https://dirtx-reservoirs4future.eu/

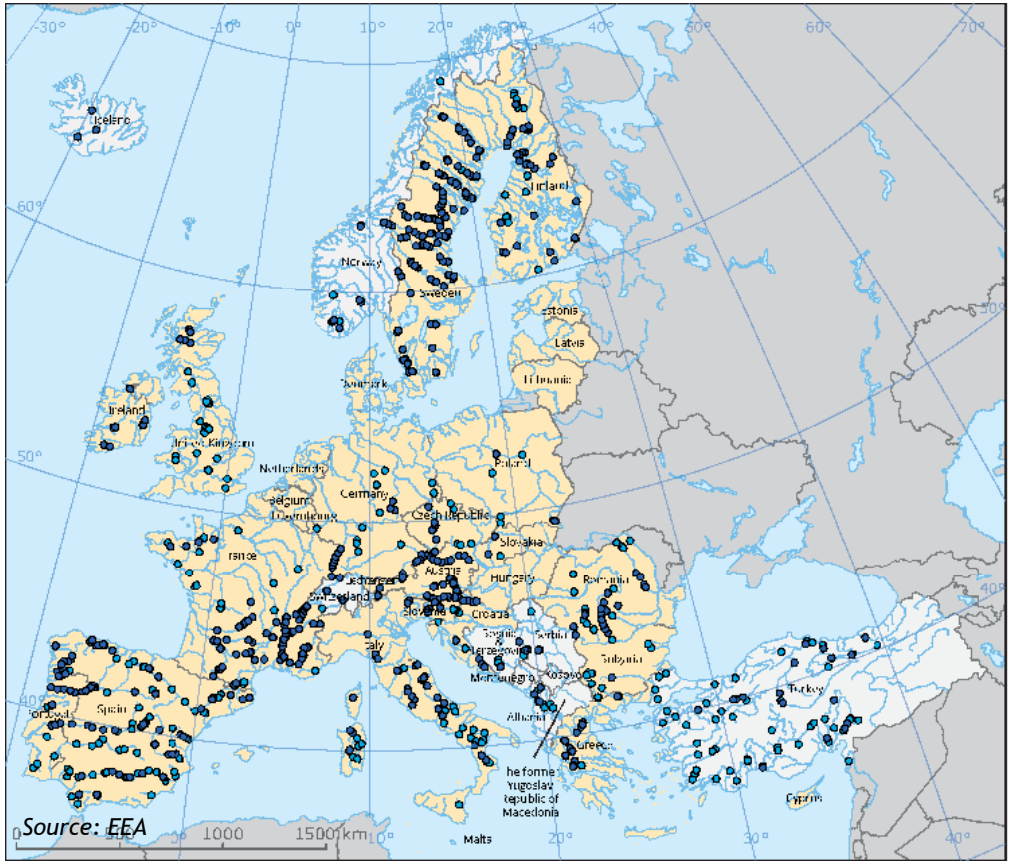
The future of water reservoirs in Europe:

What do sediments have to do with it?”

The project DIRT-X is part of AXIS, an ERA-NET initiated by JPI Climate (Grant No. 776608).

Reservoirs in Europe

- Provide essential societal functions and support life and economy



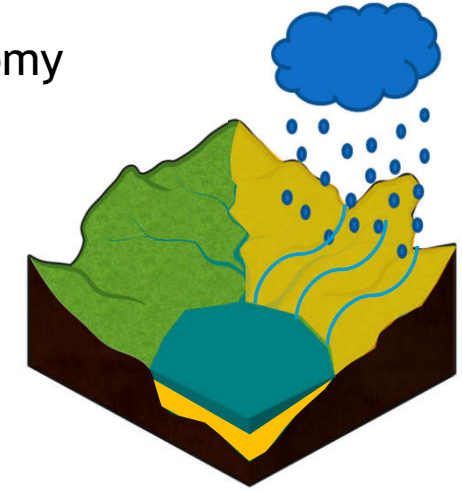
Dams with reservoirs on rivers

- Hydropower dams
- Others
- Member States of the EU
- EEA member and cooperating countries not part of the EU
- Outside coverage

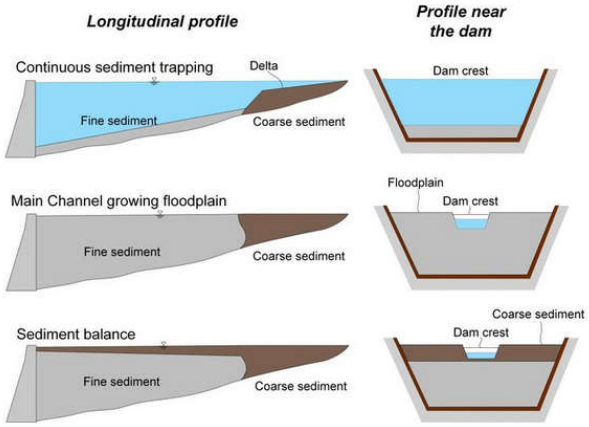
Notes

Only for rivers with a catchment > 10 000 km²

Kosovo under UNSCR 1244/99



Eroded soil is transported in stream. It settles in reservoirs, reducing their ts storage capacity



Reservoir sedimentation depends on **(i) the sediment yield**, coming from the catchment, and **(ii) reservoir characteristics**

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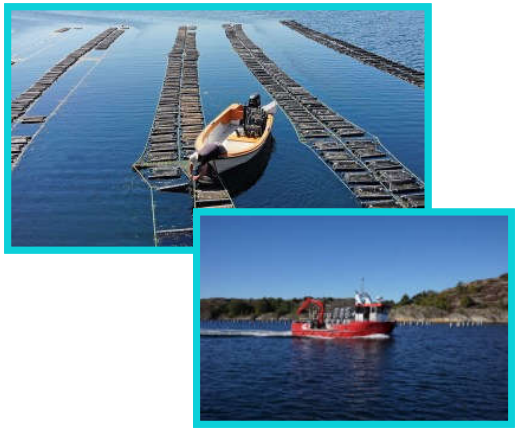
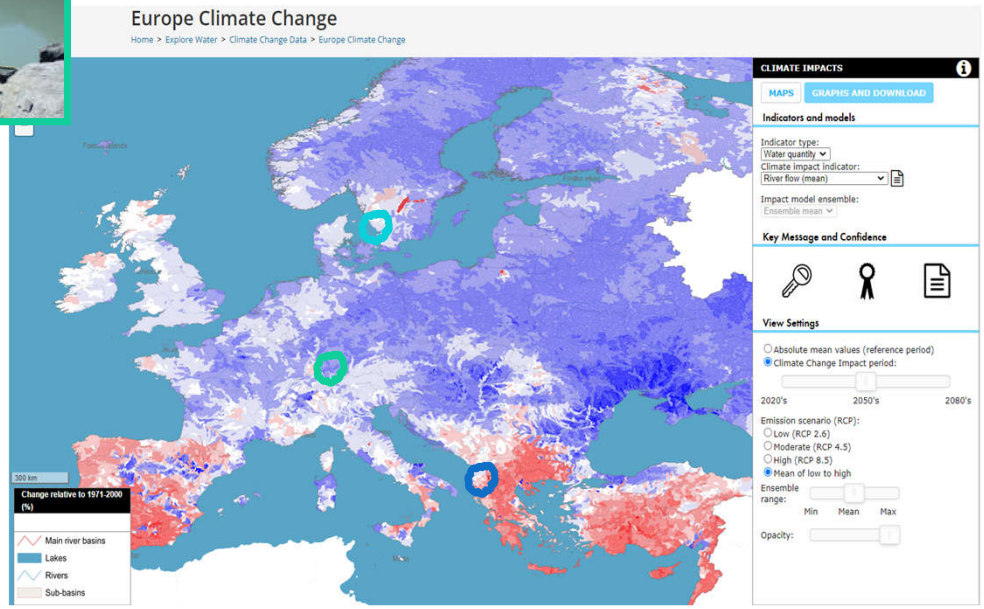
Study setup

- Detail studies of
  - Orust-Tjörn, Sweden – food production
    - Coastal basin affected by upstream reservoirs and hydropower
  - Gepatsch, Austria – hydropower
    - 139 million m3 storage, 392 MW
  - Banja, Albania – hydropower;
    - 400 million m3 storage, 72 MW



- Large scale studies
  - Transfer of local knowledge
  - Cross-scale impacts
  - Energy production under climate change



https://hypeweb.smhi.se/

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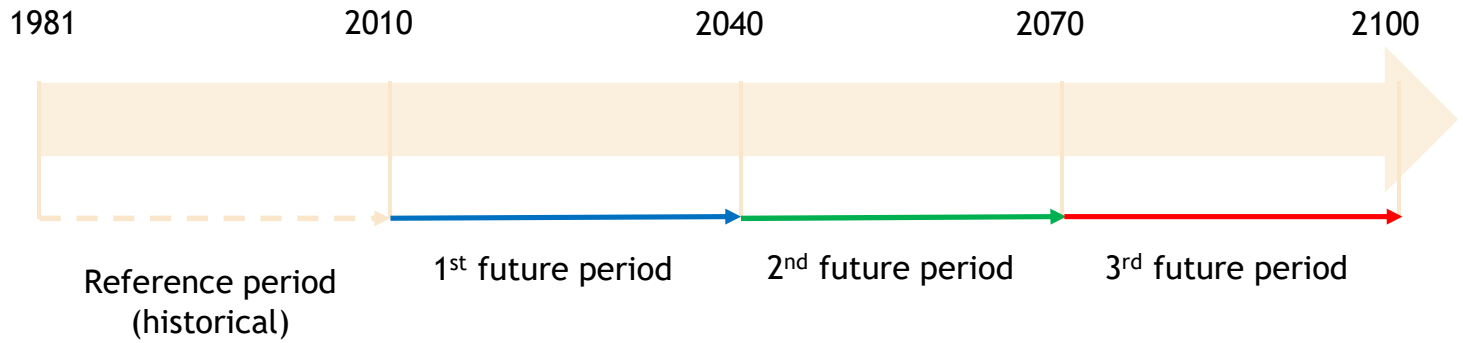
Calculation of Climate Impact Indicators



- Change in the signals from climate projections showsn as an ensemble mean

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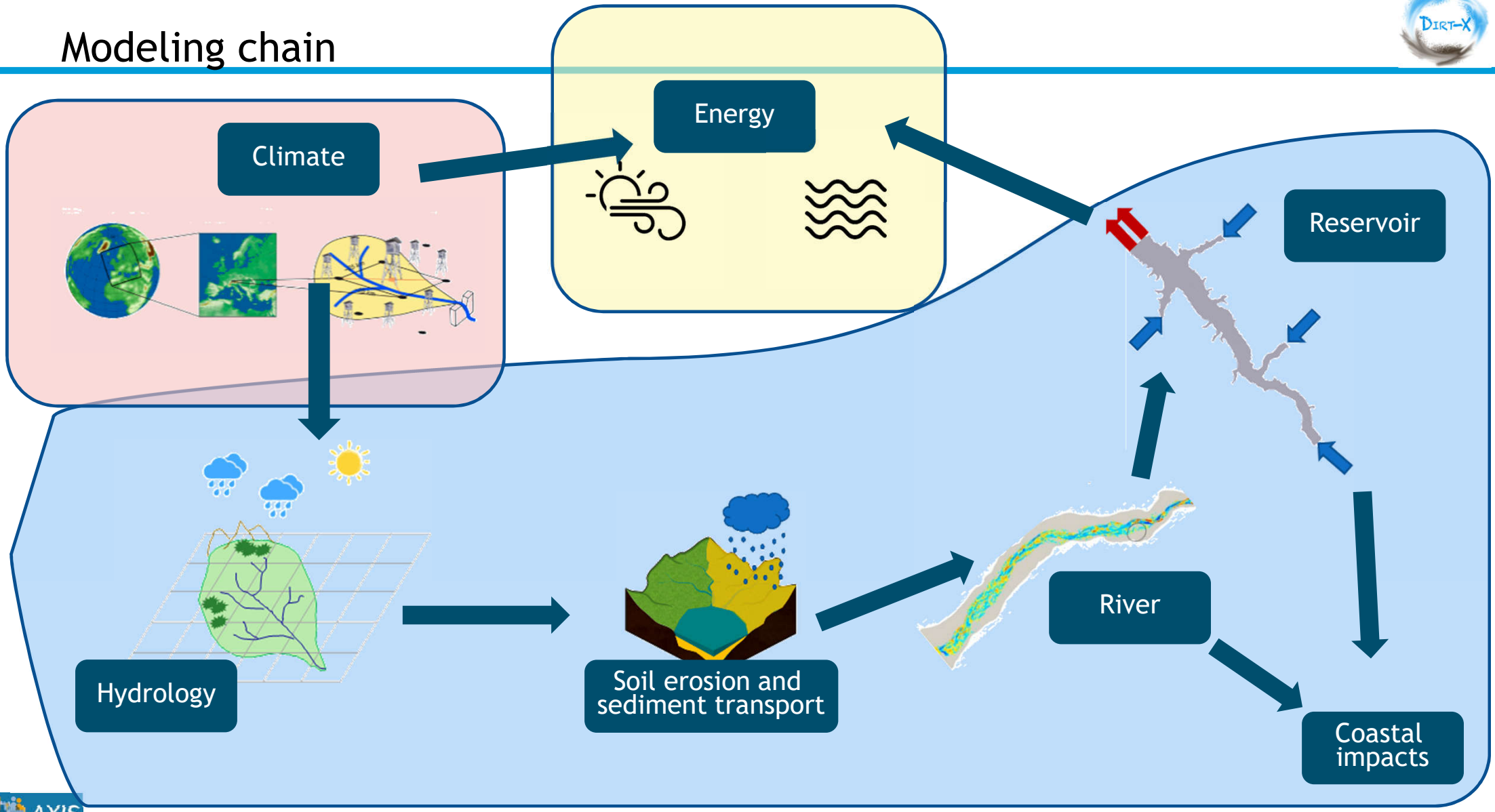
Modeling chain



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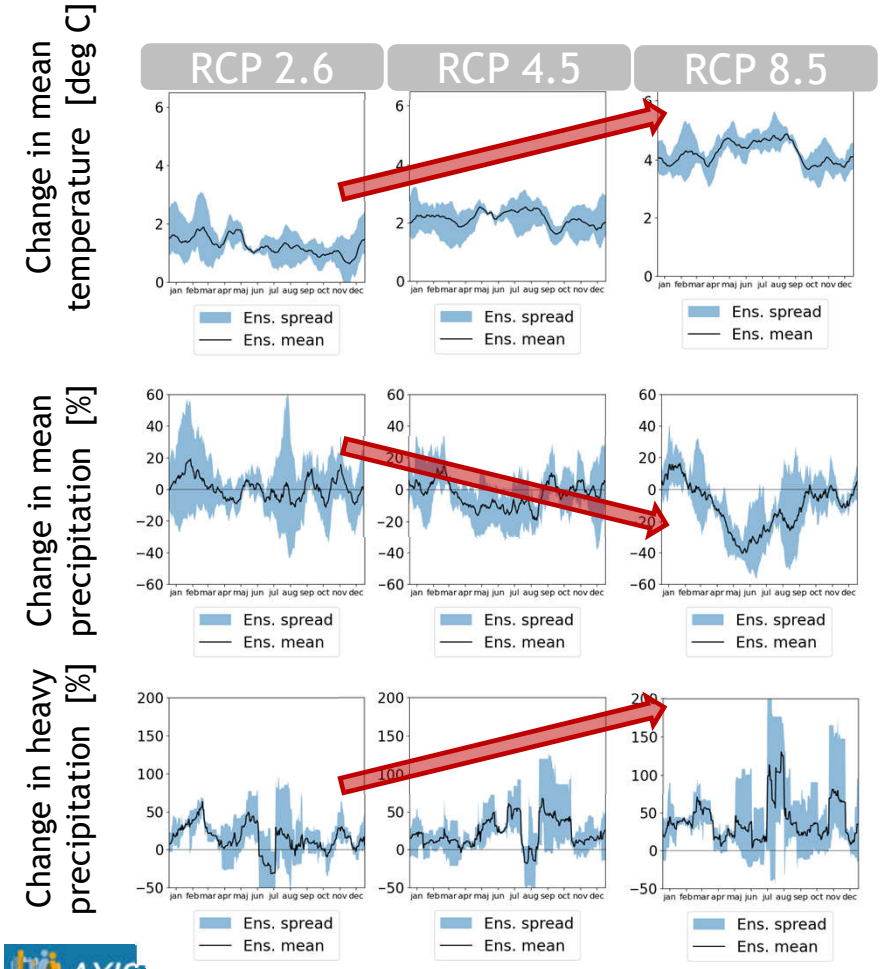
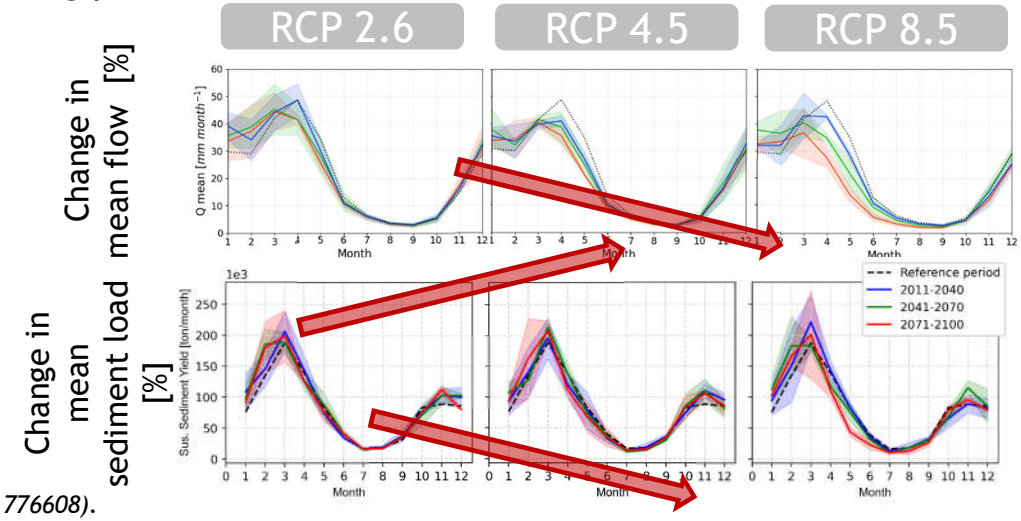
Climate impacts on Banja, Albania

Annual cycle, change from 1971-2000 projected for 2071-2100



- As the emissions increase,
  - Mean temperature increases
  - Mean precipitation decreases
  - Heavy precipitation events increase

- Runoff peak decreases and shifts to earlier
- Maximum runoff increase and minima decrease
- Sediment load decreases during low flow periods and increases during peak flows



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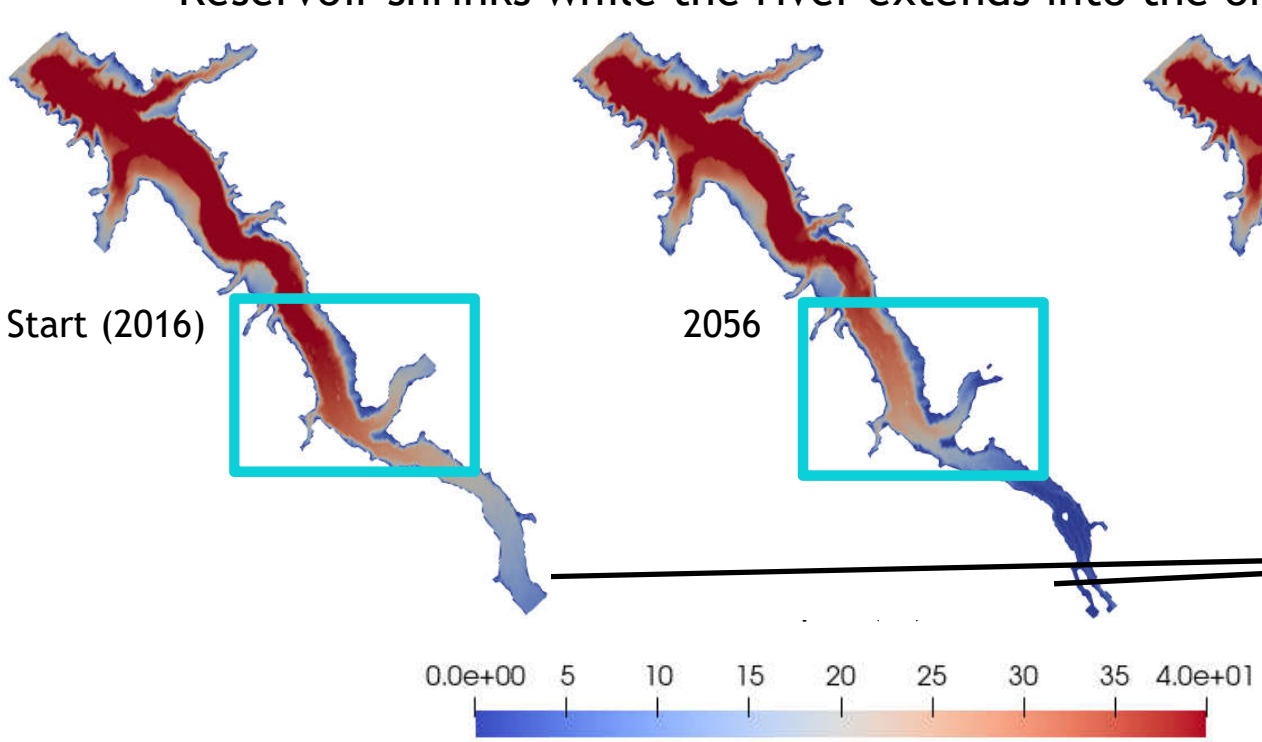
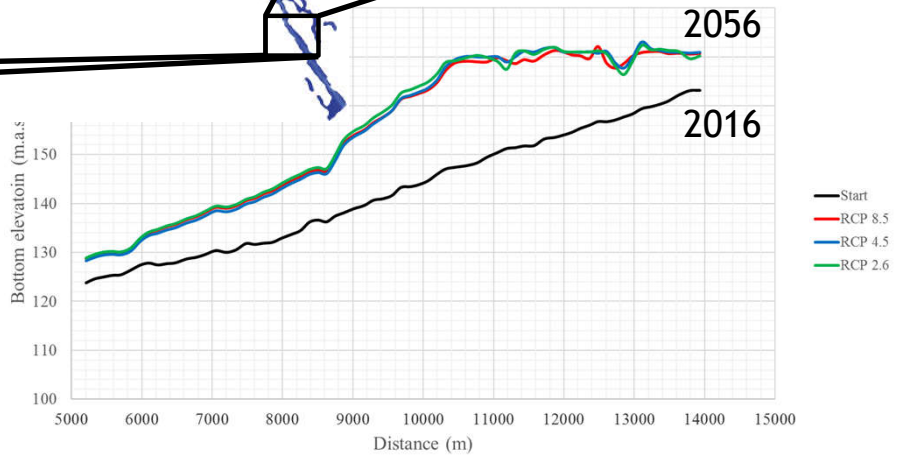
Sediment accumulates in the Banja reservoir

- As the reservoir fills with sediments, its available storage area, depth, and volume decrease
- Reservoir shrinks while the river extends into the original reservoir





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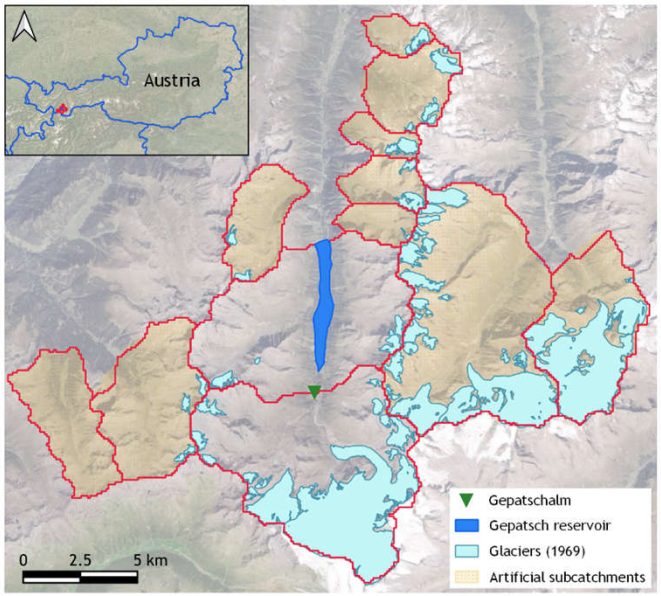
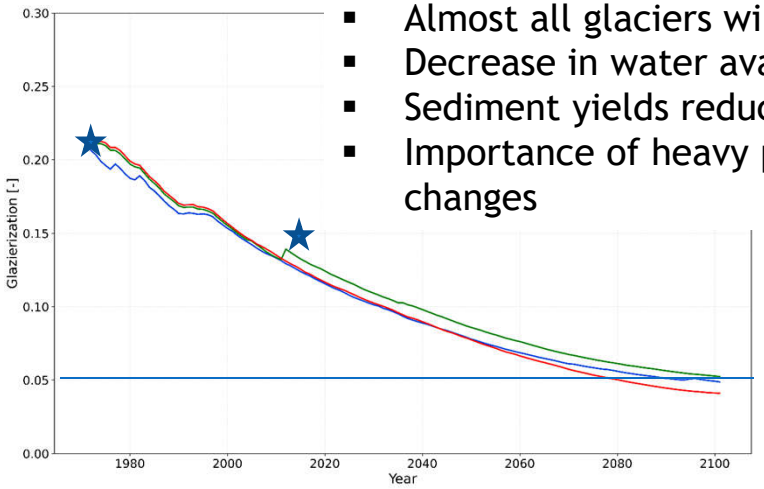
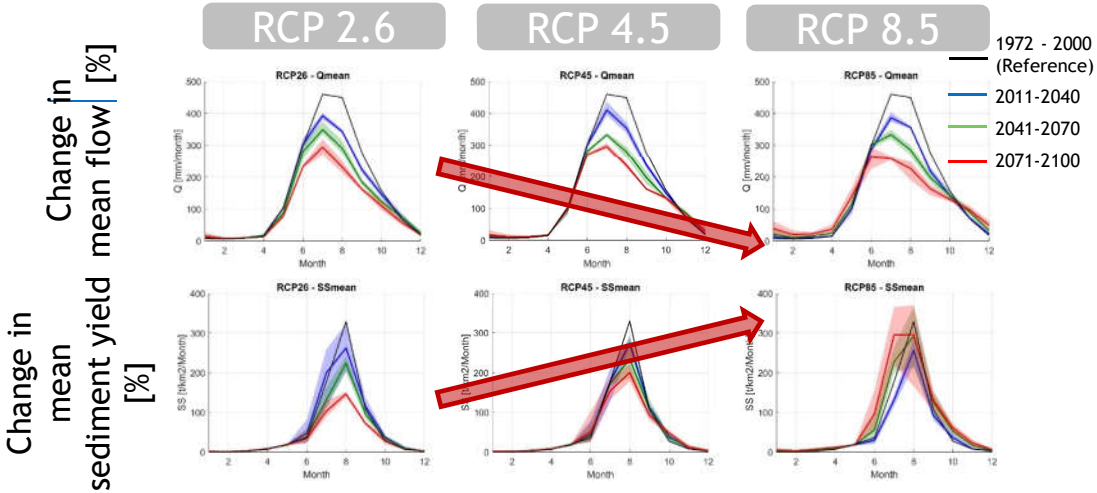
Runoff decreases due to glacier retreat in Gepatsch, Austria



Total area = 277.3 km^2
Glacier coverage = 22.1 % (1969)
= 15.4 % (201



- Continuous retreat of glaciers until the end of the century
  - Almost all glaciers will have disappeared by 2080-2100
  - Decrease in water availability
  - Sediment yields reduce, more with lower emission scenarios
  - Importance of heavy precipitation events, not just average changes



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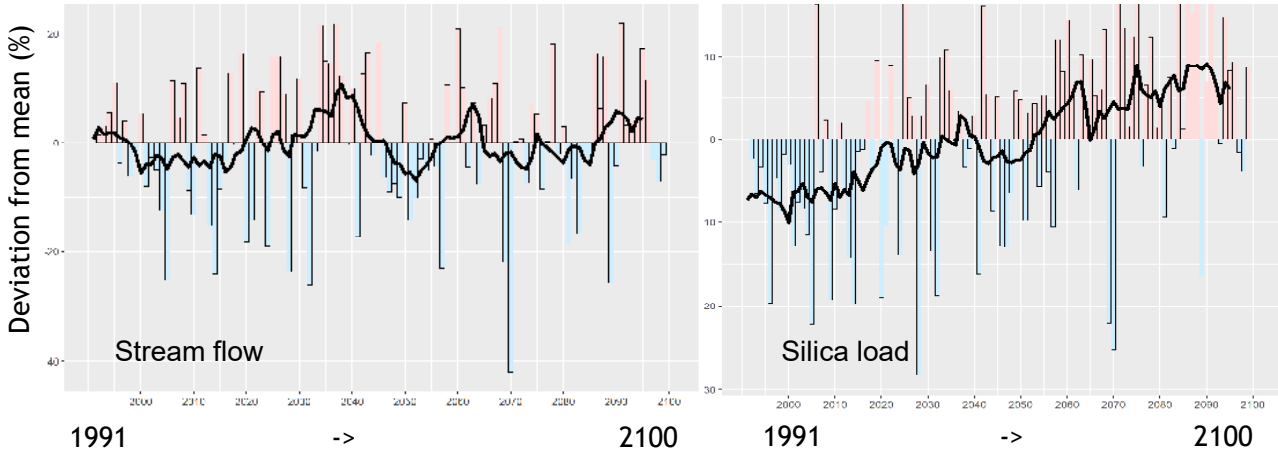
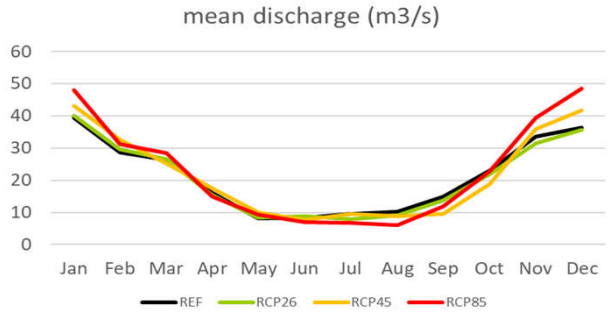
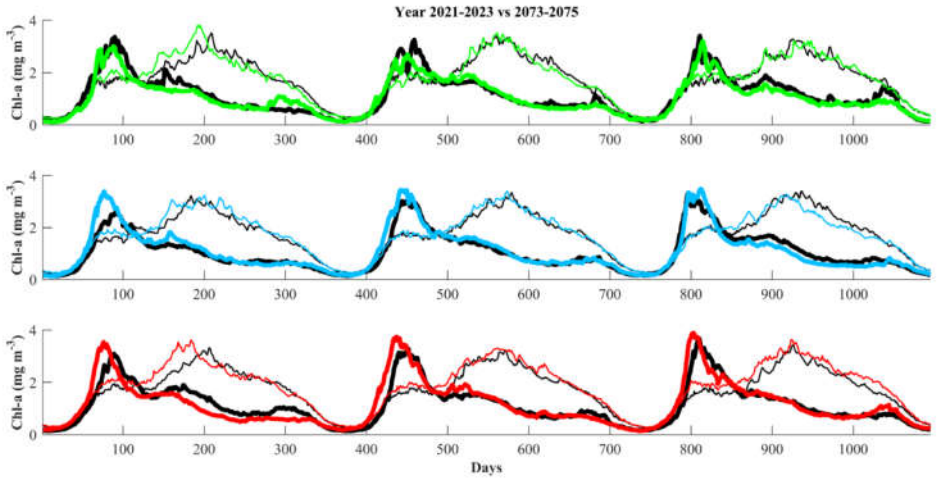
Impacts on food production and ecology in Orust-Tjörn, Sweden

- Important for mussel, oyster & fish farming
- Overall flows not affected much but inflow of sediments and silica increase
- Changes on phytoplankton composition inconclusive
- Potential exists for changes in species composition and harmful algae growth

Silica load to coast increases despite the stream flow remaining stable







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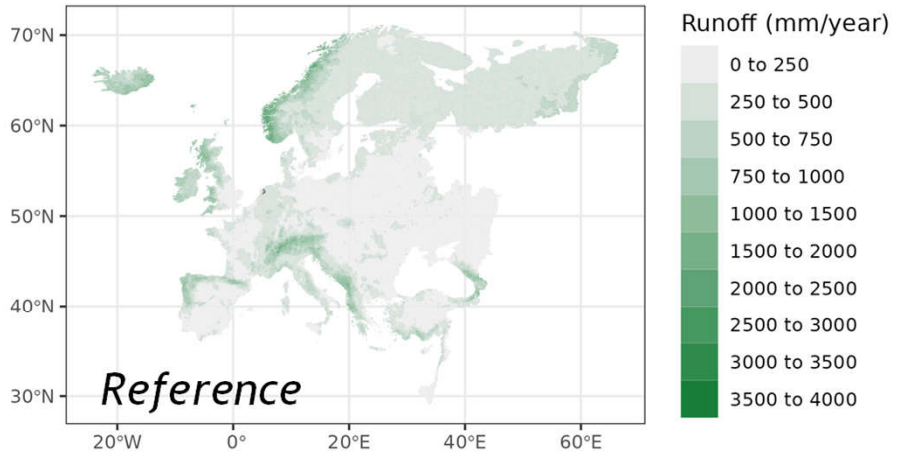
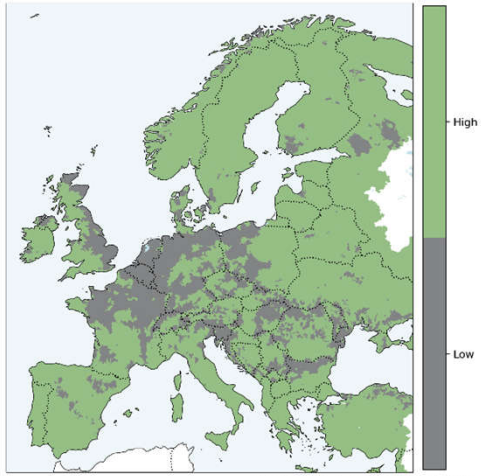
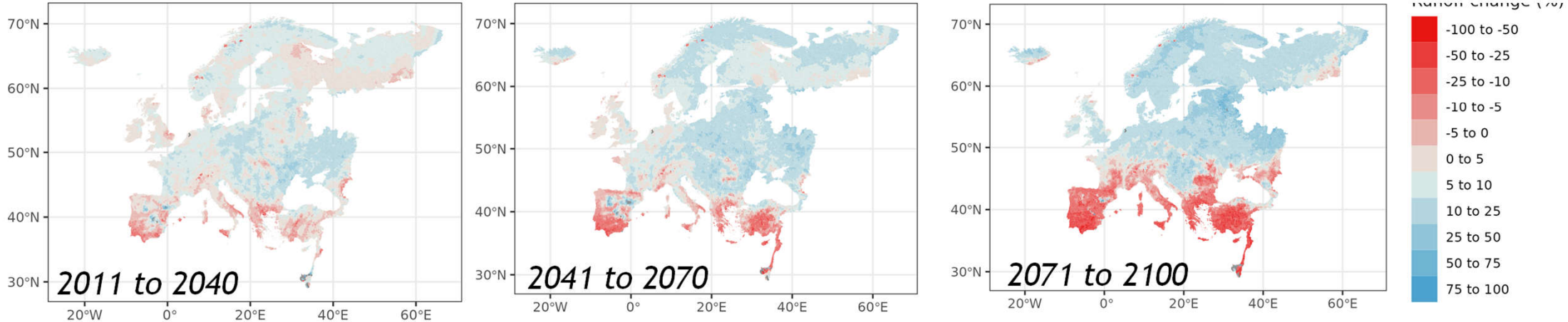
Continental indicators for water availability



- Under RCP 8.5, southern Europe will become drier and northern wetter.
- Central Europe is on average wetter
  - with some disagreement among the climate models on direction of the change
  - Use of ensemble is essential

Robustness
2071-2100





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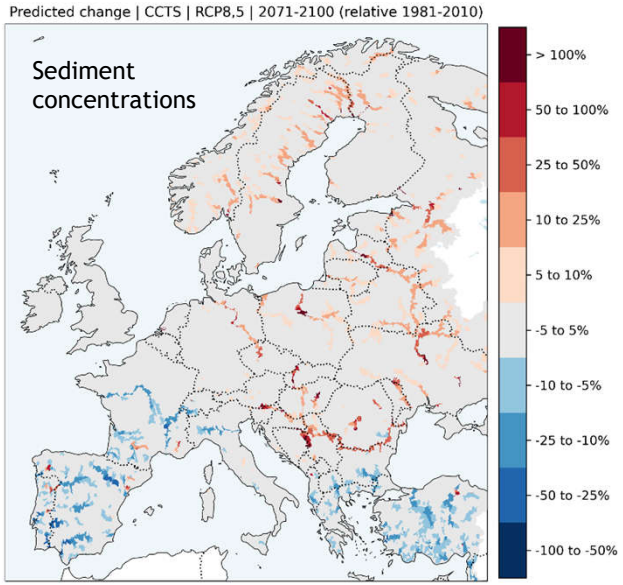
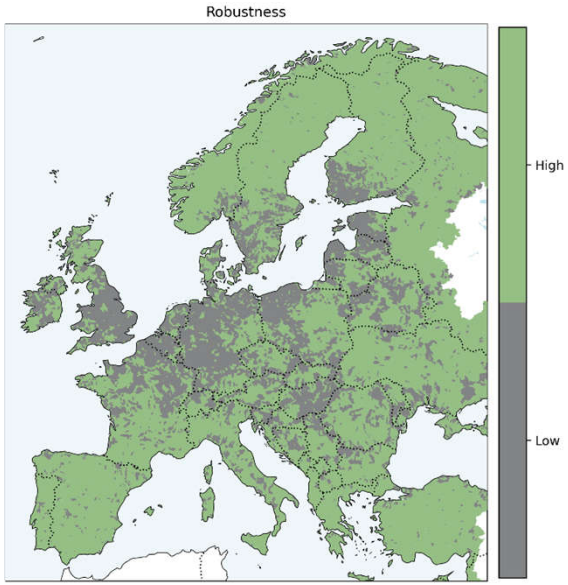
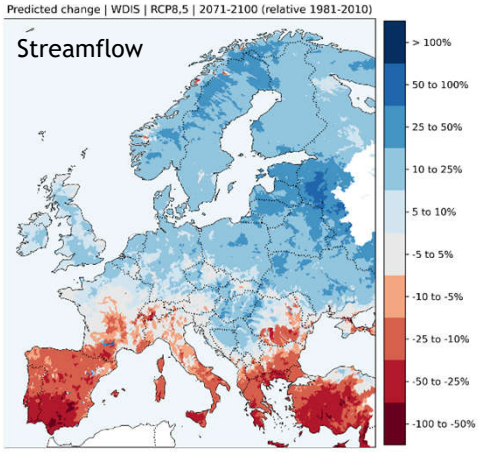
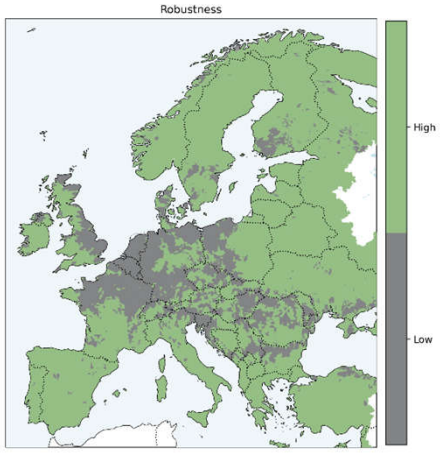
Continental indicators for sediments

- Similarity of regional patterns
- Lower robustness for sediment concentration changes in some areas
- The highest changes in sediment concentrations in larger rivers









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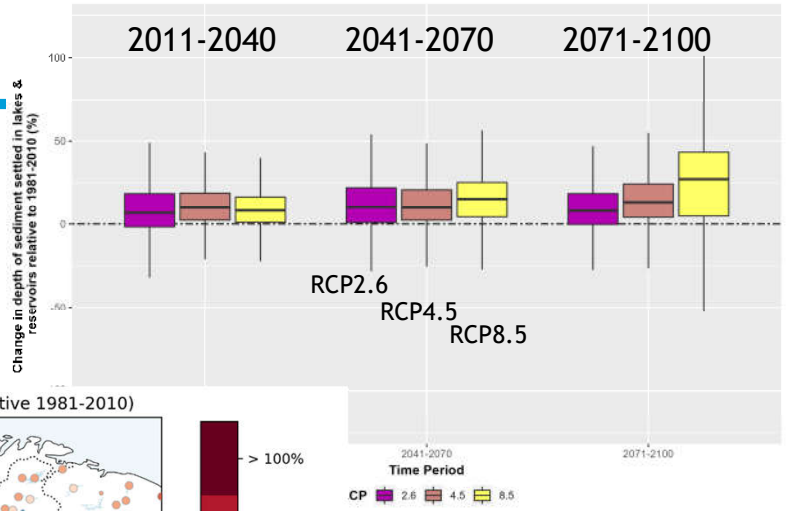
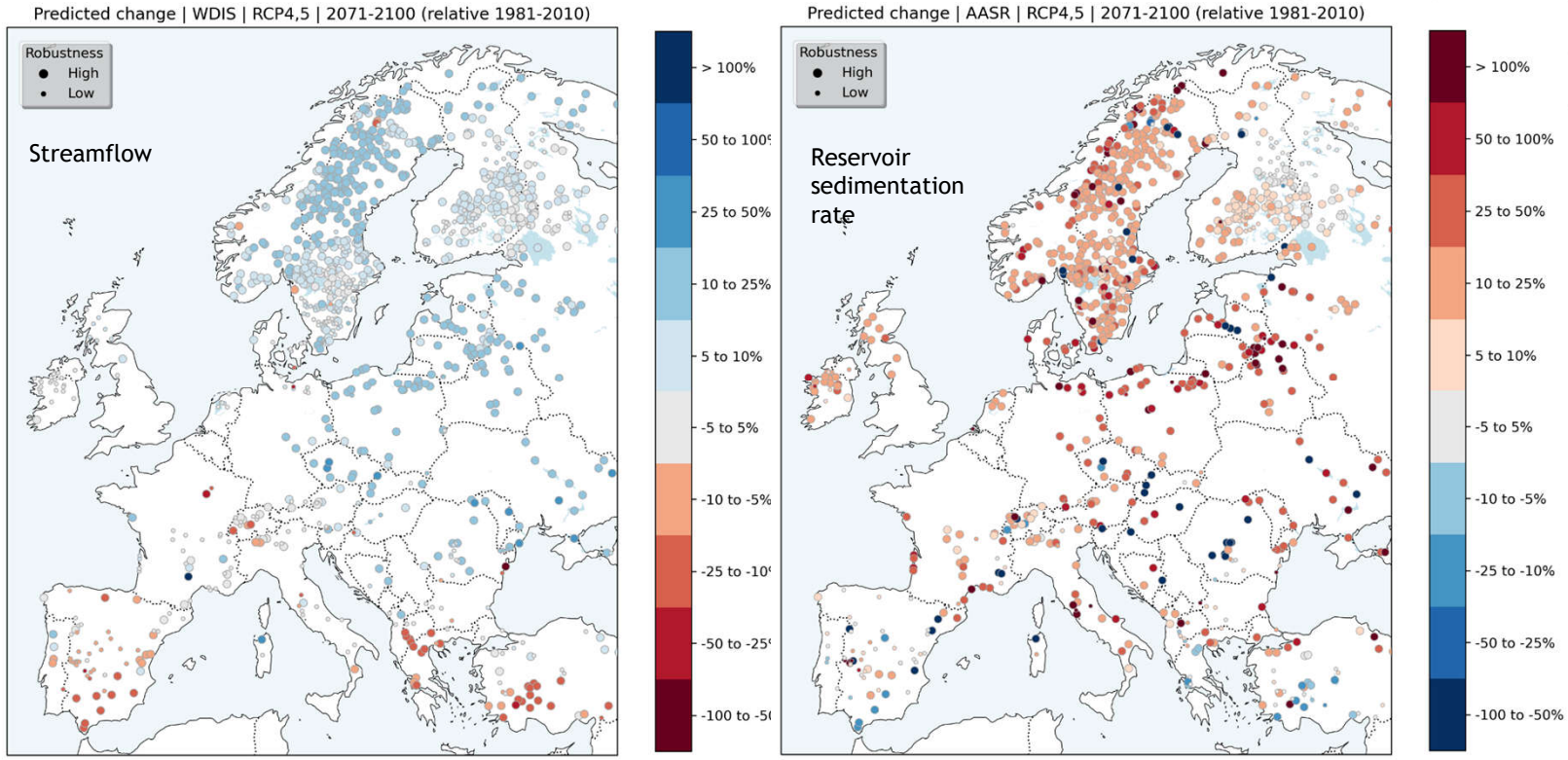
Reservoir-specific indicators

- Pattern for discharge similar to runoff
- Increase in reservoir sedimentation rate often higher than increase in water discharge





- Depth of new sediments in reservoirs increases with RCP
  - Almost doubles by the end of century

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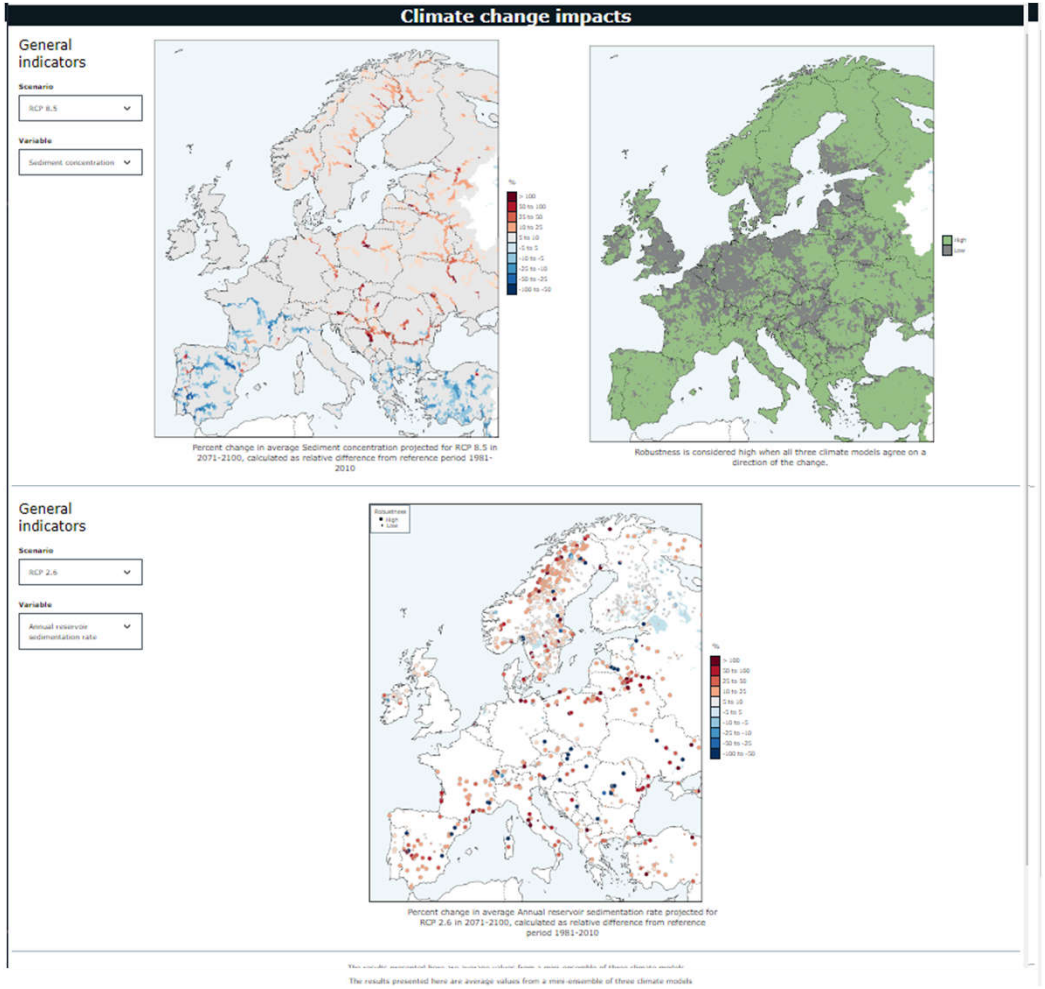
Dissemination tool

- Selected results at the European domain available at hypeweb.smhi.se
- Focus on reservoir-related impacts
- User can select one of each:
  - General indicator
  - Reservoir-specific indicator
- Also, choices for
  - Scenarios – reference period, RCP 2.6, 4.5, 8.5
  - And Impact Indicator
- Comparison with full ensemble possible for hydrological variables



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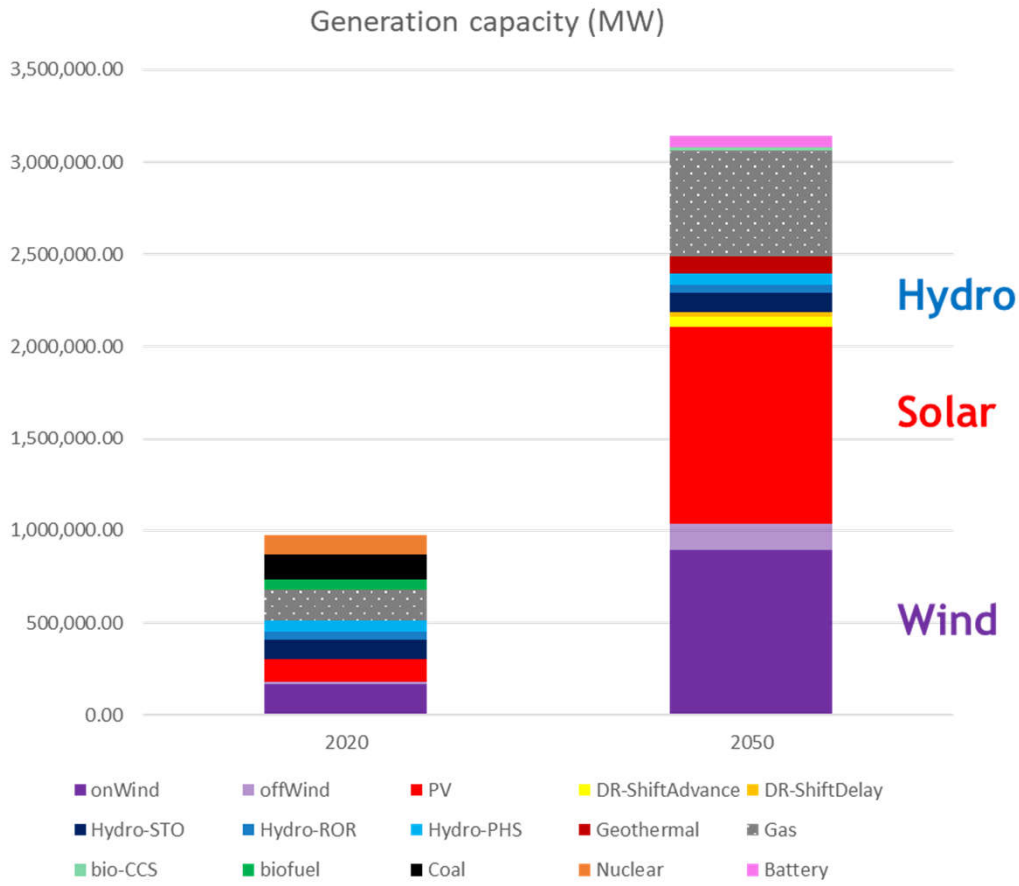
Hydropower in European Energy System

- The least-cost capacity mix in 2050 vs in 2020
  - Dominated by intermittent renewables (increase in their share 31% -> 67%)
  - Limited unexploited economic potential for hydropower (decrease in its share 21% -> 6%)

- 204 GW installed capacity + 515 TWh storage provided by hydropower currently



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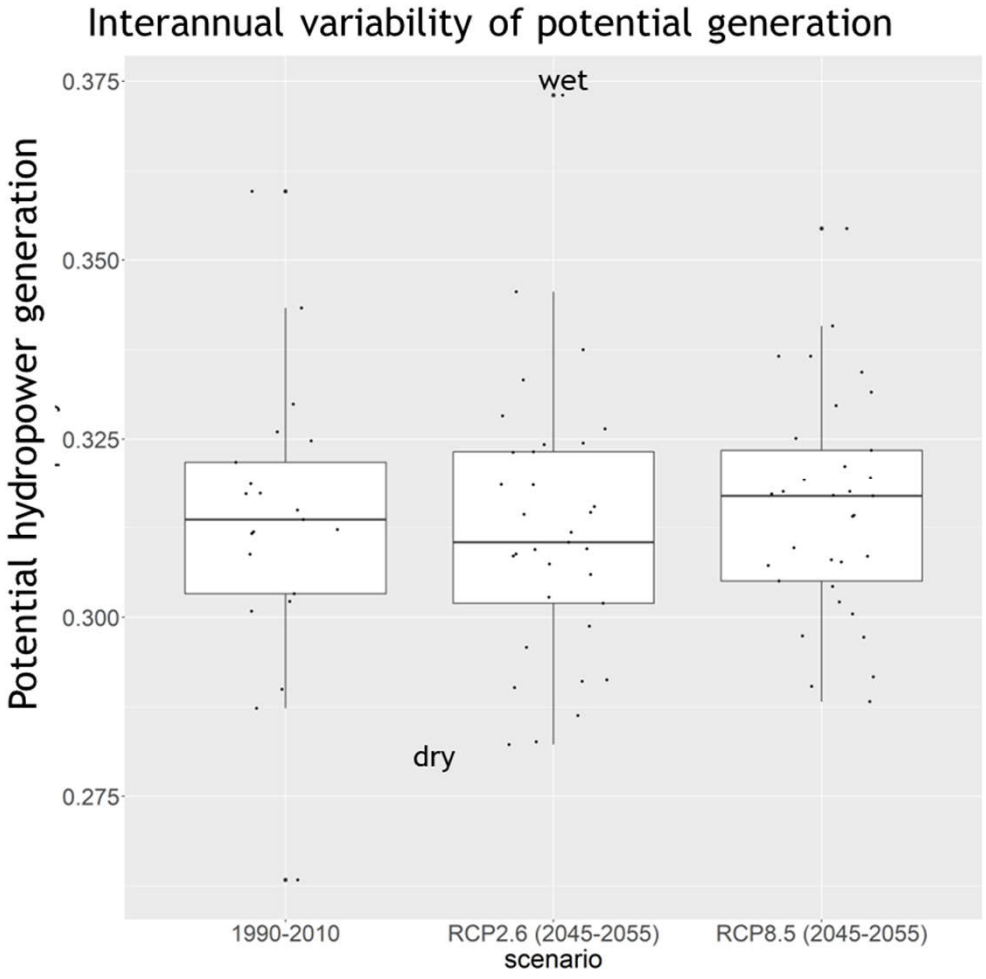
Interannual variability affects hydropower generation more than climate change

- Production sensitive to interannual variability
- On average, 10% less power is produced in a dry year than in a wet year (RCP2.6, 2045-2055)
- Strong regional variation –
  - Mediterranean countries produce 50% less in a dry year
  - Nordic countries affected much less



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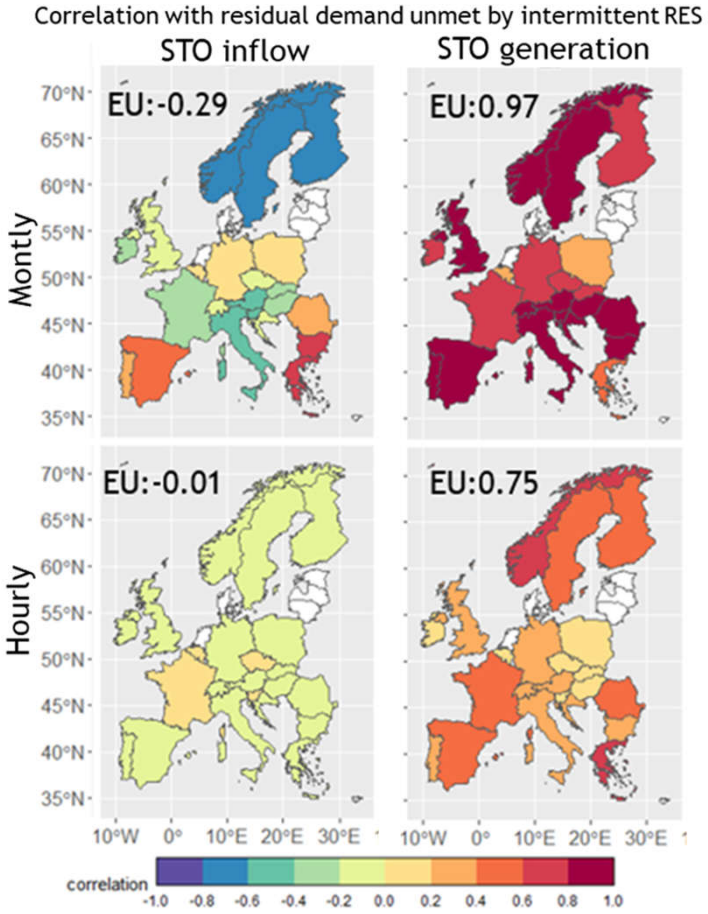
Hydropower important to provide flexibility



- Storage hydropower (STO) essential to balance residual demand
  - High correlation for storage generation
  - Low correlation for inflows to the reservoirs for most European countries
- Hydropower provides both seasonal and short term flexibility
  - Monthly and hourly agreement

**residual demand = demand not satisfied by intermittent renewable sources*

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Summary

- Future availability of water is affected by climate change with impacts varying regionally
- Soil erosion and sediment deposition can further diminish water storage in Europe
- Storage reservoirs are essential in the future European energy system to meet the demands unmet by intermittent sources
- Both inter- and intraannual variability of water is projected to change with significant effects in certain regions (e.g. southern Europe)

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