Hydrological evaluation and modeling from EURO4M data using the E-HYPE model

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Using a catchment as a precipitation gauge

- The main advantage is that it captures all precipitation reaching the ground (no under-catch and no sampling issues)

- The downside is that it takes time for the water to reach the gauging station, i.e. the discharge station at the river mouth

- During this time, the water can be:
  - Stored in the form of snow or ice (delay)
  - Stored in lakes or other reservoirs (delay)
  - Evaporated back to the atmosphere (sink)
  - Be subjected to anthropogenic extractions (sink; though often later returned to the same or nearby catchment)

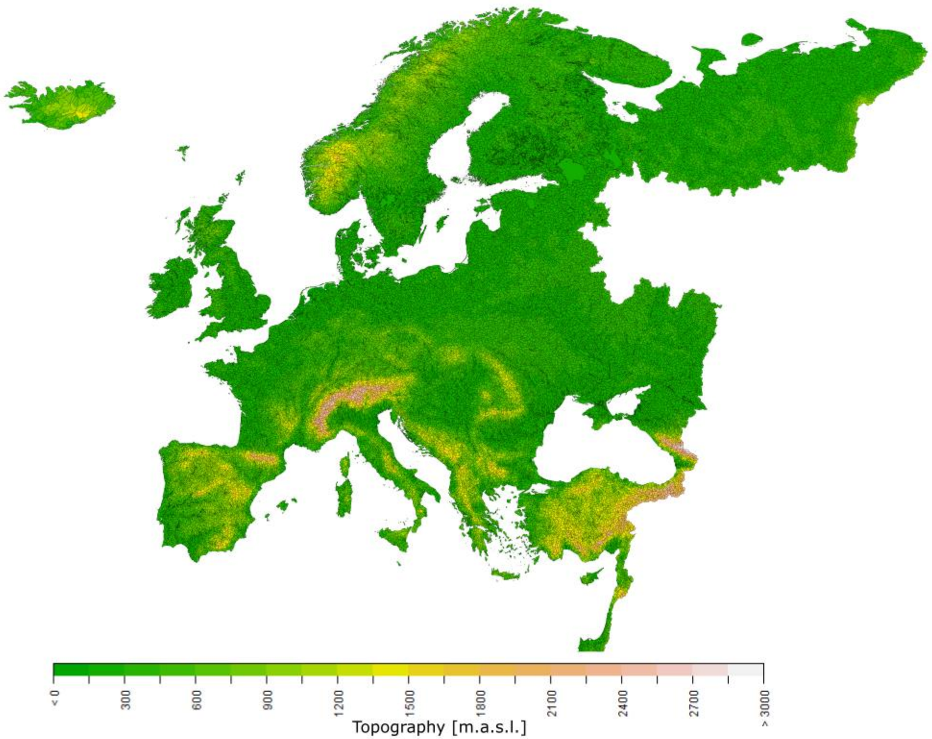
Approximate time-scales for water in a catchment

- Storage as snow ~ 1 to 10 years
- Storage in glaciers ~1 to 1000 years
- Storage in Lakes ~1 year
- Storage in anthropogenic reservoirs <1 year
- Extractions < 1 year
- Evapotranspiration ~1 to 10 years

- With an evaluation time scale of 20 to 30 years, most uncertainties will cancel out. Stronger trends can potentially have an impact.

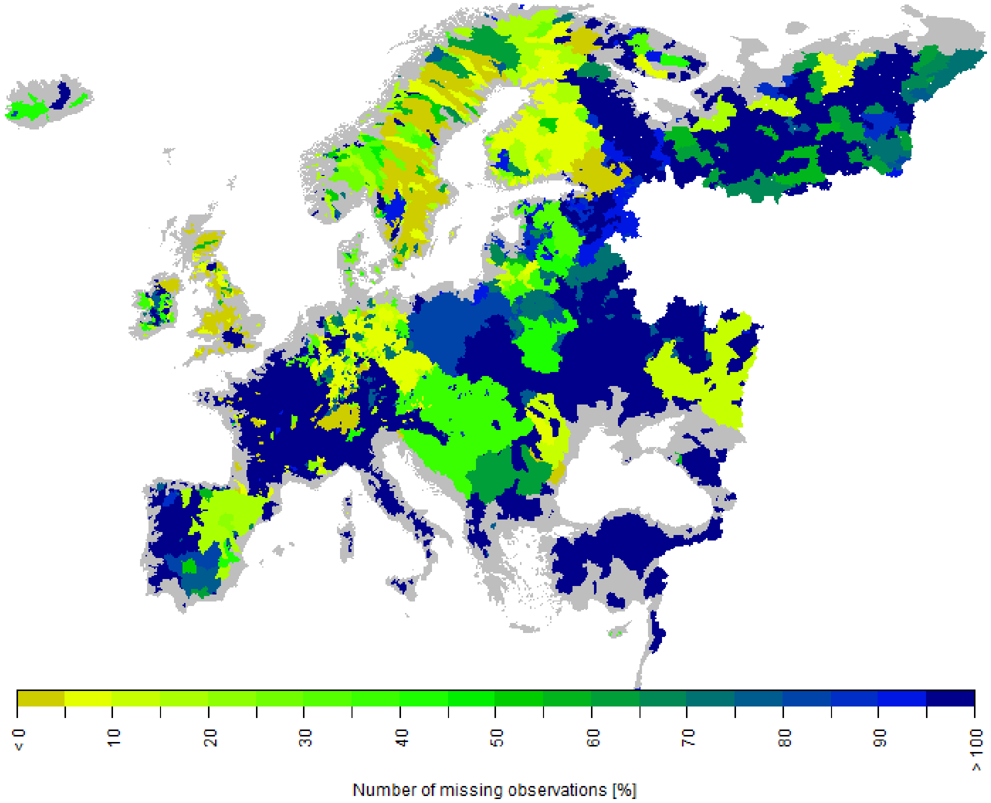
The E-HYPE model

- E-HYPE is the European version of the HYPE (HYdrological Predictions for the Environment) model
- About 35'000 catchment in Europe, with an average size of 250 km^2
- Takes inputs of temperature and precipitation at the daily timescale
- Gridded data inputs are distributed across catchments such that water is conserved on a monthly time scale. On the sub-monthly scale, precipitation follows the variability of a single representative grid point to capture the local temporal variability



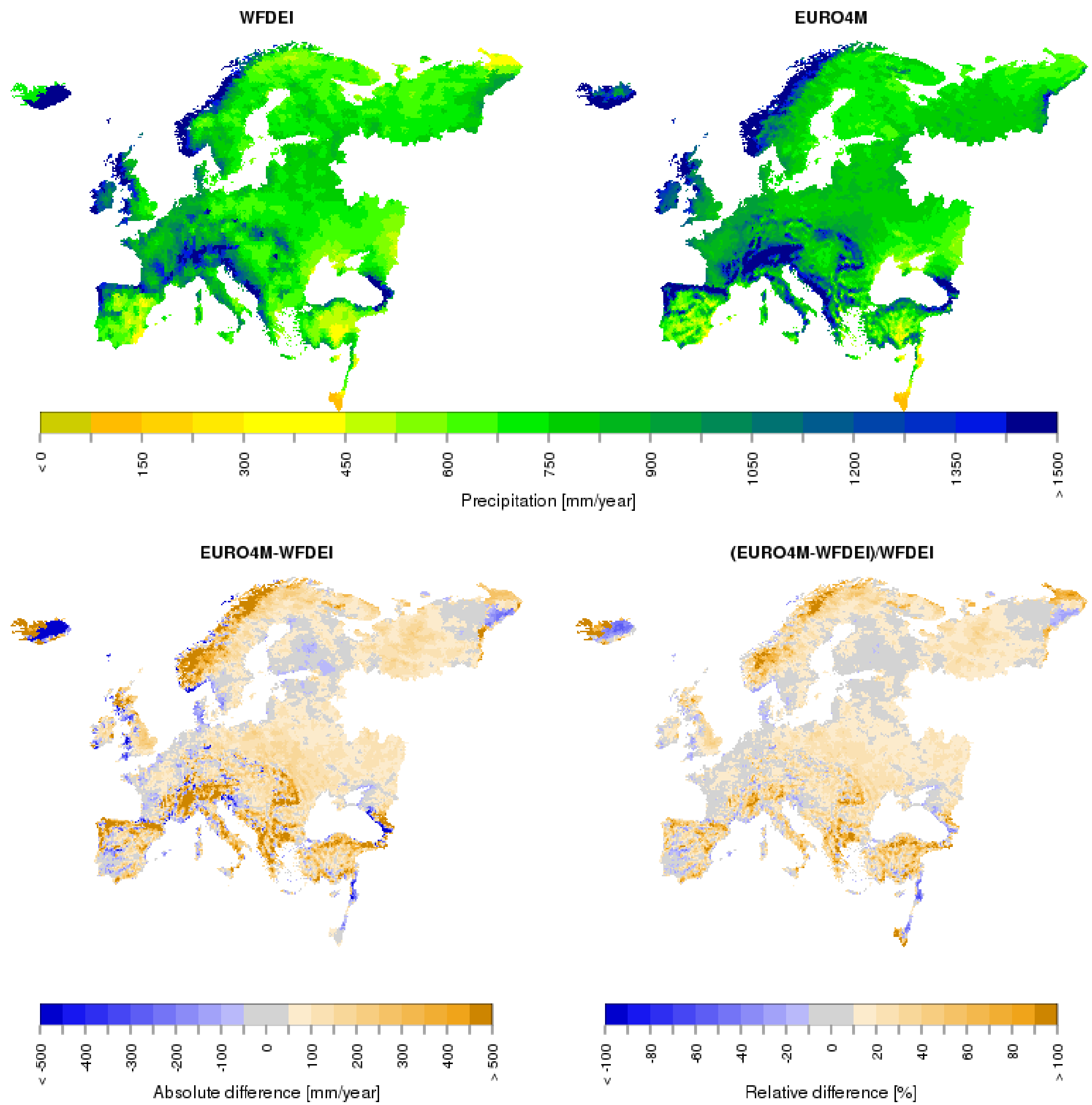
Discharge stations

- Discharge data from Europe were collected and checked for errors and homogeneity
- The figure presents amount of missing data in the analyzed stations, projected on their upstream area
- Large parts of Europe suffer from low data coverage for the period 1990-2010 in our database, but e.g. Northern Europe is fairly well covered
- For the analysis, the discharge data, was averaged over the upstream area to have units of mm/day instead of m^3/s



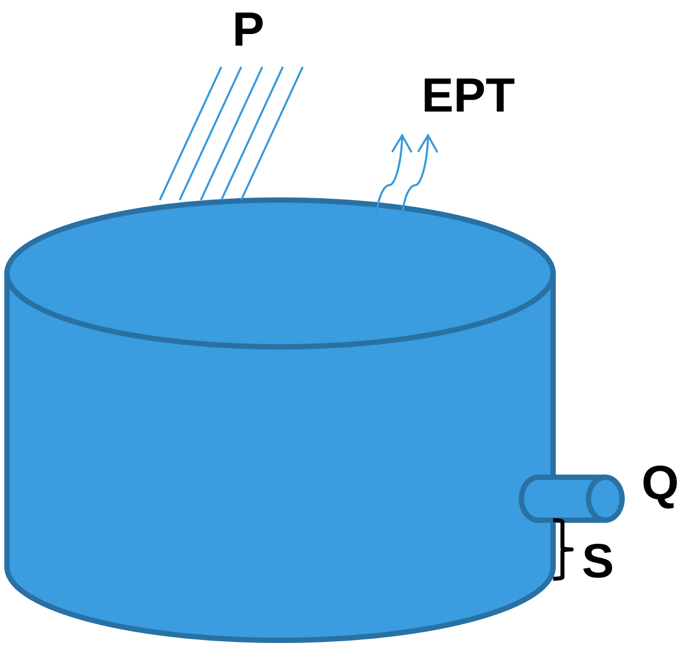
WFD and EURO4M-HIRLAM

- E-HYPE was calibrated using the WATCH Forcing Data (WFDEI) data set, which is created from ERA-Interim corrected with GPCC data on the monthly time-scale
- The figure compares the precipitation of WFDEI and EURO4M-HIRLAM input data for the period 1990-2010
- EURO4M is generally wetter than WFDEI, especially in montainous regions. Note that this is in spite of WFDEI being corrected for under-catch



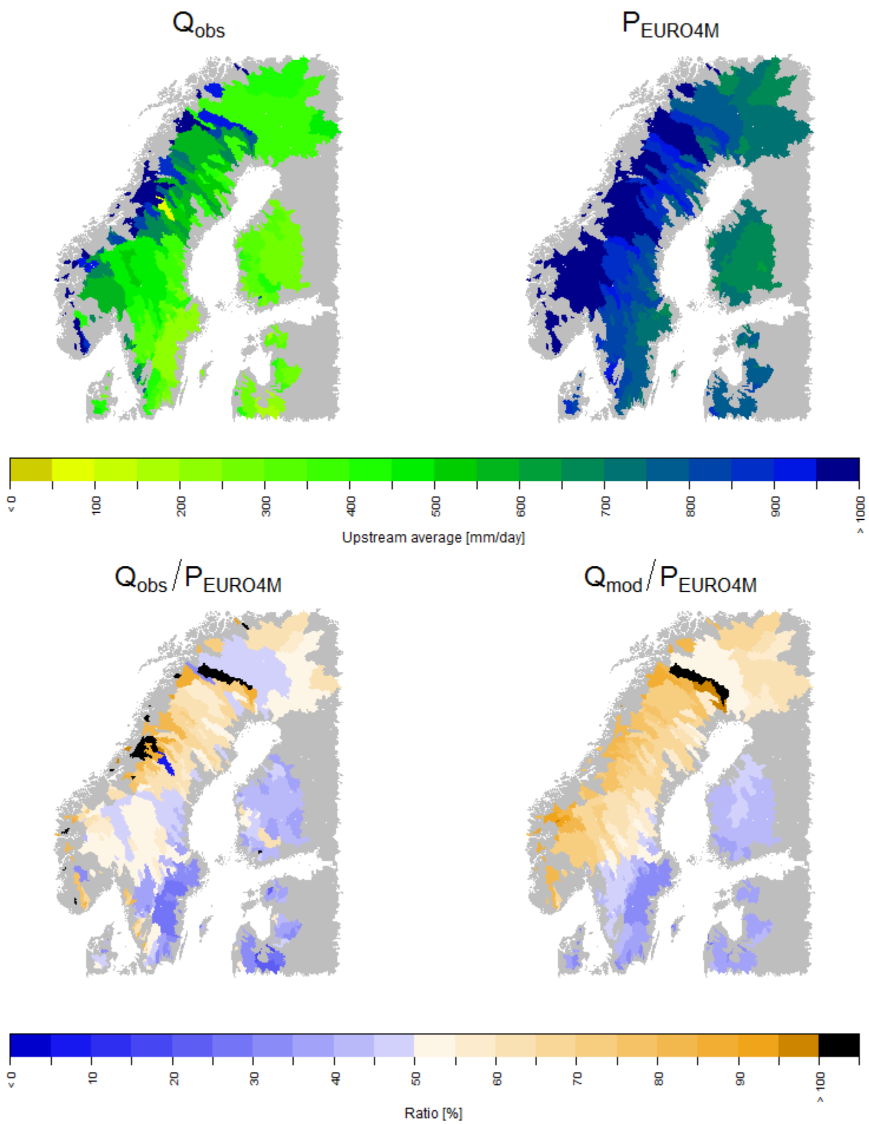
Hydrological evaluation

- We describe the balance between discharge (Q) and precipitation (P) by the ratio Q/P*100%
- If only precipitation affects the discharge, the ratio must be 100%, and other water sinks will act to reduce the ratio
- Possible sources other than P could exist, e.g. glacier melt, but in practice this requires a large fraction of glacier coverage of the catchment to have a significant effect, which was not found to be the case here
- Evapotranspiration is the main uncertainty, and here a simplified estimation based on temperature is used to estimate the effects.



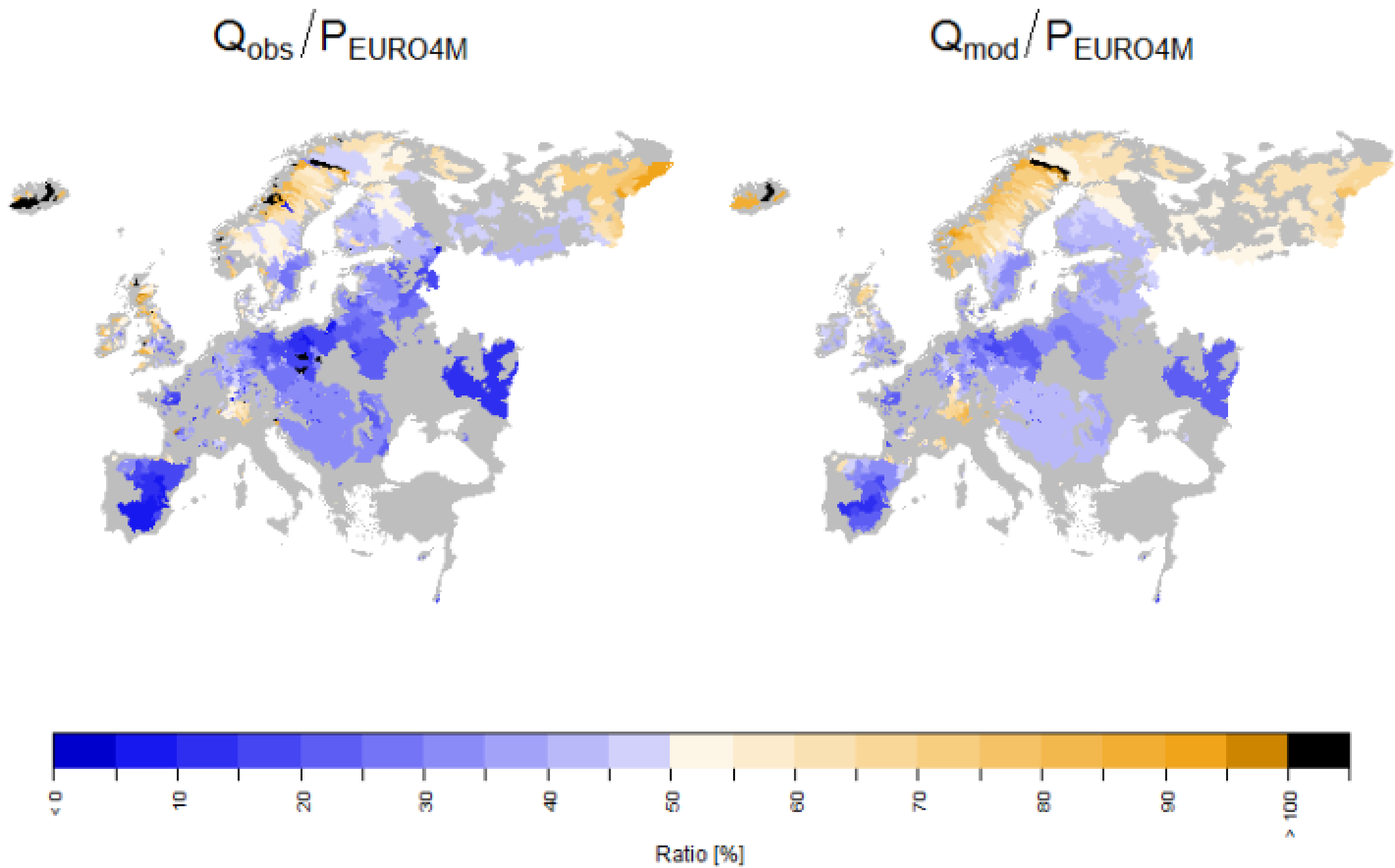
Scandinavia

- First, we perform a simple routing simulation with hydrological processes switched off, and compare the results to observed discharge
- The Q_{obs}/P-ratio must (in principle) be <1 if the precipitation amounts are correct. **Black** areas indicate Q/P>1
- The Q/P>1 in the catchment in Northern Sweden is due to a natural bifurcation sharing water with a nearby catchment, thus ok.
- Indications of too little precipitation falling west of the Scandic mountain range
- Modeled discharge Q_{mod} indicates the impact of hydrological processes on the Q/P-ratio, but is unlikely to explain the lacking water to the west of the mountains.



Europe

- Seems to be too high ratios over western England; similar situation as in Scandinavia
- For continental Europe, the evapotranspiration plays a larger role, and there are large uncertainties in estimating this



Conclusions

- Catchment scale investigations of the ratio between precipitation and discharge can provide an overview of the long term water balance, when routing with a hydrological model

- Sources of uncertainties are mainly from estimations of evapotranspiration, and for some catchments possibly from long term trends in e.g. glacier melt

- The method is most promising in regions with relatively weak evapotransipration, and where a clear water divider exists, such as the Scandic mountain range

- Further work includes more detailed investigations of discharge stations to get the most out of the data, as well as sensitivity studies using different evapotransipration calculations