Evaluation and modelling of the impact of drought on groundwater reserves in Wallonia in the context of climate change

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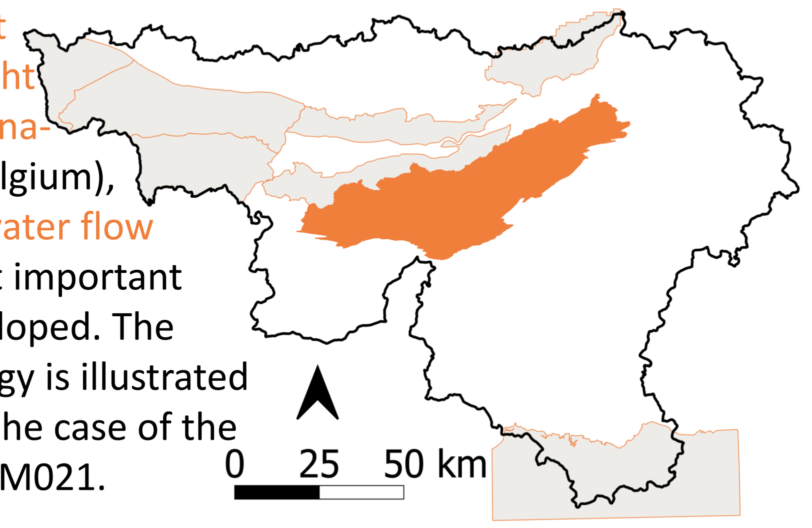
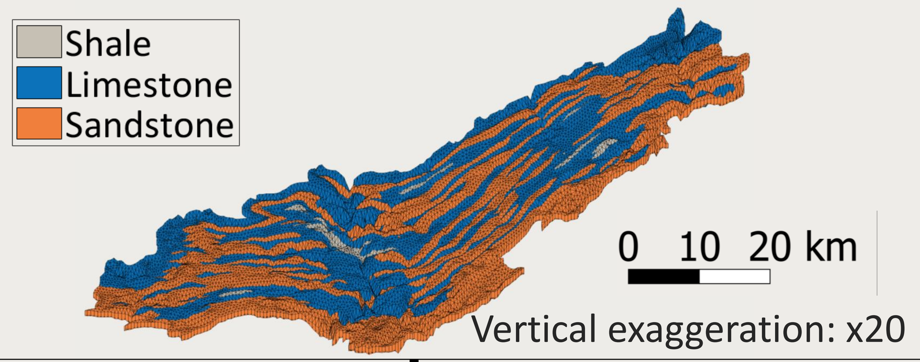
MOTIVATION & CONTEXT

To study the impact of prolonged drought on groundwater dynamic in Wallonia (Belgium), 8 regional groundwater flow models of the most important aquifers were developed. The general methodology is illustrated hereafter through the case of the regional model RWM021.



GENERAL METHODOLOGY

Model conception & data input:
Geometry, parameters, stress factors, BCs



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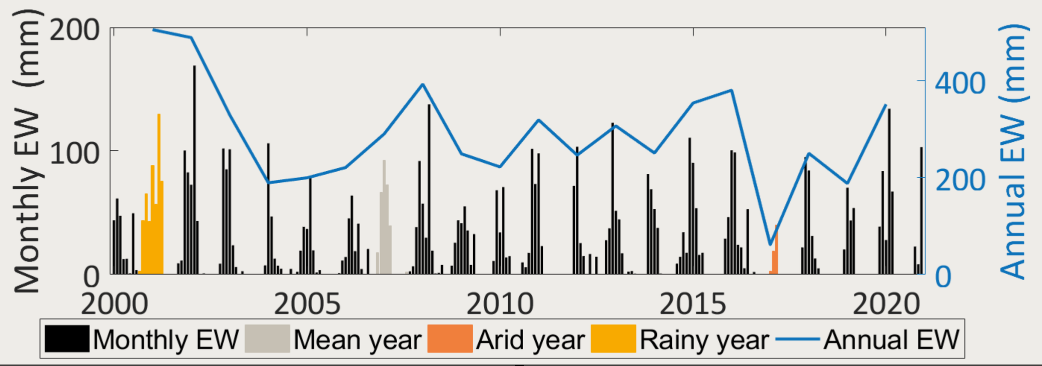
Calibration in steady & transient state (2000-2020) based on historical data



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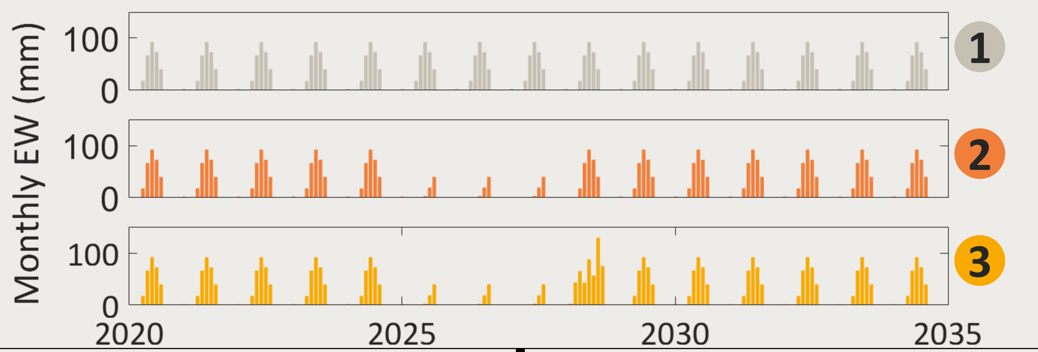
Simulation of Effective Water (EW) scenarios computed from observed mean, arid and rainy year



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Analysis for conclusion
Part A - Based on piezometric evolution
Part B – Based on groundwater budgets

Part A - INTERPRETATION BASED ON PIEZOMETRIC EVOLUTION

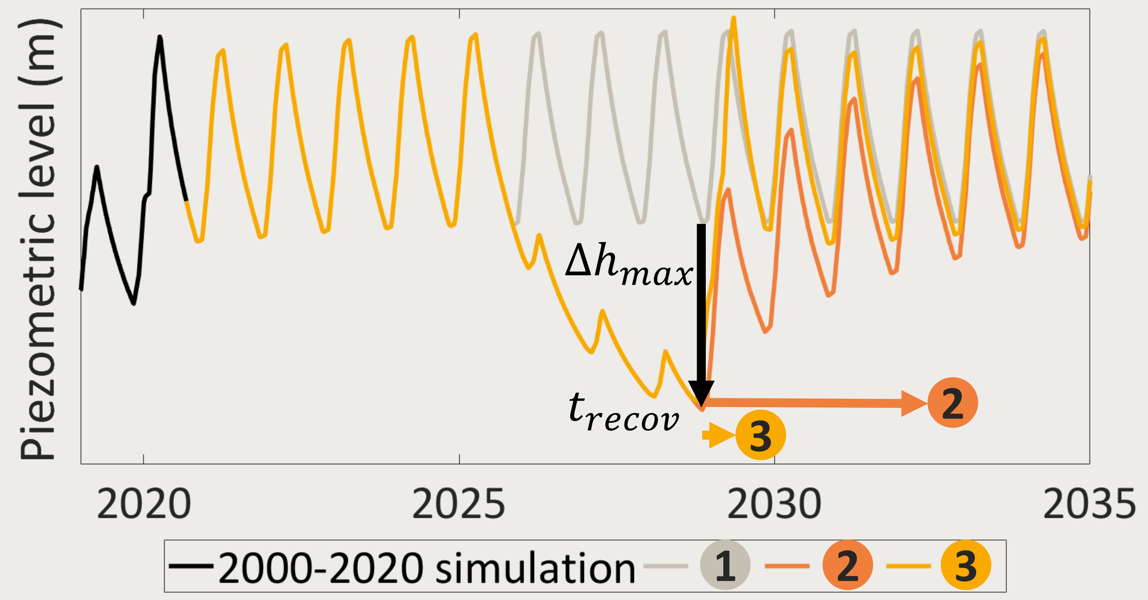
Comparison with scenario 1 in terms of piezometric drawdowns for each node:

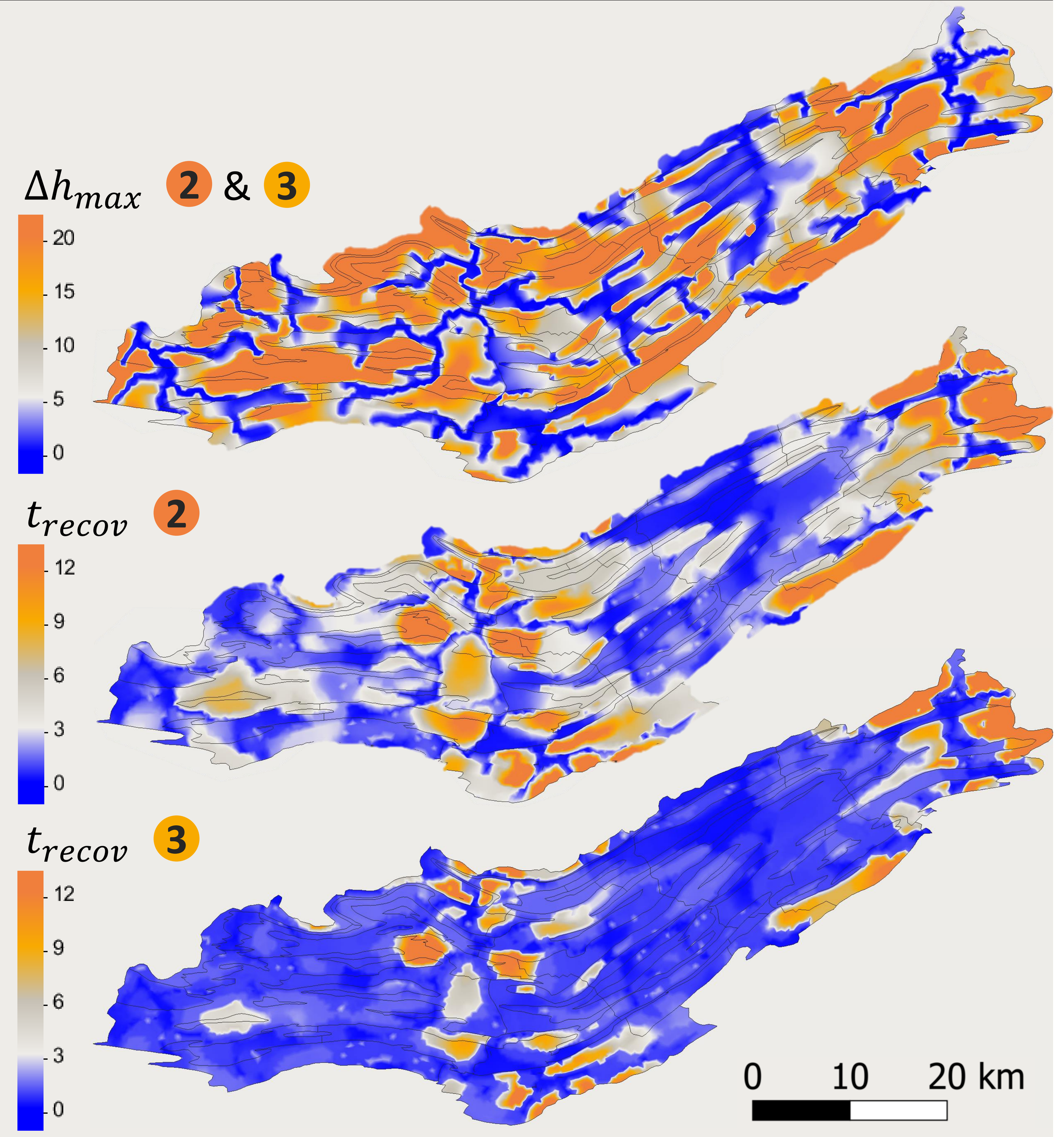
$$\Delta h_{max} = max(\{\Delta h(t)|t\})$$

Computation of the time necessary to partially recover from maximal drawdown for each node:

$$\Delta h(t_{10\%}) = 0.1\Delta h_{max}$$

$$t_{recov} = t_{\Delta hmax} - t_{10\%}$$





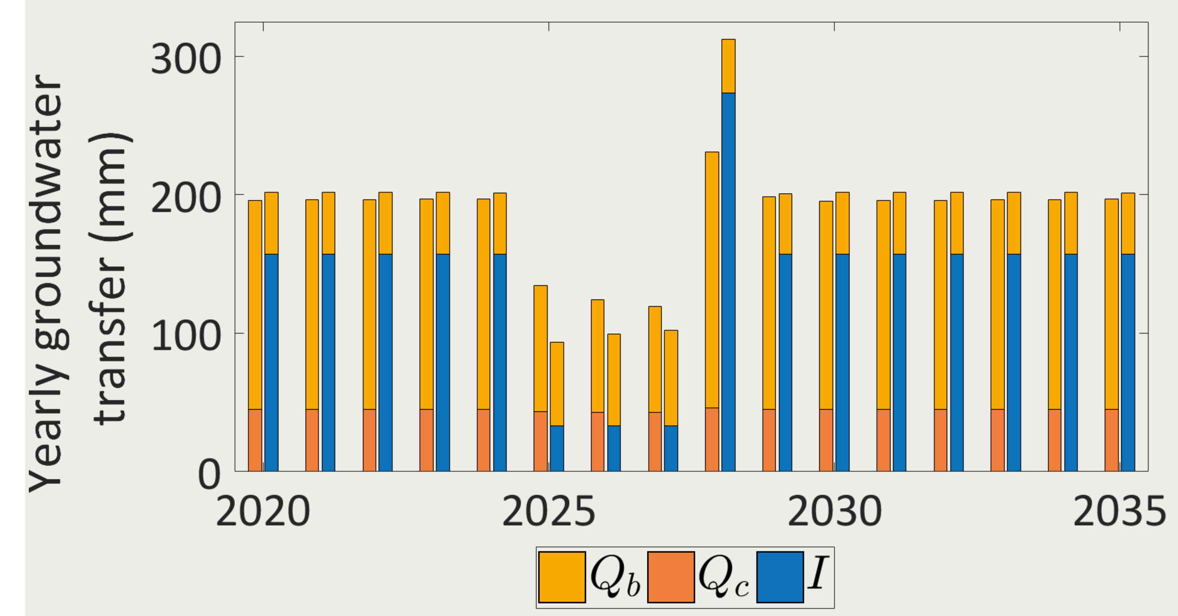
A - KEY RESULTS & DISCUSSION

- Δh_{max} & t_{recov} together bring a better understanding of the expected spatial dynamic of the groundwater levels influenced by droughts.
- Results dependent on physical properties of the aquifer, its interactions with rivers and groundwater catchments.
- t_{recov} strongly influenced by the intensity of the recharge following meteorological droughts.
- Identification of groundwater catchments possibly at risk in case of prolonged drought. However, this needs to be confirmed with smaller scale models, potentially using these regional models to define local boundary conditions.

Part B - INTERPRETATION BASED ON GROUNDWATER BUDGETS

Comparison of groundwater fluxes flowing in and out of the regional model through rivers (Q_b), adjacent aquifers (Q_{gw}), catchments (Q_c) and infiltration (I) in scenario 3

Computation of physically based indicators to quantify the expected evolution of water transfers caused by prolonged drought followed by exceptionally intense recharge



Indicator	Symbol	Formula	Description
INTRINSIC	I_{gw}^1	I/EW	Infiltration index
	I_{sw}^1	R/EW	Run-off index
	I_{gw}^2	Q_{gw}/I	Subsurface drainage with neighboring aquifers
	I_{sw}^2	Q_b/I	Drainage through rivers
	BFI	Q_b/Q_T	Base flow index
PRESSURE	P_1	Q_c/EW	Groundwater abstraction index vs effective water
	P_2	Q_c/I	Groundwater abstraction index vs infiltration
	P_3	$Q_c/(Q_c+Q_T)$	Groundwater abstraction vs streamflow

(Briers et al., 2016)

B - KEY RESULTS & DISCUSSION

- The flow budget perspective brings a better understanding of the expected evolution of groundwater fluxes between the aquifer and its rivers, its neighbours and its catchments caused by a change of infiltration.
- Results dependent on types of boundary conditions implemented to represent the different interfaces.
- Evolution of indicators in time express shifts in behaviour of groundwater fluxes.
- Possible tool for decision making in terms of sustainable exploitation as pressure indicators quantify the anthropic activity on groundwater resources.

OVERALL CONCLUSION & OUTLOOK

- Two complementary physically based approaches were implemented. The piezometric evolution approach brings a better understanding in terms of groundwater level dynamics throughout the aquifer whereas the groundwater budget approach quantifies the general fluxes at the regional scale. Used together, they might constitute a tool to make exploitation plans more resilient to drought.
- The same methodology applied to more complex scenarios, based on the expected evolution of recharge with climate change and the evolution of water demand, increasing with demographic evolution and in the case of drought, might bring new insights to make the exploitation of groundwater resources more sustainable.

ACKNOWLEDGEMENT

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Briers, P., Orban, P., Brouyère, S., 2016, Délivrable D4.1 Développement d'indicateurs des interactions entre eaux souterraines et eau de surface, Caractérisation complémentaire des masses d'eau dont le bon état dépend d'interactions entre les eaux de surface et les eaux souterraines (ESO-ESU), https://hdl.handle.net/2268/195406

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