Towards improved disaster preparedness and climate proofing in semi-arid regions: development of an operational seasonal forecasting system

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www.grow-sawam.org

www.imk-ifu.kit.edu

Iran – 2017/2018
Source: Teheran Times

Iran – 2018/2019
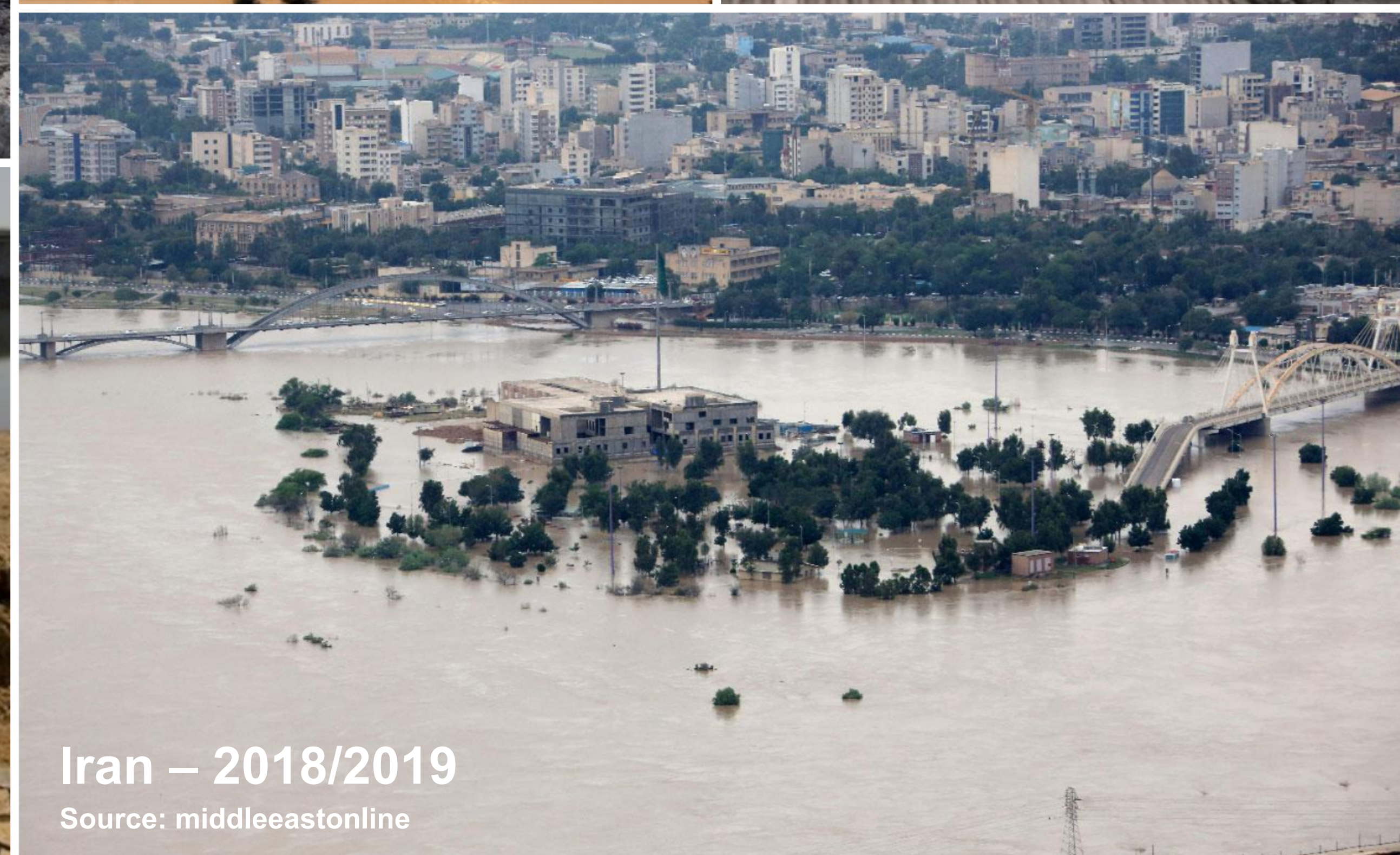Source: the iran project

Ecuador – 2020
Source: floodlist

Brazil – 2014 - 2017
Source: Climatechangenews

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Brazil – 2014 - 2017
Source: BBC

Iran – 2018/2019
Source: middleeastonline

Drought, inefficiency lead to major power shortage in Iran

Maysam Bizaer July 17, 2018

al-montior.com

Iran orders evacuation of 60,000 from flooded Ahvaz

Iran's Khuzestan province has been struggling with major floods due to heavy rains and floodwater; unprecedented flooding in normally arid Iran has killed at least 70.

Wednesday 10/04/2019

Middle-east-online.com

September 25, 2018 17:25

financialtribune.com

Iran Hydropower Production Down 36%

01.03.2018, dw.com

Hydropower supply dries up with climate change

Water power is the largest renewable energy source in the world, but some plants are running out of water due to severe droughts. Is climate change jeopardizing the future of hydropower plants?

Climate crisis blamed for rains and floods that have killed 150 in Brazil

Data seen by the Guardian shows 'extreme rainfall events' have soared over past 30 years

1.3.2020, The Guardian

August 21, 2018 | *Topic:* **Security** | *Region:* **Middle East** | *Blog Brand:* **Middle East Watch** | *Tags:* **Iran, Protests, Crisis, Drought, Regime**

The Future Is Now: Iran's Drought Crisis Is Fueling the Country's Political Instability

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by Matthew Reisener

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Improved disaster preparedness and climate proofing through knowledge about the next season is vital!
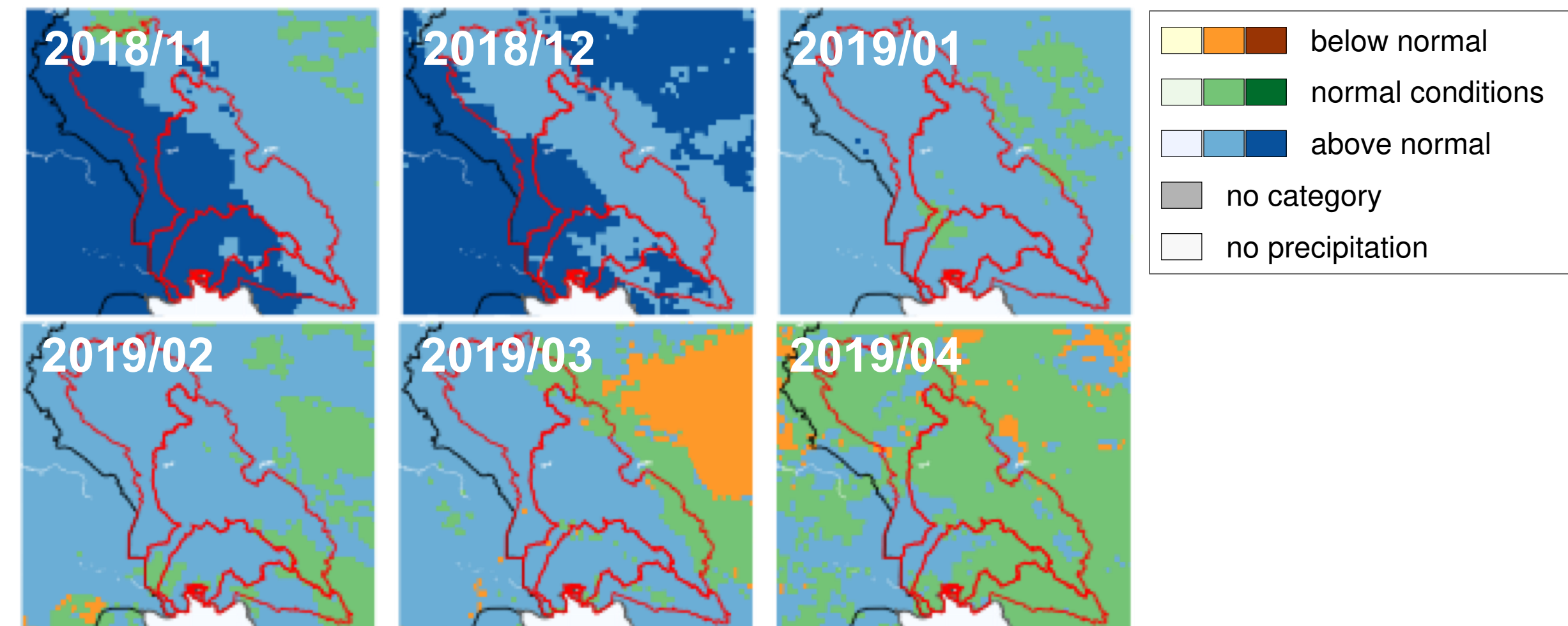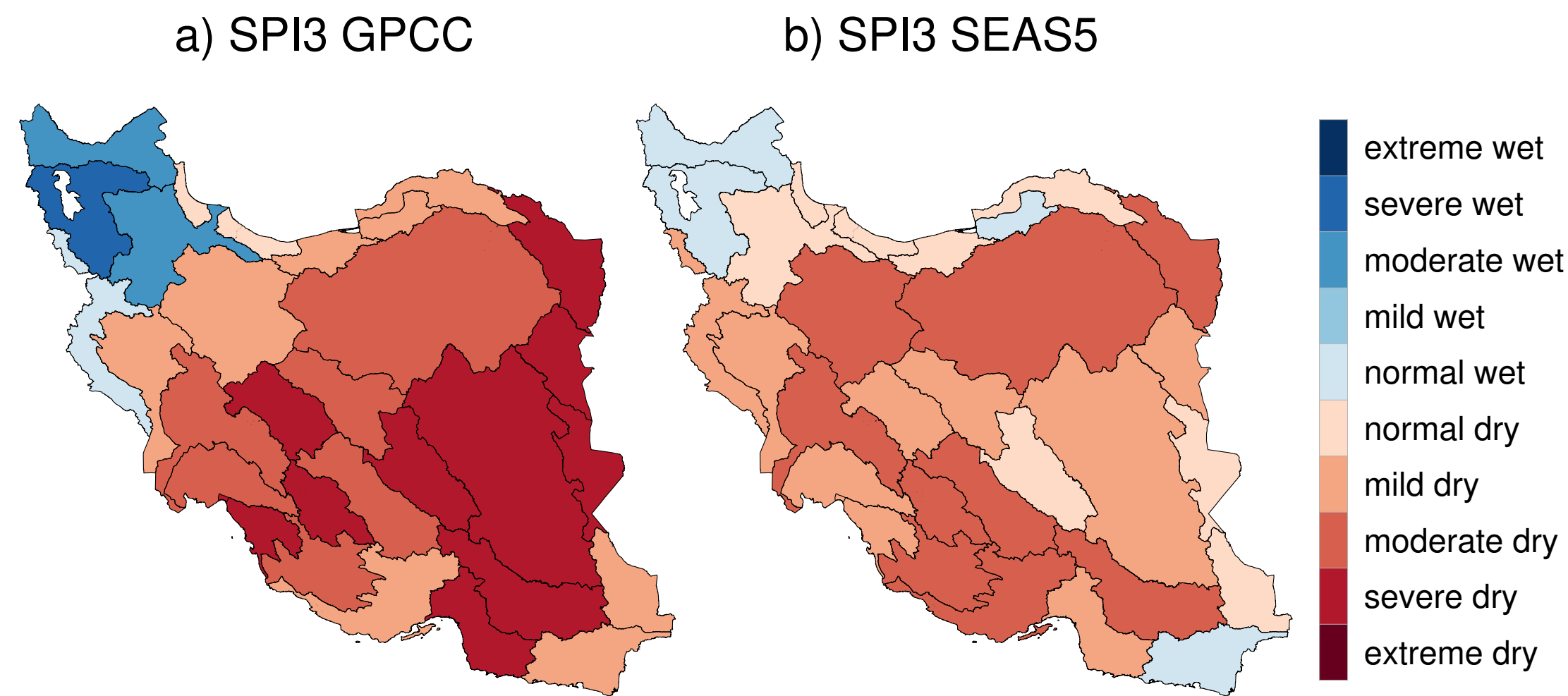
Iran – 2018/2019
Source: middleeastonline

Seasonal forecasts could be the right tool for that…

Example: Standardized Precipitation Index (SPI) 3 over Iran for the period Dec 2017 to Feb 2018, where insufficient rainfalls during the beginning of the rainy season led to severe drought conditions during the coming months

Example: Seasonal precipitation forecasts for the Khuzestan province (South-West Iran) for the rainy season 2018/2019, during which extreme rainfalls caused severe floodings across large parts of Iran

a) SPI3 GPCC   b) SPI3 SEAS5

...dry conditions were predicted from Dec 2017

...wet conditions were predicted from Oct/Nov 2018

…but raw forecasts are not directly applicable for the operational water management as they suffer from

- **model biases** → systematic errors between forecast model and reality
- **model drifts** → convergence to different climatologies, depending on the forecast horizion
- **low spatial resolution** → bad representation of e.g. precipitation over complex terrain
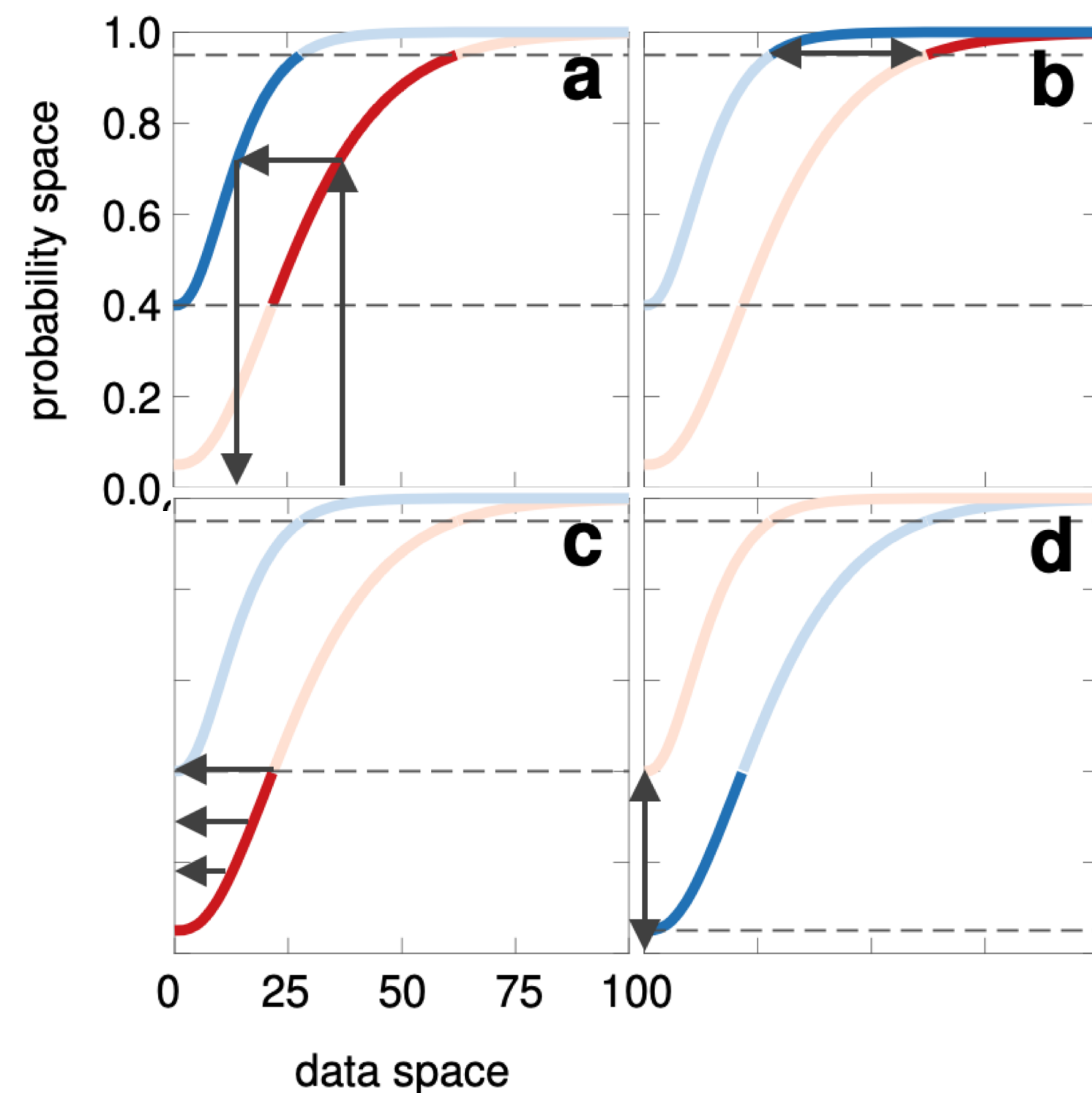
Objectives in a Nutshell
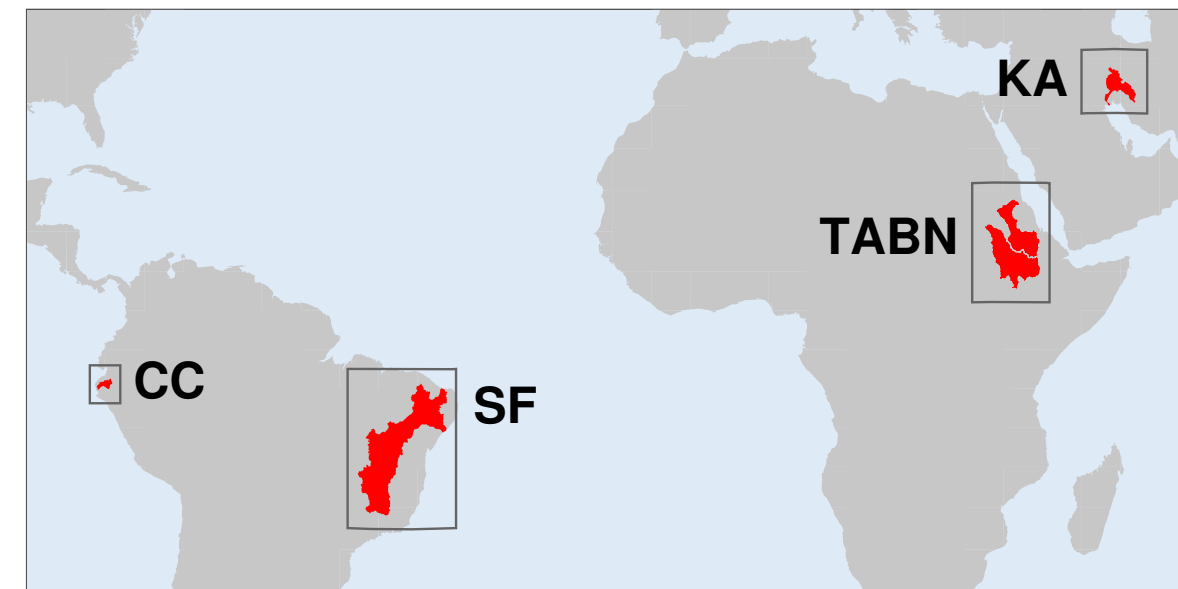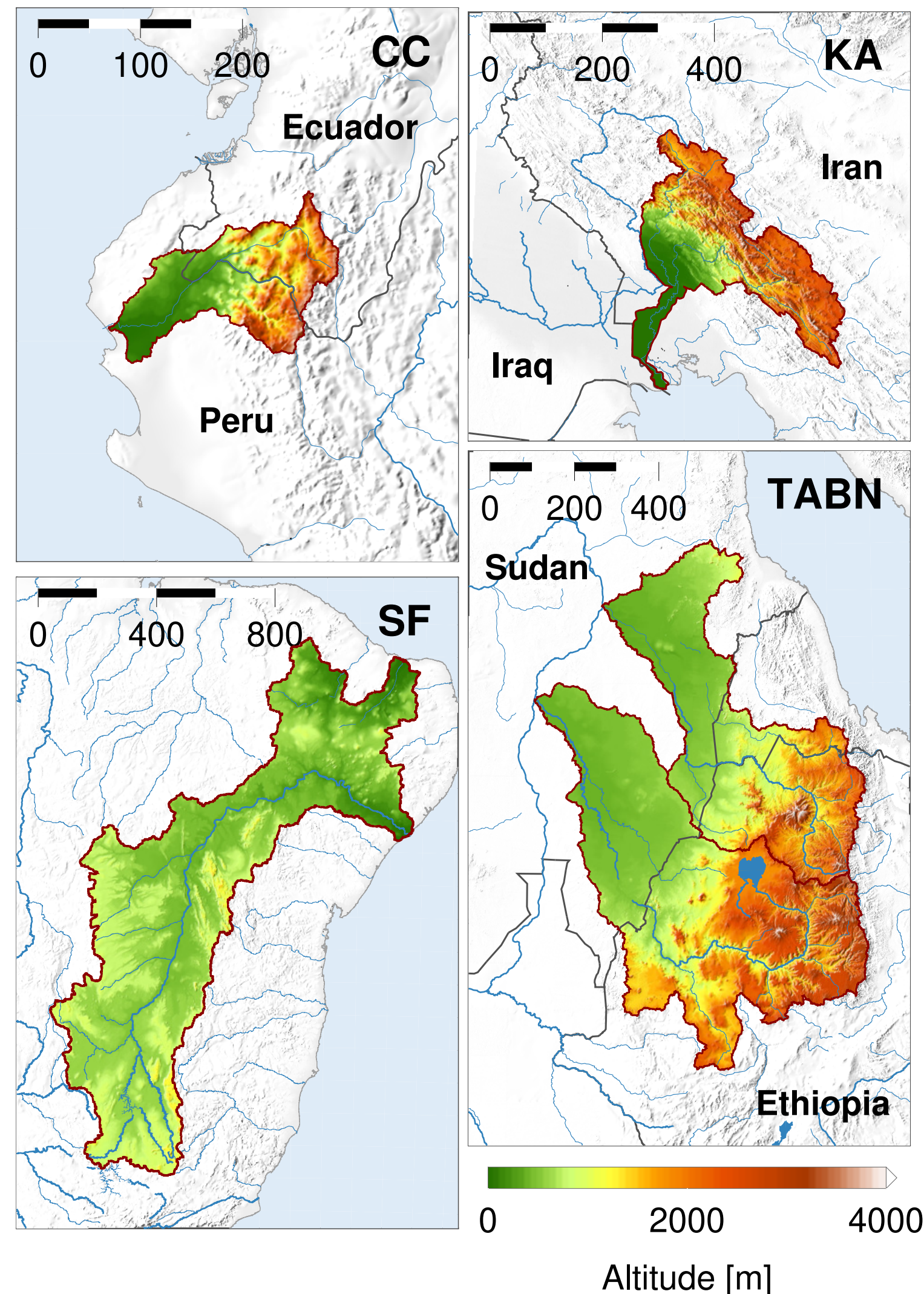
- **Development** of **regionalized seasonal forecasts** for four semi-arid domains (Brazil: Rio São Francisco Basin; Sudan/Ethiopia: Tekeze-Atbara and Blue Nile Basins, Iran: Karun Basin; Ecuador/Peru: Catamayo-Chira Basin)

- **Bias-Correction and Spatial Disaggregation** (BCSD) of ECMWFs newest 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** and *on site* **presentation** 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** (e.g. categorical forecasts, drought indicators, etc.) for supporting the regional water management

Workflow – from raw SEAS5 to SEAS5 BCSD forecasts

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 (see below)

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

BCSD reduces biases, their seasonality and their lead-dependency

Area-averaged biases and RMSEs for the Catamayo-Chira basin during the re-forecast period from 1981 to 2016 of raw (dashed) and BCSD (solid) SEAS5 forecasts from different initialization months (colors).
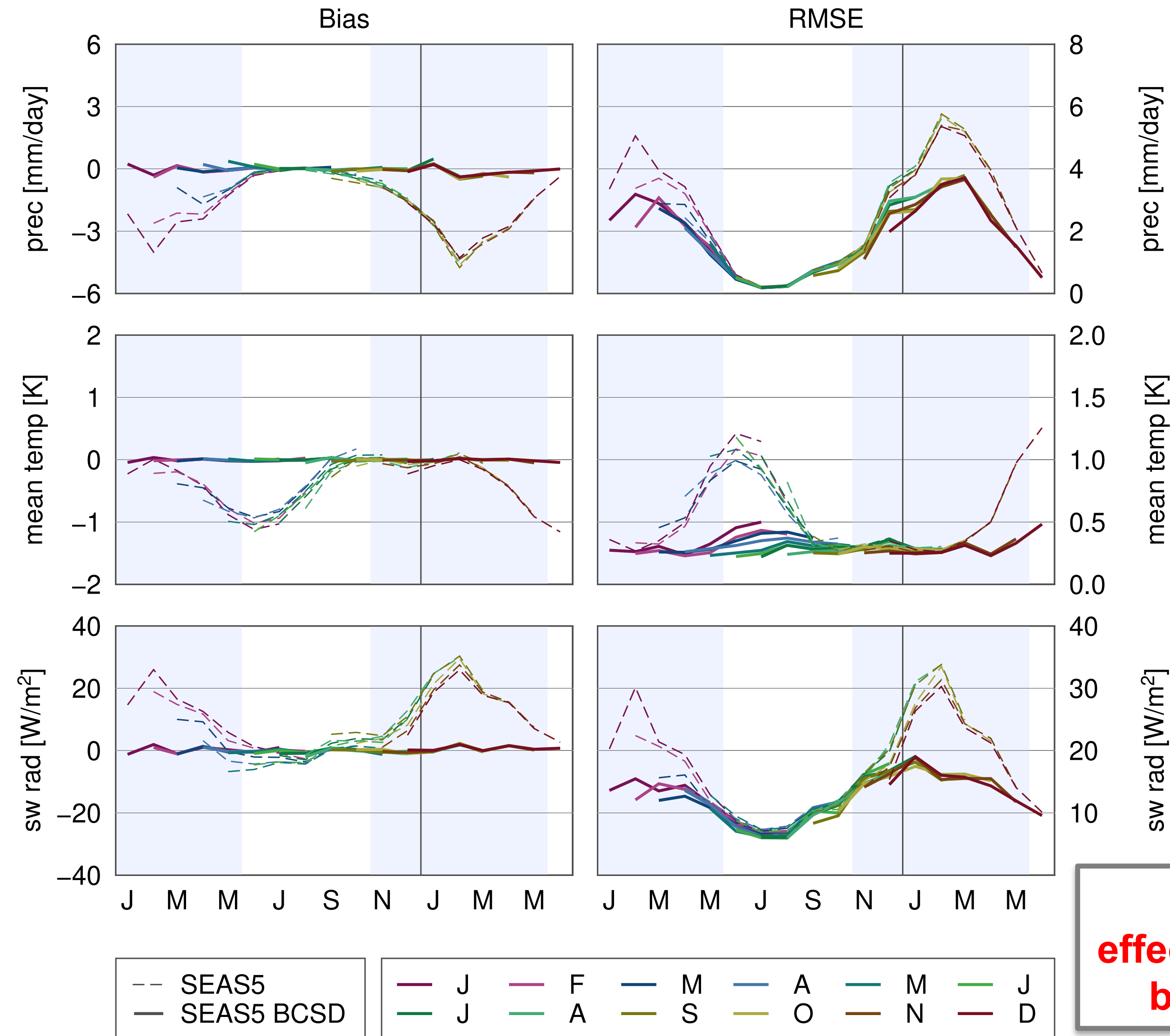
Biases after BCSD are **close to 0.**

Seasonality of biases is **reduced.**

Improved consistency across the **lead times**.
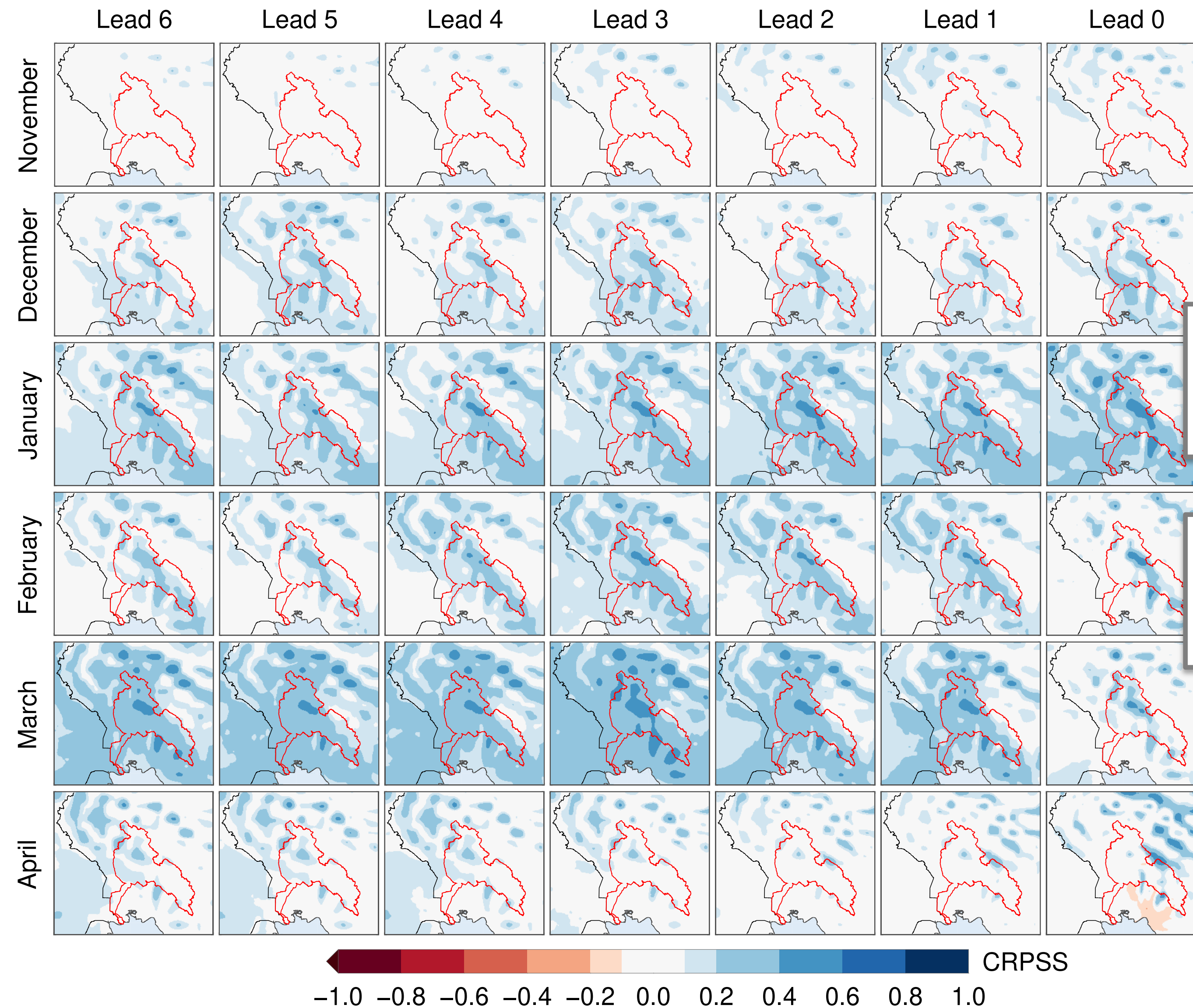

RMSE between SEAS5 and ERA5-Land is **reduced!.**

Seasonality of **RMSE** is **also reduced.**

In contrast to the bias, the **RMSE** is **not zero** after BCSD.

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

BCSD improves agreement of ensemble forecasts with ERA5 Land

CRPSS between raw and BCSD forecasts w.r.t. ERA5-Land for the Karun Basin, evaluated during the period 1981 – 2016.

Improved level of agreement with ERA5-Land **across all lead-times and initialization dates**

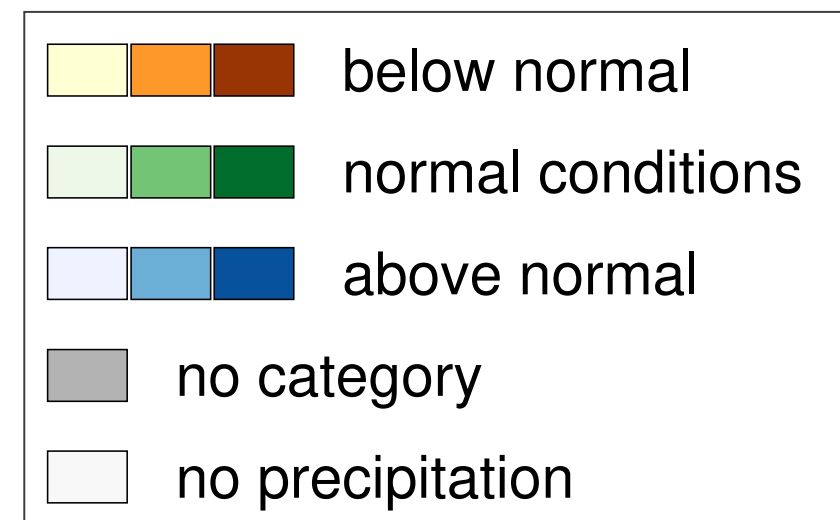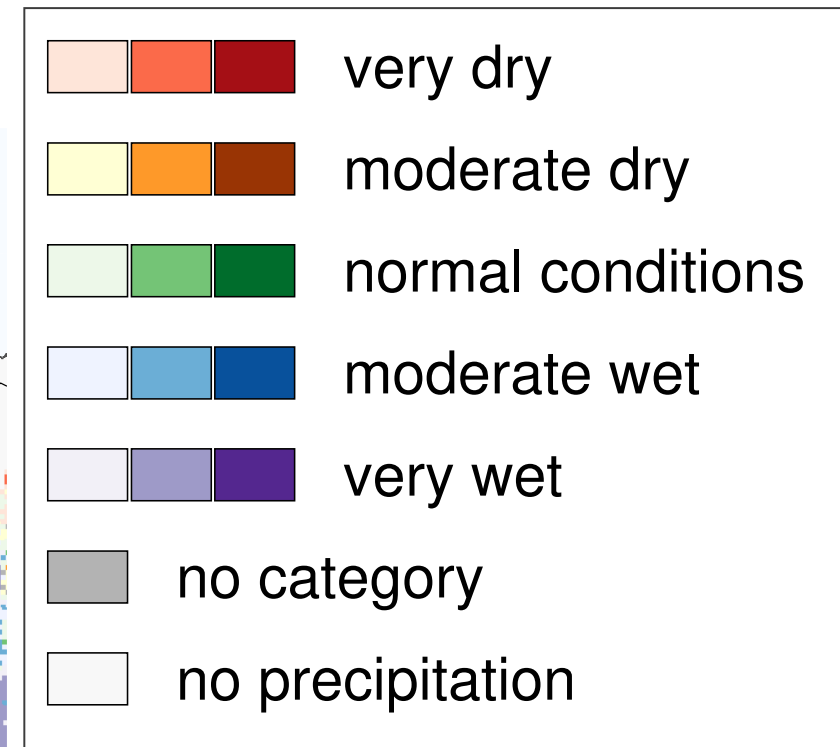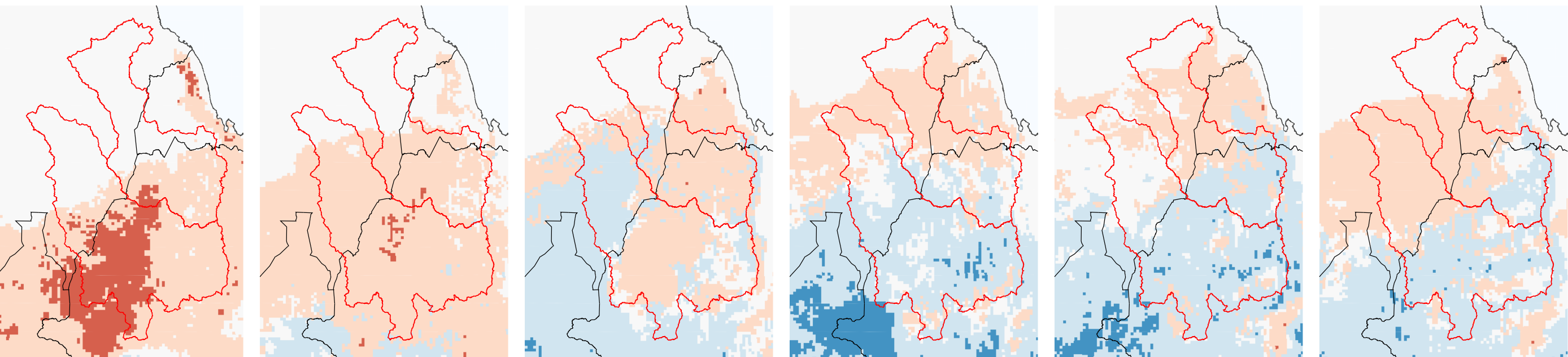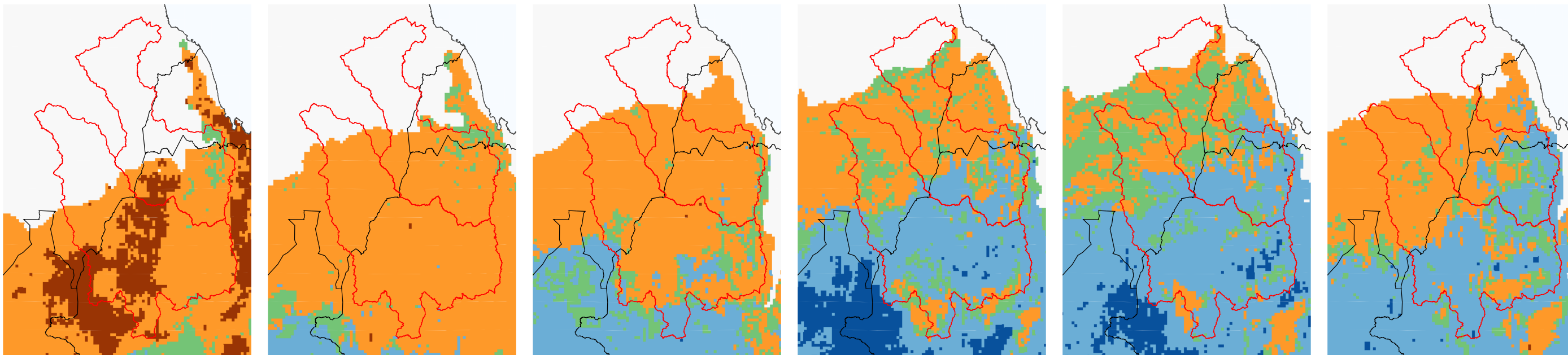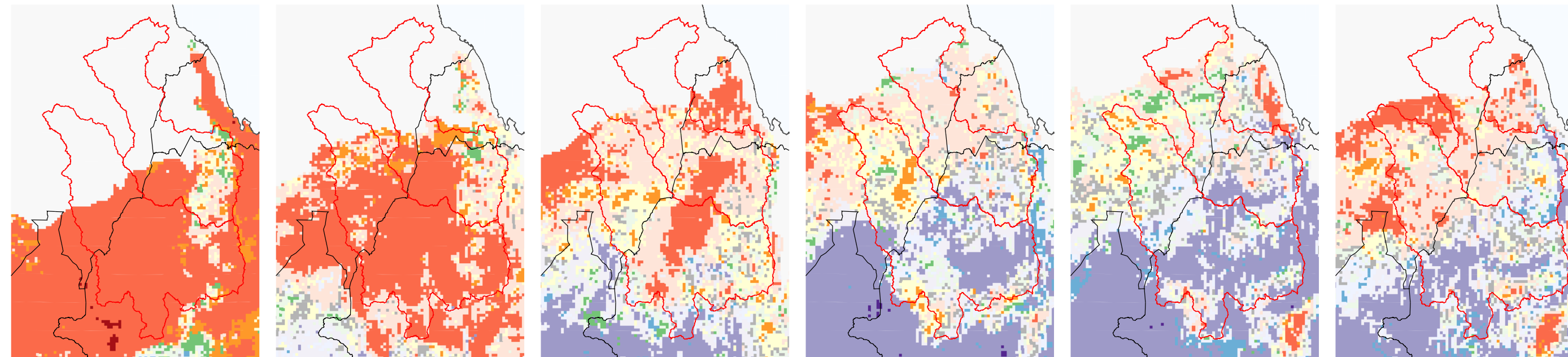**Topographic signal** in the CRPSS → bigger improvements in higher-altitude regions

Consistent improvement of SEAS5 w.r.t. ERA5-Land for precipitation, temperature, and radiation forecasts

Example: Actual forecast for the coming rainy season across the Sudan/Ethiopia domain

2020/04 2020/05 2020/06 2020/07 2020/08 2020/09

Legend (top):
- very dry
- moderate dry
- normal conditions
- moderate wet
- very wet
- no category
- no precipitation

Legend (middle):
- below normal
- normal conditions
- above normal
- no category
- no precipitation

**Legend (bottom):**
- extreme dry
- extreme wet
- no extremes

- JJAS are the four main months of the rainy season

- 70% of the Nile flow from Blue Nile and Tekeze Atbara → incoming freshwater resources vital for the whole region

- Distinction between five, three, and two (extreme) precipitation categories and different probability levels

Prediction of very wet conditions in the mountainous headwaters of the Blue-Nile and Tekeze-Atbara
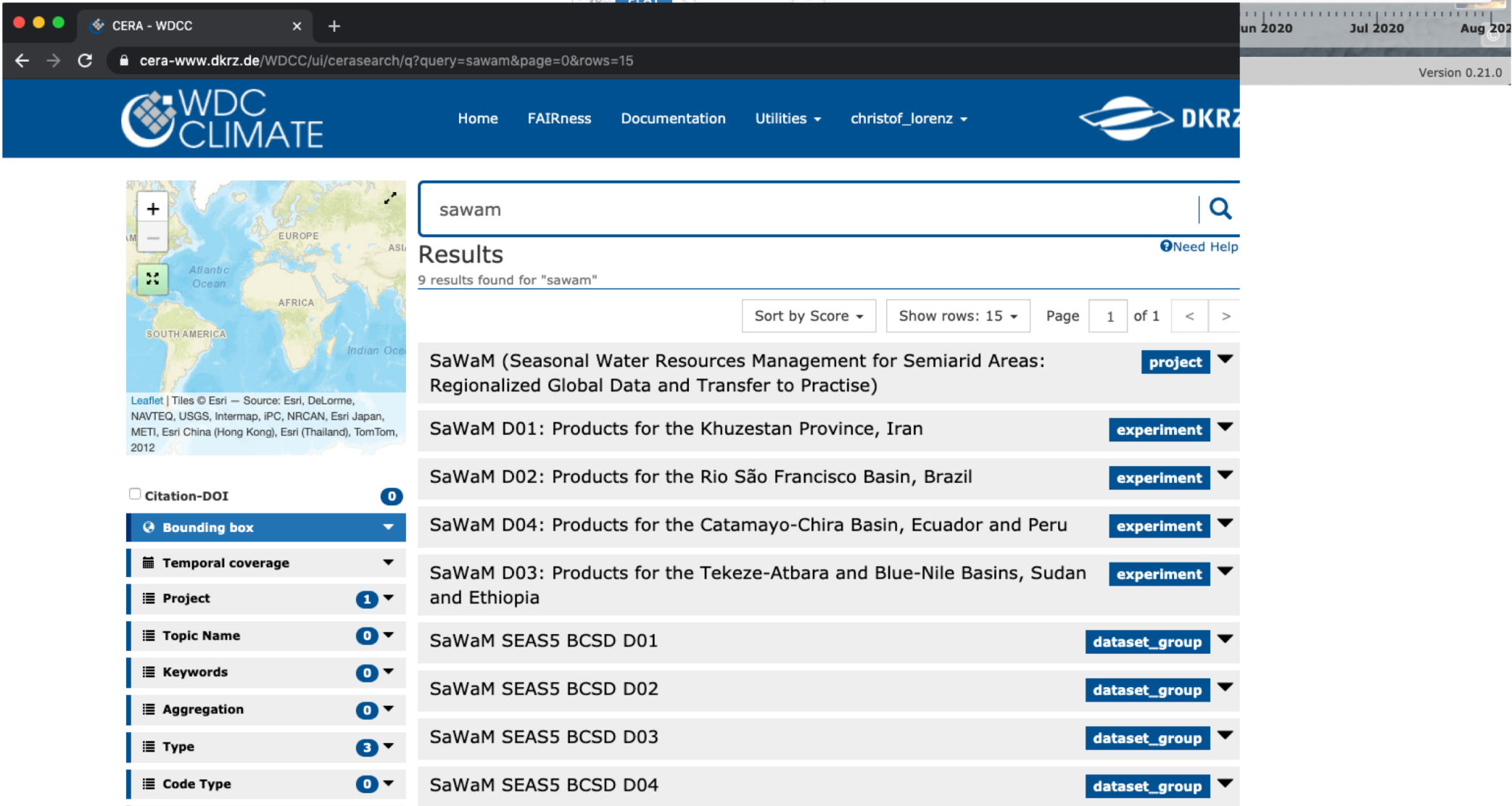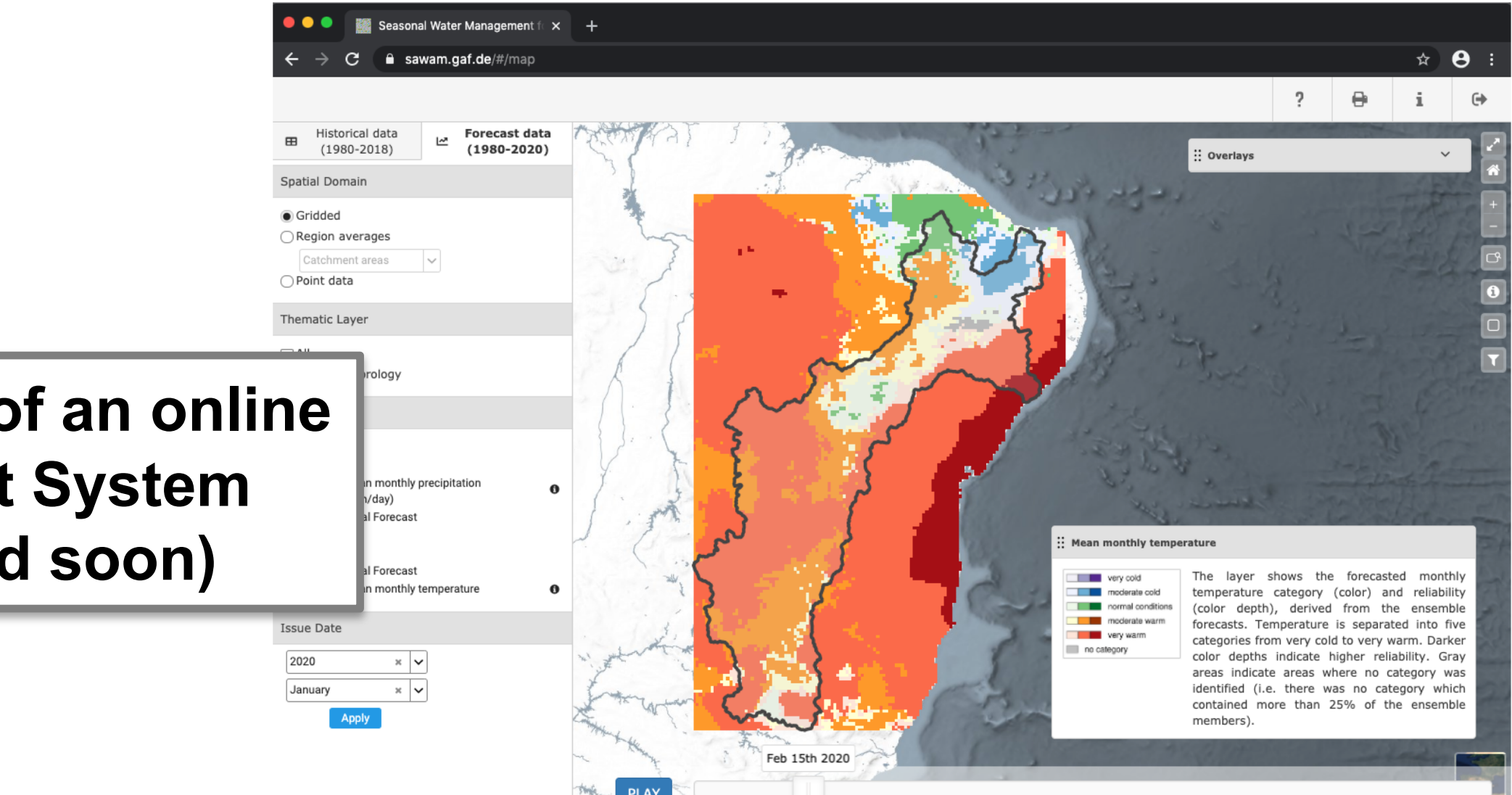
Publication, visualization and dissemination of SEAS5 BCSD
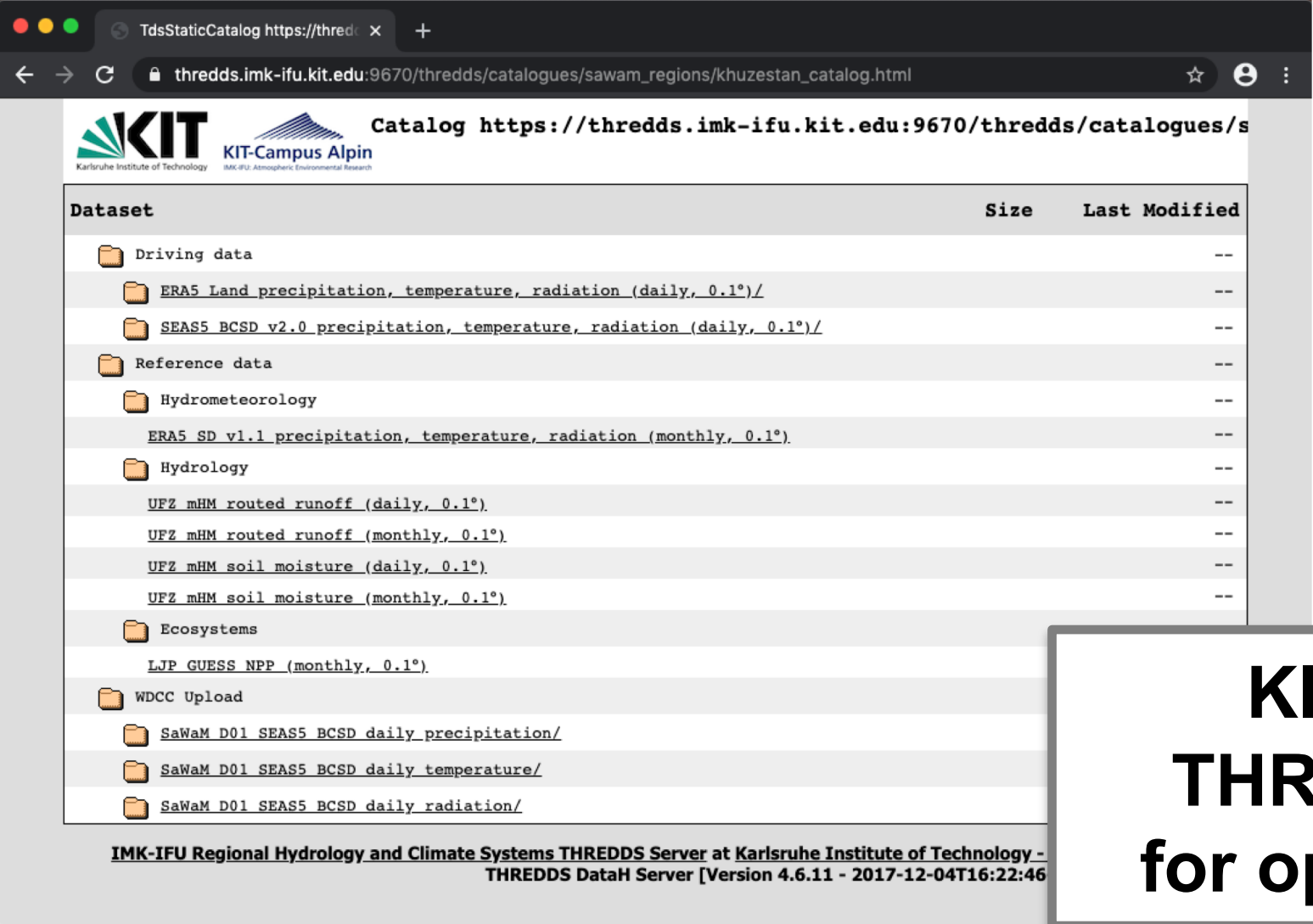
Joint development of an online Decision Support System (will be released soon)

KIT Campus Alpin THREDDS Data Server for operational products

Publication of the full dataset 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)

Summary and outlook

- Development of bias-corrected and spatially disaggregated seasonal forecasts for precipitation, temperature, and radiation for four semi-arid regions (ready)

- The final product has a spatial resolution of 0.1°, covers the full period from 1981 to the present, and contains daily ensemble forecasts (25 ensembles before 2017, 51 after 2017) for the coming 215 days from the issue date (ready)

- Publication of the developed dataset through several online repositories (KIT Campus Alpin THREDDS Server – ready, WDCC from DKRZ – ongoing)

- Joint development of visualization tools for the forecasts (ongoing) and operational dissemination of derived products to stakeholders in the study regions (ongoing)

- Next: Implementation of operational workflow-tools for improving the stability and performance; implementation of operational tools at local institutions

- This work is embedded in the SaWaM-Project (http://grow-sawam.org/), which is funded by the BMBF within the GRoW funding measure (https://bmbf-grow.de/en)

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