Categorizing Large-Scale Aquifers of the World

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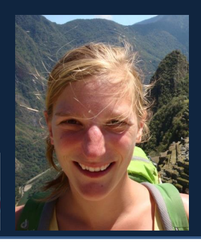

1. PROBLEM DEFINITION

Most global scale hydrological models do not include a groundwater flow component. Nonetheless, groundwater is a crucial part of the global water cycle:

- it satisfies human water needs;
- acts as a buffer water shortage;
- sustains river flows during times of drought;
- sustains evaporation during droughts in areas with shallow water tables.

2. METHODS

We developed a global scale groundwater model representing the upper unconfined aquifer. It simulated an equilibrium groundwater table at its natural state[1].

The model:

- runs at 5 arc- minutes (i.e. 10 km at equator);
- is based on MODFLOW[2], forced with recharge and surface water levels from the land-surface model PCRGLOB-WB[3];
- the aquifer parameterization is made based on available global datasets on lithology[4] and permeability[5], and an estimate of aquifer depths for sediment basins[1].

In the current work, this model is extended by information on confining layers.

Confined and unconfined aquifers are classified:

- using information in the lithological map [4] on grain size of unconsolidated sediments (Figure 4).
- Additionally, the extend of confining layers on coastal aquifers are defined based on terrain characterizations and depths are estimated (Figure 4 and Figure 5).

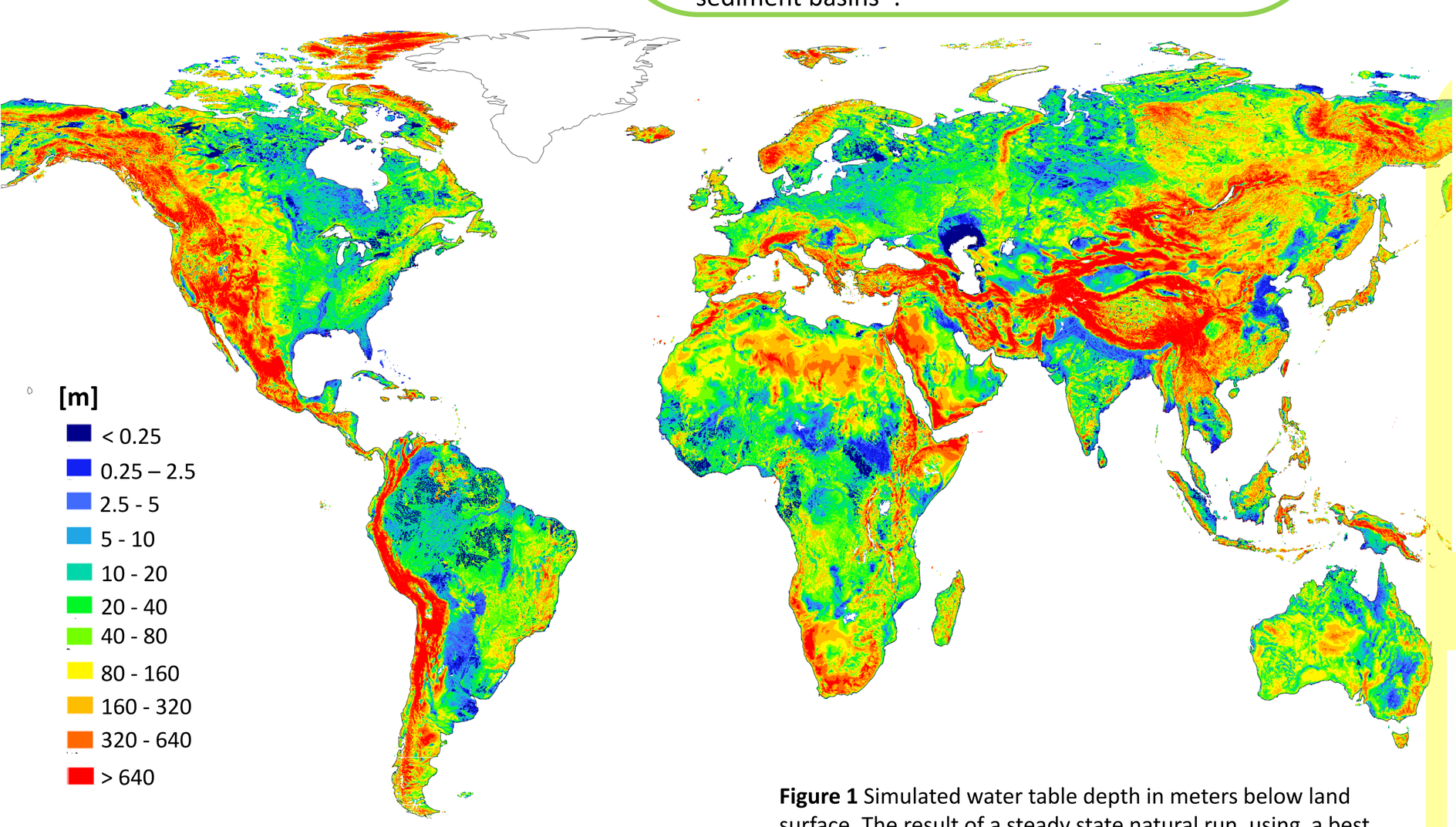

Figure 1 Simulated water table depth in meters below land surface. The result of a steady state natural run, using a best estimated parameter set.

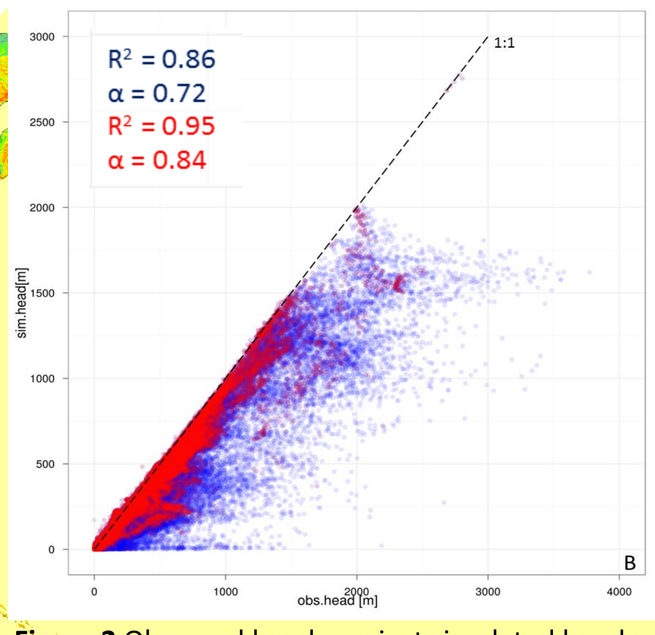

Figure 2 Observed heads against simulated heads. The model performance is better for sediment areas (red) than for mountain ranges (blue)

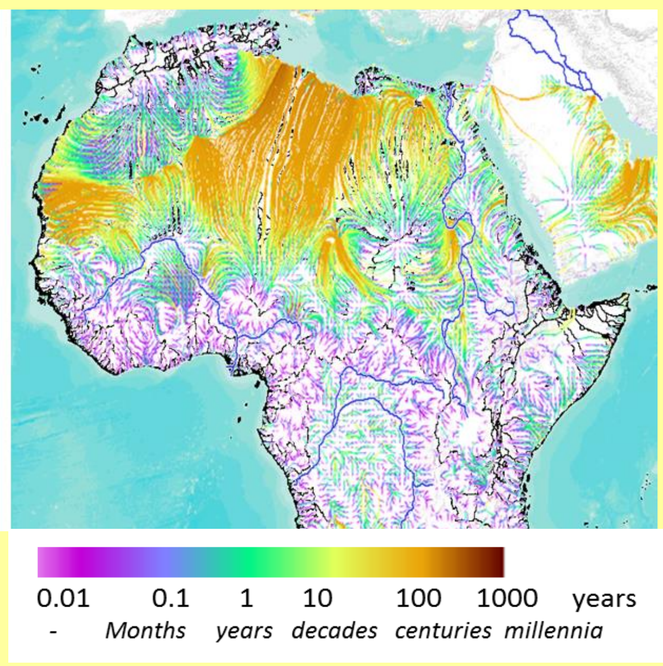

Figure 3 Flow paths simulated for North Africa, underlain by river basin boundaries overlain by major rivers

3. RESULTS

- A realistic global picture of water table depths is simulated within acceptable accuracy in many parts of the world (R^2= 0.85), especially for the major aquifer systems of the world (R^2= 0.95) (Figure 1 and 2).
- Short and long inter-basin flow paths are simulated (Figure 3), which can be important in sustaining river baseflows or act as additional recharge to large aquifer systems.
- The latter confirms the importance to include confined aquifers in the groundwater model.

4. OUTLOOK

This poster shows promising results for future research including:

- a further categorization of aquifer systems;
- transient runs;
- adding human water use and changes in climate;
- full coupling of the groundwater model to the land-surface model PCRGLOB-WB.

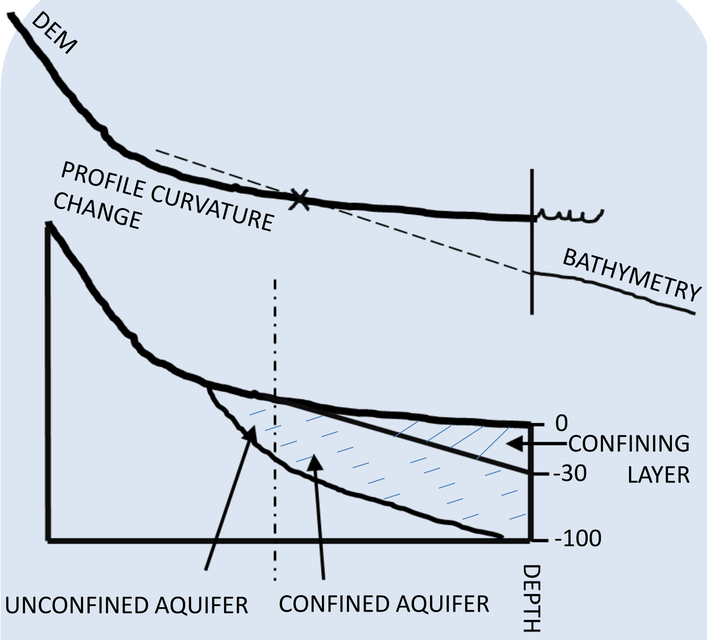

Figure 5 2-Dimensional schematic coastal confined aquifer classification using profile curvature criteria the estimate spatial expansion of the coastal aquifer. Sea level rise is used for estimation of thickness of the confining layer.

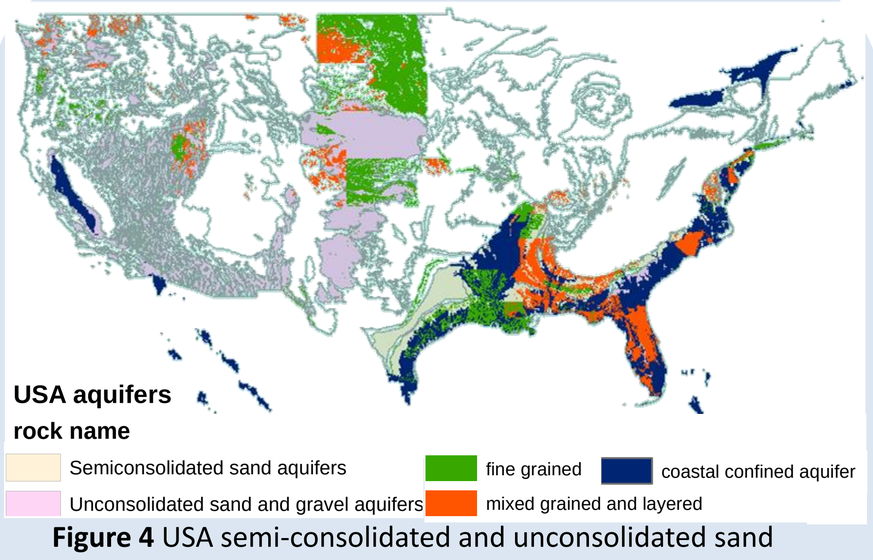

Figure 4 USA semi-consolidated and unconsolidated sand aquifers overlain estimate of coastal confined aquifers, overlain with lithological map for units *fine grained unconsolidated sediments* and *mixed grained unconsolidated sediments* and confining layers.

REFERENCES
[1]De Graaf *et al. (*2014) A High Resolution Global Scale Groundwater Model, HESSD, 11, 5317-5250
[2]McDonald and Harbaugh (2000) MODFLOW-2000, the U.S. Geological Survey modular ground-water model- User guide to modularization concepts and the ground-water flow process. U.S. geological Survey.
[3]van Beek *et al.* (2011) Global monthly water stress: 1. Water balance and water availability, *Water Resource Research.*
[4]Hartmann and Moosdorf (2012) The new global lithological map database GLiM: A representation of rock properties at the earth surface, *Geochemistry, Geophysisc, Geosystems.*
[5]Gleeson *et al.* (2011) Mapping permeability over the surface of the Earth, *Geophysical Research letters.*