Idealised SST anomaly regional climate model experiments: A note of caution

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1. INTRODUCTION

- It is well-established that climate change will significantly alter climatic variability, as well as mean climate
- Changes in climate variability will mean changes in extreme climate events e.g. increasing frequency of flooding, drought, etc. This is likely to be of far more significance for environmentally vulnerable regions such as southern Africa (defined here as Africa south of the Equator)
- This region is especially vulnerable because:
  1. Region of relatively low and highly variable rainfall
  2. High dependence on rainfed agriculture
  3. High social pressures e.g. population pressures, widespread disease, economic underdevelopment, HIV/AIDS crisis, civil war
- There has been relatively little work on the links between South Atlantic sea surface temperature (SST), atmospheric circulation and rainfall extremes over southwestern Africa. However, composite analysis from past work by the same authors suggests that days with extreme rainfall are associated with regions of both cold and warm SST anomalies throughout the South Atlantic (Williams *et al*. 2007)
- Previous general circulation modelling (GCM) experiments by the same authors (using global, atmosphere-only model HadAM3) have suggested that decreasing SST is the central South Atlantic causes an increase in extreme rainfall over central southern Africa (Williams *et al*. 2008)
- Thus, the main aim of this work is to repeat and improve upon the previous experiments using a high resolution regional climate model (RCM) from the UK Met Office Hadley Centre, HadRM3P

2. EXTREME RAINFALL AND ASSOCIATED SST

- We used a new dataset of satellite-derived rainfall estimates to avoid the problem of lack of observations – MIRA: daily rainfall estimates at 0.1° spatial resolution over southern Africa from 1993-2002 (Todd *et al*. 2001, Layberry *et al*. 2006)
- Extremes were extracted from MIRA, where an extreme is any pixel where rainfall >1.5% of climatological total for that pixel
- Composite analysis of extremes was then undertaken using NCEP/NCAR reanalysis data, to assess SST patterns corresponding to extreme rainfall

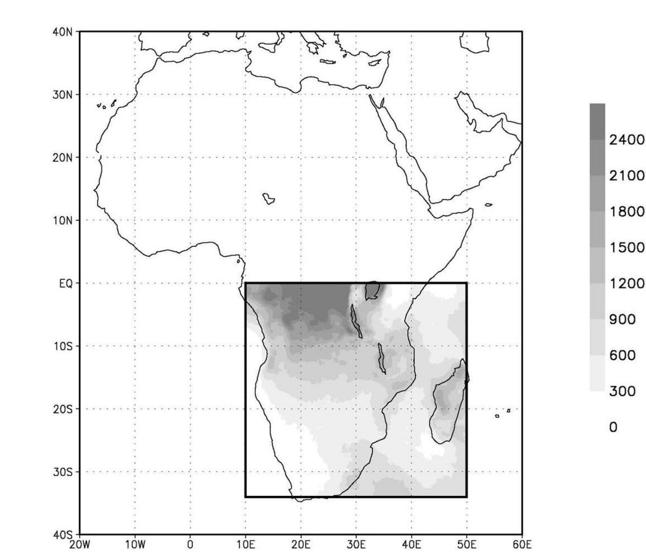


Fig. 1 – MIRA mean annual rainfall, 1993-2002

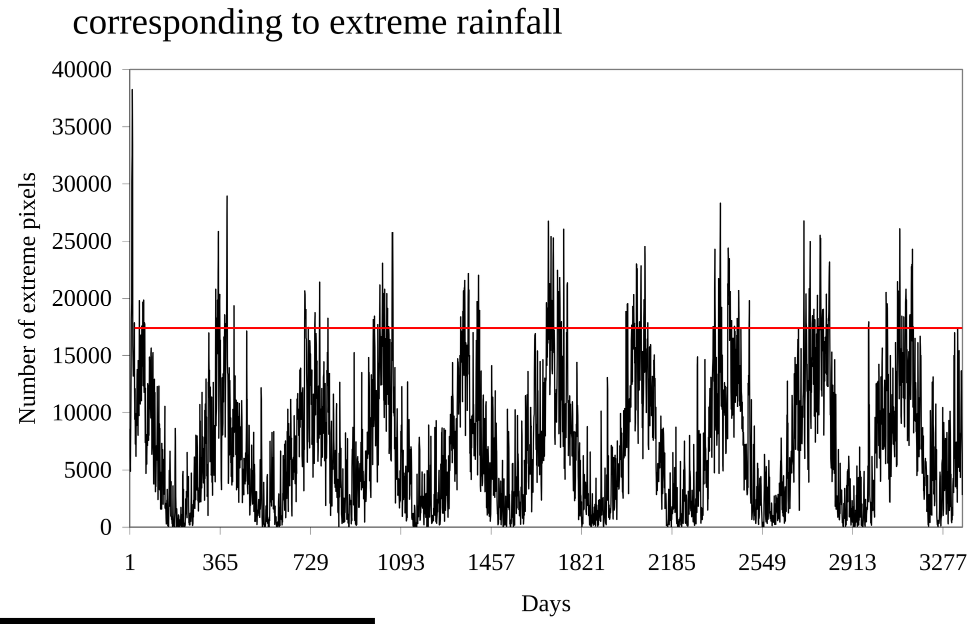


Fig. 2 – Number of extreme pixels from MIRA. Red line shows threshold for extreme days

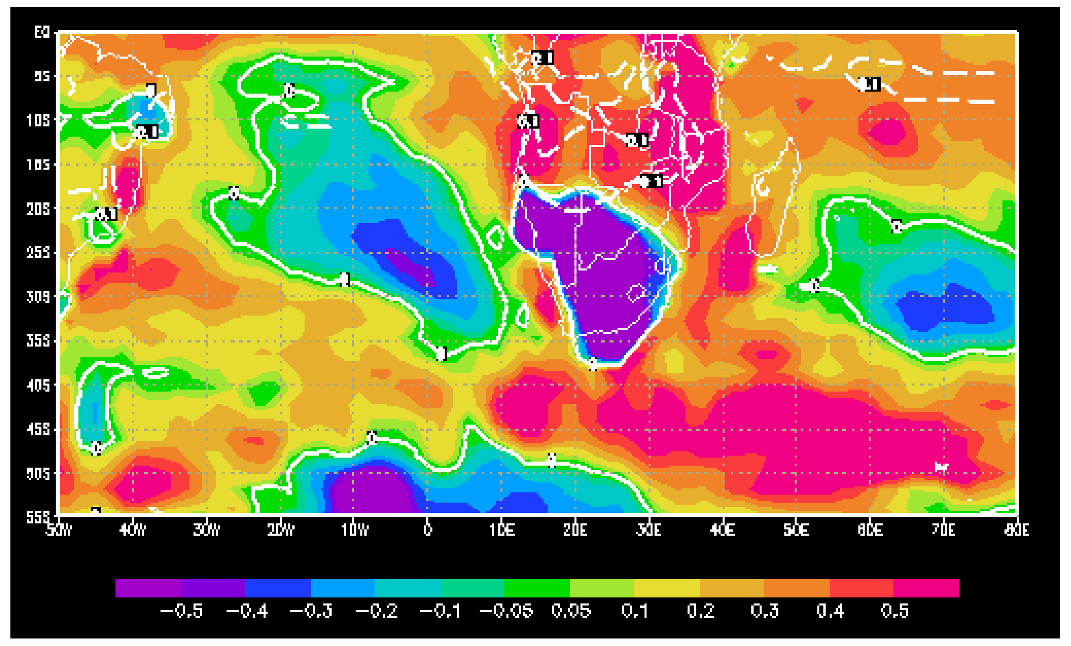


Fig. 3 – Composite of SST anomalies corresponding to extreme days

3. MODEL EXPERIMENTS

- Method: SST anomalies (seen in central South Atlantic in Fig. 3) were idealised and used to force model (Fig. 4). Experiments were run on HadRM3P, each with varying SST anomalies, for 5 years (1991-1995) and forced by ERA-40 at the lateral boundaries. SST anomalies were imposed during June-November of each year, smoothed over region below. 5 ensemble members per experiment. Experiments: Control, -1°C, -2.5°C, -5°C and +2.5°C

Fig. 5 – DJF 1992-1995, mean surface rainfall differences, ensemble mean, contours show p-values < 0.1

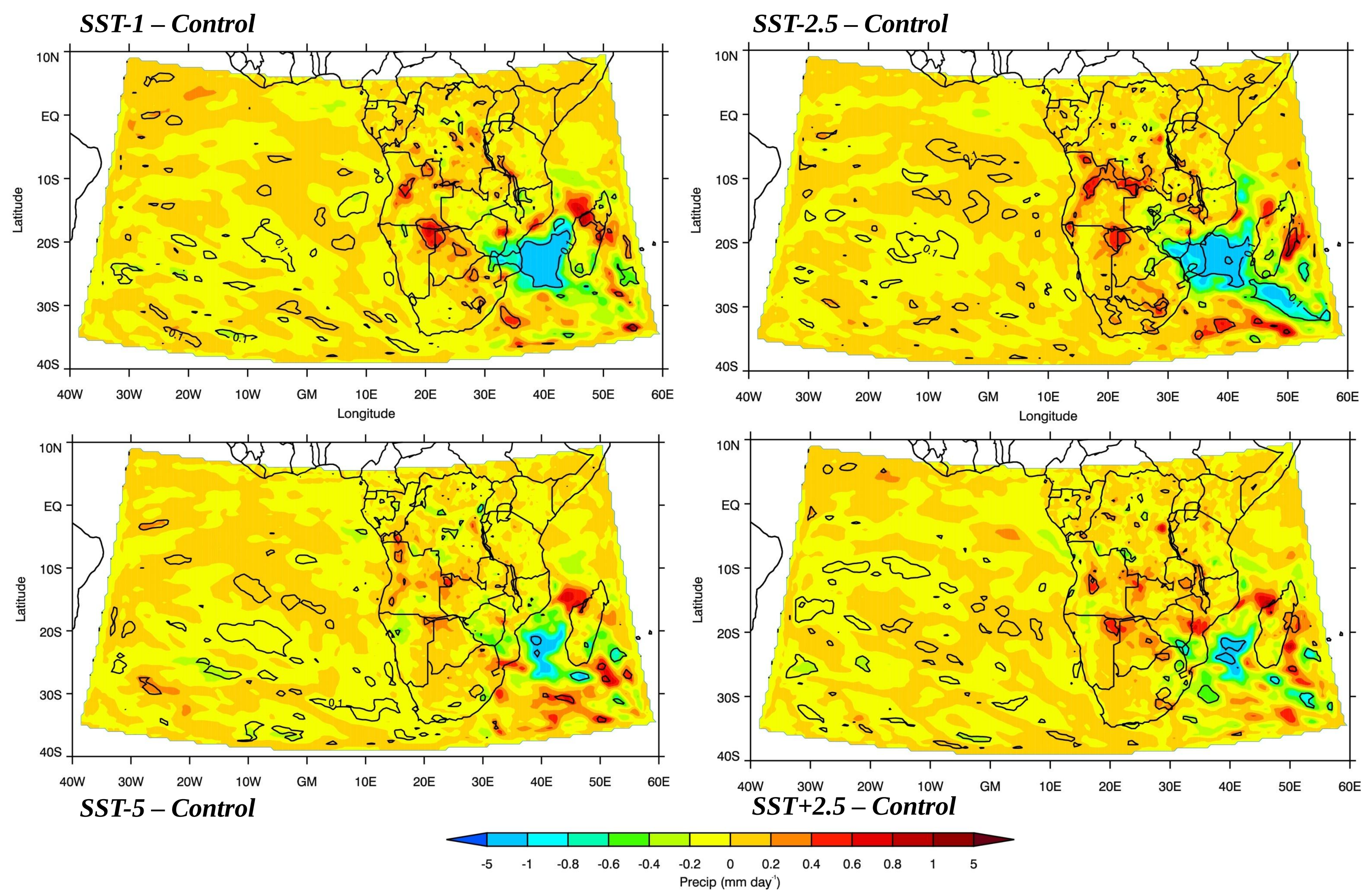


Fig. 4 – Idealised SST anomalies used to force regional model

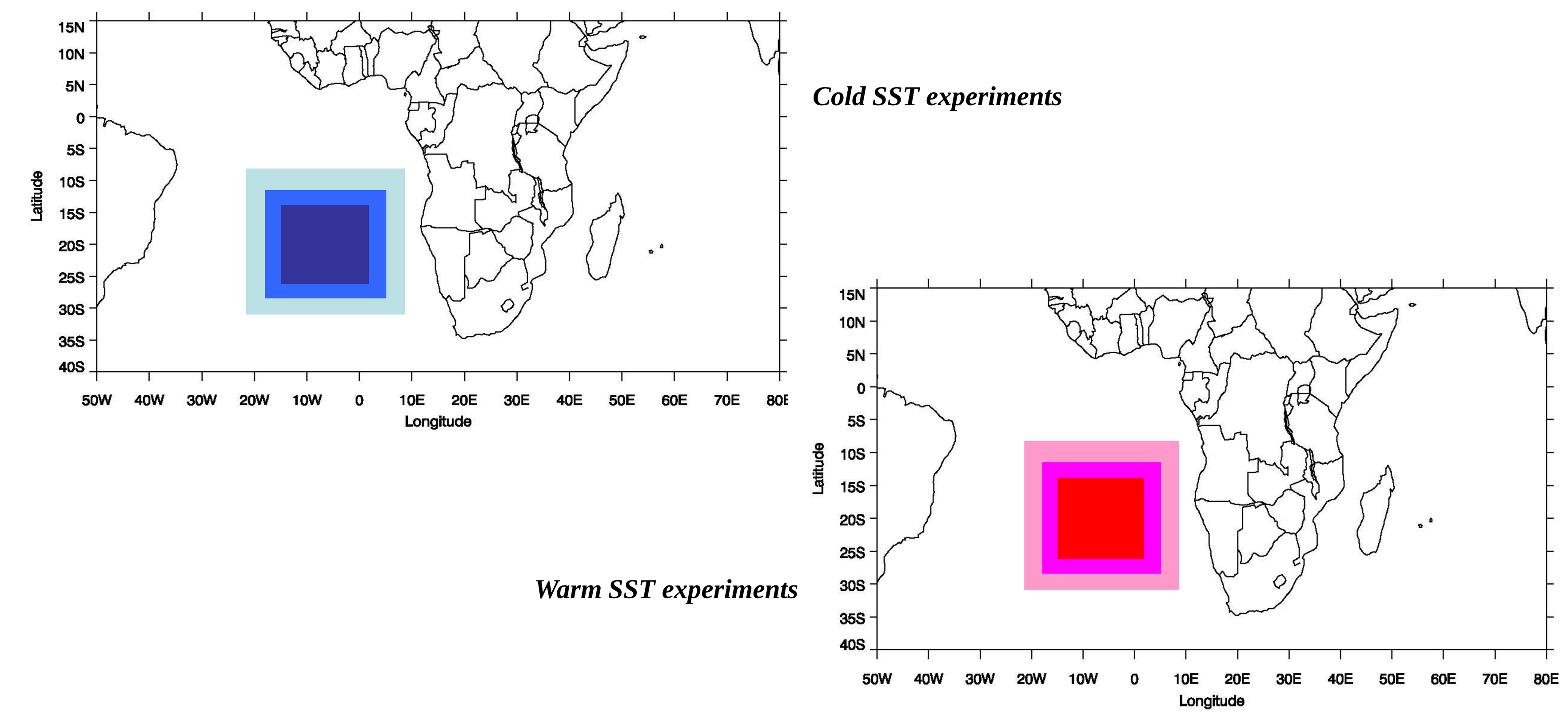


Fig. 6 – DJF 1992-1995, mean 1000mb geopotential height differences, ensemble mean

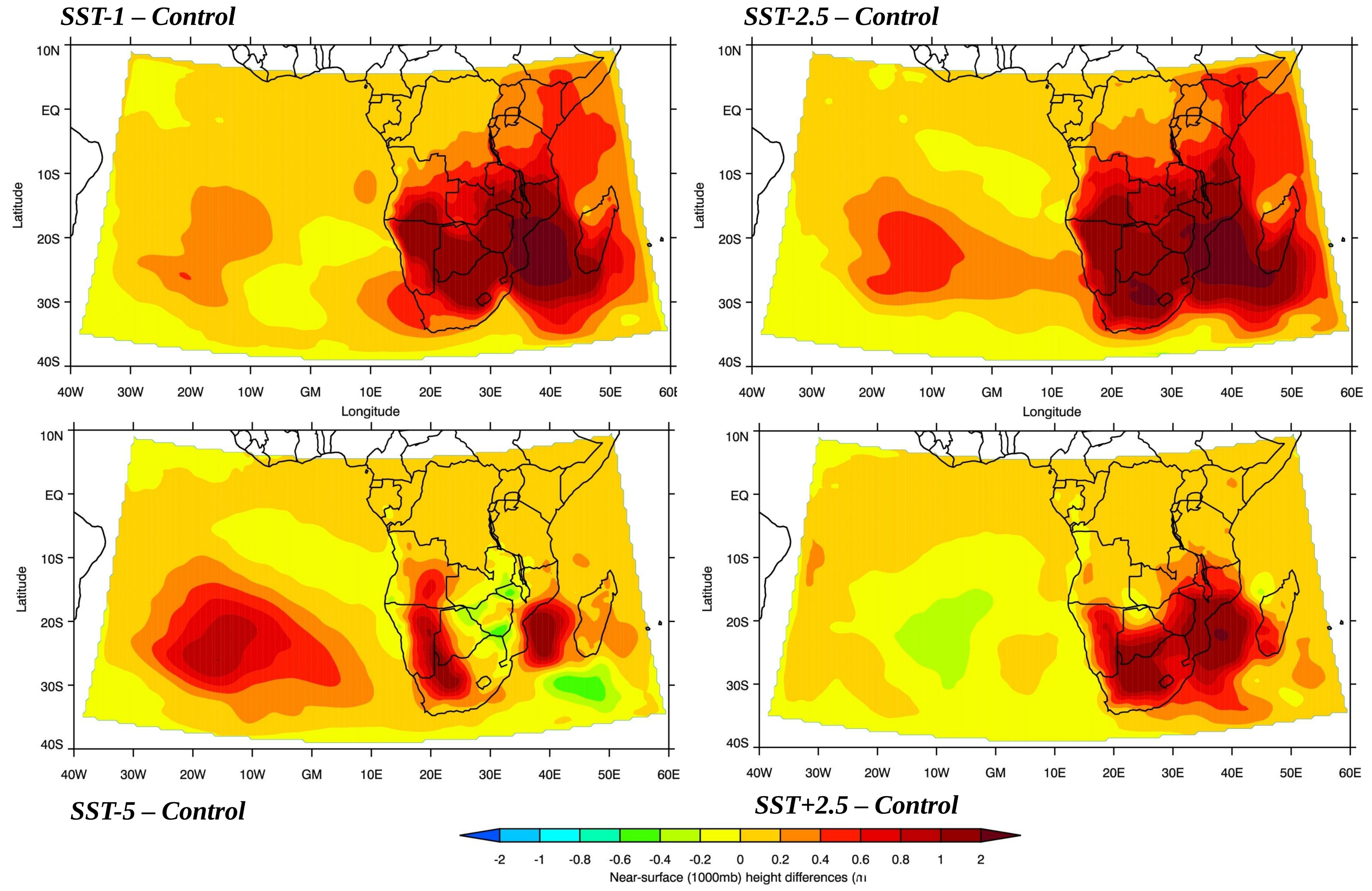
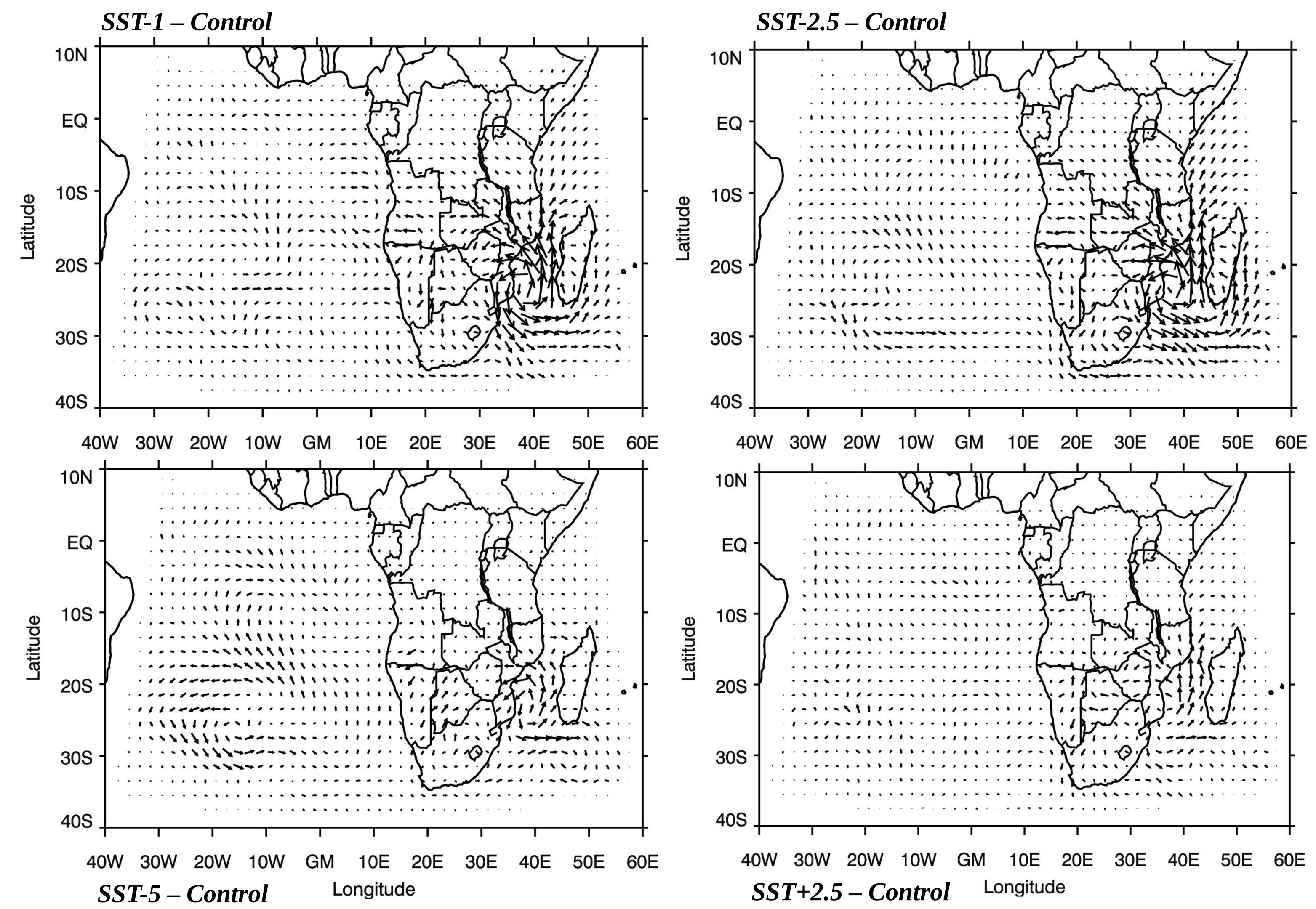


Fig. 7 - DJF 1992-1995, mean 1000mb vector wind differences, ensemble mean



4. CONCLUSIONS

a) Previous GCM work has suggested that decreasing the SST in the central South Atlantic (associated with extremes) results in increased mean daily rainfall and rainfall extremes over southern Africa
b) Current RCM work agrees with above, but also shows increased drying over southeastern Africa as a result of decreasing South Atlantic SST – this drying is associated with increased surface pressure anomalies, and increased southerlies over the Mozambique Channel transporting moisture away from the drying region
c) However, when a warm SST anomaly is imposed in the RCM, a very similar response in rainfall, pressure and wind fields is observed over southeastern Africa. This suggests that opposite forcings from Atlantic SST are causing deviations in remote (i.e. away from the forcing) rainfall of a similar sign and magnitude
d) 3 possible reasons are suggested: a) observed changes in rainfall may result from redistribution of energy (associated with upper-level changes to Rossby waves); b) changes may be an artefact of the lack of a two-way feedback between the atmosphere and ocean (resolved by using a coupled AOGCM); or c) of most concern, errors within the model in simulating the SST-rainfall interactions
e) Caution is therefore advised when interpreting experiments of this nature – work using AOGCM with SST anomalies in different regions of both South Atlantic and Indian Ocean is currently underway

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