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Analysis of satellite precipitation over East Africa during last decades

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1. Abstract

Daily precipitation time series from four satellite products, **ARC v2, TAMSAT, TMPA-3B42 v7, and CMORPH v1.0**, are analysed to extract the spatial and temporal variability of precipitation over **East Africa (EA – 5 S-20 N, 28 E-52 E)** during last decades **(1983/1998 – 2013)**.

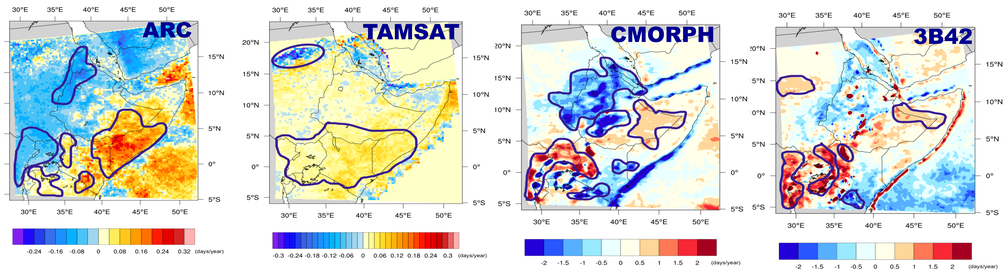
The Empirical Orthogonal Function (EOF) analysis is used to investigate the spatial and temporal precipitation variability in particular for October-November-December (OND) referred to as the short rain season. Moreover, the **connections among EA's precipitation, sea surface temperature (HadISST1-SST), soil moisture (ECV-SM), and wind (NCEP-NCAR)** are investigated through the correlation with the dominant EOF modes of variability and the composite analysis.

Time series of the joint CCI/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI, http://etccdi.pacificclimate.org/index.shtml), **R1, PRCPTOT and CDD**, are applied to extract precipitation temporal variations by **trend analysis** (Mann-Kendall technique).

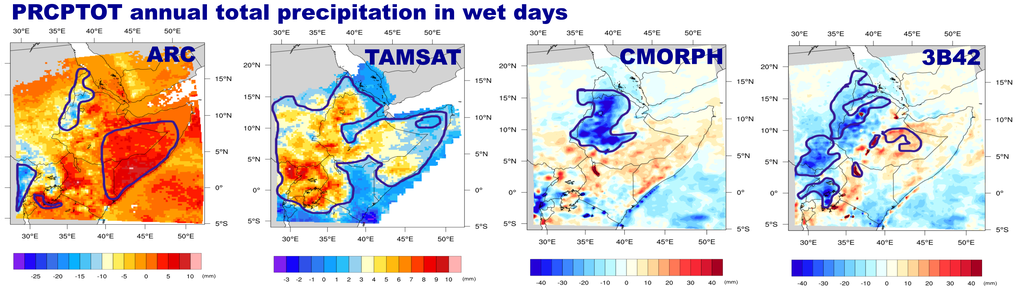
2. ETCCDI precipitation indices – Linear trend (slopes and areas of trend confidence)

Areas with trend confidence level > 95% are delimited by the blue lines.

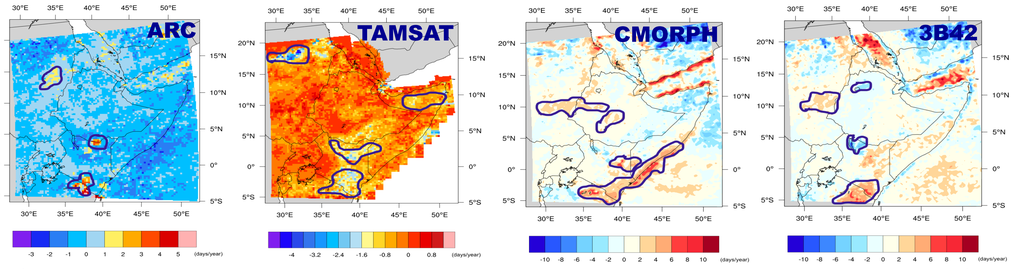
R1 annual number of wet days (> 1mm)



PRCPTOT annual total precipitation in wet days



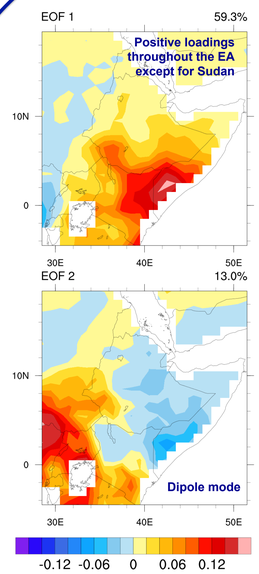
CDD maximum number of consecutive dry days (≤ 1 mm)

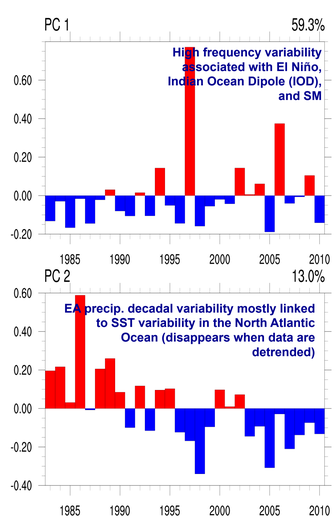


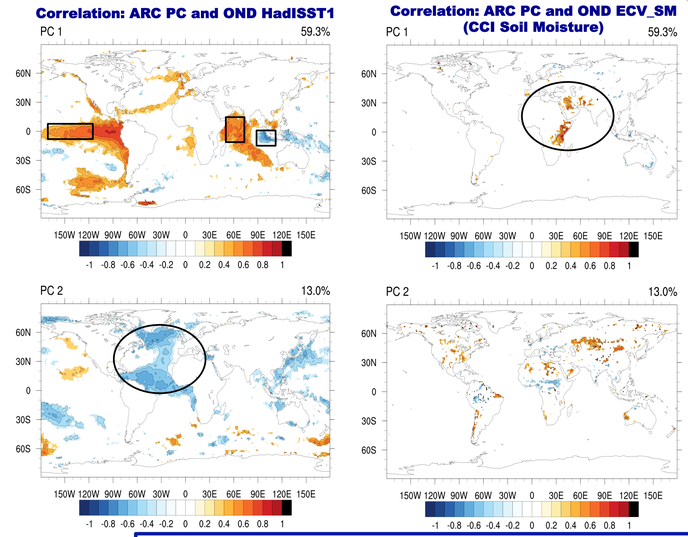
Conclusions

- High spatial variability for the ETCCDI precipitation indices.
- ARC, CMORPH, and 3B42 exhibit similar spatial patterns for R1 with positive trends over Somalia and East Ethiopia and negative over West Ethiopia. Lower agreement over South Sudan, Uganda, and Kenya, where ARC and CMORPH-3B42 have opposite behaviours. Unlike the other precipitation products, TAMSAT shows a positive trend over all EA.
- An increase in PRCPTOT is evident over East Ethiopia and Somalia from all precipitation products (only ARC and TAMSAT have in these areas trend confidence levels > 95%). ARC, CMORPH, and 3B42 present negative trends over west Ethiopia and Uganda, unlike TAMSAT showing a positive PRCPTOT trend overall EA.
- Limited areas with trend confidence levels > 95%. Small areas over Kenya are characterized by a significant increase of CDD except for TAMSAT.

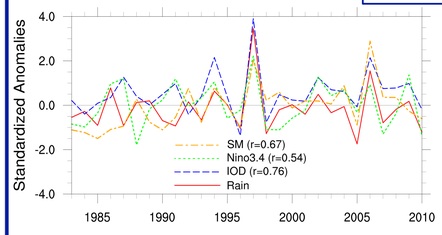
3. East Africa short rain (ARC) variability explained by SST and SM







Niño3.4 index: SST average over the Pacific Ocean (5S-5N; 120W-170W).
IOD index: difference between SST anomalies in the western (10S-10N; 50E-70E) and eastern (10S-Eq; 90E-110E) equatorial Indian Ocean.
EA rainfall index and **SM**: spatial average over EA of rainfall and SM.

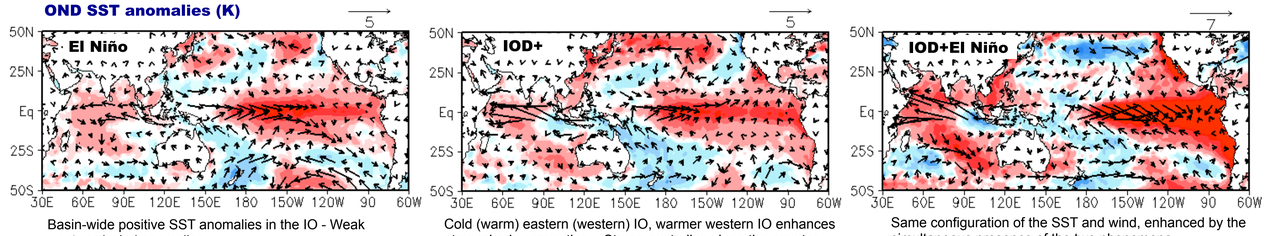


Events	Definition	Years
El Niño	Nino3.4 and IOD ~ 1 STD	1987, 1991, 2002, 2004, 2009
IOD+	IOD >> Nino3.4	1994, 2006
IOD-	IOD << Nino3.4	1996
La Niña	Nino3.4 << IOD	1988, 1999, 2007
IOD+El Niño	Nino3.4 & IOD ≥ 2	1997
IOD-La Niña	Nino3.4 & IOD < 0 & (Nino3.4 –IOD) ≤ -1 STD	1998

Conclusions

- At the high frequency time scale (EOF1) EA rainfall is affected by Pacific and Indian Ocean SSTs, as shown by the correlation between rainfall and the SST. A positive correlation is also observed between rainfall and OND SM. At the lower frequency time scale (EOF2 dipole mode), EA rainfall variability seems to be linked to the North Atlantic Ocean SSTs. However, this link is not apparent when SST data are detrended, suggesting a potential connection of the dipole mode to global warming (Schreck and Semazzi, 2004).
- Pure IOD events have a strong influence on the variability of short rains. EA receives above (below) normal rainfall during IOD+ (IOD-) events.
- For pure El Niño events, there is a tendency towards reduced rainfall over EA, even if some areas with positive rainfall anomalies are present.
- Joined IOD+ and El Niño events show a reinforced response similar to pure IOD+, with some contribution from the pure El Niño.
- OND SM shows a similar response to that of EA short rain.

OND SST anomalies (K)



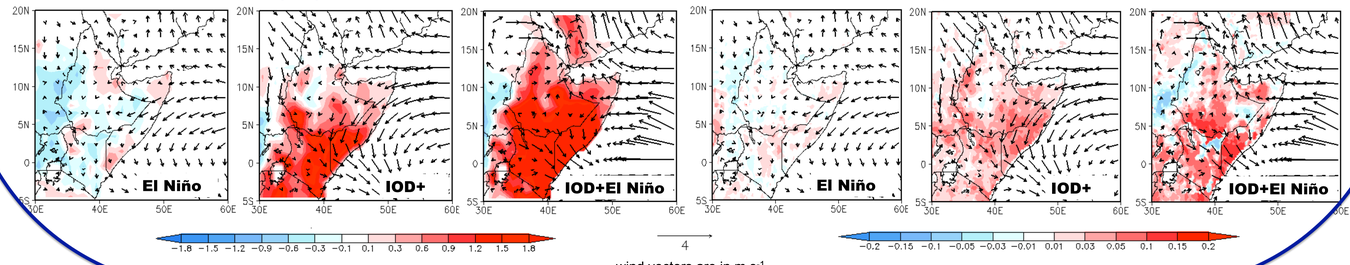
Basin-wide positive SST anomalies in the IO - Weak westward wind anomalies

Cold (warm) eastern (western) IO, warmer western IO enhances atmospheric convection – Strong easterlies along the equator

Same configuration of the SST and wind, enhanced by the simultaneous presence of the two phenomena

ARC OND rainfall anomalies (mm)

SM OND anomalies ($m^3\ m^{-3}$)



wind vectors are in m s^{-1}

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