak, 2002a). The variability of the model tropical storms are discussed in Camargo and Zebiak (2002b). In this paper time-dependent composites of model tropical storms are analysed with the aim of understanding the processes controlling tropical cyclogenesis in the model.

2. Model Tropical Storm Composite Features

Time-dependent composites of the tropical storms are created in the Western North Pacific during the typhoon season (June to October) using model storms from the entire ensemble and full period. The composites are created by averaging simulated fields from different storms in a storm-centered coordinate. All the storms are aligned on the first day they pass the detection criteria (here called day 0). The composites extend backwards and forwards for 15 days relative to day 0. Composite mean time series of model fields are produced by averaging over all storms for the same day relative to day 0. Anomalies are defined for each storm relative to monthly mean model climatology for the date and location of that storm, and then these anomalies are averaged over all storms to produce time series of anomalous fields.

Figure 1 shows time evolution of the composite mean vorticity and anomalous vorticity at $850hPa$. Initially, the mean low-level vorticity is larger than the climatological value, suggesting the presence of an initial disturbance before the tropical storm appears. The mean low-level vorticity of the composite then has a minimum at day -3 after which it sharply increases until day 3, characterizing the transition to the model tropical storm. The anomalous mean vorticity has a maximum on day 7, while the mean vorticity remains constant, suggesting that the storms usually move to a region of lower climatological vorticity. The time evolution of the vorticity in other levels of the lower troposphere is very similar. In upper levels the signal of cyclogenesis on the vorticity starts later, on day 0 and there the vorticity is negative. The vorticity then develops initially on lower levels and is later transmitted to upper levels. Higher values of vorticity at upper levels occur simultaneously with a sharp decrease of the mean composite surface pressure (not shown) and an increase of the mean composite surface windspeed (not shown).

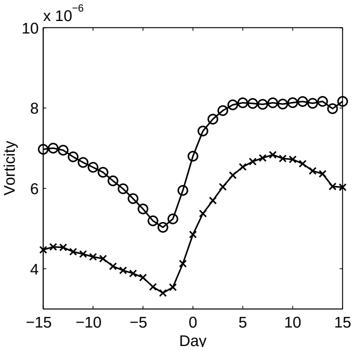

Figure 1: Composite mean vorticity (○) and anomalous vorticity (×) time evolution

The composite anomalous temperature (not shown) in different levels has a minimum around day -3 and then increases abruptly reaching a maximum around day 7, while the composite mean temperature is almost constant. Model storms are moving to regions of lower climatogical temperatures (e.g. poleward). The largest values of mean anomalous temperature occur at upper levels. The composite mean anomalous relative humidity (RH) for different levels is shown in Fig. 2. The anomalous relative humidity first increases at middle levels, then at upper levels, and then only when the storm is well developed do the lower level RH anomalies peak.

Figure 3 shows the time series of the composite mean shear, mean anomalous shear and mean climatological shear, the shear is defined as the difference of the mean zonal velocity around the center of the storm at $200hPa$ and $850hPa$. Unlike most other model variables, The mean composite shear does not have a minimum near the time when the model storm is defined, but a week later; the shear is monotonically decreasing in absolute value through the period of genesis. This temporal evolution is consistent with the hypothesis that the storms need

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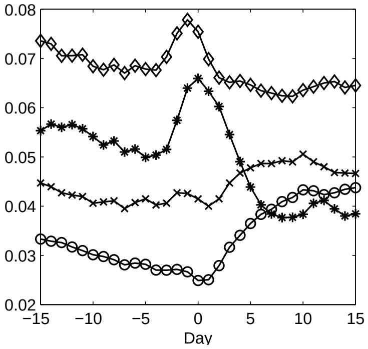

Figure 2: Time evolution of the composite mean anomalous relative humidity at 850hPa ($\circ$), 700hPa ($\times$), 500hPa ($\diamond$) and 300hPa ($\star$).

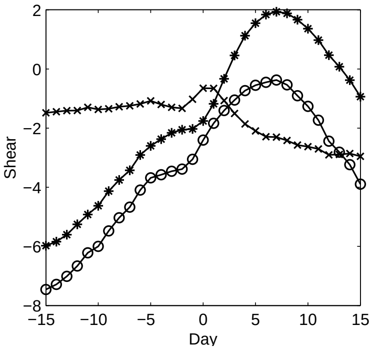

Figure 3: Time evolution of the composite mean ($\circ$), anomalous ($\times$) and climatological shear ($\star$).

an environment of weak shear in order to develop. The similarity between the time series of composite mean and climatological shear suggests that the decrease in shear is primarily due to the mean storm trajectory from regions of higher to lower shear (easterly shear becoming less so) rather than dynamical changes in shear at a given location.

The temporal behavior of the standard deviation and skewness of different variables over the distribution of model storms was also analysed. An interesting signal is found in the skewness of the RH. Because the mean RH is high (around 80%), and the maximum possible is 100%, we naively expect a negative skewness, and at most levels and times this is indeed found. However, at 850 hPa the RH skewness is positive for several days just before and through day 0, as shown in Fig. 4. This suggests a strong constraint excluding *low* RH values from the distribution. This is consistent with the physical idea that a necessary condition for model cyclogenesis is high RH values in the lower troposphere.

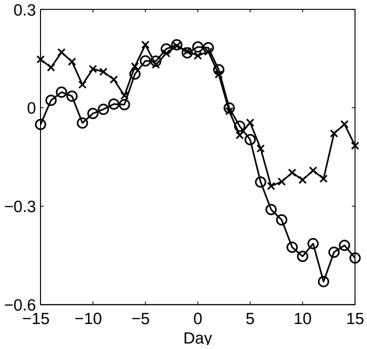

Figure 4: Time evolution of the skewness of the composite mean relative humidity ($\circ$), and of the anomalous relative humidity ($\times$) at $850hPa$.

3. Conclusion

Time-dependent composites of tropical storms on the Western Pacific are studied in a low resolution AGCM. There are clear signals of the storms in all the variables that were composited, and in most of them there is a sharp transition in the mean value of the variable near day 0. Vertical wind shear and low-level relative humidity seem to be the variables with greatest influence on the tropical cyclogenesis process. The wind shear varies significantly over the storm trajectory primarily because the mean storm trajectory moves from a region of relatively high climatological shear to one of relatively low climatological shear. A necessary condition for the development of the storm seems to be the presence of high relative humidity in lower levels days before the model storm is defined. This simulated cyclogenesis has some similarities to observed cyclogenesis Zehr (1992) despite the much larger scale and lower intensity of the simulated storms.

References

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