Antarctic stratospheric ozone and seasonal predictability over southern Africa

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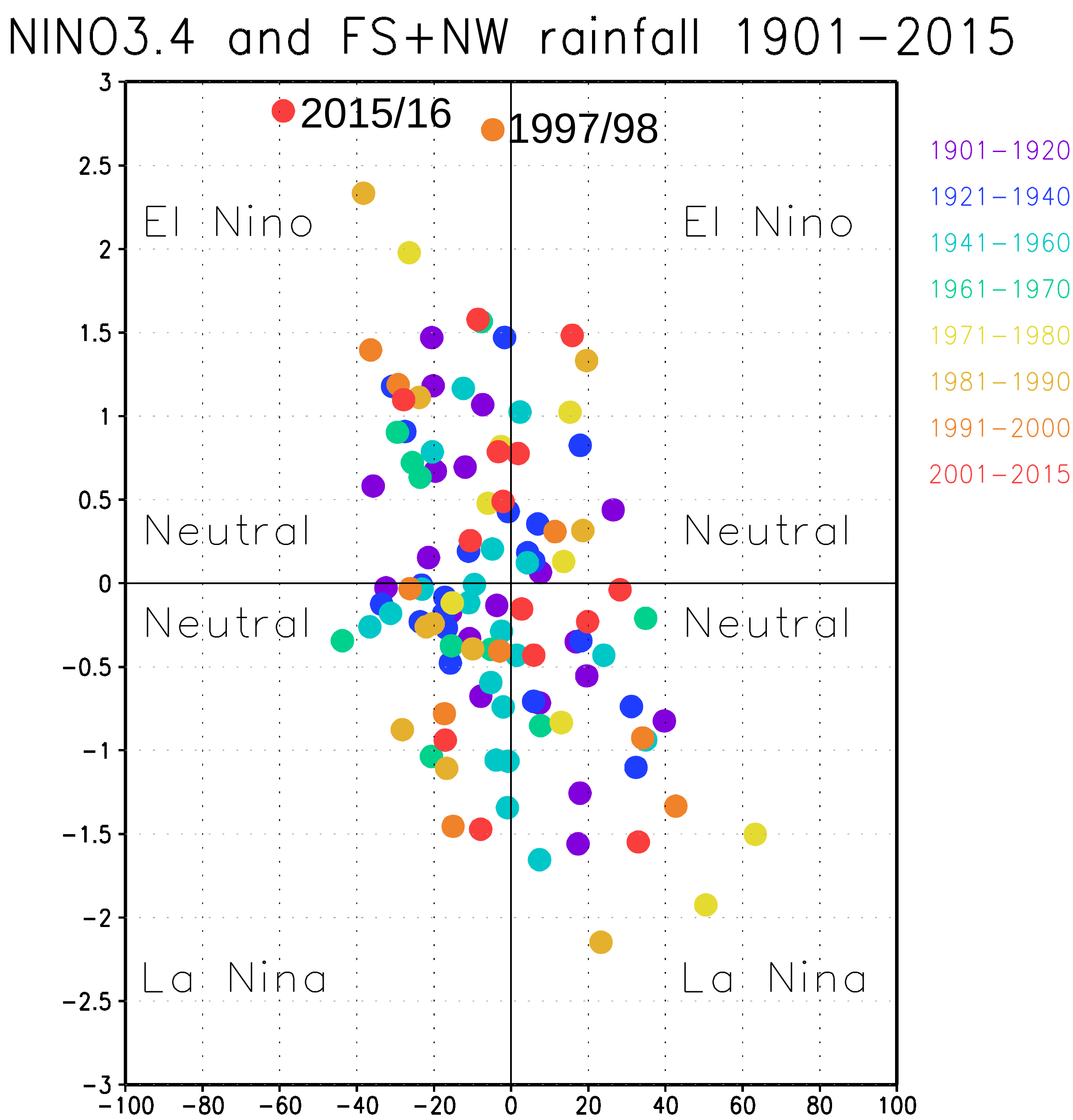
Drought in southern Africa

Depleted grazing in Kruger Park in September 2016.

By September 2016, The entire summer rainfall region was in a state of mild drought, or worse, after the 2015/16 super El Niño

The Free State, northern KwaZulu-Natal, eastern Mpumalanga and Kruger Park was in a state of severe drought .



Summer-season rainfall anomalies over the Free State and North West provinces (x-axis) and Niño 3.4 sea-surface temperature anomalies (y-axis) for 1901-2015.

Rainfall anomalies from CRU and GCPC are for DJF. SST anomalies from AMIPII are for OND.

All anomalies were calculated with respect to the 1971-2000 baseline period.

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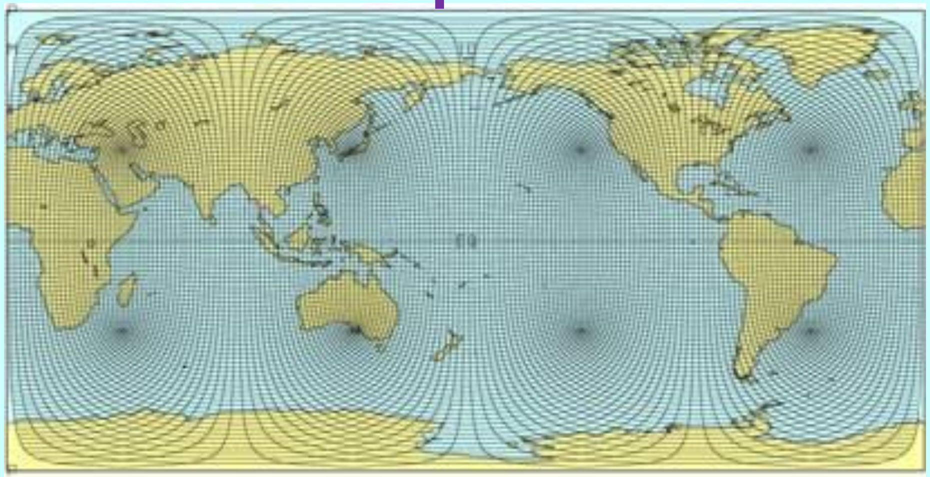
CCAM AMIP-style simulations

Control experiment



Climatological CO_2

Climatological ozone

Climatological aerosols

Observed SSTs and sea-ice

CCAM experimental design

C48 (200 km horizontal resolution)

27 sigma levels

Simulation period 1978-2005

12 ensemble members

CHPC

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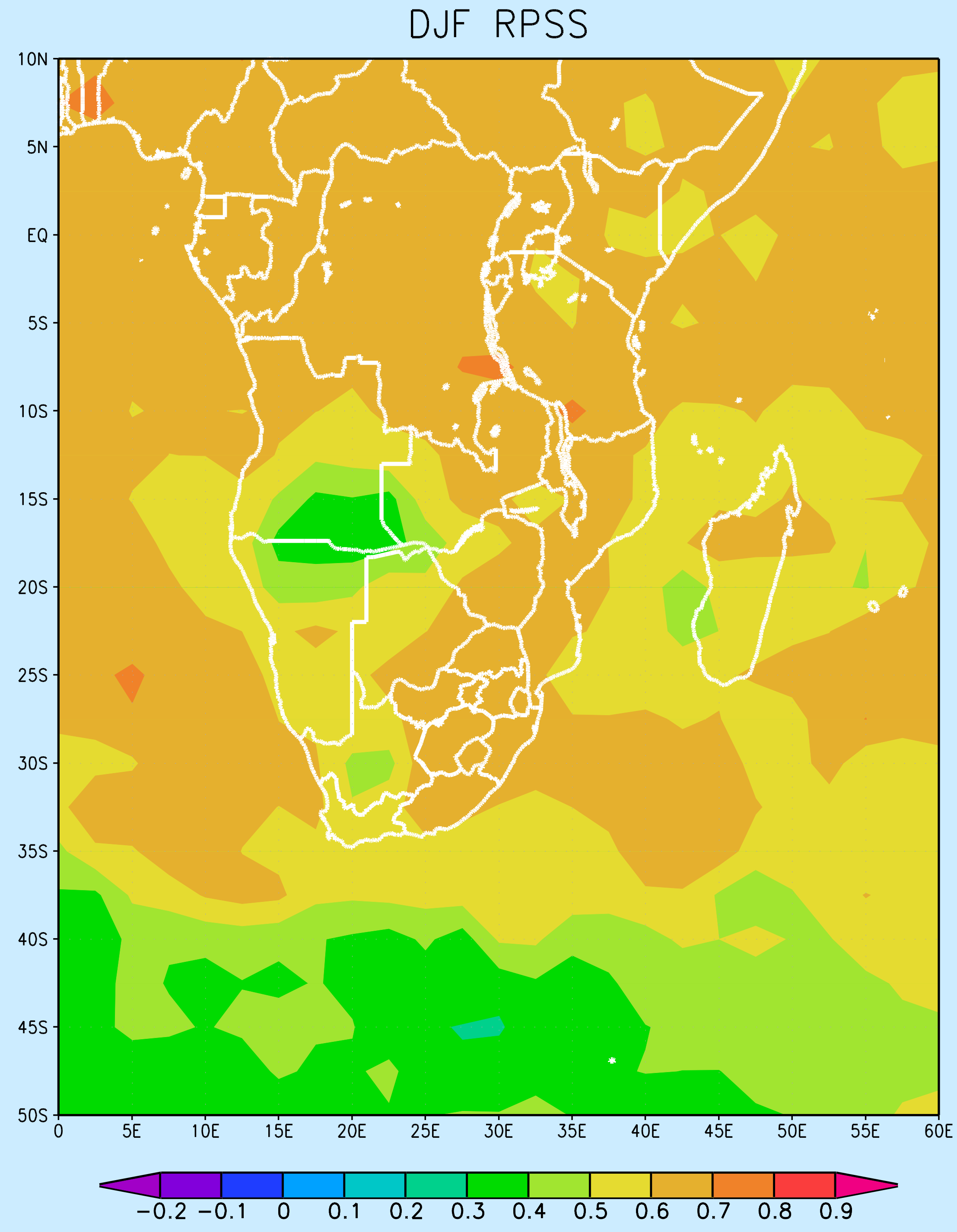
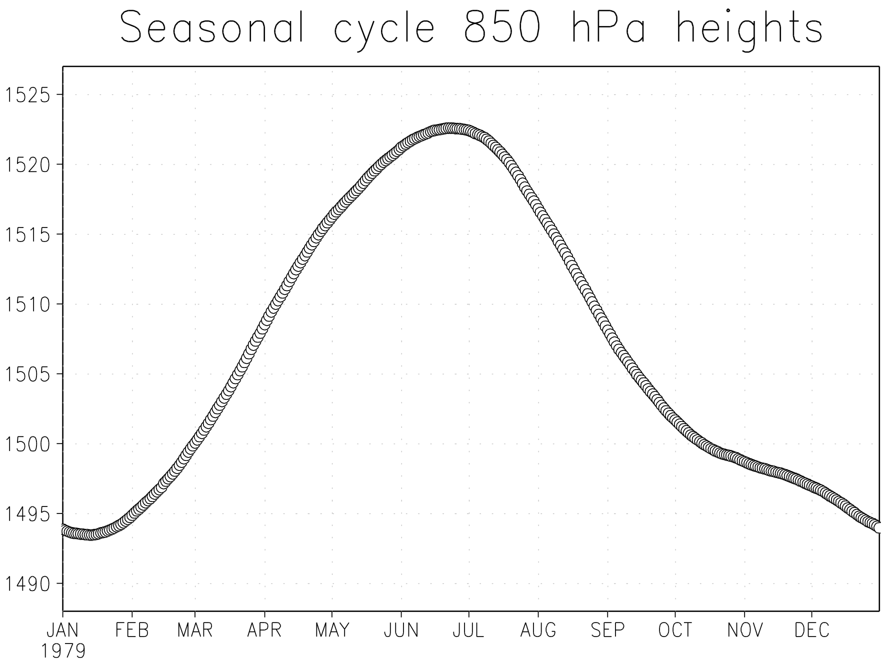
WRC Radiative Forcing K5/2163

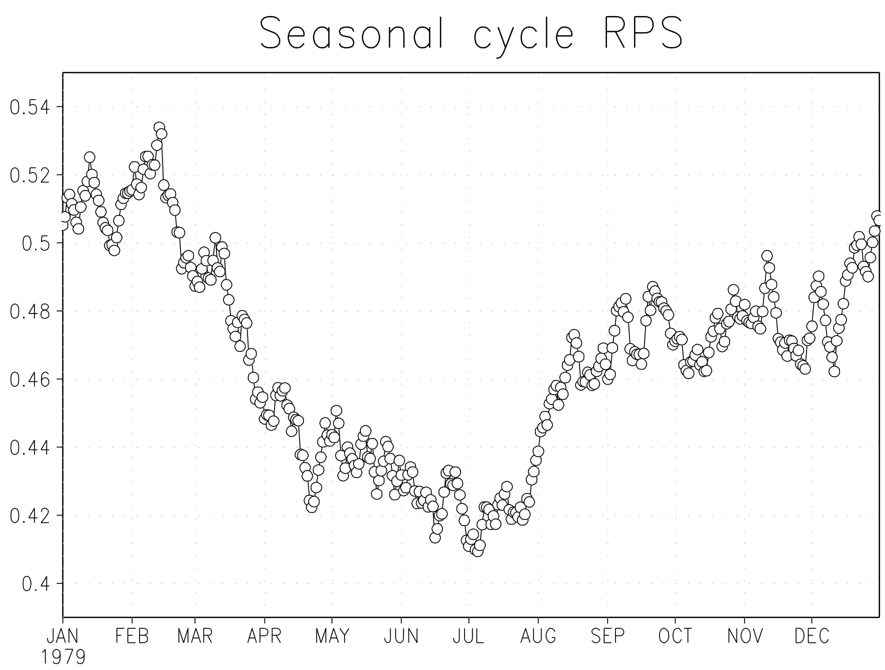


DJF CCAM AMIP-simulation skill in simulating the inter-annual variability in circulation (850 hPa geopotential heights) over southern and tropical Africa

$$\text{RPS} = \sum_{k=1}^{K}(S_k - O_k)^2$$

$$\text{RPSS} = 1 - \frac{\text{RPS}}{\text{RPS}_c}$$





Seasonal cycle in circulation and seasonal forecast skill as deduced from AMIP-style simulations

SA domain: 30 S to 10 S and 15 E to 35 E

Climatological values of radiative forcings (control experiment)

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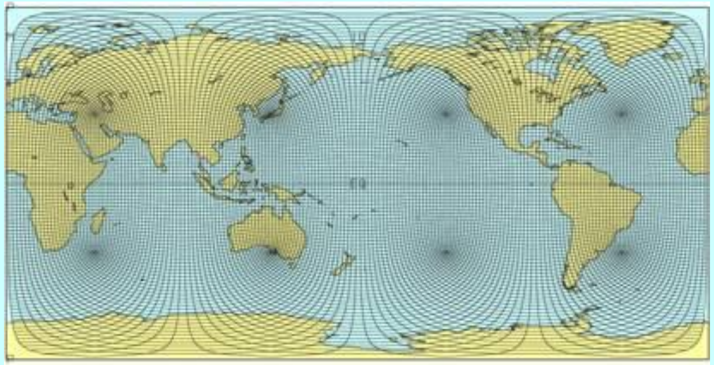
AMIP-style simulations: Antarctic stratospheric forcing

Control experiment



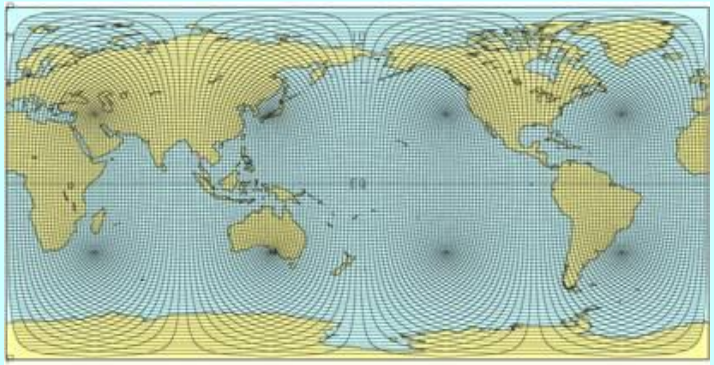
Climatological CO_2

Climatological ozone

Climatological aerosols

Observed SSTs and sea-ice

Radiative forcing: ozone



Climatological CO_2

Ozone time-varying

Climatological aerosols

Observed SSTs and sea-ice

CCAM experimental design

C48 (200 km horizontal resolution)

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Simulation period 1978-2005

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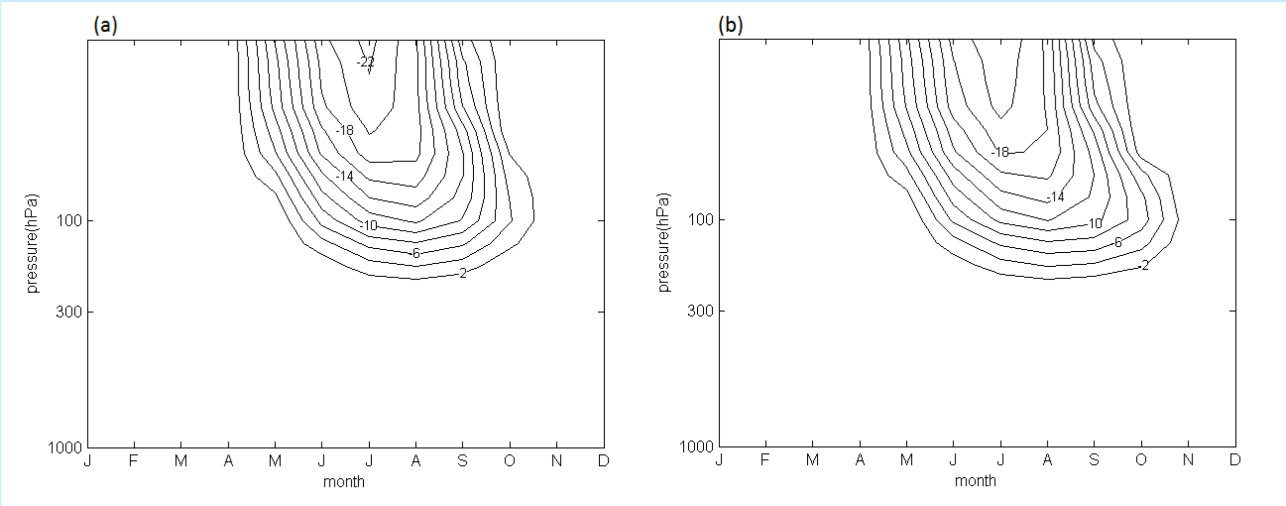
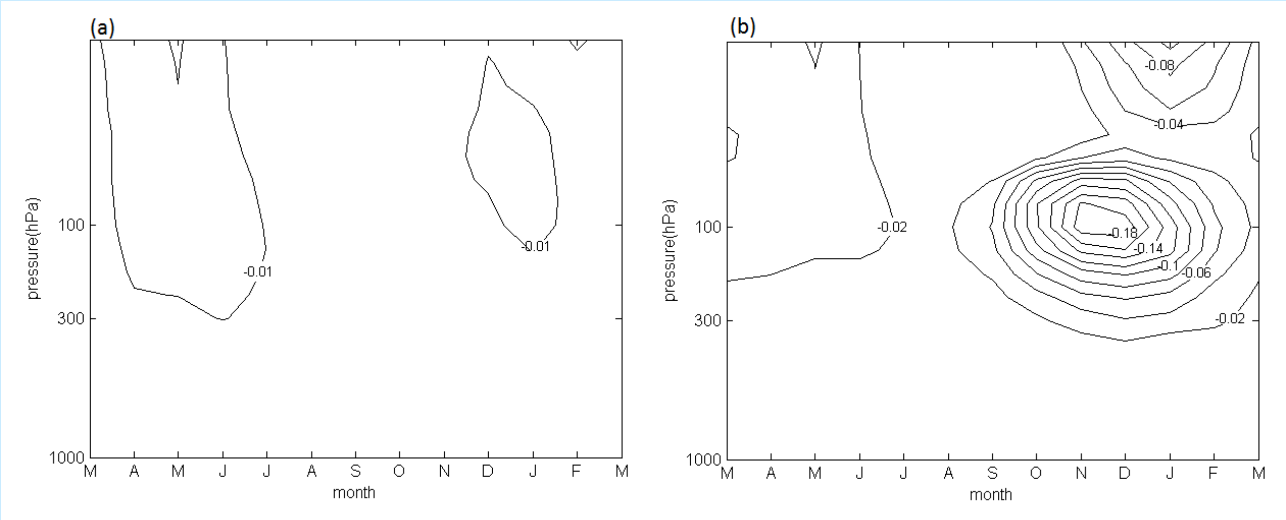
CCAM simulations of polar cap temperatures (Temp -200 K)



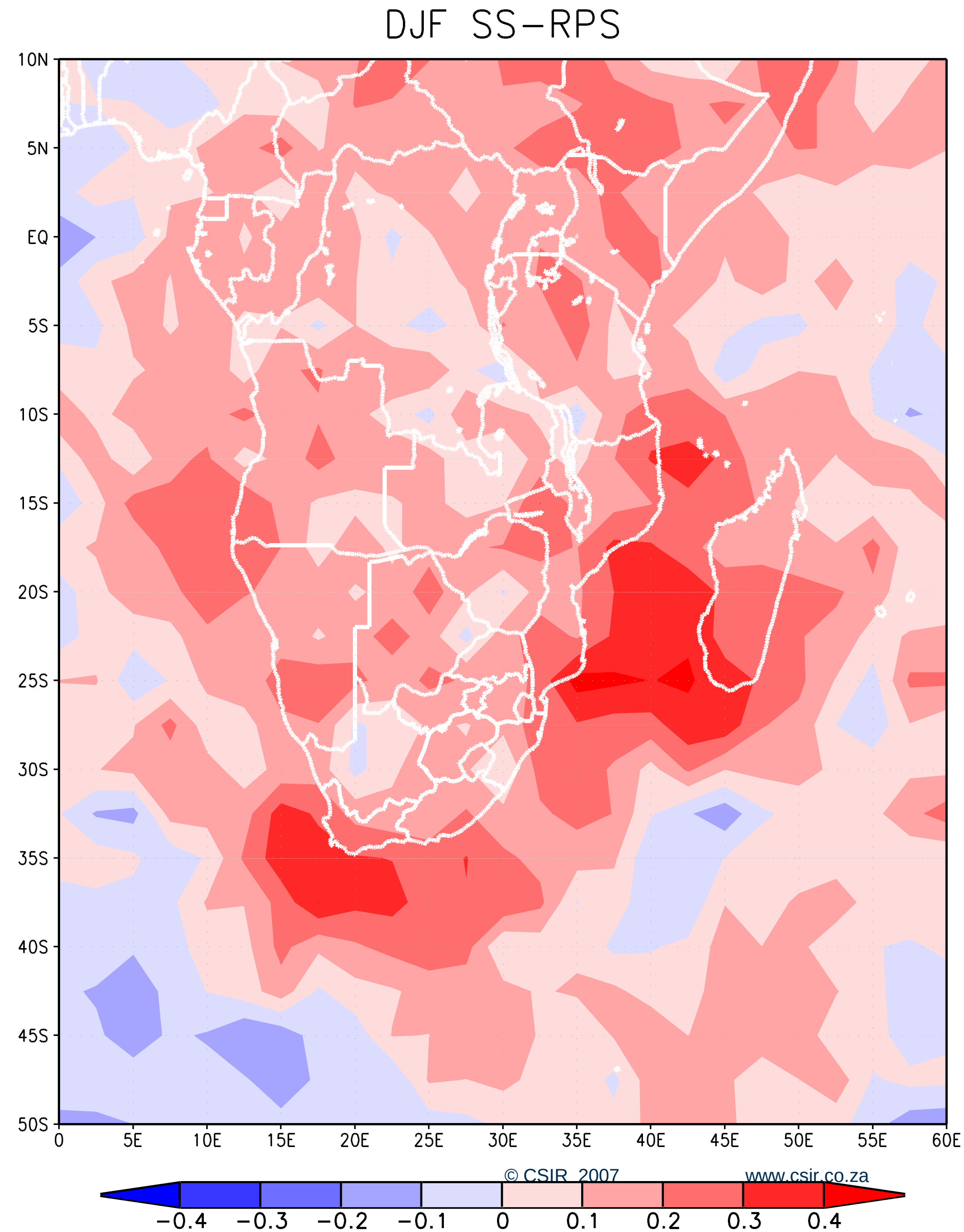
Simulated seasonal evolution of polar-cap (70S-90S) temperatures



Simulated seasonal trends in polar-cap (70S-90S) temperatures

Control experiment

Ozone Radiative forcing experiment



Change in skill for DJF: Time-varying ozone vs climatological values (control experiment)

Inclusion of time-varying stratospheric ozone leads to a step-up change in DJF predictability – the ozone signal is seemingly sufficiently strong to overcome the westerly-wave chaos-barrier

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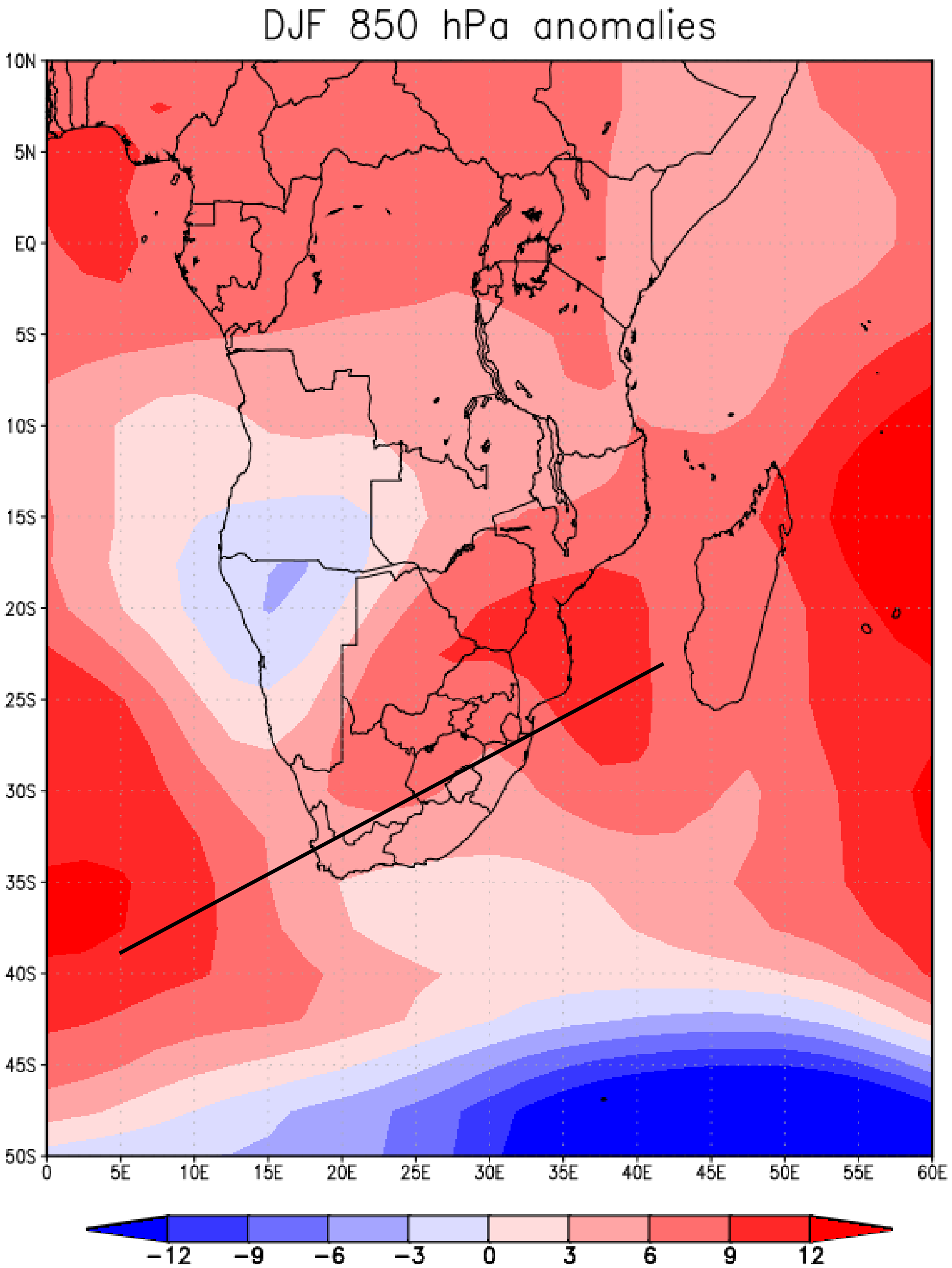

850 hPa circulation anomalies during December-February of 1997/98

Pattern of trough formation and relatively deep Angola low in the west, with a ridge-axis from the southwest to the north-east over southern Africa occurred, which promoted moisture advection from the east

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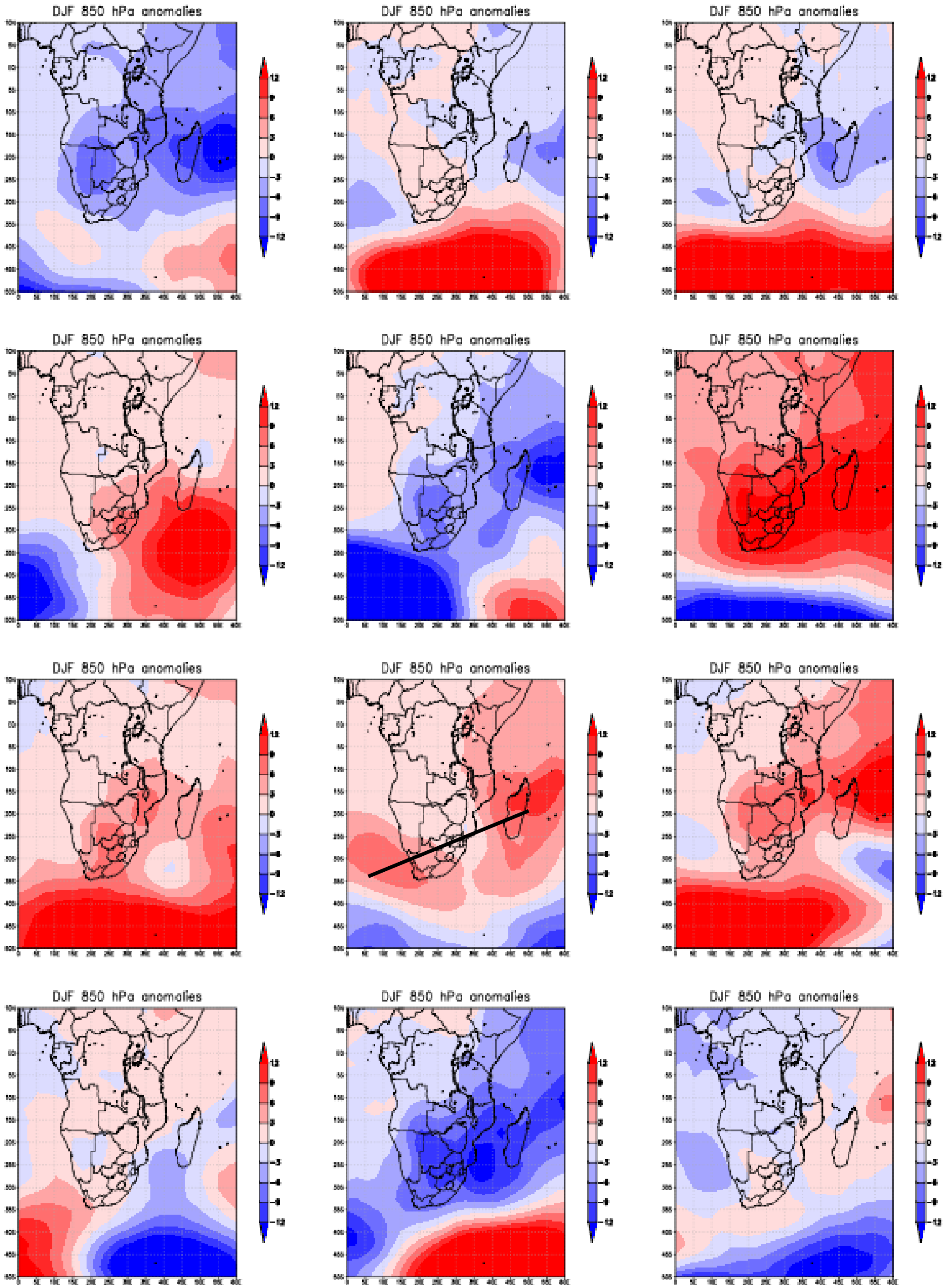
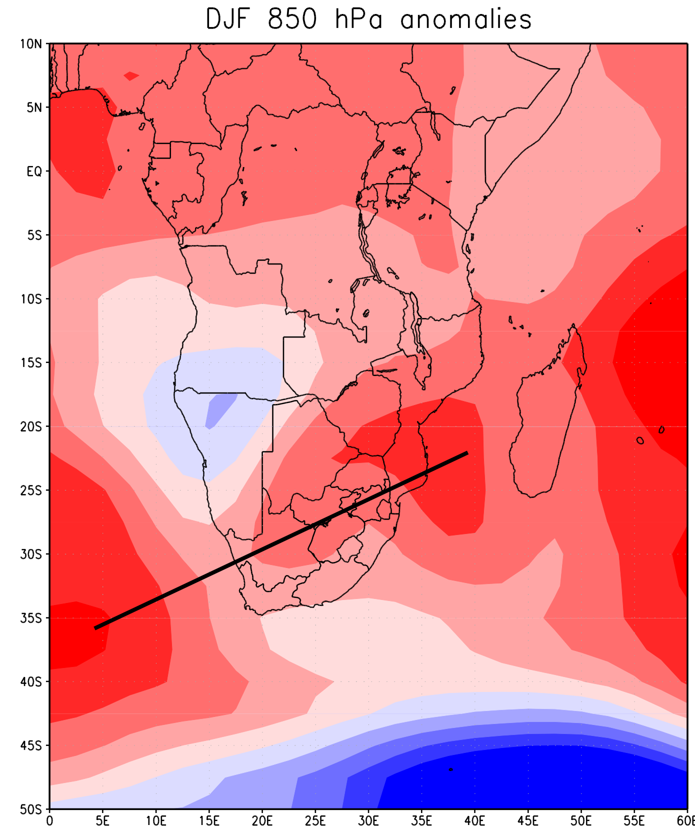
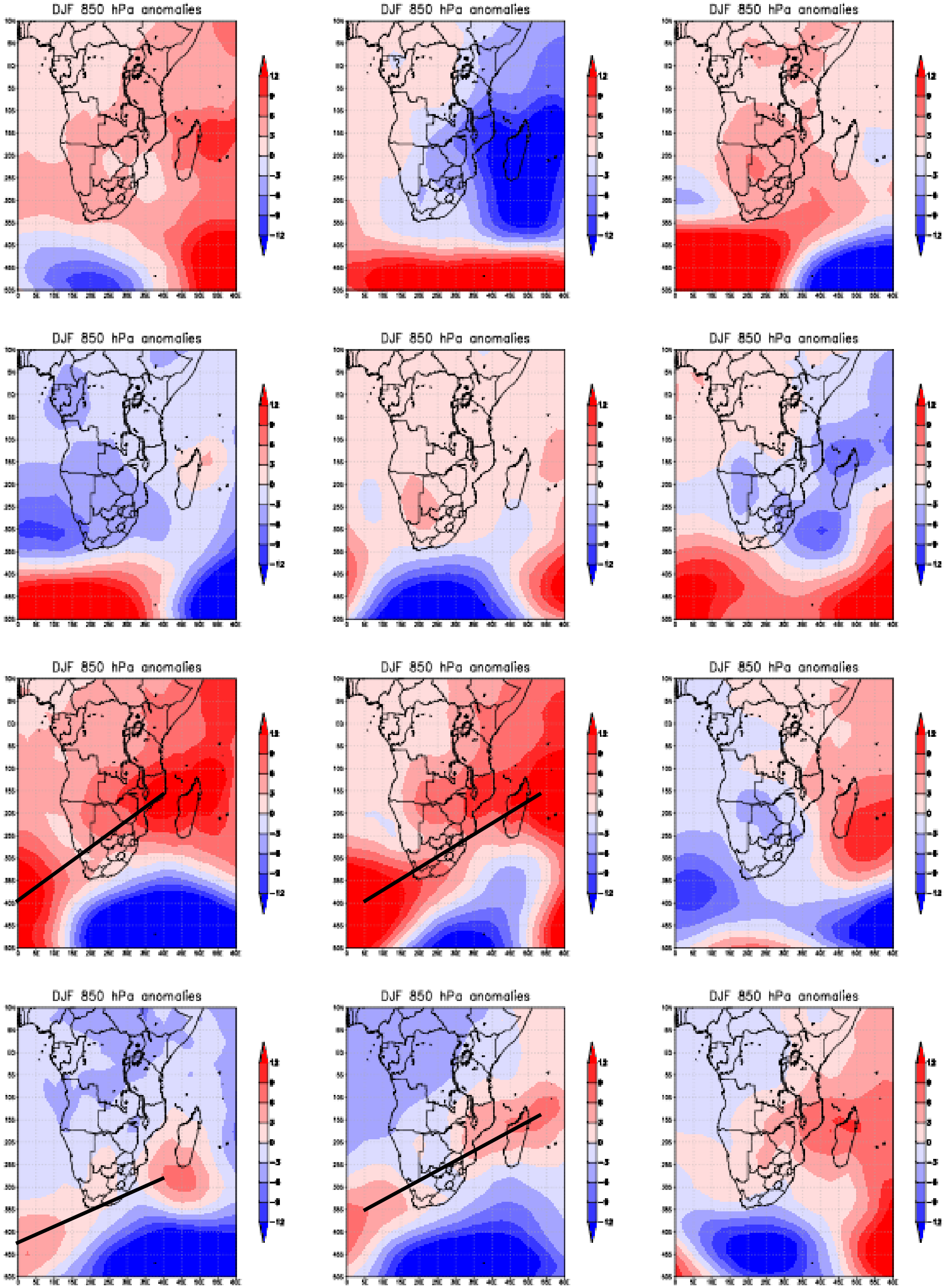
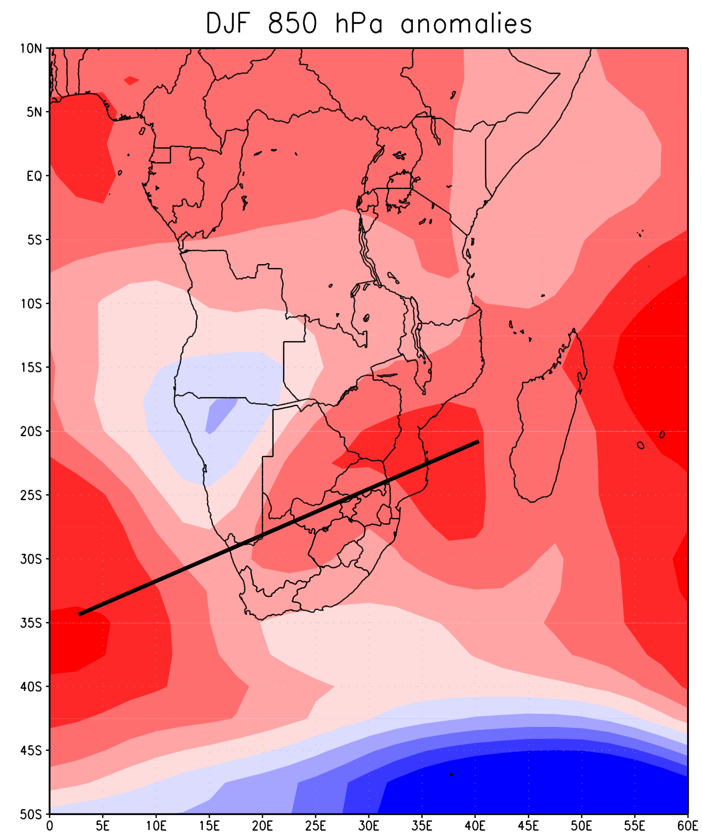


The “control” simulation (climatological ozone) fails to simulate the circulation anomalies of the 1997/98 El Niño (12 ensemble members)



“Ozone experiment”: Anomalous Antarctic stratospheric ozone concentrations may have contributed to the “normal rainfall” of the 1997/1998 El Niño over southern Africa





Conclusions

- **CCAM forced with observed time-varying ozone concentrations is capable of simulating the observed cooling trends in SH polar-cap stratospheric temperatures that have occurred over the last few decades**

- **Simulations of inter-annual variability are most skilful for DJF over southern Africa**

- **High-latitude tentacles of low predictability reach southern Africa during MAM, JJA and SON**

- **Inclusion of time-varying stratospheric ozone leads to a step-up change in DJF predictability – the ozone signal is seemingly sufficiently strong to overcome the westerly-wave chaos-barrier**

- **Further investigations with 72 level versions of CCAM and additional climate models to confirm this finding**