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Long-term monitoring of vegetation and hydrology in headwater catchments and the difficulties to embrace data-oriented and process-oriented approaches

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In the Bramke valley (western Harz mountains, North Germany), three forested headwater catchments have been monitored since decades. A broad range of observables relevant to forestry, hydrology, hydrochemistry and ecosystem research allows to compare different approaches to environmental monitoring; each of them has its own set of relevant observables. The basic temporal resolution is daily for hydrometeorology and bi-weekly for streamwater chemistry; standing biomass of the Norway spruce stands is measured every couple of years.

Tree growth (site index) has changed between and within rotation periods (of up to 129 years); changes in soil nutrient pools are typical variables used to explain this nonstationary forest growth when the spatial-temporal scales match. In hydrology, transport mechanisms of water and solutes through catchment soils are used to model and predict runoff and its chemistry. Given the homogeneity of the area in terms of geology, soils and topography as well as climate, differences between the catchments in the Bramke valley are mostly related to forestry variables. The catchments exhibit long-term changes and spatial gradients related to atmospheric deposition, management and changing climate. After providing a short multivariate summary of the dataset, we present several nonlinear metrics suitable to detect and quantify subtle changes and to describe different behavior, both between different variables from the same catchment, as well as for the same variable across catchments.

Soil water potential and solution chemistry are further links between forestry and hydrology. However, at Lange Bramke, similar to other catchment studies, the evaluation of these data sets has not converged to a consistent, realistic model at the catchment scale. We hypothesize that this lack of model integration is due to theoretical rather than technical limits. A possible representation of these limits might be phrased in a category theory approach.