A climatology of potential severe convective environments across South Africa

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FUTURE CLIMATE FOR AFRICA

8th EGU Leonardo Conference
Ourense, Spain
25-27 October 2016

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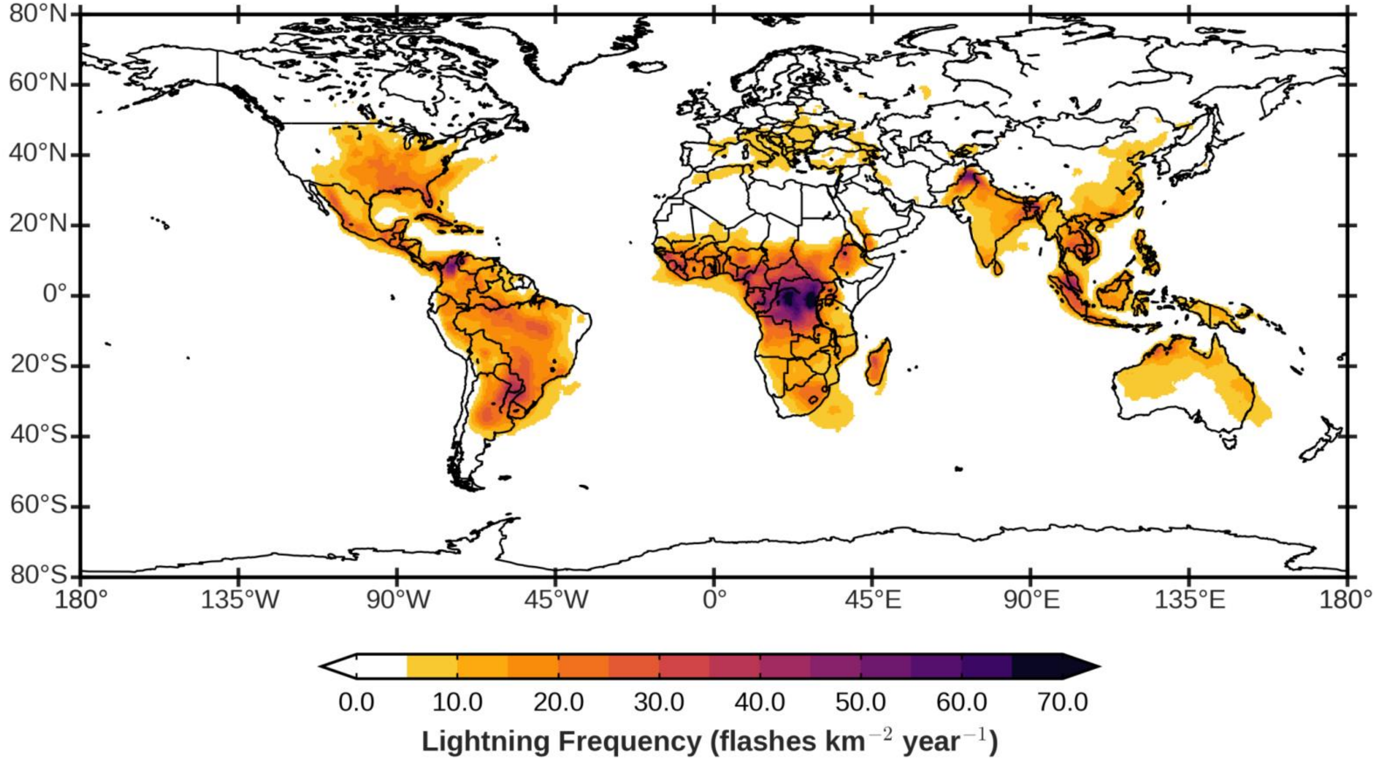
1. Introduction

- Observing and analysing convective storms and their environments from the past few decades has been a crucial in understanding and improving the current knowledge of storm activity (i.e. distribution and frequency).
- Convective storms are significant phenomena, not only being an important source of rainfall, but also by acting to stabilize the atmosphere through the redistribution of heat and moisture.
- When storms are severe, they can be associated with high wind speeds, flooding, hail, lightning and even the occurrence of tornadoes.
- Can often lead to damages to property, infrastructure and crops, disruption in travel and in extreme cases the loss of life.



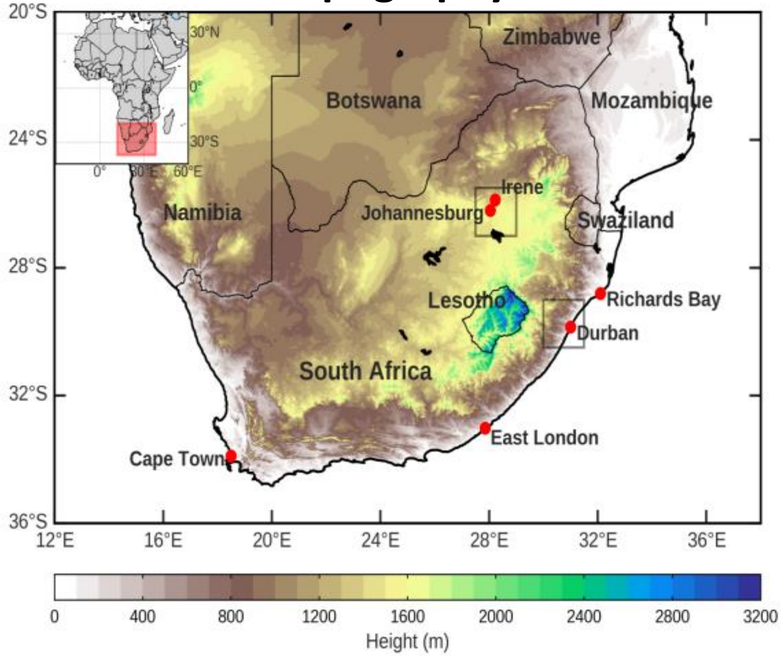
NASA Global Hydrology Resource Center LIS/OTD Climatology

Cecil (2001)

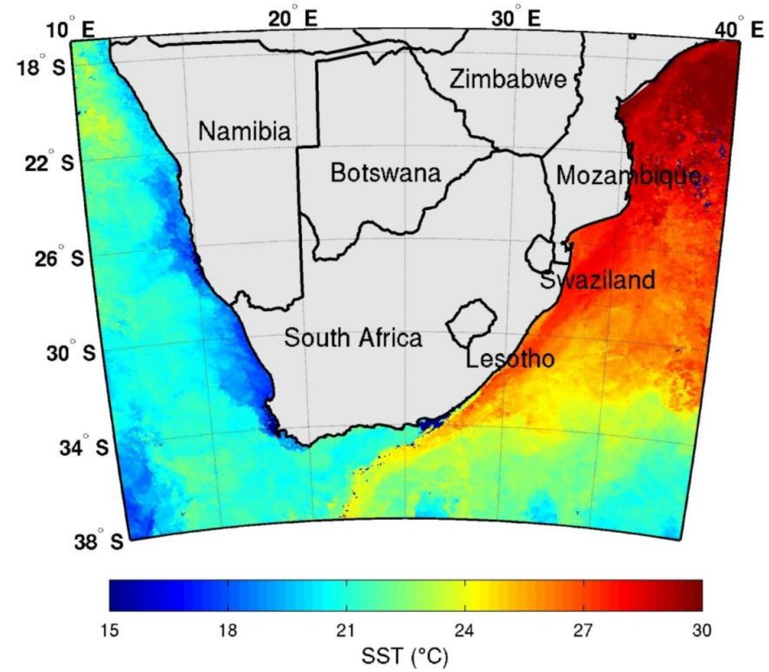
- Gill (2008) reports that lightning-related deaths in South Africa account for an average of between 1.5 - 8.8 people per million per year.
- This is considerably more than most developed countries as well as being higher than the global average (Holle 2008).

South Africa has a rather heterogeneous climate with areas ranging from arid along the west coast to wet on the east coast or on the windward slopes of large mountain ranges.

Topography



Sea surface temperature



Several factors contributing to the diversity of its climates, including its subtropical location, the complex topography and the interaction between the general atmosphere circulation with the neighbouring SSTs.

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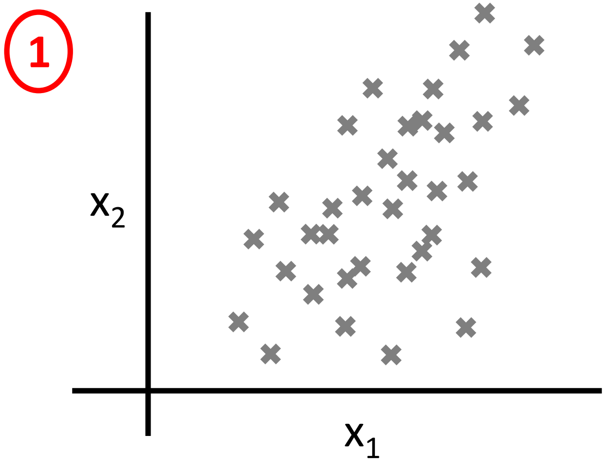
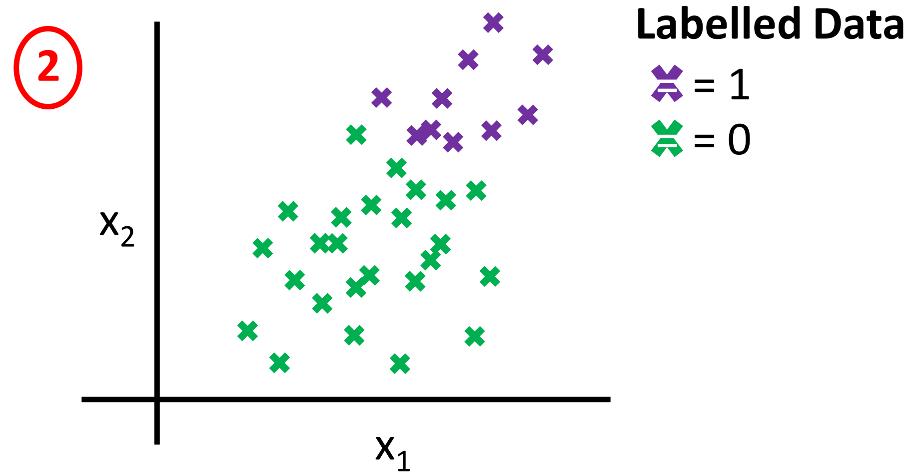
2. Methodology

1. Using observations (e.g. storm reports) distinguish days with severe vs non-severe convective storms

2. Obtain relevant index or indices from the upper air soundings / radiosondes for those severe storms

3. Identify severe storm environments within the data based on the covariate discriminant relationship between CAPE and 0-6 km Wind Shear (after: Brooks *et al.* 2003; Allen *et al.* 2011; Allen and Karoly 2014)

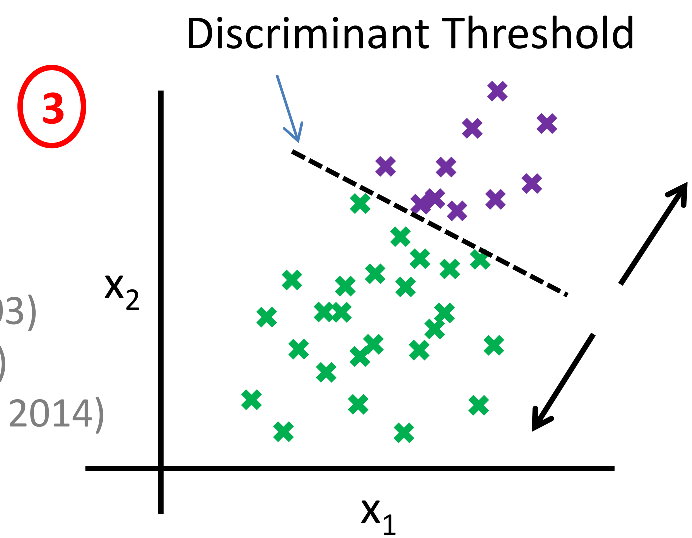




Linear Discriminate Analysis

$$(\text{CAPE})(\text{BWD})^{\gamma} \geq \boldsymbol{\beta}$$

γ = 1.6 and **β** = 46 800 $(m.s^{-1})^{3.6}$ (Brooks *et al.* 2003)
γ = 1.67 and **β** = 115 000 $(m.s^{-1})^{3.67}$ (Allen *et al*. 2011)
γ = 1.67 and **β** = 68 000 $(m.s^{-1})^{3.67}$ (Allen *and Karoly* 2014)



2. Methodology

1. Using observations (e.g. storm reports) distinguish days with severe vs non-severe convective storms

2. Obtain relevant index or indices (i.e. CAPE vs shear) from the upper air soundings / radiosondes for those severe storms

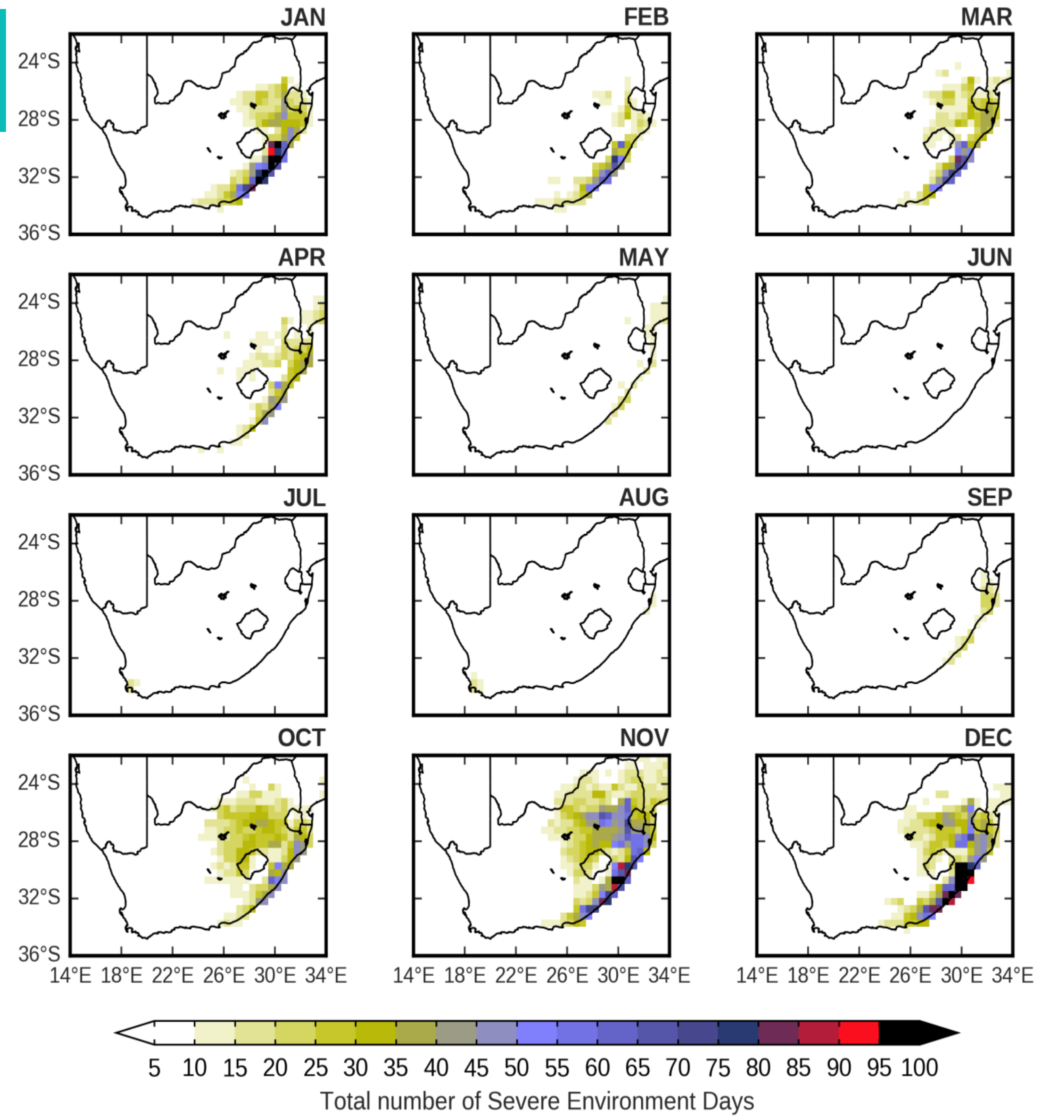
3. Identify severe storm environments within the data based on the covariate discriminant relationship between CAPE and 0-6 km Wind Shear (after: Brooks *et al.* 2003; Allen *et al.* 2011; Allen and Karoly 2014)

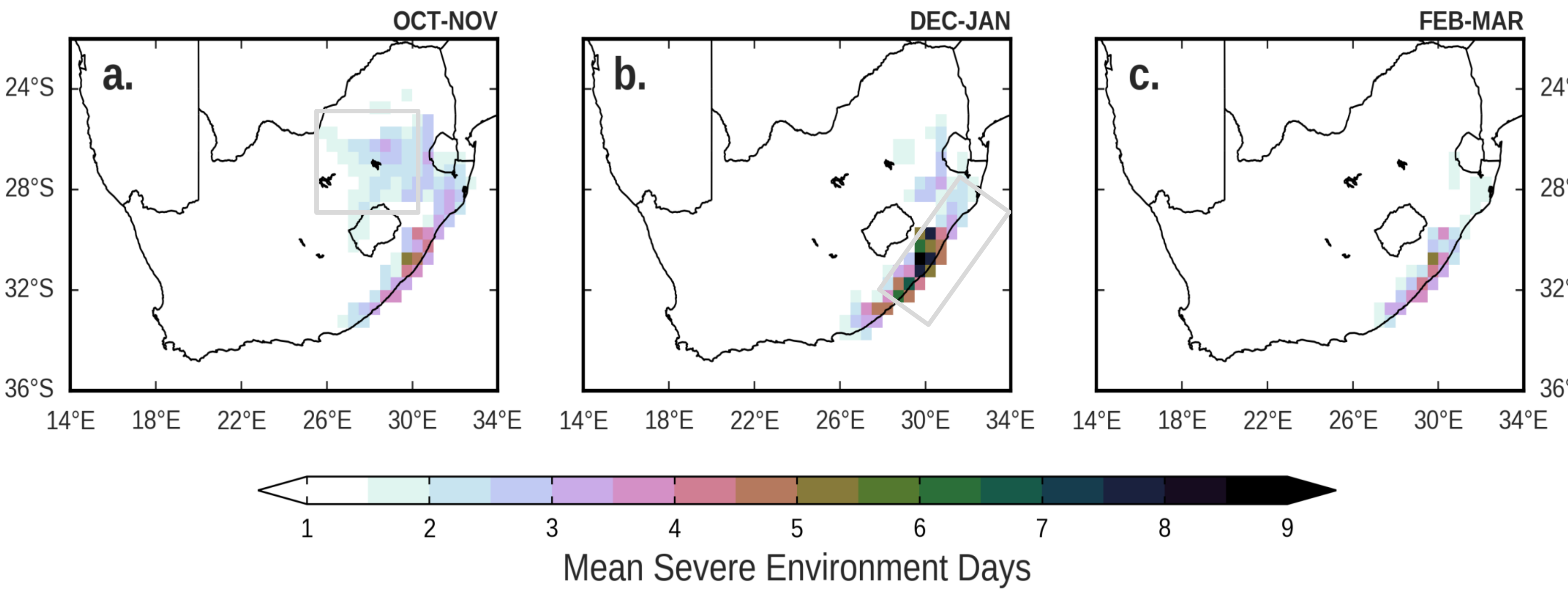
4. To get greater spatial coverage use reanalysis data or an alternative gridded data set (e.g. NWP Model)

5. For this research we build the climatology of potential severe storm environments using the Climate Forecast System Reanalysis (CFSR; Saha *et al.* 2010) data as input…

3. Results

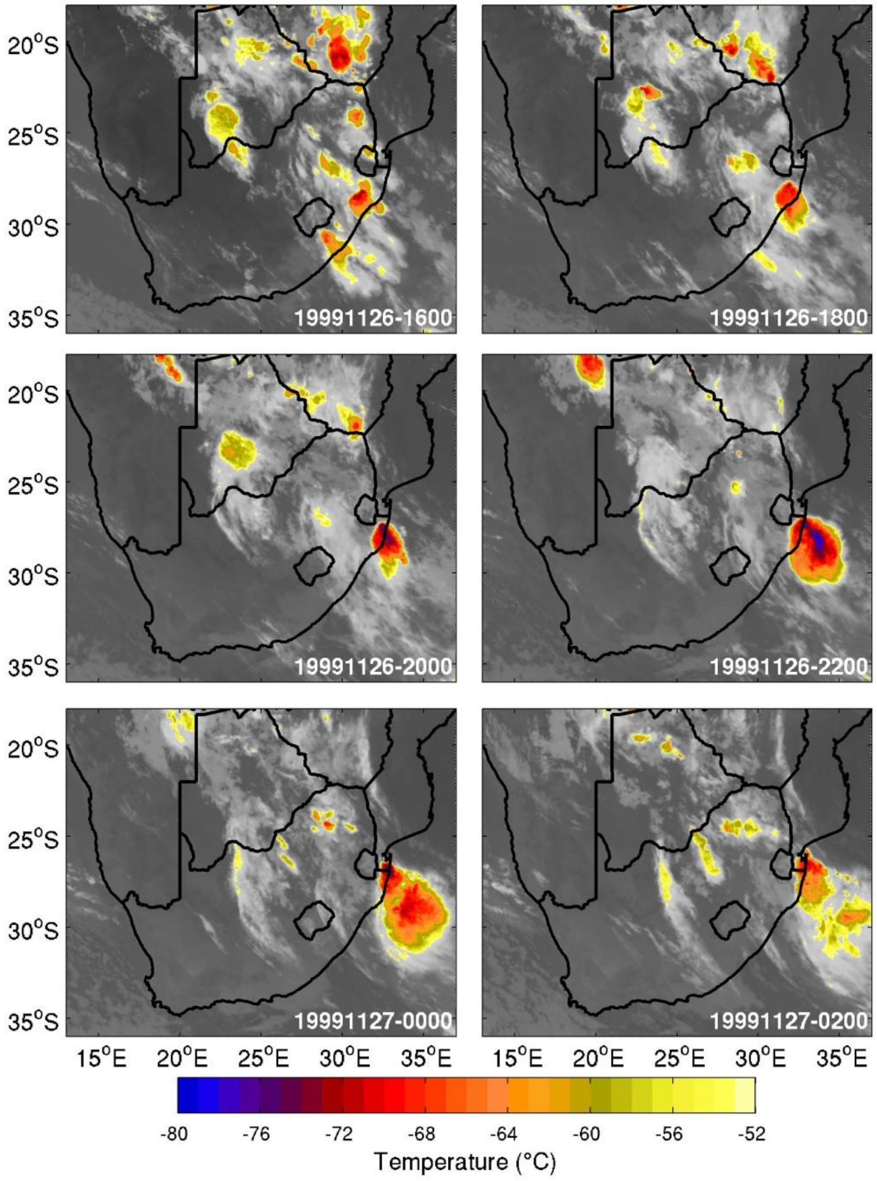
The <u>total number</u> of potential severe convective environments determined for each month over the 1979-2010 period. The potential severity is based on each grid point exceeding a discriminant threshold based on CAPE and BWD.





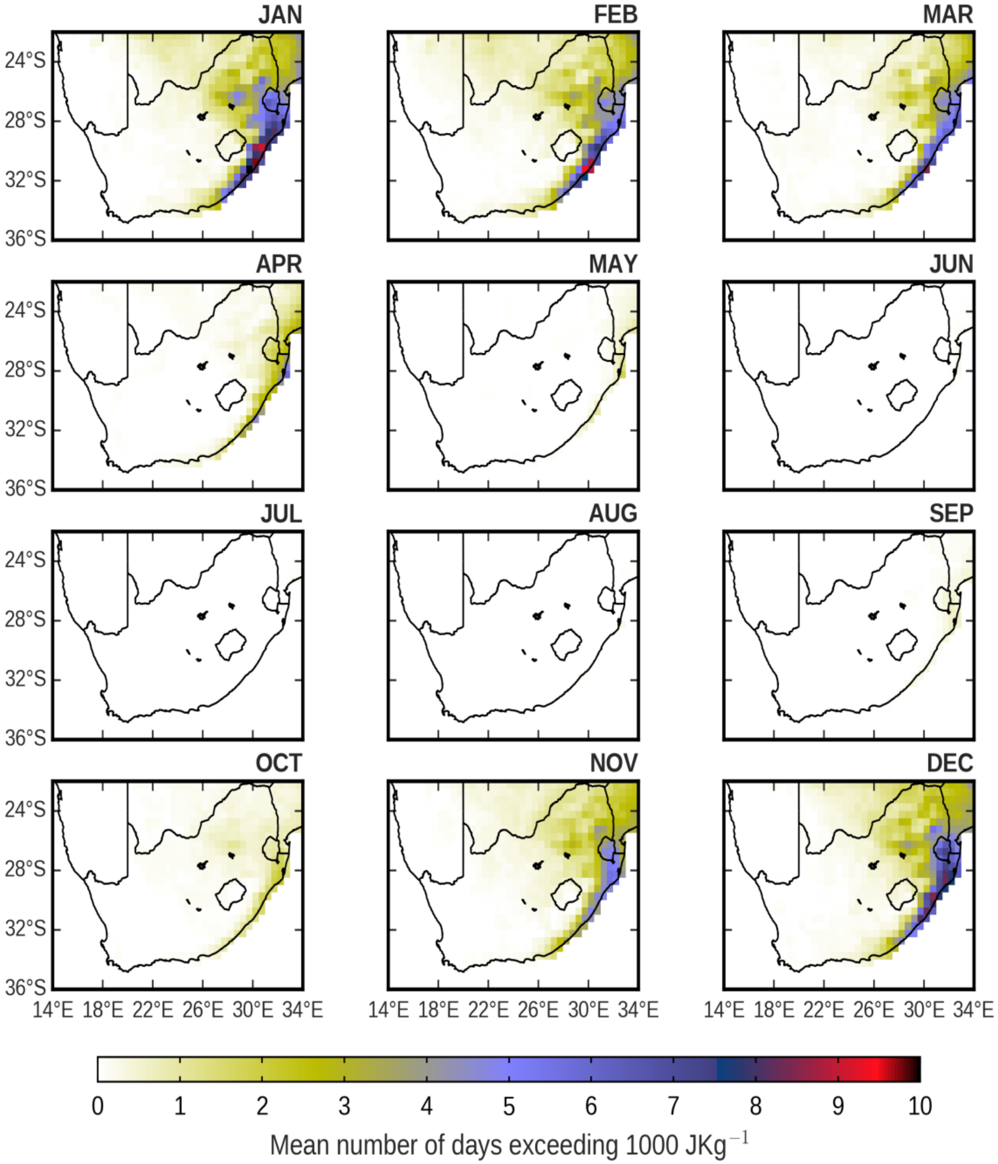
The early summer months are most likely to experience severe storms over the **interior** of the country compared to the rest of the summer period.

The **east coast** region of South Africa is a hotspot for severe convective environments throughout the summer months.

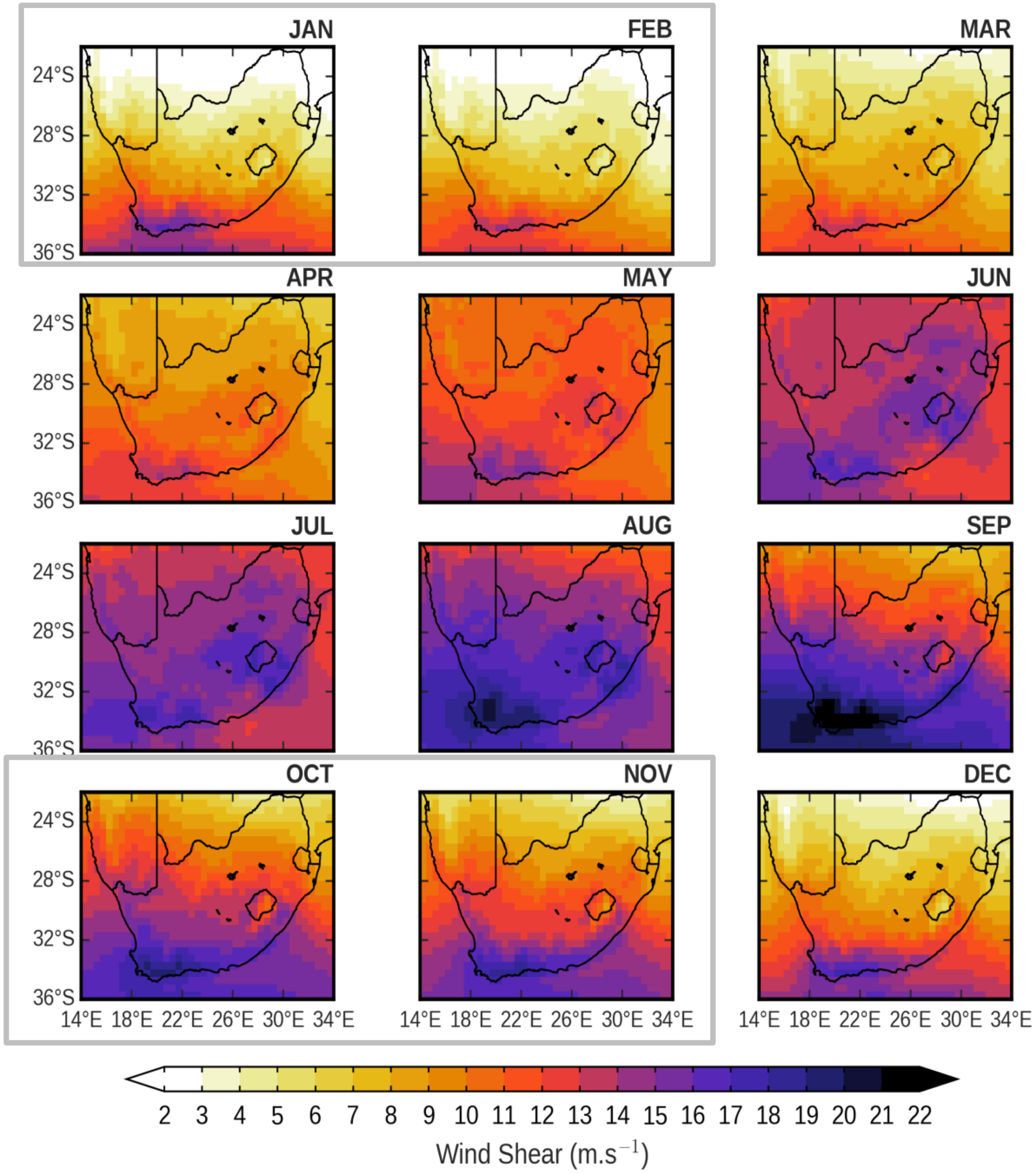


Due to the close proximity of the core of the **Agulhas Current**, which produces **high latent heat fluxes** of several hundred W.m^{-2} and also transfers **more moisture** to the atmosphere than the surrounding waters (Rouault *et al*. 2003).

Research has shown that this current is an **influential feature** on South African severe weather events (e.g. Rouault *et al.* 2002; Blamey and Reason 2009).

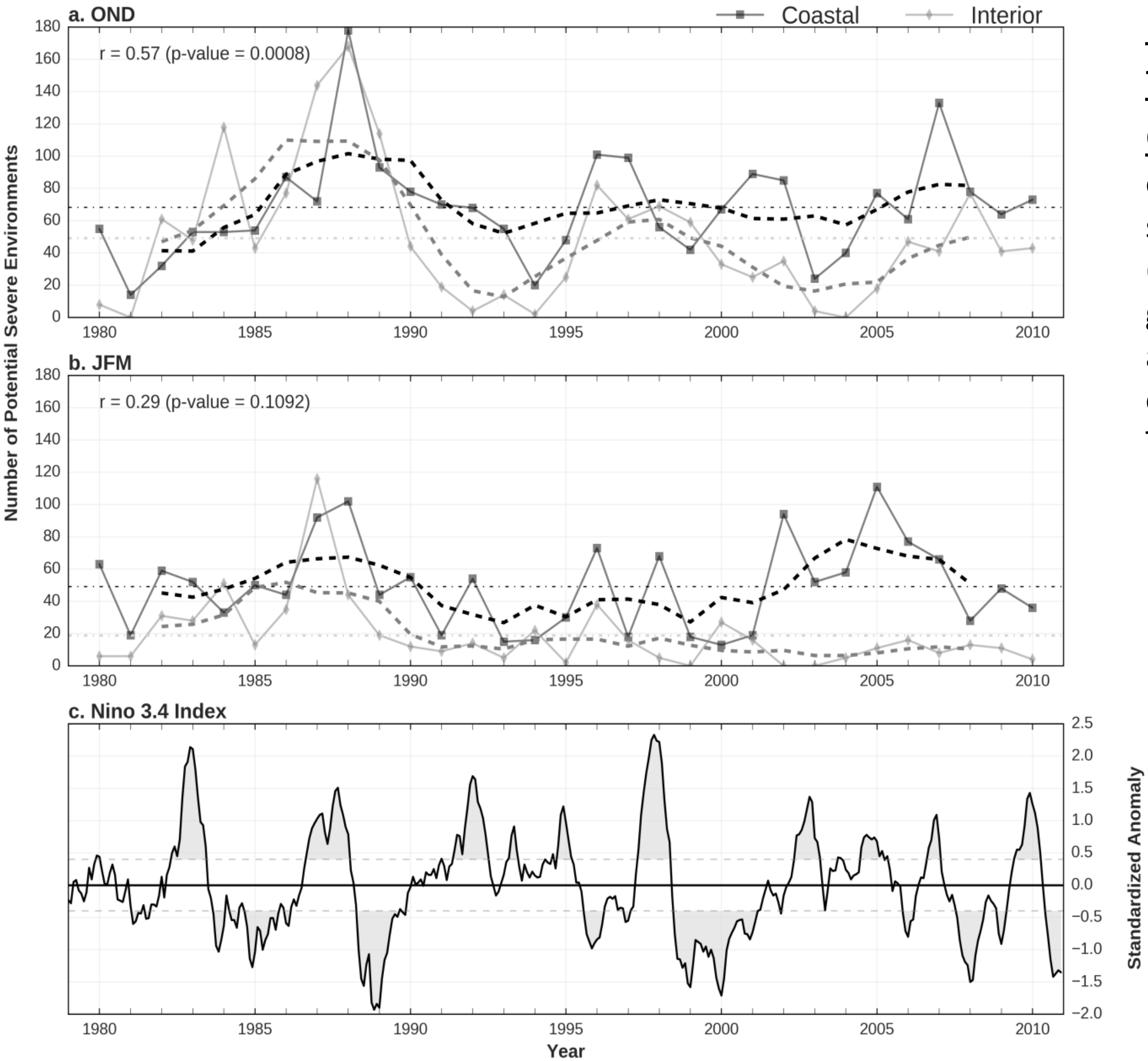


The **monthly mean** of the number of days with CAPE at 12h00 UTC exceeding 1000 JKg^{-1} over the period 1979-2010. Values over the ocean have been masked out.

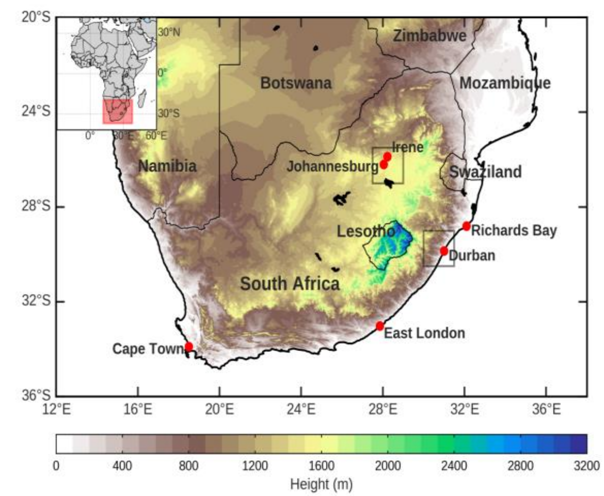


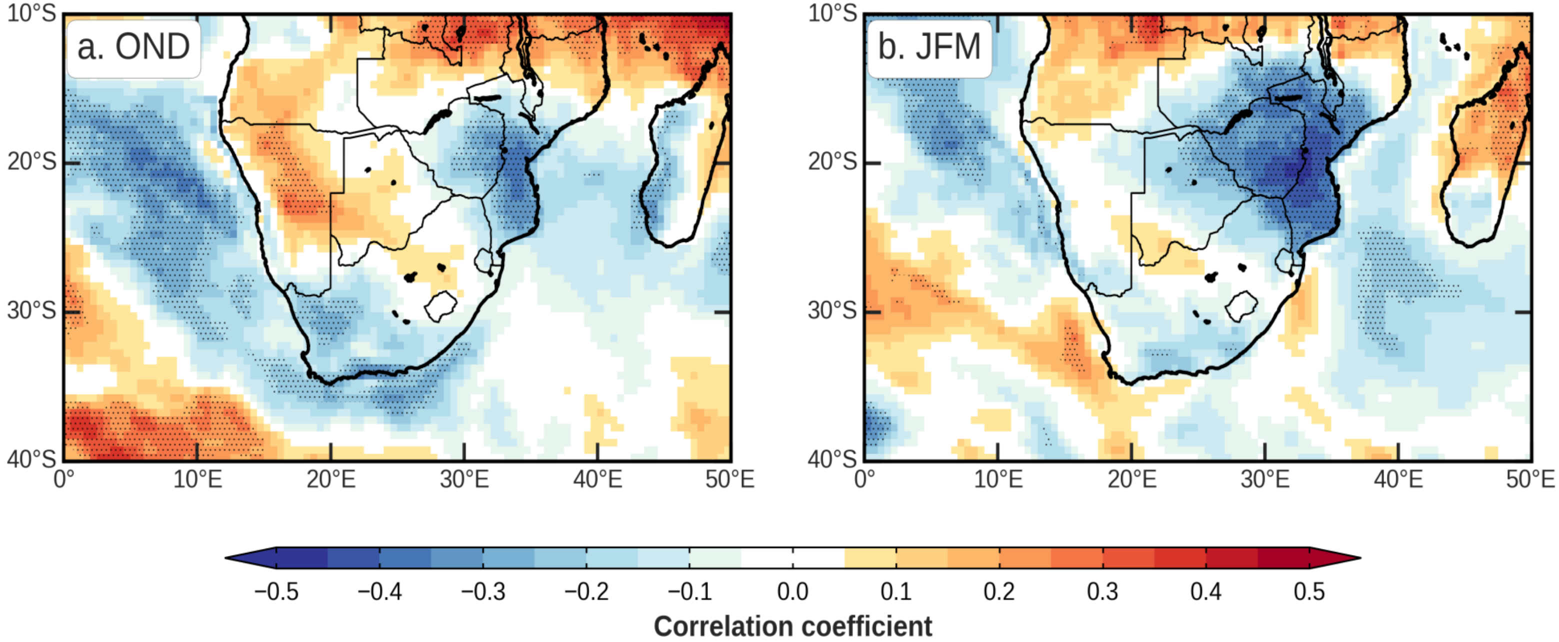
Mean monthly BWD (shaded, m.s^{-1}) at 12h00 UTC across South Africa over the period 1979-2010. The shear shown here is determined from the difference in the wind magnitude between the 400 hPa and 850 hPa pressure levels.

$$(\mathrm{CAPE})(\mathrm{BWD})^{\gamma} \geq \boldsymbol{\beta}$$



<u>Inter-annual variability of the total number of potential severe convective environments</u> for a) the early summer (Oct-Dec) and b) the late summer (Jan-Mar) for the coastal region (solid black line) and inland region (solid grey line). The black and grey dashed lines are the 5-year running mean for the coastal and interior region, respectively. The dot-dashed black (grey) horizontal line is the mean for the coastal (interior) region.





Correlation between CAPE and Nino 3.4 index (both detrended) during the early (OND; left) and late summer (JFM; right) months. Stippling denotes values that are significant at the 95% confidence level.

4. Discussion

- Marked seasonality in the occurrence of severe environments over the interior of South Africa, with **most severe environments occur in early summer**.

- Even though the highest CAPE values for this region are found during the mid-summer months, the **shear is not strong enough to produce severe storms**

- A similar result is found by Dyson *et al.* (2015) using radiosonde data. These authors noting an apparent transition in atmospheric conditions from an **extra-tropical nature in early summer to a more tropical nature in late summer** over the interior.

- The strongest correlation between ENSO and CAPE during the summer months being positioned over neighbouring Mozambique and Zimbabwe. Similar findings to that of Dowdy (2016) and Hart *et al.* (2016) using different datasets.

5. Conclusions

- This research establishes a climatology of the spatial distribution of favourable conditions for severe convective storms over the summer rainfall region of South Africa.
- Compared to the US and Australia, South Africa experiences fewer days with favourable conditions for the development of severe convective storms.
- The reasons for this “inactivity” over South Africa compared to the other regions is likely due to a combination of the geographic setting of southern Africa, as well as prevailing summer synoptic conditions in the region.
- The lower number of severe storm environments could also be linked to the choice of discriminant value used.
- Developing southern Africa appropriate discriminants would be desirable; however, this would require a thunderstorm observational dataset which does not currently exist.

Acknowledgments

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