# Bias-Corrected and Spatially Disaggregated Seasonal Forecasts: A Long- Term Reference Forecast Product for the Tekeze-Atbara and Blue Nile Basins

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2020 International Conference on the Nile and Grand Ethiopian Renaissance Dam: Science, Conflict Resolution and Cooperation

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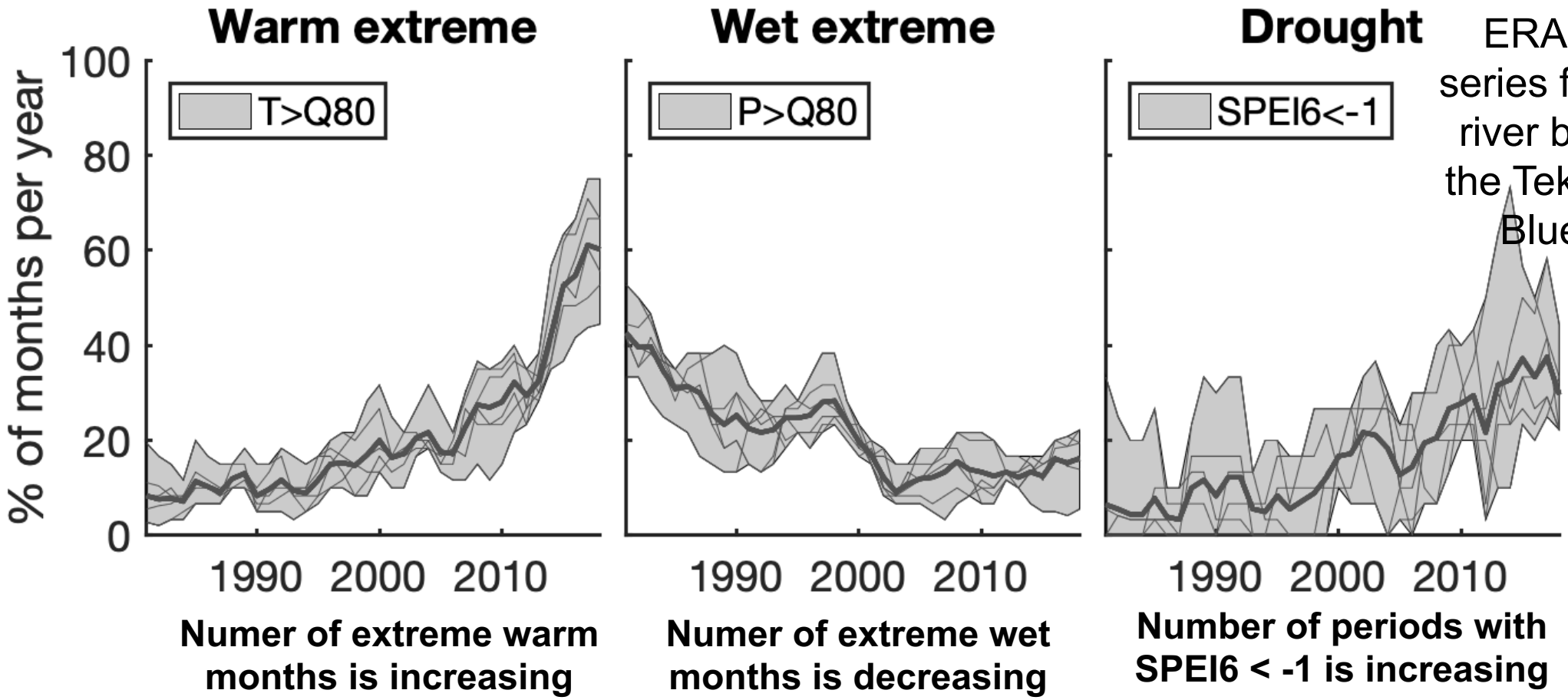
# Climate is changing in semi-arid regions




**Numer of extreme warm months is increasing**

**Numer of extreme wet months is decreasing**

**Number of periods with SPEI6 < -1 is increasing**

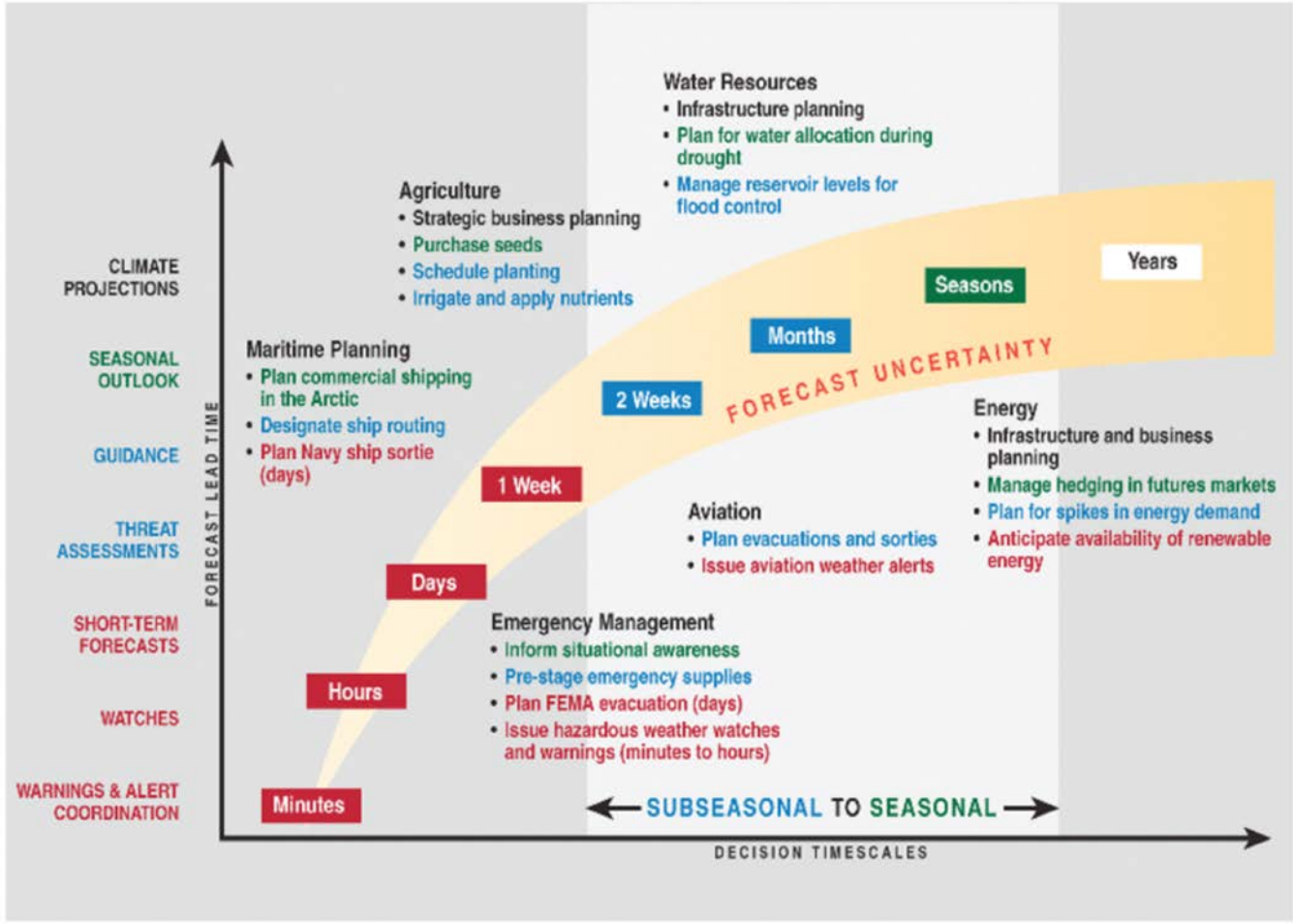
ERA5-based time-series for five semi-arid river basins including the Tekeze-Atbara and Blue-Nile Basins

**Findings based on current reanalysis data – long-term trends even worse…**

# Long-term planning is crucial…

- Allocation of freshwater resources
- Reservoir management
- Food and drinking water security
- Hydropower generation
- Extreme event prediction
- *Example: GERD filling strategies*

**Seasonal forecasts can make a decicive contribution for regional water management**




Source: *Next Generation Earth System Prediction: Strategies for Subseasonal to Seasonal Forecasts*. Washington, DC: The National Academies Press. doi: 10.17226/21873.

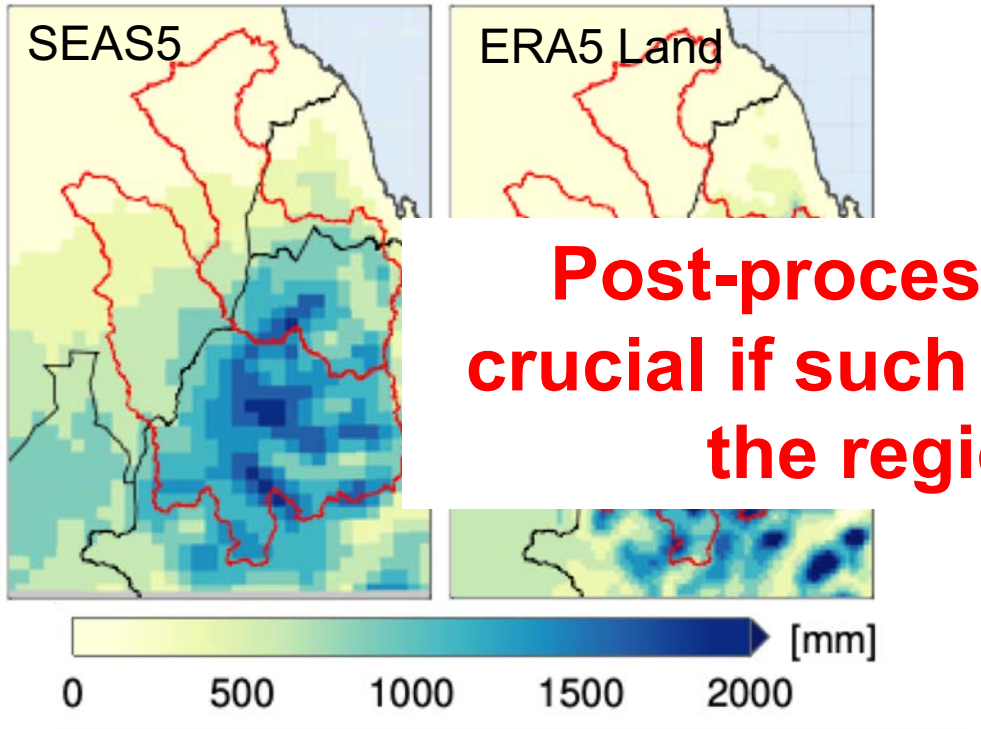
# Seasonal forecasts: a short overview

- Ensemble forecasts time-periods up to 1 year ahead
- Global products from major meteorological centers (ECMWF, Met Office, Météo France, DWD, NCEP, etc.)
- Predictability on seasonal time-scales through MJO, ENSO, soil moisture, snow cover and sea ice, etc.*
- Here: ECMWFs actual seasonal forecasting system SEAS5
  - Spatial resolution of 36km; output on 6-hourly, daily and monthly time-scales, freely available via ECMWF and Copernicus
  - 25 (from 1981 to 2016) and 51 (from 2017) ensemble member

*Vitart, F., Robertson A. and the S2S steering group Sub-seasonal to seasonal prediction: linking weather and climate. Seamless prediction of the earth system: from minutes to months, WMO-no 1156, 385-405 (2015)

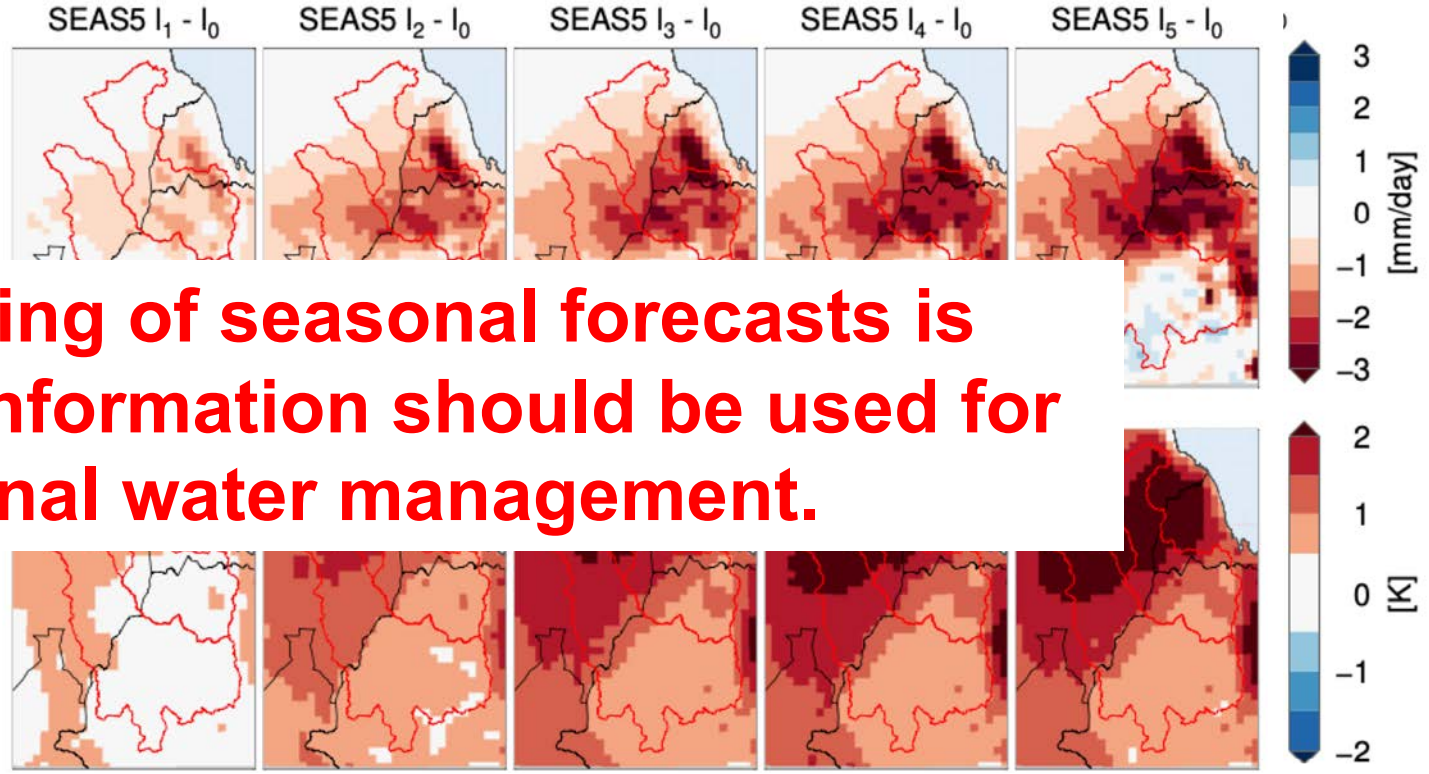
# Raw seasonal forecasts have issues…

## Model biases




Seasonal precipitation sum from June to September, averaged over the period 1981 to 2016

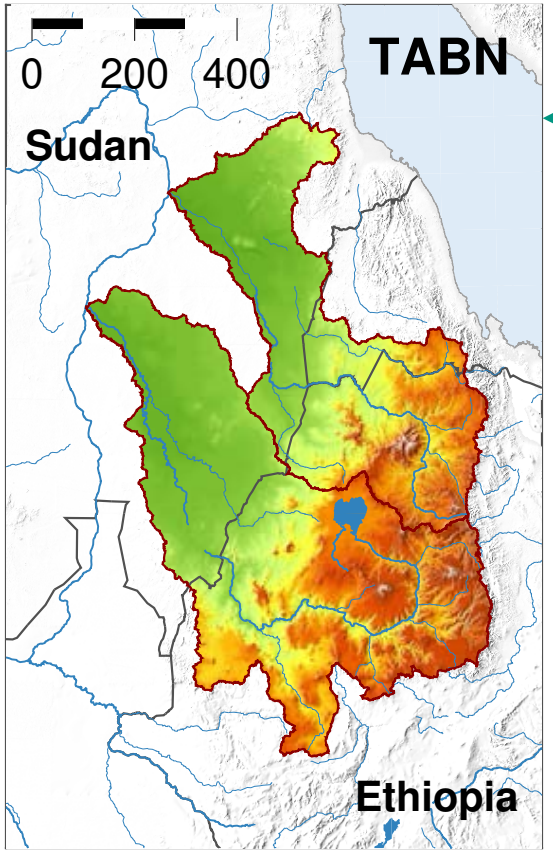
## Model drifts

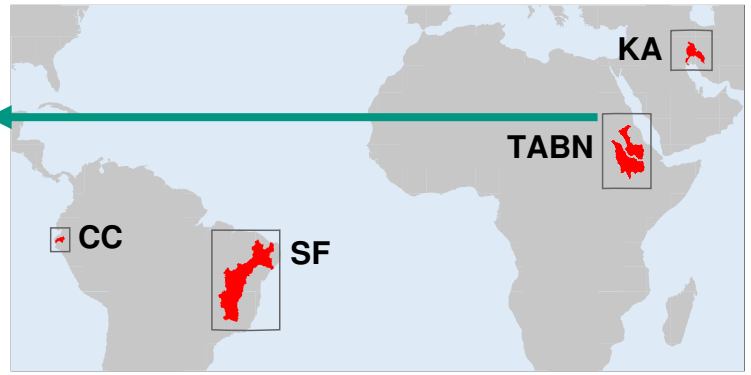



Differences of precipitation (top) and temperature (bottom) forecasts for July between different lead times, averaged over the period 1981 to 2016

**Post-processing of seasonal forecasts is crucial if such information should be used for the regional water management.**

# Objectives in a nutshell



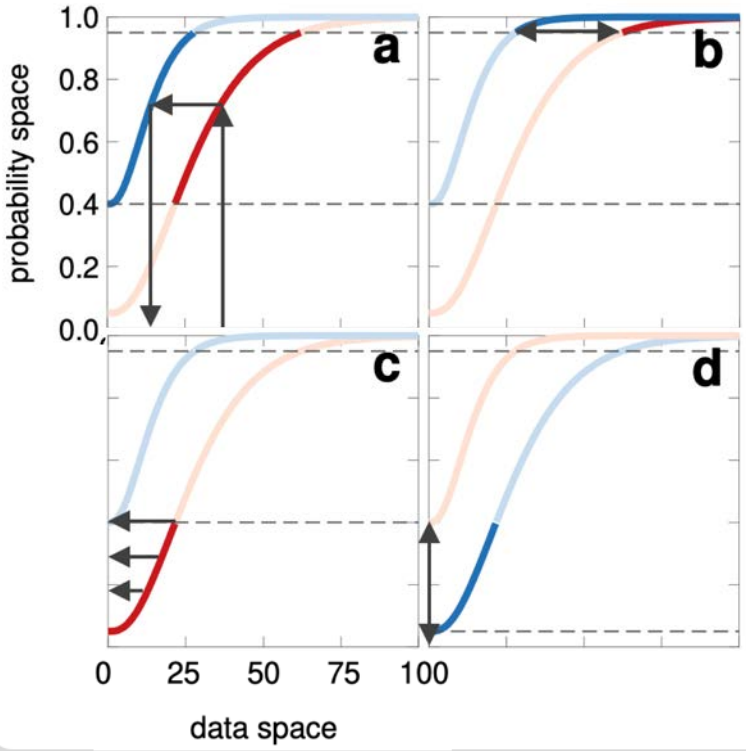





- **Development** of **regionalized seasonal forecasts** for the Tekeze-Atbara and Blue Nile Basins (Sudan, Ethiopia, and Eritrea)
- **Bias-Correction and Spatial Disaggregation** (BCSD) of ECMWFs seasonal forecast product **SEAS5** towards **ERA5-Land**, which is the offline re-run of ERA5s land surface component with an enhanced resolution of 9km.
- **Free publication** of the dataset to **build capacity and knowledge** in the field of **seasonal ensemble forecasts**.
- **Operationalization** for providing **up-to-date seasonal forecasts and derived products** for supporting the regional water management

# From raw SEAS5 to SEAS5 BCSD

1. Bilinear interpolation of SEAS5 (approx. 35km) to the ERA5-Land grid (0.1°)
2. Bias-correction of daily precipitation, temperature, and radiation using empirical quantile mapping
3. Computation of categorical forecasts, drought indicators, etc. including performance analyses



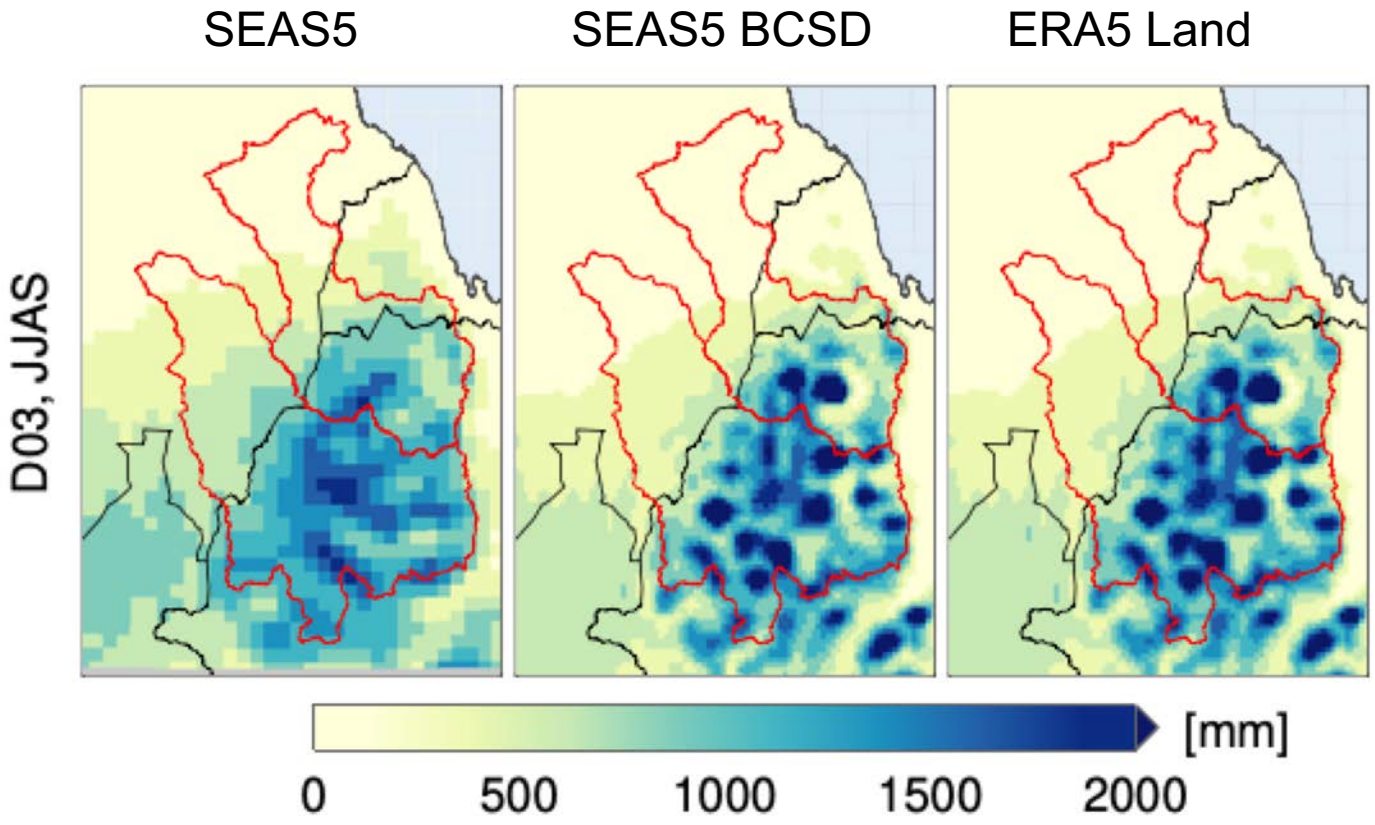

a) Empirical quantile mapping between model-based (red) and reference (blue) data → CDFs are estimated using a 31-day-window around the forecasted day during the reference period from 1981 to 2016

b) Delta-approach for correcting extreme values above the maximum quantile

c) Correction of precipitation intermittency when the dry-day probability of the reference (lower dashed line) is higher

d) Correction of precipitation intermittency when the dry-day probability of the reference is lower

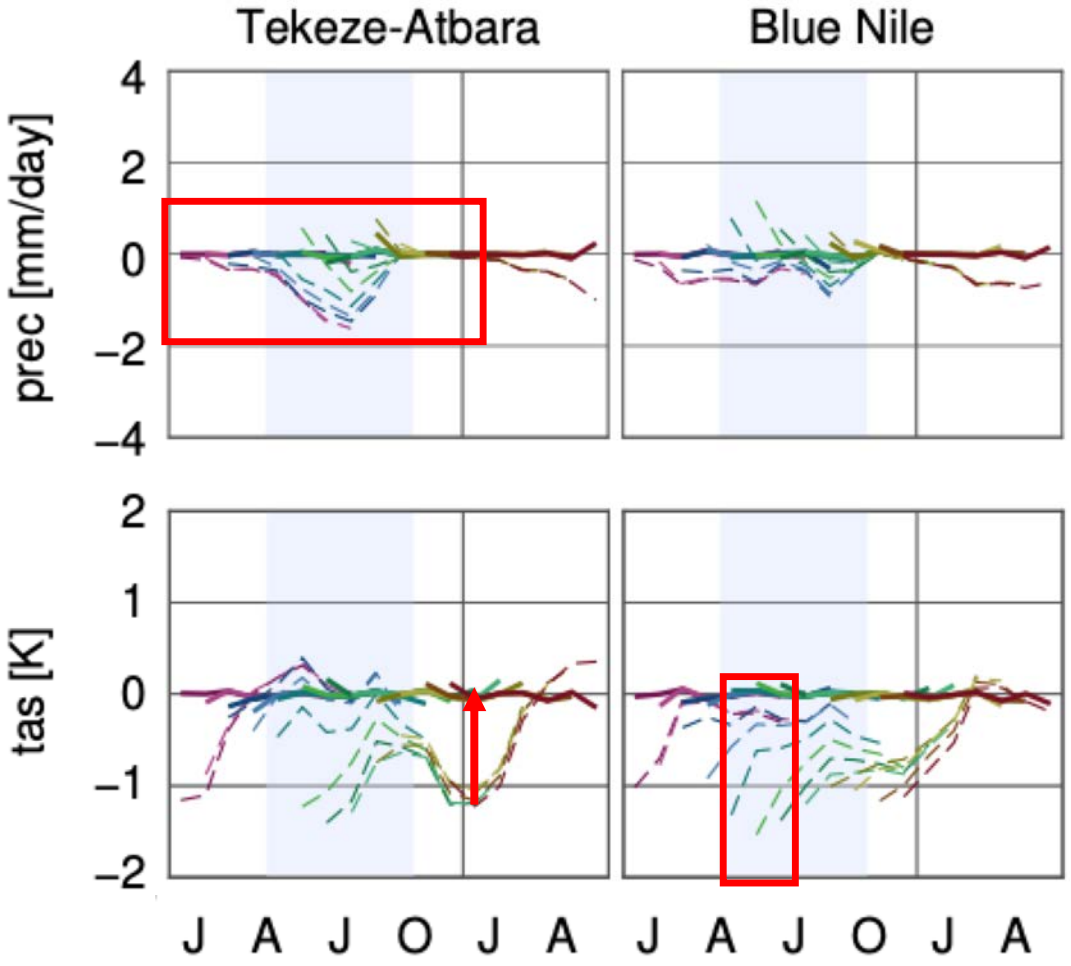
# Improvement of total seasonal precipitation




Seasonal precipitation sum from June to September, averaged over the period 1981 to 2016

**Substantially improved level of agreement w.r.t. ERA5 Land**

# Improvement of area-averaged forecasts

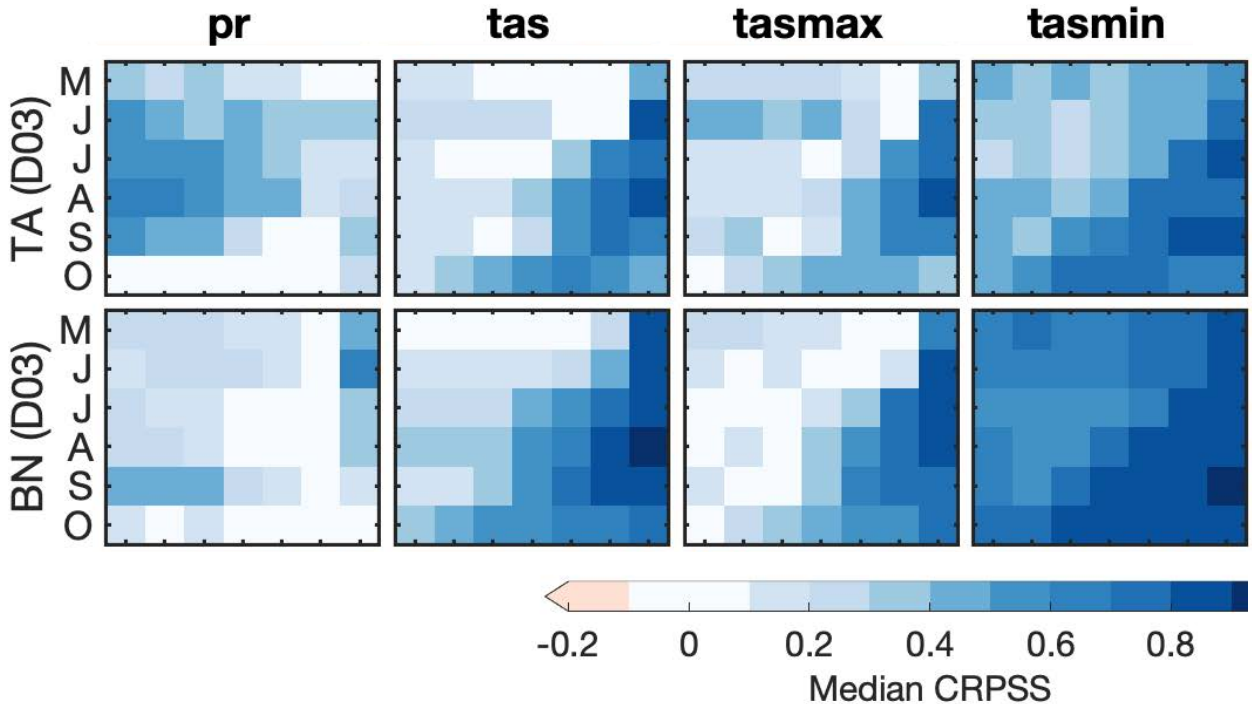



Biases of area-averaged precipitation (top) and temperature (bottom) forecasts for the Tekeze-Atbara (left) and Blue Nile (right) basins of raw SEAS5 (dashed) and SEAS5 BCSD (straight) from different issue dates (colors)

- Biases after BCSD are close to 0
- Seasonality of biases is (almost) eliminated
- Improved consistency across lead-times

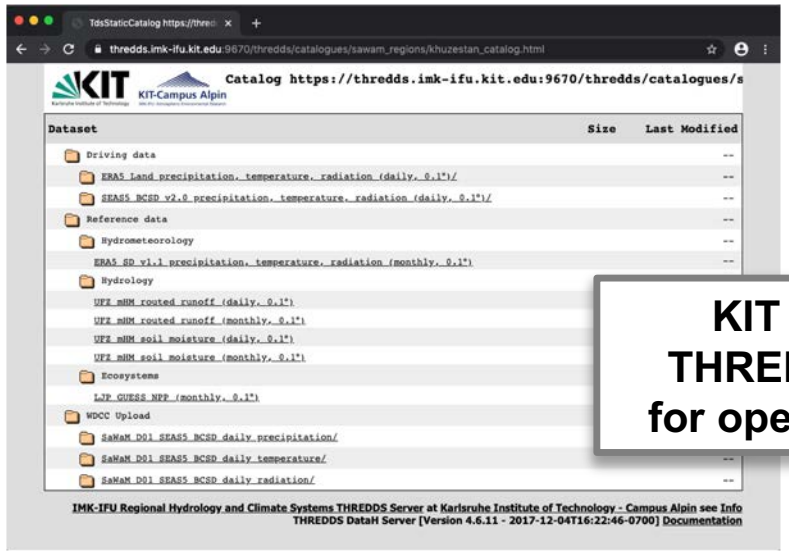
# SEAS5 BCSD vs. SEAS5 (raw) vs. ERA5 Land

- CRPSS: level of agreement between the statistical distribution of the ensemble forecasts and reference information (here: ERA5 Land)
- Raw forecast skill is quite weak across the basins (indicated by reddish CRPSS values below 0)
- CRPSS becomes positive after BCSD, particularly for temperature and low-lead precipitation forecasts (indicated by blueish CRPSS values above 0)
- Compared to the raw forecasts, BCSD shows an improvement across all lead-times and variables.

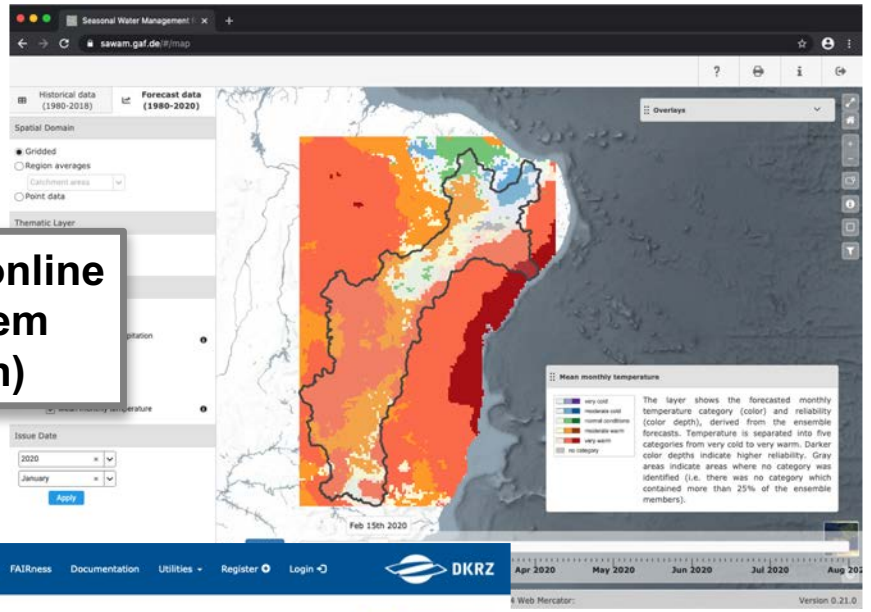



**BCSD is a simple, but effective method for reducing biases and model drifts.**

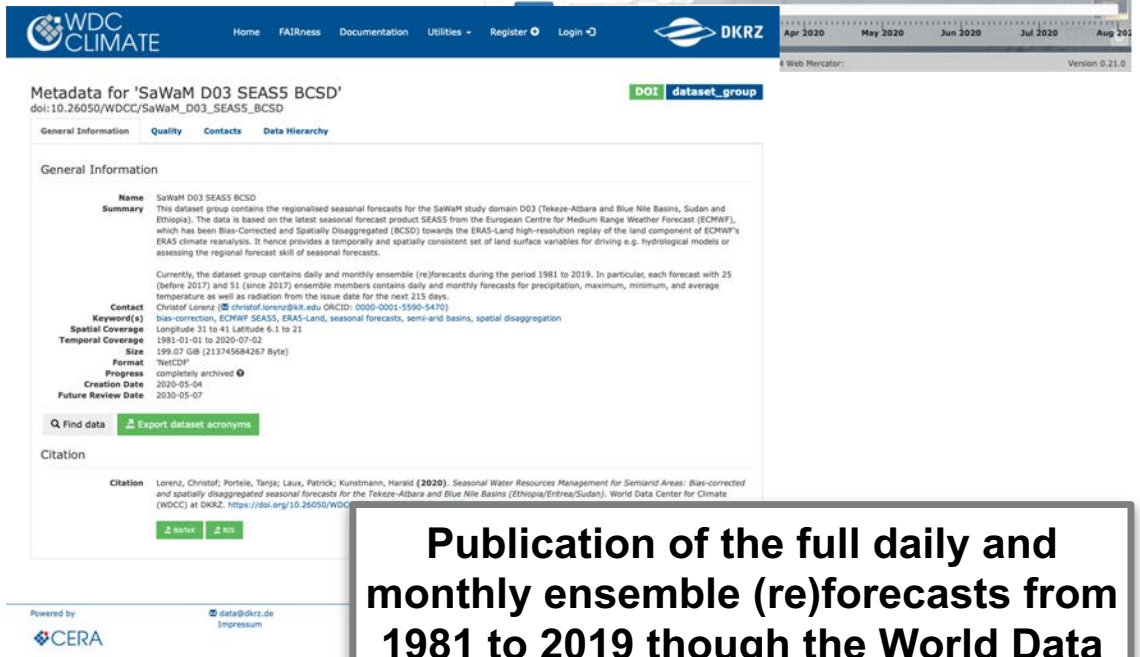
# Publication, visualization and dissemination of SEAS5 BCSD




**KIT Campus Alpin THREDDS Data Server for operational products**




**Joint development of an online Decision Support System (will be released soon)**




**Publication of the full daily and monthly ensemble (re)forecasts from 1981 to 2019 though the World Data Center for Climate (WDCC)**

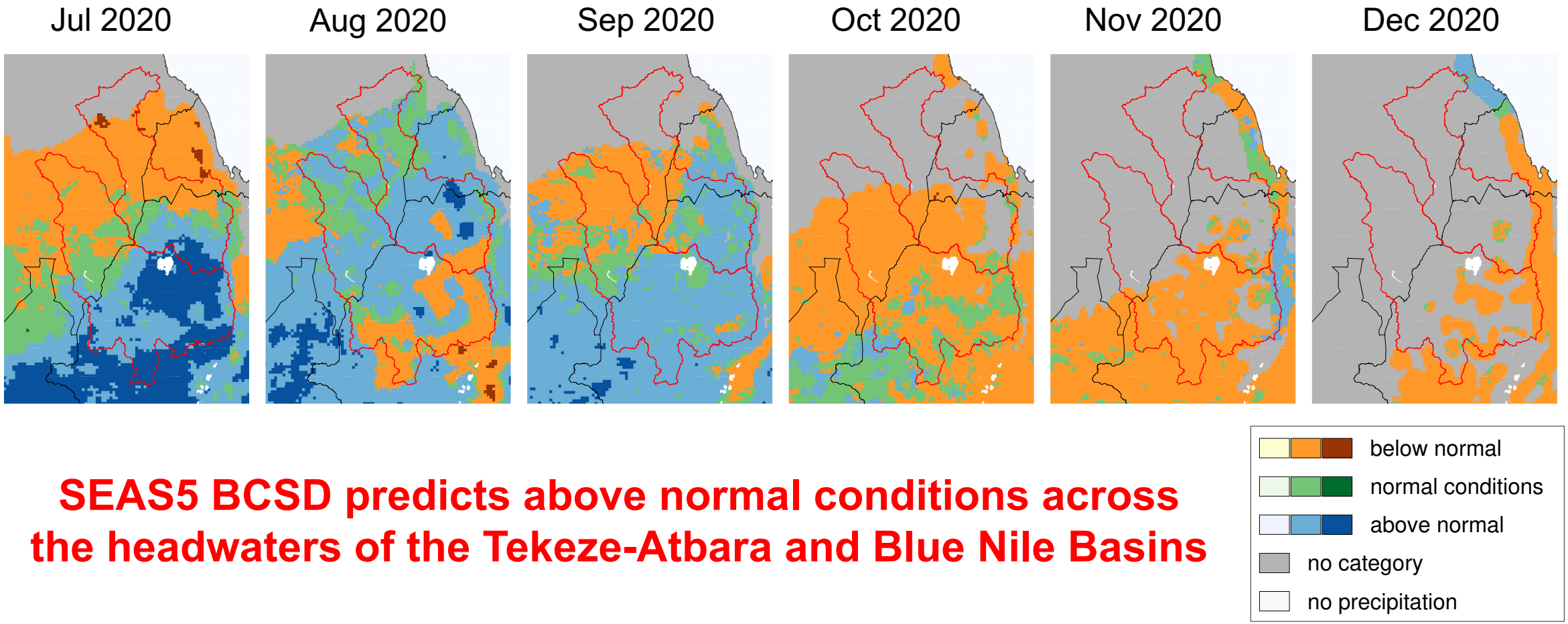
Dissemination of operational BCSD forecasts and derived products to local authorities:

- Sudan: *Ministry of Irrigation and Water Affairs, Sudanese Meteorological Association (SMA)*
- Iran: *Khuzestan Water and Power Authority (KWPA)*
- Ecuador: *National Meteorological Agency of Ecuador* (INAMHI)
- Brazil: *Foundation Cearense for Meteorology and Water Management* (FUNCEME)

# What about the current forecast?

## Categorical (tercile) precipitation forecasts from 1.7.2020*

*Forecasts from August still under development due to server issues…




**SEAS5 BCSD predicts above normal conditions across the headwaters of the Tekeze-Atbara and Blue Nile Basins**

# Summary

- Seasonal forecasts can significantly improve the water management and climate proofing in semi-arid regions (…and can help to develop climatically reasonable filling strategies)
- Raw forecasts are often not directly applicable (bad resolution, biases, etc.)
- We have applied a BCSD-approach for computing spatially and temporally consistent seasonal forecasts for a domain which includes the Tekeze-Atbara and Blue Nile basins
- Our product shows much higher forecast skill compared to the raw forecasts
- All data is freely available; operational forecasts are produced every month!

Contact: Christof.Lorenz@kit.edu

Sudan, 2018

# Thank you for your attention.

**More information: www.grow-sawam.org**

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**Feedback on and usage of our products are highly appreciated!**