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Quantitative analysis of climatic and hydrological controls on solute dynamics in the riparian zone

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Riparian wetlands are decisive for stream water quality, as biological and hydrochemical processes often alter substantially the quality of discharging groundwater. Here, a variety of processes interact at different scales and in a highly nonlinear way. Climatic variability is likely to impact hydrological and biological processes in these environments. The Research Group 562 of the German Research Foundation aims at investigating these relationships, focusing on the effects of single extreme events that are assumed to alter the system behaviour in the long-term. The field work is performed in the Lehstenbach catchment in South Germany, where about one third of the catchment area is covered by wetland soils. For this study more than 2000 samples from shallow and deep groundwater wells, upslope springs and streams were available, comprising 13 parameters. Single solutes are subject to a variety of different processes, and thus can not directly be used to study single processes. Instead, we tried to identify the prevailing processes in a quantitative way. To that end, a couple of nonlinear methods were used, including correlation dimension, isometric feature mapping, and non-linear principal component analysis. Four components were identified that explained more than 90% of the total variance. Redox processes could clearly be differentiated from other processes in a quantitative way. Consequently, the extent to which redox processes had altered solute concentration of the discharging groundwater during its passage through the wetlands could be quantified. We observed clear seasonal patterns as well as the impact of single extreme events, i.e., major rain storms and snow melt events. In addition, different types of discharge events were identified, depending on the antecedent redox conditions: During the winter season, mainly oxic, acidified water was found in the stream, associated with elevated nitrate and low silica

concentration. In contrast, during the growing season, the stream was fed mainly by anoxic water. Only during these events substantial amounts of phosphorus and arsenic were delivered to the stream. A third type of discharge events was observed after prolonged dry periods with enhanced peat decomposition and oxidation of sulfides. In addition, the effect of interannual climatic variability on the nitrogen dynamics in the riparian zone and in the groundwater could be shown that seemed to be related to the North Atlantic Oscillation Index (NAO). This approach proved to be a promising way to differentiate between anthropogenic and natural impacts on stream water quality as demanded by the EU Water Framework Directive.