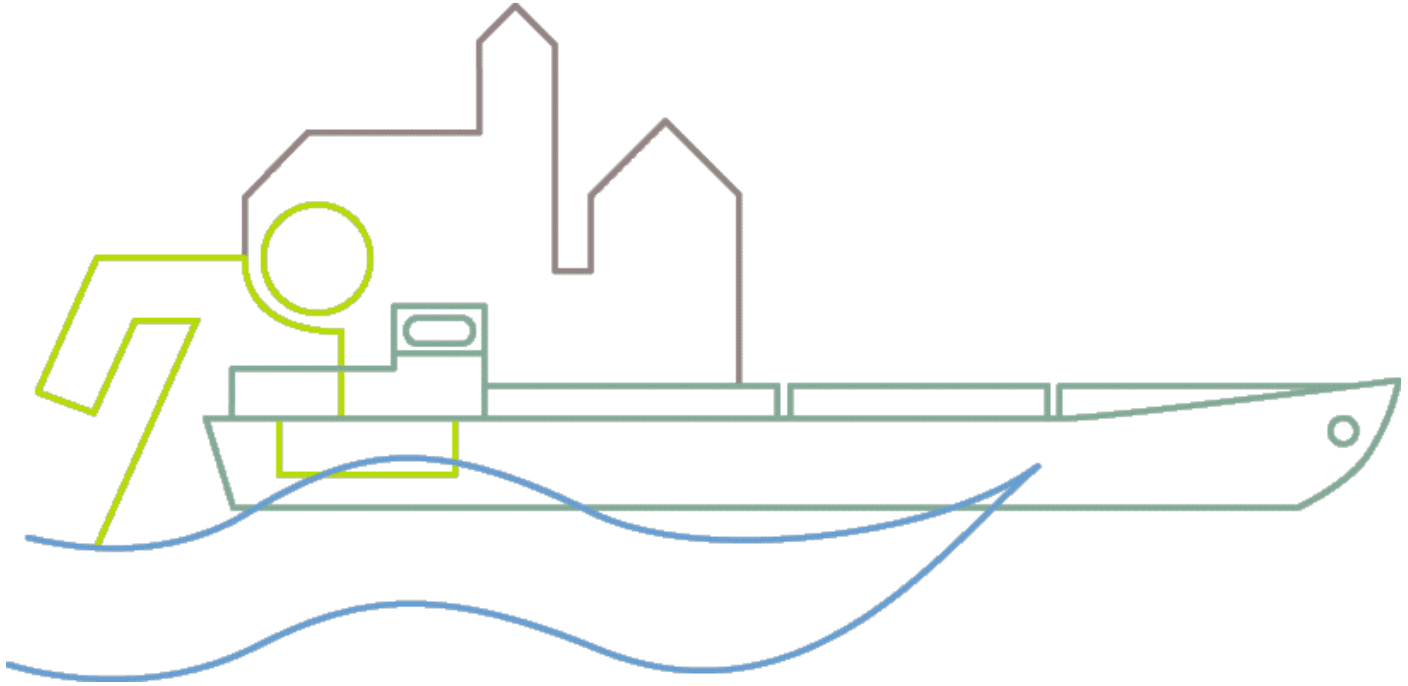


Impact of climate change on the flow conditions of the Elbe River

World Canals Conference 2022, Leipzig, 2 June 2022

Dr. Thomas Maurer
Head of Division „Water Balance, Forecasting and Predictions“
Bundesanstalt für Gewässerkunde, Koblenz, Germany

Overview

1. Climate Change in Germany

1.1 Discharge of the Elbe River

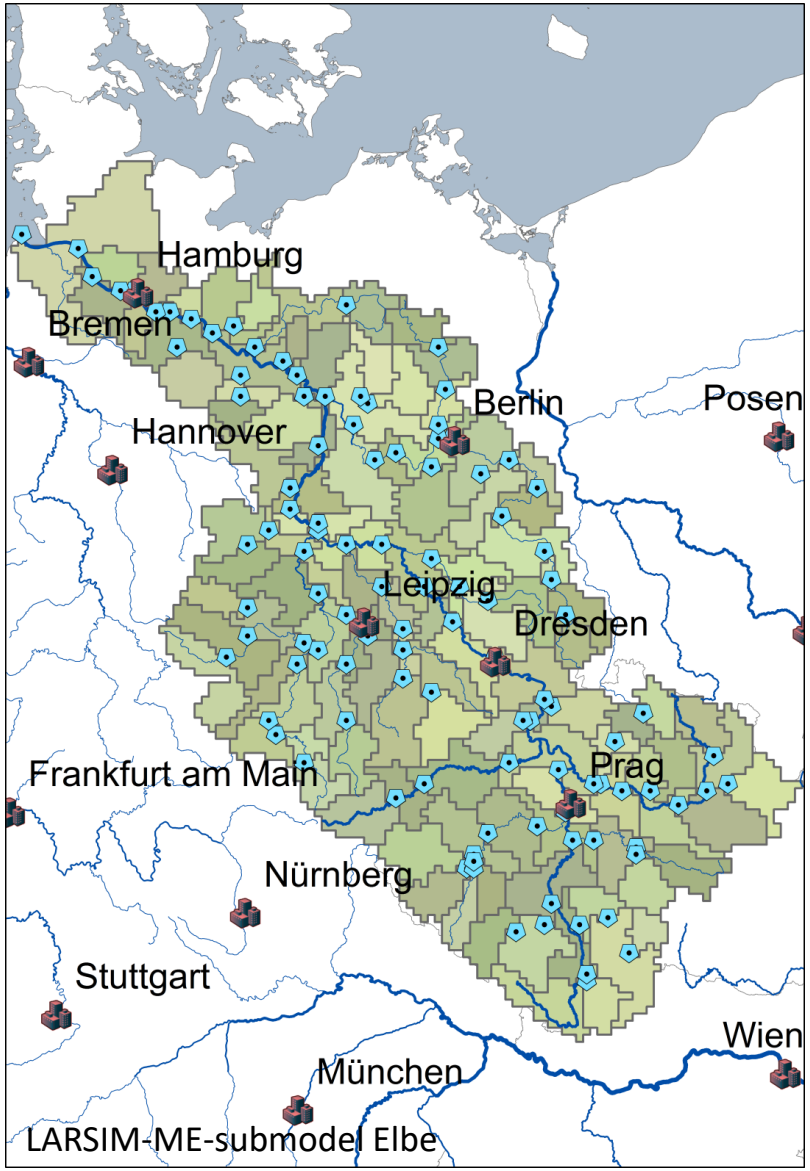
1.2 Water temperature und quality

1.3 Sediment import from the Elbe catchment into the river

2. Contributions to adaptation

2.1 Information portals

2.2 Operational forecasting



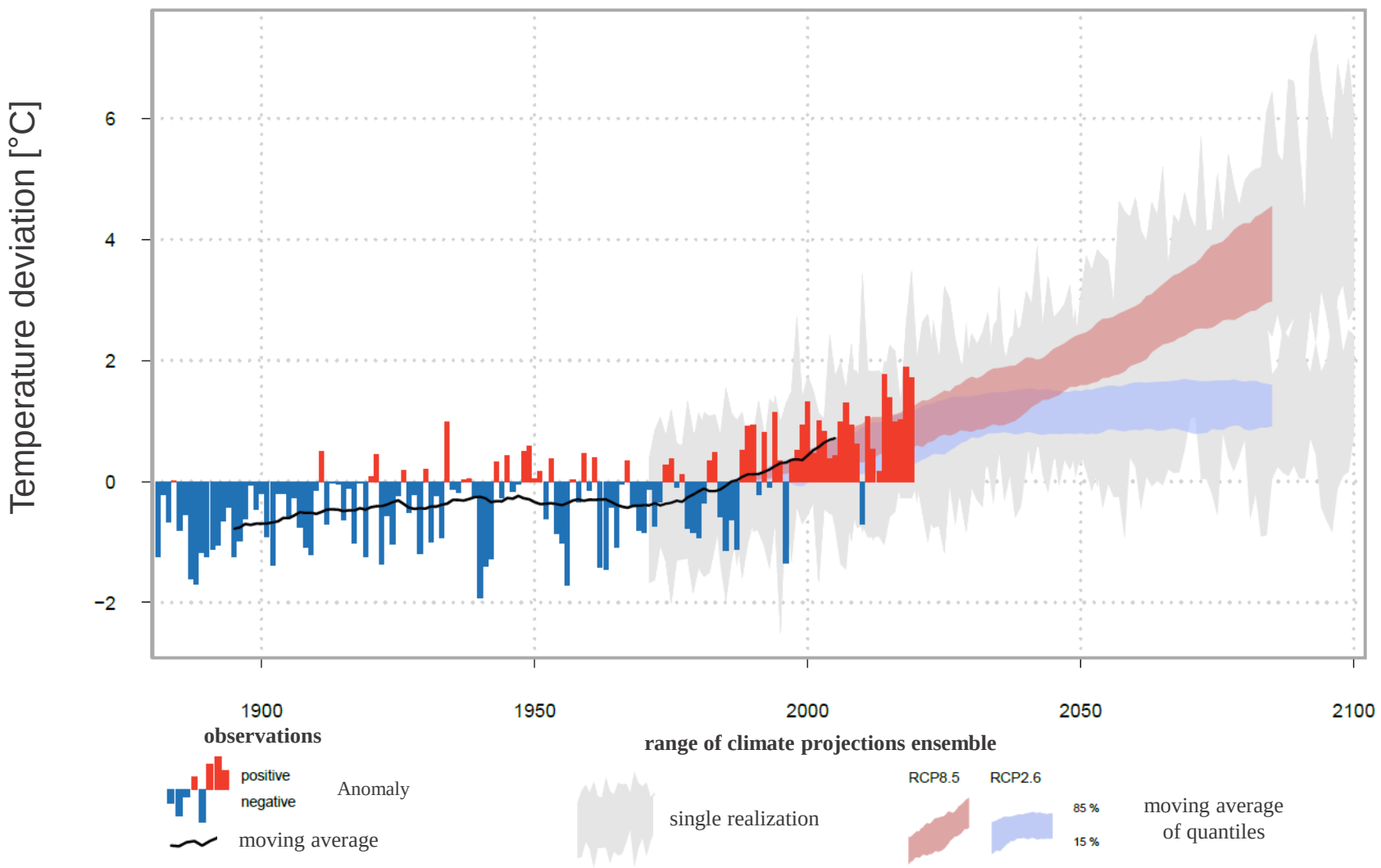
1. Climate Change in Germany

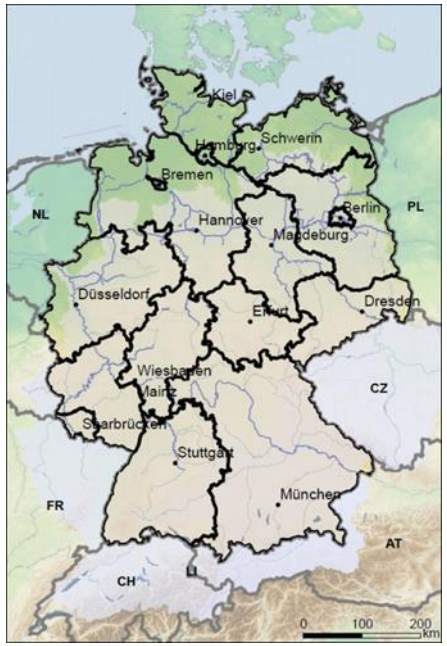
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Temperature change Germany

1881-2100

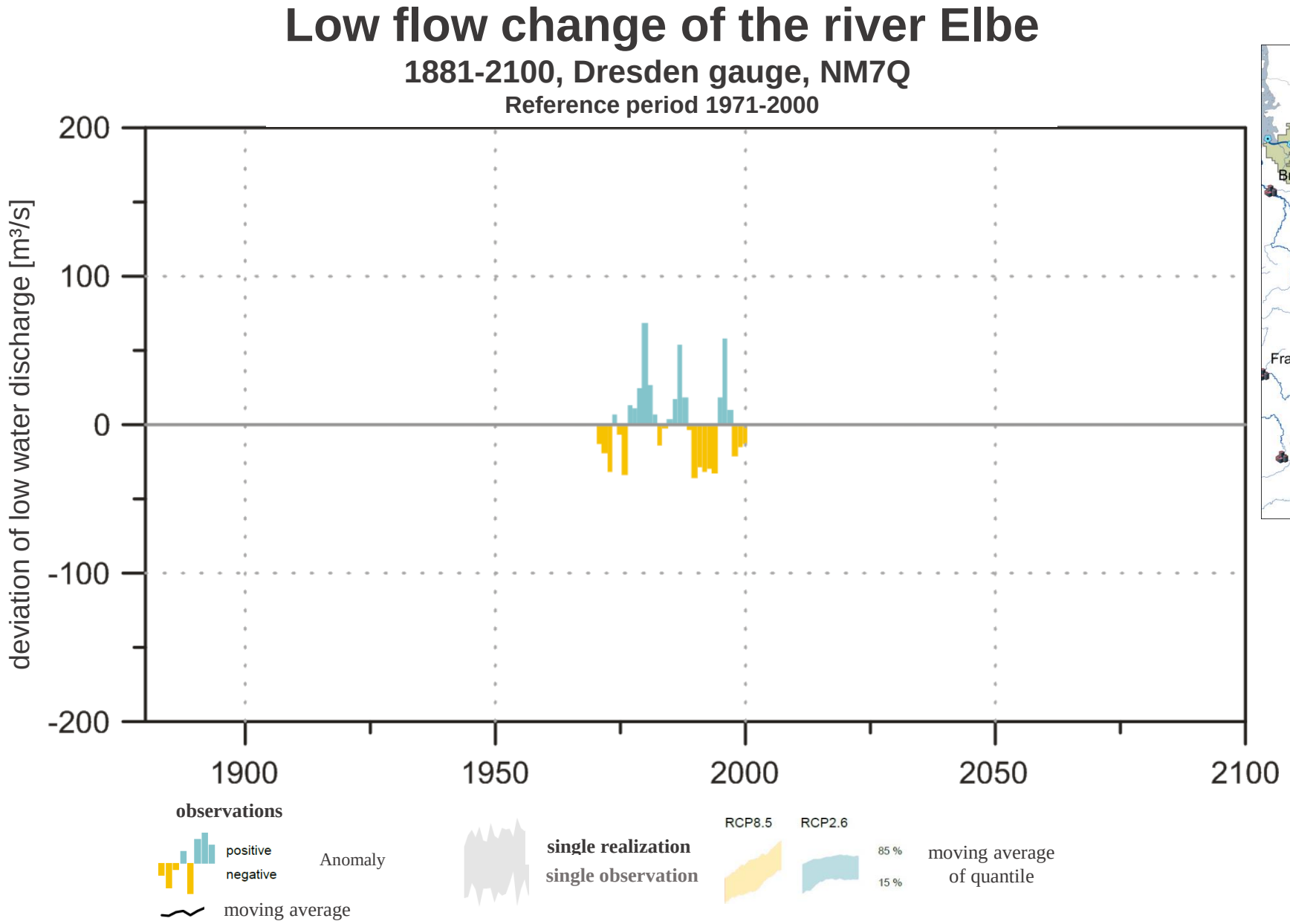
Reference period 1971-2000





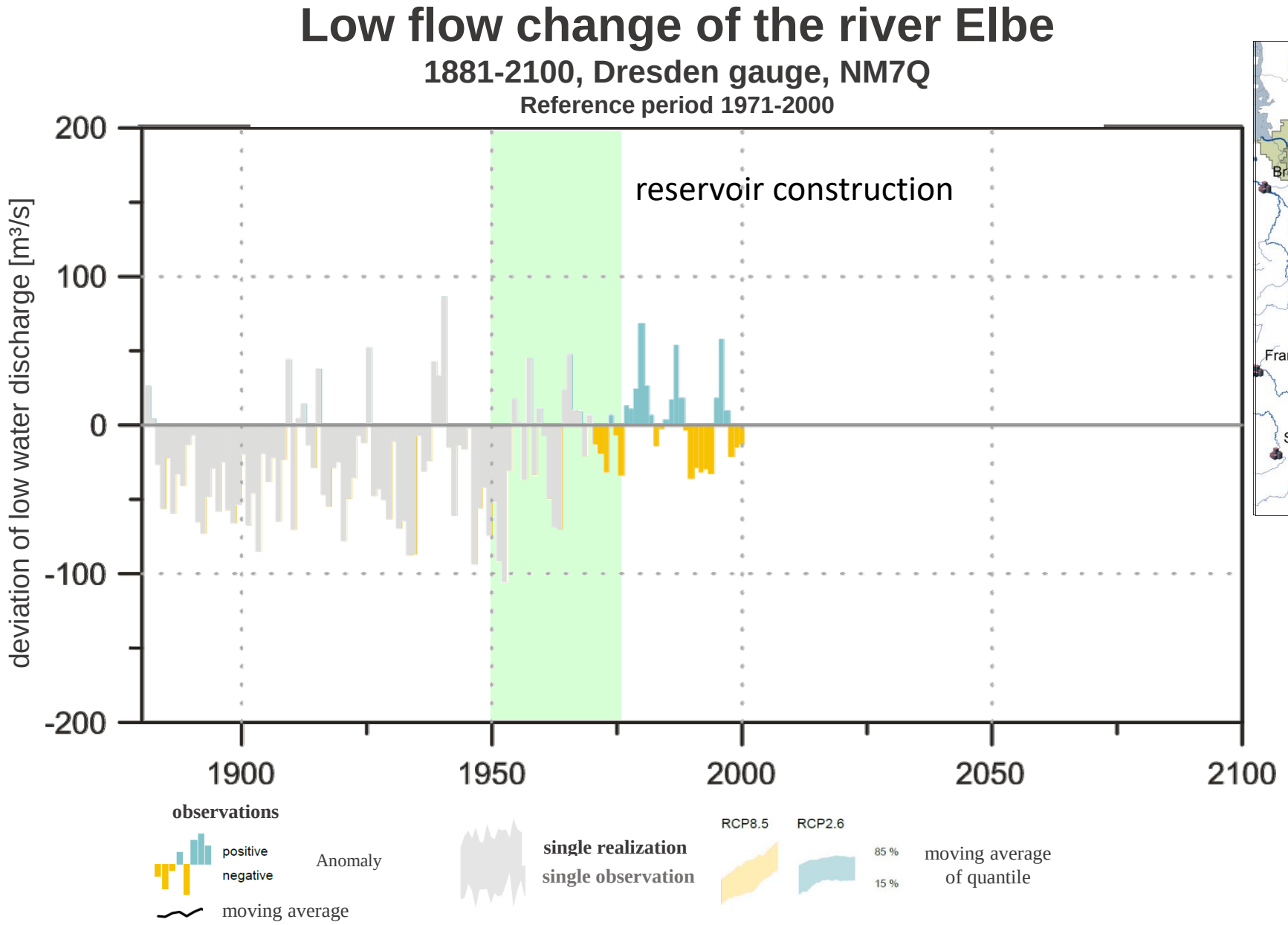
Source:
German
Weather Service

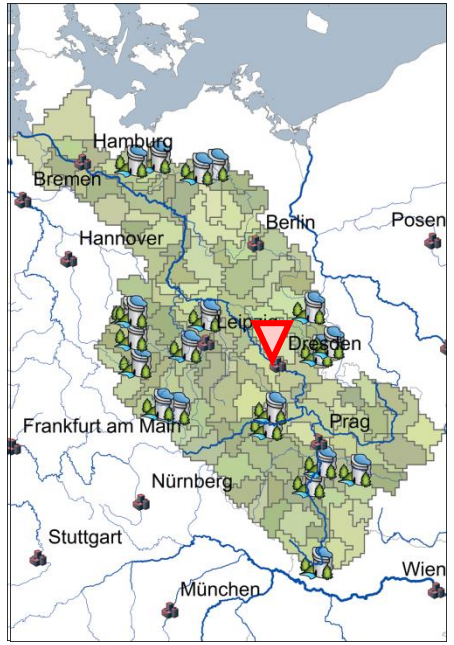
1.2 Reference (1971-2000)



Source:
Federal Institute
of Hydrology

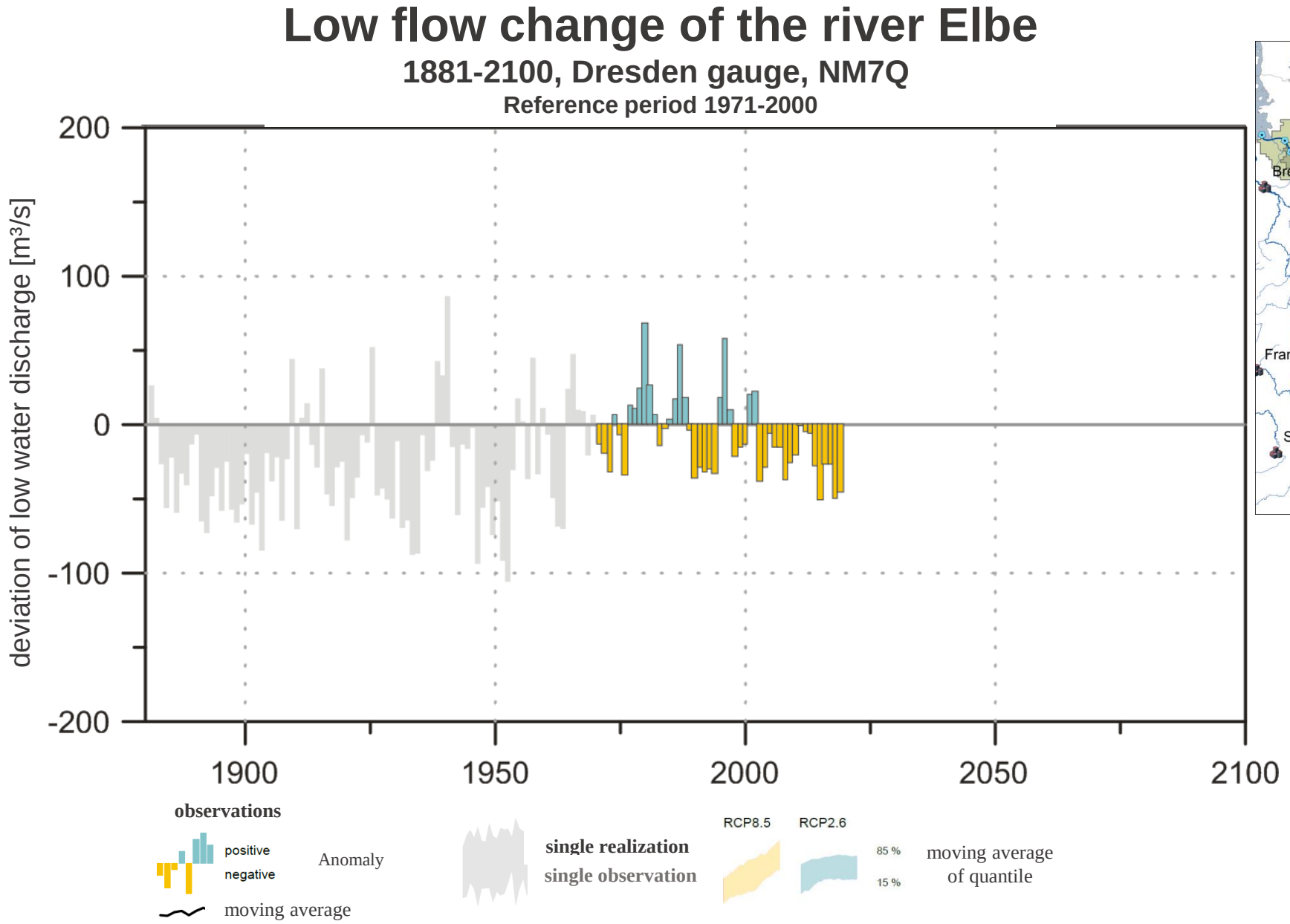
1.2 Past (since 1881)

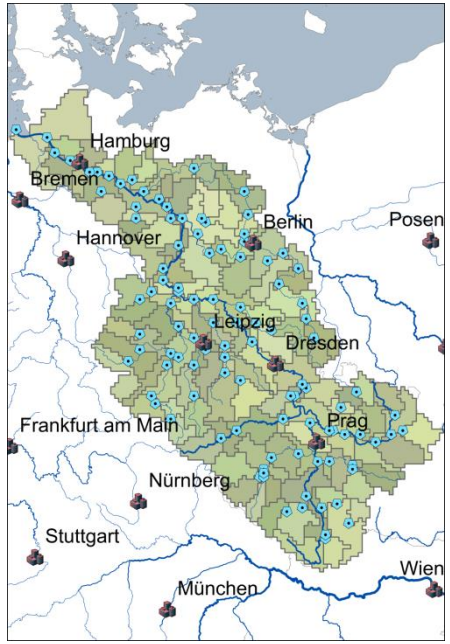




Source:
Federal Institute
of Hydrology

1.2 Present (until today)





Source:
Federal Institute
of Hydrology

1.2 Future (1 x until 2100)

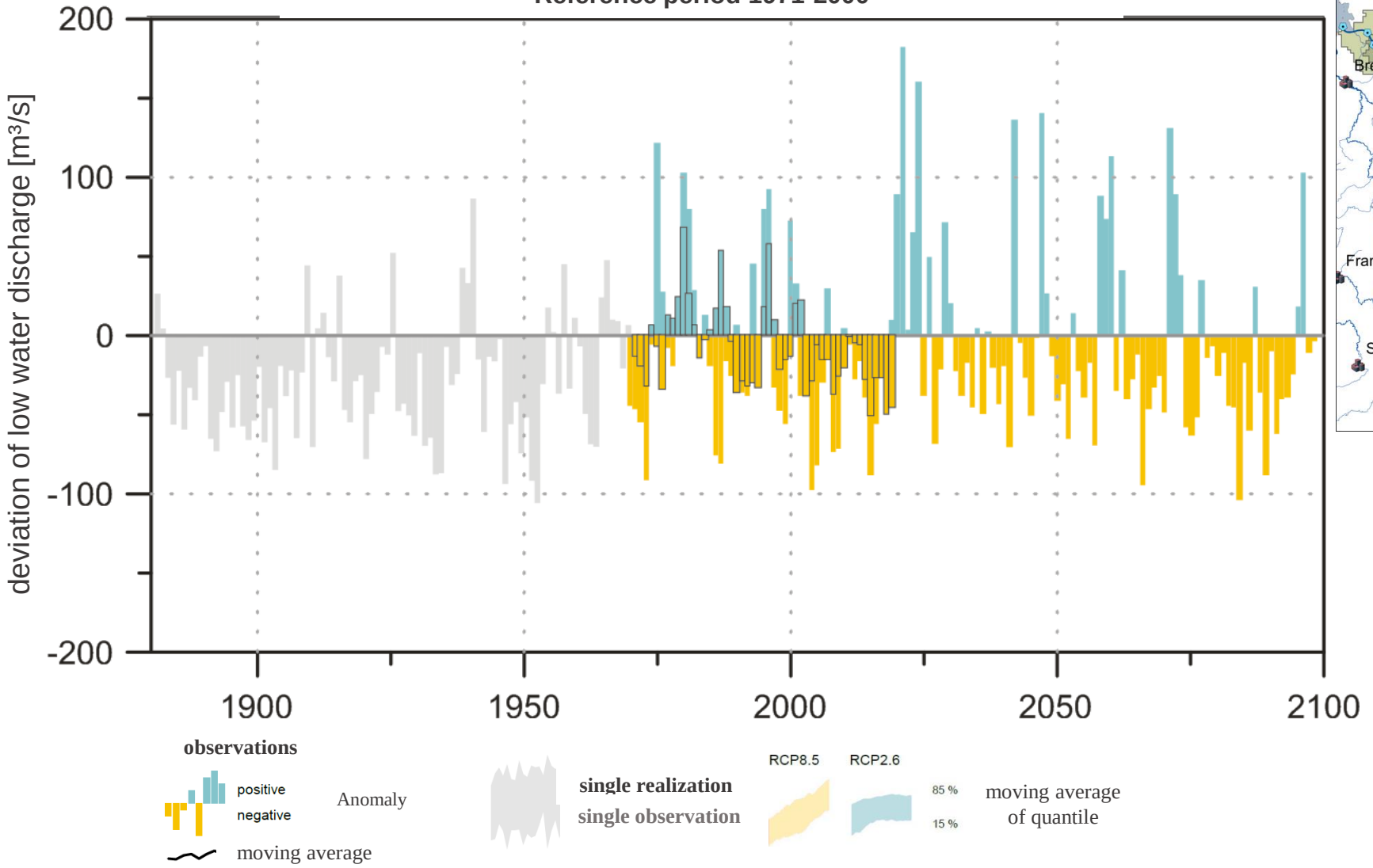
Scenario:
„limited mitigation success" (RCP8.5)

bfg Bundesanstalt für Gewässerkunde

Low flow change of the river Elbe

1881-2100, Dresden gauge, NM7Q

Reference period 1971-2000



Source:
Federal Institute
of Hydrology

1.2 Future (16 x until 2100)

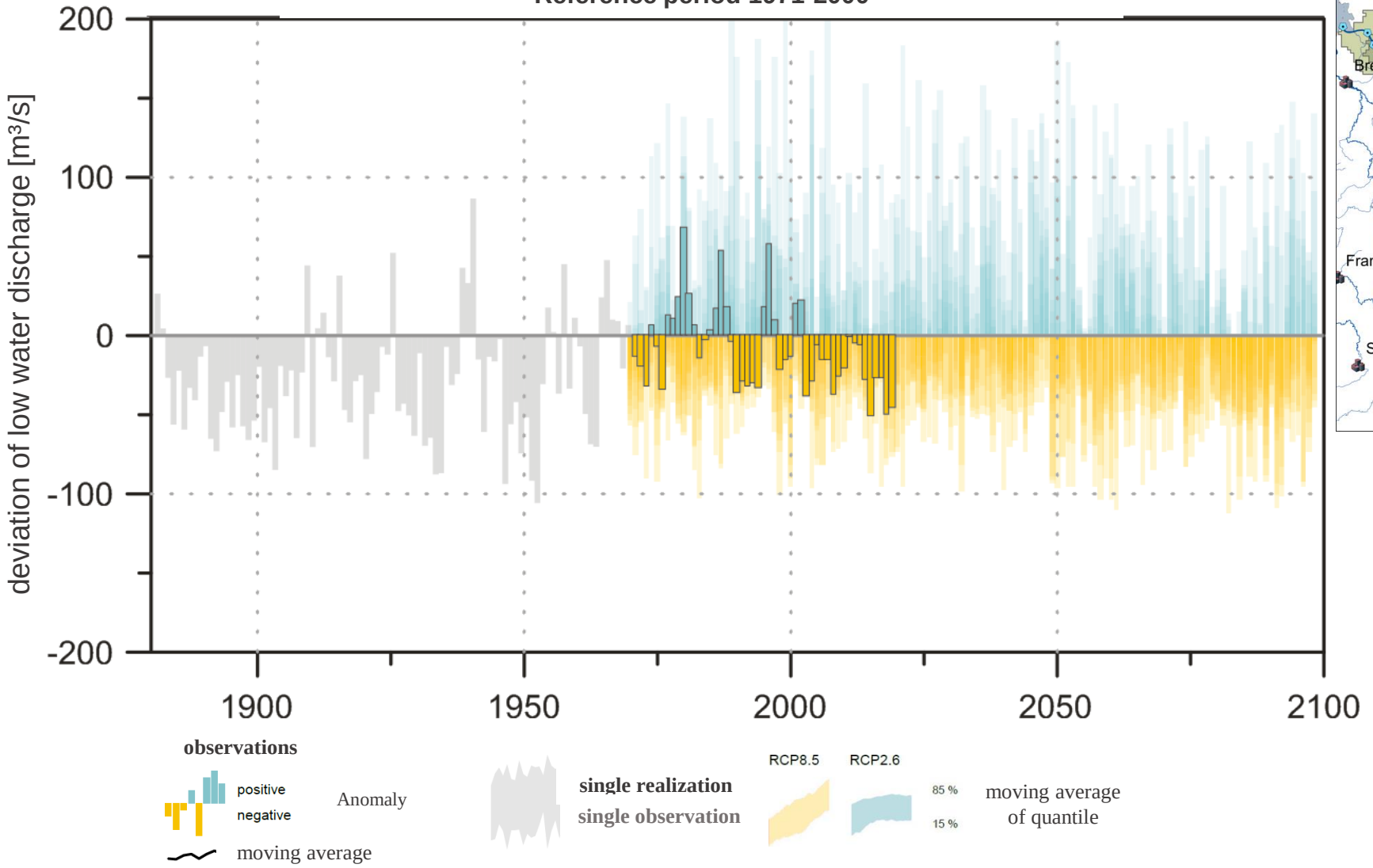
Scenario:
„limited mitigation success" (RCP8.5)

bfg Bundesanstalt für Gewässerkunde

Low flow change of the river Elbe

1881-2100, Dresden gauge, NM7Q

Reference period 1971-2000



Source:
Federal Institute
of Hydrology

1.2 Future (16 x until 2100)

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bfg Bundesanstalt für Gewässerkunde

Low flow change of the river Elbe

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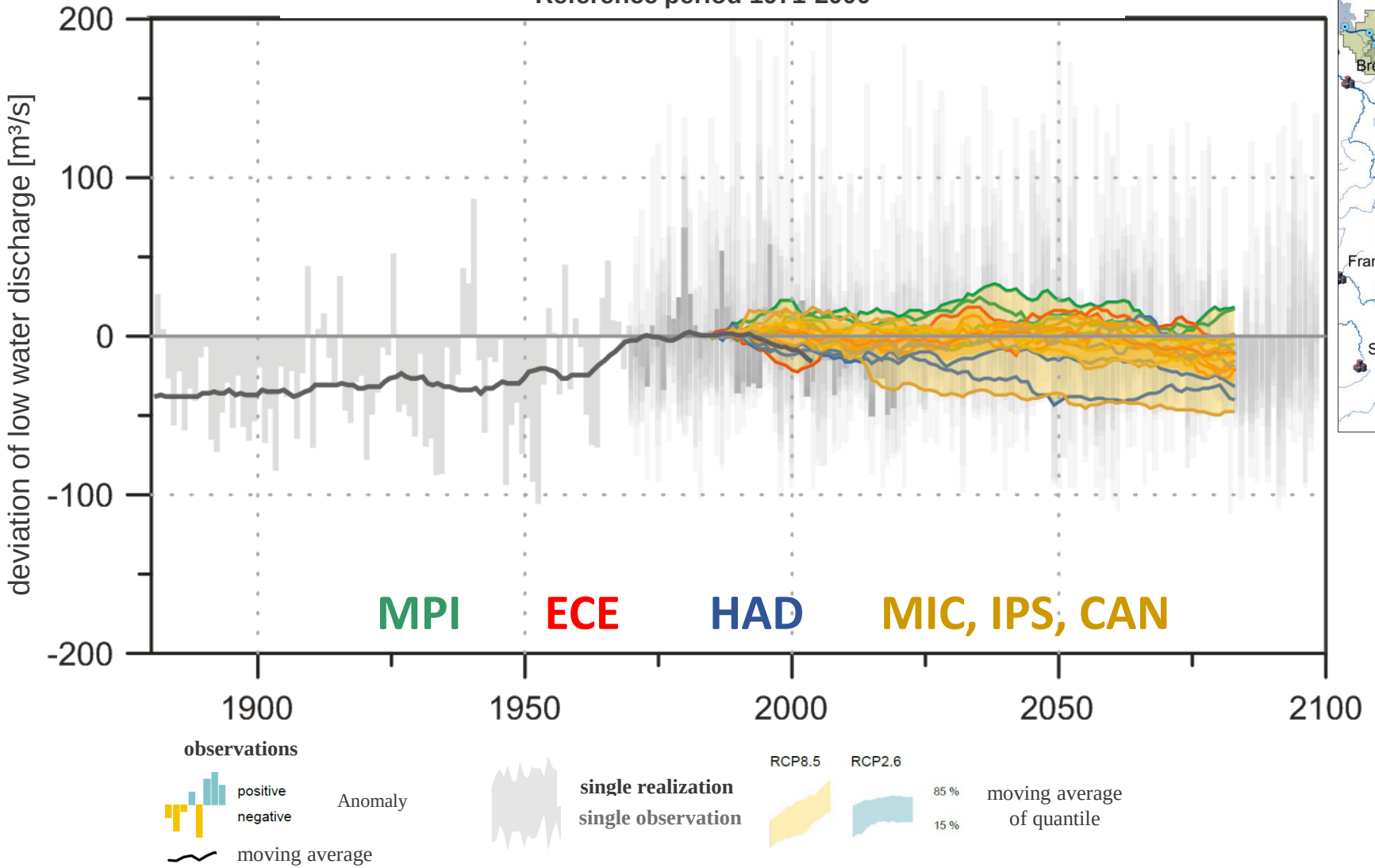

Source:
Federal Institute
of Hydrology

1.2 Future (16 x until 2100)

Scenario:
„limited mitigation success" (RCP8.5)

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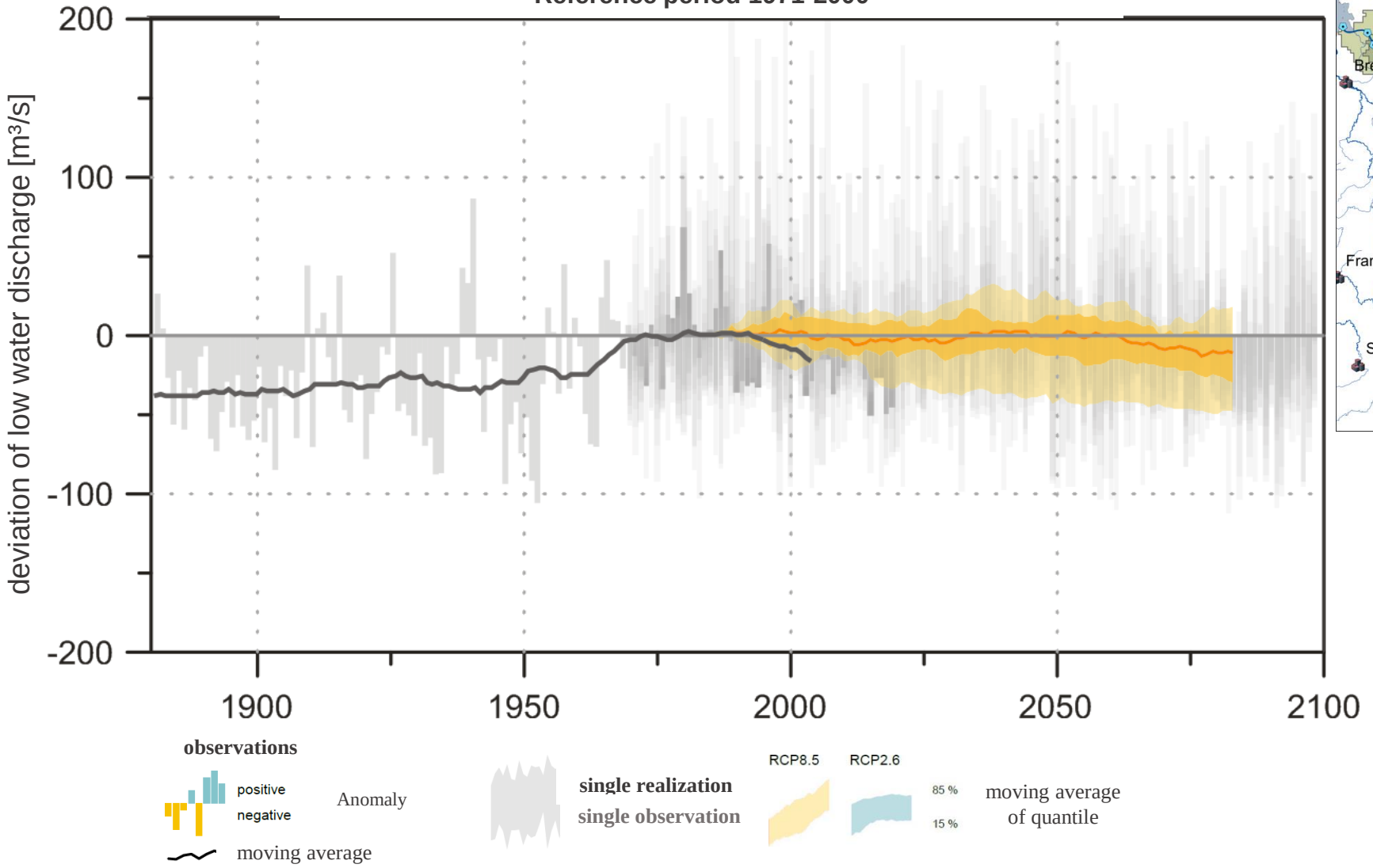
Low flow change of the river Elbe

1881-2100, Dresden gauge, NM7Q

Reference period 1971-2000



Source:
Federal Institute
of Hydrology

1.2 Future (10 x until 2100)

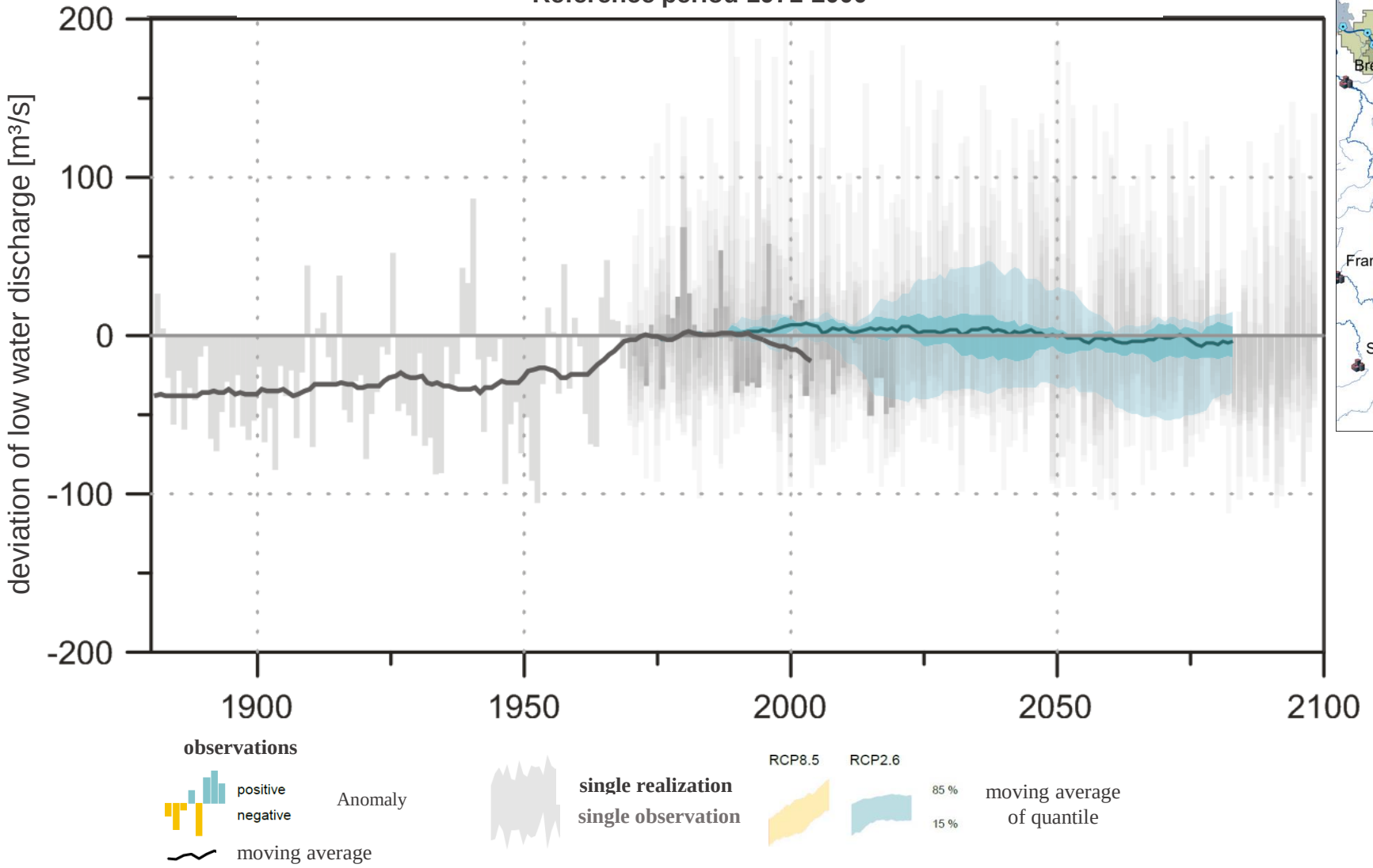
Scenario:
„mitigation successful" (RCP2.6)

bfg Bundesanstalt für Gewässerkunde

Low flow change of the river Elbe

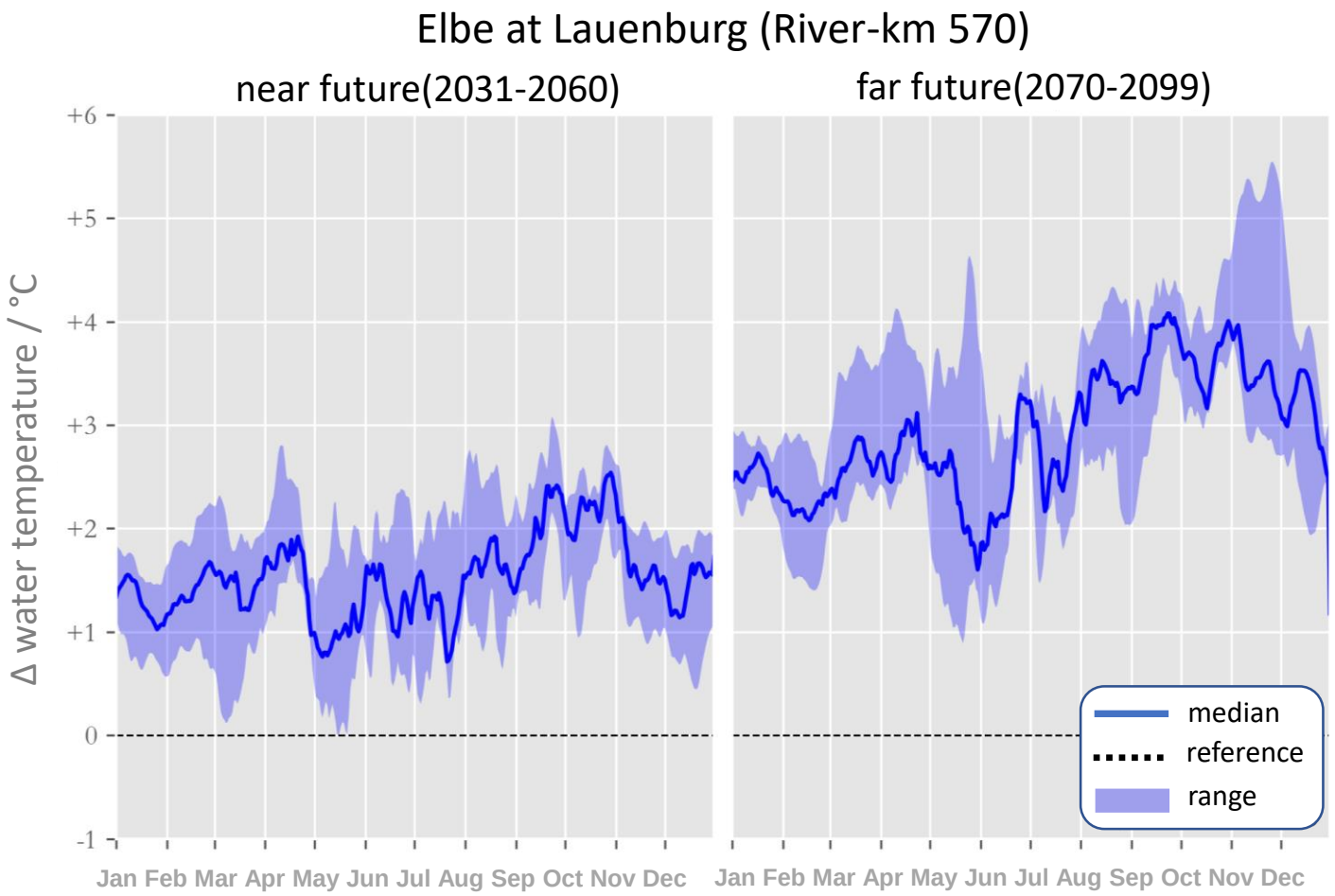
1881-2100, Dresden gauge, NM7Q

Reference period 1971-2000



Source:
Federal Institute
of Hydrology

1.3 Water temperature projections

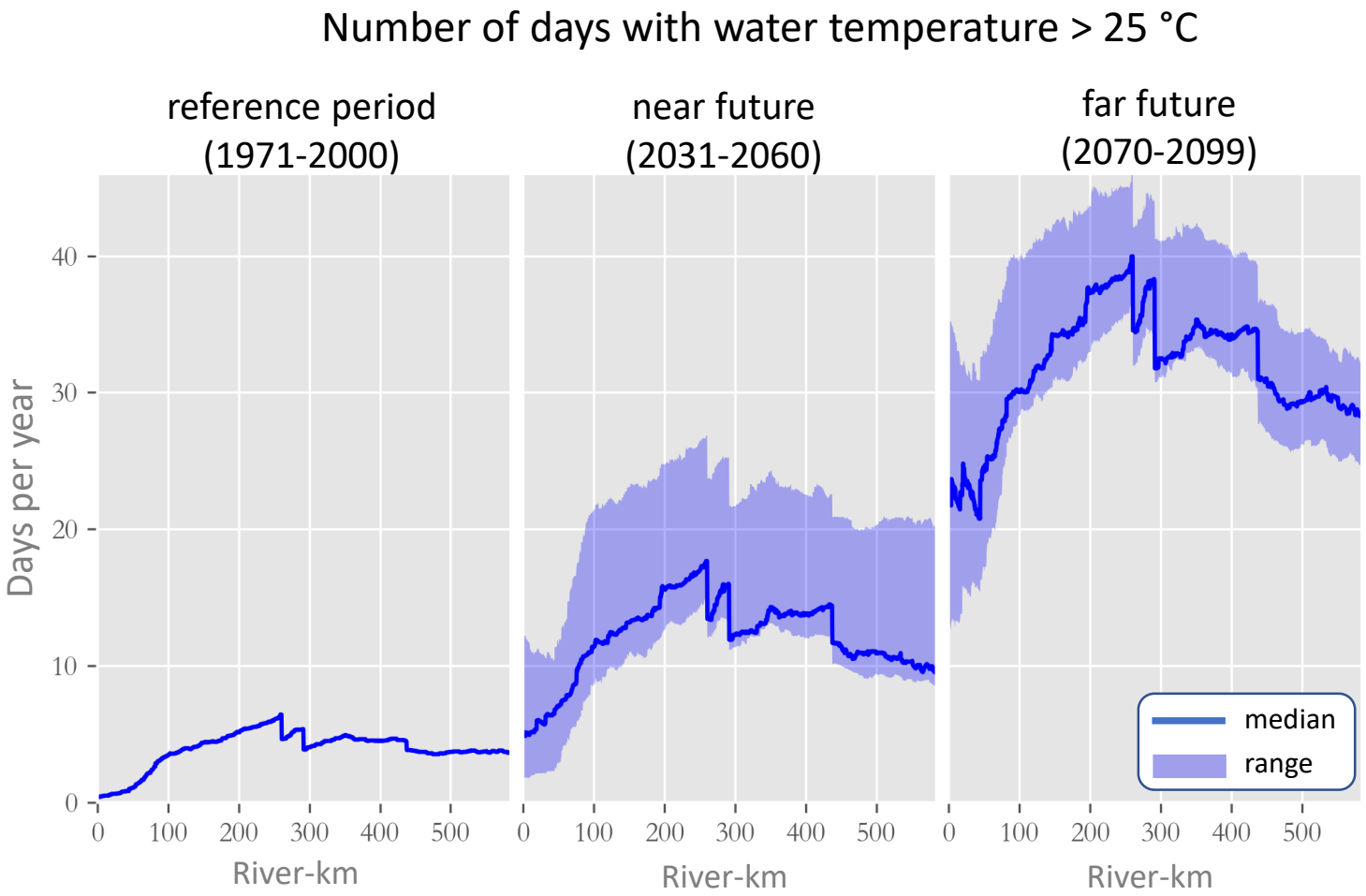


Increase of mean annual temperature:

- Near future : 1,0 – 2,2 °C
- Far future : 2,5 – 3,8 °C

5 discharge- and climate projections
Business-as-usual-scenario (RCP 8.5)

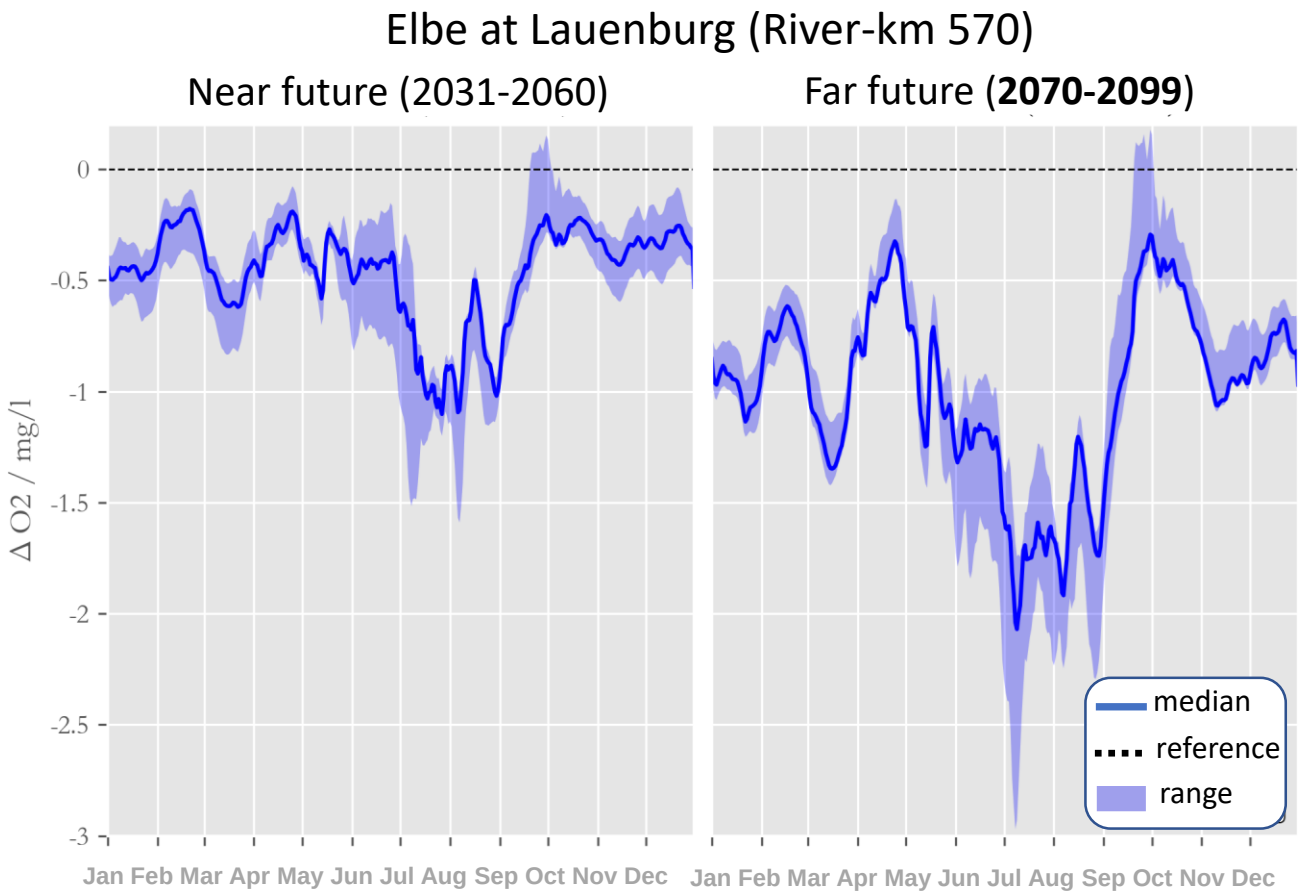
1.3 Water temperature projections



5 discharge and climate projections
Business-as-usual-scenario (RCP 8.5)

- Exceedance days per year in the far future:
  - > 30 days (25 °C)
  - > 4 days (28 °C)
- Significant increase of number of days with critical water temperatures
  → relevant for aquatic organisms (e.g. fish, mussels) and for thermal discharge

1.3 Water temperature projections



5 discharge and climate projections
Business-as-usual-scenario (RCP 8.5)

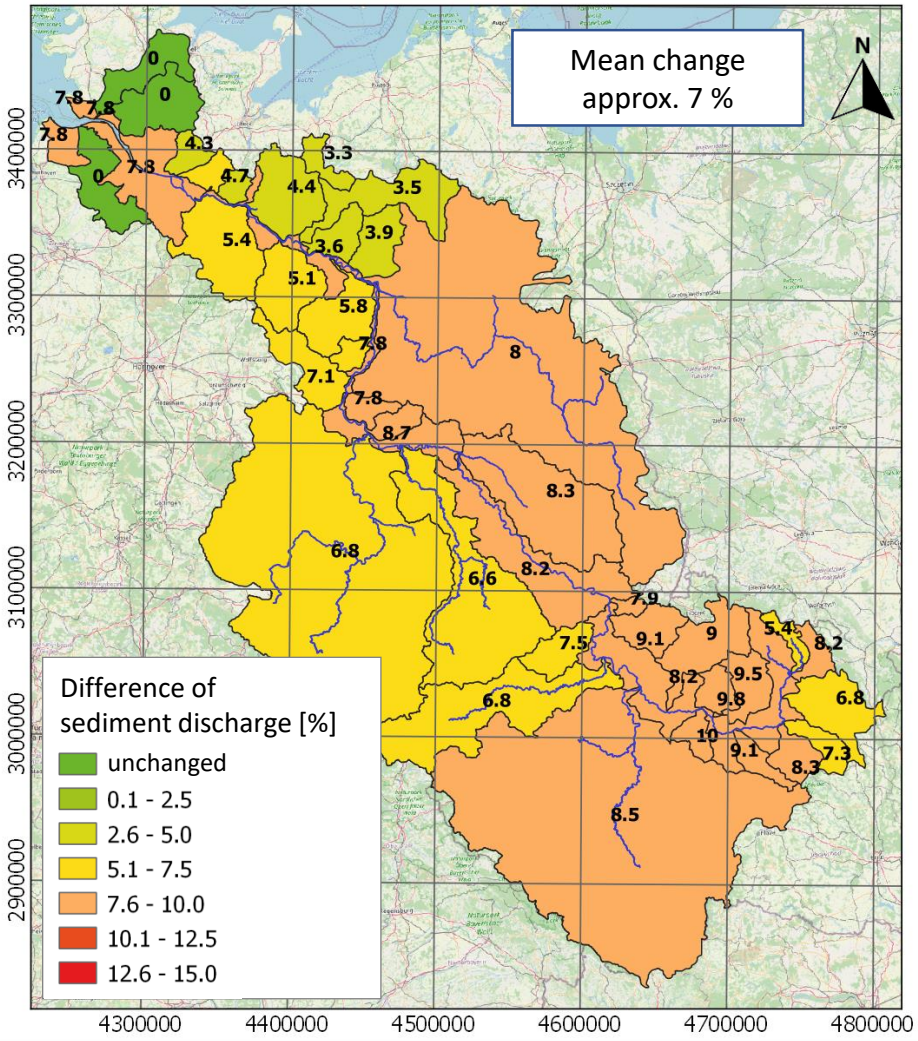
In analogy to temperature increase: partially strong decrease of oxygen content

- Near future:
  -12,5 – -16,5 %
- Far future:
  -19 – -36 %

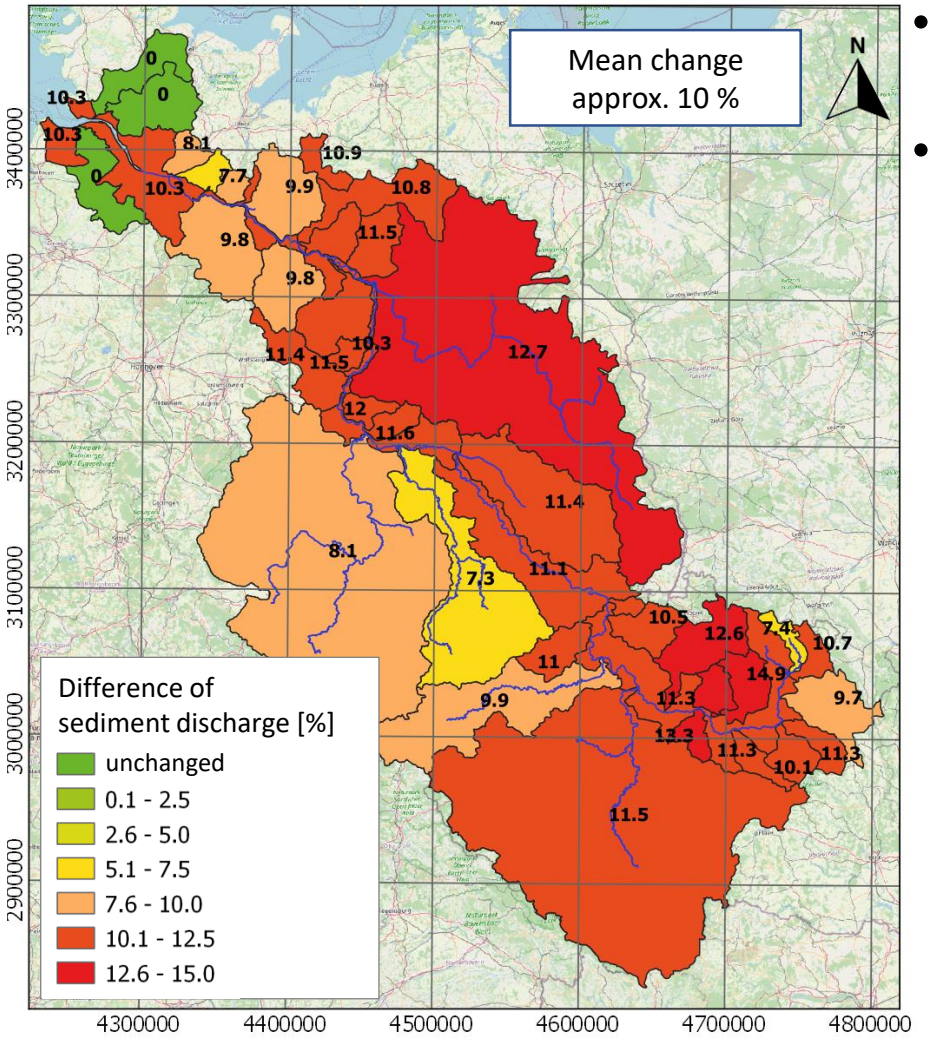
Reasons i.a. lower solubility of oxygen at higher temperatures, and spatial change of algal bloom.

1.4 Soil erosion

near future (2031 – 2060)



far future (2071 - 2100)



- Increased soil ersosion in the Elbe river basin
- Increased risk of deposition of fine sediment in the river (not in the main channel)

Percentage changes of sediment discharge from the area per sub-basin for the 50. percentile of the „Business-as-usual“ scenario (RCP 8.5).
It should be noted that the sub basins of the Elbe itself contain the cumulative changes of the upstream areas.

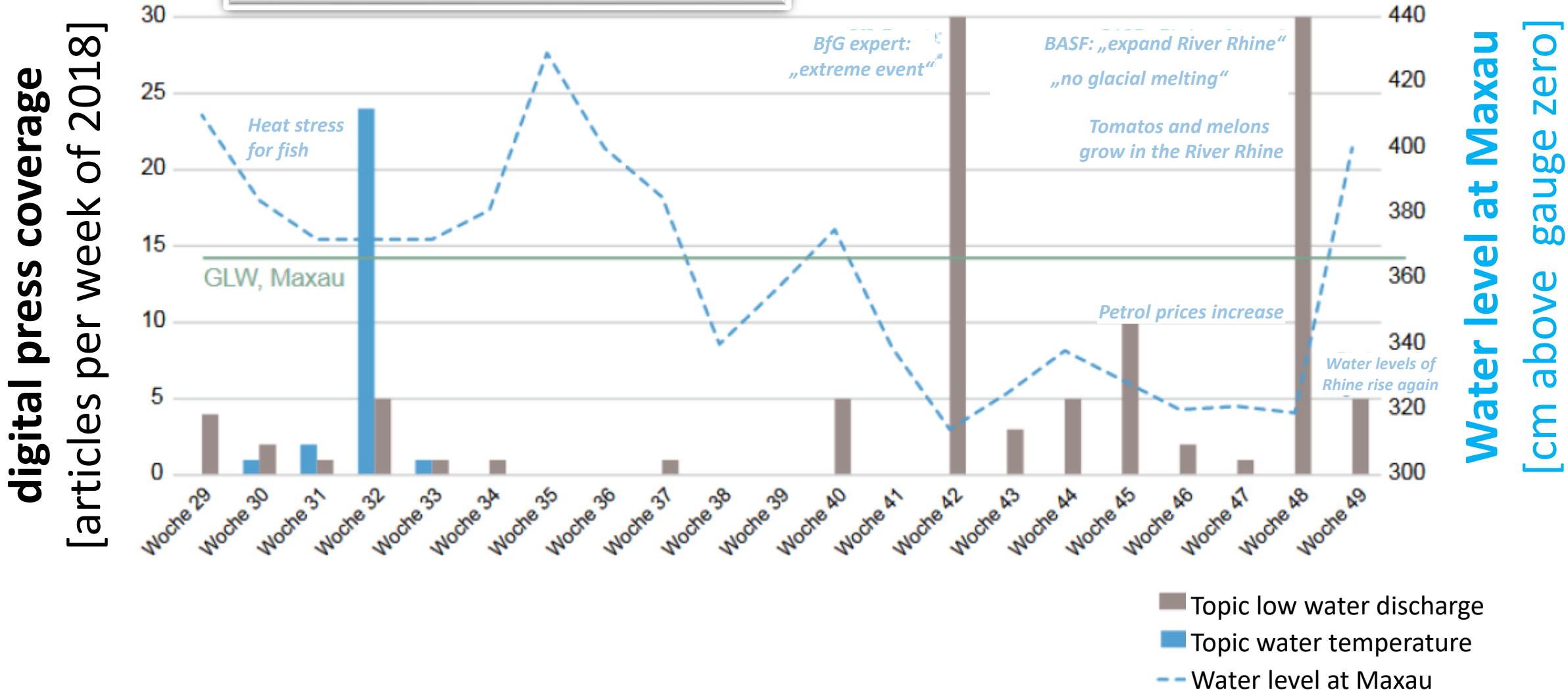
Summary Climate Change Elbe

- The ensemble of discharge projections **shows no clear change of low flows until the middle of the 21. century** (RCP8.5, 16 projections; RCP2.6, 10 projections).
- **In the second half of the 21. century** a majority of discharge projections reveal a partially significant **decrease of low water discharges** which would lead to an intensification of extreme events (RCP8.5, 16 projections).
- The discharge projections in the river Elbe basin are particularly uncertain* as compared to other rivers.
- **The current sequence of dry years** is covered by the future „scenario corridor“ of the discharge projections but **is located at the driest end of the projections ensemble** (low flow indices).
- **Water temperatures increase significantly** because of climate change. **Stress level for aquatic organisms rises**.
- The (areal) **soil erosion** in the catchment area **increases** due to climate change.
- The knowledge and data currently available on **climate change impacts** can be accessed through a climate consulting service: DAS-Basisdienst@bafg.de

* Limited water resources, unclear change signal of summer precipitation, high influence of water management…

2. Contributions to adaptation

Need for information depending on water levels/ -temperature varies…



2.1 Information portals

Topics

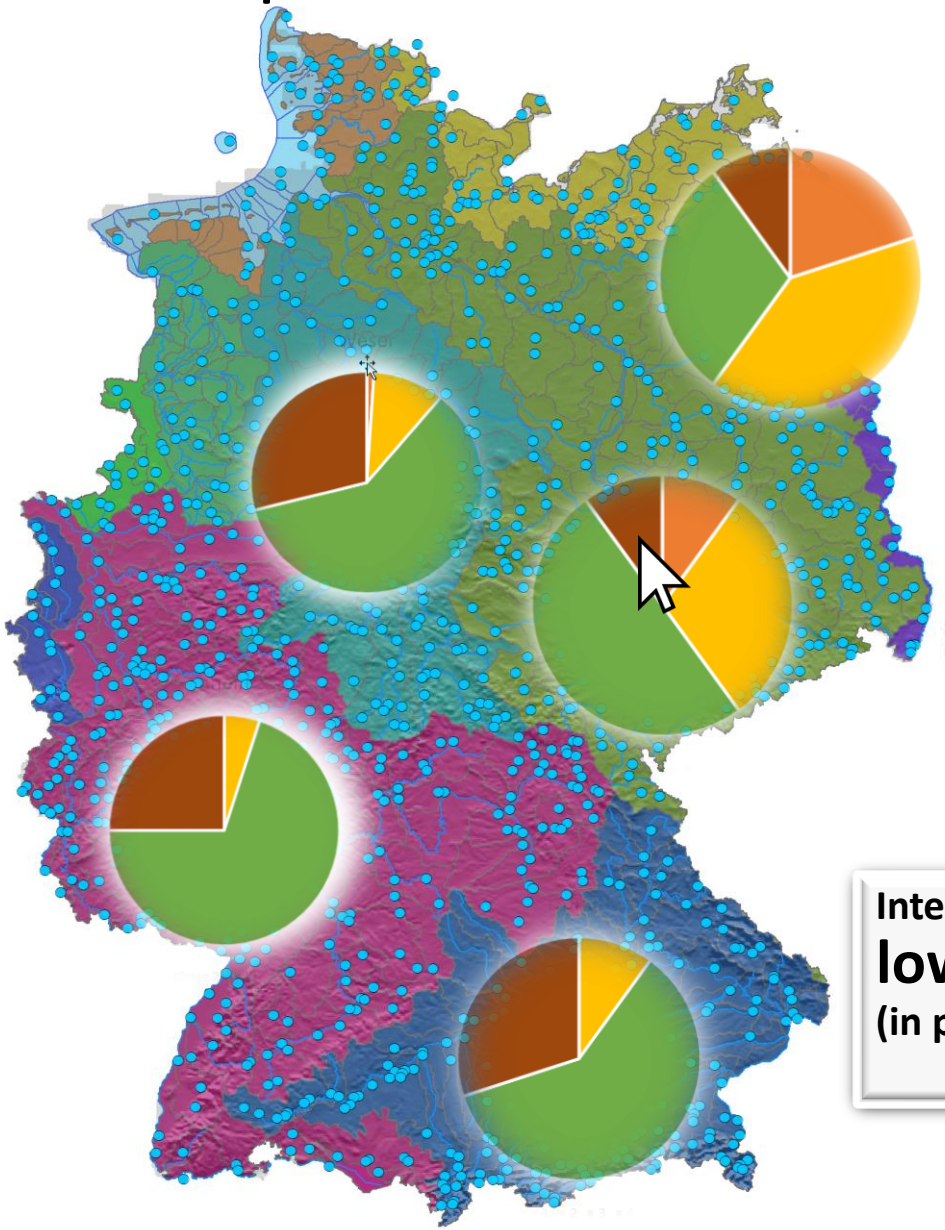
Current Situation

- Water level
- Discharge
- LW-Indices
- Volumina
- Storage
- …

Basics

Hist. Low water

Impacts



Aggregation layers

- gauge
- Catchment (>2500 km²)
- River basin
- BWaStr

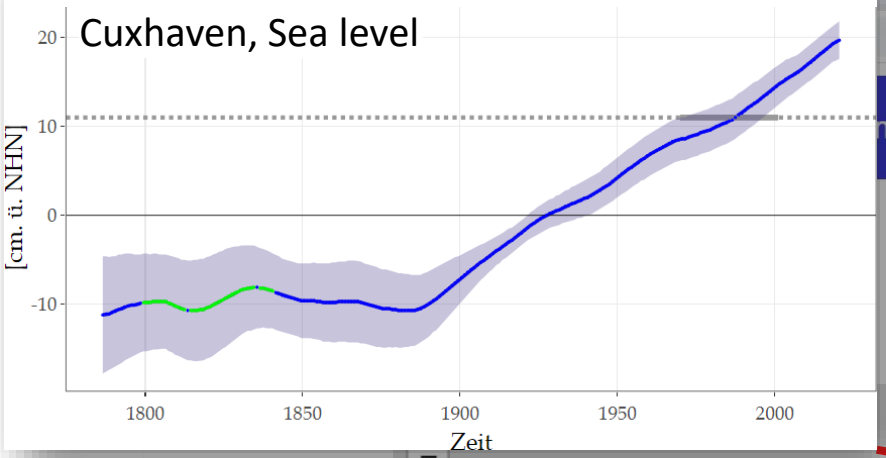
Interactive, nation-wide, homogeneous

low water-information-platform

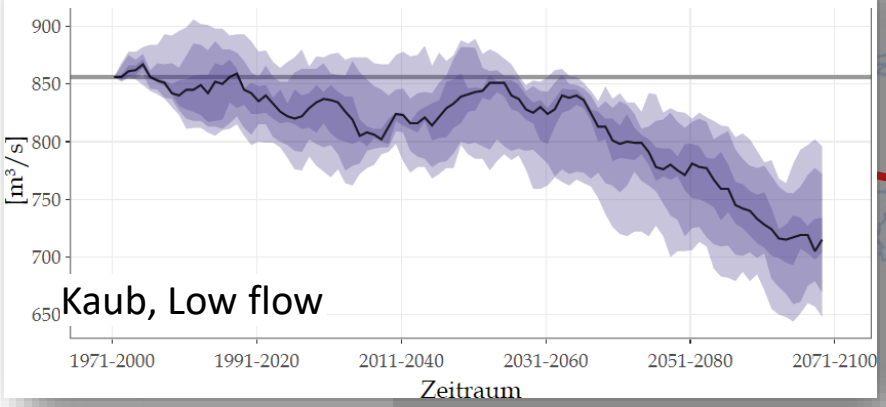
(in preparation)

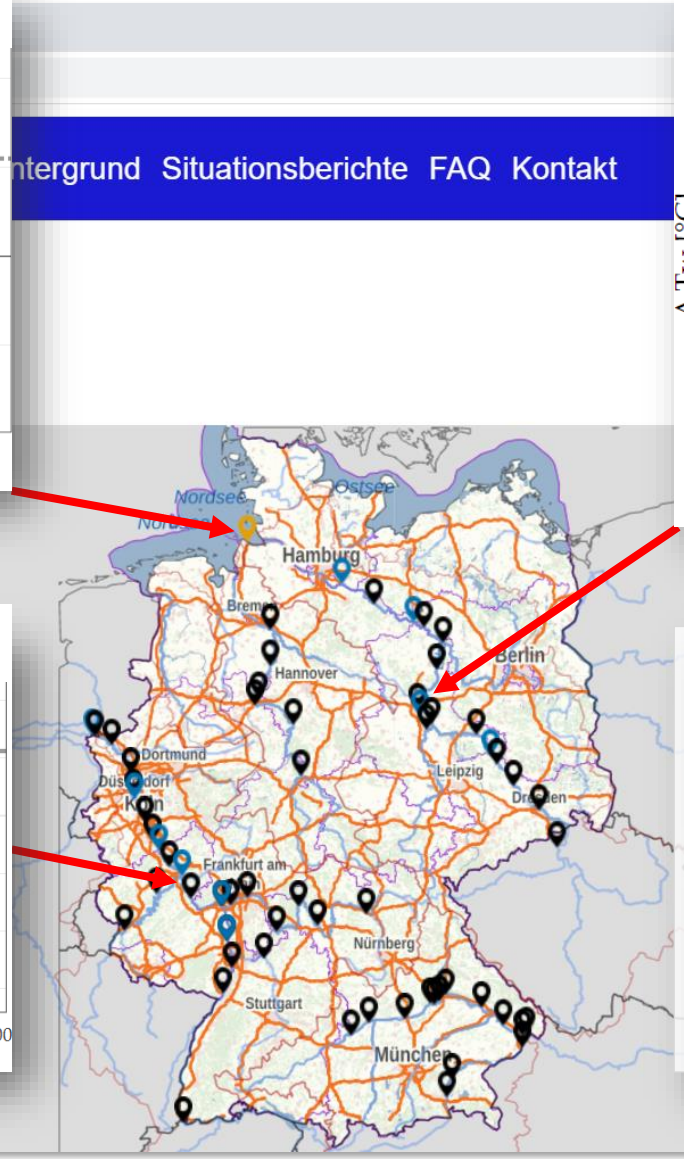
2.1 Information portals ws-klimaportal.bafg.de*

Coastal gauges (tidal indicators, …)

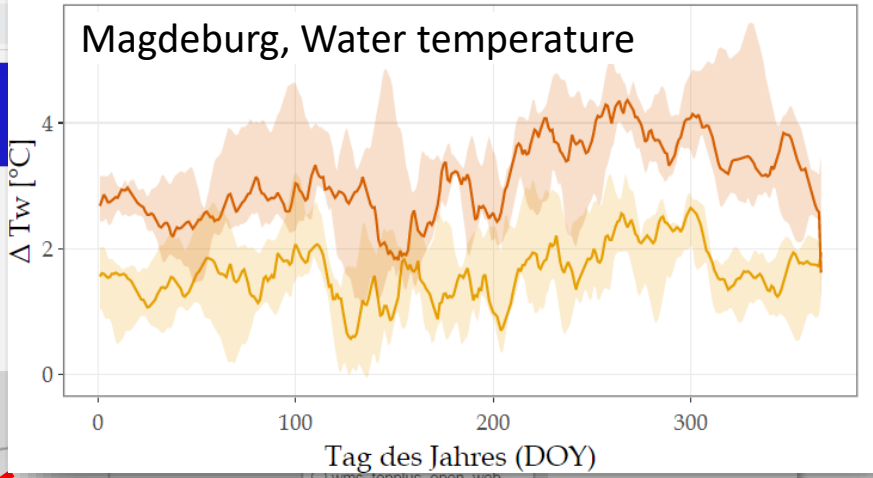


Inland gauges (river flow indicators)





Inland stations (Water quality indicators)



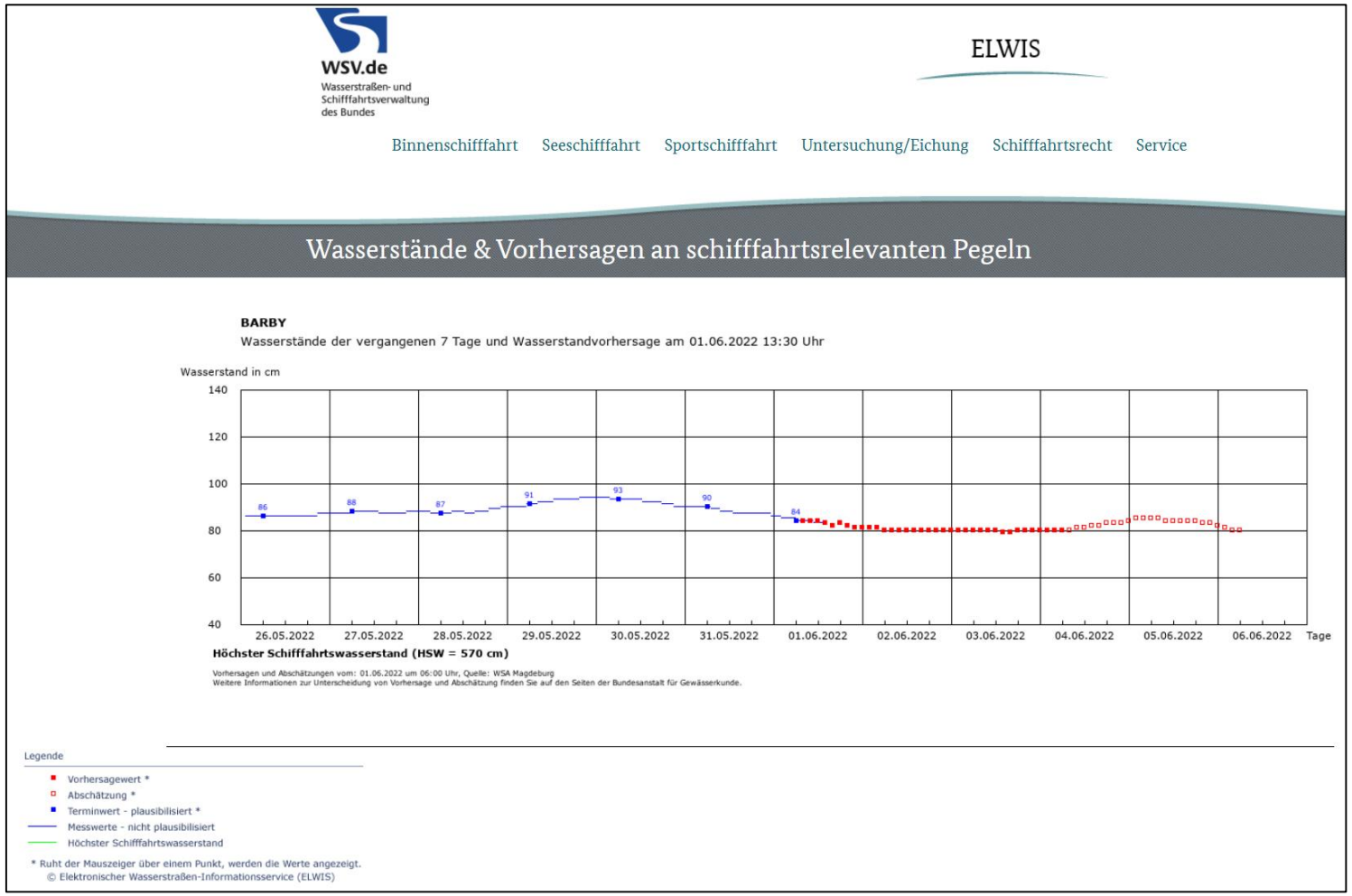
In preparation:
+ pollutants
+ floodplain ecology

For waterway engineers: special services via das-basisdienst@bafg.de!

* back online soon…

2.2. Forecasting

- Operational forecasts are published via ELWIS already since decades in order to support waterway users
- Current lead-times: 2 - 8 days (increasing in downstream direction)
- Forecast with additional lead-times are required to support logistical decisions as well as to optimise waterway management (e.g. sediment management of Elbe estuary / Port of Hamburg)

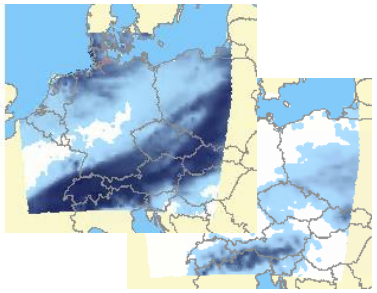


Source: ELWIS https://www.elwis.de/DE/dynamisch/gewaesserkunde/wasserstaende

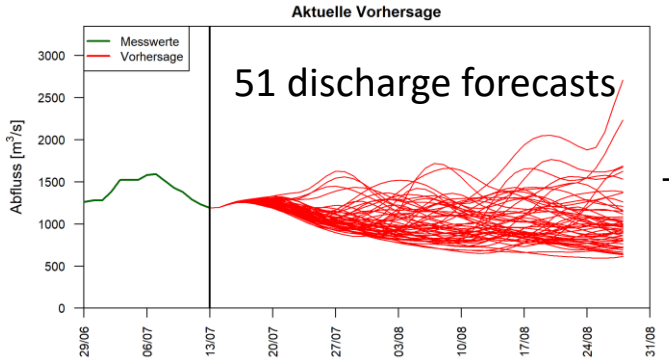
2.2. Forecasting: 6-week-forecast

current forecast

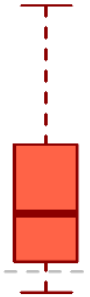
51 meteo forecasts



51 model runs

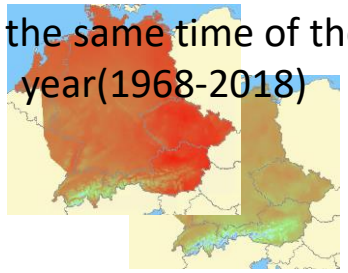


statistics

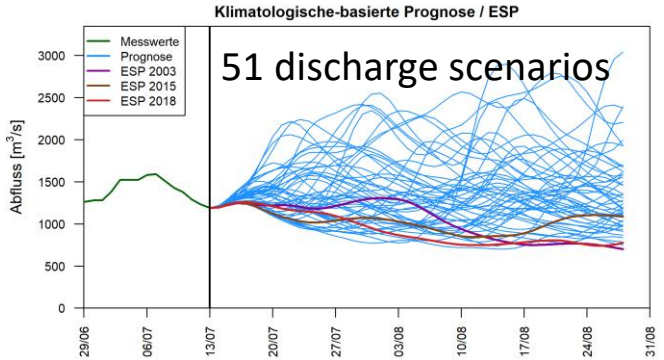


reference information

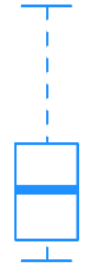
51 meteo measurements at the same time of the year(1968-2018)



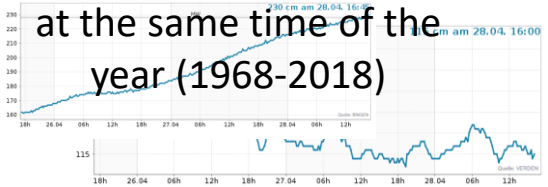
51 model runs



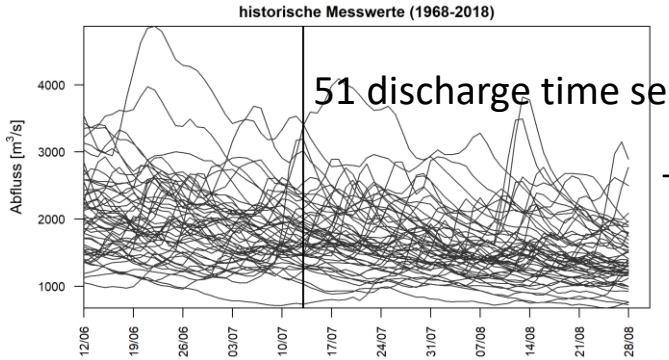
statistics



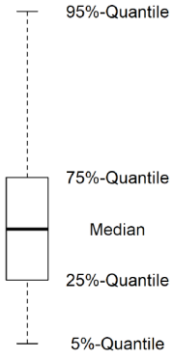
51 historical discharges at the same time of the year (1968-2018)



No model run (statistics)

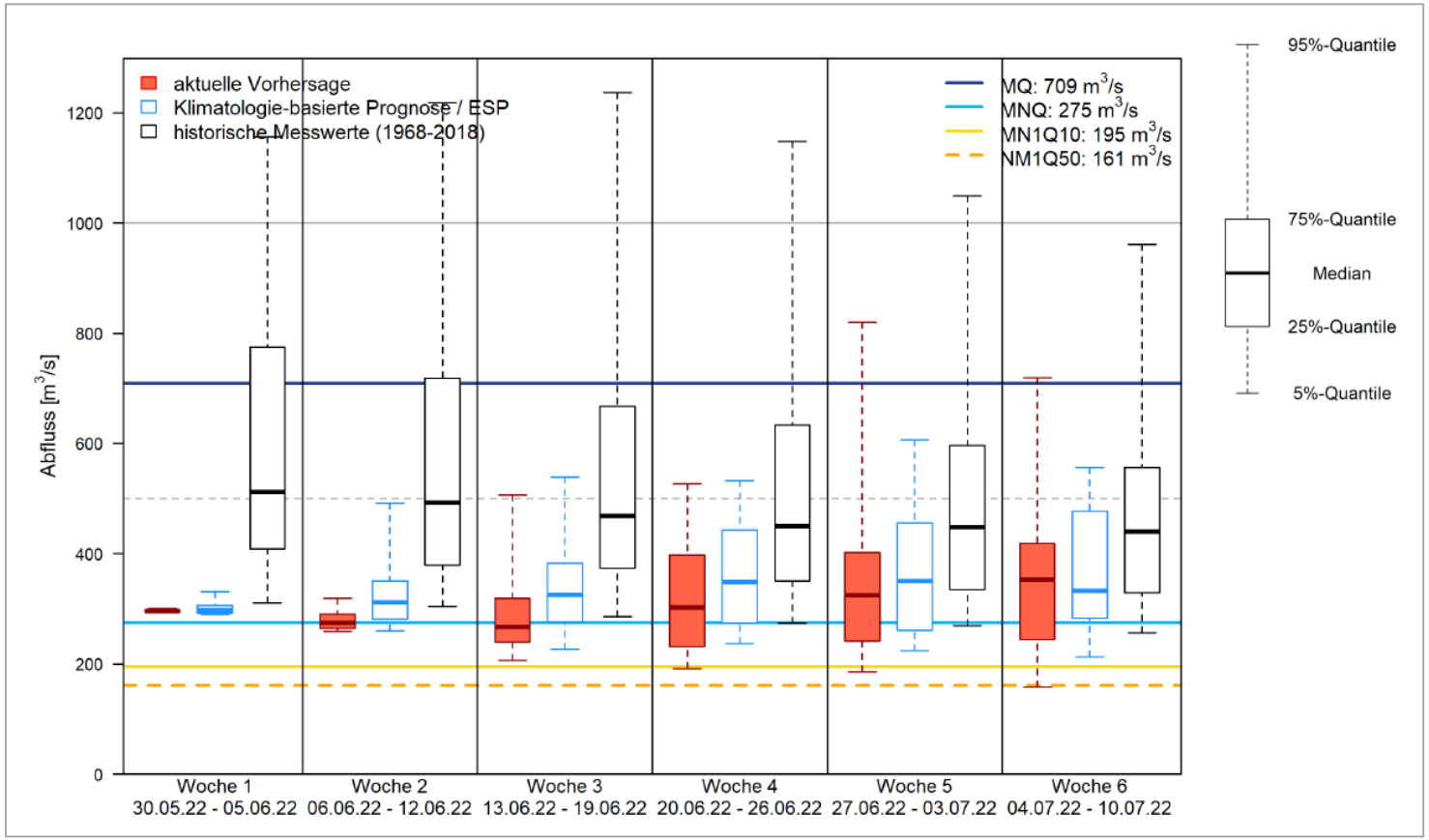


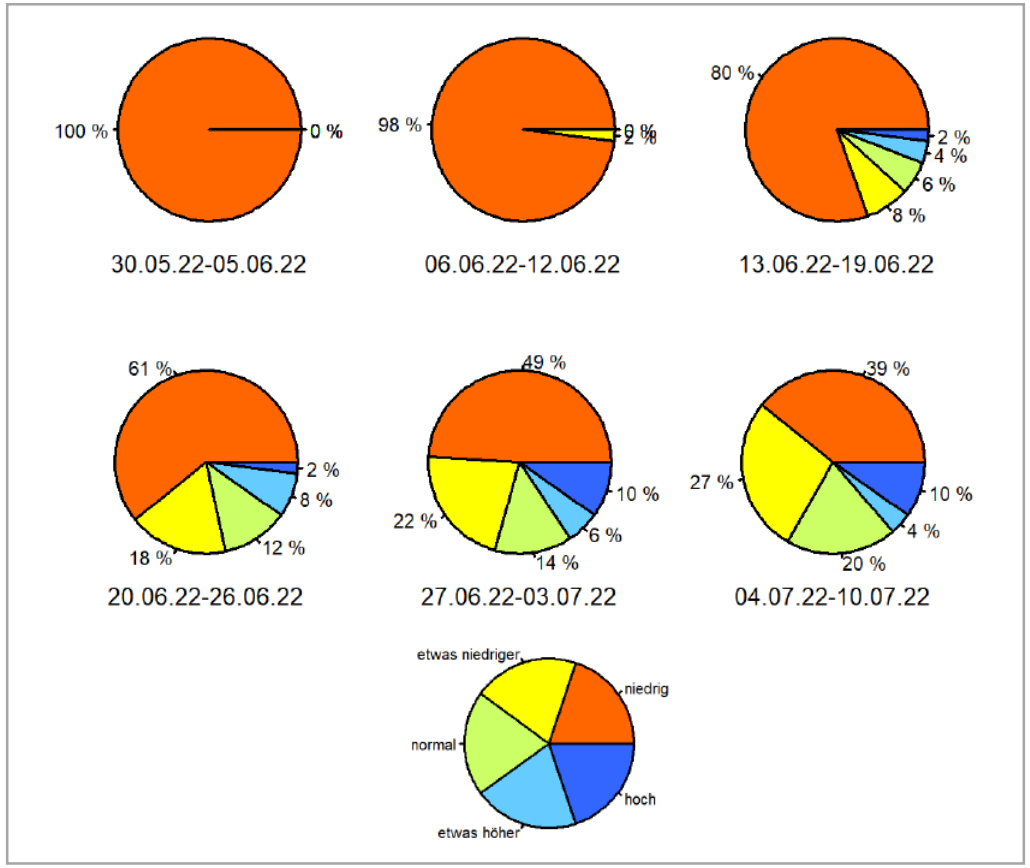
statistics



2.2. Forecasting: 6-week-forecast

- In **July 2022** the 6-week forecast will become an **operational** forecast product at Elbe and Rhine
- Different products / ways to display the forecast information and the related uncertainties





2.2. Forecasting: 6-week-forecast

- In addition to the pre-defined forecast report (PDF-report) an interactive web application is developed allowing to define e.g. individual flow / water level thresholds

Hydrologische 6-Wochen-Vorhersage

Jahr der Vorhersage: 2022

Vorhersagezeitpunkt: 30.05.2022

Bundeswasserstraße: Elbe

Pegel: Neu Darchau

Die Pegel Maxau und Barby sind seit dem 25.11.2021 verfügbar.

Darstellung:
- (●) Abfluss in m³/s
- ( ) Wasserstand in cm

Grenzwert: 500

Vorauswahl: Mittelwasser (MQ / MW)

Vorhersage
- [x] aktuelle Vorhersage
- [x] Klimatologie-basierte Prognose / ESP
- [x] historische Messwerte (1968-2018)

Plot aktualisieren

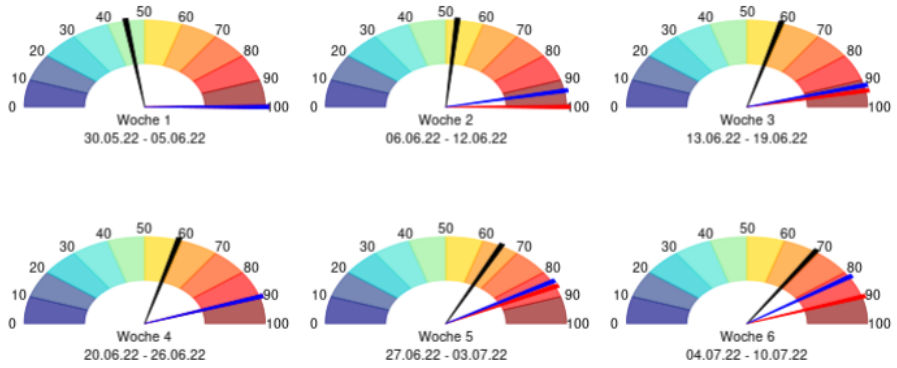
Die Tachoplots zeigen die Wahrscheinlichkeit der Unterschreitung des gewählten Grenzwertes auf Grundlage der Ensemblevorhersage. Die farblich unterschiedlichen Tachonadeln stehen für die unterschiedlichen Vorhersagen (vgl. Boxplots der Vorhersage inkl. Grenzwertlinie). Die Tabelle zeigt zusätzlich die Wahrscheinlichkeit der Unterschreitung aller Vorhersagen, eingefärbt entsprechend der Farben in den Tachoplots, für den schnelleren Überblick.

Übersicht | Tachoplots | Boxplots | FAQ | Impressum | Datenschutzerklärung

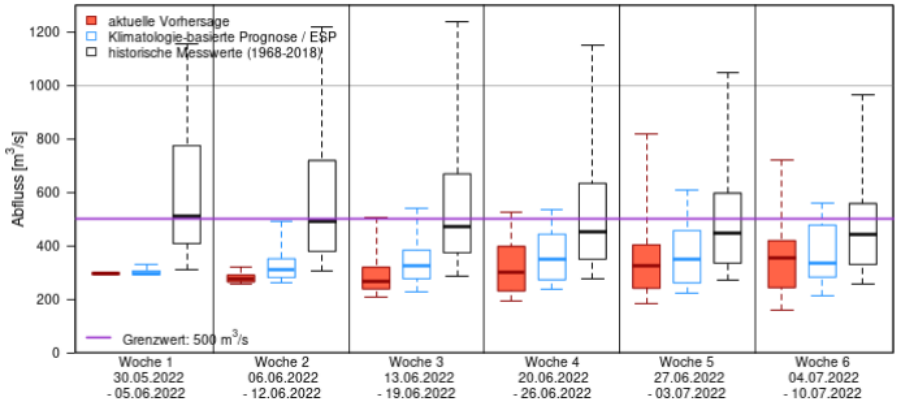
Pegel Neu Darchau: Unterschreitungswahrscheinlichkeit in %

Woche	30.05.22 - 05.06.22	06.06.22 - 12.06.22	13.06.22 - 19.06.22	20.06.22 - 26.06.22	27.06.22 - 03.07.22	04.07.22 - 10.07.22
Vorhersage	100%	100%	94%	90%	86%	90%
ESP	100%	94%	92%	90%	84%	82%
historische Messwerte	45%	53%	59%	59%	65%	69%

Unterschreitungswahrscheinlichkeit in % (Neu Darchau)

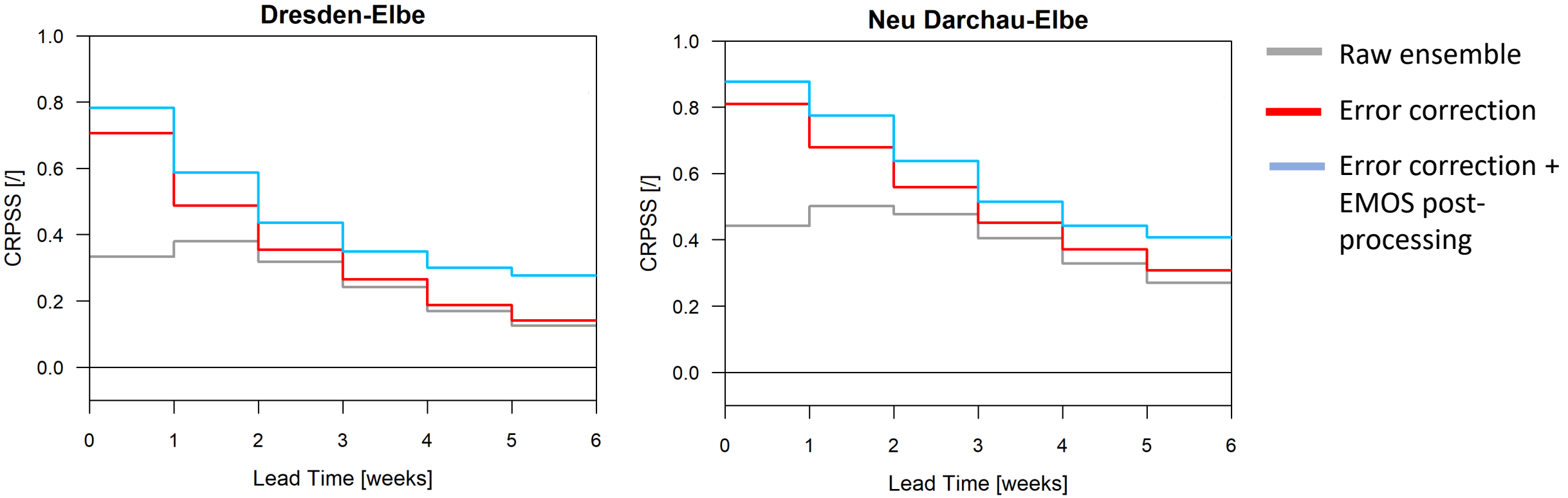


Boxplots der Vorhersage (Neu Darchau)



2.2. Forecasting: 6-week forecast

- Forecast skill significantly varies amongst rivers / gauges and seasons
- Overall forecast skill over 6 weeks (reference: climatology / historical observations)
- Error correction as well as statistical post-processing (method: Ensemble model output statistics, EMOS) significantly improves forecast skill over all lead-times.



Contacts at BfG

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Vorhersage:

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With Contributions from

Claudius Fleischer (BfG/M2), Enno Nilson (BfG/M2) → Discharge
Dennis Meißner (BfG/M2), Barbara Frielingsdorf (BfG/M2) → Forecasting
Magdalena Uber (BfG/M3), Steffen Holl (BfG/M3) → Erosion
Marieke Frassl (BfG/U2) → Water Quality