Modélisation de l'impact d'épisodes de sécheresse sur les ressources en eau souterraine de Wallonie

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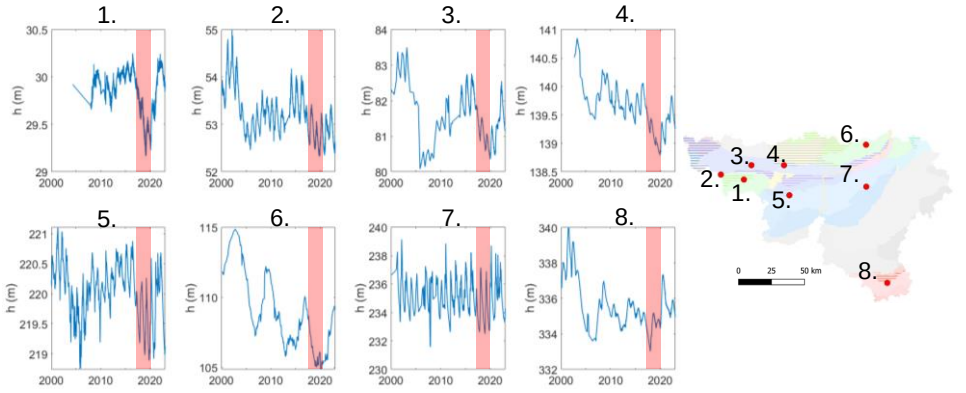
Meteorological context



- Winter drought of 2017 had effect on the piezometric levels in Wallonia
- Climate change is expected to induce longer drought periods

Objectives

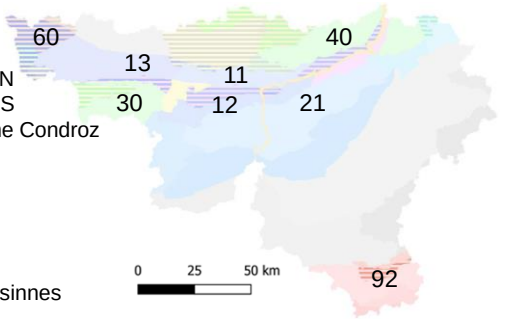
- Funded by SWDE and AWAC in the context of the SRRE 2.0
- Development of groundwater models at the regional scale of groundwater bodies to predict the impact of droughts on groundwater resources

From previous models

- RWM011 limestone of the Meuse basin N
- RWM012 limestone of the Meuse basin S
- RWM021 limestone and sandstone of the Condroz
- RWM040 Cretacean of the Geer basin
- RWE060 limestone of Tournai-Lille

From « scratch »

- RWE013 limestone of Soignies – Ecaussinnes
- RWE030 chalk of the Haine
- RWM092 Sinemurian of the belgian Lorraine



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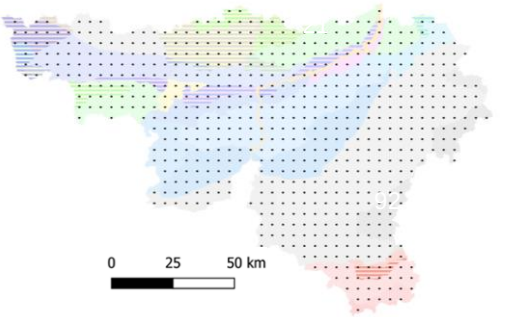
Groundwater modelling: Construction

- Model discretization (mesh/grid, boundary conditions (recharge, rivers,…))
- Model calibration on the period 2000-2020

-> Two types of data input :

- Meteorological data (IRM)
- Groundwater abstraction rates (Region)



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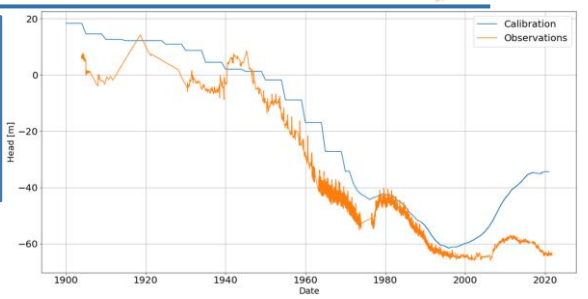
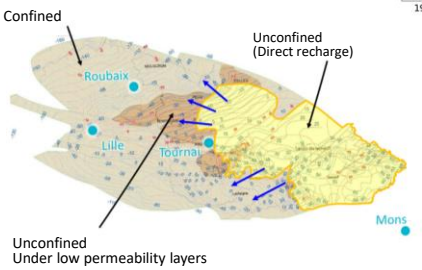
Groundwater modelling: RWE060

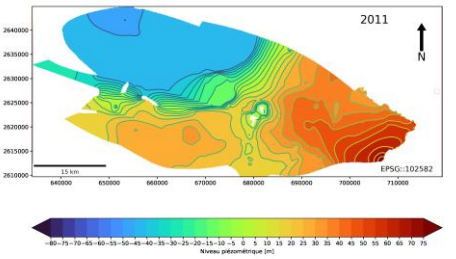
Transboundary carboniferous limestone aquifer

M.A.R.T.H.E modelling software

The model is calibrated over 100 years (1900-2010) with 30 piezometric timeseries and 3 hydrographs



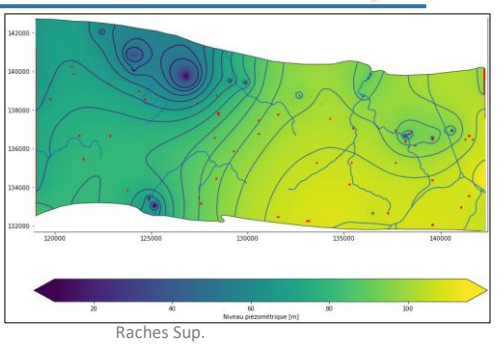




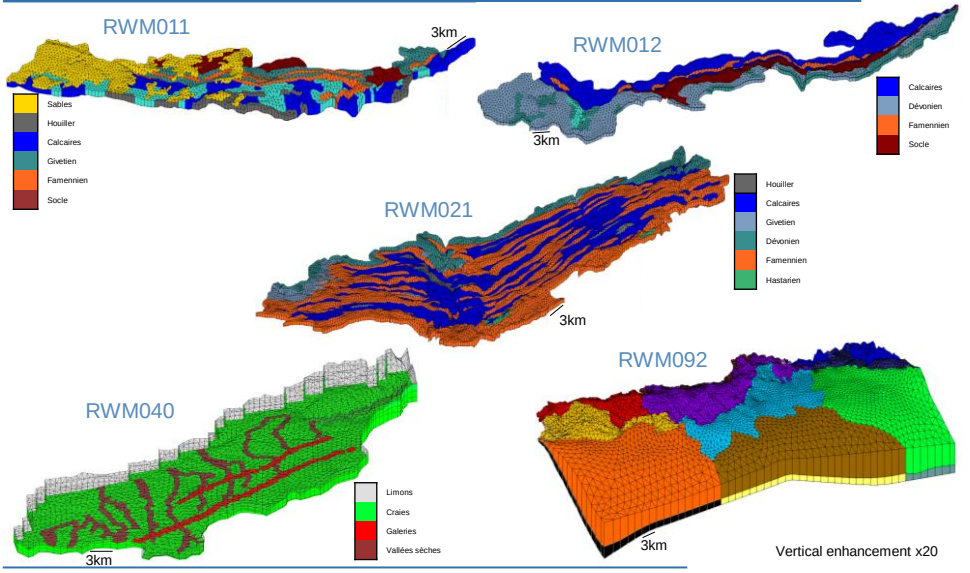
Groundwater modelling: RWE013

Carboniferous limestone aquifer of Soignies - Ecaussinnes

- Modelling process done with Modflow6 using Flopy.
- Calibration process done with PEST++.
- The model is calibrated over 20 years (2000-2020) with 12 piezometric timeseries and 4 quarries dewatering timeseries.



Groundwater modelling: Mesh



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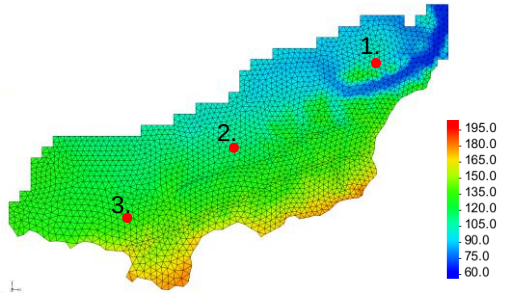
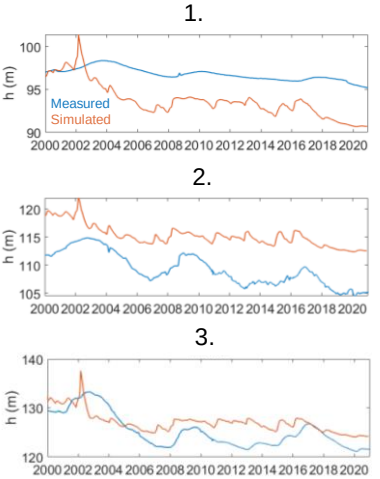
Groundwater modelling: SUFT3D

- Saturated Unsaturated Flow and Transport 3D with finite element

	Size (km^2)	Elements	Extraction rate	Piezometers	Limnimetric stations
RWM011	421	5866	45	16	4
RWM012	463	5987	52	25	5
RWM021	465	19319	185	30	25
RWM040	1747	19960	172	30	4





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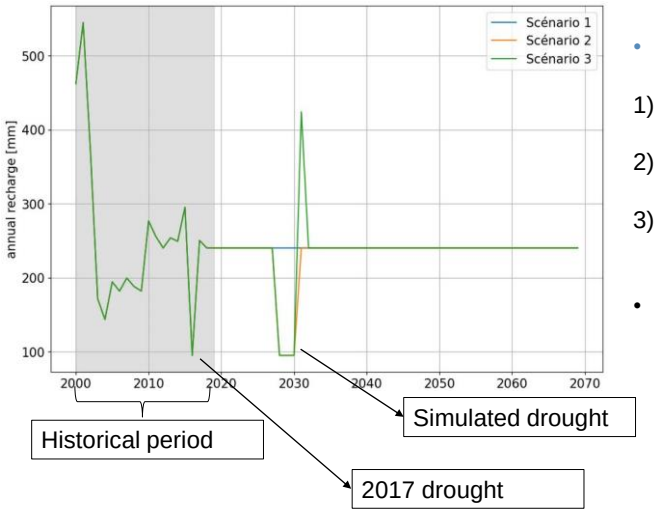
Meteorological scenarios



- 3 recharge scenarios:

1) mean recharge only
2) 3 dry years
3) 3 dry +1 wet year

- Pumping = mean values between 2015 and 2020

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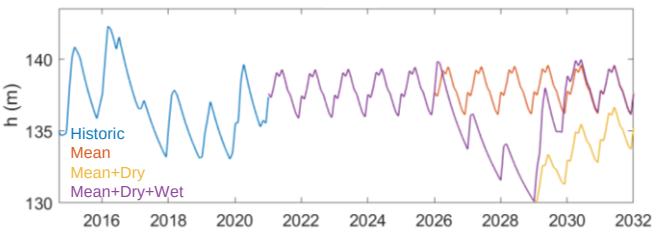
Types of results and interpretation

- Impact of droughts can be studied:

1) Evolution of piezometric level and recovery time



2) Hydrogeological balance and evolution of the reserve

$$P + Q_{esoin} = ET + Q_{esoout} + Q_b + \mathrm{Q_c} + \Delta\mathrm{Res} + \varepsilon$$

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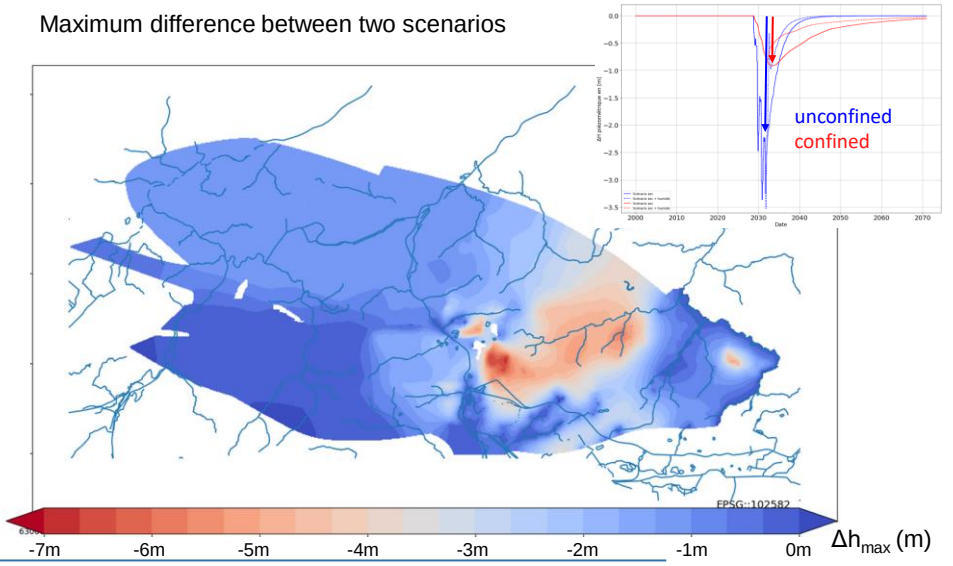
Piezometric levels: Δh_{max}

Maximum difference between two scenarios



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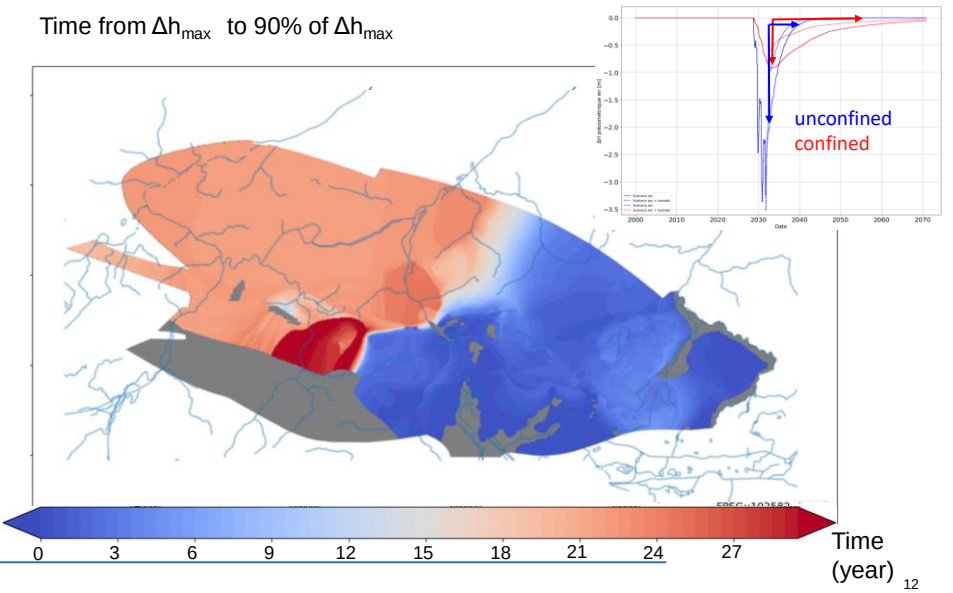
Piezometric levels: $t_{recovery}$

Time from Δh_{max} to 90% of Δh_{max}



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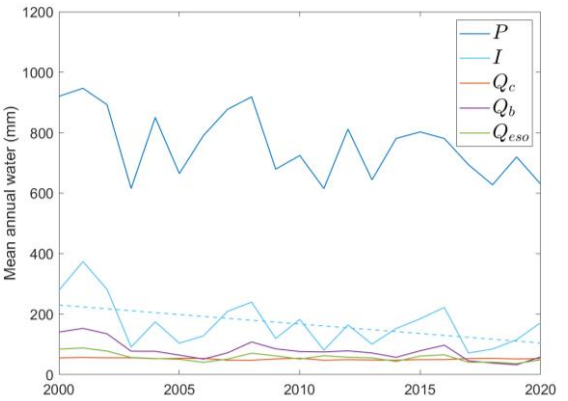
Groundwater budgets: Balance

- Balance computed from:

1) Infiltration
2) Groundwater abstraction rates
3) River conditions
4) Boundary conditions



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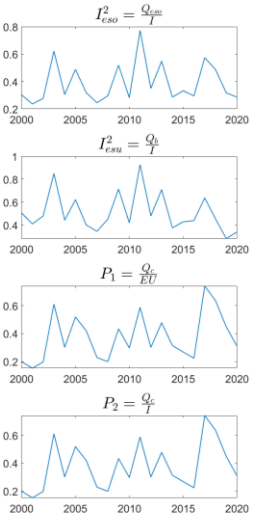
Groundwater budgets: Indicators

Indicator	Symbol	Formula	Description	RWM040 (/)
Intrinsic	I^1_{ESO}	I/EU	Infiltration index	1
	I^1_{ESU}	R/EU	Run-off index	-
	I^2_{ESO}	Q_{ESO}/I	Subsurface drainage with neighboring aquifers	0.34
	I^2_{ESU}	Q_B/I	Drainage through rivers	0.47
	BFI	Q_B/Q_T	Base flow index	0.92
Pressure	P_1	Q_C/EU	Groundwater abstraction index vs effective water	0.3
	P_2	Q_C/I	Groundwater abstraction index vs infiltration	0.3
	P_3	Q_C / (Q_C+Q_T)	Groundwater abstraction vs streamflow	-

Briers et al, 2016



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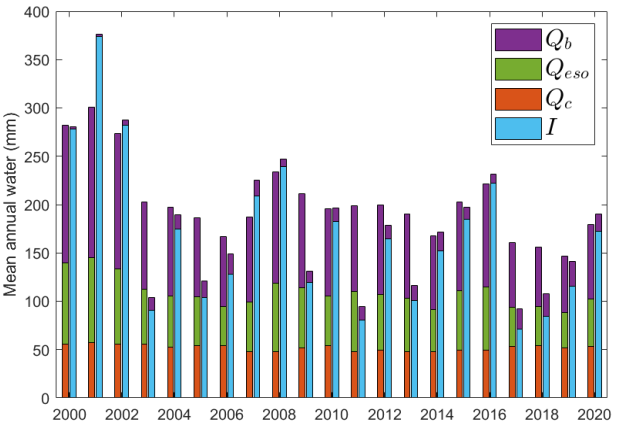
Groundwater budgets: In/out

- Comparison between:

1) Water entering the model through infiltration, rivers and other aquifers

2) Water exiting the model through extraction, rivers and other aquifers

- Annual variation of reserve ≈ difference between in and out



Conclusion and perspective

Conclusions

- Models allow to evaluate the impact of droughts in terms of piezometric level and groundwater reserves at a regional scale
- Droughts induce variable piezometric impact and recovery times
- Impact may appear acceptable for individual drought but become critical for successive repeated events
- Models already integrate a decreasing trend by using recent meteorological data

Perspectives

- Coupling winter droughts with increase of water demand in summer
- Modeling with latest climate change predictions

Thank you for your attention

BON APPÉTIT

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