Climate change impact assessement considering water discharge and nutrients in a mesoscale coastal watershed

- input from a catchment to its lagoon-

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  - CC impact assessment on water discharge and nutrients
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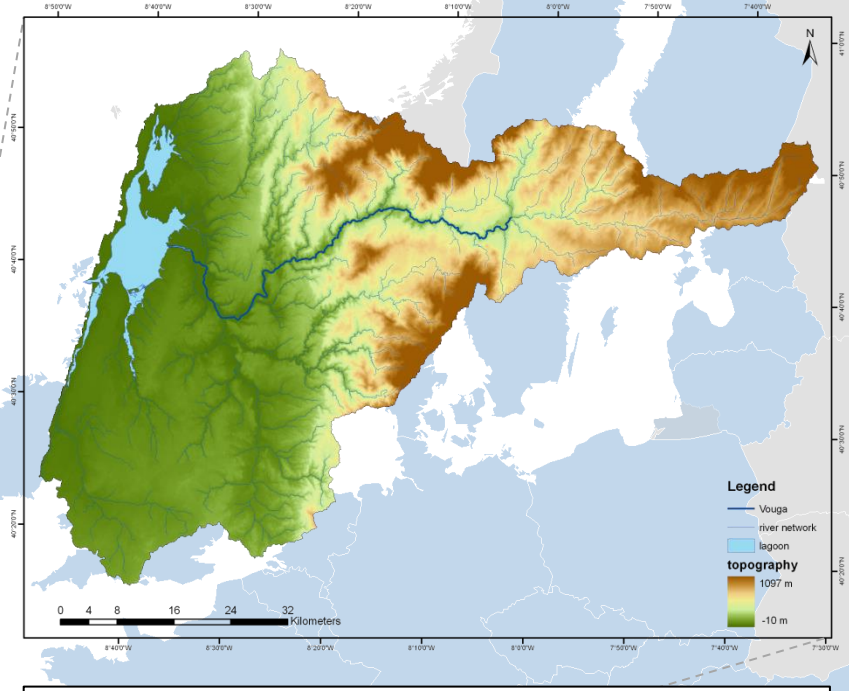
Ria de Aveiro watershed

- interface between terrestrial environment and coastal waters
- under various anthropogenic pressures, increasing during last decades
- threats with regard to overall trend of climate change and regional development
- salinization, pollution, variations in water level influenced by processes taking place in watershed



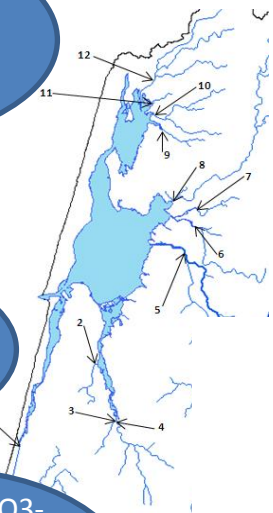
area:	3600 km²
av. precip.:	800 mm/year
av. temp.:	14°C
major landuse:	forest (64%), cropland (26%)
major river:	Vouga

Methodology

SWIM

Model set up for entire coastal watershed

DEM, Soil map, land use map, point sources, agricultural practices etc.



NSE, PBIAS, graph fitting

Hydrological and water quality calibration

Observed daily water levels

Measured NO3-N, NH4-N, PO4-P and DOX concentrations & water temp.

Changes in seasonal dynamics, Q10, Q90, nutrient loads and water temperature

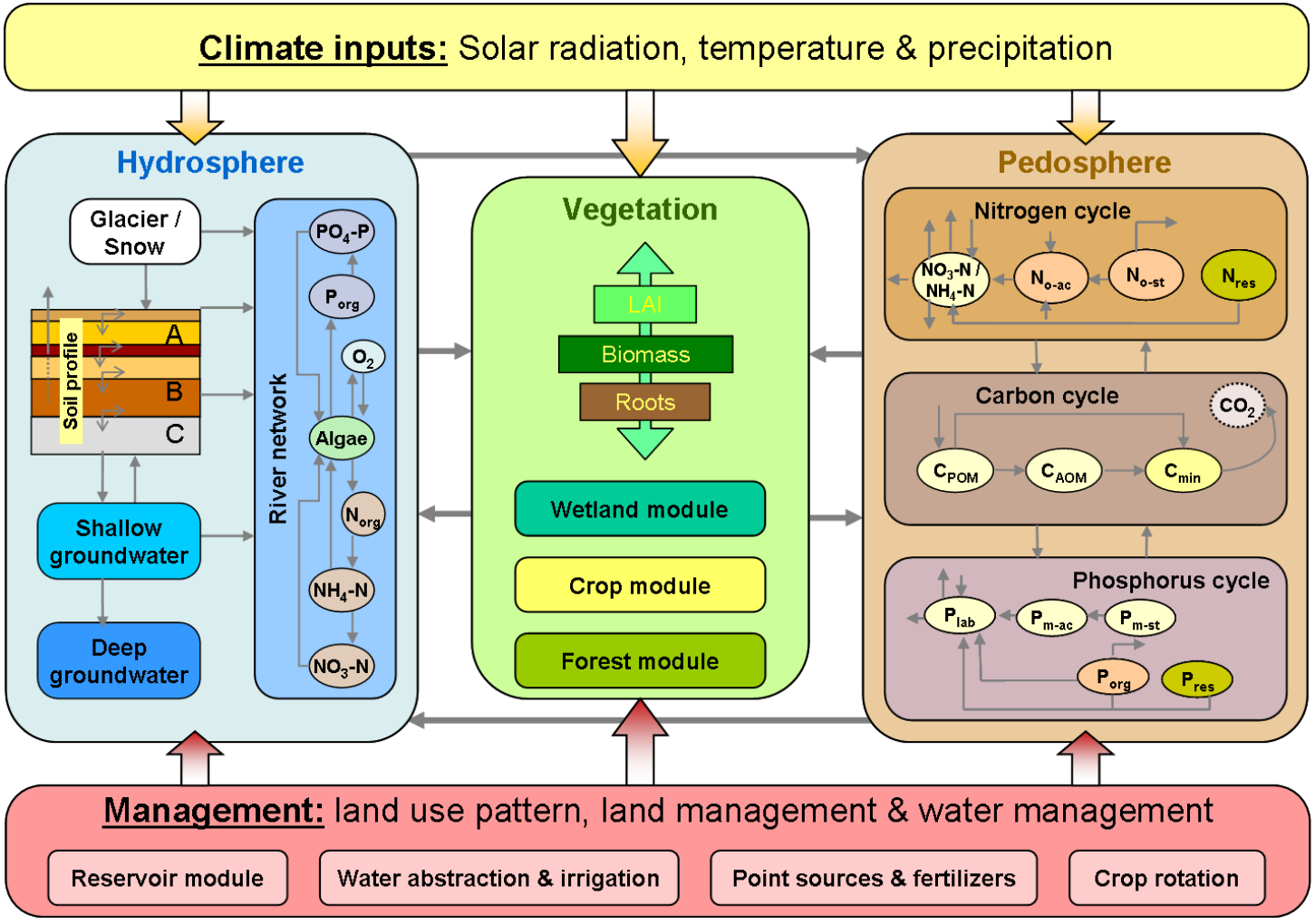
Climate change impact studies on water quantity and quality on the total input to the lagoon

ENSEMBLE of different climate change scenarios

PIK

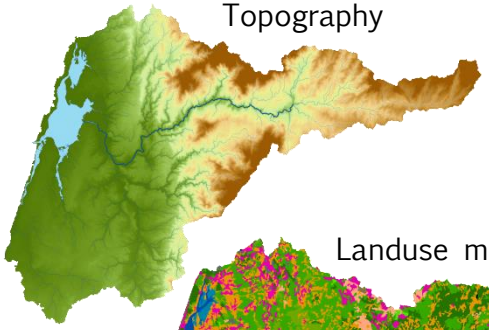
Lagoons

SWIM

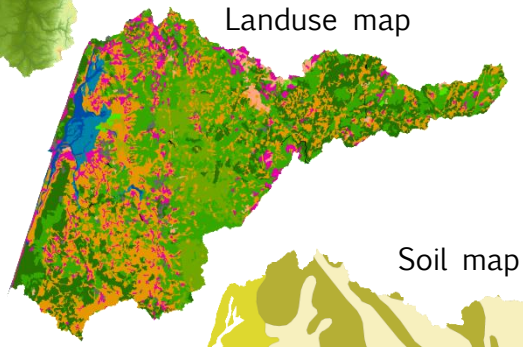

Climate inputs: Solar radiation, temperature & precipitation
Hydrosphere
Glacier / Snow
Soil profile
A
B
C
Shallow groundwater
Deep groundwater
River network
PO4-P
Porg
O2
Algae
Norg
NH4-N
NO3-N
Vegetation
LAI
Biomass
Roots
Wetland module
Crop module
Forest module
Pedosphere
Nitrogen cycle
NO3-N / NH4-N
No-ac
No-st
Nres
Carbon cycle
CO2
CPOM
CAOM
Cmin
Phosphorus cycle
Plab
Pm-ac
Pm-st
Porg
Pres
Management: land use pattern, land management & water management
Reservoir module
Water abstraction & irrigation
Point sources & fertilizers
Crop rotation

Model application

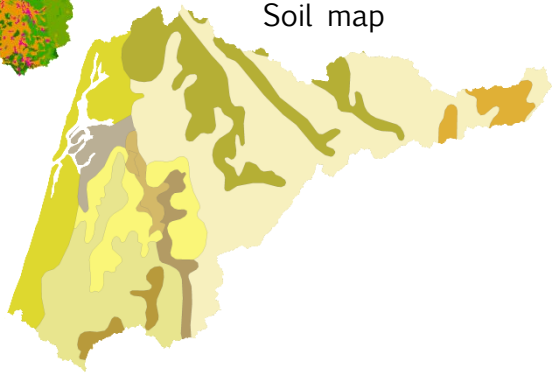
Topography



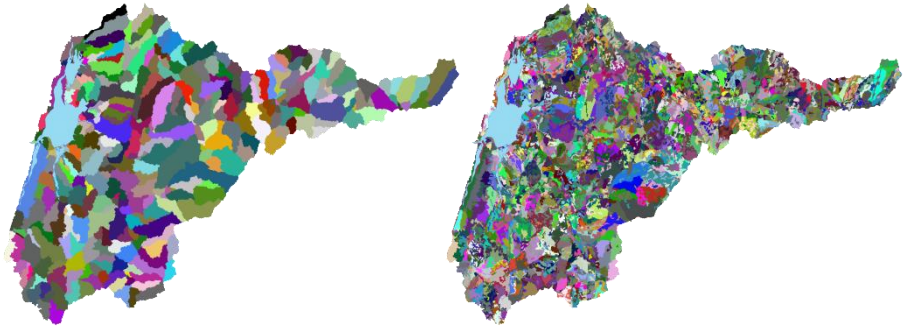
Landuse map

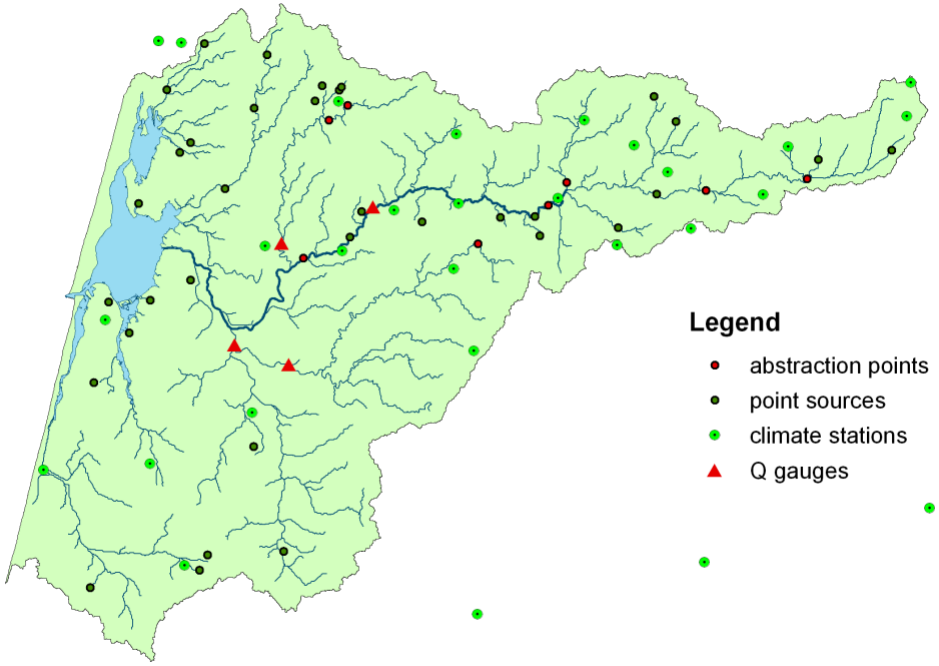


Soil map



Subbasin map → Hydrotope map





ENSEMBLES project

Climate scenario data from a multi-model approach

- variety of different Regional Climate Model (RCMs)
- boundary conditions from different Global Circulation Models (GCMs)
- A1B emission scenario (balanced used of fossil and non-fossil energy resources; assumed growing population until 2050, afterwards decreasing; temp. rise on global scale 1.8 – 4.4 °C until end of 21st century)

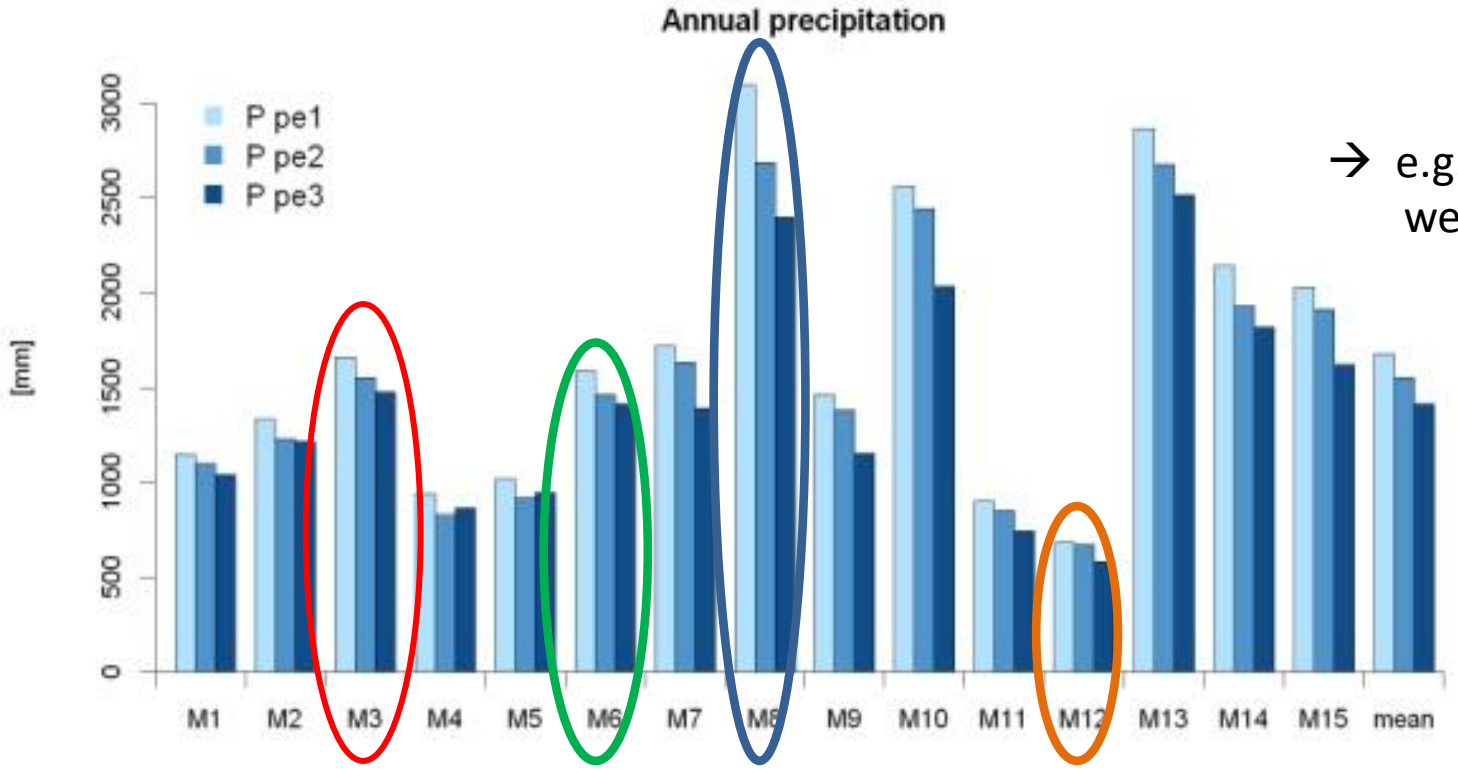
resolution of scenarios: **25** or 50km
simulation period: 1951 – 2050 or **1951 – 2100**

→ **15 climate scenarios**

GCM / Inst_RCM	HadCM 3Q0	HadCM 3Q3	HadCM 3Q16	ECHAM5-r3	BCM	ARPEGE
C4I_RCA3		M1	M5			
HC_HadRM3Q0	M2					
HC_HadRM3Q3		M3				
HC_HadRM3Q16			M4			
ETHZ_CLM	M6					
KNMI_RACMO				M7		
SMHI_RCA				M9	M8	
MPI_REMO				M10		
CNRM_Aladin						M11
DMI_HIRHAM				M13	M14	M12
ICTP_REgCM				M15		

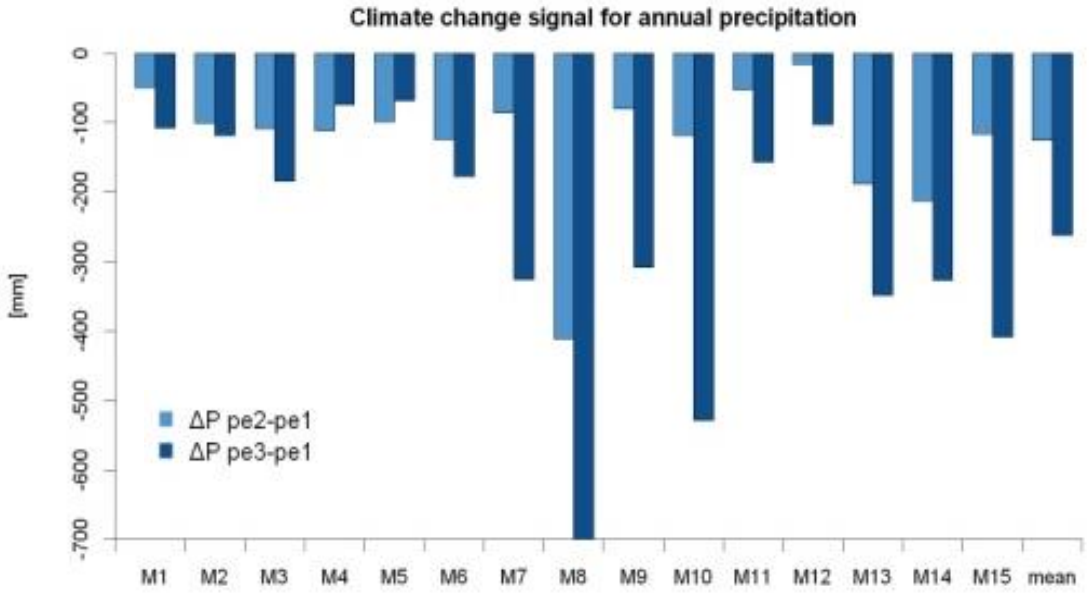
Scenarios evaluation

Reference period p1= (1971 – 2000)
1st future period p2= (2041 – 2070)
2nd future period p3= (2071 – 2098)



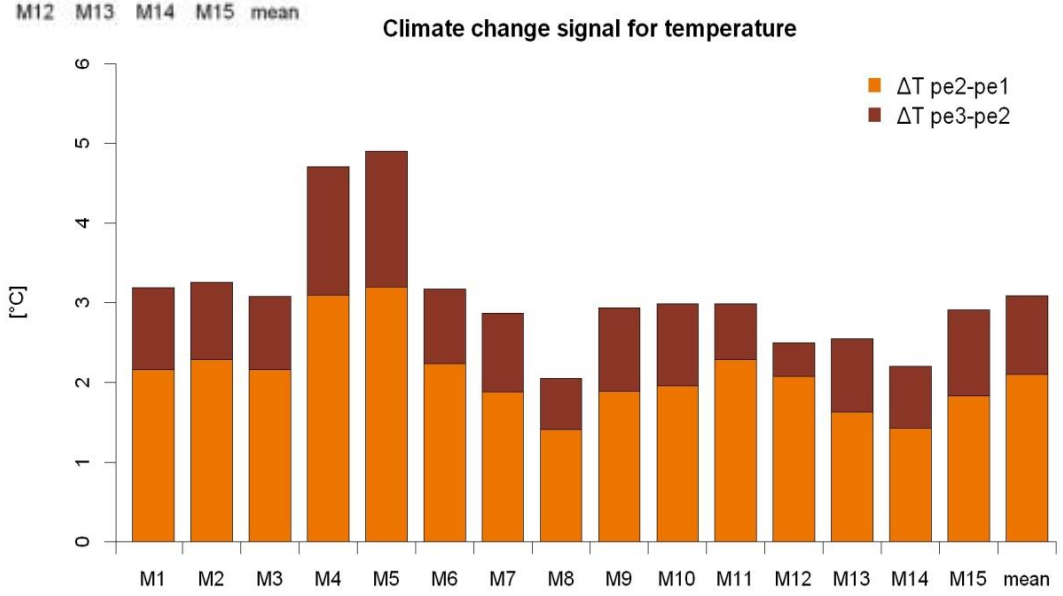
→ e.g. identify average, wettest and driest

Trends in precipitation and temperature

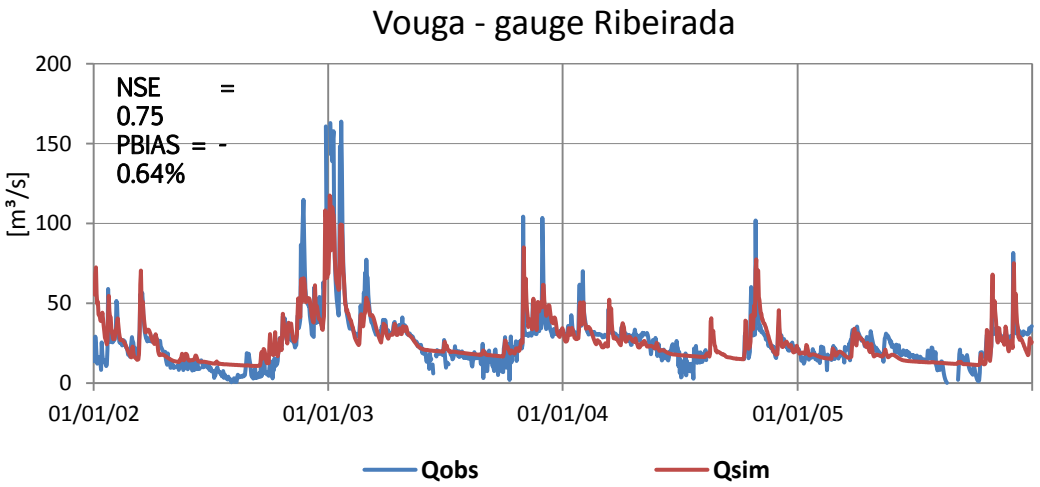


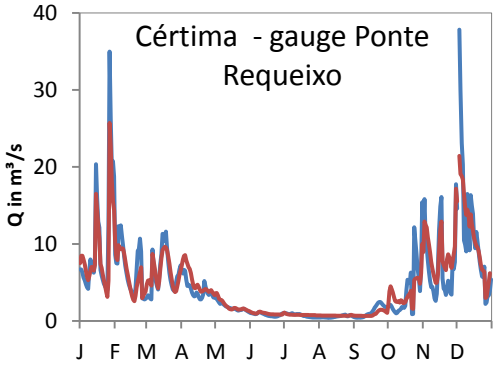
→ decreasing precipitation

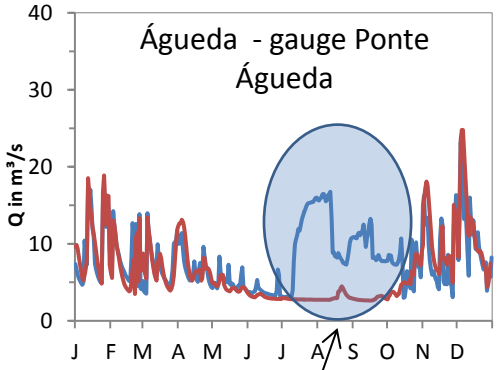
→ increasing temperature



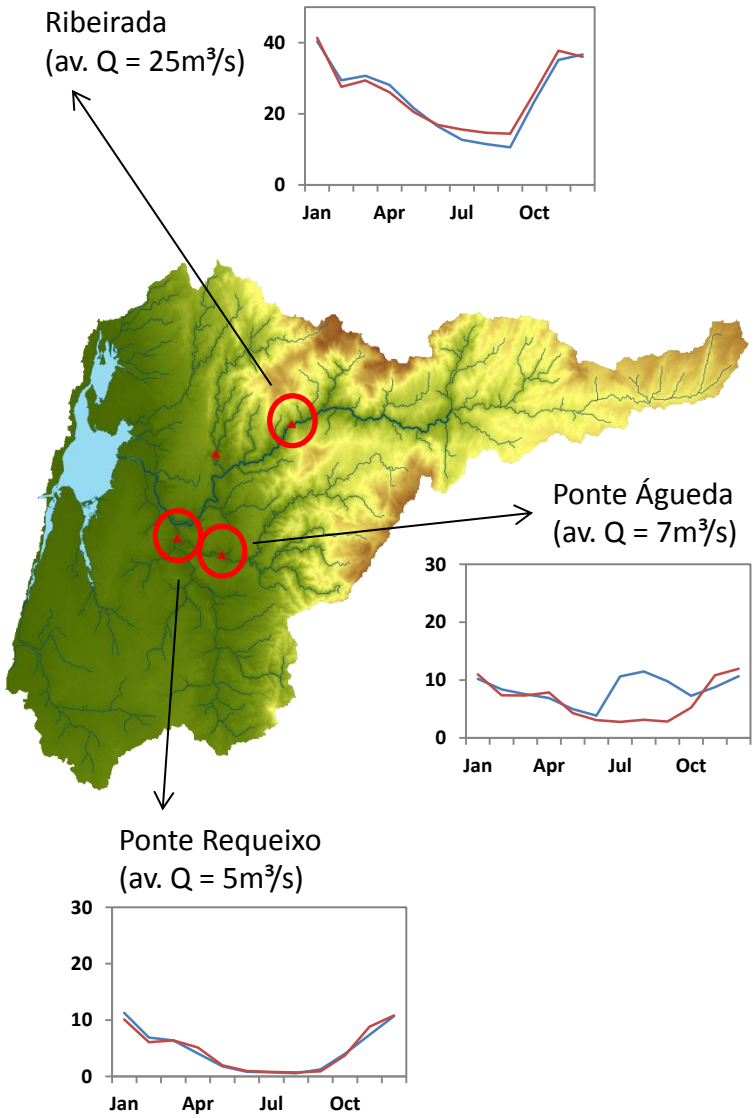
Model performance





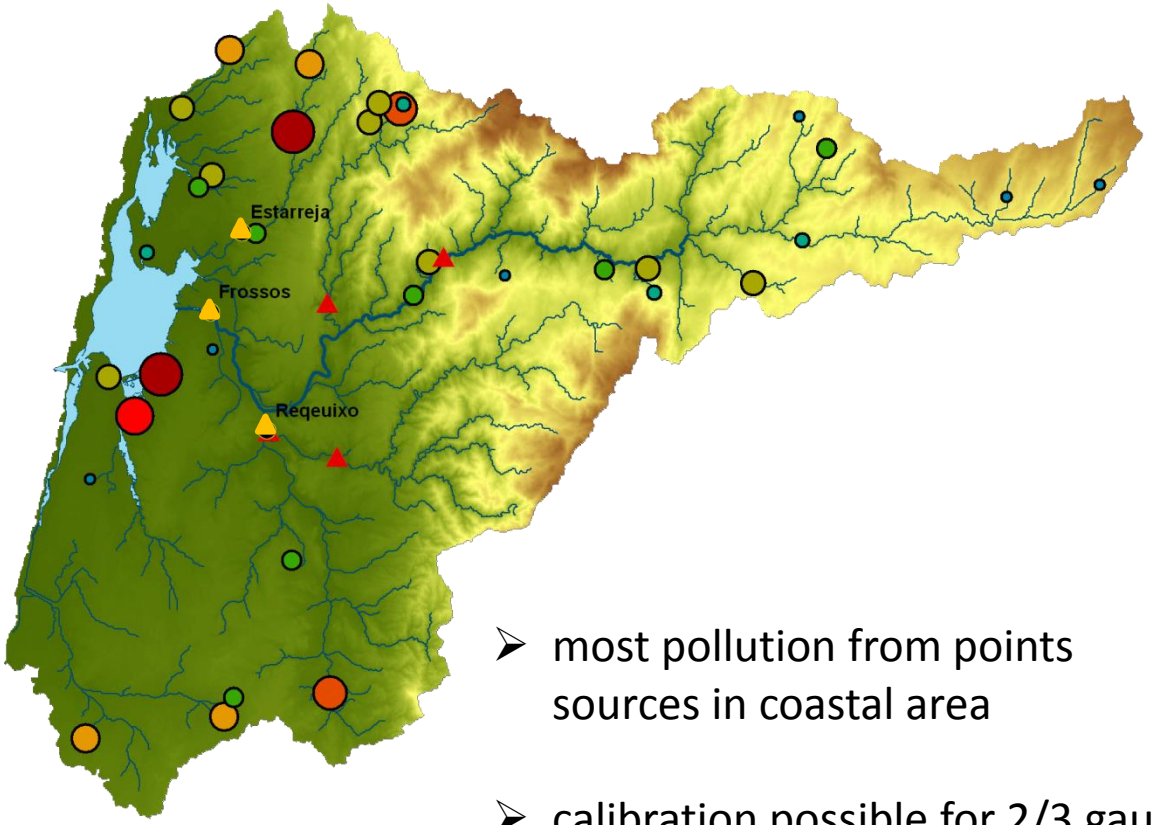


weir during summer



Water quality calibration

Estimations of total N and P for 2011 from ARH Centro



- most pollution from points sources in coastal area
- calibration possible for 2/3 gauges

Legend

- WQ gauges
- Q gauges

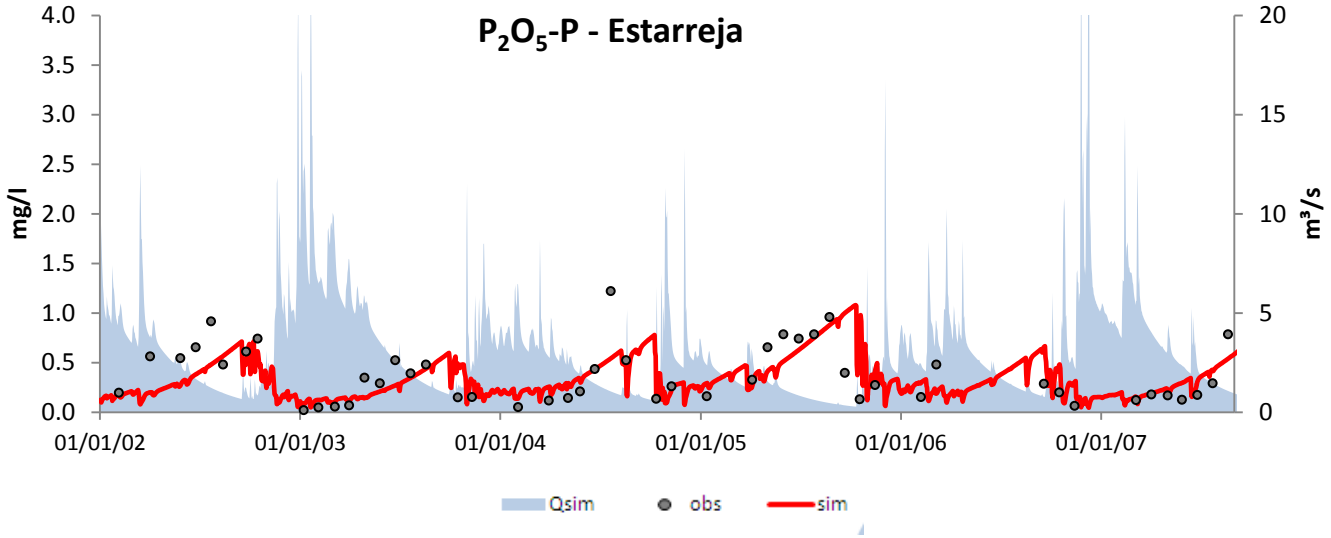
Ntotal in kg/year

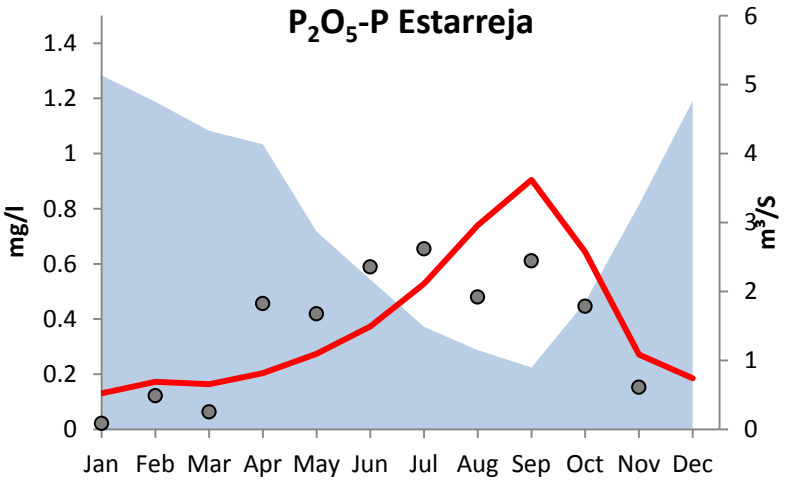
- <10 kg/year
- <100 kg/year
- <1000 kg/year
- <10000 kg/year
- <50000 kg/year
- <100000 kg/year
- <200000 kg/year
- <500000 kg/year

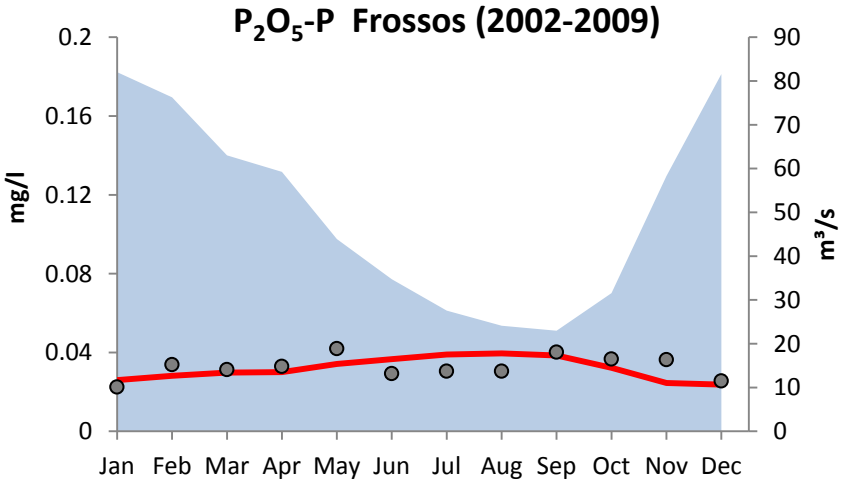
Elevation in m

- High : 1097
- Low : -10
- Ria de Aveiro watershed

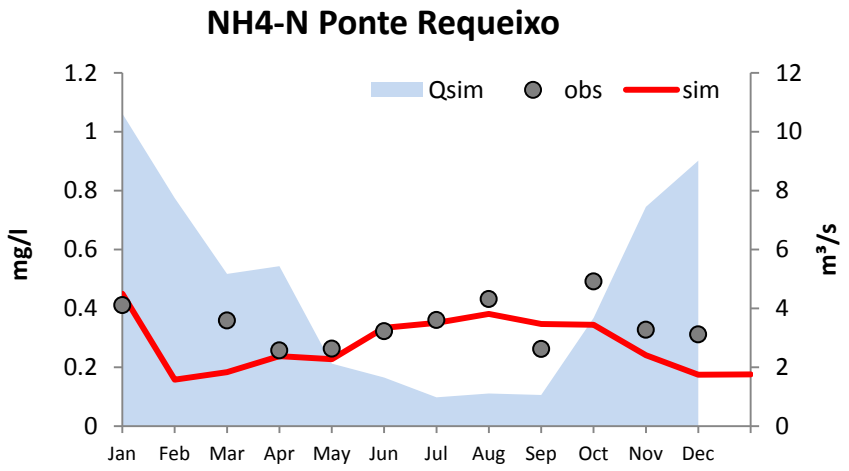
Phosphorus calibration

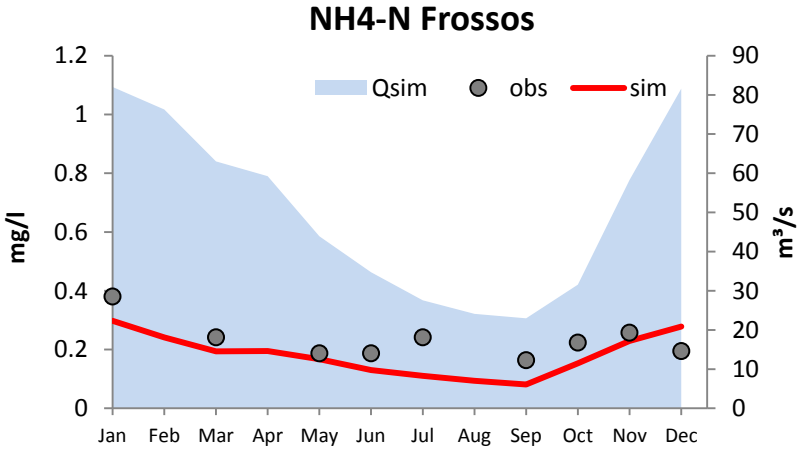


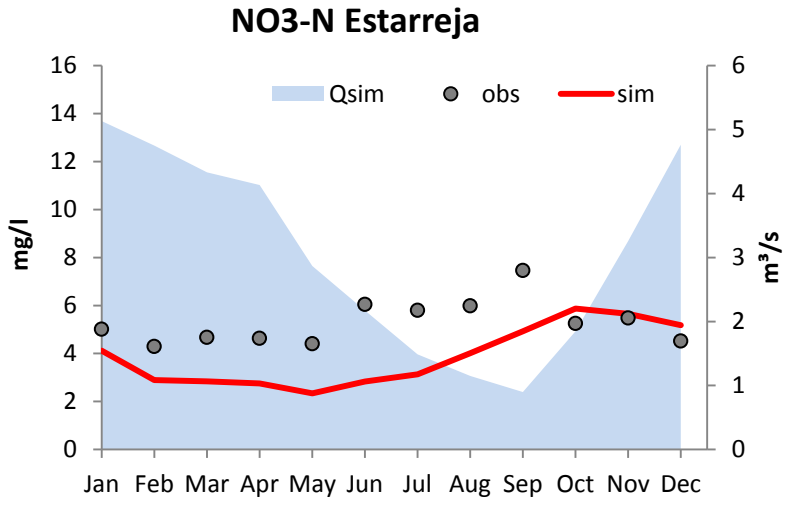


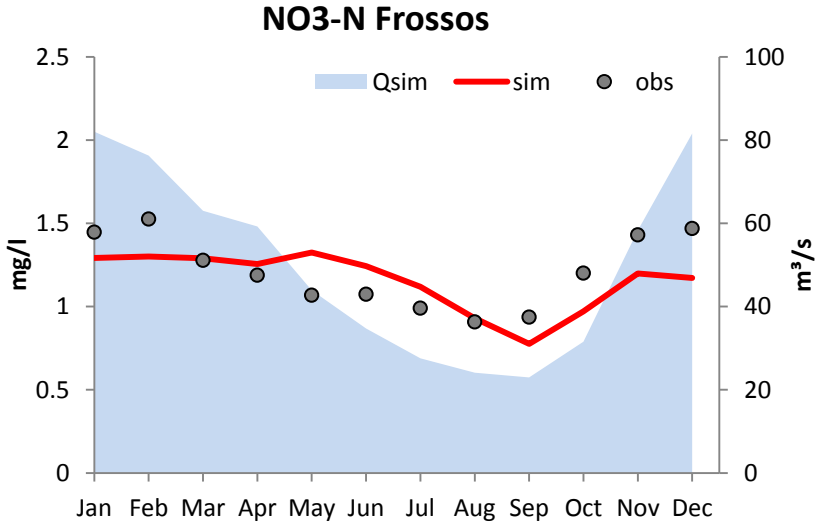


Nitrogen calibration

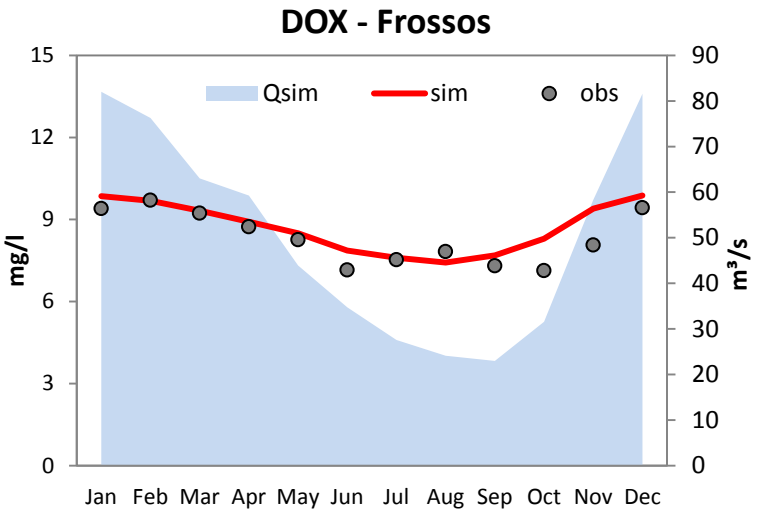


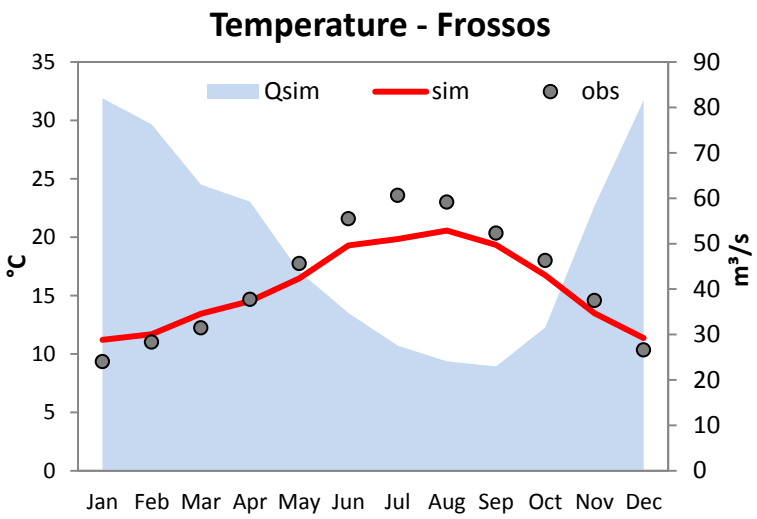






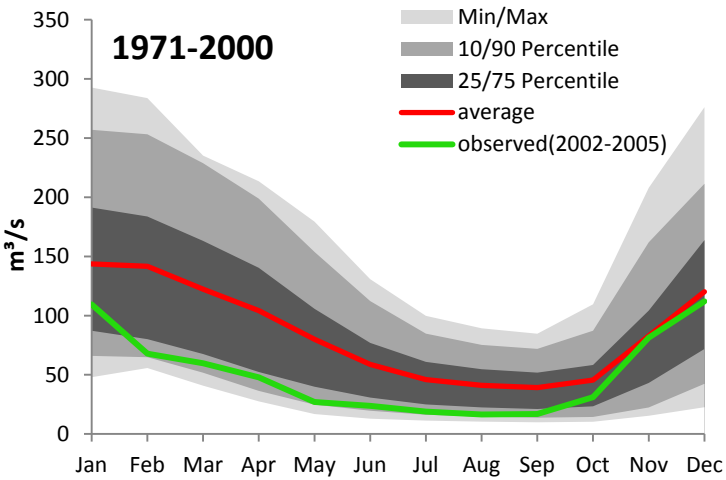
Oxygen and water temperature



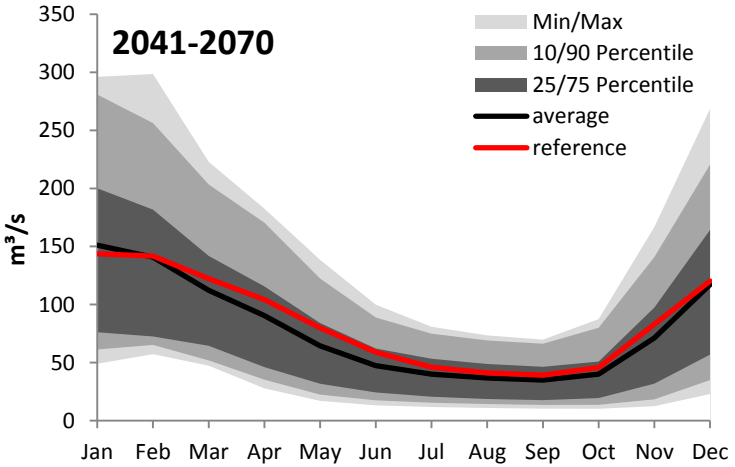


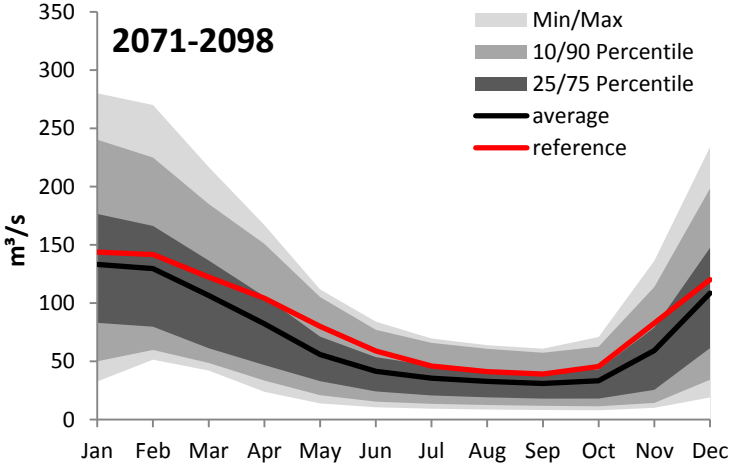
Impact assessment on water discharge

Seasonal dynamics for reference period at lagoon's inlet



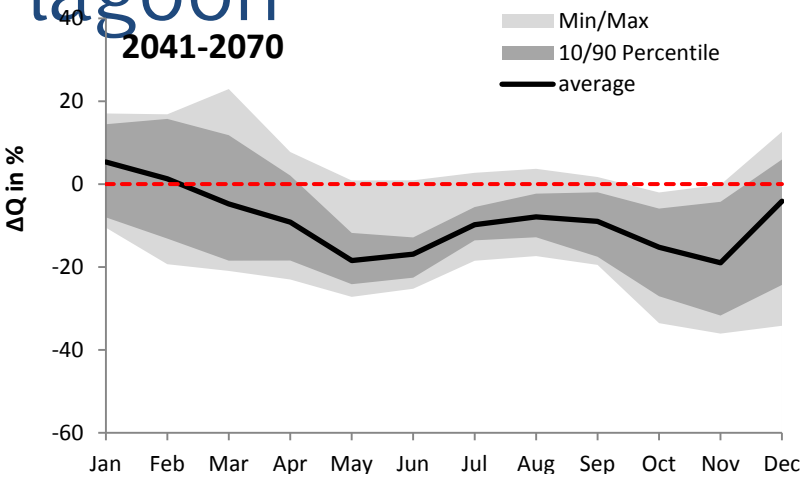
Projected runoff for 1st and 2nd future period at main inlet

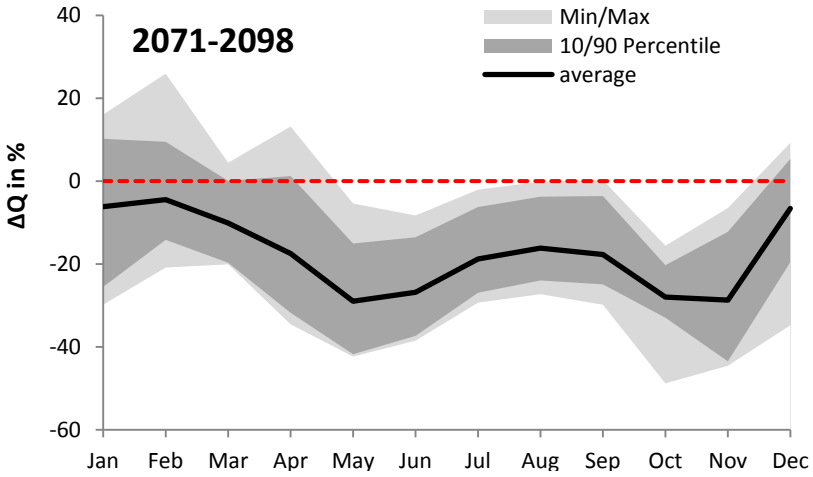


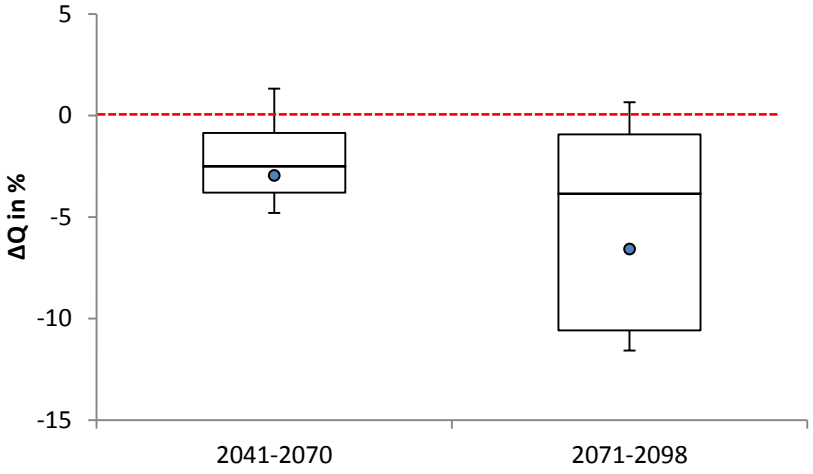


- most scenarios project higher flow than observed during calibration period
- on average moderate reduction for both future periods
- high uncertainty in winter
- certainty during summer

Changes of total inflow to the lagoon







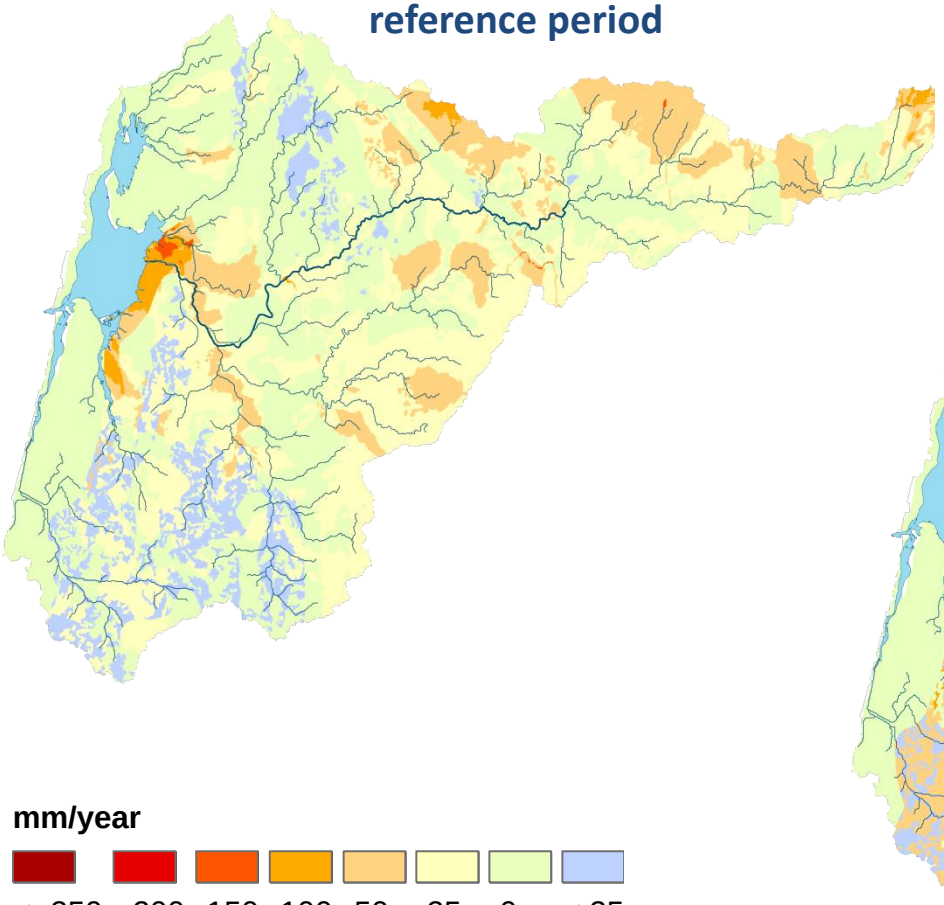
- projected mean annual reduction of total inflow to the lagoon of 3 % (2041-2070) and 7% (2071-2098)
- higher uncertainty for last half of the century

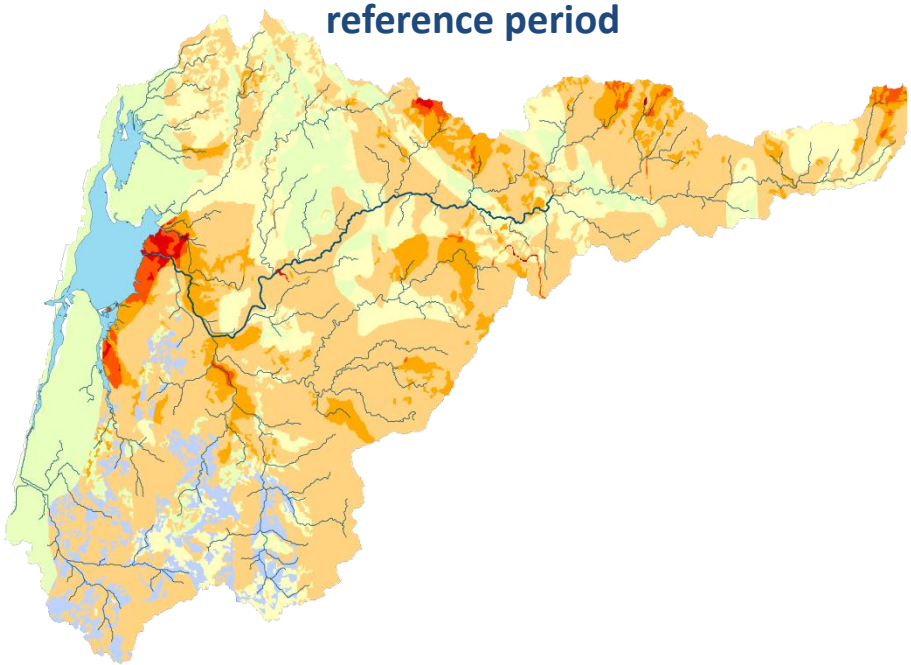
Changes in annual runoff

2047-2070compared to reference period

Average of simulations driven by all **15 scenarios**

2071-2098 compared to reference period

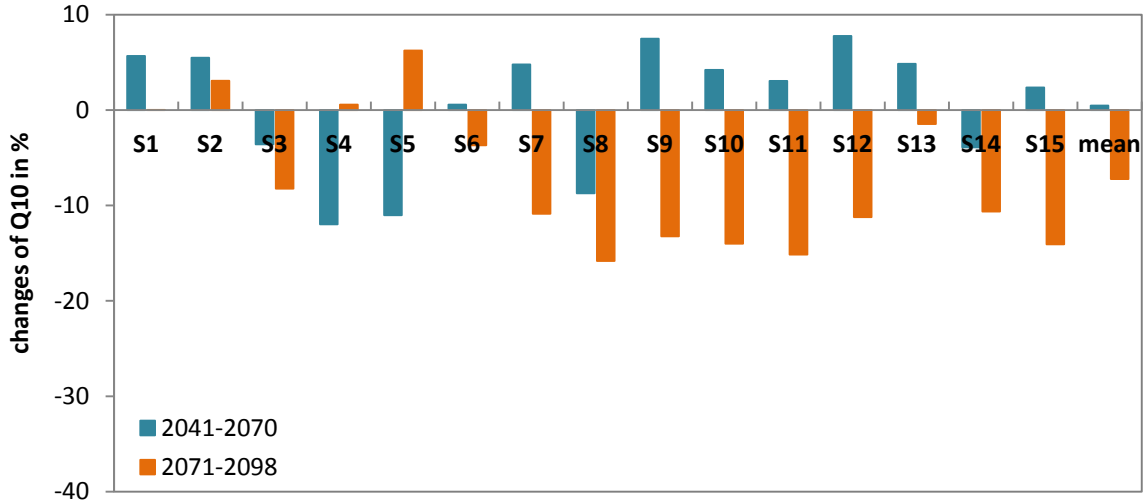




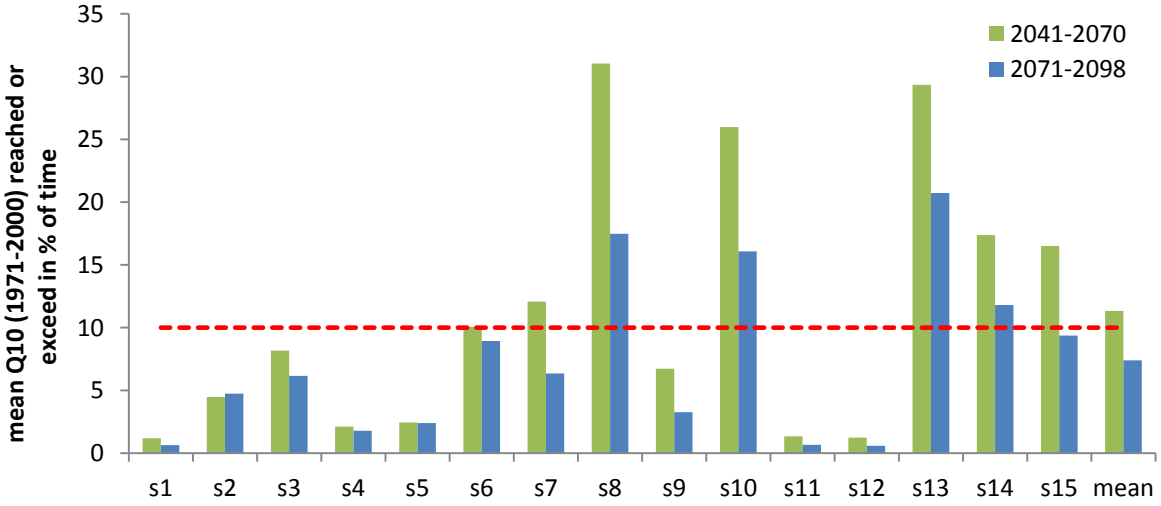
mm/year

< -250	-200	-150	-100	-50	-25	-0	< 25

Changes in extremes – high flow

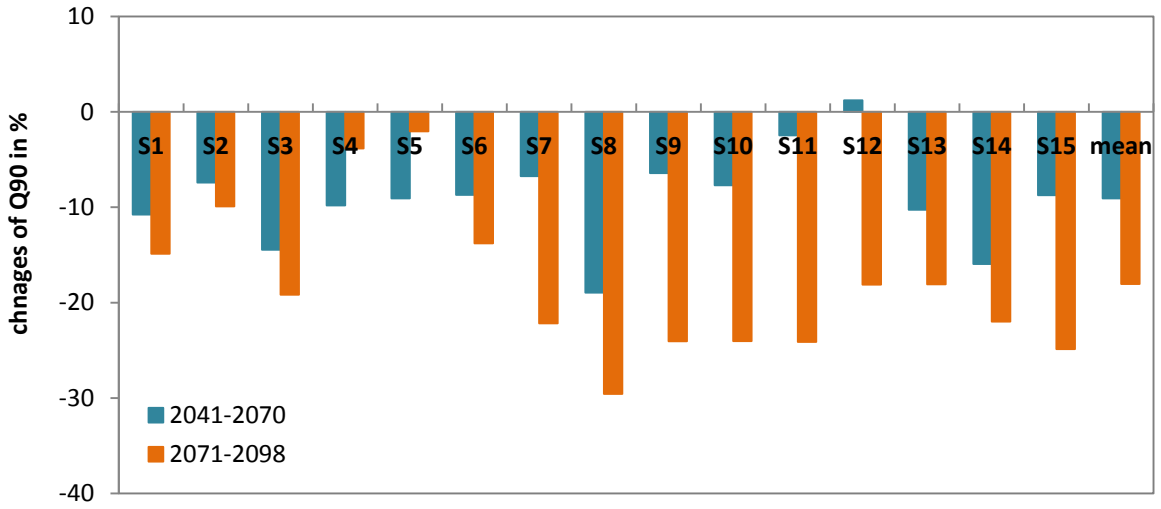


- magnitude of high flow (Q10) increases for 11 out of 15 scenarios for 2041-2070 and for 4 scenarios for 2nd period



- Q10 of reference period is reached/exceeded in more than 10% of the time by 7 scenarios in 2041-20710 and by 4 in 2071-2098

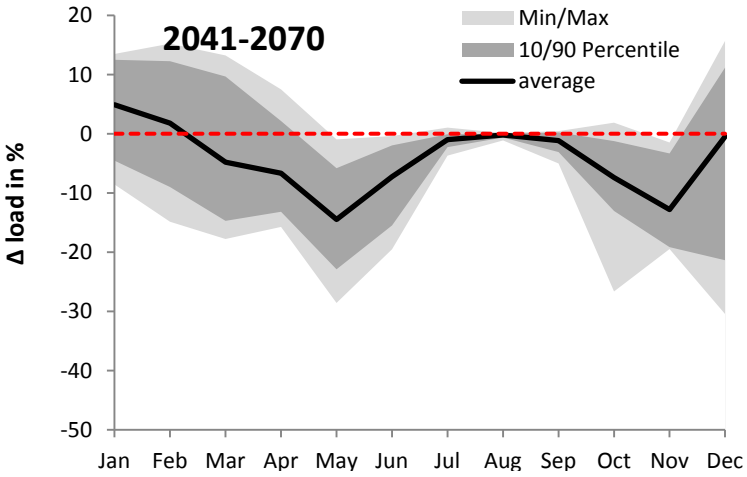
Changes in extremes – low flow

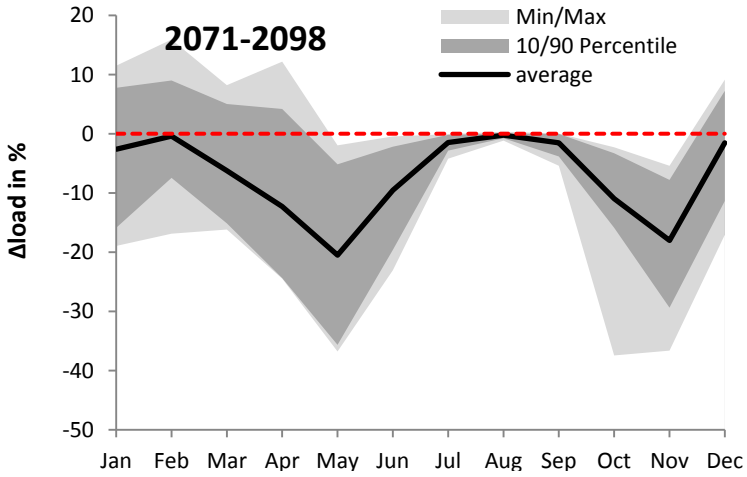


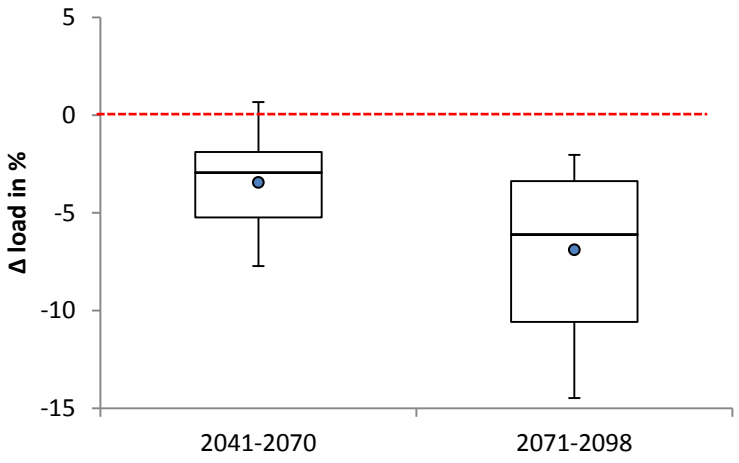
- all, except one scenario project a decrease of up to 30% in low flow for both future periods

→ higher risk of droughts
→ decrease of high flow in 2nd period but no clear signal from 1st period

Changes in PO4-P loads





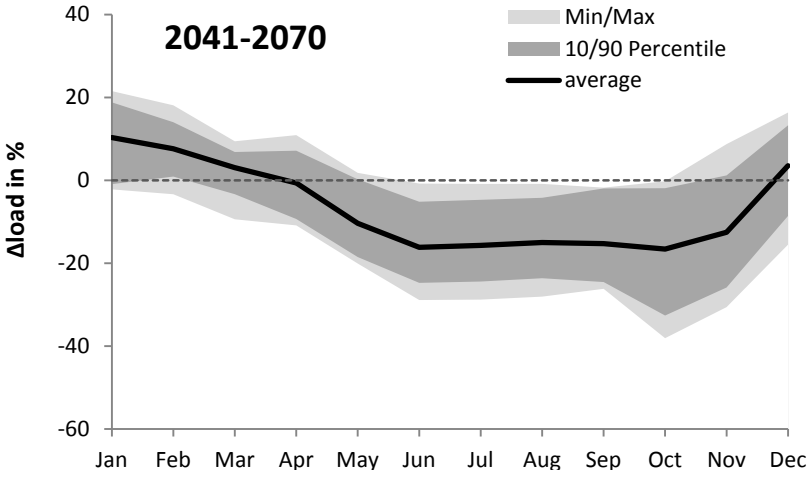


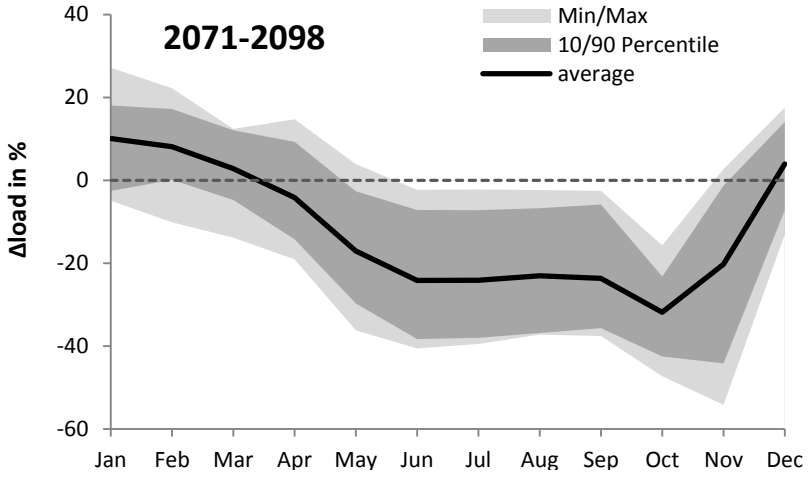
- increase during Jan – Feb for 1st period
→ correlates with overall increase of Q10

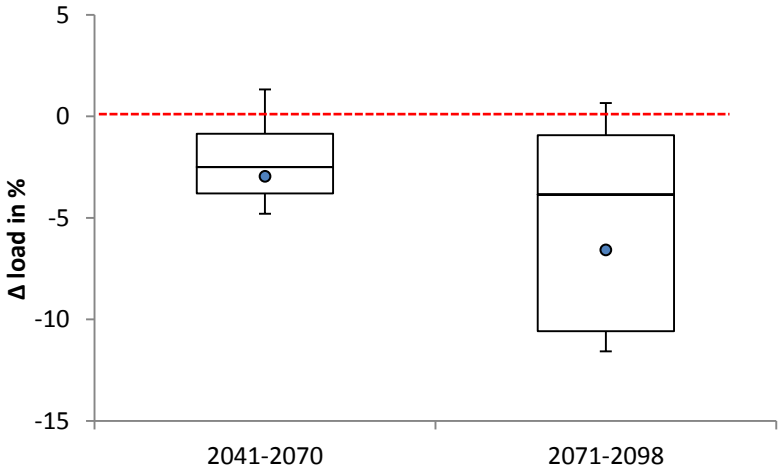
- decrease especially during wet season
→ induced by overall reduction total runoff

- on average loads reduced by 3% (2041-2070) and 7% (2071-2098) with much higher uncertainty in 2nd period

Changes in NO3-N loads







- increase during Dec-Mar

→ induced by increased runoff in winter

- overall decreasing trend of 3% (2041-2070) to 7% (2071-2098)

→ correlates with decreasing trend in total runoff

Conclusions

- high deviations of Qmean among scenarios (up to 200%)

- overall decrease in total inflow: 3% in 2041-2070
  7% in 2071-2098

- higher peaks in near future projected by 70% of the scenarios
- decrease of high flows in 2nd scenario period projected by most scenarios
- high certainty about decrease of low flow !!!

- NO_3-N and PO_4-P trends correlate with overall changes in runoff but also with extreme events > overall reduction of nutrients in combination with increase of loads in months with high flow

- Uncertainty in all trends increases towards the end of the century

Outlook

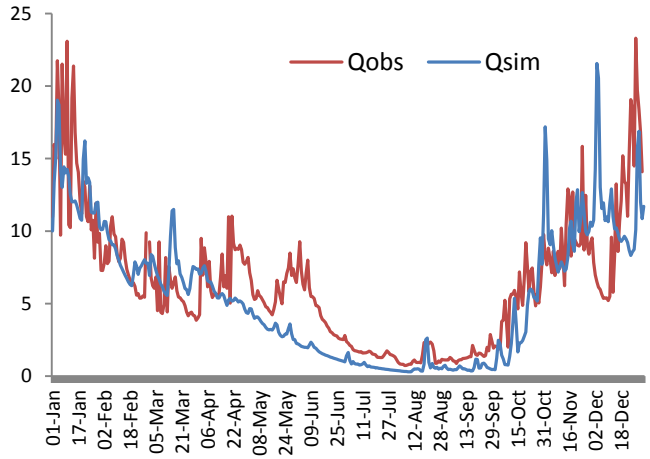
- Evaluation of inter annual variability and of month of peak occurrence
- Impact assessment on NH_4-N, DOX and water temperature
- Development and implementation of future land use scenarios
- Combined impact assessment of climate and land use change
- Estimation of uncertainty

Acknowledgements

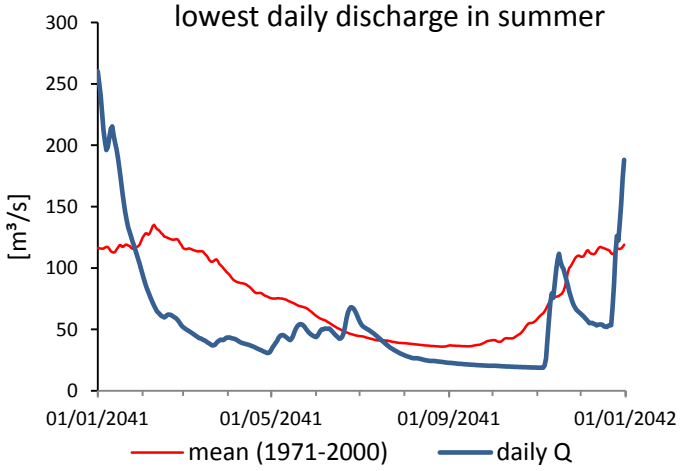
The European Commission, under the 7th Framework Programe, supported this study through the collaborative
research project LAGOONS (contract n° 283157).

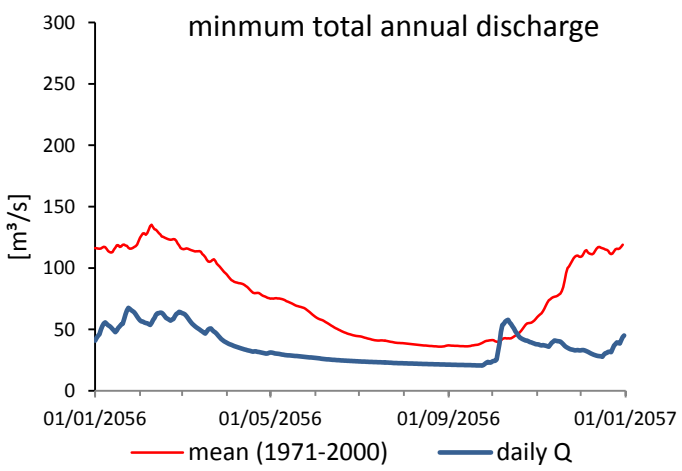
Thank you for your attention

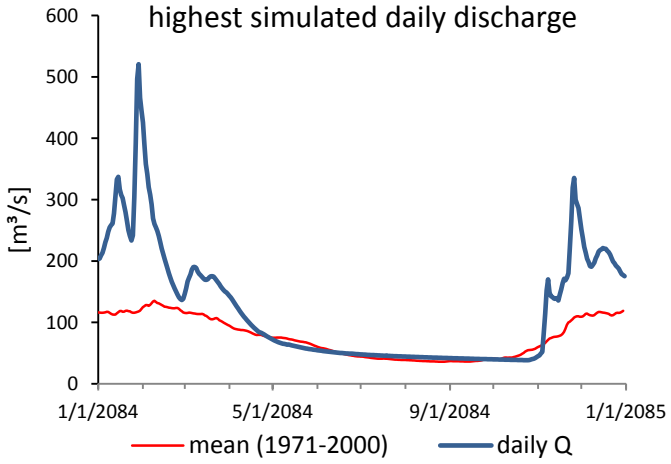
Observed (1991-2000) vs. simulated (2002-2009) av. daily flow at gauge Ponte Vale Maior on Rio Caima

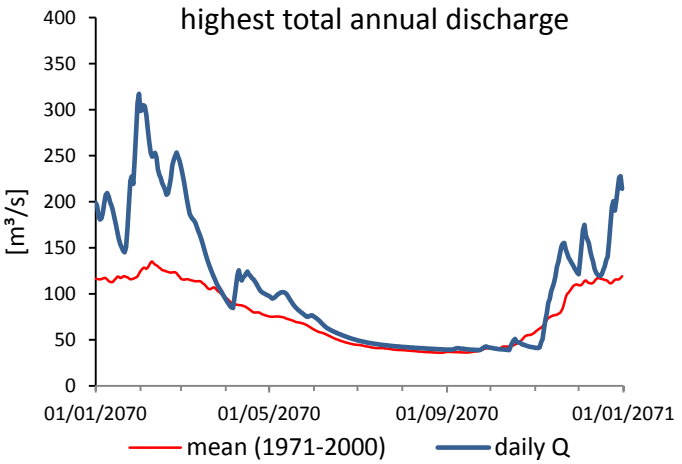


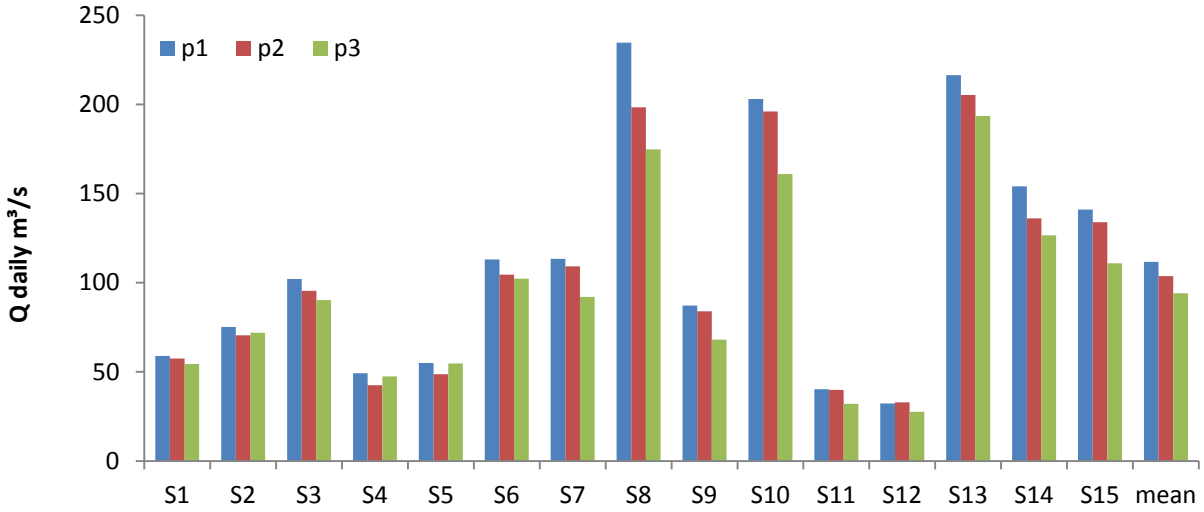
Some examples for extremes at Frossos










Q daily m³/s
250
200
150
100
50
0
p1
p2
p3
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
mean