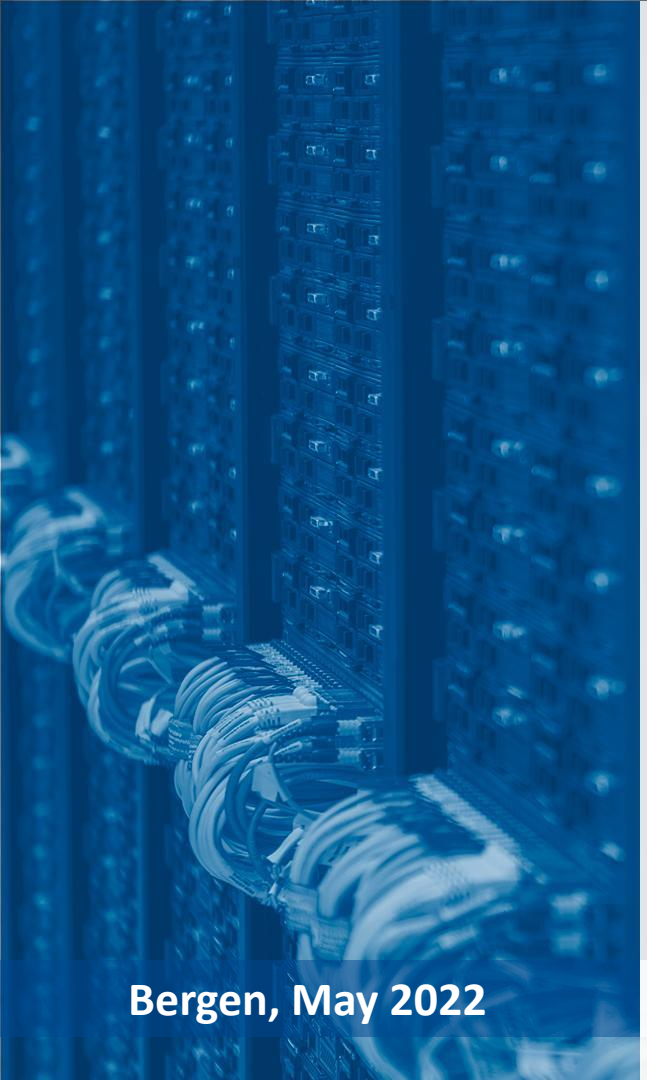

Barcelona Supercomputing Center
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ASPECT
FACILITATING SEAMLESS CLIMATE ADAPTATION

FOCUS-AFRICA

Co-production of multi-annual climate services to support food and wine production resilience

Carlos Delgado-Torres, Sara Octenjak, Raül Marcos, Francisco J. Doblas-Reyes, Markus G. Donat, Nadia Milders, Núria Pérez-Zanón, Albert Soret, Marta Terrado, Verónica Torralba and Dragana Bojovic

Bergen, May 2022

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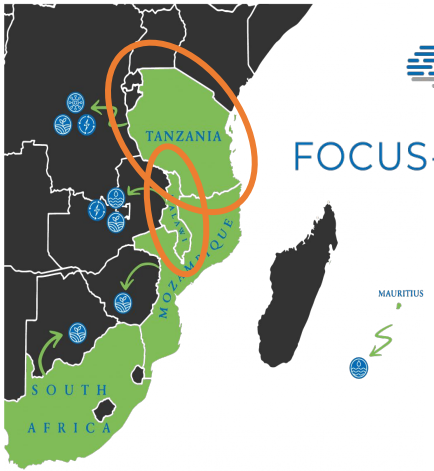
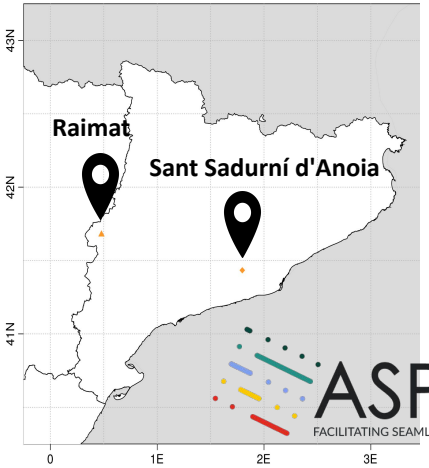
Motivation

- Climate events affecting **agricultural productivity**
  - Shifts in rainy season
  - Intensity and frequency of temperature extremes
  - Prolonged droughts
  - Floods
  - Spring frosts

- **Adaptation policies** to reduce risk and loses
  - Investment on new irrigation technologies
  - Water management
  - Delay bud-break
  - Invest in frost prevention systems
  - Selection of crop varieties
  - Agroforestry
  - Livelihood diversification
  - Post-harvest management planning



FOCUS-AFRICA



ASPECT
FACILITATING SEAMLESS CLIMATE ADAPTATION

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Printed bulletins

Document that provides **multi-annual forecasts** of temperature, precipitation and drought conditions for the next years over **Tanzania and Malawi**.

Used for **in-person meetings** with stakeholders to enhance the discussion and r**eceive feedback to improve and tailor the climate information**.

2023-2026 Climate Forecasts for Tanzania

Forecast based on multi-annual predictions made in November 2021

This document provides multi-annual forecasts of temperature, precipitation and drought conditions for the 2023-2026 period over Tanzania. The probability of the most likely category is provided with respect to the averaged 1991–2020 conditions. The complete catalogue of predictions, as well as their quality, can be found at https://earth.bsc.es/shiny/cdelgado_FOCUS-Africa-casestudy/

Outlook for the period 2023-2026:

- It is likely that the central and southeastern regions of Tanzania will have below-normal precipitation conditions for both Apr-May-Jun and Jul-Aug-Sep seasons over the 2023-2026 period (Figure 1), while the northeastern regions are expected to have wetter-than-normal or near-normal precipitation amounts.
- There is high probability of drier-than-normal conditions over most of the country during the Apr-May-Jun and Jul-Aug-Sep seasons. However, some regions are expected to have wetter- or near-normal conditions (Figure 5).
- Warmer-than-normal conditions are expected over the entire country during the 2023-2026 period (Figure 3).

Outlook of precipitation amount averaged over the 2023-2026 period

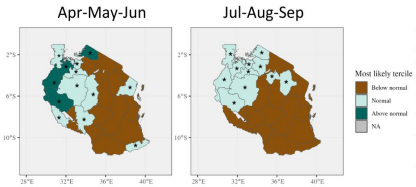

Figure 1. *Multi-annual predictions of* ***precipitation amount*** *for the 2023-2026 average [Apr-May-Jun amount on the left; Jul-Aug-Sep amount on the right] produced in November 2021. Colours correspond to the most likely tercile category (drier-than-normal, near-normal and wetter-than-normal conditions).*

The maps of Tanzania in Figure 1 provide the most likely tercile for precipitation conditions during the 2023-2026 period. The April-May-June precipitation amount is shown on the left, while the July-August-September amount is shown on the right. The forecasts point to drier-than-normal precipitation conditions over the southern, eastern and central parts of the country for both seasons. Near-normal and wetter-than-normal conditions are expected over some regions of the northern and western part. It should be noted that the multi-model ensemble does not show skill over some regions. Thus, the climatological and persistence forecasts have been used in such cases (marked with asterisks in the maps).

Forecast performance for SPEI3 (July-August-September accumulation) for 4-year averages

To illustrate how the forecasts performed in the past in predicting the most likely category of SPEI3 for the July–August–September season, Figure 6 shows the probabilities for tercile categories for multi-annual predictions of SPEI3 in the past years averaged over Pwani (Tanzania). Darker colors indicate higher probability occurrence, while the black dot shows the category in which the observation fell.

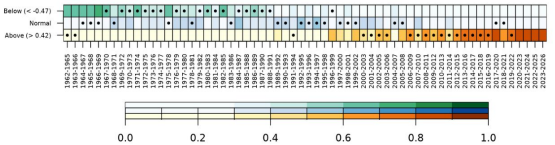

Figure 6*. Time series of the probabilities for tercile categories (drier-than-normal, near-normal and wetter-than-normal conditions) produced with the multi-annual predictions of the* ***SPEI3 index*** *for the* ***forthcoming 4 years*** *(from 1962–1965 to 2023–2026) over Pwani (Tanzania). Darker colors indicate higher probability of occurrence, while the black dots indicate the observed category for each multi-annual average.*

Background information

The temperature and precipitation forecasts were generated using monthly data. The Consecutive Dry Days (CDD) index has been computed as the length of the longest dry spell (days with precipitation amounts below 1mm/day). The Standardised Precipitation and Evapotranspiration Index 3 (SPEI3) forecasts were generated using monthly minimum and maximum temperature and precipitation. To compute the SPEI, the Potential EvapoTranspiration (PET) has been estimated with the Hargreaves method, and the SPEI is then computed as the standardized (using the three-parameter shifted log-logistic probability distribution with the unbiased probability weighted moments method) difference between accumulated precipitation and PET during the specified season.

The predictions have been produced with the CMIP6/DCPP multi-model ensemble available at the beginning of 2021. When the multi-model ensemble forecasts have less skill than the climatology or persistence forecasts, we used these instead of the multi-model forecast. The most likely tercile has been calculated as the tercile category with the highest number of ensemble members falling into it. Such categories were estimated using historical data (1991–2020). The quality of the probabilistic predictions has been estimated with the Ranked Probability Skill Score (RPSS), using the climatology and persistence forecasts as reference forecasts.

This product sheet shows some of the predictions that have been produced. The rest of the predictions (e.g., for additional variables, indices, forecast periods, and different number of categories for the probabilistic products) can be found in the online app: **https://earth.bsc.es/shiny/cdelgado_FOCUS-Africa-casestudy/**.

FOCUS-Africa Project – Full-value chain Optimised Climate User-centric Services for Southern Africa. This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 869575.

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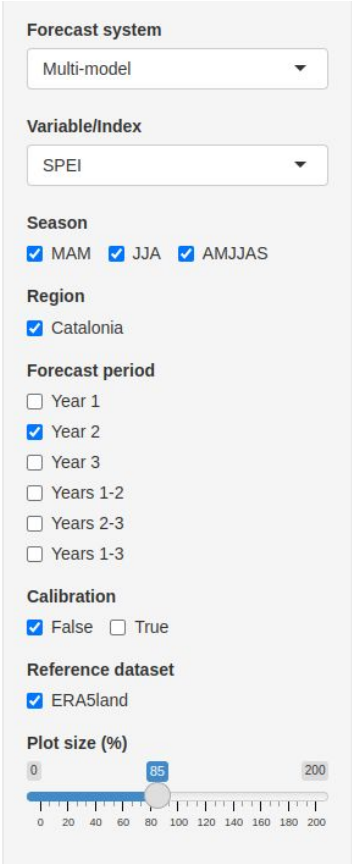
Multi-annual forecasts

- **Variables and indicators**
  - Mean temperature and precipitation
  - Extreme maximum temperature: TX90p, TXx, HWMI
  - Extreme minimum temperature: FD, TN10p, TNn and CSDI
  - Extreme precipitation: CDD and CWD
  - Drought conditions: SPEI

- **Forecast systems**
  - Individual models
  - Multi-model ensemble
  - Climatology
  - Persistence



Forecast quality

Forecast quality | Forecast maps | Regional forecasts | Scorecards | Info

Forecast system

Multi-model

Variable/Index

SPEI

Season

☑ MAM ☑ JJA ☑ AMJJAS

Region

☑ Catalonia

Forecast period

☐ Year 1
☑ Year 2
☐ Year 3
☐ Years 1-2
☐ Years 2-3
☐ Years 1-3

Calibration

☑ False ☐ True

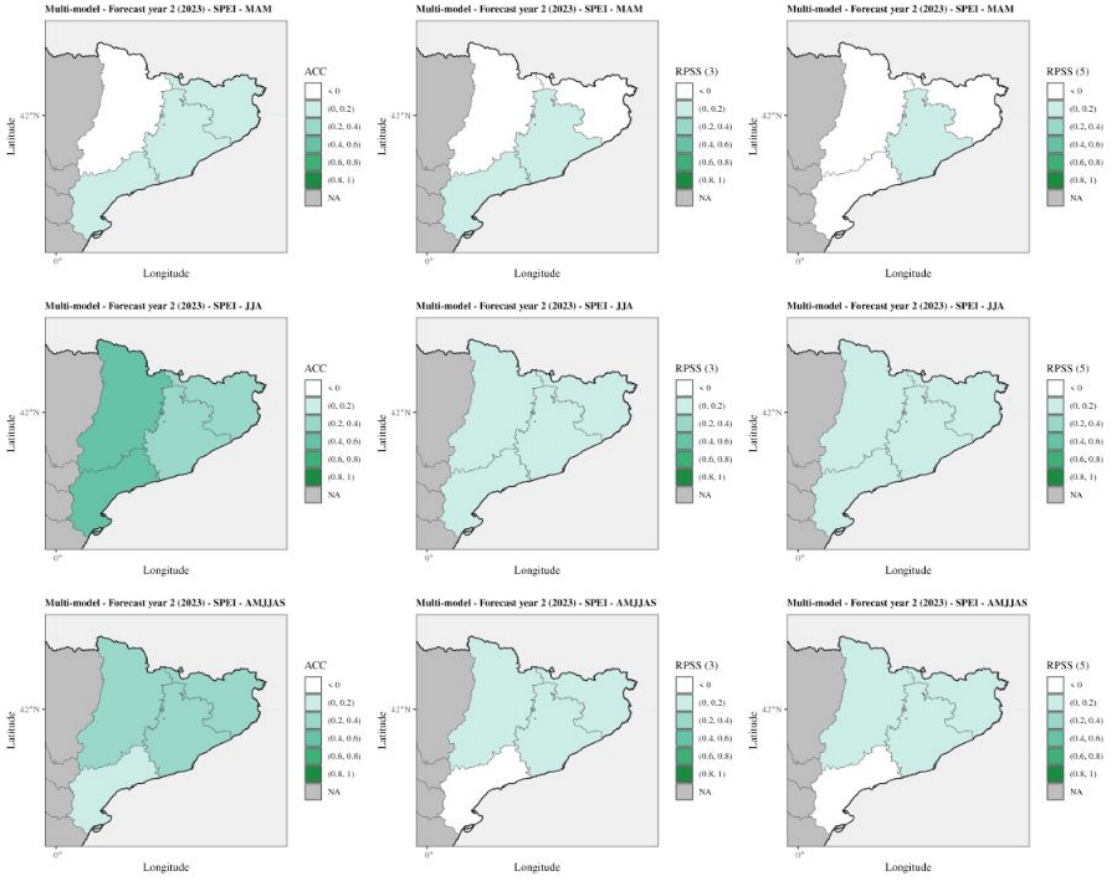
Reference dataset

☑ ERA5land

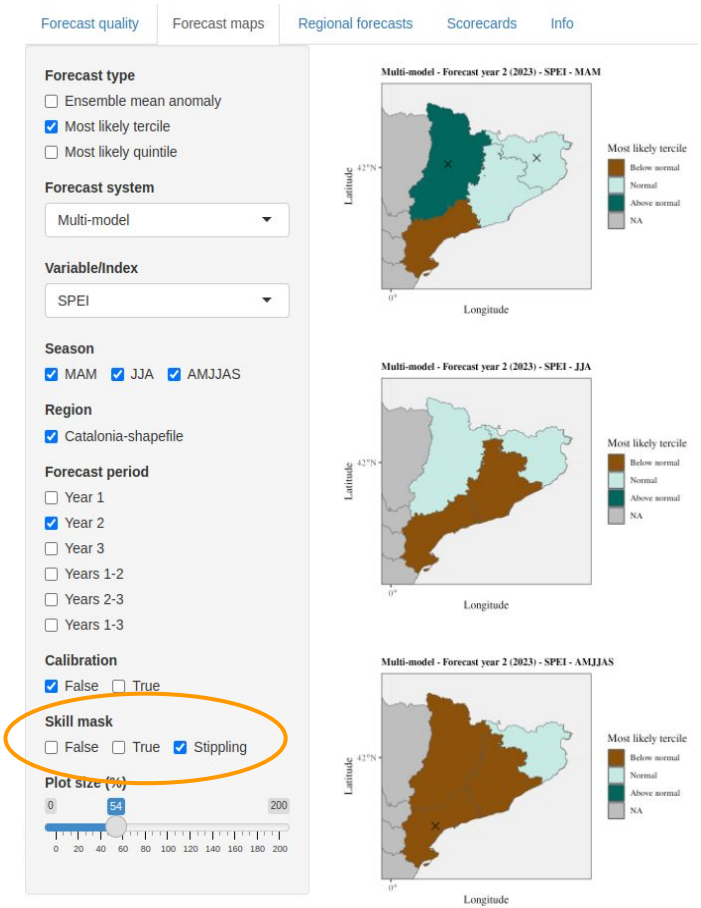
Plot size (%)

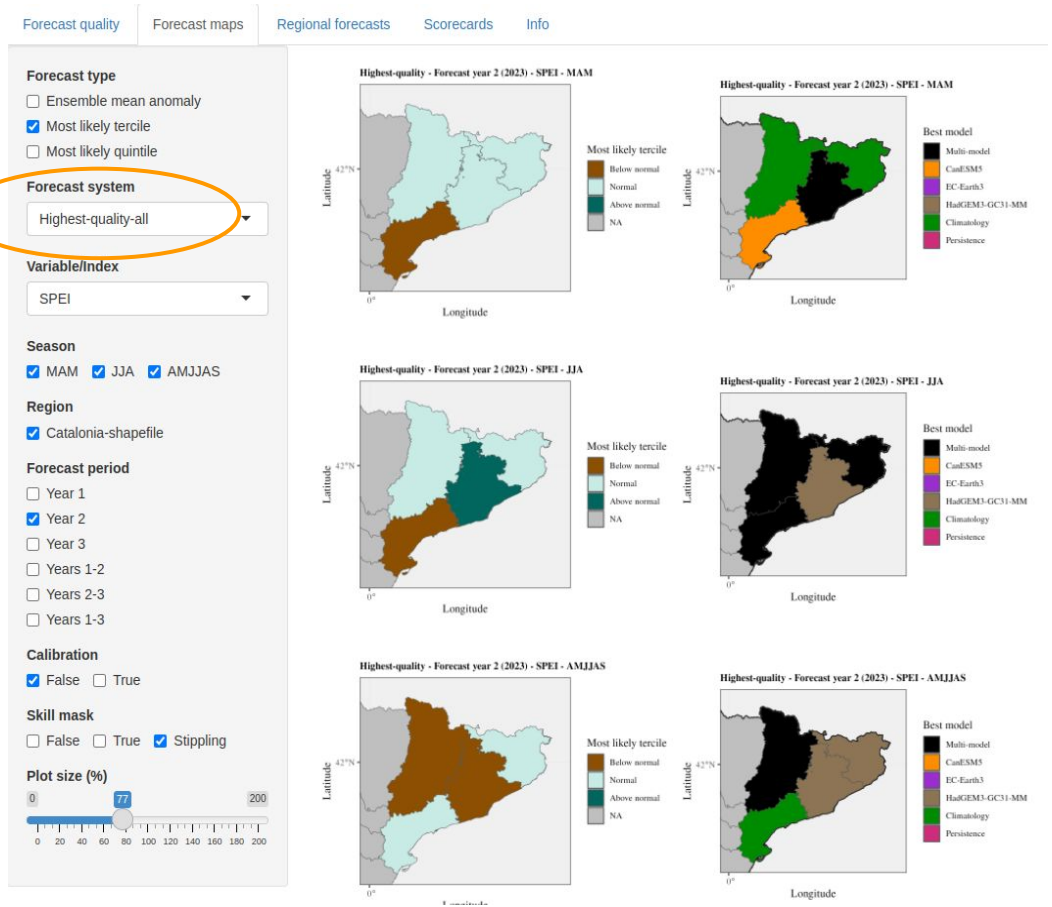
0 85 200

0 20 40 60 80 100 120 140 160 180 200

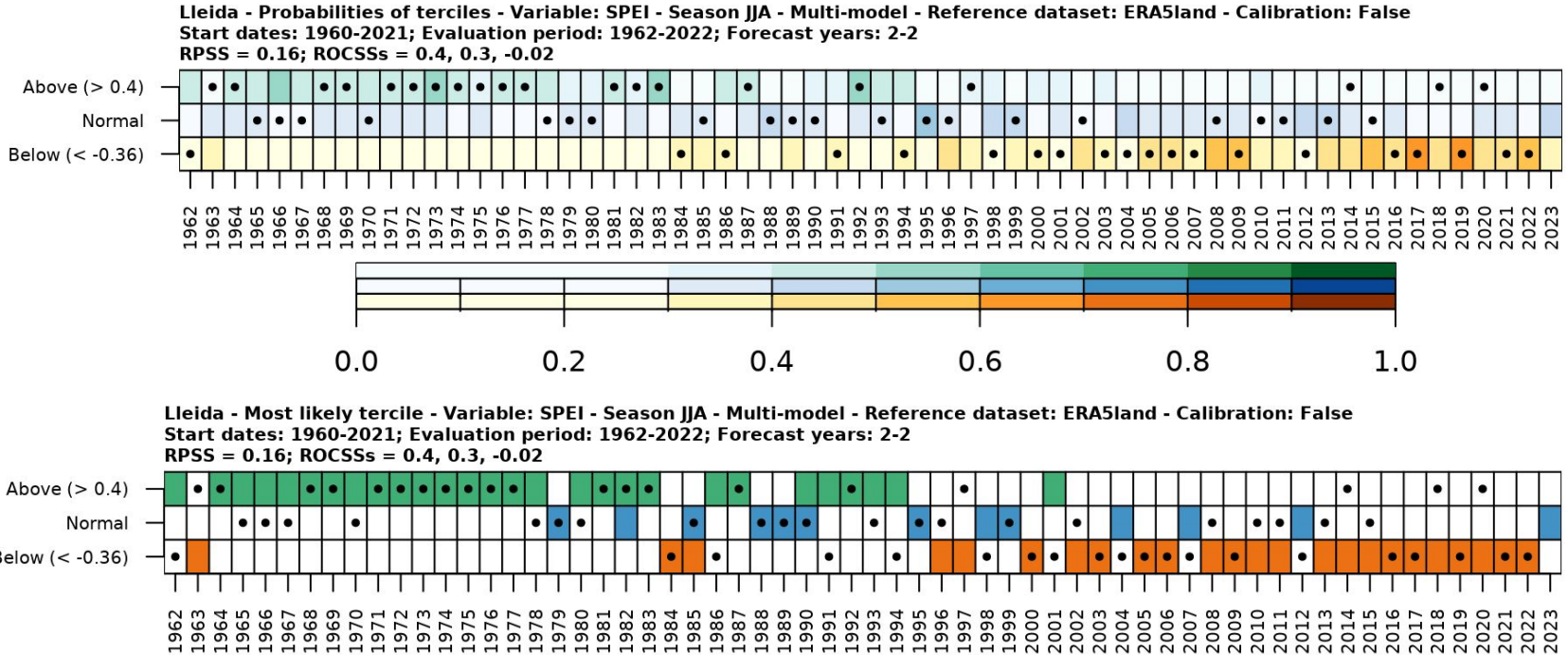


Forecast maps





Regional forecast



Scorecards

Forecast quality (measured with ACC using ERA5land as reference) over Catalonia

Years: 1961-2022; Calibration: False

		Multi-model				CanESM5				CNRM-ESM2-1				EC-Earth3				FGOALS-f3-L				HadGEM3-GC31-MM				MIROC6				MPI-ESM1-2-LR			
Variable	Forecast period	Barcelona	Girona	Lleida	Tarragona	Barcelona	Girona	Lleida	Tarragona	Barcelona	Girona	Lleida	Tarragona	Barcelona	Girona	Lleida	Tarragona	Barcelona	Girona	Lleida	Tarragona	Barcelona	Girona	Lleida	Tarragona	Barcelona	Girona	Lleida	Tarragona	Barcelona	Girona	Lleida	Tarragona
TAS - MAM	Year 1	0.57	0.58	0.58	0.59	0.53	0.53	0.56	0.57	0.54	0.49	0.51	0.57	0.49	0.49	0.47	0.48	0.26	0.29	0.21	0.26	0.53	0.54	0.48	0.55	0.62	0.62	0.64	0.63	0.49	0.51	0.51	0.51
	Year 2	0.63	0.62	0.65	0.66	0.61	0.60	0.62	0.63	0.57	0.58	0.61	0.58	0.51	0.51	0.50	0.54	0.58	0.58	0.56	0.60	0.55	0.54	0.58	0.58	0.60	0.59	0.62	0.60	0.59	0.59	0.62	0.61
	Year 3	0.61	0.61	0.64	0.65	0.64	0.63	0.64	0.64	0.52	0.48	0.53	0.53	0.53	0.54	0.52	0.57	0.54	0.51	0.56	0.54	0.55	0.54	0.56	0.60	0.49	0.50	0.52	0.52	0.54	0.51	0.55	0.57
	Years 1-2	0.72	0.74	0.76	0.73	0.71	0.72	0.75	0.73	0.69	0.67	0.70	0.69	0.68	0.69	0.67	0.64	0.61	0.62	0.58	0.60	0.69	0.69	0.70	0.70	0.78	0.78	0.81	0.77	0.68	0.70	0.71	0.66
	Years 2-3	0.77	0.77	0.81	0.76	0.80	0.80	0.83	0.78	0.71	0.71	0.72	0.70	0.69	0.69	0.71	0.67	0.69	0.71	0.70	0.68	0.74	0.74	0.77	0.72	0.70	0.69	0.75	0.70	0.68	0.68	0.71	0.68
	Years 1-3	0.80	0.82	0.82	0.79	0.81	0.82	0.84	0.81	0.79	0.80	0.79	0.79	0.73	0.76	0.73	0.69	0.68	0.73	0.67	0.68	0.77	0.79	0.78	0.77	0.80	0.82	0.84	0.78	0.73	0.76	0.74	0.71
TAS - JJA	Year 1	0.72	0.73	0.77	0.75	0.74	0.74	0.78	0.77	0.63	0.67	0.65	0.60	0.60	0.60	0.67	0.68	0.58	0.54	0.54	0.60	0.68	0.67	0.72	0.70	0.60	0.61	0.62	0.63	0.64	0.64	0.66	0.64
	Year 2	0.73	0.73	0.77	0.75	0.74	0.73	0.77	0.76	0.65	0.64	0.70	0.67	0.58	0.57	0.59	0.62	0.65	0.63	0.66	0.68	0.69	0.67	0.72	0.69	0.79	0.80	0.79	0.78	0.73	0.73	0.77	0.76
	Year 3	0.72	0.71	0.78	0.75	0.74	0.73	0.78	0.75	0.65	0.64	0.70	0.65	0.67	0.64	0.71	0.72	0.59	0.63	0.61	0.64	0.71	0.69	0.78	0.74	0.62	0.63	0.62	0.66	0.60	0.60	0.64	0.63
	Years 1-2	0.83	0.84	0.85	0.85	0.87	0.87	0.87	0.86	0.80	0.79	0.81	0.81	0.72	0.72	0.72	0.75	0.75	0.73	0.74	0.76	0.84	0.83	0.85	0.82	0.81	0.82	0.80	0.82	0.76	0.78	0.77	0.78
	Years 2-3	0.83	0.83	0.85	0.84	0.85	0.86	0.87	0.84	0.78	0.80	0.79	0.76	0.71	0.70	0.73	0.75	0.75	0.76	0.77	0.75	0.81	0.80	0.84	0.82	0.81	0.82	0.80	0.82	0.79	0.78	0.81	0.78
	Years 1-3	0.89	0.89	0.90	0.91	0.91	0.91	0.91	0.90	0.88	0.87	0.88	0.89	0.79	0.78	0.78	0.79	0.79	0.79	0.79	0.79	0.92	0.91	0.91	0.90	0.85	0.85	0.82	0.84	0.83	0.83	0.83	0.83
TAS - AMJJAS	Year 1	0.71	0.73	0.73	0.72	0.73	0.74	0.74	0.74	0.68	0.71	0.70	0.66	0.61	0.63	0.61	0.63	0.59	0.60	0.59	0.61	0.67	0.68	0.68	0.69	0.72	0.73	0.74	0.73	0.60	0.64	0.63	0.62
	Year 2	0.74	0.75	0.77	0.75	0.74	0.75	0.76	0.75	0.72	0.74	0.74	0.72	0.66	0.66	0.67	0.69	0.68	0.68	0.68	0.70	0.72	0.72	0.73	0.74	0.76	0.77	0.76	0.75	0.74	0.77	0.77	0.75
	Year 3	0.72	0.73	0.76	0.75	0.74	0.75	0.76	0.74	0.67	0.67	0.71	0.71	0.69	0.69	0.71	0.72	0.66	0.69	0.66	0.66	0.74	0.75	0.78	0.77	0.67	0.67	0.67	0.68	0.63	0.64	0.67	0.63
	Years 1-2	0.84	0.85	0.86	0.86	0.85	0.86	0.87	0.86	0.82	0.81	0.83	0.82	0.78	0.76	0.77	0.79	0.78	0.78	0.79	0.77	0.85	0.84	0.84	0.85	0.86	0.87	0.87	0.86	0.80	0.81	0.81	0.80
	Years 2-3	0.86	0.86	0.88	0.87	0.87	0.87	0.90	0.87	0.83	0.82	0.83	0.84	0.80	0.79	0.82	0.82	0.79	0.79	0.80	0.79	0.85	0.84	0.87	0.86	0.85	0.85	0.84	0.85	0.79	0.80	0.82	0.81
	Years 1-3	0.89	0.90	0.92	0.91	0.90	0.90	0.92	0.90	0.88	0.88	0.89	0.89	0.82	0.82	0.83	0.83	0.82	0.83	0.84	0.81	0.90	0.91	0.91	0.91	0.90	0.91	0.89	0.90	0.83	0.84	0.85	0.83
PR - MAM	Year 1	-0.23	-0.24	-0.19	-0.18	0.02	0.04	-0.03	-0.03	0.14	-0.06	0.12	0.23	-0.19	-0.23	-0.13	-0.10	0.00	0.02	0.01	-0.10	0.11	0.13	0.03	-0.02	-0.10	-0.09	-0.18	-0.16	-0.37	-0.46	-0.26	-0.26
	Year 2	0.02	0.09	0.03	-0.02	0.09	0.07	-0.14	0.00	0.03	0.15	0.10	-0.02	-0.04	-0.10	-0.01	-0.02	0.21	0.23	0.28	0.29	0.08	0.05	0.08	0.02	-0.06	0.00	-0.02	-0.15	-0.05	-0.05	0.03	-0.03
	Year 3	-0.12	-0.08	-0.14	-0.21	-0.02	-0.04	-0.10	-0.13	0.02	0.01	0.04	0.01	-0.21	-0.16	-0.12	-0.22	0.05	0.05	0.18	0.13	0.10	-0.09	0.02	-0.17	-0.09	0.06	-0.15	0.01	-0.11	-0.07	-0.19	-0.12
	Years 1-2	-0.19	-0.17	-0.15	-0.07	0.14	-0.01	-0.06	0.03	-0.05	-0.11	0.00	-0.02	-0.22	-0.20	-0.09	0.01	0.00	0.06	-0.01	-0.04	0.02	-0.02	-0.15	0.04	-0.10	-0.02	-0.13	-0.25	-0.35	-0.32	-0.28	-0.29
	Years 2-3	-0.21	-0.12	-0.25	-0.21	0.16	0.21	-0.05	-0.07	-0.21	-0.13	-0.12	-0.04	-0.38	-0.37	-0.23	-0.26	0.12	0.08	0.12	0.14	0.04	-0.02	-0.14	-0.20	0.08	0.18	-0.02	-0.01	-0.18	-0.16	-0.16	-0.11
	Years 1-3	-0.23	-0.16	-0.19	-0.14	0.29	0.21	0.07	0.04	-0.12	-0.18	-0.04	0.10	-0.45	-0.40	-0.28	-0.24	-0.03	-0.01	0.00	-0.04	0.09	-0.03	-0.15	-0.05	0.10	0.24	0.02	-0.07	-0.35	-0.36	-0.33	-0.26
PR - JJA	Year 1	0.13	0.15	0.18	0.09	0.20	0.29	0.35	0.21	-0.05	0.00	-0.01	-0.08	-0.18	-0.21	-0.10	-0.05	0.13	0.14	0.13	0.08	0.12	0.12	0.10	0.13	0.25	0.18	0.13	0.11	0.16	-0.03	0.01	-0.04
	Year 2	0.25	0.22	0.24	0.21	0.17	0.11	0.24	0.17	-0.12	-0.03	-0.01	0.12	-0.05	-0.03	-0.05	-0.07	0.20	0.23	0.37	0.10	0.38	0.27	0.30	0.30	0.25	0.31	0.16	-0.01	0.22	0.19	0.10	0.20
	Year 3	0.27	0.14	0.40	0.30	0.15	0.13	0.36	0.27	0.21	0.27	0.17	0.10	-0.04	-0.18	-0.07	-0.03	-0.13	-0.10	0.03	-0.03	0.14	0.03	0.35	0.22	0.01	-0.08	-0.09	-0.11	0.09	0.03	0.16	0.18
	Years 1-2	0.27	0.25	0.26	0.25	0.36	0.36	0.45	0.33	0.02	0.05	0.00	0.04	-0.19	-0.18	-0.24	-0.11	0.21	0.19	0.29	0.16	0.31	0.25	0.29	0.36	0.23	0.24	0.12	0.01	0.22	0.08	0.08	0.08
	Years 2-3	0.25	0.14	0.31	0.32	0.22	0.25	0.31	0.18	-0.02	-0.05	0.13	0.10	-0.17	-0.25	-0.22	-0.16	0.28	0.29	0.31	0.20	0.38	0.26	0.49	0.47	0.02	0.07	-0.18	-0.18	0.23	0.08	0.29	0.31
	Years 1-3	0.27	0.18	0.31	0.31	0.33	0.33	0.47	0.30	0.06	0.00	0.07	0.09	-0.32	-0.38	-0.41	-0.25	0.32	0.28	0.36	0.31	0.48	0.34	0.47	0.45	-0.15	-0.09	-0.24	-0.24	0.15	-0.04	0.14	0.12
PR - AMJJAS	Year 1	0.03	-0.07	0.01	-0.08	0.12	0.15	0.11	-0.04	-0.08	-0.11	-0.15	-0.19	-0.16	-0.23	0.00	-0.03	0.09	0.05	0.13	0.03	0.12	0.00	0.22	0.19	0.09	0.12	-0.03	0.08	0.03	-0.03	-0.03	-0.04
	Year 2	0.01	0.03	0.15	-0.02	0.01	0.06	0.11	-0.04	0.03	-0.05	0.12	0.13	-0.15	-0.09	0.01	0.02	-0.01	0.05	0.22	0.10	0.21	0.01	0.18	-0.10	0.14	0.21	0.19	-0.03	-0.01	-0.06	-0.01	-0.13
	Year 3	0.12	-0.04	0.15	-0.04	0.05	0.04	0.18	-0.11	0.07	0.03	0.01	0.01	-0.22	-0.21	-0.05	-0.08	0.22	0.20	0.14	0.25	0.24	-0.01	0.09	-0.11	0.08	-0.04	-0.10	0.07	-0.01	-0.01	0.05	-0.03
	Years 1-2	0.16	0.17	0.17	0.04	0.24	0.23	0.30	0.04	0.10	0.07	0.05	0.14	-0.15	-0.20	-0.07	0.01	0.18	0.18	0.25	-0.01	0.33	0.29	0.34	0.16	0.24	0.26	0.18	0.11	-0.06	-0.03	-0.11	-0.24
	Years 2-3	-0.03	-0.05	0.04	-0.09	0.22	0.31	0.23	-0.05	0.04	0.08	0.09	0.03	-0.38	-0.39	-0.21	-0.07	0.12	0.10	0.13	0.14	0.24	-0.01	0.07	-0.13	0.07	0.08	-0.05	-0.04	-0.06	-0.13	0.04	0.00
	Years 1-3	0.11	0.09	0.18	0.09	0.23	0.24	0.30	0.06	0.18	0.06	0.14	0.21	-0.29	-0.36	-0.20	-0.05	0.13	0.05	0.20	0.09	0.37	0.34	0.36	0.15	0.18	0.19	0.03	0.01	-0.04	-0.10	-0.02	-0.04
TX90p - MAM	Year 1	0.38	0.37	0.34	0.34									0.33	0.33	0.30	0.32					0.31	0.36	0.22	0.25								
	Year 2	0.25	0.31	0.25	0.36									0.13	0.17	0.09	0.23					0.27	0.30	0.27	0.38								
	Year 3	0.45	0.53	0.49	0.51									0.33	0.33	0.34	0.42					0.49	0.59	0.52	0.51								
	Years 1-2	0.51	0.57	0.52	0.48									0.46	0.51	0.43	0.41					0.51	0.54	0.50	0.49								

Key challenges

- Identification of users' needs
- Communication of the forecast quality and uncertainty
- Limited forecast quality → selecting the highest-quality source of information (individual forecast systems, multi-model ensemble, climatology, persistence)
- Availability of the predictions → larger multi-model ensemble size for hindcasts than for forecasts
- Timeliness of the predictions → low availability of start date 2023 on ESGF
- Spatial resolution → statistical downscaling
- Temporal resolution → sub-daily resolution is required for certain variables (e.g. wind speed)

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ASPECT
FACILITATING SEAMLESS CLIMATE ADAPTATION

Thank you!

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