G-STREAM – An observation-based global monthly river discharge reconstruction
Contact: gionata.ghiggi@epfl.ch

Rivers play important roles in shaping global hydrological and biogeochemical cycles and river discharge quantification in space and time is highly relevant for a large variety of socio-economic activities ranging from irrigation supply, hydropower and thermal energy production, inland navigation to riverine biodiversity. More generally, knowledge of the hydrological states and their variability on our planet is key information for a variety of scientific disciplines, including geology, ecology, and agriculture.

Unfortunately, most of the stream reaches in the world are poorly or not monitored at all due to the inaccessibility of most headwaters and a lack of financial and human resources; and access to hydrological data is often hindered by political barrier. Global hydrologic models (GHMs) simulations can be used to predict river discharge in ungauged basins, but recent works demonstrated that GHMs struggle in reproducing several characteristics of the monthly hydrograph, especially for what concern river flow dynamics and climatology (Ghiggi et al., 2019).

To overcome GHMs deficiencies, Ghiggi et al., 2019 exploited a large database of global in-situ river discharge measurements to constrain monthly runoff, which is defined as the amount of water draining from a land unit to the river network. The derived global monthly runoff reconstruction GRUN (Ghiggi et al., 2019) spans 120 years and has been shown to outperform the accuracy of GHMs.

This Master Thesis Projects aims to create a global reconstruction of monthly river discharge over the period 1900-2019 by routing the runoff estimates of GRUN (Ghiggi et al., 2019) through global hydrography datasets such HYDROSHEDS (Lehner et al., 2008,2013) and MERIT Hydro (Yamazaki et al., 2019)(see Fig. 1).

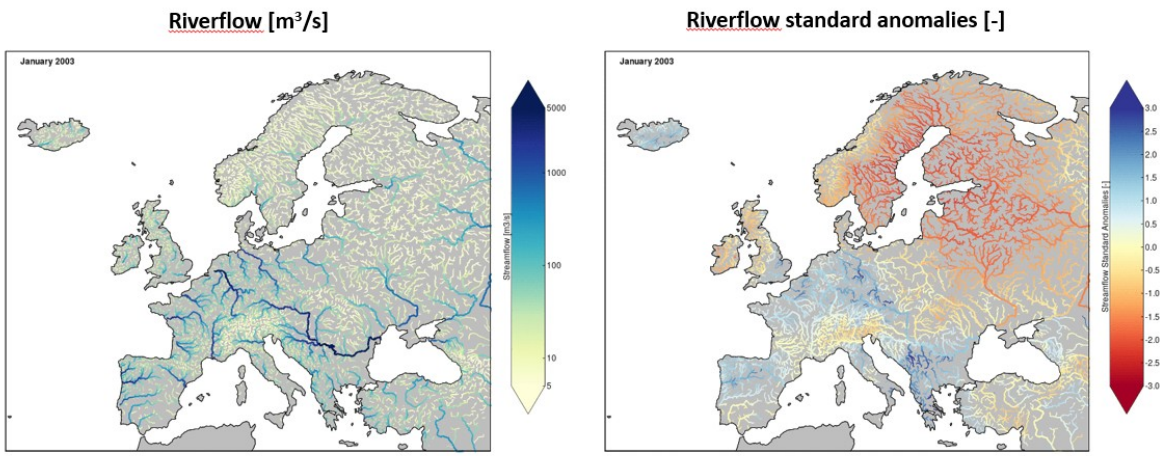

Figure 1. River discharge reconstruction over Europe (from Ghiggi et al., 2018)

The student is therefore asked to develop an efficient simple routing algorithm (Fig. 1), able to route (cumulate) runoff down to the river basin outlets. The derived gridded/vectorized river discharge reconstruction will then be benchmarked against publicly available existing global datasets such FLO1K (Barbarossa et al., 2018), GRADES (Lin et al., 2019) and GLOFAS (Harrigan et al., 2020). Finally, a climatology analysis of the dataset is expected to complement existing hydro-environmental rivers characteristic datasets such HYDROATLAS (Linke et al., 2019).

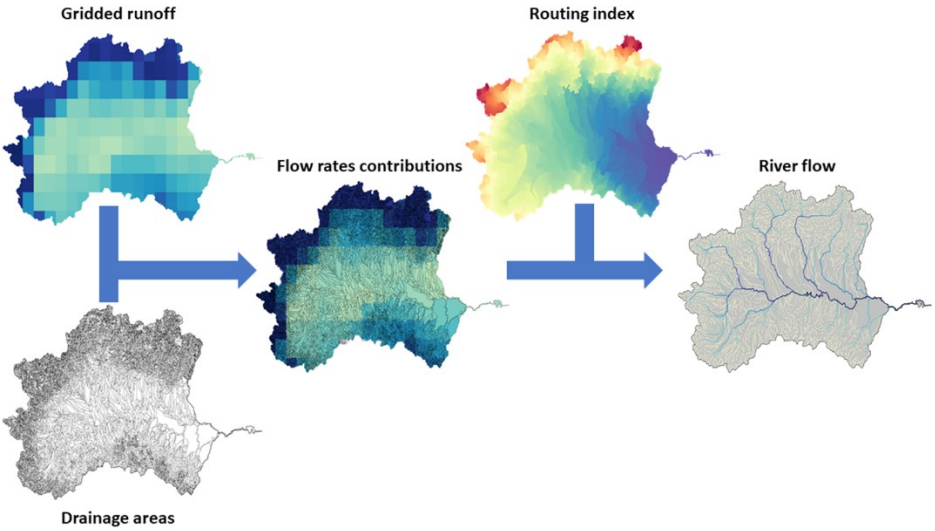

Figure 2. Workflow for runoff routing in the Po river basin (from Ghiggi et al., 2018)

Objectives

- Development of an efficient a river routing algorithm
- Production of a global reconstruction of river discharge
- Benchmark against current river discharge datasets (GRADES, GLOFAS, FLO1K)
- Short climatological analysis of hydrological regimes

Requirements

- Interest in hydrology and GIS
- Good programming skills in python or R

References

Alfieri, L., Lorini, V., Hirpa, F. A., Harrigan, S., Zsoter, E., Prudhomme, C. and Salamon, P.: A global streamflow reanalysis for 1980-2018, J. Hydrol., 2019.

Barbarossa, V., Huijbregts, M., Beusen, A. et al.: FLO1K, global maps of mean, maximum and minimum annual streamflow at 1 km resolution from 1960 through 2015. Sci Data **5,** 180052, 2018.

Ghiggi, G.: Reconstruction of European monthly runoff and river flow from 1951 to 2015 using machine learning algorithms, Master Thesis, ETHZ, 2018

Ghiggi, G., Humphrey, V., Seneviratne, S. I., and Gudmundsson, L.: GRUN: an observation-based global gridded runoff dataset from 1902 to 2014, Earth Syst. Sci. Data, 11, 1655–1674, https://doi.org/10.5194/essd-11-1655-2019, 2019.

Lehner, B., Verdin, K. & Jarvis, A.: New global hydrography derived from spaceborne elevation data. Eos Trans. AGU **89**, 93–94, 2008

Lehner, B. & Grill, G.: Global river hydrography and network routing: baseline data and new approaches to study the world's large river systems. Hydrol. Process. **27**, 2171–2186, 2013.

Linke, S., Lehner, B., Ouellet Dallaire, C. et al.: Global hydro-environmental sub-basin and river reach characteristics at high spatial resolution. Sci Data **6,** 283, https://doi.org/10.1038/s41597-019-0300-6, 2019.

Lin, P., Pan, M., Beck, H. E., Yang, Y., Yamazaki, D., Frasson, R., et al.: Global reconstruction of naturalized river flows at 2.94 million reaches. Water Resources Research, 55, https://doi.org/10.1029/2019WR025287, 2019

Harrigan, S., Zsoter, E., Alfieri, L., Prudhomme, C., Salamon, P., Wetterhall, F., Barnard, C., Cloke, H., and Pappenberger, F.: GloFAS-ERA5 operational global river discharge

reanalysis 1979–present, Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2019-232, in review, 2020.

Yamazaki, D., Ikeshima, D., Sosa, J., Bates, P. D., Allen, G. H., & Pavelsky, T.M.: MERIT Hydro: a high-resolution global hydrography map based on latest topography dataset. Water Resources Research, 55, 5053–5073. https://doi.org/10.1029/2019WR024873, 2019.