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Modeling falling groundwater tables in major cities of the world

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Groundwater use and its over-consumption are one of the major drivers in the hydrology of many major cities in the world, particularly in delta regions. Yet, a global assessment to identify cities with declining groundwater table problems has not been done yet. In this study we used the global hydrological model PCR-GLOBWB (10 km resolution, for 1960-2010). Using this model, we globally calculated groundwater recharge and river discharge/surface water levels, as well as global water demand and abstraction from ground- and surface water resources. The output of PCR-GLOBWB model was then used to force a groundwater MODFLOW-based model simulating spatio-temporal groundwater head dynamics, including groundwater head declines in all major cities - mainly in delta regions - due to escalation in abstraction of groundwater to meet increasing water demand.

Using these coupled models, we managed to identify a number of critical cities having groundwater table falling rates above 50 cm/year (average in 2000-2010), such as Barcelona, Houston, Los Angeles, Mexico City, New York, Rome and many large cities in China, Libya, India and Pakistan, as well as in Middle East and Central Asia regions. However, our simulation results overestimate the depletion rates in San Jose, Tokyo, Venice, and other cities where groundwater usages have been aggressively managed and replaced by importing surface water from other places. Moreover, our simulation might underestimate the declining groundwater head trends in some familiar cases, such as Bangkok (12 cm/year), Ho Chi Minh City (34 cm/year), and Jakarta (26 cm/year). The underestimation was due to an over-optimistic model assumption in allocating surface water for satisfying urban water needs. In reality, many big cities, although they are located in wet regions and have abundant surface water availability, still strongly rely on groundwater sources due to inadequate facilities to treat and distribute surface water resources.