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A Bayesian Network for extreme river discharges in Europe

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RAIN PROJECT

Background

- Project "*Risk Analysis of Infrastructure Networks in response to extreme weather*" is aiming to provide an operational analysis framework that identifies critical infrastructure components impacted by extreme weather events and minimise the impact of these events on the EU infrastructure network.
- The project includes a "hazard identification" work package. Our group is analysing return periods and extents of river floods and coastal floods in EU countries under present and future climate.

RAIN PROJECT

http://rain-project.eu/

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 608166

This project is funded by the European Union

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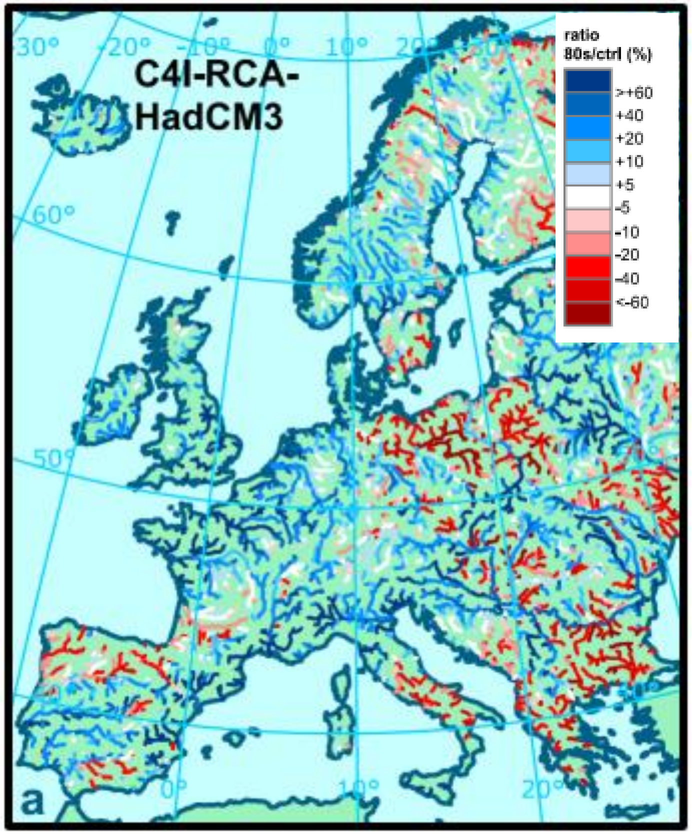
Calculating river discharges

- Rainfall-runoff models based on physical equations are used.
- They are computationally demanding
- Statistical models used for small applications

The rational equation:

$$Q = c \times i \times A$$

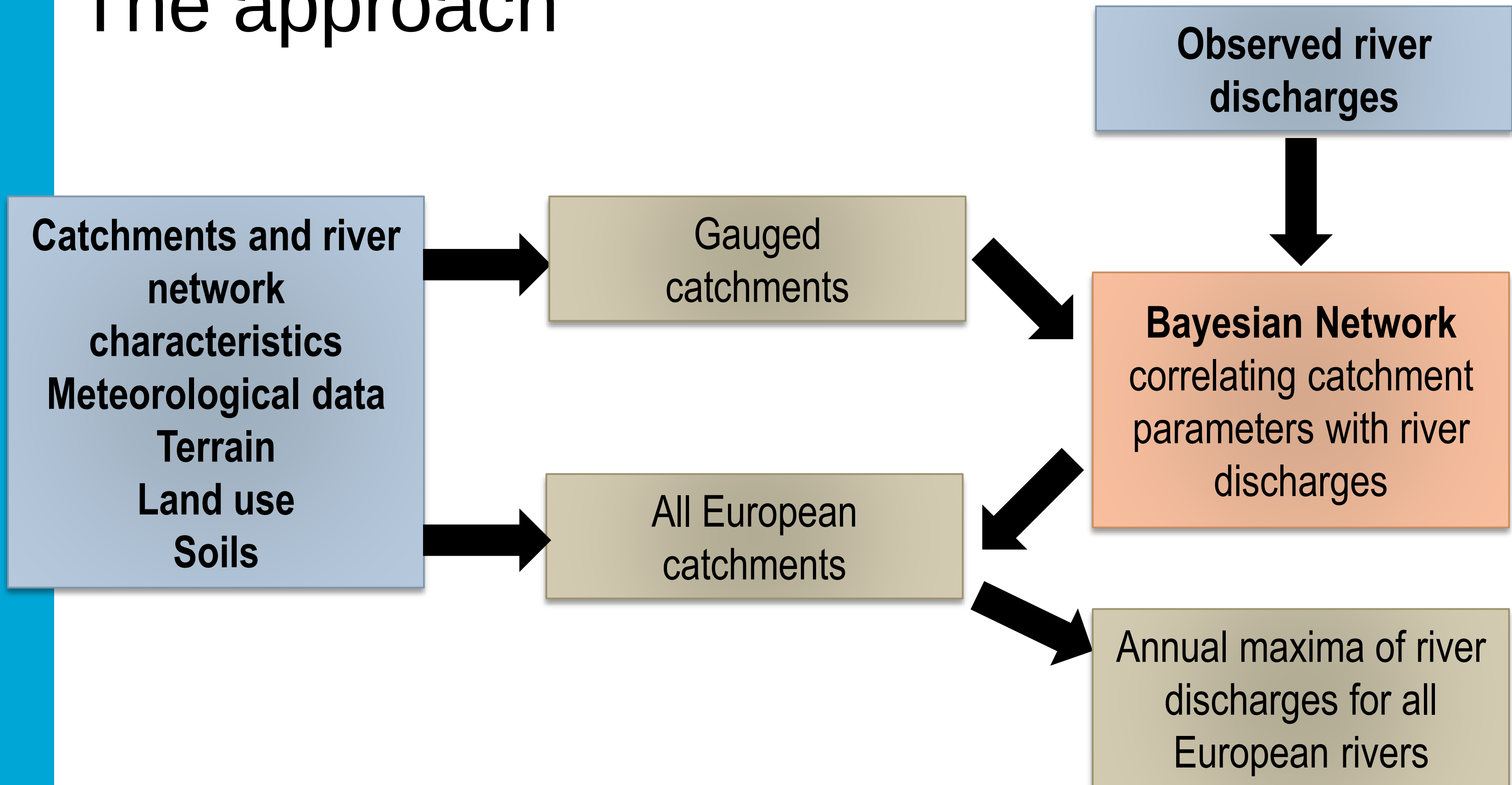
Q = peak discharge
c = runoff coefficient
i = rainfall intensity
A = drainage area



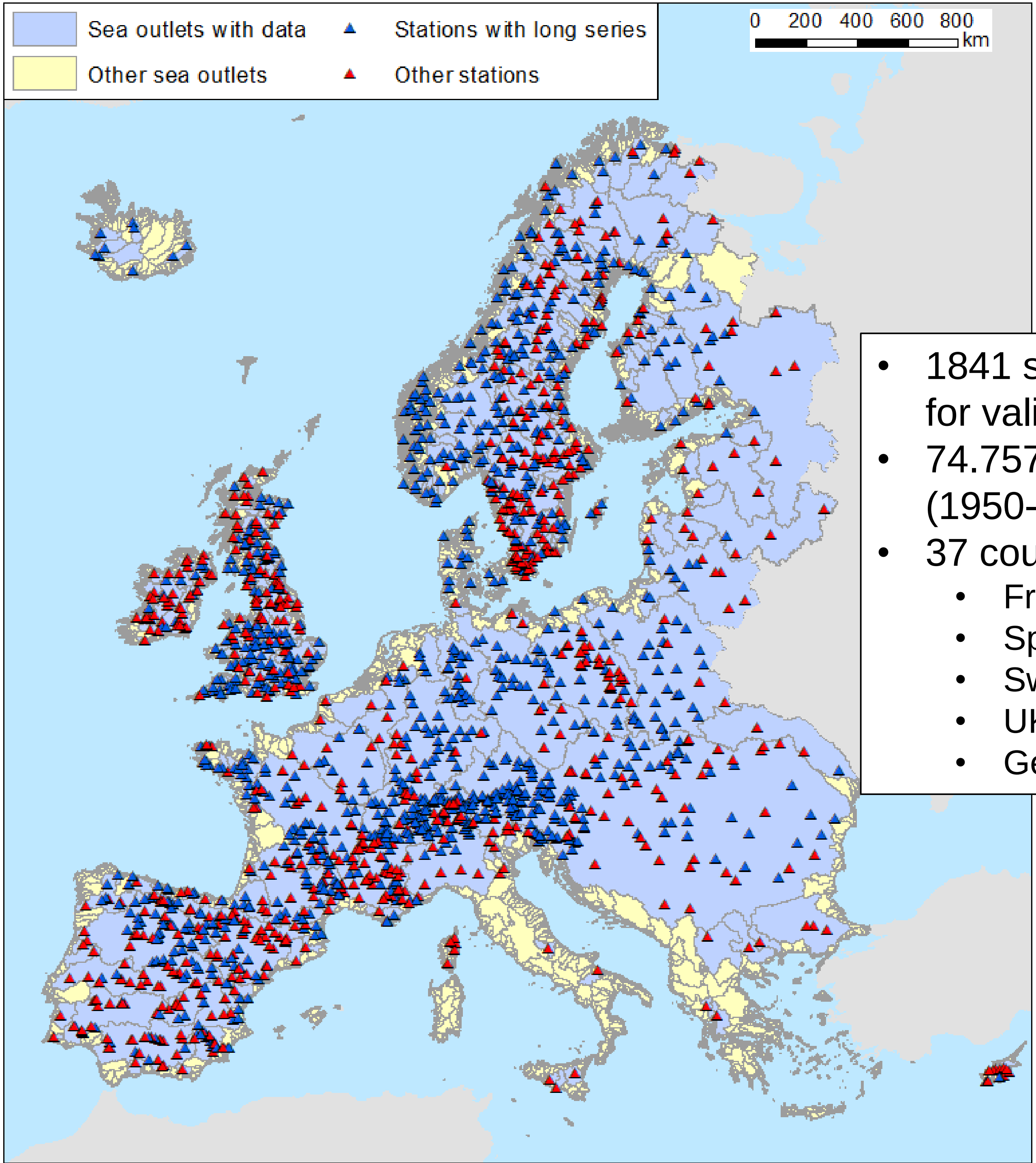
Rojas et al. (2012) J Geophys Res 117:D17109

Our approach: Bayesian Networks

The approach



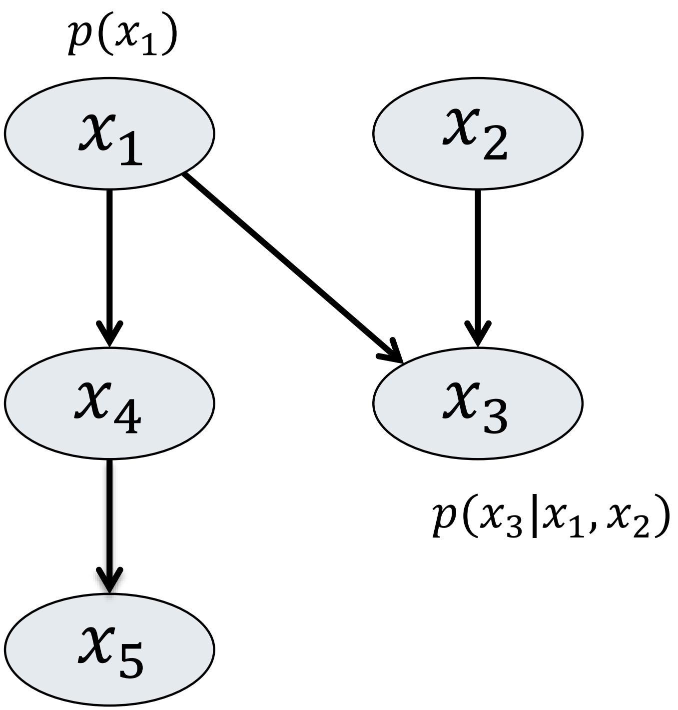
- CCM River and Catchment Database v2.1
- EU-DEM elevation model
- Corine Land Cover 2000
- Climate data from EURO-CORDEX simulations (EC-EARTH / COSMO-CLM models)
- Discharge data from Global Runoff Data Centre and national sources

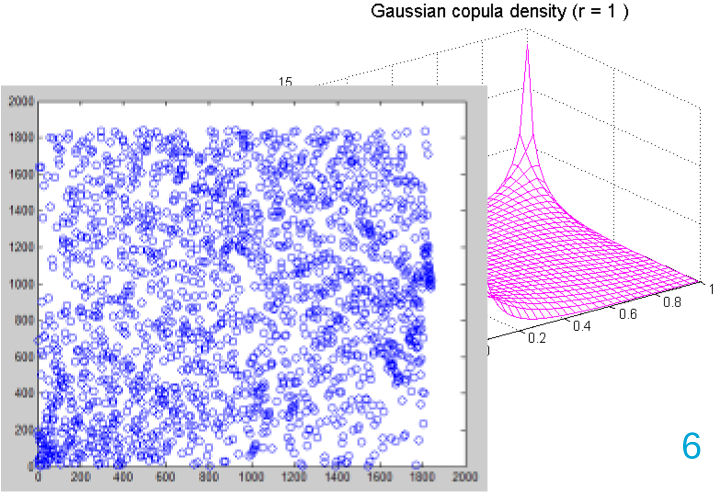


- 1841 stations (1125 for validation)
- 74.757 station-years (1950-2005)
- 37 countries
  - France 14%
  - Spain 14%
  - Sweden 14%
  - UK 12%
  - Germany 9%

The approach

- A probabilistic graphical model that encodes a set of random variables and their probabilistic interdependencies:
  - Nodes represent variables (river discharge and catchment parameters)
  - Links represent child-to-parent dependencies
  - The conditional probability distribution describes each node conditioned on its parents (in this case: normal/Gaussian copulas)





The model

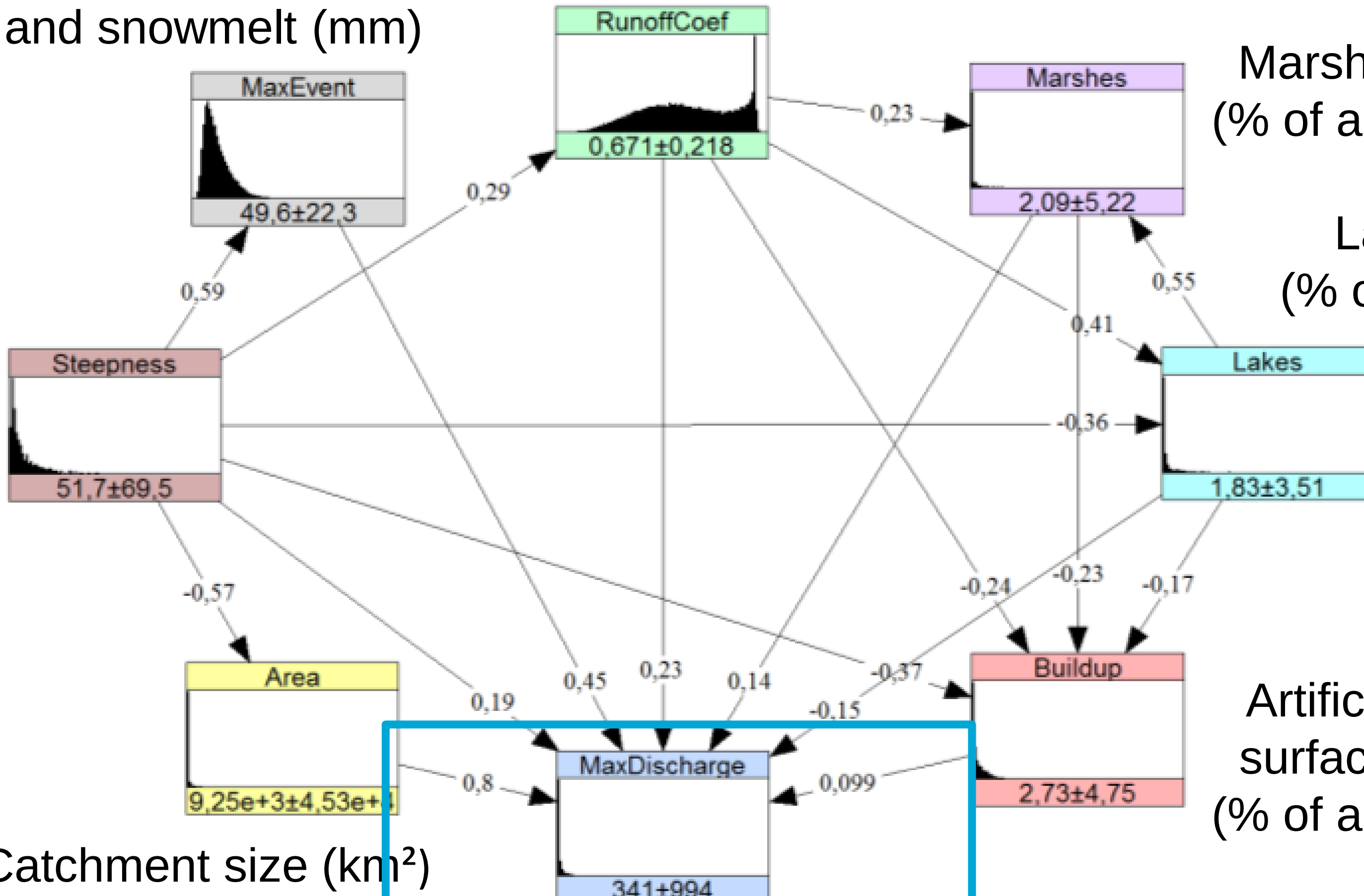
Annual maximum of daily precipitation and snowmelt (mm)

Annual maximum of daily total runoff divided by *MaxEvent*

Marshes (% of area)

Lakes (% of area)

Terrain steepness (‰)



Artificial surfaces (% of area)

Catchment size (km²)

Annual maximum of daily discharge (m³/s)

The model

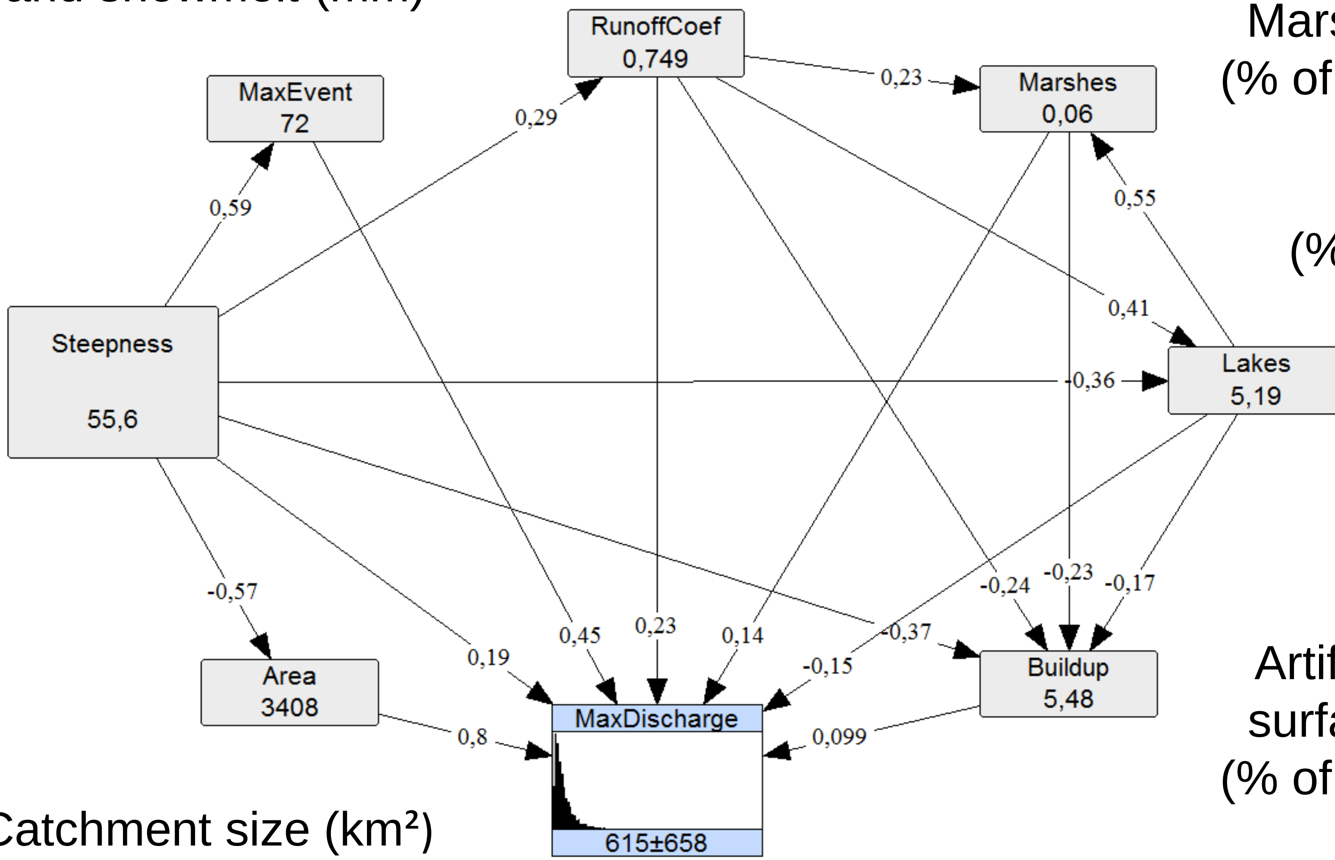
Annual maximum of daily total runoff divided by *MaxEvent*

Annual maximum of daily precipitation and snowmelt (mm)

Marshes (% of area)

Lakes (% of area)

Terrain steepness (‰)



Artificial surfaces (% of area)

Catchment size (km²)

Annual maximum of daily discharge (m³/s)
Observed: 783 m³/s

Mellingen (CH), Reuss river, 2005

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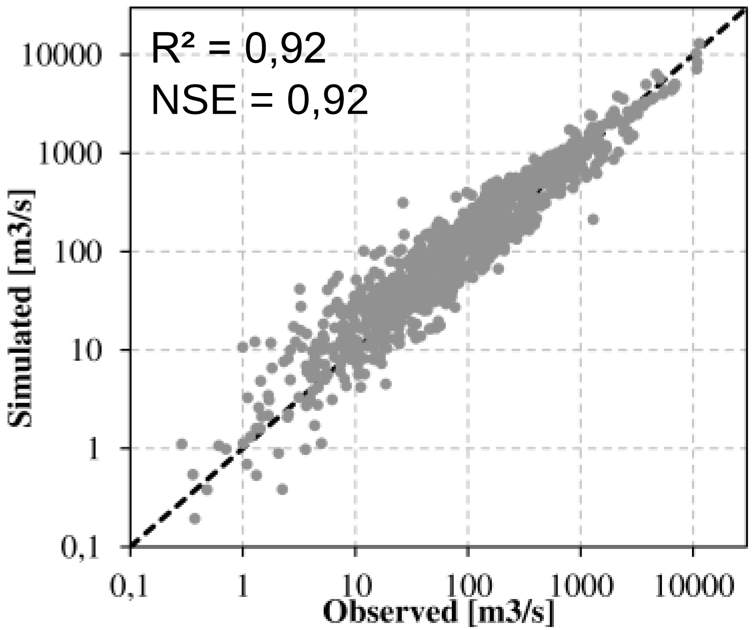
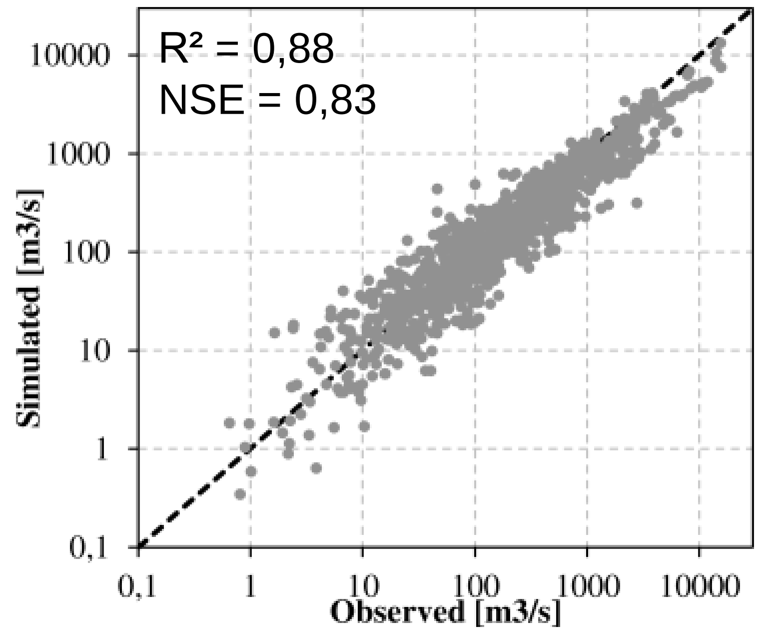
Validation

1125 stations, 30-year periods

- Average annual maxima
- Annual maxima with 100-year return period



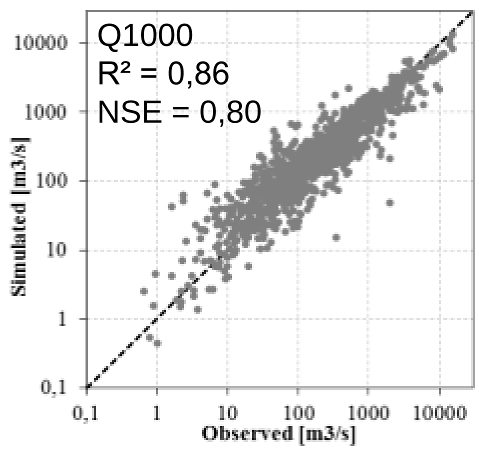


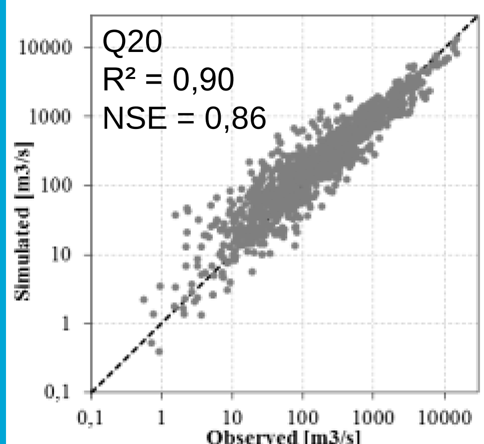
Validation

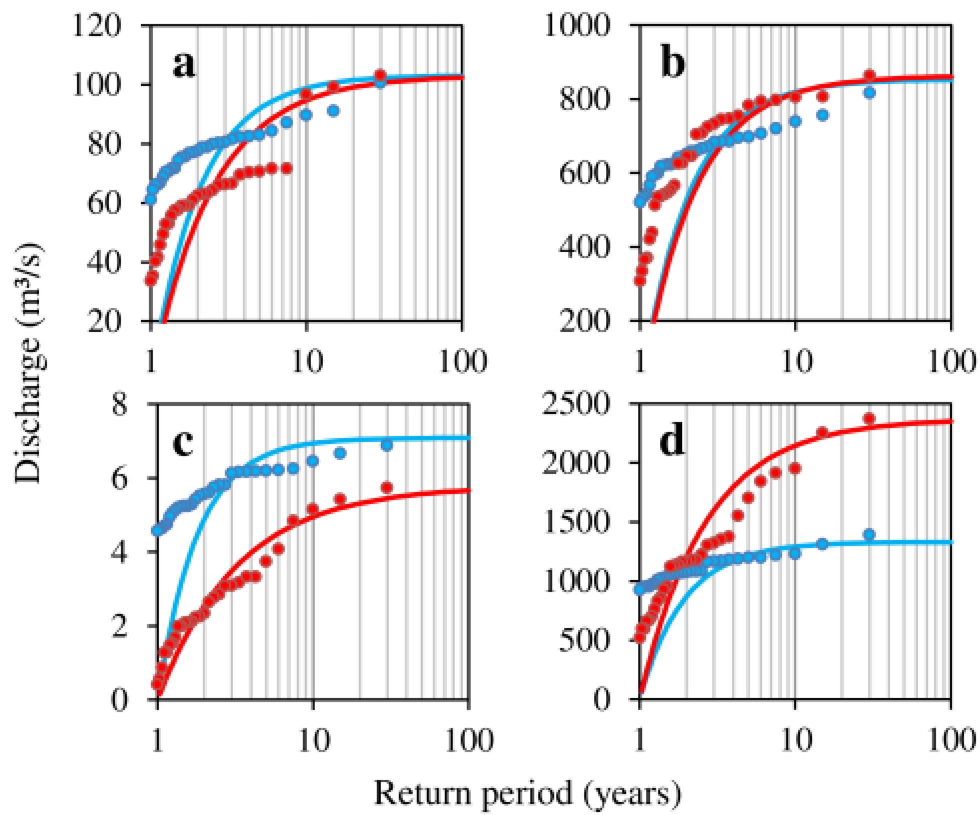
1125 stations, 30-year periods

- Return periods

Simulated • and observed • discharge







Validation

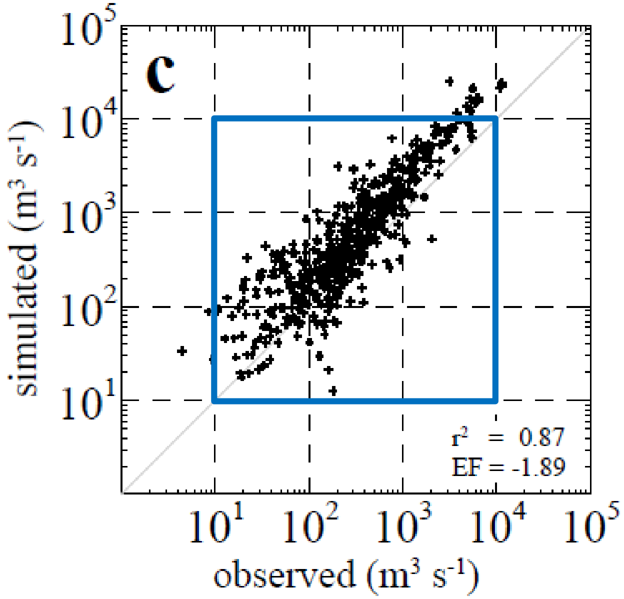
1125 stations, 30-year periods

Region / period	Average annual maxima		100-year return period		No. of stations
	R^2	NSE	R^2	NSE	
Central Europe	0,89	0,71	0,81	0,80	**138**
British Isles	0,86	0,85	0,75	0,73	**145**
Western Europe	0,97	0,96	0,95	0,85	**261**
Iberian peninsula	0,79	0,78	0,63	0,48	**112**
Danube	0,93	0,93	0,94	0,89	**167**
Scandinavia	0,92	0,83	0,90	0,89	**227**
Other regions	0,79	0,82	0,61	0,63	**75**
1951-1980	0,93	0,92	0,87	0,81	**512**
1961-1990	0,93	0,93	0,90	0,85	**792**
1971-2000	0,93	0,93	0,91	0,87	**958**
1981-2010	0,91	0,91	0,89	0,85	**763**

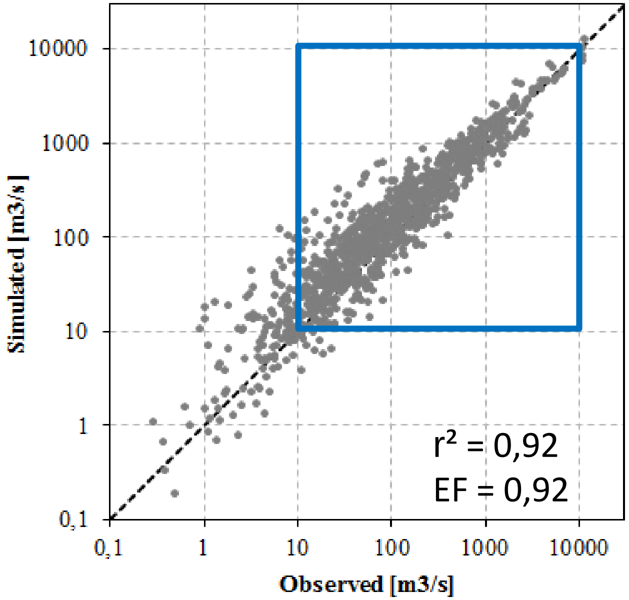
Comparison

Average annual maxima

- Rojas et al. (2011), 1961-1990, 552 stations (without bias correction)



- This study, 1125 stations

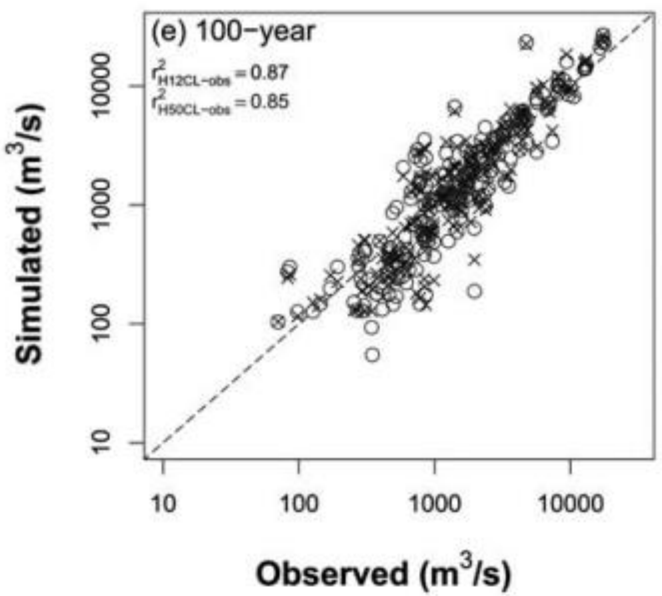


Rojas et al. (2011) Hydrol Earth Syst Sci 15:2599–2620

Comparison

100-year return period

- Dankers and Feyen (2008), 1961-1990, 209 stations



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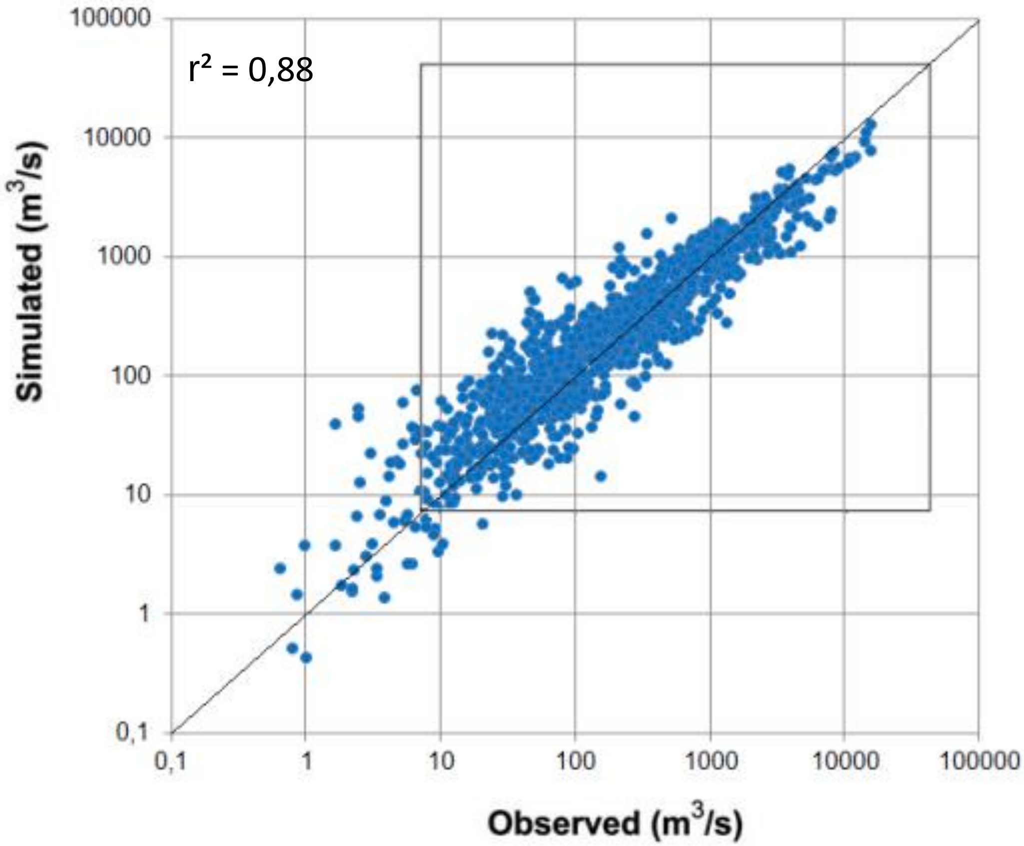
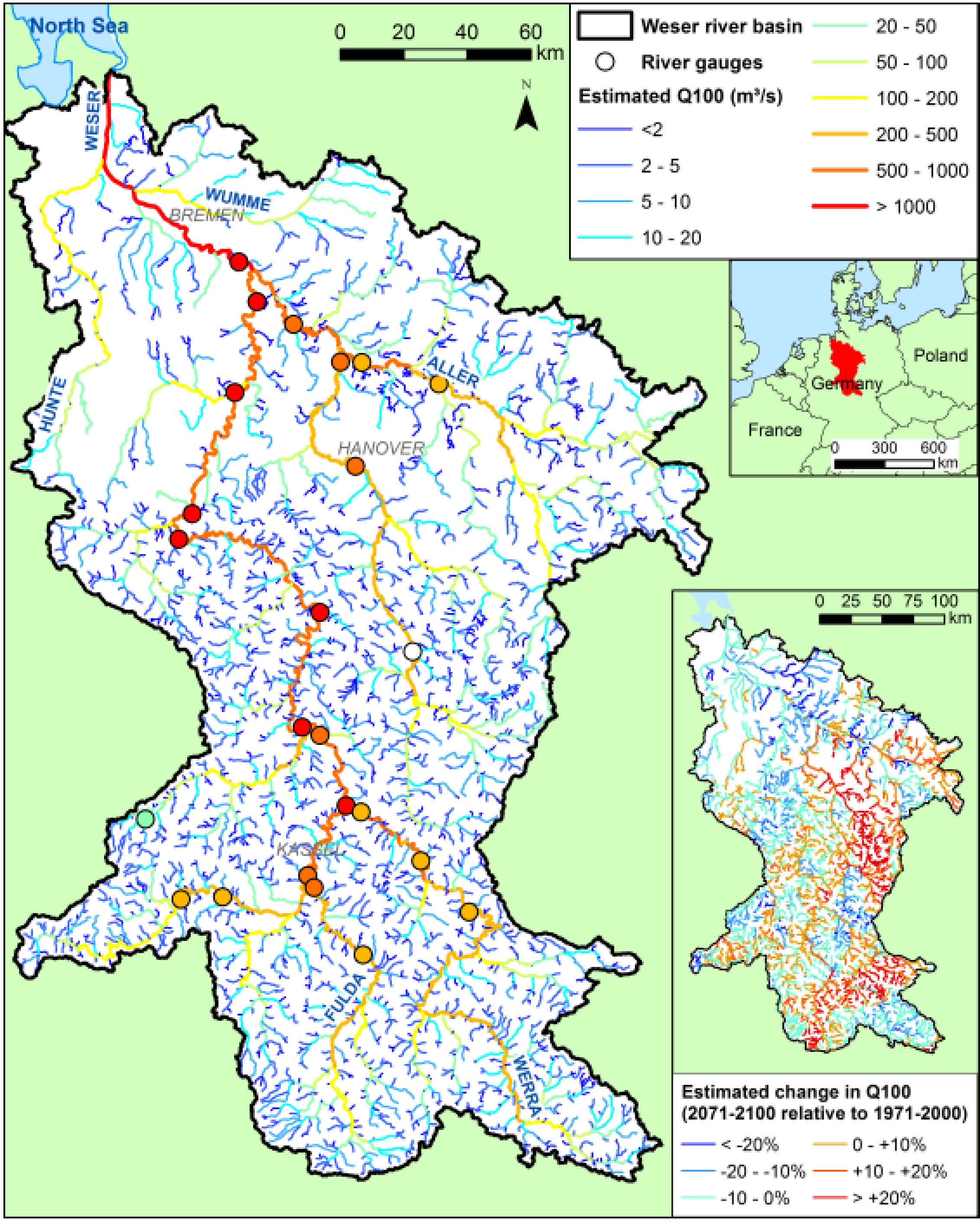


Dankers and Feyen (2008) Hydrol Earth Syst Sci 15:2599–2620

Application

Example:
Weser river basin

Extreme river discharges for each CCM2 river section and catchment under present and future climate



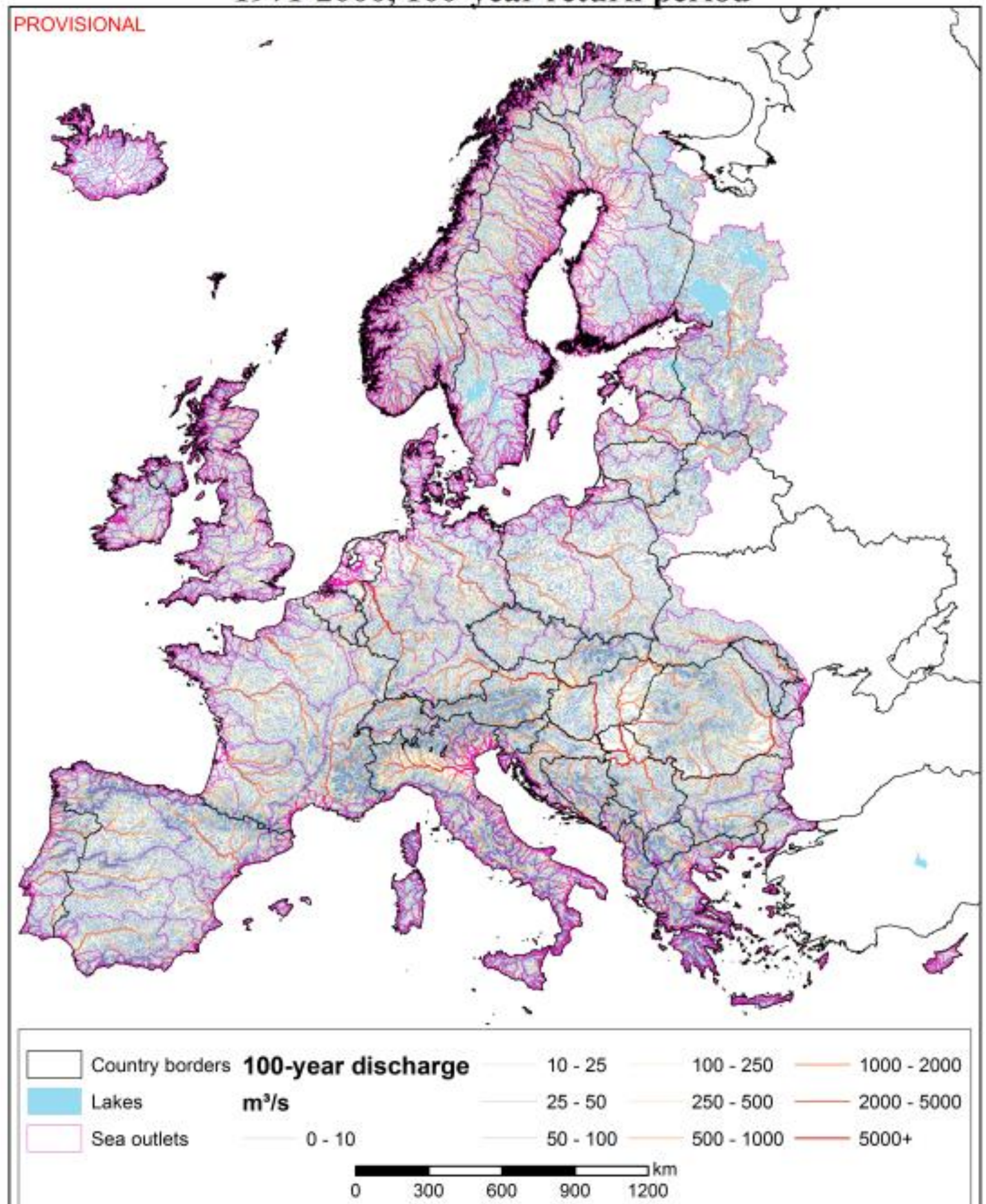
Application

Full database of river discharges and flood extents for 831.125 river sections

- 1971-2000
- 2021-2050
- 2071-2100
- RCP4.5
- RCP8.5

Expected date:
May 2016

ESTIMATED EXTREME DAILY RIVER DISCHARGE
1971-2000, 100-year return period



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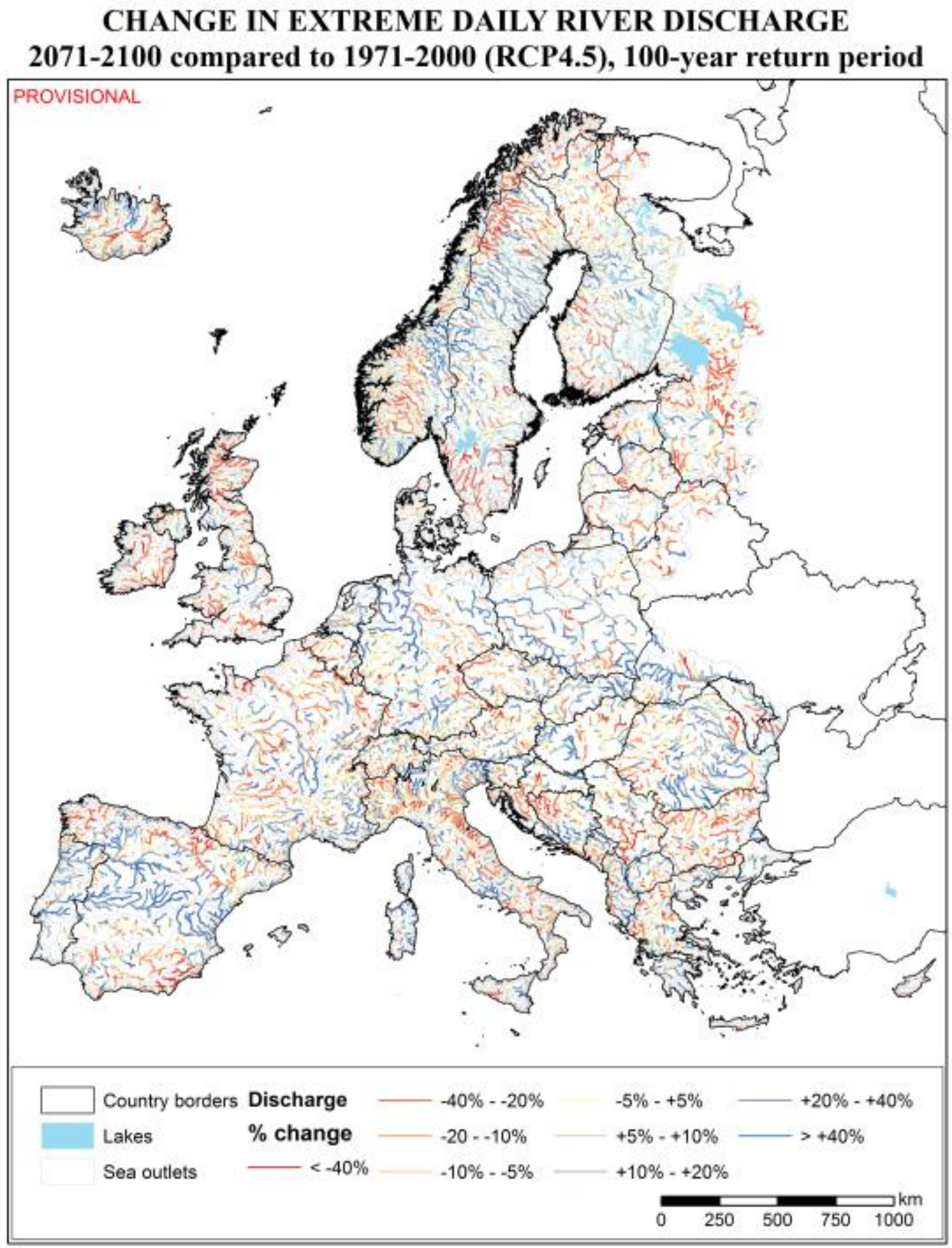

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