Dynamics of the dominant modes of rainy season extreme pluvial events over West Africa

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Motivation

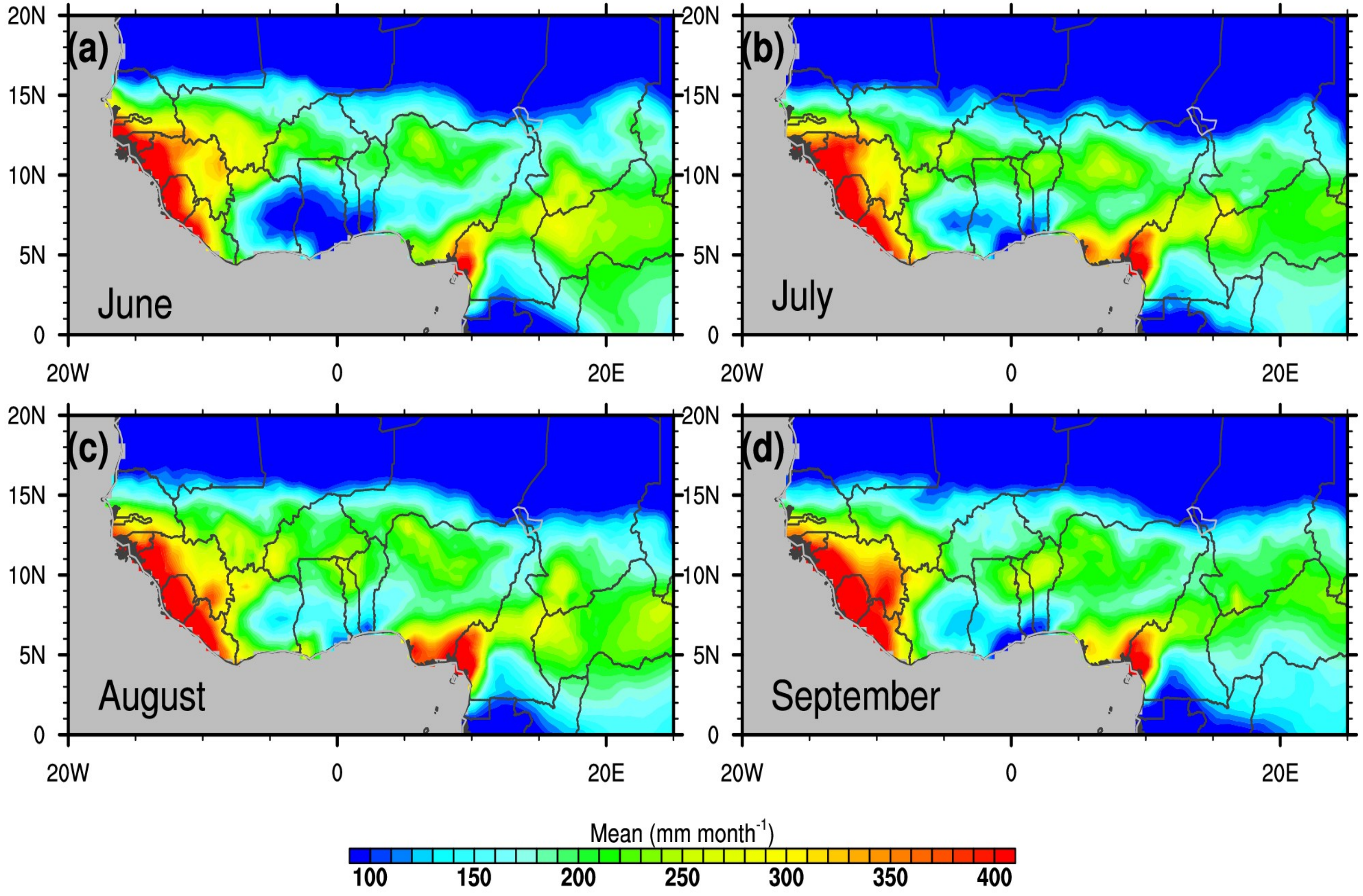
The mean state of rainy season precipitation over West Africa

- **The climate of the region is modulated by the West African monsoon system (WAM).**

- **The dominant wind system is controlled by the position of the Inter-tropical Convergence Zone (ITCZ).**

- **Profound impacts on regional and global climates.**

- **We seek to understand the dynamics of summer monsoon precipitation interannual variability**



Data Source: CRU, 1950–2022.

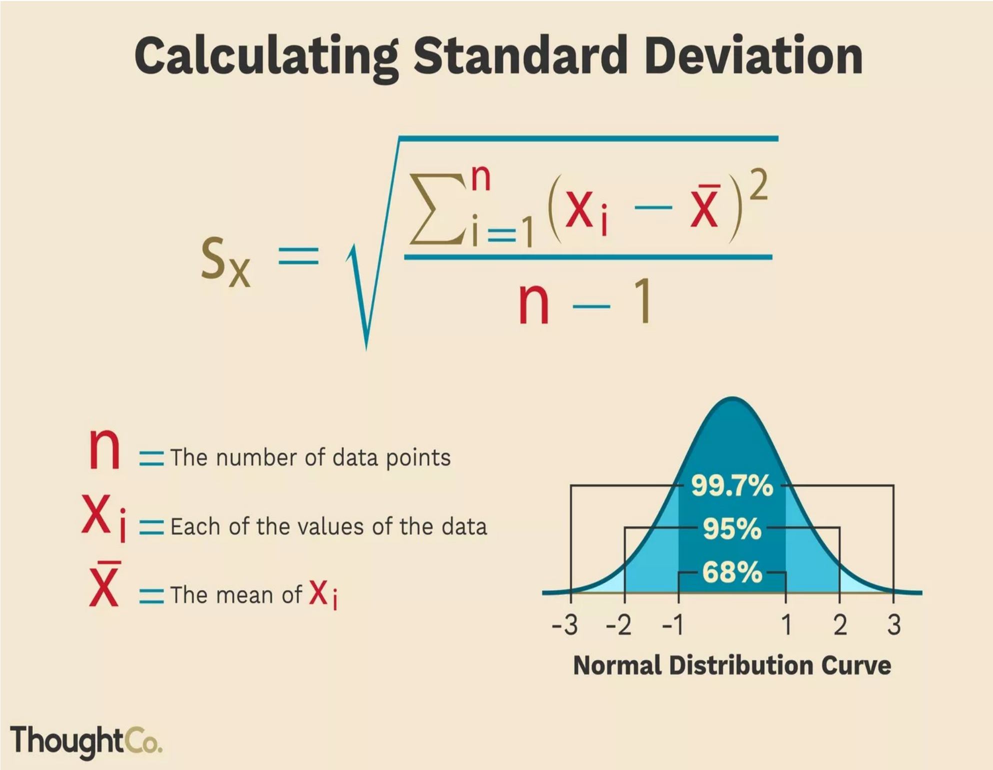
Data and Methods

TABLE 1. The names, sources, periods, time steps, and resolutions for the datasets used in this study					
Name	**Source**	**Period**	**Time step**	**Resolution**	**Reference**
CRU	Climatic Research Unit	1950-2022	Monthly	0.5° x 0.5°	Harris et al. 2020
HadISST	Met Office Hadley Center	1950-2022	Monthly	1.0° x 1.0°	Rayner et al., 2003
ERA5	European Centre for Medium-Range Weather Forecasts reanalysis	1950-2022	Monthly	0.25° x 0.25°	Hersbach et al., 2020

- Dataset were remapped to a 2.5° spatial resolution and linearly detrended
- We used standardised precipitation anomaly, composite analysis, season-reliant EOF (S-EOF) analysis, Student's t test
- We concentrated our analysis on the rainy months of June-July-August-September.

Definition of an extreme event

- Wet event => +1 sd
- Dry event <= -1 sd

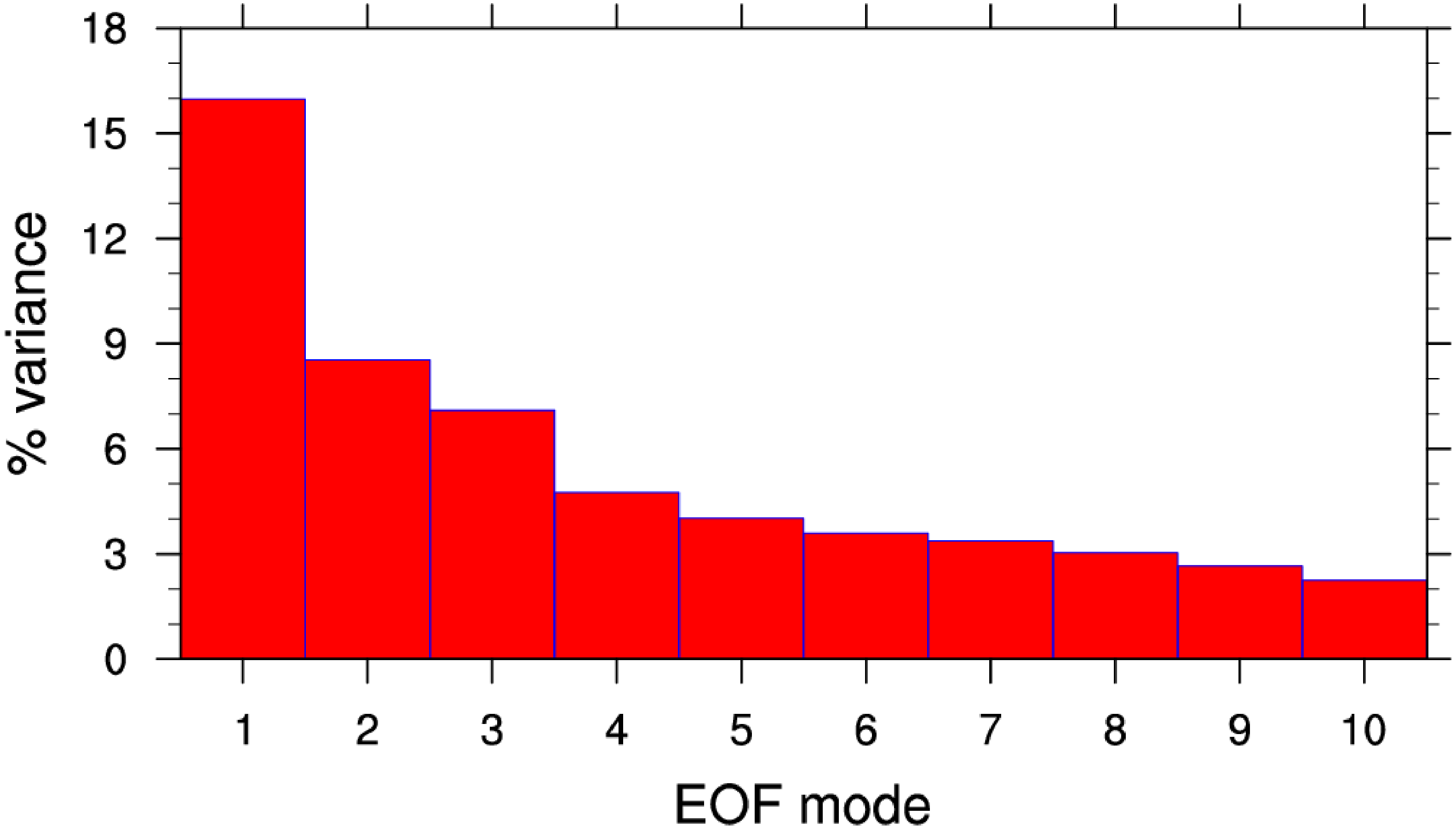


Source: https://www.thoughtco.com/calculate-a-sample-standard-deviation-3126345

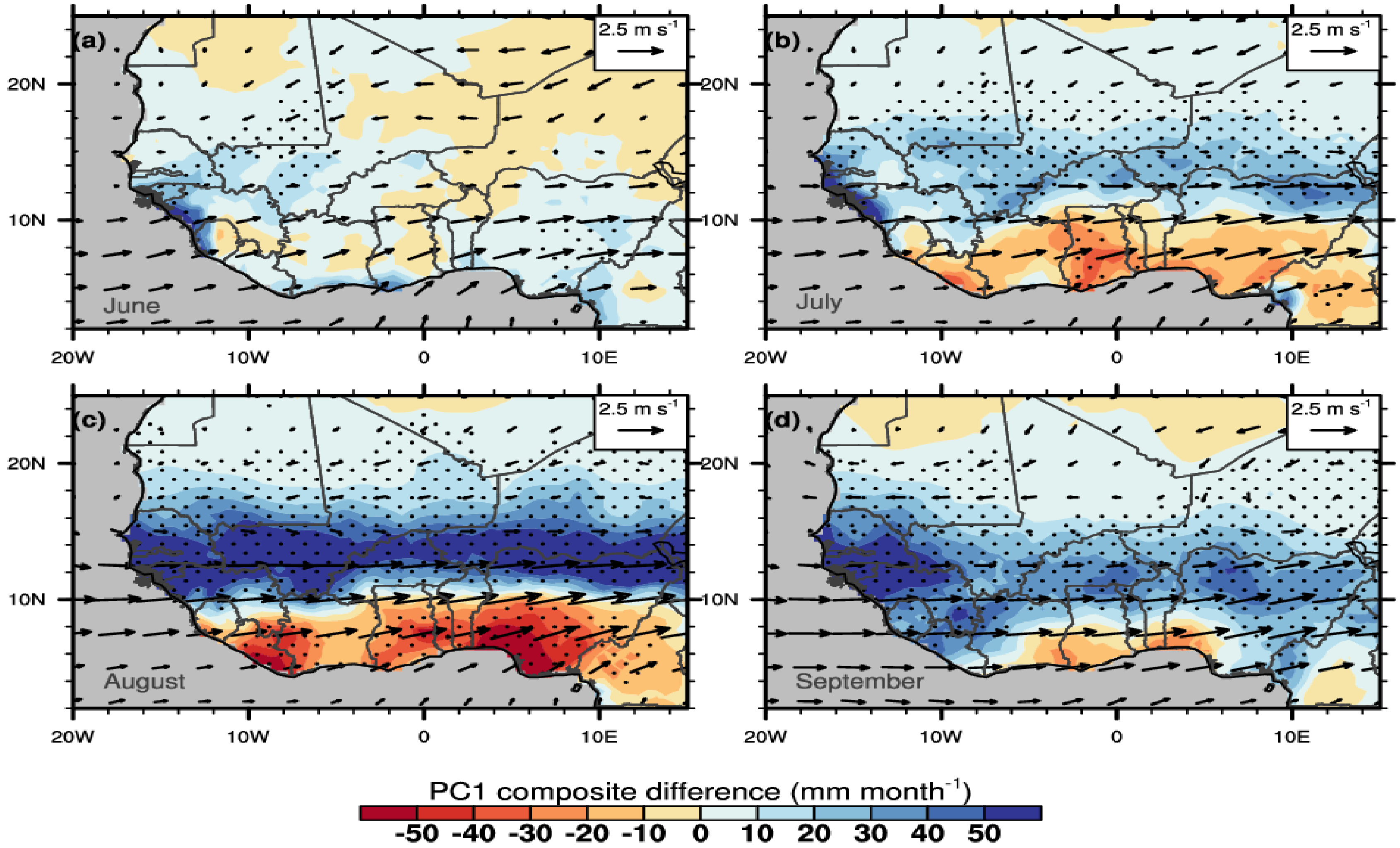
TABLE 2. Indices used in the study			
Index	**Longitude**	**Latitude**	**Reference (s)**
Guinea coast (GC) Index	10°W - 15°E	4° - 10° N	
Sahel (SH) index	10°W - 15°E	10° - 16° N	
Eastern Mediterranean SST index (EMS)	5°W – 25° E	30° - 42° N	Gaetani et al., 2010; Rowell, 2003; Diatta & Fink, 2014
Atlantic Meriodional mode (AMM)	50-10° W 30W - 0	5 – 15 ° N 5- 15 ° S	Servain 1991
Atlantic nino (ATL3) index	20°W - 0°	3S - 3°N	Zebiak, 1993
Nino3.4	170°W–120°W	5°S - 5°N	Trenberth, 1997
South Atlantic Ocean Dipole (SAOD)	20° W – 10° E 40° W – 10° E	15° S – 0° 25° - 40° S	Venegas et al 1996; Nnamchi & Li, 2011
Indian Ocean Basin (IOB)	40° – 100° E	20° S –20° N	Ashok & Saji, 2007

RESULTS

Percentage variance (%) explained by the first ten leading S-EOF modes

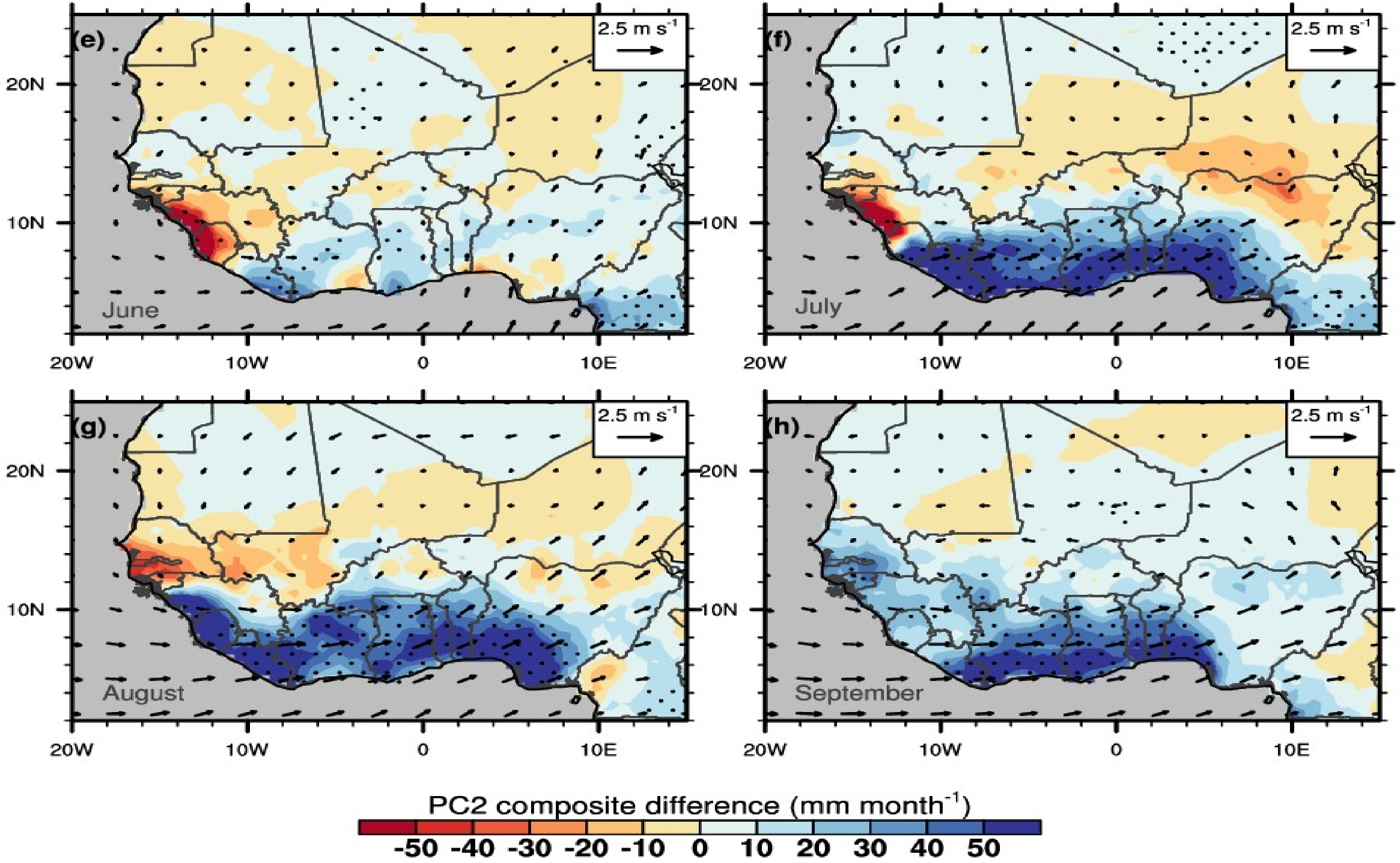


Evolution pattern of the leading mode of West African precipitation variability overlaid by horizontal winds at 850 hPa



Stipples denote statistical significance at the 95% confidence level

Evolution pattern of precipitation variability in the second mode overlaid by horizontal winds at 850 hPa



Stipples denote statistical significance at the 95% confidence level

PCs of the leading modes of precipitation variability

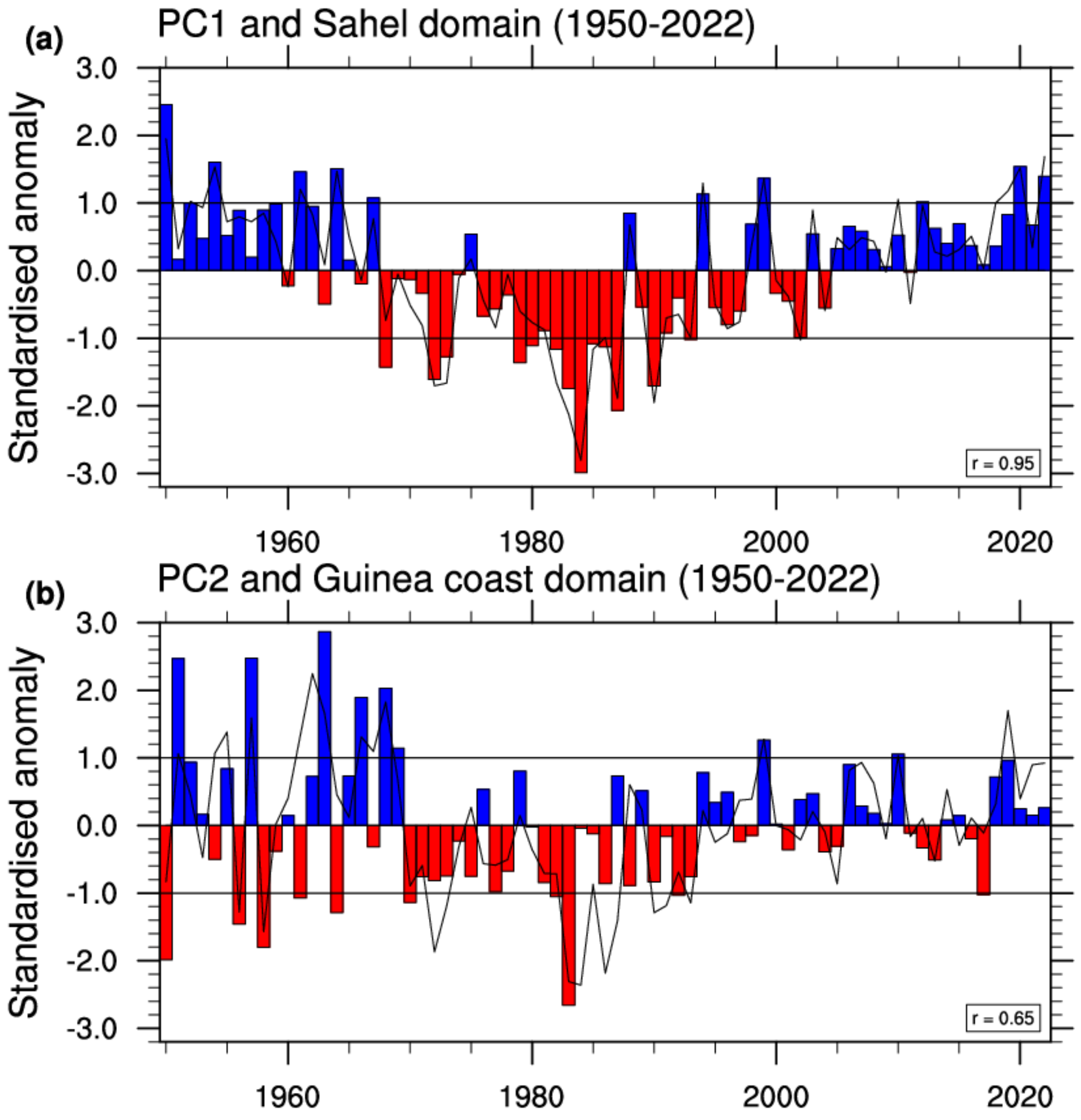
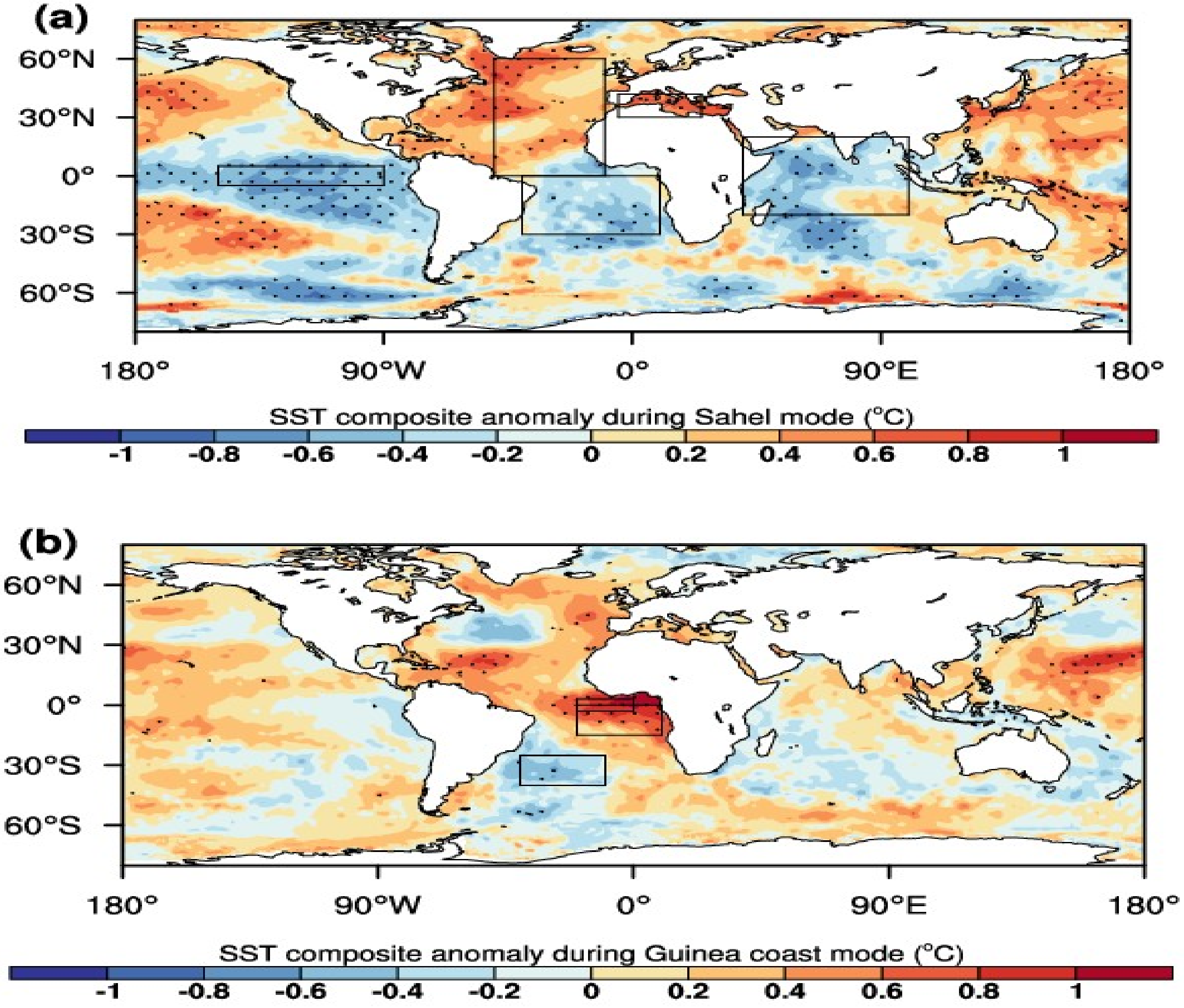


Table 3. Identified extreme precipitation events years		
S-EOF	**Climatological year**	**Total**
Mode 1	Wet years: 1950, 1952, 1953, 1954, 1955, 1956, 1958, 1959, 1961, 1962, 1964, 1967, 1988, 1994, 1998, 1999, 2003, 2006, 2010, 2012, 2013, 2015, 2019, 2020, 2021, 2022	26
	Dry years: 1963, 1968, 1972, 1973, 1976, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1990, 1991, 1993, 1995, 1996, 1997, 2000, 2001, 2002	23
Mode 2	Wet years: 1950, 1954, 1956, 1958, 1972, 1976, 1978, 1982, 1983, 1986, 1990, 1991, 1992, 1993, 1997, 2005, 2013, 2015, 2017	19
	Dry years: 1951, 1952, 1955, 1957,1959, 1962, 1963, 1965, 1966, 1968, 1979, 1985, 1987, 1989, 1996, 1999, 2006, 2007, 2010, 2018, 2020	21
Concurrent Wet	1950, 1954, 1956, 1958, 2013, 2015	6
Concurrent Dry	1963, 1968, 1979, 1985, 1987, 1996	6

West African precipitation modes -SSTA teleconnections



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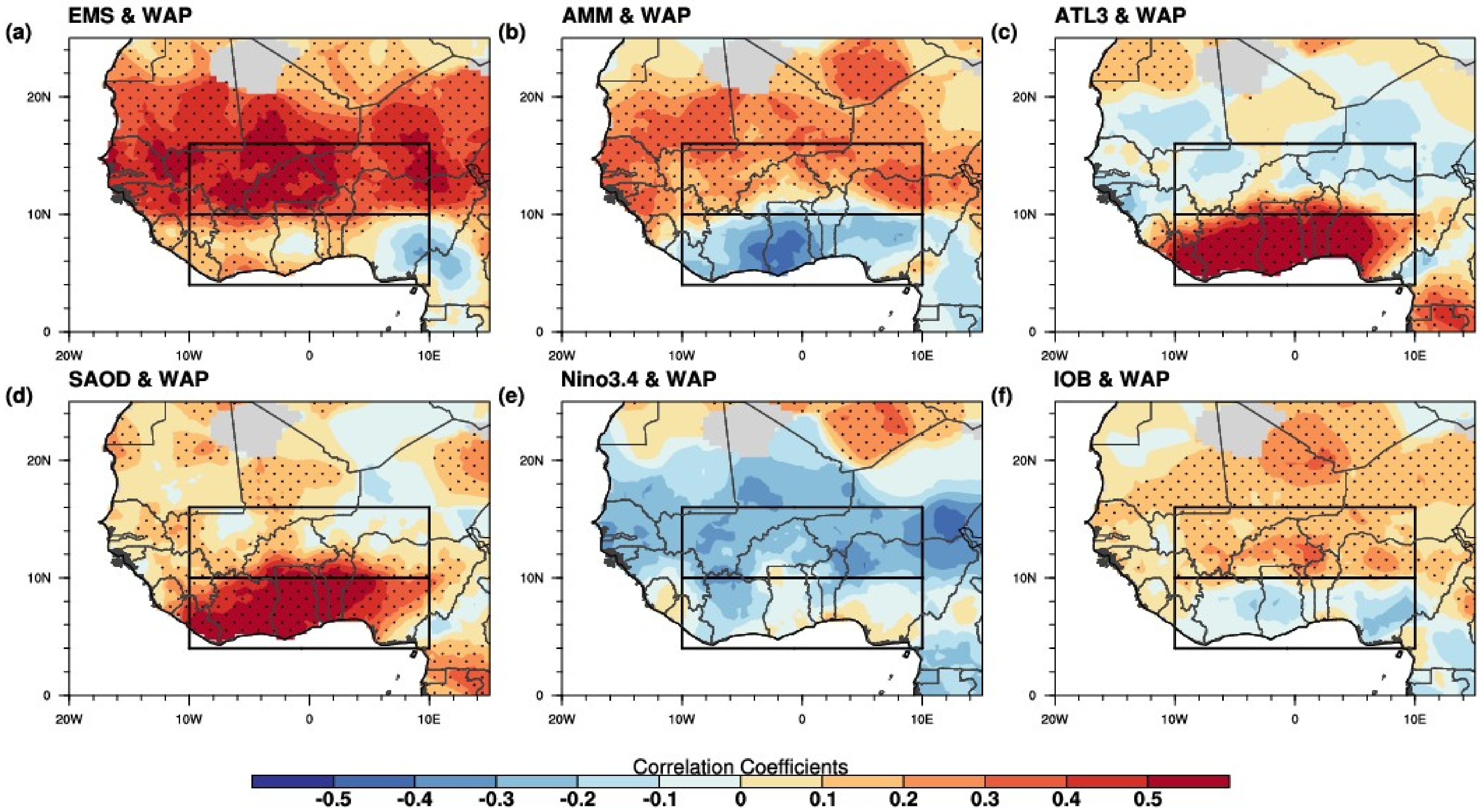
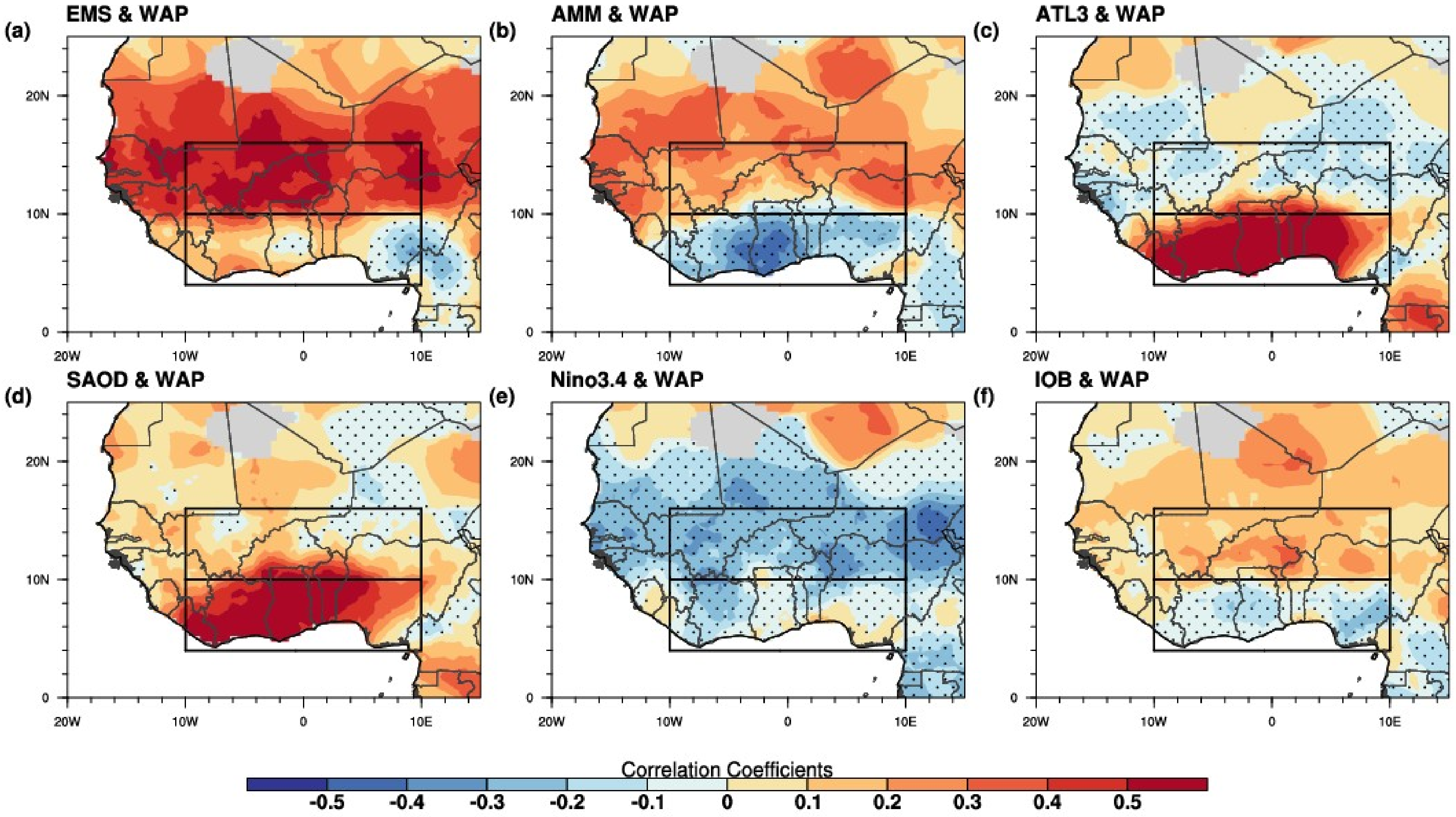
Relationship between sst indices and precipitation over West Africa



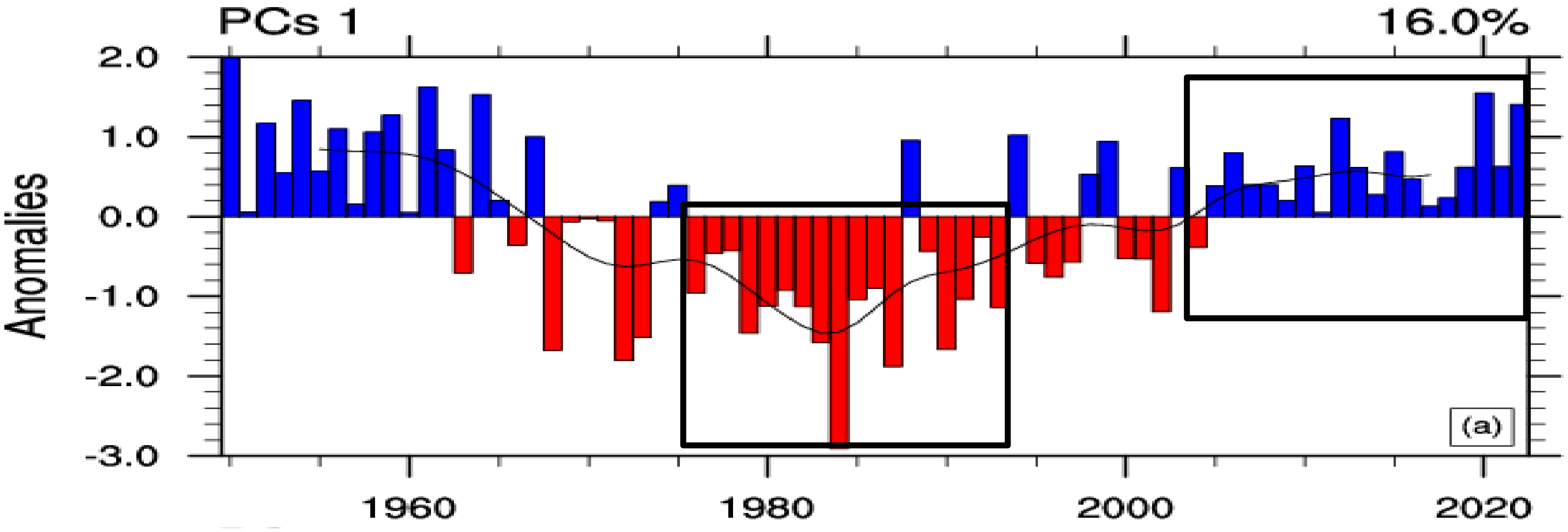
This plot shows only areas of significant positive relationship

Relationship between sst indices and precipitation over West Africa



This plot shows only areas of significant negative relationship

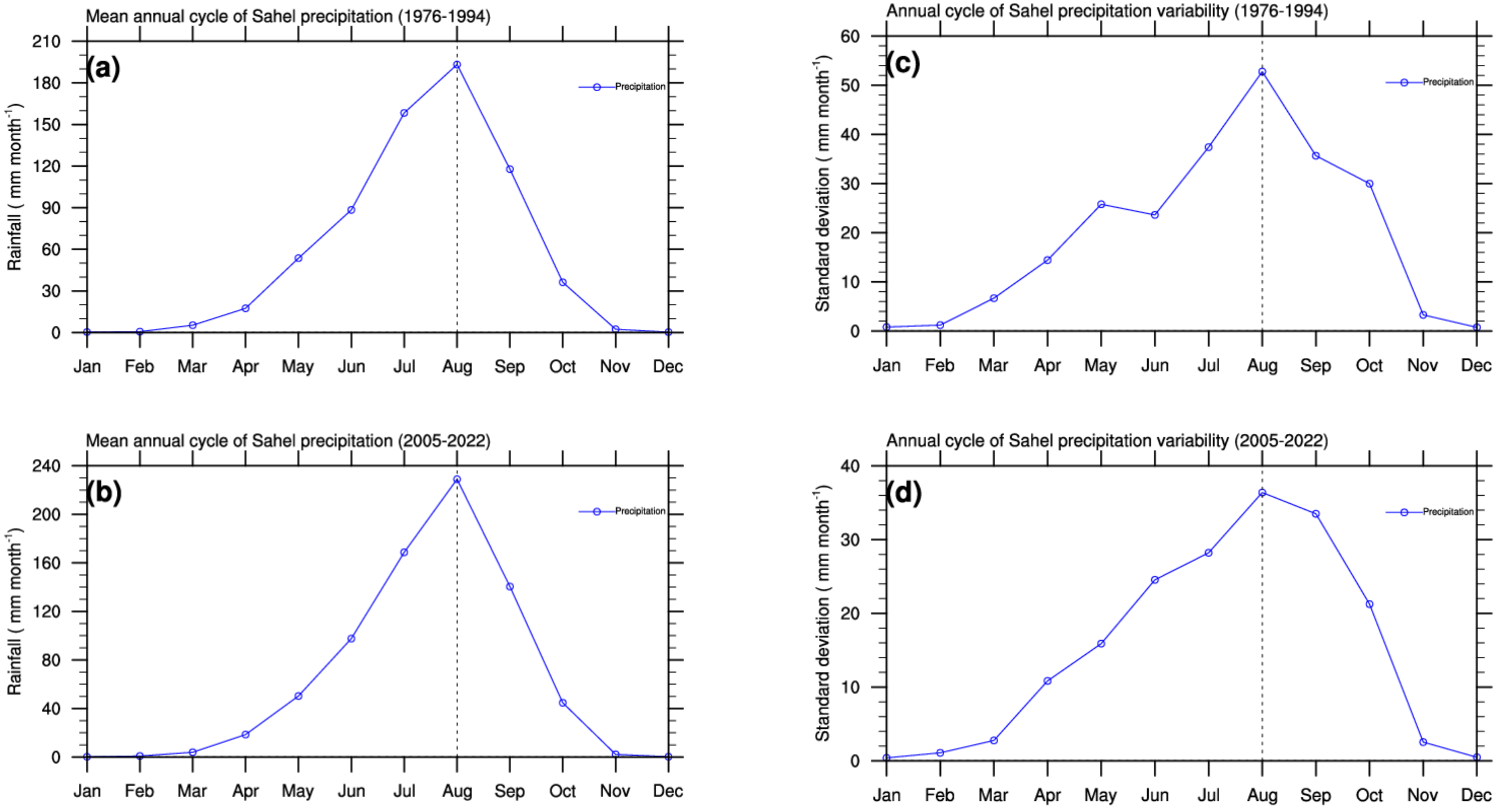
Which oceanic basin is driving the increasing wet events at Interannual scale over West Africa?



56 years are classified as normal years with 41.1% being.

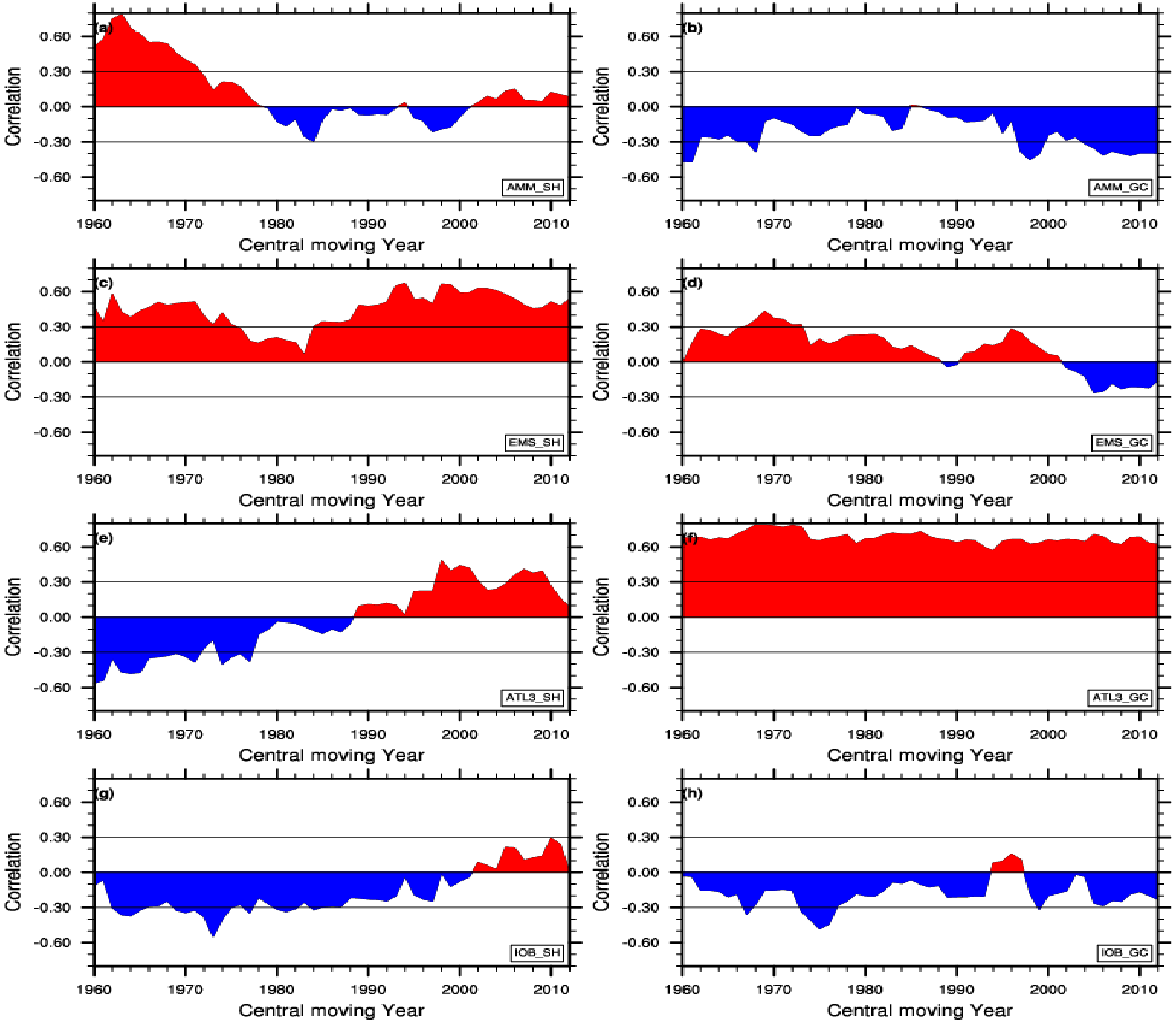
Dry monsoon period = 1976 to 1994
Wet monsoon period = 2005 to 2022

Comparing the dry and wet consecutive years



Increased domain averaged rainfall in August and September and more persistent rainy season variability pattern in recent years

Nonstationarity in WAM-SST teleconnections



Summary and Conclusion (1)

- Two dominant modes of summer precipitation over West Africa. EOF1 (Sahel) exhibits a dipole mode with 16% variance, while EOF2 presents a monopole mode with 8.5% variance.
-
- The key mechanisms driving this modes of variability differ considerable; The Sahel mode is significantly associated negatively (positively) with summer Nino3.4 SSTA (ENSO) and Mediterranean Sea Surface Temperature Anomaly (SSTA), while most parts of the Guinea coast region is notably connected to the Atlantic zonal (Atlantic Nino) mode of SSTA.
-
- Other significant drivers includes the South Atlantic Ocean dipole index and the Indian Ocean Basin index.

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Summary and Conclusion (2)

- The Mediterranean and ATL3 SSTA account for 81% of the precipitation variability drivers over West Africa

- Recent increases in extreme wet events especially over the Sahel region is due to the persistence of the Sahel mode of precipitation variability.

- The causes of these wet anomaly and persistence of the Sahel mode of variability are attributed to the following 1) remote ENSO forcing, 2) weakened Atlantic SSTA, 3) enhanced walker circulation, and 4) Sahara heat low.

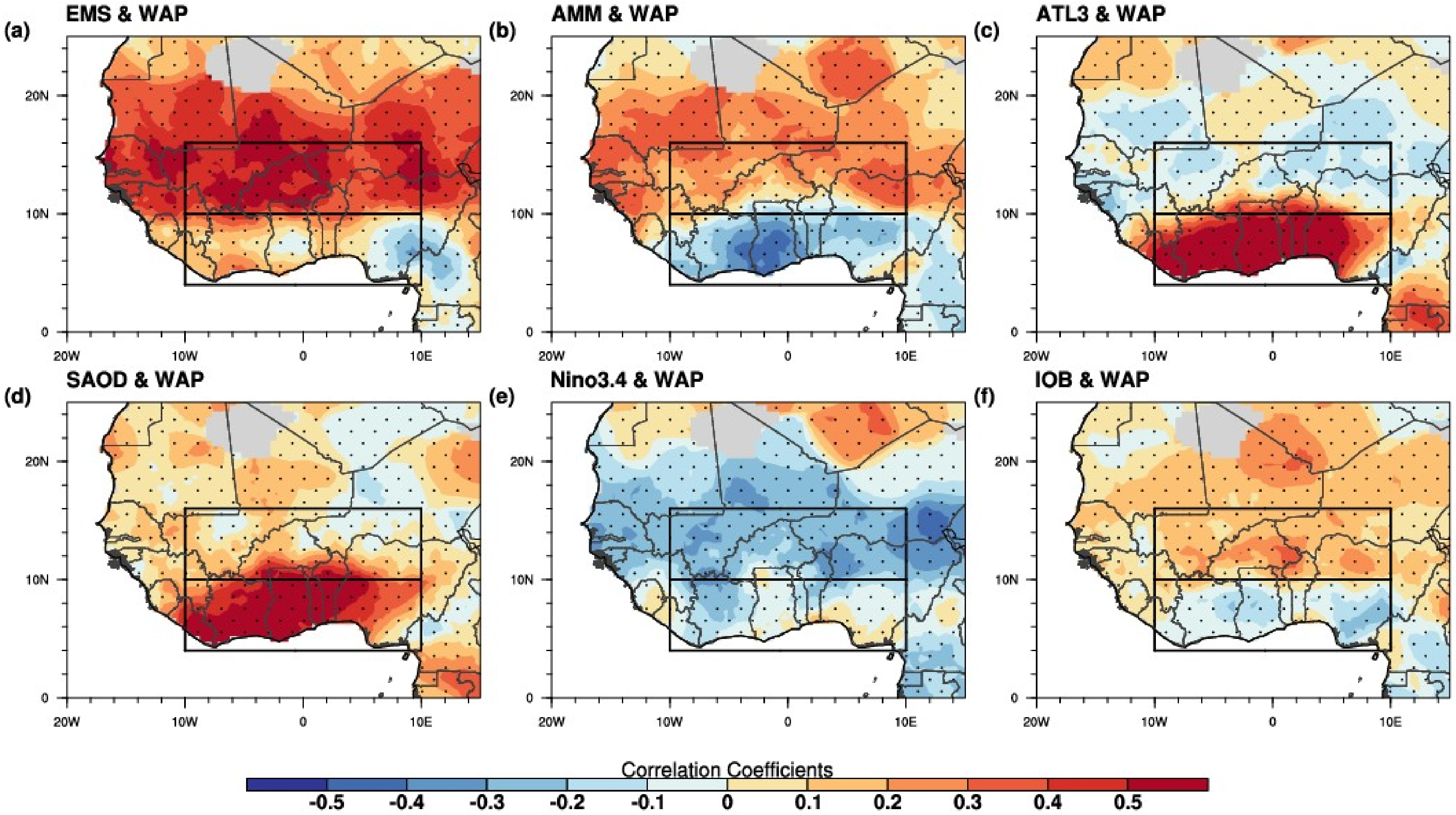
Recommendation

- We advocate for constant monitoring of the evolution of the climate modes.
- Improved understanding of the Atlantic Nino and its predictability.
- Proactive disaster risk management strategies such as: sustained sensitisation outreaches, land use/landcover planning and enforcement.
- Futuristic planning and preparedness especially under and increasing global warming as warmer climate decreases (enhances) precipitation over the Sahel and Guinea coast region respectively.

Merci Beaucoup

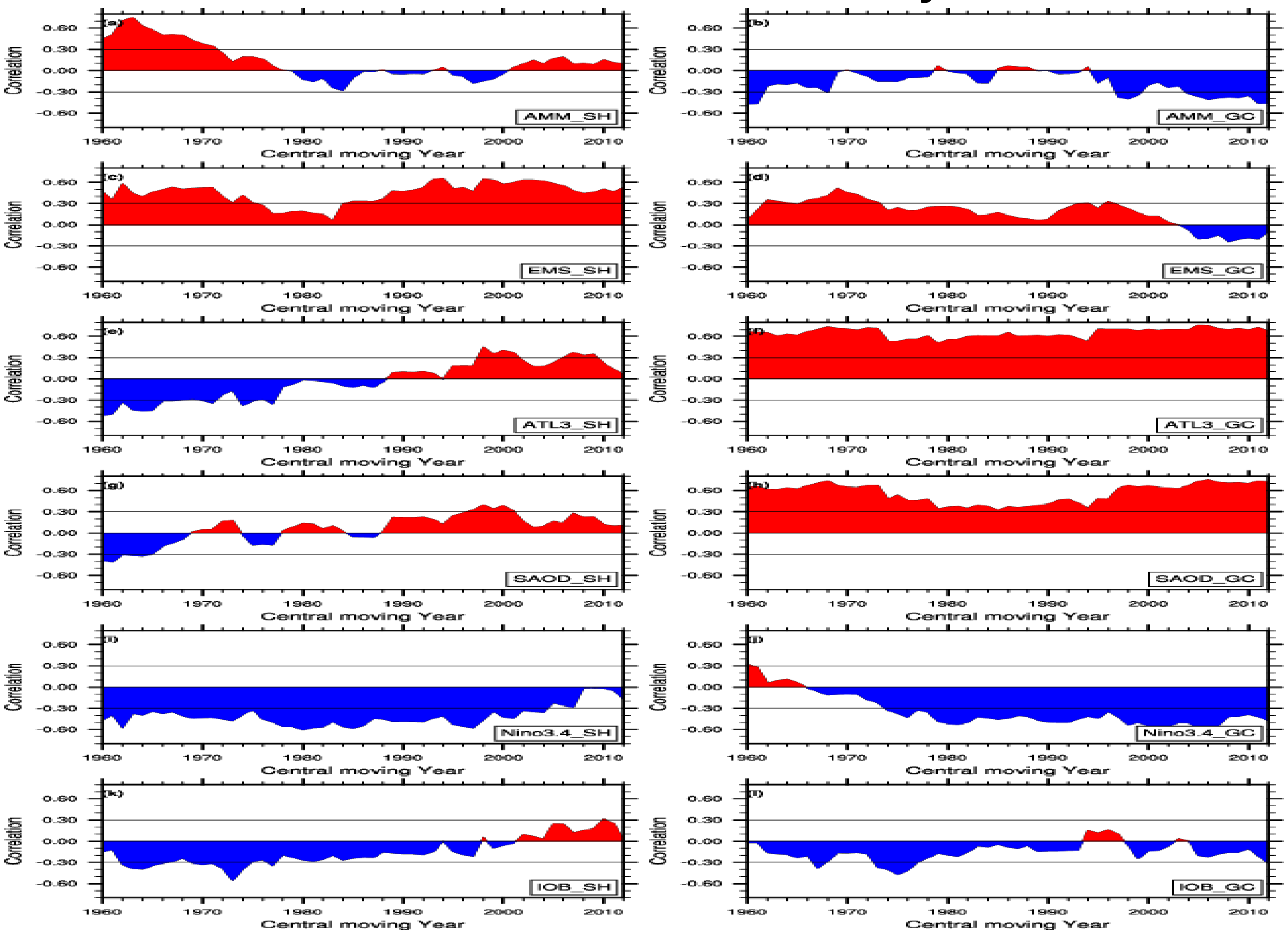
Supplementary

Correlation between identified SST indexes and West African precipitation



Stipples denote statistical significance at the 95% confidence level.

21 year running correlation between SST indices and leading modes of West African rainfall variability



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