DOCTORAL PROGRAMME CLIMATE CHANGE

KARL-FRANZENS-UNIVERSITÄT GRAZ
UNIVERSITY OF GRAZ
FWF-DK Climate Change

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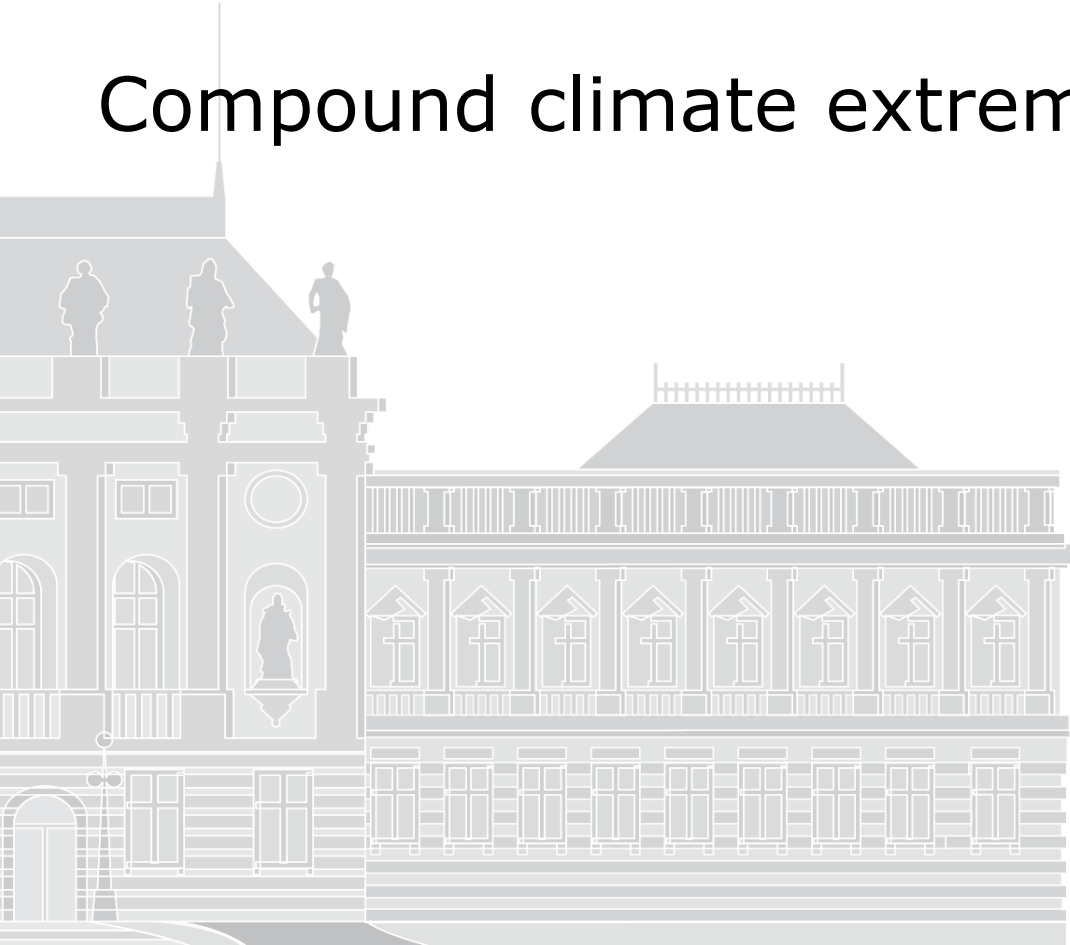
Compound climate extreme events in Africa



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Outline

- Introduction
- Drought-related compound extreme events
- Detection and Attribution
- Risk and vulnerability assessment

Compound extreme (CE) events

CEs are the combination of multiple *drivers and/or hazards* that contribute to societal or environmental impact (risk).

- Drivers: weather and/or climate processes, variables and phenomena

- Hazards: Changes in variability and extremes, Long-term changes/trends in average conditions

- Primary means of interaction: temporal compounding, spatial compounding, preconditioning, and concurrence of multiple variables

Raymond et al. (2020), Nature Climate Change

Compound extreme events: hazards and drivers

Table 1 | Climate-related hazards with compound physical drivers as well as exacerbating societal drivers

Hazard(s)	Climatic drivers	Societal drivers	Refs.
Drought	Precipitation, evapotranspiration, antecedent soil moisture, temperature	Water management, land-use change	48,49,56
Physiological heat stress	Temperature, atmospheric humidity, diurnal cycle	Urbanization, irrigation	96
Fire risk	Temperature, precipitation, relative humidity, wind, lightning	Forest management, ignitions	97,98
Storm risk	Wind speed, humidity, large-scale atmospheric circulation	Urbanization, deforestation	99
Coastal flooding	River flow, precipitation, coastal water level, surge, wind speed	Hard infrastructure, removal of natural coastal barriers	100,101
Flooding at river confluences	Precipitation, river water levels, large-scale atmospheric circulation	Water management, urbanization	58
Concurrent heat and drought	Temperature, precipitation, evapotranspiration, atmospheric humidity	Water management, soil management, land-use change	48,49
Concurrent wind and precipitation extremes	Wind speed, precipitation, orography, large-scale atmospheric circulation	Few or none	75
Concurrent heat and air pollution	Temperature, solar radiation, sulfur dioxide, NOx, ozone, particulate matter	Urbanization, agricultural and industrial activities	99

Examples of how compounding climatic drivers and societal drivers interact to produce connected climate extremes, modified from Table 1 of ref. [9]. The societal drivers listed are non-exhaustive; additionally, only those that contribute directly to the hazard are considered, rather than those that contribute to the impact. Long-term anthropogenic climate change plays into many of these hazards, but is omitted here for simplicity. References are for societal drivers only (for climatic-driver references, see ref. [9]).

Raymond et al. (2020), Nature Climate Change

Impacts of compound extreme events

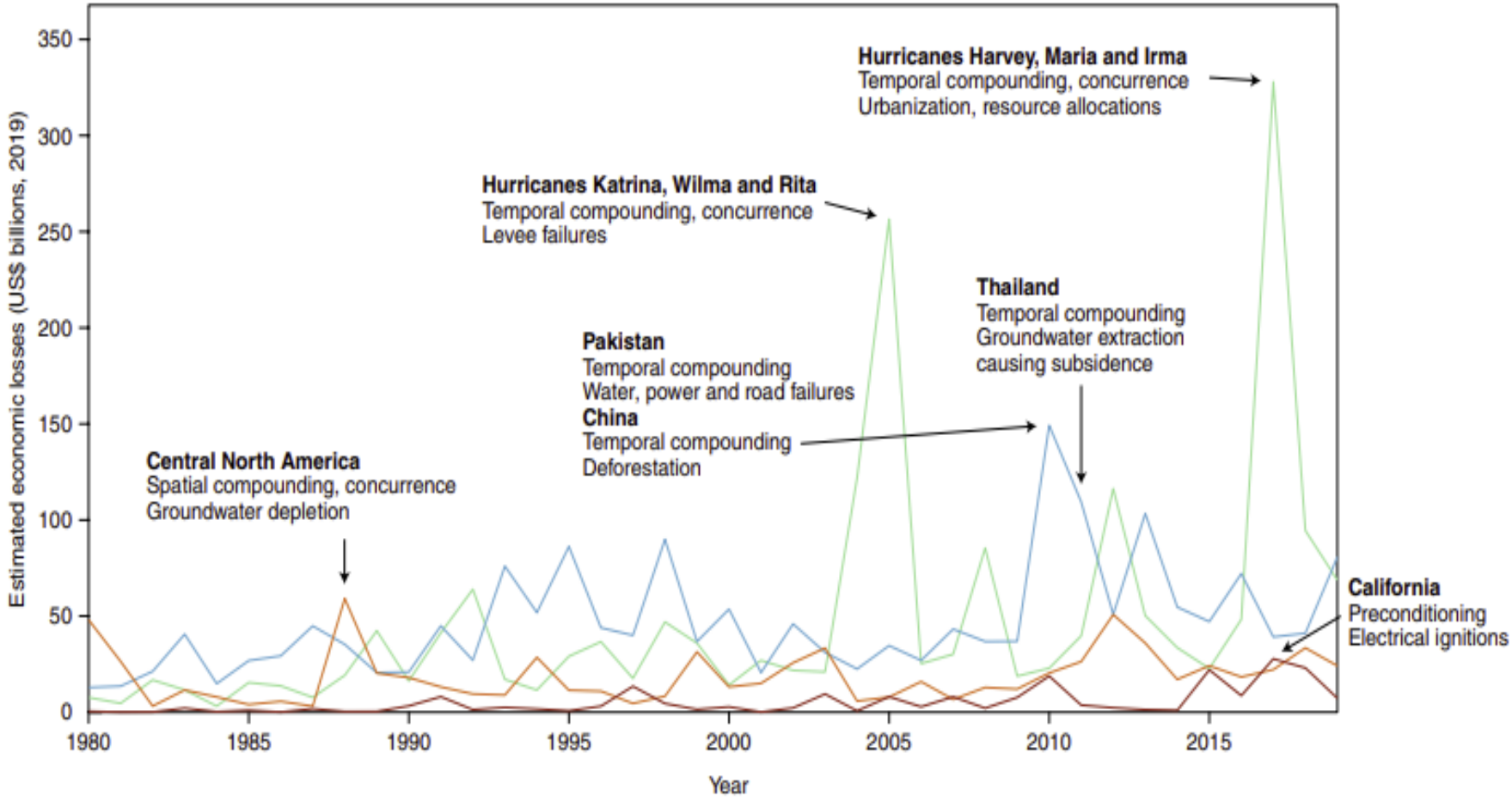
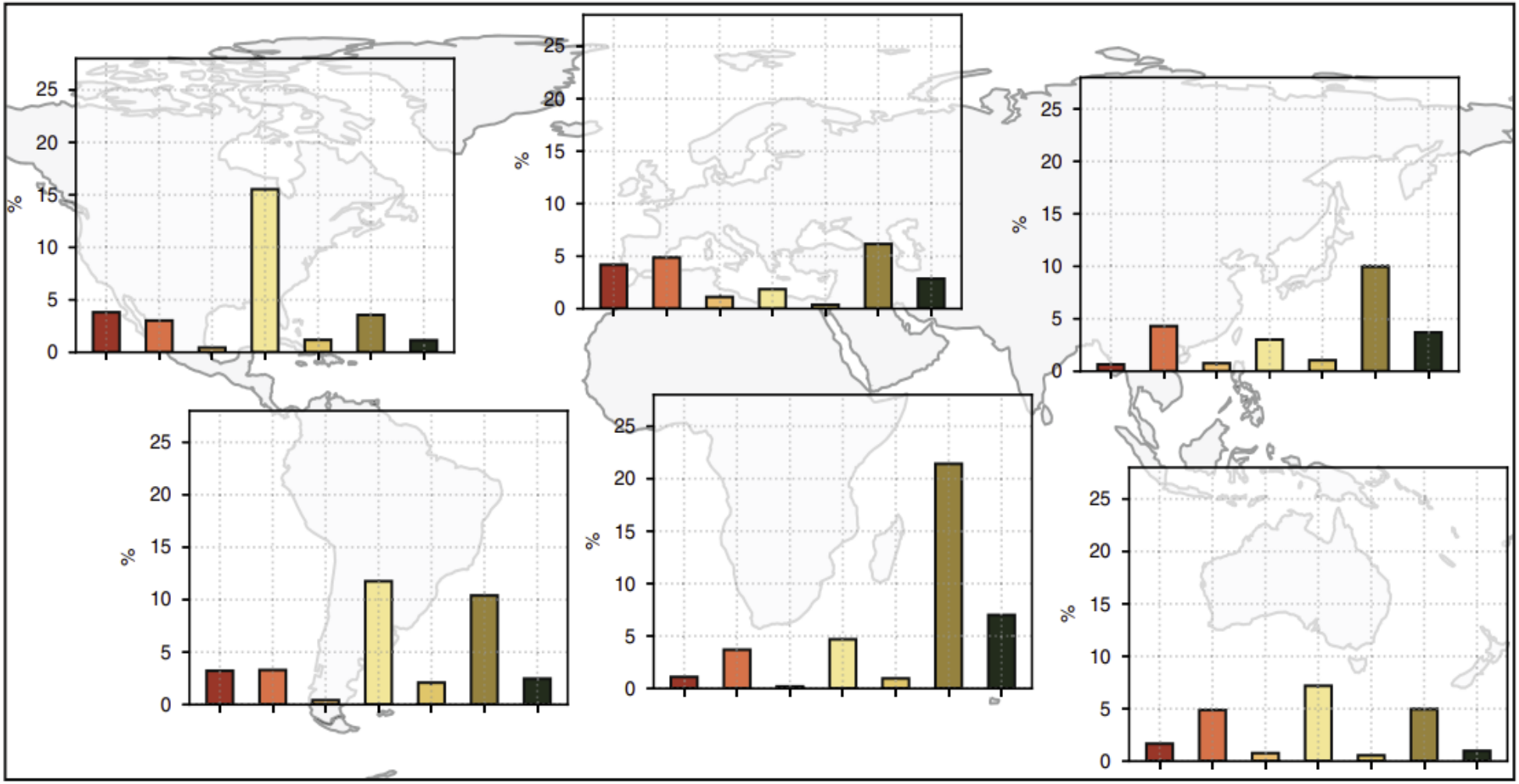


Fig. 2 | Major losses caused by extreme climate events over 1980–2019 and their connective elements. Lines trace the annual global sum of estimated economic losses caused by tropical cyclones (green), floods (blue), droughts (orange) and wildfires (red). Annotations indicate the largest events in high-loss years followed by several of the (first row) physical and (second row) societal drivers that shaped the total impacts. Economic-loss data are from Aon, Catastrophe Insight Division.

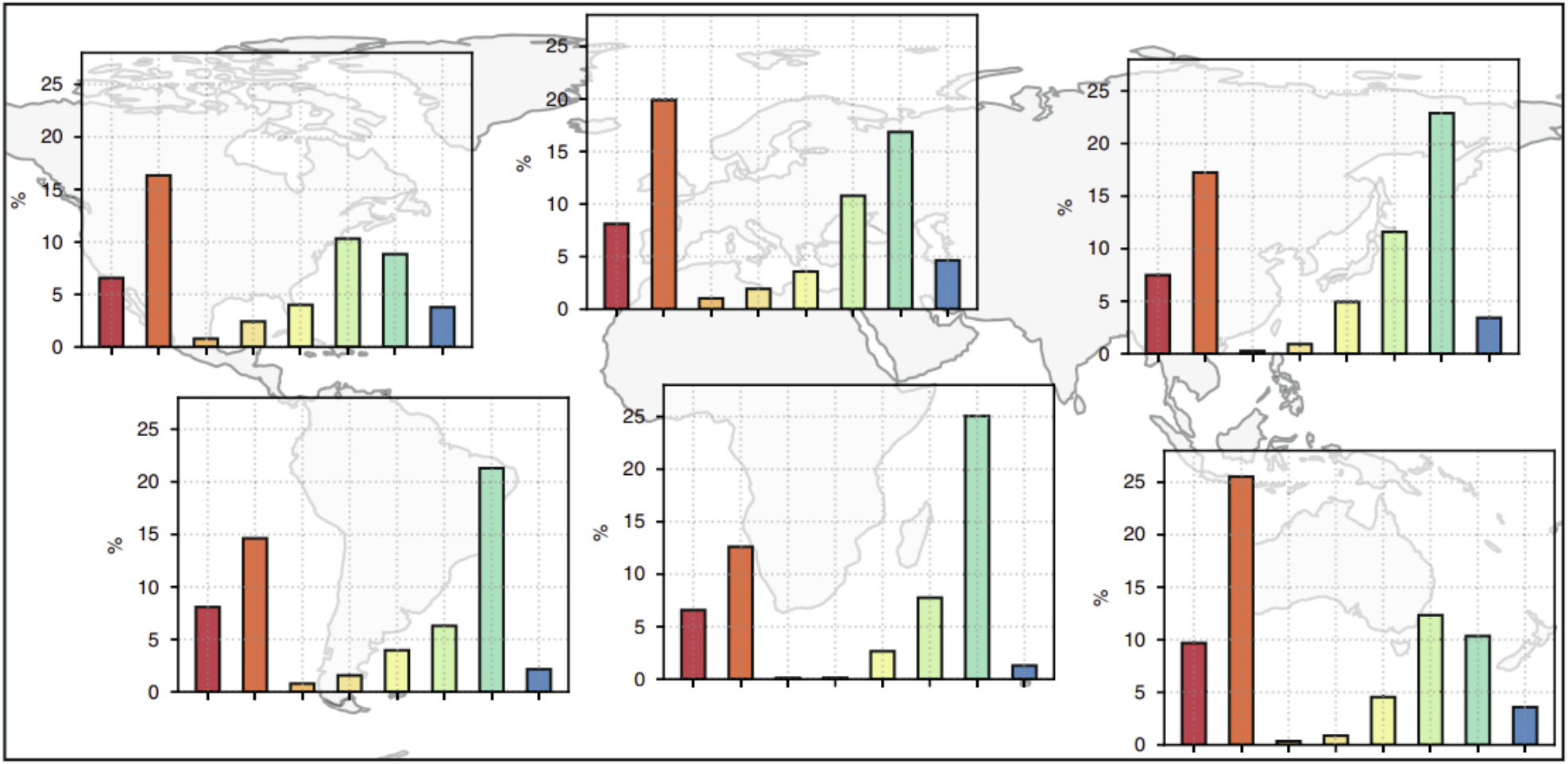
Raymond et al. (2020), Nature Climate Change

Precipitation-related compound events



Ridder et al. (2020), Nature Communication

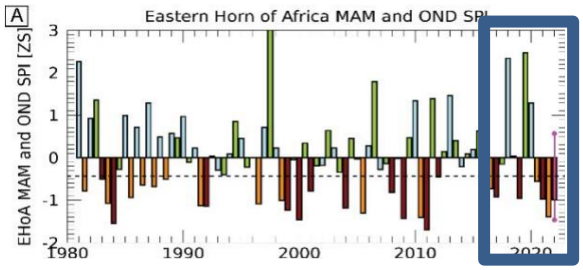
Precipitation- and temperature-related compound events

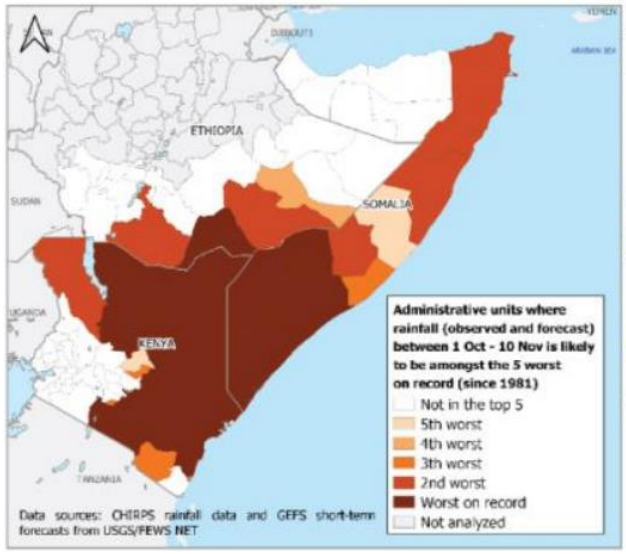


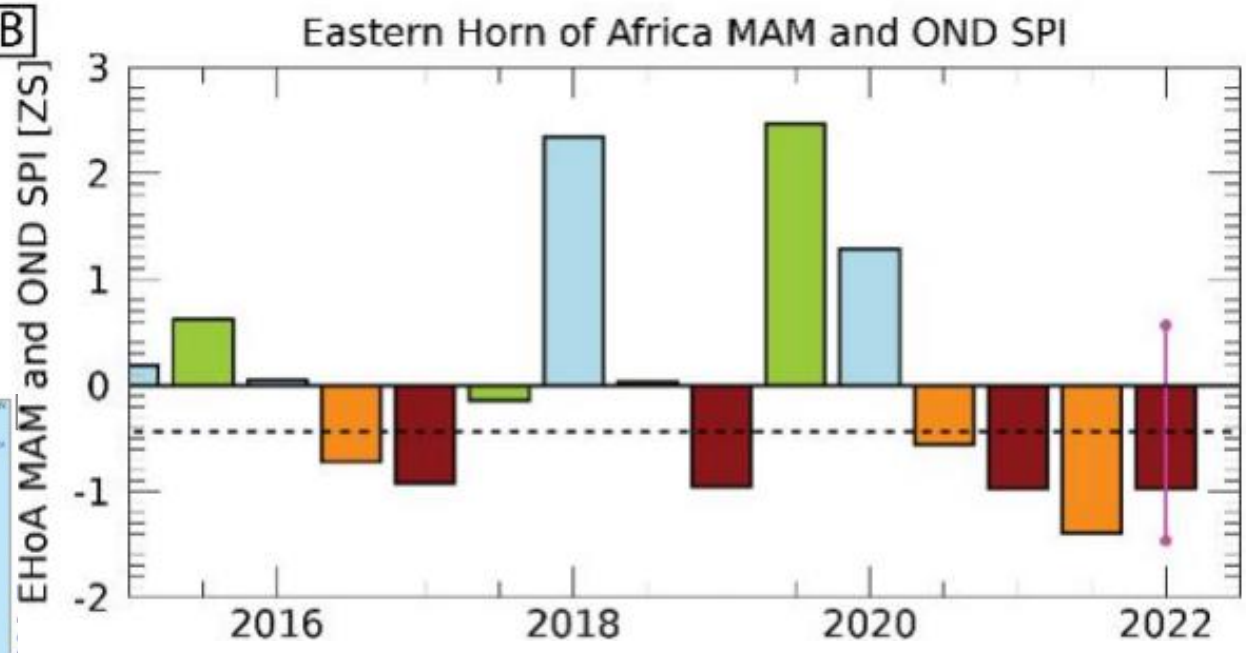
Ridder et al. (2020), Nature Communication

Compound events of interest

- Long-term changes in drought-related compound extremes in Africa
- The 2020-2022 drought over Eastern Africa







"Climate variability, climate change, vulnerability and exposure are creating an exceptional level of risk for food security and livelihoods"

FEWS NET, 2021; https://fews.net/sites/default/files/multi-agency-east-africa-drought-alert-120121.pdf

Data and methods

- Change detection

What combination of hazards/drivers to assess?

Probability of ocurrence, magnitude, persistence?

Definition of event(s)

- Detection methods

Statistical methods: event coincidence analysis

- Data

In-situ, EO and blended satellite products

Length of record

Attributing changes in compound extremes

- Attribution
- Statistical method that consider climate modelling uncertainty
- Bivariate fraction of attributable risk (FAR)

Climate models

Ribes et al. (2017), Climate Dynamics; Zscheischler and Lehner (2022), BAMS

Risk and vulnerability assessment

- Risk = Hazard × Vulnerability × Exposure

- Top-down Vs bottom-up approaches

- Vulnerability assessment for sectors of priority:

Reviewing scientific literature and government documents

Conclusion

Drought-related compound climate extremes

- Change detection and attribution
- Risk and vulnerability assessment
- Inputs for adaptation