1C.5 OBJECTIVE DETECTION OF TROPICAL CYCLONES IN CLIMATE MODELS

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1. INTRODUCTION

Global climate models (GCMs) are able to generate low pressure systems that have many of the observed characteristics of tropical cyclones, and numerous studies have examined their ability to do so. These studies have used different threshold criteria for deciding the cut-off between systems of tropical storm and tropical depression strength, which for observed storms in the eastern hemisphere is a 10-minute wind speed of 17.5 ms^{-1} (39 mph) measured at a height of 10 metres (1-minute winds in the western hemisphere). The use of differing threshold criteria makes it difficult to compare objectively the simulation of cyclone formation numbers from model to model and between models and observations.

In this study, an objective threshold criterion is derived from observations. This enables objective evaluation of the ability of climate models to generate the observed numbers of tropical cyclones.

2. METHODS

The data analyzed is the Extended Best Track File of Pennington et al. (2000) from 1988-2003, recently analyzed by Kimball and Mulekar (2004). These data contain cyclone position and central pressure, but also structural criteria such as the radius of maximum winds. For each cyclone analyzed, the central pressure and radius of maximum winds were used to create an idealized wind field profile, using the method of Holland (1980). Idealized wind fields were created for storms whose maximum wind speeds were exactly 35 knots, as these represent observed storms that have just surmounted the threshold for tropical storm formation. A total of 113 storm days were analysed.

The wind fields were then averaged over grids of varying horizontal resolutions and the maximum wind speeds at these resolutions were recalculated for each storm. The average of all maximum wind speeds over the 113 storm days at this resolution was taken to be the typical maximum wind speed of a threshold storm at this resolution.

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Other methods were used to check this technique. The values at the grid points were taken instead of the grid averages and the same calculation of average maximum wind speed was taken for each resolution. A similar method was applied using another implementation of the Holland (1980) model, that of Hubbert et al. (1991). Finally, six storms of threshold intensity listed on the publicly-available HRD wind analyses (Powell et al. 1998) were analysed with the same technique, taking grid averages at various resolutions. More details are given in Walsh et al. (2006).

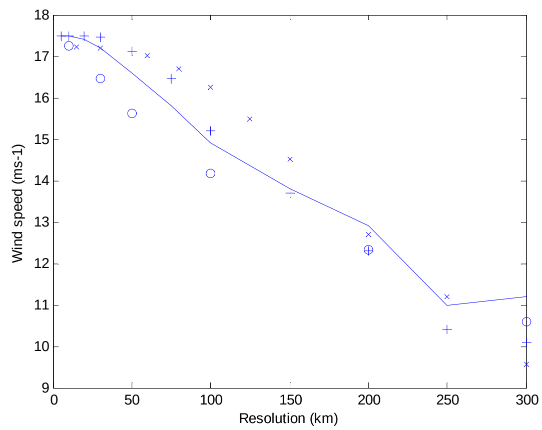

Figure 1. Variation of threshold detection wind speed with resolution, as derived from analytical curve fitting using the method of Holland (1980), as described in the text, for (solid line) grid box averages and (plus signs) grid point calculations. Also indicated (circles) are values derived from a selection of HRD wind analyses and values (x symbols) derived using the model of Hubbert et al. (1991).

3. RESULTS

The main result is shown in Fig. 1. This shows the threshold tropical storm maximum wind at various resolutions. At very fine model horizontal resolutions (less than about 10 km), the observed threshold of 17.5 ms^{-1} may be appropriate. For a resolution of 30 km, 17.0 ms^{-1} is appropriate. This threshold decreases with coarser resolution. For the horizontal resolution of a typical climate model (about 300 km), a threshold of about 10.5 ms^{-1} is best.

The results could be improved through the use of more HRD analyses, as it can be argued that these are considerably more realistic than the curve-fitting technique also used here, although they appear to give similar results for the limited number of HRD analyses examined here.

4. DISCUSSION AND CONCLUSIONS

The main use of this technique is for model intercomparison. The issue of how to evaluate whether a climate model is producing a reasonable climatological pattern of tropical cyclogenesis has not been addressed objectively before. Model studies to date have used detection criterion that have been tuned to obtain a good simulation of cyclone numbers, or have used the observational threshold without modification for resolution, or have ignored the issue. Additional, a number of studies have used detection criteria imposed at heights other than 10m.

Additional structural detection criteria are also imposed in such studies to eliminate the detection of mid-latitude cyclones: for instance, a requirement is imposed that the detected storm has a warm core. These additional criteria should not be so restrictive as to also eliminate symmetric, warm-core storms that meet the resolution-adjusted 10m wind speed criterion. When reasonable structural criteria are used in conjunction with the results presented here, they provide a simple, objective method of determining the ability of a climate model to produce tropical cyclones.

5. REFERENCES

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