Altimetry **R**iver **R**each **M**ethods (ARRM)

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Introduction, The Altimetry River Reach Methods (**ARRM)** is an **R-package** to reconstruct temporally densified water level time series based on multi-mission satellite altimetry data sets acquired over a river reach. The underlying model is a state-space model implemented via the **R-package RTMB** [1]. The water levels are predicted on a grid with time and chainage (distance along the centerline) in the 2 dimensions. To account for the correlation in space and time a Gaussian Markov Random Field is applied. Observations are assumed to be Gaussian distributed. In addition ARRM can exploit the reach and node information in **SWORD** [2] to acquire river centerlines making it easy to setup the model anywhere. ARRM is partly developed within the ESA EO4FLOOD project [3].

Data Format

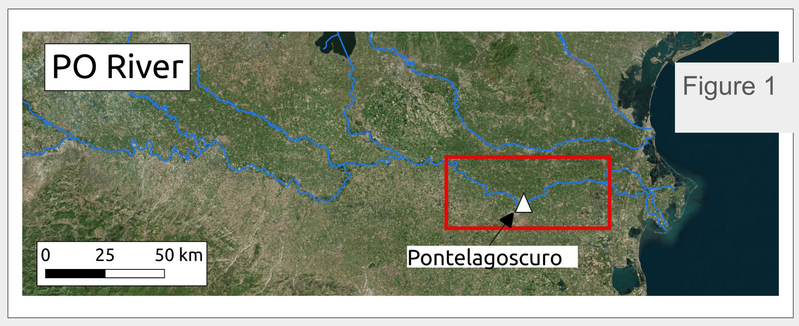
The altimetry data set “dat” must contain the following columns; **`time`** (*decimal years*), **`lat, lon, height`** (*water surface elevations*), **`chainage`** (*distance along the centerline from a downstream point*)

Model setup

- Specify the grid dimension in time `tdim` and chainage `xdim`
- Specify the # knots `Nknot` in the spline representing the average profile slope, the # iterations `nit`, and the percentage of expected outliers `cutp`
- The solution is then predicted via the function `riverReachTS`

Example from the Po River

- Here we apply water surface elevations from CryoSat-2, Sentinel-3, Sentinel-6, SARAL/AltiKa, ICESat-2, and SWOT(RiverSP) located over 17 SWORD reaches (red box in Figure 1).
- The nadir altimetry was acquired via the Altimetry River Reach Database (see box below).
- The observations from the different missions are illustrated in Figure 2 as a function of time and chainage, chainage and water surface elevation, and longitude and latitude.
- The grid resolution in this example is 2 days in the temporal dimension and 2km in the spatial dimension.
- The model over the entire reach is illustrated in Figure 4, and the water level time series at the chainage of the Pontelagoscuro gauge is illustrated in Figure 3.
- By combining several mission it is possible to obtain a dense water level time series that is able to capture several flood events.



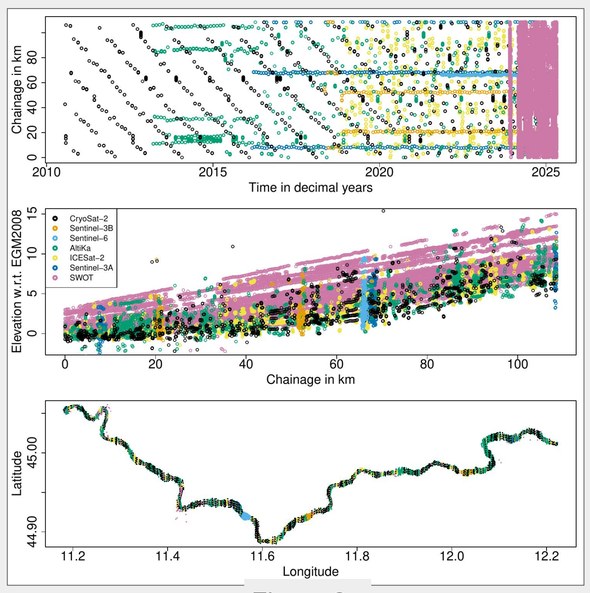


Figure 2

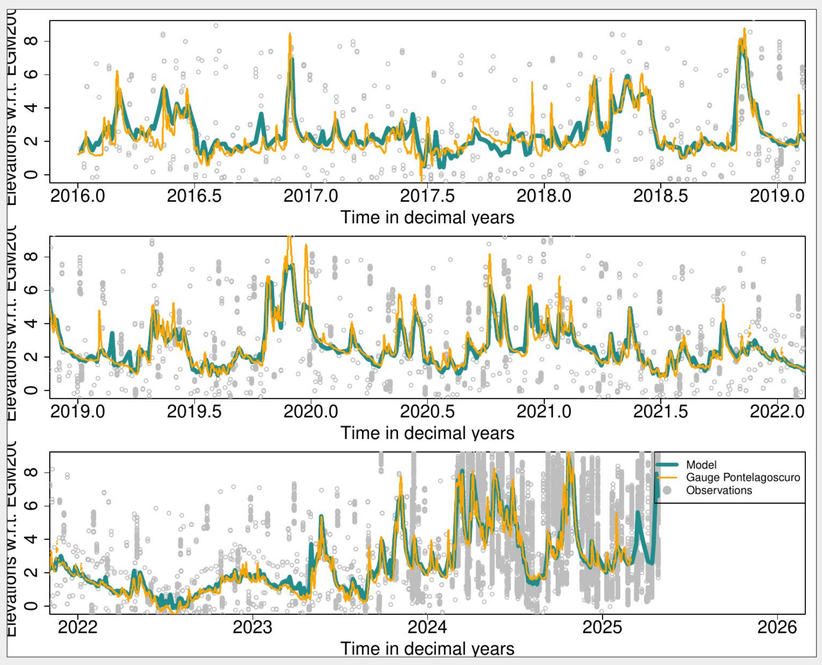


Figure 3

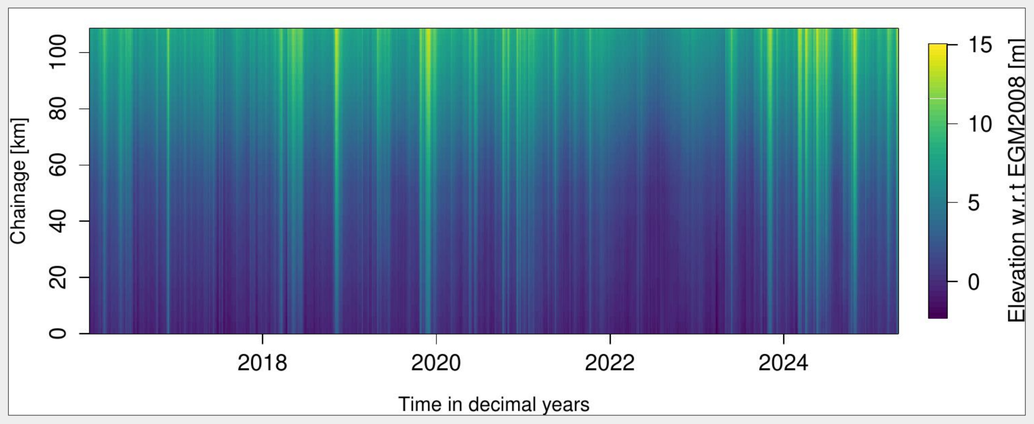


Figure 4

ARRD, Altimetry River Reach Database (*under construction*) is a collection of nadir altimetry surface elevation based on standard retrackers (CryoSat-2, Sentinel-3, Sentinel-6, ICESat-2, SARAL/AltiKa, …) that are assigned to a given SWORD node. This allows easy access for any given reach id making it easy to use together with SWOT data.

Limitations

- The river reaches should be continuous e.g. avoid dams and waterfalls
- The solution will depend on the amount and quality of the data.

Summary

- Fast and easy due to automatic differentiation and exploitation of sparse matrices in RTMB.
- Provided a framework to combine altimetry observation from different missions to obtain densified water level time series.
- The package is under development, please be patient :-).
- Please contact me is you are interested in collaboration regarding the ARRM package or the Altimetry River Reach Database.

Get the code here

References

[1] Kristensen, K., Nielsen, A., Berg, C.W., Skaug, H. and Bell, B.M., 2016. TMB: automatic differentiation and Laplace approximation. Journal of statistical software, 70, pp.1-21.
[2] Altenau, E. H., Pavelsky, T. M., Durand, M. T., Yang, X., Frasson, R. P. D. M., & Bendezu, L. (2021). The Surface Water and Ocean Topography (SWOT) Mission River Database (SWORD): A global river network for satellite data products. Water Resources Research, 57(7), e2021WR030054.
[3] https://eo4flood.org/