High resolution model projections of tropical cyclone landfall over southern Africa under enhanced anthropogenic forcing

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1. INTRODUCTION

Tropical cyclone landfall within the southwest Indian Ocean (SWIO) basin occurs on average about 3 times per year over Mozambique and Madagascar (Mavume et al., 2009). Rainfall associated with tropical cyclones over the interior of southern Africa can also cause widespread flooding over the eastern parts of the southern African interior (Reason and Keibal, 2004; Crimp and Mason, 1999) and contributes to a large extent to the widespread heavy rainfall events over that area (Malherbe et al., 2011). While a decrease has been noted in the landfall of tropical cyclones from the SWIO (Mavume et al., 2009), no such change has been noted when all closed warm-core low pressure systems are considered (Malherbe et al., 2011). Several studies have through the use of coupled global circulation models globally reported a projected decrease in the number of tropical cyclones expected under enhanced anthropogenic forcing but an increase in the maximum wind strength obtained (Oouchi et al., 2006; Bengtsson et al., 2007; Yu et al., 2010).

2. MATERIALS AND METHODS

2.1 Data

The Conformal Cubic Atmospheric Model (CCAM) was forced with the bias-corrected sea-surface temperatures and sea-ice simulations of six coupled global climate models (CGCMs) that contributed to Assessment Report 4 (AR4) of the International Panel for Climate Change (IPCC). All six CGCMs responded to greenhouse gas forcing corresponding to the A2 (business as usual) emission scenario of the Special Report on Emission Scenarios (SRES), for the period 1961-2100. These models were selected based on their ability to provide realistic simulations of El Niño Southern Oscillation (ENSO) events, average sea level pressure fields in the Southern Hemisphere and tropical belt and the Madden Julian Oscillation (MJO). The ENSO phenomenon and the MJO have been shown to have an influence on the behaviour of tropical cyclones worldwide (Wang and Chan 2002; Irwin and Davis, 1999; Ho *et al.*, 2006).

2.2 Tracking of closed warm-core low-pressure systems

In this study, a closed-low finding-and-tracking algorithm based on the identification of all 700 hPa minima and the temporal tracking of these minima subjected to various tracking criteria were performed. Additional criteria included various thresholds for upper and lower tropospheric temperatures, heights, vorticity and wind in order to identify warm-cored systems only. This was done for all six ensemble members for current (1961-1990) and future (2071-2100) conditions. The numbers of times that a track overlaid a grid point were counted and compared between the two periods. From the set of warm-core low pressure systems, tropical cyclones were selected based on the pressure gradient at 700 hPa.

3. RESULTS AND DISCUSSION

The spatial patterns of simulated tracks of tropical systems are in agreement for the period 1961-1990 to that observed from the NCEP Reanalysis dataset (Figure 1) with a spatial correlation of 0.78.

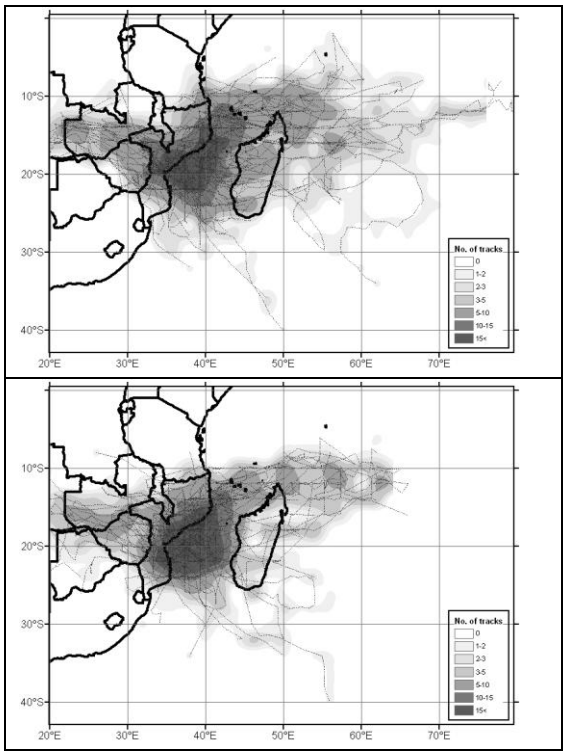

Figure 1: Tracks (lines) and track densities (shades) of landfalling tropical systems as simulated by one of the CCAM ensemble members (top) and observed (bottom).

Over most of the SWIO, including the east coast of southern Africa, a decrease in the frequency of tropical cyclones is indicated (Figure 2).

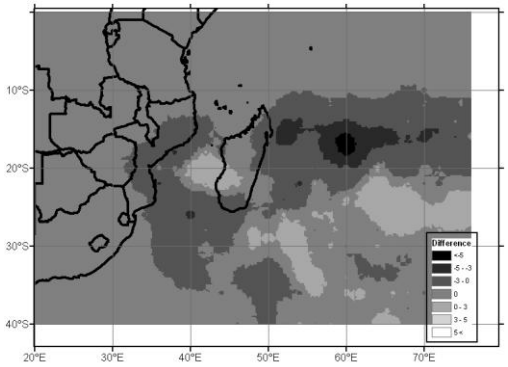

Figure 2 Ensemble average of the change in track density of tropical cyclones between current and future conditions.

The preferred tracks of all closed warm low pressure systems are indicated to shift somewhat to the northeast in the southern African region (Figure 3).

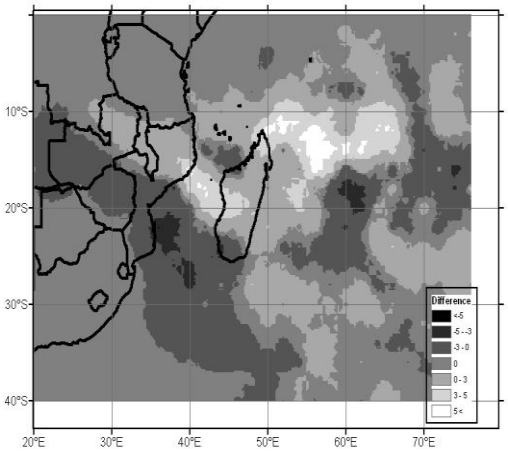

Figure 3 Ensemble average of the change in track density of tropical systems between current and future conditions.

The simulated change in height anomalies at 700 hPa (Figure 4) provides a physical mechanism for the diminishing frequency of tracks of tropical systems in the region as well as the concurrent decrease in average rainfall.

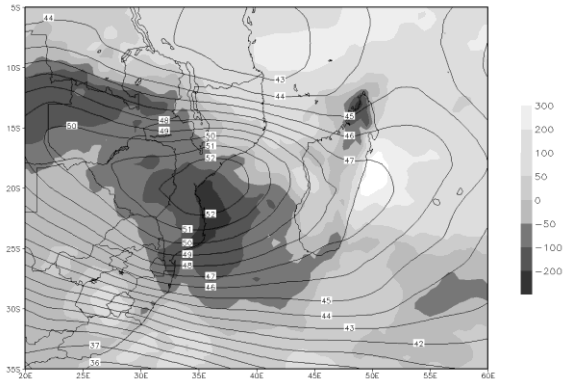

Figure 4 Change in precipitation (shaded) and change in average 700 hPa height (contours) between current and future conditions as simulated by a CCAM ensemble member.

4. CONCLUSIONS

The ensemble of six CCAM members has yielded realistic closed warm low pressure system tracks over the SWIO and into southern Africa under current conditions. According to this ensemble, the behaviour of tropical systems from the SWIO will change as follows under enhanced anthropogenic forcing:

- A general decrease in the occurrence of tropical cyclones over the SWIO.
- No significant change in the number of tropical systems making landfall.

- A northward shift in the preferred landfall position along the southern African east coast.
- A northward shift in the track over the southern African interior after landfall.

The change in track characteristics of tropical systems in the southern African region seems to be the result of a relatively large strengthening of the subtropical high pressure system over the eastern parts of southern Africa. The change is also reflected by a decrease in average January-to-March rainfall over the same region.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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