Assessement and comparison of socio-economic and climate change impacts on water resources in four European lagoon catchments

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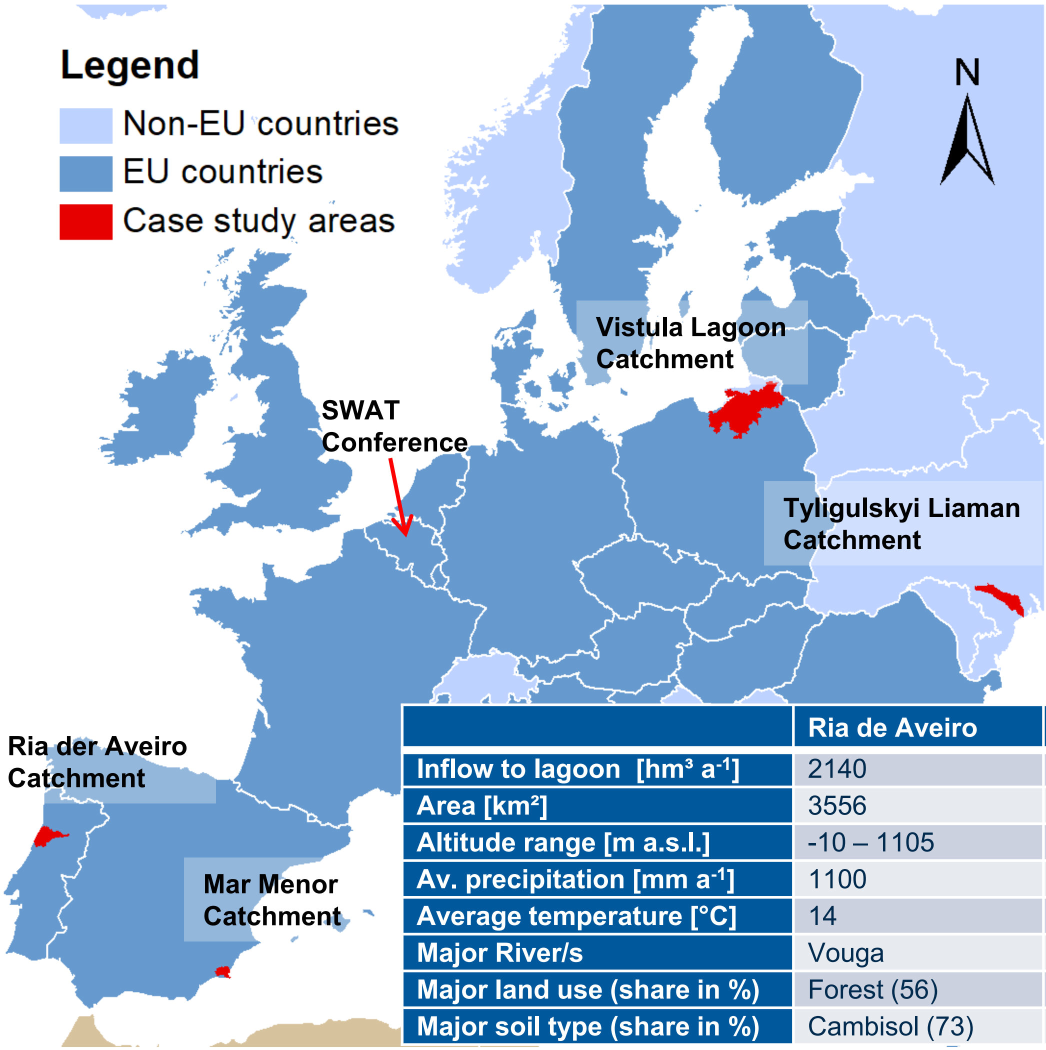
Case Study Areas

Locations, Characteristics & Threats

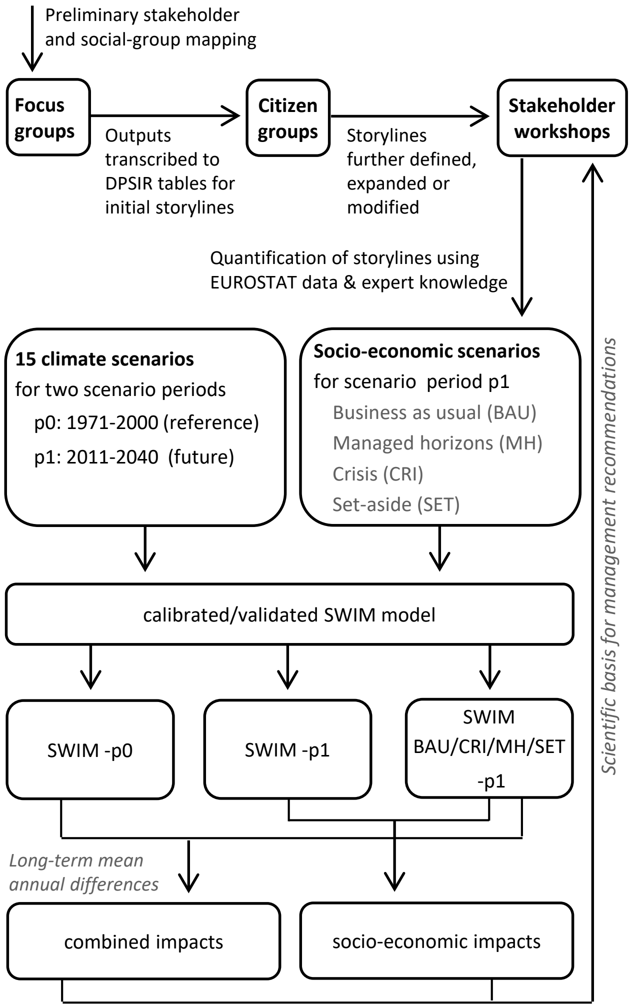


- Point source and diffuse pollution
- Innapropriate water management practices
- Climate change (e.g. lower freshwater inflow to the lagoon)

	Ria de Aveiro	Mar Menor	Tyligulskyi Liman	Vistula Lagoon
Inflow to lagoon [$hm^3\ a^{-1}$]	2140	8.7	23	4035
Area [km^2]	3556	1380	5240	20730
Altitude range [m a.s.l.]	-10 – 1105	-5 – 1061	-6 – 254	-27 – 308
Av. precipitation [$mm\ a^{-1}$]	1100	337	515	750
Average temperature [°C]	14	25	10	8
Major River/s	Vouga	Albujon	Tyligul	Pregolya & Pasleka
Major land use (share in %)	Forest (56)	Agriculture (82)	Agriculture (80)	Agriculture (67)
Major soil type (share in %)	Cambisol (73)	Cambisol (76)	Chernozem (77)	Cambisol (38)

Methodology

Study Framework, SWIM & Climate Scenarios

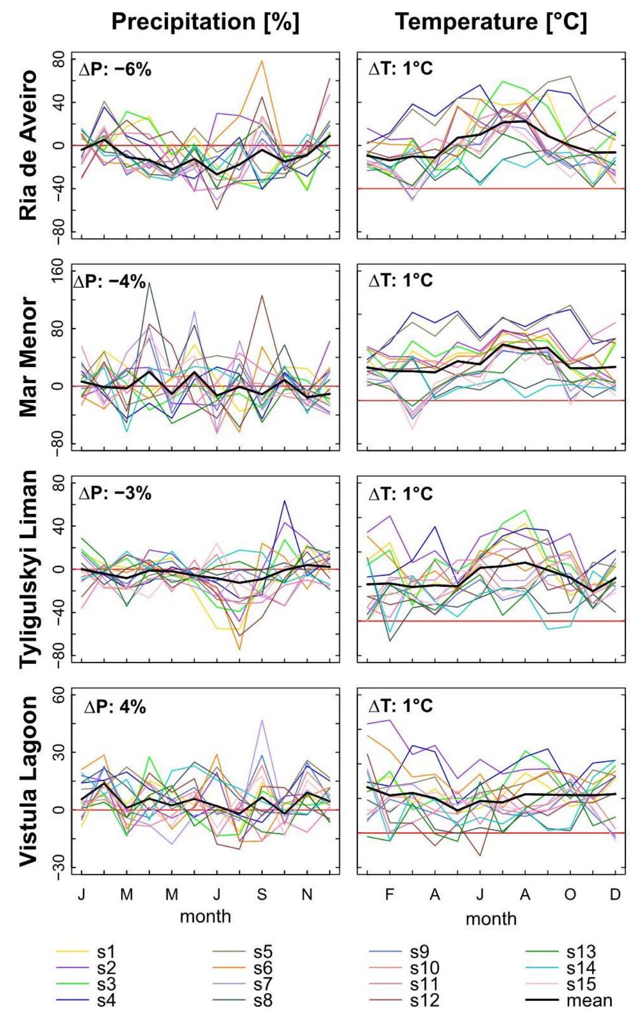


SWIM = Soil and Water Integrated Model – PIK* Version of SWAT

ENSEMBLES

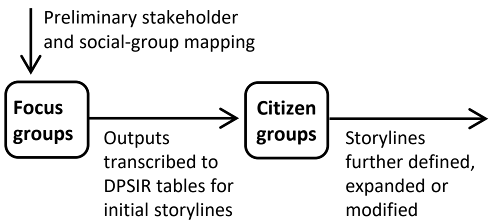
.GCM-RCM projections with 25km grid resolution

. based on SRES A1B scenarios



*PIK: Potsdam Institute for Climate Impact Research

Methodology
Socio-economic Scenarios



Economy +

Business **A**s **U**sual –
a possible future based on past trends; assumes a positive trend in economic development, and its negative effects for the environment

Managed **H**orizons -
economic growth comes along with the introduction of appropriate measures that are considered beneficial for the environment

Environment -

Environment +

Crisis –
shrinking of the local economy paired with environmental degradation

Set-aside –
negative economic trend that has the potential to improve environmental conditions

Economy -

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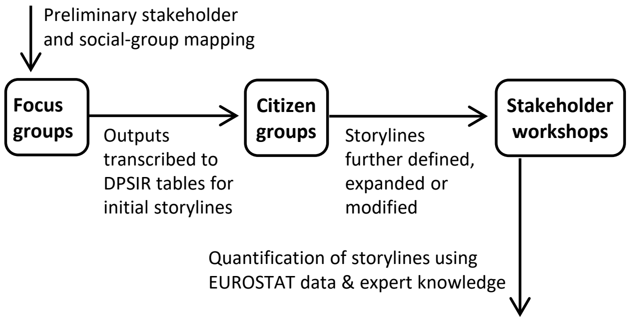
Methodology

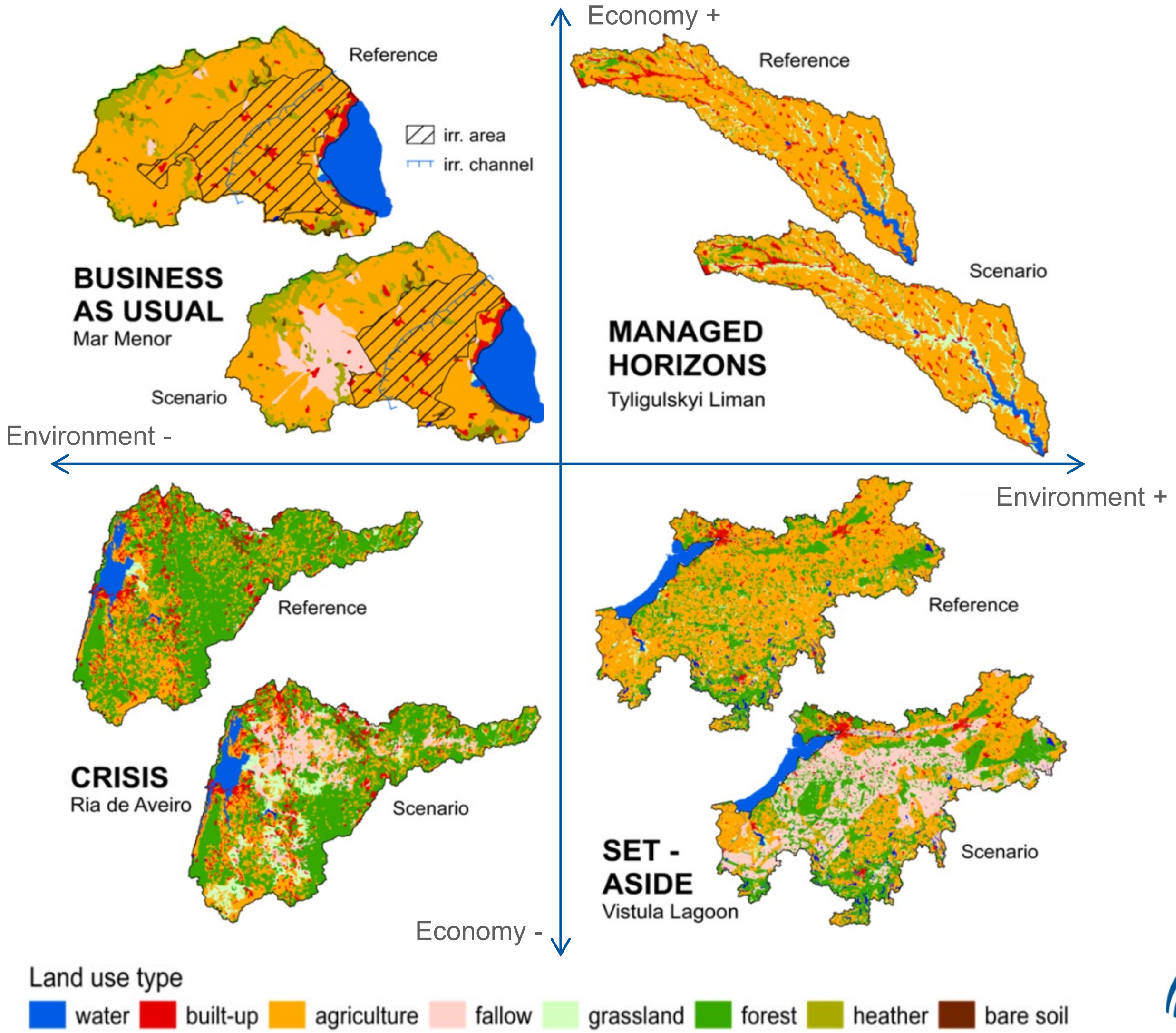
Socio-economic Scenarios



Changes in [%]	Ria de Aveiro				Mar Menor				Tyligulskyi Liman				Vistula Lagoon			
	BAU	CRI	MH	SET	BAU	CRI	MH	SET	BAU	CRI	MH	SET	BAU	CRI	MH	SET
agriculture	-11	-16	-	-32	-14	-30	5	-15	-	-	-10	-30	1.4	-10	2	-50
fallow	300	1200	-100	600	1500	3000	-100	1500	-	New	-	New	-9	New	-	New
grassland	180	520	-100	-10	-	-	-	-	-	-	215	-	-6	-	-75	-
forest	-	-26	3	5	-	-20	5	10	-	-50	10	40	-3	-20	17	86
heather	-	-	-	-	-	-	-30	-	-	-	-	-	-	-	-	-
wetlands	-	-	-	-	-	-	-	-	-	-	-	-	-5	-	-67	-
point sources	-2	7	-8	-18	16	-10	5	-11	-8	-20	-50	-35	-10	-30	-40	-35
N_{min}- & P- fertilizer	5	-20	-15	-20	-	-20	-15	-20	-	-50	500	200		-10	100	10
N_{org} - fertilizer	-10	-20	15	20	-	-20	15	20	-	10	10	-10	-	-10	300	-
abstraction	6	-30	12	-15	-	-	-	-	-8	-30		-15	-	-	-	-
discharge	-	-	-	-	22	-20	7	-11	-	-	-	-	-	-	-	-
irrigation	-	-	-	-	-22	-45	5	-25	-	-	-	-	-	-	-	-
ponds	-	-	-	-	-	-	-	-	-	-	-50	-75	-	-	-	-

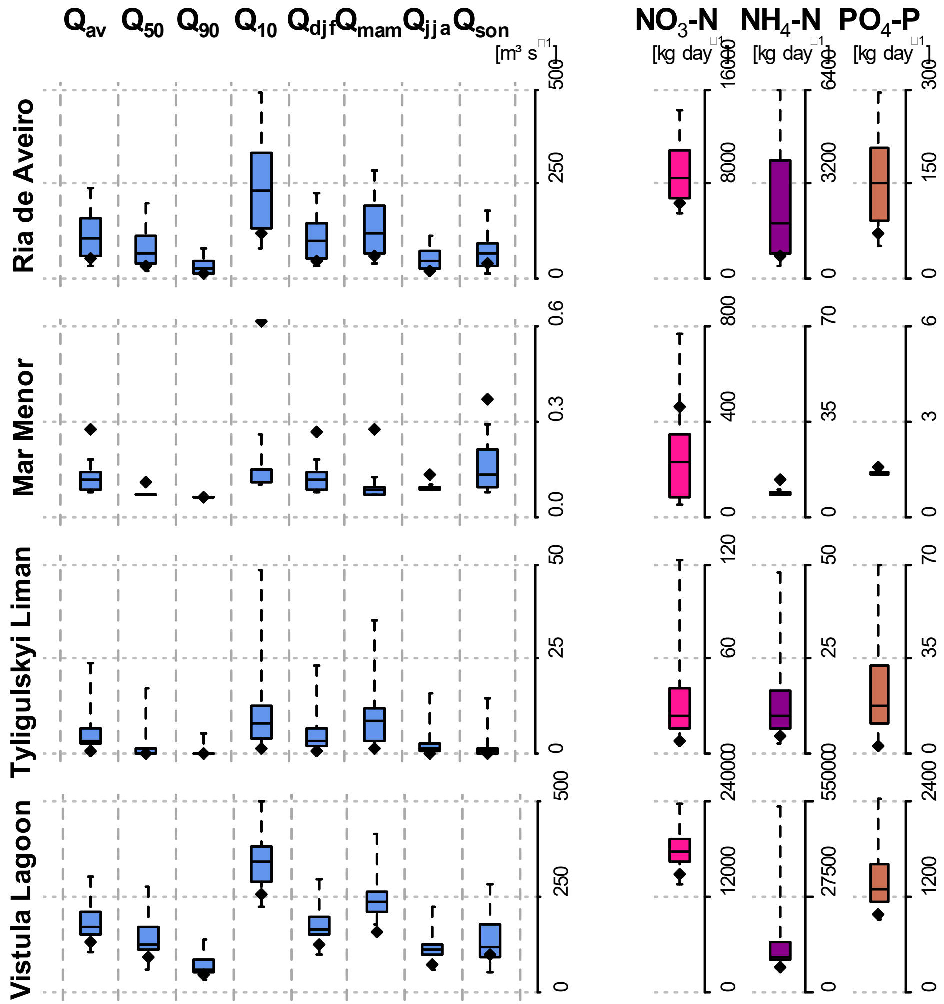
Methodology

Socio-economic Scenarios - example maps



Results

Discharge & nutrients under reference conditions



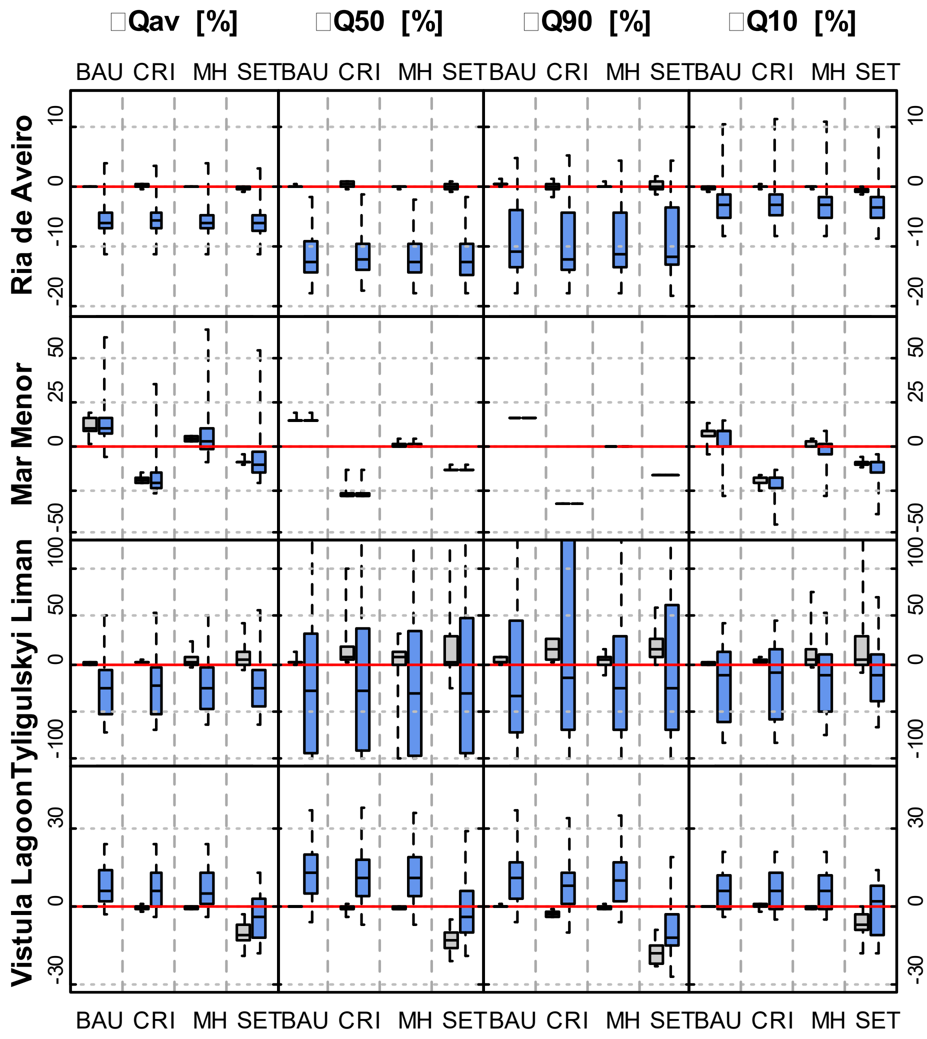
Average annual discharges and nutrient loads for the reference period using climate scenario data, shown as boxplots and observed climate data, shown as dots. The whiskers represent the min/max values, boxes the 25th/75th percentiles and thick lines the median values of SWIM outputs.

On the left: Q_{av} (mean flow), Q_{50} (median flow), Q_{90} (low flow), Q_{10} (high flow), Q_{djf} (winter flow), Q_{mam} (spring flow), Q_{jja} (summer flow) and Q_{son} (autumn flow)

On the right: NO_3-N (nitrate nitrogen), NH_4-N (ammonium nitrogen) and PO_4-P (phosphate phosphorus) loads

Results

Changes in the average, median, high & low flows



Average annual changes in discharge (Q_{av} – mean discharge, Q_{50} – median discharge, Q_{90}-low flow and Q_{10}-high flow) for each socio-economic scenario (BAU, CRI, MH and SET) with (in blue) and without (in grey) climate change shown as boxplots. In grey: driven by the reference climate. In blue: for the scenario period (2011–2040) compared to the reference period (1971-2000)

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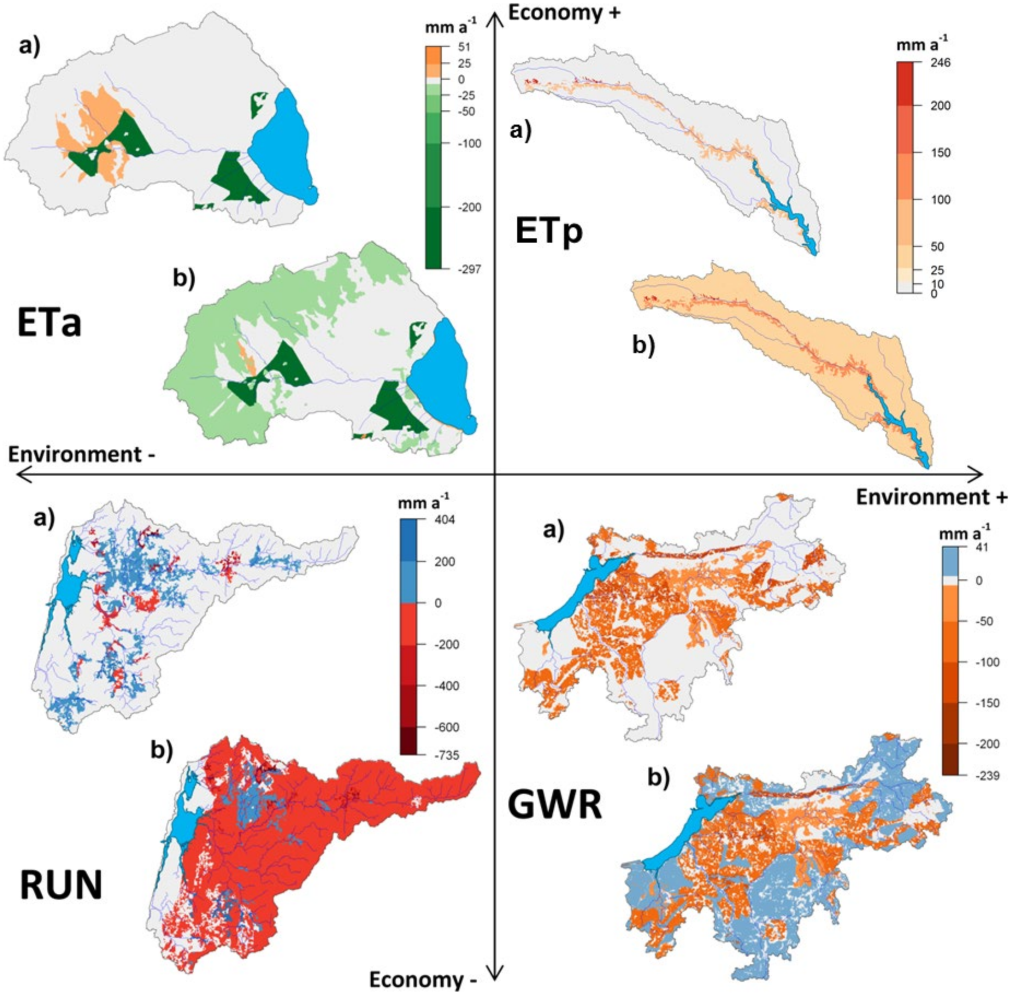
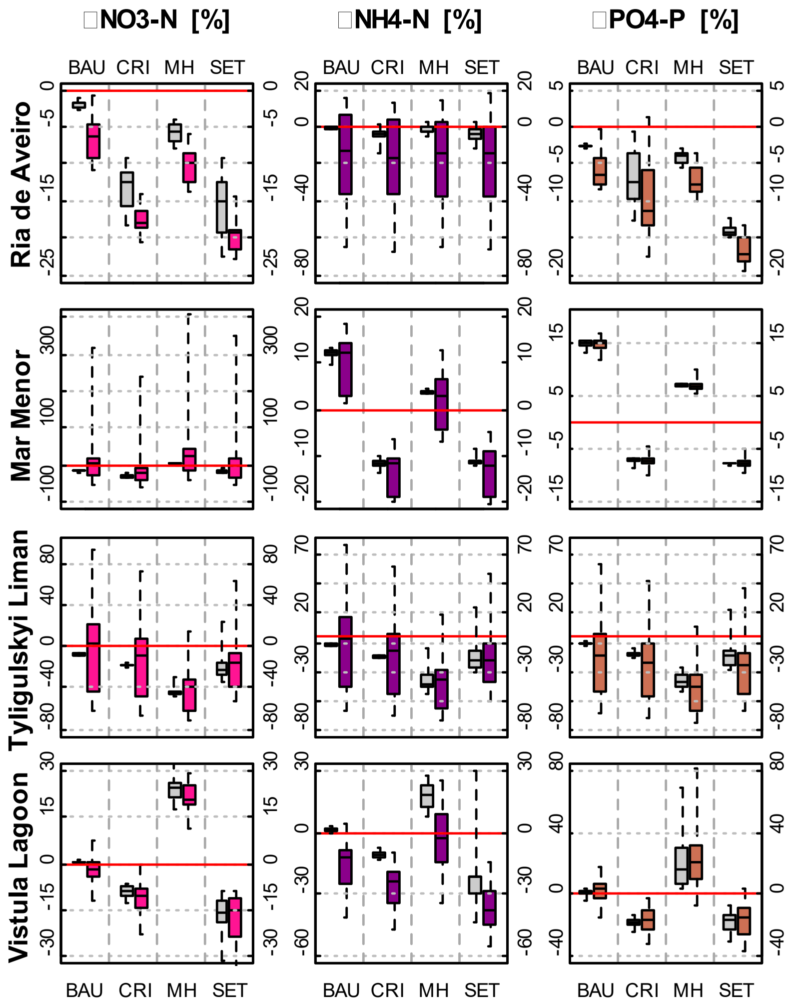
Results
Changes in major water cycle components – examples of spatial variability



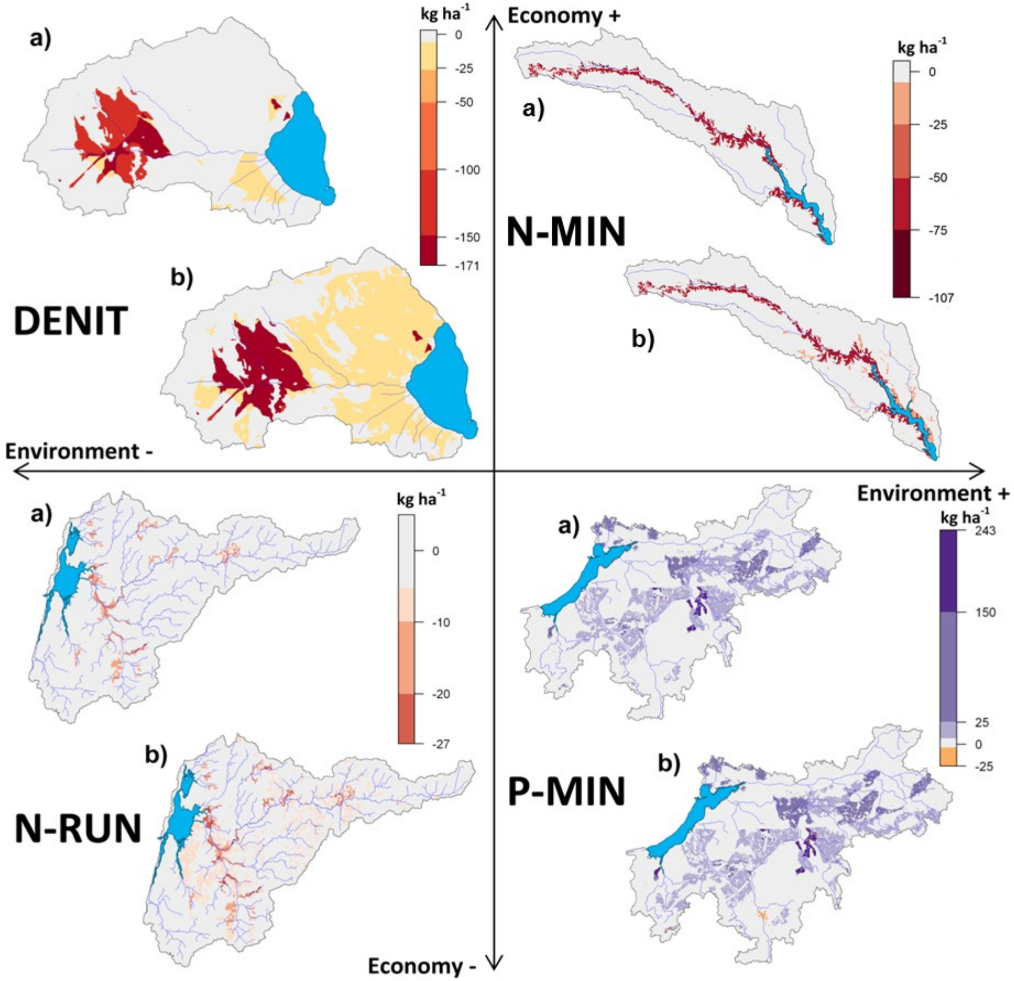
Results
Changes in major nutrient loads



Long-term average annual changes in nutrient loads (NO_3-N, NH_4-N and PH_4-P) for four socio-economic scenario (BAU,CRI, MH and SET) shown as boxplots with (in colour) and without (in grey) climate change. In grey: driven by the reference climate. In colour: for the scenario period (2011–2040) compared to the reference period (1971–2000).

Results

Changes in nutrient transformation & transportation processes – examples of spatial variability



Summary

Flows simulated with scenario climate on average higher than under observed climate, except for intensely managed Mar Menor catchment

Simulated impacts correspond well to precipitation trends in the two relatively natural catchments of Ria de Aveiro and Vistula Lagoon

In intensily managed Mar Menor catchment socio-economic scenarios determine direction of change

In strongly regulated Tyligulskyi Liman catchment socio-economic scenarios have a notable impact which is reversed by climate change

Summary

Results of water quality assessment very heterogeneous

In Ria de Aveiro catchment socio-economic scenarios intensify decreasing trend in NO_3-N an PO_4-P but do not influence NH_4-N

In Vistula Lagoon catchment socio-economic scenarios cause different trends in NO_3-N, NH_4-N and PO_4-P and climate change has little additional impacts

In Mar Menor catchment NO_3-N (mainly from diffuse pollution) is impacted equally strong by climate change and socio-economic scenarios, whereas NH_4-N and PO_4-P (mainly from point source pollution) affected only by socio-economic scenarios

In Tyligulskyi Liman catchment socio-economic scenarios able to decrease nutrients input to the lagoon but climate change adds big uncertainty to results (high disagreement among climate scenarios)

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Limitations

Structural and parameterization uncertainties of climate and hydrological models

Data availability and quality for model set-up and calibration

Climate scenarios range and reliability of regional climate scenarios

Plausibility and static character of socio-economic scenarios

Conclusions

The implications of potential socio-economic changes can intensify, weaken or even reverse the effects of global warming

The heterogeneity of results (across catchments and variables) demonstrates the uniqueness and complexity of each CSA

→we cannot formulate specific management recommendations at pan-European level, as initially intended

→ importance of a regional approach in climate change studies when these are used to provide a scientific basis for adaptation/mitigation strategies

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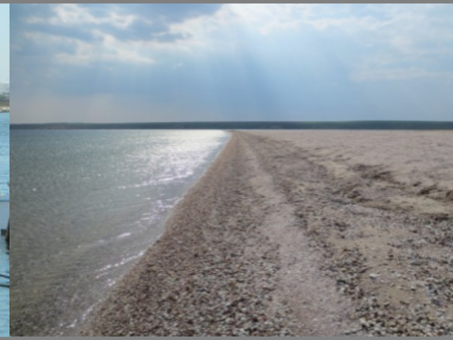
Thank you for your attention

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Methodology

Calibrated and validated SWIM models

Catchment	**Q [$m^3 s^{-1}$]**			**NSE**	**PBIAS**
Rivers	obs.	SWIM	period		
Ria de Aveiro					
Águeda	6.5	6.6	01/02–12/05	0.8	5.6
Cértima	4.6	5.0	01/02–12/05	0.8	-8.0
Vouga	22.8	22.6	01/02–12/05	0.8	0
Mar Menor (biweekly time step)				r^2=	
Albujon	5.5	5.5	10/02–02/04	0.7	0.1
Tyligulskyi Liman (monthly time step)					
Tyligul	0.6	0.6	01/84–12/88	0.9	0.4
Vistula Lagoon					
Pasleka	18.8	17.6	01/07–12/09	0.7	-12.9
Pregolya	80.0	80.5	01/83–12/96	0.7	-0.6

Catchment	**NO_3-N [mg l^{-1}]**			**NH_4-N [mg l^{-1}]**			**PO_4-P [mg l^{-1}]**		
River	obs.	SWIM	period	obs.	SWIM	period	obs.	SWIM	period
Ria de Aveiro									
Antua	4.58	5.26	01/03–12/09	0.64	0.64	01/02–12/09	0.40	0.74	01/02–12/07
Vouga	1.21	1.18	01/02–12/09	0.15	0.22	01/06–12/09	0.03	0.03	01/03–12/09
	NO_3-N [t a^{-1}]			**NH_4-N [t a^{-1}]**			**PO_4-P [t a^{1}]**		
	obs.	SWIM	period	obs.	SWIM	period	obs.	SWIM	period
Mar Menor									
Albujon	154	113	02/03–02/04	35	30	10/02–02/04	2.54	2.57	10/02–02/04
Tyligulskyi Liman									
Tyligul	4.57	4.53	01/01–12/07	2.52	2.41	01/01–12/07	1.94	1.94	01/01–12/07
Vistula Lagoon									
Sum of 9 rivers	4384	4540	01/80–12/09	3024	2235	01/80–12/09	462	424	01/80–12/09

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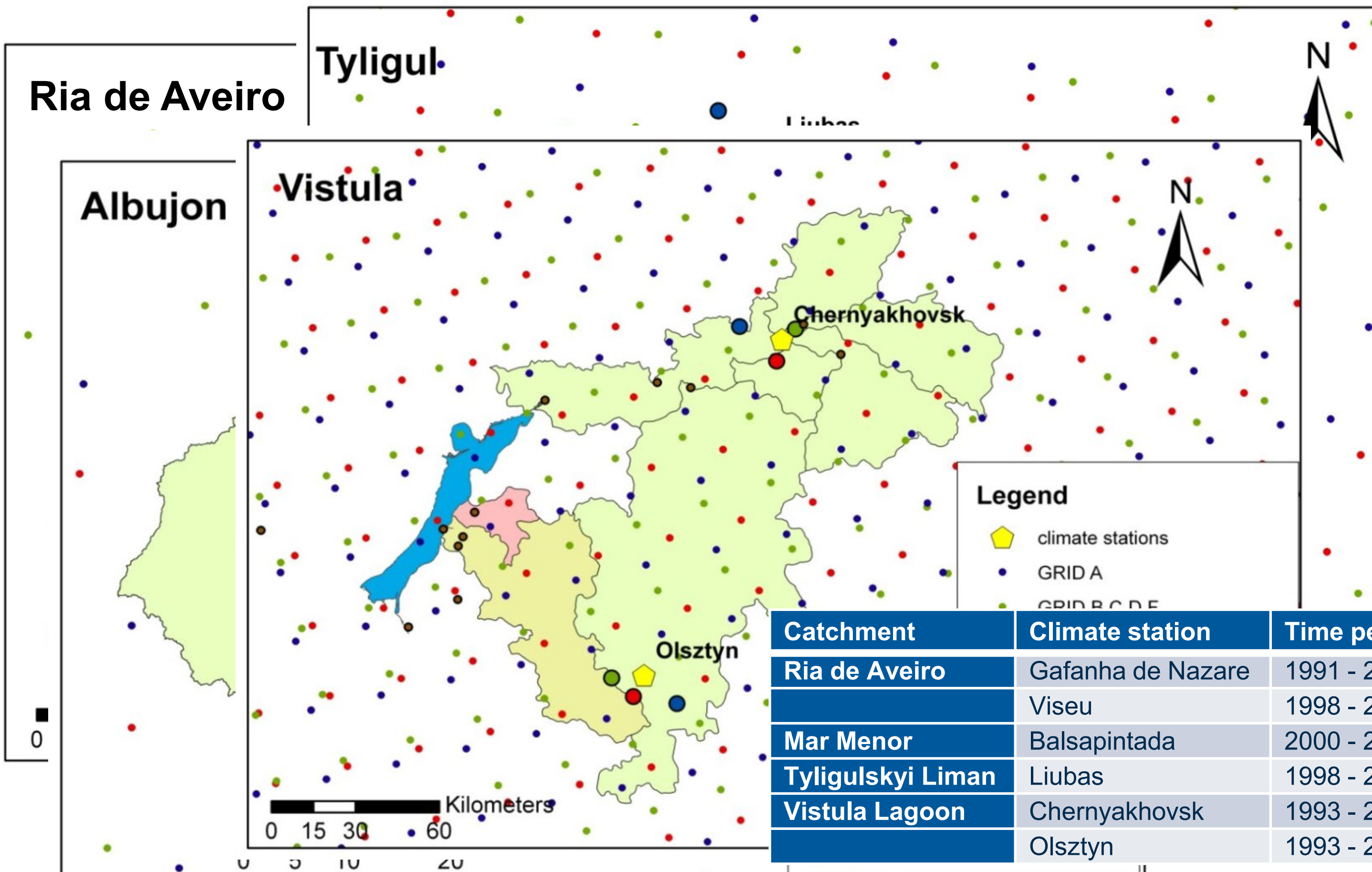
Results

Changes in water cycle components – annual means

		Ria de Aveiro				Mar Menor				Tyligulskyi Liman				Vistula Lagoon			
		ses only		combined		ses only		combined		ses only		combined		ses only		combined	
		mm a^{-1}	%	mm a^{-1}	%	mm a^{-1}	%	mm a^{-1}	%	mm a^{-1}	%	mm a^{-1}	%	mm a^{-1}	%	mm a^{-1}	%
BAU	RUN	1.33	*0*	-37.04	*-6*	0	*0*	0	*0*	0	*0*	-2.08	*-15*	0.61	*1*	9.90	*12*
	GWR	-0.19	*0*	-55.96	*-6*	-2.03	*-9*	-2.30	*-2*	0	*0*	-3.12	*-16*	0.61	*1*	10.23	*12*
	ETa	1.26	*0*	-5.49	*-1*	-22.95	*-5*	-24.41	*-5*	0	*0*	-10.45	*-2*	-0.89	*0*	8.96	*2*
	ETp	0.27	*0*	68.95	*7*	-4.05	*0*	26.10	*1*	0	*0*	40.67	*5*	-0.07	*0*	14.90	*1*
CRI	RUN	2.86	*1*	-35.52	*-6*	0	*0*	0	*0*	0.27	*0*	-1.81	*-14*	-4.87	*-5*	4.42	*6*
	GWR	1.00	*0*	-54.77	*-6*	-3.80	*-16*	-4.06	*-10*	0.29	*0*	-2.83	*-15*	-4.89	*-5*	4.73	*6*
	ETa	-2.22	*-1*	-8.98	*-2*	-46.25	*-9*	-47.70	*-9*	-0.64	*0*	-11.08	*-2*	2.05	*0*	11.90	*2*
	ETp	1.86	*0*	70.54	*7*	-4.71	*0*	25.44	*1*	-3.92	*0*	36.74	*5*	1.57	*0*	16.54	*2*
MH	RUN	-0.11	*0*	-38.49	*-6*	0	*0*	0	*0*	-1.27	*-4*	-3.35	*-19*	0.10	*0*	9.32	*12*
	GWR	-0.09	*0*	-55.86	*-6*	0.37	*1*	0.11	*10*	-1.33	*-4*	-4.45	*-20*	1.67	*0*	9.72	*12*
	ETa	0.67	*0*	-6.09	*-2*	6.16	*1*	4.70	*1*	3.13	*1*	-7.32	*-2*	-0.40	*0*	11.52	*2*
	ETp	-0.17	*0*	68.51	*7*	-3.19	*0*	26.97	*1*	7.71	*1*	48.38	*6*	0.10	*0*	14.57	*1*
SET	RUN	4.61	*1*	-33.76	*-6*	0	*0*	0	*0*	-3.78	*-12*	-5.86	*-25*	-24.40	*-25*	-15.22	*-17*
	GWR	0.01	*0*	-55.76	*-6*	-1.98	*-9*	-2.24	*-1*	-3.89	*-12*	-7.01	*-26*	-24.50	*-25*	-14.88	*-17*
	ETa	4.75	*1*	-2.00	*0*	-26.02	*-5*	-27.48	*-5*	5.57	*1*	-4.88	*-1*	27.96	*5*	37.81	*7*
	ETp	0.51	*0*	69.18	*7*	-4.05	*0*	26.10	*1*	3.06	*0*	43.73	*6*	5.00	*1*	19.96	*2*

Climate scenario reliability
Evaluation of precipitation projections

Comparison of climate scenario data for the past with station data from the lagoon catchments

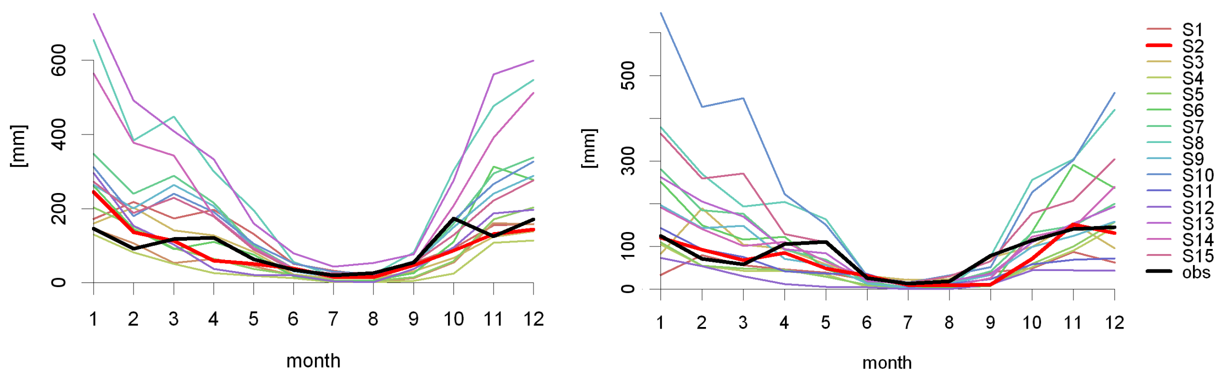


Catchment	Climate station	Time period	Number of years
Ria de Aveiro	Gafanha de Nazare	1991 - 2000	10
	Viseu	1998 - 2010	13
Mar Menor	Balsapintada	2000 - 2011	12
Tyligulskyi Liman	Liubas	1998 - 2007	10
Vistula Lagoon	Chernyakhovsk	1993 - 2011	19
	Olsztyn	1993 - 2011	19

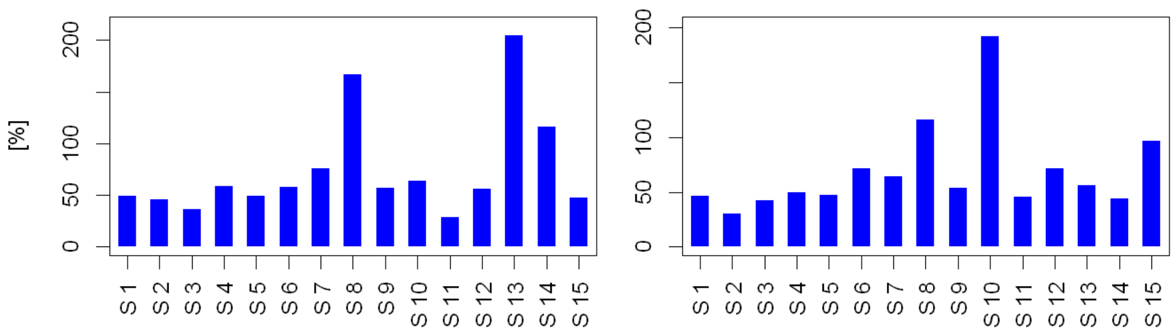
Climate scenario reliability

Seasonal dynamics for precipitation – Ria de Aveiro

station Viseu **station Gafanha de Nazare**



Observed (obs) and projected seasonal dynamics for precipitation



Differences between observed and projected mean monthly values for precipitation

Mean monthly precipitation

$$MMP_{o,i} = \frac{\sum_1^N P_{o,i}}{N}$$

$$MMP_{s,i} = \frac{\sum_1^N P_{s,i}}{N}$$

where P is precipitation, o represents observed data, s - scenario (s1 to s15), i – month (1 to 12) and N- Number of years for comparison

Difference in mean monthly precipitation

$$DMMP_{s,i} = MMP_{s,i} - MMP_{o,i}$$

Average of normalized difference of mean monthly precipitation

$$ADMMP_s = \frac{\sum_1^{12} \left| \frac{DMMP_{s,i}}{MMP_{o,i}} * 100\ \% \right|}{12}$$

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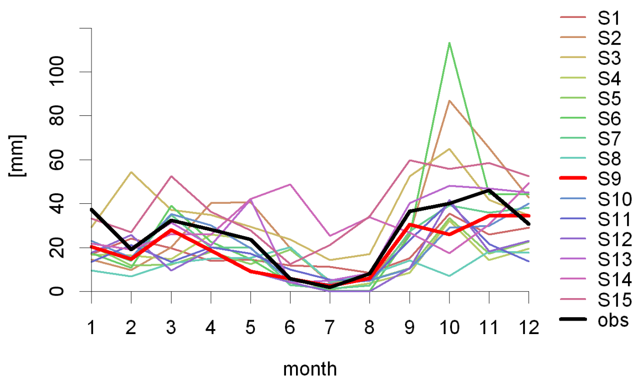
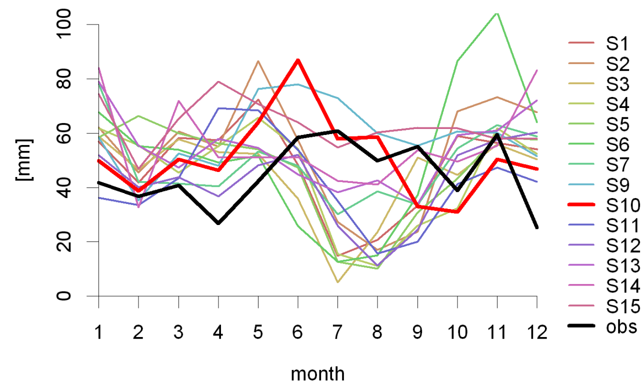
Climate scenario reliability
Seasonal dynamics for precipitation

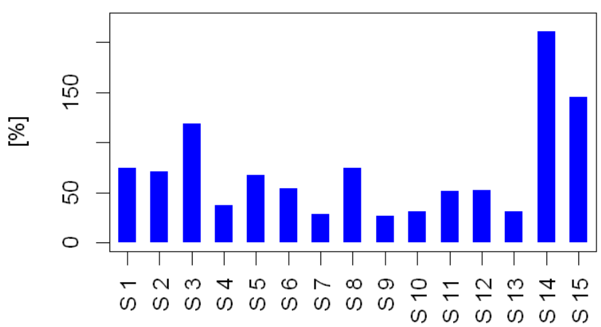
Mar Menor Catchment | **Tyligulskyi LIman Catchment**

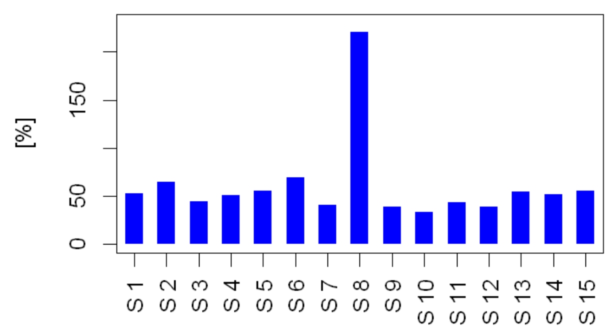
Observed (obs) and projected seasonal dynamics for precipitation





Differences between observed and projected mean monthly values for precipitation

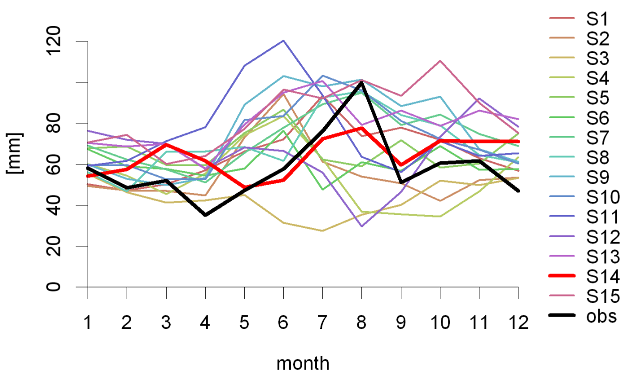


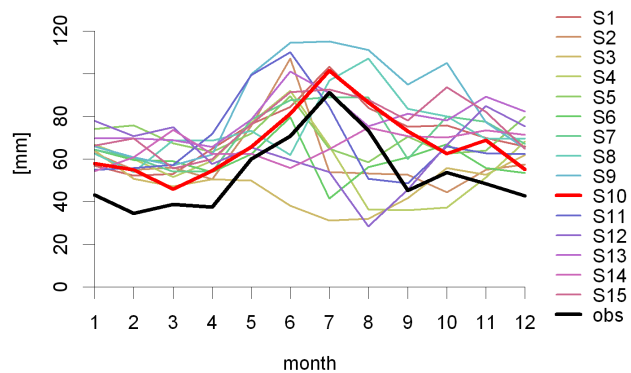


Climate scenario reliability
Seasonal dynamics for precipitation – Vistula Lagoon

station Chernyakhovsk **station Olzstyn**

Observed (obs) and projected seasonal dynamics for precipitation





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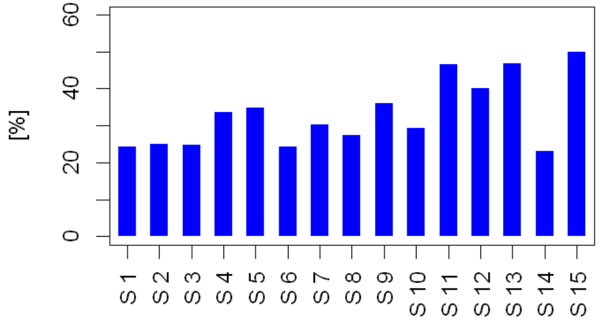

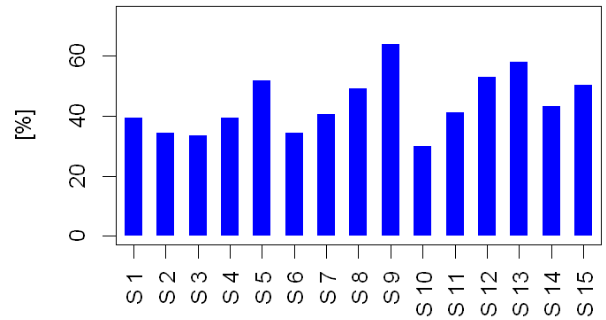

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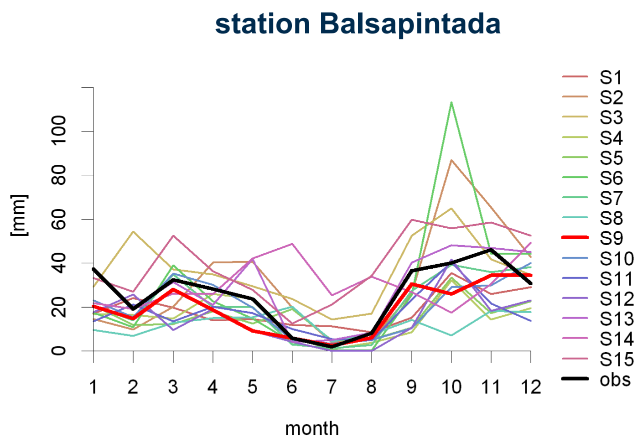
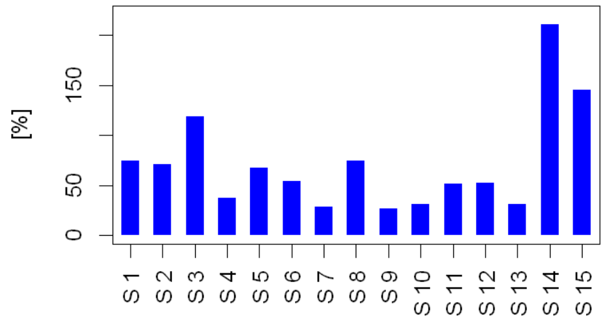
Climate scenario reliability

Seasonal dynamics for precipitation –



Observed (obs) and projected seasonal dynamics for precipitation



Differences between observed and projected mean monthly values for precipitation