Global groundwater depletion map [10 km]

Towards a global land subsidence map

Universiteit Utrecht

Deltares
Enabling Delta Life

Edwin Sutanudjaja & Gilles Erkens *(✉: e.h.sutanudjaja@uu.nl)*

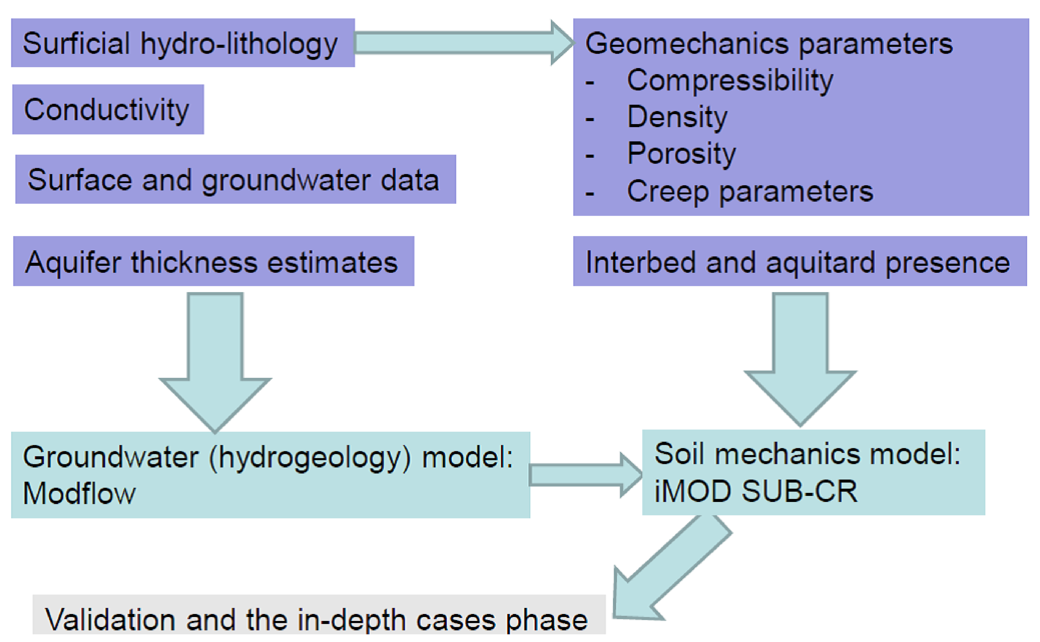
Overview

Land subsidence is a global problem, but a global land subsidence map is not available yet. Such map is crucial to raise global awareness on land subsidence, as it causes extensive damage (probably in the order of billions of dollars annually). Additionally, with a global land subsidence map, relative sea level rise predictions may be improved, contributing to more accurate global flood risk calculations.

We aim to produce a global land subsidence map that is derived from numerical model calculations. In this way, we are able to introduce a temporal component showing both historical and predicted future land subsidence under different development scenarios.

Methodology

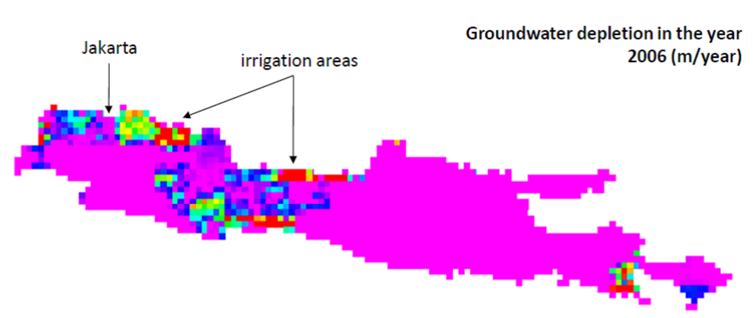
The integrated hydrological and water resources model, PCR-GLOBWB, serves as the starting point. PCR-GLOBWB simulates discharge and groundwater recharge, as well as surface water and groundwater abstraction rates. The latter are estimated internally within the model based on the simulation of their availabilities and demands for irrigation and other sectors. The PCR-GLOBWB output is then used to force MODFLOW resolving groundwater head dynamics. The simulated head changes are input to a land subsidence model, iMOD-SUB-CR.



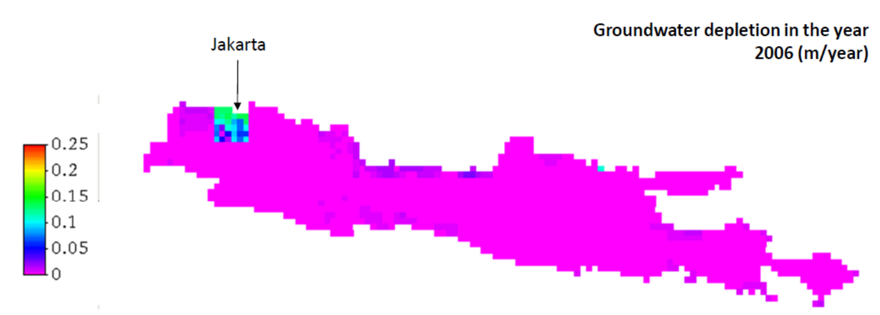
Current progress

The world map shows the rates of groundwater depletion, i.e. the abstraction not being replenished by recharge, as simulated by PCR-GLOBWB. This result matches known areas of subsidence and groundwater extraction, such as urban areas in the western half of Taiwan, the cities of Bangkok, Jakarta, Sacramento, and Mexico City. It also captured agricultural area with strongly depleted aquifers, such as the North China Plain, the Indus Basin, and the High Plain and Central Valley aquifers. These results give confidence in the validity of the model.

Some cities, such as Ho-Chi-Minh City or Albuquerque are, however, missed due to an overestimation of simulated surface water abstraction. On the other hand, the model still calculates a depletion of 3.27 m/yr in San Jose. In reality, surface water is now being imported from elsewhere and is partly used for recharging the aquifer systems.



Initial depletion (m/yr) results as calculated by the global hydrology model for Java. It misses known depleted urban areas, such as Jakarta.



Revised depletion (m/yr) results for Java. It shows the ground water abstraction depletion in Jakarta and te depletion in the irrigation areas is now minor.

First land subsidence results (1958-2010) from the global model. Red areas are karst areas and the modeled subsidence (> 2 meters) is a model artifact. Urban areas are captured by the model, although subsidence rates (50-60 cm) are underestimated.