

Groundwater drought evolution in a changing climate in Wallonia (Belgium)



LIÈGE université
Sciences Appliquées

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Groundwater and climate change : quantitative aspects, Adams Beach Hotel, Ayia Napa (Famagusta), Cyprus, 26/05/2026

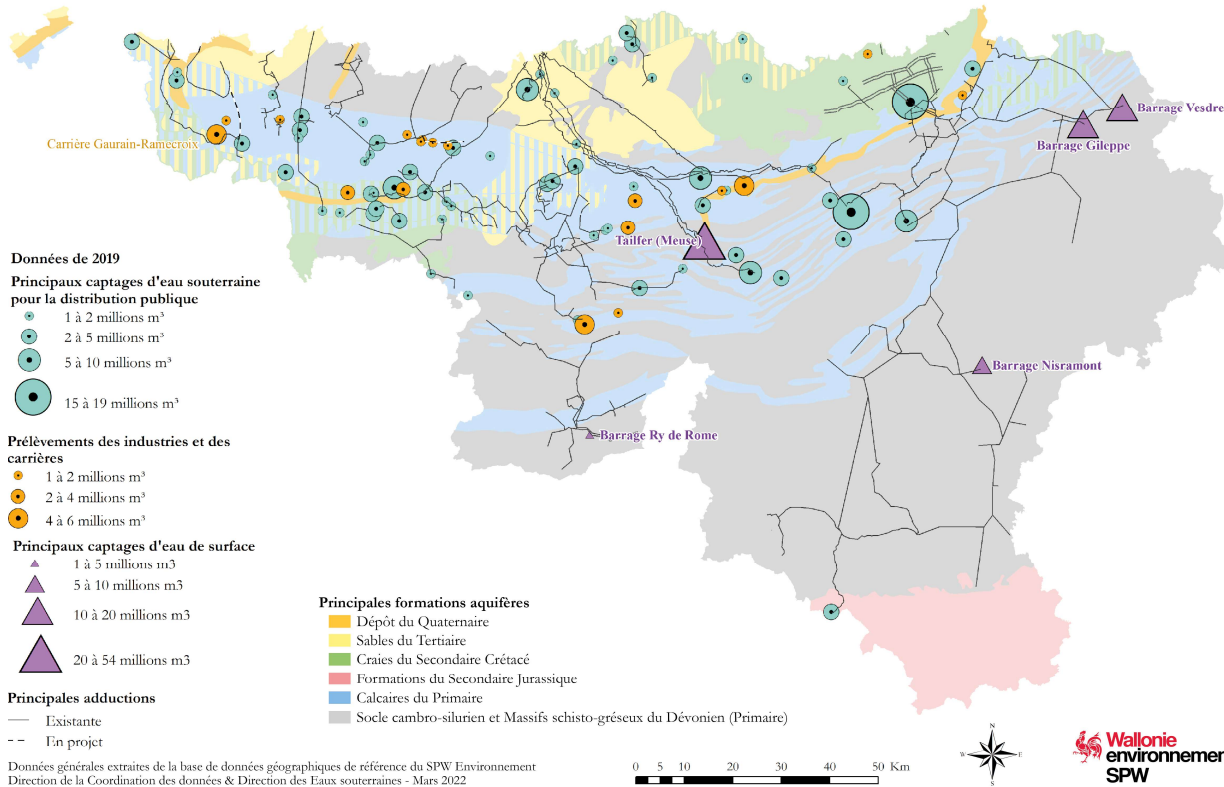
Introduction - Context of the study



- Work funded by **Walloon Agency for Air and Climate (AWAC)** in charge of investigating climatic evolution of the region and its consequences
- Part of a wider study with the objective of developing maps and tools to quantify the impact of an increase of +2°C, +3°C and +4°C on a set of sectors
 - Water resources
 - Air quality
 - Biodiversity
 - Economical
 - Evolution of droughts at different scales
 - ...
- Results available for the public and decision-makers through reports and online portal
<https://portailclimat-awac.be/>
- (Cost of inaction for the sensibilization of the inhabitants with direct link with the temperature increase)
- All based on the same climate change scenarios (CMIP6) for consistency



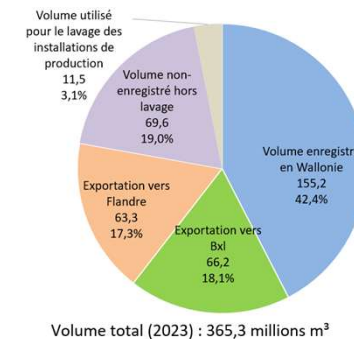
Groundwater resources in Belgium - Wallonia



In 2021: Total volume for public water distribution = **362,5 Mm³**, of which :

- **Groundwater = 289,9 Mm³ (79%)**
- **Surface water = 75,6 Mm³ (21%)**

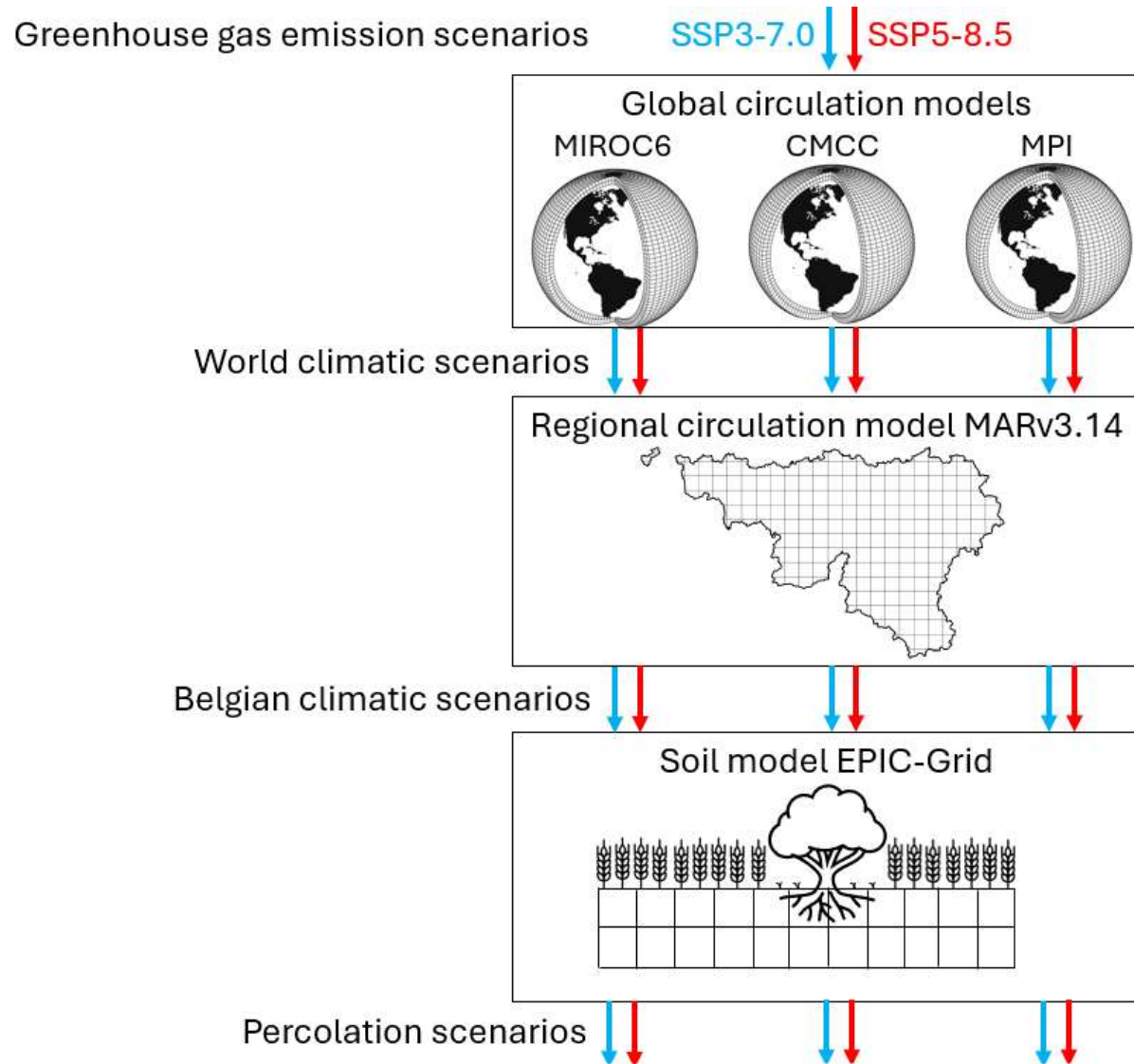
Rem: a significant of this water is exported to Brussels & Flanders (~38%)



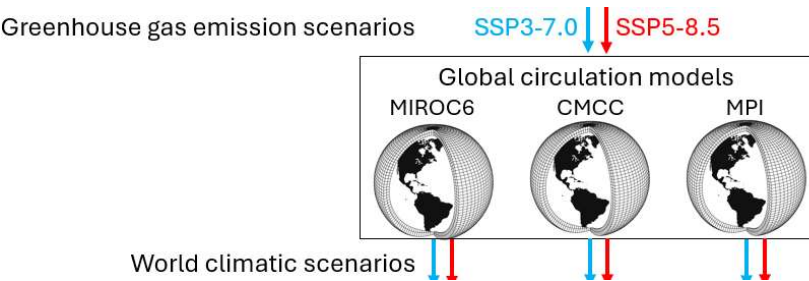
Source : Etat des nappes et des masses d'eau souterraine de Wallonie, March 2022.. **ISNN** 2795-6091 (N)
SPW - DEE – Groundwater division

Knowing this strong dependence, what are the expected impacts of climate change on groundwater during drought periods in Worlds at +2°C, +3°C or +4°C ?

General methodology



General methodology

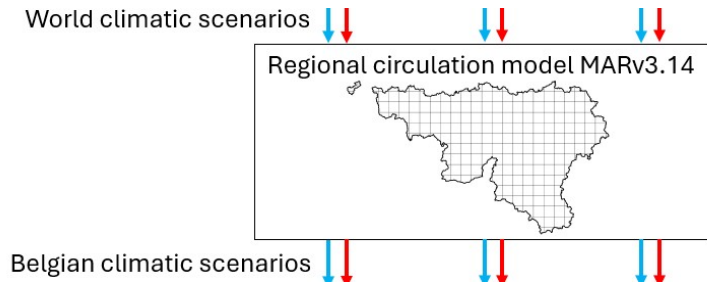


+ 9 scenarios made of 30 years intervals of the 3 world climatic scenarios showing increase in temperature of +2, +3 and +4°C compared to pre-industrial period.

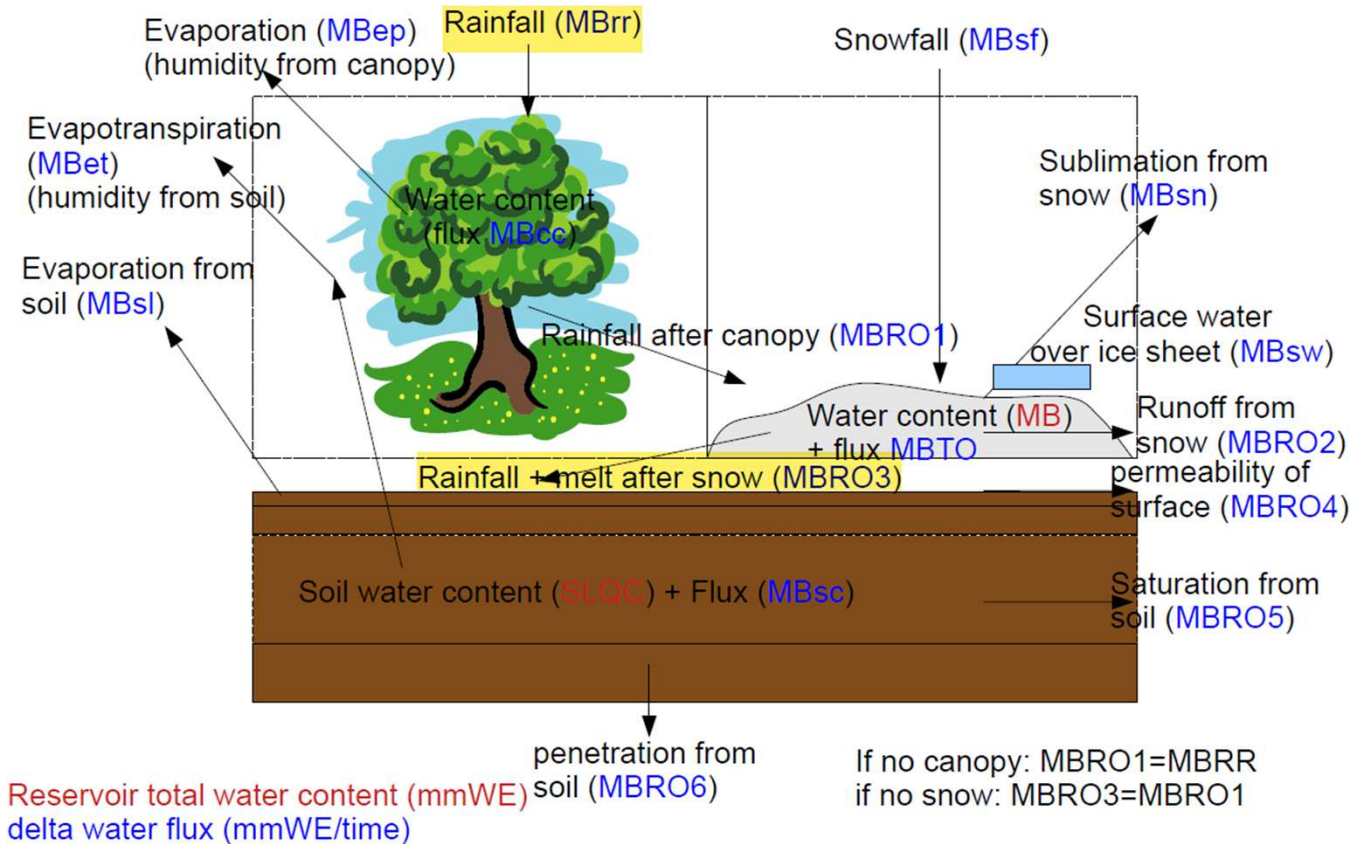
Model	+2°C (SSP3-7.0)	+3°C (SSP3-7.0)	+4°C (SSP5-8.5)
MIROC6	2045-2074	2071-2100	2081-2100
CMCC	2024-2053	2048-2077	2060-2079
MPI	2036-2065	2066-2095	2081-2100

Reference time period : 1974 -2022

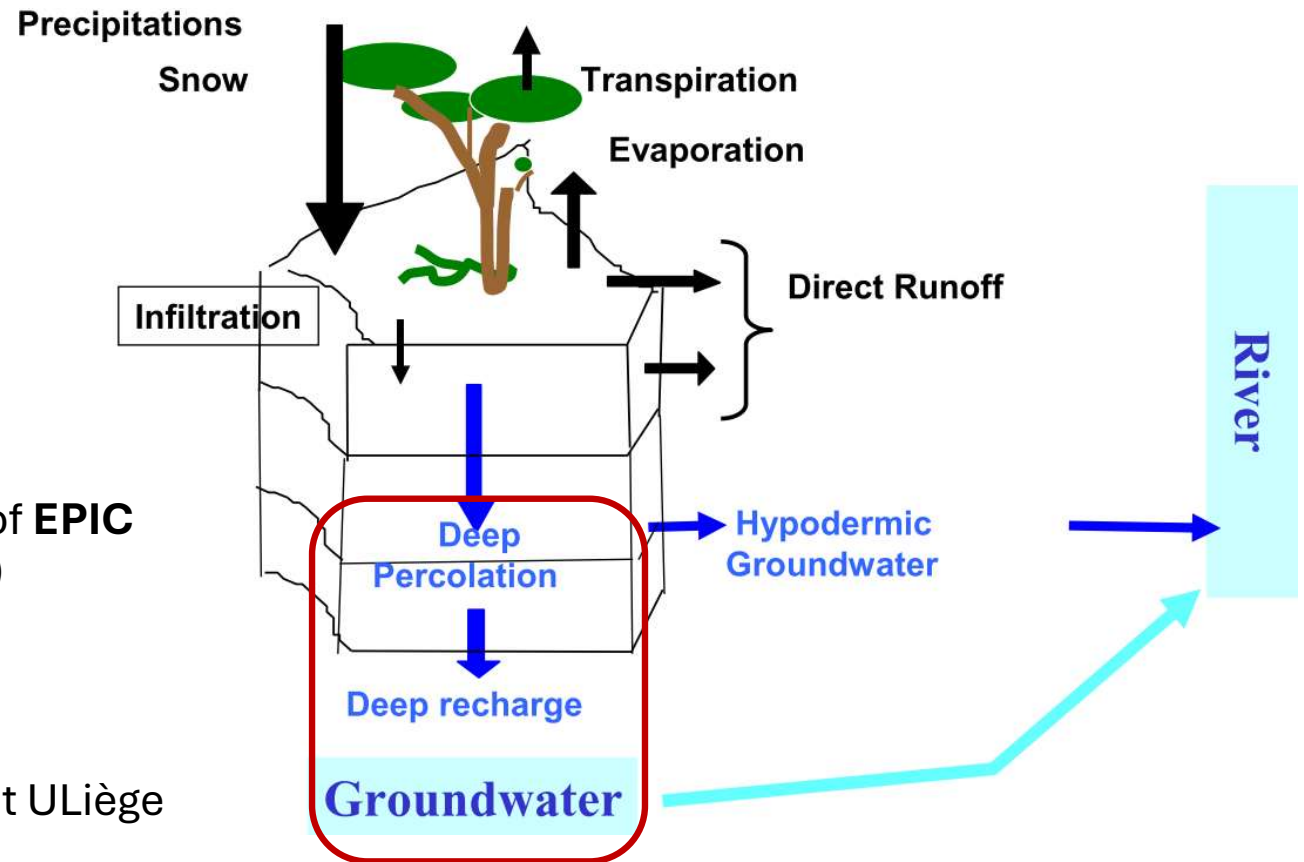
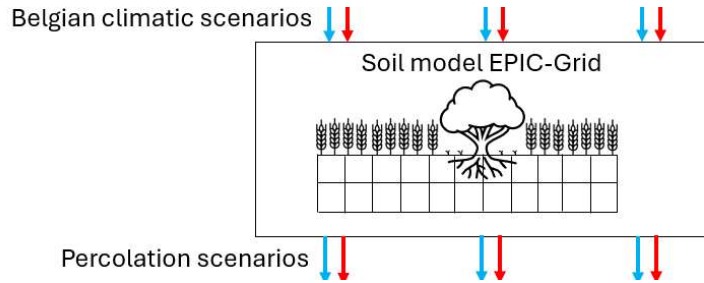
Downscaling to Belgian climatic conditions using MARv3.14



MAR = Regional Atmospheric Model
 Solves 3D high resolution water, ice, energy balances at regional scale (3D, high resolution of 5 to 10 km)
 Developed by X.Fettweis at ULiège

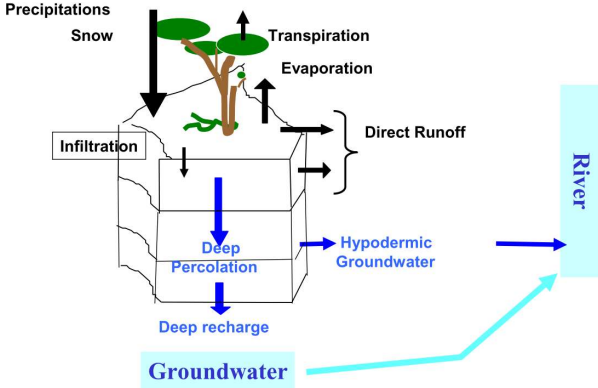
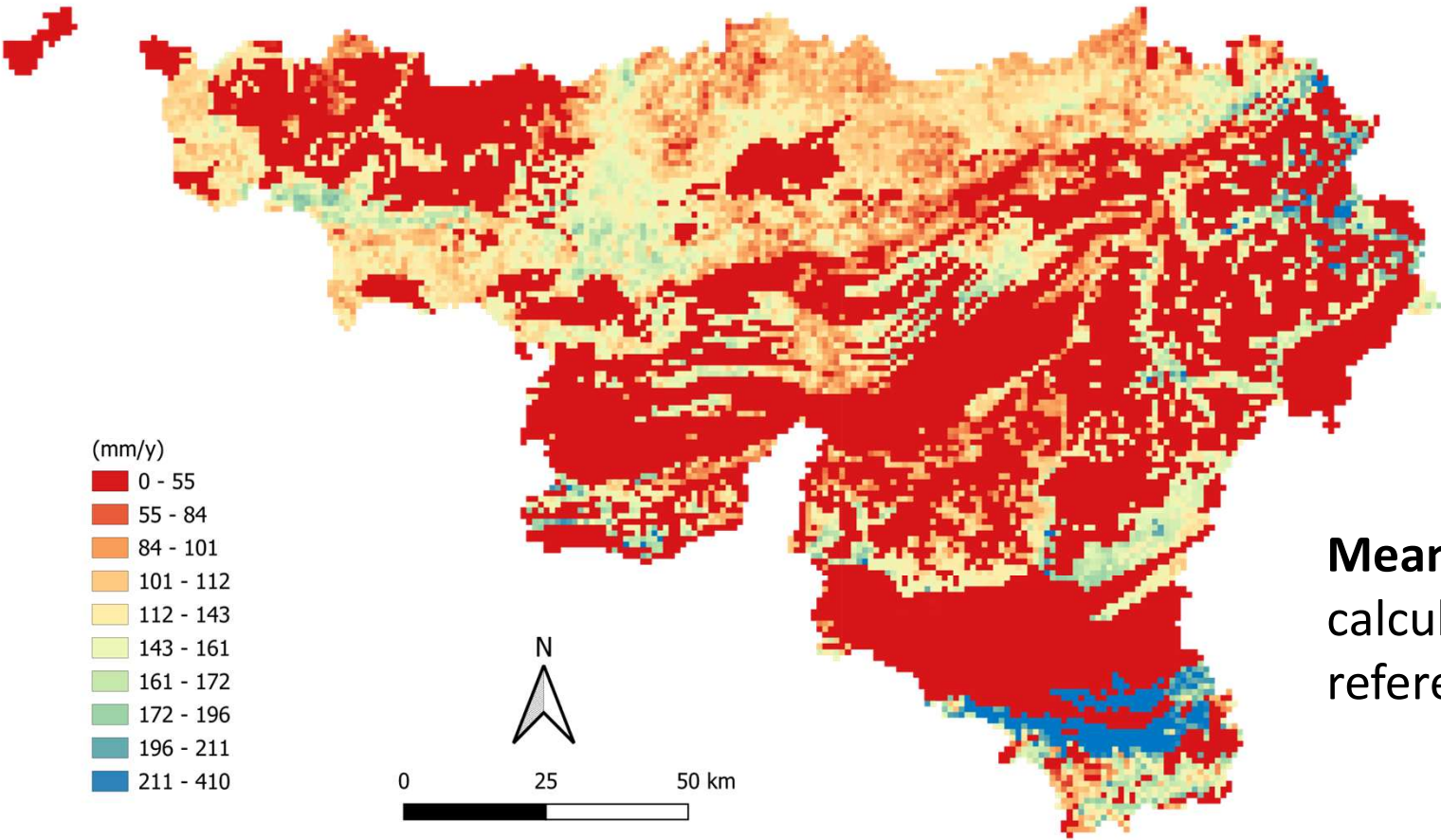


Modelling hydrological fluxes at catchment scale using EPICgrid



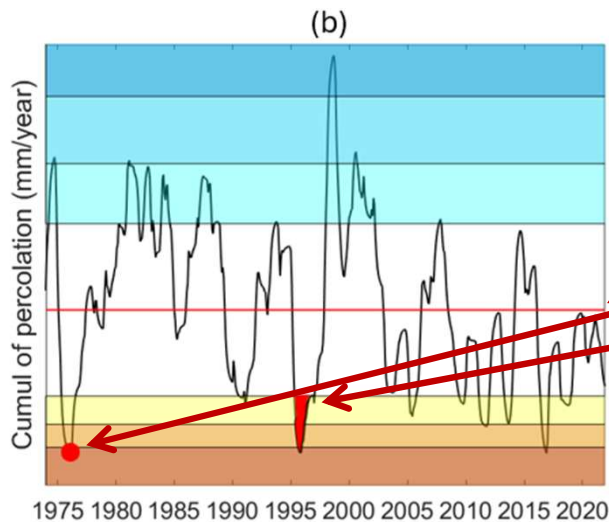
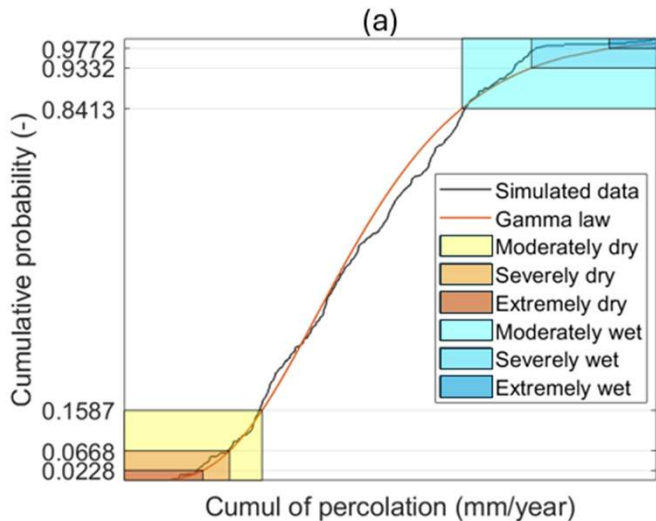
EPICgrid = spatially distributed version of **EPIC** (**Erosion-Productivity Impact Calculator**)
Solves soil-water-plants processes at catchment scale
Resolution of $1 \times 1 \text{ km}^2$
Developed by Gembloux Agro-Bio Tech at ULiège

Analysis of calculated percolation (groundwater recharge)



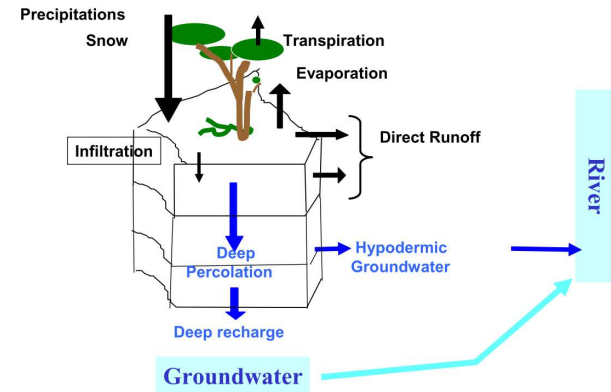
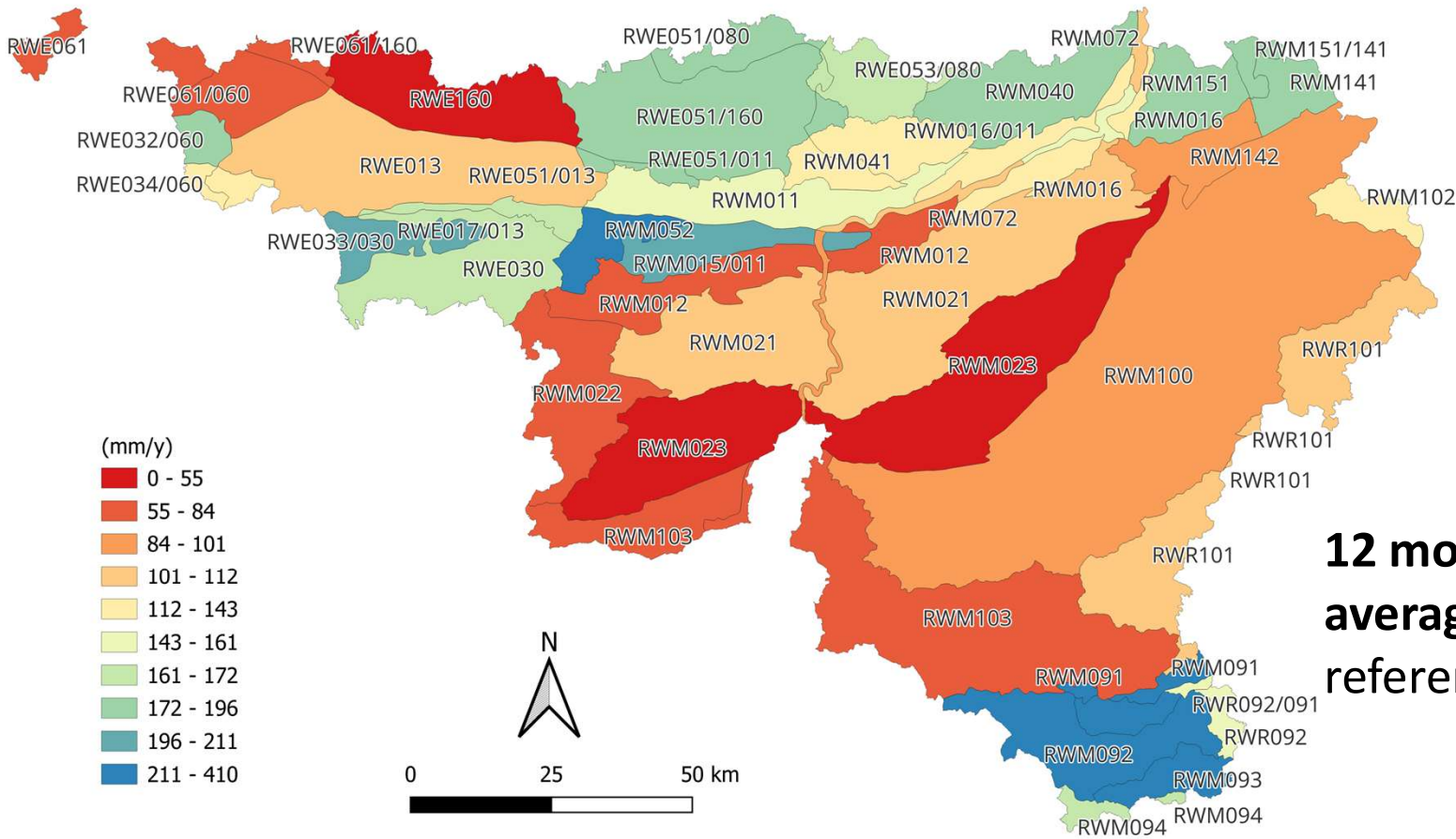
Mean annual percolation calculated using EPICgrid for the reference period 1974 - 2022

Definition of a groundwater drought : 4 indicators



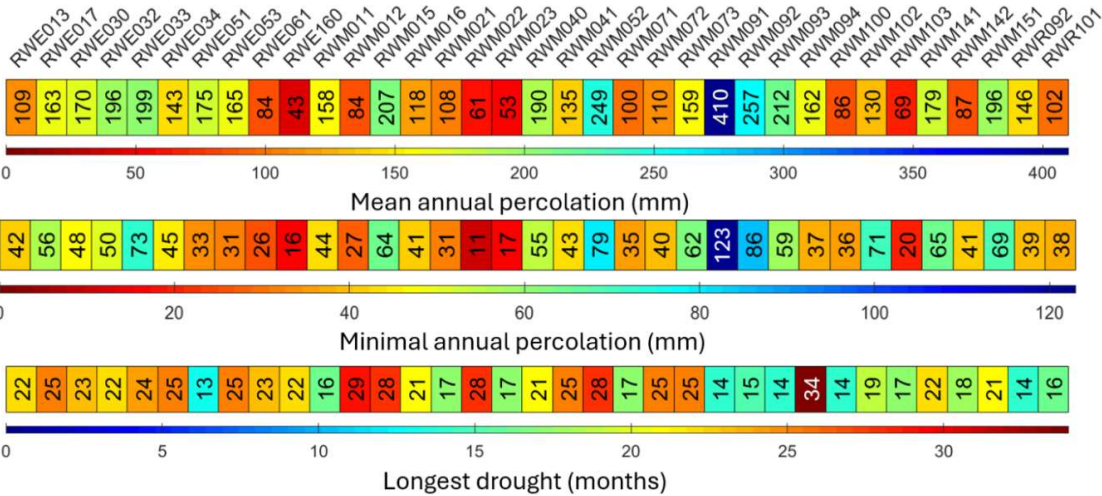
- **At the scale of each groundwater body** because of their specific dynamics
- **Cumulative recharge over 12 months** because of the groundwater inertia : need for 12 months below average to be in hydrogeological drought
- Definition and use of a **Standardized Percolation Index** to identify drought conditions and for comparison between the reference period and the 9 climate change scenarios
- **3 (+ 1) indicators used to define droughts** experienced by a specific groundwater body:
 - Mean annual recharge
 - minimal annual recharge
 - longest drought
 - [Groundwater exploitation rate]
- Based on historical data and recomputed for every scenario in relative terms to assess the evolution

Analysis of calculated percolation (groundwater recharge)

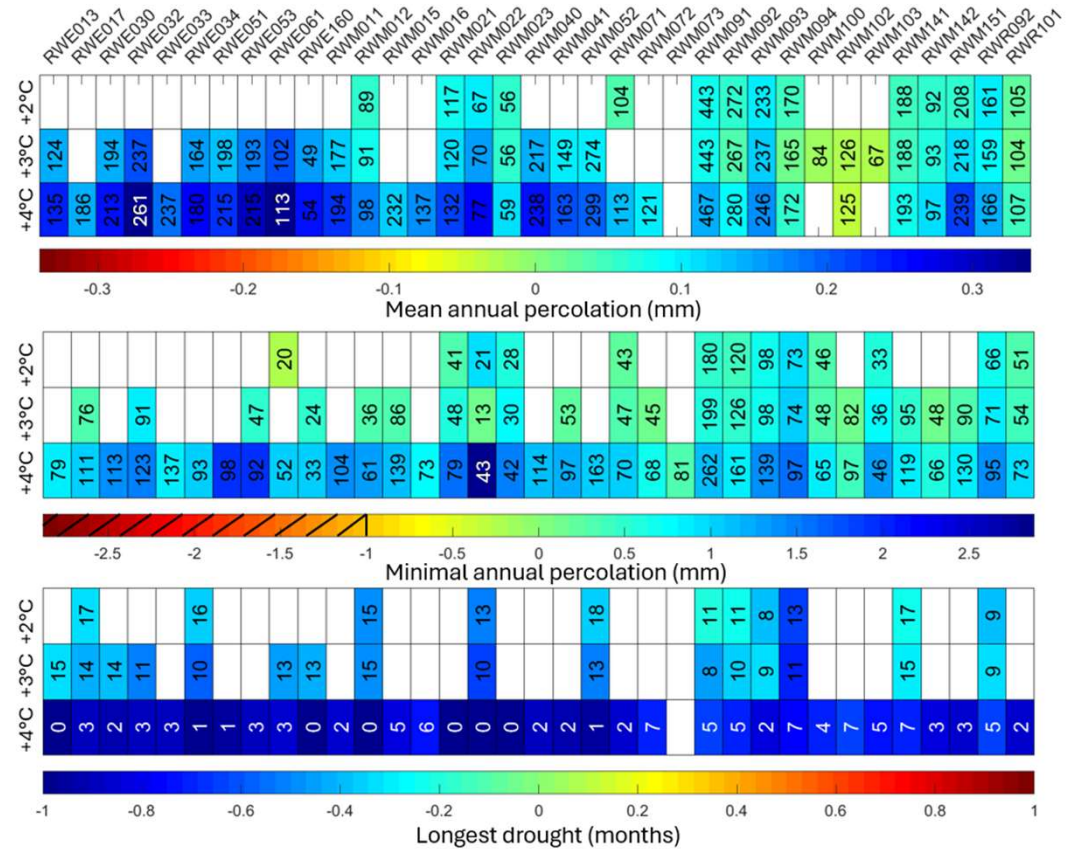


12 months – GW body scale averaged percolation for the reference period 1974 - 2022

Results for the 3 indicators for each GW body



3 drought indicators calculated for each groundwater body for the reference period 1974-2022

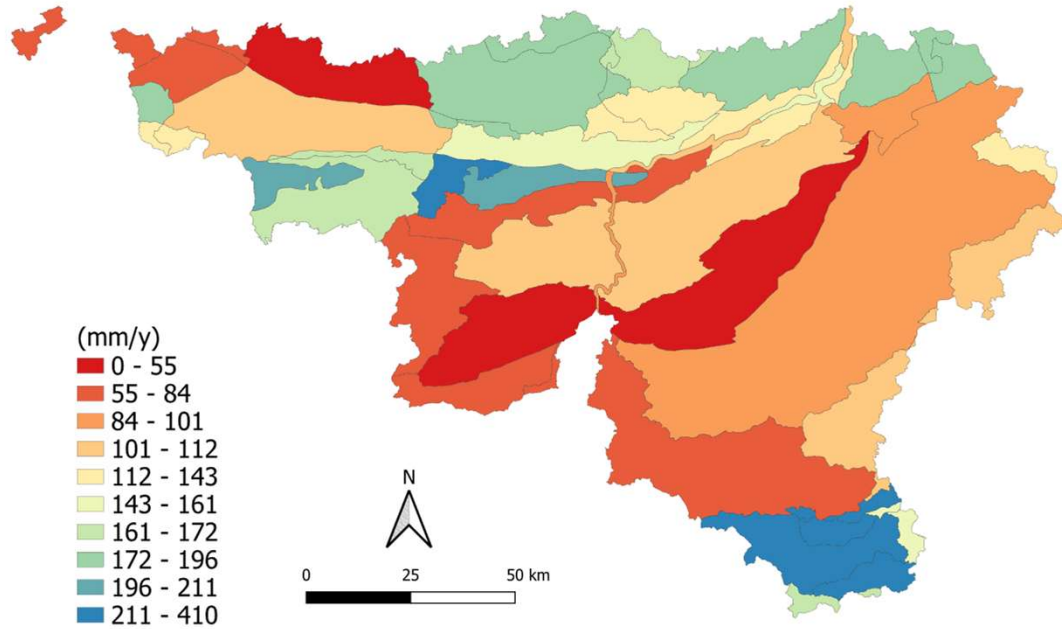


Relative evolution of the three drought indicators) in colormap (in writing : absolute value for each groundwater body)
 White cells : undetermined evolution (disagreement between scenarios)
 Black stripes : impossibility of a decrease > 100%

Results for the mean annual percolation indicator



Reference
1974-2022



(%)

- 5 - 0
- 0 - 5
- 5 - 10
- 10 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- > 35

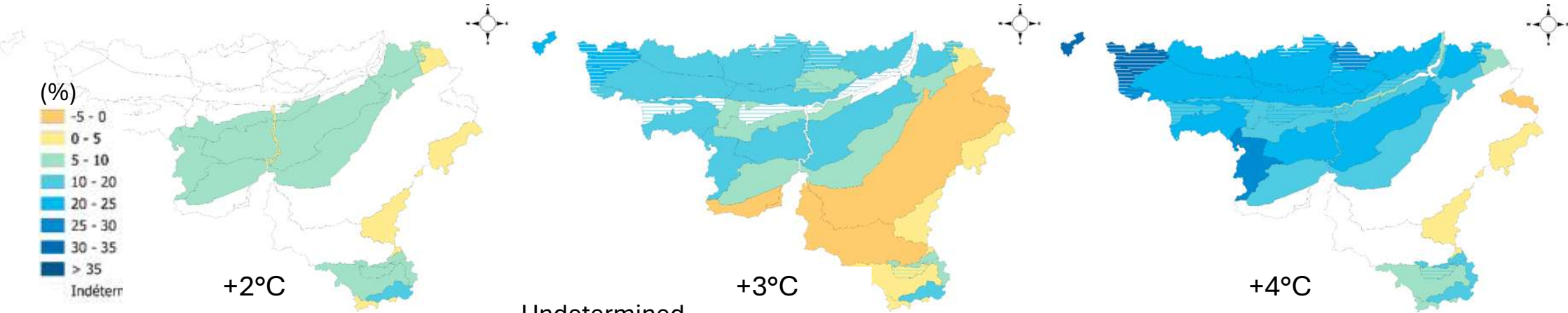
Indéterr

+2°C

Undetermined

+3°C

+4°C



Conclusions and perspectives



- Even if in a World at +2°C divergences are observed in terms of groundwater drought evolutions, **results obtained with the different scenarios generally indicate increased groundwater recharges related to increased precipitation during winter and decreasing groundwater drought conditions**
- Results are however based on calculated deep percolation obtained with a semi-distributed water catchment model that probably **oversimplifies groundwater flow processes in aquifers** → results should be confirmed with **more advanced groundwater flow modelling tools** (ongoing work at ULiege)
- Generally speaking, **predicting increased groundwater recharge offers good groundwater management perspectives** ... However, this should be confronted with the **perspective of dryer summers and higher water demand** (irrigation ...).

Thanks for listening ! Any question ?

Useful links & references :

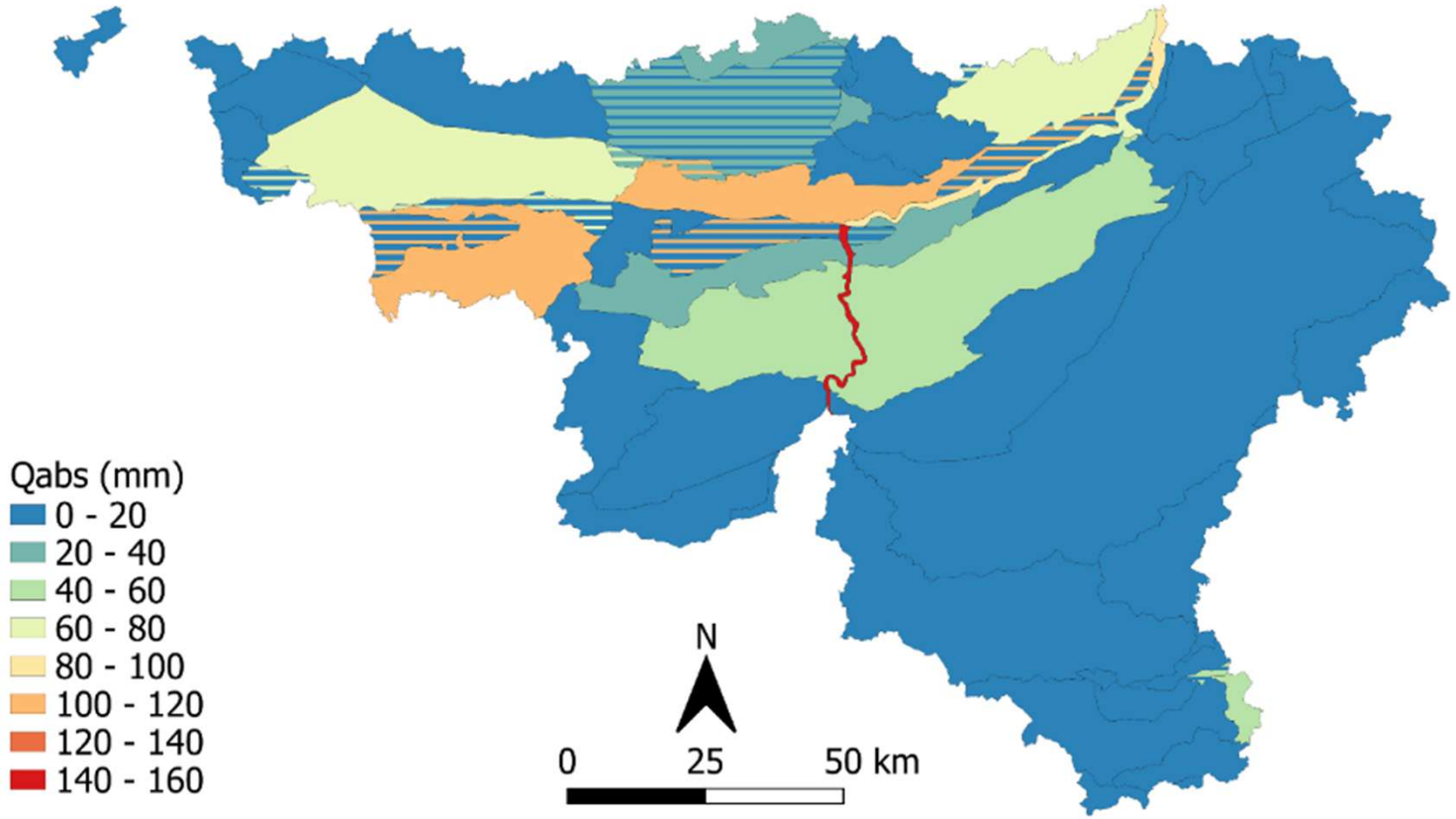
AWAC Portal (In French, sorry !) : <https://portailclimat-awac.be/>

Groundwater drought indicator report (in French as well but a paper is under preparation !) : <https://hdl.handle.net/2268/342299>

MAR Model and GCM to RCM work : Fettweis, X., Denis, T., Fiol, L., Harchies, M., 2024. Actualisation des projections climatiques sur la Wallonie à l'aide du modèle régional MAR forcé par les données les plus récentes (CMIP6) de 6 modèles climatiques globaux selon les scénarios SSP370 et SSP585.

EPICgrid model : Sohier, C., 2011. Développement d'un modèle hydrologique sol et zone vadose afin d'évaluer l'impact des pollutions diffuses et des mesures d'atténuation sur la qualité des eaux en région wallonne. Université de Liège - Gembloux Agro-Biotech.

Tools: I4?



Because not all resources are exploited equally

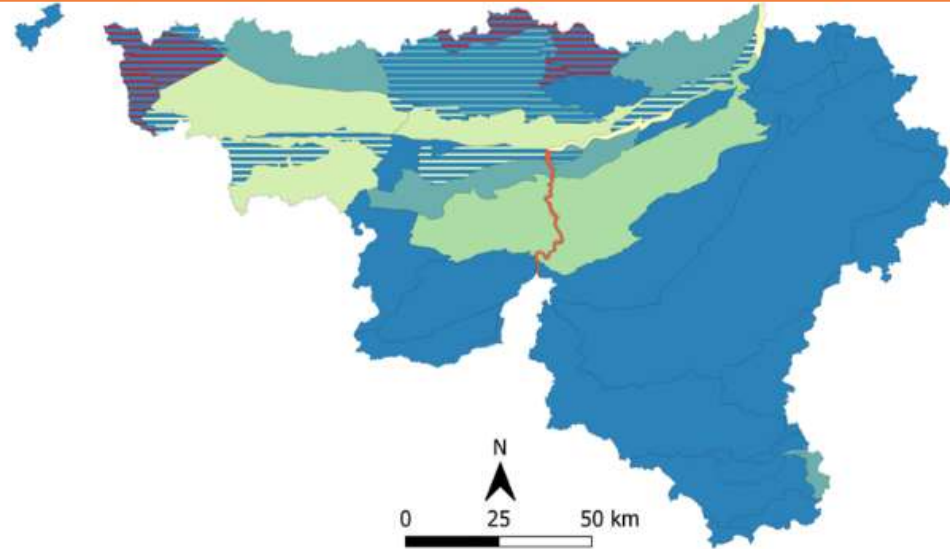
$$I_4 = \frac{Q_{abs}}{P}$$

Results: I4



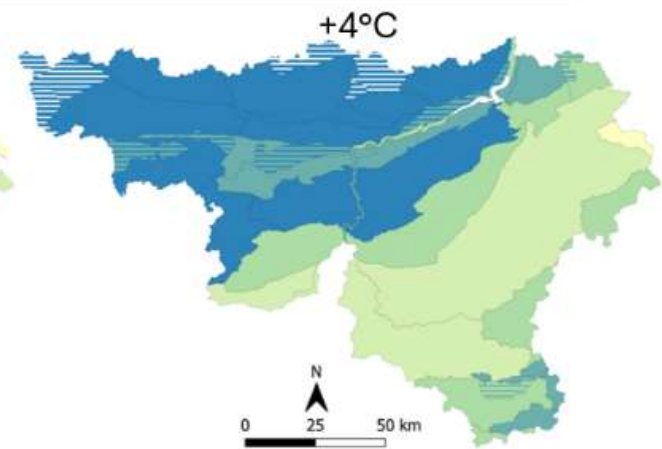
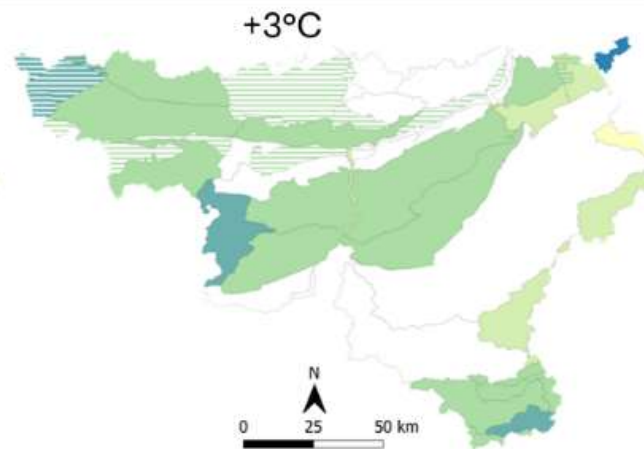
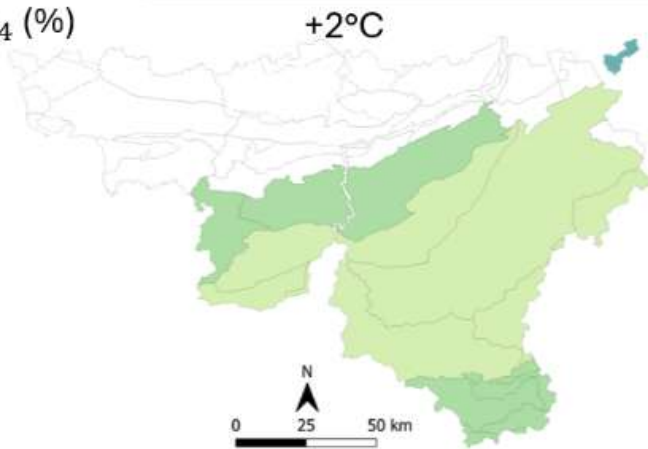
I_4 (1974-2022)

- 0 - 0,2
- 0,2 - 0,4
- 0,4 - 0,6
- 0,6 - 0,8
- 0,8 - 1
- 1 - 1,2
- 1,2 - 1,4
- 1,4 - 1,6



Evolution of I_4 (%)

- 30 - -22.5
- 22.5 - -15
- 15 - -7.5
- 7.5 - 0
- 0 - 7.5
- 7.5 - 15
- 15 - 22.5
- 22.5 - 30
- Undetermined



Expected evolution of climate in Belgium



According to MARv3.14 downscaling model under global warming scenarios of +2°C to +4°C relative to the preindustrial period (Fettweis et al., 2024; Pirlot et al., 2025) :

- Rise in summer temperatures by +1.73°C to +4.72°C
- Decrease in summer precipitation by 6% to 17%
- Increase in consecutive dry days by 14% to 32%
- Rise in evapotranspiration of 12% to 31%.

➔ Expected intensification of drought conditions, particularly in summer months.

At the same time, expected increase in precipitation and evapotranspiration during winter (groundwater recharge period)

➔ Drier summer + wetter winters → How does this translate for groundwater resources ?