Impact of ENSO on Southern African Climate in CMIP5 coupled models

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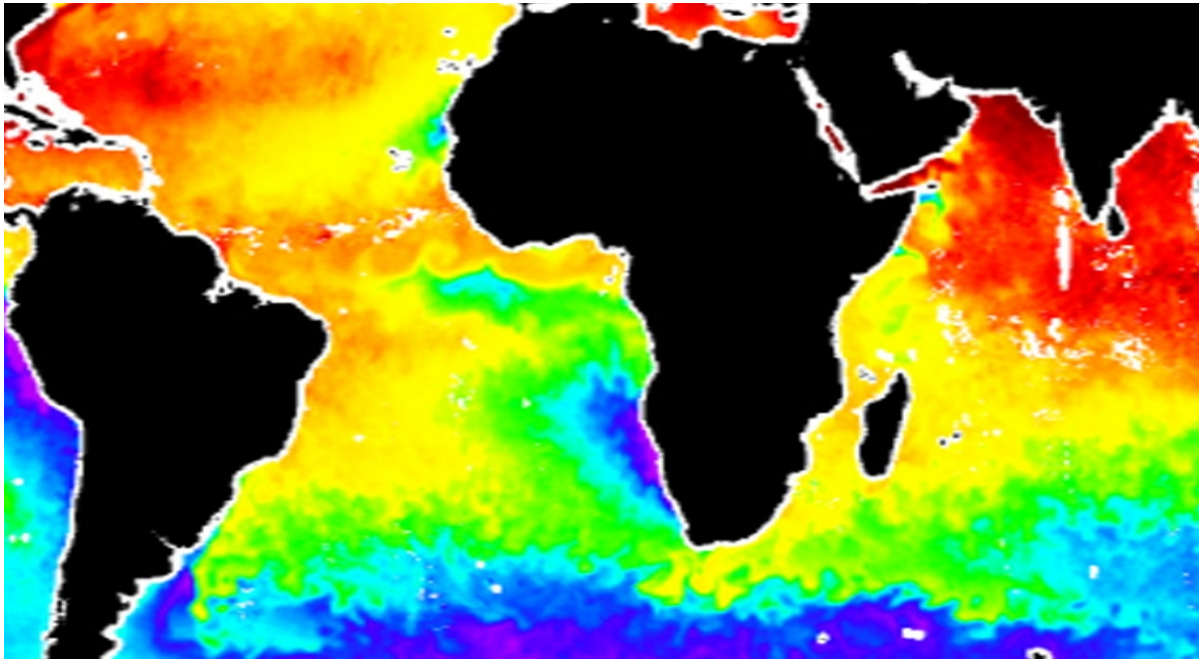
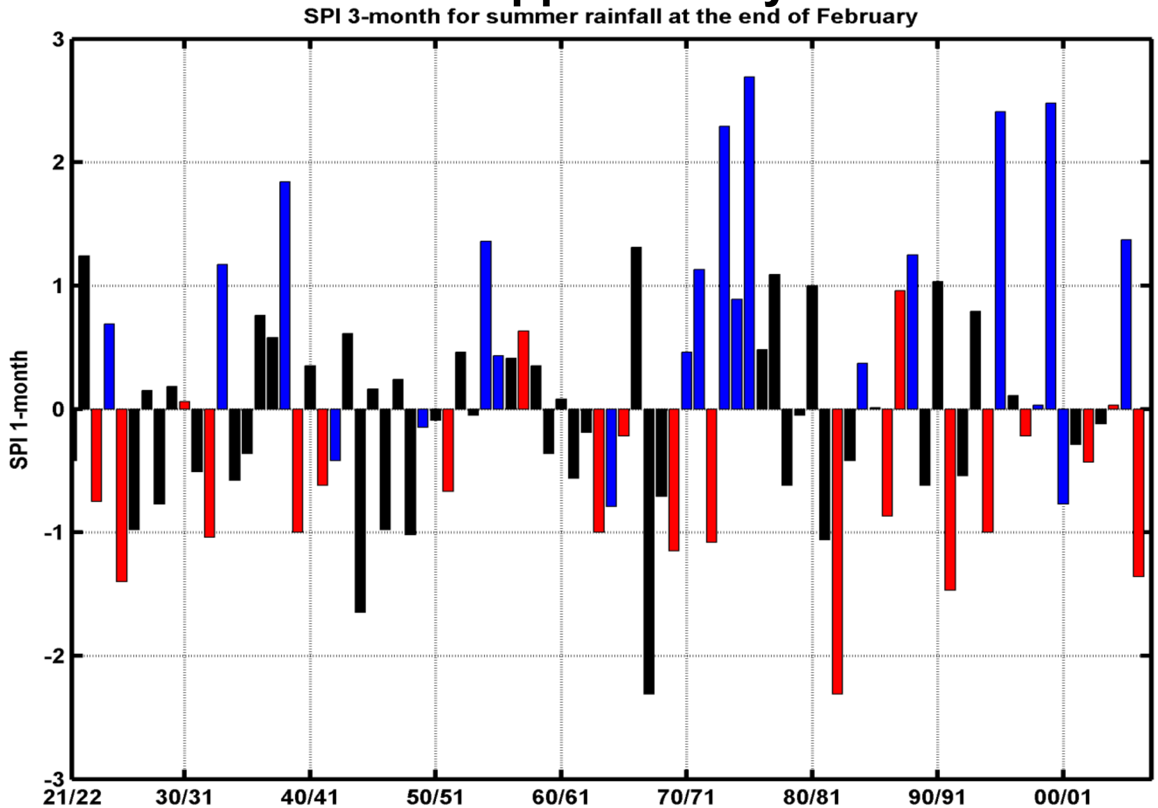


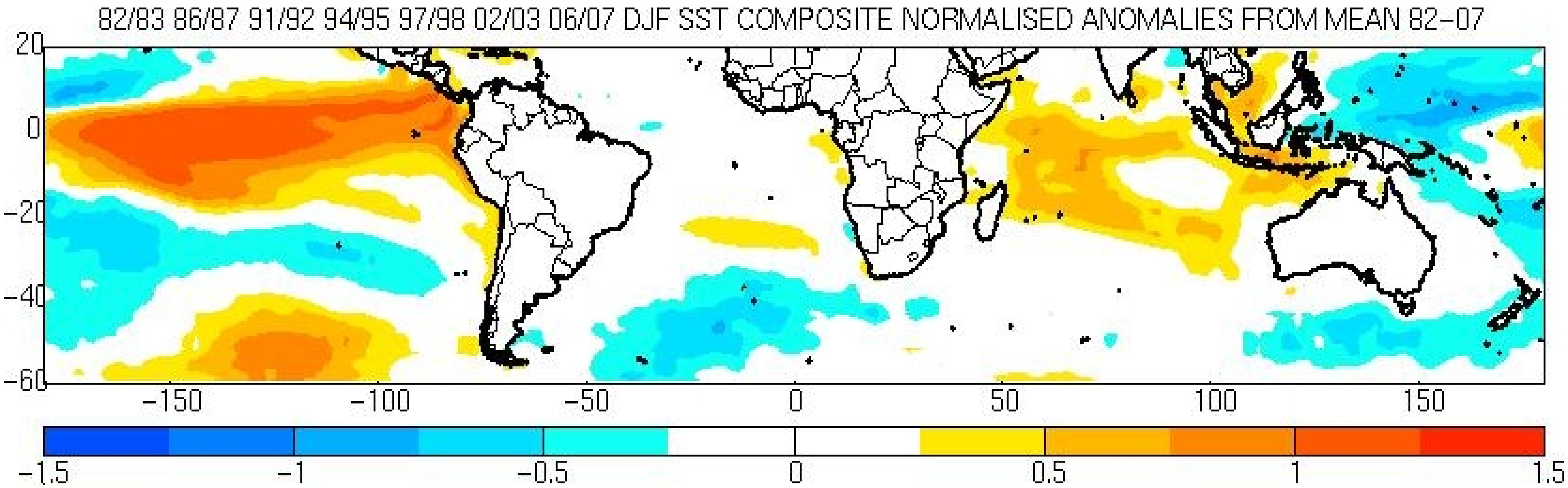
AMSR MICROWAVE SEA SURFACE TEMPERATURE ESTIMATE

Sponsor: Nansen-Tutu Center, ACCESS, NRF, WRC

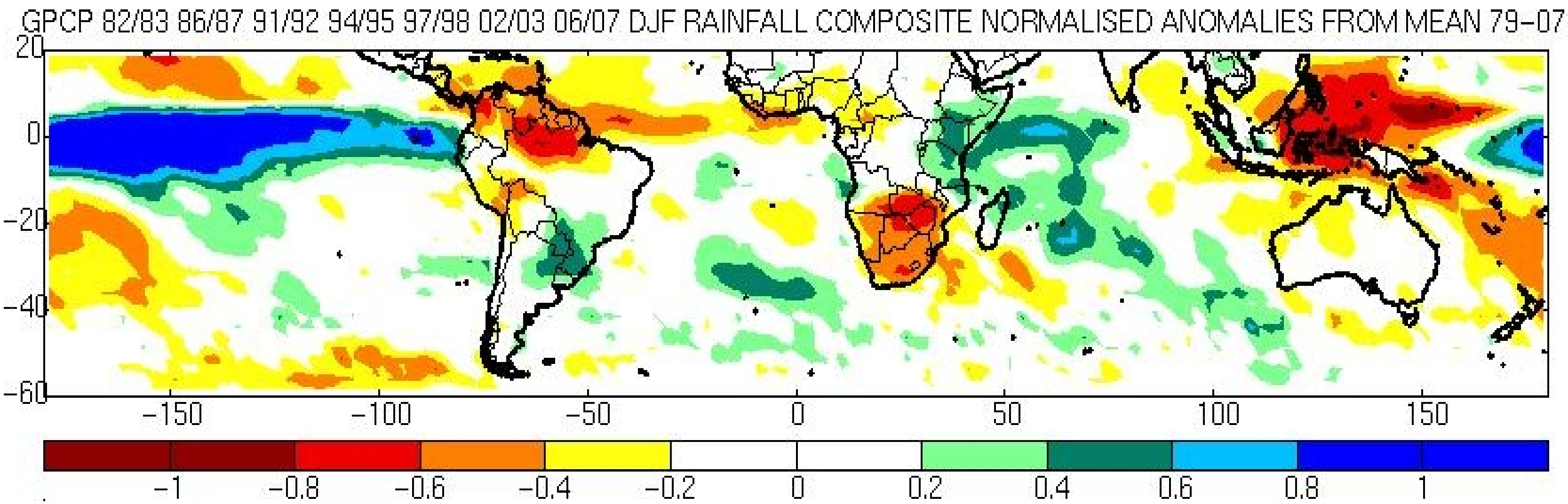
1. **Most but not all abnormal events occur during El Nino or La Nina**
2. **No relation between strength of ENSO and climate impact**
3. **This general caveat can be applied everywhere and for all parameters**



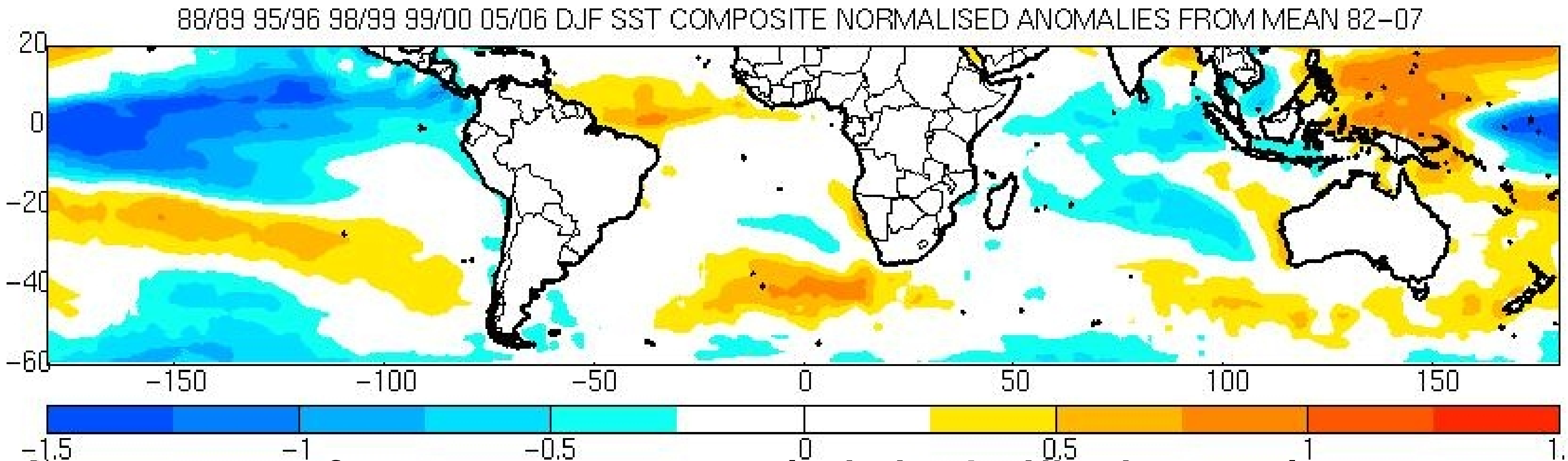
Summer (DJF) rainfall standard precipitation index (SPI) for South Africa summer rainfall region from 1921/1922 to 2007/2008. El Nino year are in red, La Nina in blue. Positive value is wetter than normal. Negative is dryer. Value between 1 and -1 occur 66 % of the time above or below one 17 % respectively (Rouault et al, 2003, 2005)



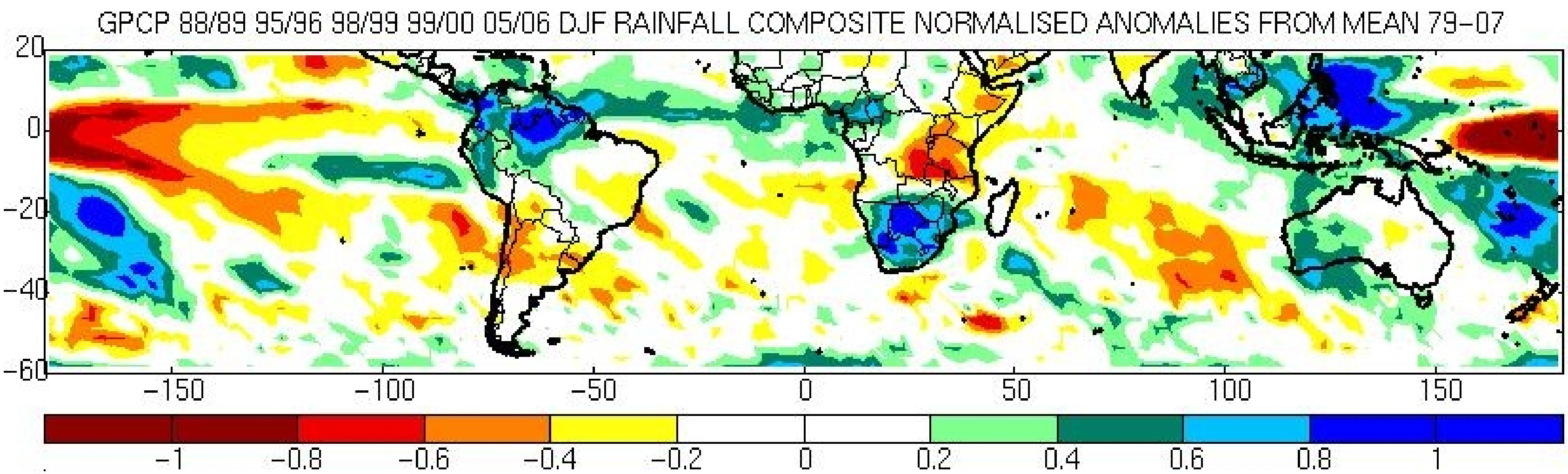
Average sea surface temperature anomaly during EL NINO in austral summer.



Average rainfall normalized anomaly (anomaly divided by standard deviation) during EL NINO in austral summer. Blue/green is wetter than normal, yellow/red is dryer than normal.



Average sea surface temperature anomaly during La Nina in austral summer.

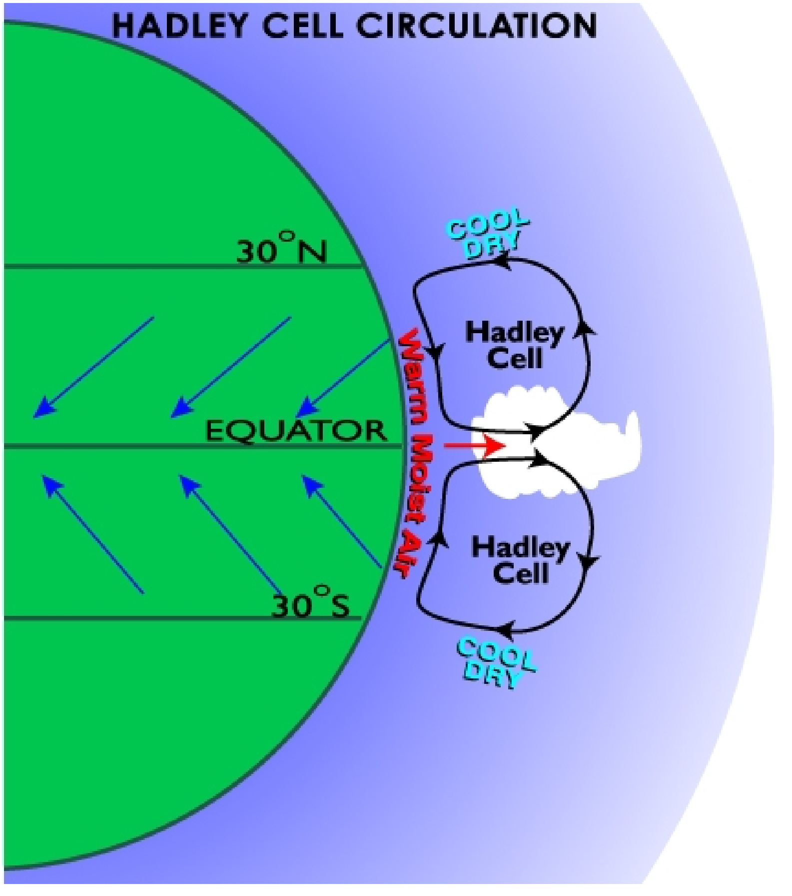


Average rainfall normalized anomaly (anomaly divided by standard deviation) during La Nina in austral summer. Blue/green is wetter than normal, yellow/red is dryer than normal.

Hadley circulation

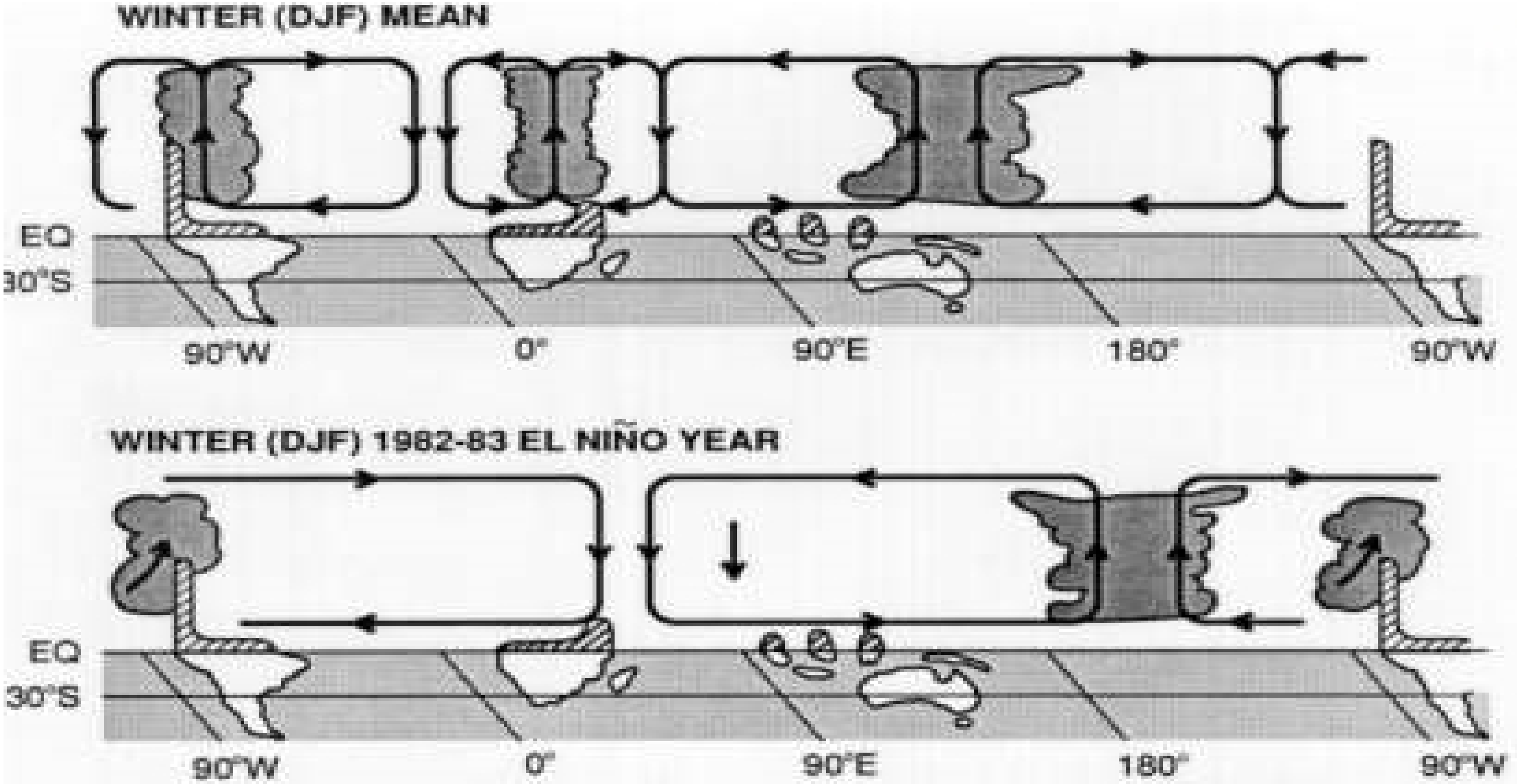
Warm air rises almost constantly around the Equator creating clouds and rain. Air is then moved polewards and sinks in the subtropics creating high pressure systems and trade winds. This also tends to prevent rainfall to occur.

A warming at the Equator would intensify that system. Warming (or cooling) occurs regularly during El Nino, La Nina or Indian Ocean Dipole explaining changes experienced from year to year.



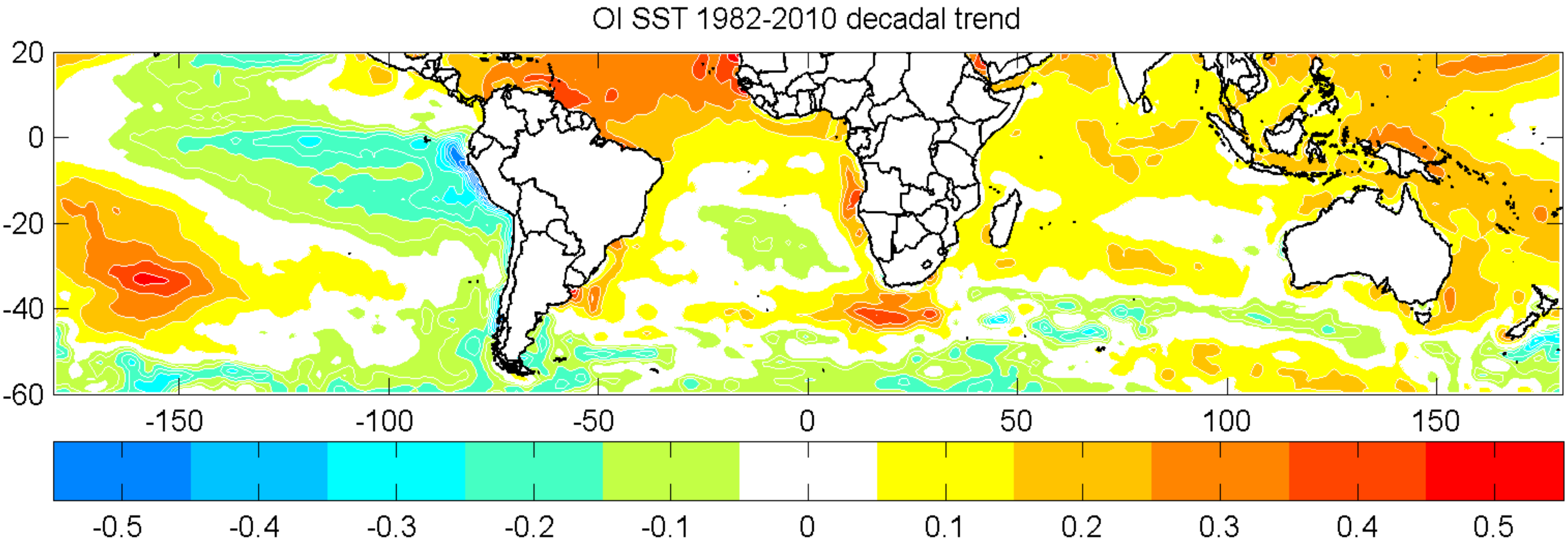
Courtesy W Ruddiman

Walker Circulation



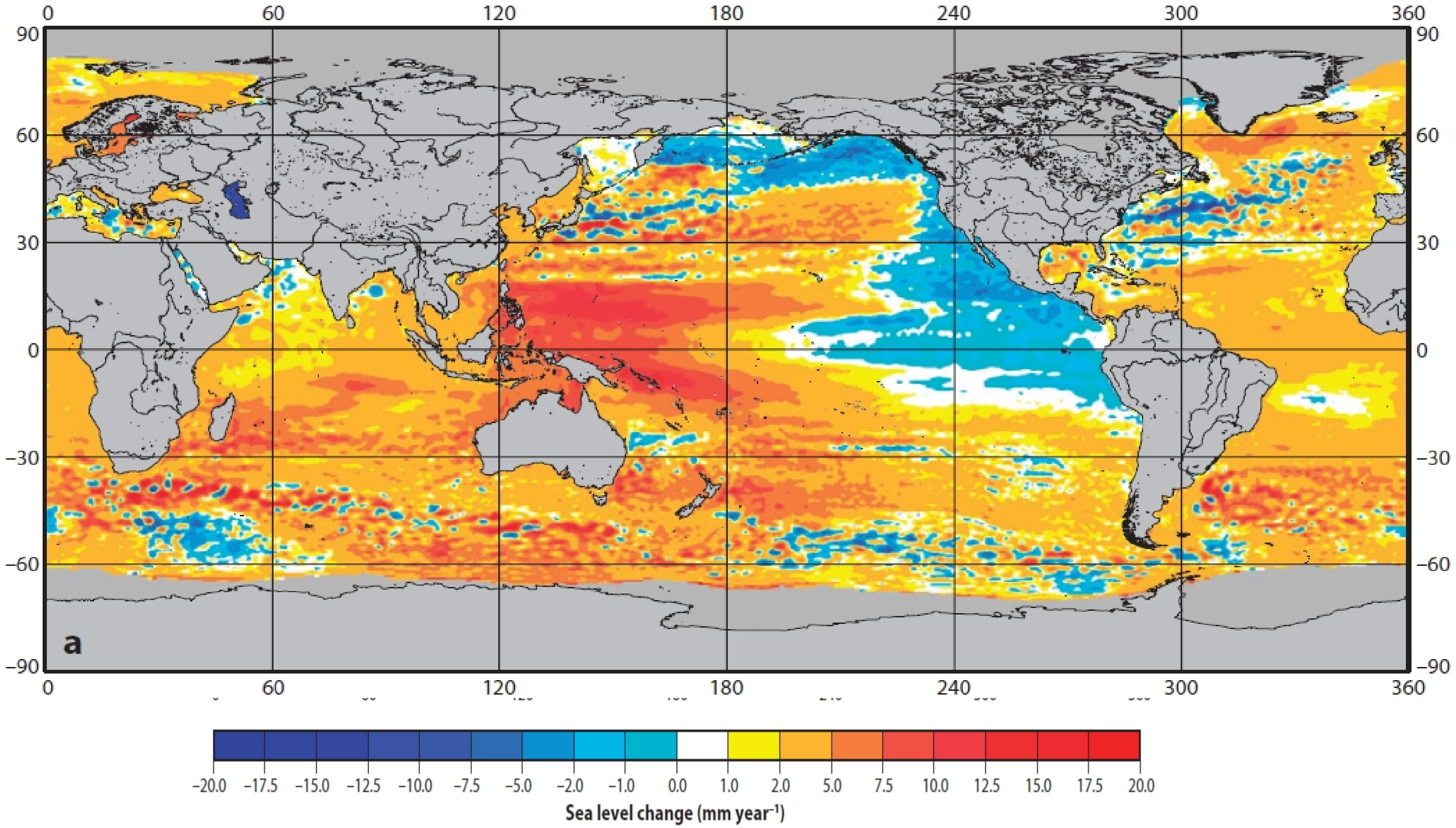
The Walker circulation is due to differences in temperature between ocean and land. During normal condition air rises above continent and descends above ocean but during El Nino this schema is perturbed. Both Hadley and Walker circulation explain why region of the world are remotely controlled by other regions or Oceans further away

Change in SST since 1982 in C per decade (10 years) using Optimally interpolated Reynolds SST. Combination of Satellite (AVHRR) and observations)



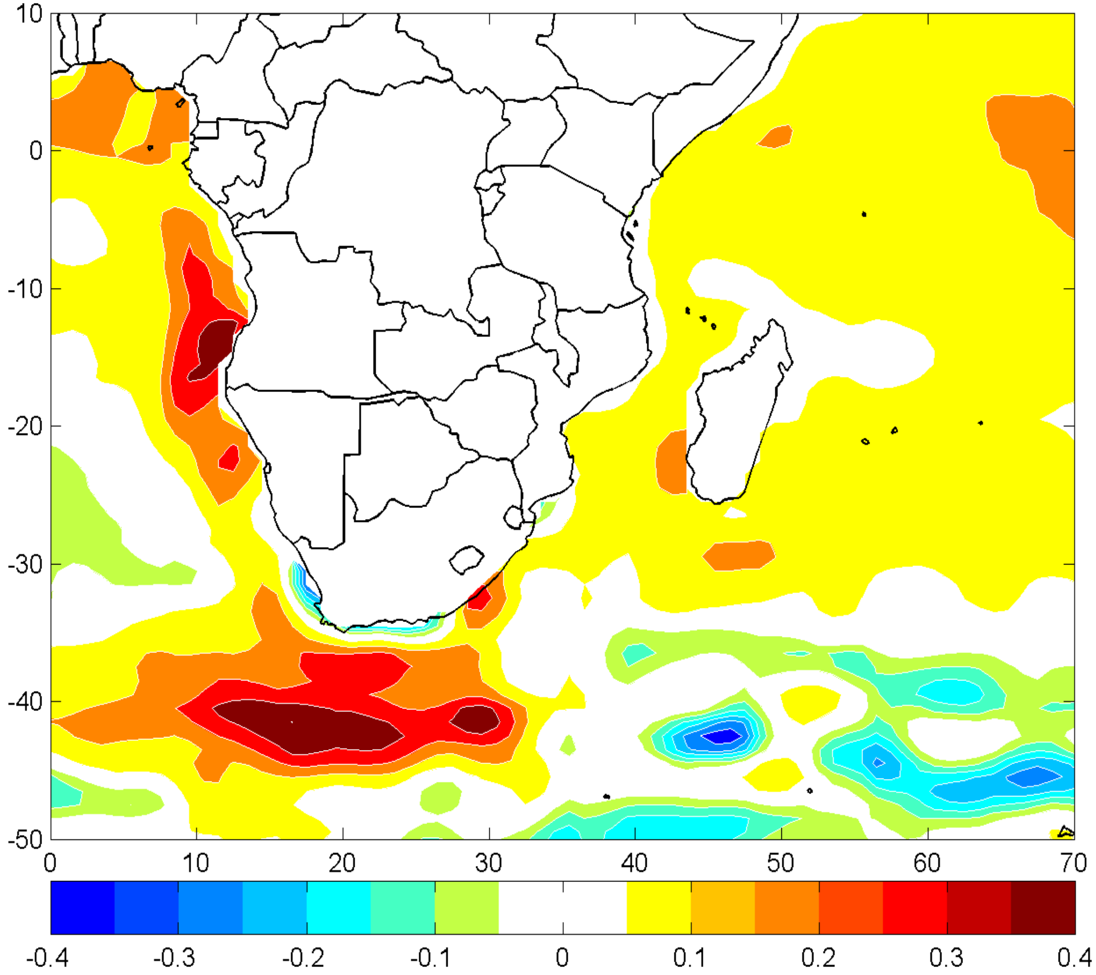
Over that last 30 years satellite remote sensing allows to cover most the ocean with high resolution. Here, linear trends in sea surface temperature shows that some regions have warmed up but some region have cooled down due for instance to stronger wind that have cooled the surface. The warming is clearly not uniform.

Sea level rise since 1992 observed globally by altimeter



Spatial trend of observed sea level between January 1993 and December 2008. Although the mean trend is 3.4 mm per year, it is clear that the rise is not uniform. Particularly a trend of up to 10 mm a year is apparent around the Indian Ocean Island (Cazenave and Llovel, 2010)

Linear trend in SST since 1982 in C per decade using 1x1 degree Reynolds SST



A zoom of the former graph shows that closer to Africa the Agulhas Current system has significantly warmed up by up to 1.5 °C since the 1980's.

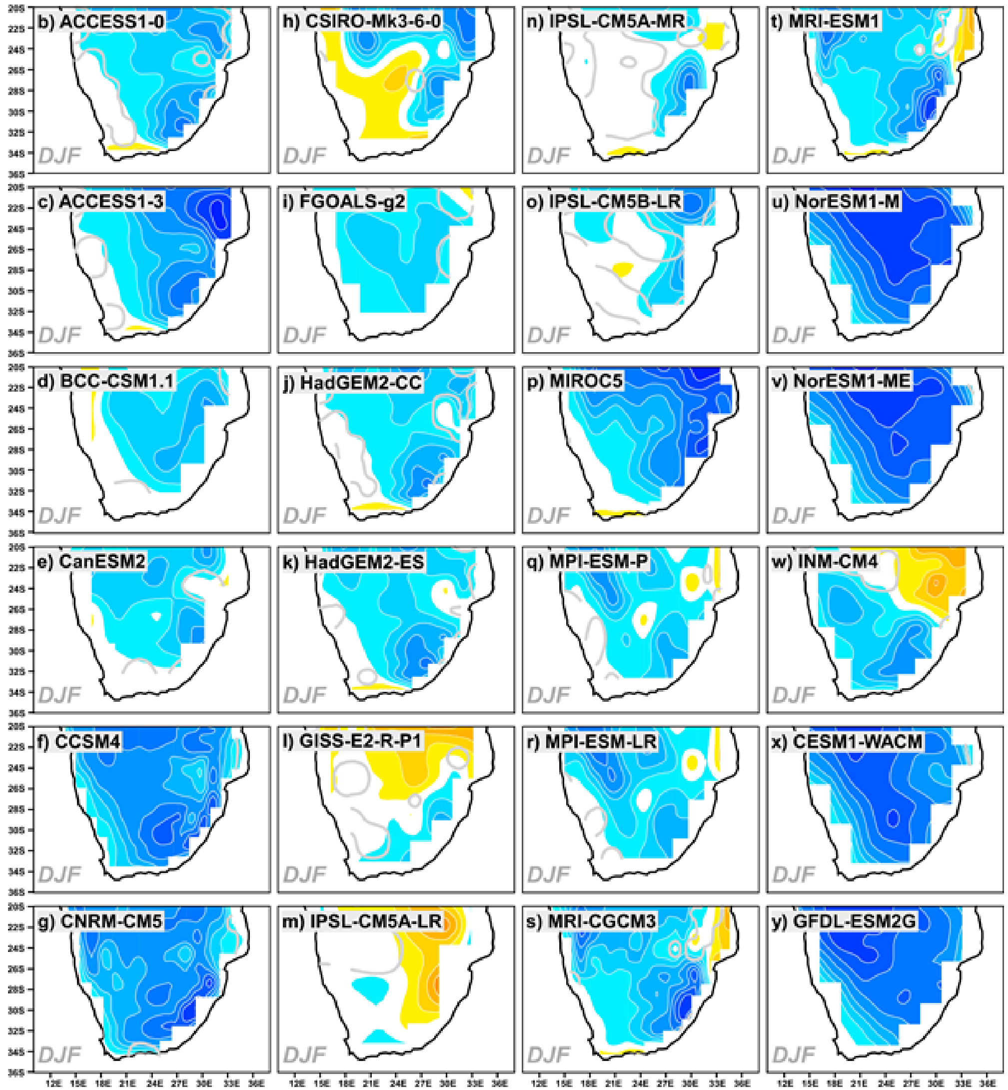
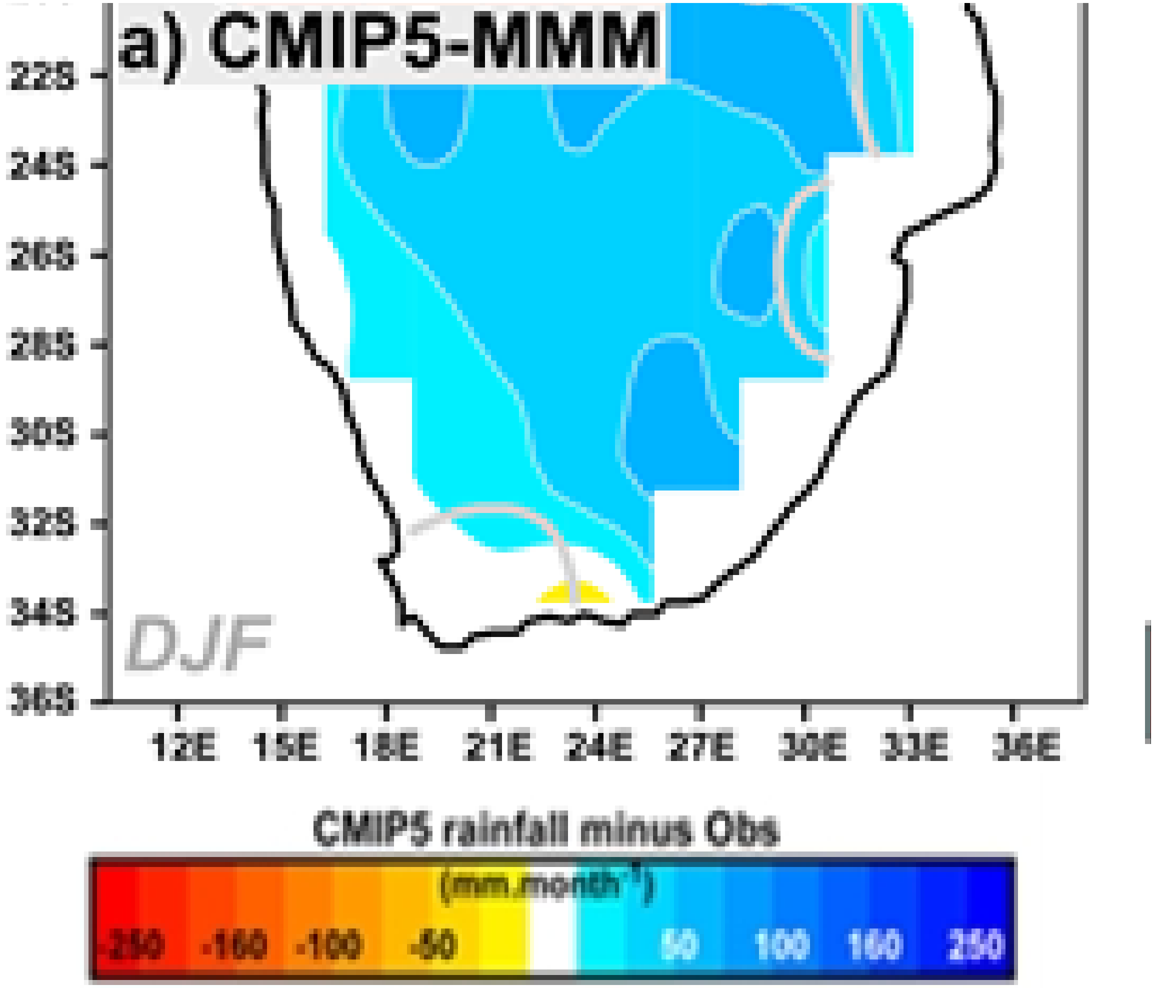


Figure 2. Summer-month (DJF) differences between simulated and observed rainfall fields (mm.month^{-1}) between 1950 and 2005 for the 24 individual models from CMIP5 experiments. The statistical significance of differences (grey contours) has been estimated using a Student t-test at p=0.05.



Summer-month (DJF) differences between simulated and observed rainfall fields (mm.month^{-1}) between 1950 and 2005 for the mean of 24 individual models from CMIP5 experiments.

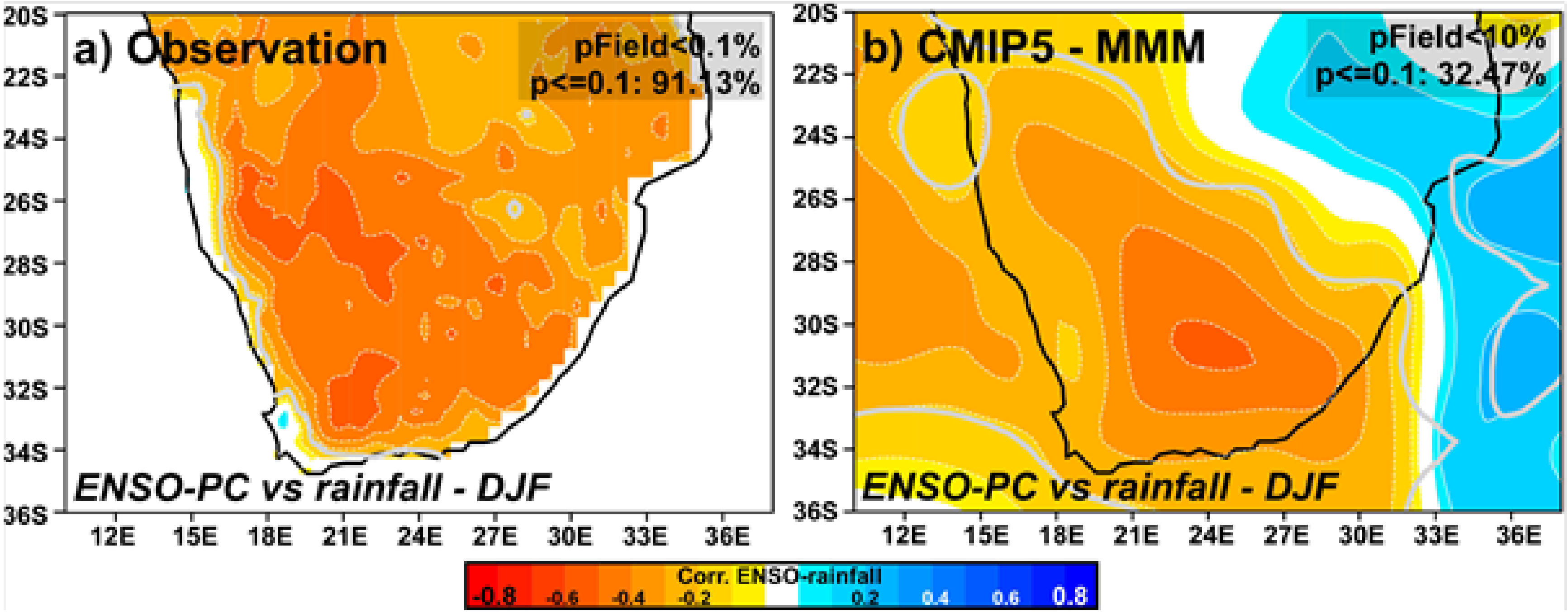


Figure 11. Observed and simulated summer-month correlations between ENSO components and South African rainfall. (a) Summer-month pointwise correlation between the ENSO component extracted by EOF and South African rainfall in the observation. (b) Idem for the CMIP5-MMM. Grey contours indicate the 90% confidence level of Pearson's product moment correlation coefficient assuming independent normal distributions.

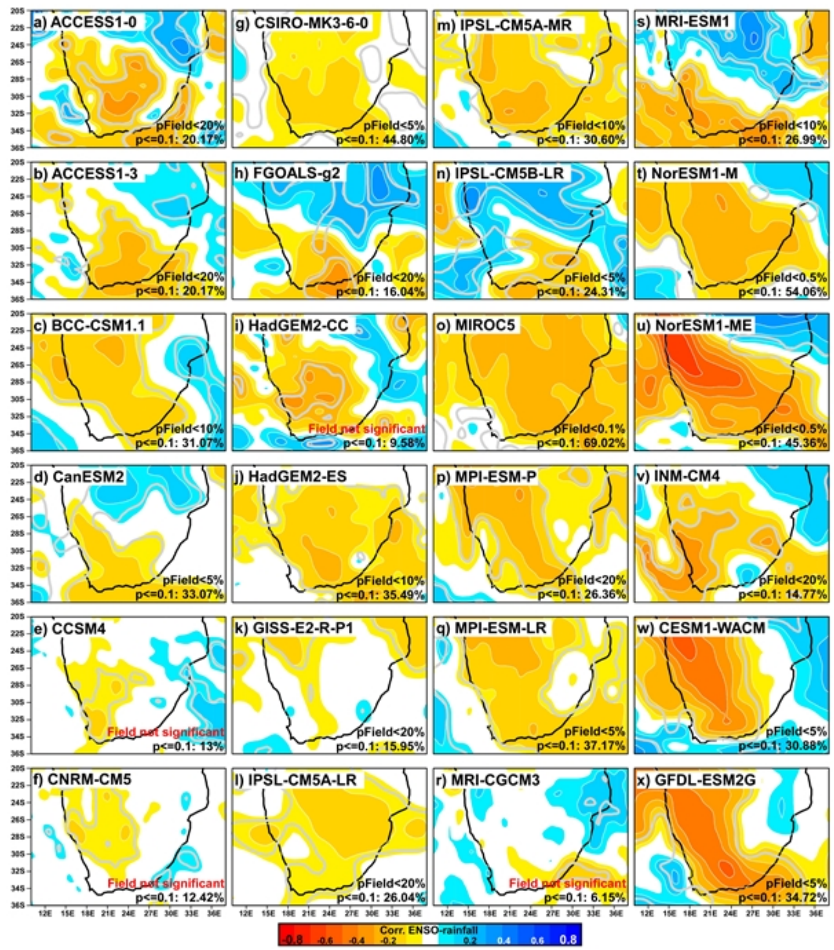


Figure 12. Simulated summer-month correlations between ENSO components and South African rainfall. (a-x). Summer-month pointwise correlation between the ENSO component extracted by EOF and South African rainfall in the individual models from CMIP5 experiments. Grey contours indicate the 90% confidence level of Pearson's product moment correlation coefficient assuming independent normal distributions.

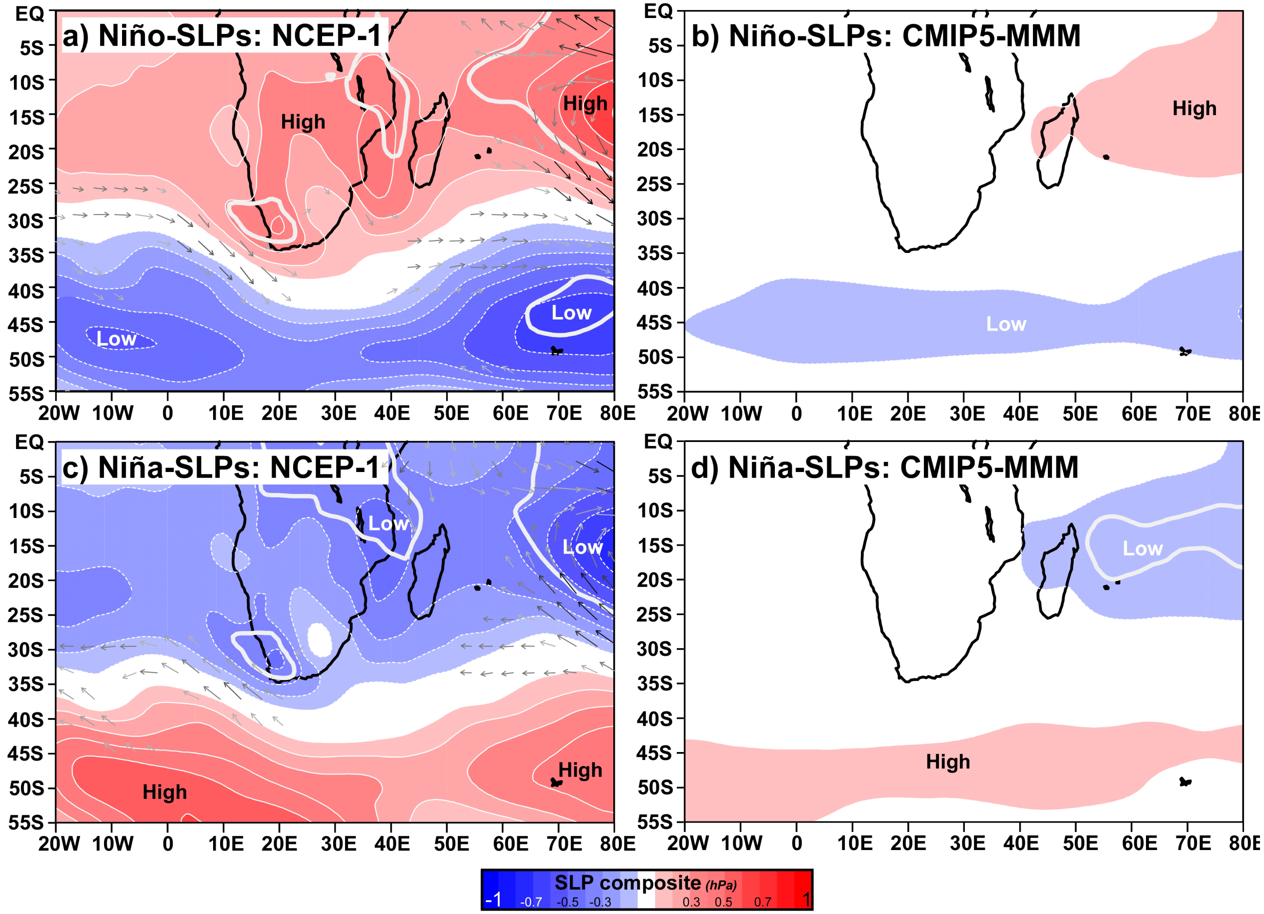


Figure 13. Observed and simulated El Niño/La Niña summer anomalies of the surface atmospheric circulation near South Africa. Top. El Niño composite anomalies (i.e., ENSO-PC>0.01) of SLPs (in hPa) in (a) the NCEP-1 reanalysis and in (b) the CMIP5-MMM. Bottom. (c-d). Idem for La Niña composite anomalies (i.e., ENSO-PC<-0.01). Wind anomalies (vectors, m.s^{-1}) are only displayed for the NCEP-1 reanalysis.

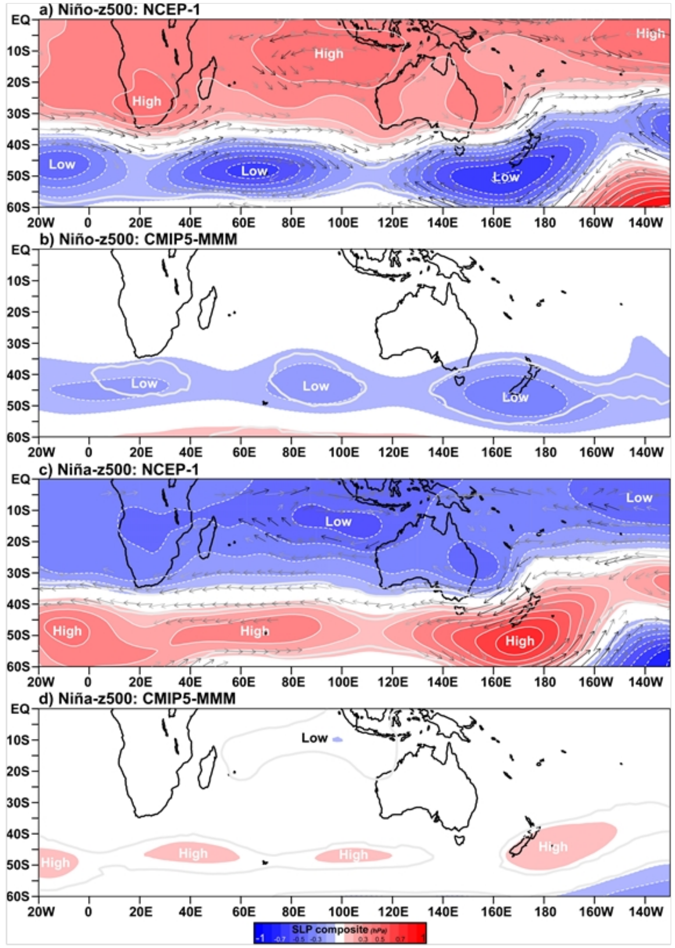


Figure 16. Observed and simulated El Niño/La Niña summer anomalies of mid-troposphere atmospheric circulation over the southern hemisphere. Top. El Niño composite anomalies (i.e., ENSO-PC>0.01) of z500 (in m) in (a) the NCEP-1 reanalysis and in (b) the CMIP5-MMM. Bottom. (c-d). Idem for La Niña composite anomalies (i.e., ENSO-PC<-0.01). Wind anomalies (vectors, m.s^{-1}) are only displayed for the NCEP-1 reanalysis.

Conclusion

- Relative success in reproducing the ENSO/Southern African Climate relationship
- No consensus between model on the future of EL NINO
- Improvement of coupled model needed
- Get ready for the next drought, it will happen anytime soon
- Chance of drought increases during El Nino