Expected future hydrological conditions and crop productivity under selected climate scenarios
A Pannonian case study

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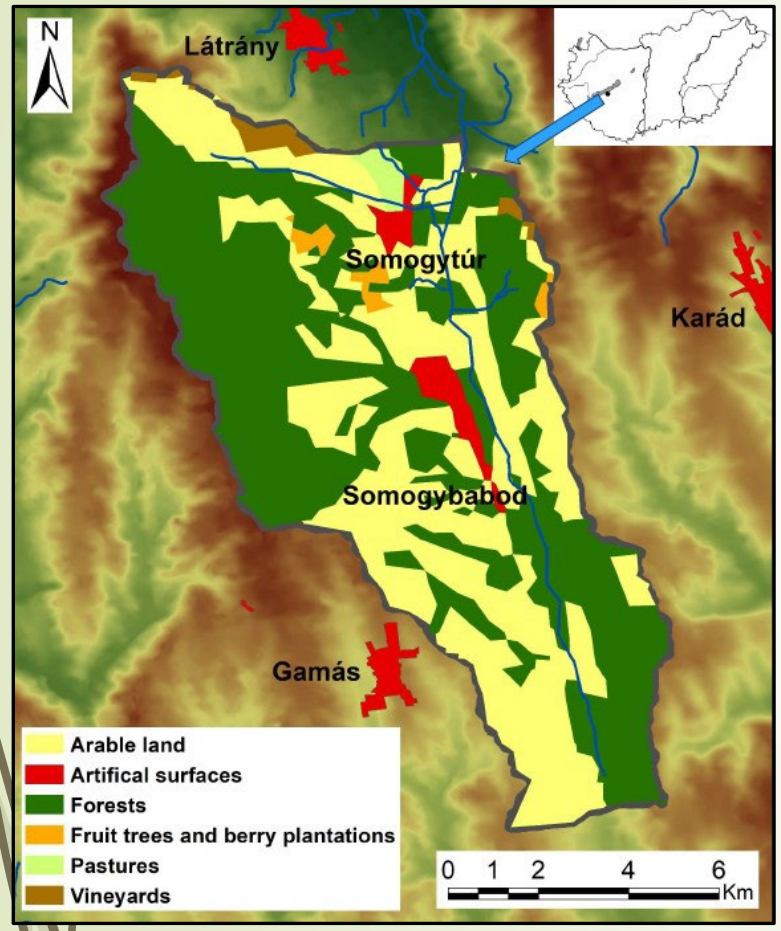
Tetves watershed



Tetves, pannonian region

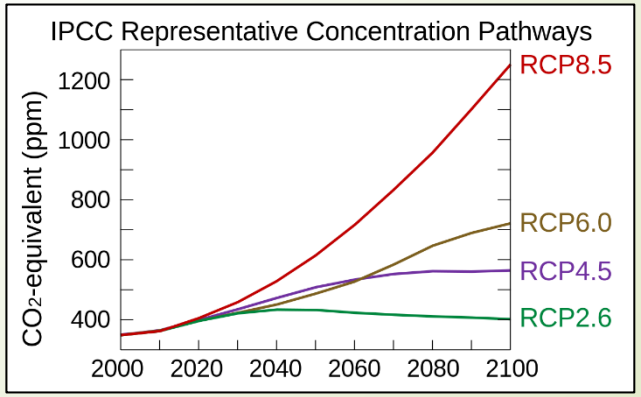
Catchment area: 72,36 km^2
Elevation range: 106-295 m a.s.l.
Precipitation: 689 mm/year
Annual mean temperature: 11.2°C
Dominant land use: agriculture and forest

Time horizons

- 1991-2020 - “baseline”
- 2036-2065 - “near future”
- 2070-2099 - “end of century”

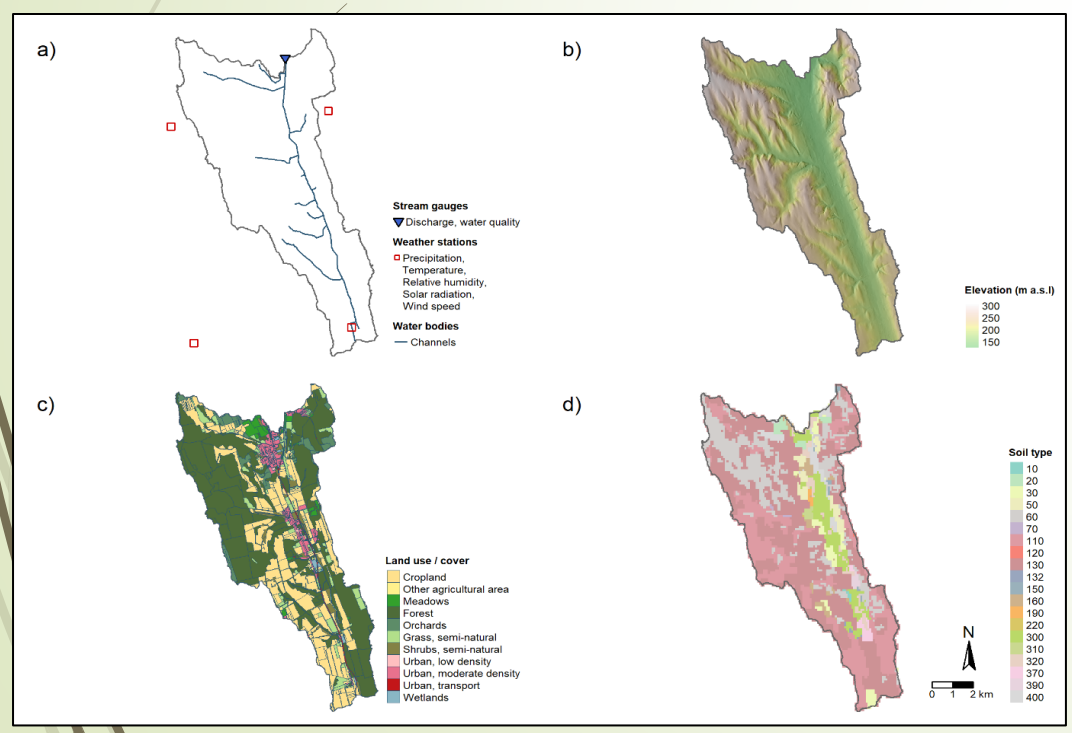
Representative Concentration Pathways

- RCP 2.6
- RCP 4.5
- RCP 8.5



Baseline Modell Input Data

- The model for the catchment was set up based on the OPTAIN workflow (Schürz et al., 2022).
- In the case of the land cover and land use map we generated time-series crop rotation maps for arable land categories using remote sensing data. The most important crops are maize, winter wheat ,winter barley, winter rape, sunflower and lucerne. HRUs were defined based on the land use map.
- Basic soil data like soil layering, maximum rooting depth, organic carbon content, clay, silt, and sand content was retrieved from the national Hungarian database (DOSoReMI.hu) (Pásztor et al., 2018).



GIS input data:

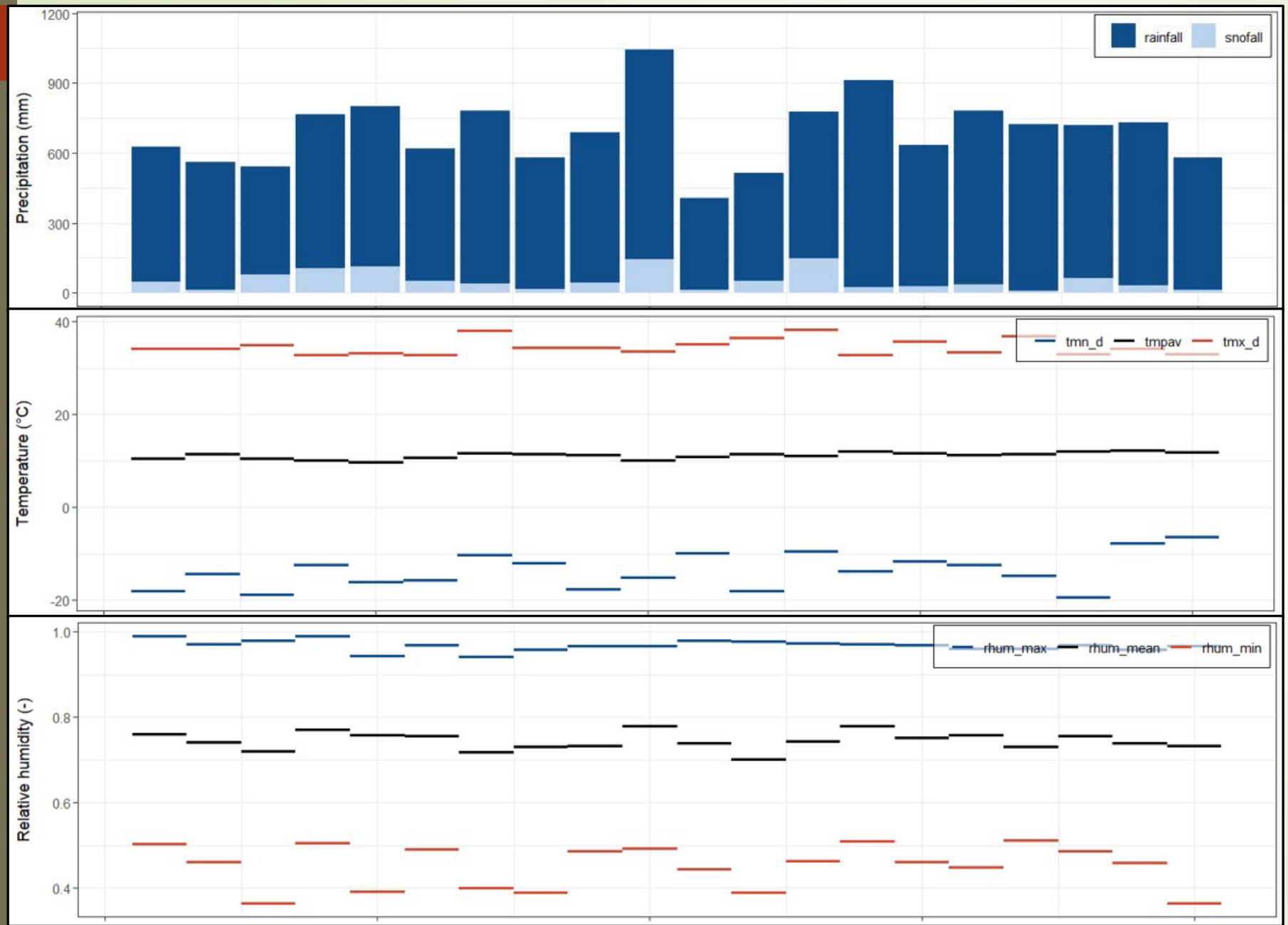
a) flow gauge, water quality monitoring points, meteorological stations, channels and catchment boundary

b) elevation map

c) land use map

d) soil property maps

Climate data for baseline



Average annual:

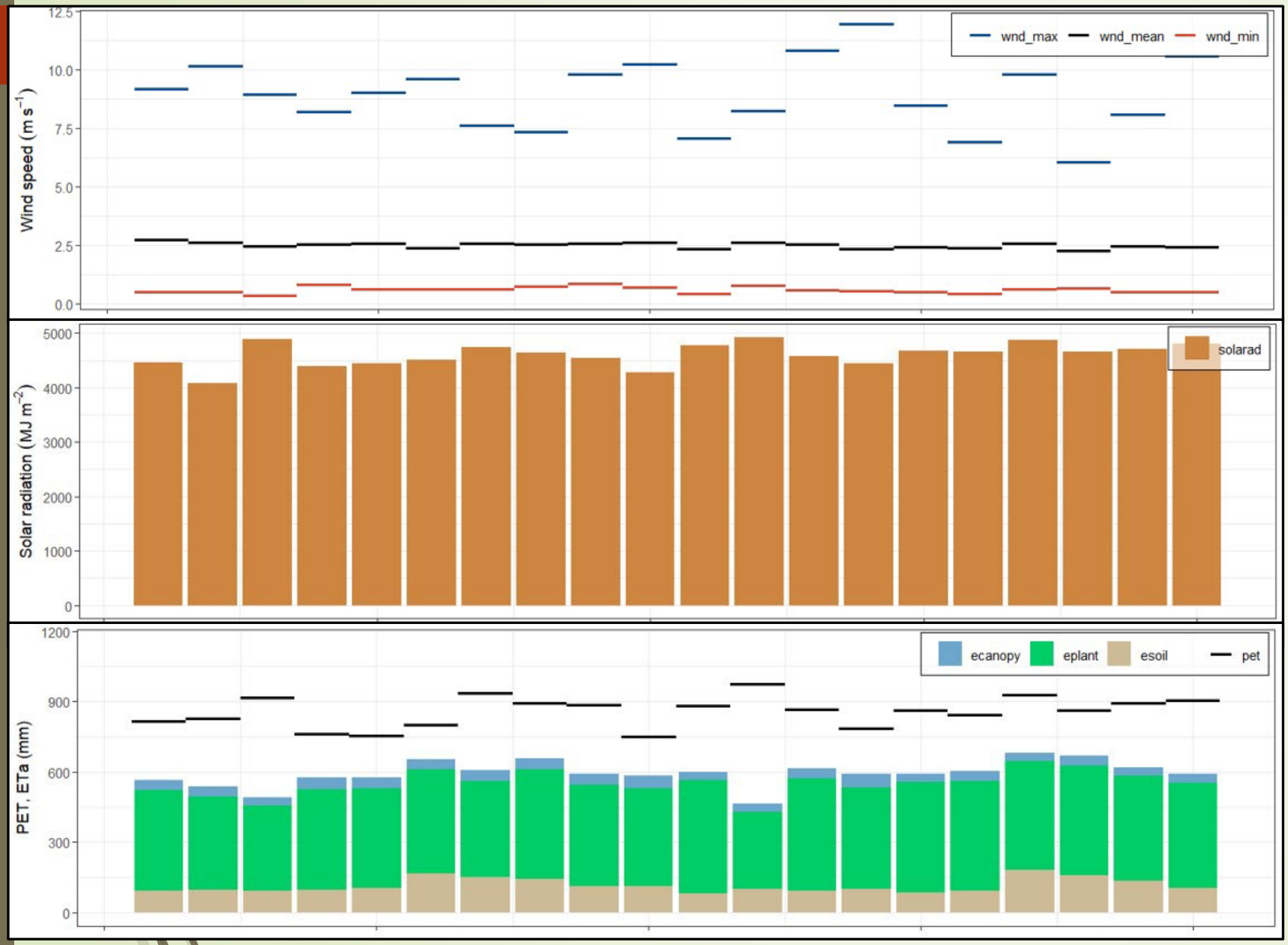
- Precipitation 689mm
- Rainfall 636 mm
- Snowfall 53 mm

- Tmin day -19,5°C
- Tmax day 38,4°C
- Average day 11,2°C

- Relative humudity 0,75

2001.01.01-2020.12.31.

Climate data for baseline



Average annual:

- Wind speed 2,52 m/s

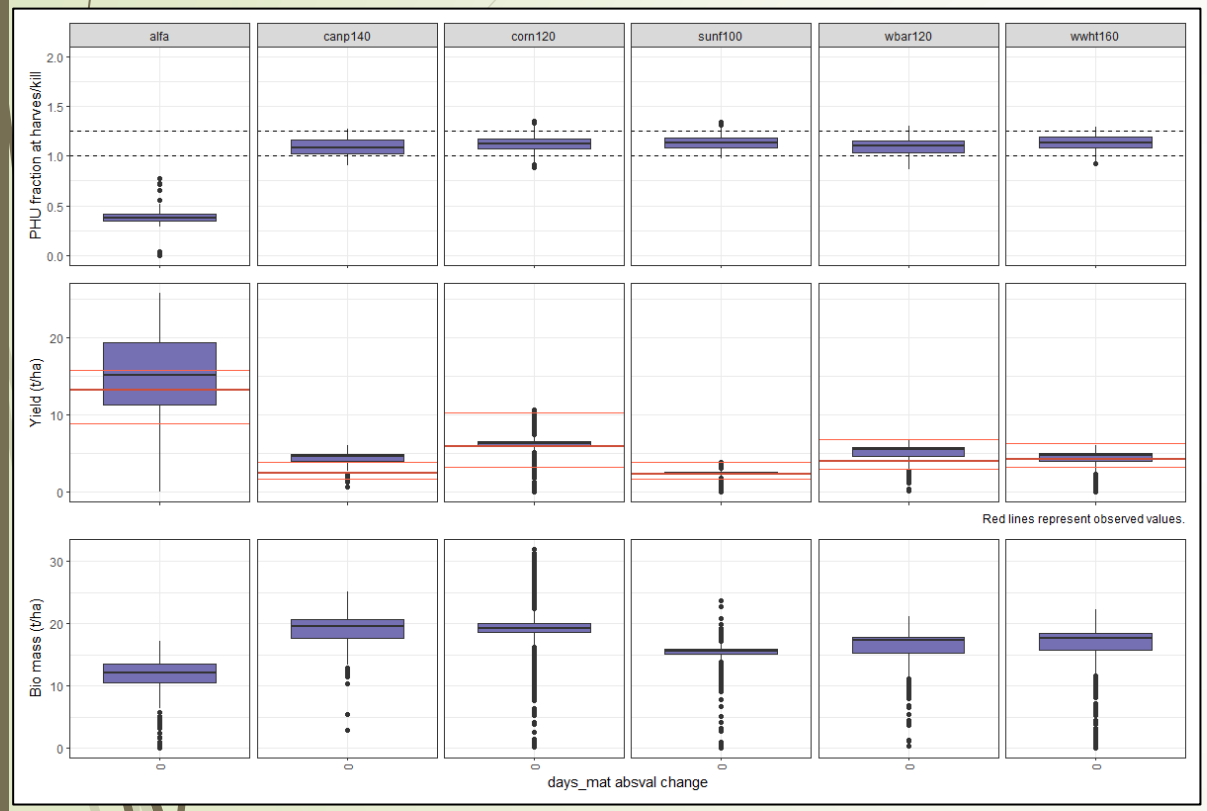
- Solar radiation 4605 MJ/m^2

- Pet 857mm
- Et 593mm
- Ecanopy 42mm
- Eplant 435mm
- Esoil 115mm

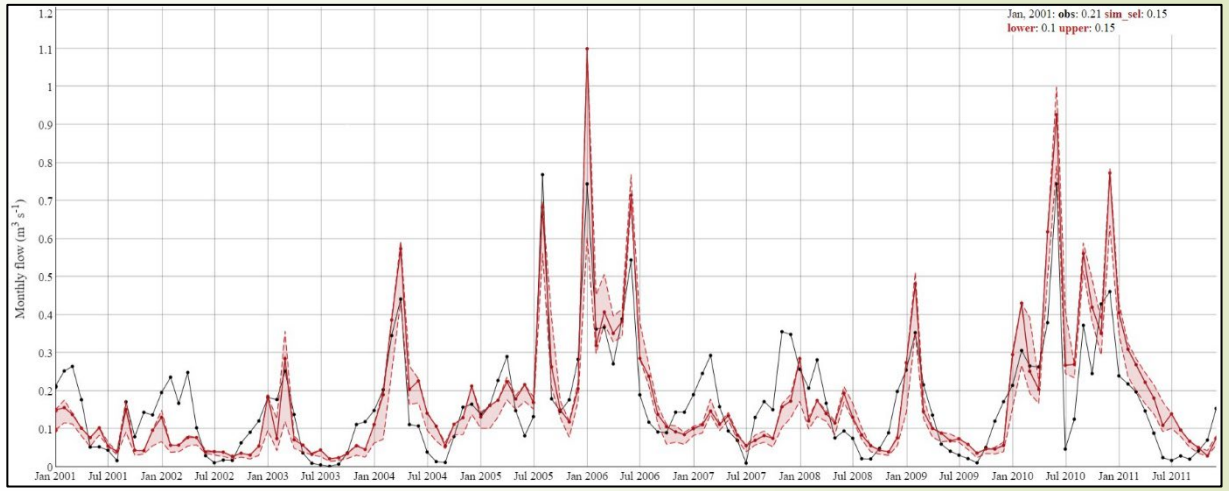
Baseline Modell Setup

- The uncalibrated model setup was developed using the SWATbuildR (version 1.5.10) and SWATfarmR (version 3.2.0). The SWAT+ model revision 61.0.64 was used in all simulations.
- SWATdoctR was used to the SWAT+ model setup verification.
- For the soft calibration we used crop yield and water yield ratio as observation data.
- Hard calibration was performed based on discharge and N-NO_3 concentrations.
- R scripts were derived in OPTAIN project for soft and hard calibration, validation, running model with future climate data.

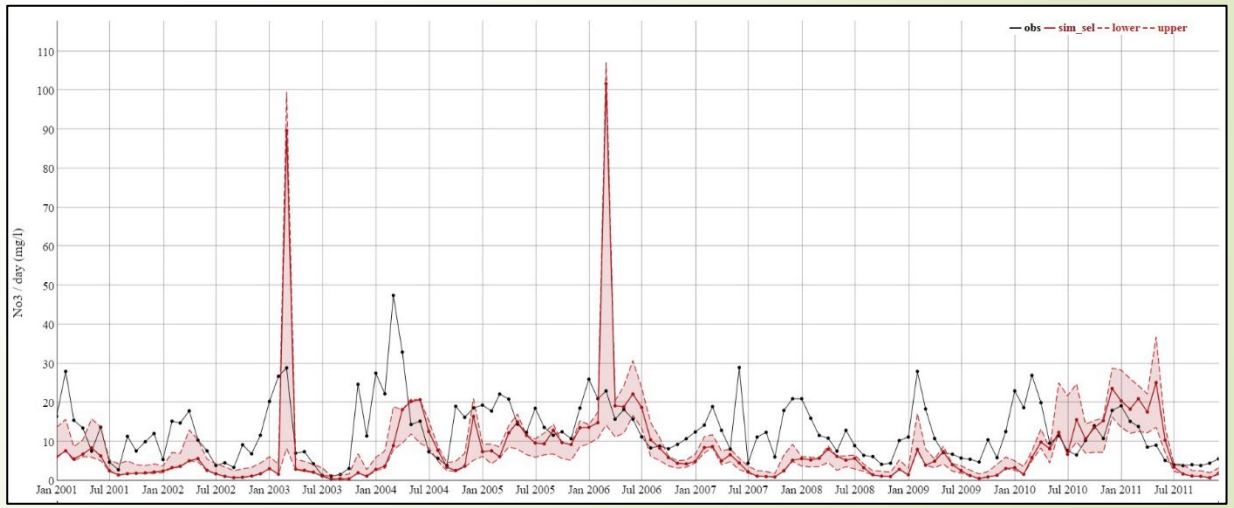
Calibration results



Crop yield soft calibration.



Simulated vs. observed discharge



Simulated vs. observed $N\text{-}NO_3$ concentrations

Effect of climate change

- We examine the effects:
- on the water balance
- nutrient losses
- crop yields

In the analysis we included:
-precipitation,
-snowfall,
-snow melt,
-potential evapotranspiration,
-actual evapotarnspiration,
-percolation,
-soil moisture content,
-surface runoff flowing into channels,
-lateral soil flow into
-channels,
-tile flow.

For the bias correction, locally measured data was considered.

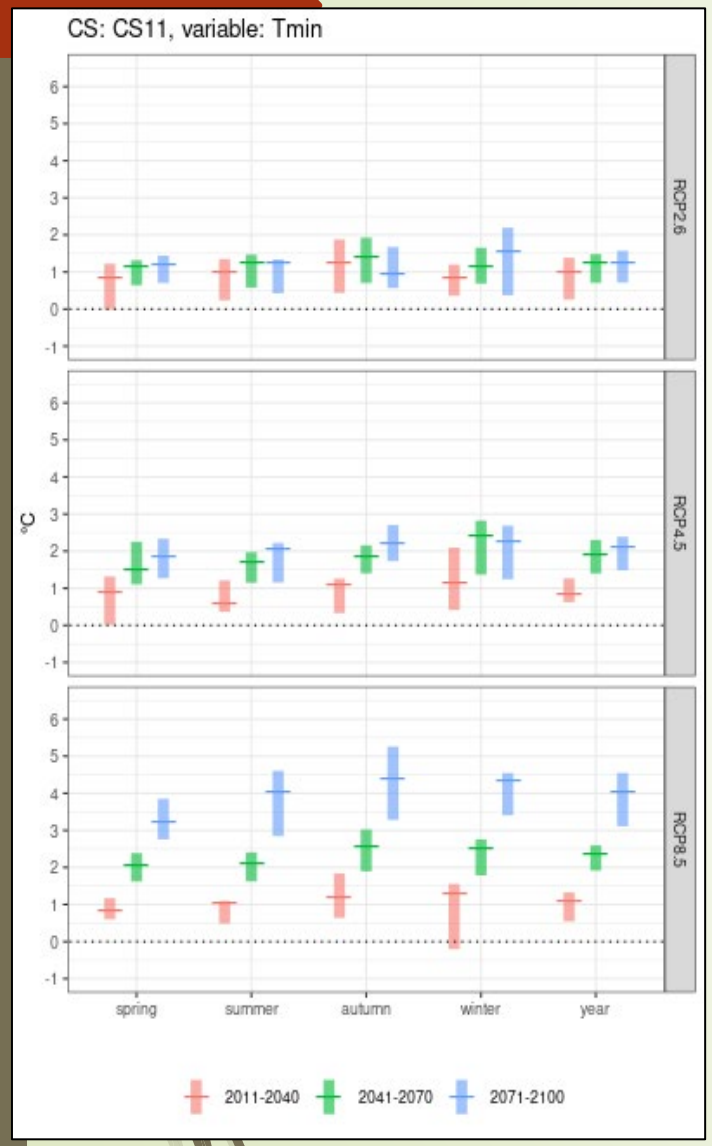
We applied combinations of six RCMs (Regional Climate Model), three RCPs and three time horizons.

Projected changes in annual and seasonal minimum and maximum temperature as well as precipitation were taken into consideration.

Future climate data was derived within the OPTAIN project.

Honzak, L. (2022). Bias-corrected EURO-CORDEX RCM simulations for the OPTAIN case studies (v4) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.6202062

Projected Tmin, Tmax changes



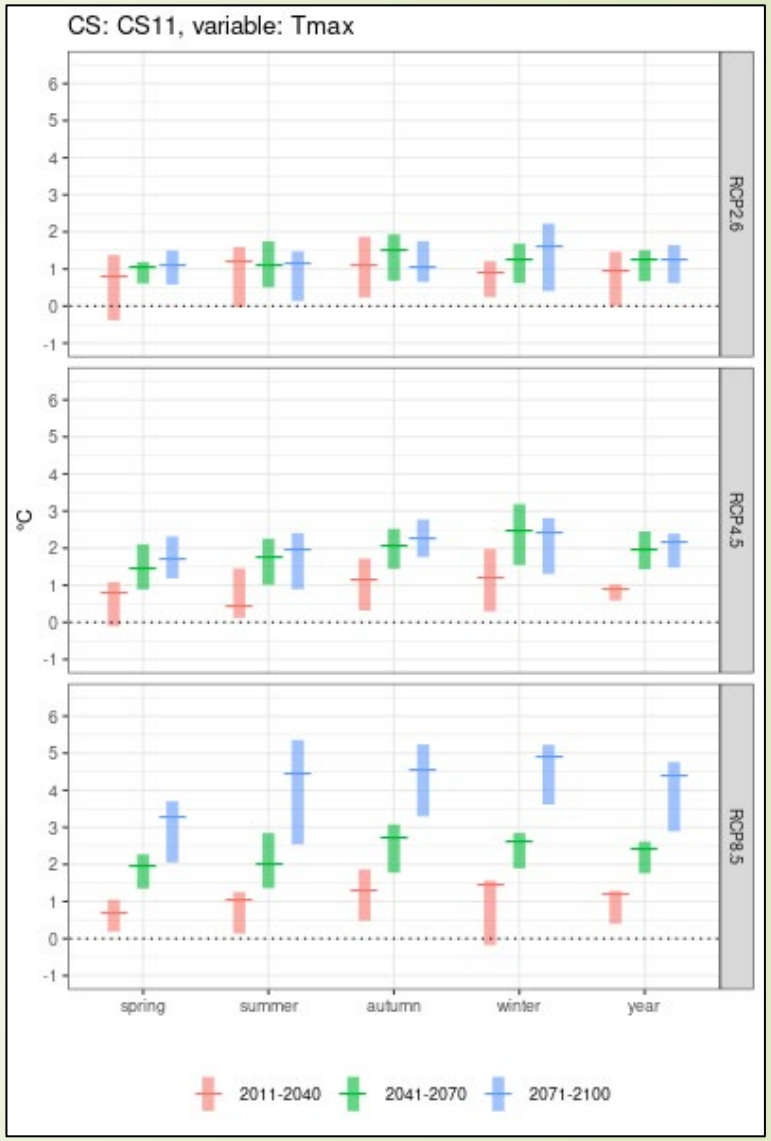
There is a warming pattern in the case of RCP8.5, projected increase in Tmin and Tmax is between 2.5 and 3.5 °C.

On avarage the highest magnitude of the warming signal occurs in winter, while the lowest in spring.

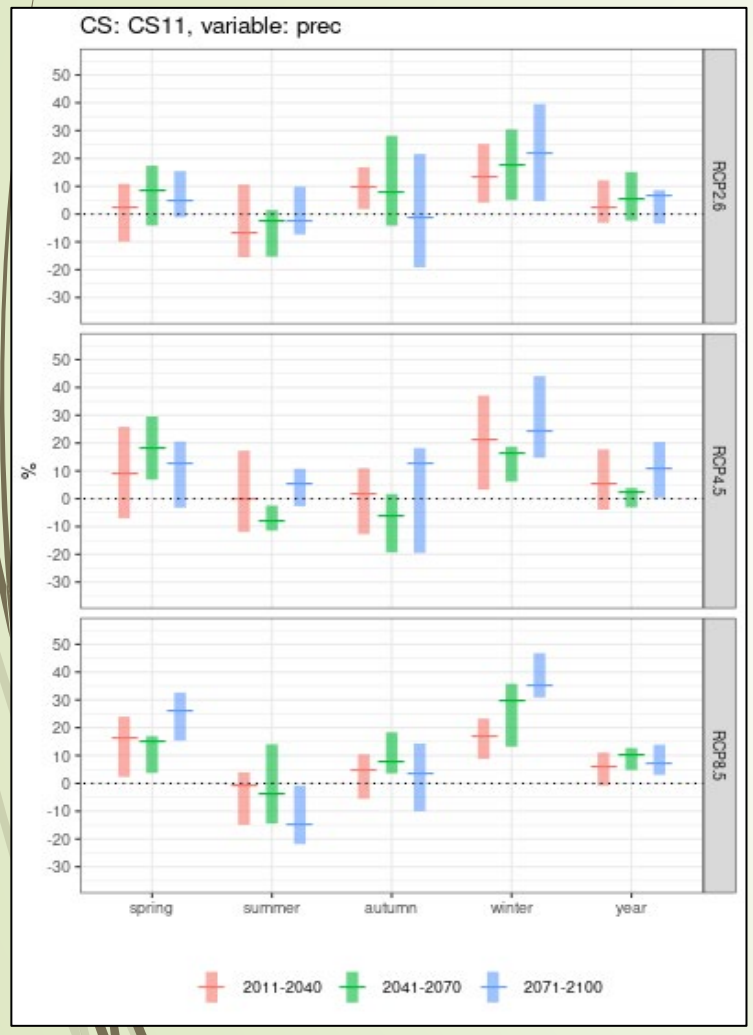
Under RCP2.6 the projected change does not generally exceed 1 °C.

The 2071-2100 period is characterised by the highest model spread.

In general, projected changes in wind speed, solar radiation and relative humidity are relatively low, even under RCP8.5, and thus should not contribute a lot to the effect of climate change on the studied indicators.



Projected precipitation changes

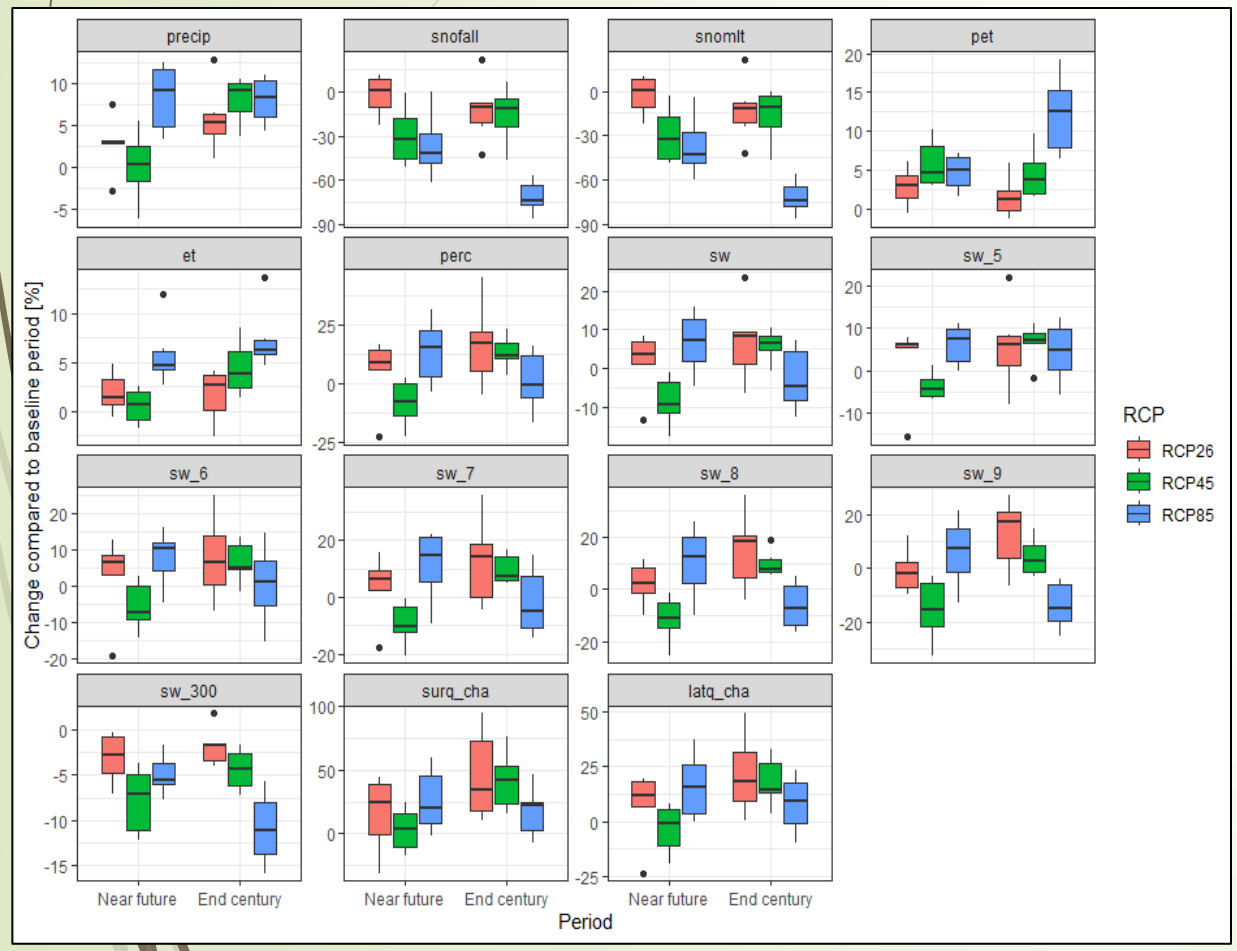


Precipitation projections show a signal of wetter future across all RCPs based on annual expexted changes.

Under RCP8.5 spring and winter is wetter, summer is drier close to the end of the century.

Under RCP2.6 autumn is drier, winter is wetter close to the end of the century.

Projected changes in selected basin-averaged water balance components simulated by SWAT+



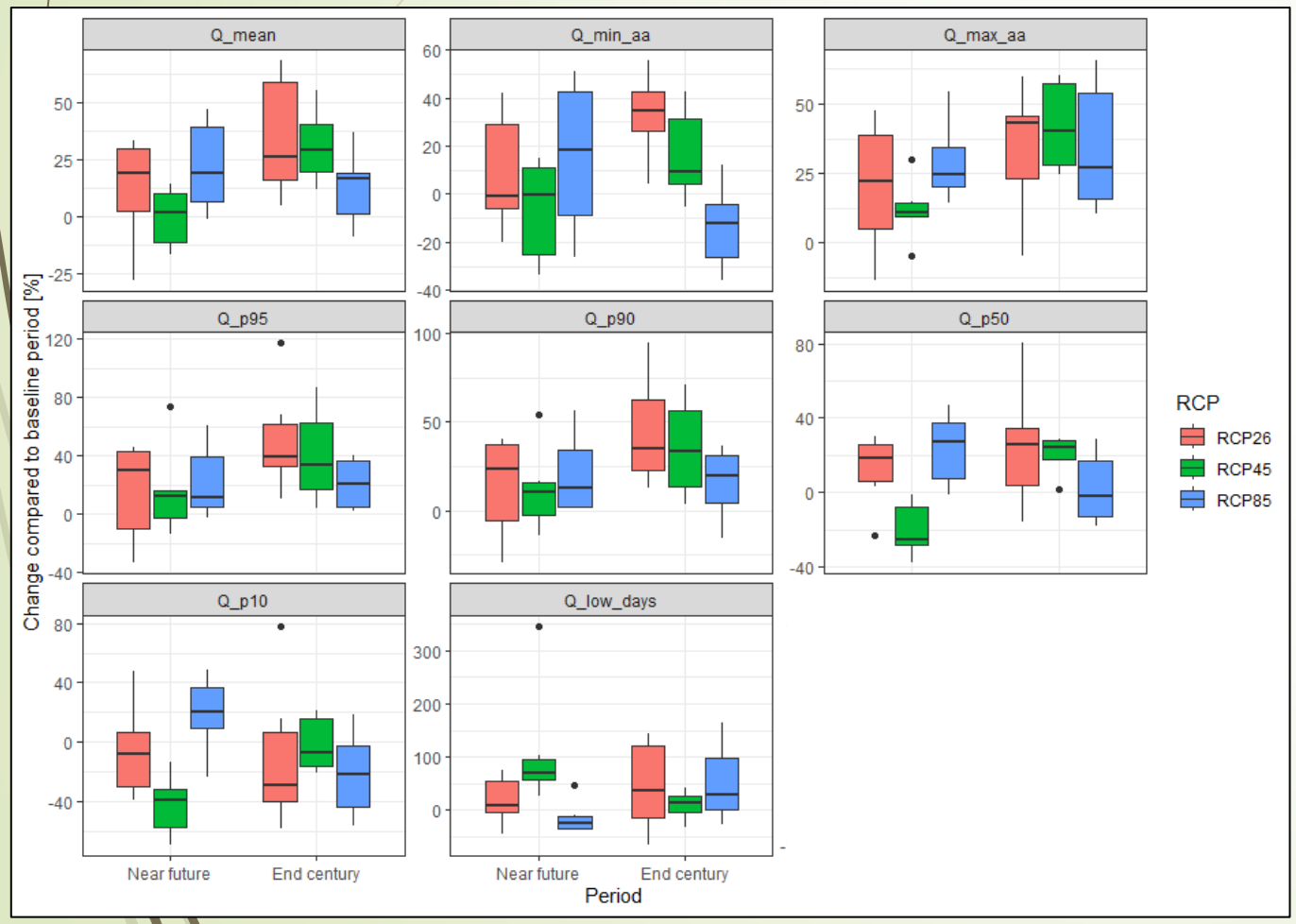
Decrease of snowfall, snowmelt and average annual soil moisture in top 30 cm is projected.

Soil water content in the period of May-September is expected to decrease only in the case of RCP4.5 in the near future period and RCP8.5 close to the end of the century, especially in August.

Potential and actual evapotranspiration, surface runoff flowing into channels and lateral soil flow into channels are expected to increase in general.

sw_300:
average annual soil moisture in top 30 cm

Projected changes in selected streamflow indicators simulated by SWAT+



In the case of RCP2.6 average and median flow is projected to increase 20-25 %.

In the case of RCP4.5 average flow does not change in the near future but is expected to increase in the end of the century.

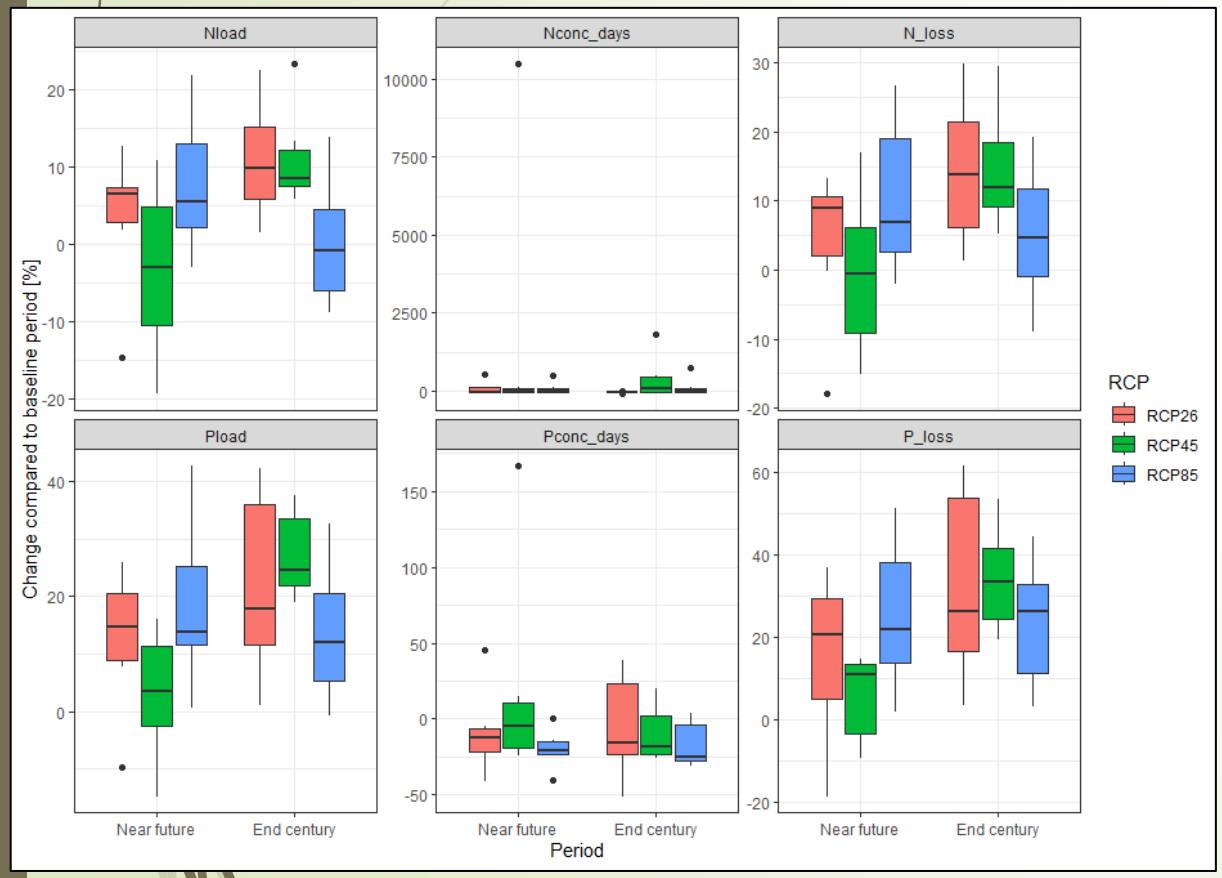
In RCP8.5, average flow is projected to increase 20 % in the near future which is kept at the end of the century.

Low flow days are projected to increase in RCP2.6 and 4.5.

In the case of RCP8.5 low flow days are expected to decrease in the near future and increase at the end of the century.

Q :daily discharge [m/s]

Projected changes in selected water quality indicators simulated by SWAT+



The plots show total nitrogen (TN) from NO_3-N. Phosphorus (P) was not calibrated, it's reliability is lower.

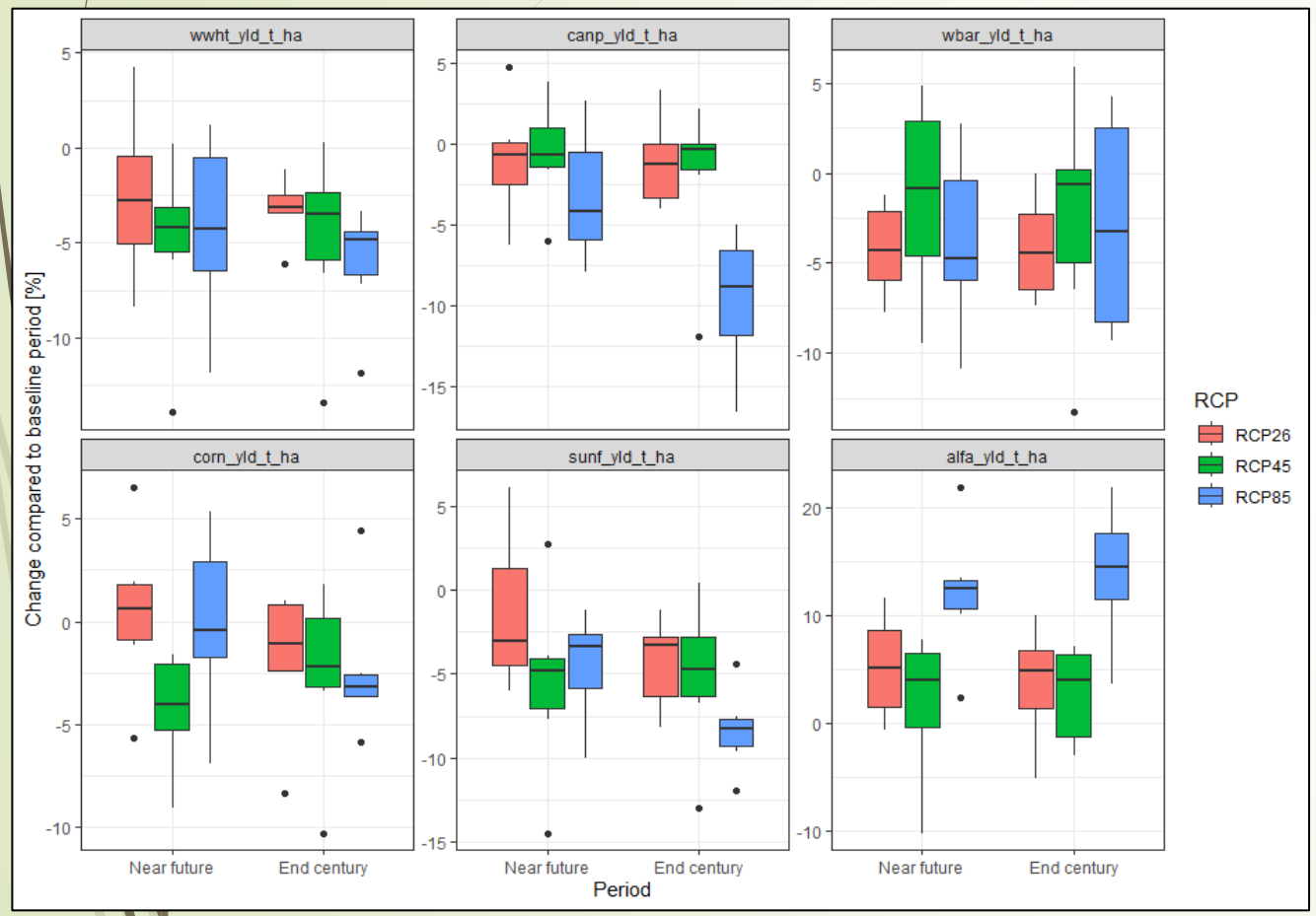
In general, under wetter conditions in the future, TN and P losses are projected to increase.

The frequency of days with high TN concentration is projected to increase, the opposite happens to TP concentration.

Average nitrogen load of the stream is projected to increase up to 10 % at the end of the century in RCP2.6. Expected trends are different for RCP4.5 and 8.5.

Average phosphorus load of the stream is projected to increase up to 25 % at the end of the century in the case of RCP4.5.

Projected changes in selected crop yields simulated by SWAT+



The mean crop yield of winter wheat, winter rape, winter barley, and sunflower is projected to decrease 1-8 % in the case of all analysed RCPs.

Highest decrease is expected in the case of RCP8.5, especially for winter rape and sunflower.

For corn, a slight increase is expected in the near future in RCP2.6, but in all other cases a 1-4 % decrease is projected.

For lucerne, yield increase is projected, around 5 % under RCP2.6 and 4.5 and 12-15 % under RCP 8.5.

Conclusion

On the Tetves watershed:

- In general, the temperature is expected to increase, especially in the case of RCP8.5.
- The precipitation is expected to increase, especially in the case of RCP2.6 and RCP4.5, except in summer. RCP8.5 predicts less increase in precipitation and an even drier summer. However the snowfall is expected to decrease in every case.
- Nitrogen and phosphorus loss are expected to increase, especially in the case of RCP2.6 and RCP4.5, which might be related to the increased precipitation.
- ET and PET is expected to increase, especially in the case of RCP8.5.
- Despite the increased precipitation soil moisture is expected to decrease due to increase of evapotranspiration, especially in the case of RCP8.5.
- The crop yield in the area is expected to decrease, except for lucerne, especially in the case of RCP8.5.

Thank you for your attention!

- This work received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 862756, project OPTAIN (OPtimal strategies to retAIN and re-use water and nutrients in small agricultural catchments across different soil-climatic regions in Europe)