Climate change: when the near future is more uncertain than the far future.

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Objectives:

Predict the effects of climate change on groundwater levels and river flows in the Upper Rhine plain.

Approach:

Build a hydrological model capable of reproducing the observed variables of interest (groundwater levels and flow rates in rivers) over the period 1980 - 2010 based on the results of climate models (temperature, rainfall, snow).

Use this model in conjunction with climate projections (temperature, rainfall, snow) provided by the IPCC to predict groundwater levels and flows in rivers from today to 2100.

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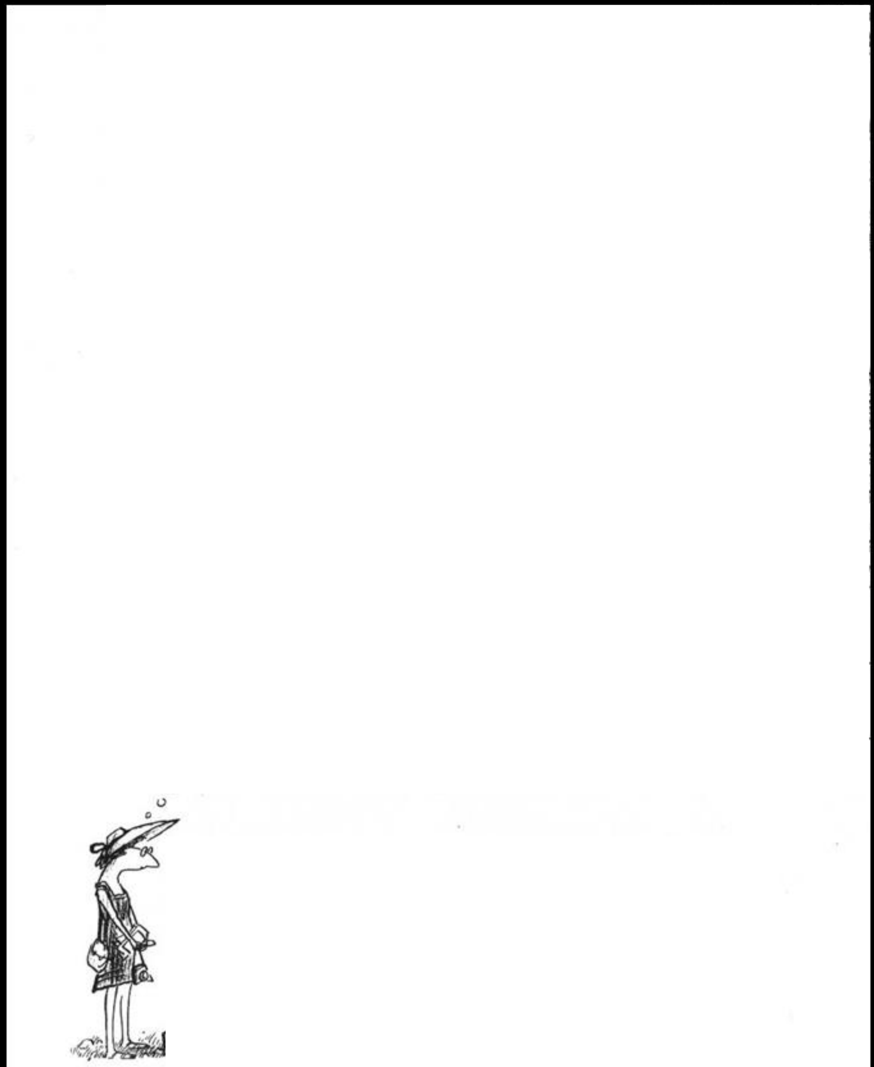
Some scientific challenges



Model designer (Sempé)

A model is a representation of a reality that has been simplified by:

- removing properties considered as irrelevant;
- unidentified properties.

Scientific challenge: 1: model design

What if the model designer is changed ?

The model is depending on the model designer's background.

Scientific challenge: 2: Picture the underground

Groundwater reservoirs are not visible and heterogeneous.

Each parameter has its own spatial variability.

We have very limited information on parameters and state variables. The data quality can be affected by measurement errors.

The accuracy of the solution is depending on the provided information.

The support volume (scale) of the data is of great importance.

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Scientific challenge: 2: Picture the underground

Assumptions about the parameter distribution cannot be avoided (parameterization).

Zonation

Interpolation

We want to handle hard information (he/she is wearing glasses) with soft information (he/she is a man/woman).

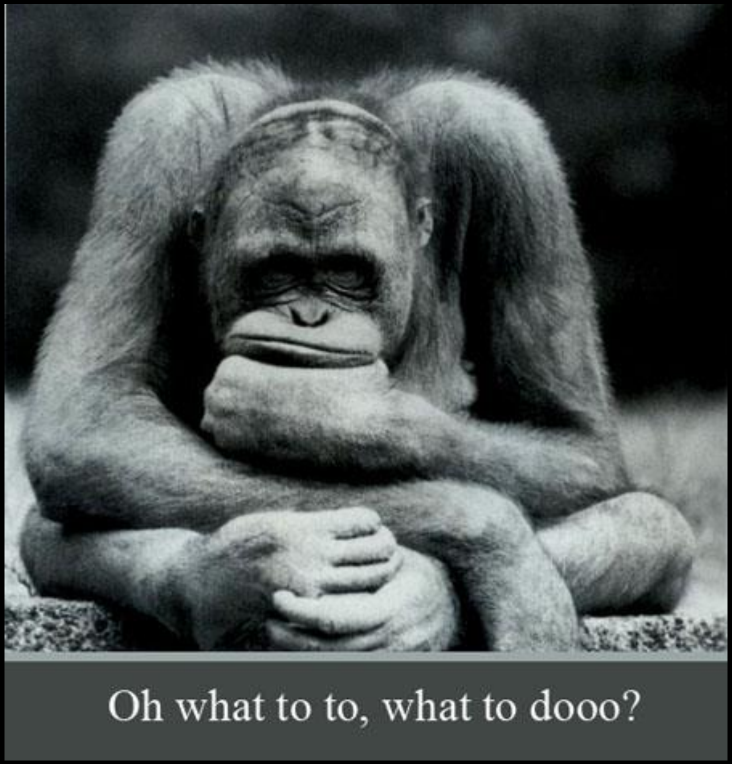
But non-unicity will remain…

Conclusion

The solution is not unique

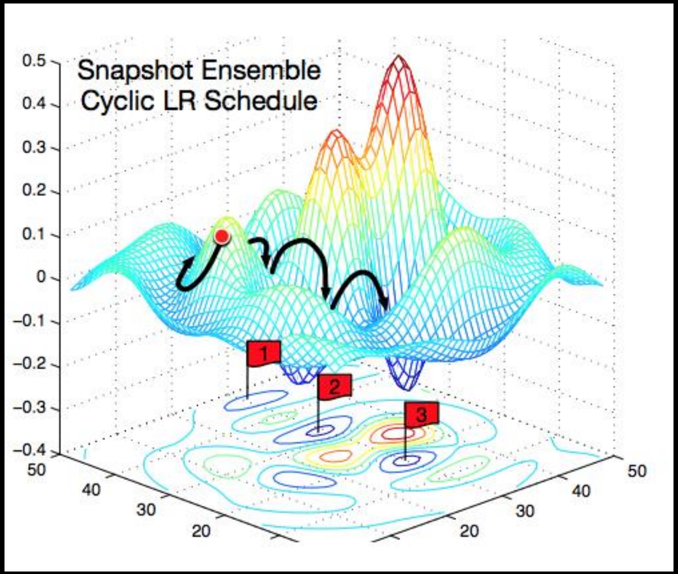
We do not have enough measurements

The few measurements we have, are scale dependent…



Scientific challenge 3: Find an ensemble of acceptable solutions

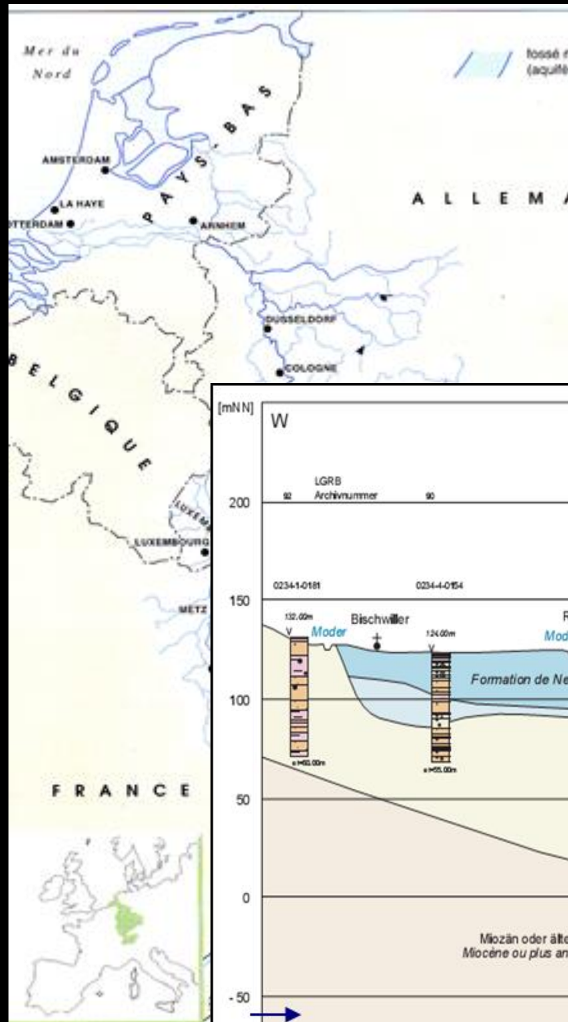
Measure of the difference between model and observation



Parameters

We are looking for the most probable parameter sets conditioned by the observations.

The predictions are no more single values but values with their associated probability.



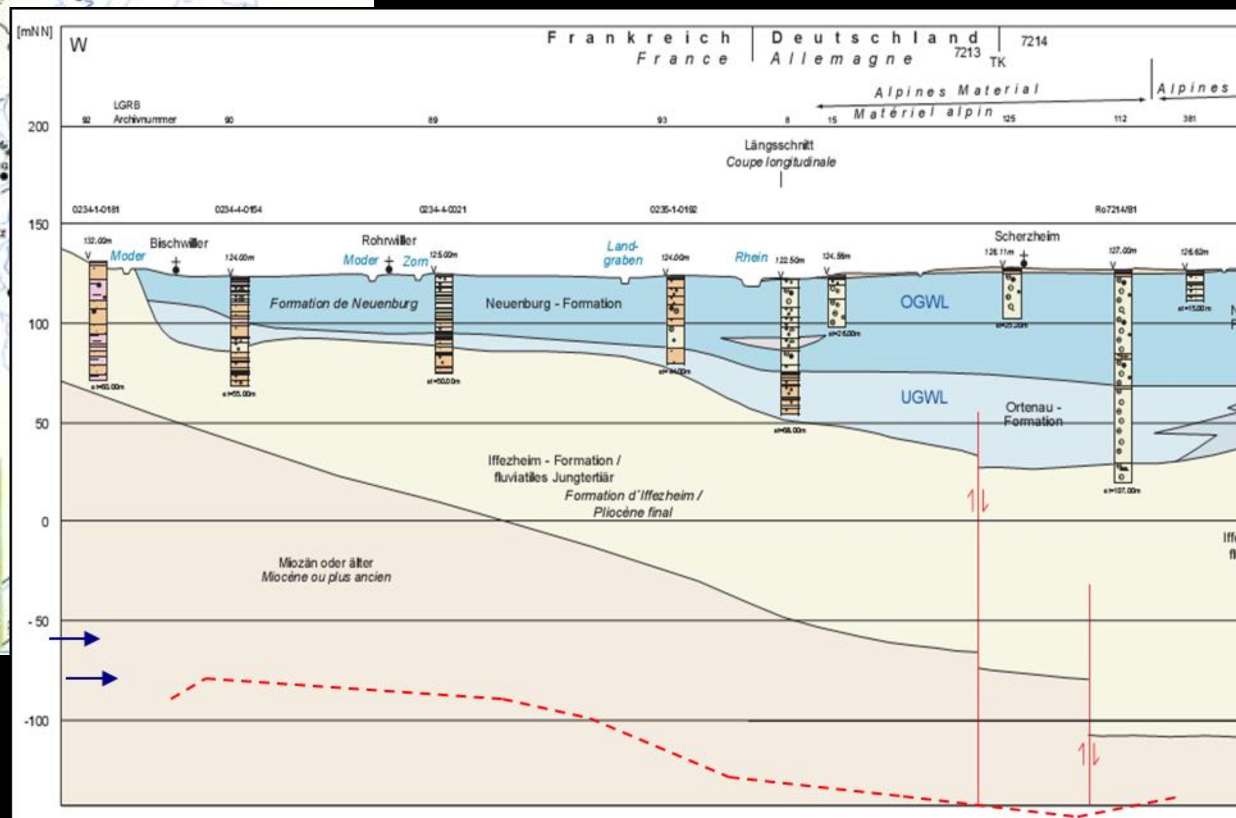
Alsatian aquifer

Area : 2850 km^2

Volume of water: 30 à 50 billions m^3

Recharge : 1,3 à 1,5 billions m^3/y

Pumpings : 0,5 billions m^3 /y



Objectives:

Predict the effects of climate change on groundwater levels and river flows in the Upper Rhine plain.

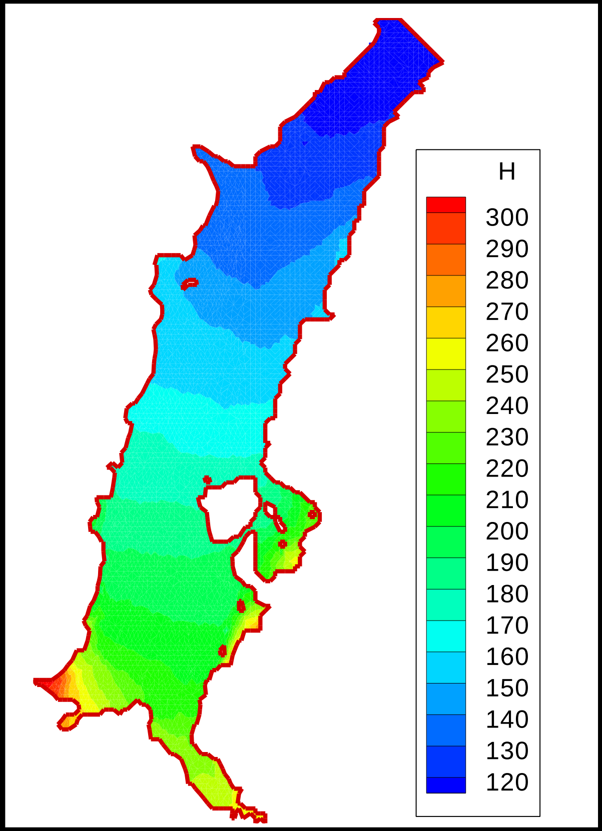
Approach:

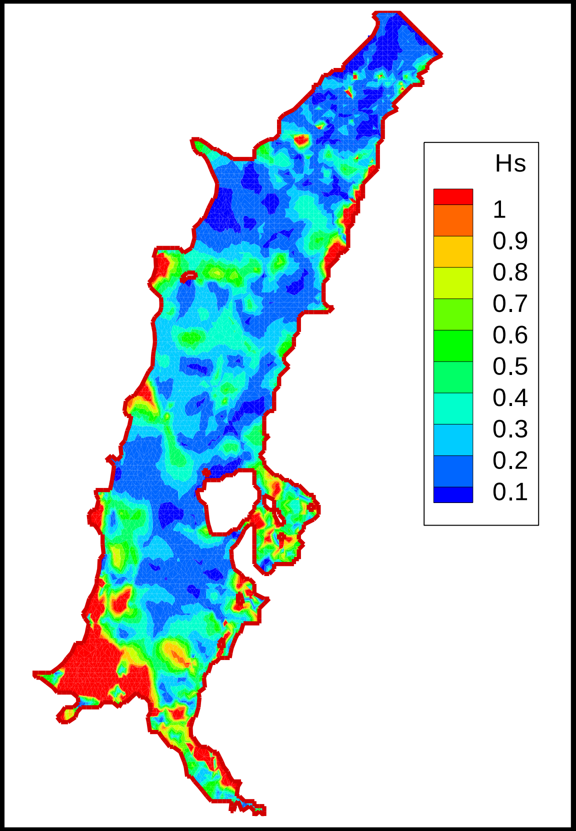
Groundwater/surface water model calibrations (fully coupled surface water – groundwater) based on measured groundwater levels and flow rates in rivers over the period 1980 - 2010.

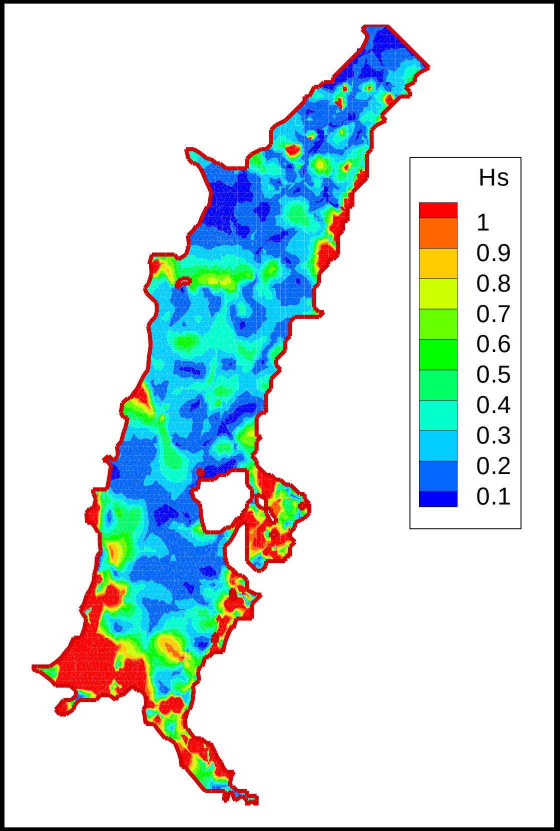
About 100 calibrated and acceptable models, that differ in parameters values (K, S) and Neumann boundary conditions. Recharge is assumed to be known.

Use this model in conjunction with climate projections (temperature, rainfall, snow) provided by the IPCC to predict groundwater levels and flows in rivers from today to 2100.

Simulated water levels (calibration period – about 100 models)







Average GW levels
(average of 100 values at the element scale)

Uncertainties for a low water situation
(Std of 100 values at the element scale)

Uncertainties for a high water situation
(Std of 100 values at the element scale)

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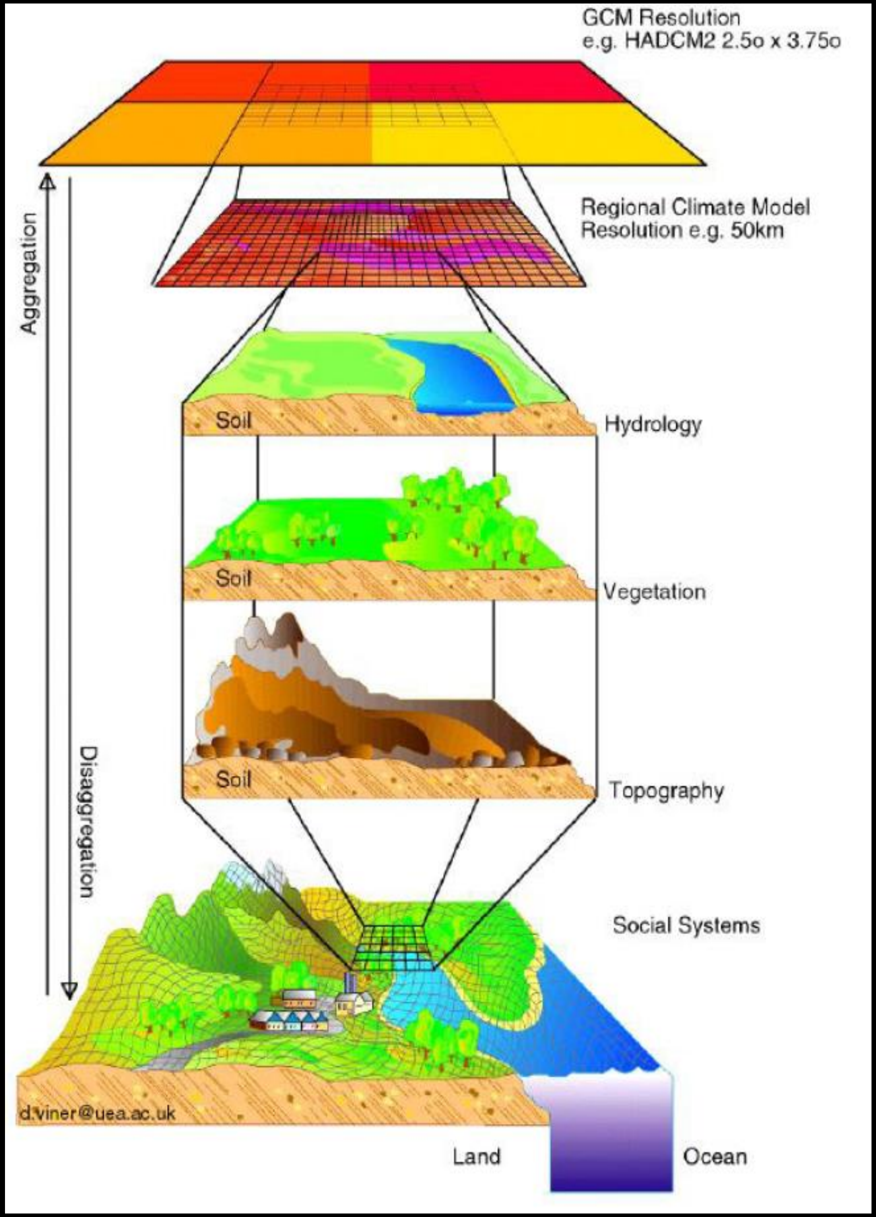

Downscaling

From about 110 km grid size for the Atmospheric Oceanic Global Circulation Model from IPCC
to 8 km grid size for the regional model

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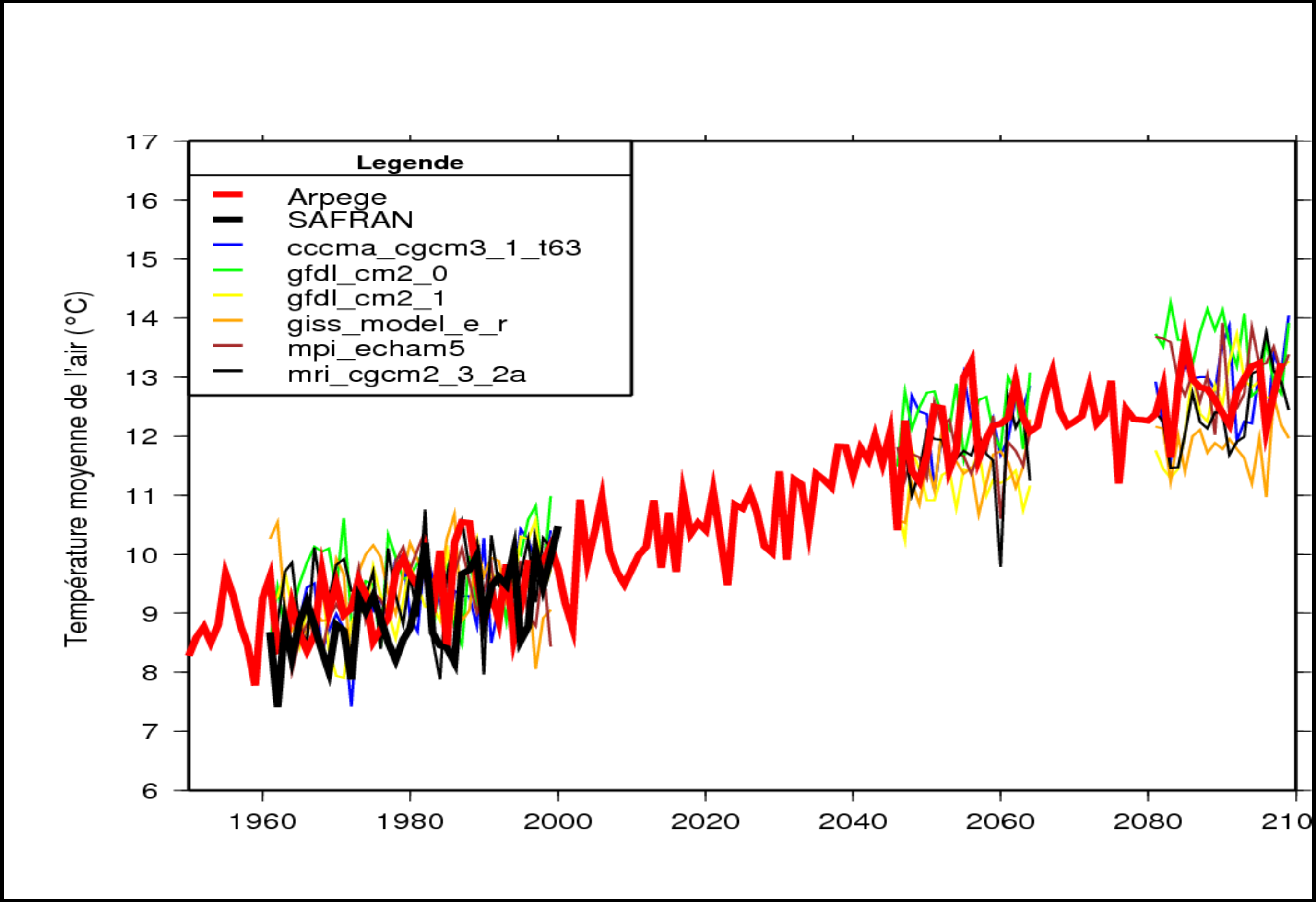
Uncertainty on climate model predictions



Change of temperature in the upper Rhine valley.

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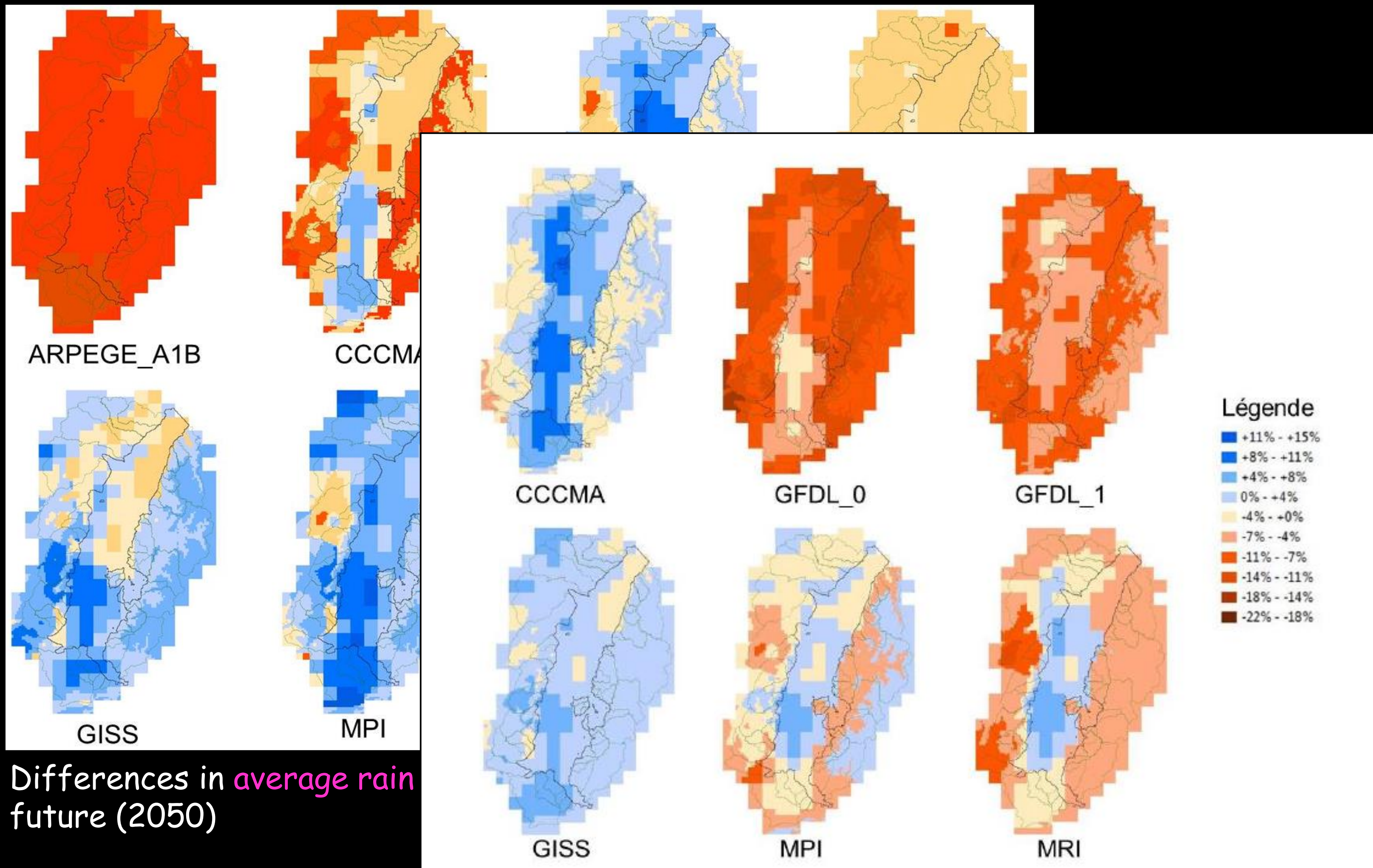
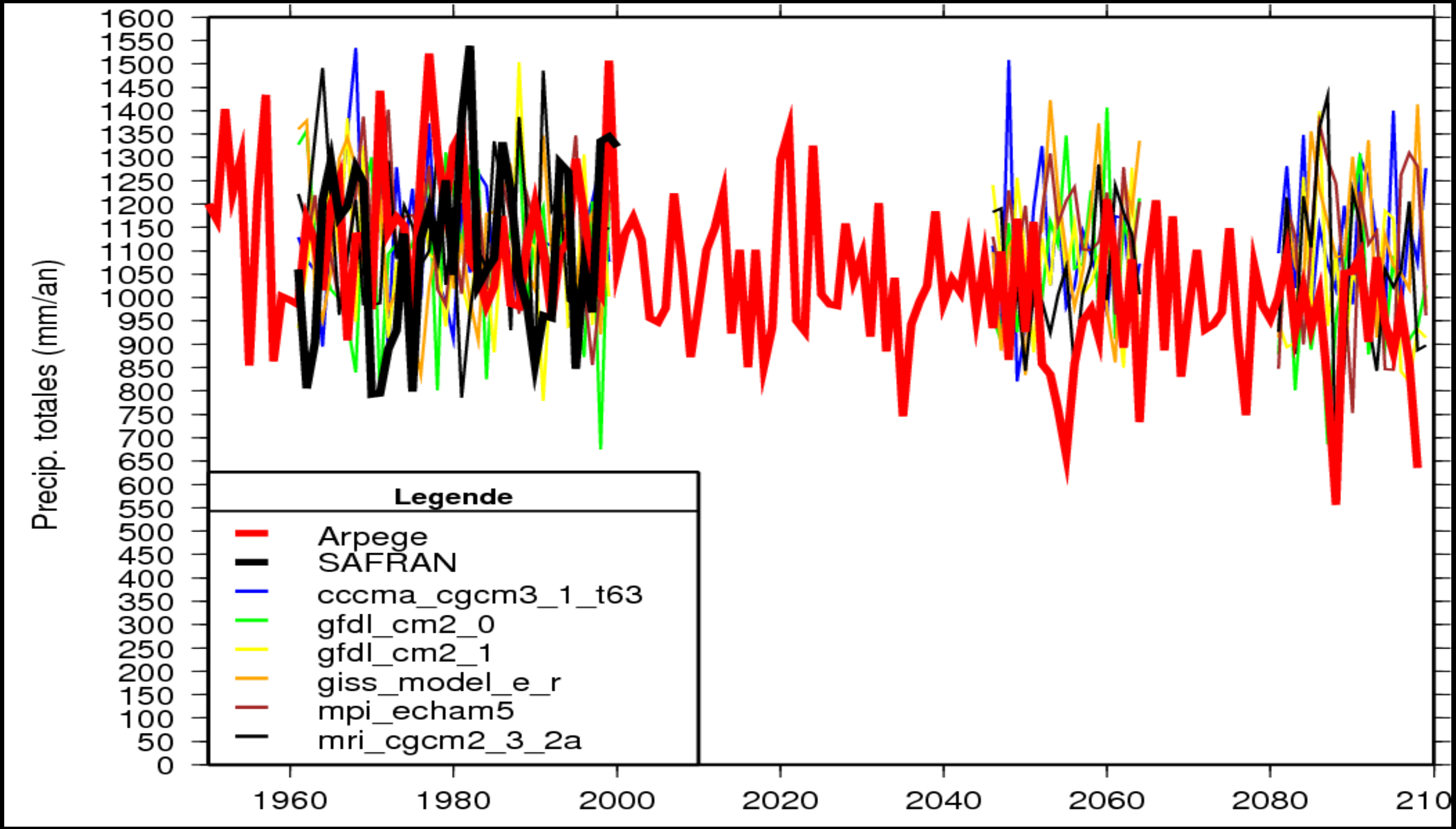


Differences in average rain
future (2050)

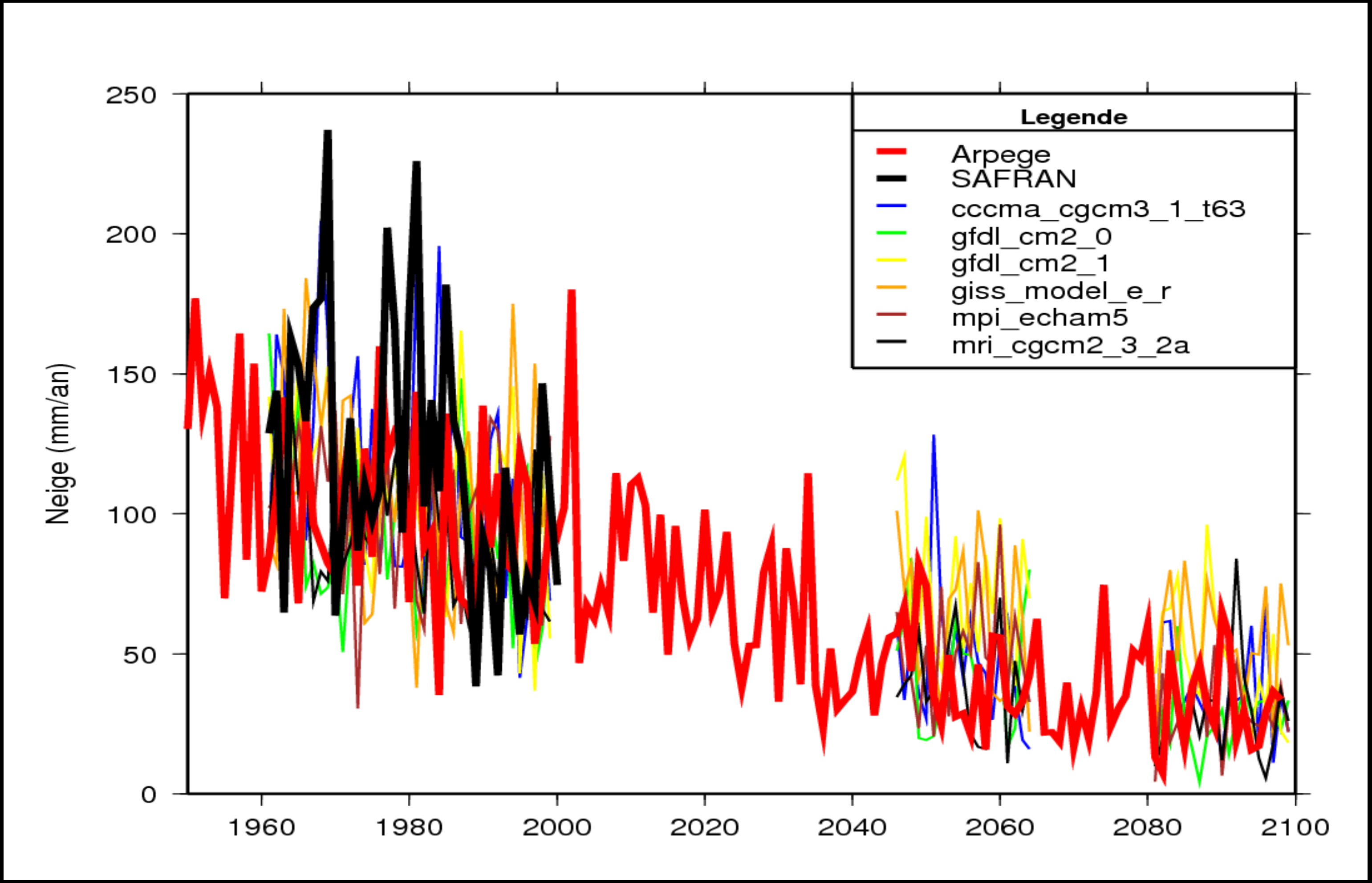
Differences in average rain fall between today (1990-2000) and far future (2100)

Uncertainty on climate model predictions

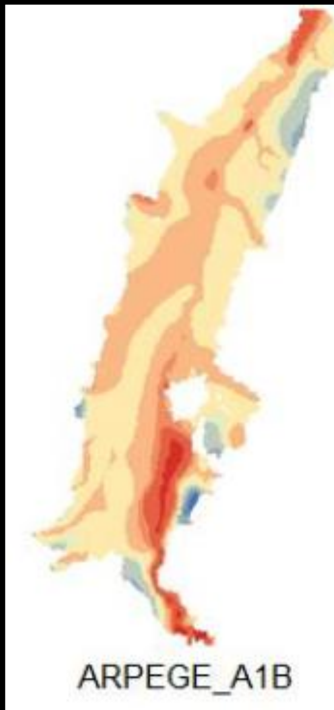


Change of the precipitation in the upper Rhine valley.

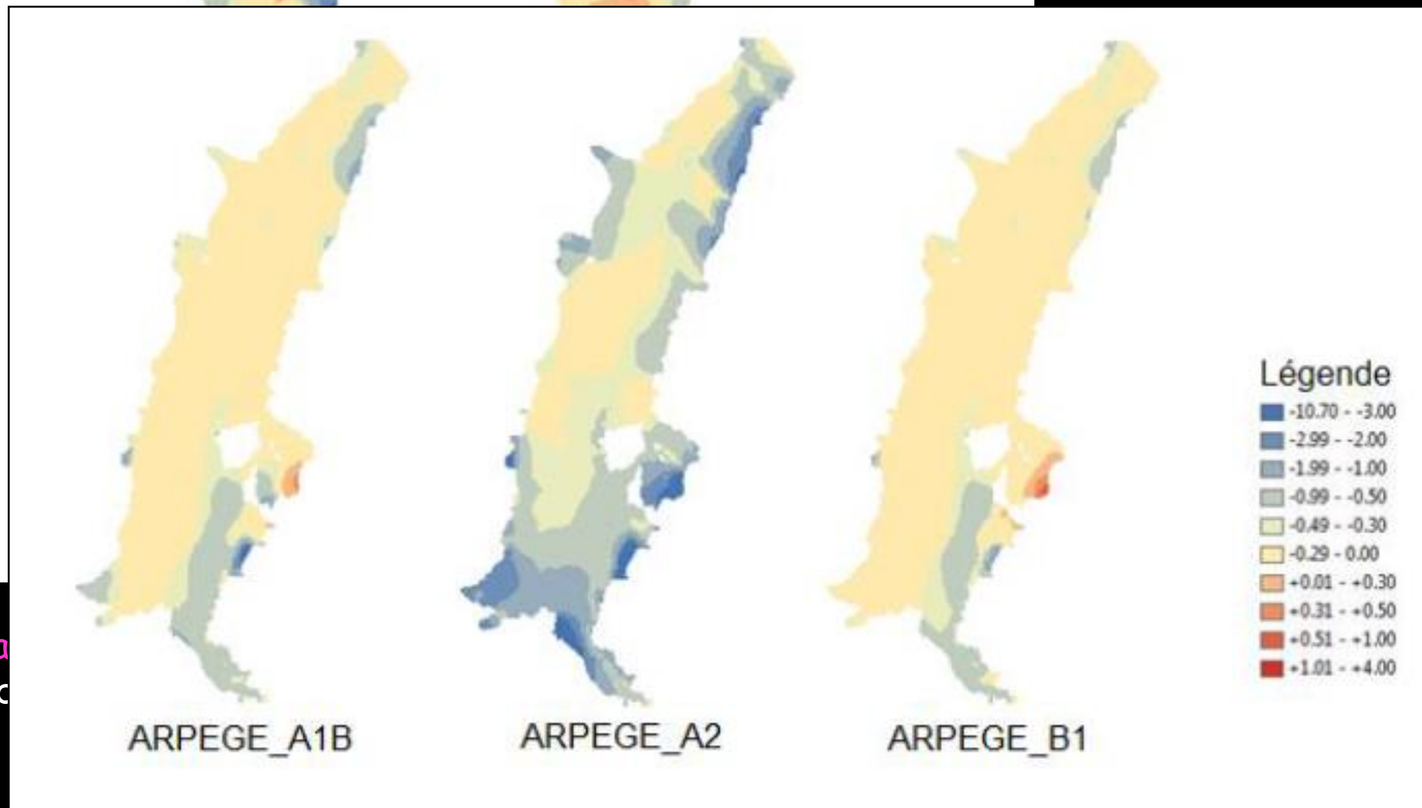
Uncertainty on climate model predictions



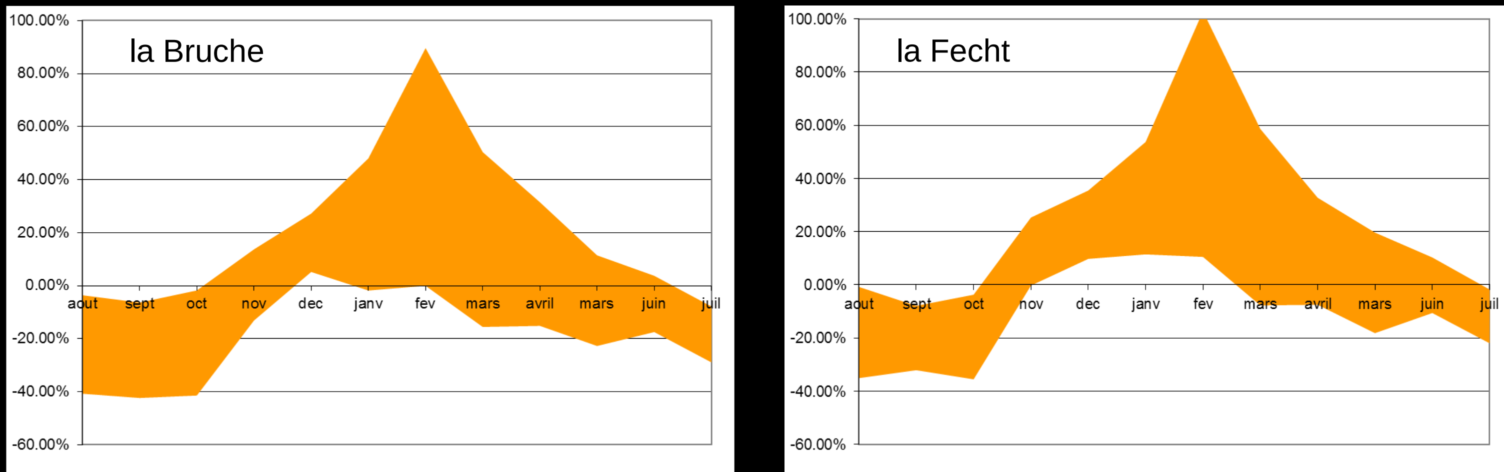
Change of the snow cover in the upper Rhine valley.



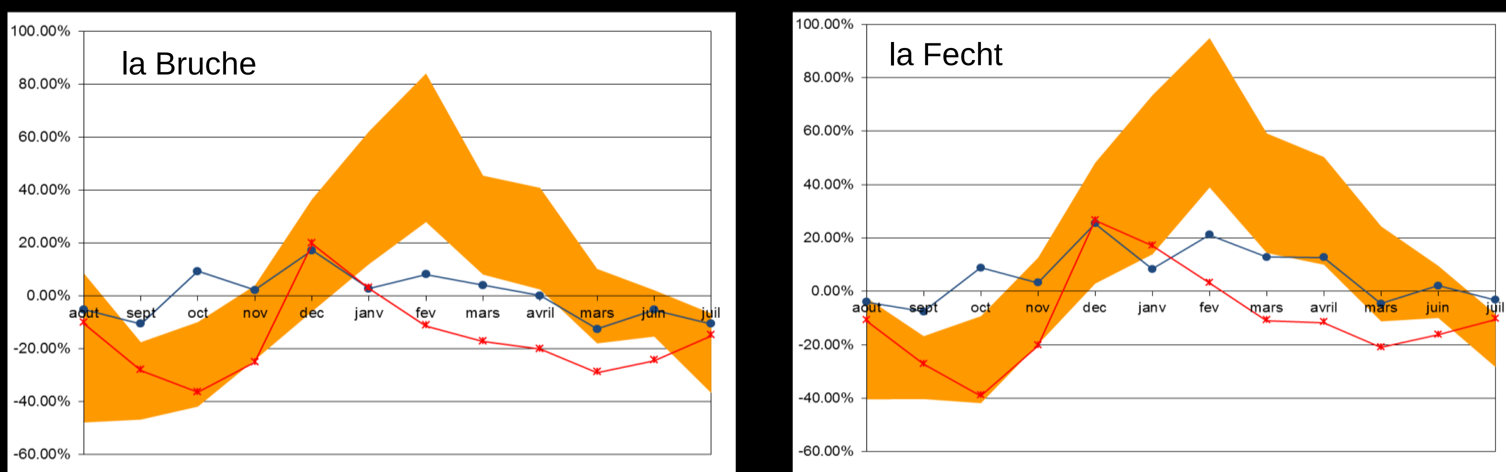
Differences in a
(1990-2000) anc



Differences in average groundwater level between today (1990-2000) and far future (2100) for a low water situation



Evolution of monthly flow rates for the ‘near’ future period - 2050



Evolution of monthly flow rates for the ‘far’ future period - 2100

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CONCLUSIONS

- The predicted monthly flow rates are more uncertain in the near future than in the far future due to the evolution of the snow pack in the Vosges mountains (Max. 1436 m). For the far future, all IPCC models predicts the absence of snow.

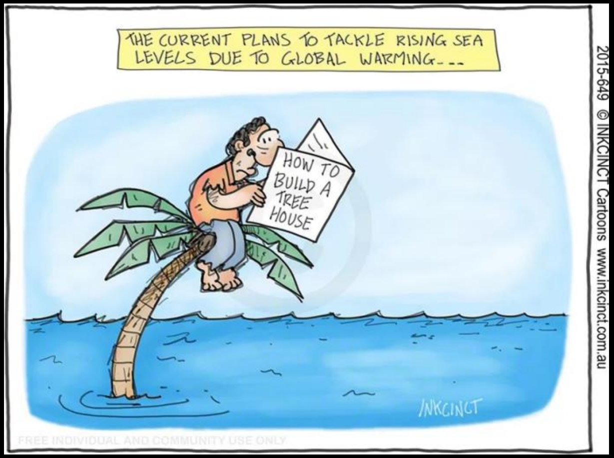
- The stream flow rates distribution over the year will be changed toward a significant increase during the high water period and a significant decrease during the low water period.

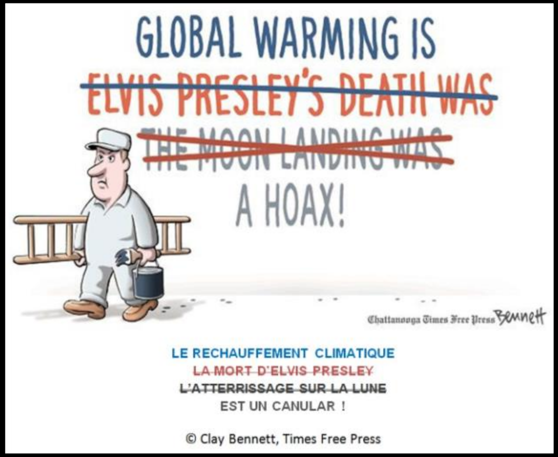
- Significant flooding may occur in spring and fauna/flora will threatened by lack of water at the end summer.

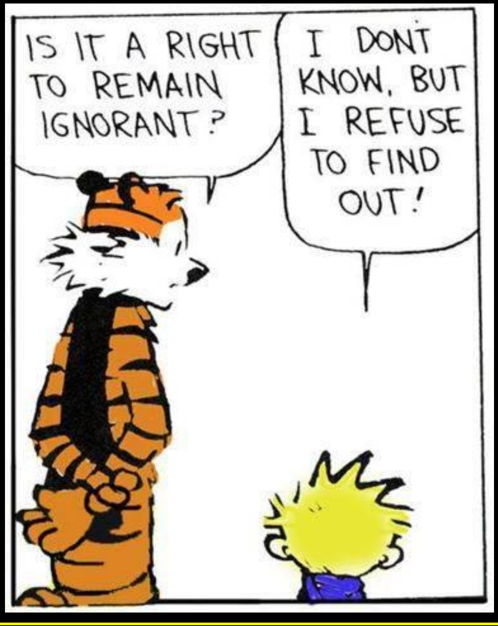
- Water resources may be limited in the mountains and in the south of the plain.

Many thanks to the co-workers,

Many thanks for your attention







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