Combination of regional modelling and in-situ data analysis for groundwater assessment in the Mediterranean region

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PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

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ABSTRACT #22

1. INTRODUCTION AND MOTIVATION

- The Mediterranean region is well-known as a data-scarce region.
- Groundwater is considered as a strategic freshwater reserve; however, its status remains poorly characterized and its total budget uncertain.
- Large-scale modelling has shown to be a beneficial tool to understand the challenges of climate change impacts on groundwater availability and to test the efficiency of implementing science-based adaptation and mitigation options.
- Groundwater modelling has moved from local to regional/global scale, offering insights into the status of data-scarce regions. However, it remains unclear to what extent those models can be used to support management decisions.

2. RESEARCH OBJECTIVE

- This study aims to evaluate the performance of three global gradient-based groundwater models to represent the steady-state of groundwater levels in the Mediterranean region using ensemble-models (de Graaf et al., 2015, Reinecke et al., 2019 , Fan et al., 2013),
- To advance our understanding of large-scale groundwater modeling, which in turn can be an important tool for an improved groundwater resources management by using modelling as means for predicting the effect of climate change and anthropogenic pressures on groundwater levels in data-scarce regions.

3. MODELS' DESCRIPTION

Description of the selected models

- Three global gradient-based groundwater models are currently available and suitable for regional scale application (de Graaf et al., 2015; Fan et al., 2013; Reinecke et al., 2019). These models are introduced briefly below and Table 1, is presenting the main characteristics of each model (modified from Reinecke et al., 2020).

Input data	de Graaf et al. (2015)	G³M	Fan et al. (2013)
Spatial resolution	6′ (~10 km)	5′ (~10 km) 30″	30″ (~900 m)
Timescale	Steady-state or transient	Steady-state or transient	Steady-state
Surface elevation	30″ DEM from HydroSHEDS	Avg. of 30″ DEM	Avg. of 30″ DEM
Conductivity data	GLHYMPS 1.0 (Gleeson et al. 2014)	GLHYMPS 2.0 (Huscroft et al. 2018)	Global lithology (Hartmann and Moosdorf 2012)
Aquifer thickness	Calibrated	200 m	Infinite
Layers	2	2	1
Groundwater recharge	Simulated long-term averages PCR-GLOBWB (1960-2010)	WaterGAP mean (1901–2013)	Simulated mean of annual recharge multiple GHMs (1961-1990)
Surface water body location	In almost every cell	In every cell	No surface water
Calibrated	Manual	No	Manual
Software	MODFLOW	G³M-f	unnamed

4. METHODOLOGY

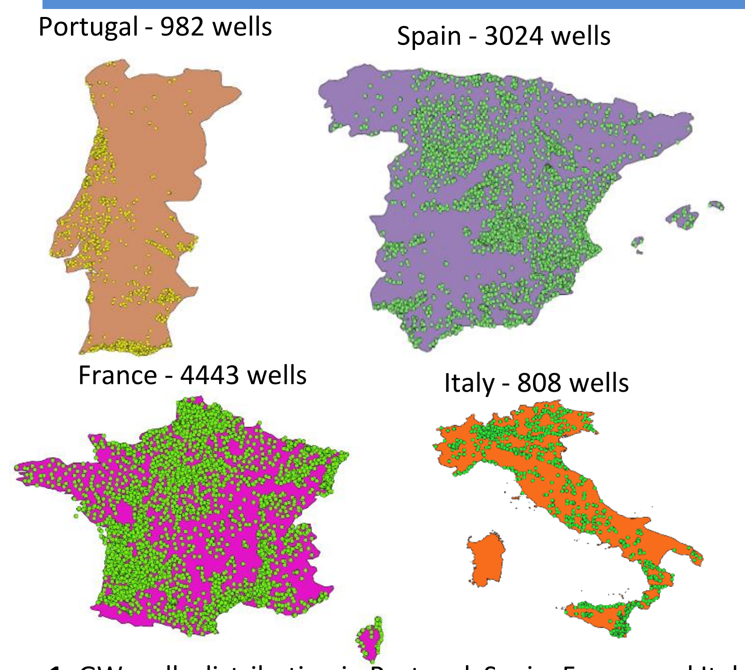

Figure 1: GW wells distribution in Portugal, Spain, France and Italy.

✓ Time series from all Spain, Portugal and France as well as some wells in Greece and Tunisia were collected.

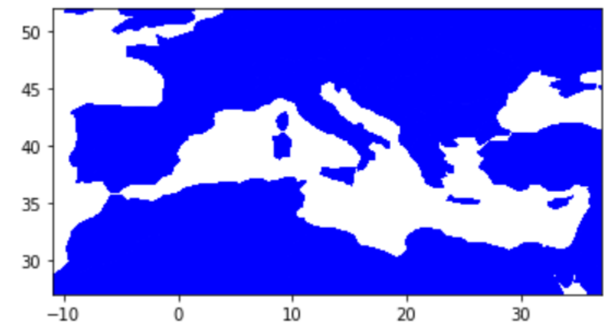

Figure 2: The MED grid with **4.44 km**

✓ The comparison between the three models has been done by aggregation to a rectangular grid that covers the Mediterranean region; with spatial resolution of 4.44 km.

5. EXPLANATORY VARIABLES

Karstic map of the MED (Derived from the World Karst Aquifers Mapping project WHYMAP (WOKAM, Chen et al., 2017) shows that, 41% of the Mediterranean contains karstifiable rocks and Continuous Carbonate Rocks.

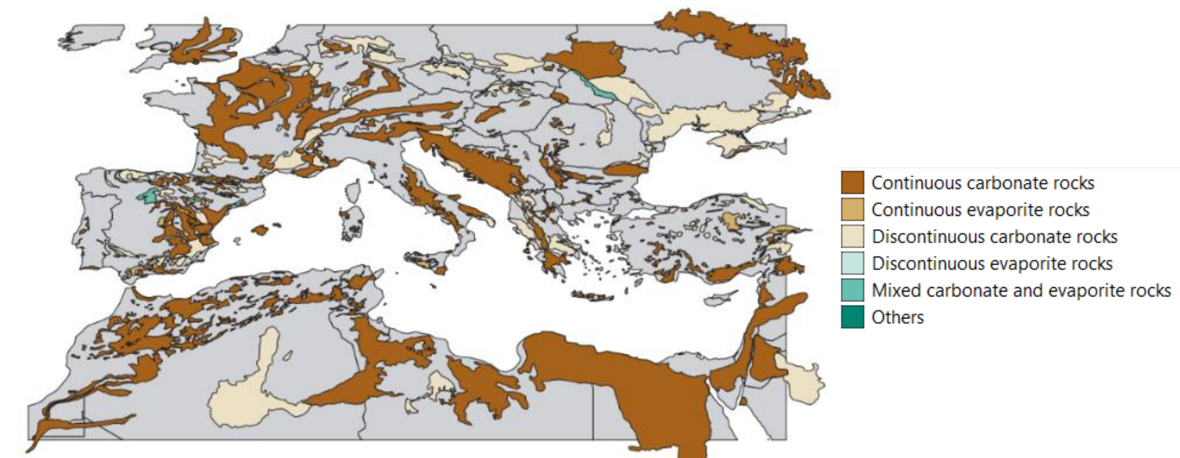

Figure 3: Karstic map of the MED (Derived from the World Karst Aquifers Mapping project WHYMAP (WOKAM) (Chen et al., 2017))

6. PRELIMINARY RESULTS

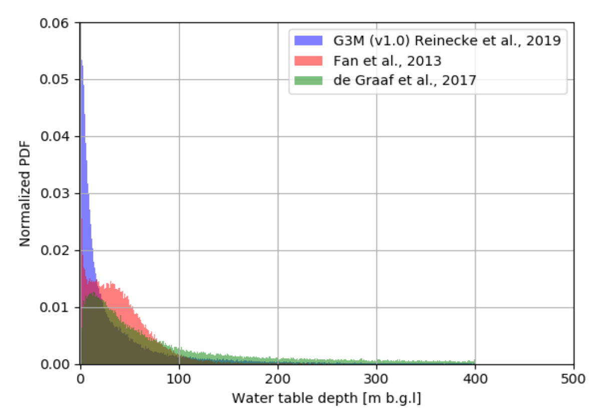

Figure 4: Histograms of the three compared models.

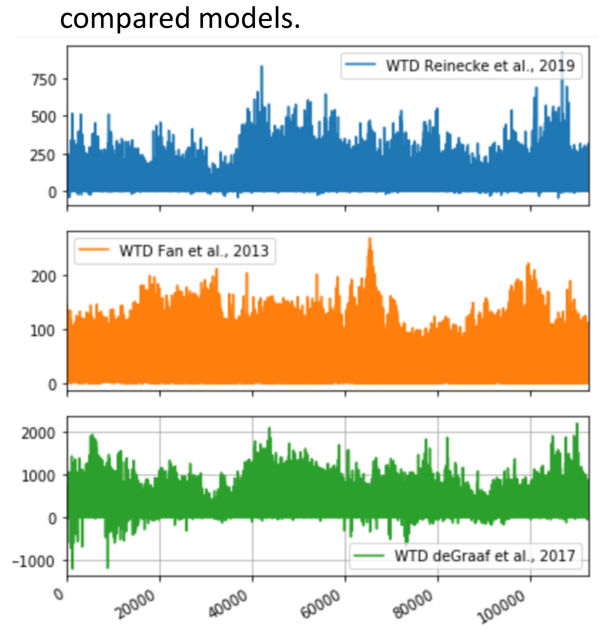

Figure 5: Inter-comparison between models' outputs

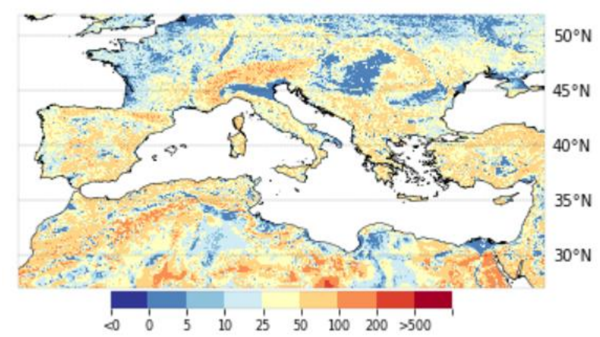

Figure 6: WTD (m b.g.l) Fan et al., 2013.

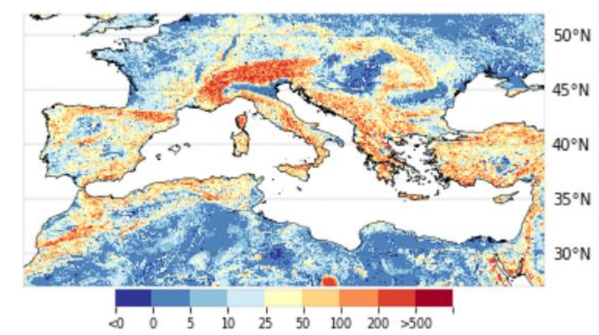

Figure 7: WTD (m b.g.l) G³M, Reinecke et al 2019.

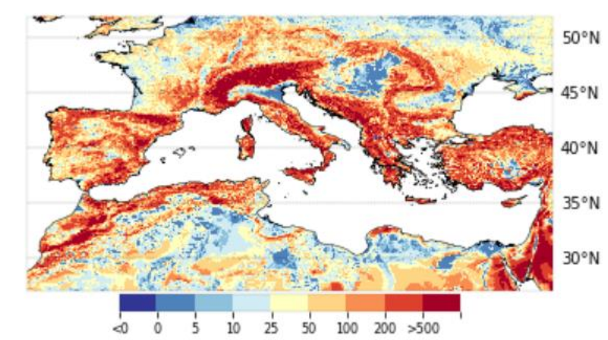

Figure 8: WTD (m b.g.l) de Graaf et al., 2015.

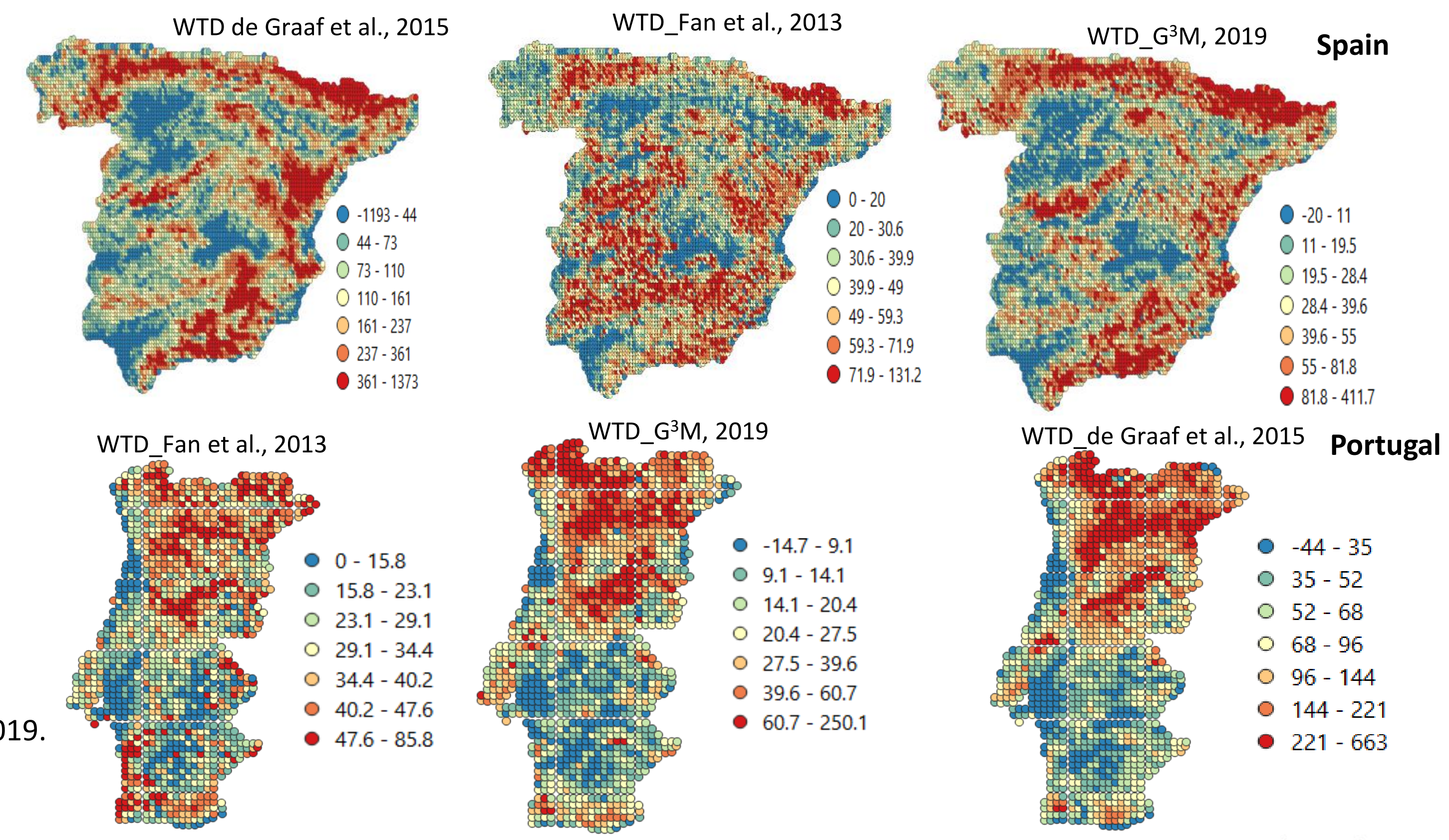

Figure 9: Comparison of the WTD models outputs for Spain and Portugal.

→ Preliminary results showed that there is a big discrepancy between the three compared model outputs.

→ More specifically, the de Graaf et al. (2017) model presents a deeper water table than Reinecke et al. (2019) and Fan et al. (2013).

→ de Graaf et al. (2017) generally shows a greater variability in simulated water table depth.

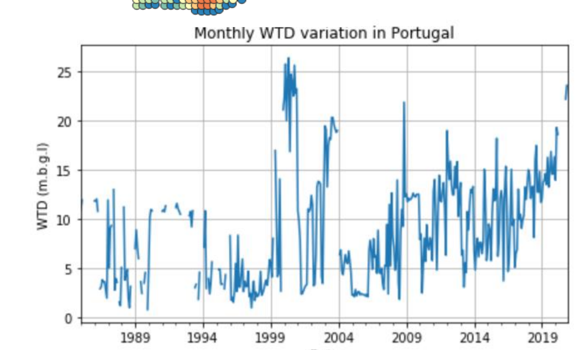

Figure 10: Trend of monthly WTD data for Portugal (982 wells, Fig. 1). Consistently, groundwater depletion is observed since 2005.

7. RESEARCH SIGNIFICANCE and SCIENTIFIC MERIT

✓ We argue that large-scale groundwater modelling is crucial tool to confront the challenges of climate change impacts on groundwater availability and to implement science-based adaptation and mitigation measures in the Mediterranean.

8. FUTURE WORK

✓ Models' outputs will be compared against observations at countries and case studies scales (e.g., Spain, Greece, Crete Island, La Mancha aquifer).

✓ Set-up of G³M (v1.0) in the MED (at steady and transient condition).

REFERENCE

1 Reinecke, R. et al. 2019. Challenges in developing a global gradient-based groundwater model (G³M v1.0) for the integration into a global hydrological model. *Geosci. Model Dev.* 12, 2401-2418.

2 de Graaf, I. et al. 2017. A global-scale two-layer transient groundwater model: Development and application to groundwater depletion. *Adv. Water. Resour.* 102, 53-67.

3 Fan, Y. et al. 2013. Global patterns of groundwater table depth. *Science* 339, 940-943.

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