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The world in 5 minutes - new features of the large scale hydrological model WaterGAP

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We present the first high-resolution global hydrological model, WaterGAP3, operating on a 5 arc minutes spatial grid (approx. 6 x 9 km in Europe) covering the global land area with the exception of Antarctica.
The WaterGAP model (Water - Global Assessment and Prognosis) has been developed at the Center for Environmental Systems Research (CESR) with the aim of providing a basis both for an assessment of the current state of water resources and water use, and for gaining an integrated perspective of impacts of global change on the water sector. WaterGAP consists of two main components: a global water use model and a global hydrology model. The water use model takes into account basic socio-economic factors such as population and GDP on a national level, to estimate water withdrawals and consumptive water uses for the domestic, industry, irrigation, and livestock sectors. The aim of the hydrological model is to simulate the characteristic macro-scale behavior of the terrestrial water cycle in order to estimate water availability. Based on the time series of climatic data, the hydrological model calculates the daily water balance for each grid cell, taking into account physiographic characteristics of drainage basins (e.g. soil, vegetation, slope and aquifer type), the inflow from upstream cells, the extent and hydrological influence of lakes, reservoirs, dams, and wetlands, as well as the reduction of river discharge by human water consumption (as computed by the water use model).
For the current version, WaterGAP3, the spatial resolution has been enhanced, from 0.5° by 0.5° (longitude and latitude) to 5 by 5 arc minutes gridded scale, for two main reasons: First, most model input data for both the hydrological model and the water use model now feature a distinctively higher resolution. Secondly, the WaterGAP framework has recently been extended by a large scale water quality sub-model (WorldQual) in order to determine chemical fluxes in different pathways which allows the combination of water quantity with water quality analysis but requires a considerably higher resolution of the stream network.
Partially enabled by the enhanced spatial resolution, the process representations of runoff formation and runoff concentration in the hydrological model have been substantially improved: (1) the snow routine has been revised by modeling snow dynamics on sub-grid scale (~0.4 x 0.4 km); (2) a module has been added for a dynamic representation of permafrost occurrence, which directly influences groundwater recharge; (3) in order to distinguish between mountainous rivers with steep river bed slopes and rivers in lower regions a variable flow velocity algorithm has been implemented; (4) the river length has been enhanced by applying an individual meandering factor for each grid cell derived from a high-resolution drainage direction map; (5) an approach has been developed which utilizes Köppen regions to estimate potential evapotranspiration and groundwater recharge.
As a last point, dams from the Global Reservoir and Dam Database (GRanD) have been implemented into WaterGAP3 in order to consider anthropogenic flow regulation. Thereby, all dams with a storage capacity higher than 0.1 km^3 have been taken into account and a management scheme according to the algorithm of Hanasaki et al. (2006) has been applied.
We will demonstrate how the aforementioned model revisions affect the simulation of certain components of the hydrological cycle on the basis of selected case studies.

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