Understanding the large scale driving mechanisms of rainfall variability over central Africa

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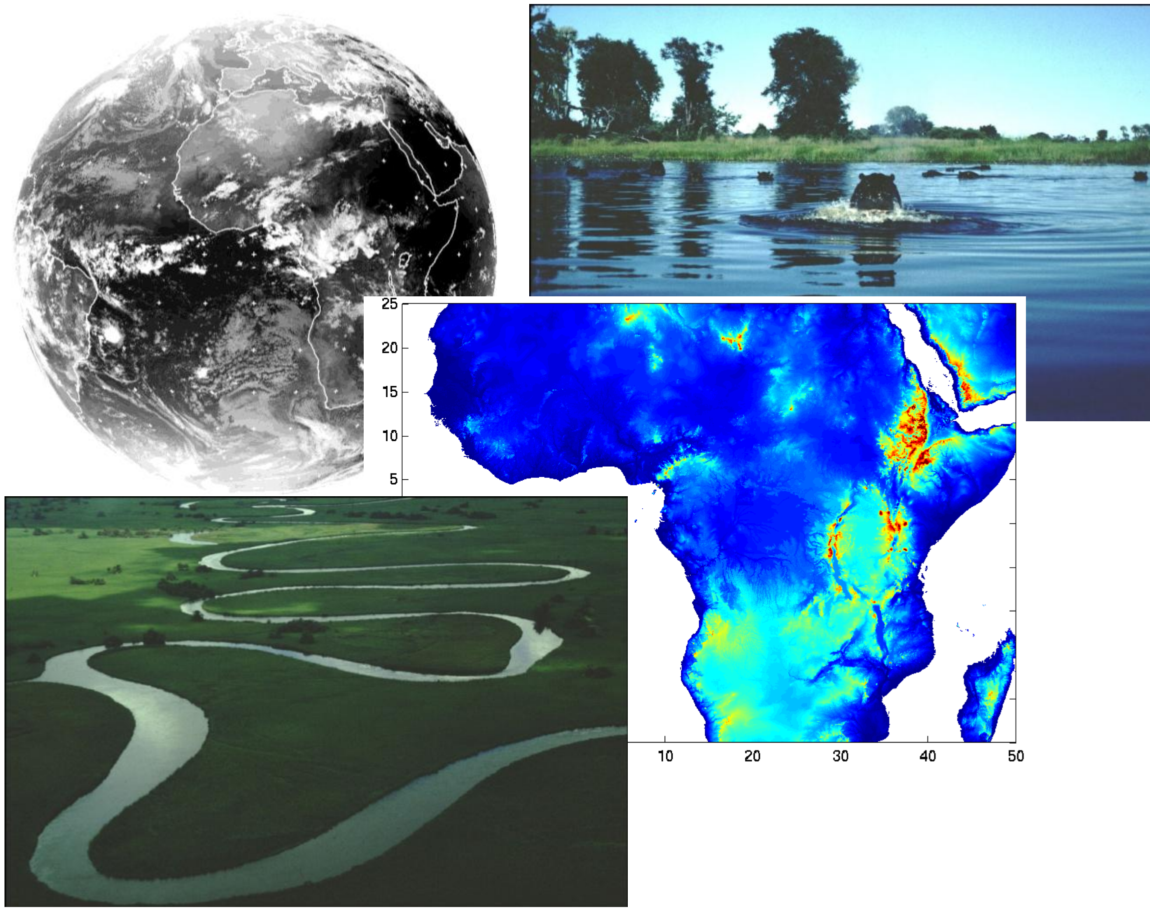

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Outline

- Introduction and background
- Aims and objectives
- Rainfall variability
- Composite analysis
- Summary

Introduction and background

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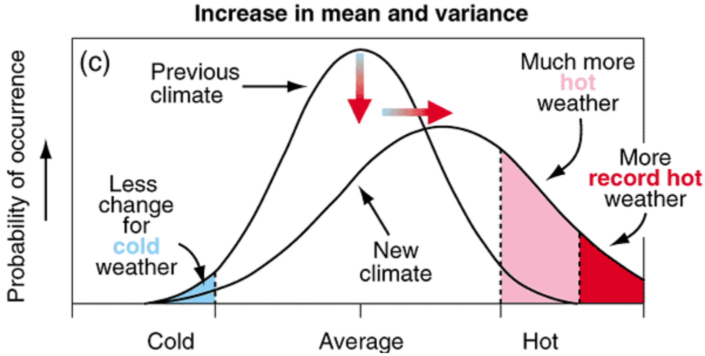
- Well-established that climate change will significantly alter climatic variability, as well as mean climate

- Changes in climate variability = changes in extreme climate events e.g. increasing frequency of flooding, drought, etc – likely to be of far more significance for environmentally vulnerable regions e.g. Africa



- Especially problematic here because of
  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

- In particular, central Africa has often been neglected, relative to other regions, despite having a complex climate with many different yet related factors influencing rainfall variability

- Covering an area roughly 2.6% of the planet and with an estimated population of ~119 million (rising to over ~252 million by 2050), the pressures upon this system will only increase. It is thus essential to understand the region's climate, its rainfall variability, and associated atmospheric, oceanic and land surface processes

Aims and objectives

Overall goal

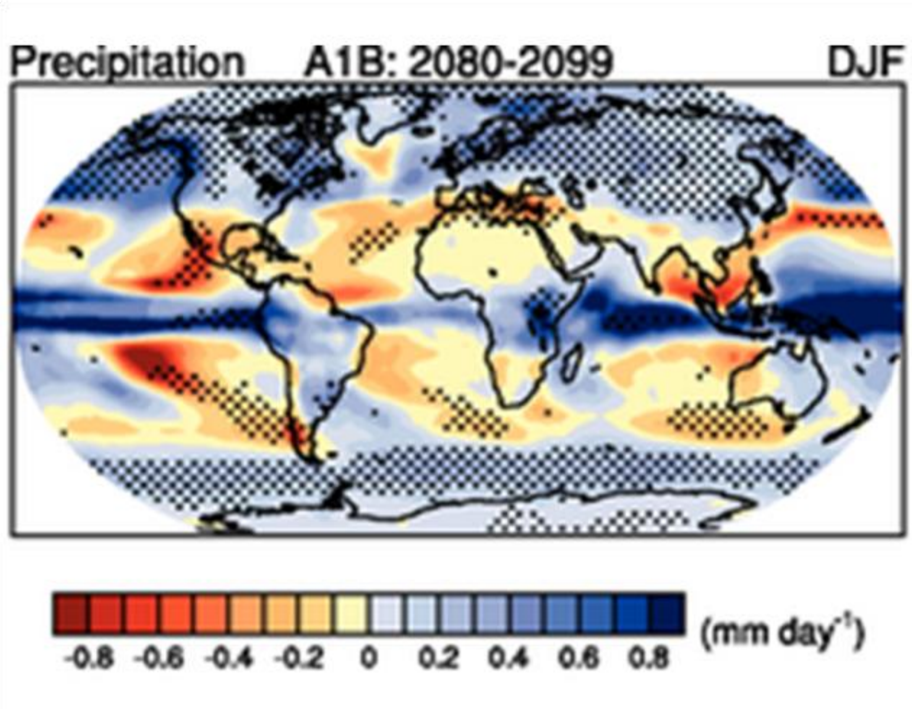
- Address the lack of understanding of climatic processes controlling rainfall variability in the region, including atmospheric, oceanic and land surface interactions, leading to improvements in seasonal forecasting and, ultimately, an increase in the social, economic and environmental well-being of African society

Specific objectives of this study

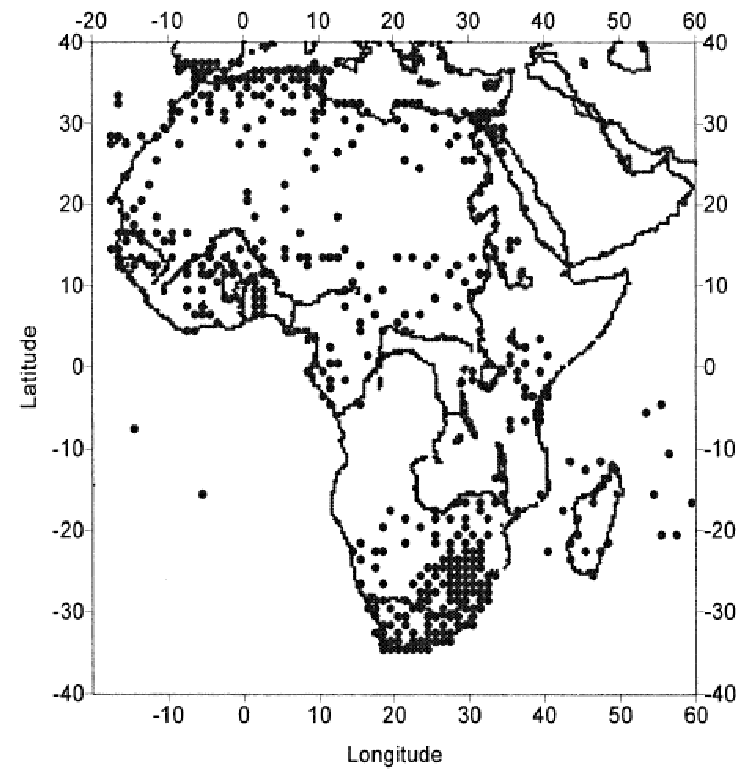
- Understand climate, in particular rainfall, variability over central Africa
- Investigate larger scale mechanisms controlling rainfall variability
- Assess the influence of regional and global teleconnections on the region

2 major challenges for climate (especially rainfall) work over Africa:

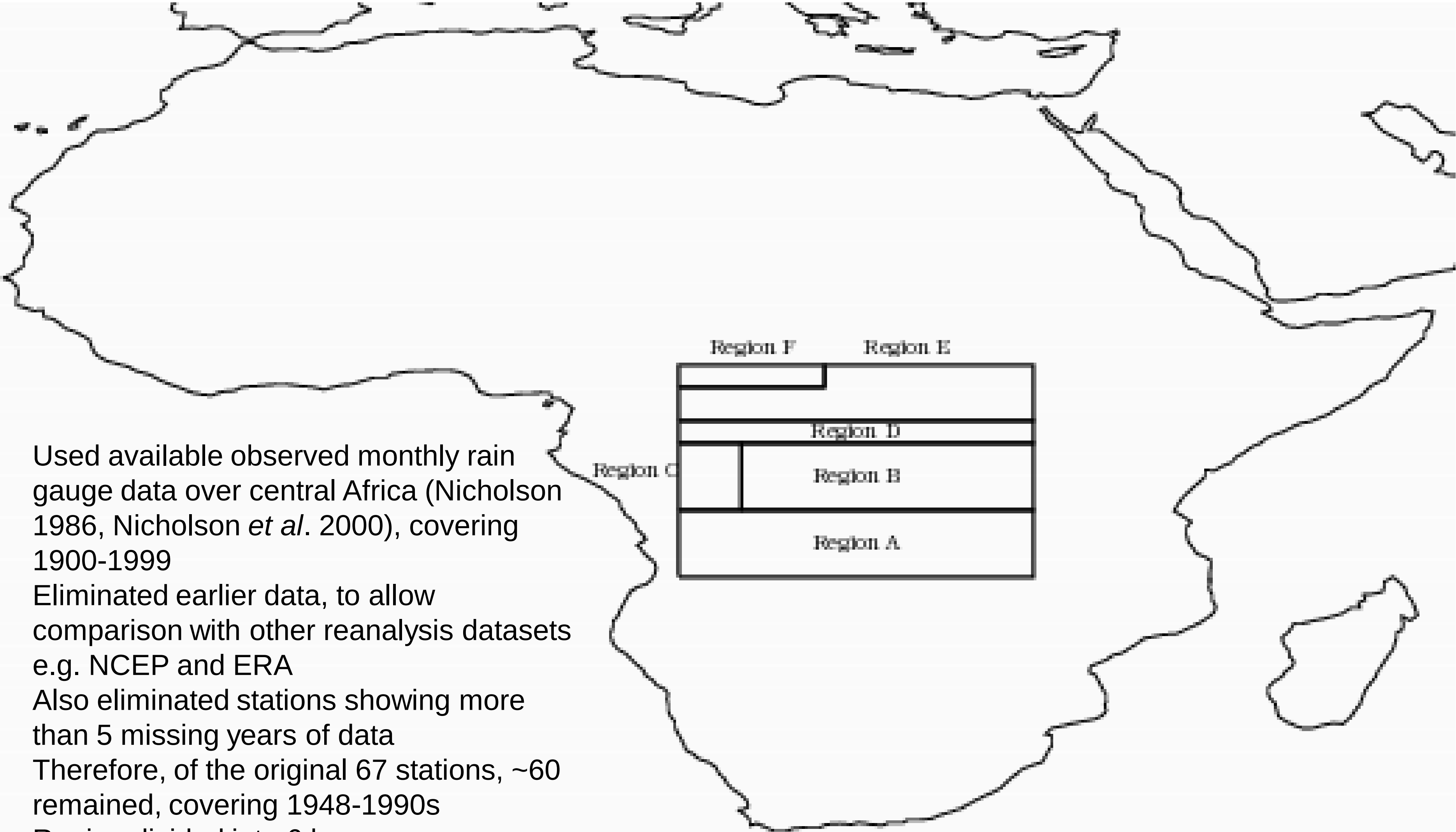
Challenge 1: Uncertainty from climate models – lack of agreement between models of sign, let alone magnitude, of potential future climate change



Challenge 2: Uncertainty from limited understanding of climate - lack of observational data, e.g. sparse GTS coverage

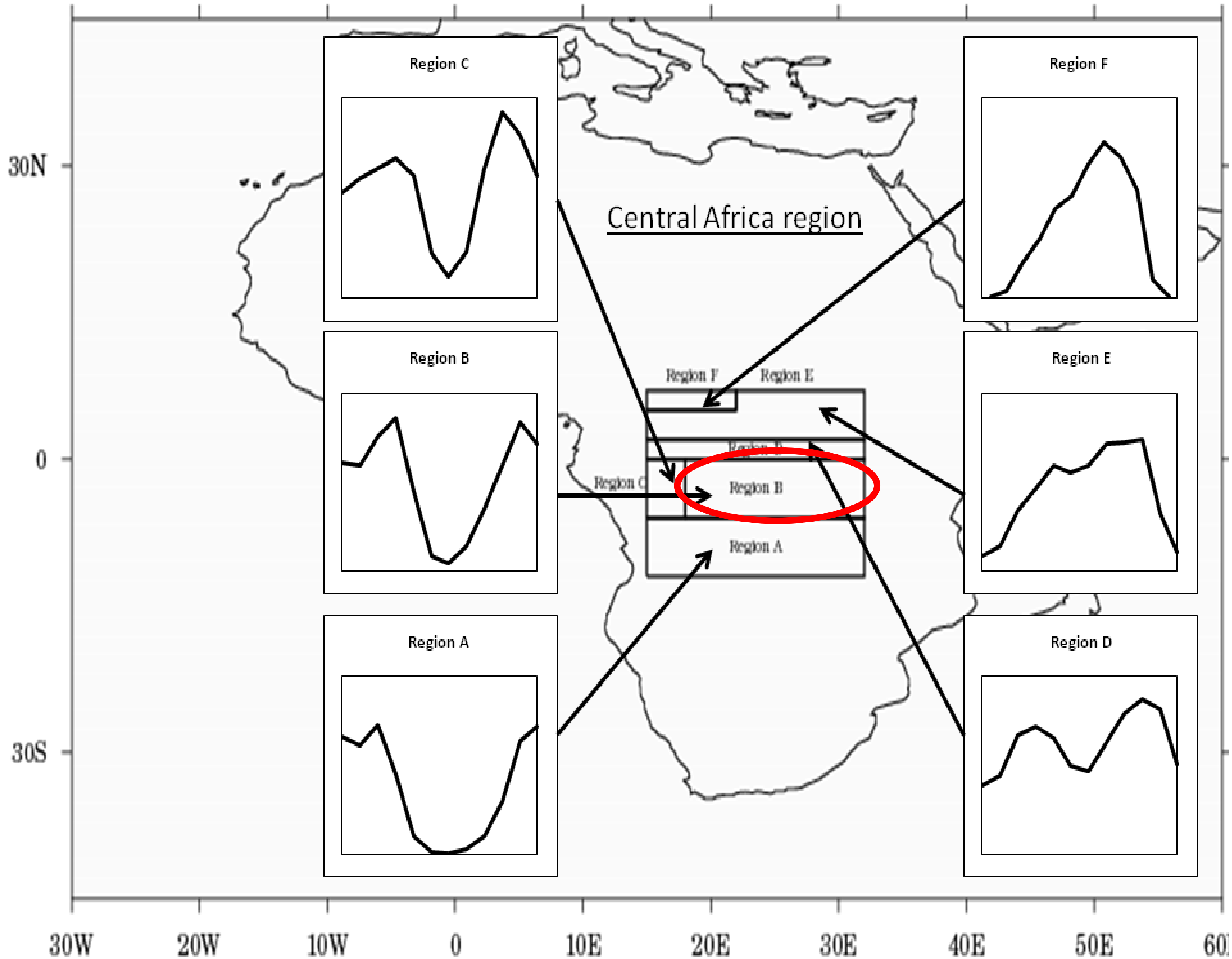


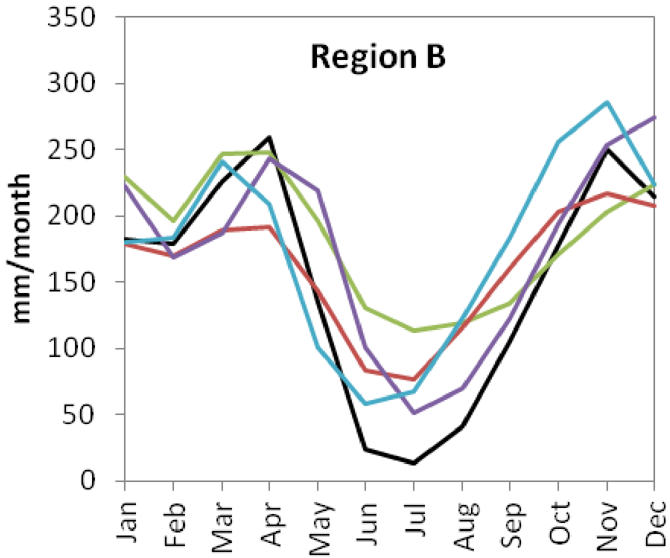
Rainfall variability



- Used available observed monthly rain gauge data over central Africa (Nicholson 1986, Nicholson *et al*. 2000), covering 1900-1999
- Eliminated earlier data, to allow comparison with other reanalysis datasets e.g. NCEP and ERA
- Also eliminated stations showing more than 5 missing years of data
- Therefore, of the original 67 stations, ~60 remained, covering 1948-1990s
- Region divided into 6 homogenous zones, based on the seasonal rainfall cycle from each (from Balas *et al*. 2007)

Balas, N. *et al*. (2007). *Int. J. Climatol.* **27**: 1335-1349
Nicholson, S. (1986). *J. Clim & App Met*. **25**:1365-1381
Nicholson, S. *et al*. (2000). *J Clim.* **13**: 2628–2640


Central Africa region
Region C
Region B
Region A
Region F
Region E
Region D
Region F
Region E
Region C
Region B
Region A
30N
0
30S
30W
20W
10W
0
10E
20E
30E
40E
50E
60

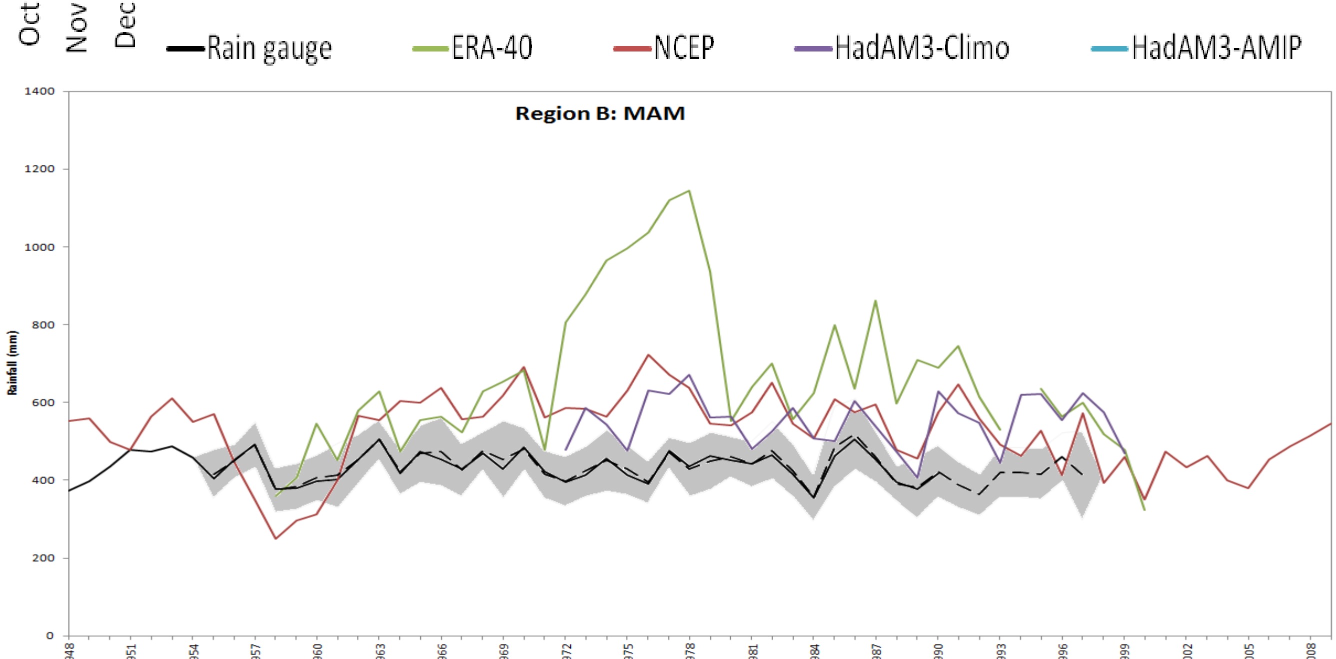


All datasets overestimate annual cycle of rainfall, relative to rain gauges, particularly HadAM3

Nevertheless, all datasets get bimodal distribution of rainfall, and get both timing and magnitude of wet and dry seasons roughly correct

For this region and season, uncertainty of rain gauge observations is low

Datasets show some agreement through time, despite some obvious errors



Composite analysis

- Monthly rainfall then averaged spatially over each region, and temporally for each year – years then ranked according to rainfall amount
- 5 wettest years and 5 driest years identified
- Composite analysis using NCEP-NCAR reanalysis data then undertaken using these wet and dry years, to investigate larger-scale atmospheric and oceanic processes associated with these years
- Wet and dry years compared to 1968-1996 climatology

Wet years	Dry years
1963	1949
1975	1955
1982	1958
1986	1993
1995	1996

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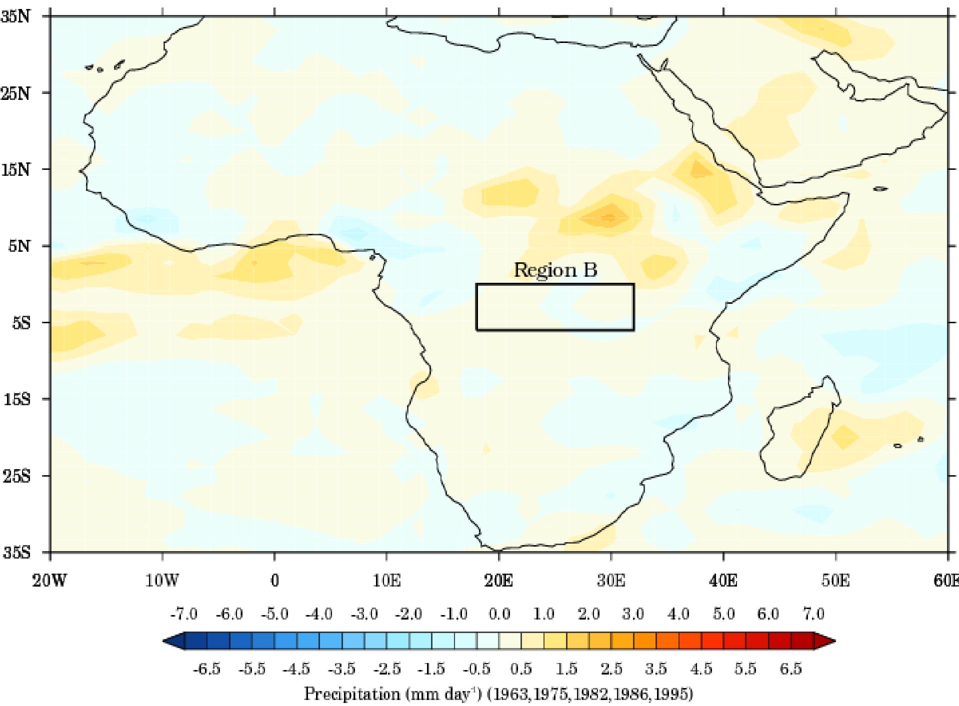
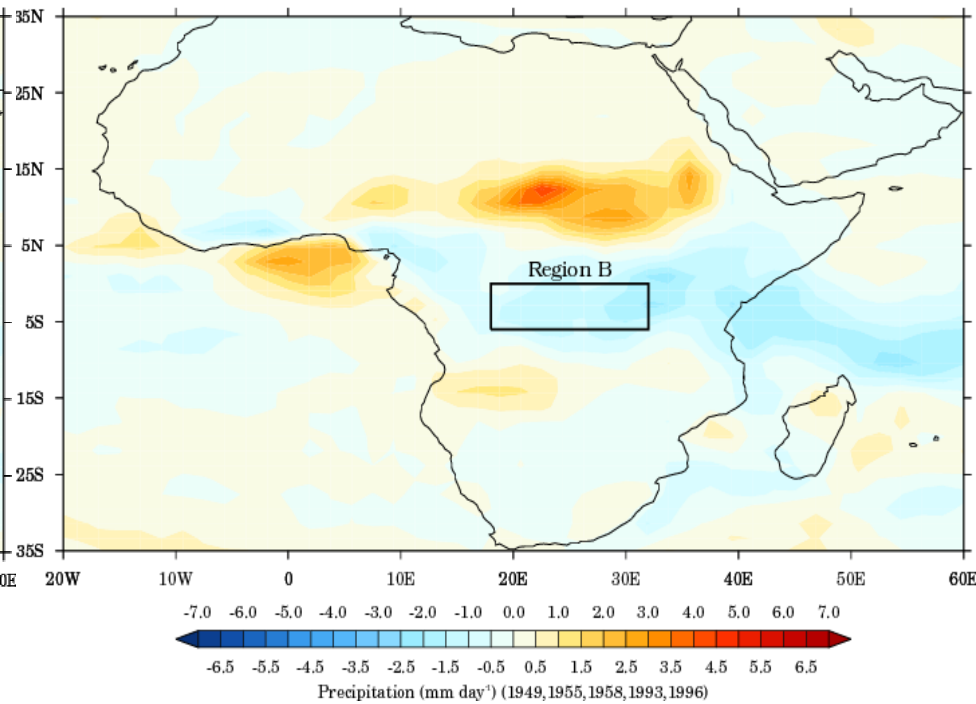
Near surface precipitation anomalies

Wet years



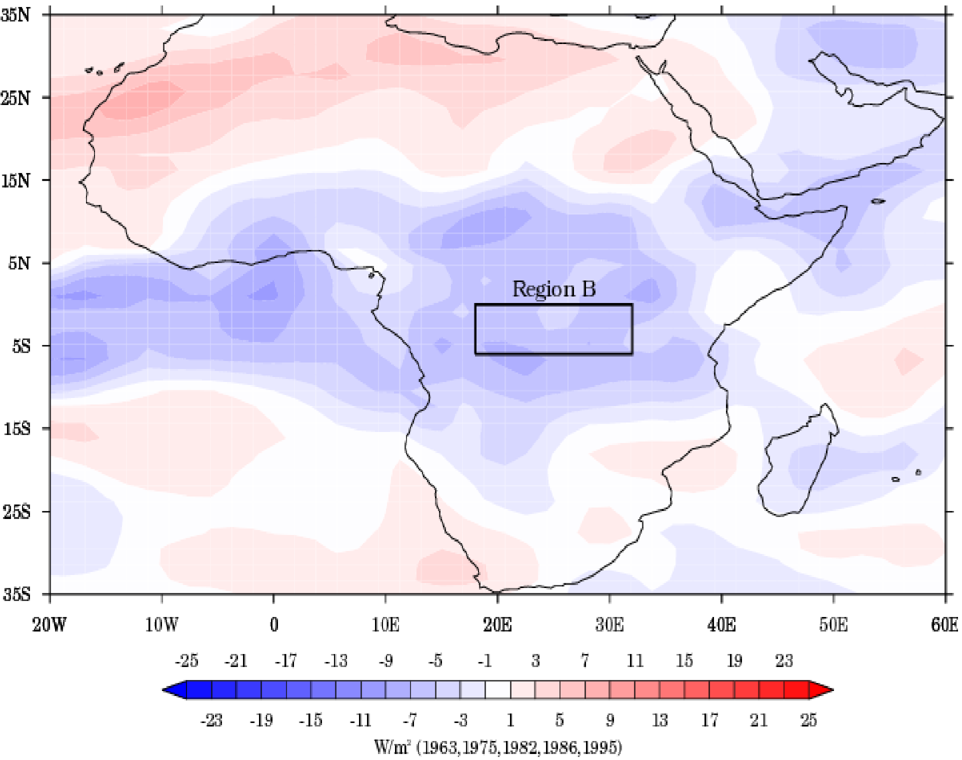
Dry years



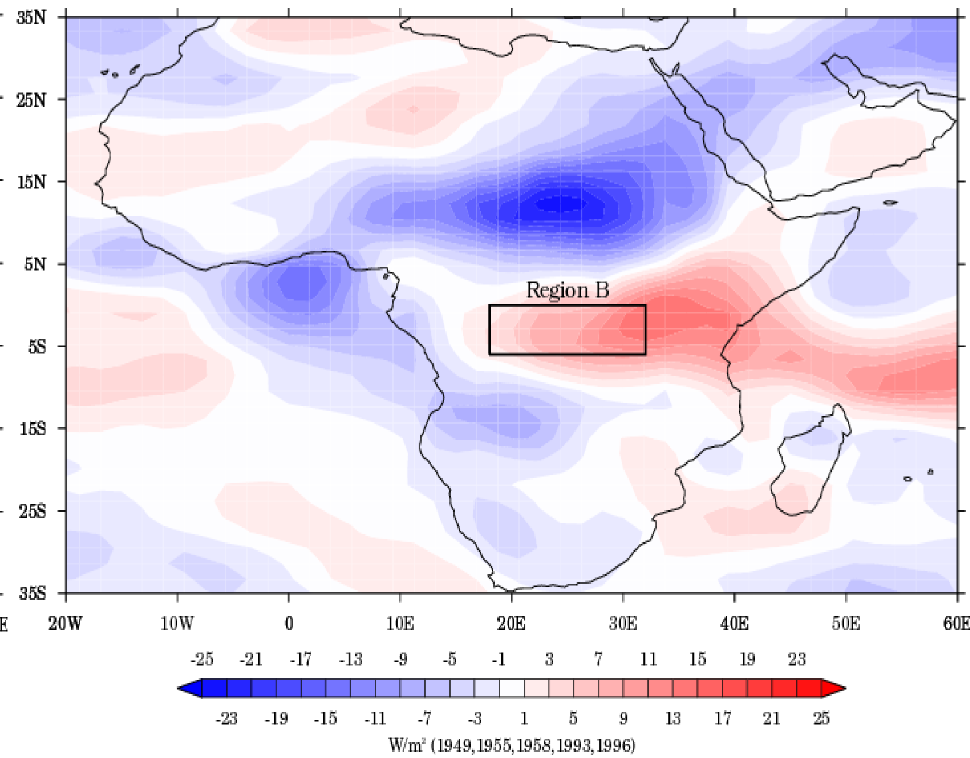
As expected, large area of negative precipitation anomalies (i.e. reduction in rainfall) over region during 5 driest years. Less obvious signal during 5 wettest years, with only small positive precipitation anomalies – possibly indicative of NCEP's known difficulties in reproducing observed rainfall over Africa

Near surface OLR anomalies

Wet years



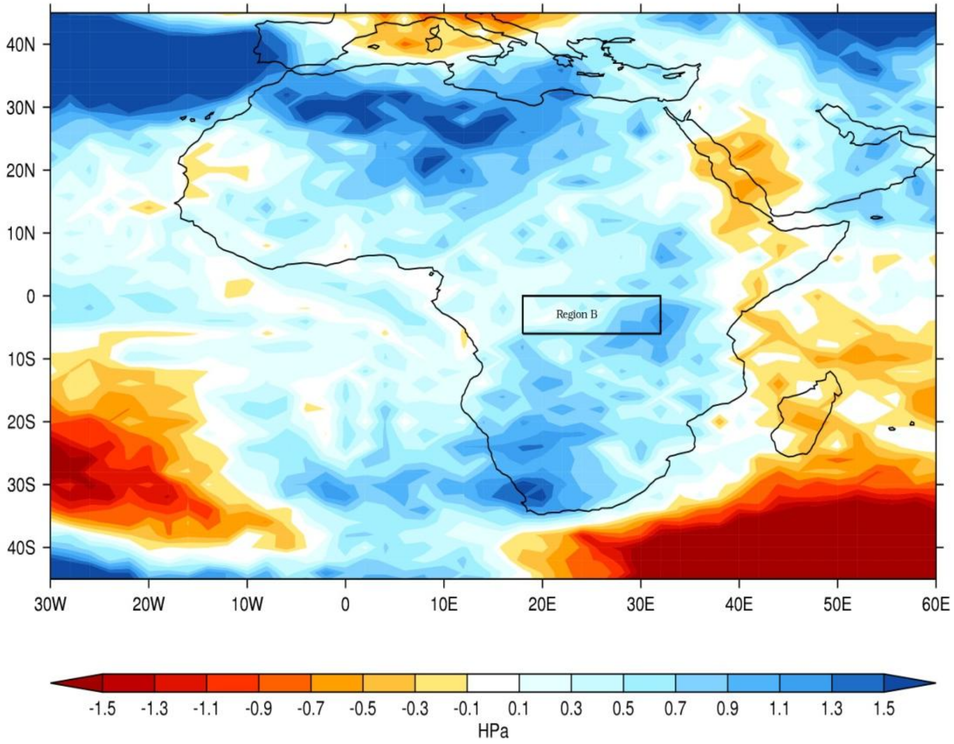
Dry years



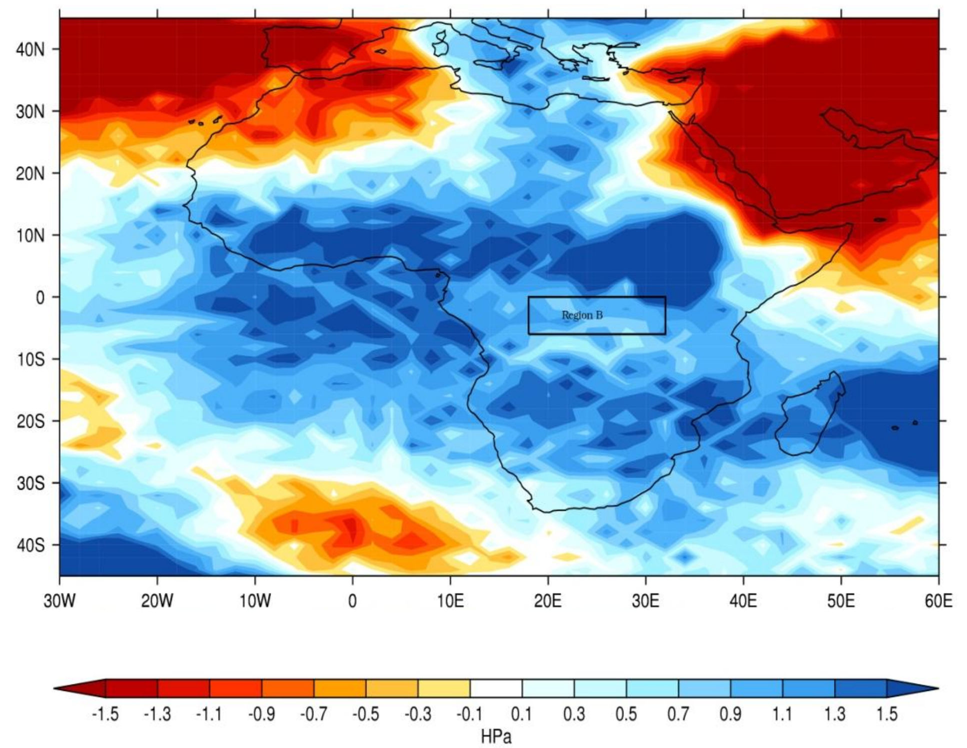
Agrees with precipitation plots – large region of positive OLR anomalies (= reduced cloud cover = indication of reduction in rainfall) over region during 5 driest years. However, opposite pattern of positive anomalies (increased rainfall) during 5 wettest years, more in line with expected result

Mean sea level pressure anomalies

Wet years



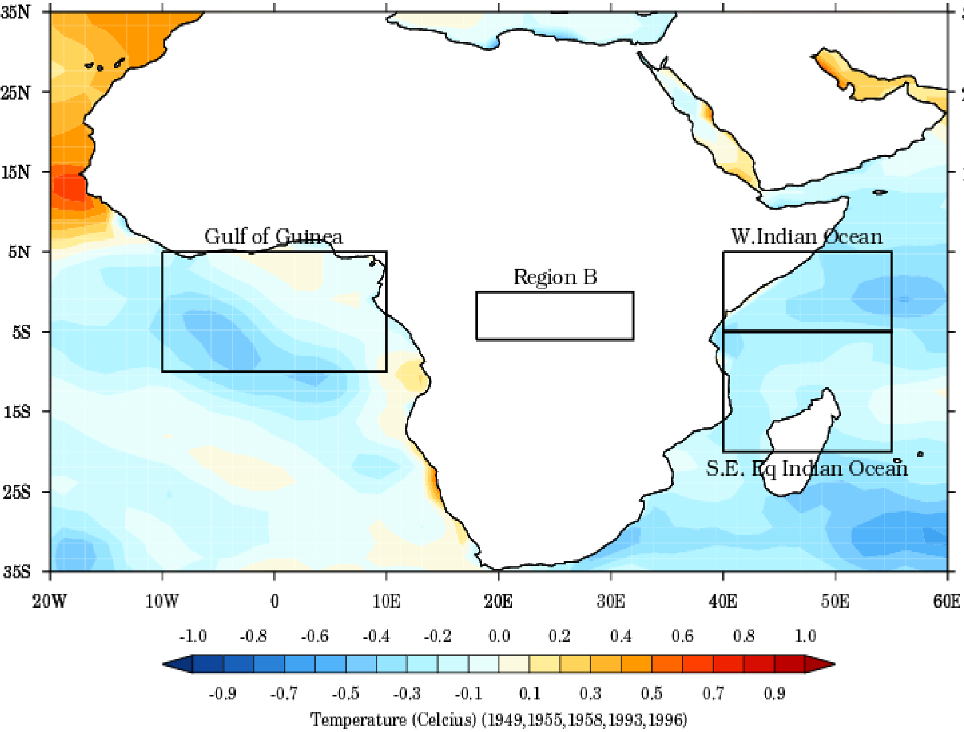
Dry years



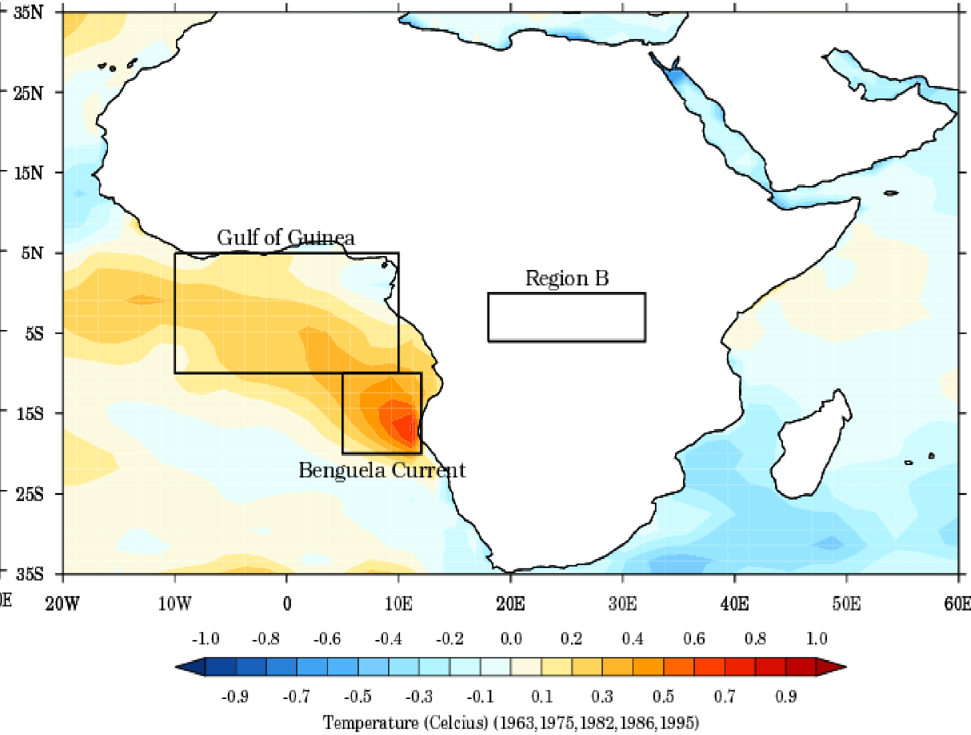
Agrees with precipitation/OLR plots – widespread high pressure over region (and most of Africa) during 5 driest years. Opposite pattern of lower pressure over entire region during 5 wettest years, as expected

Local SST anomalies

Wet years



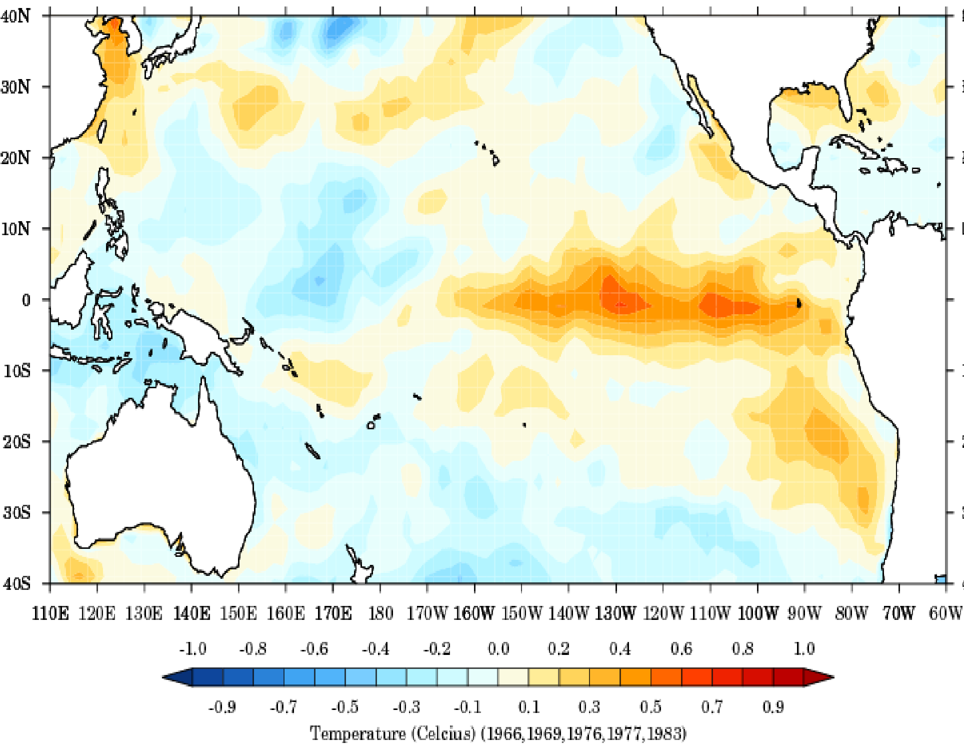
Dry years



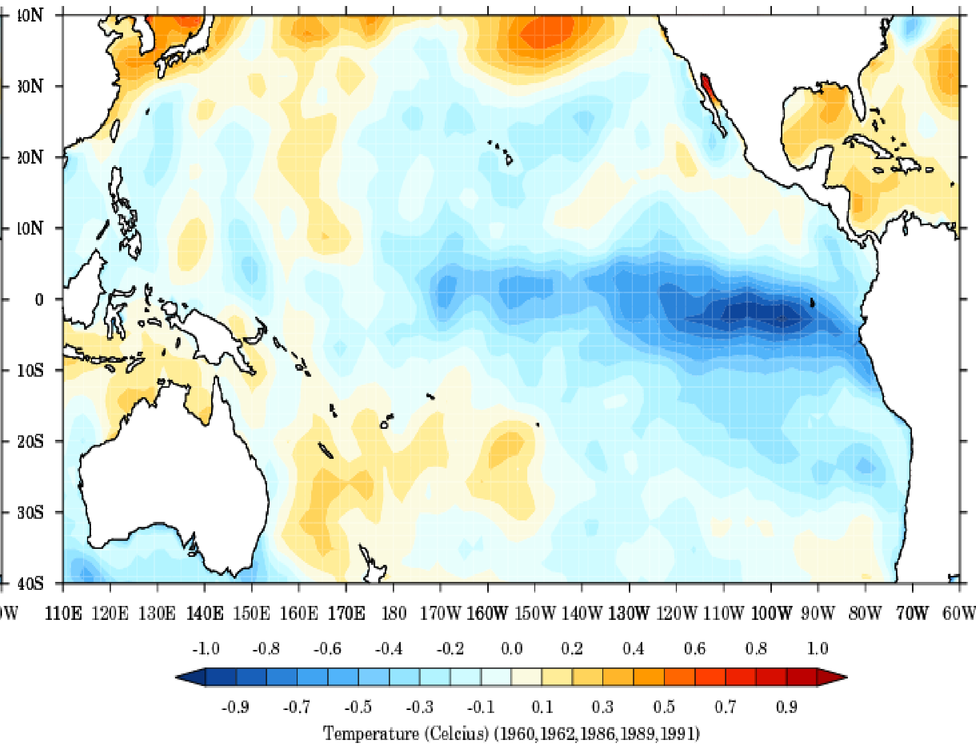
Cold SST anomalies in both Gulf of Guinea region and western Indian Ocean during wet years. Conversely, warm anomalies in Gulf of Guinea region during dry years, especially strong in northern part of Benguela current

Remote SST anomalies

Wet years



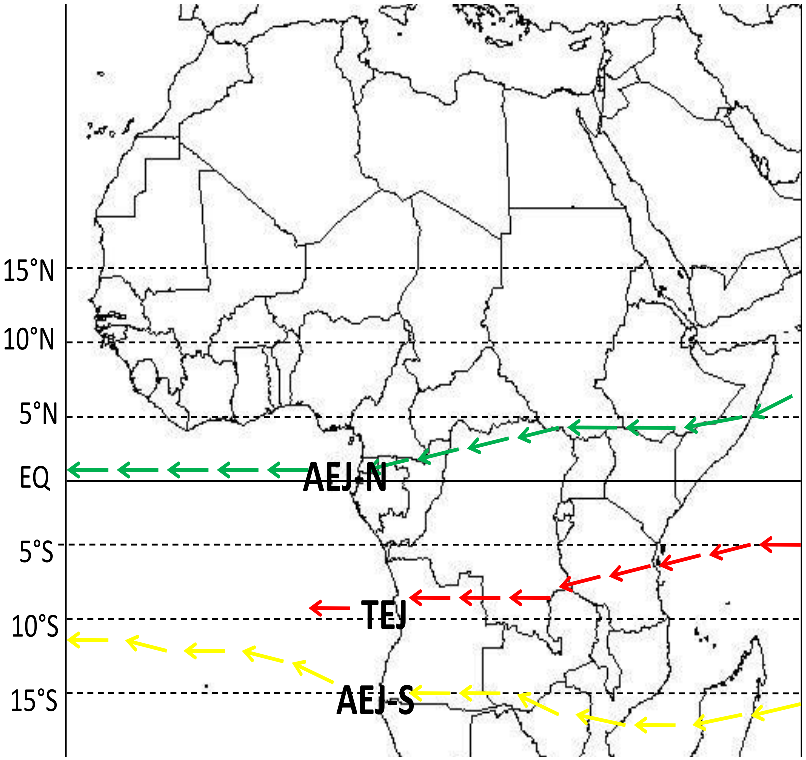
Dry years



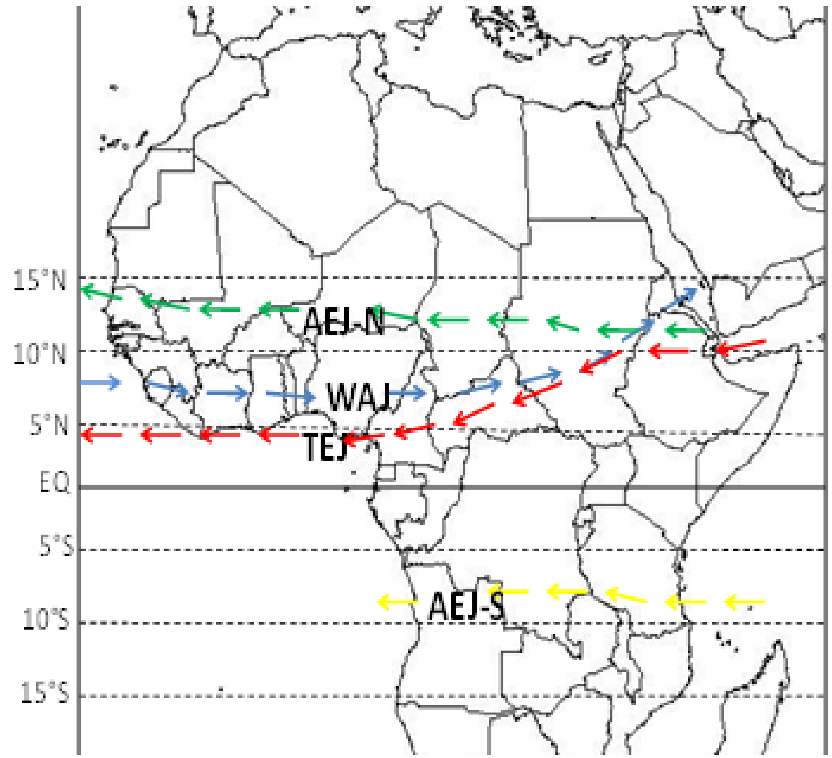
Warm SST anomalies in eastern equatorial Pacific during wet years, reminiscent of El Niño pattern. Conversely, cold anomalies in same region during dry years, reminiscent of La Niña

Normal jet locations

January

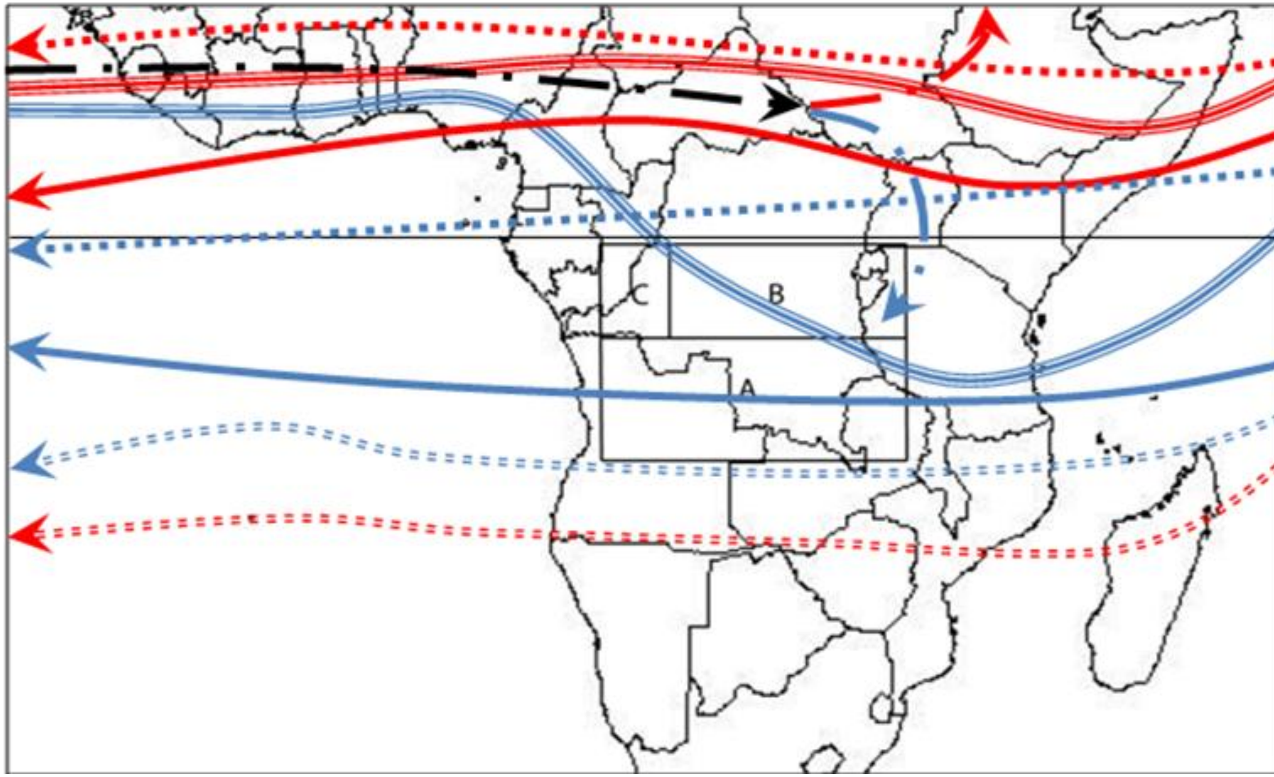


August



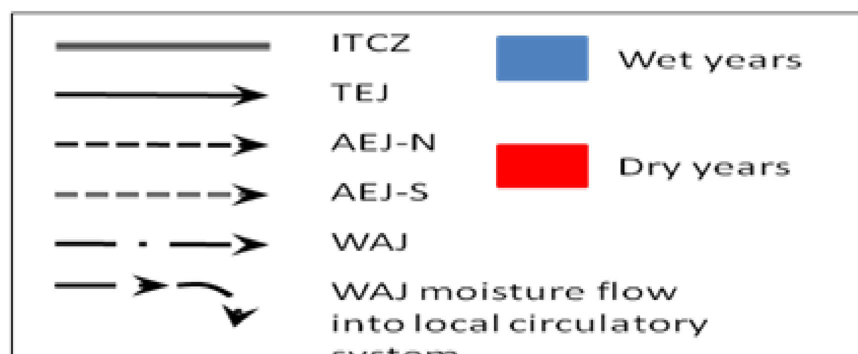
<u>NH winter</u>: all jets located in Northern hemisphere, with AEJ-N near Equator and TEJ/AEJ-S between 10-15°S.

<u>NH summer</u>: all jets have moved north to between 5-15°N, except AEJ-S which is found around 7°S. WAJ becomes prominent during summer months



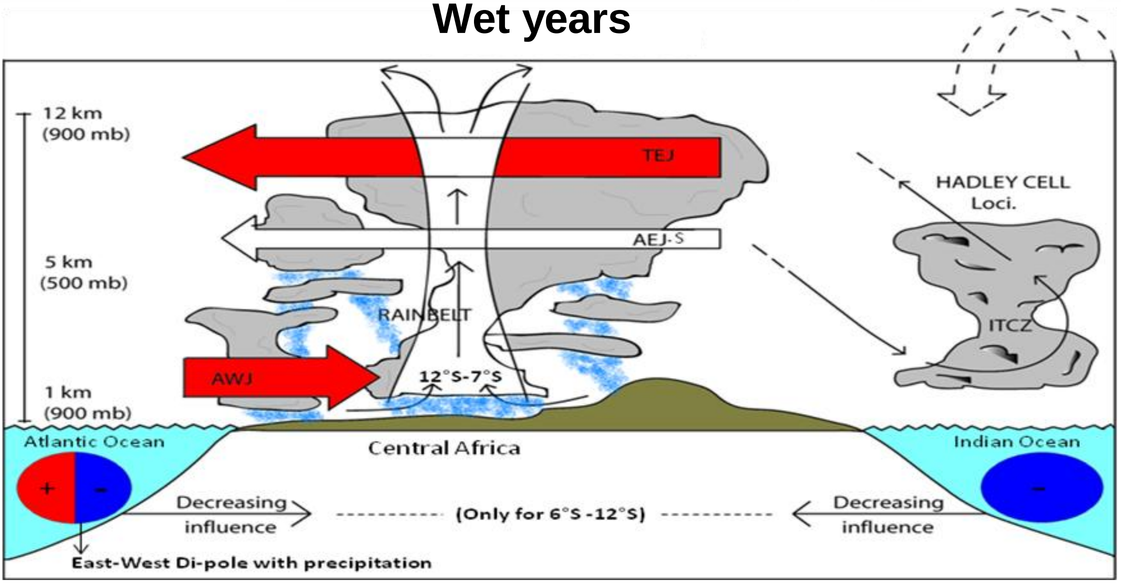
During wet years, ITCZ is is further south, as is upper-level jet (TEJ). Lower-level jet (AEJ) is located further north

During dry years, ITCZ is is further north, as is upper-level jet (TEJ). Lower-level jet (AEJ) is located further south



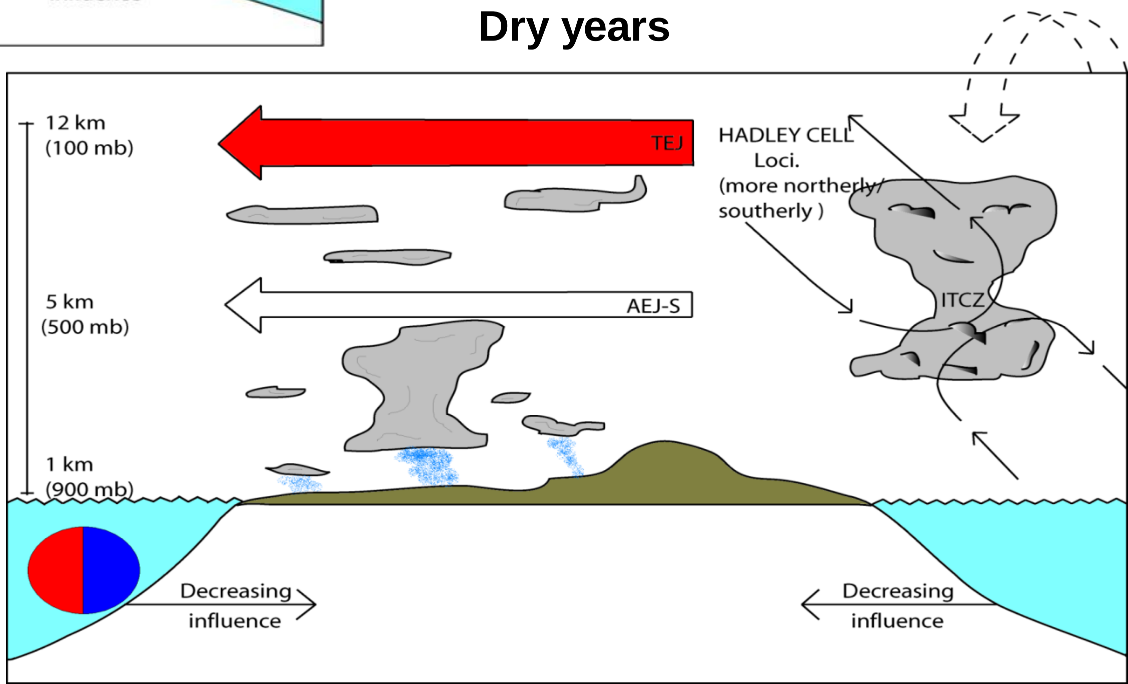
Summary

Wet years

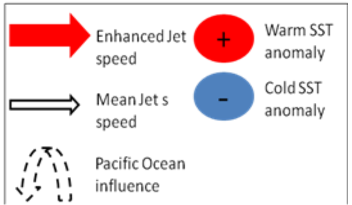


In general, during wet years we see an increase in convection over the region associated with a stronger TEJ, a stronger AWJ, cold SST anomalies in both Atlantic and Indian Oceans and an El Niño like pattern in the Pacific

Dry years



During dry years we see much less convection over the region, associated again with a stronger TEJ but an absence of other jets, warm SST anomalies in Atlantic and a La Niña like pattern in the Pacific



Thank you

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