Impact of climate change on the French part of the River Meuse -the CHIMERE 21 project

AG HYCAR 27 septembre 2021

Context and goals of the project

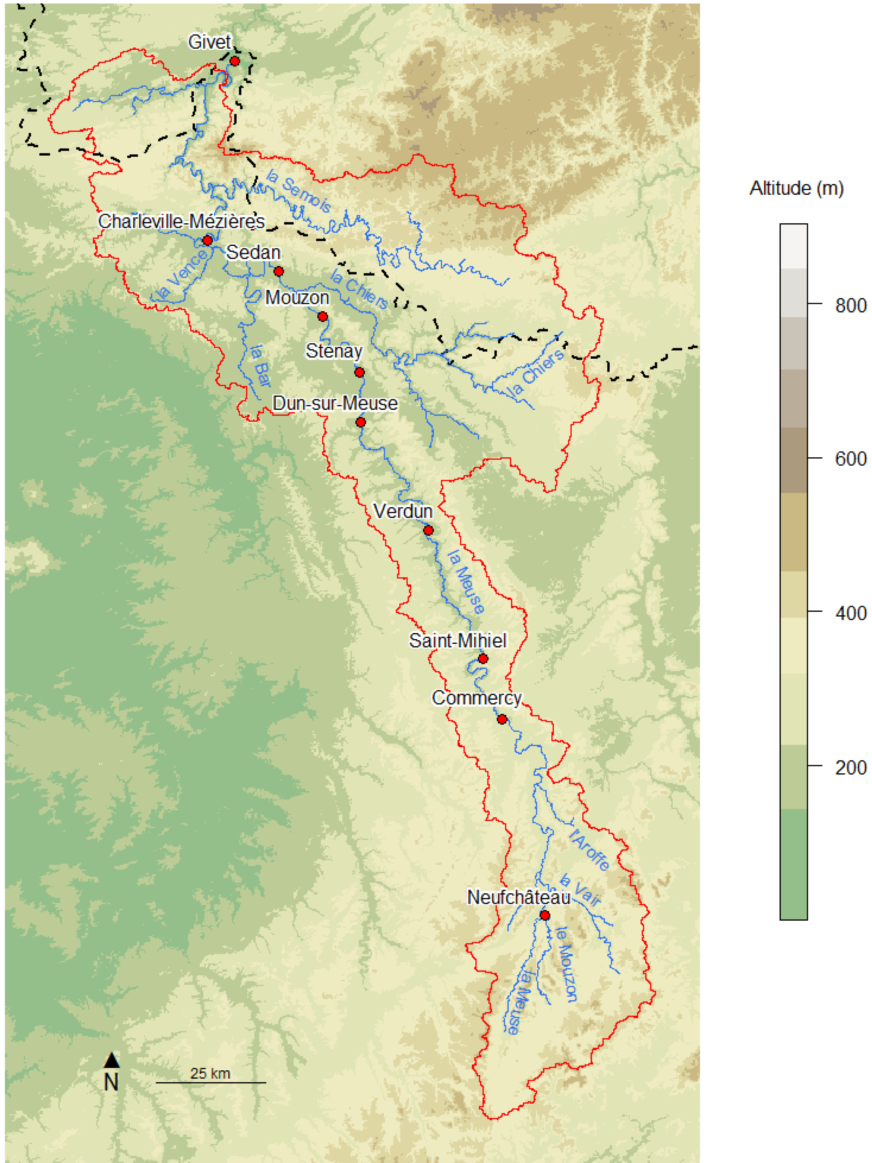
The CHIMERE 21 project

CHIers - 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

Funding by Agence de l'Eau Rhin-Meuse



The context

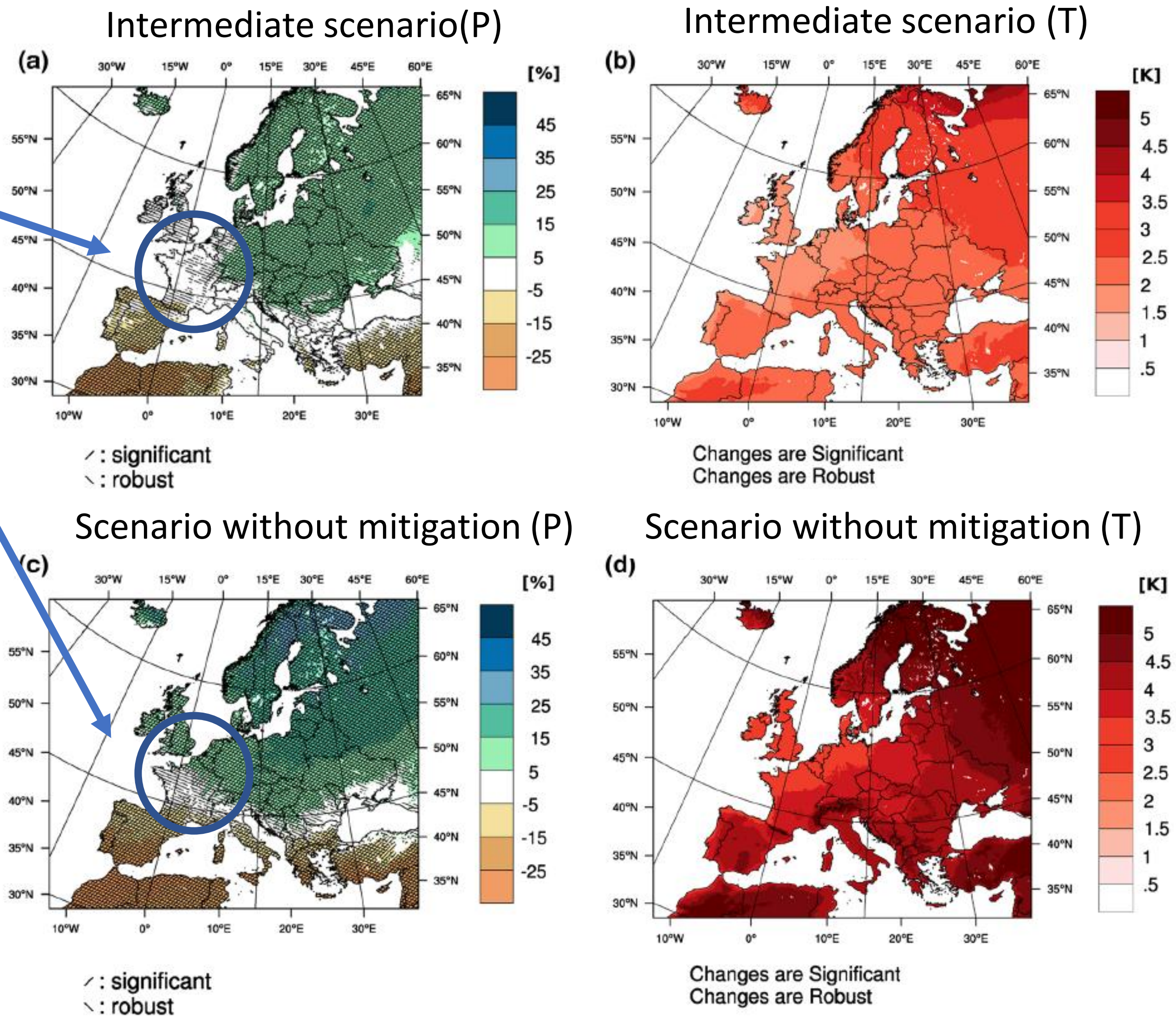
CHIers - MEuse: hydrological Regime Evolution in the 21st century

Jacob et al. (2013)

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



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

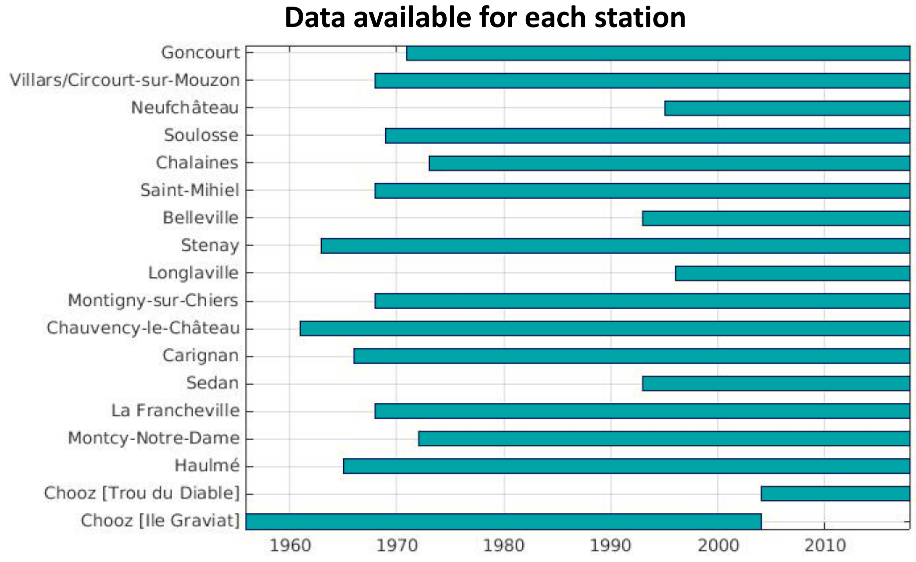
Objectives of CHIMERE 21

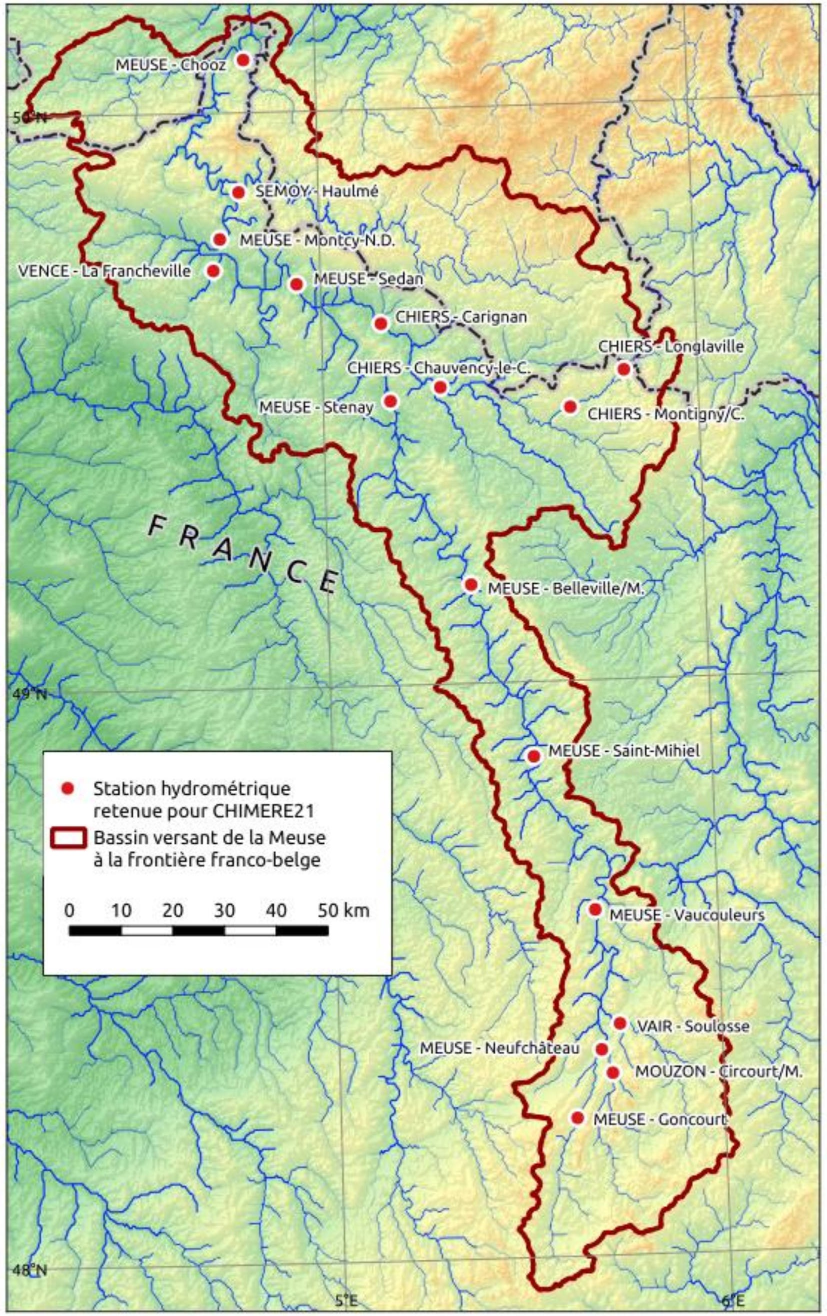
Objectives of the project:

- Study of the impact of climate change on future Meuse streamflows (Explore 2070 and Amice are beginning to be old)
- Focus on uncertainties and low flows
- Production of synthetic sheets

Presentation of the basin and data

Hydro data





16 stations (one for around 480 km²)

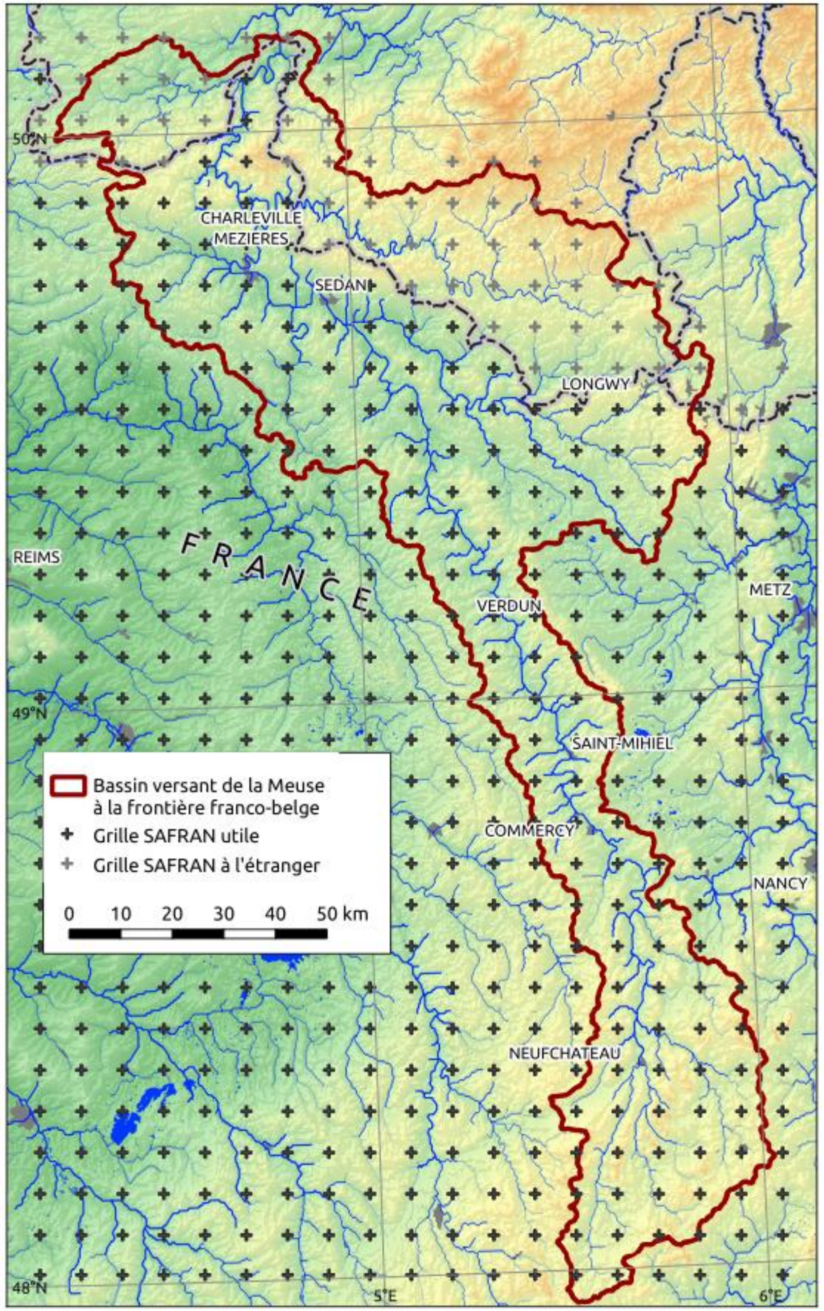
- Dubious daily discharge values removed through visual inspection
- At Chooz, the evaporation water consumption was estimated using daily air temperature and the nuclear power plant charge
- Other influences were not removed from time series:
  - Either low impact at the basin scale
  - Or too much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

<u>Modelling chain</u>: composed of several steps

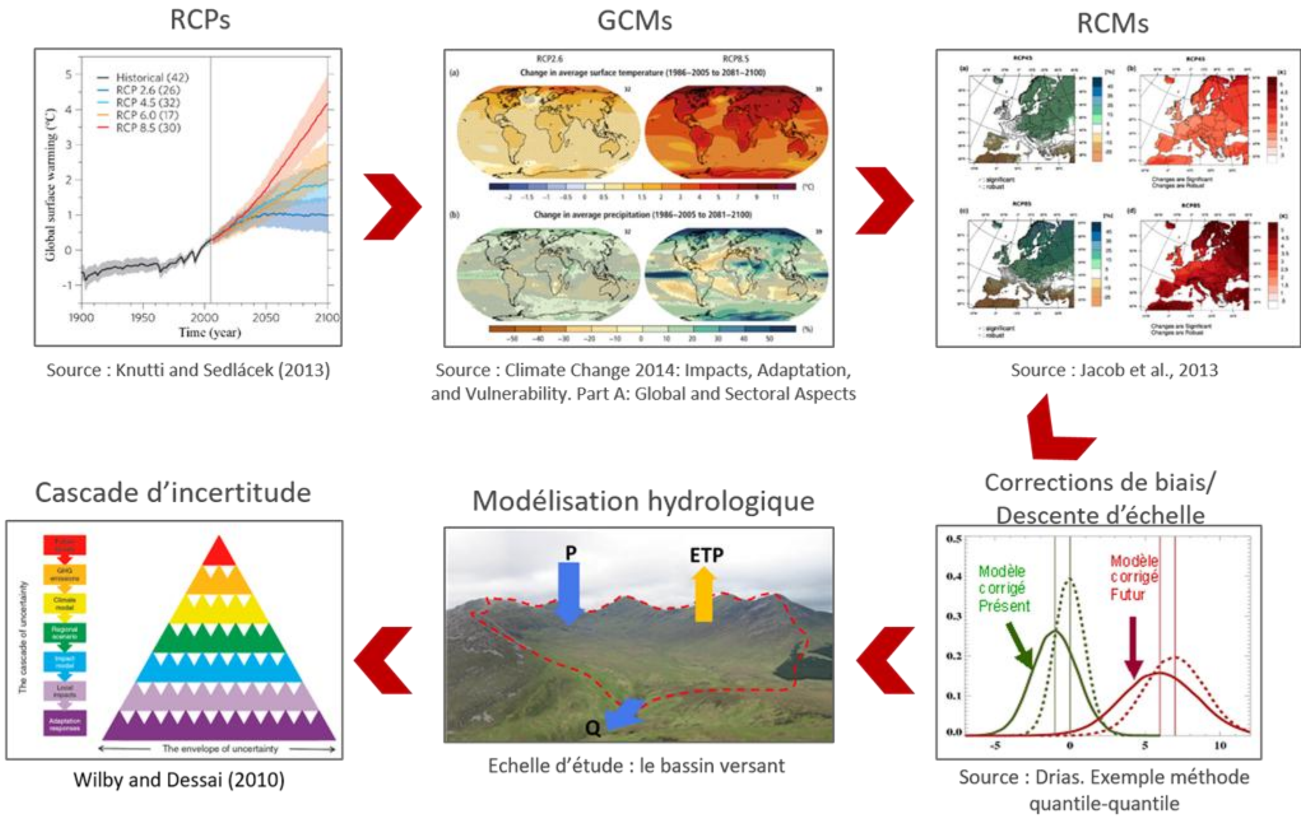
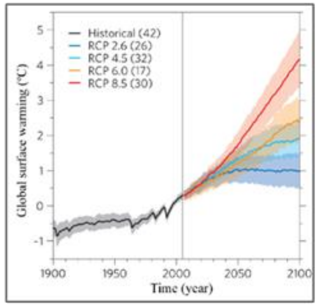


Figure from Lemaitre-Basset (2020)

Climate change over the Meuse basin

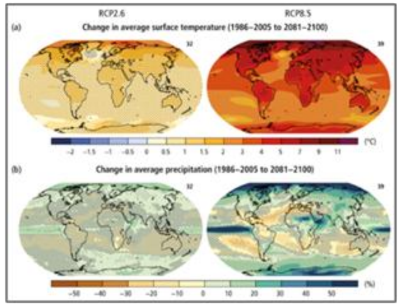
Selection of climate data for CHIMERE 21:

RCPs



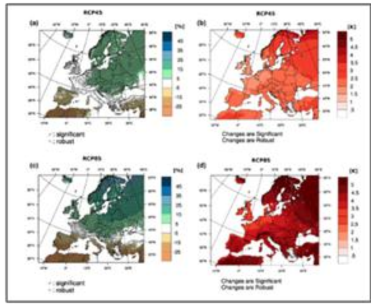
Source : Knutti and Sedlácek (2013)

GCMs



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

RCMs



Source : Jacob et al., 2013

- 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

Large uncertainty

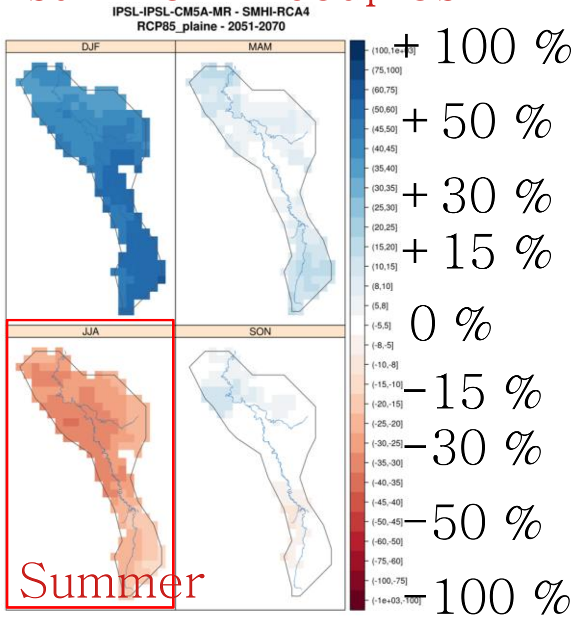
Summer (all models and RCPs)	Temperatures	Precipitation
Near future	+ 0,4 to + 1,2 °C	−14 to + 23 %
Far future	+ 1 to + 4,4 °C	−39 to + 21 %

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 %

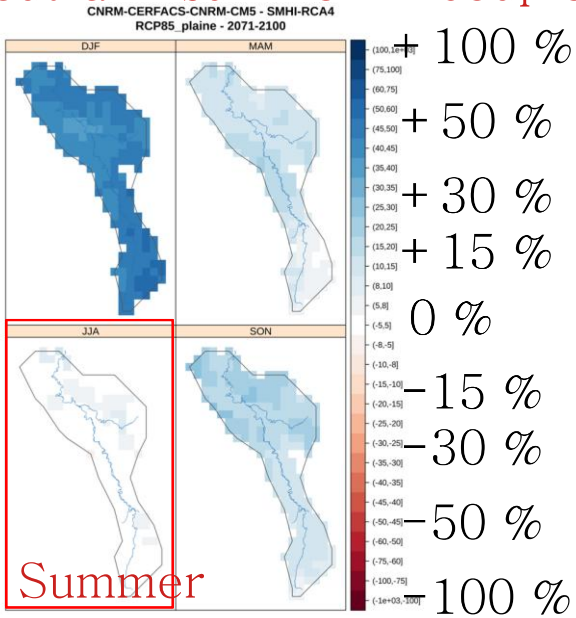
Far future
RCP 8.5

Difference related to the historical period

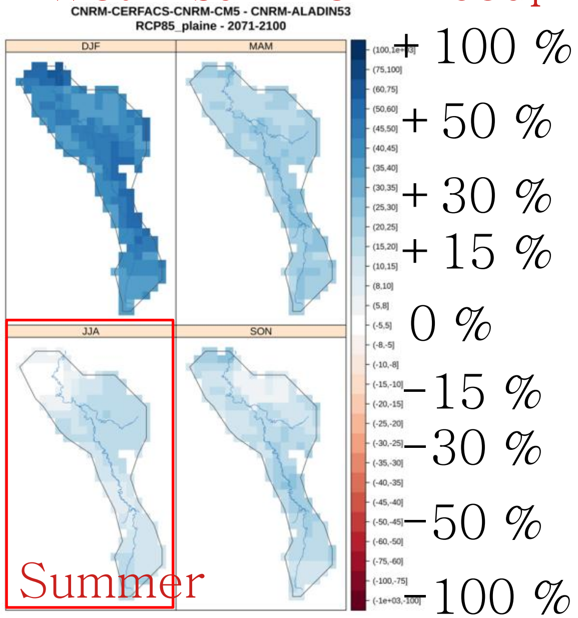
« Dry » summer: 2 couples



« Neutral » summer: 1 couple



« Wet » summer: 2 couples



Hydrological modelling

Hydrological modelling

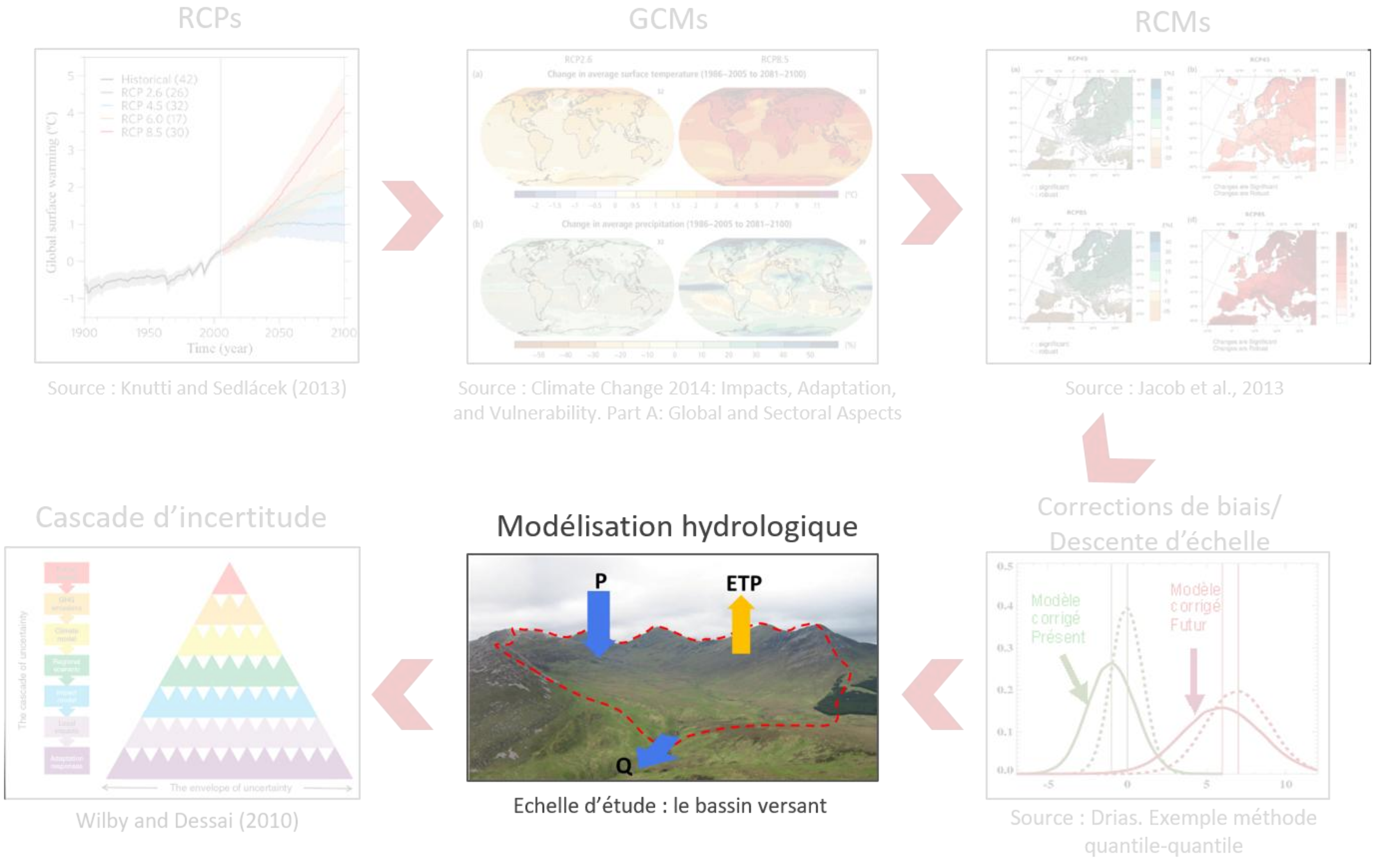


Figure from Lemaitre-Basset (2020)

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)

Impact of climate change on hydrology

Impact of climate change on hydrology

RCPs

Source : Knutti and Sedlácek (2013)

GCMs

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

RCMs

Source : Jacob et al., 2013

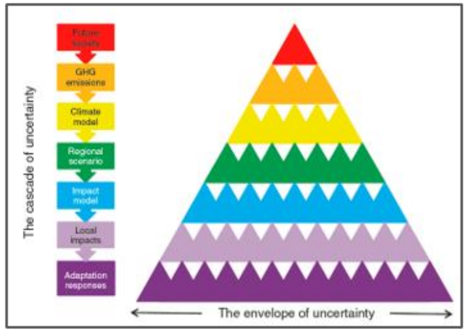
Corrections de biais/ Descente d'échelle

Source : Drias. Exemple méthode quantile-quantile

Modélisation hydrologique

Echelle d'étude : le bassin versant

Cascade d'incertitude



Wilby and Dessai (2010)

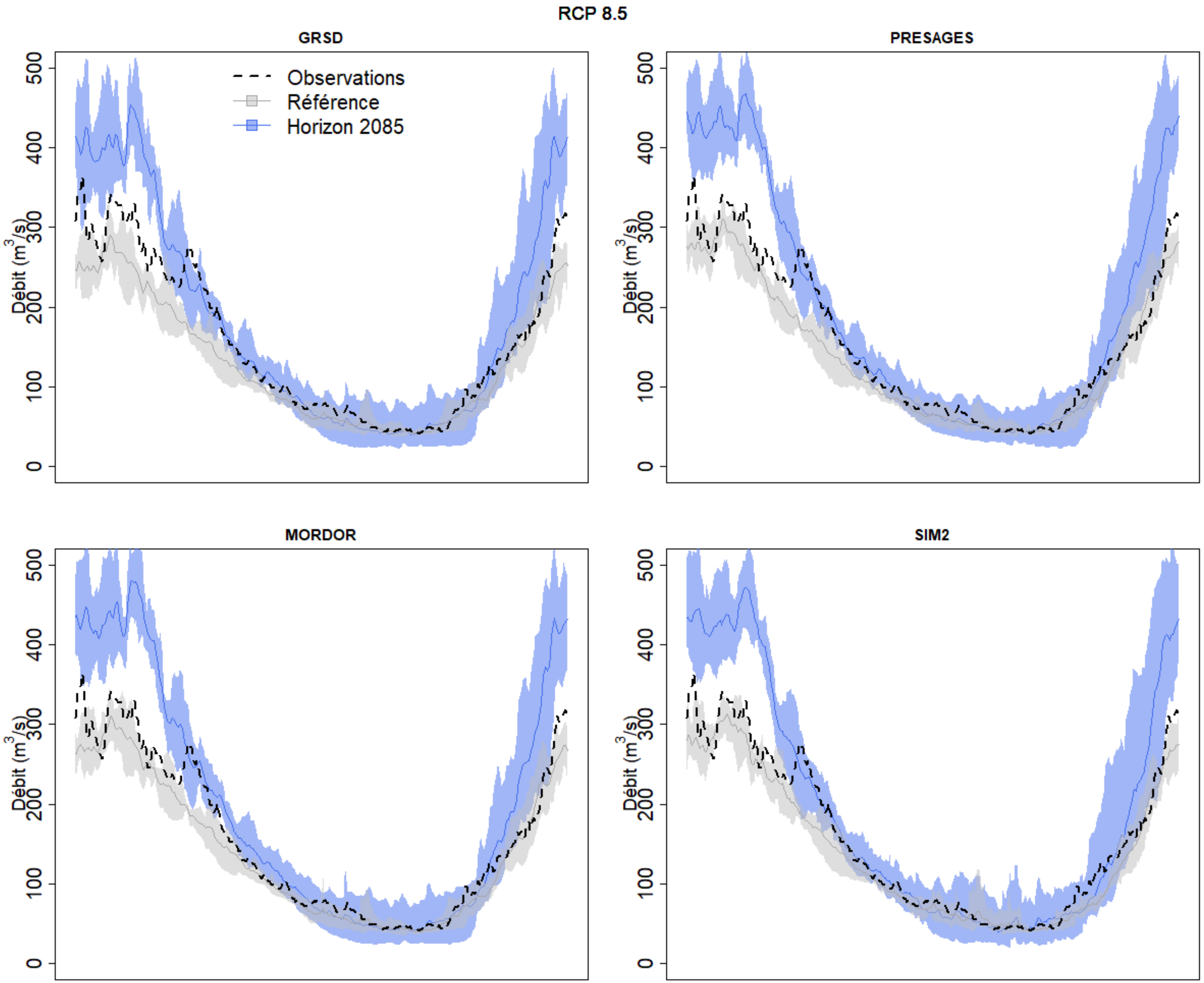
Future regimes

RCP 8.5, Horizon 2071-2100

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

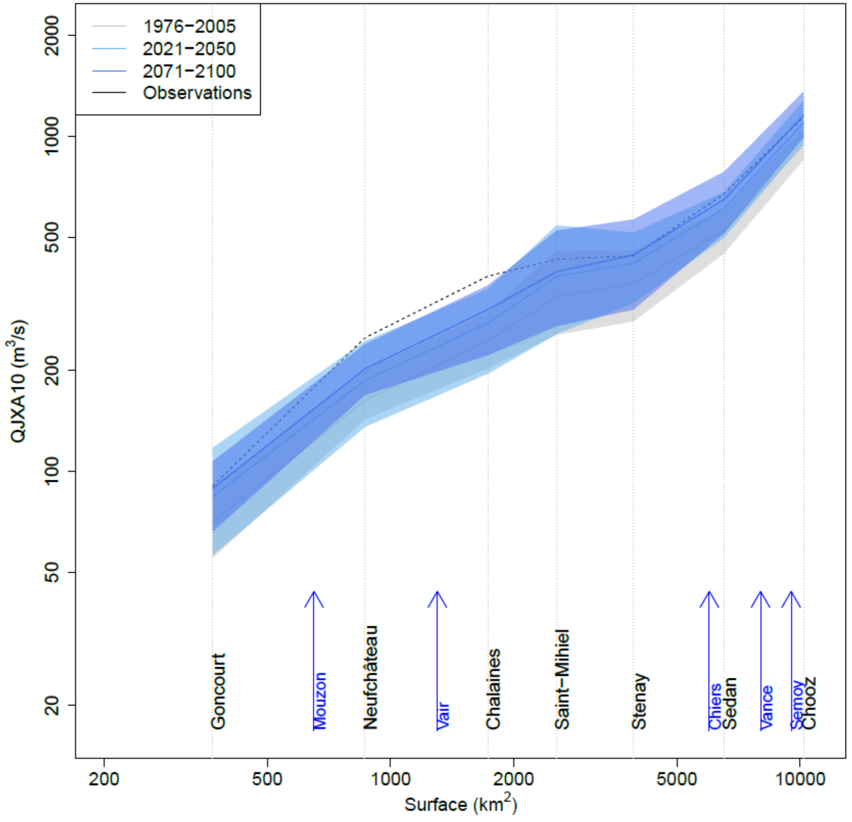
Large increase of streamflows during the high flow period

Large uncertainty of low flows

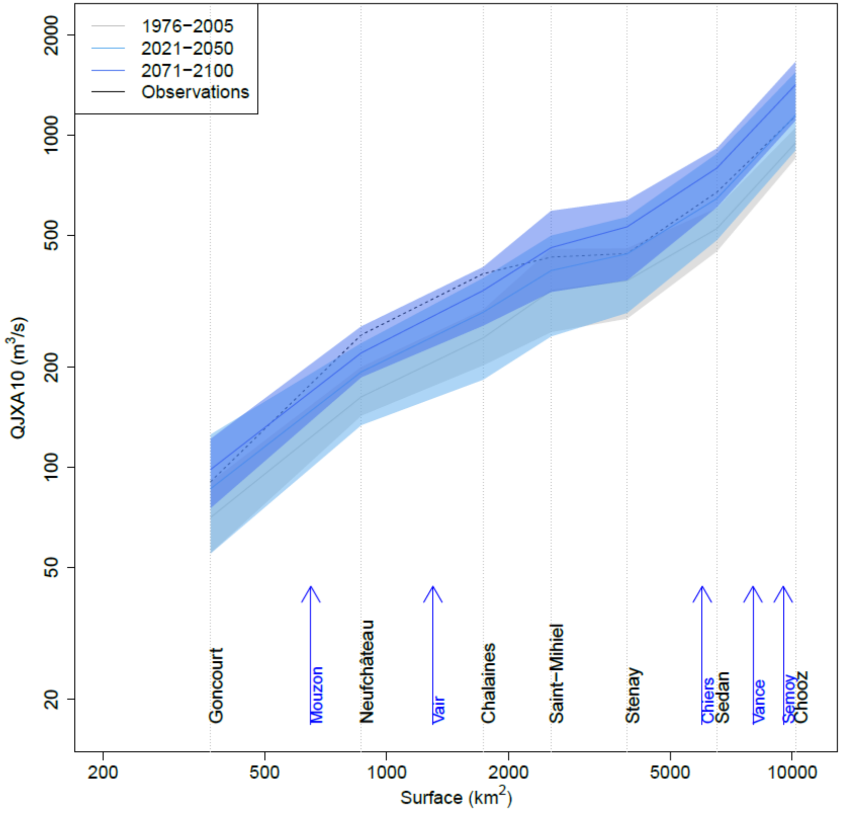


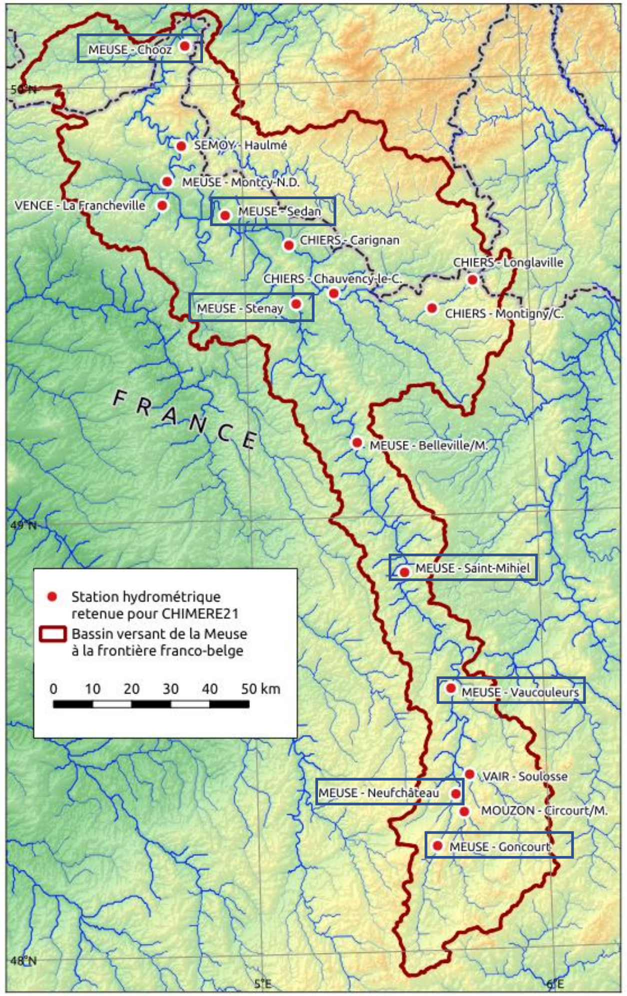
Evolution of high flows along the Meuse

RCP 4.5



RCP 8.5





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

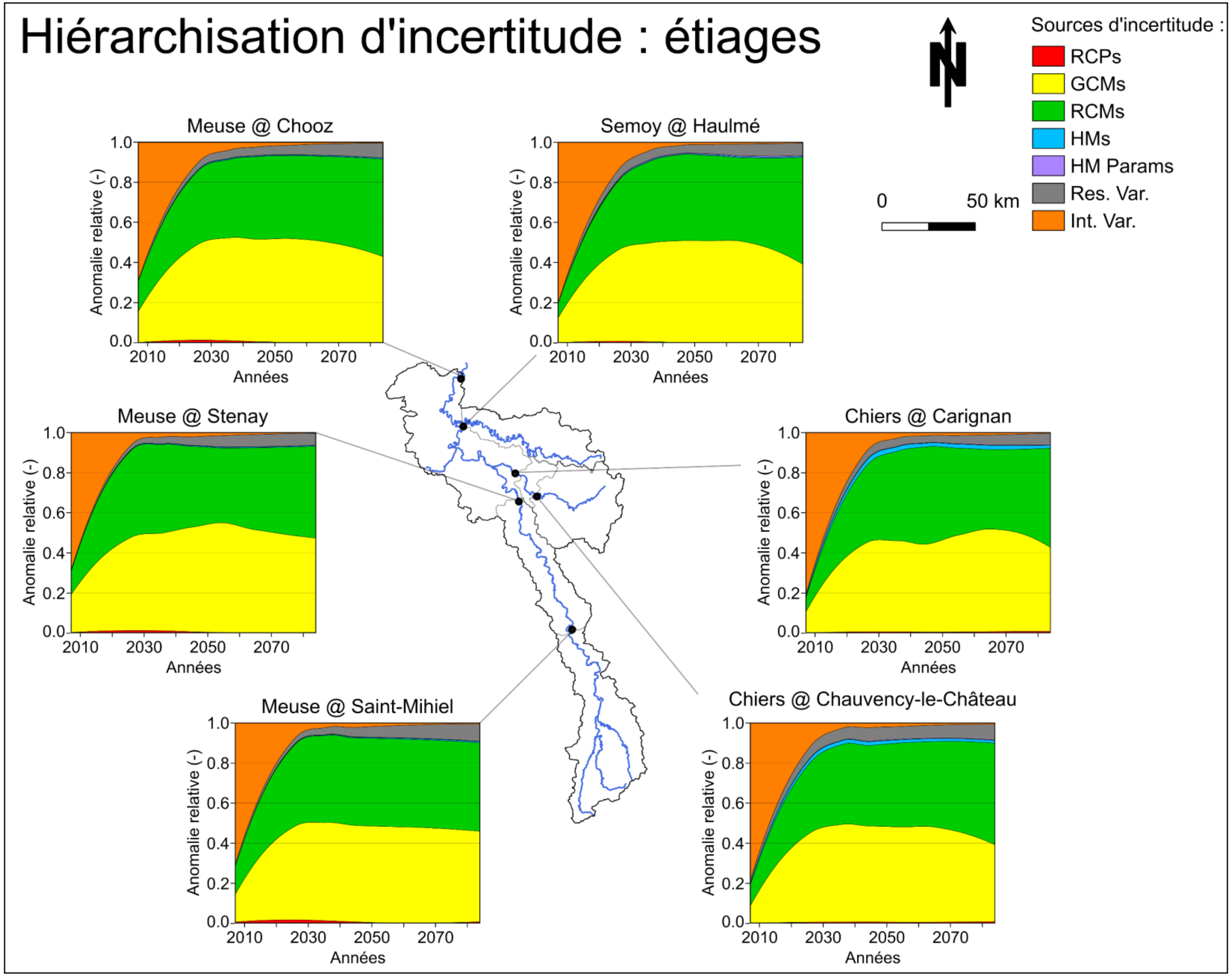
Hierarchy of uncertainties for low flows

Indicator = VCN3

Internal variability dominates for near future

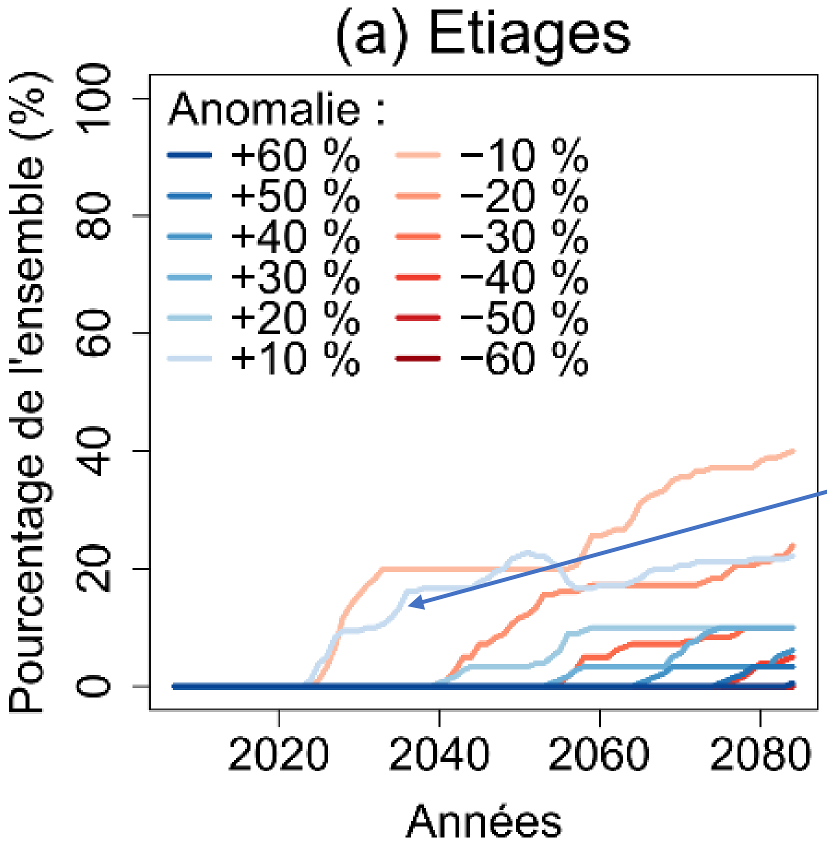
GCMs and RCMs dominate then

Other sources remain limited



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

Hydroclimate 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 previous works

Hydrology:

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

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 (started recently)

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

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