MOSARH21 future discharges in the French Rhine

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MOSARH21 – future discharges in the French Rhine

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Funding: Rhin-Meuse Water Agency (France)

https://webgr.inrae.fr/en/mosarh21/

Aims of the MOSARH21 project

Main goal: Producing future discharge estimations for the French tributaries of the Rhine

Sub-goals:

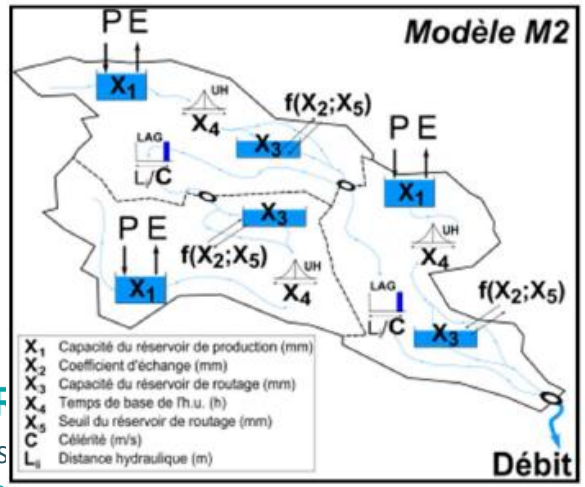
- Adopting a rigorous testing protocol for hydrological models
  - Temporal robustness
- Quantifying uncertainties of the different steps of the modelling chain
  - Several elements used for each step
- Comparing future discharge estimations of MOSARH21 with former projects results
  - CMIP3 vs CMIP5

Hydrological models

Two different approaches

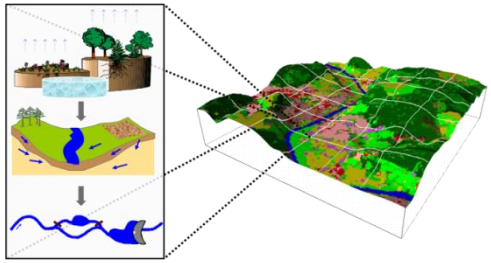
GR5J (semi-distributed)

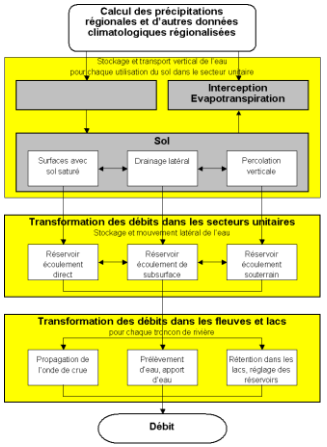
- Conceptual model
- Sub-basins discretisation
- Daily time step
- 7 parameters, automatic calibration
- Used in Explore 2070



LARSIM water balance model

- Conceptual model
- Grid mesh discretisation
- Daily time step
- 7 parameters, manual calibration, was automatised for MOSARH21
- Used in Flow-MS



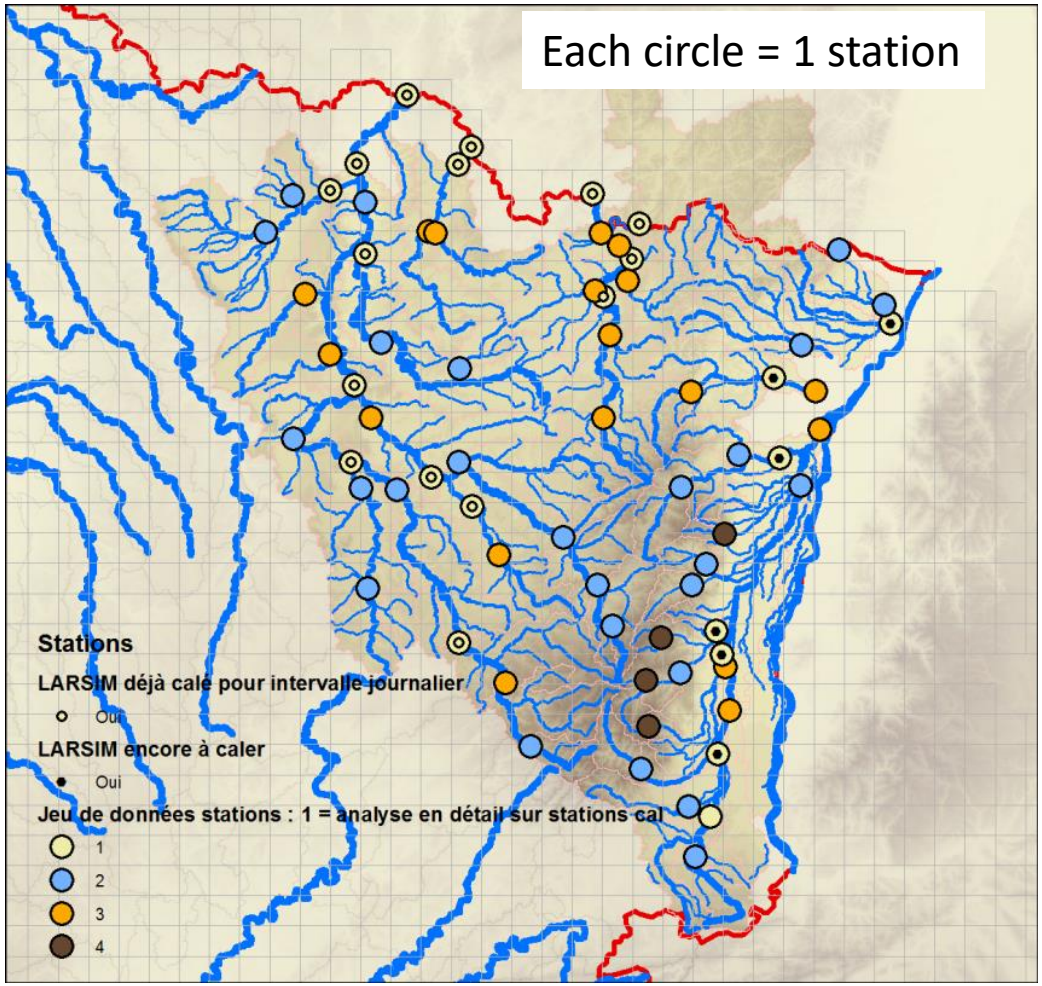


Gauged stations

70 stations

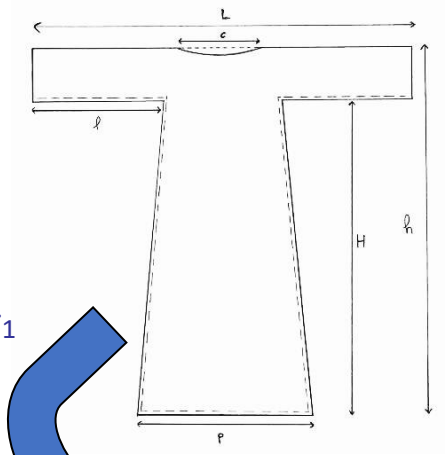
22 of which contain simulations obtained with both models calibrated (category 1)

Observed discharge for all stations



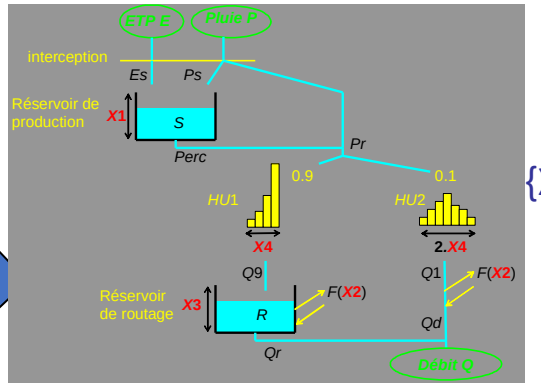
Hydro models parameters calibration

To better suit catchments characteristics

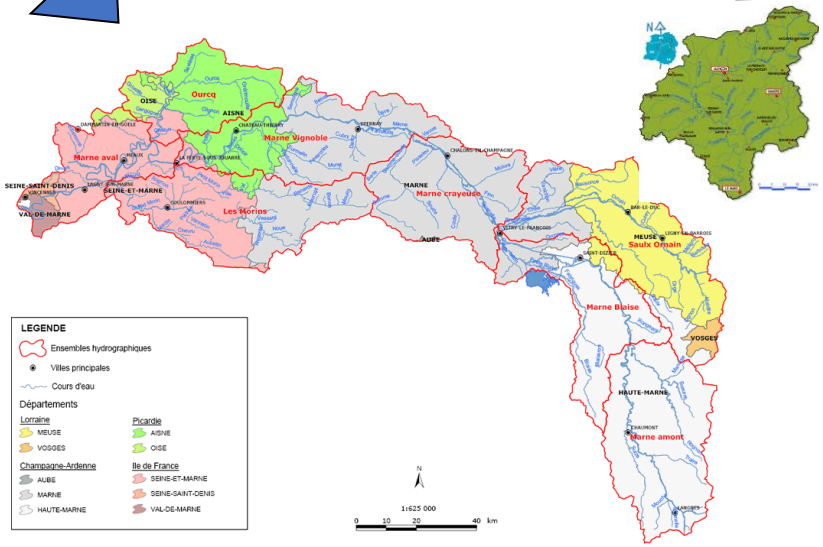


$\{c, l, L, h, H, p\}_1$

$\{c, l, L, h, H, p\}_2$

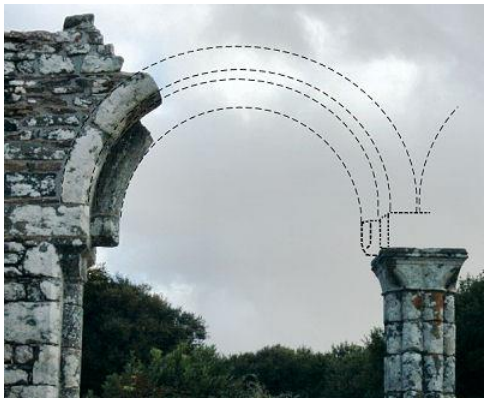


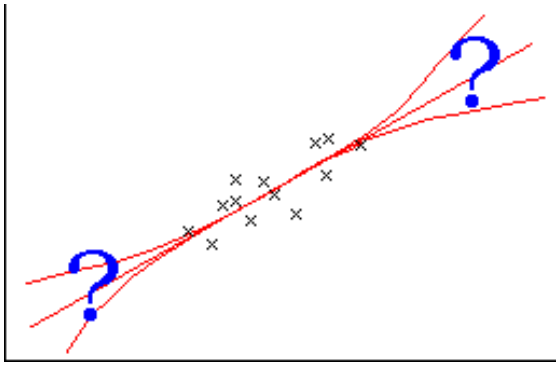
$\{X1, X2, X3, X4\}_2$

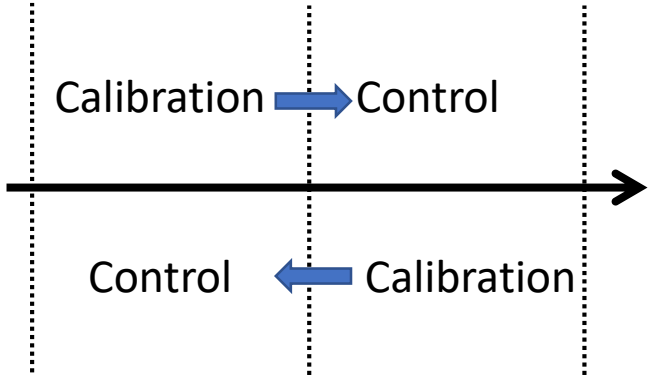


On the temporal robustness of hydro models

Application of a classical split-sample test, a necessity for CC applications (Thirel et al., 2015)







GRSD + LARSIM

Thirel, G., Andréassian, V., Perrin, C., 2015. On the need to test hydrological models under changing conditions. *Hydrological Sciences Journal*, 60:7-8, pages 1165-1173, DOI:10.1080/02626667.2015.1050027.

LARSIM automatic calibration

Based on the GR methodology

First time an automatic calibration of LARSIM was done

7 parameters were selected and calibrated sequentially according to main processes:

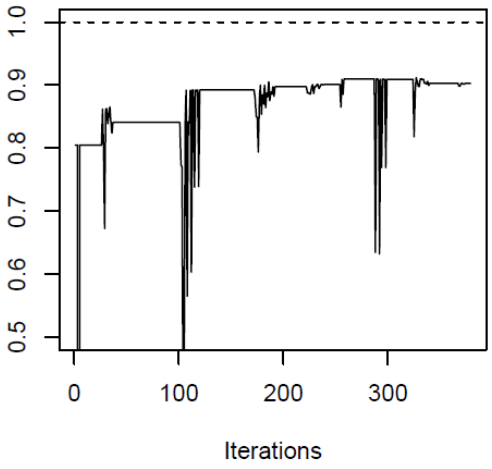
- Water balance (1 param)
- Low flows (2 params)
- Mid-flows (2 params)
- High flows (2 params)

For each step, a specific objective function was used

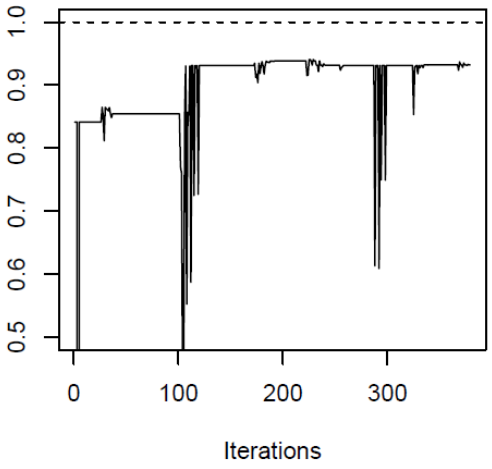
Evolution of performance of LARSIM during its calibration

High flows

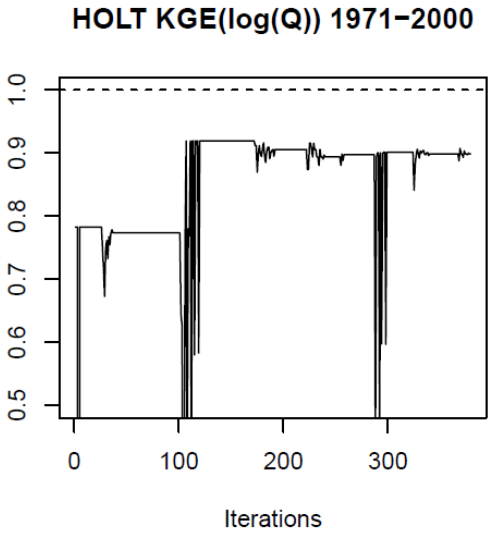
Holtzheim station



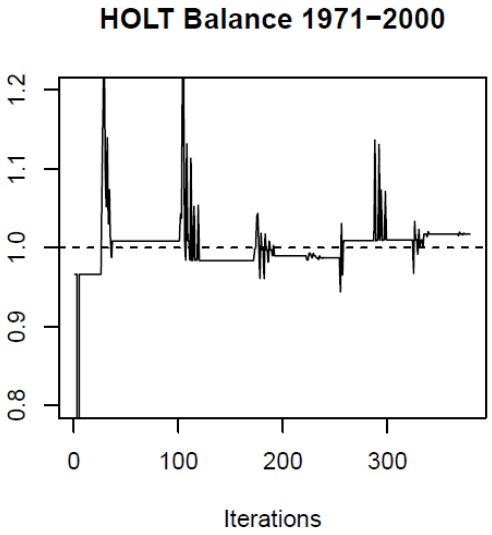
Mid-flows



Low flows

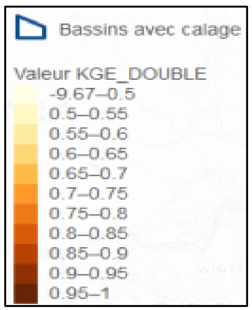


Water balance

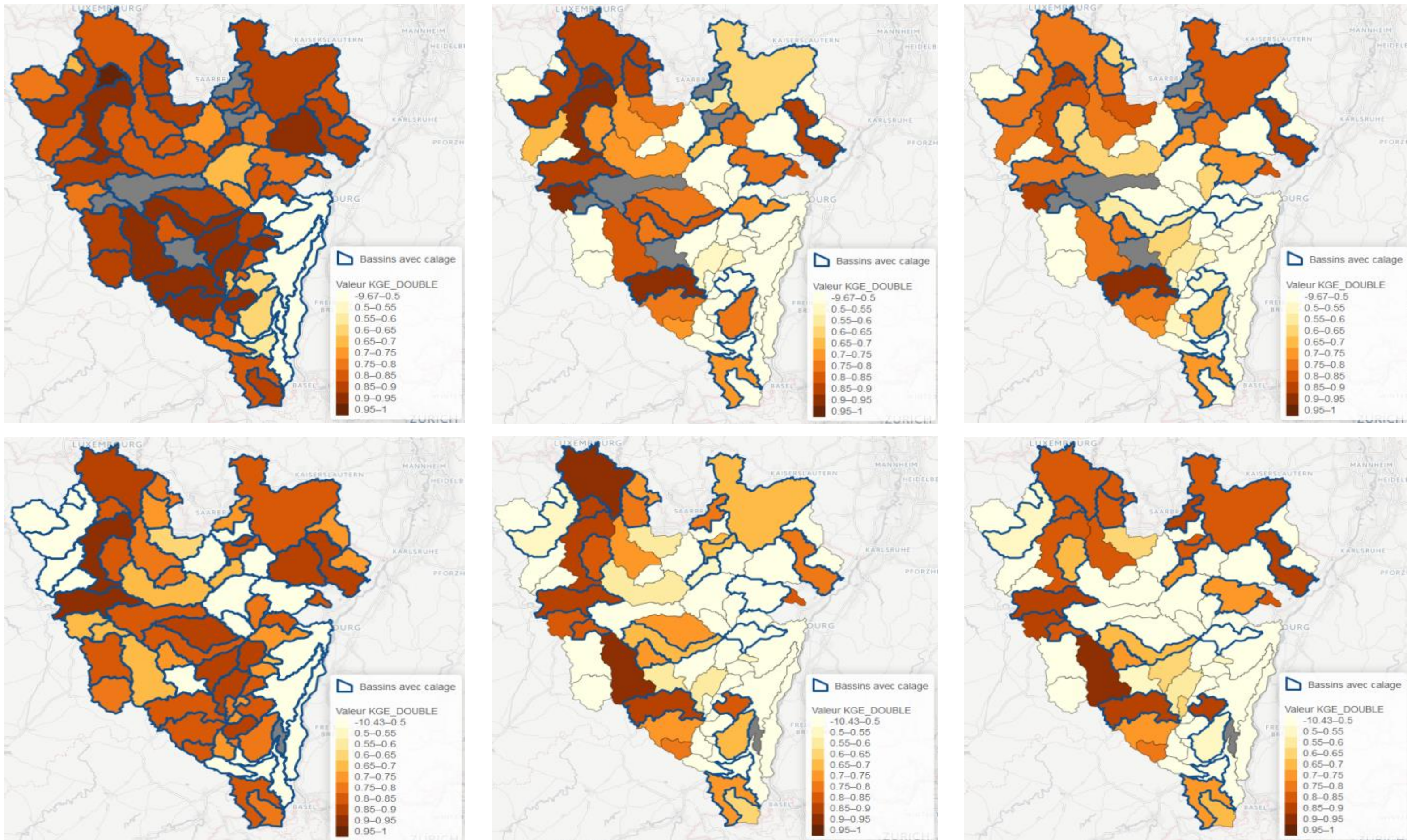


Spatial performances

Calibration (1971-1985)



Validation (1986-2000)

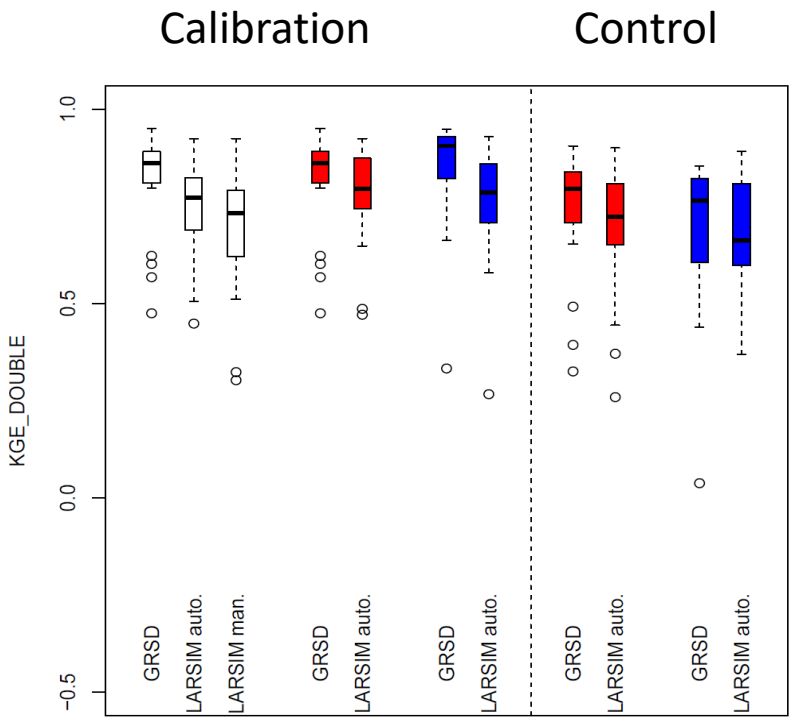


GRSD

LARSIM automatic calibration

LARSIM manual calibration

Temporal robustness of hydro models



Only stations calibrated for GRSD and LARSIM on this graph

Calibration on complete period

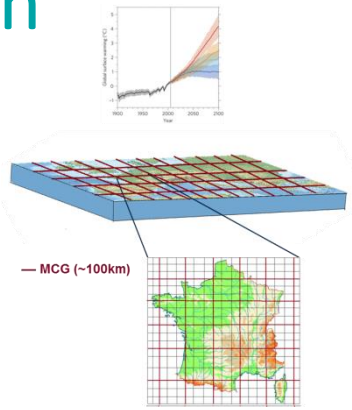
Calibration on P1 (1971 - 1985)

Calibration on P2 (1986 – 2000)

- Slight deterioration of performances on independent periods

➢ Models seem robust

CC impact modelling chain



Scénarios d'émission *ou*
Profils d'évolution de la concentration
GIEC

Modèles de Circulation Générale
CMIP3 / CMIP5

Régionalisation
(Méthode de Descente d'Echelle)

DONNÉES MÉTÉOROLOGIQUES MESURÉES

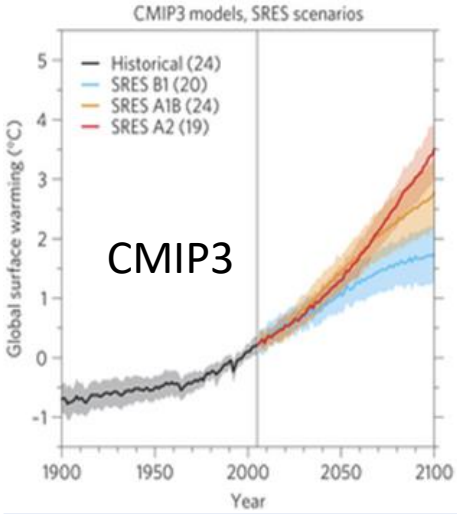
PROJECTIONS CLIMATIQUES

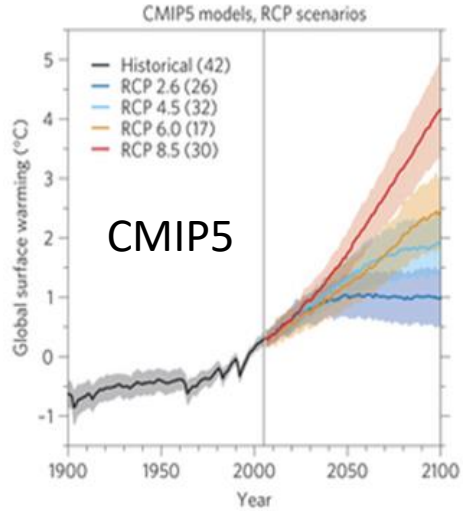
MODELES HYDROLOGIQUES (GRSD, LARSIM)

ÉTAT ACTUEL	ÉTAT ACTUEL	ÉTAT ACTUEL	SCENARII FUTURS
Débits mesurés 1971-2000	Débits simulés avec données mesurées 1971-2000	Débits simulés avec données de projections climatiques	Débits simulés avec données de projections climatiques

VÉRIFICATION	VÉRIFICATION	MODIFICATION
MODELISATIONS HYDROLOGIQUES	MODELISATIONS CLIMATIQUES	PREVISIBLE

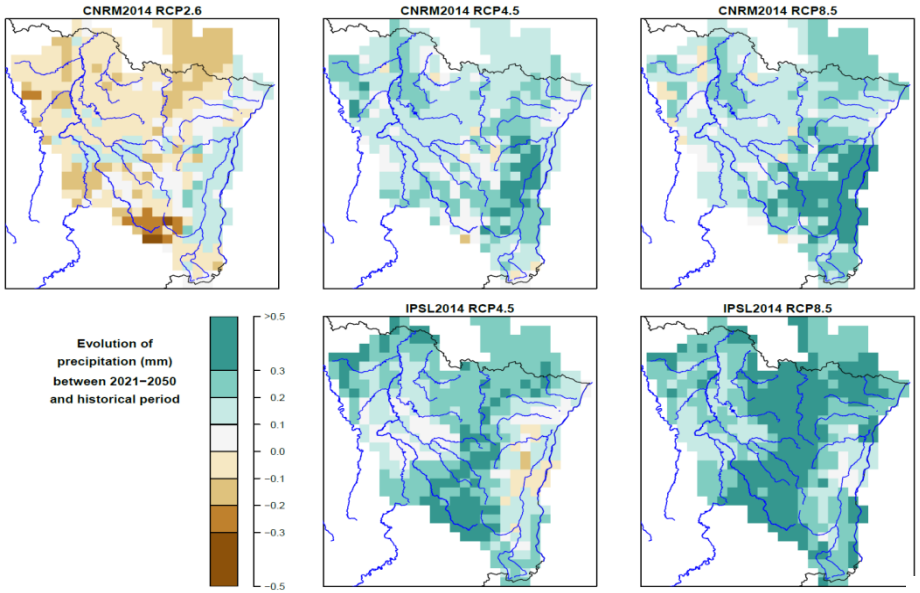
Climate projections used



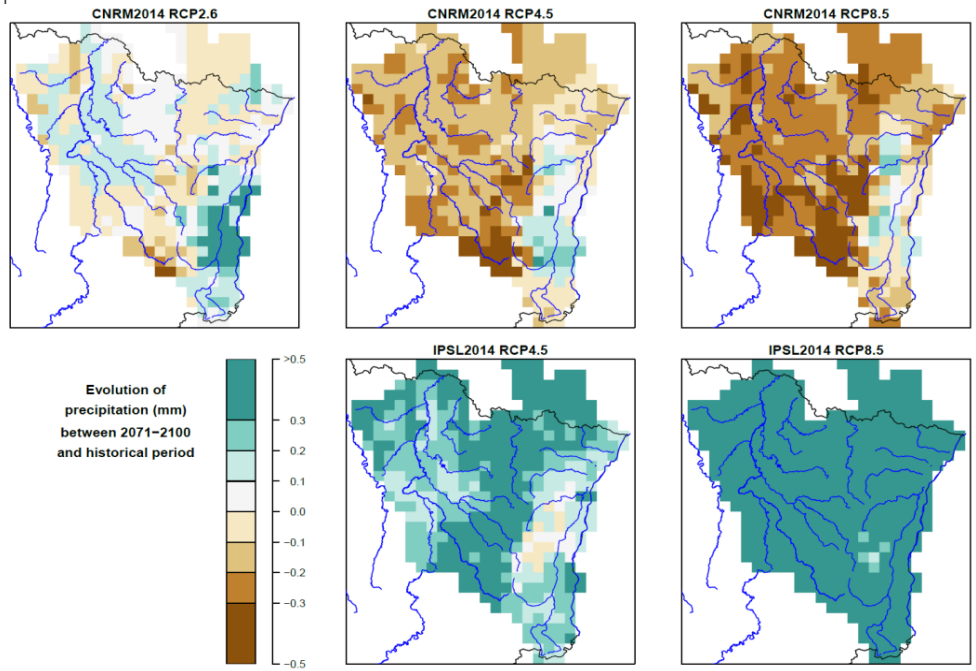


						GRSD			LARSIM		
Projet	Rapport du GIEC	Scenarios	GCM	MDE	Débiaisage	Période PST	Période 1 TFUT	Période 2 TFUT	Période PST	Période 1 TFUT	Période 2 TFUT
Explore 2070	AR4	A1B	CCCMA-CGCM3 ECHAM5-MPI CNRM-CM3 GFDL-CM2.1 GISS-MODEL-ER MRI-CGCM2.3.2	SCRATCH08	-	1961-1990	2045-2065	-	1961-1990	2045-2065	-
FLOW-MS Alsace	AR4	A1B	ECHAM5-MPI	COSMO-CLM	linear-scaling quantile-quantile	1971-2000	2021-2050	-	1971-2000	2021-2050	-
FLOW-MS Moselle-Sarre	AR4	A1B	ECHAM5-MPI	COSMO-CLM	linear-scaling quantile-quantile	1971-2000	2021-2050	-	1971-2000	2021-2050	-
Méthode ADC	AR5	RCP2.5 RCP4.5 RCP8.5 RCP4.5 RCP8.5 RCP2.5 RCP8.5 RCP4.5 RCP2.5 RCP4.5 RCP8.5	CNRM-CM5 IPSL-CM5B-LR GFDL-CM3 GISS-E2-R MRI-CGCM3	Advanced Delta Change		1971-2005	2021-2050	2071-2100	-	-	-
Portail DRIAS (CNRM2014 et IPSL2014)	AR5	RCP2.5 RCP4.5 RCP8.5 RCP4.5 RCP8.5	CNRM-CM5 IPSL-CM4	Aladin WRF	Quantile-quantile CDFt	1971-2000 1971-2000	2021-2050 2021-2050 2021-2050 2021-2050 2021-2050	2071-2100 2071-2100 2071-2100 2071-2100 2071-2100	- - 1971-2000 - 1971-2000	- - 2021-2050 - 2021-2050	- - 2071-2100 - 2071-2100

Precipitation projections

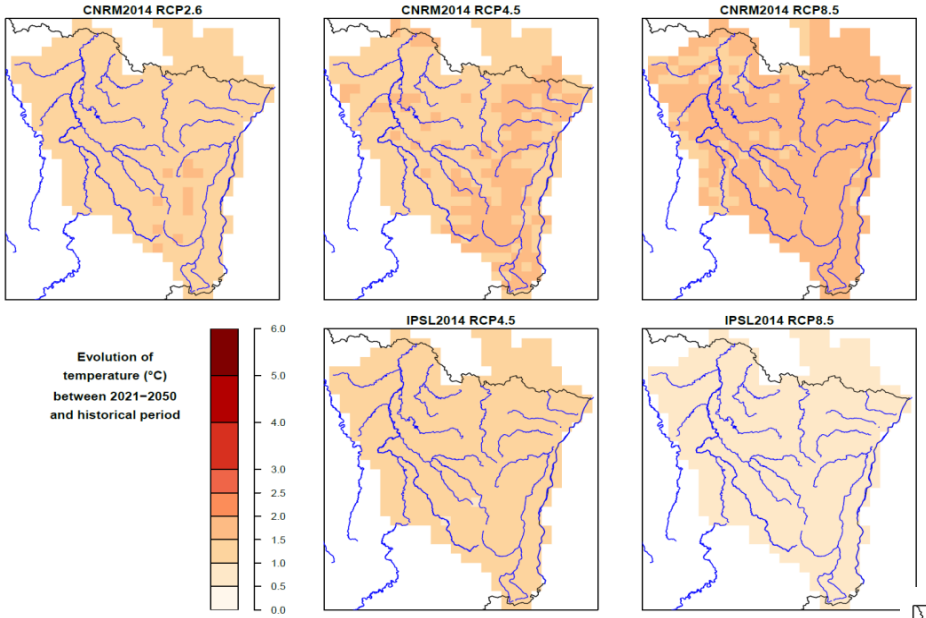


Near future

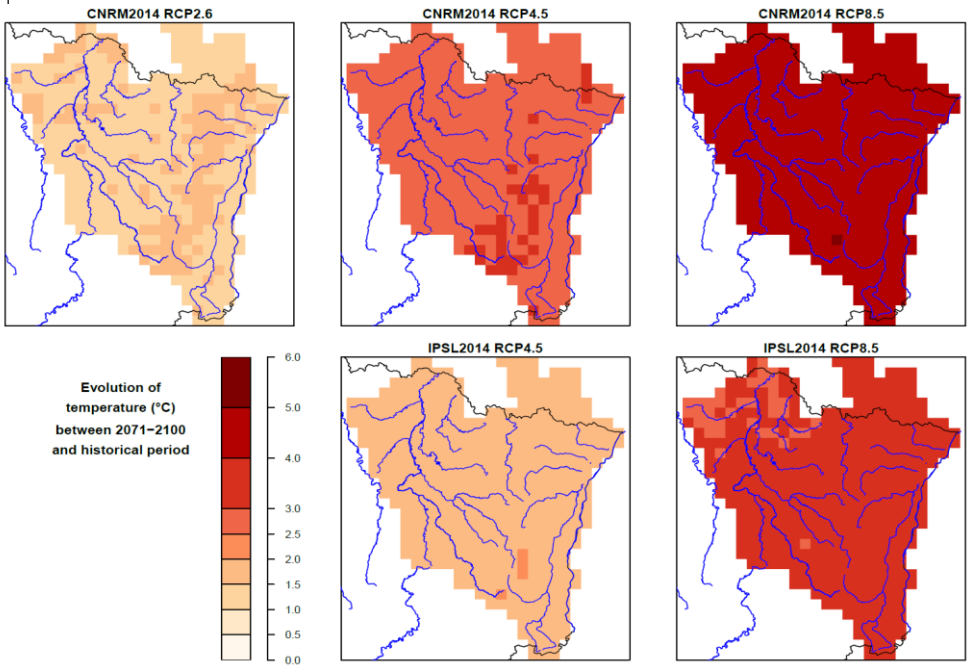


Far future

Temperature projections

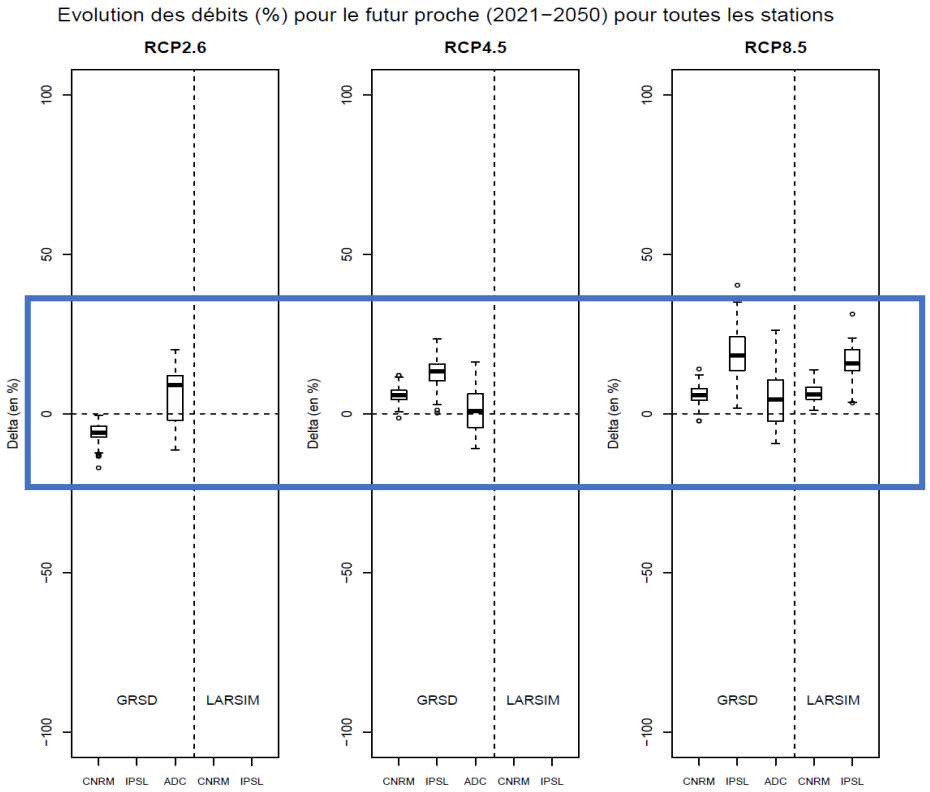


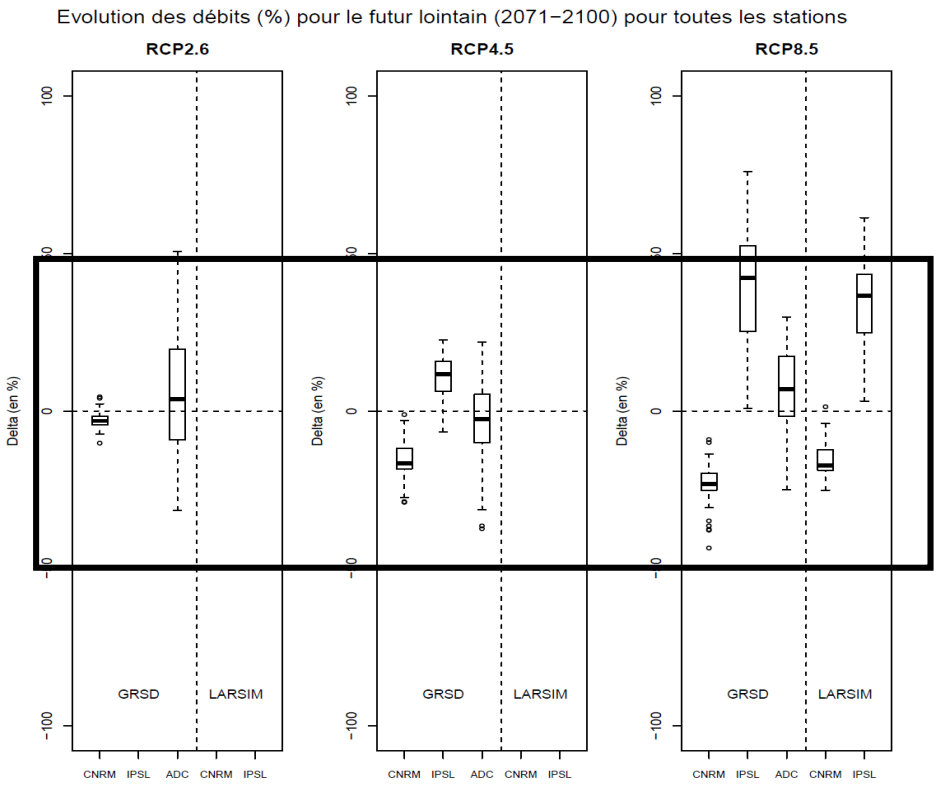
Near future



Far future

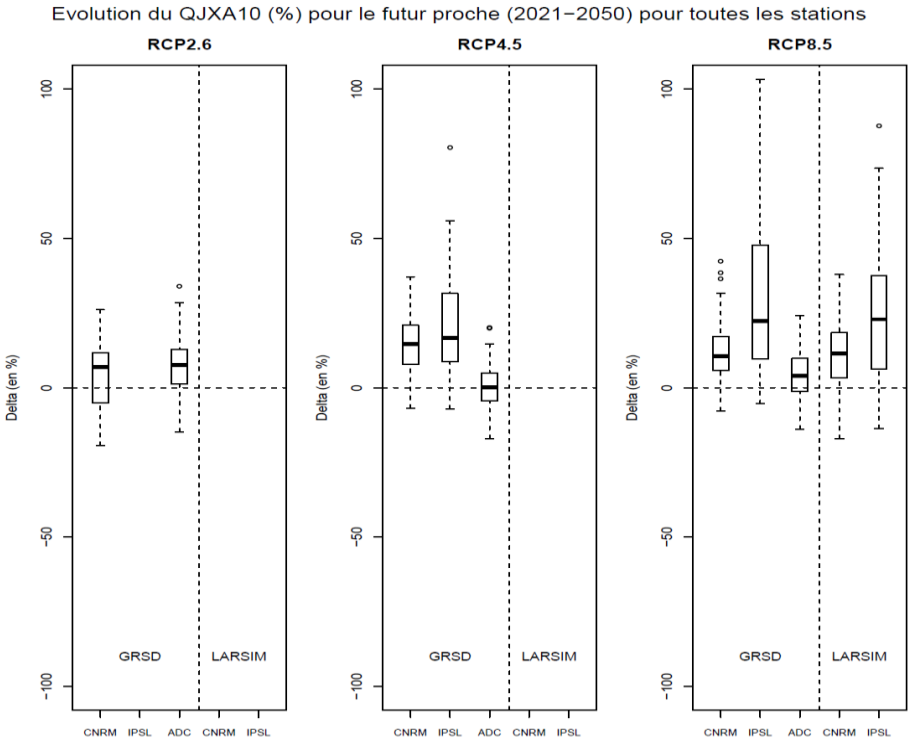
Hydrological projections (evol. of mean flows in %)

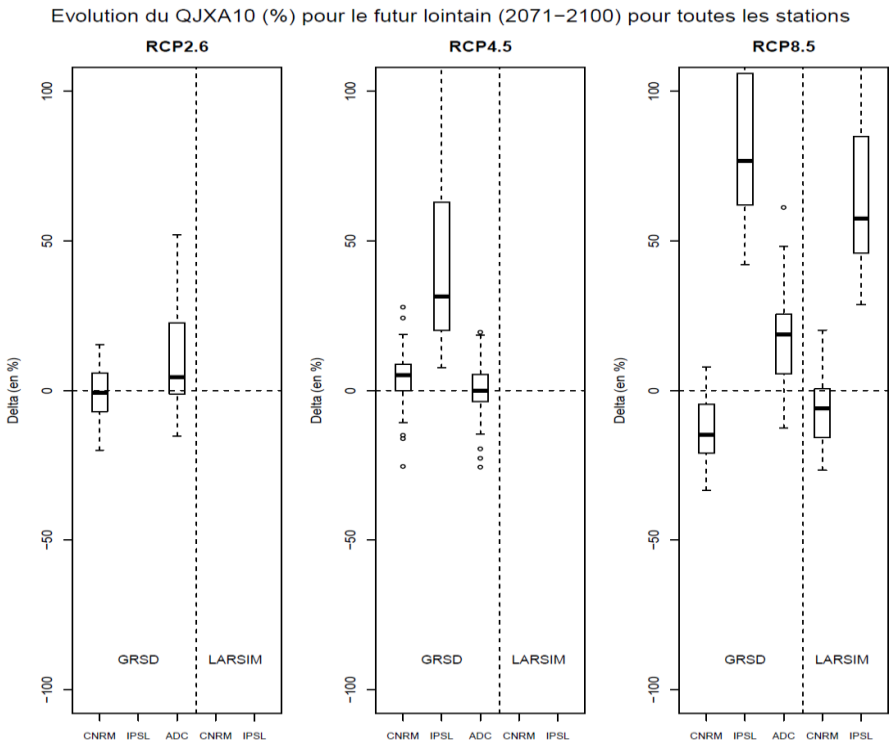




- Low to medium increase of Qmean in near future except RCP2.6
- Contrasted evolution in far future (see climate projections). GRSD behaves more extremely

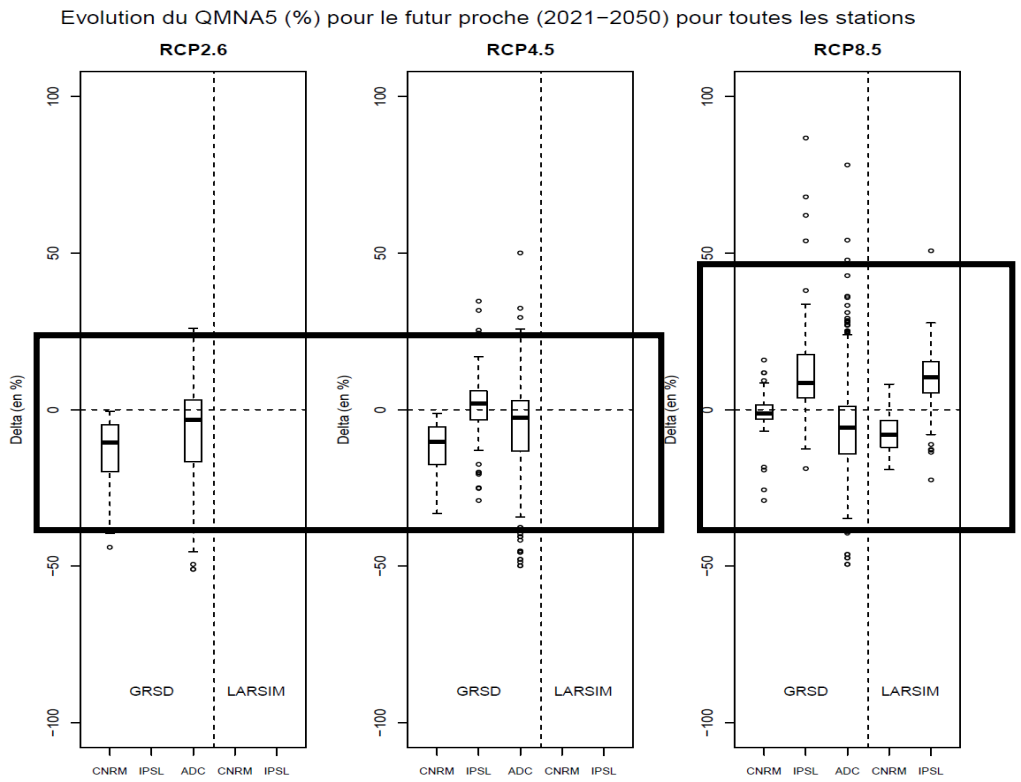
Hydrological projections (evol. of high flows in %)

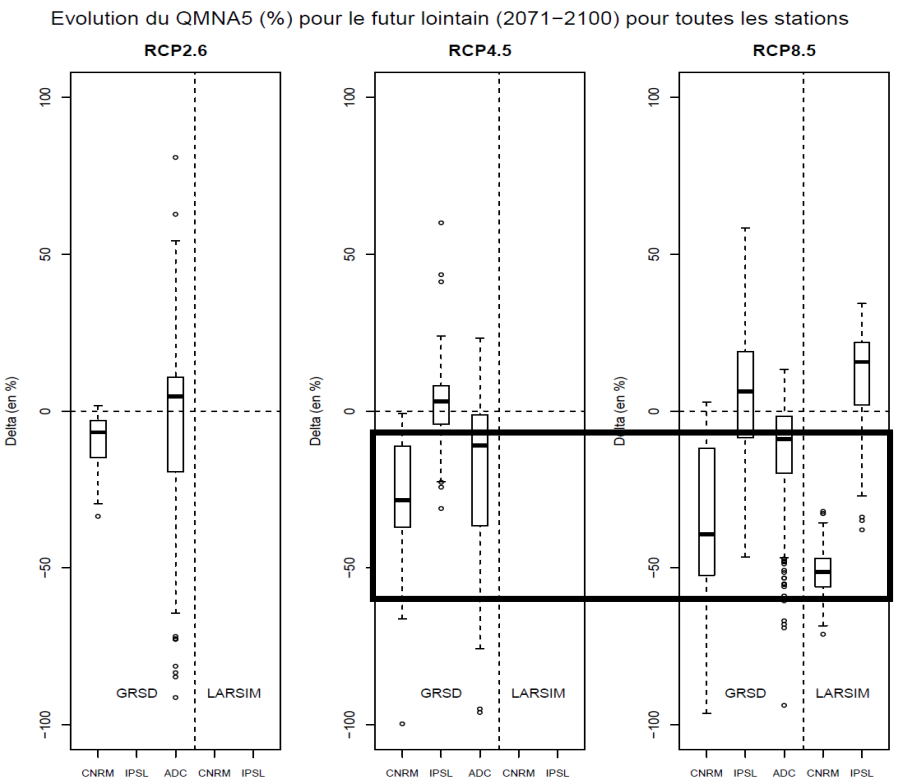




- Low to medium increase of high flows in near future
- Contrasted evolution in far future (see climate projections). GRSD behaves more extremely

Hydrological projections (evol. of low flows in %)





- Low to medium decrease of low flows in near future, except RCP8.5
- Contrasted evolution in far future. Poteltial very strong decrease for the most pessimistic scenarios

Projet MOSARH 21
Financement Agence de l'Eau Rhin-Meuse

Ordre de grandeur des débits futurs possibles sous les scénarios du cinquième rapport du GIEC, les profils représentatifs d'évolution de concentration (RCP).

Avertissement : ces résultats comportent de très nombreuses incertitudes. Ils sont donnés à titre indicatif. Il ne s'agit pas de prévisions mais d'indications d'évolutions possibles.

Station	Perl (DE)
Rivière	Moselle
Code HYDRO	PERLXXXX
Surface	11556 km²
Coordonnées Lamb. II (m)	892426, 2504755
Modèles hydrologiques	GRSD , LARSIM
Calage GRSD	Oui
Calage LARSIM	Oui
Période de calage	1971-2000
Période de référence	1971-2000
Période futur proche	2021-2050
Période futur lointain	2071-2100

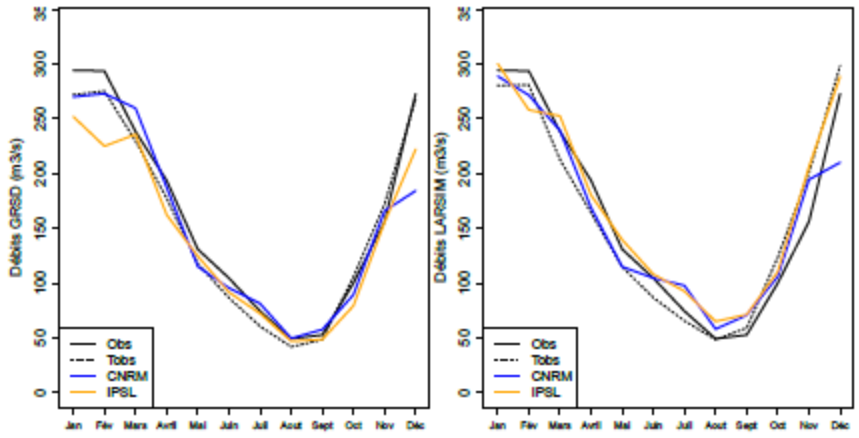
Fiche crues - Moselle à Perl (DE)

Les évolutions hydrologiques sont calculées entre des simulations de référence en climat présent (1971-2000) et des simulations en climat futur proche (2021-2050) et futur lointain (2071-2100). Différents modèles climatiques désagrégés sont utilisés en forçage des modèles hydrologiques : les modèles du CNRM et de l'IPSL avec désagrégation dynamique, ainsi que de trois à quatre modèles avec désagrégation statistique grâce à la méthode de l'Advanced Delta Change (ADC). Les résultats futurs sont présentés sous forme de deltas entre présent et futur, (FUT-PST)/PST. Les valeurs minimales, médianes et maximales sont calculées pour les scénarios ADC. Selon les stations, les scénarios et les périodes, un ou deux modèles hydrologiques ont été utilisés.
Cette fiche fournit des régimes et des indicateurs hydrologiques liés aux crues. Pour les étiages et le climat, des fiches étiages et climat additionnelles sont disponibles. Le rapport final du projet MOSARH21 donne de plus amples détails sur la méthodologie et la configuration des modèles climatiques et hydrologiques.

Situation de référence (1971-2000)

Régimes et indicateurs des débits observés et simulés sur la période de référence. Tobs indique que les modèles ont été forcés par les observations SAFRAN, Tpst indique que les modèles ont été forcés par les sorties des modèles climatiques. Les débits et indicateurs obtenus avec les scénarios ADC, de par leur construction, sont identiques à Qsim Tobs.

	Jan		Fév		Mars		Avril		Mai		Juin		Juil		Aout		Sept		Oct		Nov		Déc		Annuel	
Qobs (m3/s)	294.1		293.5		238.3		193.6		130.9		104.5		74.4		49.2		52.7		100.1		156.0		272.6		163.1	
Qsim Tobs (m3/s)	271.9	280.4	275.1	280.7	229.6	212.7	177.6	164.1	117.5	114.7	86.5	86.7	60.5	65.5	41.8	48.5	48.3	59.0	105.7	123.6	171.9	200.3	268.4	298.5	154.0	160.7
Qsim Tpst CNRM (m3/s)	269.8	288.8	272.8	271.5	259.7	239.2	187.2	168.8	115.1	114.9	95.5	104.6	81.3	97.8	49.5	58.0	57.6	70.7	89.3	106.1	165.8	194.4	184.2	210.0	151.7	159.8
Qsim Tpst IPSL (m3/s)	251.9	300.2	224.9	257.9	235.6	252.5	162.4	180.2	124.6	139.5	91.7	108.1	72.2	92.6	46.9	65.0	48.6	71.2	79.3	110.3	155.4	206.2	222.0	288.2	142.7	172.4

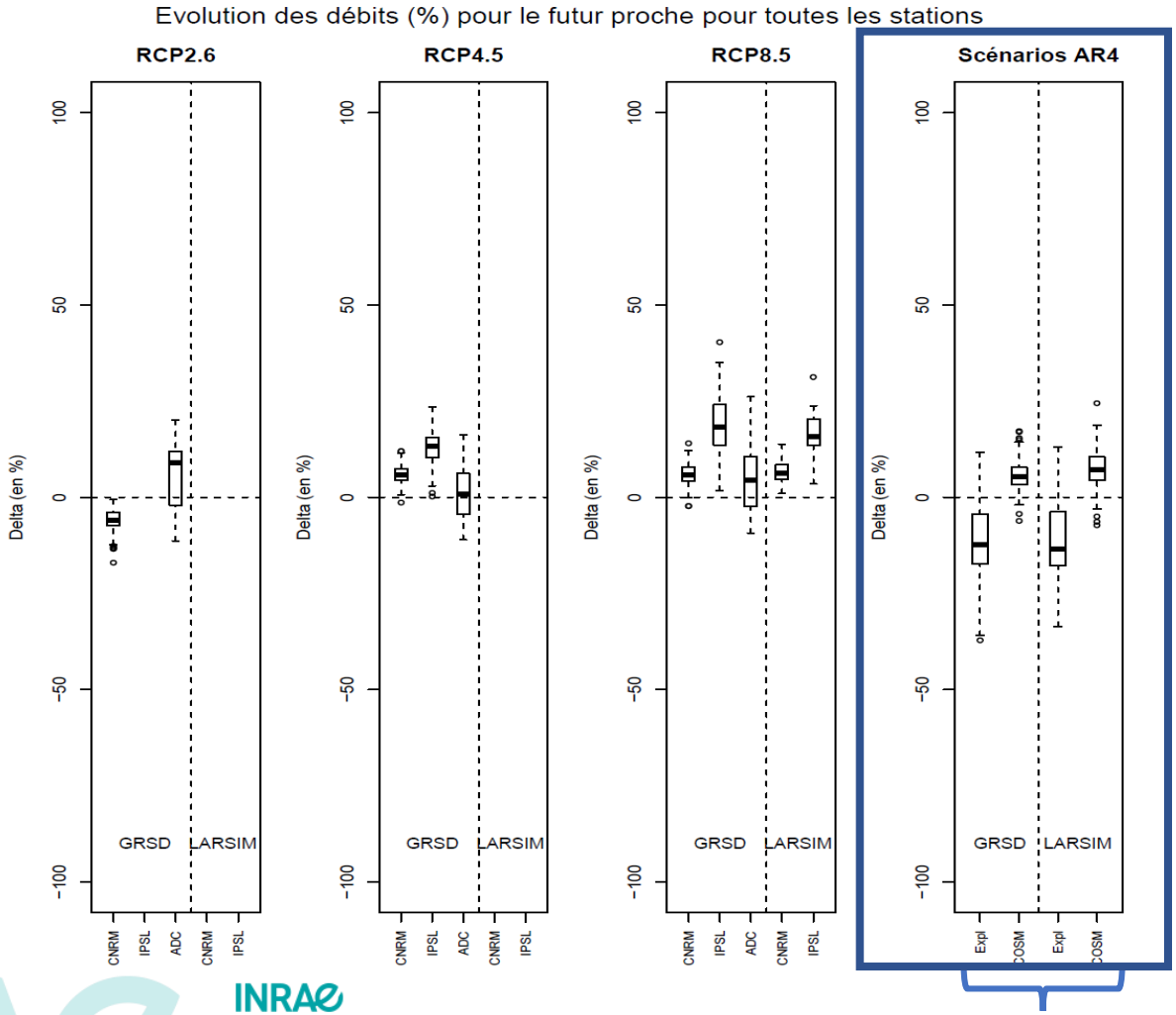


	QJXA2		QJXA10		QJXA100	
Qobs (m3/s)	1066.8		1651.4		2380.6	
Qsim Tobs (m3/s)	1002.4	930.6	1603.9	1380.3	2354.1	1941.1
Qsim Tpst CNRM (m3/s)	931.8	869.3	1442.1	1244.7	2078.6	1712.9
Qsim Tpst IPSL (m3/s)	754.1	746.4	1131.0	1069.2	1601.1	1471.9

	Q95		Q99	
Qobs (m3/s)	519.0		938.0	
Qsim Tobs (m3/s)	494.0	515.6	889.2	918.5
Qsim Tpst CNRM (m3/s)	476.3	488.9	836.2	842.6
Qsim Tpst IPSL (m3/s)	401.3	460.5	649.4	696.3

Where the hydro projections from Explore 2070 and FLOW MS that different?

Evol. of mean flows in %



Prior studies

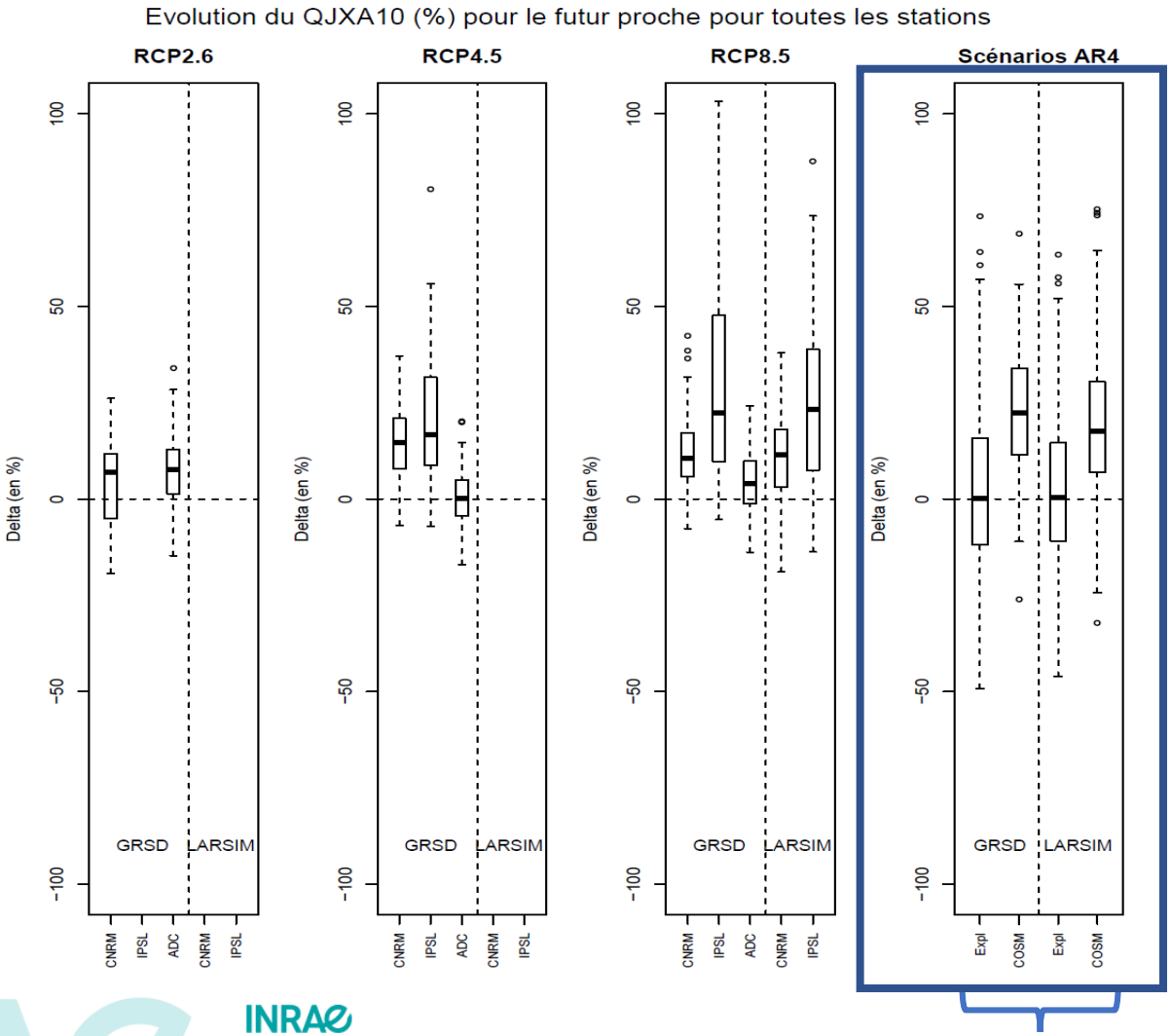
/!\ Beware, the Explore 2070 future period is 2045-2065, not 2021-2050.

FLOW MS rather similar to RCP 4.5

Explore 2070 differs, it is closer to far future of MOSARH 21 evolutions!

Where the hydro projections from Explore 2070 and FLOW MS that different?

Evol. of High flows in %



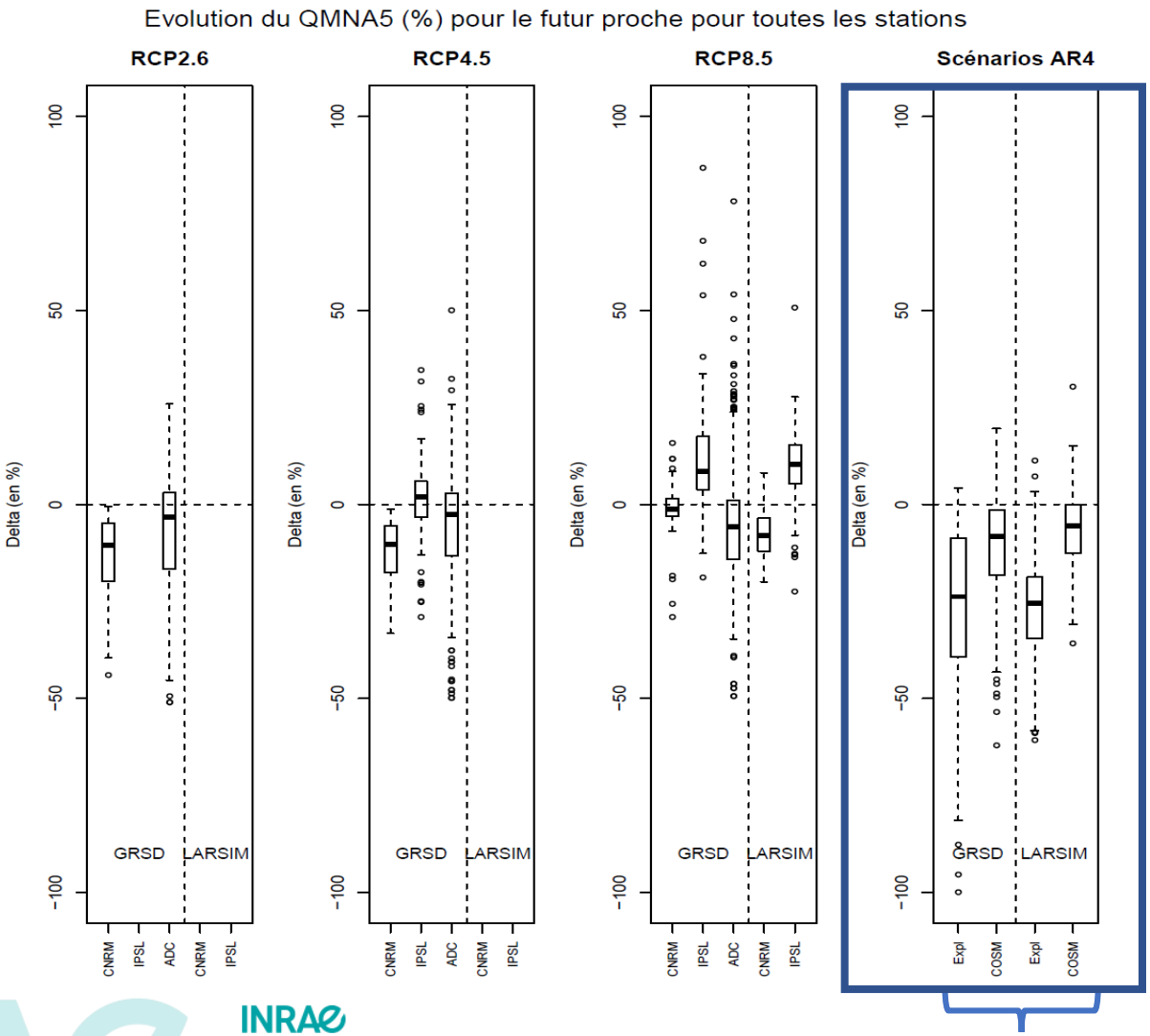
Prior studies

FLOW MS rather similar to RCP 8.5

Explore 2070 more uncertain, it is closer to far future of MOSARH 21 evolutions!

Where the hydro projections from Explore 2070 and FLOW MS that different?

Evol. of low flows in %



Prior studies

FLOW MS rather similar to CNRM and ADC projections

Explore 2070 more pessimistic, it is closer to far future of MOSARH 21 evolutions!

Conclusions

- We updated the hydro projections of Mosel, Sarre and French Rhine
- We took into account uncertainties
- We undertook an automatic calibration of LARSIM

- Mean flows should slightly increase (except IPSL RCP 8.5)
- High flows should increase in near future, more uncertainty later
- Low flows should decrease in near future, more uncertainty later but potential very high decrease

- Uncertainties: GCMs > RCPs > Sampling > Hydro models

- Prior studies: with CMIP5, we globally are consistent with FLOW MS or Explore 2070, but:
  - Explore 2070 corresponds rather to an intermediate state between MOSARH 21 near and far futures
  - FLOW MS cannot be linked to a specific RCP