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Biogeomorphology from space: Using optical satellite imagery time series for spatially and temporally continuous observation of the interaction of vegetation and hydromorphology along the Naryn River, Kyrgyzstan

Florian Betz[1], Magdalena Lauermann[1], Gregory Egger[2], and Bernd Cyffka[1]
[1]Catholic University Eichstätt-Ingolstadt, Applied Physical Geography, Eichstätt, Germany (florian.betz@ku.de)
[2]Karlsruhe Institute of Technology, Department of Wetland Ecology, Karlsruhe, Germany

The structure and development of river corridors are controlled by an interplay of hydrological, geomorphological and ecological processes over a range of spatial and temporal scales. This is why rivers have been termed biogeomorphological systems by some scholars. Despite the acknowledgement of the relevance of multiple scales, the majority of existing studies on fluvial biogeomorphology focus either on conceptual development or on investigations on the scales of single geomorphic units or study reaches. With this study, we extend the view on biogeomorphology beyond the reach scale using time series of multispectral satellite imagery. We take the Naryn River in Kyrgyzstan as an example for demonstrating our satellite time series approach to biogeomorphological analysis of river corridors. The Naryn is still in a natural state on an entire flow length of more than 600 km with full longitudinal and lateral connectivity. In the central part of the catchment, the Naryn is a highly dynamic braided river system shaped by the annual summer floods of a glacial discharge regime. This makes this river ideal to study large scale biogeomorphological dynamics. In our study, we follow the well-established concept of biogeomorphological succession proposed by Dov Corenblit and his colleagues. We mapped the different succession phases in the field and used the results to derive spectral-temporal indices characterizing the different biogeomorphological succession phases. The normalized difference vegetation index (NDVI) and modified normalized difference water index (MNDWI) have been found to be well suited in the fluvial environment. Monthly time series of these indices derived from the Landsat archive as well as from the more recent Sentinel-2 imagery have now been used to compute statistical trends and changepoints by means of a Bayesian time series decomposition algorithm. The results are then evaluated regarding biogeomorphological succession and disturbance events. The results show that such dense time series of optical satellite imagery are well suited to derive indicators of biogeomorphological interactions on large spatial scale. The temporally continuous nature of this kind of observations allows an observation of processes and an interpretation for instance against the background of the theory of adaptive cycles and panarchy. In conclusion, such satellite time series approach has the potential to give new insights in the structure and functioning of biogeomorphological dynamics of entire river corridors or networks. In particular the recently available Sentinel imagery will allow to observe

biogeomorphological processes in a spatially and temporally continuous way at a reasonable spatial resolution.