Analysis and prediction of hydrological extreme conditions for a small headwater catchment in a German lower mountain range

HS4.6 – From sub-seasonal forecasting to climate projections: predicting hydrologic extremes and improving water management

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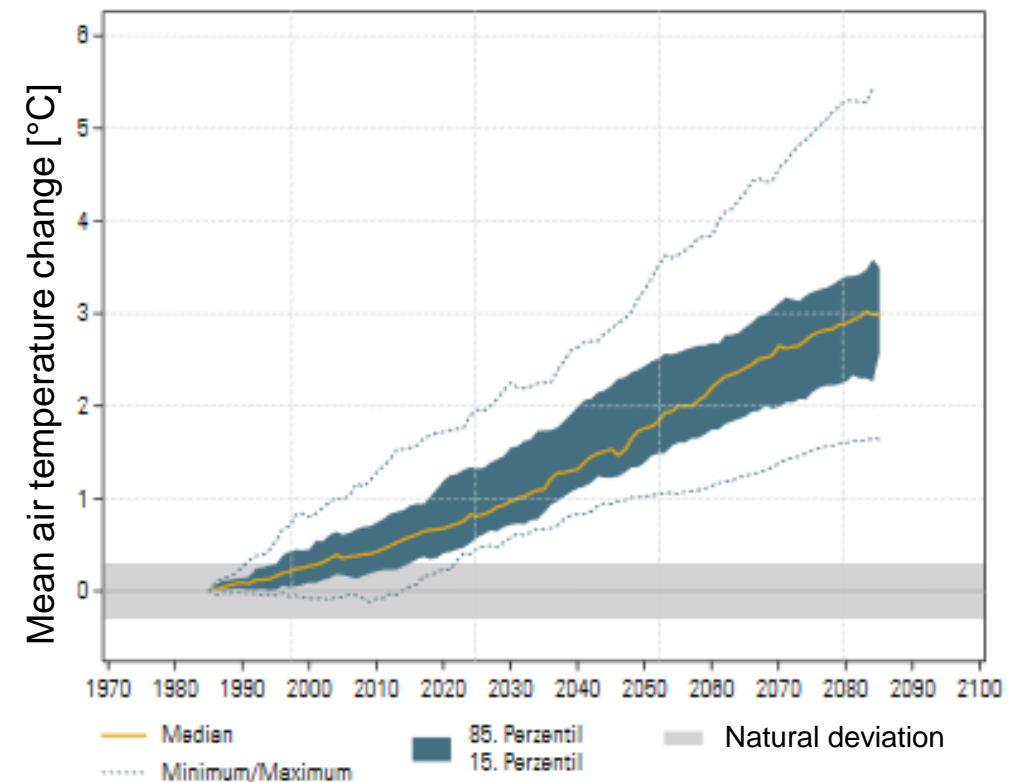
Introduction

Headwater catchments and riparian wetlands especially are very sensitive towards **changing climate conditions**.

We want to describe possible impacts climate change might have on bavarian headwater systems by implementing a **process-based model** (HydroGeoSphere) in one test catchment.

By utilizing a wide range of **climate change projections** of three scenarios (RCP2.6, RCP4.5 and RCP8.5) based on two different Global and four different Regional Climate Models, we will be able to cover future climate conditions.
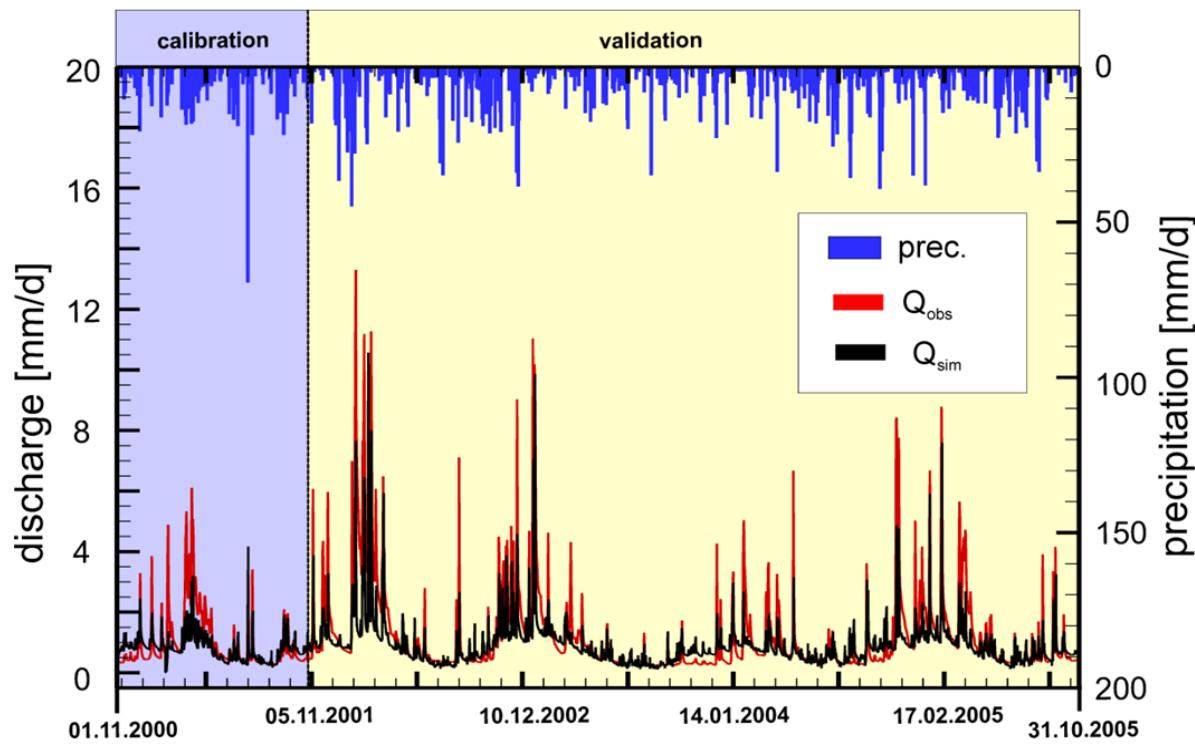
Due to the current **drought** phenomena, we will put special emphazise on the catchments possible response to future drought conditions.
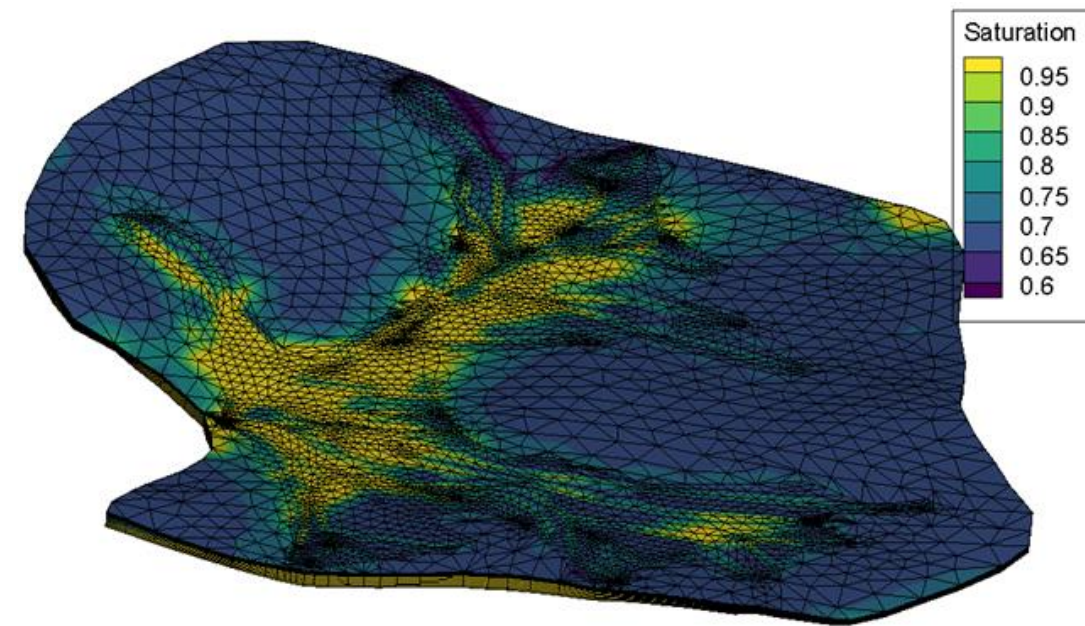
Climate Change in Bavaria, Germany

Bavarian climate adaptation strategy, 2016 (altered)

Process-based model: HydroGeoSphere

Partington et al., 2013

Numerical hydrological model of the test catchment
(Lehstenbach, Fichtel Mountains, NO Bavaria, Germany)

- Reproduction of flow processes in the catchment
- Input: precipitation and potential evapotranspiration
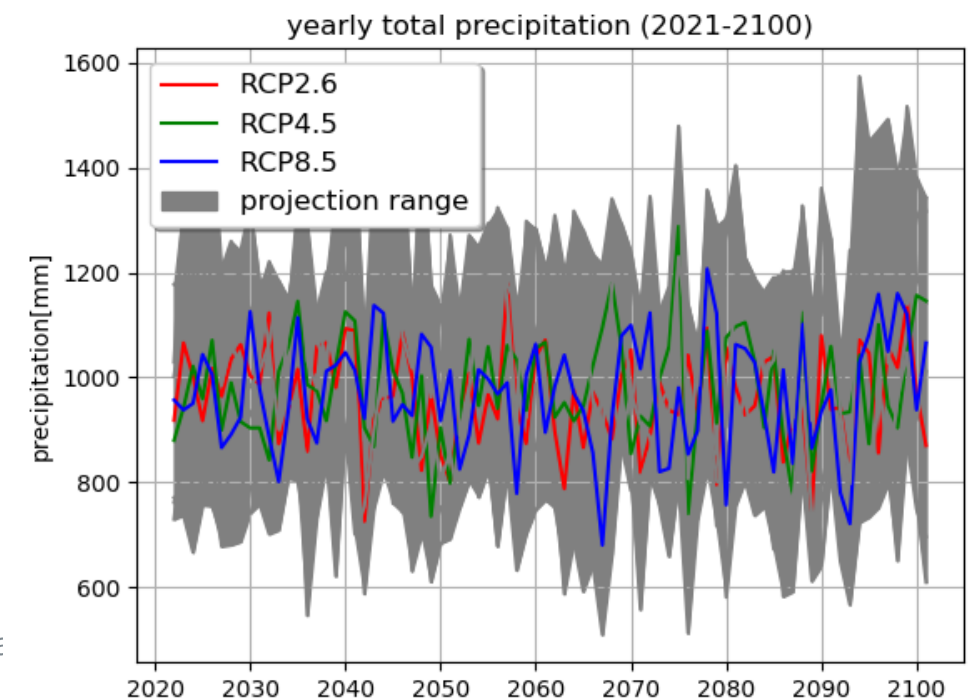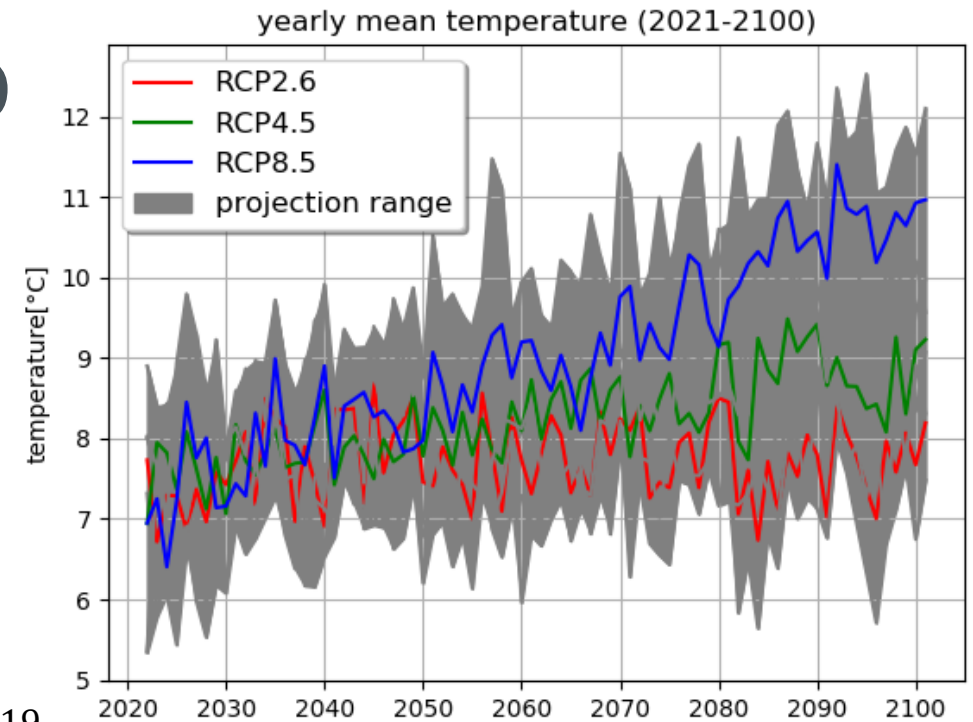- Prognosis: climate scenarios

Partington, Daniel, et al. "Interpreting streamflow
generation mechanisms from integrated
surface-subsurface flow models of a riparian wetland and
catchment." *Water Resources Research* 49.9 (2013):
5501-5519.

Climate Change Scenario

GCM/RCM	RCM from	RCP2.6	RCP4.5	RCP8.5
ICHEC KNMI 1	Netherland		x	x
ICHEC KNMI 12	Netherland	x	x	x
ICHEC SMHI	Sweden	x	x	x
ICHEC CLMcom	Germany	x	x	x
MPI KNMI	Netherland	x	x	x
MPI SMHI	Sweden	x	x	x
MPI UHOH	Germany	x		x

$\sum$ 19

Overview of chosen climate projections and GCM/RCM combinations
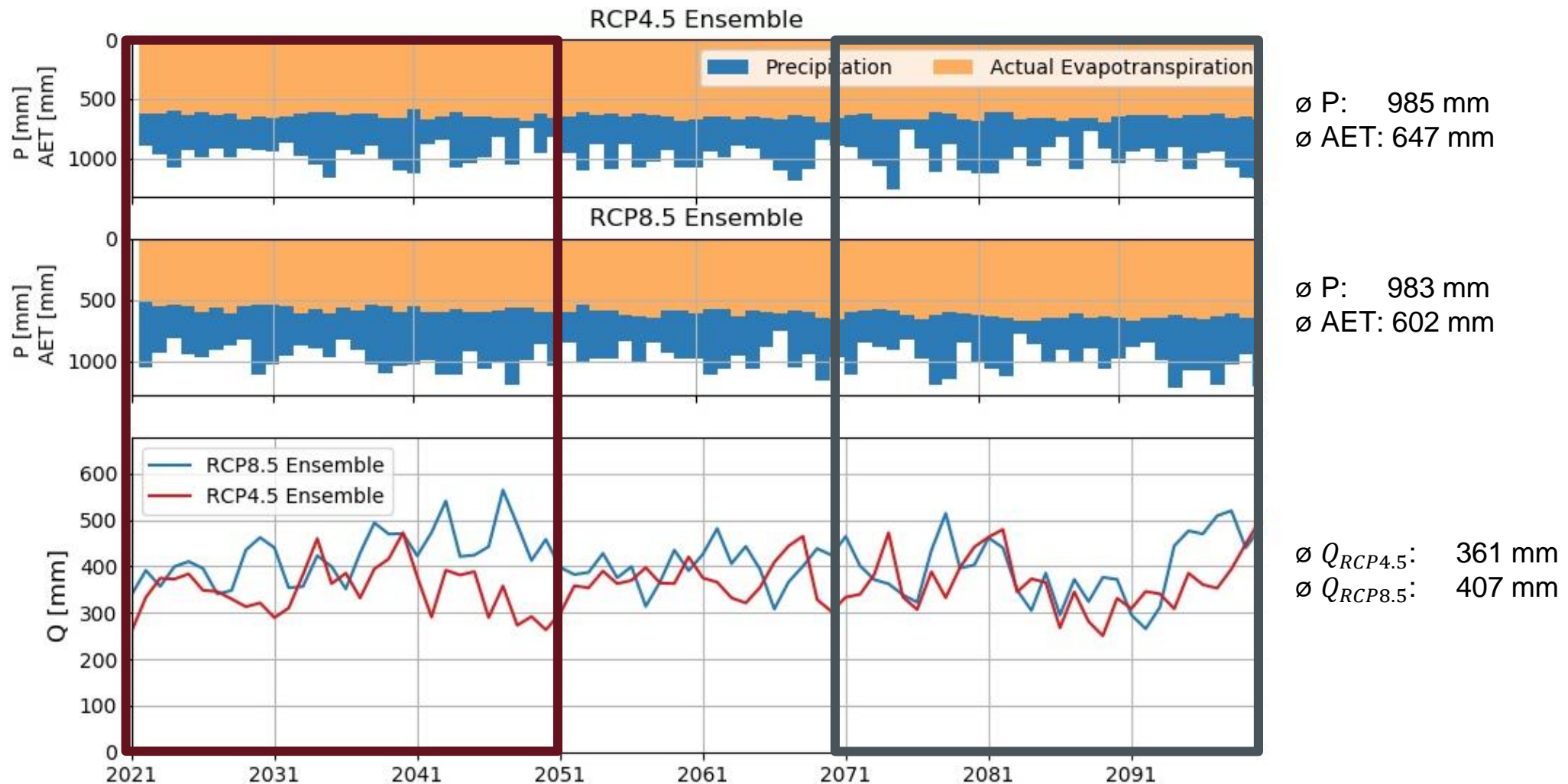
- Data set is regionalized and bias-corrected
- Each projection is individually calculated
- Use of ensemble mean for further calculations

yearly mean temperature (2021-2100)

yearly total precipitation (2021-2100)

Lisa

Ensemble Results

ø P: 985 mm
ø AET: 647 mm

ø P: 983 mm
ø AET: 602 mm

ø $Q_{RCP4.5}$:   361 mm
ø $Q_{RCP8.5}$:   407 mm

Near Future

RCP 4.5	RCP 8.5
ø P: 964 mm	ø P: 973 mm
ø AET: 639 mm	ø AET: 575 mm
ø Q: 351 mm	ø Q: 426 mm

Far Future

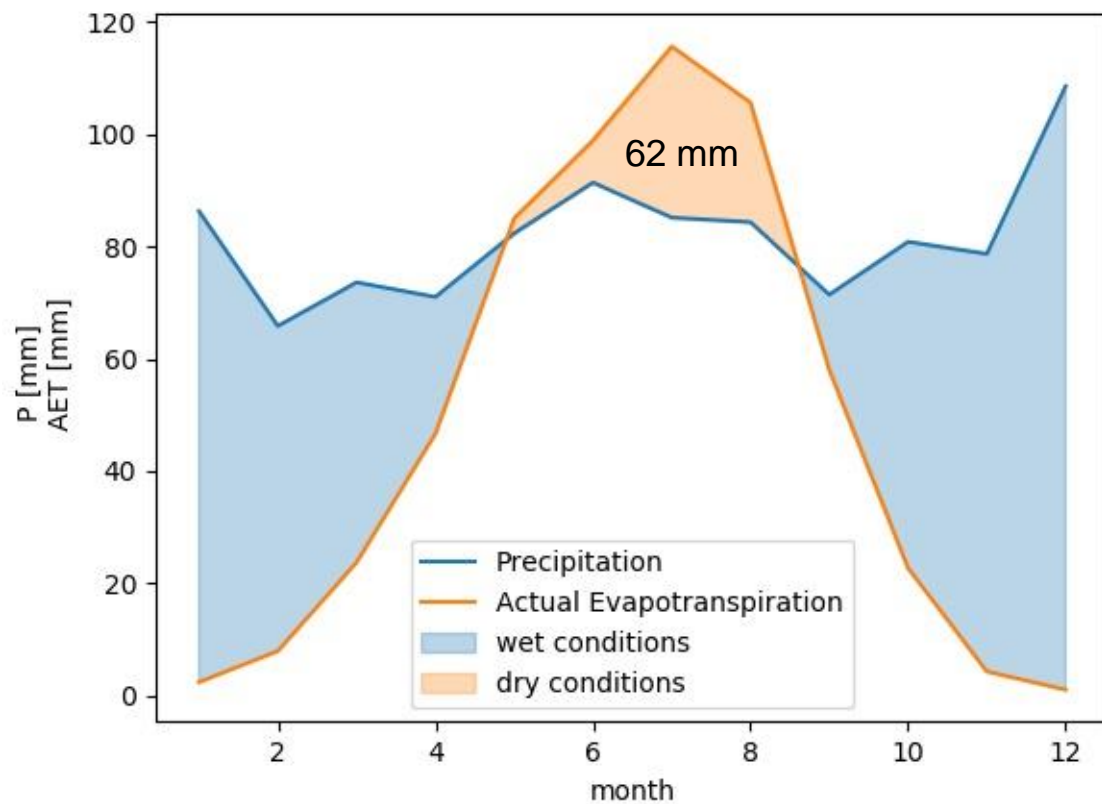| RCP 4.5	RCP 8.5
ø P: 999 mm (+3.5%)	ø P: 997 mm (+2.4%)
ø AET: 653 mm (+2.1%)	ø AET: 632 mm (+9.0%)
ø Q: 366 mm (+4.1%)	ø Q: 397 mm (- 7.3%)

Strong increase

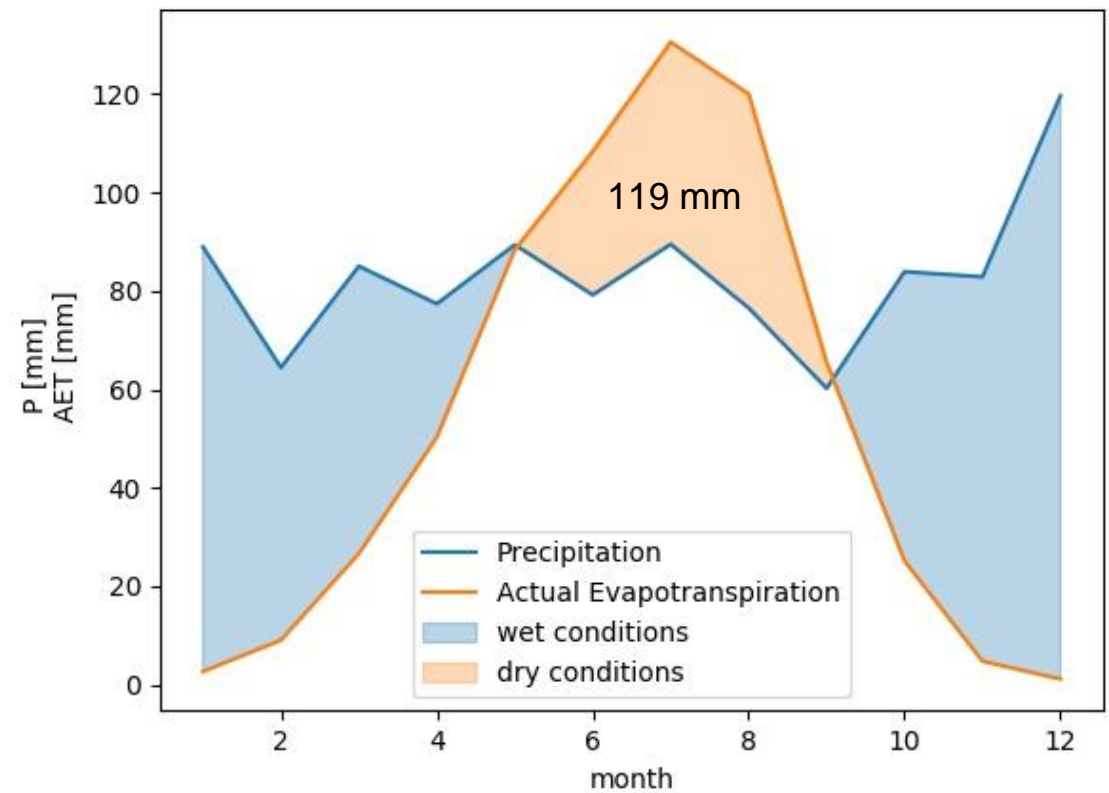Lisa Hennig, Sven Frei   lisa.hennig@uni-bayreuth.de l 5

P-AET-Diagram: RCP 8.5 - Ensemble

= Comparison of precipitation (P) and actual evapotranspiration (AET) rates
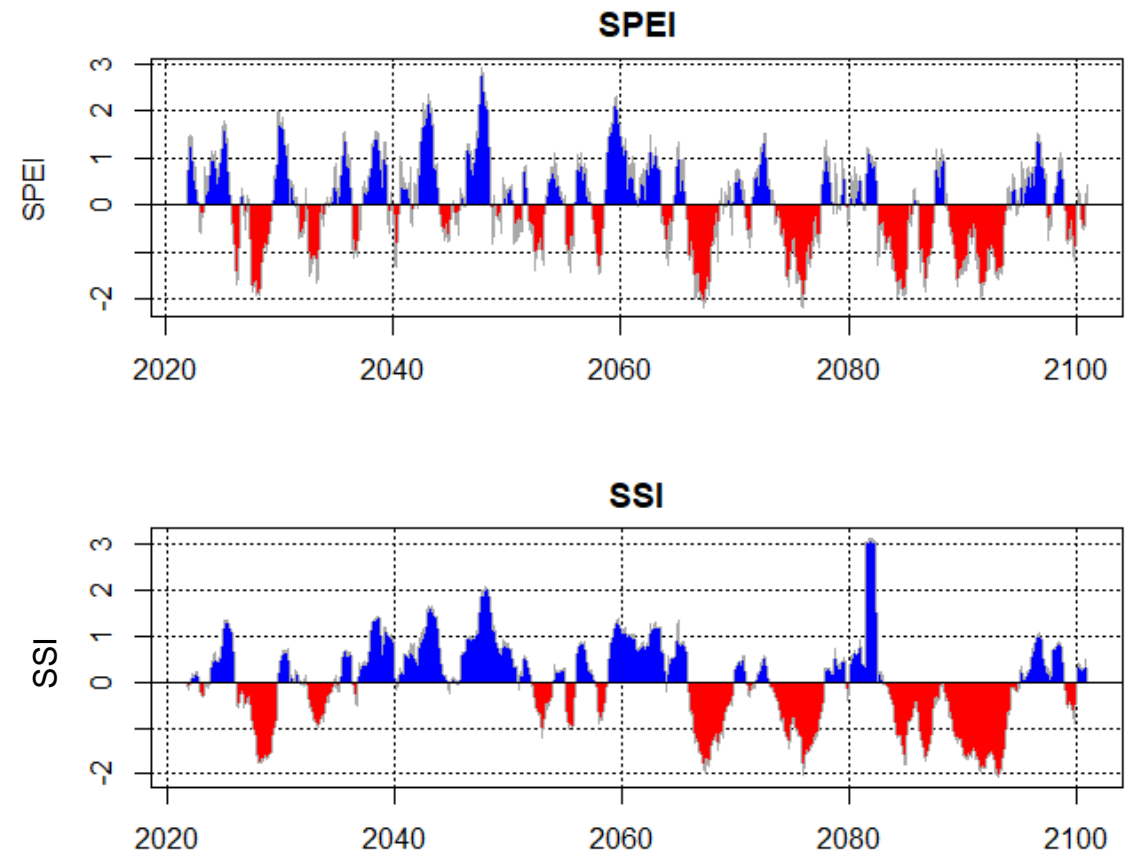- Indicates intensfying negative water balance in summer

Area between the curves (approx. with trapezoid rule)

Drought Conditions: RCP 8.5 – one projection only

- Standardized Precipitation-Evapotranspiration Index (SPEI): How wet (blue) or dry (red) are current meteorological conditions?

- Standardized Streamflow Index (SSI): How wet (blue) or dry (red) are current hydrological conditions?

- Values of SPEI and SSI indicate intensity

- Results show continuously longer as well as more intense and frequent drought events in this projection

Potential Impacts on the Lehstenbach catchment

- Reduction of yearly runoff
  - Runoff falls below ecologically necessary runoff more often
  - Effect on flora and fauna composition
  - Further impacts on water quality and quantity in middle and lower reaches

- Intensifying of drought periods

  - Impacts on spruce (70 % of the catchment):
    - water stress might lead to lower growth rates
    - higher tree mortality possible
    - higher infestation risk with bark beetle possible
  - Impacts on wetland function (30 % of the catchment):
    - Possible change of species composition with less water dependent species
    - Possibly less water retention volume, increasing drought and flood conditions
    - Possible changes in soil and evapotranspiration properties → might lead to changes in flow pathways and overland flow properties