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# The global freshwater availability and water use model WaterGAP 2.2d

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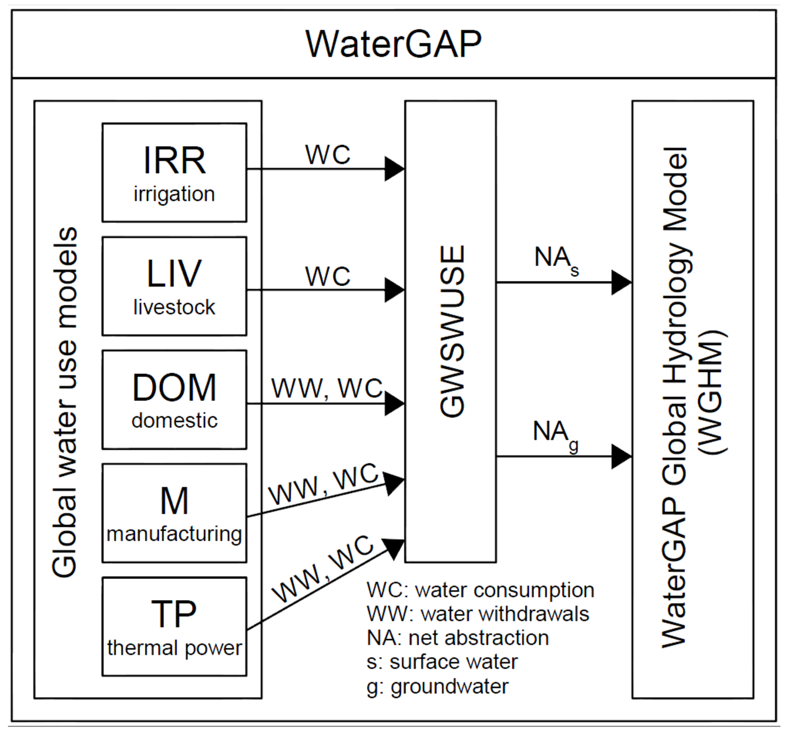
## WaterGAP 2.2d




- Water use and availability model
- 0.5°x0.5°
- Global land area (w/o Antarctica)
- WATCH-CRU-land/ocean mask
- In development since 1996

Fig. 1 The WaterGAP 2 framework with its water use models and the linking module GWSWUSE that provides net water abstraction from groundwater and surface water as input to the WaterGAP Global Hydrology Model (WGHM).

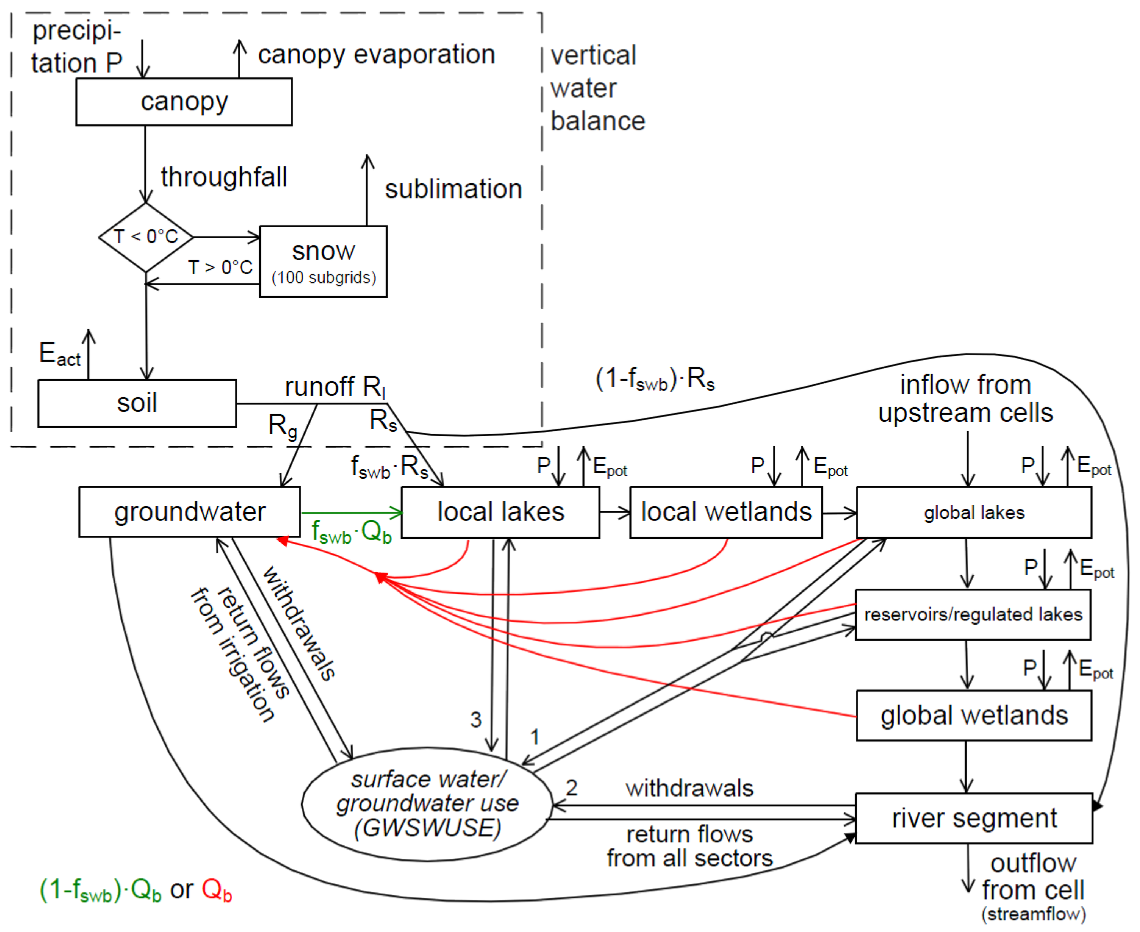
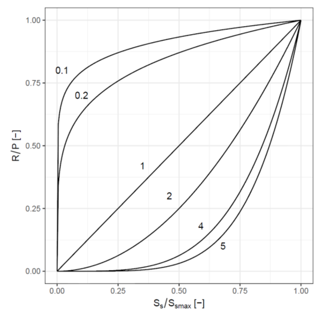



Fig. 2 Schematic of WGHM in WaterGAP2.2d. Boxes represent water storage compartments, arrows represent water fluxes. Green (red) colour indicates processes that occur only in grid cells with humid (semi-arid/arid) climate.

**Some new features in WaterGAP 2.2d:**

- Integration of the historical irrigation dataset (Siebert et al., 2015) in the global irrigation model
- Updated soil water capacity input (Batjes 2012)
- Update of reservoir information and implementing reservoir commissioning years
- New storage-based river velocity algorithm
- Improving soil moisture calculation in semi-arid/arid regions by keeping the calculated groundwater recharge in the soil if specific precipitation threshold is not reached (before it was handled as runoff)
- Improved naturalized runs (disentangling reservoir and human water use effects)
- Reducing the water balance error to $1*10^{-2}$ km$^3$ yr$^{-1}$

## Calibration



$$R_l = P_{eff}\left(\frac{S_s}{S_{s,max}}\right)^{\gamma}$$

- 1319 basins
- GRDC data
- ~54% of land

CS1: adjust parameter $\gamma$ in the limits of [0.1-5] to match $Q_{obs}$ within ±1%.
CS2: as CS1, but within ±10%.
CS3: as CS2 but apply area correction factor (adjusts runoff of each grid cell in a range of [0.5-1.5]) to match $Q_{obs}$ with ±10%.
CS4: as CS3 but apply the station correction factor CFS (multiplies Q at the location of the gauging station by a factor without value limitation) to match $Q_{obs}$ with ±10%.

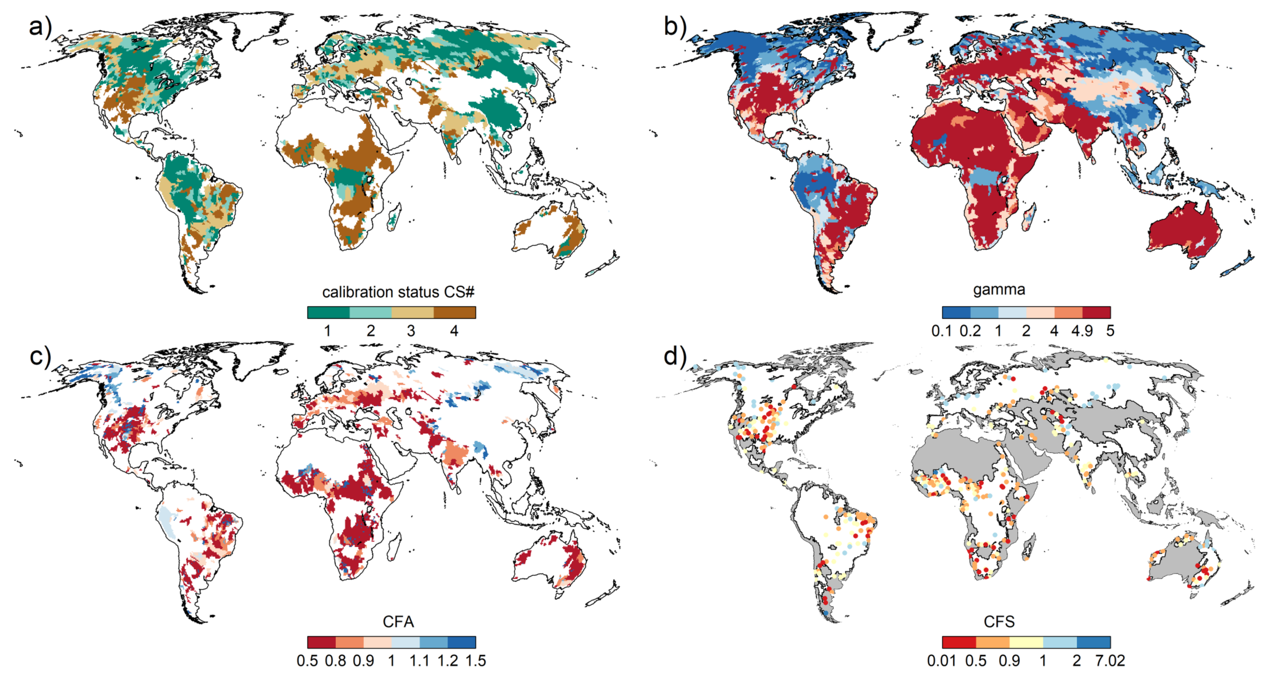



Fig. 3 Results of WaterGAP 2.2d calibration to WFD/WFDEI-GPCC climate forcing with a) calibration status, b) calibration parameter $\gamma$, c) area correction factor CFA, d) station correction factor CFS. Grey areas in d) indicate regions with regionalized calibration parameter.

## Results I

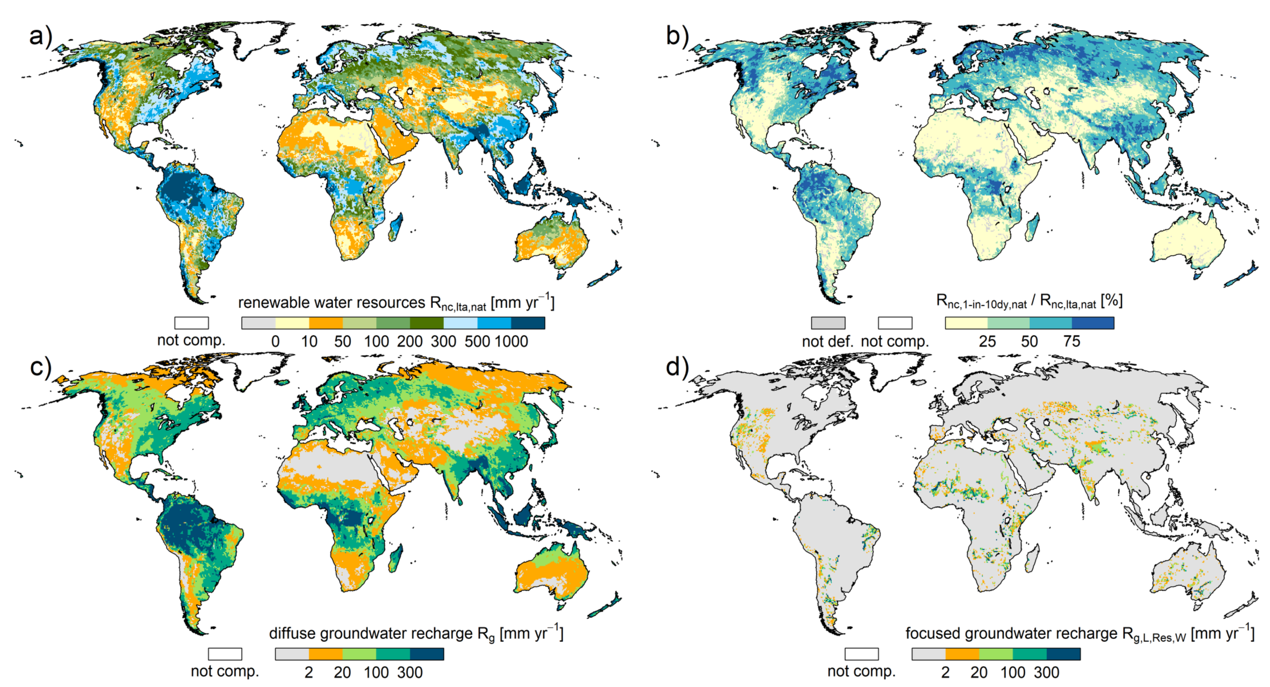


Fig. 4 Water resources assessment 1981-2010 under naturalized conditions. Focused groundwater recharge (d) occurs only in semi-arid/arid grid cells and below lakes, wetlands or reservoirs.

## Results II

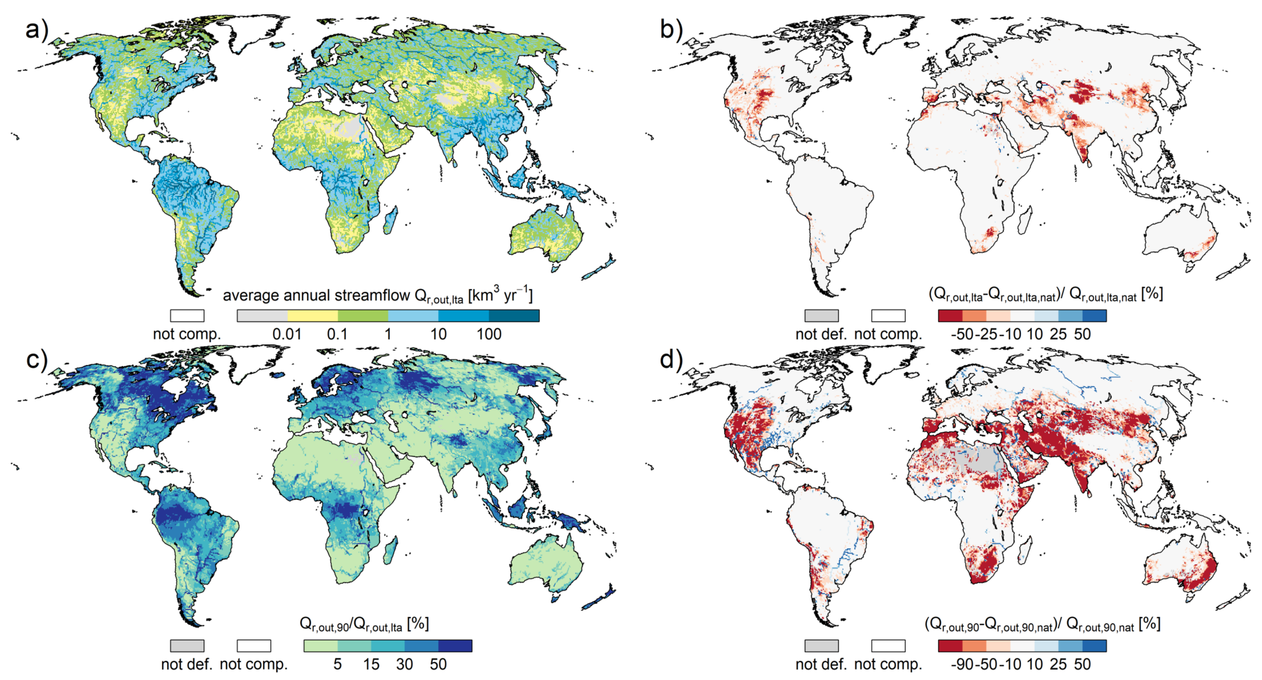


Fig. 5 Streamflow indicators for 1981-2010 with a) long-term average annual streamflow $Q_{r,out,lta}$, b) impact of human water use and man-made reservoirs on naturalized $Q_{r,out,lta,nat}$, c) statistical monthly low flow in percent of $Q_{r,out,lta}$, d) as b) but for statistical low flows.

Tab. 1 Water balance components for given time spans and global coverage (except Antarctica, Greenland) as simulated with WaterGAP 2.2d and a combination of WFD and WFDEI (Weedon et al., 2014)

| Water balance component [km$^3$ yr$^{-1}$] | 1981-2010 | 2001-2016 |
|---|---|---|
| Precipitation | 111616 | 112559 |
| Actual evapotranspiration | 72015 | 72362 |
| Discharge into oceans and inland sinks | 39642 | 40323 |
| Water consumption | 1145 | 1301 |
| Net abstraction from surface water | 1217 | 1348 |
| Net abstraction from groundwater | -72 | -47 |
| Change in total water storage | -41 | -126 |
| Water balance error | 0.11 | 0.01 |

## Evaluation

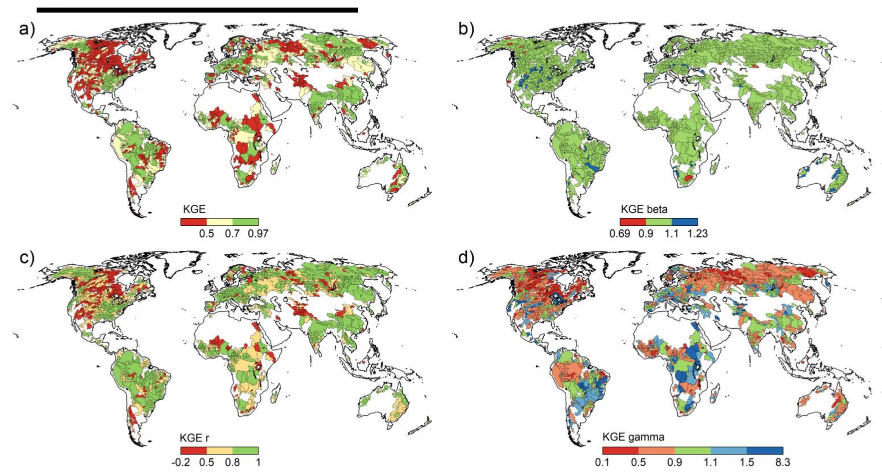


Fig. 6 Kling-Gupta efficiency metrics for the 1319 calibration basins and GRDC data

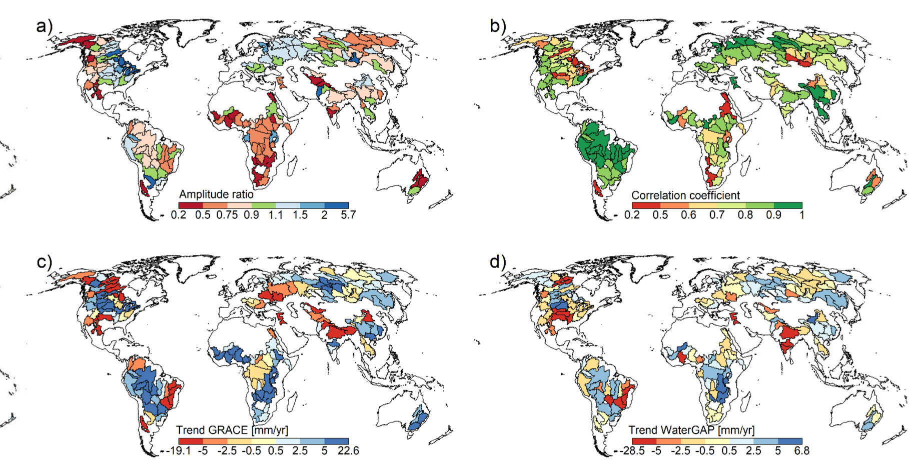


Fig. 7 Comparison of total water storage anomaly with GRACE mascons (JPL, CSR, GSFC)

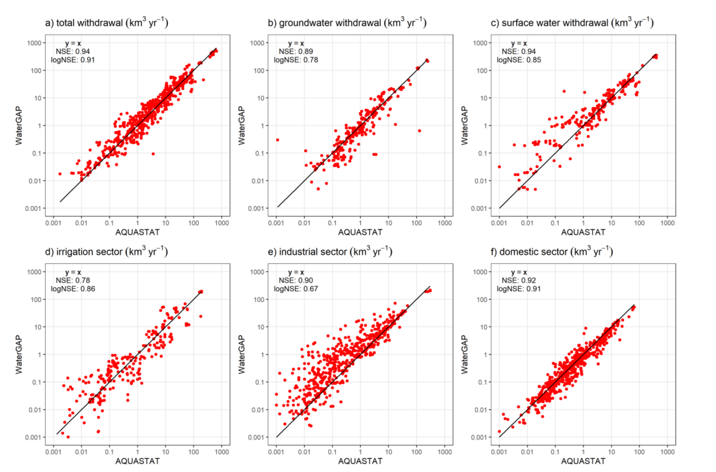


Fig. 8 Comparison of potential water withdrawals with values from AQUASTAT

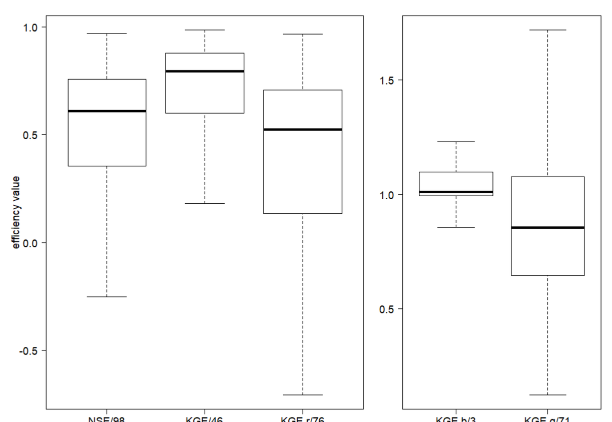


Fig. 9 Efficiency metrics for monthly streamflow at the 1319 GRDC stations. Values outside the 1.5x inter-quartile range are excluded but number of stations that are defined as stations are indicated.

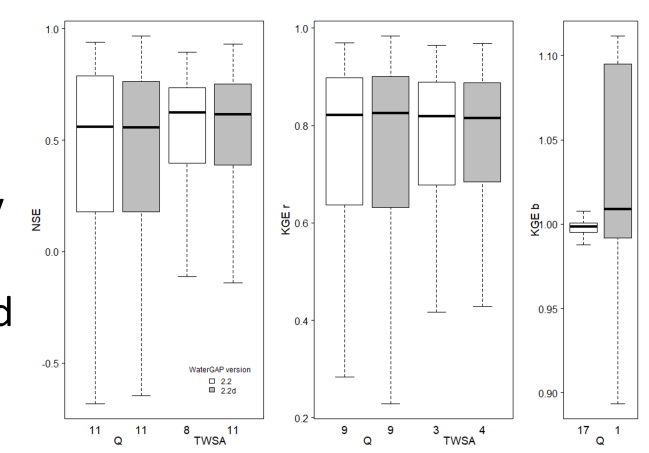


Fig. 10 Comparison of efficiency metrics for streamflow and total water storage anomaly for model versions WaterGAP 2.2 and 2.2d and river basins larger than 200,000 km².

## Availability

A model description paper is in progress (to be subm. to GMD). Model output is available (under CC BY-NC 4.0) on request to (hydrology@em.uni-frankfurt.de) and soon available via https://www.pangaea.de

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WaterGAP