Decadal variability of the West African monsoon and eastern equatorial Africa

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CLIVAR-ICTP Workshop on Decadal Climate Variability and Predictability: Challenge and Opportunity
The Abdus Salam ICTP, Trieste
19 November 2015

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Two themes/threads

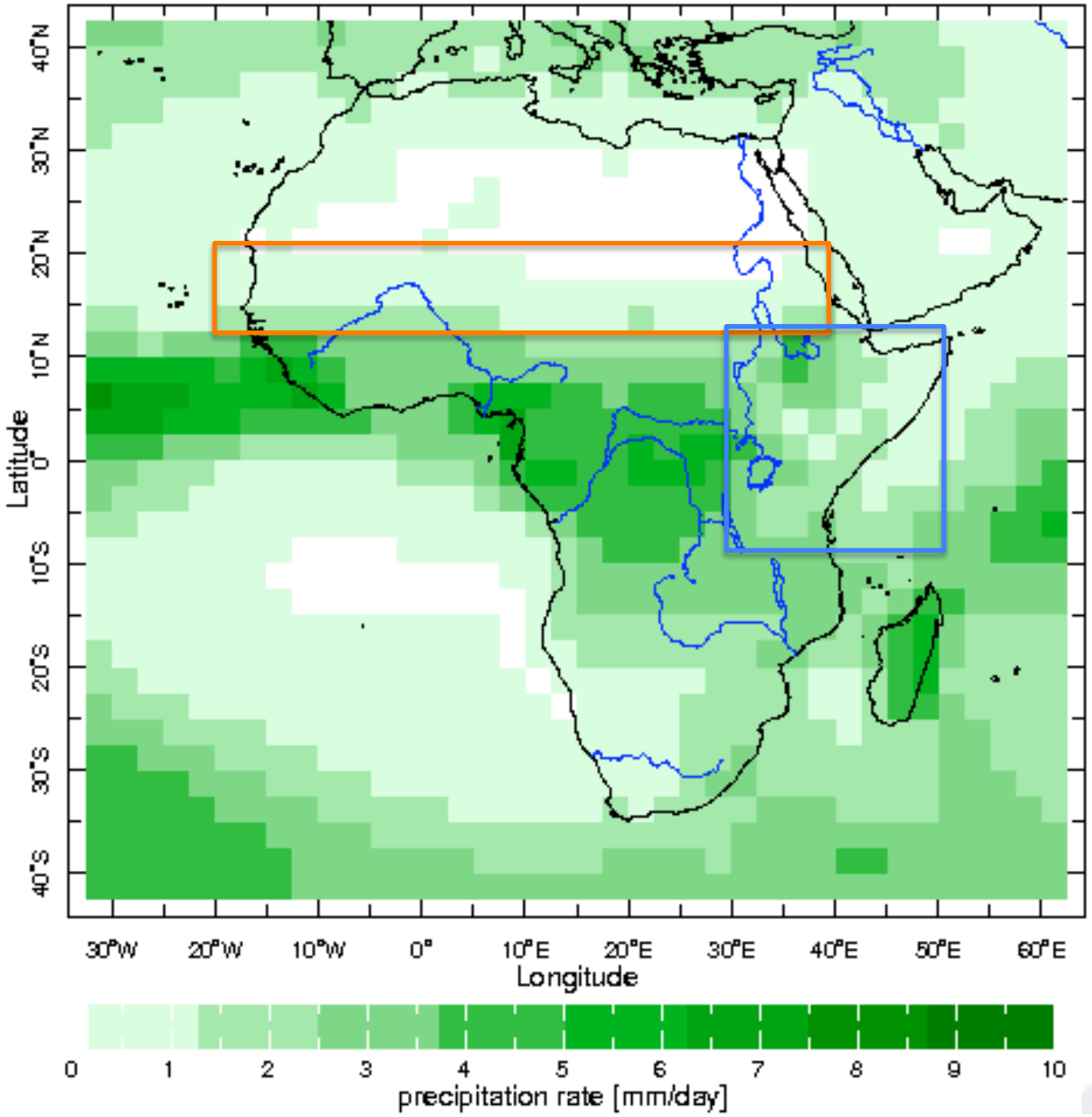
Physical processes can be made sense of that explain regional precipitation variations across time scales, from days to decades, and connect [natural] variability and [anthropogenic] change

- *What controls vertical instability?*
  [and how do oceans contribute?]

Decadal scale is evident. It comes from oceanic forcing

- Anthropogenic influence [GHGs, aerosols…] can also be argued indirectly, through oceans

African drylands: *margins of convection?*
GPCP 1979-2015



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Sahel/West African monsoon

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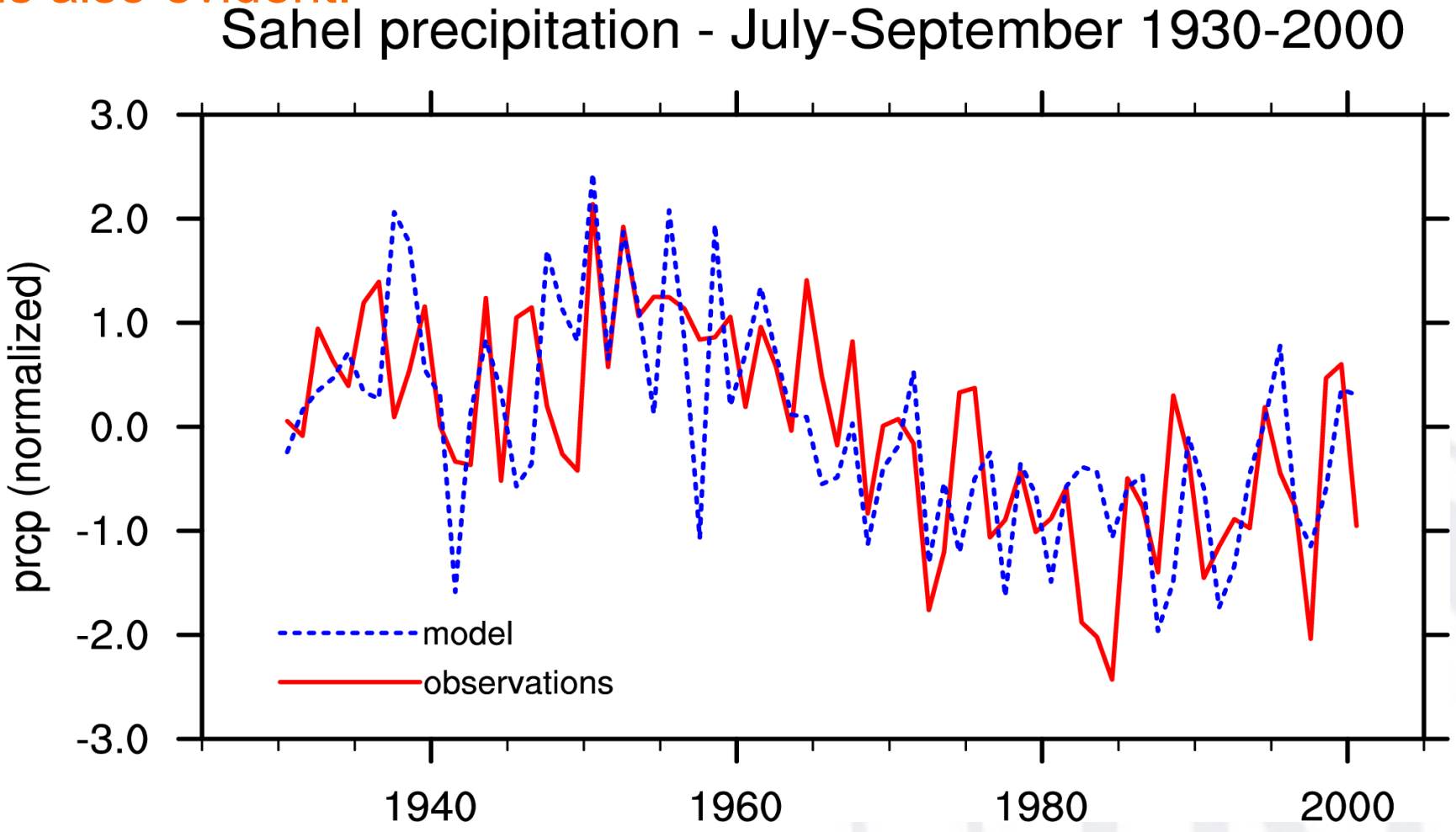
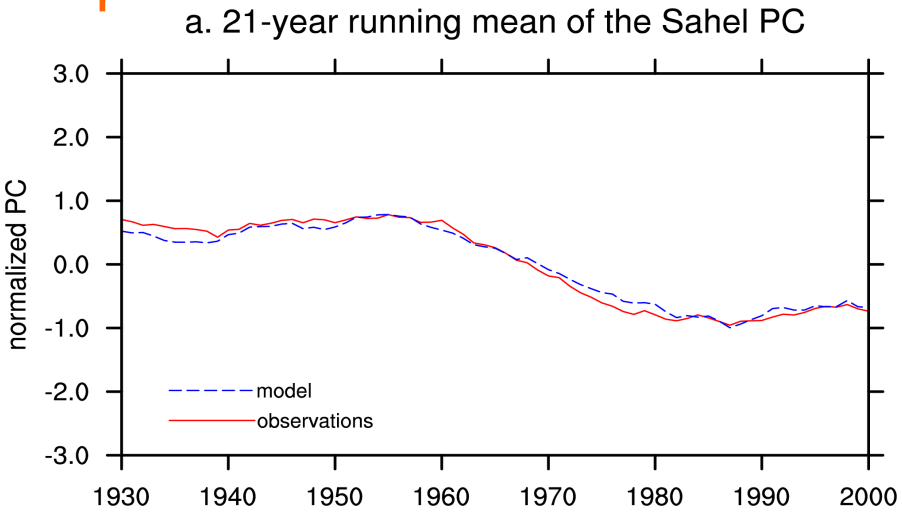
Decadal variation is evident.

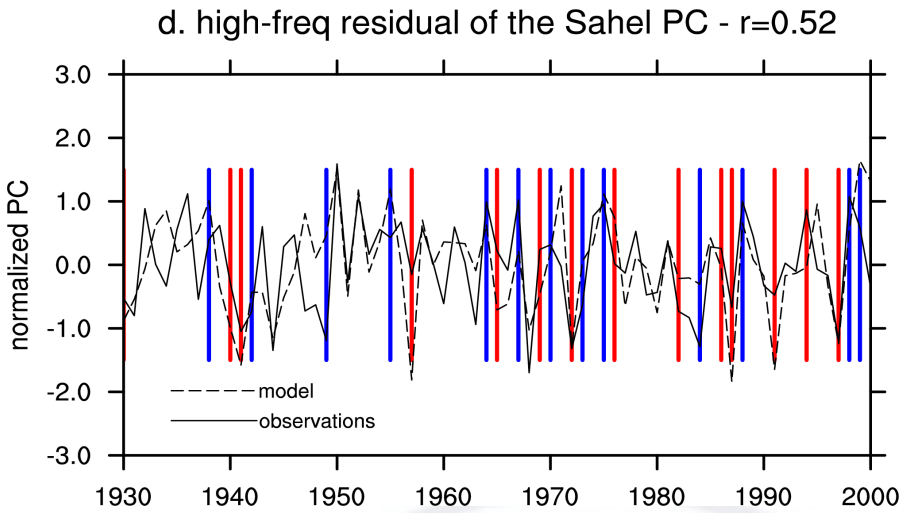
Oceanic forcing of late 20th century Sahel drought [and recovery] is also evident.

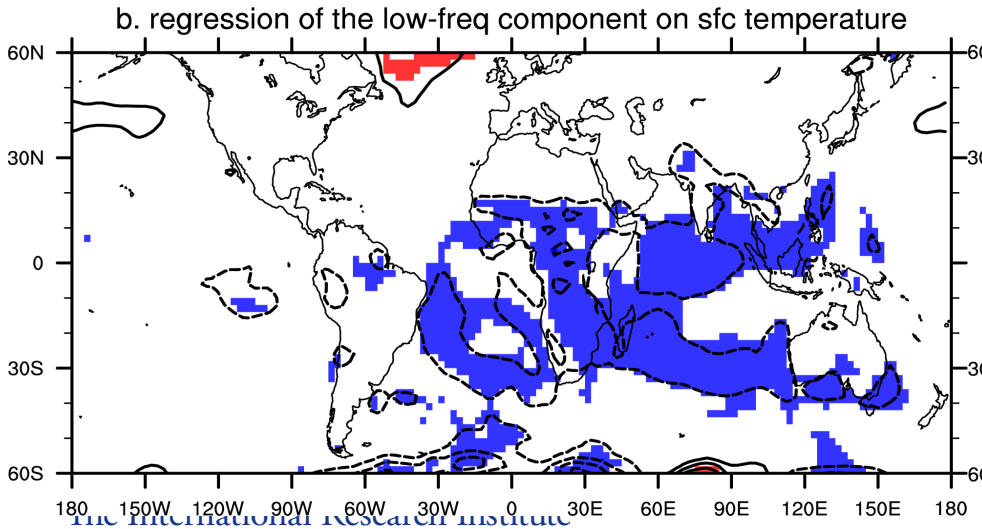


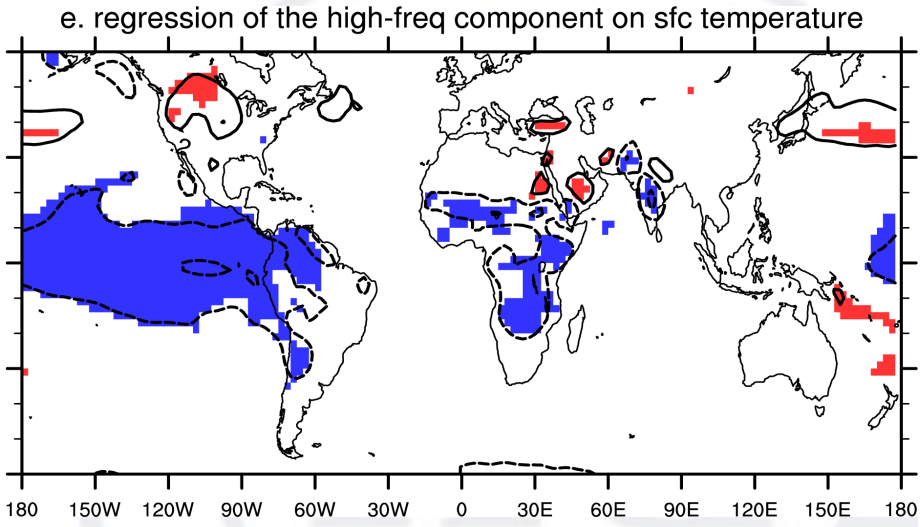
Giannini, A, R Saravanan and P Chang 2003, in Science

Which oceans?
Atlantic and Indian on decadal,
tropical Pacific on interannual time scales









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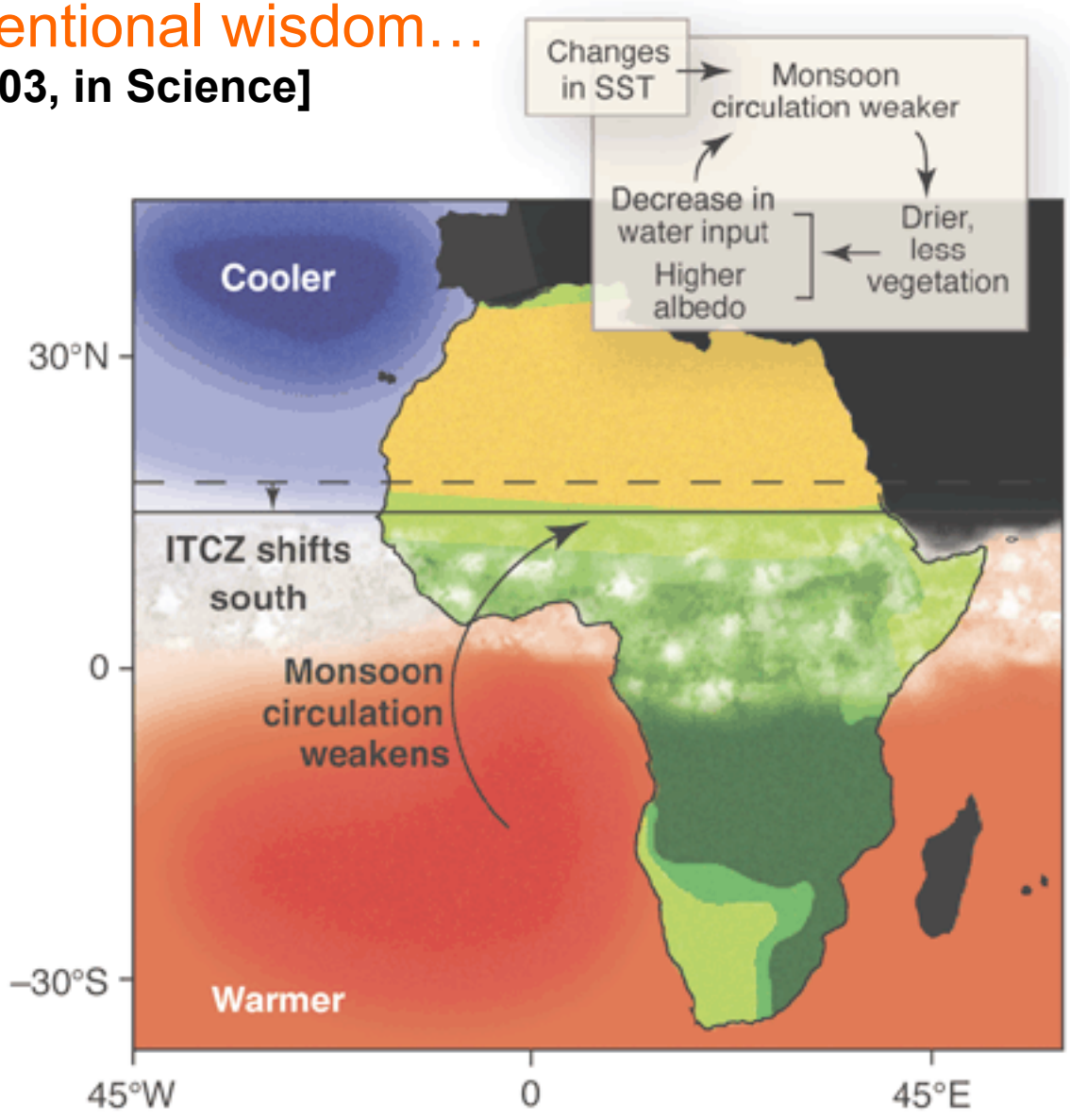
Giannini, A, R Saravanan and P Chang 2003, in Science

Reinterpreting conventional wisdom…

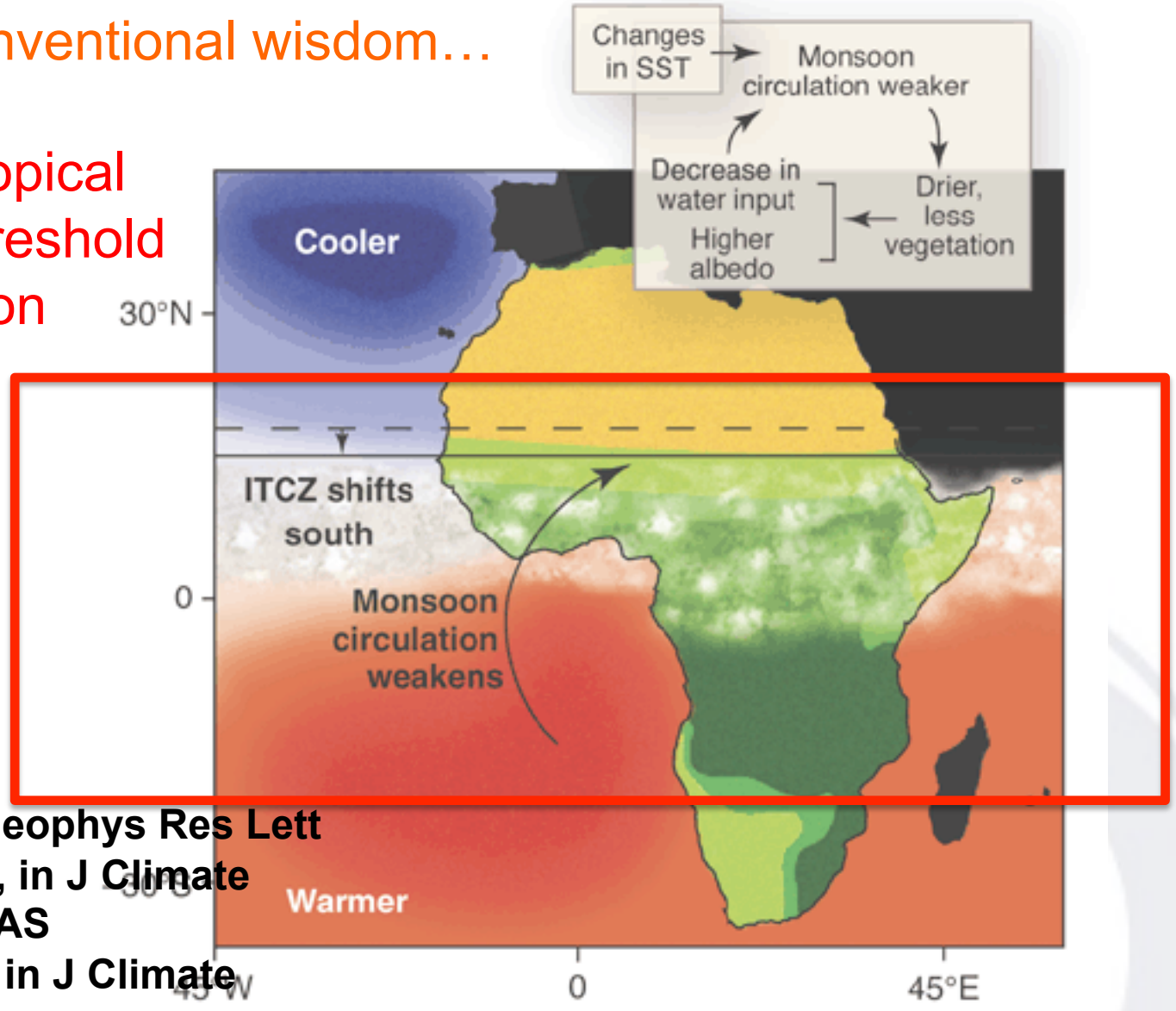
[cartoon is from Zeng 2003, in Science]



Reinterpreting conventional wisdom…

(1/2) the global tropical oceans set the threshold for deep convection

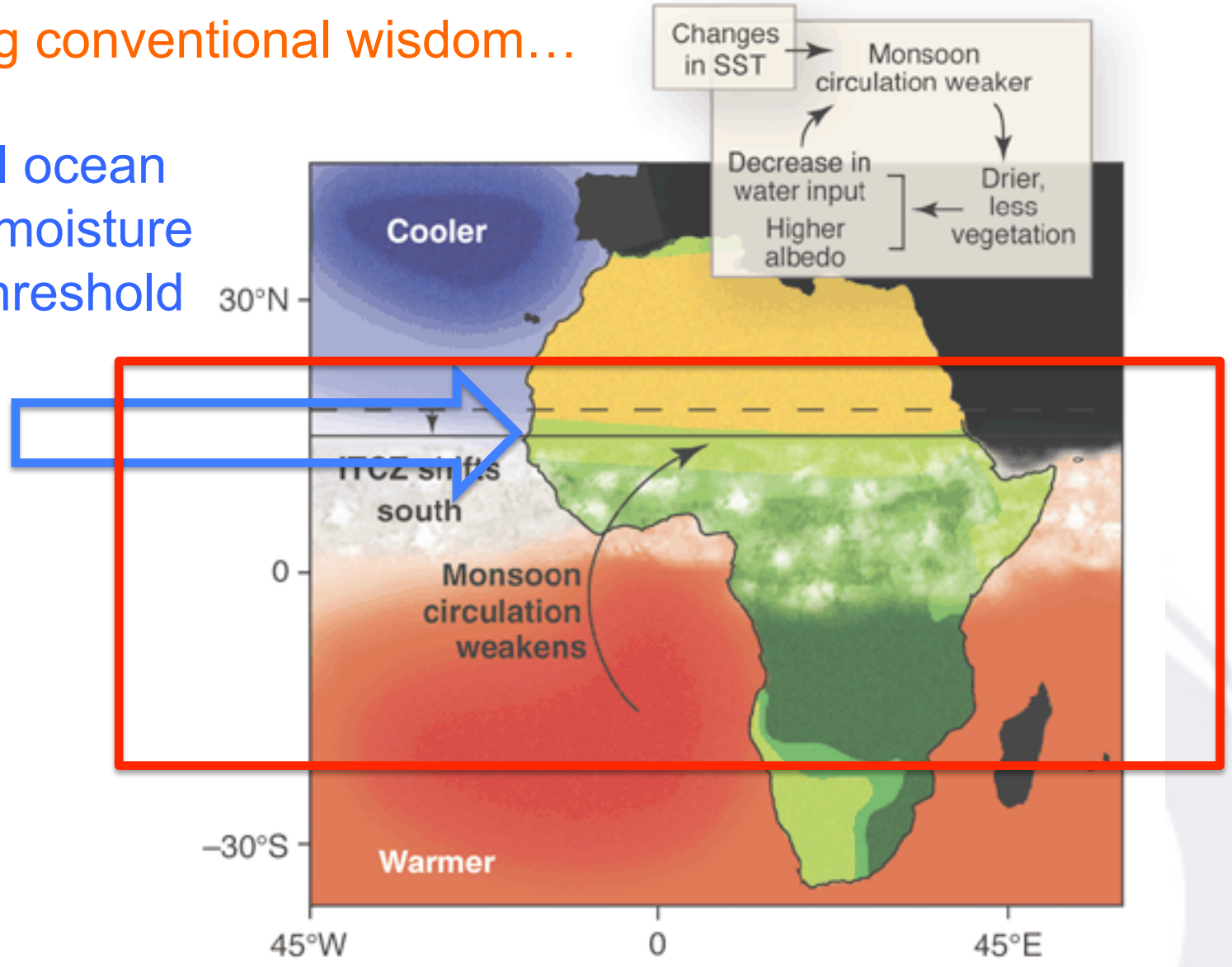
e.g., “upped ante”



Neelin et al. 2003, in Geophys Res Lett
Chou and Neelin 2004, in J Climate
Held et al. 2005, in PNAS
Held and Soden 2006, in J Climate

Reinterpreting conventional wisdom…

(2/2) the local ocean provides the moisture to meet the threshold



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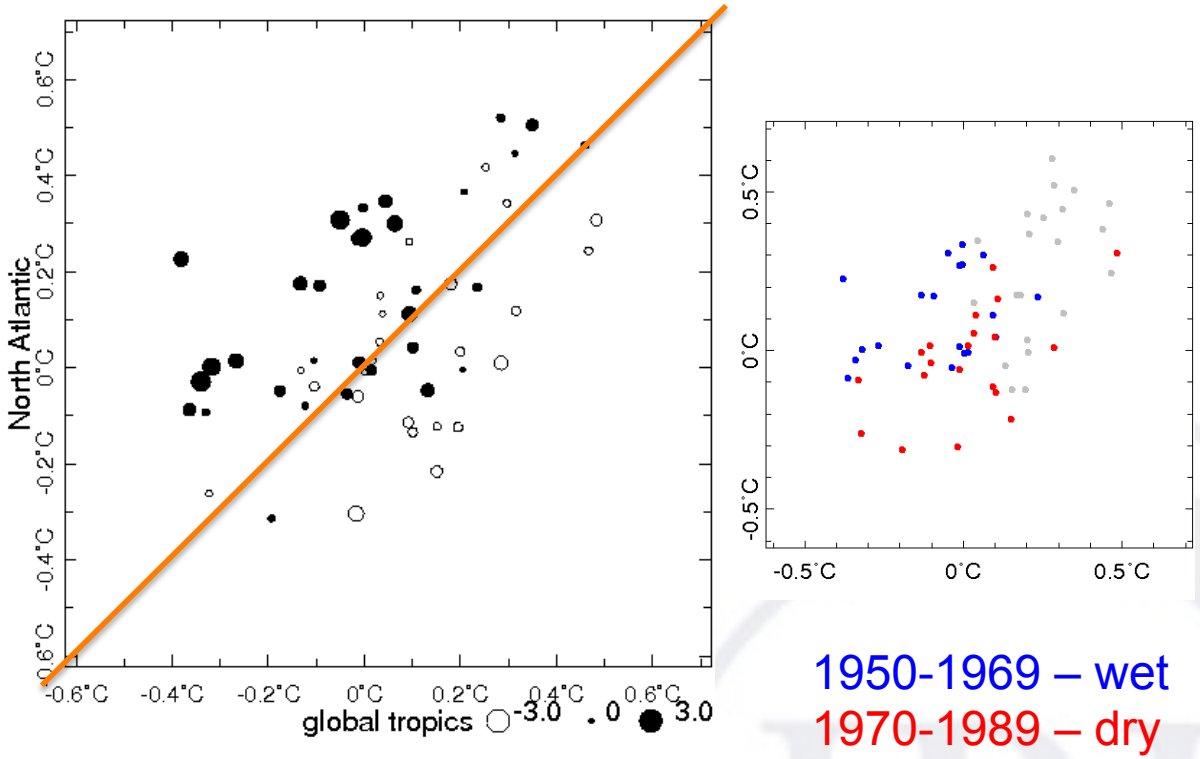
The relative temperature of the North Atlantic with respect to the global tropical oceans explains interannual variability

rainfall index is from **Ali and Lebel 2009, in Int J Clim**



1950-1969 – wet
1970-1989 – dry
1990-2006 – variable

- open circles are negative anomalies – dry
- full dots are positive anomalies – wet

Giannini, Salack, Lodoun et al. 2013 in Env Res Lett

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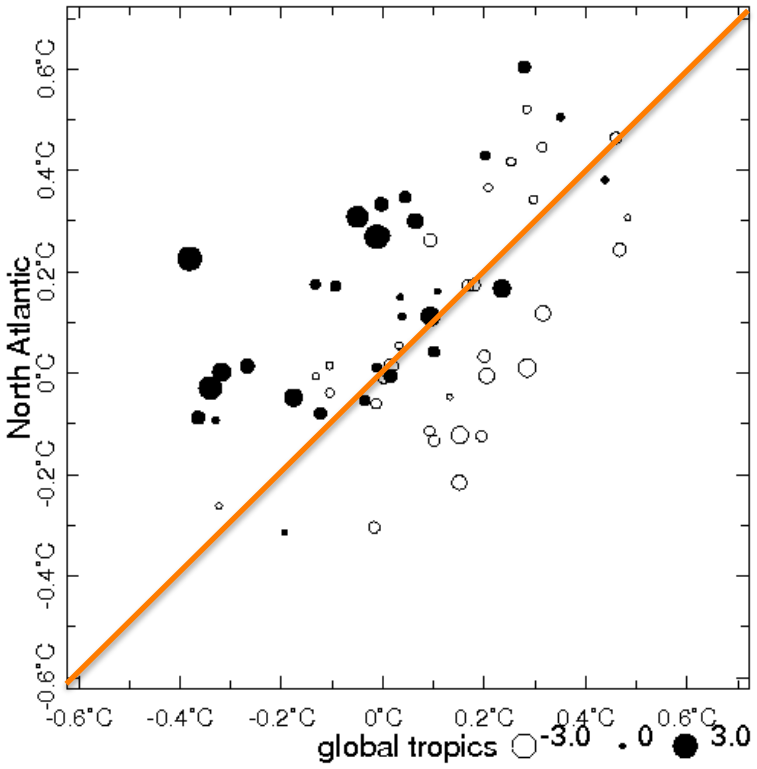
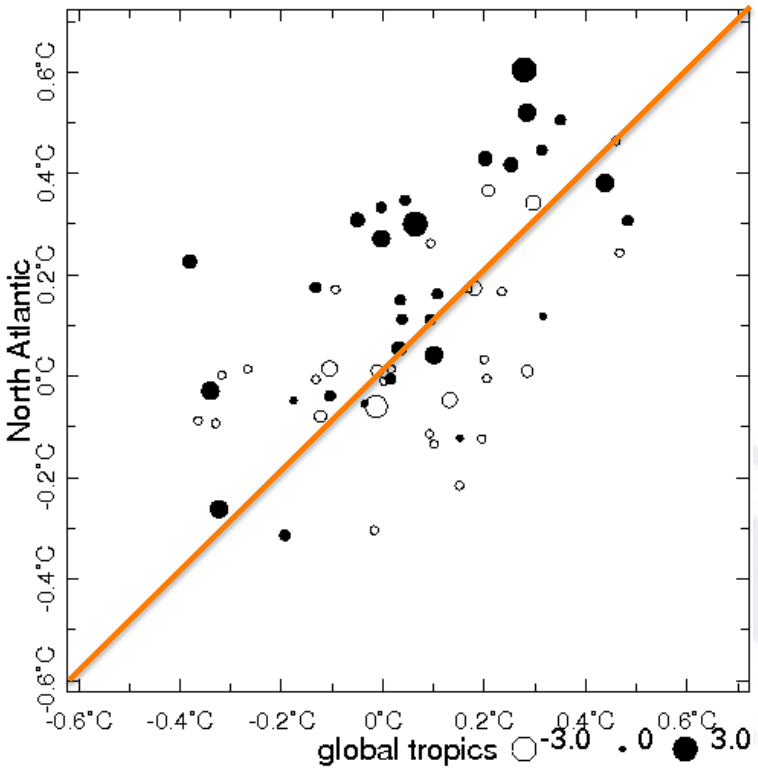
The relative temperature of the North Atlantic with respect to the global tropical oceans in frequency (left) and intensity (right) of daily rainfall in Senegal (1950-2010)





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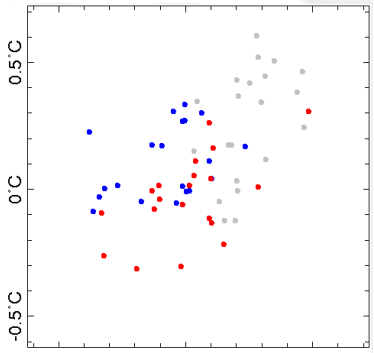

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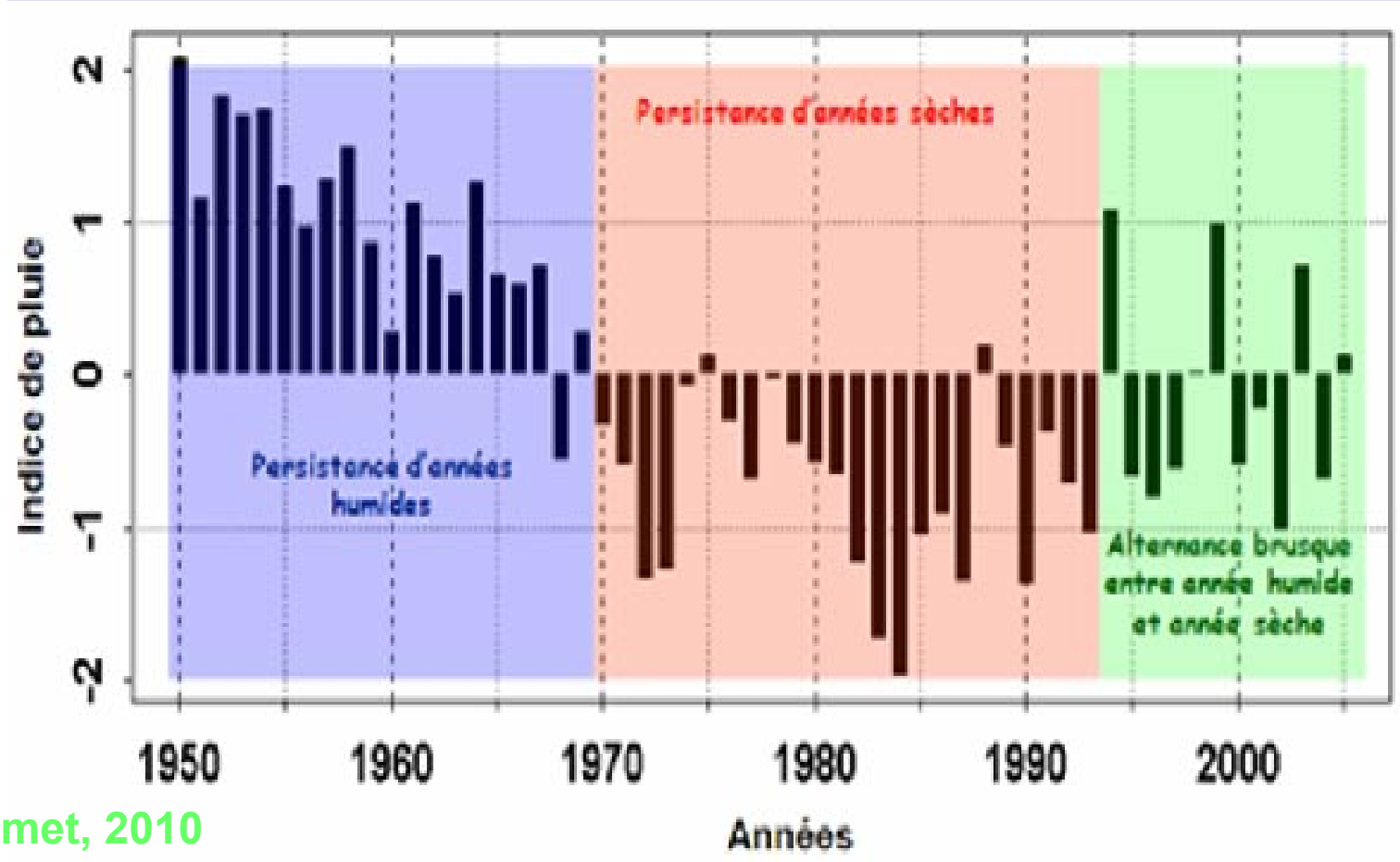
The recent evolution of Sahel rainfall: anomalously wet, persistently dry, increased variability?



Agrhymet, 2010

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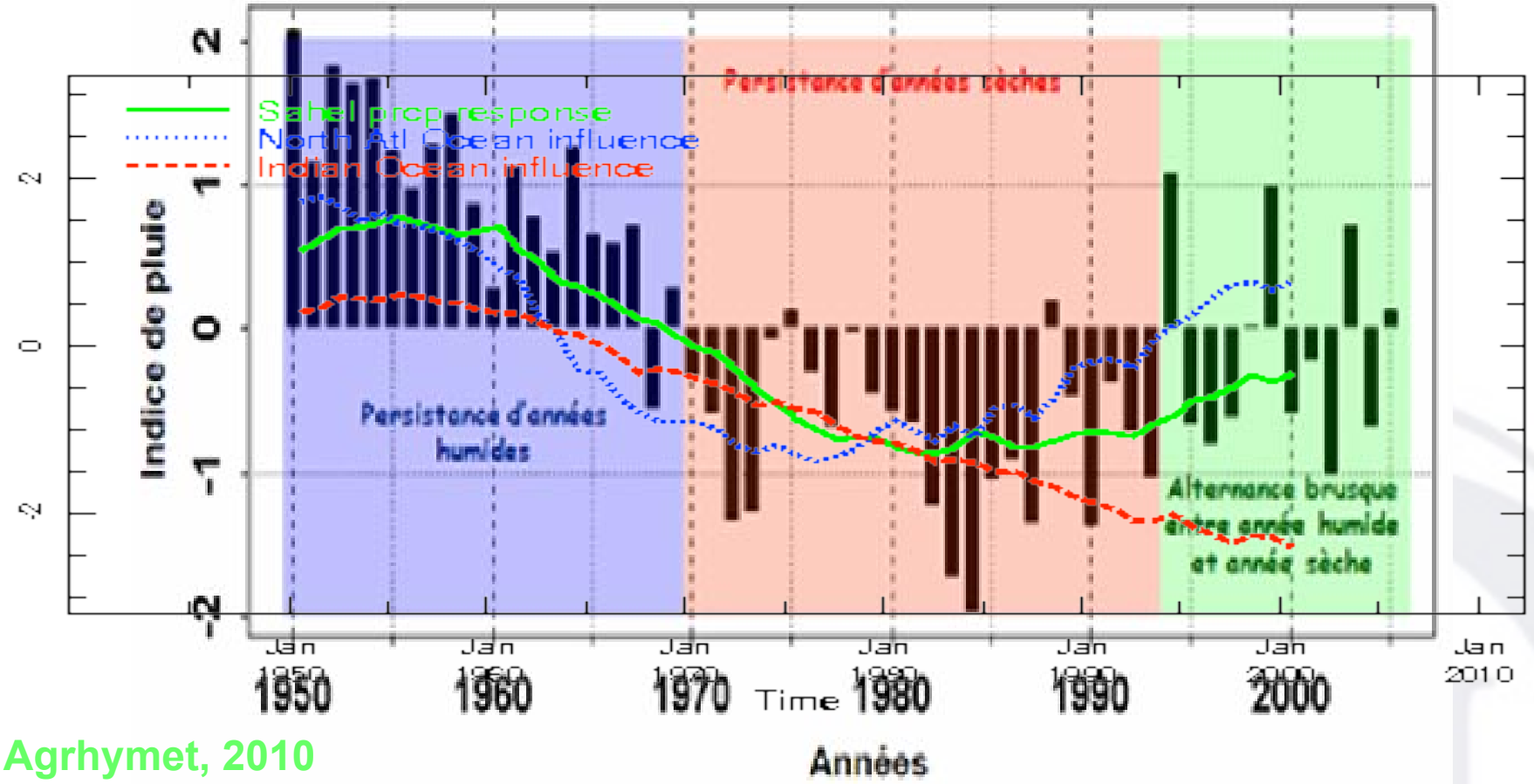

Agrhymet, 2010

North Atlantic – global mean Indian Ocean Sahel rainfall

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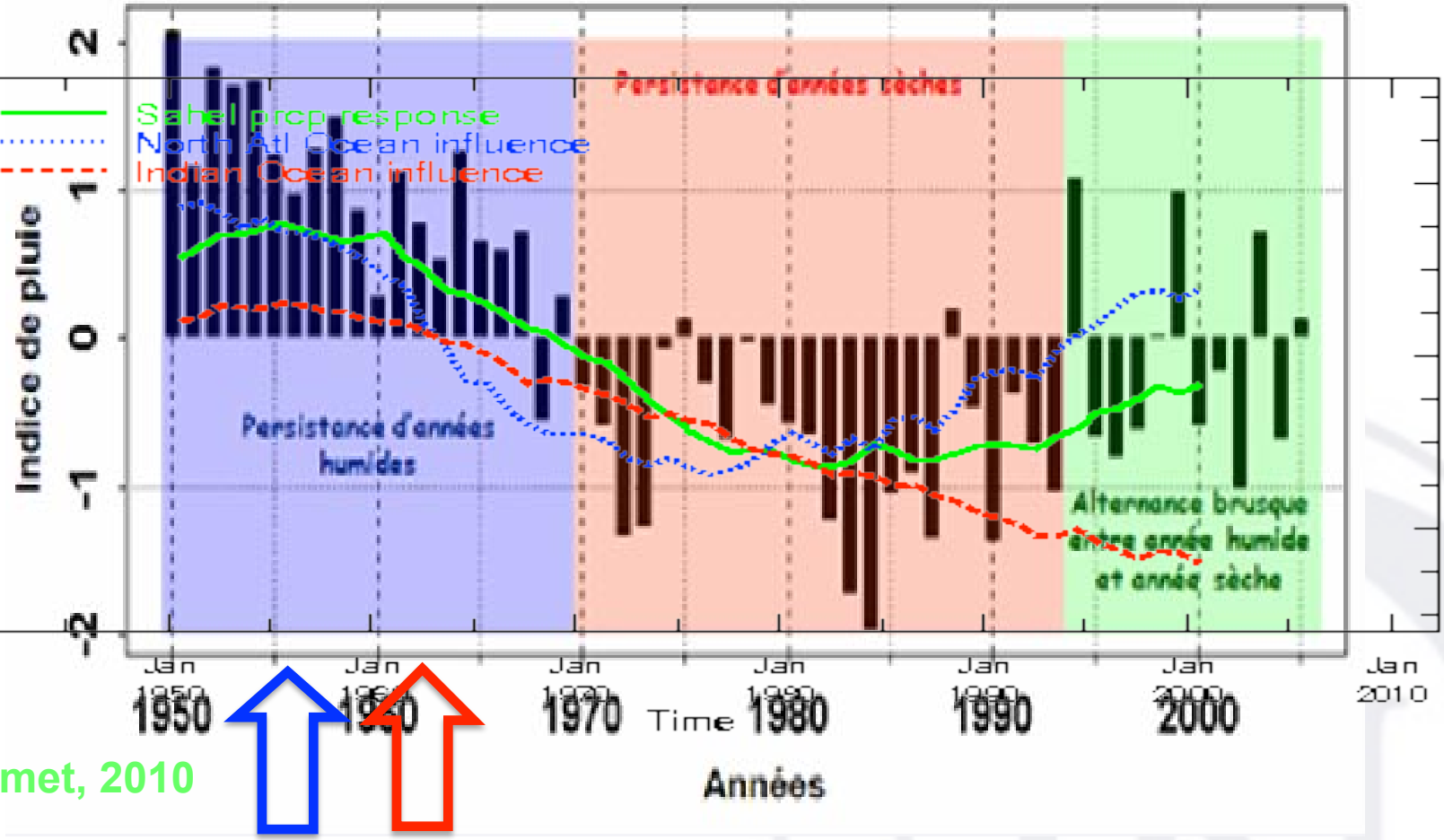

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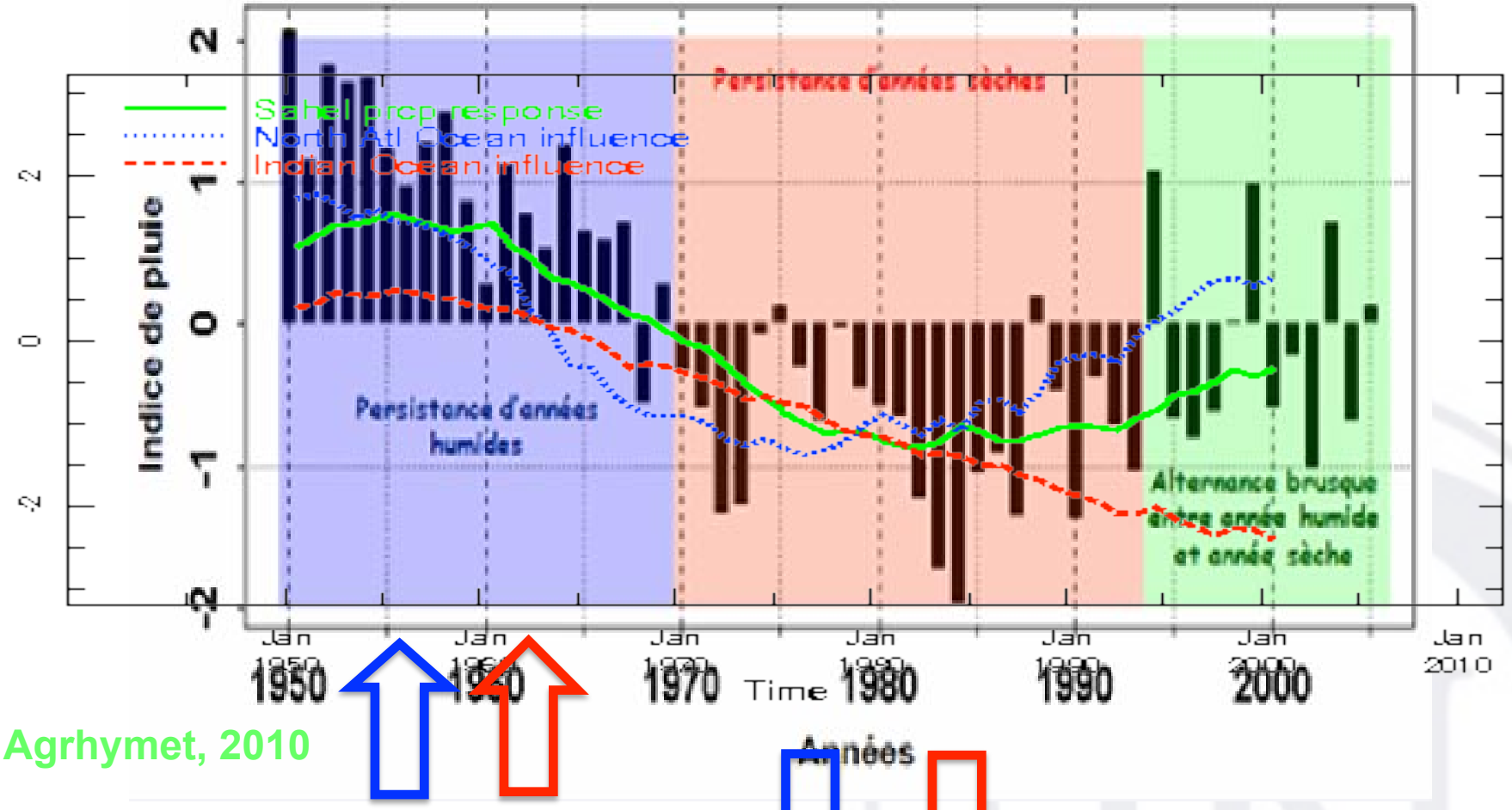

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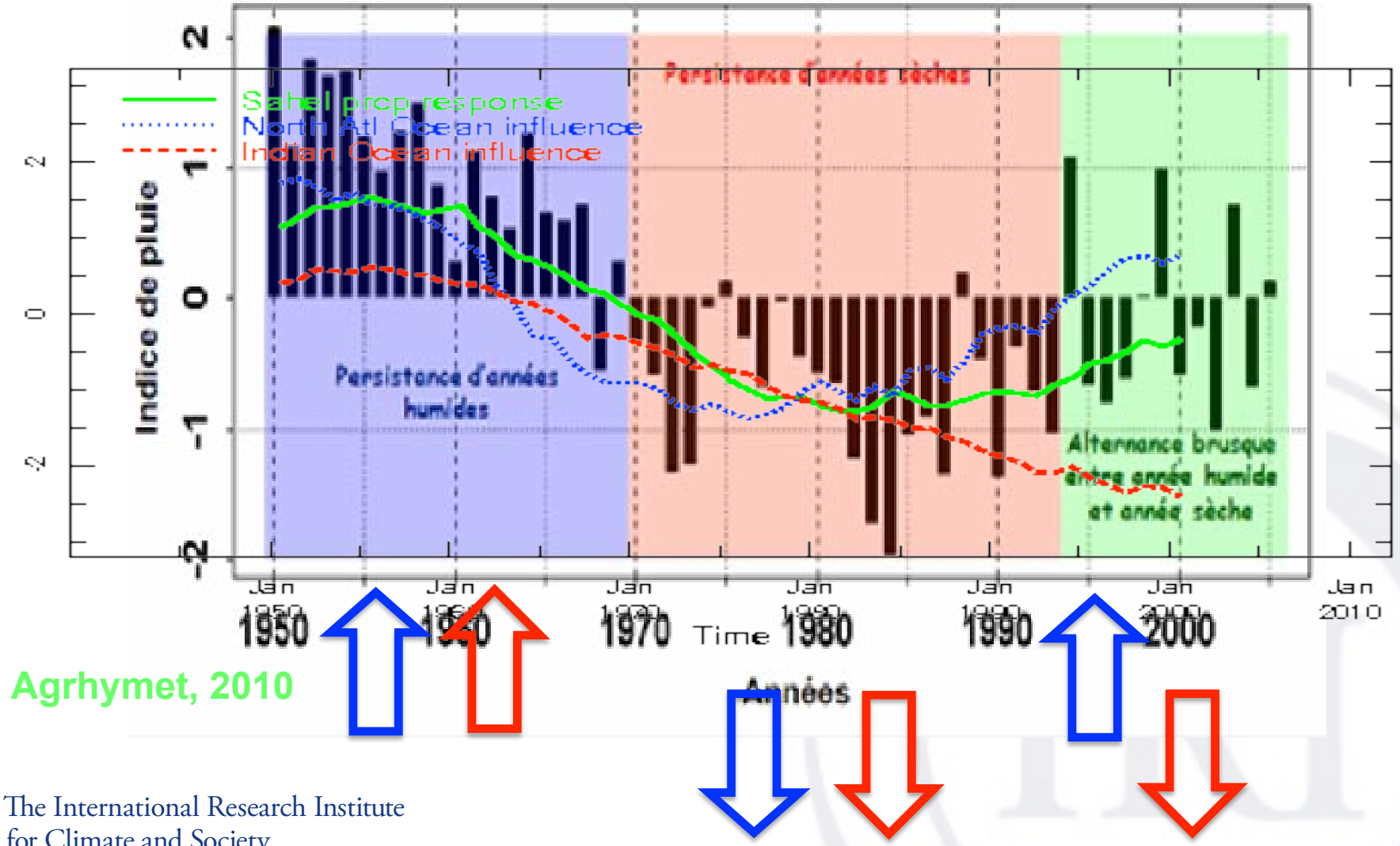

Agrhymet, 2010

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eastern equatorial Africa

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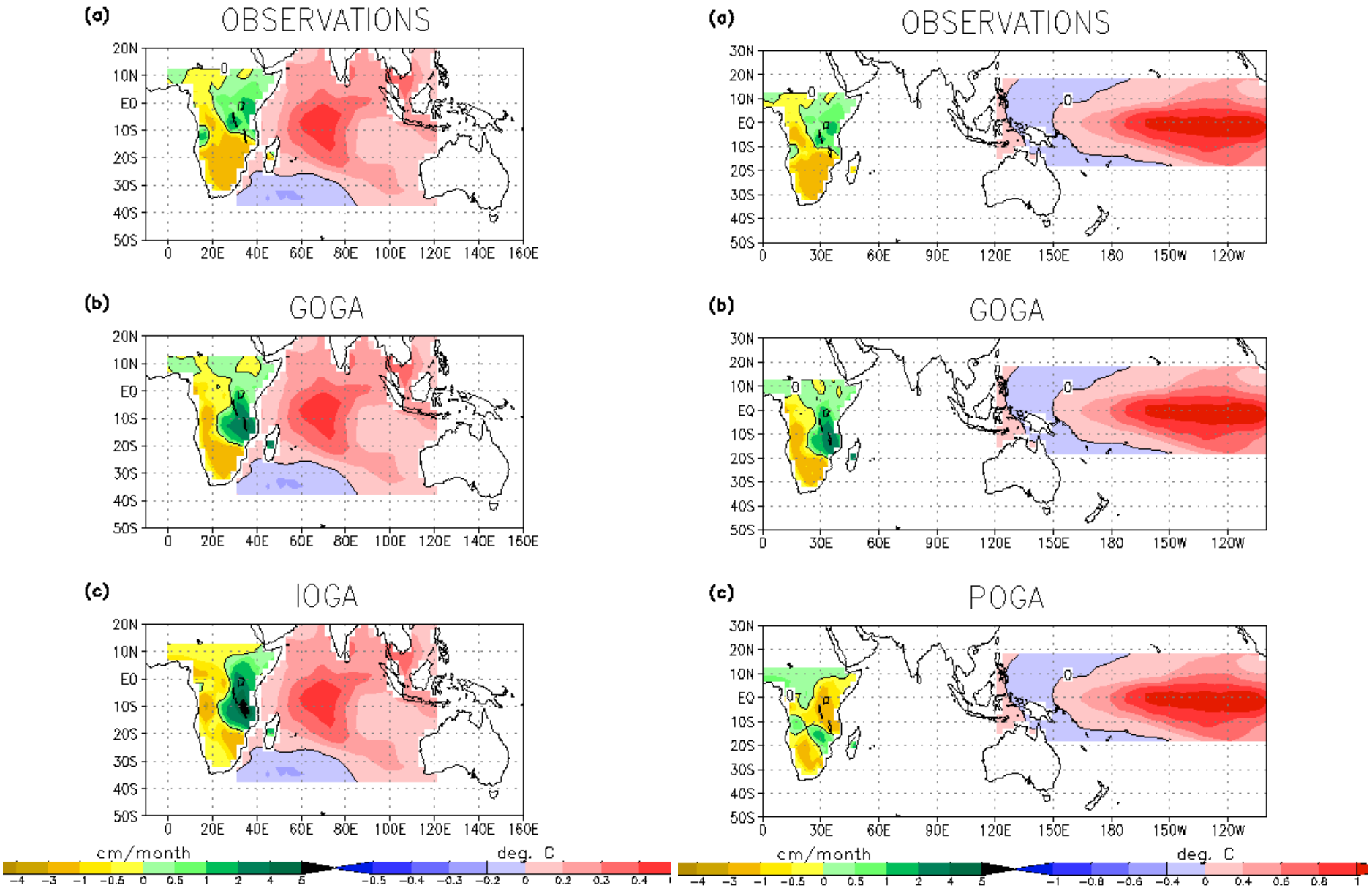
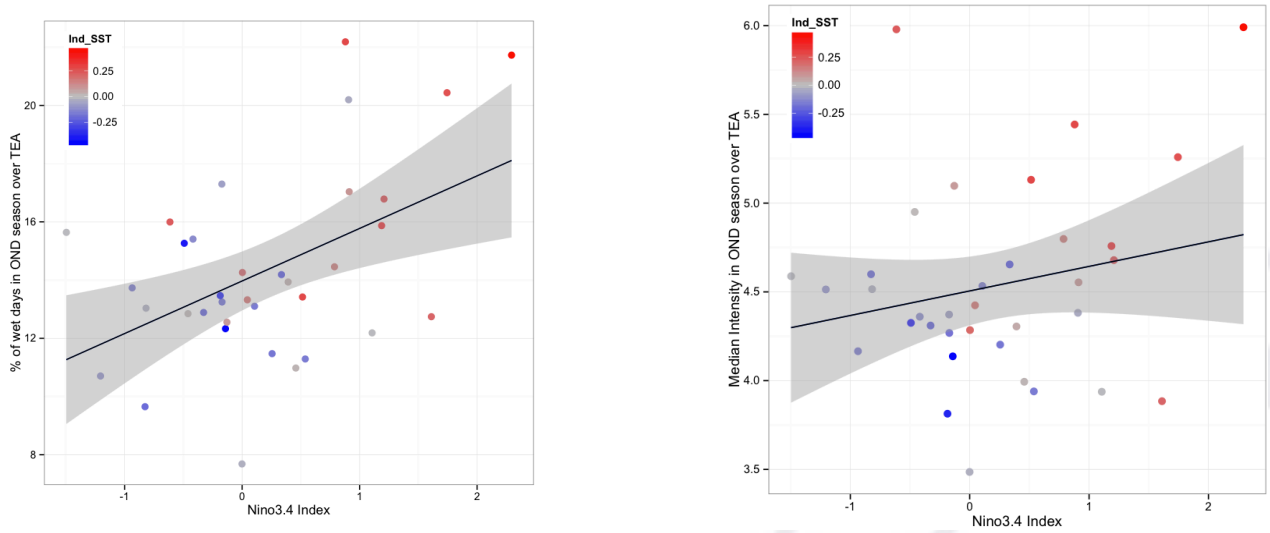
Importance of Indian Ocean for simulating East African rainfall

Goddard and Graham 1999 in J Geophys Res



Resolving contrasting regional rainfall responses to El Niño over tropical Africa

Parhi *et al.* J Climate, in press



frequency [left] and median intensity [right]
of daily rainfall during the east African short rains

[daily rainfall data from CPC unified gridded product]

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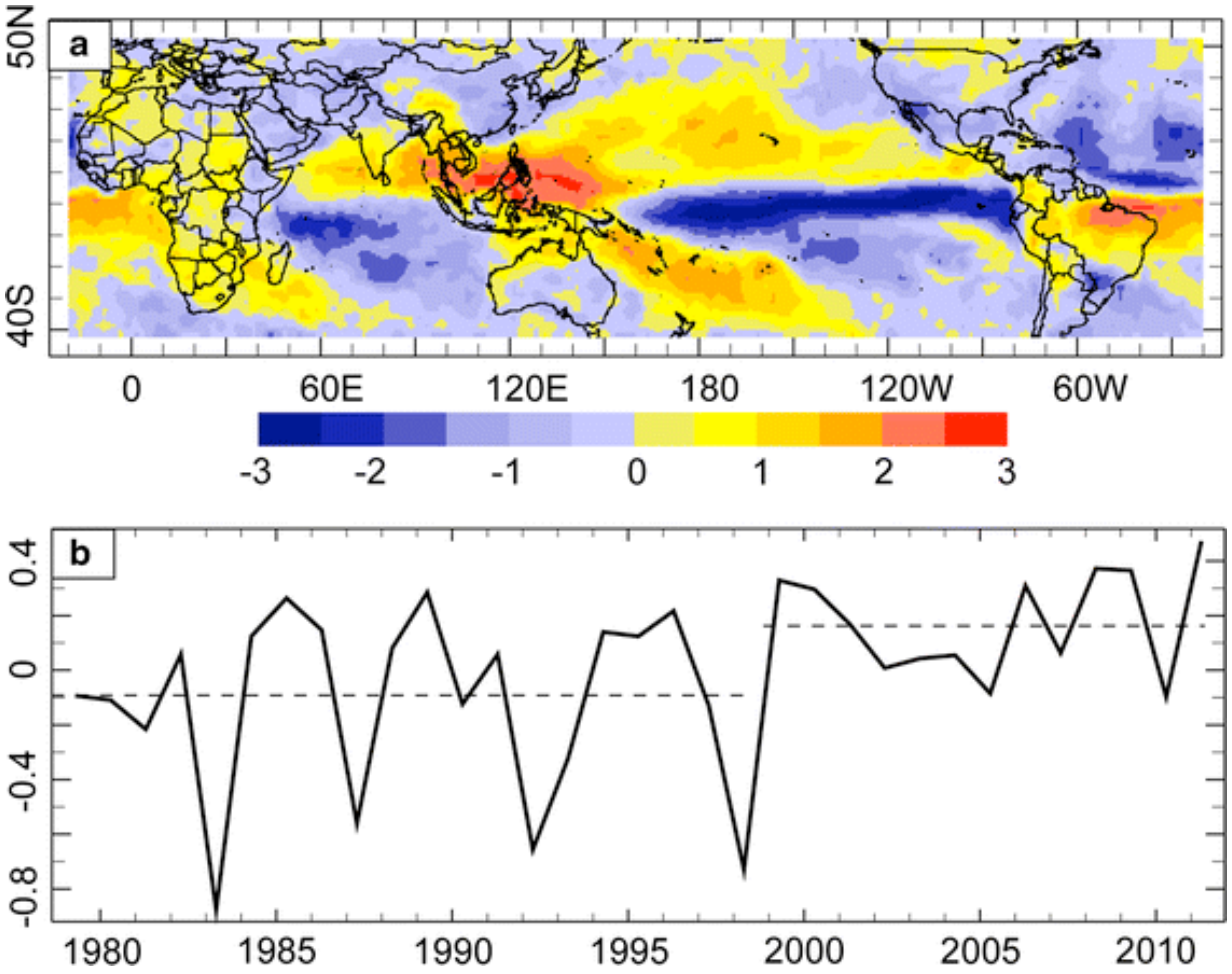
Tropical Pacific forcing of a 1998–1999 climate shift

leading EOF/PC of MAM CMAP precipitation over the period 1979–2011

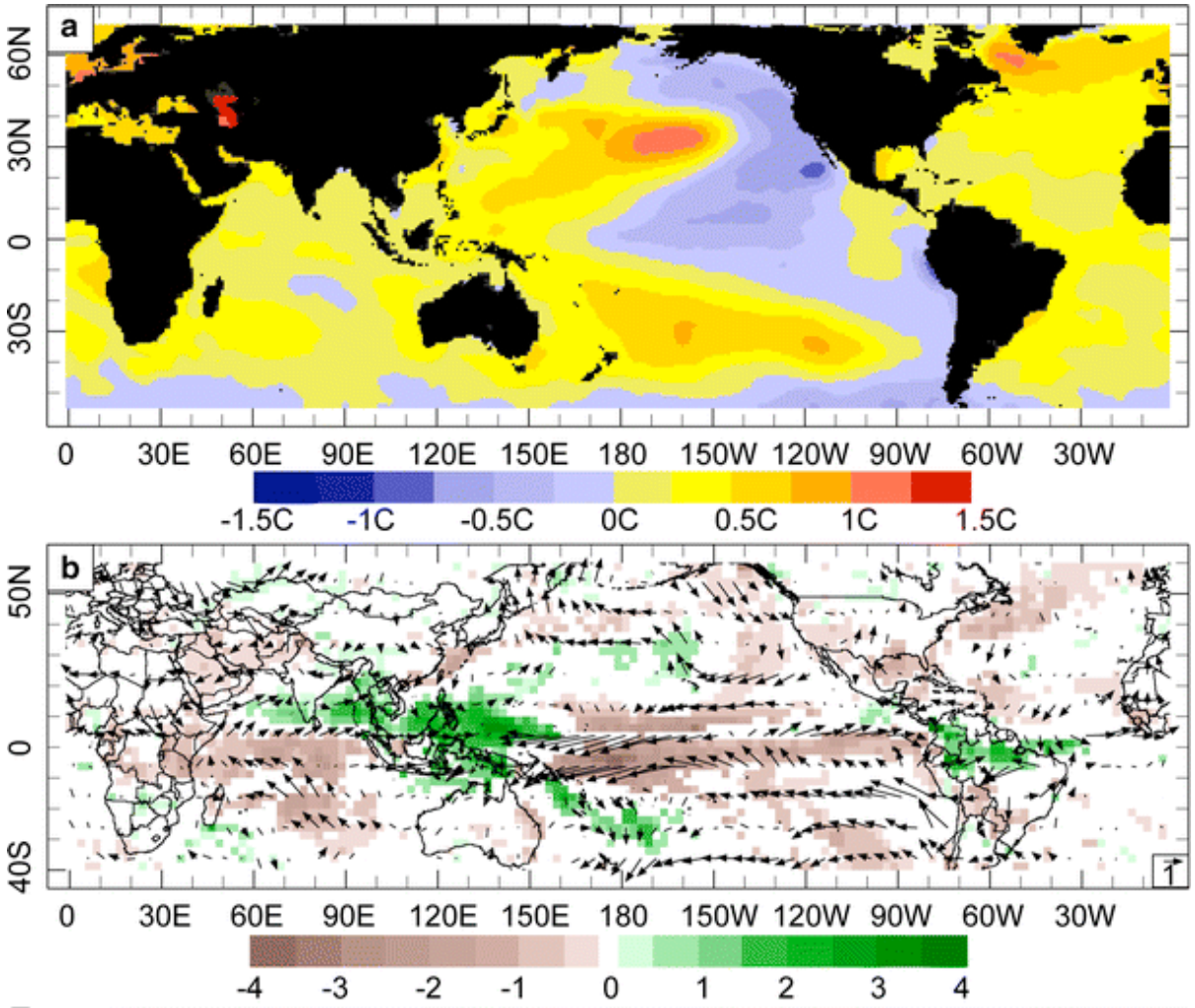
Lyon et al. in Clim Dyn 2014



Tropical Pacific forcing of a 1998–1999 climate shift

1999–2012 minus 1979–1998 differences in ERSST, CMAP precipitation ($p < 0.10$) and 850 hPa wind from R2

Lyon et al. in Clim Dyn 2014



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leading EOF of the MAM residual* SST data evaluated over the period 1900–2012

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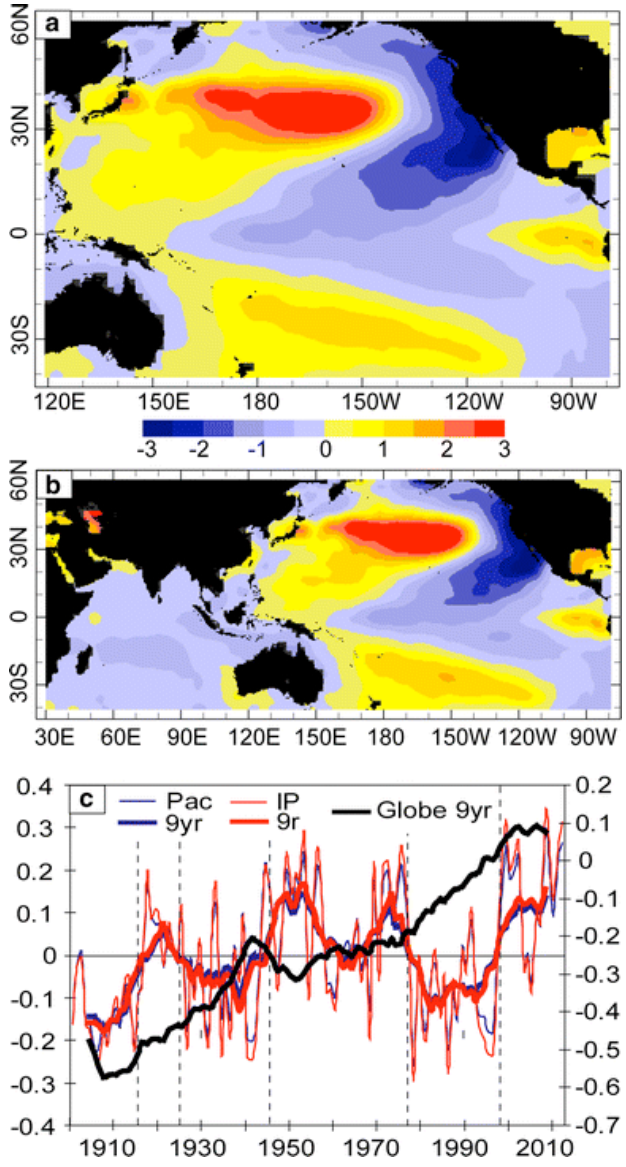

*after removing ENSO and global trend

Conclusions

1. Decadal scale is evident. It comes from <u>oceanic forcing</u>

- *Atlantic and Sahel*
- *Pacific and eastern equatorial Africa*

2. Current theories that exploit the El Niño analogue to understand the response of deep convection to global warming can be applied to processes at work on time scales from sub-seasonal to multi-decadal

Thank you!

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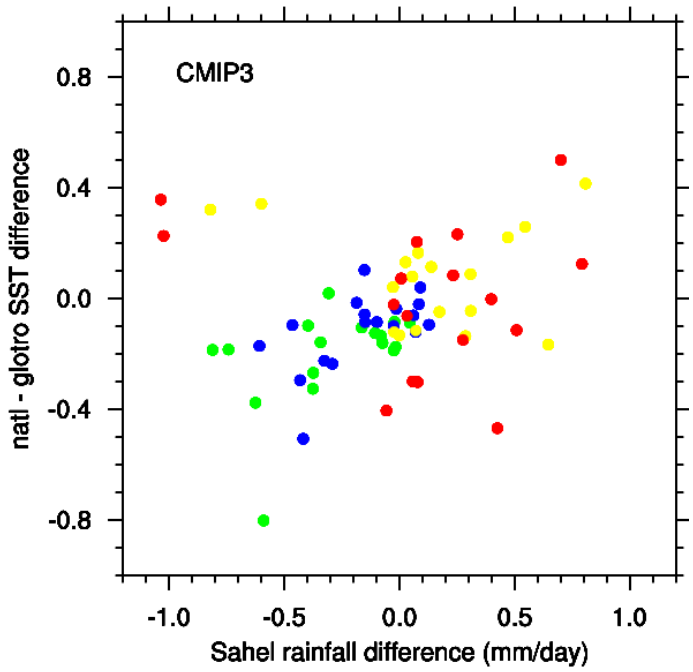
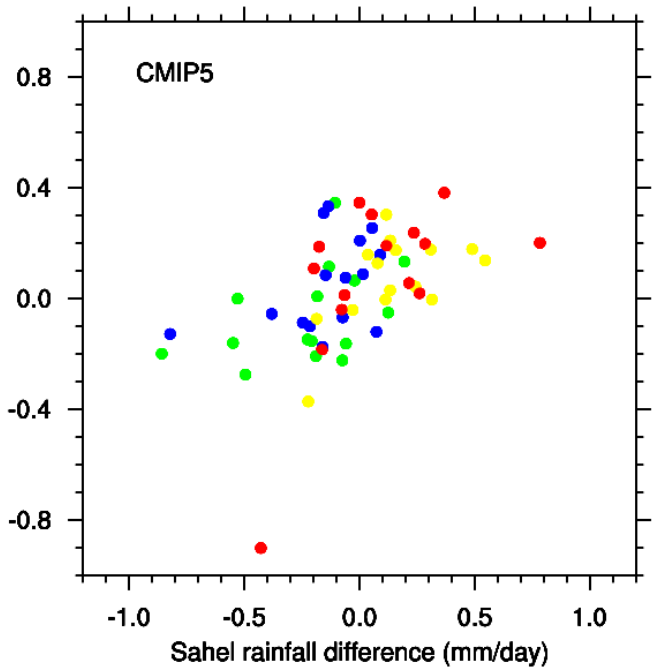
The difference between sub-tropical North Atlantic and global tropical sea surface temperature explains past drought and potential future recovery





Giannini, Salack, Lodoun et al. 2013, in Env Res Lett

Past

Green: end 20th century – pre-Industrial

Blue: end – beginning 20th century

Future

Yellow: mid-21st (A1B) – end 20th

Red: end 21st – end 20th

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