Changes in extreme temperatures and heat waves in Africa

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Motivation

In the recent decades, temperature extremes showed changes in temporal trends, occurrence, intensity and spatial extents. There are no efforts made to attribute the relative contribution of human-induced climate change in the observed changes in heat waves. This thesis project, aims to estimate the relative contribution of anthropogenic climate change to the observed heat waves over different regions of Africa. In a first step, we investigate changes in extreme temperature and heat waves in different African regions.

Data and methods

- We used observational Climate Research Unit Time Series version 4.03 (CRU) and reanalysis datasets (The European Center for Medium-Range Weather Forecasts Reanalysis 5 (ERA5), the National Oceanic Atmospheric Administration's Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA2), and the Japanese Meteorological Agency's 55 years reanalysis (JRA-55)).
- Changes in temperatures are assessed using monthly CRU, ERA5, MERRA2 and JRA-55 datasets while heat waves are based on only daily reanalysis datasets.
- Heat waves definitions used in this study are summarized in Table 1.
- Linear regression and Man-Kendall's significance test are used to estimate heat waves' decadal trend and significance, respectively, of heat waves.
- Geopotential height (at 500 hPa) is used to investigate if circulation-driven changes had contributed for selected exceptional heat wave events.

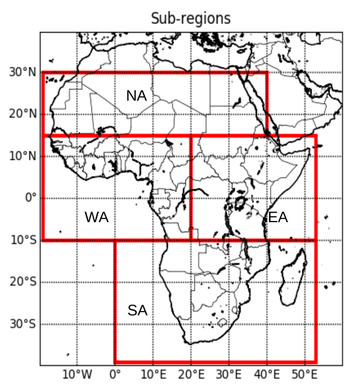

Figure 1: Sub-regions over the African continent used in this study, Northern Africa (NA), Western Africa (WA), Southern Africa (SA) and Eastern Africa (EA), defined after Field et al. (2012).

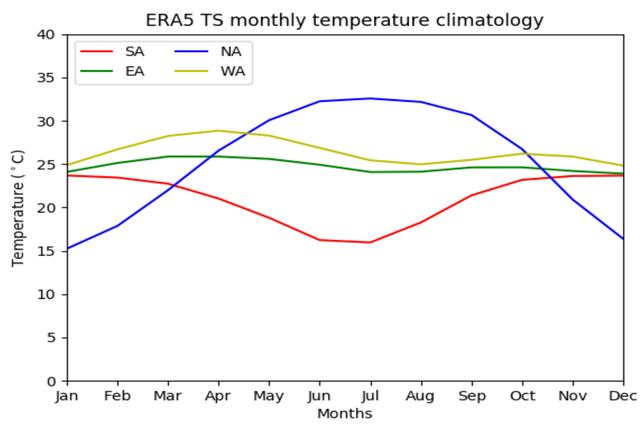

Figure 2: Monthly mean temperature climatology (1980–2018) of Northern Africa (NA), Western Africa (WA), Southern Africa (SA) and Eastern Africa (EA).

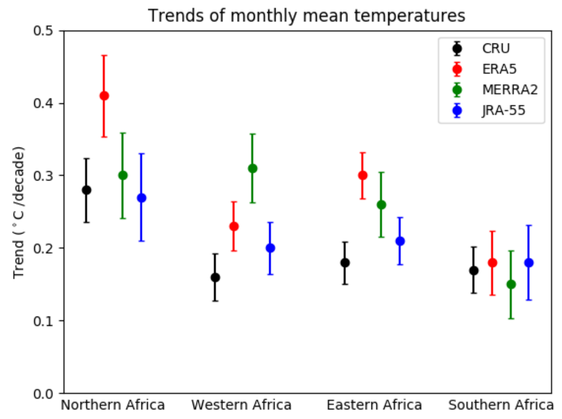

Figure 3: Trends of monthly mean temperature from CRU, ERA5, MERRA2 and JRA-55 datasets over NA, WA, EA and SA regions. Error bars denote the 95% confidence interval of decadal trends.

Abbreviation	Description of indices
SU	Number of summer days (Tmax > 35°C)
TR	Number of tropical nights (Tmin > 24°C)
TX90P	Percentage of days when Tmax > 90th percentile
WN	Number of warm nights when Tmin > 95th percentile (at least 2 consecutive days)
WSDI_3	Warm spell duration index when Tmax > 95th percentile (at least 3 consecutive days)
WSDI_6	Warm spell duration index when Tmax > 90th percentile (at least 6 consecutive days)

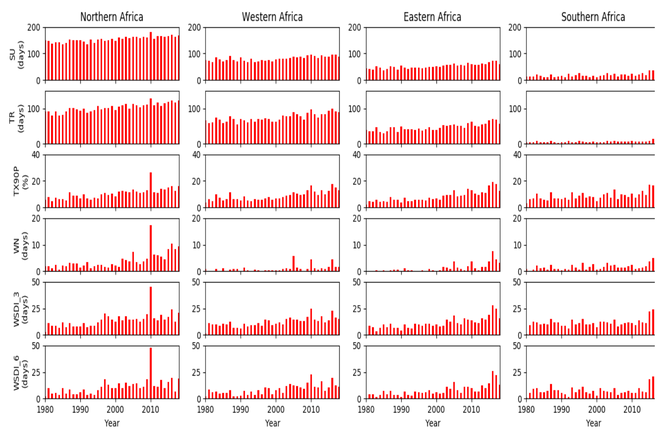

Figure 4: Heat wave indices computed from ERA5

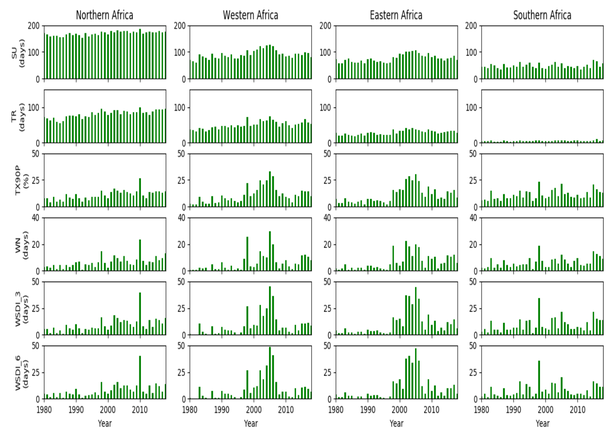

Figure 5: Heat wave indices computed from MERRA2

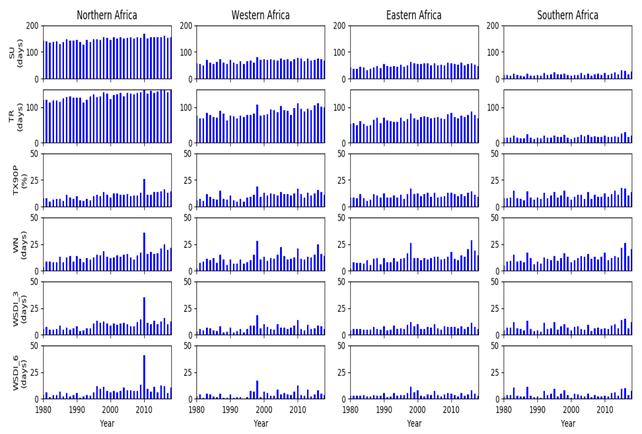

Figure 6: Heat wave indices computed from JRA-55

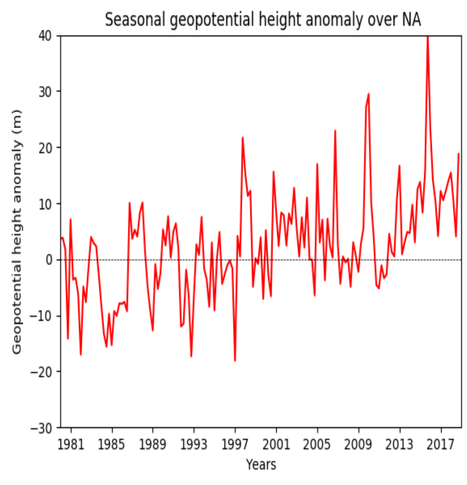

Figure 7: Seasonal geopotential height anomaly at 500 hPa (relative to 1980 – 2009 reference period) from ERA5 dataset over NA

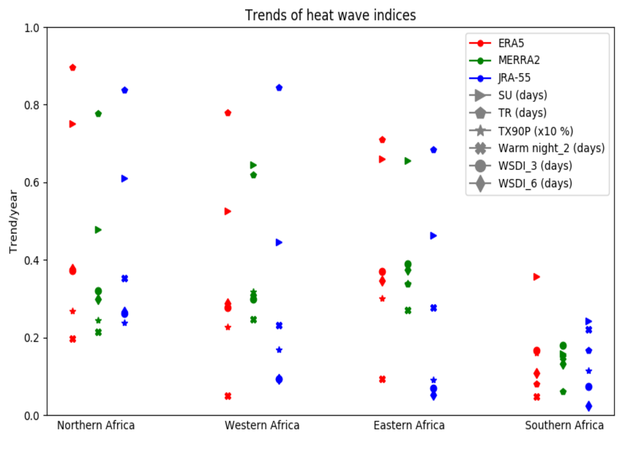

Figure 8: Trends of heat wave indices from ERA5, MERRA2 and JRA-55 datasets over NA, WA, EA and SA regions

Summary:

- Both the observational and reanalysis datasets show an increasing trend in temperature over the four regions of Africa.
- The indices show that the highest number of heat waves occurred over NA and WA in the year 2010 and EA and SA in 2016.
- Geopotential height (500 hPa) anomalies show that months (Dec 2009, and Jan, Feb, Mar in 2010) were exceptionally amplified by circulation driven atmospheric changes.
- Absolut threshold indices (SU and TR) dominate the highest decadal trends in NA, WA and EA regions.
- Heat wave indices show significant increase in the number of heat wave days at 95% confidence level in all the inspected regions of Africa.

Reference: Expert Team on Climate Change Detection, Monitoring and Indices (ETCCDI) available at: http://etccdi.pacificclimate.org/indices.shtml Access date:[28 May, 2019]

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