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The CHIMERE 21 project

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CHIMERE 21

MICCA meeting 6th July 2021

➤ Context and goals of the project

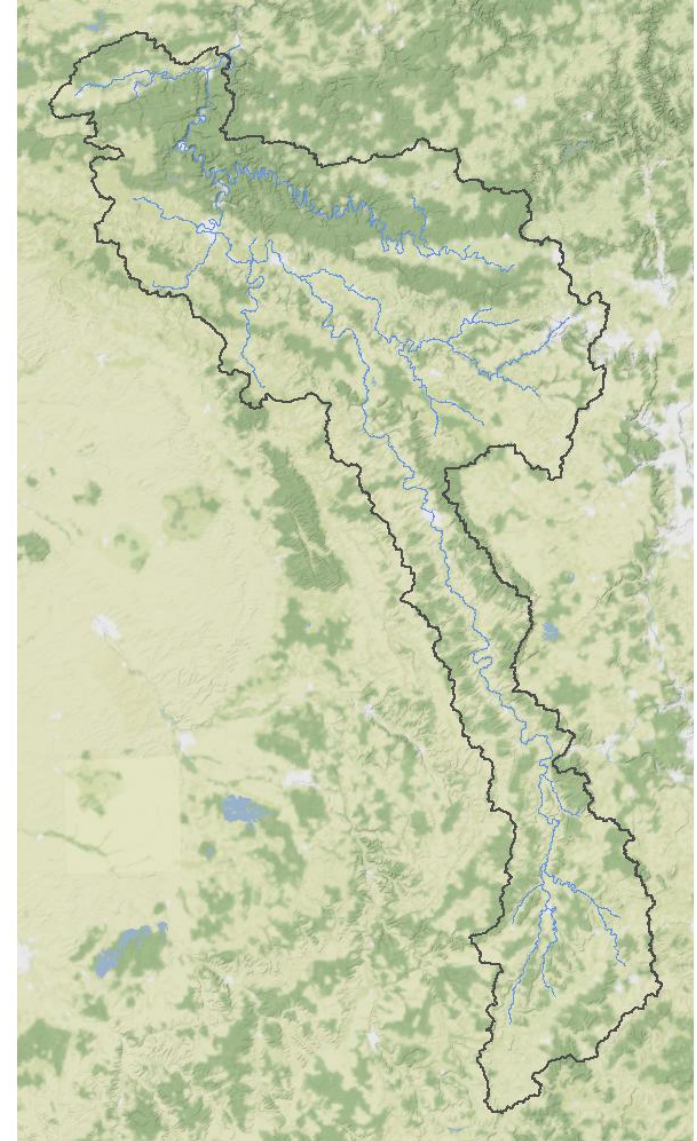
➤ The CHIMERE 21 project

CHlers - MEuse: hydrological Regime Evolution in the 21st century

Topic of the project: Study of the impact of climate change on the streamflows of the Chiers and Meuse Rivers

Partners: INRAE (formerly Irstea), Météo-France, EDF, Université de Lorraine, DREAL Grand-Est

Funded by Agence de l'Eau Rhin-Meuse: 188 k€



➤ The CHIMERE 21 team



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(DREAL Grand-Est)



> The context

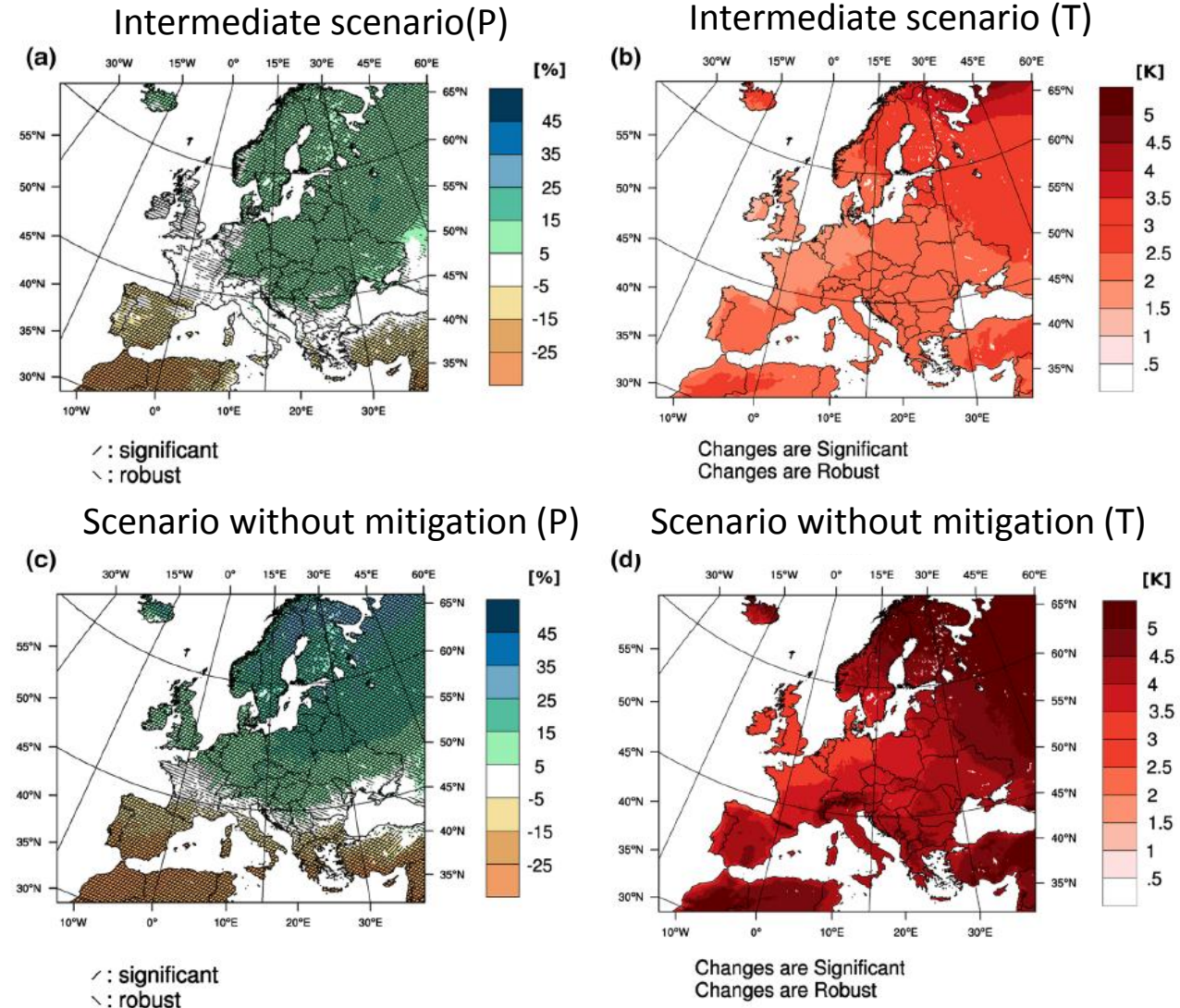
CHlers - MEuse: hydrological Regime Evolution in the 21st century

Global scale evolutions need to be refined at the local scale through specific studies

Past studies:

- Explore 2070: France-wide project
- Amice: Meuse-wide project

Jacob et al. (2013)



Mean evolution of precipitation (left) and temperature (right) by 2071-2100

➤ Objectives of CHIMERE 21

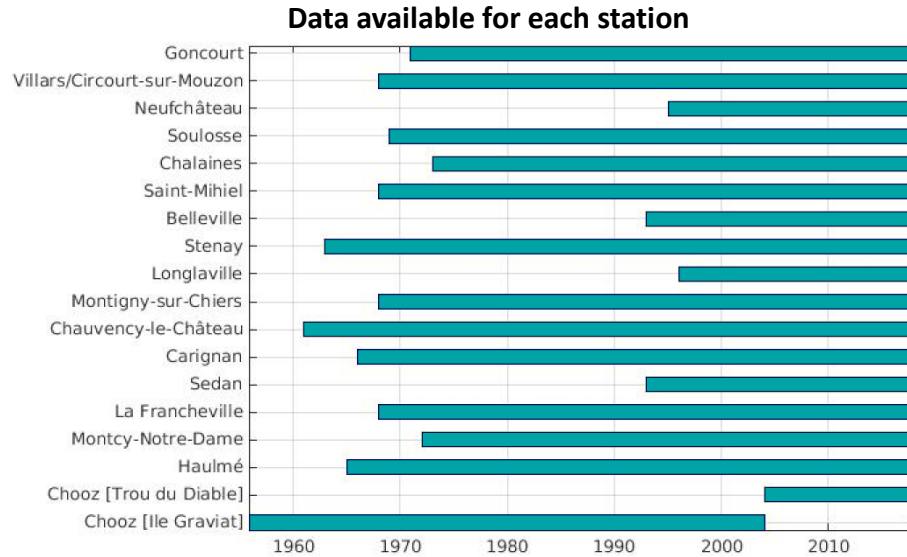
- Update existing knowledge (Explore 2070 and Amice are beginning to be old)
- Refine results (needs of local studies)
- Huge stakes for low flows

Objectives of the project:

- Study of the impact of climate change on future Meuse streamflows
- Focus on uncertainties
- Production of synthetic sheets

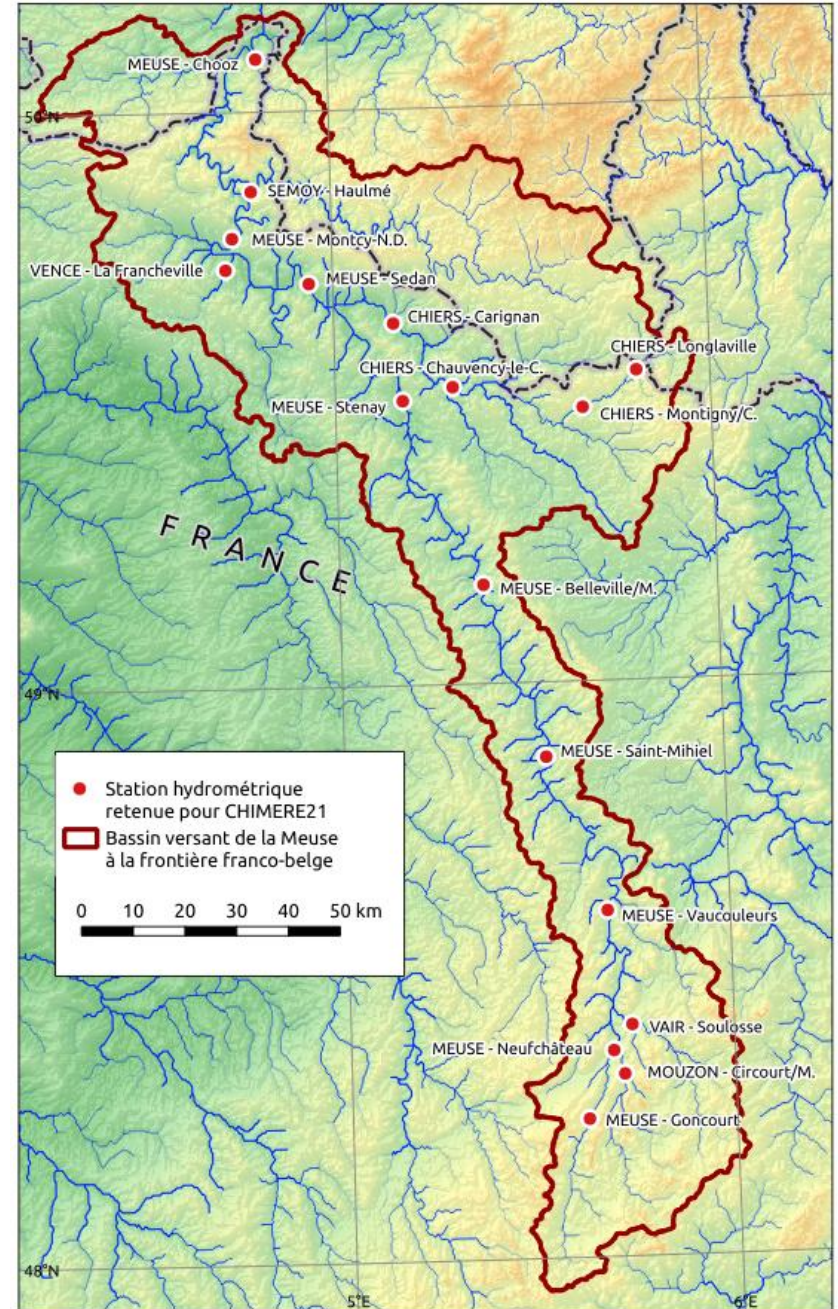
➤ Presentation of the basin and data

➤ Hydro data



➤ 16 stations (one for around 480 km²)

- Dubious daily discharge values removed through visual inspection
- At Chooz, the evaporation water consumption was estimated using daily air temperature and the nuclear power plant charge
- Other influences were not removed from time series:
 - Either low impact at the basin scale
 - Or too much uncertainty so data were just discarded



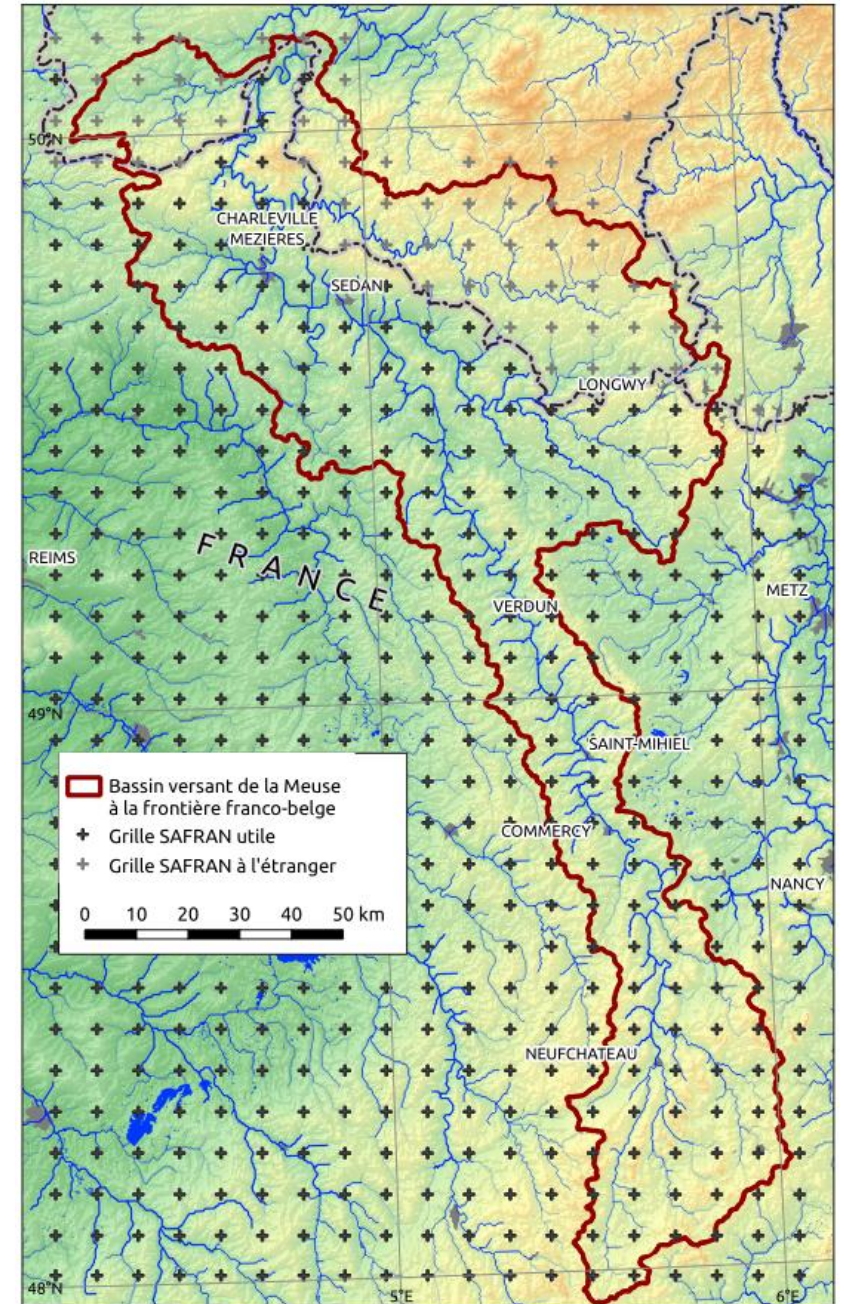
➤ Observed meteo data

Météo-France SAFRAN reanalysis: combination between observed in situ data and model simulations

➤ Spatialised data on a regular grid: 8 km x 8 km

➤ Daily data

- Potential evapotranspiration = Penman-Monteith (using SAFRAN variables)



➤ Climate change over the Meuse basin

➤ Climate change over the Meuse basin

Modelling chain: composed of several steps

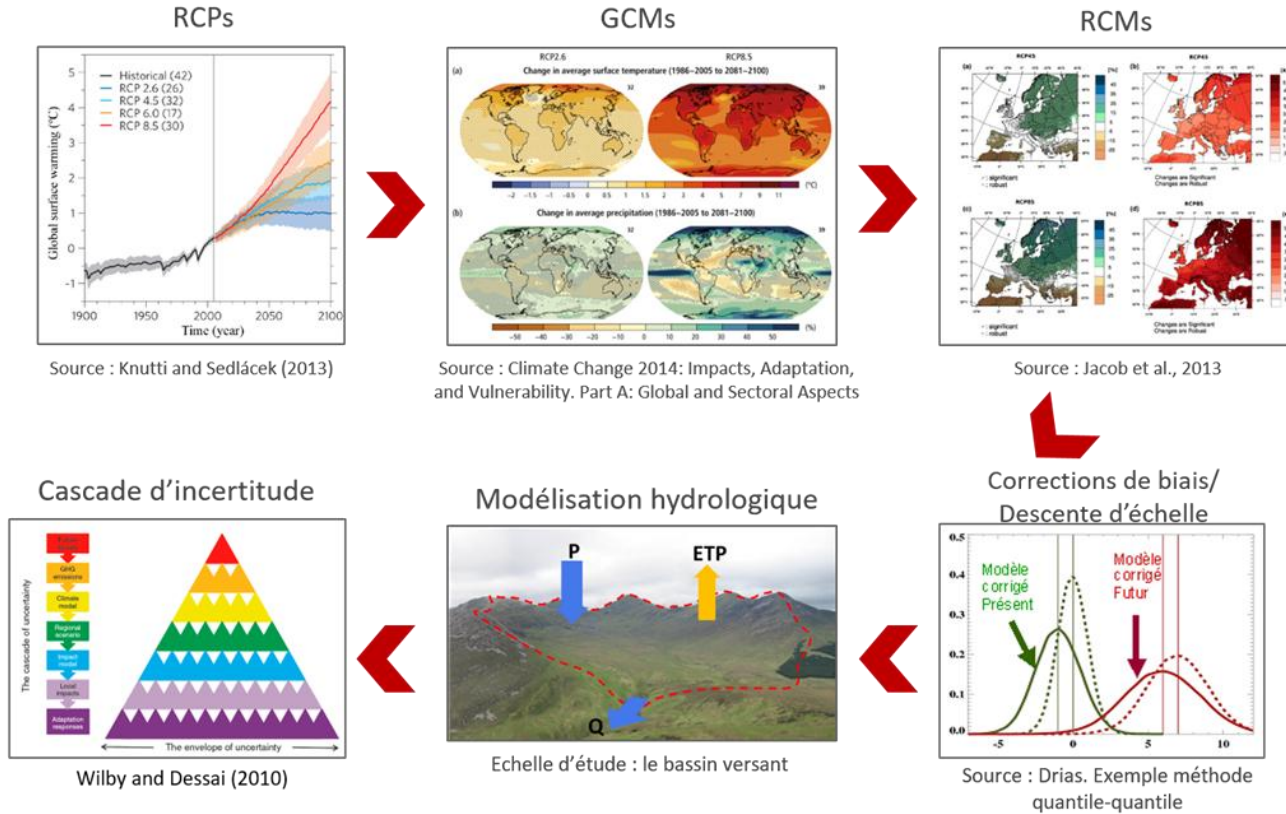
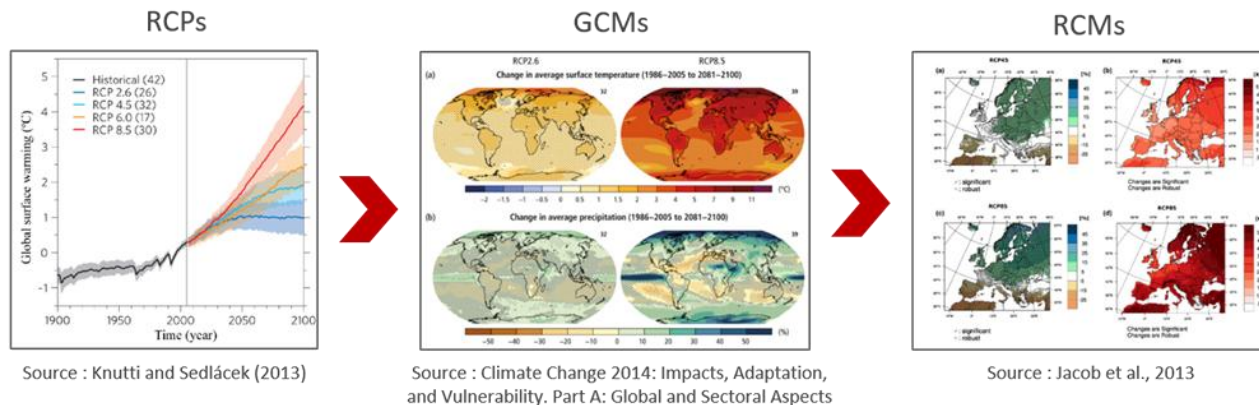


Figure from Lemaitre-Basset (2020)

➤ Climate change over the Meuse basin

Selection of climate data for CHIMERE 21:



.RCP 4.5
.RCP 8.5

	GCM	RCM
Couple 1	CNRM-CM5	ALADIN53
Couple 2	IPSL-CM5A	IPSL-INERIS-WRF
Couple 3	CNRM-CM5	RCA4
Couple 4	IPSL-CM5A	RCA4
Couple 5	MPI-ESM	RCA4

3 different GCMs, 3 different RCMs

➤ Climate change over the Meuse basin

Seasonal climate evolution

Summer (all models and RCPs)	Temperatures	Precipitation
Near future	+ 0,4 to + 1,2 °C	-14 to + 23 %
Far future	+ 1 to + 4,4 °C	-39 to + 21 %

Large uncertainty

Winter (all models and RCPs)	Temperatures	Precipitation
Near future	+ 0,8 to + 1,5 °C	+ 1 to + 35 %
Far future	+ 1,8 to + 4,4 °C	+ 18 to + 57 %

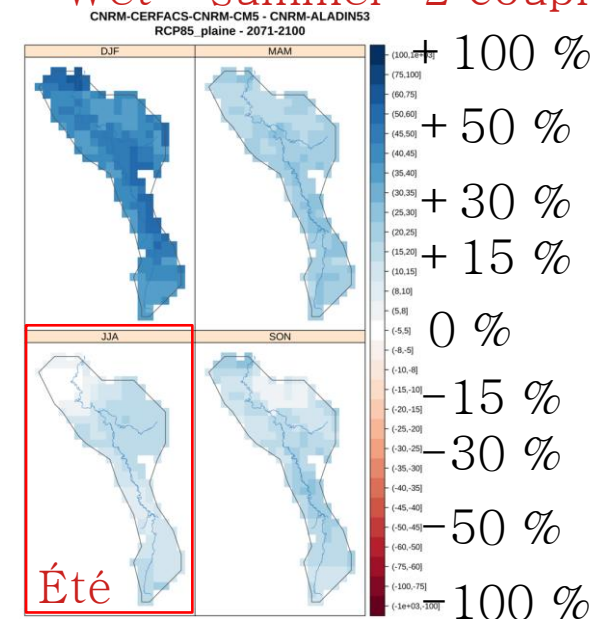
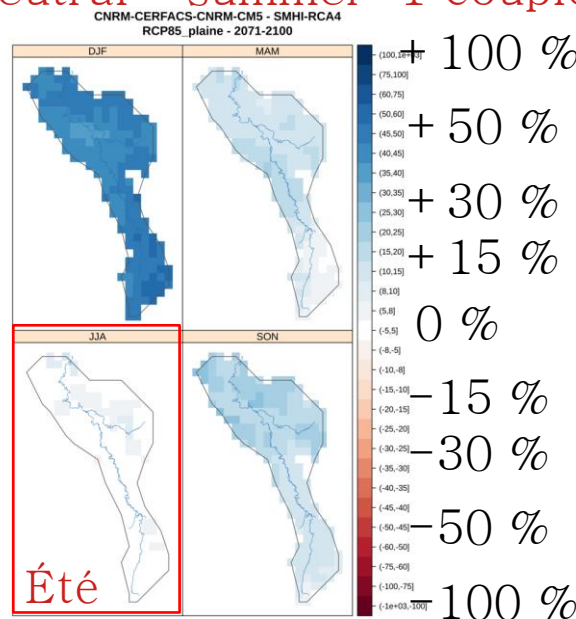
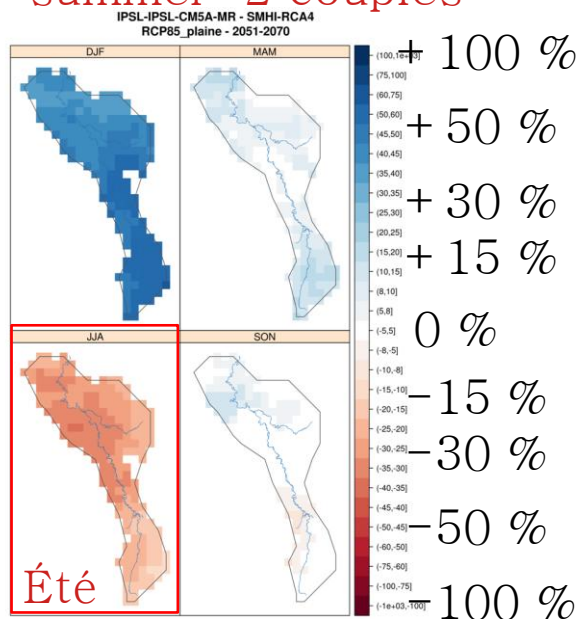
« Dry » summer: 2 couples

« Neutral » summer: 1 couple

« Wet » summer: 2 couples

Far future
RCP 8.5

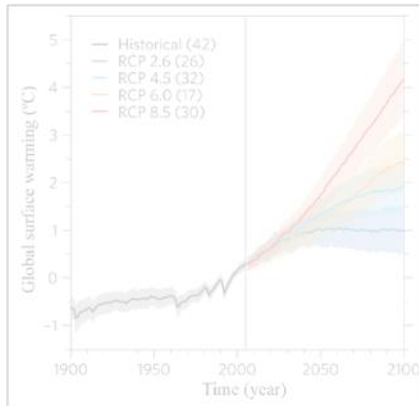
Difference related to
the historical period



➤ Hydrological modelling

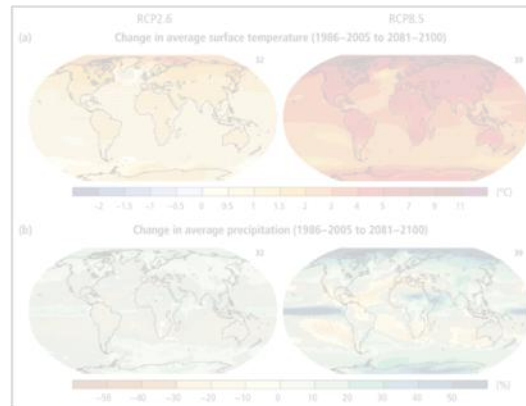
➤ Hydrological modelling

RCPs



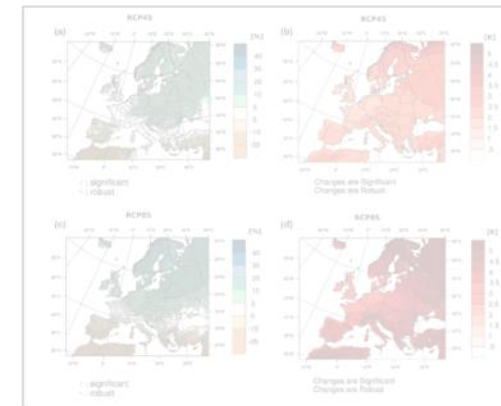
Source : Knutti and Sedláček (2013)

GCMs



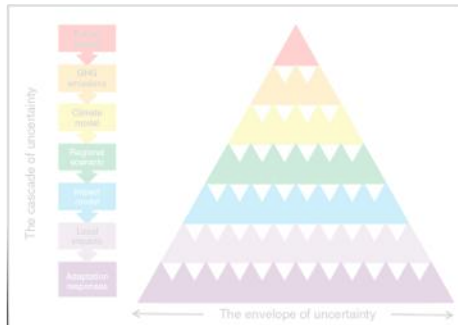
Source : Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects

RCMs



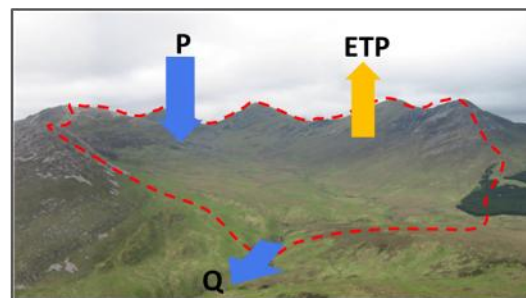
Source : Jacob et al., 2013

Cascade d'incertitude



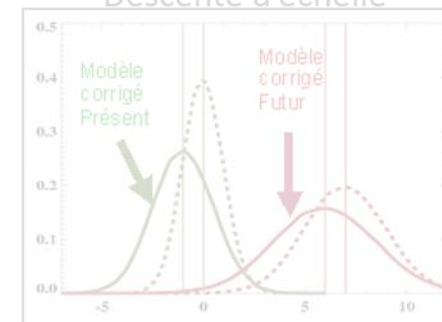
Wilby and Dessai (2010)

Modélisation hydrologique



Echelle d'étude : le bassin versant

Corrections de biais/
Descente d'échelle



Source : Drias. Exemple méthode quantile-quantile

Figure from Lemaitre-Basset (2020)

➤ Hydrological modelling

Four hydrological models

Several models are necessary to verify to which extent all models provide similar trajectories



GRSD

Conceptual
Semi-distributed
(sub-basins)



MORDOR

Conceptual
Semi-distributed
(sub-basins)



PRESAGES

Conceptual
Lumped

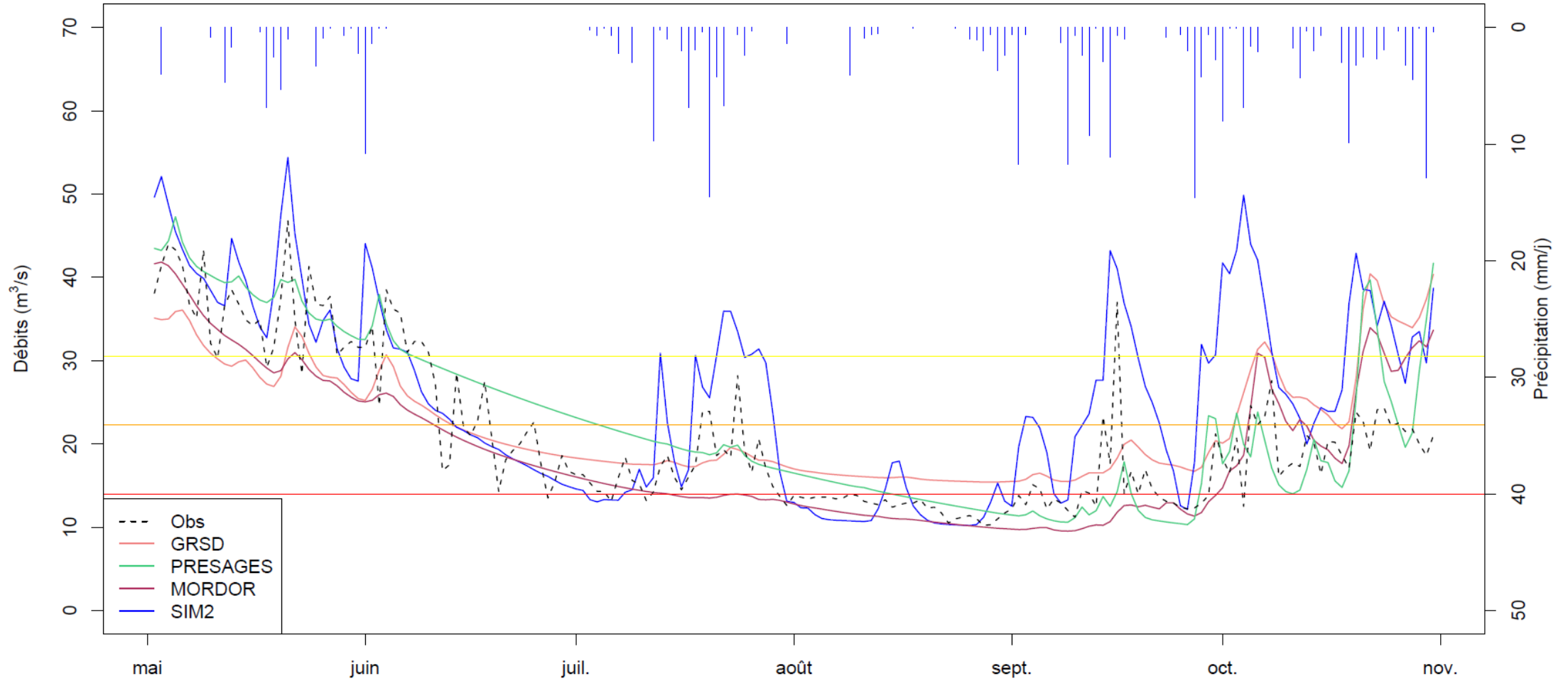


SIM2

Physically-based
Distributed
(regular grid)

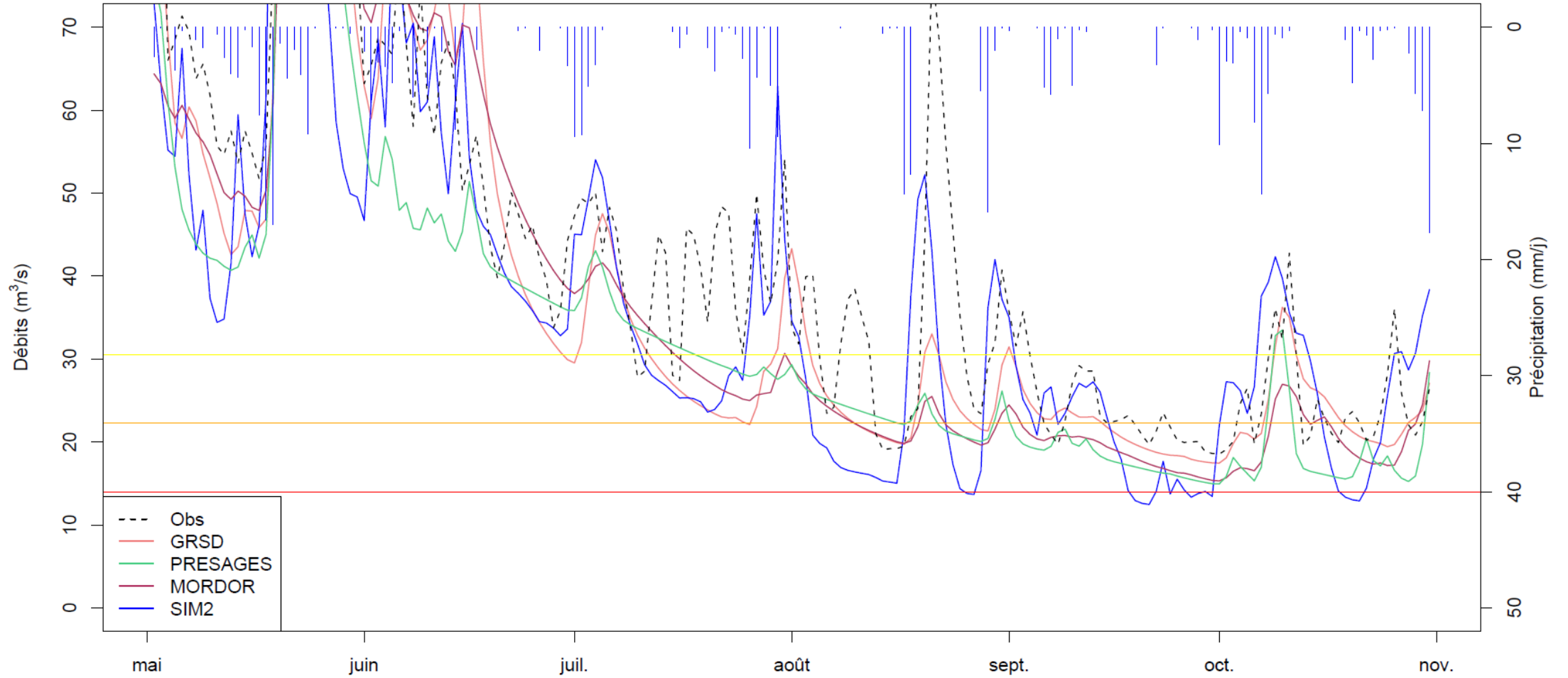
➤ 1976 Drought

Sécheresse de 1976 pour La Meuse à Chooz [Trou du Diable]



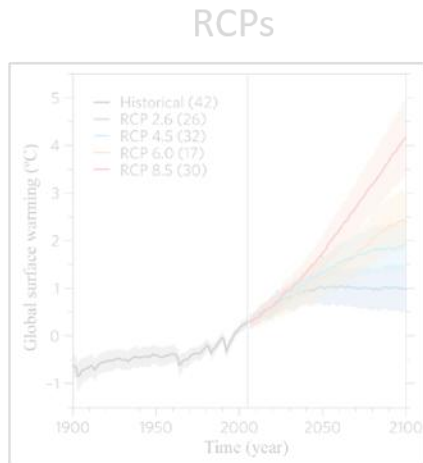
➤ 2003 drought

Sécheresse de 2003 pour La Meuse à Chooz [Trou du Diable]

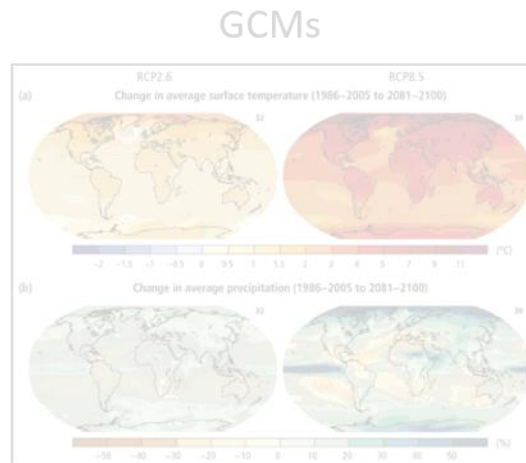


➤ Impact of climate change on hydrology

➤ Impact of climate change on hydrology



Source : Knutti and Sedláček (2013)

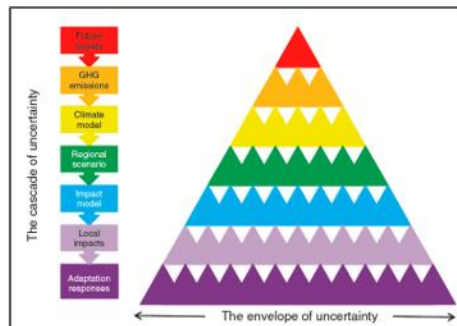


Source : Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects



Source : Jacob et al., 2013

Cascade d'incertitude



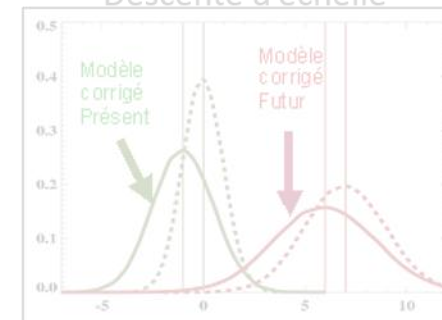
Wilby and Dessai (2010)

Modélisation hydrologique



Echelle d'étude : le bassin versant

Corrections de biais/ Descente d'échelle



Source : Drias. Exemple méthode quantile-quantile

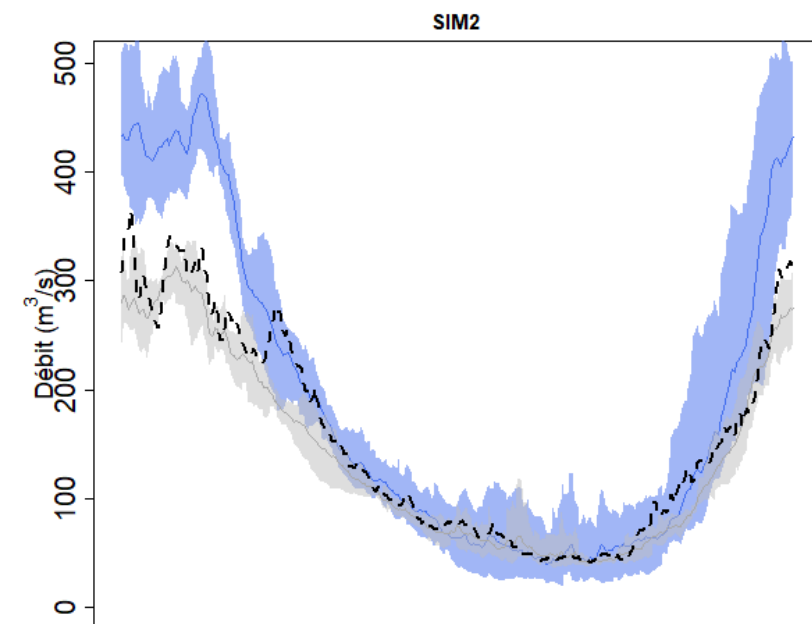
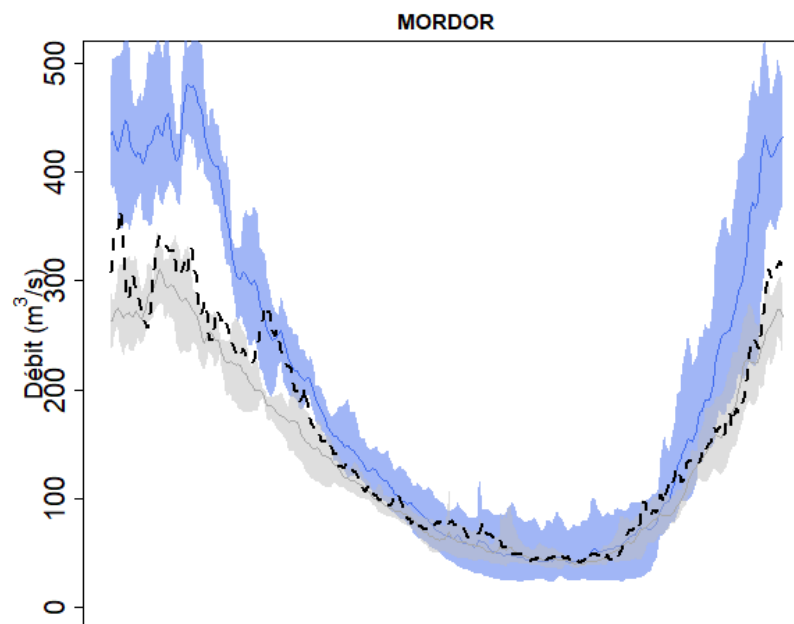
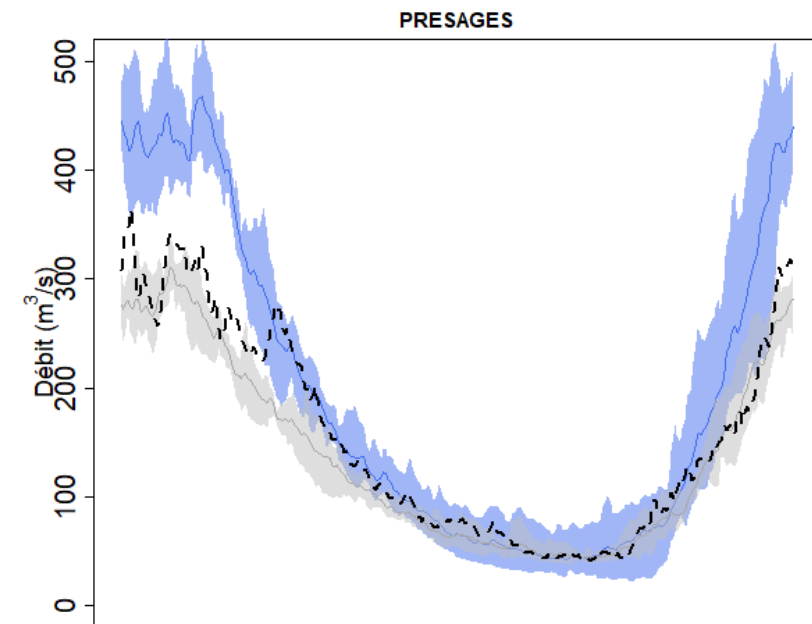
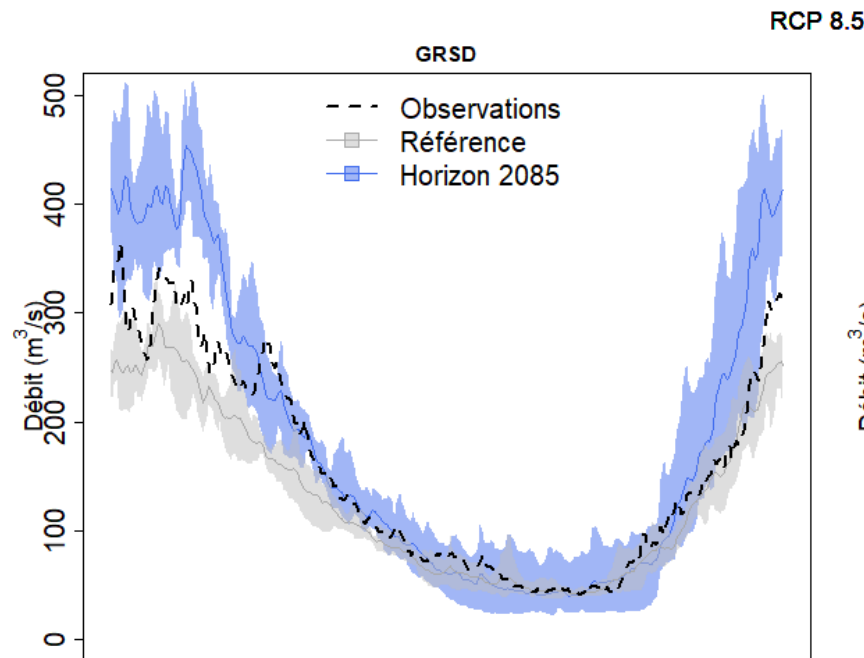
➤ Future regimes

RCP 8.5, Horizon 2051-2100

Analysis of future regimes (all climate models included) at Chooz

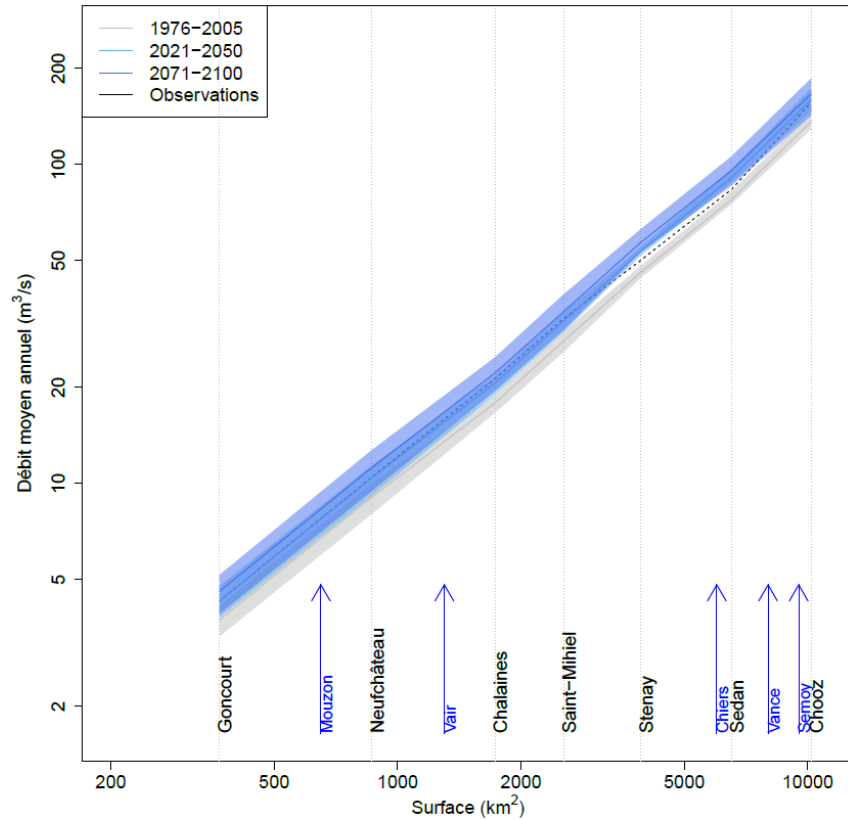
Large increase of streamflows during the high flow period

Large uncertainty of low flows

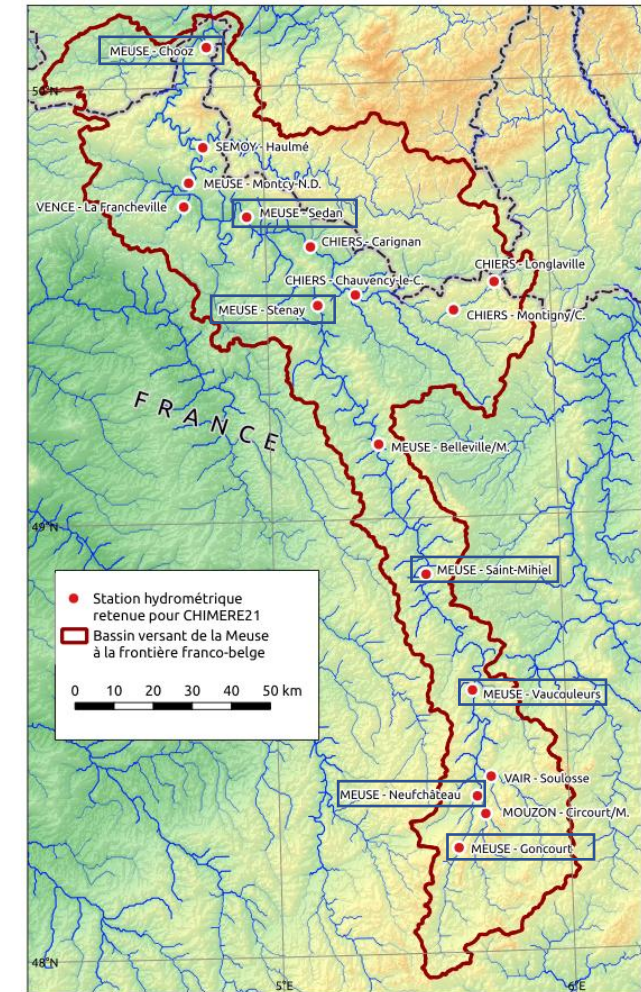
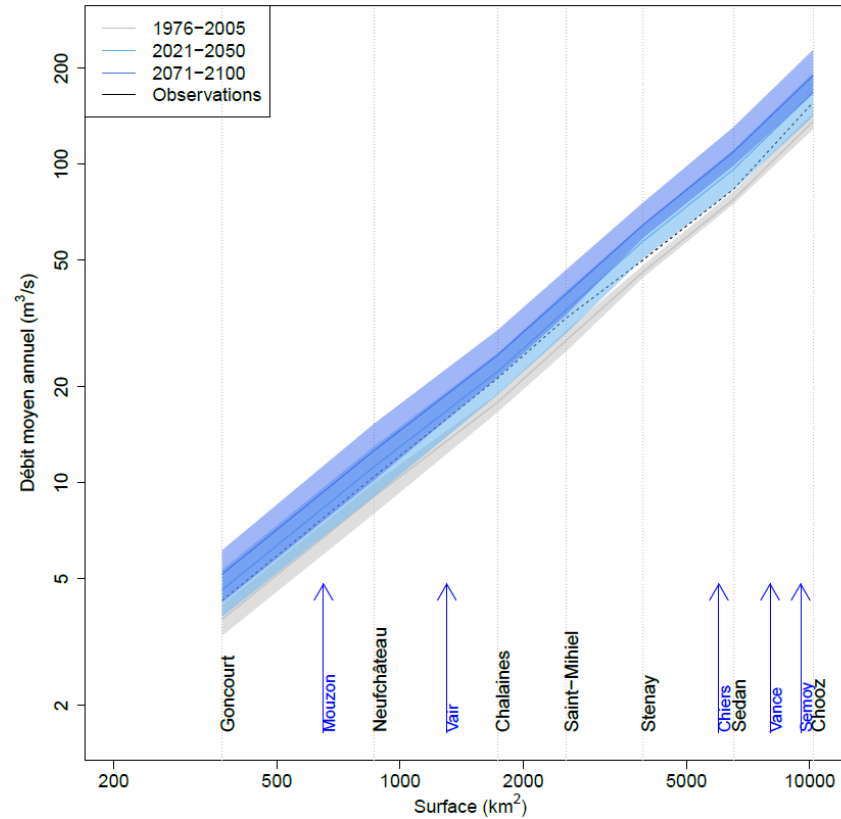


➤ Evolution of mean flows along the Meuse

RCP 4.5



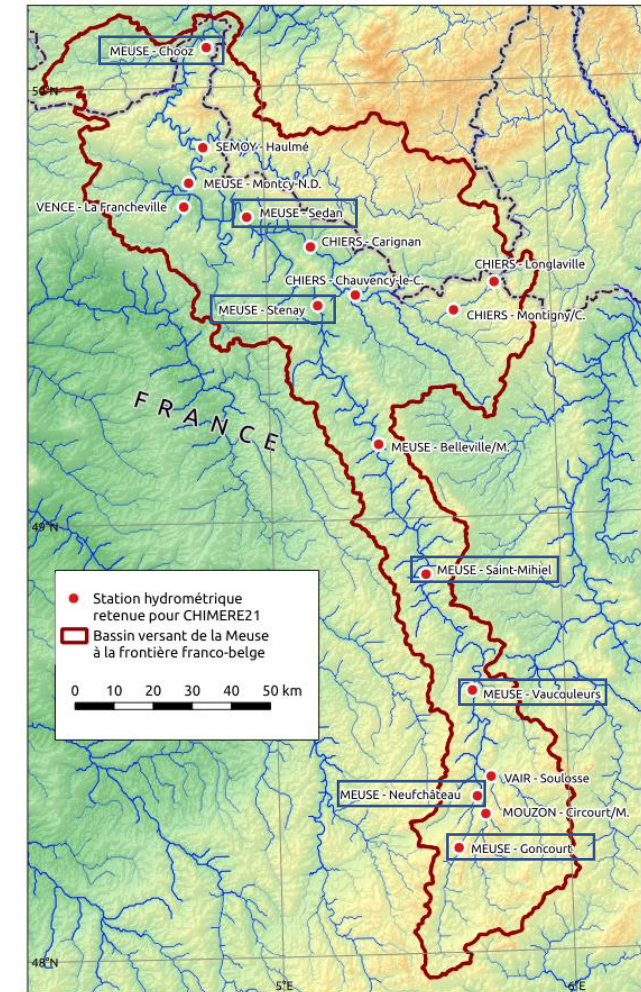
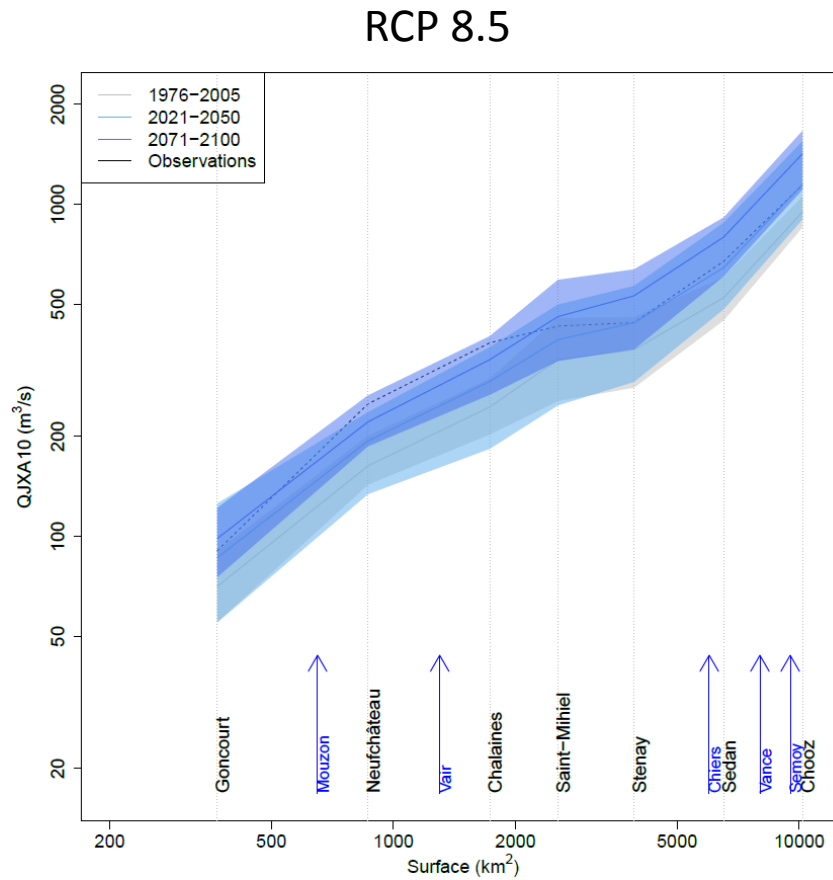
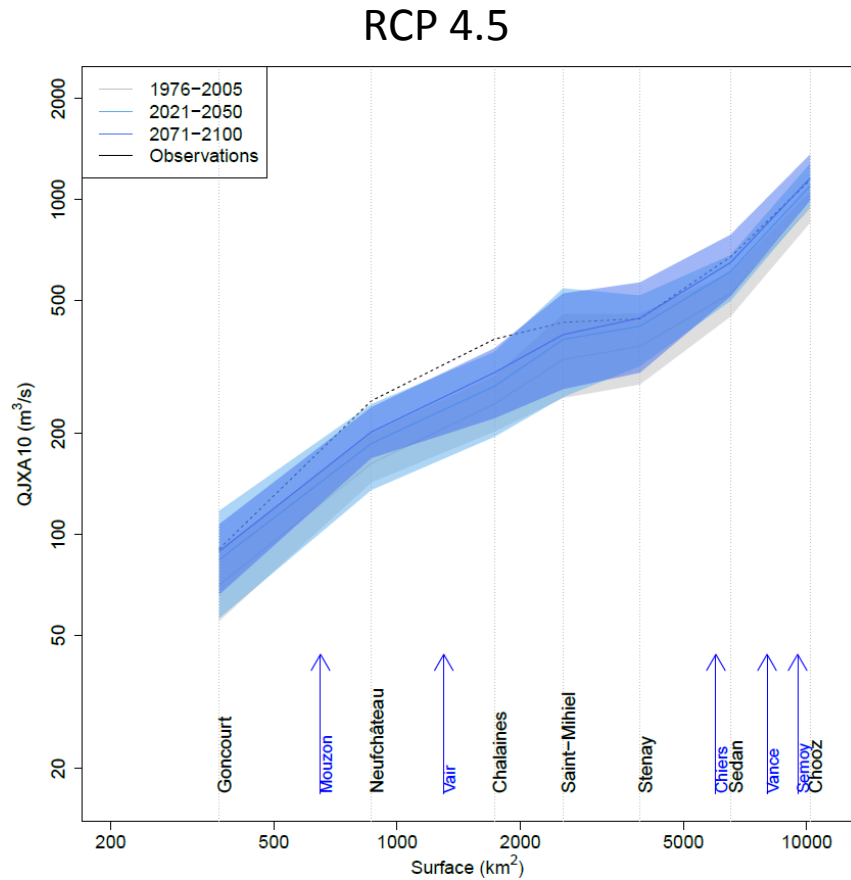
RCP 8.5



RCP 4.5: increase of mean flows, especially downstream

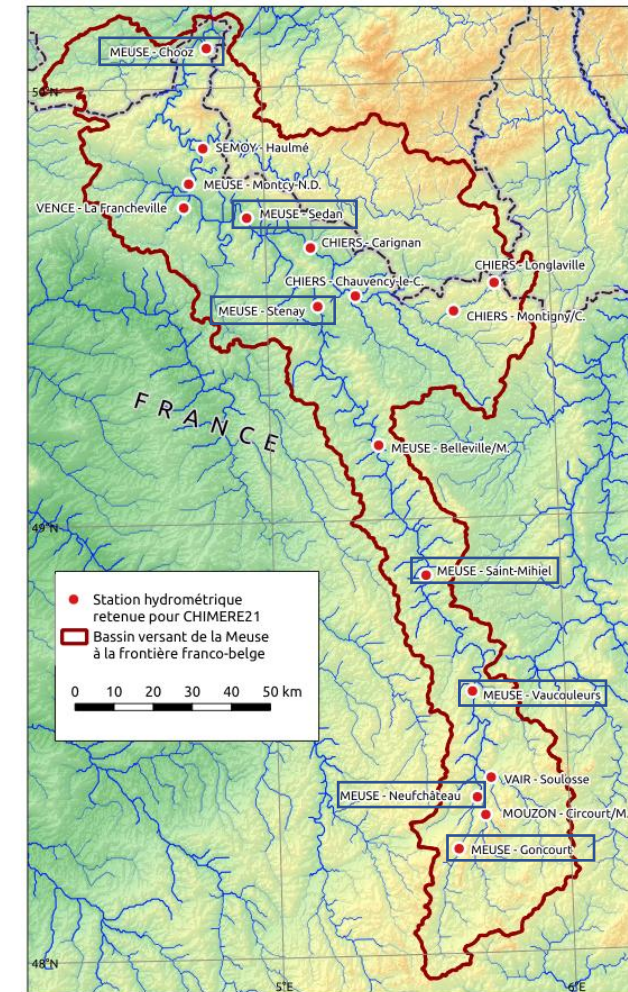
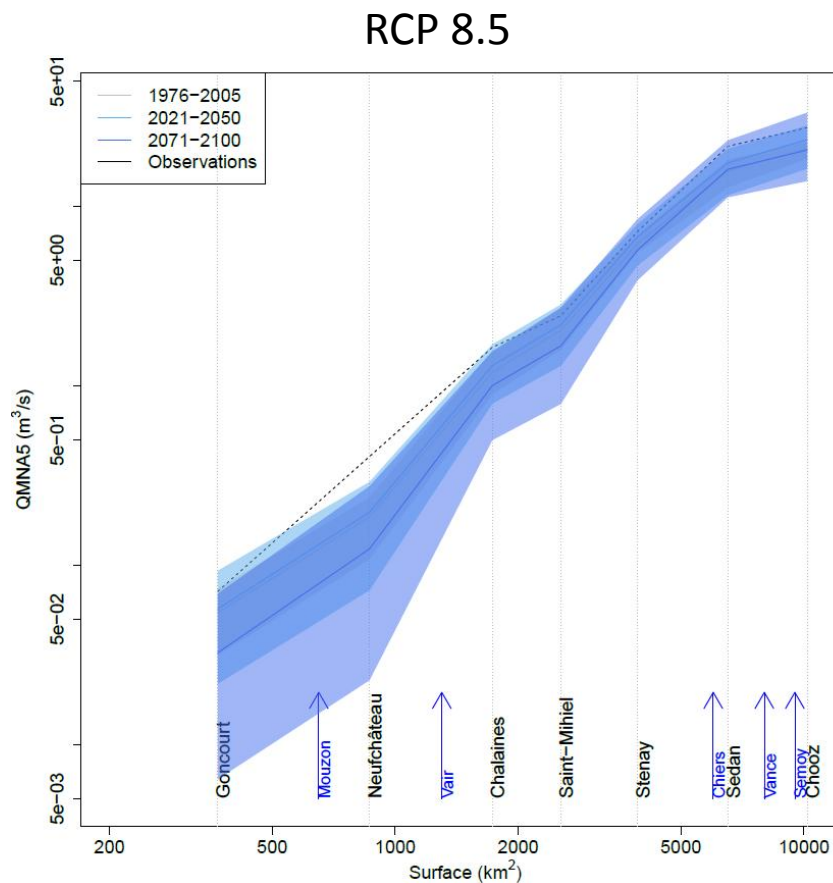
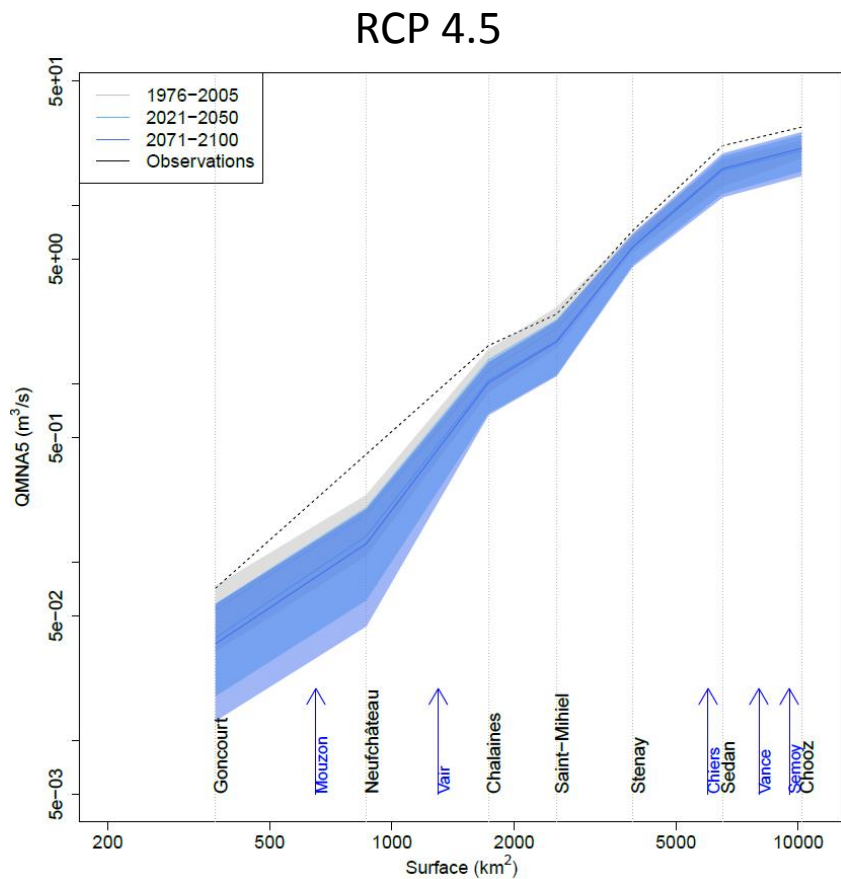
RCP 8.5: increase everywhere, especially for the far future

➤ Evolution of high flows along the Meuse



RCP 4.5: moderate increase (only for the far future)
 RCP 8.5: important increase, especially downstream

➤ Evolution of low flows along the Meuse



RCP 4.5: slight decrease, especially upstream

RCP 8.5: moderate decrease upstream for far future, slight otherwise

➤ Hierarchy of uncertainties for low flows

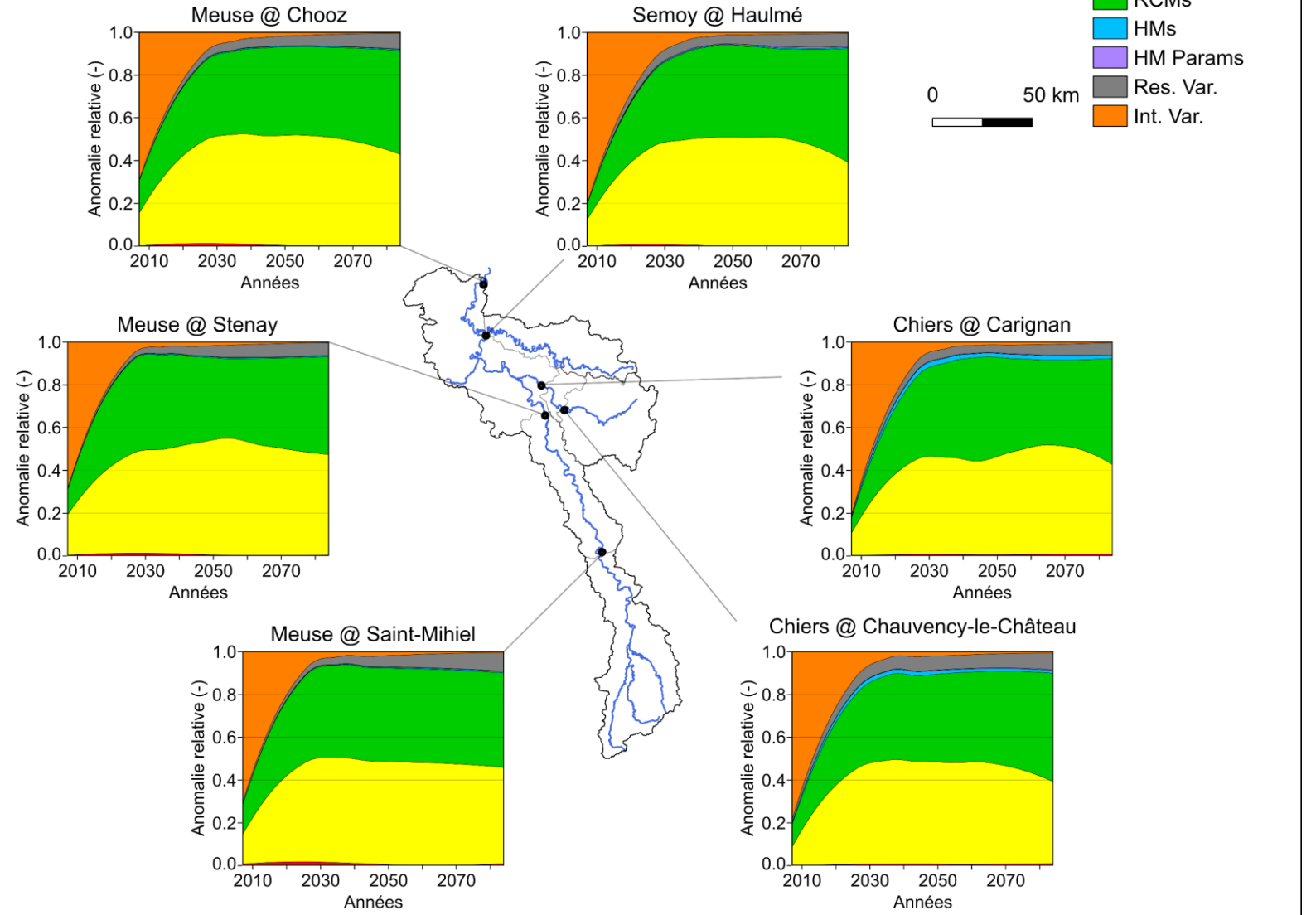
Indicator = VCN3

Internal variability dominates for near future

GCMs and RCMs dominate then

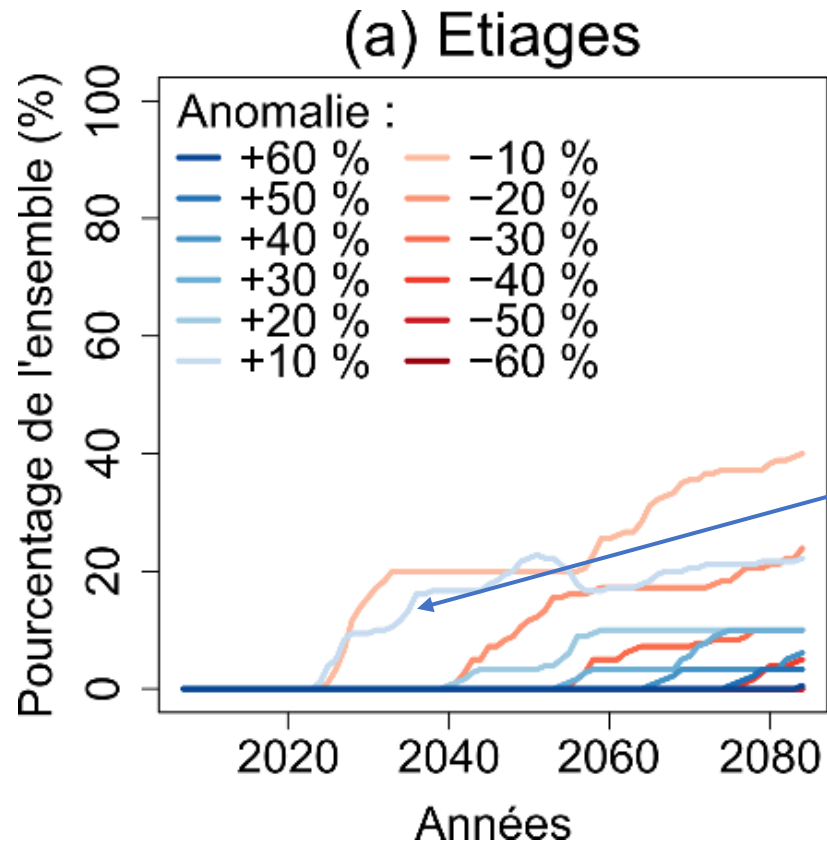
Other sources remain limited

Hiérarchisation d'incertitude : étiages



➤ Probabilities of different trends

Need to answer the following questions: « What is the probability that an indicator change of X % under climate change? » et « At which temporal horizon could this trend emerge? »



Pourcentage of all simulations indicating a trend of at least 10% of low flows(VCN3)

➤ Conclusions and perspectives

➤ Main conclusions of CHIMERE 21

Hydrocliate evolutions

Climate:

- Temperature increase, especially for RCP 8.5 and far future
- Heterogeneous precipitation evolution: increase for winter, large uncertainty for summer
- Projections of CHIMERE 21 warmer and wetter than Explore 2070 but consistent with Drias 2020

Hydrology:

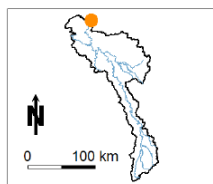
- Large uncertainties for summer, possible decrease for upstream
- Increase during winter, especially downstream
- Climate brings most of uncertainties on Meuse streamflows

Projet CHIMERE 21

Synthetic sheets

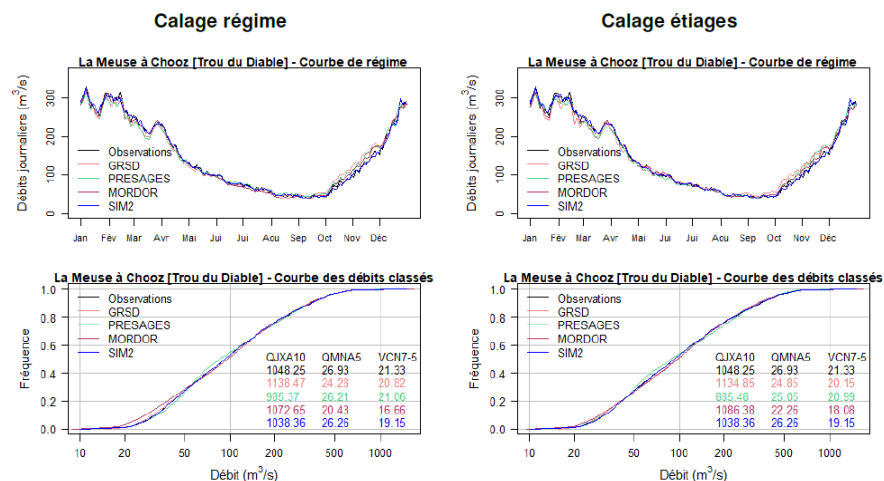
Fiche synthétique

B7200000 – La Meuse @ Chooz [Trou du Diable]

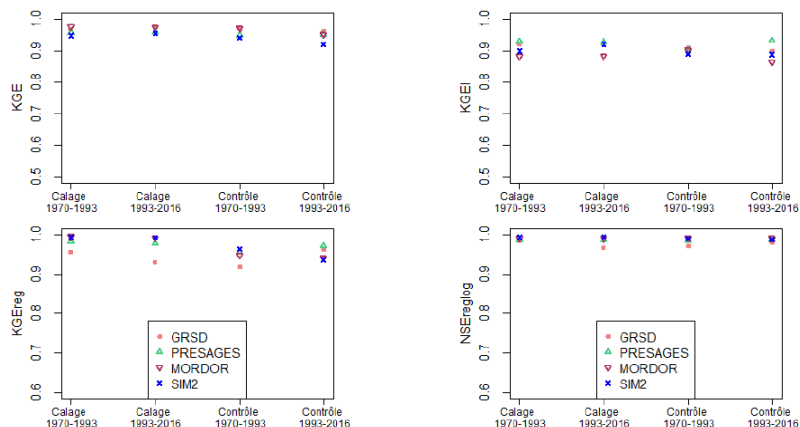


CALAGE DES MODELES

PERFORMANCE SUR 1970-2016



ROBUSTESSE

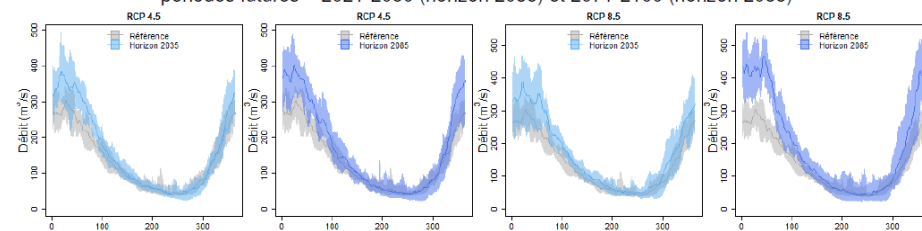


<- page 1

Page 2 ->

PROJECTIONS FUTURES

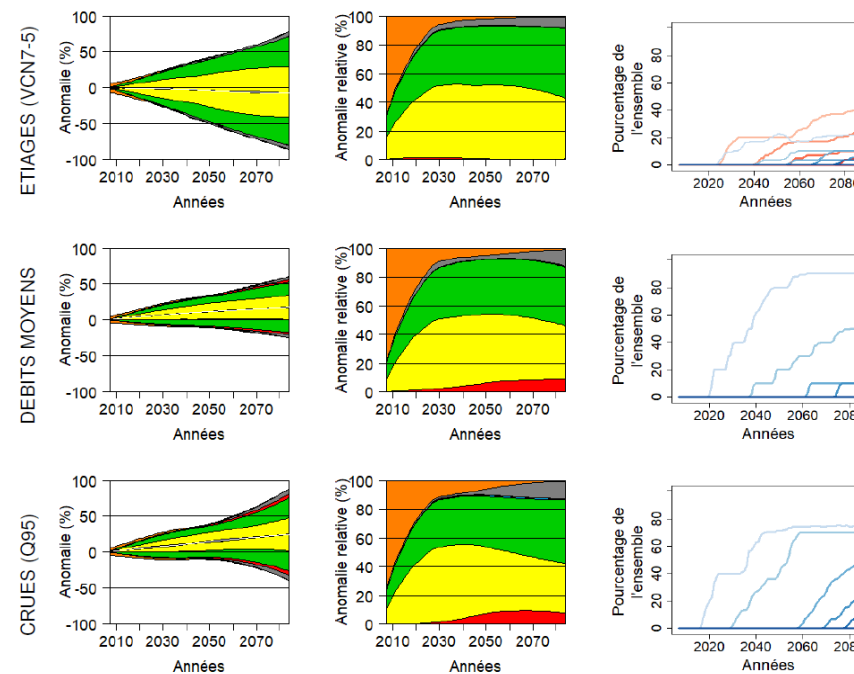
Régimes interannuels projetés, tous modèles hydrologiques confondus : période de référence = 1976-2005, périodes futures = 2021-2050 (horizon 2035) et 2071-2100 (horizon 2085)



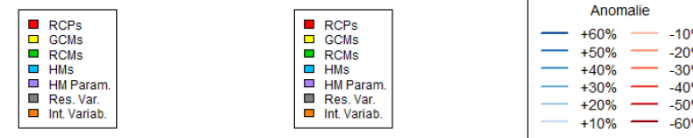
Incertitudes et tendances Anomalie

Hierarchisation

Probabilité de tendance



LEGENDES



> Perspectives

The CHIMERE 21 study gave thoughts for food regarding adaptation strategies

- Evolutions of streamflows question strong stakes:
 - Increase of streamflow downstream, which is already identified as a territory with high risk of floods
 - Possible decrease of low flows upstream

Explore 2: a France-wide project aiming at evaluating impacts of climate change using Drias 2020 (starting soon)

LIFE Eau&Climat (<https://www.gesteau.fr/life-eau-climat>): a project aiming at helping local water stakeholders to evaluate climate change impacts, to take them into account for planning and to undertake adaptation strategies