LINKING DIURNAL TEMPERATURE RANGE SHIFTS OVER SOUTHERN AFRICA TO THE SOUTHERN ANNULAR MODE

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INTRODUCTION

- sole changes in the mean SAT are limited as an indicator of climate change compared to the relative changes in the maximum and minimum temperatures (Tmax, Tmin) as measured by the diurnal temperature range (DTR = Tmax-Tmin)
- This makes DTR, a meteorological parameter with more useful information (Karl et la., 1984; Sun et al., 2006), independent of internal climate variation and therefore considered a signature of observed climate change (IPCC, 2001; Braganza et al., 2004).
- This works seeks to establish the changes in DTR over southern Africa and link it to the Southern Annular Mode, considered the dominant climate mode over the southern Hemisphere.
- The link between SAM and DTR over southern Africa may provide a better understanding of the changing climate of the sub-region as an additional insight to the traditional attribution of ENSO

STUDY AREA

SOURCE: HTTPS://WWW.GOOGLE.CO.ZW/MAPS/

DATA

- Datasets were primarily derived from the Climatic Research Unit (CRU) TS (time-series) datasets.
- The datasets are month-by-month variations in climate calculated on high-resolution (0.5x0.5 degree) grids.
- Datasets are composed of cloud cover, monthly average daily maximum and minimum temperature.
- Precipitation chosen from a different dataset: Global Precipitation Climate Center (GPCC).
- To account for the impacts due to increased greenhouse gases we used the Mauna Loa (19°32N, 155°35W) growth of CO_2 data to approximate the average for the globe for the OND season.
- Data used are from 1960-2012 for the first part of the rainfall season (OND)

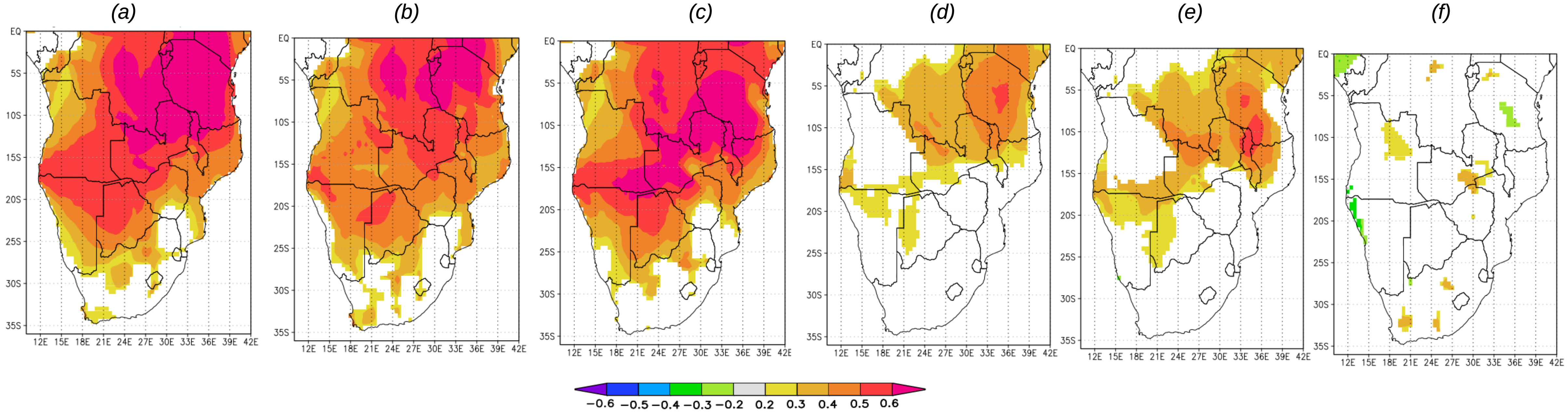
METHODS

- *We applied the* eigentechnique of the S-mode *empirical orthogonal function (EOF,* Compagnucci et al., 2000) *analysis, or the principal component (PC) analysis* to isolate the dominant modes of the DTR spatial and temporal domain.
- Pearson correlation method and regression analyses are applied to account for linear relationships between the DTR and different atmospheric parameters of interest and also served in better understanding of the origins of observed DTR trends and variability.
- A two-tailed Student's t-test is used to calculate the statistical significance of the results.
- To bring out the decadal relationships of the DTR with other meteorological variables, sliding correlations are calculated and their significances are determined against a 1000 sample Monte Carlo(Dwass, 1957) at 90% confidence level.
- To detect the shifts, the Sequential Regime Shift Detection and the CUMSUM techniques were used.

METHODS

- In order to remove the linear influence of greenhouse gas-induced global warming, we detrended the data before doing any statistical operation.
- The climatic time series used in this study consist of 3-monthly (Oct-Dec) values per year. As expected, no robust autocorrelation on time series is found. Therefore we considered the impact of autocorrelation of the time series in significant hypothesis testing as unimportant.
- Anomalies were computed by subtracting the climatological mean from the data.

LINEAR & NON LINEAR IMPACT OF CO_2

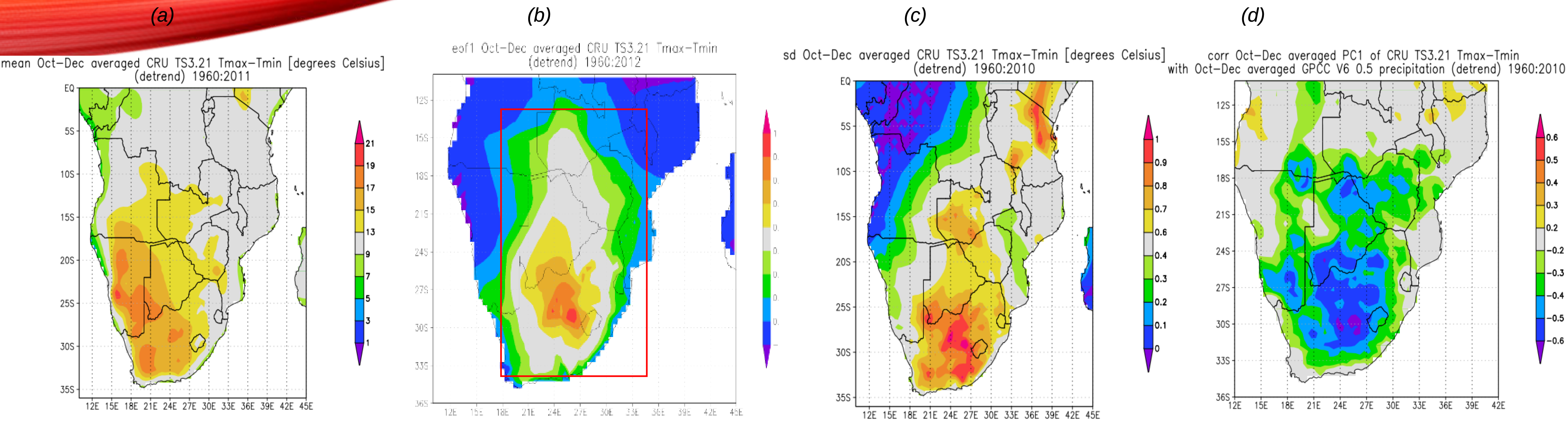


-*Spatial distribution of correlation between Manua Loa CO_2 index with averaged SAT (a)mean (b) Tmax (c) Tmin (d) and (e) SAT mean and Tmin respectively but with detrended data, and (f) DTR from 1960 to 2012 during the OND period. Shaded regions are significant above the 90% confidence level.*

-*Manua Loa CO_2 index is inked to both linear and non linear signal over southern Africa*

-*subtropical southern Africa, especially SA not significantly linked to global warming signal.*

RESULTS



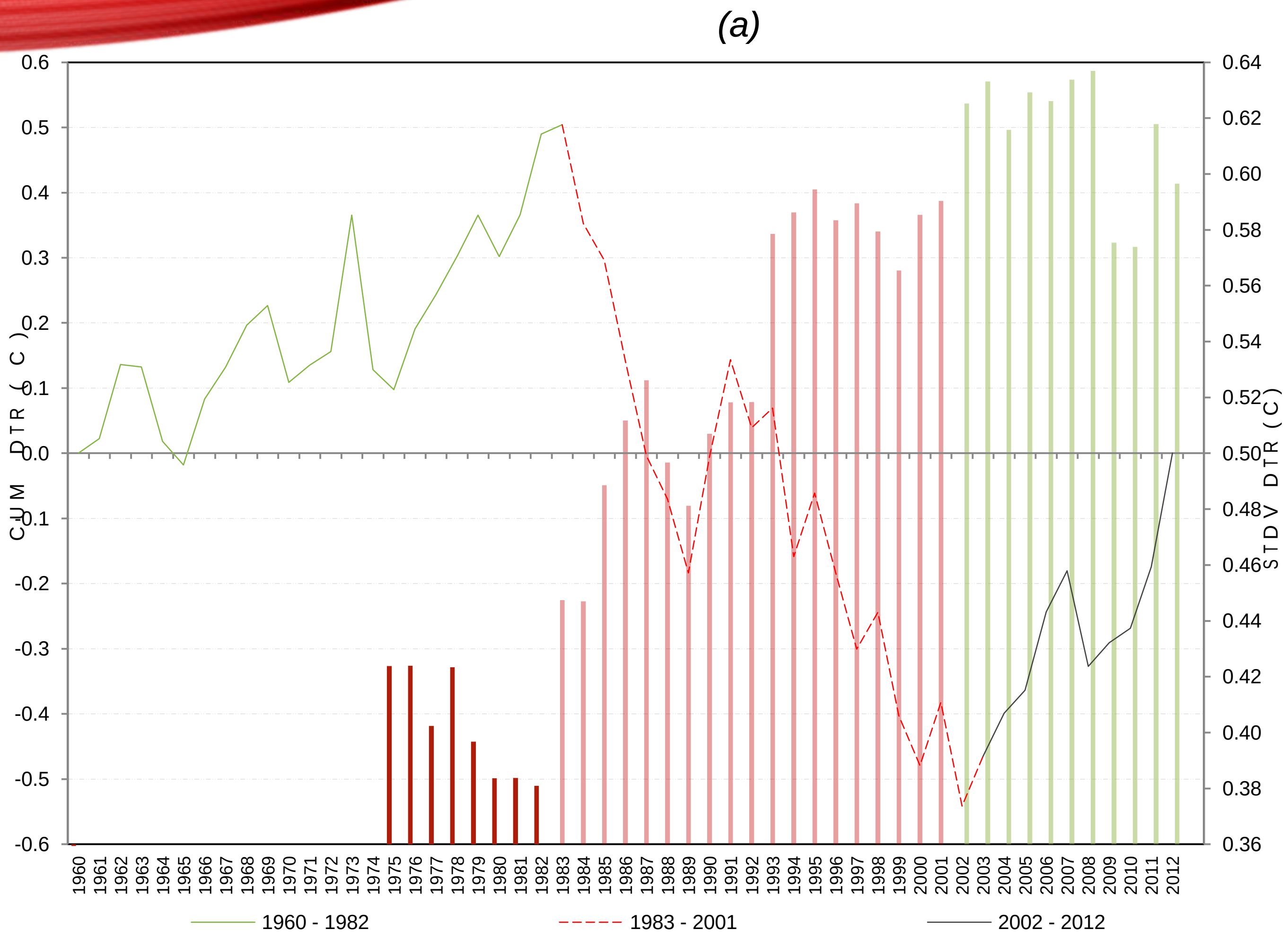
Spatial distribution for (a) DTR mean (b) DTR EOF1 (c) DTR standard deviation and (c) correlation field between DTR PC1 & GPCC for the period 1960 to 2012 during OND.

Table 1. The first 4 EOFs for DTR during the period 1960 - 2012

# Eigenvalue	Explained Var	Cumulative Var
1. 49.772	31.07%	31.07%
2. 28.399	17.73%	48.80%
3. 18.585	11.60%	60.41%
4. 12.561	7.84%	68.25%

The spatial loadings are largely unimodal, hence suggesting that the dominant variability of DTR of southern Africa respond to the same trigger or at least closely related forcing processes which are predominantly meridional in orientation and of pole ward origins.

RESULTS



(a) CUM DTR (line graph) and superimposed are DTR PC1 15-yr standard deviation overlapping segments (bars) (b) 15-yr running correlations between GPCC rainfall over southern Africa and cloud cover fraction. Values are at the end of the 15-yr segments.

RESULTS

Results of the regime shift detector for the DTR in the mean from 1960 to 2012.

Year	DTR Anom (yr -1)	RSI(yr -1)	Mean(yr -1)	Length	P
1983	-0.8791(0.2450)	-0.0491(0.0000)	-0.3306(0.0599)	23	0.02
2002	0.6429(-0.8871)	0.8229(0.0000)	0.4459(-0.3306)	19	0.00

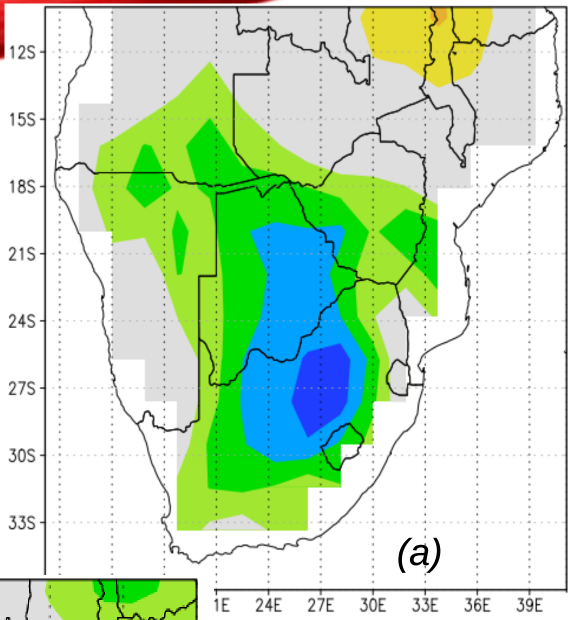
RSI: Regime Shift Index; Mean: Weighed means of the regimes using the Huber's weight function with the parameter = 3; Length: Length of the regimes; P: Significance level of the difference between the mean values of the neighboring regimes based on the Student's two-tailed t-test with unequal variance (TTEST procedure in Excel). yr -1: the year before the shift.

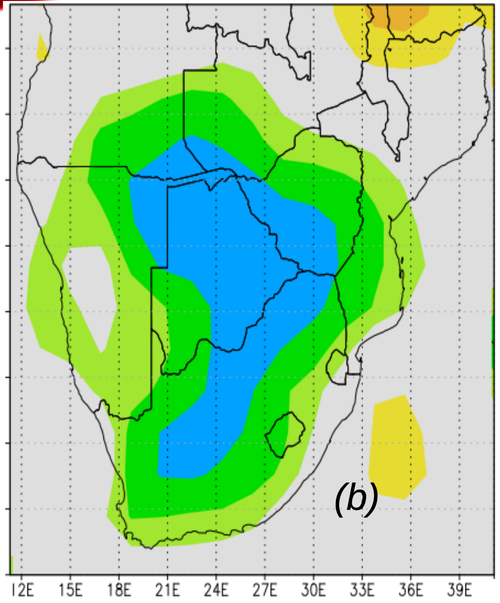
Results of the regime shift detector for the DTR variance from 1960 to 2012.

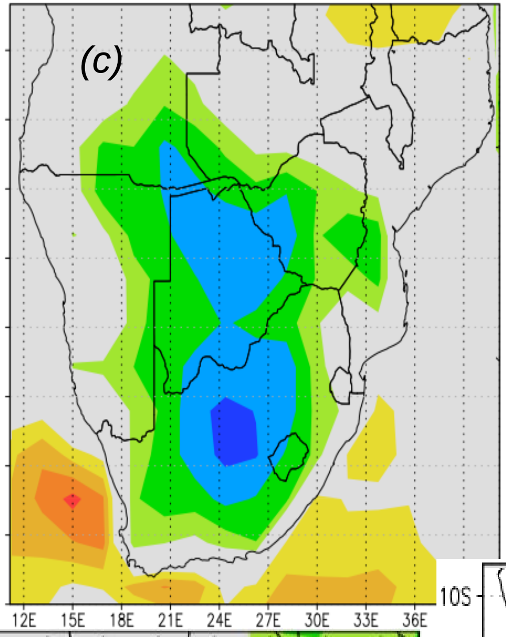
	DTR Anom (yr -1)	RSSI(yr -1)	Var(yr -1)	Length	P
1983	-0.8791 (0.2450)	0.0696(0.0000)	0.3664(0.1434)	23	0.0279

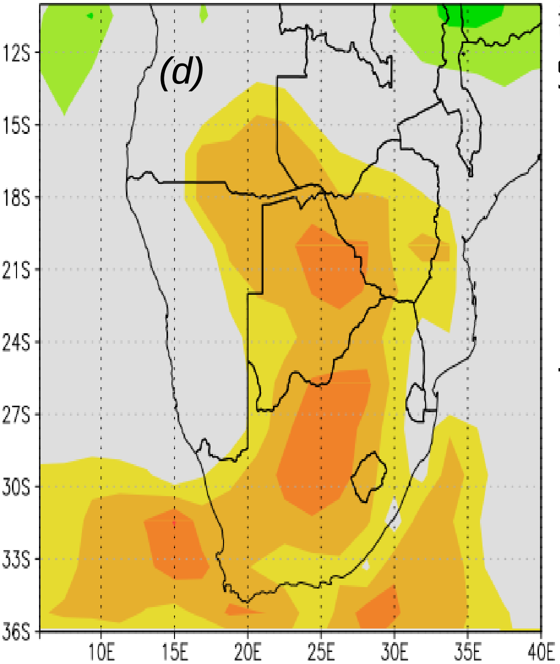
RSSI: Residual Sum of Squares Index; Var: Variance of the regimes; Length: Length of the regimes; P: Significance level of the difference between the variances of the neighbouring regimes based on the Fisher's F-test; yr -1: the year before the shift.

RESULTS



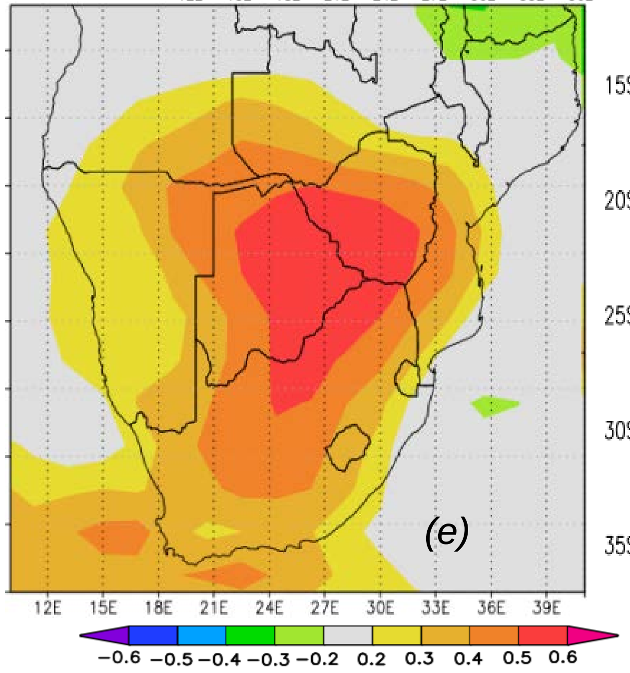


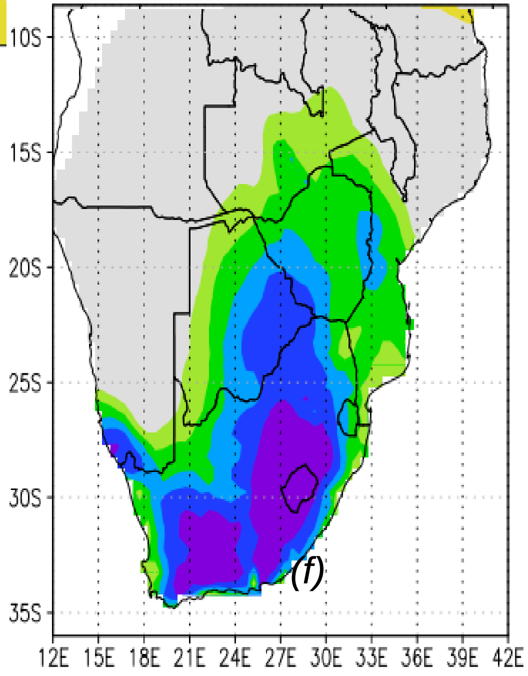




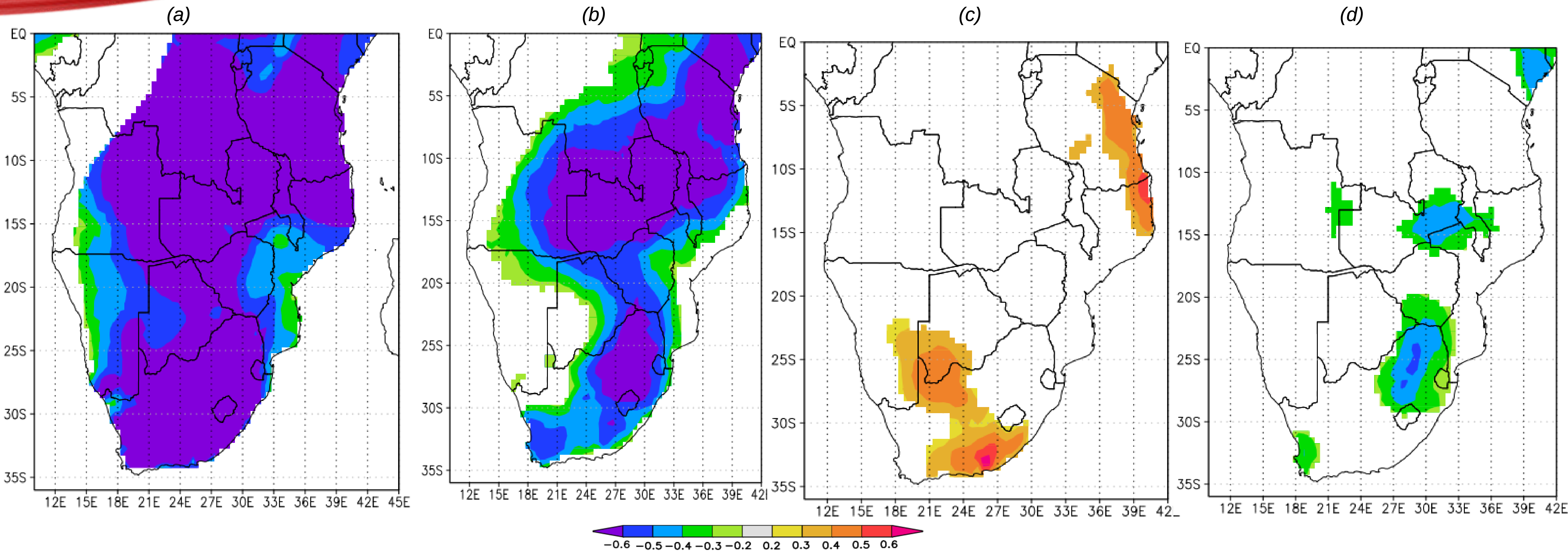
Spatial distribution of the correlation coefficients between DTR aerially averaged over the red box &(a) soil moisture (b) net solar radiation (c) latent heat flux (d) sensible heat flux (e) net longwave radiation & (f)precipitation.

The negative correlation fields displayed in the figures imply that the corresponding parameters summarily reduce DTR save for the last two which are associated with increases in the DTR.



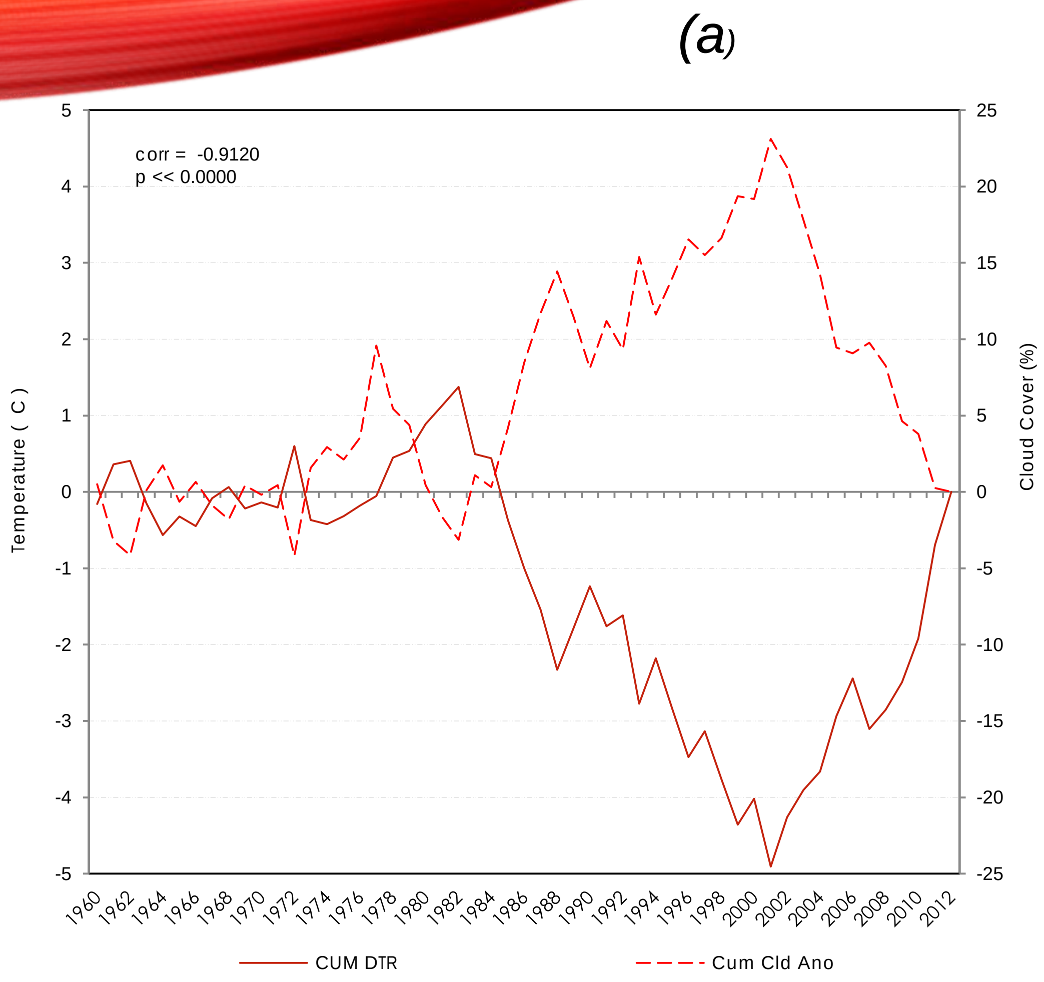


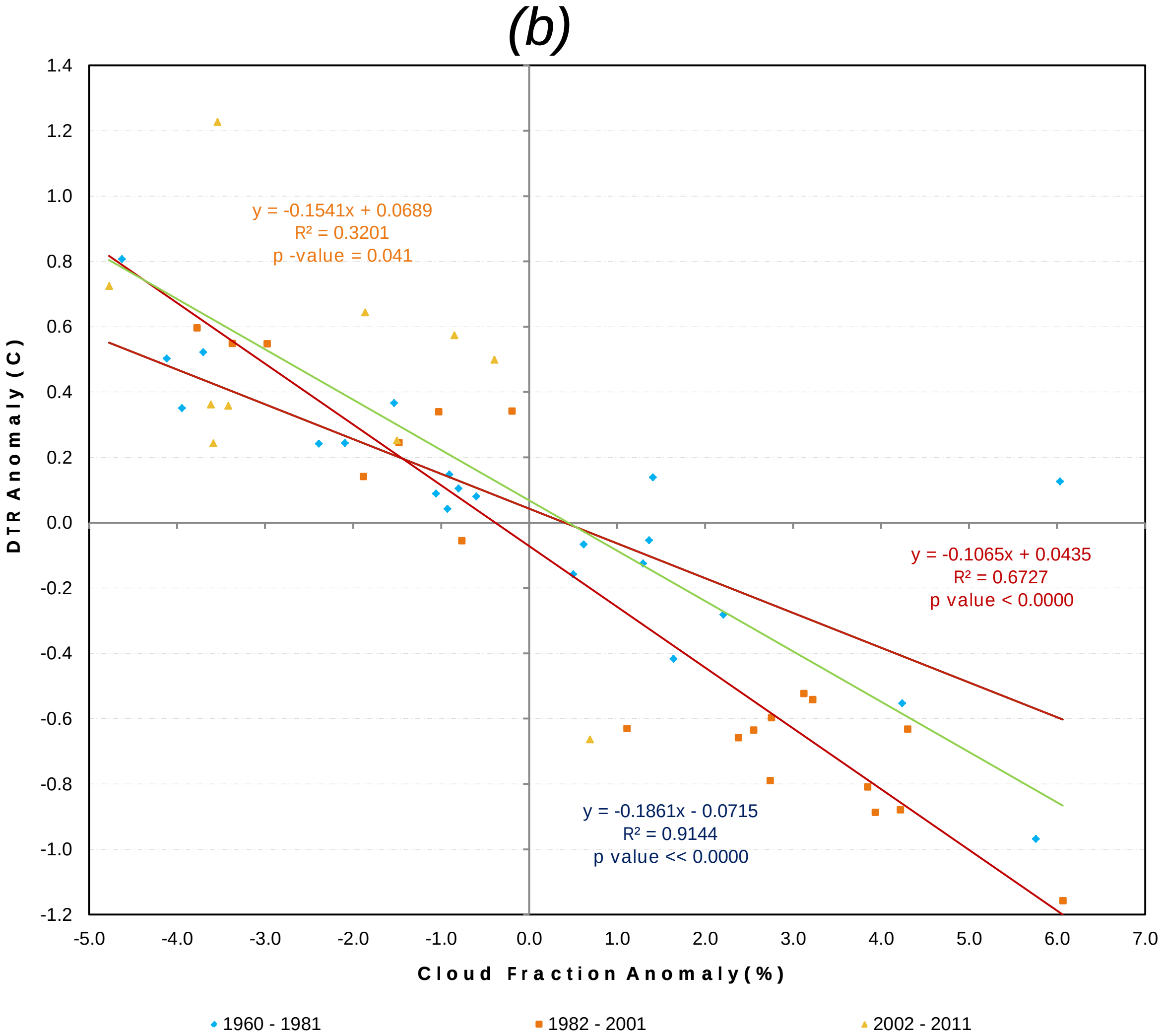
RESULTS



- *Pointwise correlation between cloud fraction and (a) DTR (b) Tmax (c) Tmin (d) Tmean during the OND period on detrended data. Regions with correlation coefficients which are significant above 90% confidence level are shaded. Data analysed is for the OND period during 1960 to 2012.*
- *Over subtropical southern Africa cloud fraction is not sign related to desert region.*

RESULTS

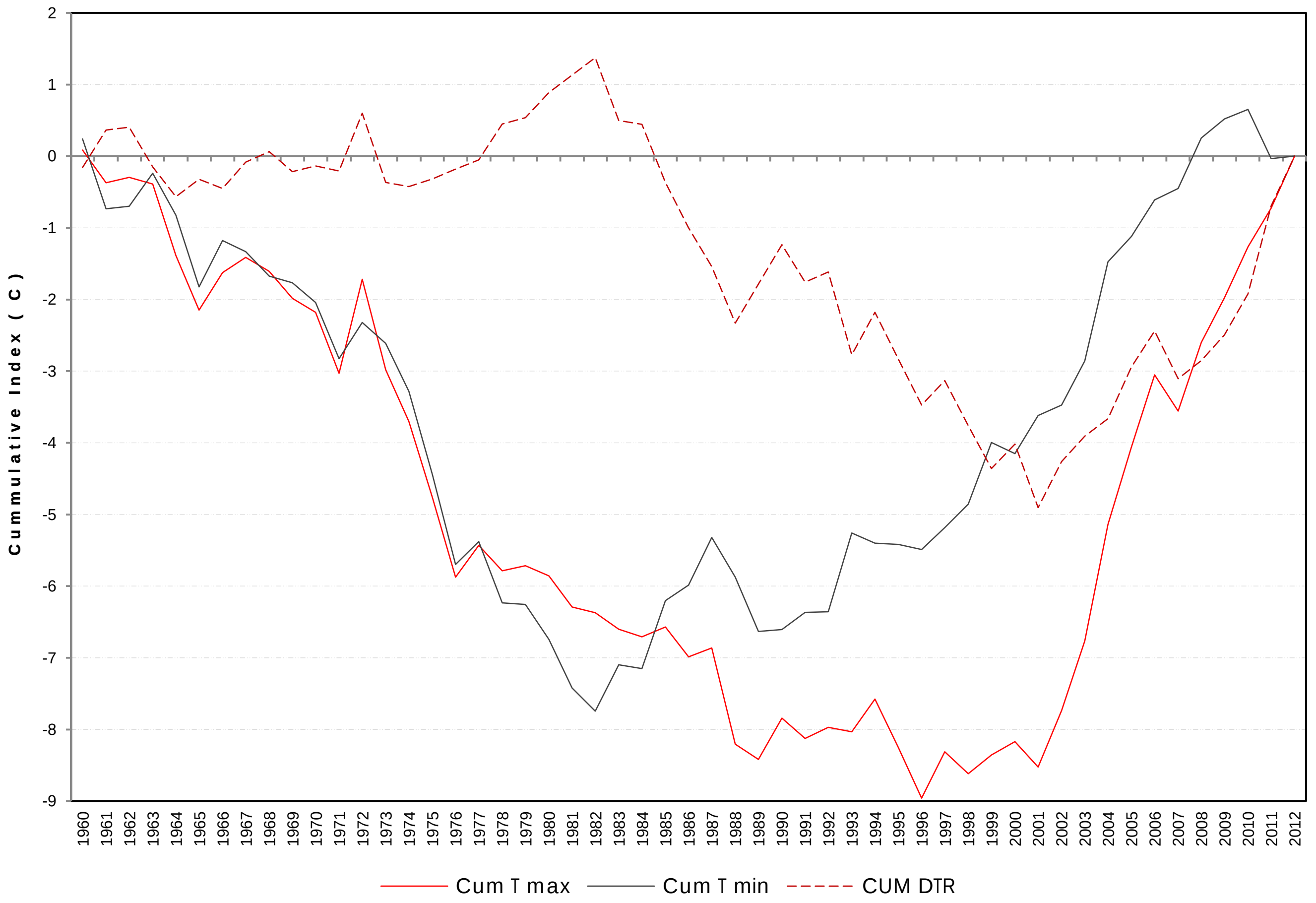




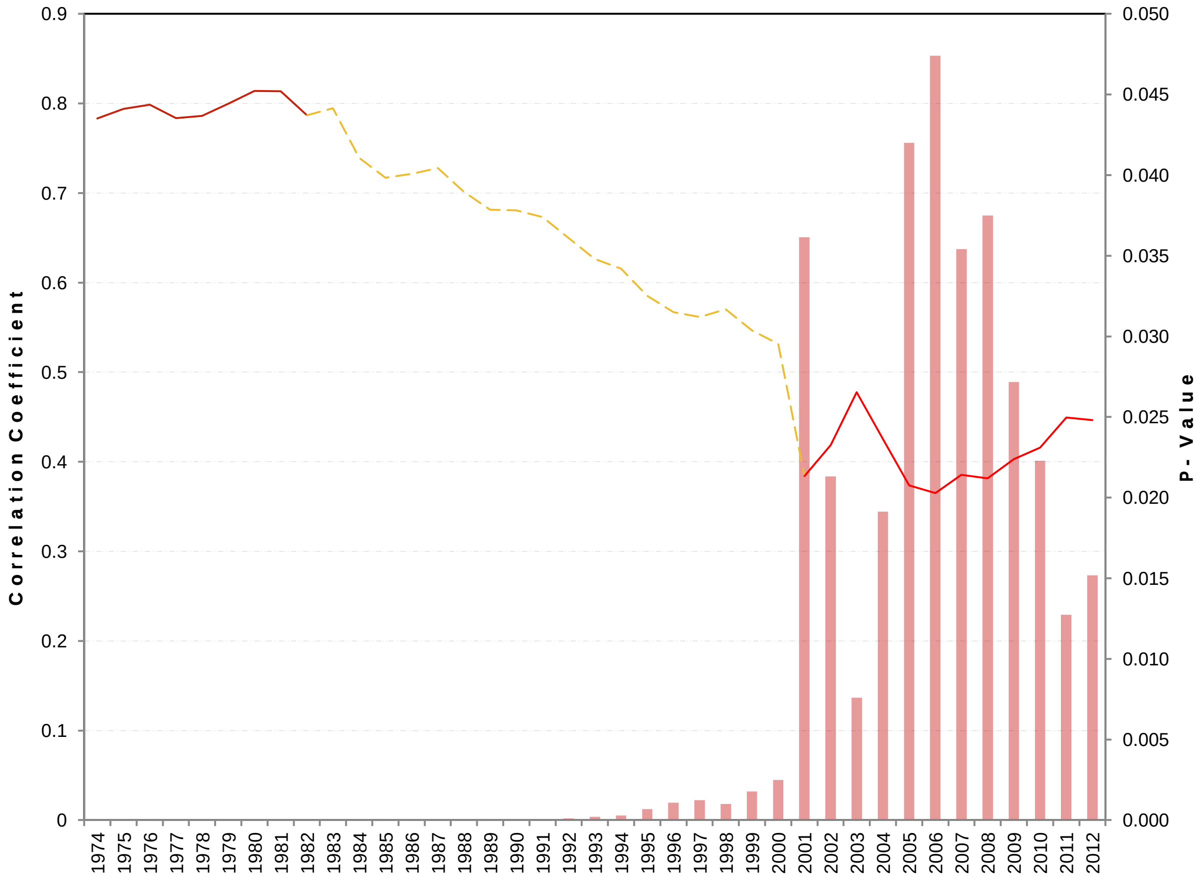
- *(a) Temporal manifestation of the cumulative time series and (b) scatter plot for DTR and Cloud cover anomalies for the period OND from 1960 to 2012. In the insert is (a) the correlation coefficient between the two time series and (b) regression equations and coefficients of determination, alongside their p-values for the 3 epochs.*

RESULTS

(a)

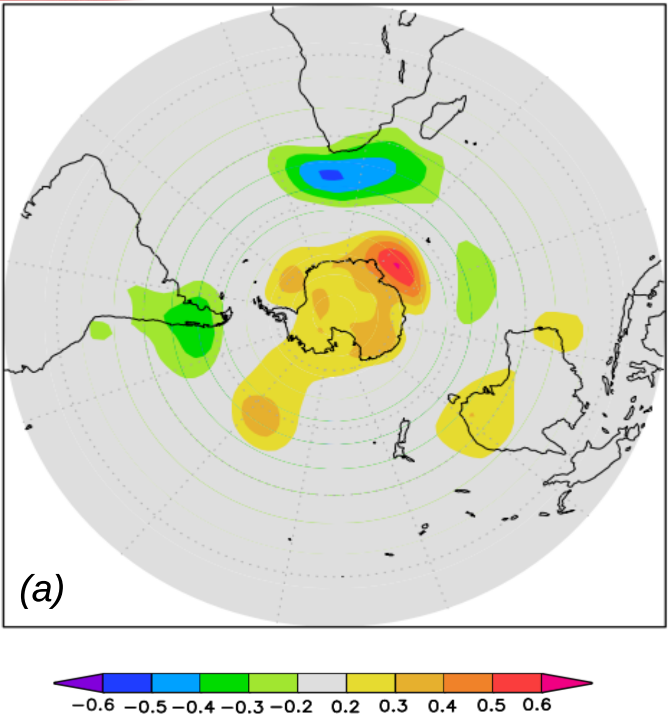


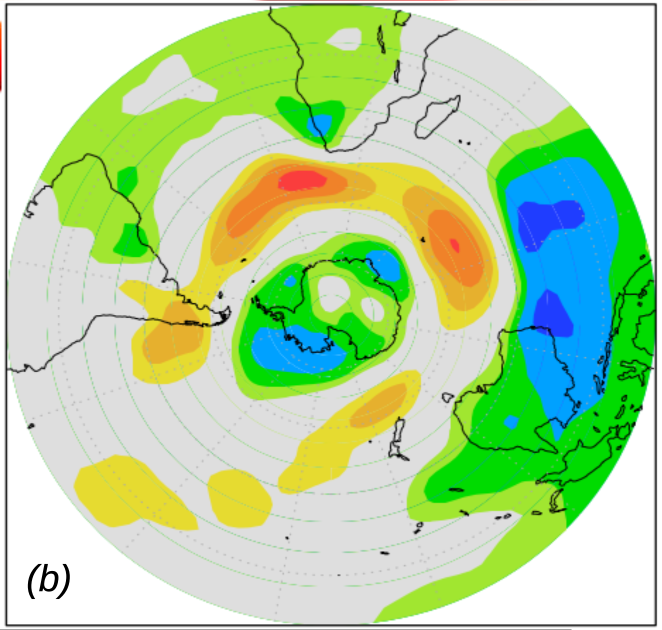
(b)

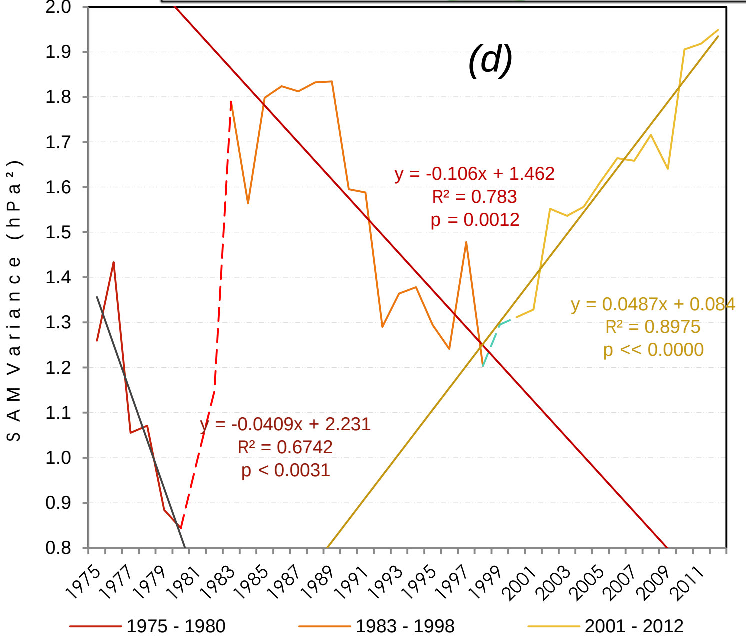


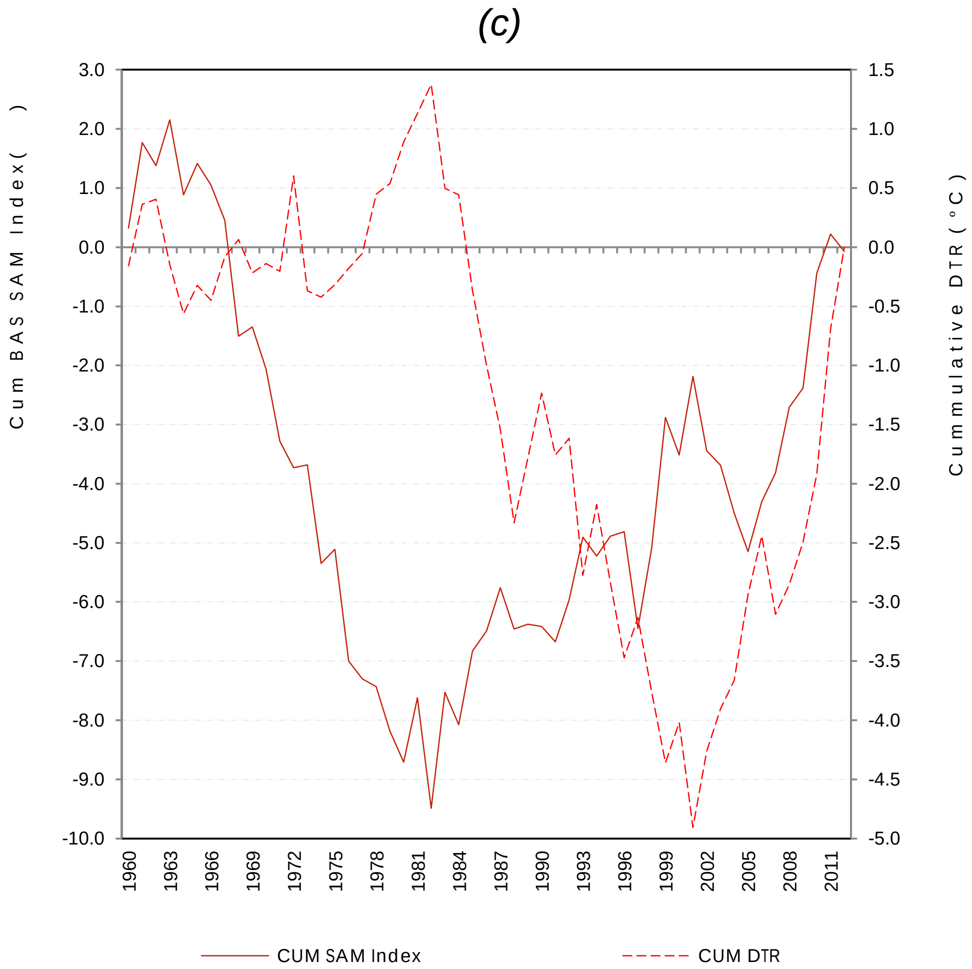
- *(a) Temporal manifestation of the cumulative indices for Tmax, Tmin, and DTR and (b) 15 yr running correlation between T max and T min for the period 1960 to 2012 during OND*

RESULTS









Corr (a) DRT (b) Precipitation, with geopotential at 850 hPa level. Temporal manifestation of the CUM time series of (c) SAM (solid line) and DTR (broken line (d) 15 year running segments of SAM variance with regressions equations for the epochs in the insert.

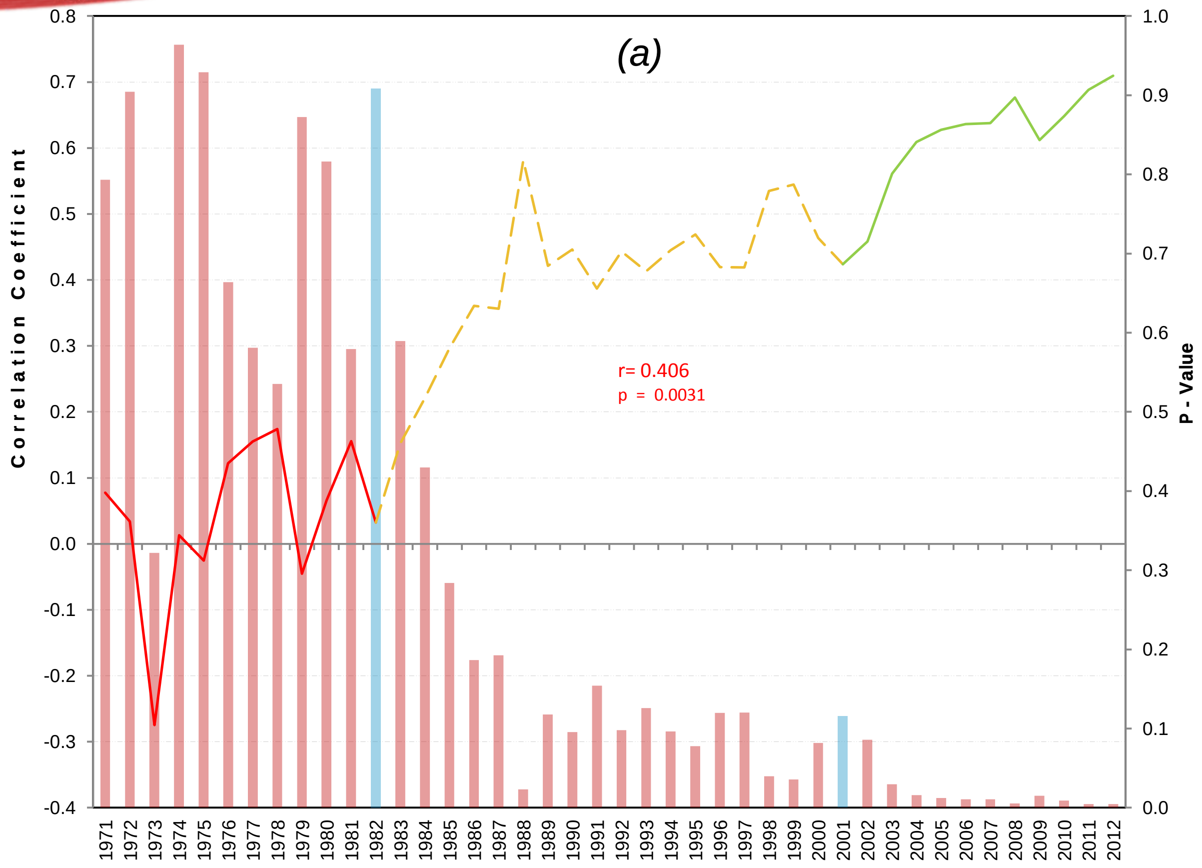
RESULTS

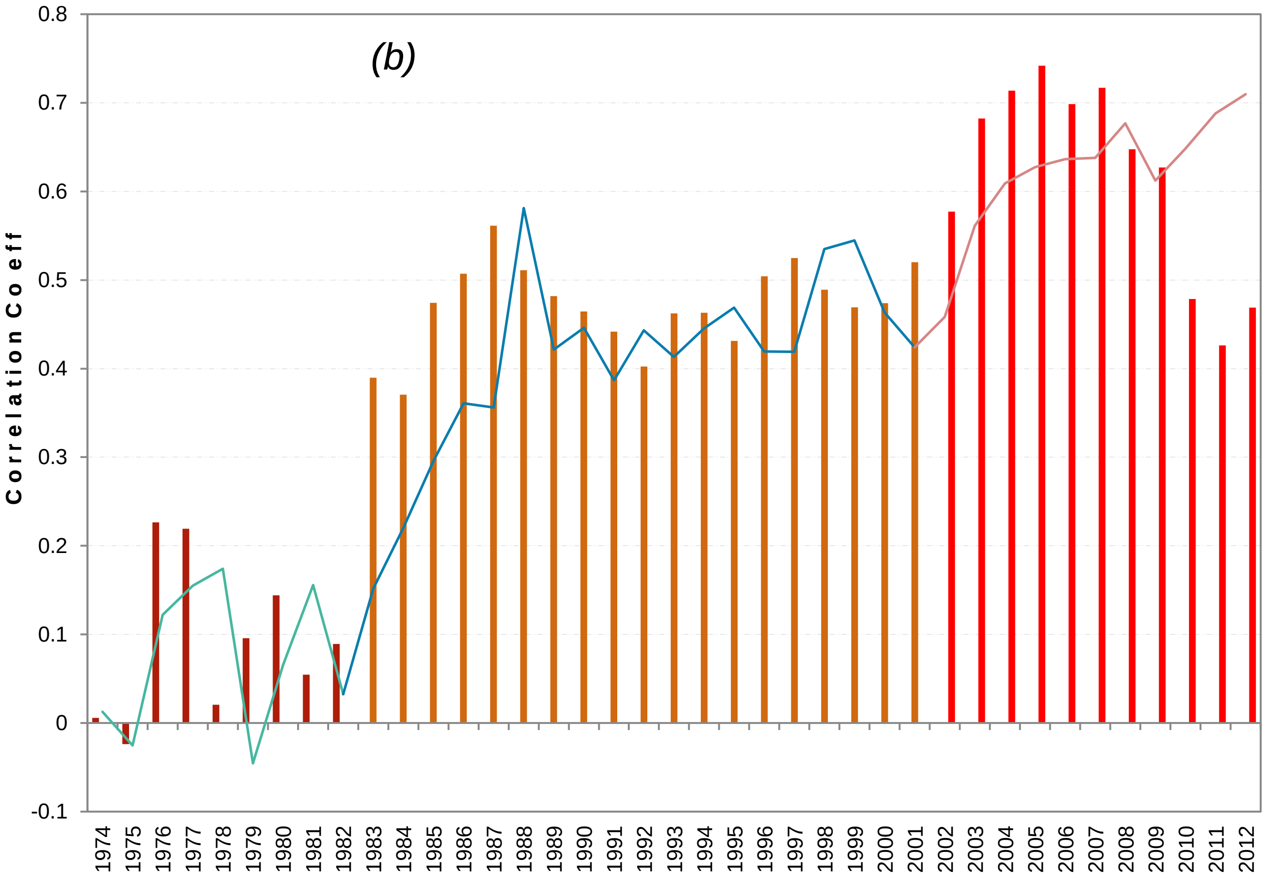
Results of the regime shift detector for the mean in SAM from 1960 to 2012.

Shift Yr	SAM Anom (yr -1)	RSSI(yr -1)	Var(yr -1)	Length	P
1983	2.4533 (-2.2233)	0.1884 (0.0000)	0.4689 (-0.4462	23	0.0072

RSI: Regime Shift Index; Mean: Weighed means of the regimes using the Huber's weight function with the parameter = 3; Length: Length of the regimes; P: Significance level of the difference between the mean values of the neighbouring regimes based on the Student's two-tailed t-test with unequal variance (TTEST procedure in Excel). yr -1: the year before the shift.

RESULTS





- *15 year running correlation between BAS SAM and (a) southern Africa rainfall. Bars are the corresponding p-values and values are at the end of the 15 yr segments. (b) Temporal comparison of running 15 year running correlations between SAM and rainfall (solid line); and SAM and DTR (bars). Different colours represent the three distinct epochs.*

Table 2: Results of the regime shift detector for the mean in cloud cover from 1960 to 2012.

Year	DTR Anom (yr -1)	RSI(yr -1)	Mean(yr -1)	Length	P
2002	-1.8627(3.9334)	-0.2282(0.0000)	-2.1007(0.5502)	42	0.0009

RSI: Regime Shift Index; Mean: Weighed means of the regimes using the Huber's weight function with the parameter = 3; Length: Length of the regimes; P: Significance level of the difference between the mean values of the neighbouring regimes based on the Student's two-tailed t-test with unequal variance (TTEST procedure in Excel). yr -1: the year before the shift.

CONCLUSIONS

- Over subtropical southern Africa cloud cover is so strongly coupled to precipitation that the respective times series highly explain each other's variance.
- Cloud Cover/precipitation is highly correlated to DTR
- Shifts in cloud cover over southern Africa coincides with those in SAM
- Cloud Cover/precipitation is strongly coupled to SAM
- It is highly likely that SAM controls cloud cover/precipitation though its related circulation patterns
- It is most probably SAM's impacts on cloud cover/precipitation that displays the large bearing on DTR variability
- Therefore SAM is probably responsible for the dominant component of climate change over subtropical southern Africa.

THANK YOU

FOR GIVING ME THE OPPORTUNITY TO MINGLE WITH SOME OF THE FINEST BRAINS IN THE WORLD & SEE

KIT