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WCRP World Climate Research Programme

Mesoscale Convective Complexes over southern Africa

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1. Introduction:

Positioned in the ocean dominated Southern Hemisphere, subtropical southern Africa (**Fig. 1**) experiences considerable spatial and temporal variability in climate and is susceptible to a wide range of severe weather phenomena. One such severe weather producing system that may contribute to the intense convective activity over the region is the mesoscale convective complex (MCC).

The MCC, defined by **Maddox (1980)**, is identified as convective cloud system that is large, long-lived and exhibits a quasi-circular cloud shield. However, compared to other MCC regions, rather little research has been done on southern African systems.

Thus, the main objectives of this study is twofold, with the first relating to the development of the MCC climatology and the second being to obtain a better understanding of the role MCCs play in southern African austral summer rainfall. The results from the first phase are presented here.

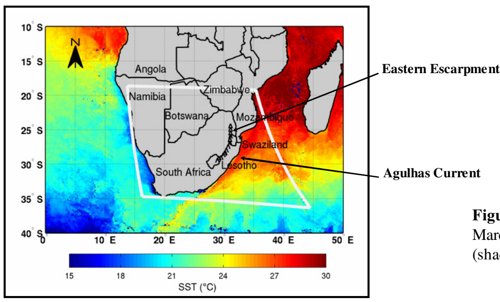

Figure 1: AVHRR 4 km sea surface temperatures surrounding southern Africa for January 2000, with the domain used by MASCOTTE being the light grey box inside.

5. Seasonal Cycle:

Peak MCC occurrence over southern Africa is during the months of November and December, followed closely by February (**Fig. 7**). January, one of the core summer months, receives slightly fewer systems than February.

The November/December peak in activity has also been documented in South America (**Velasco and Fritsch 1987; Durkee and Mote 2009**), whereas the peak in activity in southeast Australia occurs in January (**Perrin and Reason 1997**).

Outside of the core summer months, MCCs are relatively infrequent, with no systems found in October and only a few found in March.

MCCs in southern Africa appear to display seasonal migration with systems occurring further poleward in the earlier part of the season (November and December) and then shift equatorward during the later stages (**Fig. 7**).

There is also considerable inter-annual variability in MCC occurrences in the region, with the average (median) being about 9 (8) events per season and ranging from a minimum of 4 to a maximum of 18 events per season (**Fig. 8**).

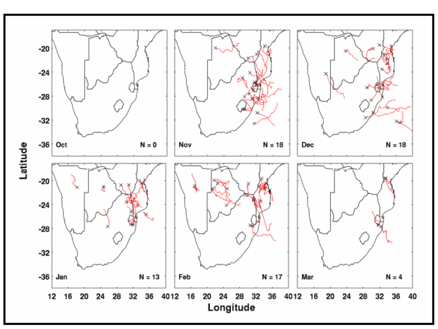

Figure 7: Tracks (red lines) and origin points (x) of MCCs found during the different summer months (*N* is equal to the number of systems).

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Perrin, G. M. and C. J. C. Reason, 1997: Southeast Australian mesoscale convective weather systems. Preprints, *Fifth International Conf. on Southern Hemisphere Meteorology and Oceanography, Pretoria, South Africa,* Amer. Meteor. Soc., 174-175.

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2. Data and Methodology:

Meteosat-7 infrared (IR) satellite data, with an approximate 5-km spatial resolution over subtropical southern Africa and a 30-minute temporal resolution, was provided by EUMETSAT for this study.

MCCs are identified using **Maddox (1980)** criteria (excluding the -32°C temperature threshold) via an automated tracking program.

The automated method utilized in this study is the MAximum Spatial COrrelation TEchnique (MASCOTTE), developed by **Carvalho and Jones (2001)**. The MASCOTTE domain used here is given in **Fig. 1**.

Only systems developing during the austral summer months, as well as the transition seasons (late spring and early autumn) for the period 1998-2006, are considered (i.e. October-March).

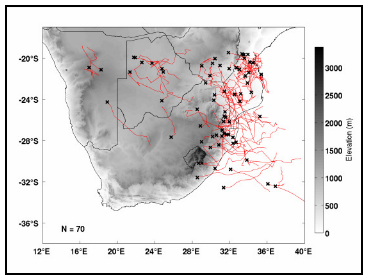

Figure 2: MCC tracks (red lines) and origin points (x) for the October-March period, 1998-2006. Also shown is the topography of the region (shaded). *N* is equal to the number of systems during this period.

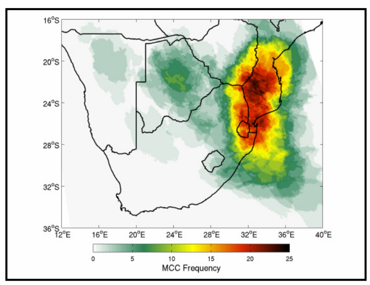

Figure 3: The frequency of MCCs over the region (based on the number of times the cold cloud shield was located on the grid point).

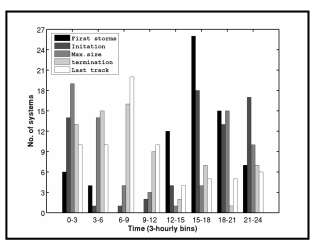

Figure 4: The frequency of systems during a day. The times are in local standard time (LST). The key stages of the MCC lifecycle as described in the text.

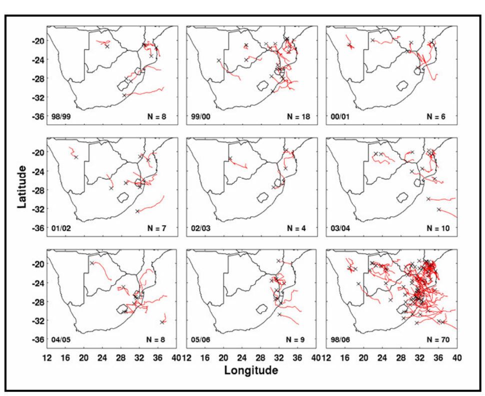

Figure 8: Same as Fig. 7, but now for the eight warm seasons.

3. Spatial Distribution of MCCs:

A total of 70 MCCs were identified and tracked during the eight warm seasons (**Fig. 2**). This result is less than the number of systems observed in subtropical South America (e.g. **Durkee and Mote 2009**) or the central plains of the U.S (e.g. **Ashley et al. 2003**), but greater than that found in southeast Australia (e.g. **Perrin and Reason, 1997**).

As found by **Laing and Fritsch (1993)**, a large percentage of the systems are found to develop along the eastern escarpment (see **Fig. 1** for location). This is not uncommon, with most MCC populations found near large mountain ranges, such as the Andes in South America (e.g. **Durkee and Mote 2009**) or the Rockies in the U.S. (e.g. **Ashley et al. 2003**).

Most systems are also found to occur in close proximity to the warm Agulhas Current (**Fig. 3**). The influence of this warm current (see **Fig. 1** for location) on regional circulation patterns and heavy precipitation events over the region is well known.

Although not numerous in number over the eight warm seasons, **Fig. 2** and **Fig. 3** shows that a few systems may develop over Namibia or Botswana, likely as a result from tropical-extratropical interactions taking place over southern Africa during the summer.

4. Evolution Characteristics:

MCCs over southern Africa predominantly contain a nocturnal life cycle (**Fig. 4**), which is consistent with the global population of these systems (**Laing and Fritsch 1997**).

1. First storms tend to initiate in the early afternoon,
2. Followed by MCC initiation in the late afternoon / early evening.
3. The maximum extent of the systems is found to occur during the night, predominantly between 0000 and 0300 (LST).
4. The decay of the system takes place during the morning hours.

The average duration of the 70 systems over southern Africa (~ 9.5 hours; **Fig. 5**) is slightly shorter than the global average (~ 10 hours; **Laing and Fritsch 1997**) and much less than those found in subtropical South America (14 hours; **Durkee and Mote 2009**).

An unusual finding is that systems over southern Africa tend to be a lot smaller than their global counterparts. **Figure 6** illustrates that just over 20% of the systems exceed 150,000 km².

The average size of the systems is just under 121,100 km² (95% confidence limits ±10,700 km²), which is just under 50% of the average size of subtropical South American systems documented by **Durkee and Mote (2009)**.

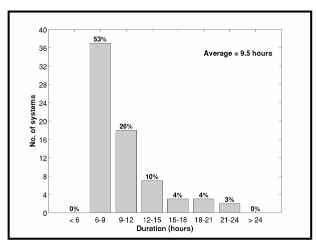

Figure 5: Bar graph of warm season MCC duration, with the percentage contribution shown at the top of each bar.

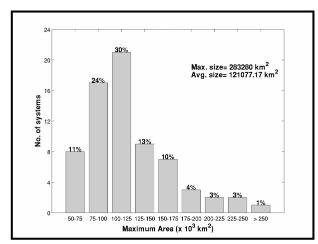

Figure 6: Same as Fig. 5, but for the maximum size of the systems (based on the -52° C cloud shield).

6. Summary:

1. This study has attempted to contribute towards the knowledge of the global population of MCCs by developing a longer climatology for southern Africa than what currently exists.

2. Using a hybrid automated/manual tracking method, 70 MCCs that occurred over southern Africa during 1998-2006 are identified.

3. Most systems initiate along the eastern escarpment and then propagate downstream across the warm waters of the Agulhas Current.

4. The reasons for the low frequency of systems over southern Africa compared to the Americas is not obvious, but is likely as a result of the geographic setting of the different regions (i.e. terrain, moisture sources).

5. Apart from the average size of systems being relatively small, the southern Africa MCCs compare favourably with the global population in terms of having a similar nocturnal life cycle.

6. The results also show that there is variability in MCC frequency on monthly and seasonal timescales, as might be expected given that the climate variability of the region is complex and often influenced by numerous forcing factors.