Trends in Extreme Precipitation over Belgium and Resulting Hydrological Responses in the Ourthe Basin

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BRAJKOVIC Josip.
FETTWEIS X., GHILAIN N., DOUTRELOUP S.,
DESSERS C. & ARCHAMBEAU P.

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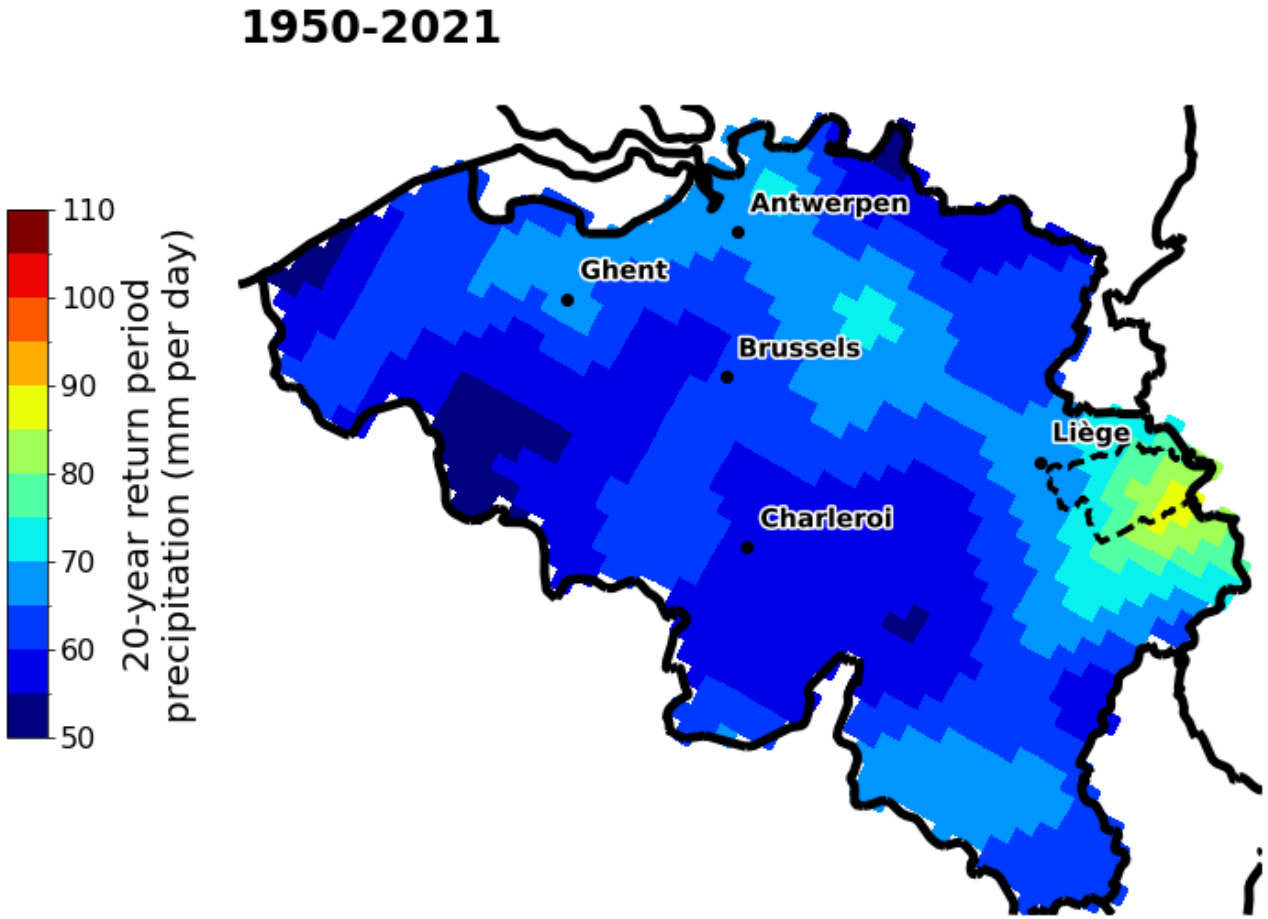
Climatologie & Topoclimatologie

LIÈGE université
Urban & Environmental Engineering

Part 1

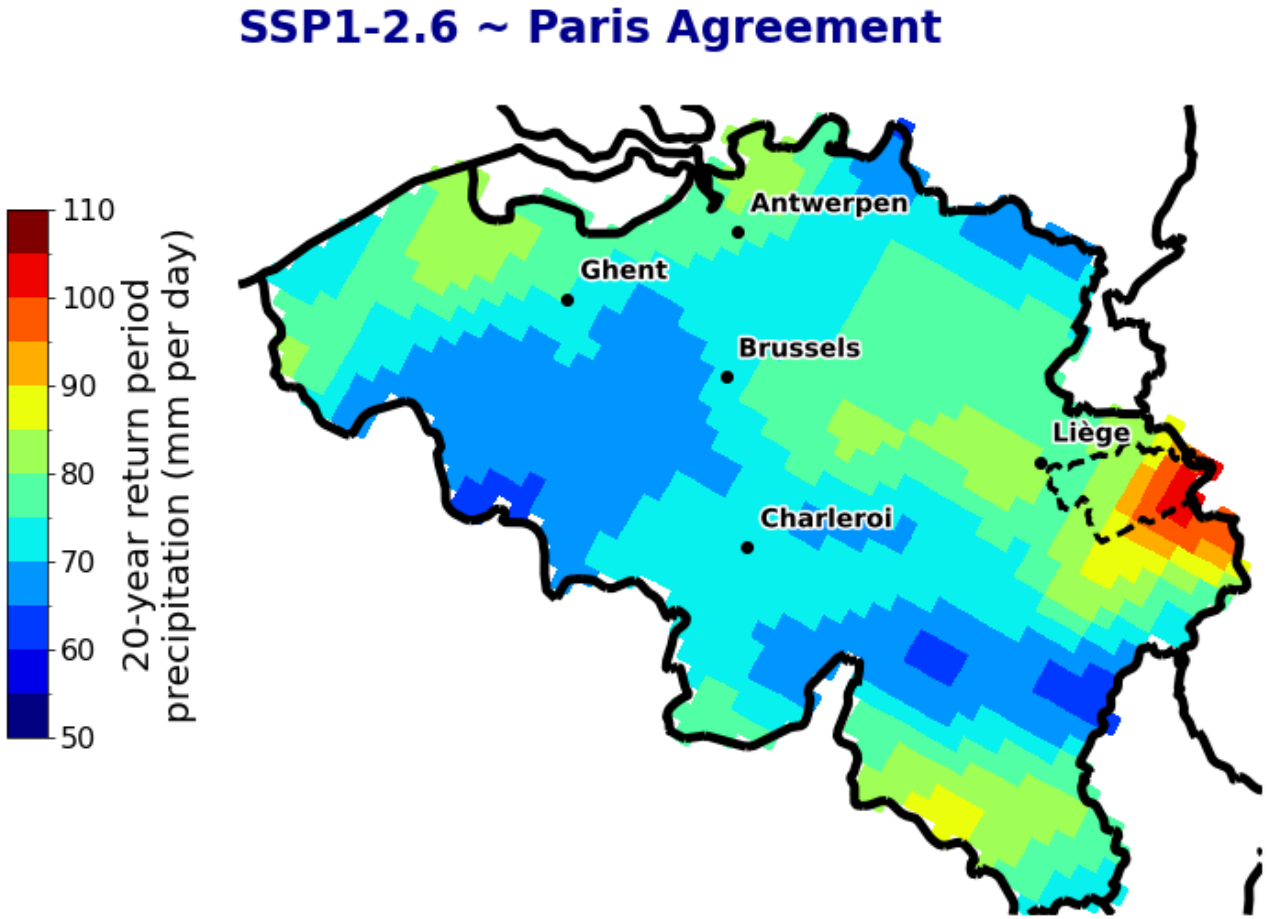
Research context

A bit of context...



(Brajkovic et al., 2025)

A bit of context...



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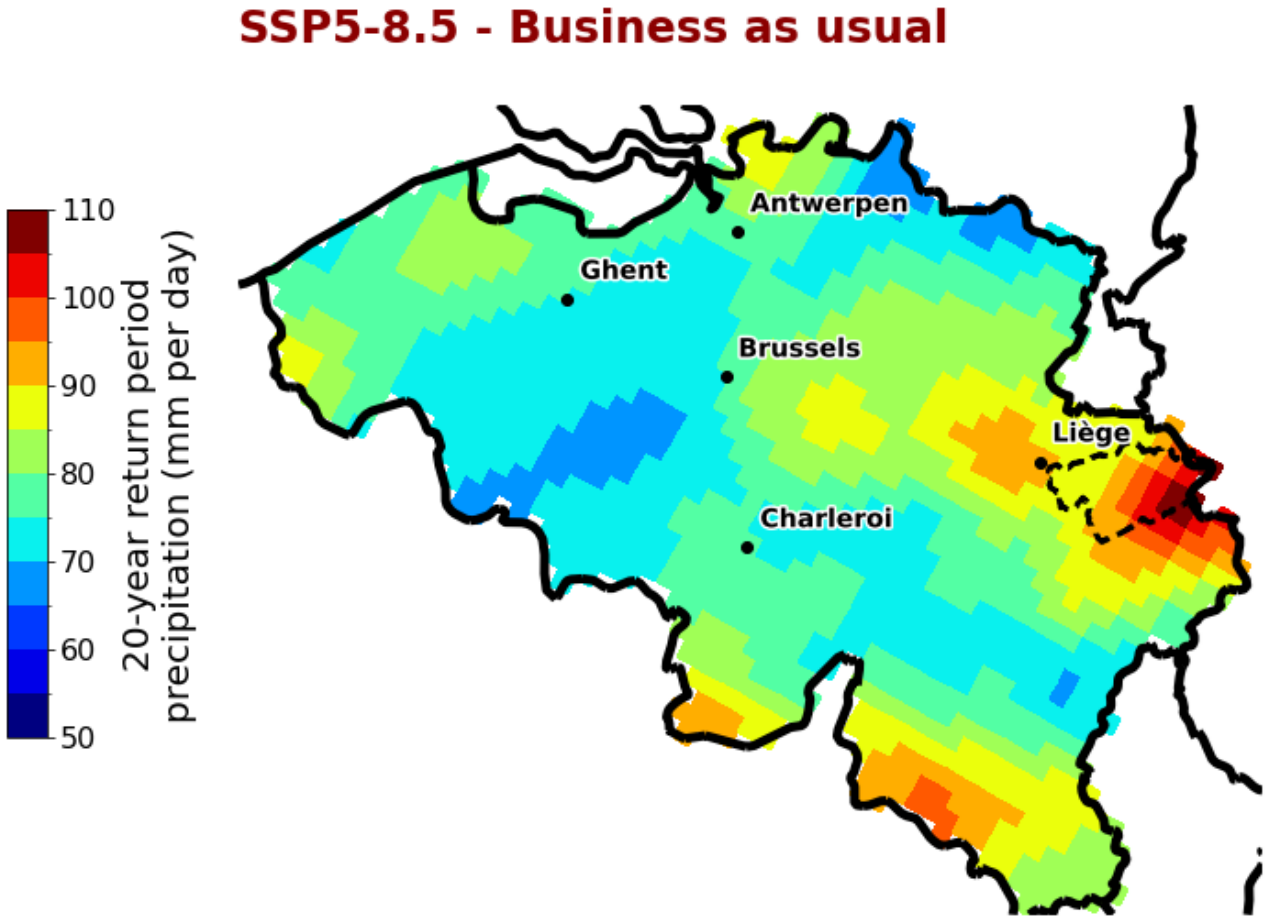

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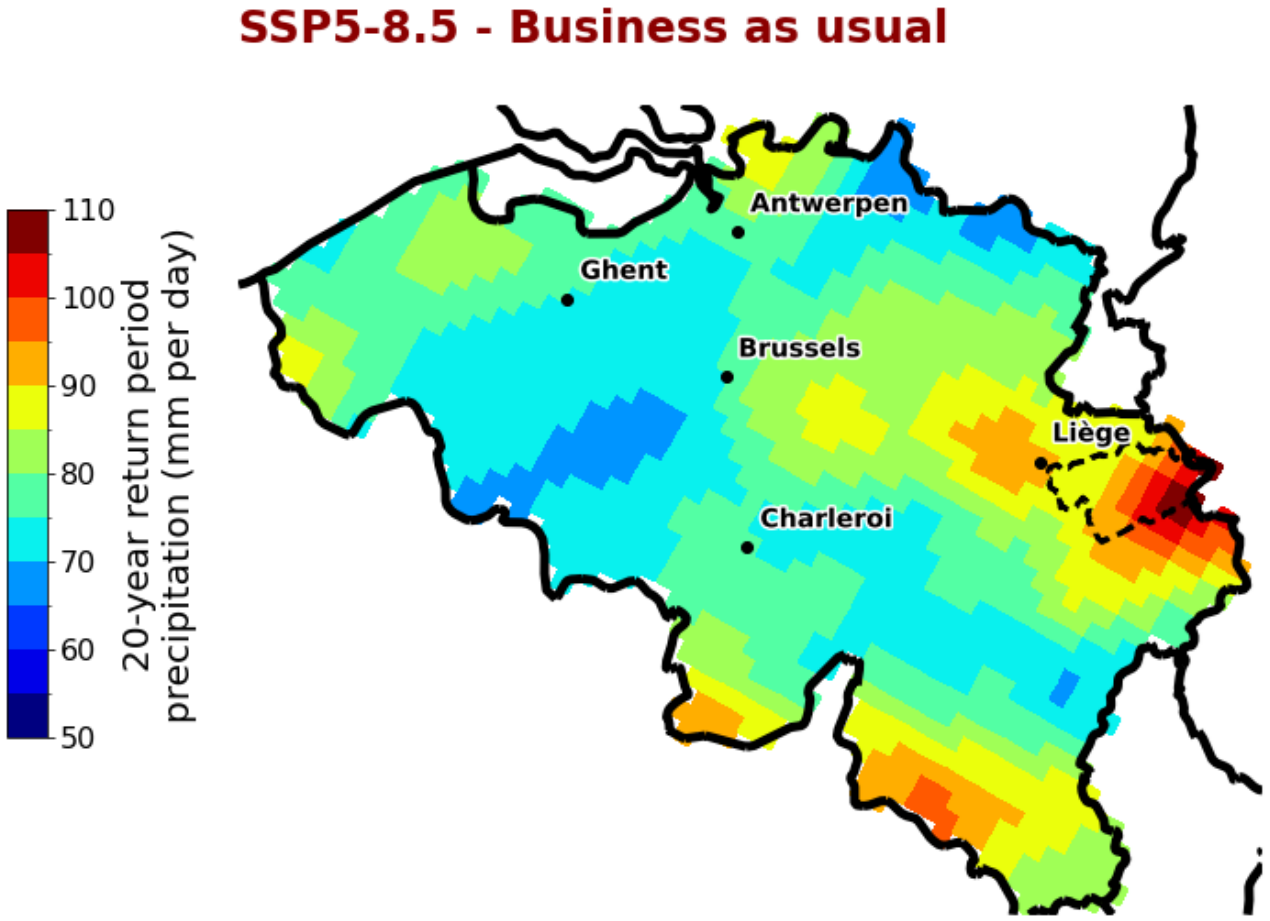
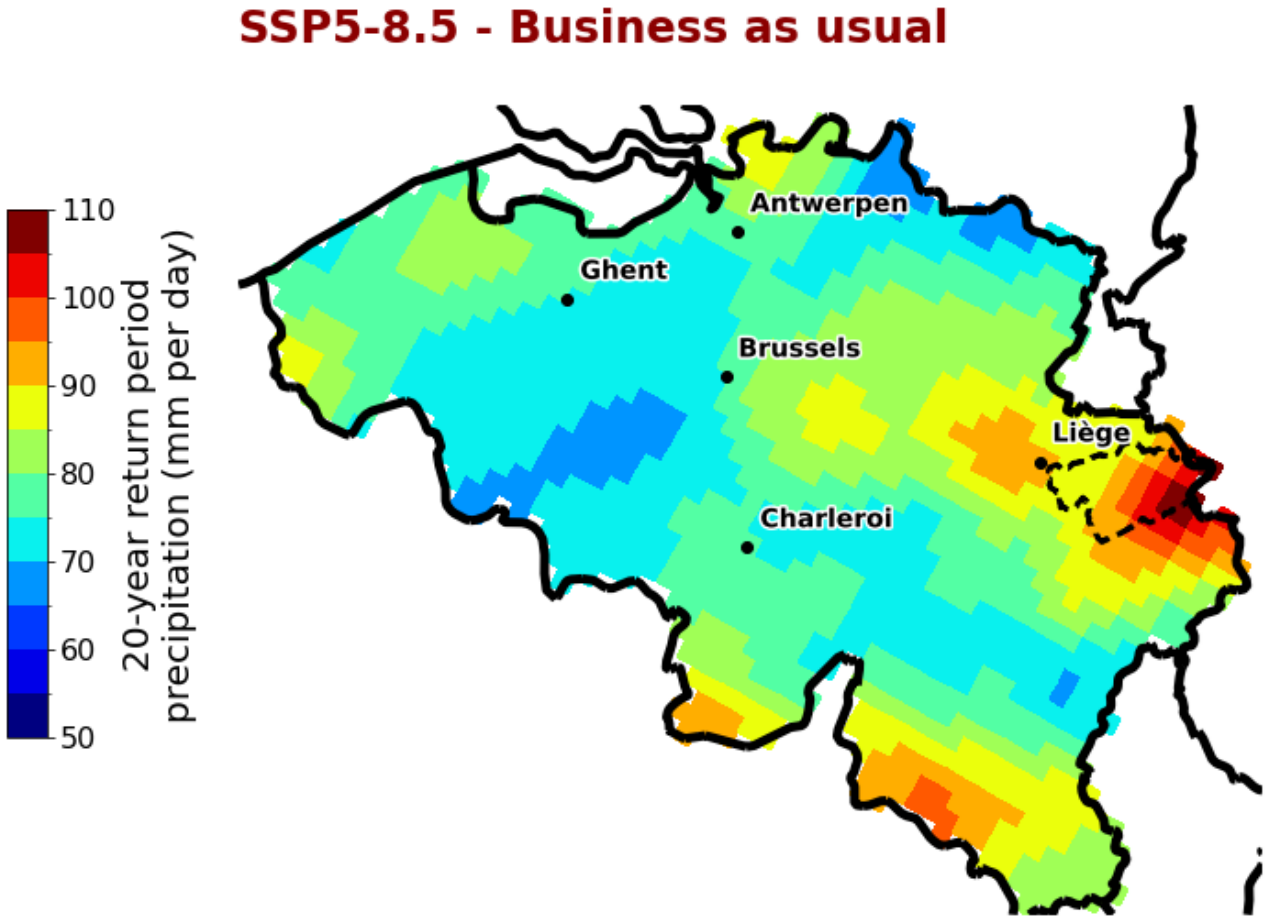


(Brajkovic et al., 2025)

- Based on 6 downscaled IPCC model projections (2015-2100)
- Regional Climate Model MAR

A bit of context...



(Brajkovic et al., 2025)

- Based on 6 downscaled IPCC model projections (2015-2100)
- Regional Climate Model MAR
- **~7% intensity increase per degree of Global Warming**

A bit of context...

(Brajkovic et al., 2025)

- Based on 6 downscaled IPCC model projections
- Regional Climate Model MAR

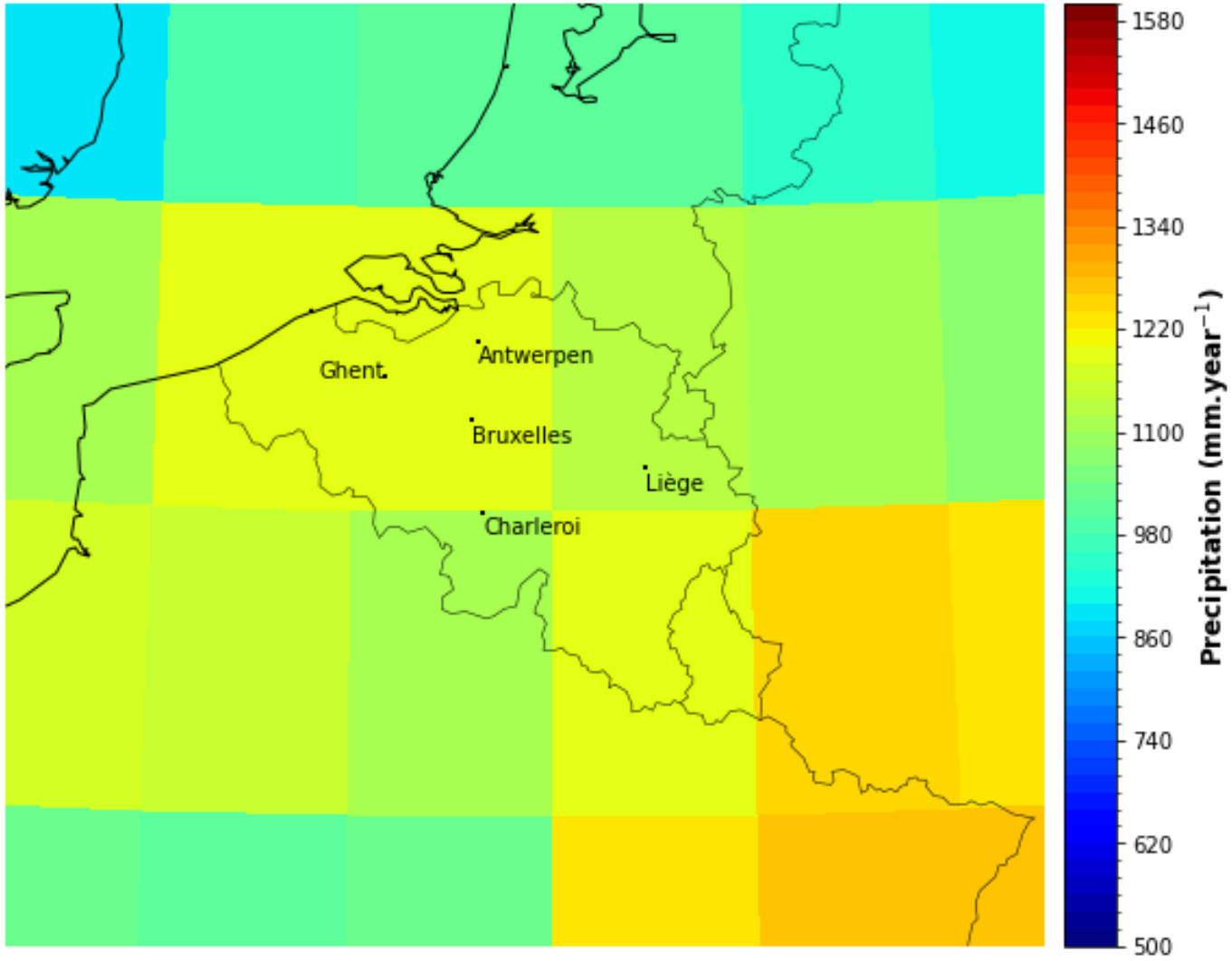
How will Belgian rivers react to these changes ?

Part 2

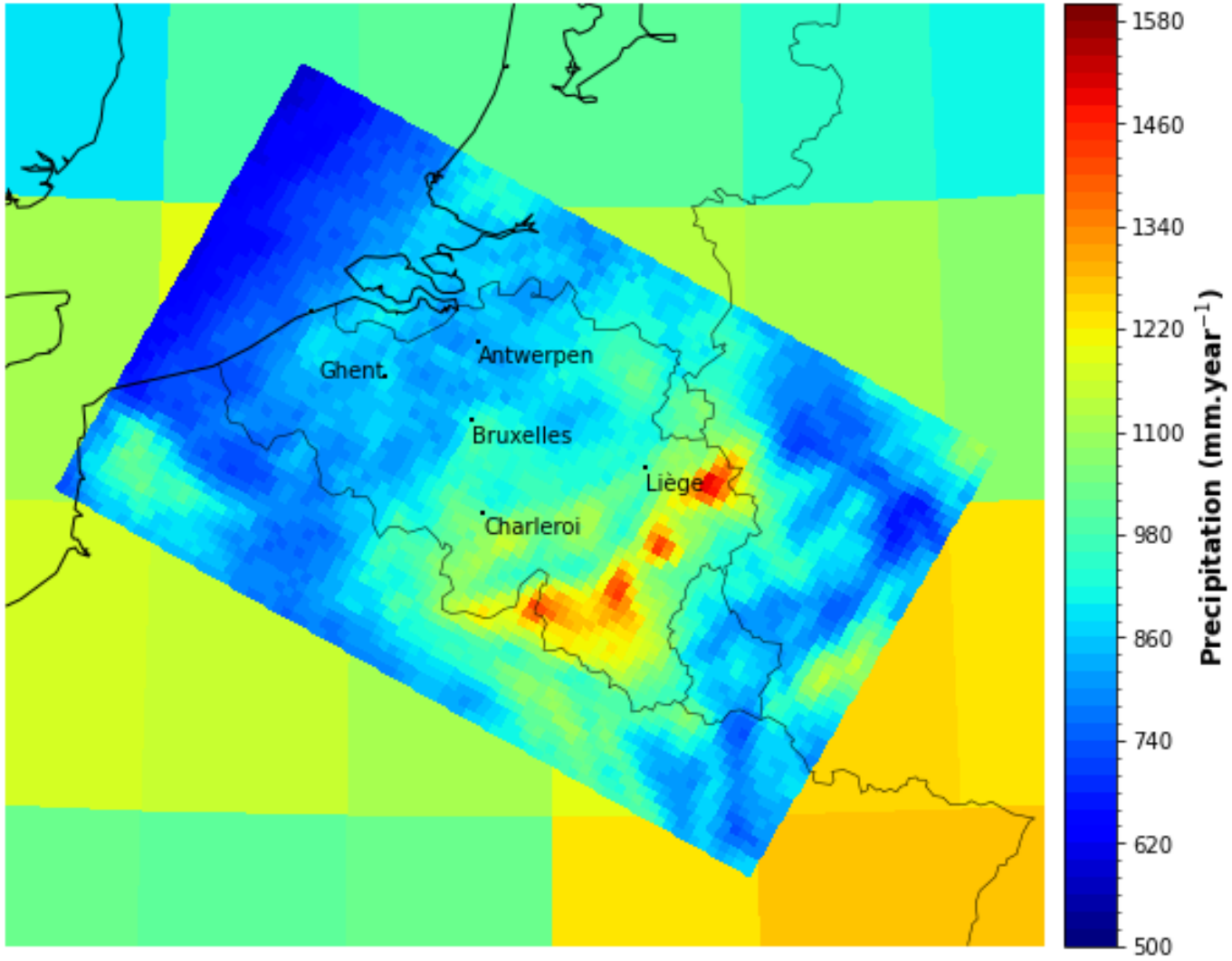
Input datasets

IPCC model projections (2015-2100)

Earth System Models (ESMs)

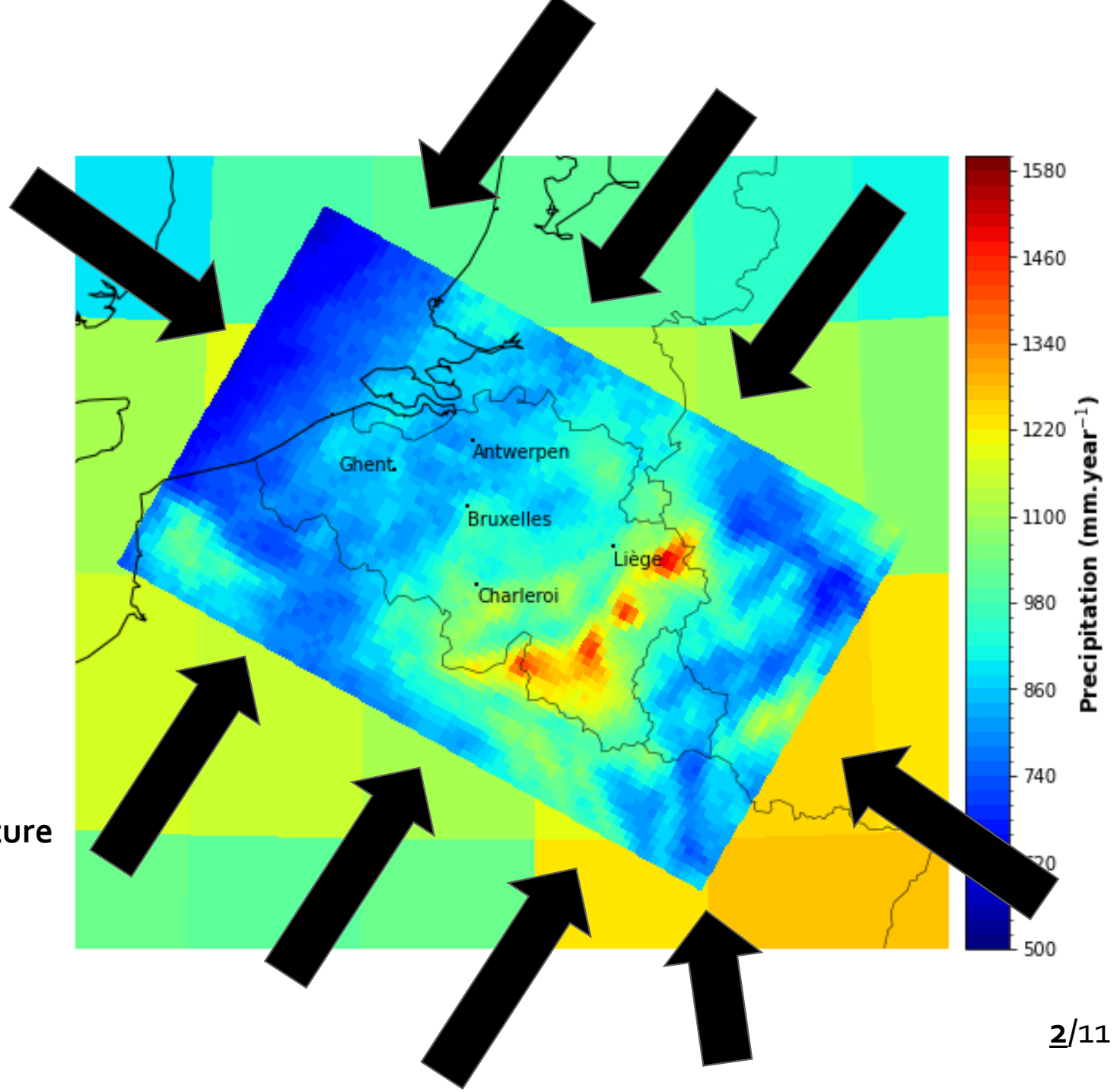


MAR Model
(Modèle atmosphérique régional)



MAR Model (Modèle atmosphérique régional)

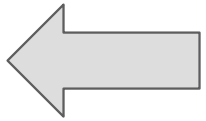
5-km resolution



Pressure
Temperature
Humidity
Winds

Input datasets:

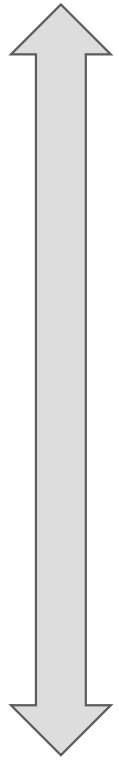
Forcing datasets	Model name	Periods
ERA5 Reanalyses (Observations)	MAR-ERA5	1940-2023



Climate reconstruction

Input datasets:

Forcing datasets	Model name	Periods
ERA5 Reanalyses (Observations)	MAR-ERA5	1940-2023
MPI-ESM1-2-HR	MAR-MPI	1981-2014 2015-2100 (4 scenarios)
IPSL-CM6A-LR	MAR-IPSL	Same
EC-Earth3-Veg	MAR-EC3	Same
MIROC6	MAR-MIR	Same
CMCC-CM2-SR5	MAR-SR5	Same
NorESM2	MAR-NOR	Same



Projections

Input datasets:

Forcing datasets	Model name	Periods
ERA5 Reanalyses (Observations)	MAR-ERA5	1940-2023
MPI-ESM1-2-HR	MAR-MPI	1981-2014 2015-2100 (4 scenarios)
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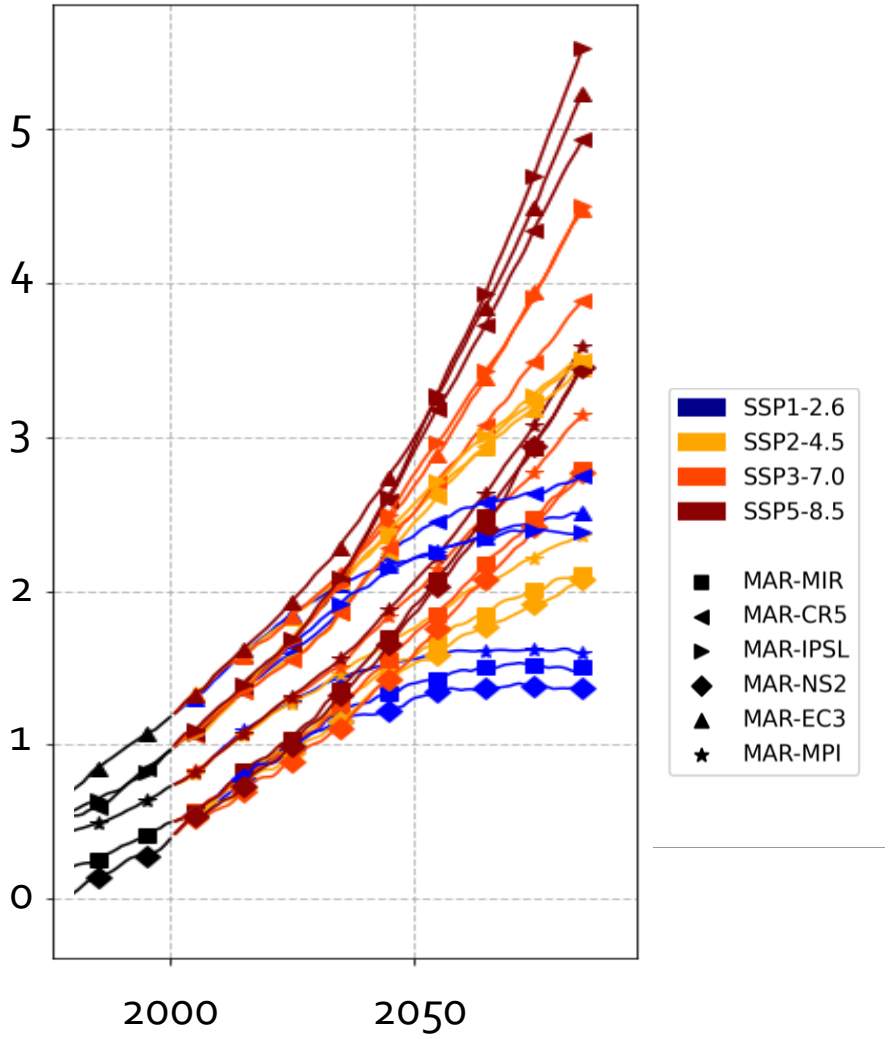
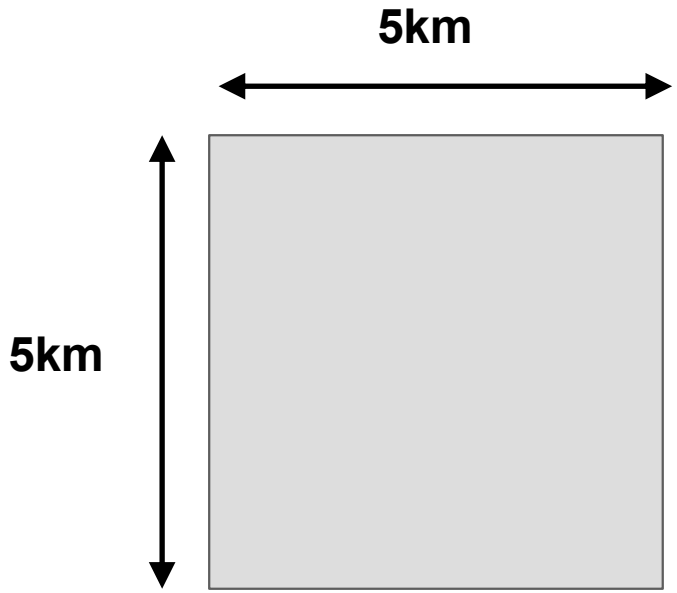
CMCC-CM2-SR5	MAR-SR5	Same
NorESM2	MAR-NOR	Same

GMST anomaly (K)
(ref: 1850-1899)

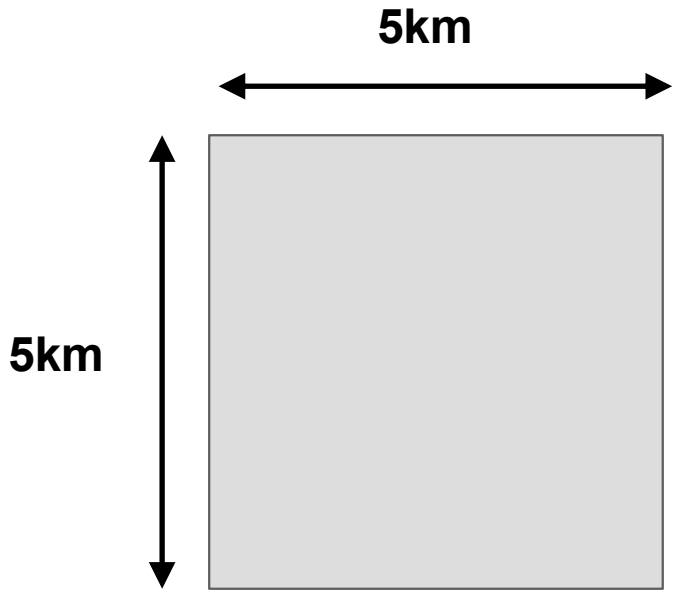


With this dataset we get, for each pixel



- **Hourly time series of various climate variables (Precip, Temperatures, Sea level pressure…)**

With this dataset we get, for each pixel

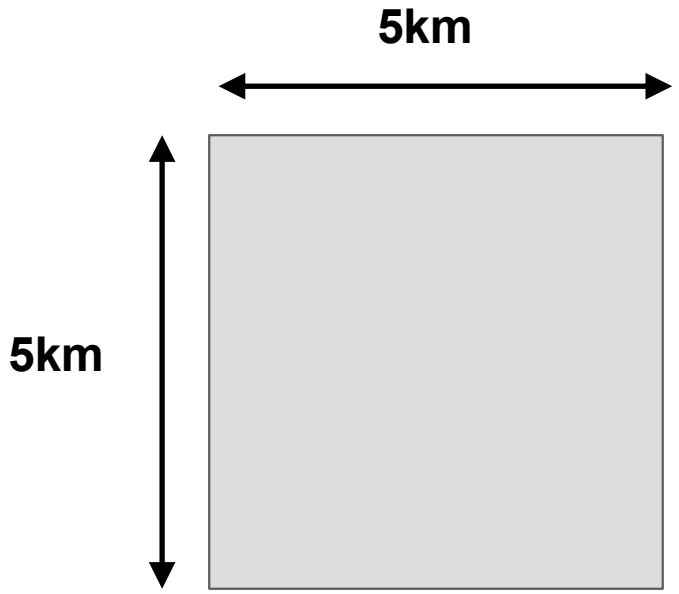


- **Hourly time series of various climate variables (Precip, Temperatures, Sea level pressure…)**
- **For various periods :**

Climate reconstitution : **MAR-ERA5**

1940 2023

With this dataset we get, for each pixel



- **Hourly time series of various climate variables (Precip, Temperatures, Sea level pressure…)**
- **For various periods :**

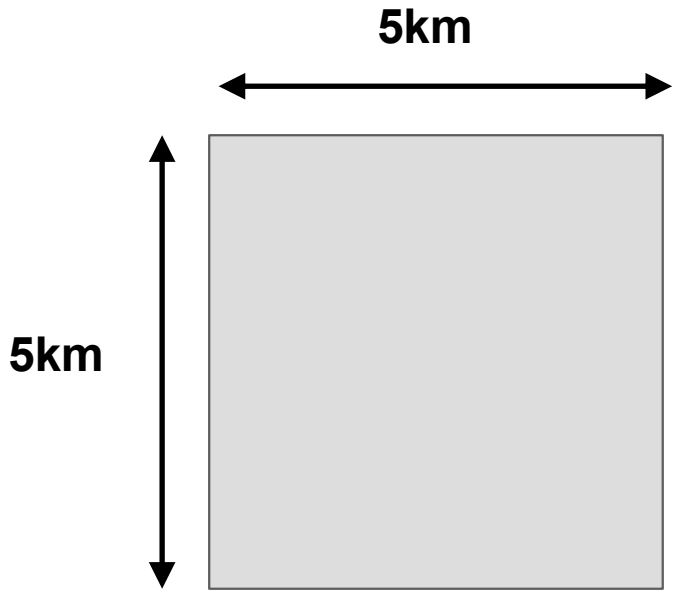
Climate reconstitution : **MAR-ERA5**

1940 2023

Climate projections : MAR forced by **6ESMs** **under 4 scenarios**

2015 ..... **2100**

With this dataset we get, for each pixel



- **Hourly time series of various climate variables (Precip, Temperatures, Sea level pressure…)**
- **For various periods :**

Climate reconstitution : **MAR-ERA5**

Historical runs : **for each ESM**

Climate projections : MAR forced by **6ESMs** **under 4 scenarios**

Part 3

Hydrological Modelling

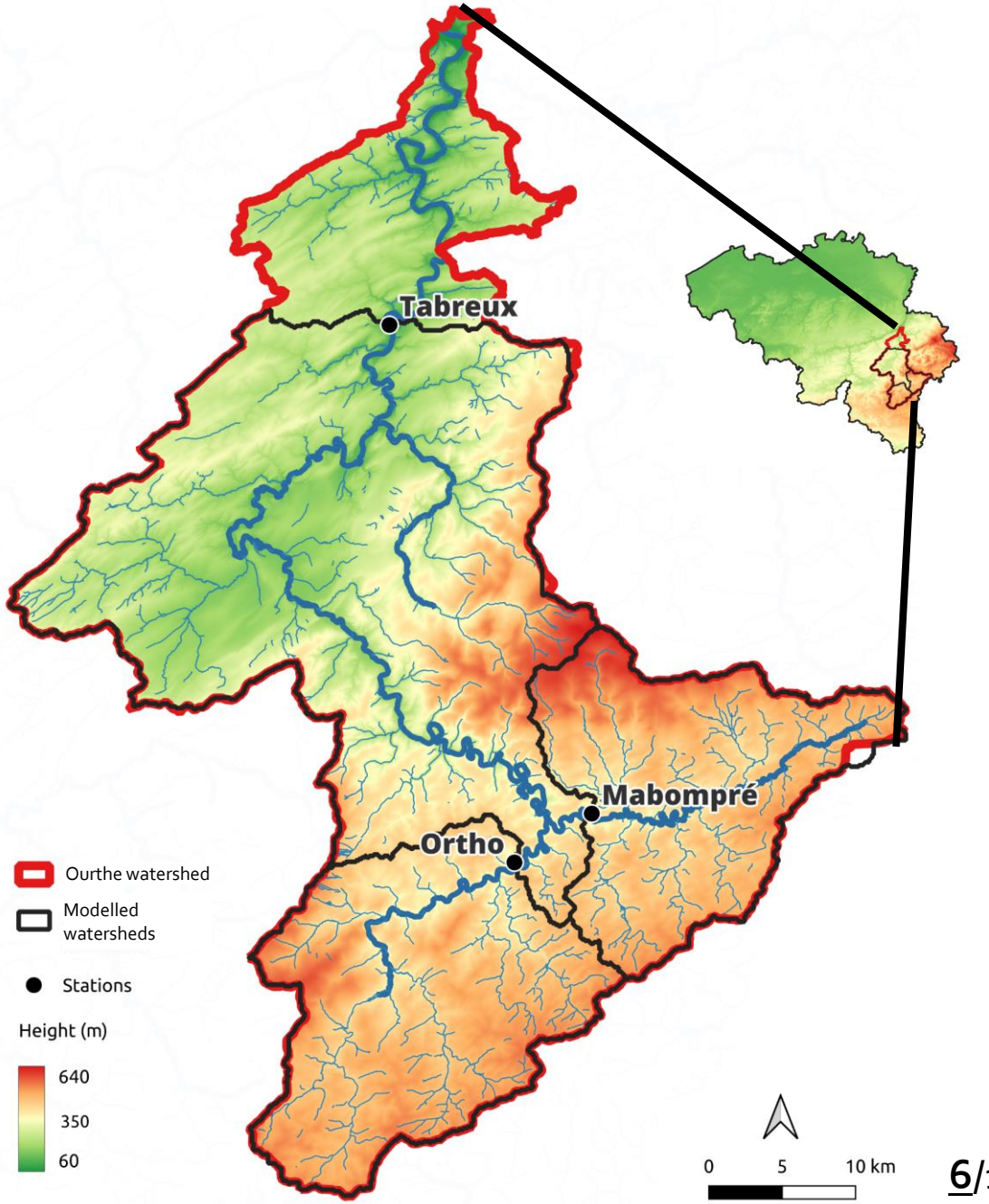
WOLFhece package :

- **Python package (Windows)**
- **User interface**
- **Hydrological/hydraulic modelling**

⟶ Direct Downloading of observational data from web services

⟶ Definition of the modelling domain (watershed)

⟶ Optimization of the model (Monte-carlo procedure)


Tabreux
Mabompré
Ortho
Ourthe watershed
Modelled watersheds
Stations
Height (m)
640
350
60
0
5
10 km

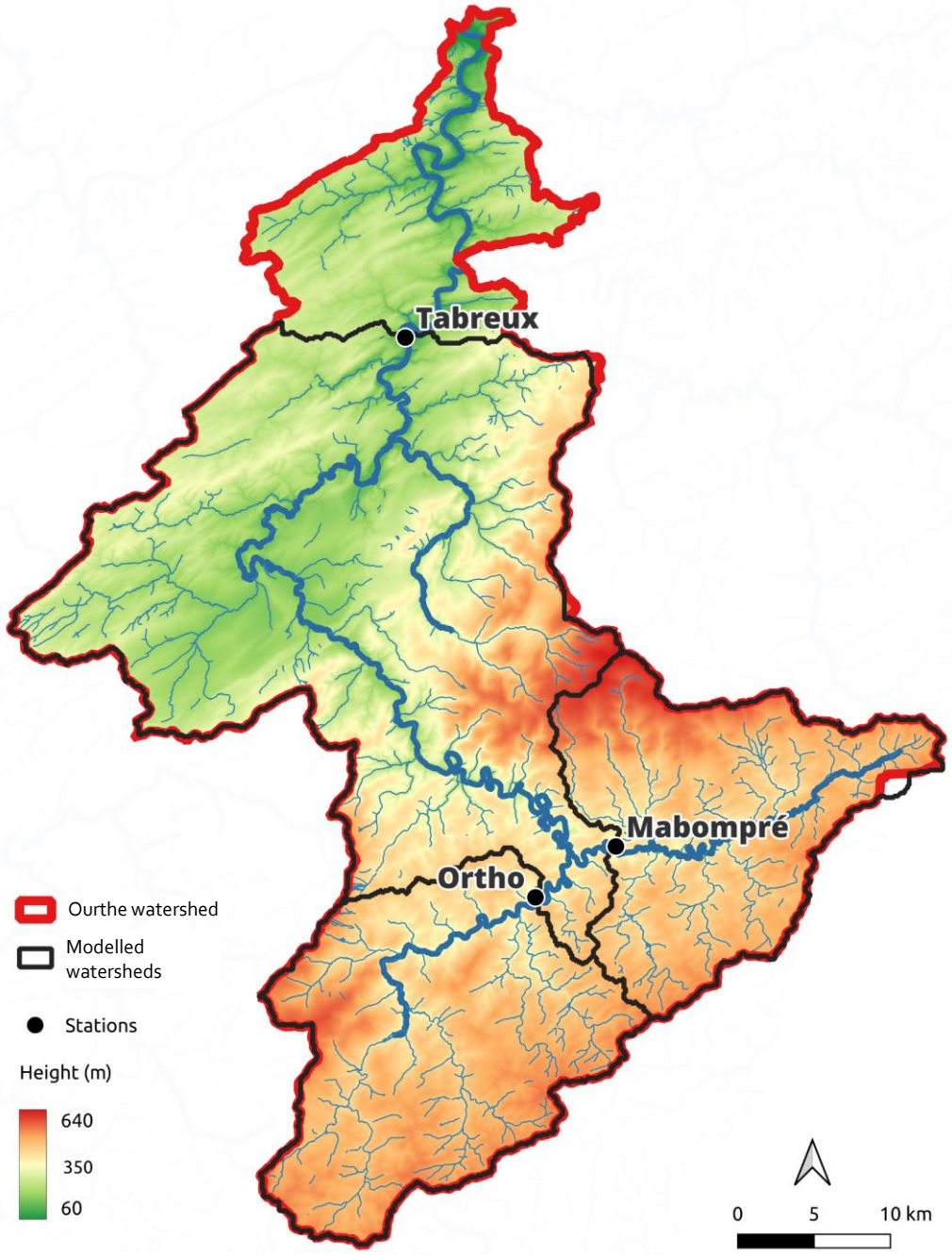
GR4H model – *Génie Rural 4 paramètres horaire*

X1 – Maximum capacity of the production reservoir (mm)

X2 – Groundwater exchange coefficient (dimensionless)

X3 – Maximum capacity of the routing reservoir (mm)

X4 – Base time of the routing function (hours)



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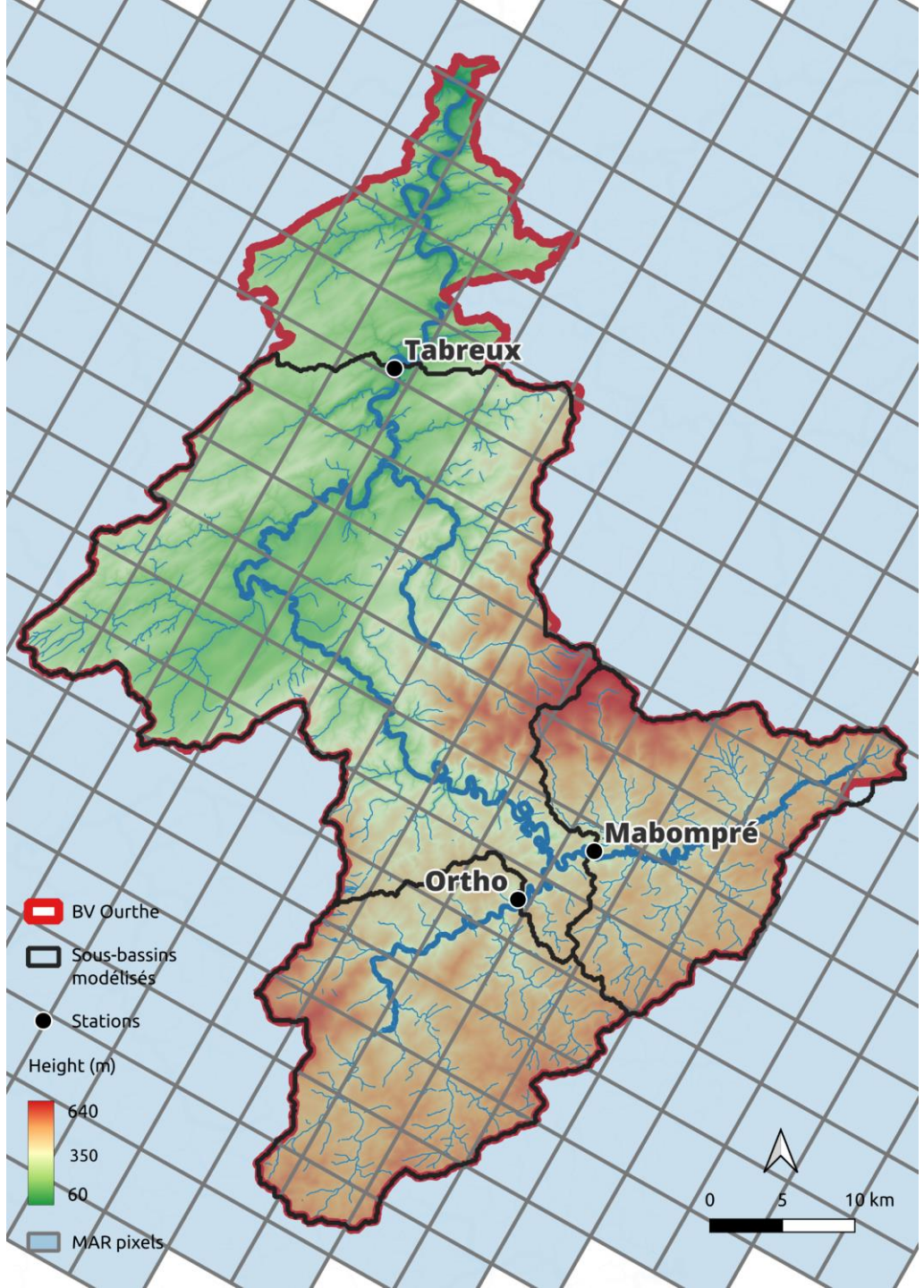
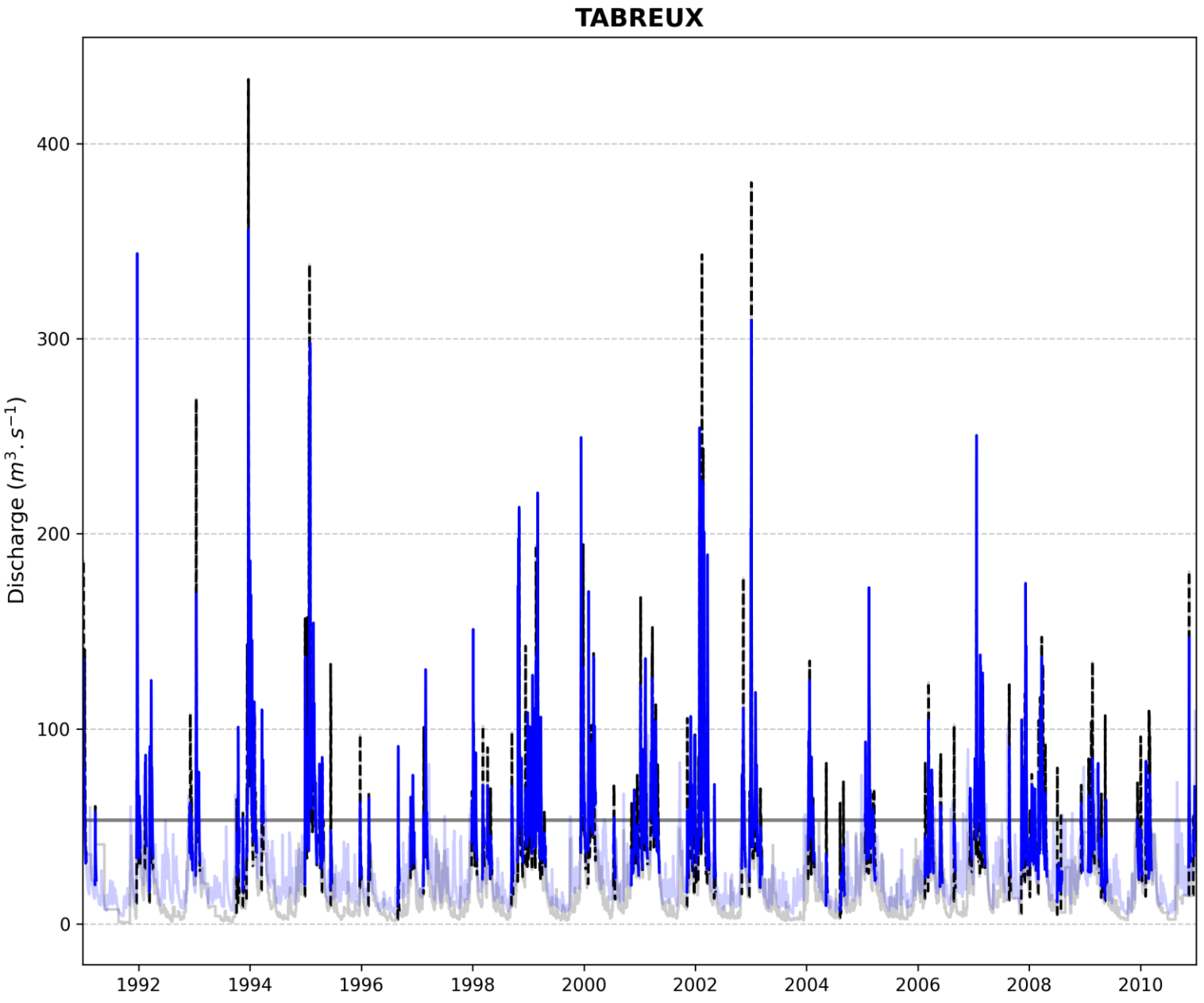




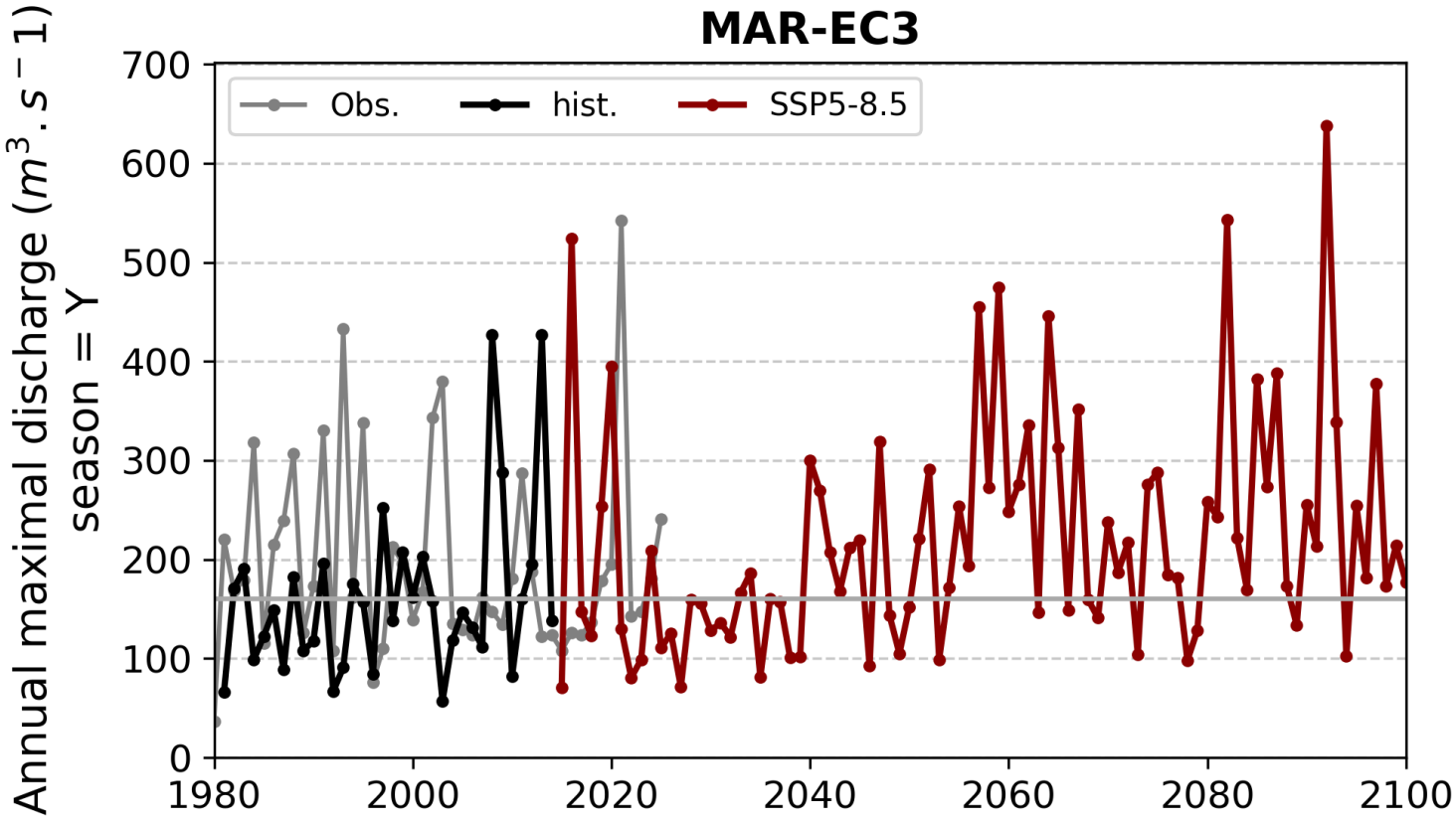
- **NSE : Nash-Sutcliffe performance criterion**

→-1 = really bad
→ 1 = as good as observed

- **MBE : Mean bias**

- **mw24h : moving 24-hour window**

Hydroclimatic projections



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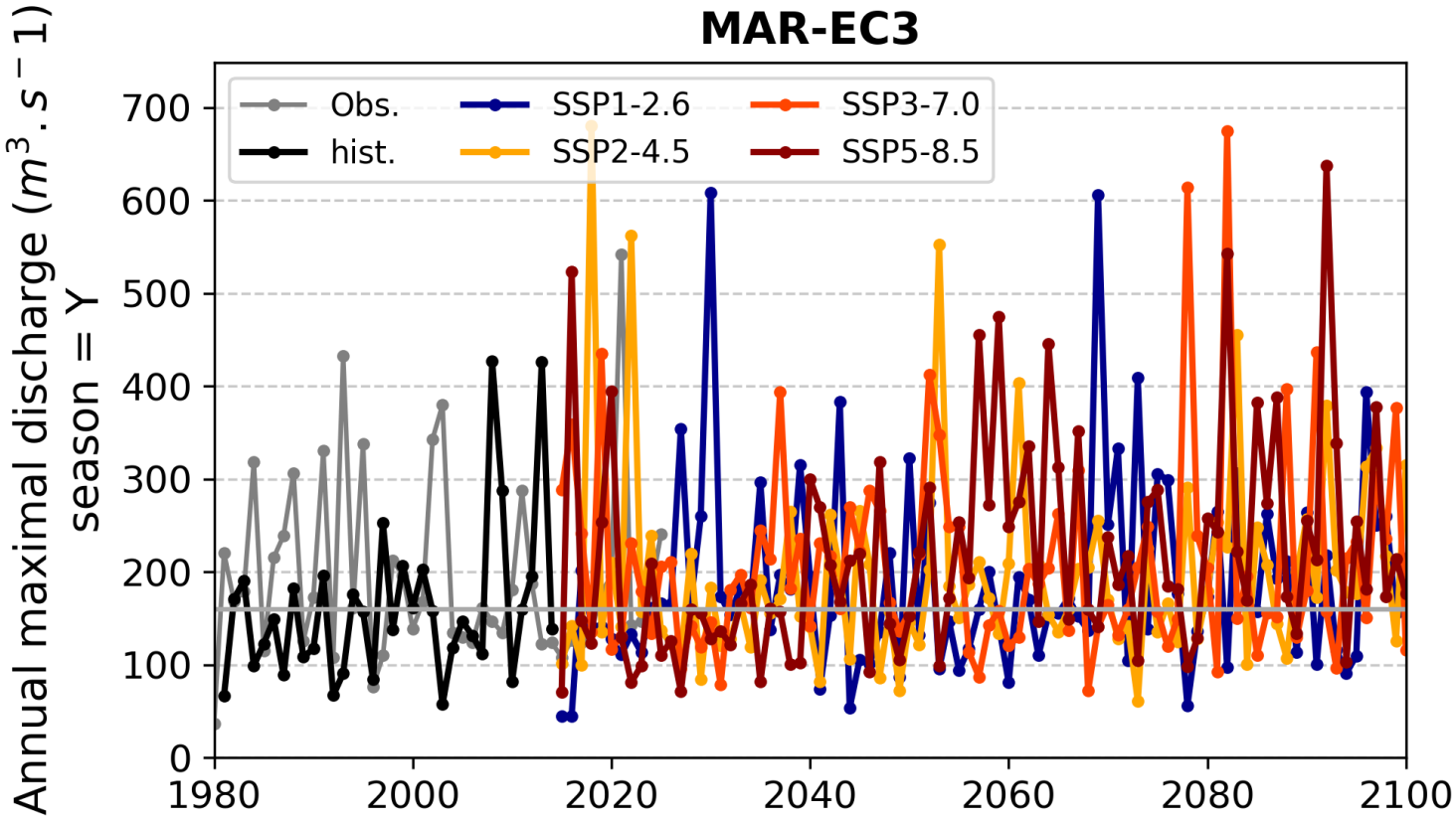

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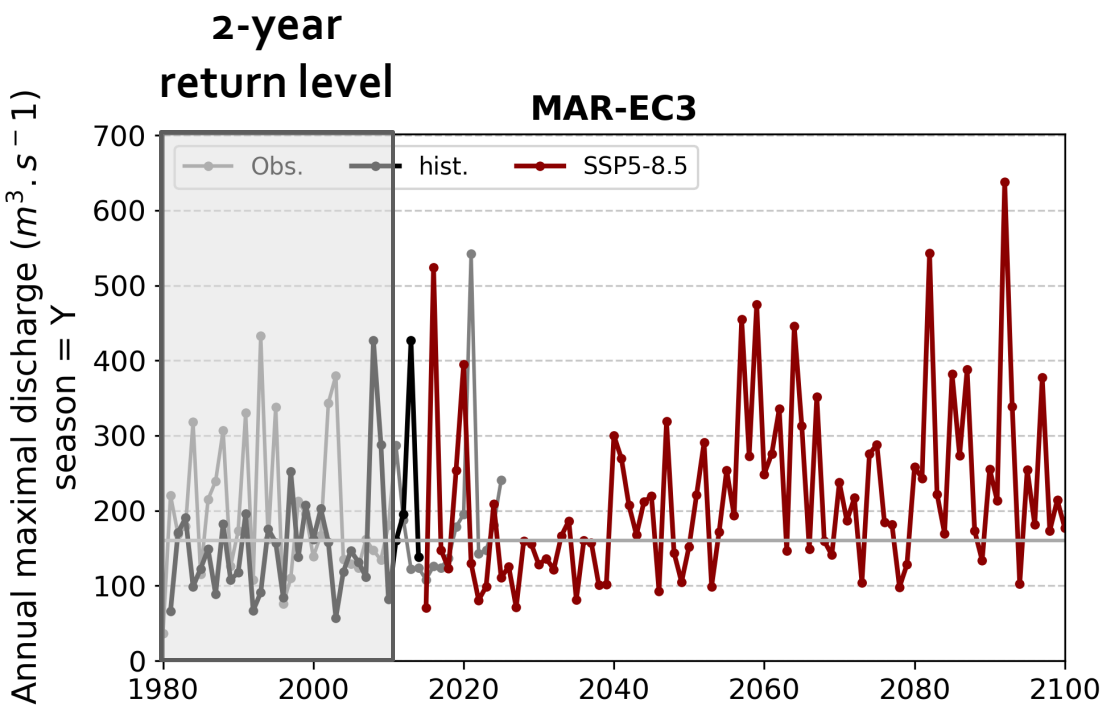

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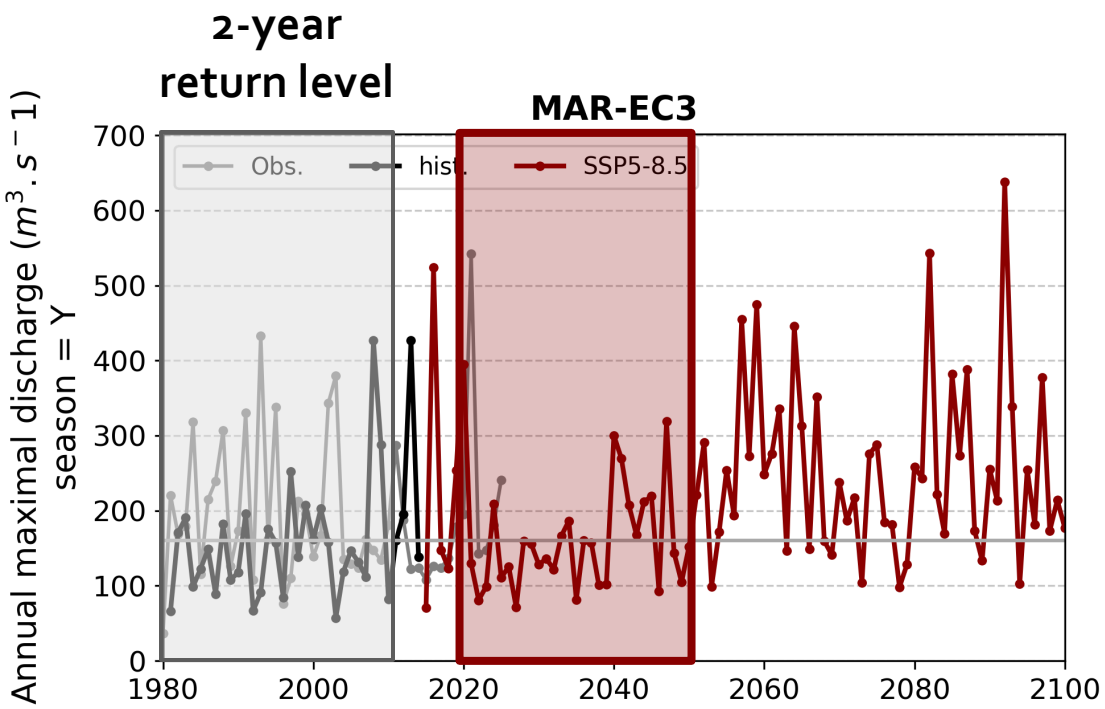

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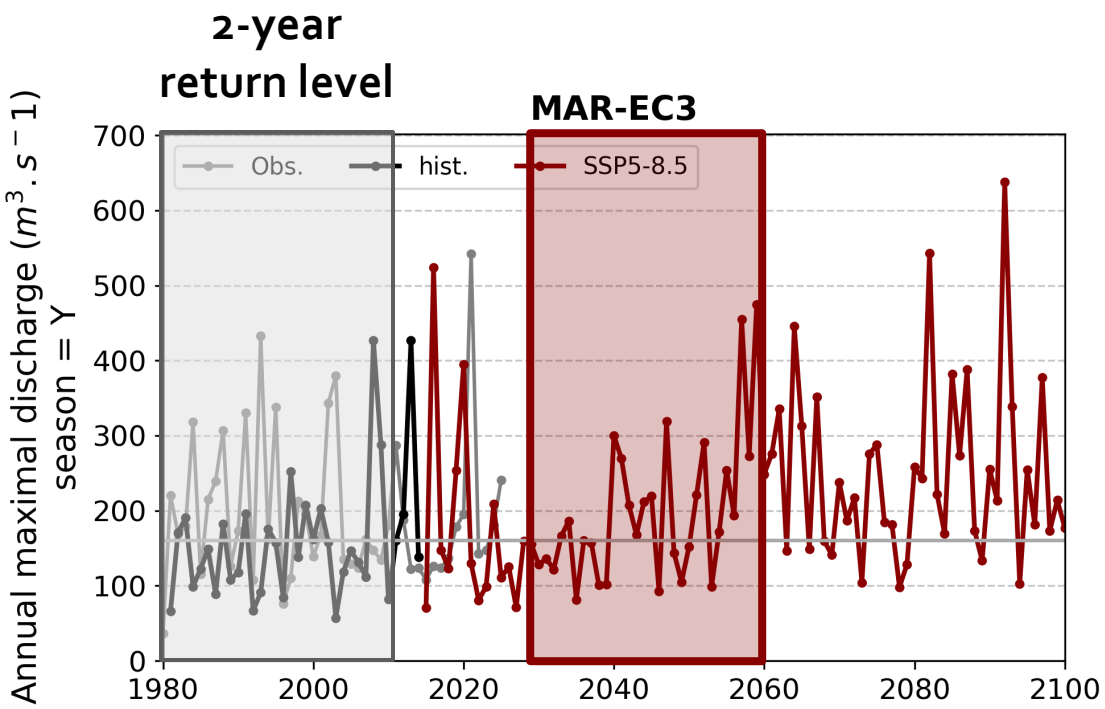

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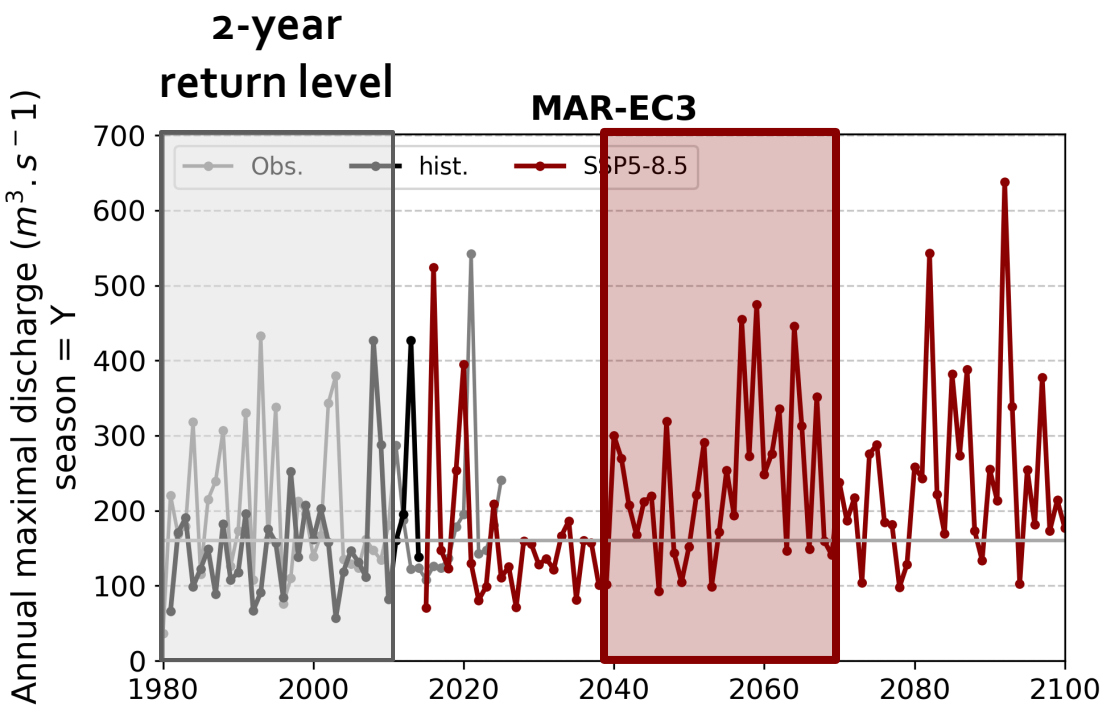

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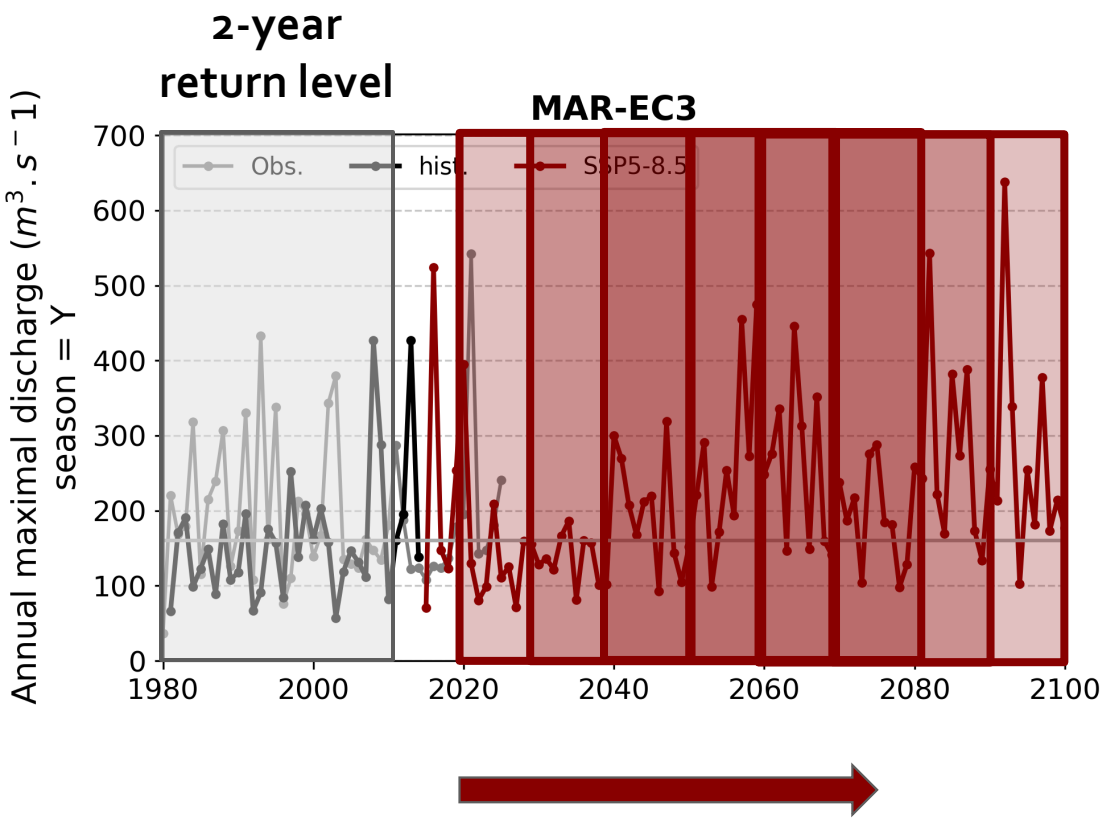

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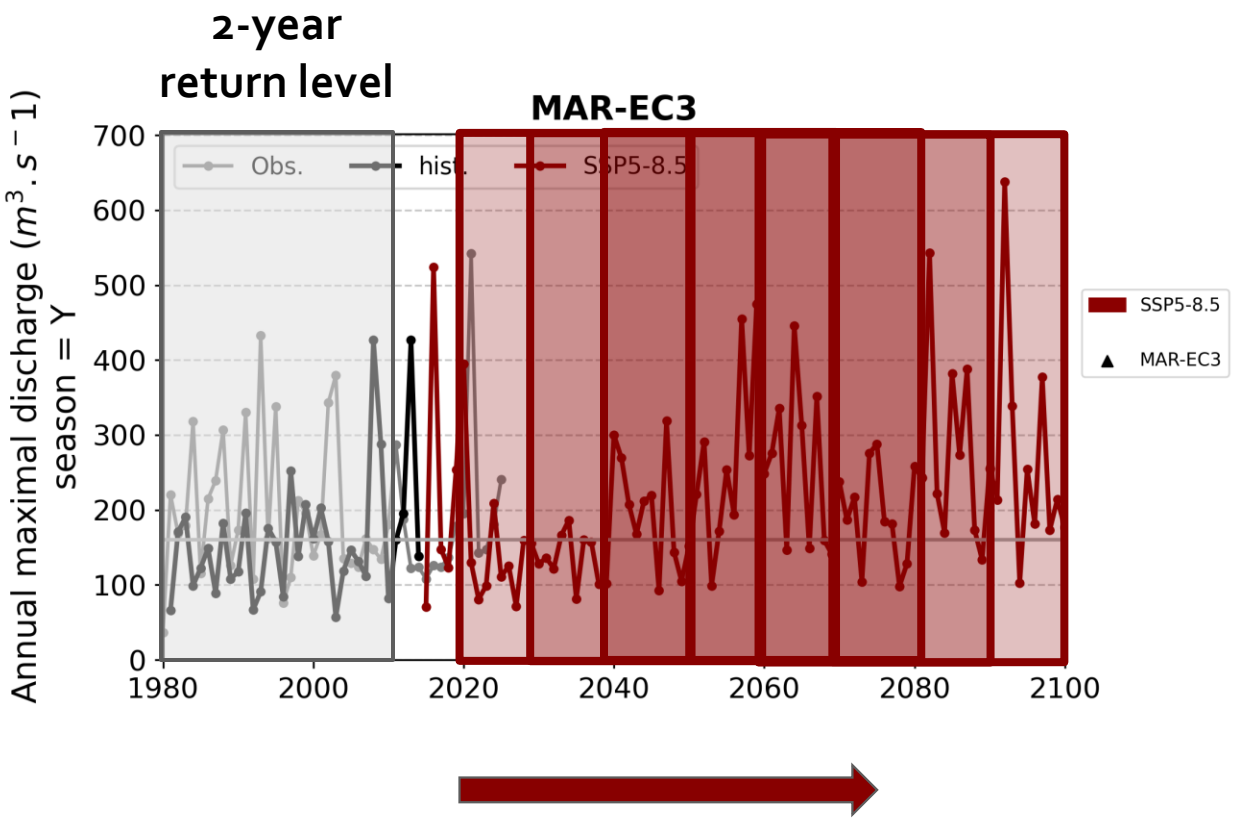
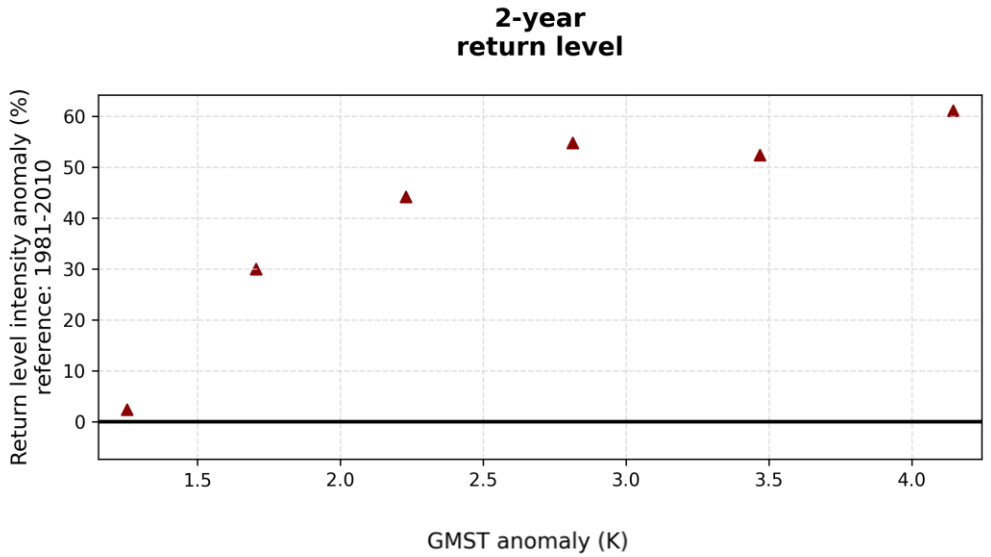


30-year moving window
(10-year step)



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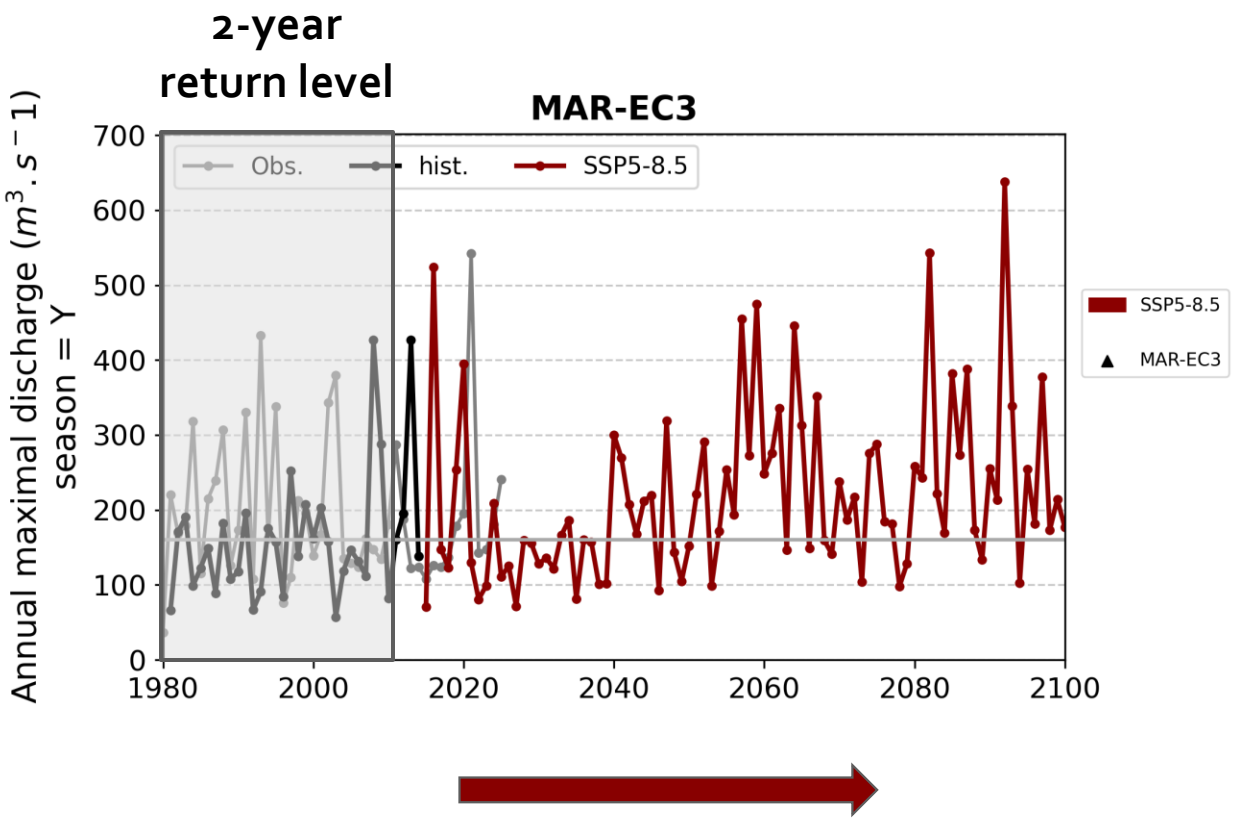

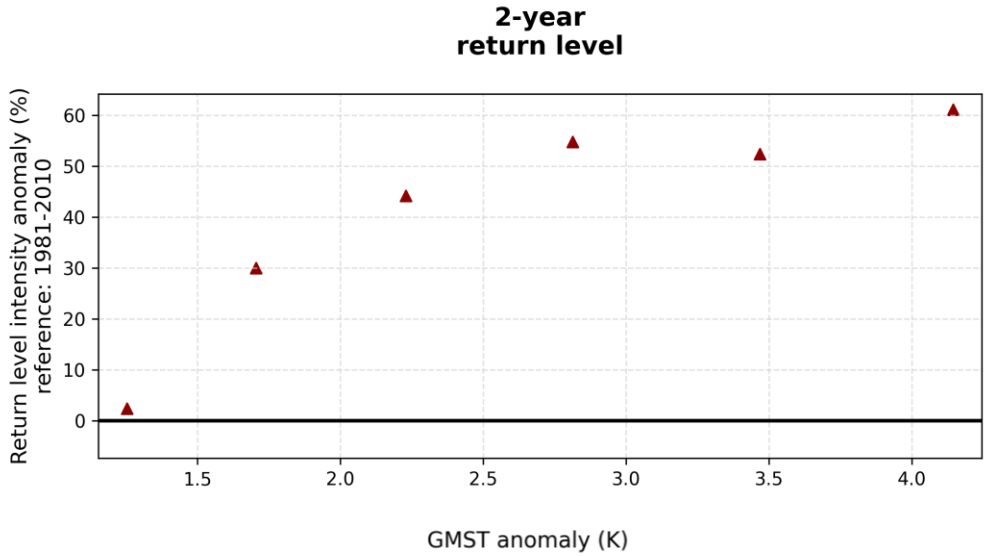

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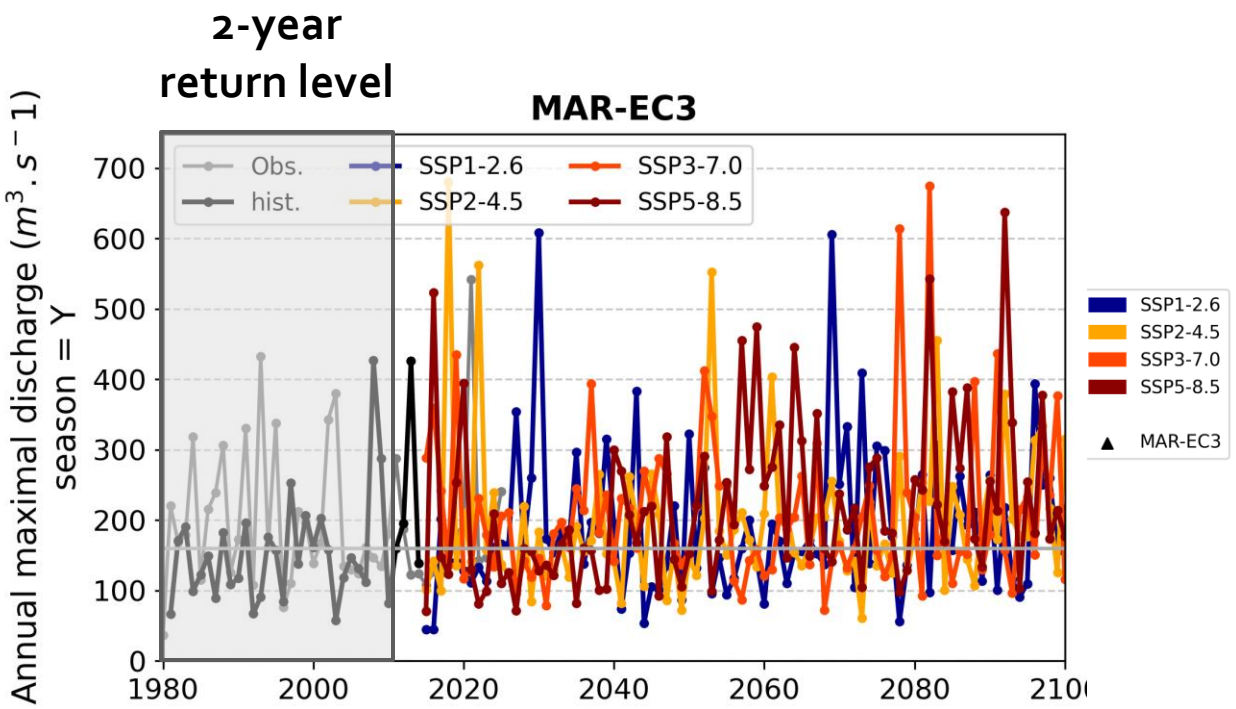

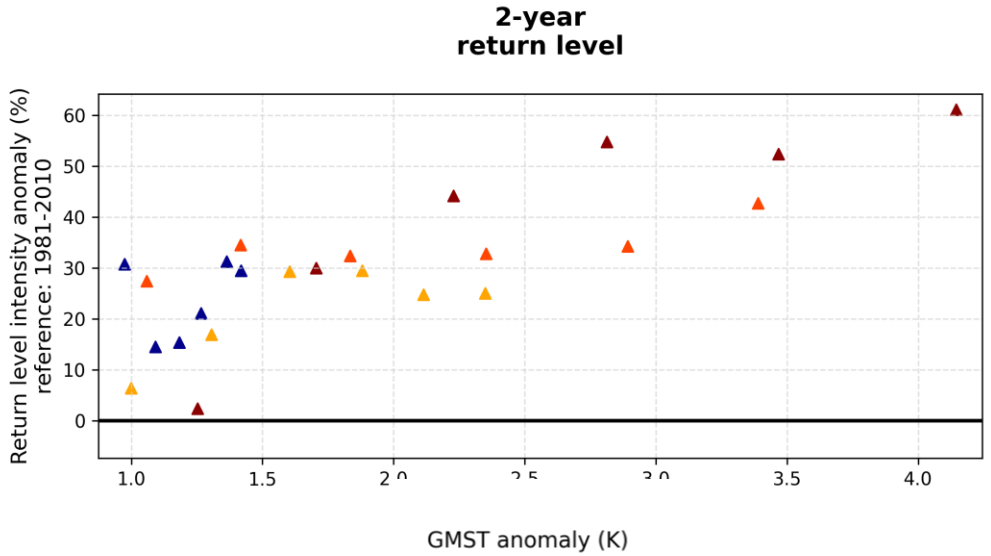

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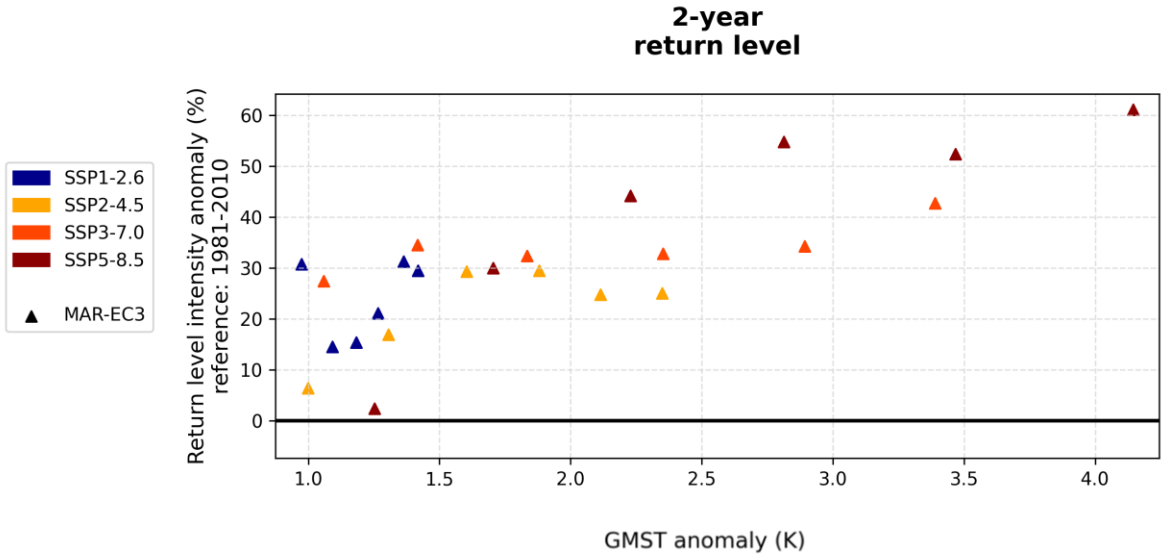

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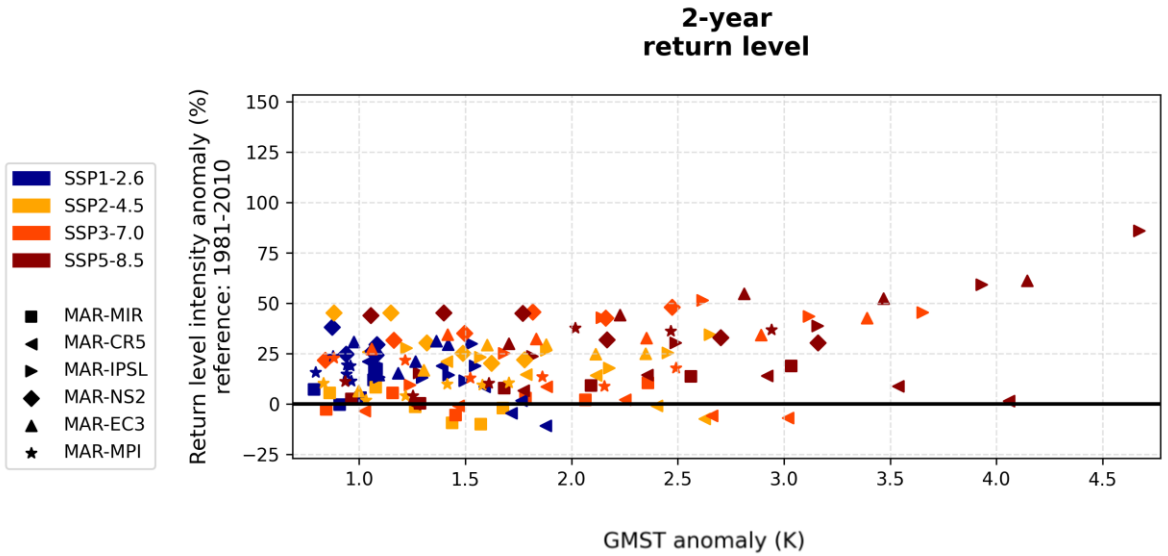

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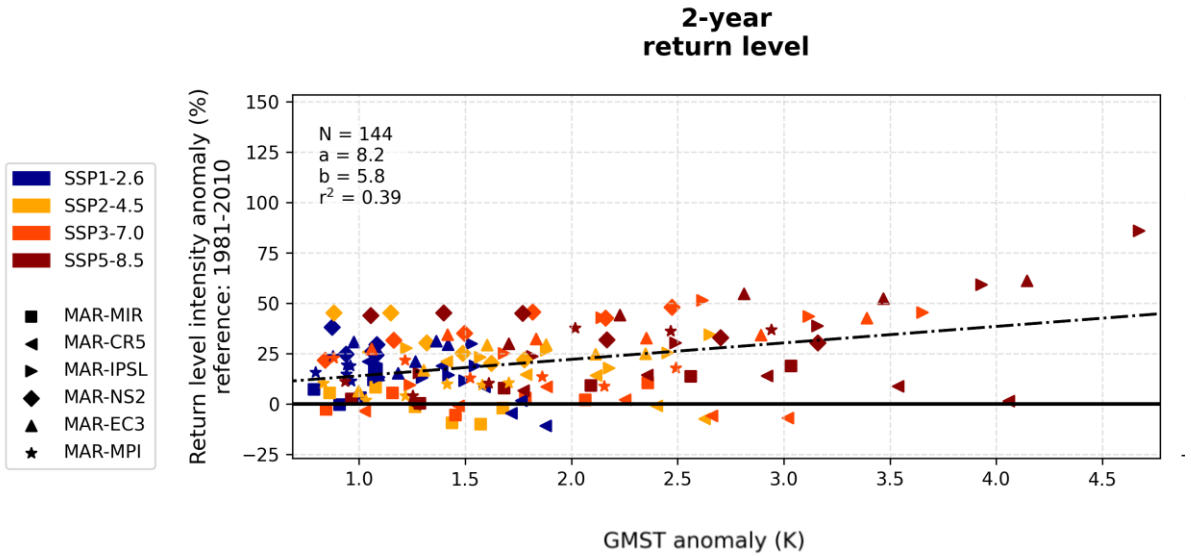

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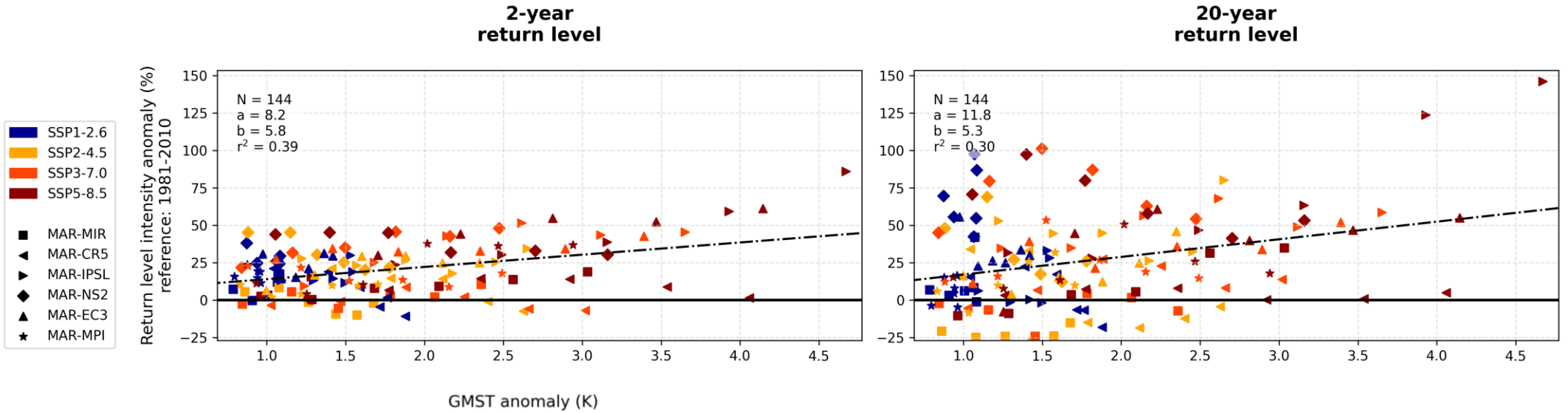

Take-home message

- **Discharge response is non-linear and strongly modulated by natural variability**
- Extreme events emerge irregularly in time, not progressively
- Framework can be adapted to any Cordex-Be.2 outputs and to any watershed

Paper reference : Brajkovic, J., Fettweis, X., Noël, B., Vyver, H. V. D., Ghilain, N., Archambeau, P., Pirotton, M., and Doutreloup, S. (2025). Increased intensity and frequency of extreme precipitation events in Belgium as simulated by the regional climate model MAR. Journal of Hydrology: Regional Studies, 59:102399.

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CORDEX.be II

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