Investigating the Variations in the Predictability of South African Provincial Seasonal Climates through HadRM3P Ensemble Spreads

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Predictability (the extent to which a skilful forecast can be made quantitatively) **has LIMIT(S)!**

Seasonal Climate prediction is no exception.

Limit(s) attributable to:

- **Physics**
- **Chemistry**

} of the atmosphere

An accurate prediction requires……

a) …..an accurate modeling tools of dynamics and interactions of the land, ocean and atmosphere (Houghton, 1991 and Pennell & Reichler, 2010);

b) …..knowledge of the initial states of ocean, land and atmosphere (Pielke et al., 2006);

c) ……knowledge of future changes in boundary conditions e.g. Seasonal distribution of solar radiation, Variations in chemical composition of the atmosphere, etc (Buckle, 1996; Hegerl et al., 2007 and Stott et al., 2010).

The atmosphere varies rapidly and has a relatively short memory of the initial state.

Therefore, a little perturbation in the atmosphere always lead to rapid departure from an initial state / condition.

Hence, any predictability must arise from the slower varying components of the climate system.

Even then……

…..modellers and forecasters still run multiple simulations with varying initial conditions to scan across multiple possibilities permitted by the relevance of atmospheric, ocean and land surface initial state.

…..method known as Ensemble Forecasting Technique.

Despite numerous contributions to accurate seasonal forecasts over South Africa, what remains unclear is……

- **Whether the potential predictability varies from one year to the next.**
- **Does the range of possible seasonal forecasts vary from year to year over South Africa?**
- **Are there long term trends in these variations over South Africa?**

Aim

To assess the existence and importance of long-term trends in the predictability of South African seasonal climates.

…..by examining Precipitation and Temperature hindcasts in a quasi-stochastic atmospheric system.

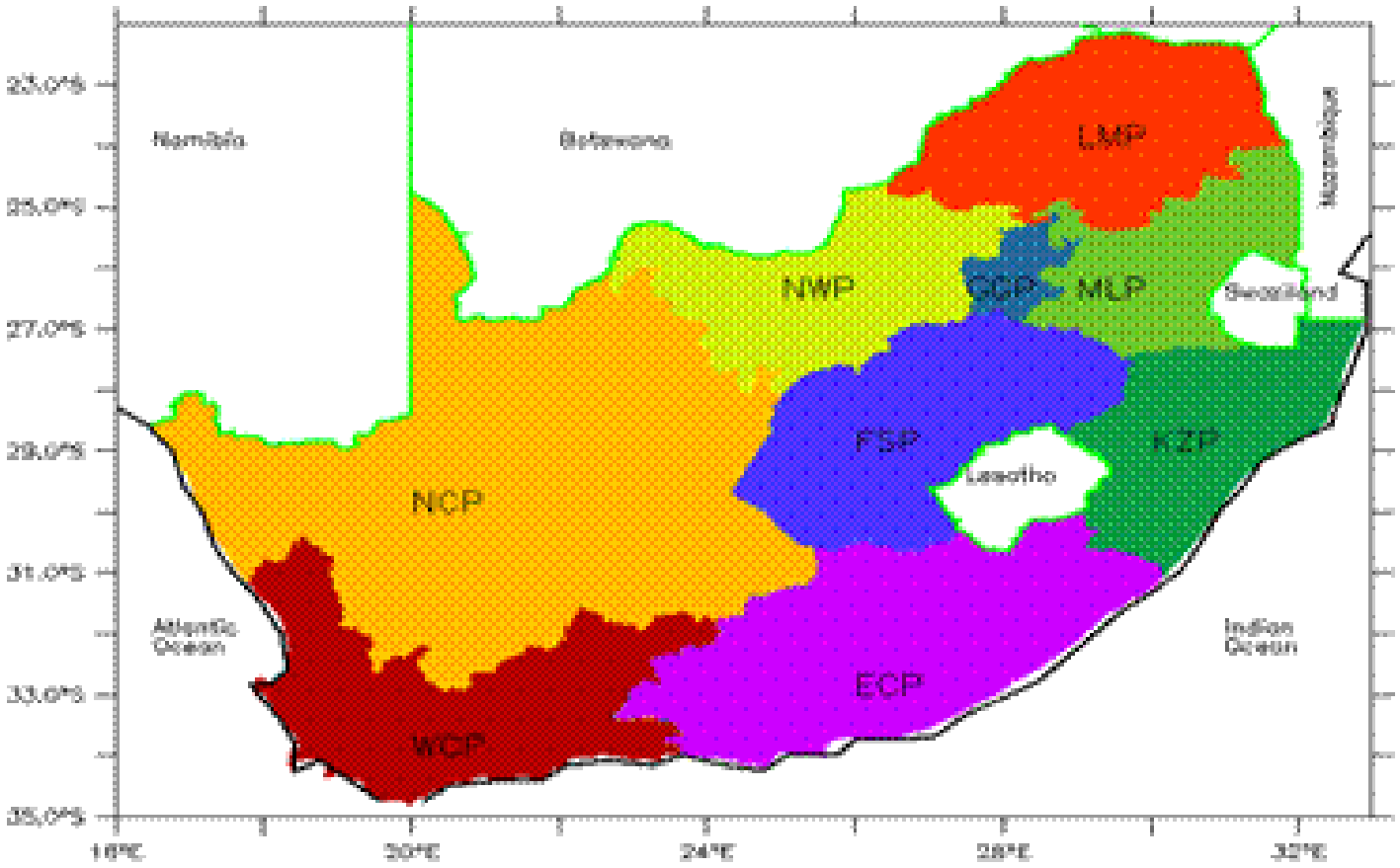
Data

Multi-decadal HadRM3P hind-cast setup for monthly temperature and precipitation from December 1959 to November 2010.

Simulations driven with observed SST, anthropogenic and natural external radiative forcing.

Obtained from weatherathome/SAF project (http://climateprediction.net/weatherathome/)

Study domain……



Modified map of the Republic of South Africa showing its provinces: ECP – Eastern Cape Province; FSP – Free State Province; GGP – Gauteng Province; KZP – KwaZulu Natal Province; LMP – Limpopo Province; MLP – Mpumalanga Province; NCP – Northern Cape Province; NWP – North West Province and WCP – Western Cape Province. Data source: CSIR Satellite Applications Centre.

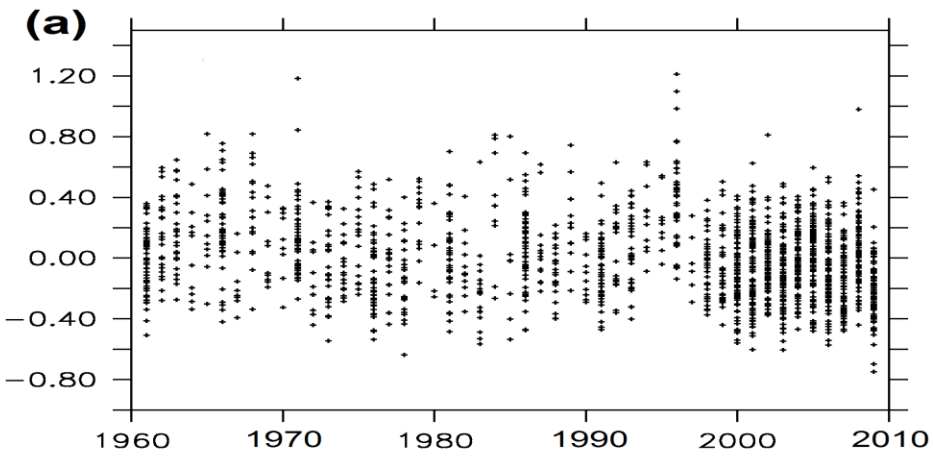
Analysis procedures……

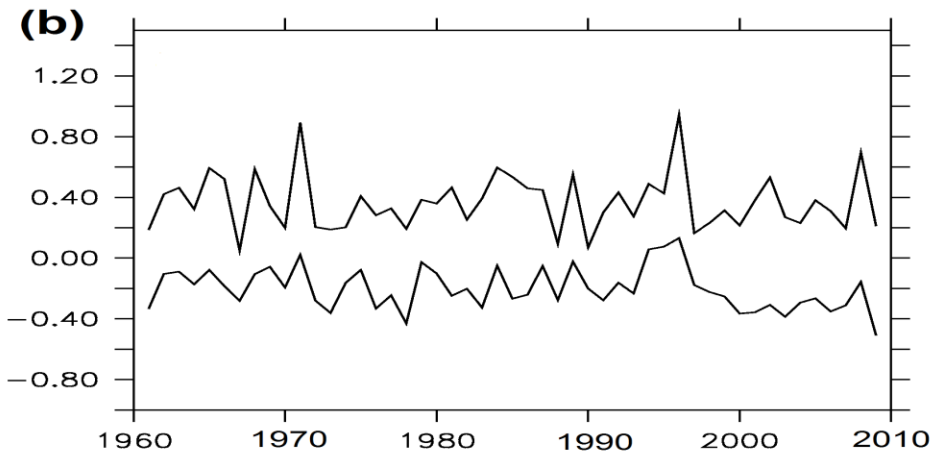
Quantify ensemble spread through the evaluation of two metric of scales –

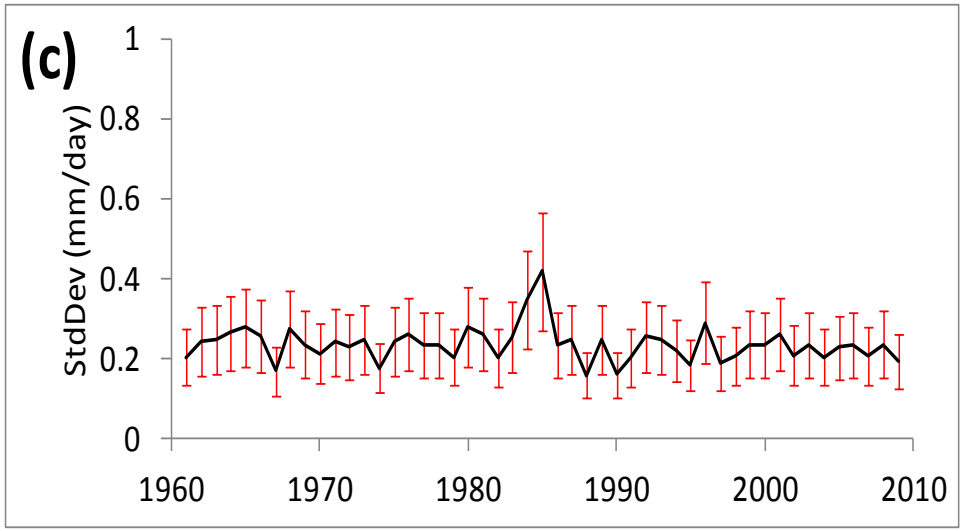
1. **Standard Deviation (StdDev)**
2. **Range of Possibility (RoP) = 90^{th} minus 10^{th} percentiles**

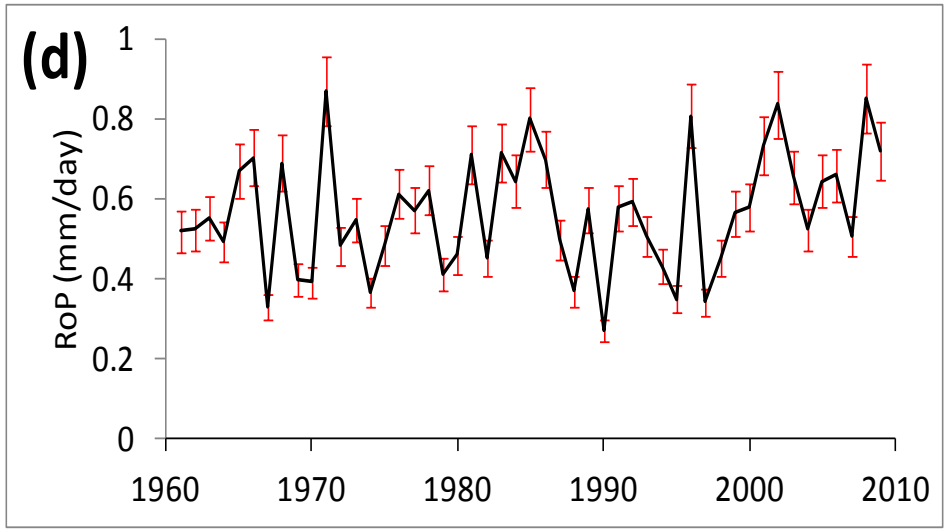
- **Evaluate and carry out analytical comparisons for seasonal trends of StdDev and RoP.**

- **Use Monte-Carlo bootstrap re-sampling techniques to characterize sampling uncertainty in the results.**

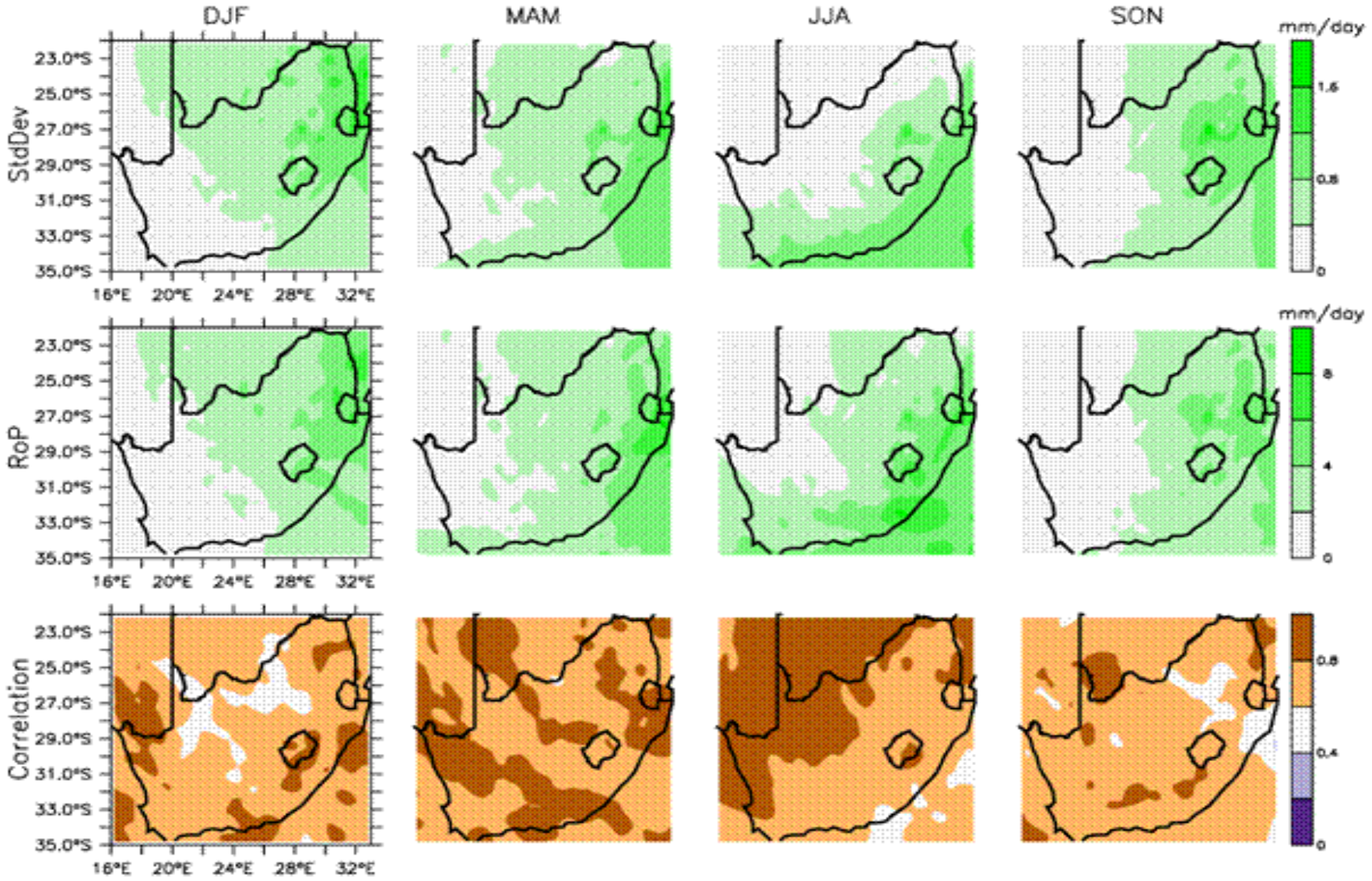




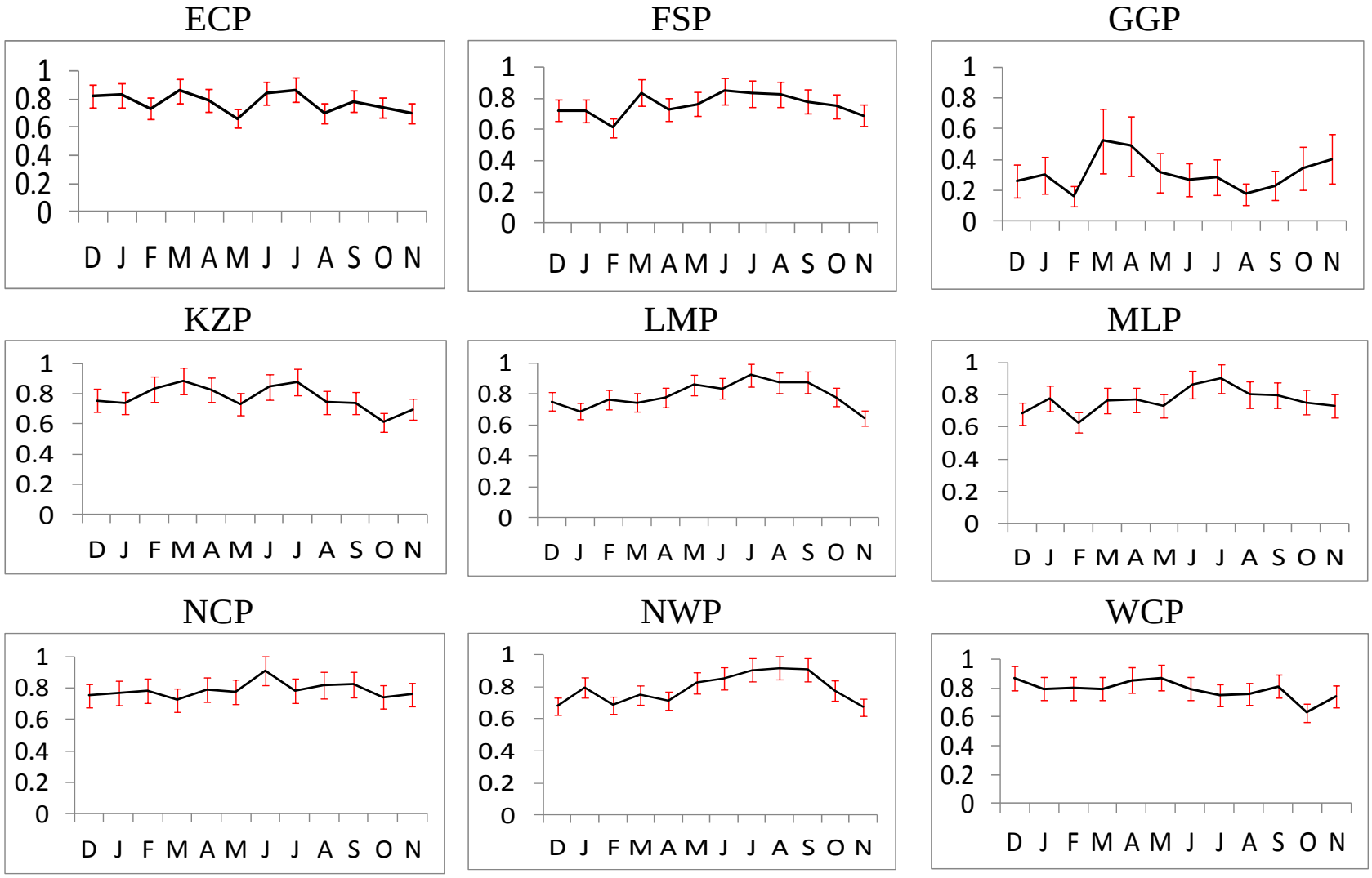




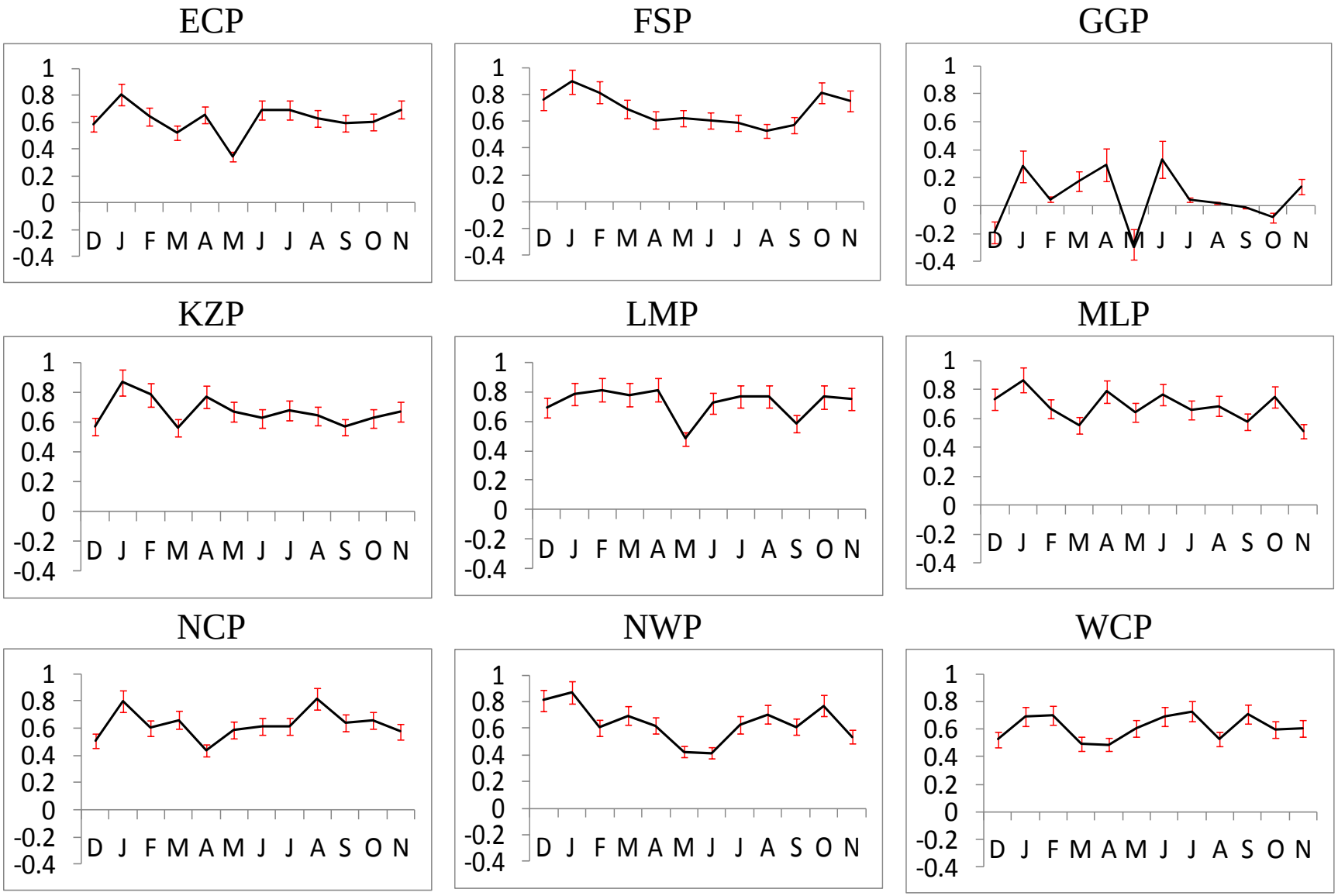
Temperature variables from a small sample of the simulations for the month of July – (a) Ensemble members; (b) the percentiles; (c) StdDev; and (d) RoP



Seasonal spatial ensemble spread analysis for precipitation.

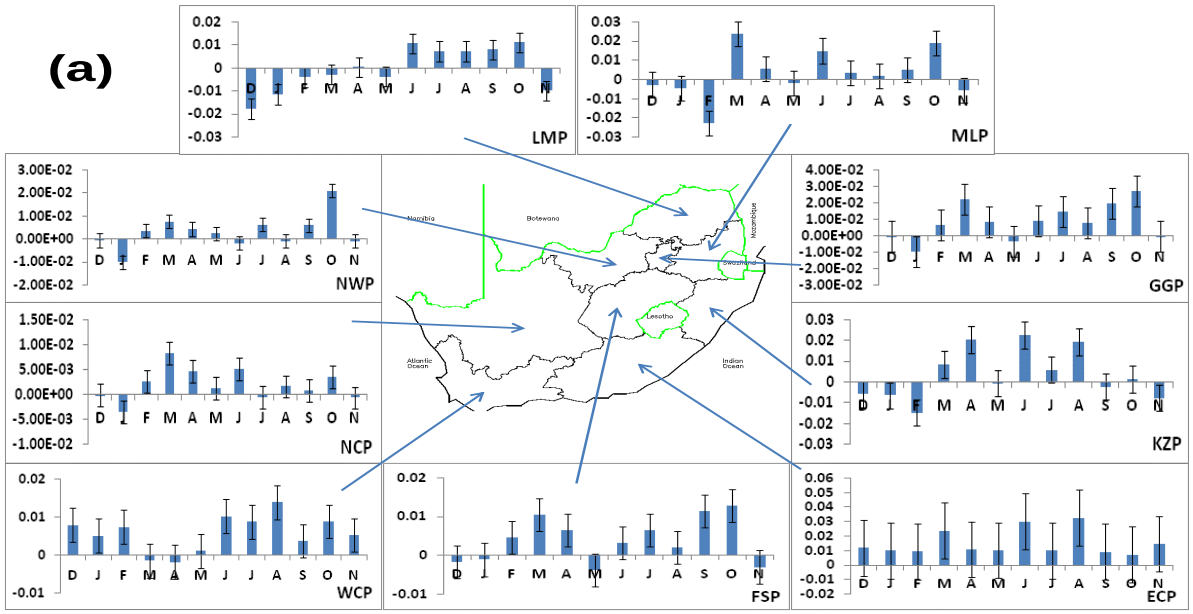


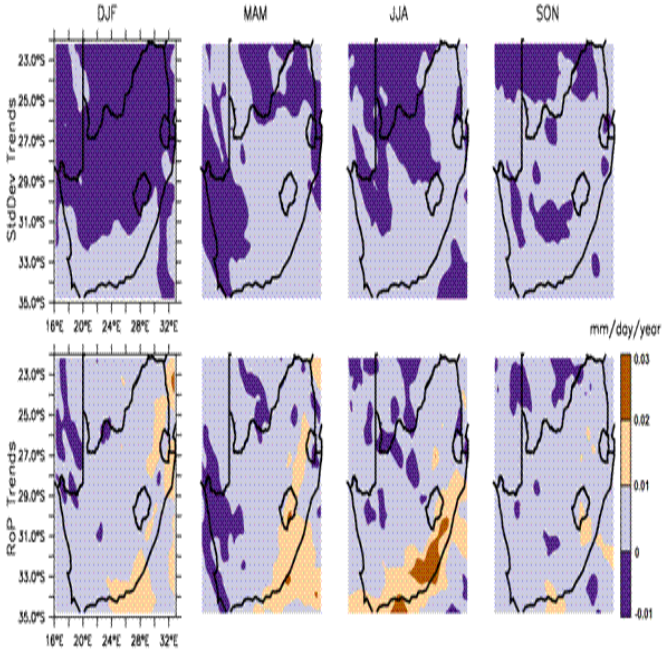
Correlation coefficients of inter-annual variations between RoP and StdDev for precipitation.

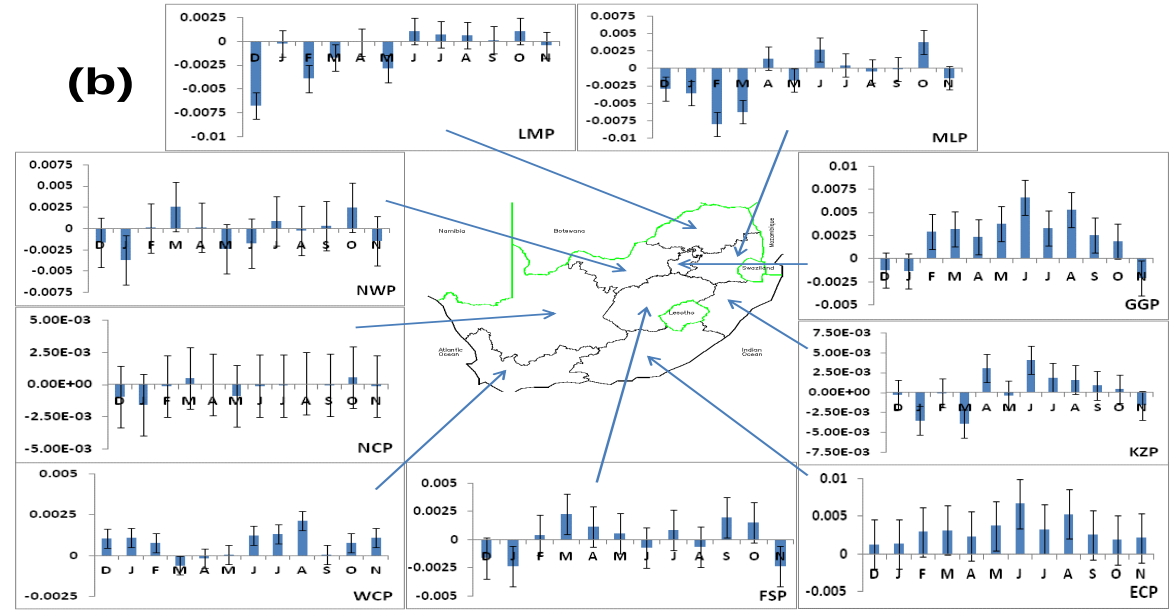


Correlation coefficients of inter-annual variations between RoP and StdDev for temperature.

Trends analysis for precipitation

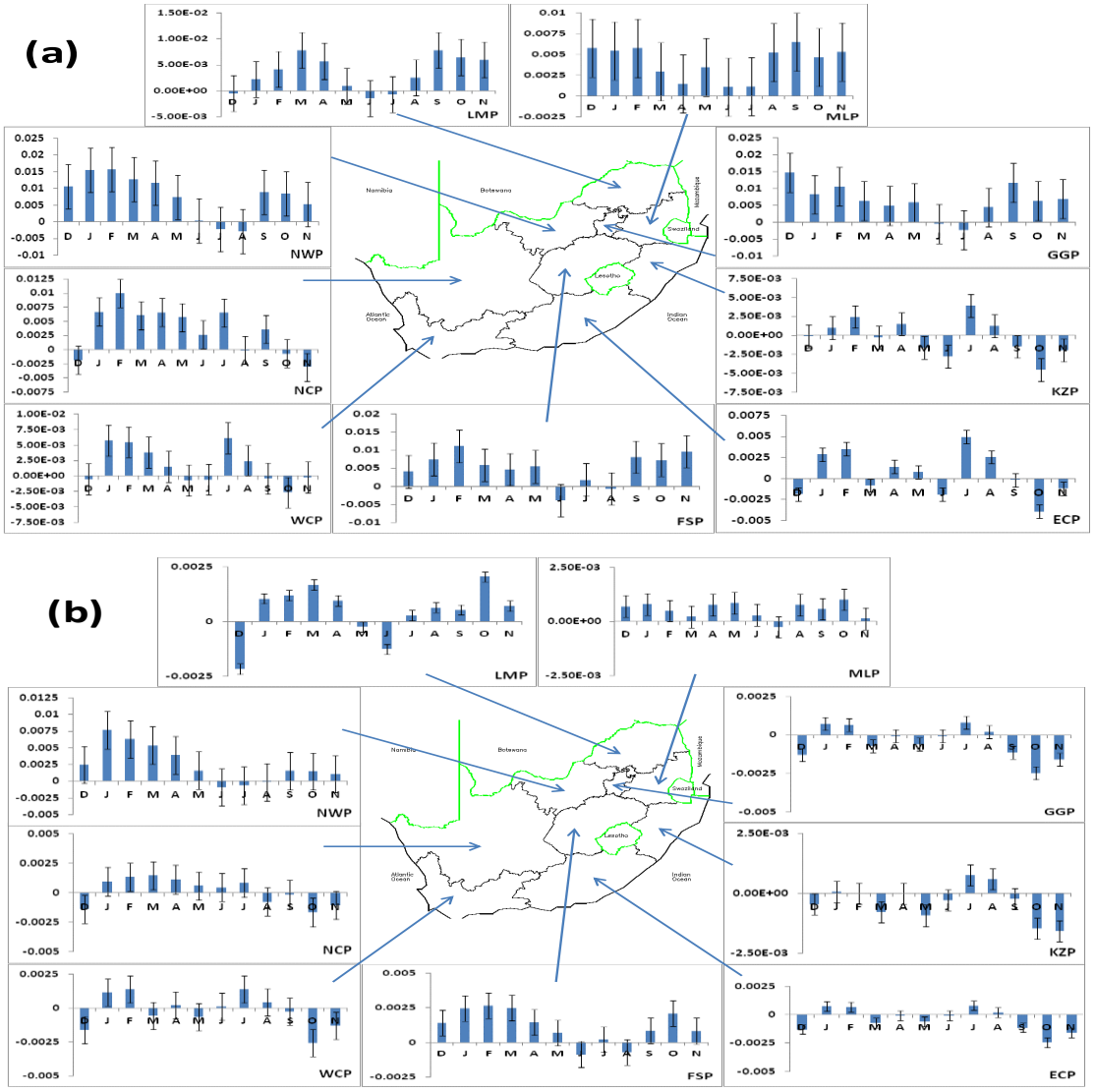


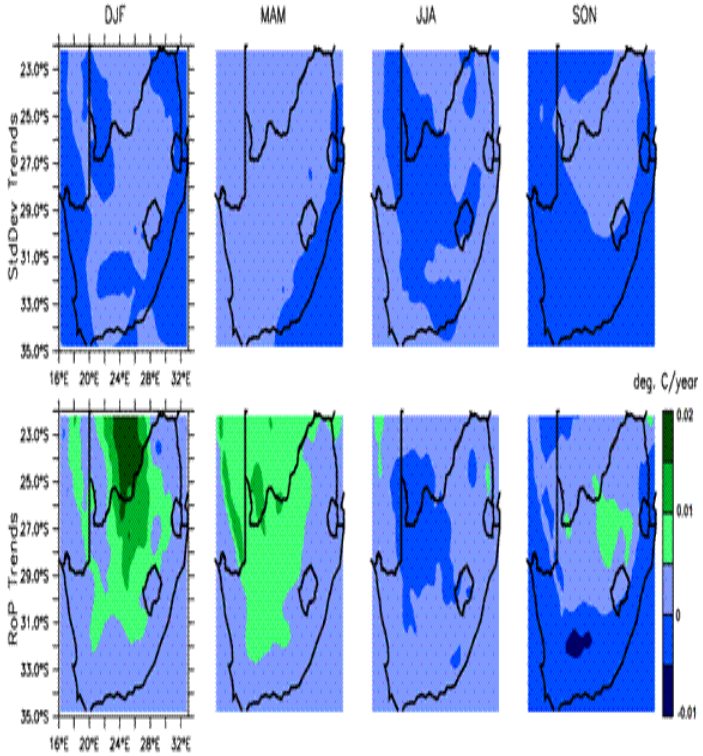




There are narrowing (negative trends) of range of possible seasonal climate predictions from late spring to mid-summer for inland provinces.

Trends analysis for temperature





There are narrowing of ensemble spreads over coastal provinces, mostly in spring and early periods of summer.

Summary and Conclusions……

Of the 108 province-month realisations for each variables and measure…..

……53 of the RoP cases and 45 of the StdDev cases for precipitation have zero trends outside their 80% confidence intervals,

……70 of the RoP cases and 64 of the StdDev cases for temperature do so.

At random, only 22 cases would be expected, indicating that these trends are generally reflecting real changes occurring within the climate model framework.

✓**There is predominantly a strong direct relationship between the measures of ensemble spreads, except over GGP.**

✓**The regions of higher spread migrate seasonally to follow the patterns of seasonal rainfall and temperature.**

✓**The range of possible seasonal forecasts can vary from year to year over South Africa.**

✓**There exist a significant number of long-term trends in the ensemble spreads of simulations that mimics a chaotic atmosphere.**

Possible causes of variability and trends……

……. Either be remotely-forced or locally-based

- **atmospheric composition**
- **changes in sea surface temperature**
- **changes in cloud cover**
- **a shift in the frequency of weather patterns**
- **the model and its simulation techniques**

……beyond the scope of the present study, but is the subject of planned future research.


Thank you!