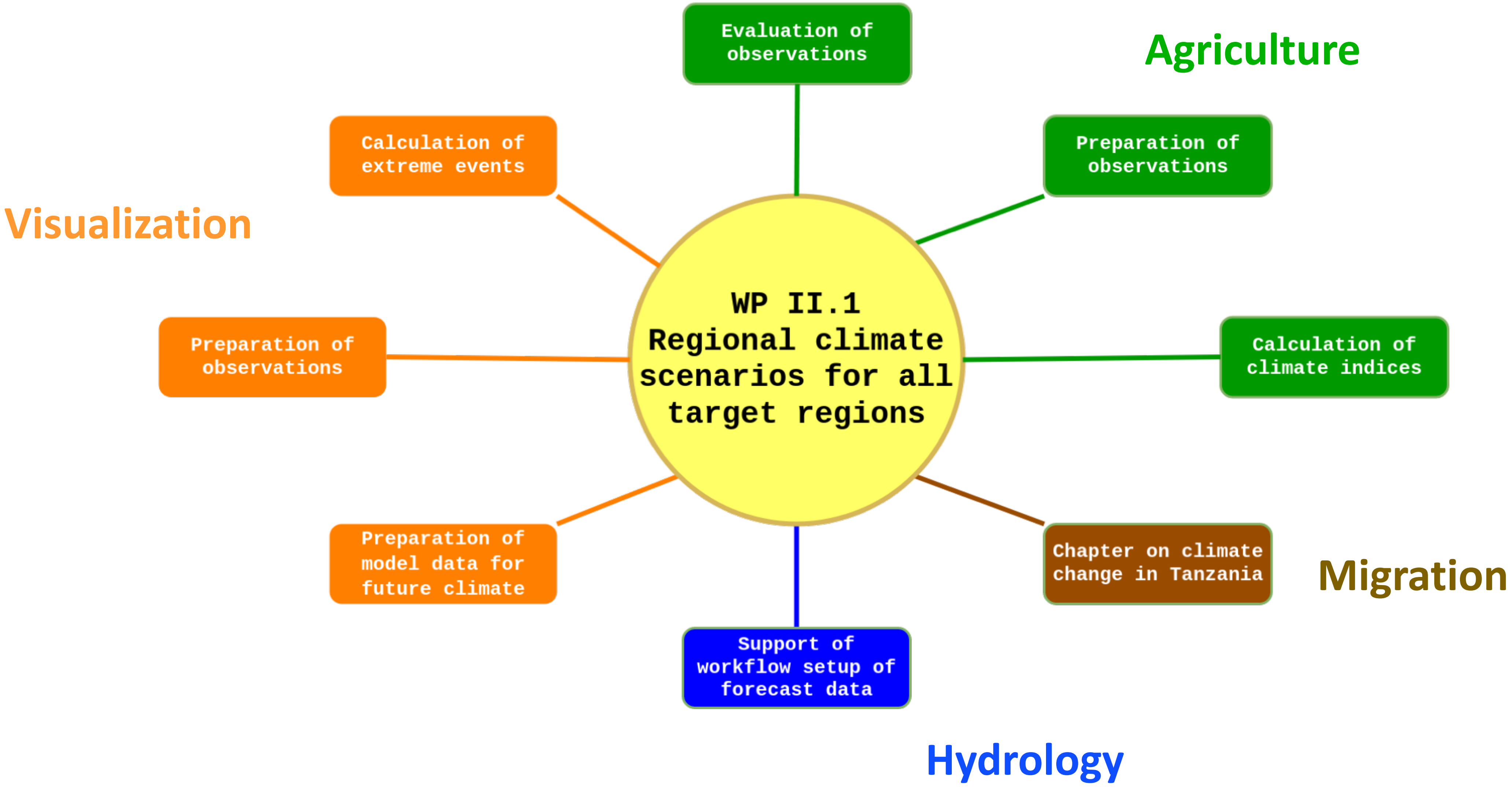
# *Climate Data for Tanzania*
# *- Past and Future -*

B-EPICC
BRAZIL EAST AFRICA PERU INDIA CLIMATE CAPACITIES

EPICC results from Working Package
**Regional Climate Data**

Stephanie Gleixner

# Collaboration within EPICC



# Overview

1. Historical climate data - an evaluation of ERA5 reanalysis data
2. Future climate data – a new approach to find robust precipitation trends
3. Climate Services – Climate Risk Profile for Tanzania

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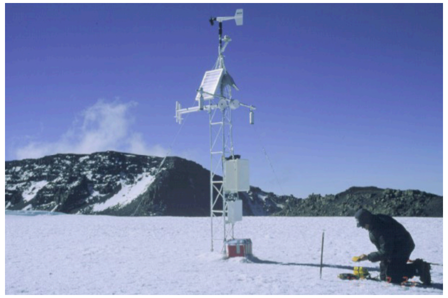
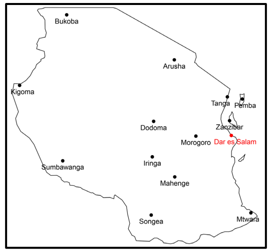
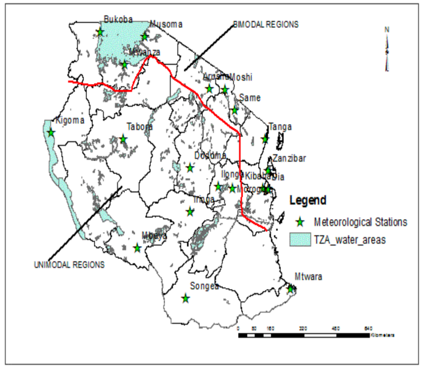
# Types of historical climate data

## Station data






Ngailo et al, 2018




Luhunga et al, 2016

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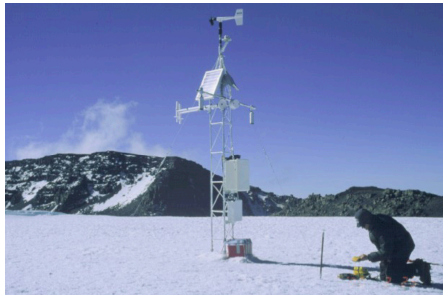

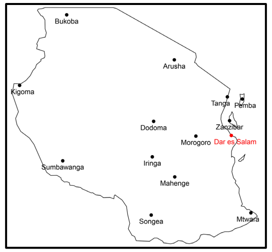


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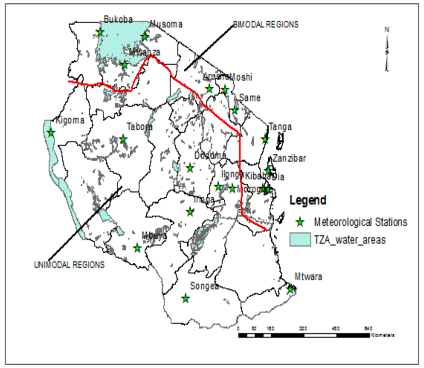
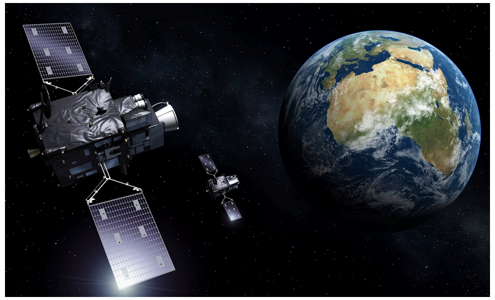



Luhunga et al, 2016

Need for more covarage

## Satellite-based data



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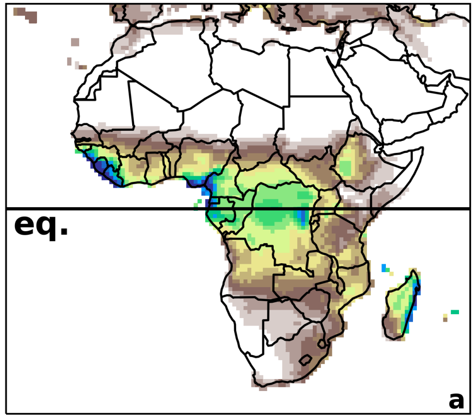

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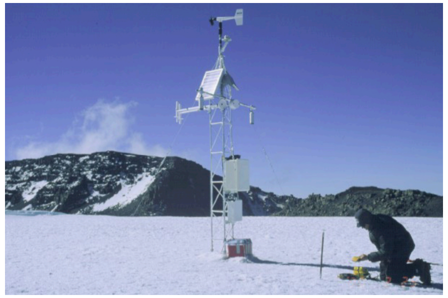

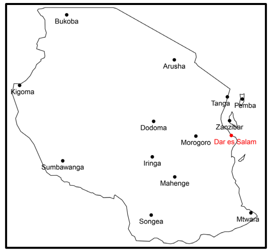


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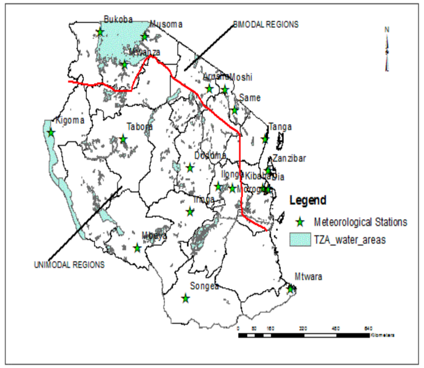


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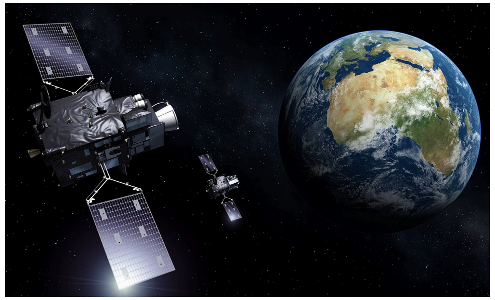
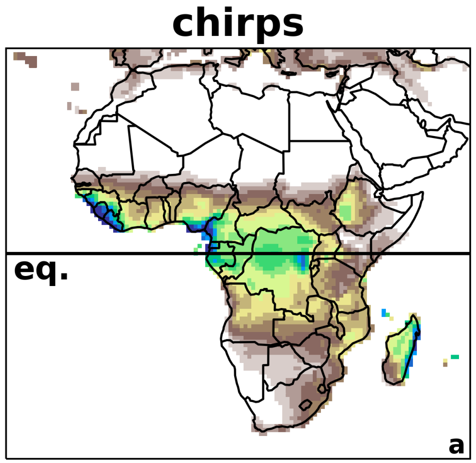
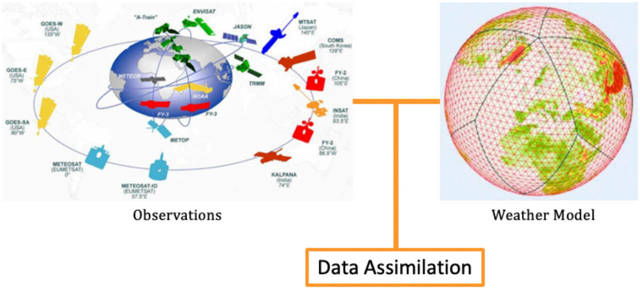





Need for more coherence

## Reanalysis data




- Hundreds of variables
- Complete coverage of surface and atmosphere
- Complete temporal coverage

-> quality issues

# ERA5 – ECMWFs latest reanalysis product

- First complete set published in 2019
- Several hundreds of variables for the ground, the atmosphere and the ocean
- Spatial resolution of 0.25° (~ 25-30 km)
- 137 levels up to 80 km altitude
- Preliminary product within 5 days of real time
- Easily accessible throught Copernicus Climate Data Store, Google Earth Engine, KNMI climate explorer ….

atmosphere

MDPI

*Article*

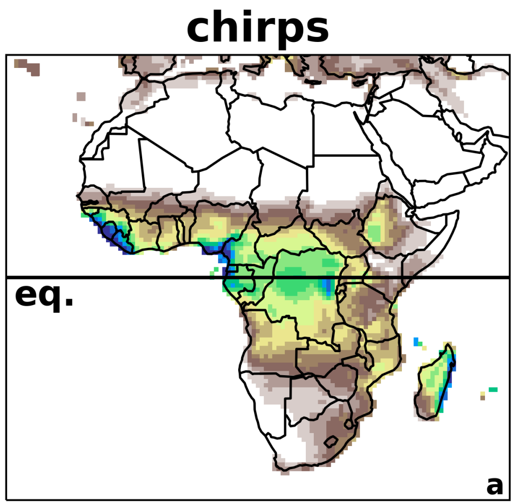
# Did ERA5 Improve Temperature and Precipitation Reanalysis over East Africa?

Stephanie Gleixner [1,*], Teferi Demissie [2,3] and Gulilat Tefera Diro [4]

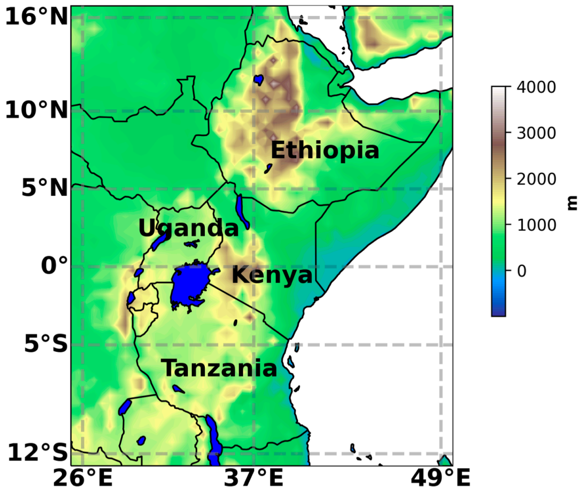
Comparison of ERA5 to predecessor ERAinterim and ridded observations

# Study region

## Africa



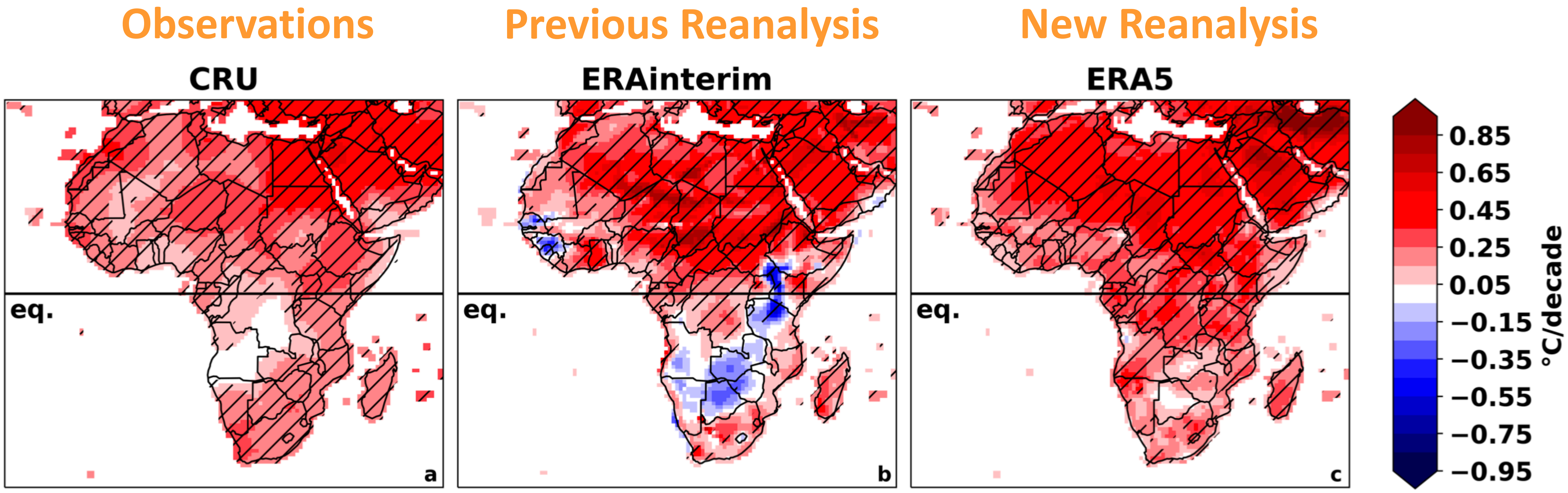

## East Africa



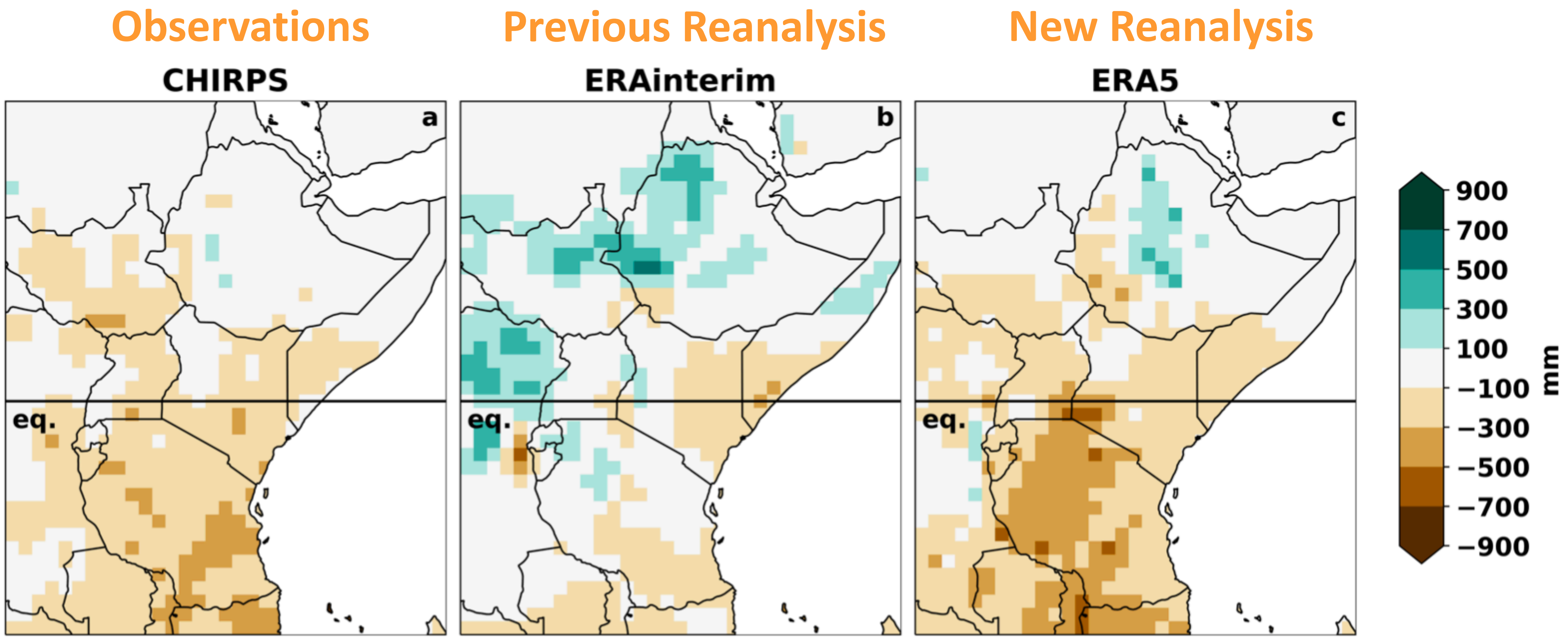

## National

- Ethiopia
- Uganda
- Kenya
- Tanzania

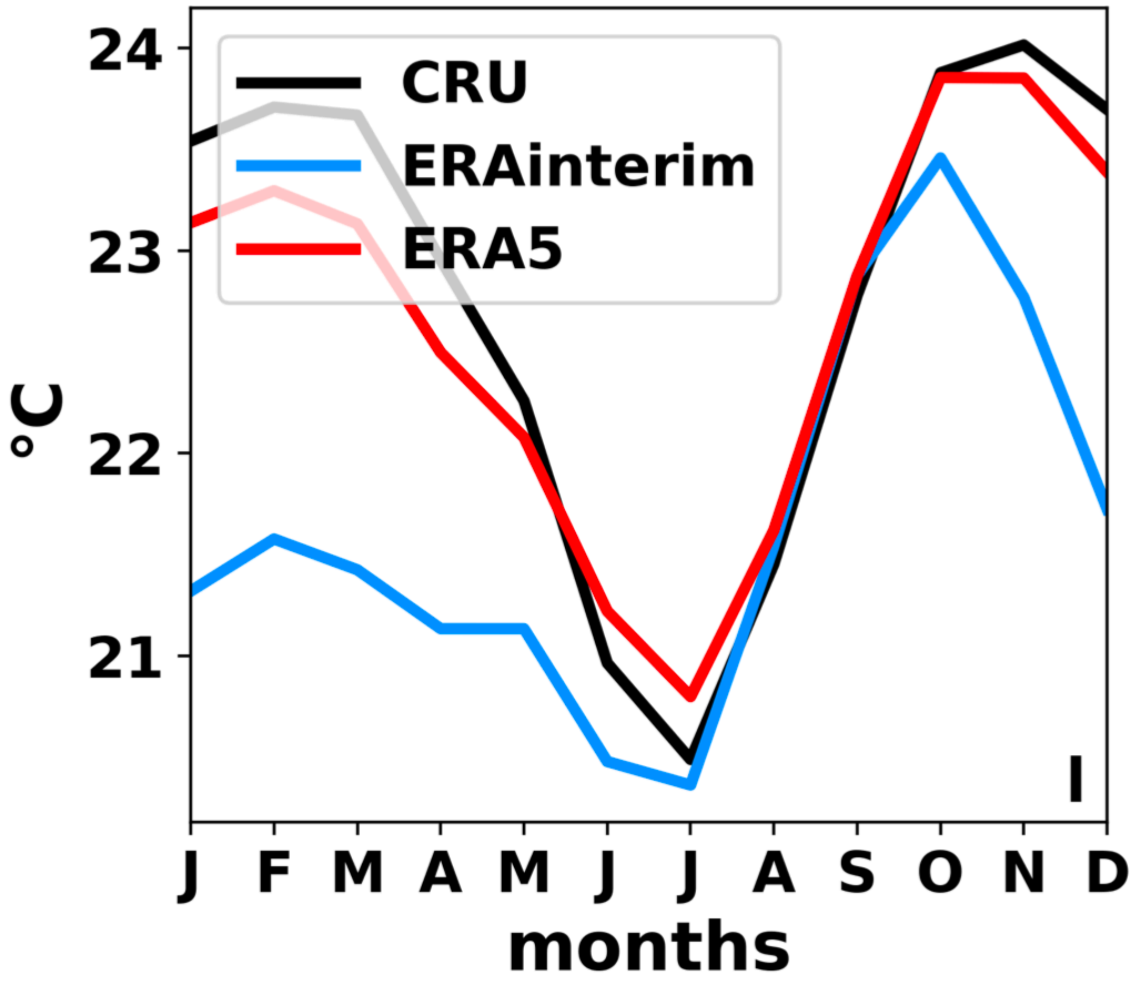
# Surface Temperature trends



# Dry year 2005



# Annual temperature cyle in Tanzania



# Summary

- ERA5 shows substantial changes from previous reanalysis generation
- In most locations in Africa the temperature and precipitation bias is reduced
- Neither reanalysis dataset captures precipitation trends in observations
- No more cooling trends in ERA5
- Improvement of the annual precipitation cycle of East Africa
- ERA5 captures spatial distribution of precipitation in extreme years in East Africa
- Improvement of the annual temperature and precipitation cycle of Tanzania

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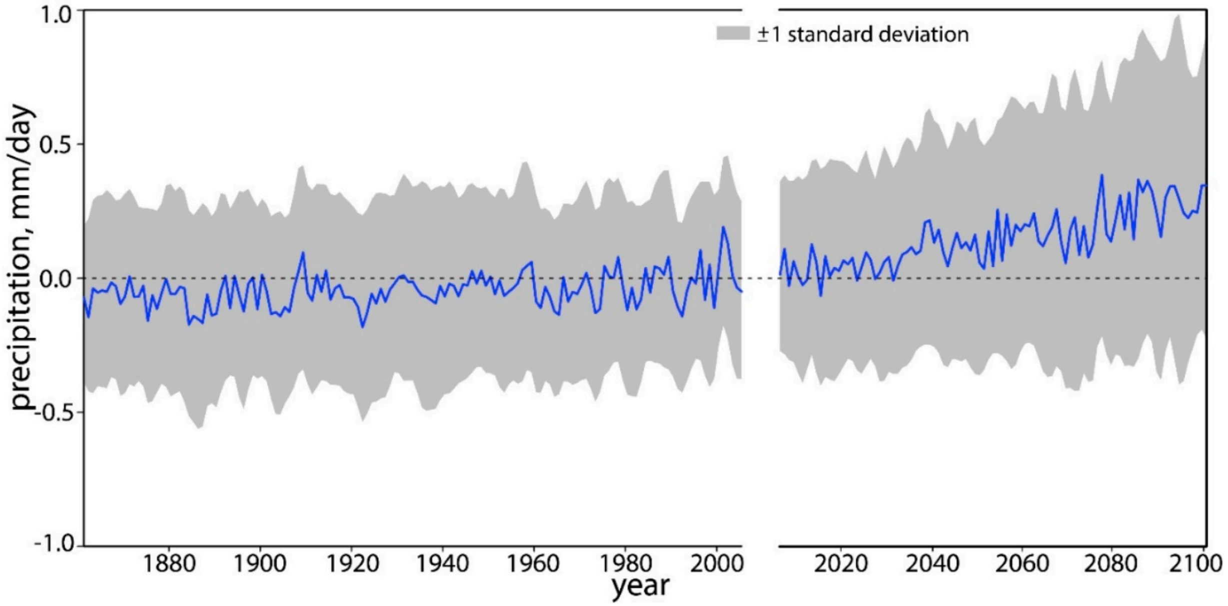
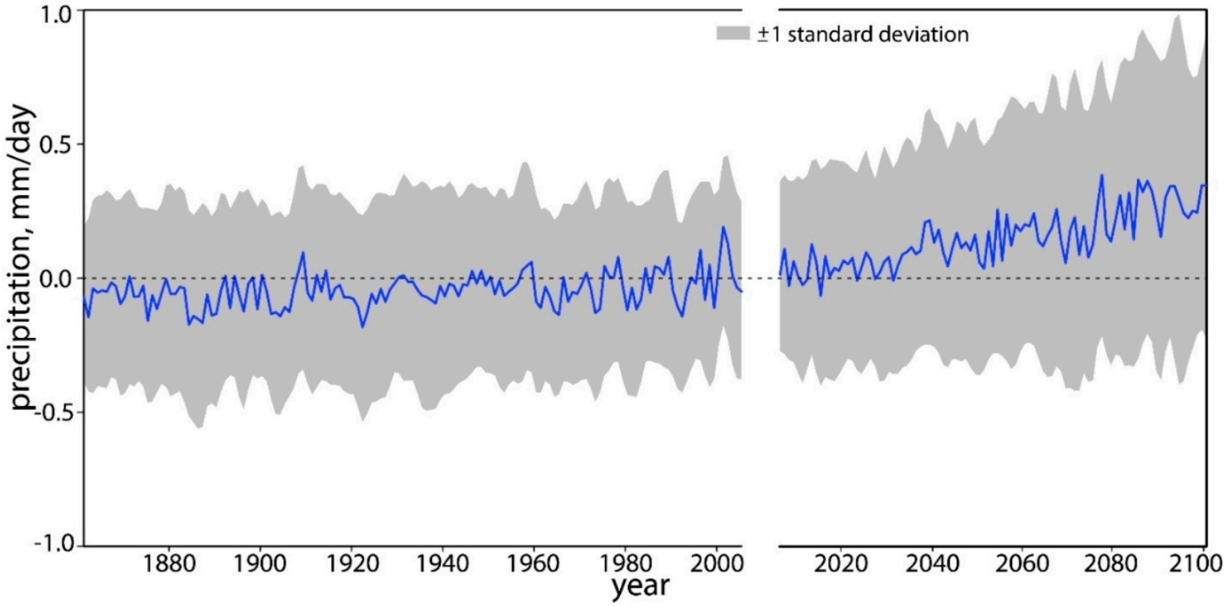
# Precipitation Projections for Tanzania



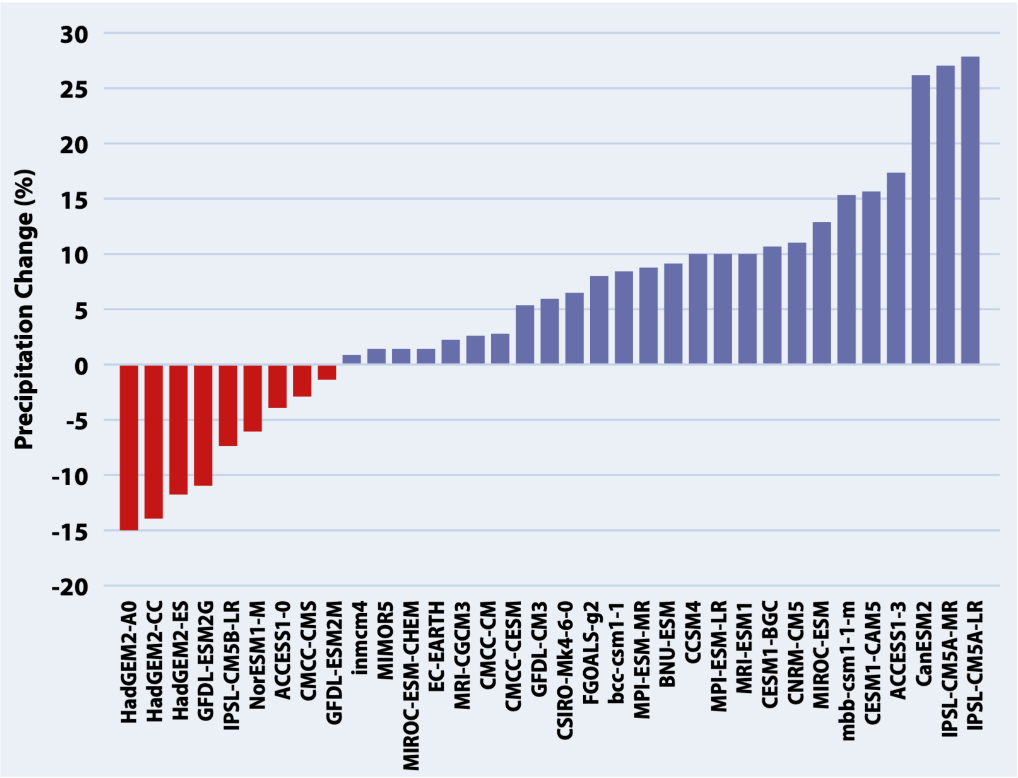

Borhara et al., 2020

# Precipitation Projections for Tanzania




Borhara et al., 2020

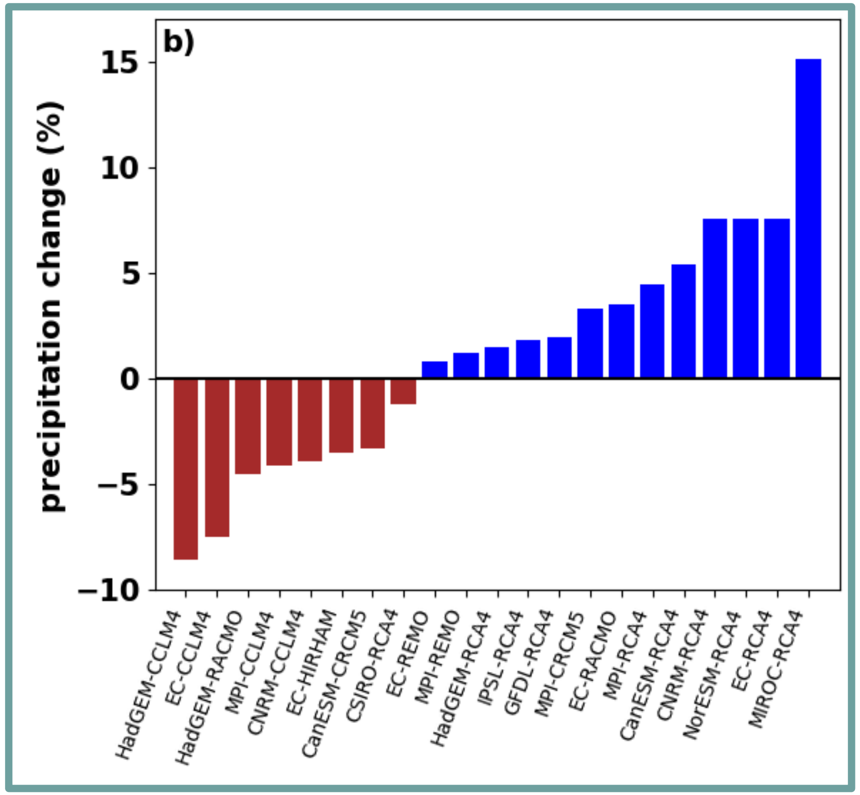
## CMIP5 – Gobal Climate Models




FCFA Climate Brief, 2017

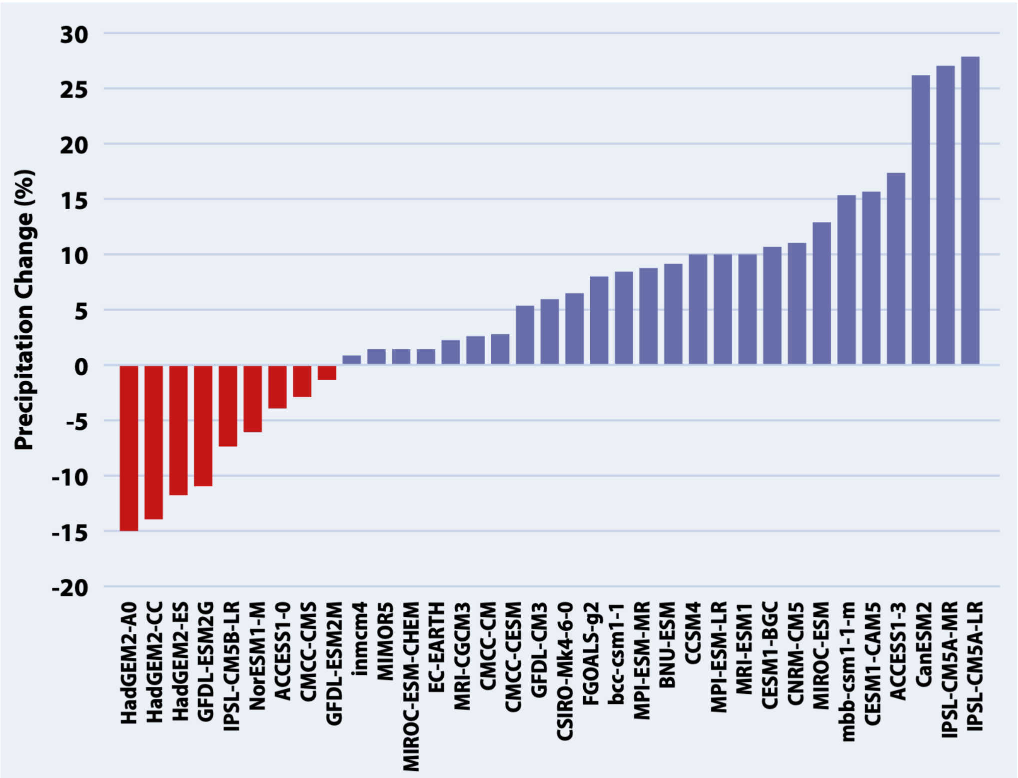
# Precipitation Projections for Tanzania

## CORDEX – Regional Climate Models




Gleixner et al., in preparation

## CMIP5 – Gobal Climate Models



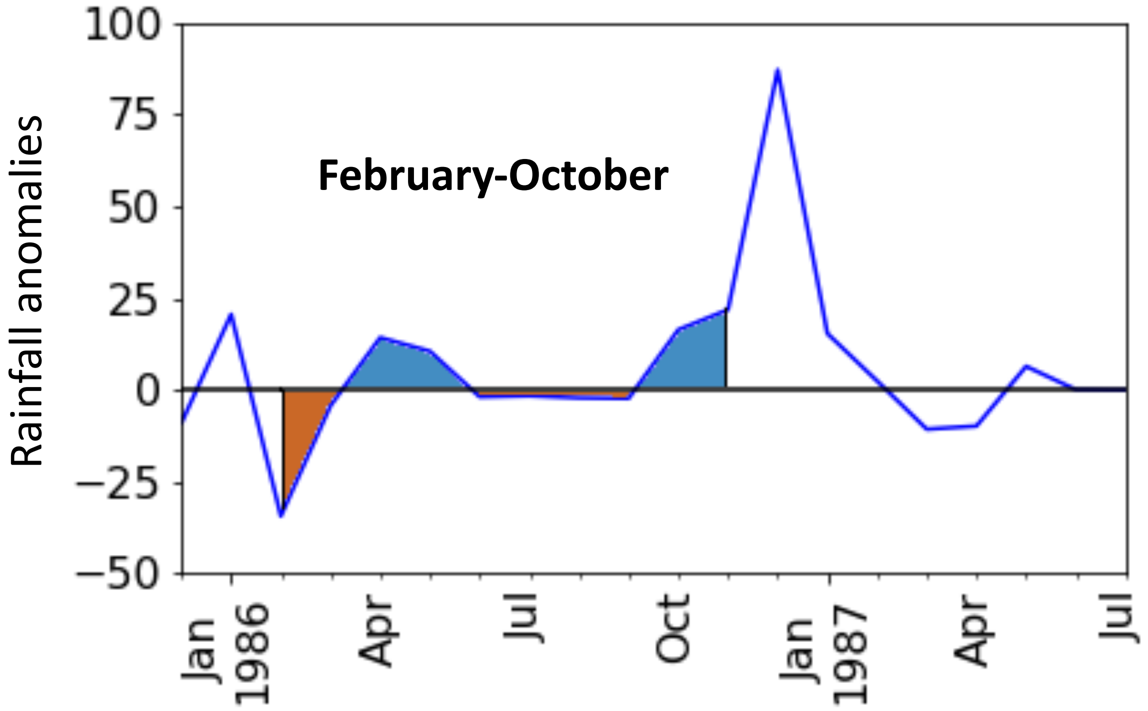

FCFA Climate Brief, 2017

# A new perspective on projected precipitation changes in Tanzania

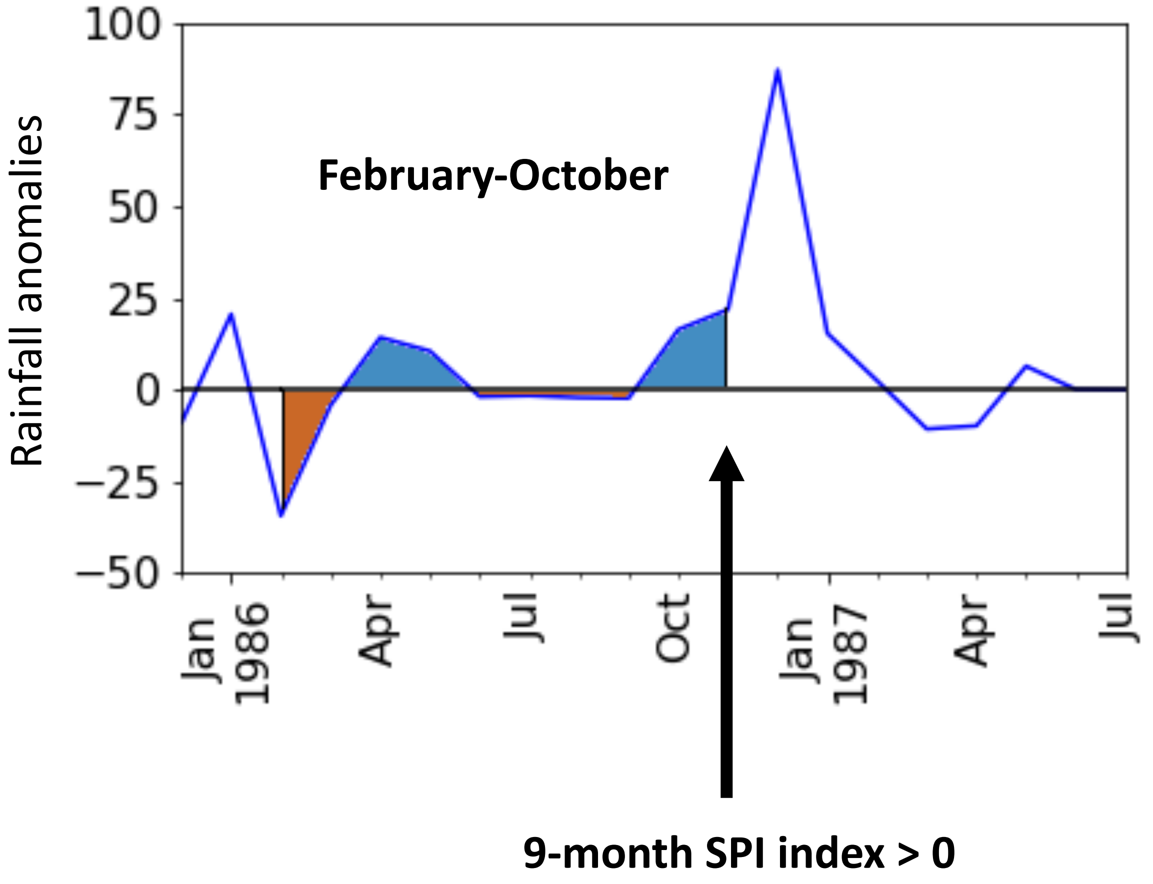
Stephanie Gleixner, Jascha Lehmann, Christoph Gornott

in preparation

# Approach – SPI index



# Approach – SPI index



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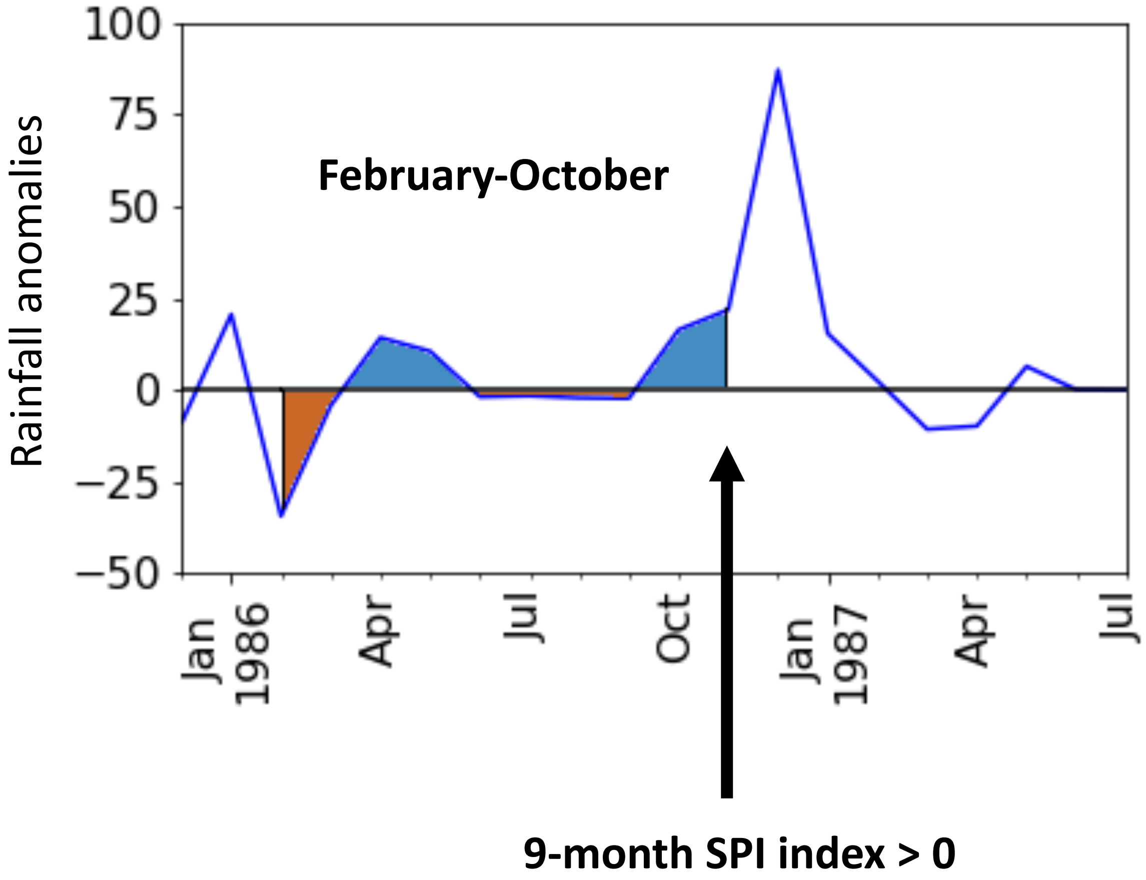


| SPI | Category |
|---|---|
| SPI ≤ -2.0 | extremely dry |
| -2.0 < SPI ≤ -1.5 | severely dry |
| -1.5 < SPI ≤ -1.0 | moderately dry |
| -1.0 < SPI ≤ -0.5 | mildly dry |
| -0.5 < SPI < +0.5 | normal |
| +0.5 ≤ SPI < +1.0 | mildly wet |
| +1.0 ≤ SPI < +1.5 | moderately wet |
| +1.5 ≤ SPI < +2.0 | severely wet |
| +2.0 ≤ SPI | extremely wet |

# Approach

Database:

- Full **CORDEX Africa** Ensemble
- RCP2.6, **RCP4.5** and RCP8.5
- SPI index on 3, **6**, 9 and 12 month scales
- Shifts for **two future** periods

Analysis:

- Counting of months in SPI categories

| SPI | Category |
|---|---|
| SPI $\leq$ -2.0 | extremely dry |
| -2.0 $<$ SPI $\leq$ -1.5 | severely dry |
| -1.5 $<$ SPI $\leq$ -1.0 | moderately dry |
| -1.0 $<$ SPI $\leq$ -0.5 | mildly dry |
| -0.5 $<$ SPI $<$ +0.5 | normal |
| +0.5 $\leq$ SPI $<$ +1.0 | mildly wet |
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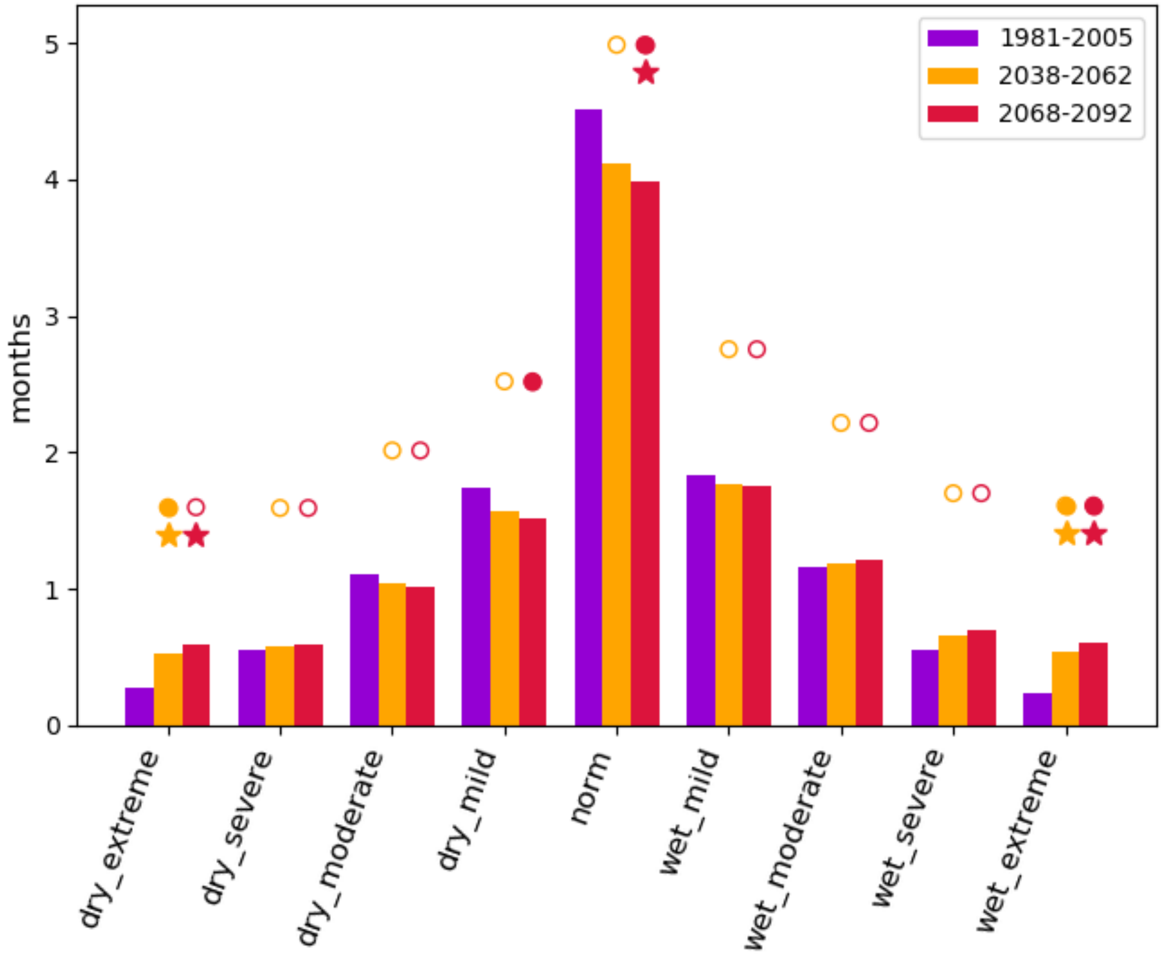
| +1.5 $\leq$ SPI $<$ +2.0 | severely wet |
| +2.0 $\leq$ SPI | extremely wet |

# Results for RCP 4.5 and 6 months accumulation



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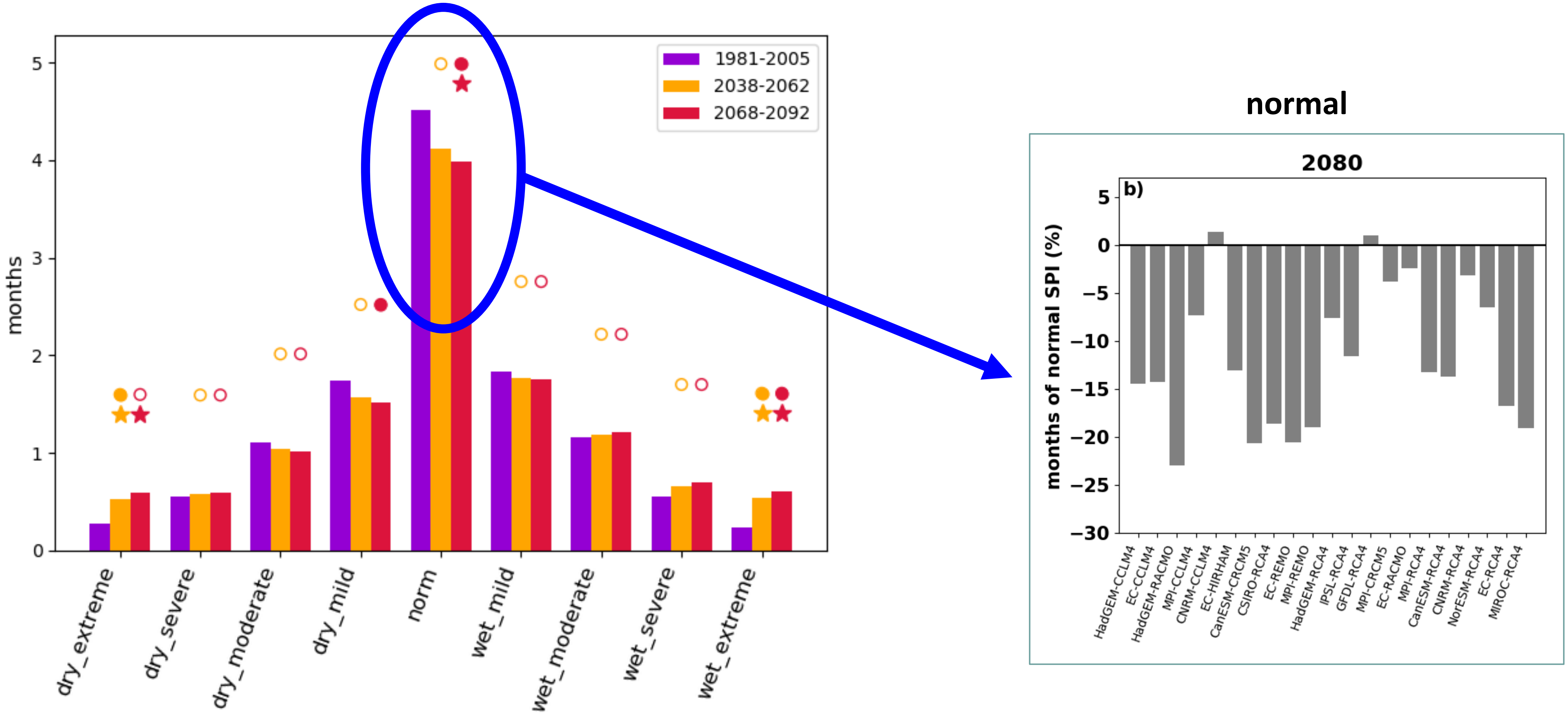

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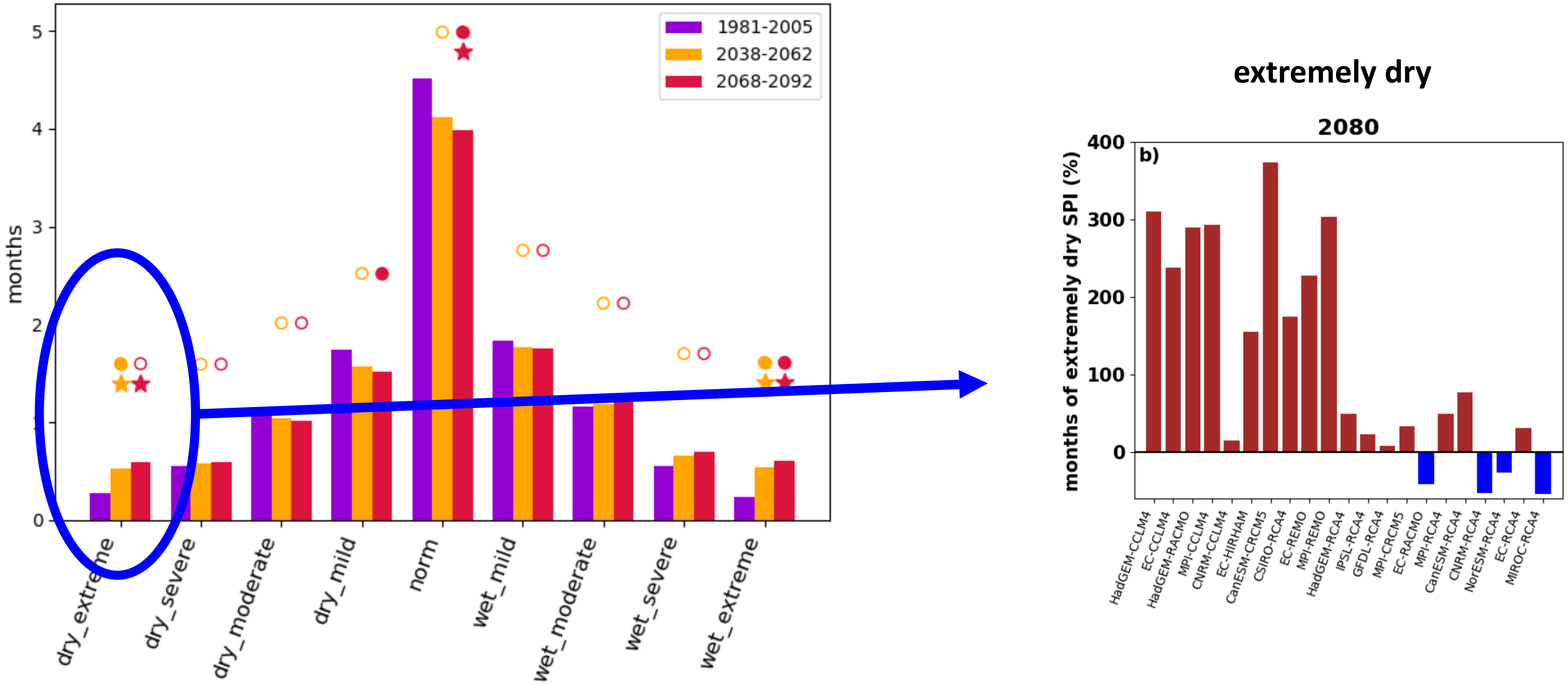

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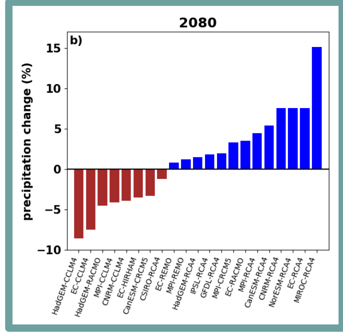
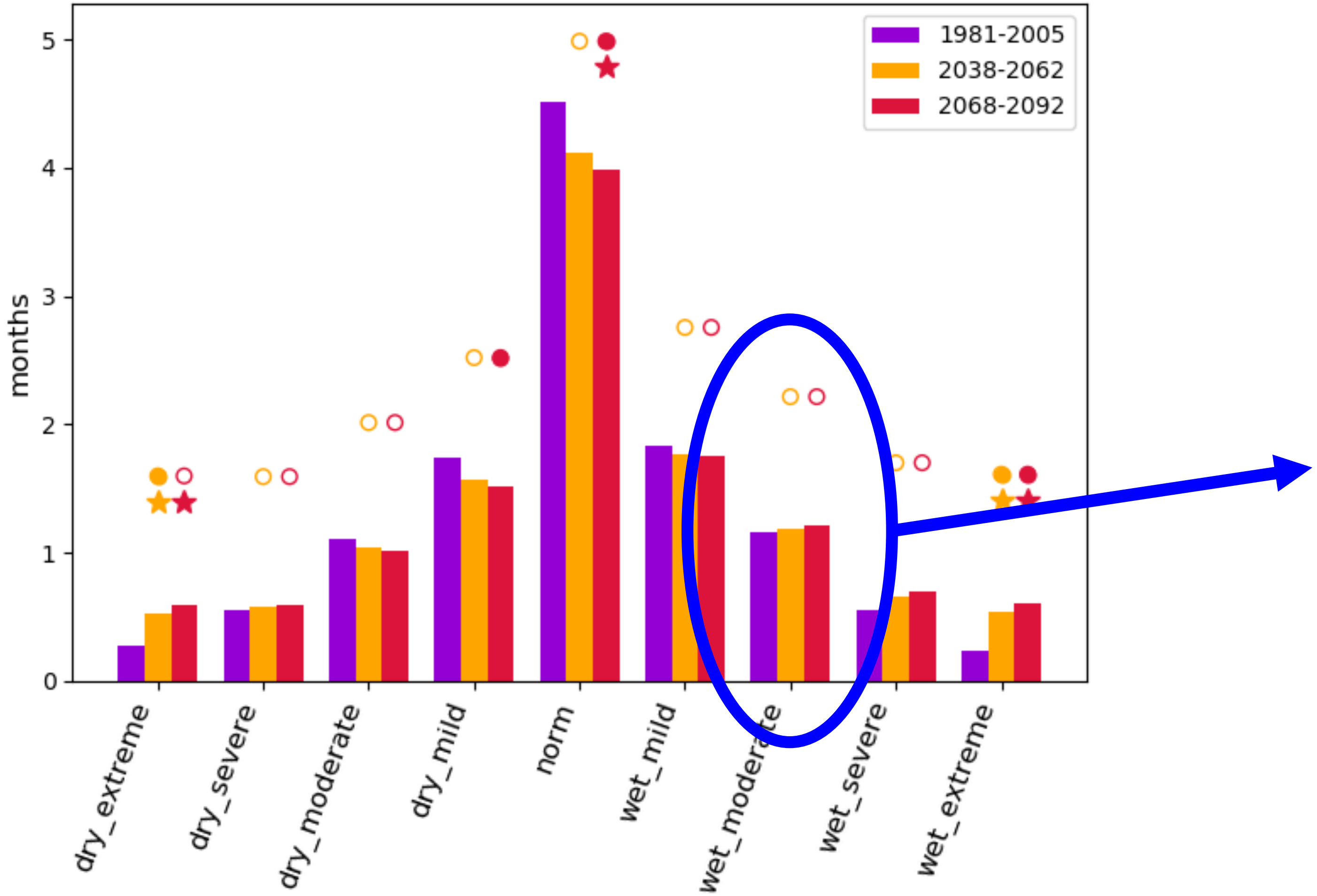
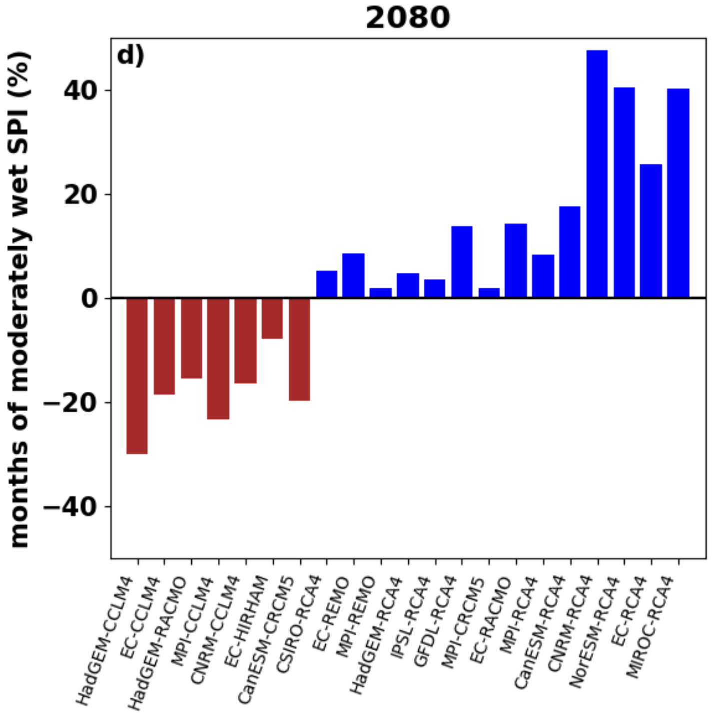



## moderately wet



# Summary

- Projections of SPI classes show a broadening of the rainfall distribution especially toward extremely wet conditions

- Increase in extreme wet and extreme dry SPI conditions and decrease in normal conditions are robust among CORDEX models

- Model differences in projections for total rainfall stem from differences in changes of moderateSPI  conditions

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In collaboration with

# AGRICA

# Climate Risk Profiles for Sub-Saharan Africa

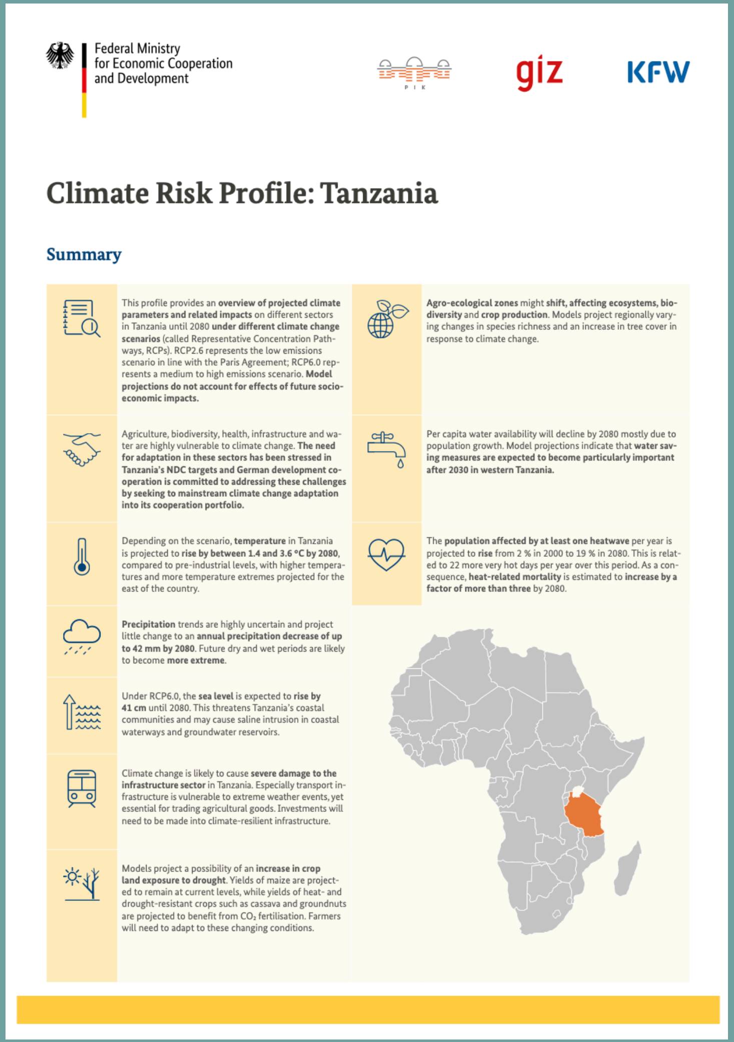
Julia Tomalka, **Stephanie Gleixner,** Stefan Lange, Christoph Gornott, Ylva Hauf, Enrico Grams, Sibylla Neer, Naima Lipka, Regina Vetter

… and many more

# The idea of a climate risk profile

Brief for NDC and NAP implementation and climate risk-informed decision making:

- **Comprehensive:** Projected changes for climate and its impacts in five related sectors under two GHG emission scenarios
- **Coherent:** Climate and climate impact projections based on ISIMIP data
- **Concise:** 12 page document



Federal Ministry for Economic Cooperation and Development

giz KFW

## Climate Risk Profile: Tanzania

### Summary

This profile provides an **overview of projected climate parameters and related impacts** on different sectors in Tanzania until 2080 **under different climate change scenarios** (called Representative Concentration Pathways, RCPs). RCP2.6 represents the low emissions scenario in line with the Paris Agreement; RCP6.0 represents a medium to high emissions scenario. **Model projections do not account for effects of future socio-economic impacts.**

Agriculture, biodiversity, health, infrastructure and water are highly vulnerable to climate change. **The need for adaptation in these sectors has been stressed in Tanzania's NDC targets and German development co-operation is committed to addressing these challenges by seeking to mainstream climate change adaptation into its cooperation portfolio.**

Depending on the scenario, **temperature** in Tanzania is projected to **rise by between 1.4 and 3.6 °C by 2080**, compared to pre-industrial levels, with higher temperatures and more temperature extremes projected for the east of the country.

**Precipitation** trends are highly uncertain and project little change to an **annual precipitation decrease of up to 42 mm by 2080**. Future dry and wet periods are likely to become **more extreme**.

Under RCP6.0, the **sea level** is expected to **rise by 41 cm** until 2080. This threatens Tanzania's coastal communities and may cause saline intrusion in coastal waterways and groundwater reservoirs.

Climate change is likely to cause **severe damage to the infrastructure sector** in Tanzania. Especially transport infrastructure is vulnerable to extreme weather events, yet essential for trading agricultural goods. Investments will need to be made into climate-resilient infrastructure.

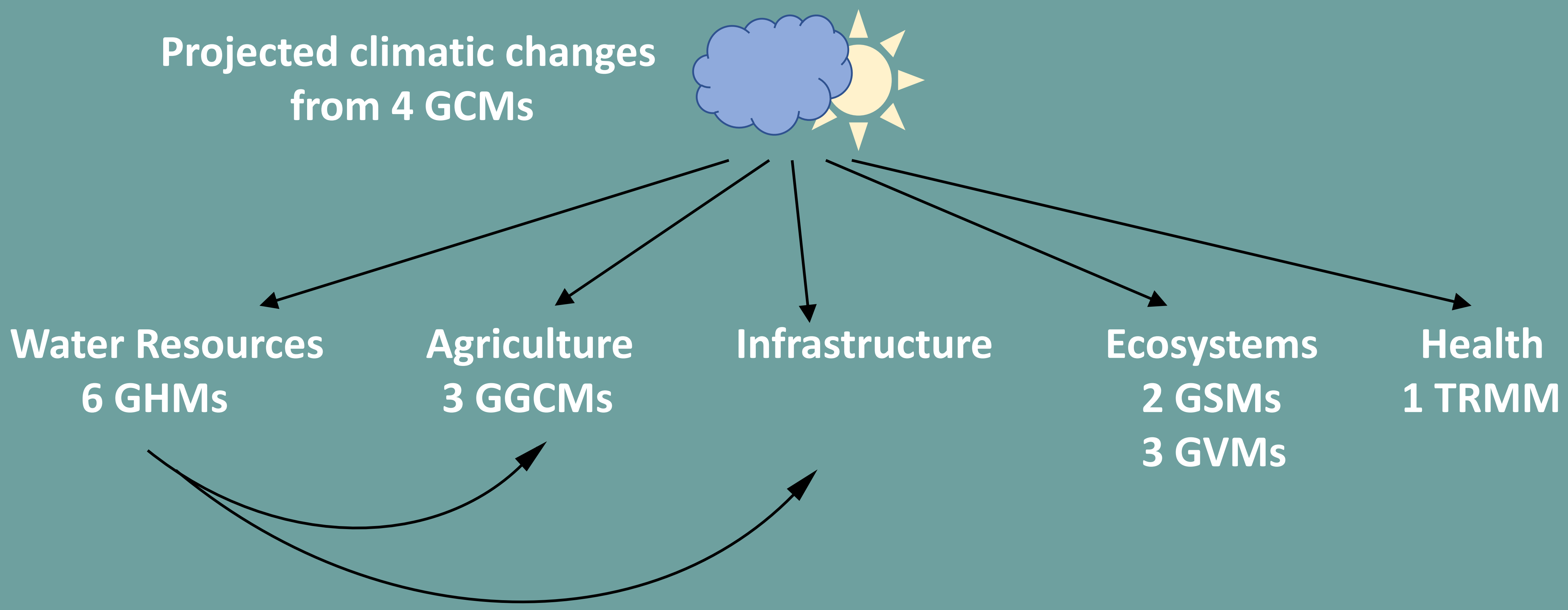
Models project a possibility of an **increase in crop land exposure to drought**. Yields of maize are projected to remain at current levels, while yields of heat- and drought-resistant crops such as cassava and groundnuts are projected to benefit from $CO_2$ fertilisation. Farmers will need to adapt to these changing conditions.

**Agro-ecological zones** might **shift, affecting ecosystems, biodiversity** and **crop production**. Models project regionally varying changes in species richness and an increase in tree cover in response to climate change.

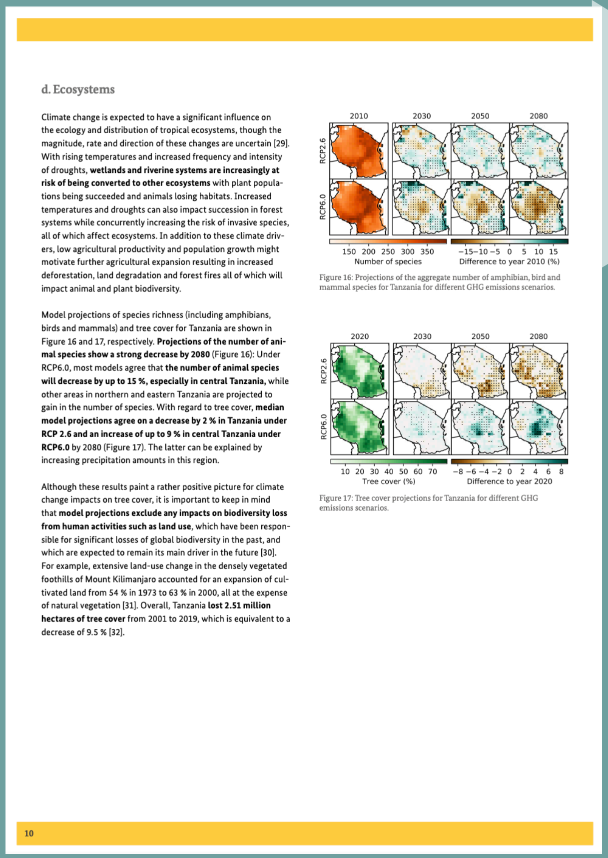
Per capita water availability will decline by 2080 mostly due to population growth. Model projections indicate that **water saving measures are expected to become particularly important after 2030 in western Tanzania.**

The **population affected by at least one heatwave** per year is projected to **rise** from 2 % in 2000 to 19 % in 2080. This is related to 22 more very hot days per year over this period. As a consequence, **heat-related mortality** is estimated to **increase by a factor of more than three** by 2080.

# Data of a climate risk profile



# Impressions of Tanzanias climate risk profile



d. Ecosystems

Climate change is expected to have a significant influence on the ecology and distribution of tropical ecosystems, though the magnitude, rate and direction of these changes are uncertain [29]. With rising temperatures and increased frequency and intensity of droughts, **wetlands and riverine systems are increasingly at risk of being converted to other ecosystems** with plant populations being succeeded and animals losing habitats. Increased temperatures and droughts can also impact succession in forest systems while concurrently increasing the risk of invasive species, all of which affect ecosystems. In addition to these climate drivers, low agricultural productivity and population growth might motivate further agricultural expansion resulting in increased deforestation, land degradation and forest fires all of which will impact animal and plant biodiversity.

Model projections of species richness (including amphibians, birds and mammals) and tree cover for Tanzania are shown in Figure 16 and 17, respectively. **Projections of the number of animal species show a strong decrease by 2080** (Figure 16): Under RCP6.0, most models agree that **the number of animal species will decrease by up to 15 %, especially in central Tanzania,** while other areas in northern and eastern Tanzania are projected to gain in the number of species. With regard to tree cover, **median model projections agree on a decrease by 2 % in Tanzania under RCP 2.6 and an increase of up to 9 % in central Tanzania under RCP6.0** by 2080 (Figure 17). The latter can be explained by increasing precipitation amounts in this region.

Although these results paint a rather positive picture for climate change impacts on tree cover, it is important to keep in mind that **model projections exclude any impacts on biodiversity loss from human activities such as land use**, which have been responsible for significant losses of global biodiversity in the past, and which are expected to remain its main driver in the future [30]. For example, extensive land-use change in the densely vegetated foothills of Mount Kilimanjaro accounted for an expansion of cultivated land from 54 % in 1973 to 63 % in 2000, all at the expense of natural vegetation [31]. Overall, Tanzania **lost 2.51 million hectares of tree cover** from 2001 to 2019, which is equivalent to a decrease of 9.5 % [32].

Figure 16: Projections of the aggregate number of amphibian, bird and mammal species for Tanzania for different GHG emissions scenarios.

Figure 17: Tree cover projections for Tanzania for different GHG emissions scenarios.

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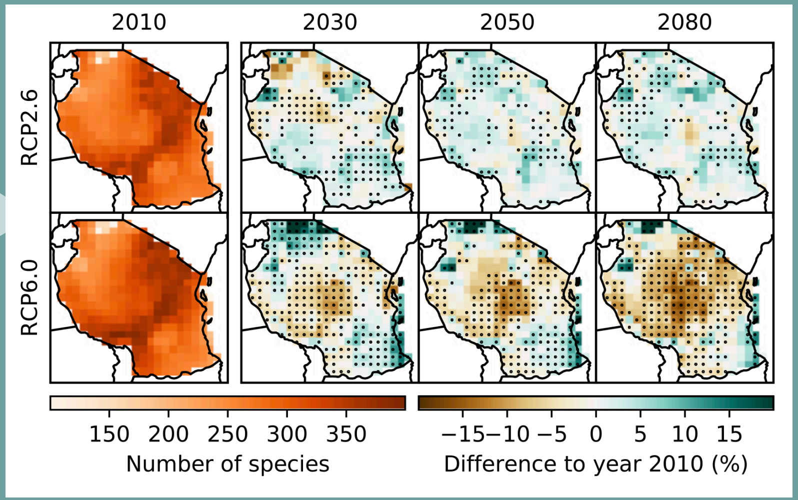


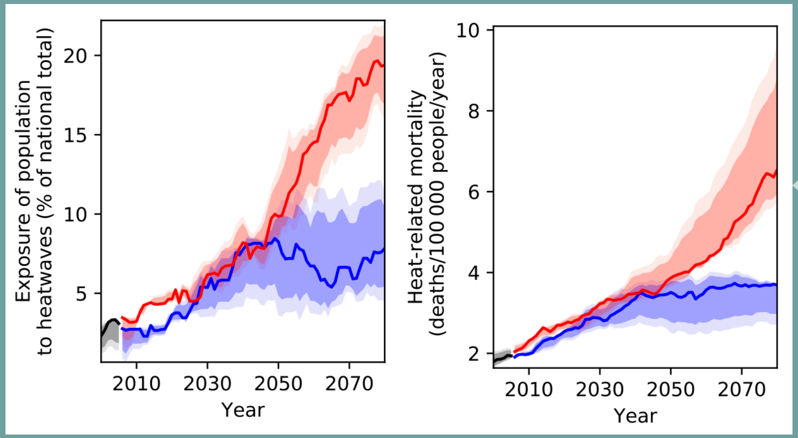


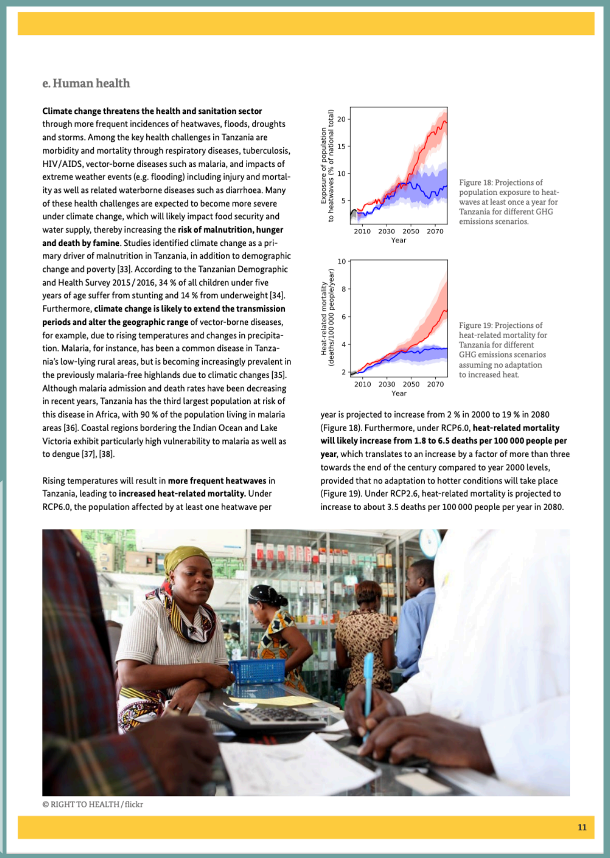

e. Human health

**Climate change threatens the health and sanitation sector** through more frequent incidences of heatwaves, floods, droughts and storms. Among the key health challenges in Tanzania are morbidity and mortality through respiratory diseases, tuberculosis, HIV/AIDS, vector-borne diseases such as malaria, and impacts of extreme weather events (e.g. flooding) including injury and mortality as well as related waterborne diseases such as diarrhoea. Many of these health challenges are expected to become more severe under climate change, which will likely impact food security and water supply, thereby increasing the **risk of malnutrition, hunger and death by famine**. Studies identified climate change as a primary driver of malnutrition in Tanzania, in addition to demographic change and poverty [33]. According to the Tanzanian Demographic and Health Survey 2015 / 2016, 34 % of all children under five years of age suffer from stunting and 14 % from underweight [34]. Furthermore, **climate change is likely to extend the transmission periods and alter the geographic range** of vector-borne diseases, for example, due to rising temperatures and changes in precipitation. Malaria, for instance, has been a common disease in Tanzania's low-lying rural areas, but is becoming increasingly prevalent in the previously malaria-free highlands due to climatic changes [35]. Although malaria admission and death rates have been decreasing in recent years, Tanzania has the third largest population at risk of this disease in Africa, with 90 % of the population living in malaria areas [36]. Coastal regions bordering the Indian Ocean and Lake Victoria exhibit particularly high vulnerability to malaria as well as to dengue [37], [38].

Rising temperatures will result in **more frequent heatwaves** in Tanzania, leading to **increased heat-related mortality.** Under RCP6.0, the population affected by at least one heatwave per year is projected to increase from 2 % in 2000 to 19 % in 2080 (Figure 18). Furthermore, under RCP6.0, **heat-related mortality will likely increase from 1.8 to 6.5 deaths per 100 000 people per year**, which translates to an increase by a factor of more than three towards the end of the century compared to year 2000 levels, provided that no adaptation to hotter conditions will take place (Figure 19). Under RCP2.6, heat-related mortality is projected to increase to about 3.5 deaths per 100 000 people per year in 2080.

Figure 18: Projections of population exposure to heat-waves at least once a year for Tanzania for different GHG emissions scenarios.

Figure 19: Projections of heat-related mortality for Tanzania for different GHG emissions scenarios assuming no adaptation to increased heat.

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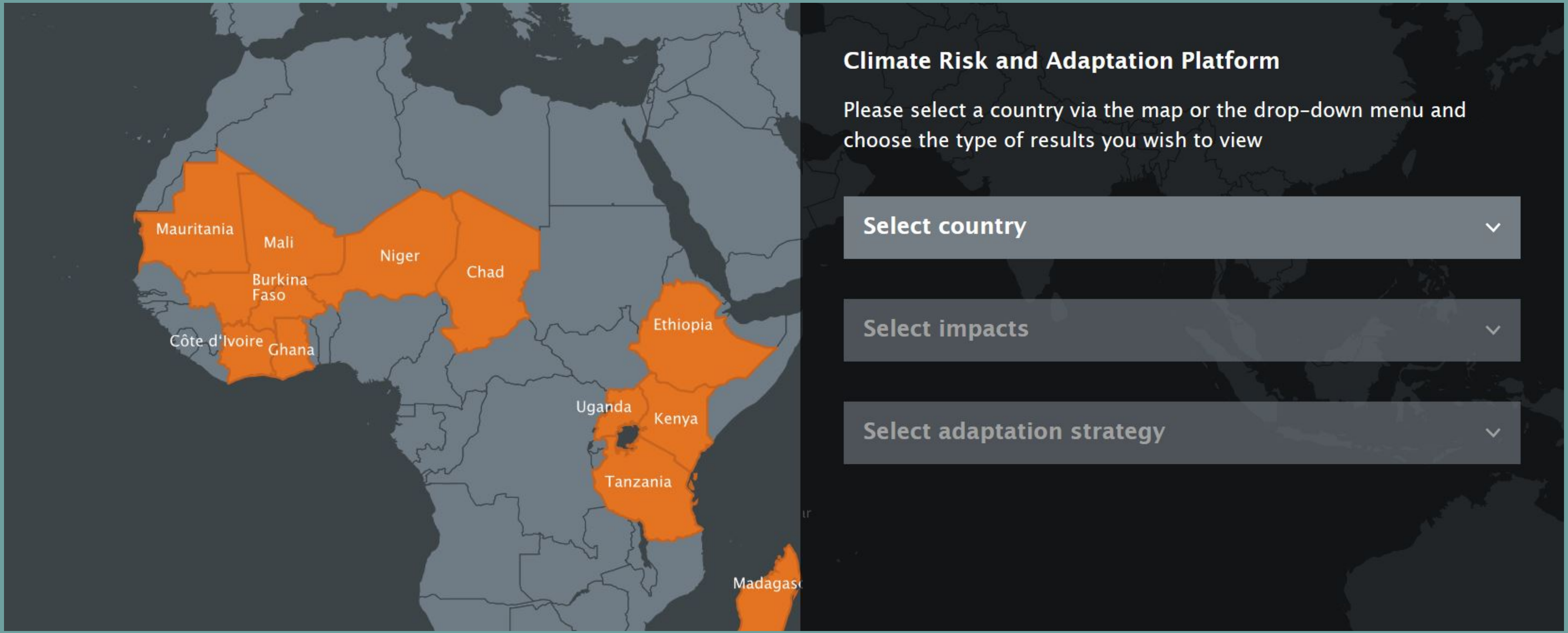
# Website and portfolio




Climate risk profiles for **12 sub-Saharan African countries**

available on **www.agrica.de**

# Thank you for your attention.

gleixner@pik-potsdam

Celebrating 30 years of integrated climate impact research at the Potsdam Institute.

Leibniz Association