

CONTROLS OF THERMODYNAMICS AND THE TELECONNECTIONS ON PRECIPITATION VARIABILITY IN CENTRAL-EAST AFRICA

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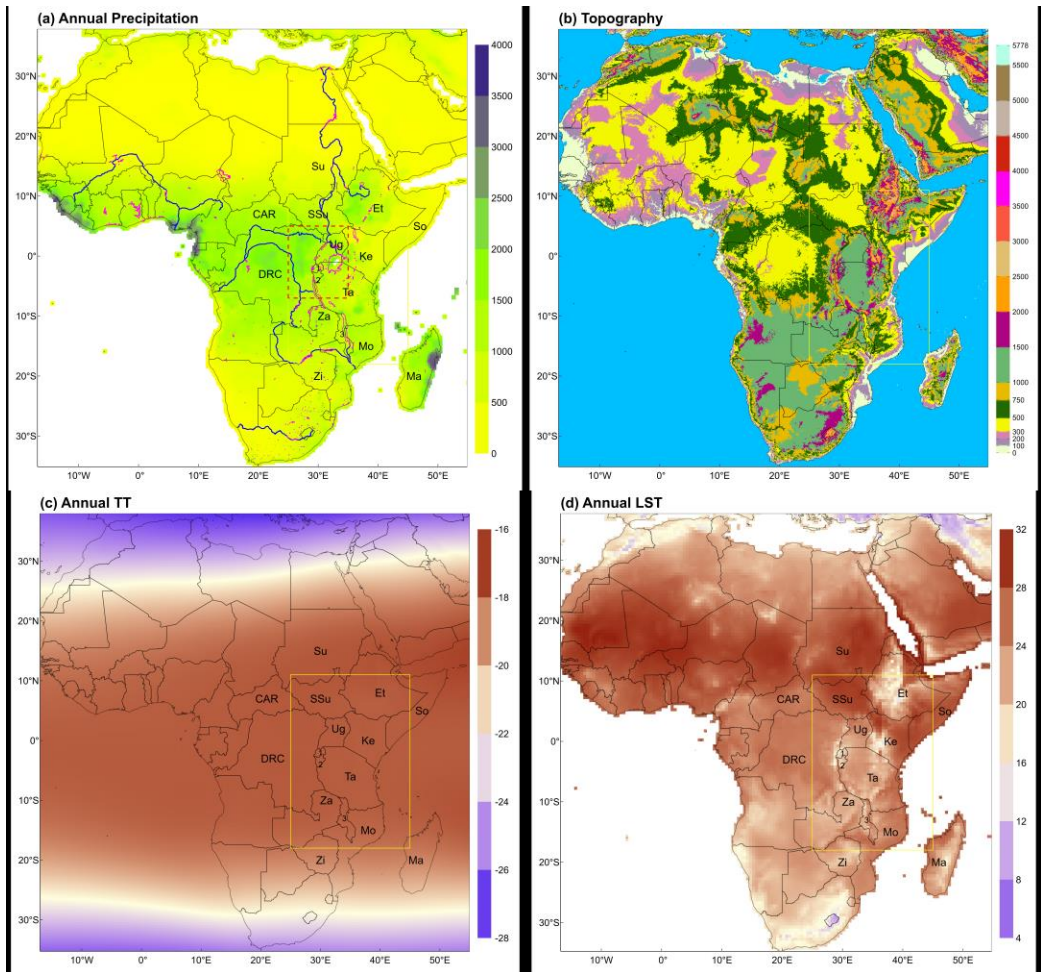
RESEARCH OVERVIEW

Central-East Africa experiences strong seasonal contrasts in rainfall, with consequences for floods, droughts, agriculture and water resources. This study examines precipitation variability and widespread wet/dry events across 1981–2020, linking local thermodynamic conditions, atmospheric moisture transport and large-scale tropical Indo-Pacific climate variability.

STUDY AIMS

What the study investigates

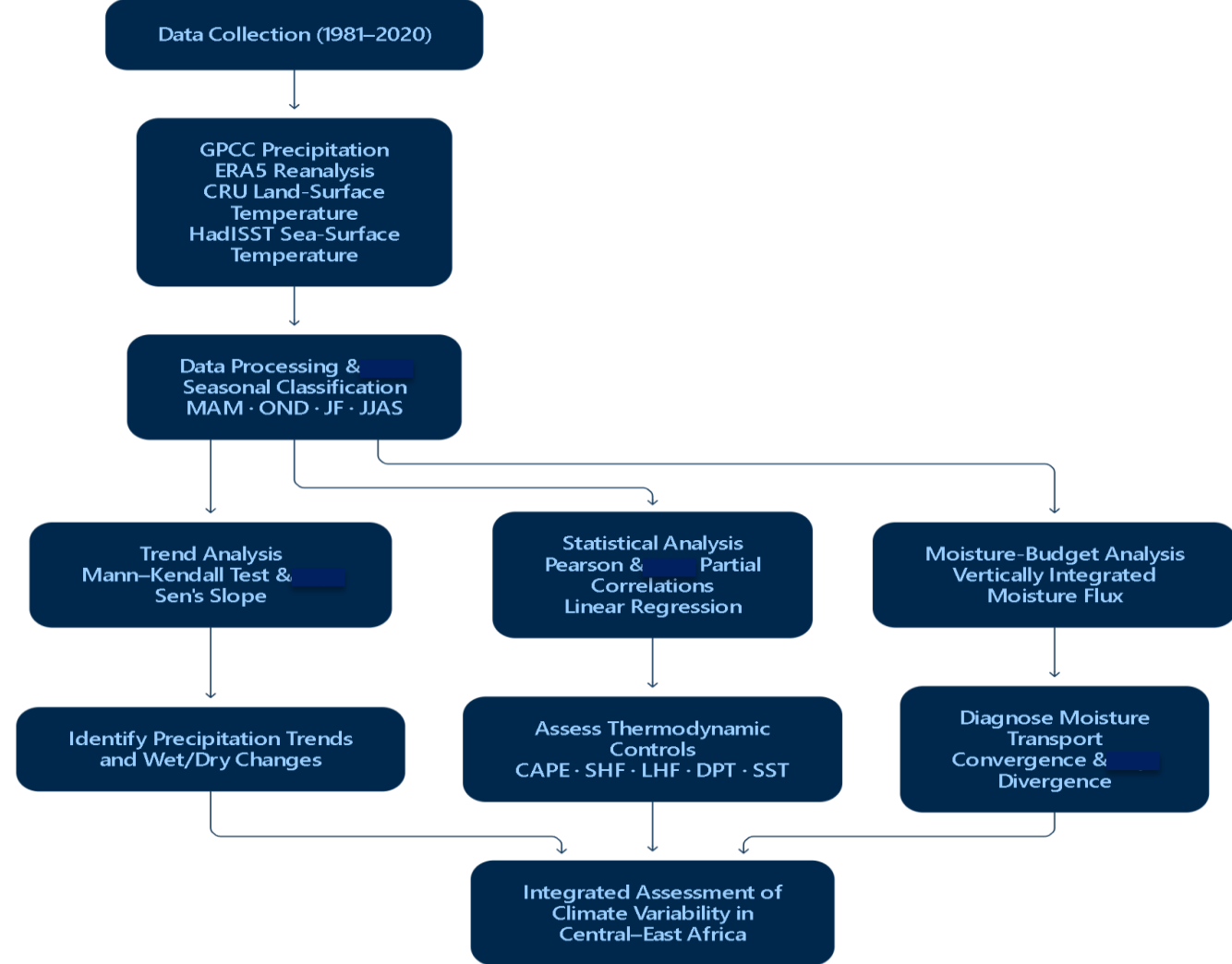
- Quantify monthly and seasonal precipitation trends.
- Compare the long rains (MAM), short rains (OND), boreal winter (JF) and boreal summer (JJAS).
- Assess how thermodynamic variables and climate teleconnections relate to precipitation and SPI.
- Connect widespread wet/dry events with atmospheric moisture-budget anomalies.



DATA & METHODS

Multi-dataset analysis

- GPCC monthly precipitation, $0.25^\circ \times 0.25^\circ$ (1981–2020).
- ERA5 atmospheric reanalysis, $0.25^\circ \times 0.25^\circ$; CRU land-surface temperature, 0.5° ; HadISST sea-surface temperature, 1° .
- Mann–Kendall trend test and Sen's slope; linear regression with a 95% significance test.
- Pearson/partial correlation, SPI dependency analysis and vertically integrated moisture-budget diagnostics.



CLIMATE INGREDIENTS

Local to oceanic drivers

LOCAL THERMODYNAMICS
Dewpoint temperature (DPT) • CAPE • sensible and latent heat fluxes • tropospheric temperature

ATMOSPHERIC DYNAMICS
Low-level winds • specific humidity • moisture-flux convergence • geopotential height

LARGE-SCALE MODES
IOD • Niño 3.4 / ENSO • MJO • PDO • AO • NAO

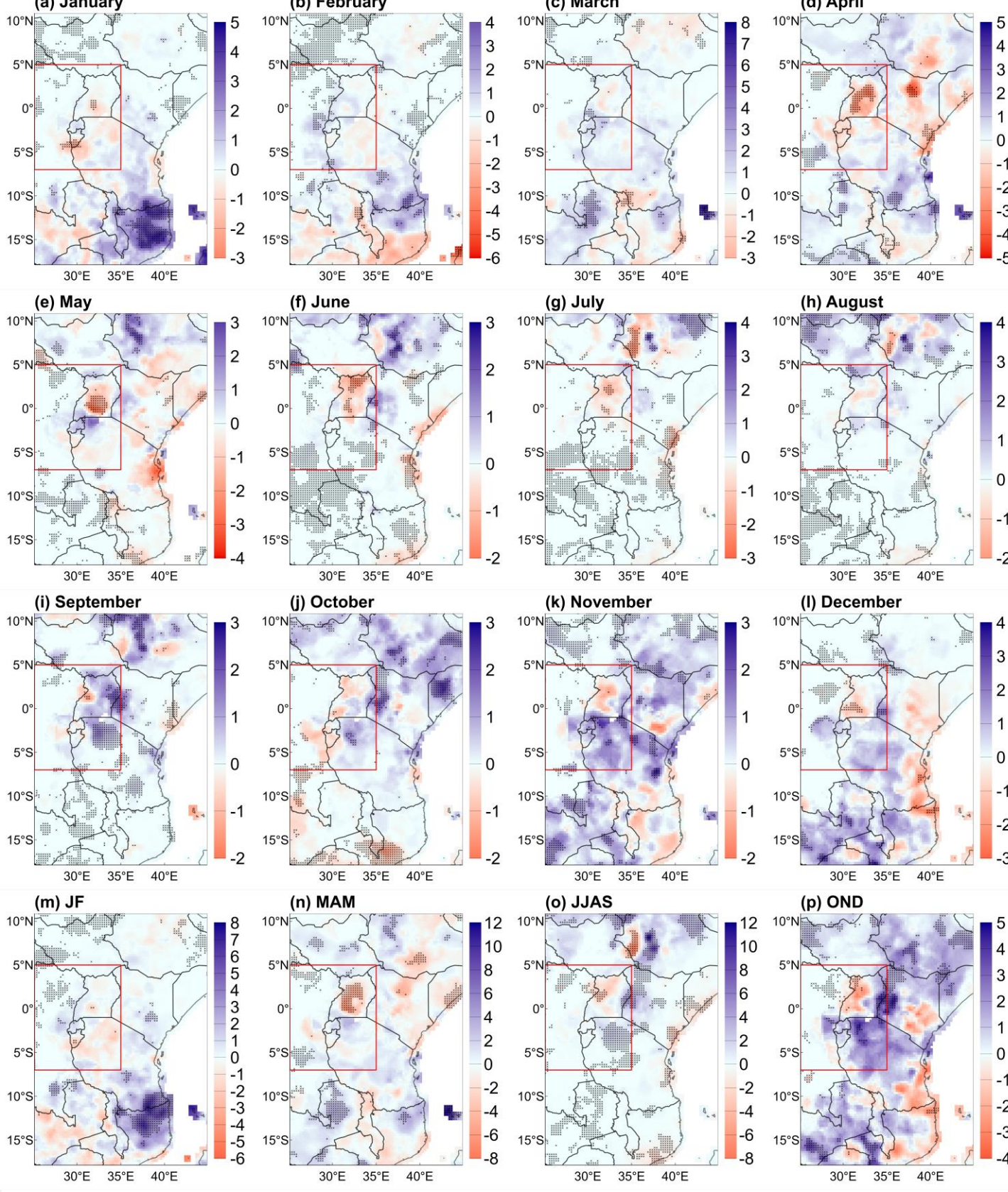
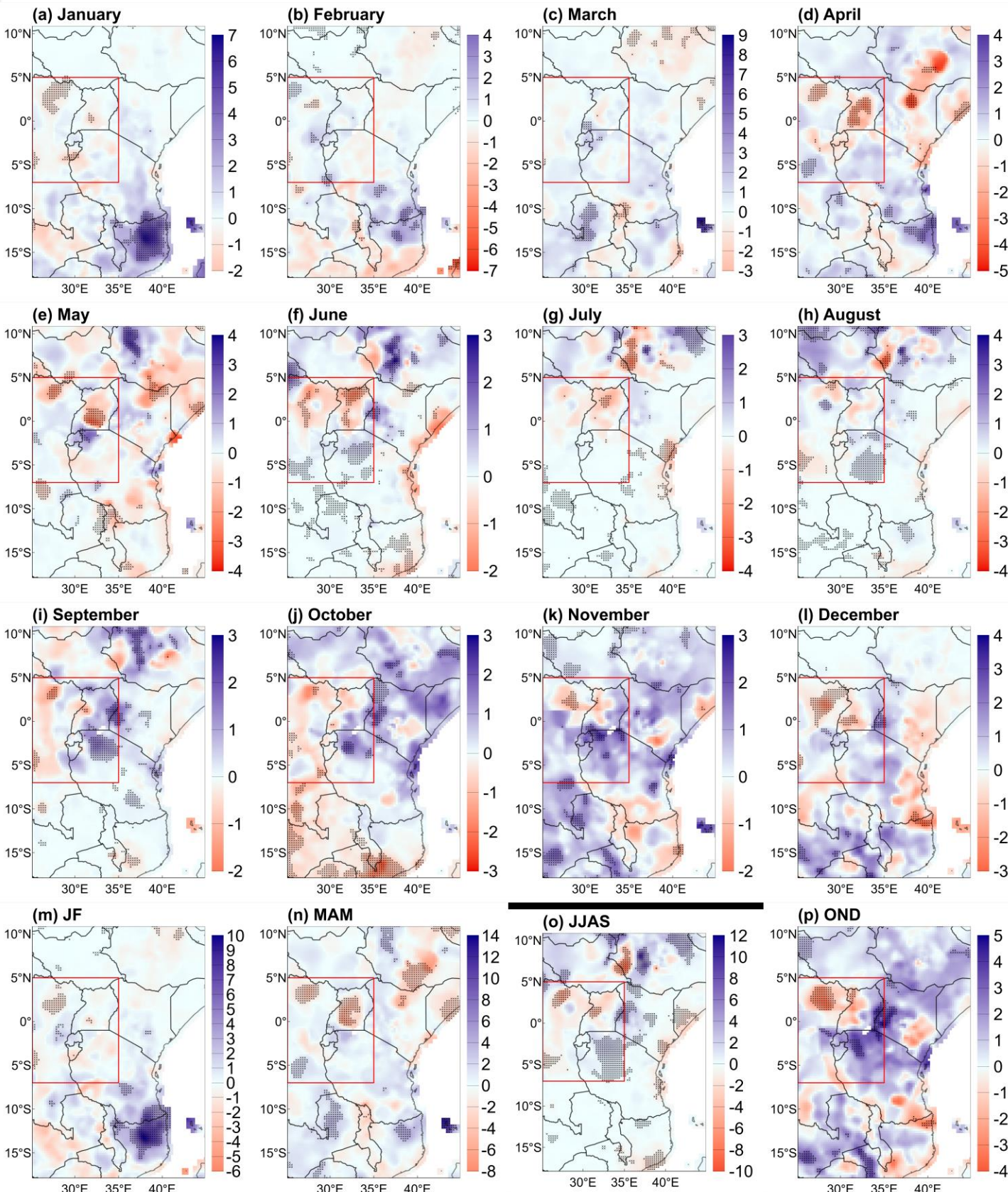
Table 1. Datasets used in this study

Sl. no.	Variable	Source	Spatial resolution	Period
1	Precipitation	https://gpcp.data.dwd.de/climate_environment/GPCP.html/	$0.25^\circ \times 0.25^\circ$	1981–2020
2	DPT, CAPE, LHF, SHF, VIDME, TT, zonal and meridional winds, geopotential height, and specific humidity	https://cds.climate.copernicus.eu/	$0.25^\circ \times 0.25^\circ$	1981–2020
3	LST	https://crutdata.uea.ac.uk/cru/data/hrp/	$0.5^\circ \times 0.5^\circ$	1981–2020
4	SST	https://www.metoffice.gov.uk/hadobs/hadisst/data/download.html	$1.0^\circ \times 1.0^\circ$	1981–2020
5	Niño3.4, Dipole Mode Index, PDO, AO, NAO	https://psl.noaa.gov/gcos_wgsp/Timeseries/	Nil	1981–2020
6	MJO	http://www.bom.gov.au/climate/mjo/	Nil	1981–2020

KEY FINDINGS

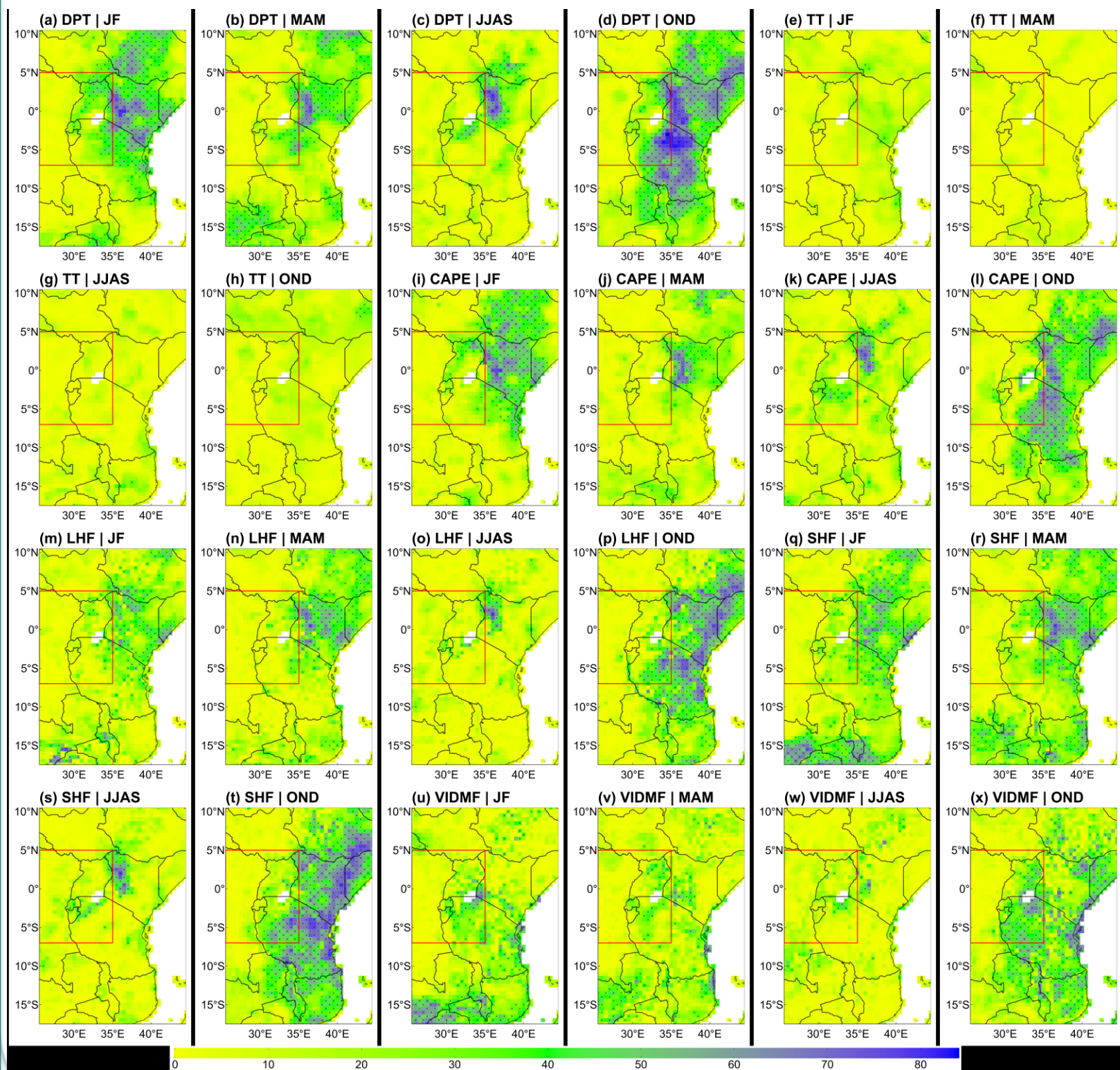
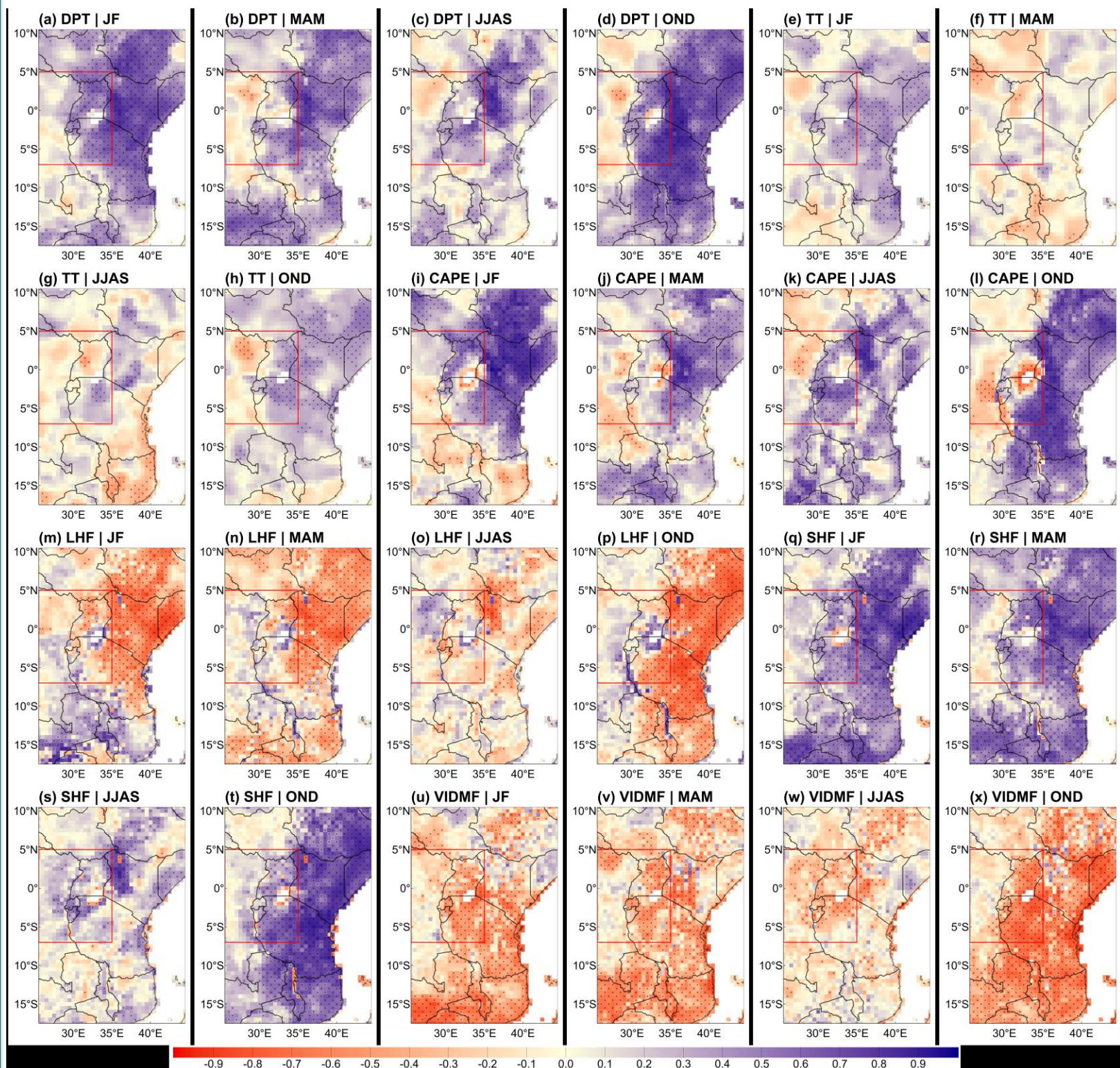
1 | Seasonal rainfall shifts

- Long rains show a prevalent drying tendency over parts of eastern Africa, while short rains show widespread wetting.
- Boreal summer has strong regional contrasts, including both rising and declining trends in Ethiopia.
- January precipitation rises by about 3.5 mm year^{-1} on average in parts of Mozambique; some areas of Burundi, DRC and Tanzania show declines.



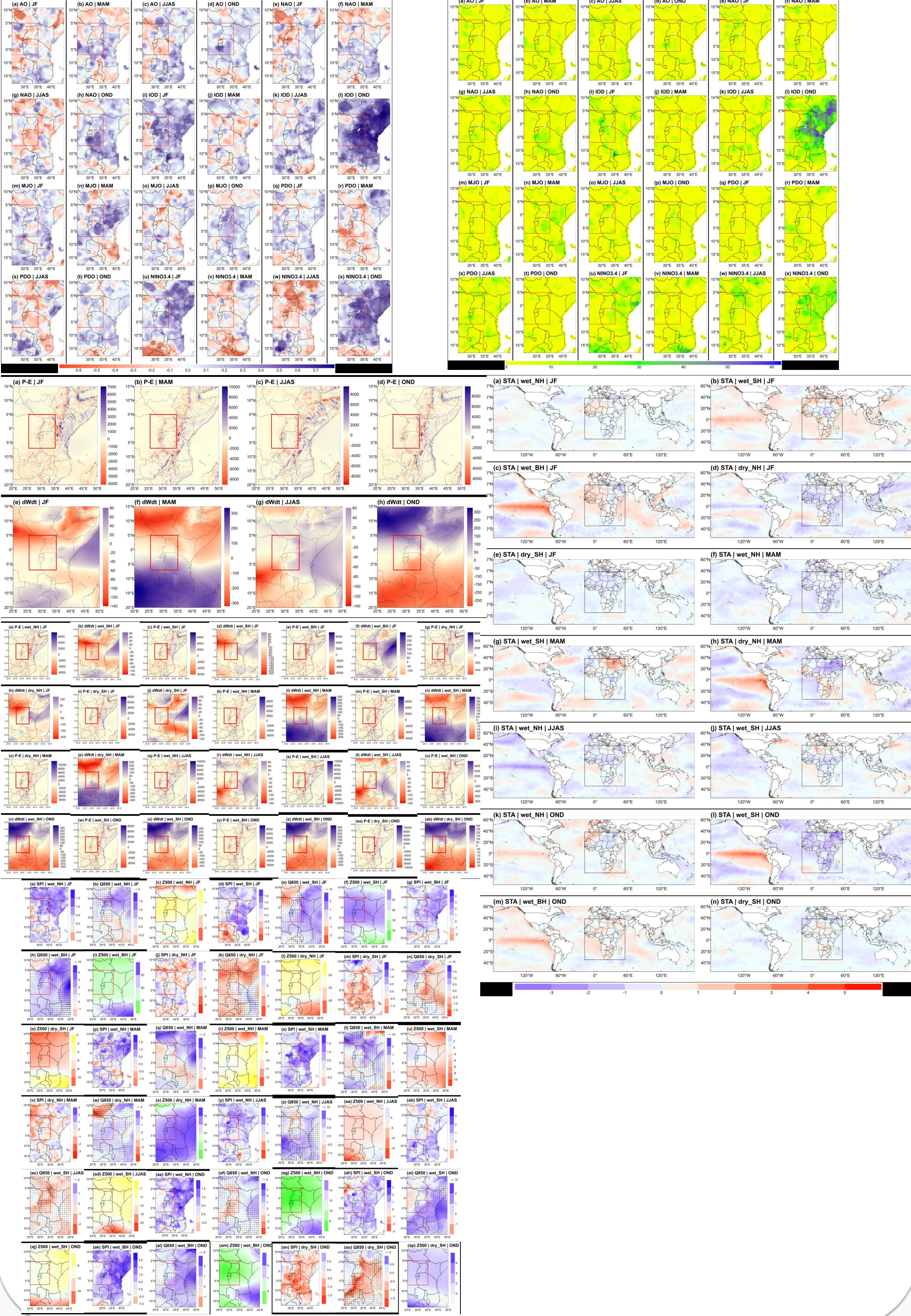
2 | Thermodynamic controls

- DPT is positively associated with accumulated precipitation across much of the region.
- CAPE is positively correlated with precipitation in all seasons overall, but negative relationships occur in parts of eastern DRC and around Lake Victoria.
- SHF is positively associated with precipitation in all seasons except boreal summer; LHF relationships vary spatially with moisture/energy constraints.



3 | Ocean–atmosphere links

- Short-rains precipitation is strongly positively correlated with IOD and Niño 3.4, indicating an important tropical Indian and Pacific Ocean influence.
- Wet events tend to coincide with positive DPT, CAPE, SHF and moisture-convergence anomalies; dry events are commonly associated with negative DPT and moisture divergence.
- Dry events in the African water tower are linked to anomalously dry westerly and northeasterly flow.



SYNTHESIS: A CONNECTED CLIMATE SYSTEM



Interpretation: seasonal precipitation reflects the combined influence of remote oceanic forcing, atmospheric circulation and regional land–atmosphere thermodynamics. The strength and direction of these relationships differ by season and location.

CONCLUSIONS

Main takeaways

- Central-East African rainfall trends are spatially heterogeneous and season-dependent.
- The long-rains drying / short-rains wetting contrast highlights a shift in rainfall seasonality.
- Thermodynamic variables and moisture transport jointly shape wet and dry conditions, with tropical Indo-Pacific variability especially relevant during short rains and boreal winter.
- The study suggests afforestation and inland water-resource conservation as measures that may help reduce flood and drought impacts.

DATA SOURCES & SELECTED REFERENCES

Datasets: GPCC precipitation (Schneider et al., 2022); ERA5 reanalysis (Hersbach et al., 2020); CRU land-surface temperature (Harris et al., 2020); HadISST sea-surface temperature (Rayner et al., 2003). Methods: Mann (1945); Kendall (1975); Sen (1968); McKee et al. (1993). Full references are provided in the manuscript.

STUDY DETAILS

Scope & terms

Region: Central-East Africa, including the African water tower and adjacent humid to semi-arid areas.

MAM: March–May (long rains)
OND: October–December (short rains)

JF: January–February
JJAS: June–September

SPI: Standardized Precipitation Index
CAPE: Convective Available Potential Energy
SHF/LHF: Sensible/Latent Heat Flux