University of Stuttgart
Institute for Modelling Hydraulic and Environmental Systems

Climate reanalysis data with global coverage enable sediment load prediction in the absence of systematic field data

Kilian Mouris, Sebastian Schwindt, Stefan Haun, Silke Wieprecht
University of Stuttgart, Stuttgart, Germany
Nils Rüther, Kordula Schwarzwälder
Norwegian University of Science and Technology, Trondheim, Norway
Maria Herminia Pesci, Kristian Förster
Leibniz University Hannover, Hannover, Germany

Background

Hydro-morphodynamic models are increasingly popular for predicting sedimentation processes in reservoirs. To leverage the accuracy of such models, their boundary conditions have to be defined as precise as possible. While hydrological models provide efficient routines to establish inflow hydrographs at the model boundaries, the determination of sediment input is challenging and involves large uncertainties. For this purpose, erosion and transport processes in the catchment area of the Banja Reservoir (Albania) are analyzed here with freely accessible precipitation data.

Study Area

The Banja Reservoir is located on the Devoll River in the Southeast of Albania and has a storage capacity of 400 Million m³. The catchment area (Fig.1.) has a size of 2,900 km² and lies in a mountainous region. The climate is characterized by dry and hot summers and humid winters. There are significant differences in precipitation patterns in the catchment due to topography and with increasing distance from the coast in the West of the country. Because snowfall is frequent in winter, the runoff regime of the Devoll River and its tributaries is driven by precipitation and snowmelt.

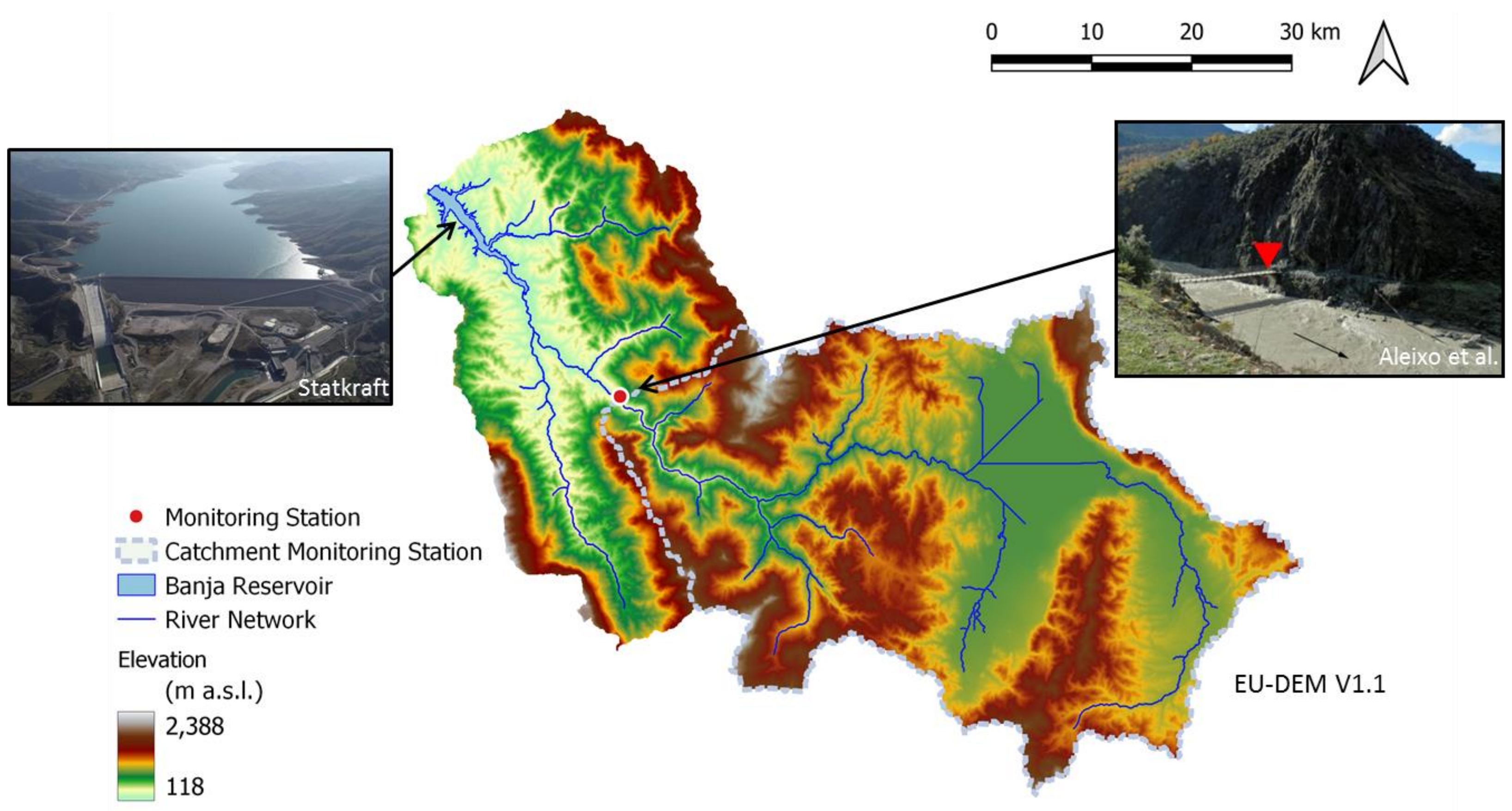

Fig. 1: Topography of the study area including the river network, the location of the Banja reservoir and the monitoring station

Methods

- Application of the Revised Universal Soil Loss Equation (RUSLE, [1]) coupled with the SEdiment Delivery Distributed (SEDD, [2]) model.
- Rainfall erosivity model for complex terrains to calculate the R-factor [3].
- ERA 5 reanalysis dataset as input data for precipitation.
- Elevation-dependent regression and distance-based interpolation to adapt coarse precipitation data to finer model resolution.
- Suspended sediment load measured at a monitoring station upstream of the reservoir (Fig.1) for model calibration.

Due to data gaps caused by low flow periods, the observed sediment loads are considered reliable for 10 months (Fig. 3).

Results

Fig. 2 shows a computed map of the annual sediment yield. The average sediment yield is 6.9 t/(ha yr) where the highest sediment yields (>50 t/(ha yr)), occur in hilly and sparsely vegetated areas close to the river network. There are also steep areas with significant soil erosion in the eastern part of the watershed. Much of the eroded soil is deposited in flat areas near the source regions and not transported into the river network. Thus, the computed sediment yield is smaller.

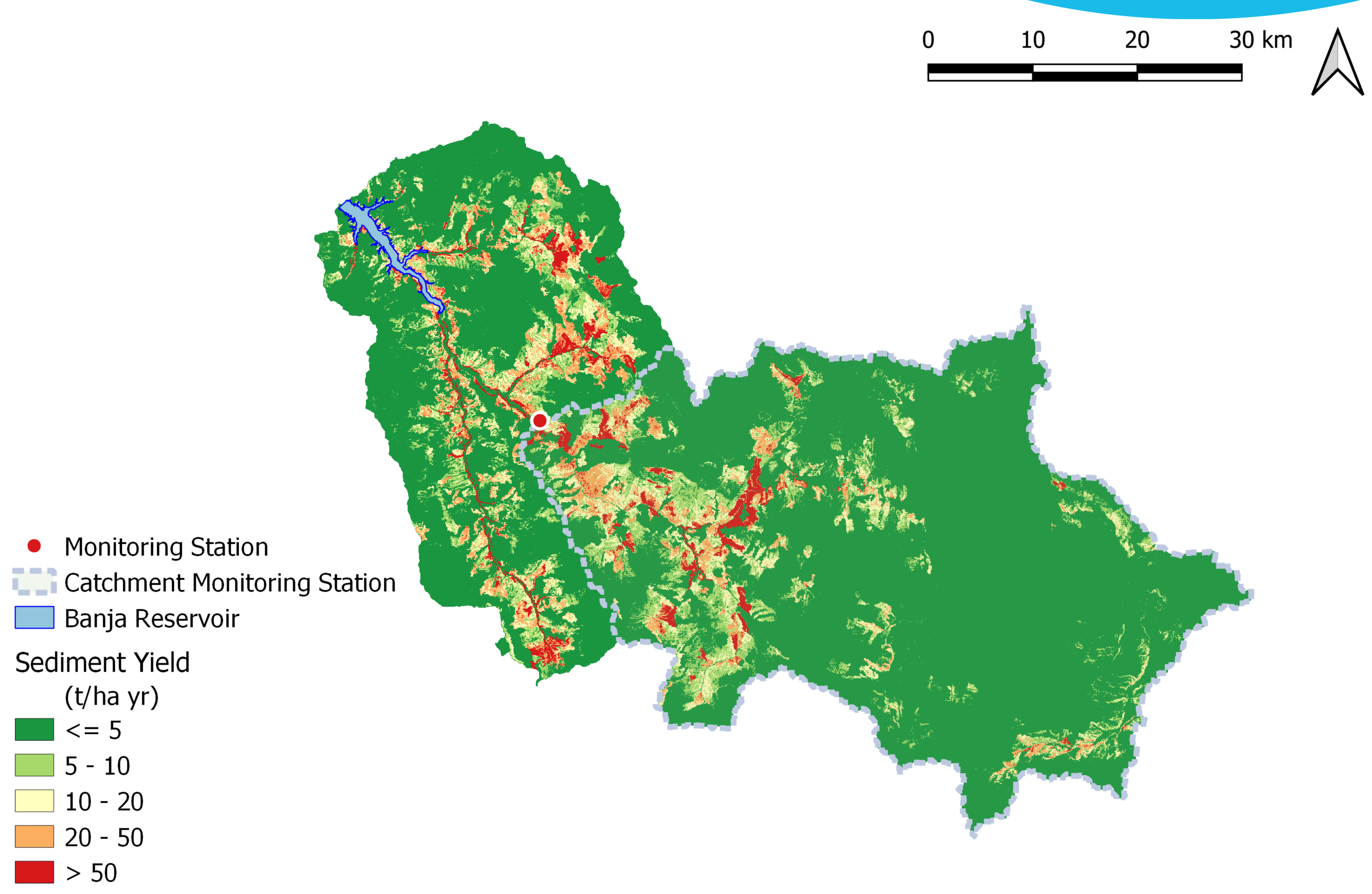

Fig. 2: Computed map of the annual sediment yield from 05/2016 to 04/2018.

Figure 3 shows that the sediment load highly depends on monthly precipitation. The model is able to reproduce monthly suspended sediment loads with good accuracy. Furthermore, precipitation in February and March 2018 cause almost 50% of the total suspended sediment load within the 2 years observation period.

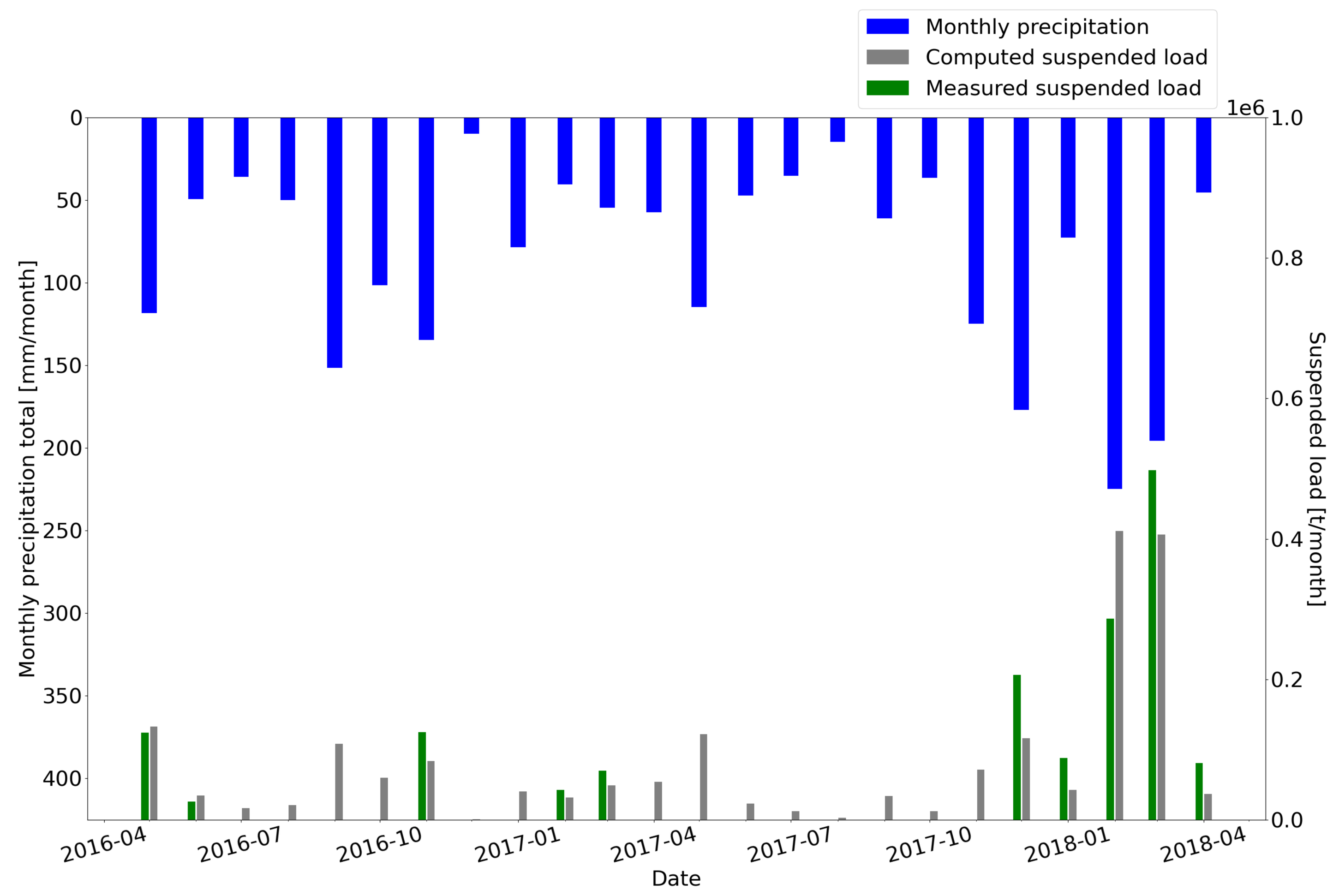

Fig. 3: Computed and observed monthly suspended sediment and precipitation during the observation period.

Outlook and Conclusion

The model predicts sediment loads that are in good agreement with measurement data (NSE = 0.81). Consequently, climate reanalysis datasets in the form of precipitation totals are a viable alternative in data-sparse regions. The spatial representation of the results suggests that the sediment load into the reservoir mainly originates from steep and sparsely vegetated or agricultural areas close to the river network. Further model improvement is expected by considering snowfall and snowmelt.

References

[1] Renard, K.G., 1997. Predicting soil erosion by water: a guide to conservation planning with the revised universal soil loss equation (RUSLE), Agriculture handbook. Washington, D. C..
[2] Ferro, V., Porto, P., 2000. Sediment Delivery Distributed (SEDD) Model. Journal of Hydrologic Engineering 5, 411–422. https://doi.org/10.1061/(asce)1084-0699(2000)5:4(411)
[3] Diodato, N., Bellocchi, G., 2007. Estimating monthly (R)USLE climate input in a Mediterranean region using limited data. Journal of Hydrology 345, 224–236. https://doi.org/10.1016/j.jhydrol.2007.08.008

kilian.mouris@iws.uni-stuttgart.de
www.iws.uni-stuttgart.de

DIRT-X

EGU General Assembly 2021

www.dirtx-reservoirs4future.eu