Aalto-yliopisto

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Spatial allocation of low resolution runoff model outputs to a high resolution stream network

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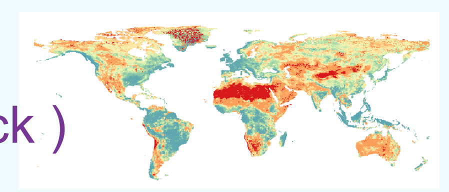
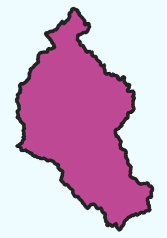
Workflow in ‘hydrostreamer’ R package

Legend
Analysis inputs
Function output
[Optional]

Runoff timeseries
(Raster or RasterBrick)





[Area of interest]
(polygon)

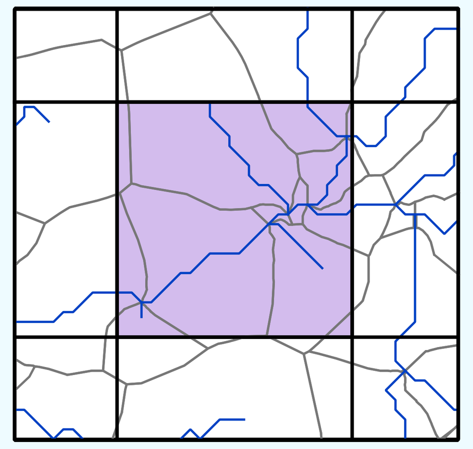
River network
(connected linestrings)

polygrid_timeseries(brick,[aoi]) 1
polygonized raster (HSgrid)
[average_monthly_runoff(*HSgrid*)]

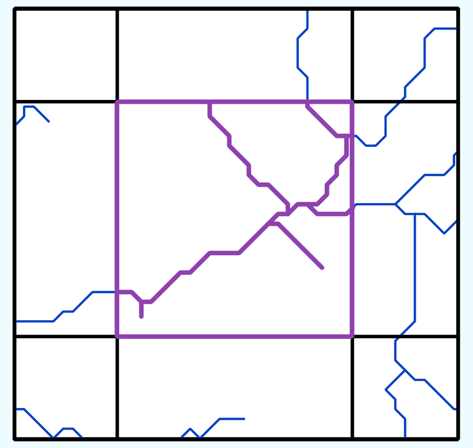
compute_weights(river,HSgrid, [aoi],[basin],[drain.dir],[segment.weight]) 2

i.e. compute river segment weights by

Basin:
using area of catchment within a grid cell to weight by
a. river segment Voronoi polygon
b. delineated from drainage direction
c. user input



River network:
using weights for each river segment by
a. equal weights
b. segment length
c. Strahler stream order
d. user input



HSragrid object
- routed river network
- weighted basin features
- HSgrid

HSrgrid object
- weighted and routed river network
- HSgrid

compute_segment_runoff(*HSragrid or HSrgrid*) 3
i.e. allocate weighted cell runoff to each river segment
River network with segment specific runoff timeseries (HSrunoff)

accumulate_runoff(*HSrunoff*) 4
i.e. apply river routing
River network with flow timeseries (HSflow)

‘hydrostreamer’ in GitHub:
https://github.com/mkkallio/hydrostreamer

Purpose

- To improve global water scarcity assessments.
- Runoff allocated to river segments within output grid cells (i.e. **downscaling runoff into explicit high-res river network**).
- Done as simply and with the least input requirements as possible.

How? **An Open Source R [1] package ‘hydrostreamer’**

1. Create polygon grid from input raster
2. Weight river segments or basins within each grid cell
3. Assign grid cell value to river segments according to weights.
4. Apply river routing

- **Minimum input data: runoff timeseries, river network**

3S Basin Test Case

- 79 500 km² tributaries of the Mekong - Sekong, Sesan and Srepok.
- Monsoon climate with distinct dry and wet season.
- Total runoff output from 12 models at 30 minute resolution obtained from Inter-Sectoral Model Intercomparison Project (ISIMIP) [2]
- Tested also one model at 6 minute and another one with 3km resolution.
- Simplest possible river routing: add everything downstream at each timestep (month)

Results

- **VISIT performs best at most stations**
- Different weighting methods differ in results only at the smallest streams. at higher stream orders the small differences upstream are efficiently averaged out.
- When stream density-to-raster resolution gets too low, segment-based weighting is not valid as not all cells contain river segments.

Conclusion and future **‘hydrostreamer’**

- **Results meaningful on monthly scale,** but issues in the edges of area of interest.
- Confirmed Karimipout et al [3] that **Voronoi is viable alternative to DEM delineated catchment areas.**
- Recommended weighting by physical properties of segments: either basin (Voronoi, or DEM delineated), or segment length.

- Investigate providing an interface in ‘hydrostreamer’ to existing river routing applications (e.g. RAPID [4] or mizuRoute [5]).
- Add functions in ‘hydrostreamer’ to create optimal station-specific model ensembles of several input models.

References

[1] R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.
[2] Potsdam Institute for Climate Impact Research. ISIMIP Data Archive. https://esg.pik-potsdam.de/projects/isimip/. Accessed: 28 March 2018.
[3] Karimipout, F. et al (2013). Watershed delineation from the medial axis of river networks, Computers & Geosciences, 59, 132-147. DOI: 10.1016/j.cageo.2013.06.004
[4] David, Cédric H. et al (2011). River network routing on the NHDPlus dataset, Journal of Hydrometeorology, 12(5), 913-934. DOI: 10.1175/2011JHM1345.1
[5] Mizukami, N. (2016). mizuRoute version 1: a river network routing tool for a continental domain water resources applications, Geoscientific Model Development, 9, 2223-2238. DOI: 10.5194/gmd-9-2223-2016

Graph legend
Observed flow
Equal weights
Strahler weights
Length weights
Voronoi basin weights
DEM delineated basin weights

3S River Basin

Measurement station
HydroSheds 15 arc second river network
River segment Voronoi polygon
0.5 degree (30 min) grid
Country border

List of models tested:
@ 30 minute
CARAIB, DBH, H08, LPJ-GUESS, LPJML, PCR-GLOBWB, MPIHM, VIC, VISIT, WATERGAP, WATERGAP2, WBM

For full reference: