

Introducing HydroPy, an updated global hydrology model rewritten in Python

Additional material for EGU21-3928



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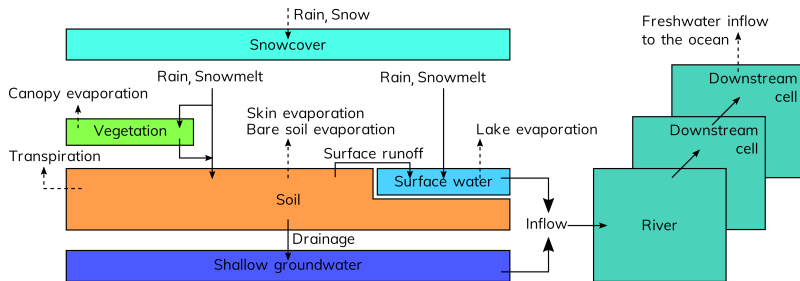
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Summary

- we rewrote the MPI-HM, a global hydrological model, from scratch because it became increasingly difficult to implement new processes and maintain its source code
- the new version, HydroPy (Slide 3), is written in Python and designed to facilitate easy model development, debugging and simulation setup (Slide 4)
- compared to observations, HydroPy successfully reproduces river discharge (Slides 6, 7) and evapotranspiration (Slide 5) on the global scale
- its results are very similar to the MPI-HM (Slide 9) except for some regions where different land cover properties affect the representation of wetlands (Slide 10)
- for details please refer to Stacke T. & Hagemann S. (2021), [1], <https://doi.org/10.5194/gmd-2021-53>

Model description

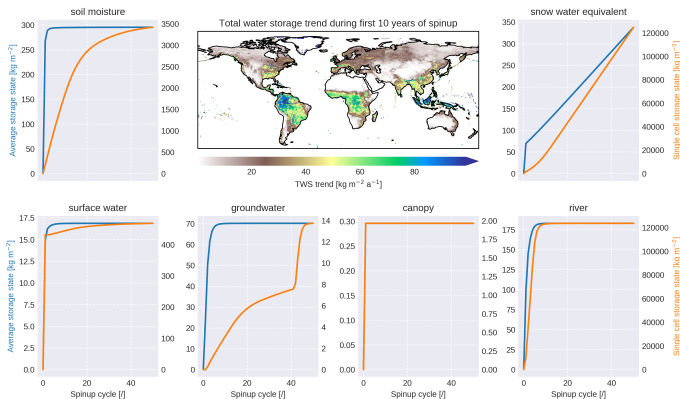
Schematic of water storages in HydroPy. Connecting water fluxes are shown with solid arrows. Input and output fluxes are denoted with dashed arrows.



- daily time step, 0.5 deg resolution
- humble data requirements: Temperature, precipitation, geographical information, routing network

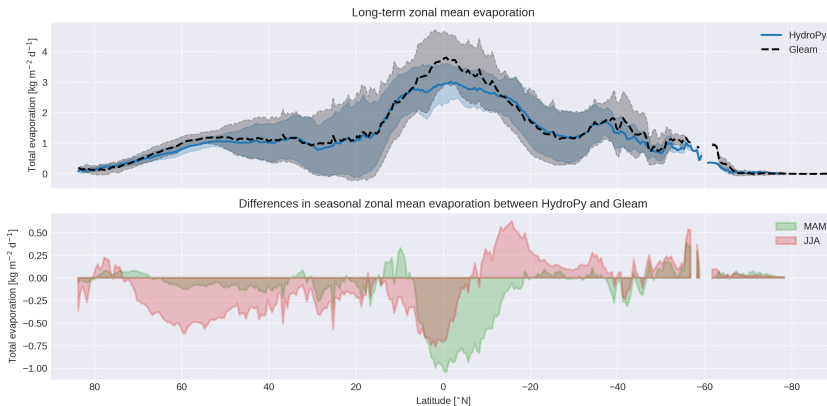
Model description

Evolution of various storage contents during HydroPy spin-up. Blue lines show values averaged over the whole land surface and orange lines represent the grid cell with the largest residual trend at the end of the spin-up period. The central map shows the trends in the total water storage (all storages accumulated) during the first 10 years of spin-up.



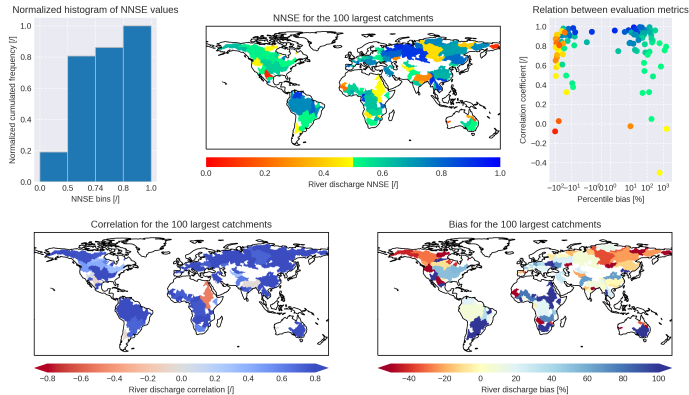
Model evaluation

Zonal mean evaporation averaged over the period 1980-2014 for HydroPy and Gleam [2, 3] (upper panel) as well as their seasonal differences in the boreal spring (MAM) and summer (JJA) (lower panel)



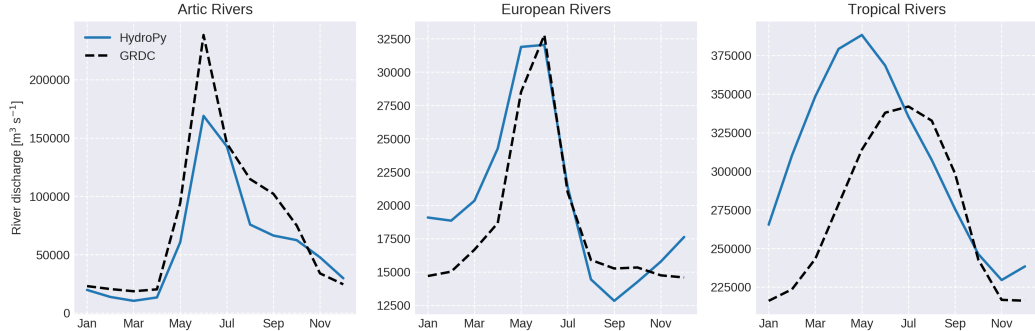
Model evaluation

Normalized Nash-Sutcliffe efficiency of simulated river discharge for the world's 100 largest catchments compared to GRDC observations [4]: the upper panel shows the cumulative histogram (left) of the spatial distribution (middle) of NNSE values as well as its relation (right) to the temporal correlation and percentile bias. The spatial distribution of the two latter metrics are shown in the lower panels.



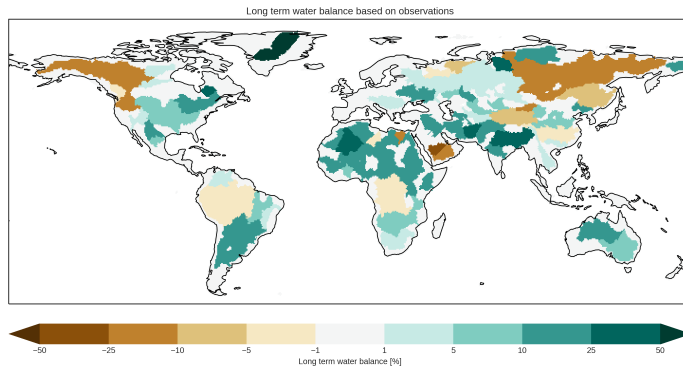
Model evaluation

Climatological river discharge curves averaged for selected rivers in three regions: Arctic Rivers (Lena, Ob, Yenisey, Amur, Kolyma, Mackenzie River, and Yukon), European Rivers (Danube, Rhine, Rhone, Po, Vistula, Pechora, and Neva) and Tropical rivers (Amazon, Congo, Orinoco, Mekong, Rio Magdalena, Zambezi, and Niger). Simulated HydroPy discharge curves are indicated in blue and GRDC observations [4] in dashed black.

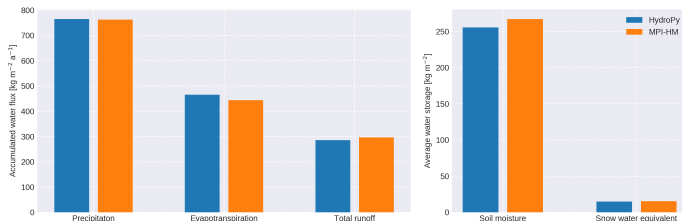


Model evaluation

Long-term water balance based on GSWP3 precipitation, GLEAM evaporation [2, 3] and GRDC [4] river discharge remapped to catchment scale. Note, that this water balance is only a first order estimate. No trends in storage content are included. Furthermore, the GRDC river discharge climatologies often represent different time periods than GSWP3 and GLEAM. Dry biases correspond well with dry biases in river discharge simulation indicating that observational inconsistencies contribute to the biases found in the evaluation (Slide 6).

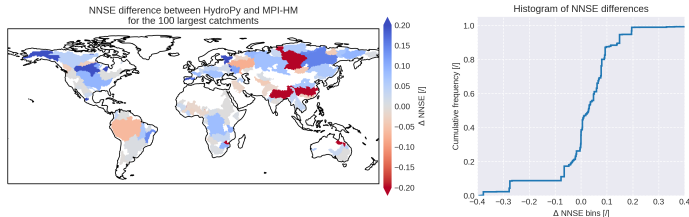


Comparison to MPI-HM

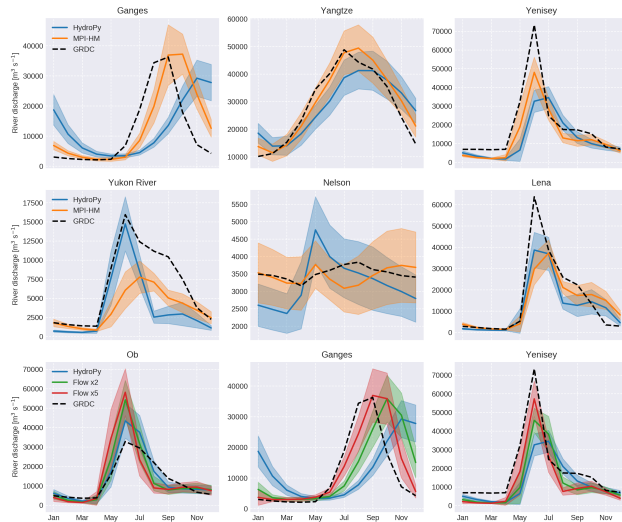


Land surface water fluxes (left panel) and storage states (right panel) averaged over the simulation period for HydroPy (blue) and MPI-HM (orange).

Spatial distribution (left panel) and cumulative histogram (right panel) of NNSE differences for river discharge between HydroPy and MPI-HM.



Comparison to MPI-HM



Monthly climatologies of river discharge for different river catchments with GRDC observations [4] (dashed black). The upper two rows also show simulated discharge from HydroPy (blue) and MPI-HM (orange). The lower row show simulated river discharge produced with the default parameters in HydroPy (blue) as well as those with modified reference flow velocities for wetlands using factors of two (green) and five (red).

References



T. Stacke and S. Hagemann

HydroPy (v1.0): A new global hydrology model written in Python
Geosci. Model Dev. Discuss. [preprint] (2021)
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GRDC

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