Functional principal component analysis for non-stationary dynamic time series with an application to high-frequency hydrological data

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The goal of this paper is to introduce a novel functional principal components (FPCs) approach that identifies and accounts for volatility in Functional Time Series (FTS). Traditional FPCs, do not take into account (i) the temporal dependence between the functional observations and (ii) the changes in the covariance/variability structure over time in FTS, which could result in inappropriate analysis and inadequate dimension reduction. The methodology we introduced involves the development of frequency domain FPCs that vary smoothly over frequency and time, which simultaneously account for the temporal correlation between the curves and adapt to the changes in the auto-covariance structure of the series. Using a bootstrap inference procedure, these time-varying FPCs allow investigation of whether and how the variability structure in an FTS changes over time. Although this time-varying dynamic FPCs analysis has been initially motivated by and applied to a highly dynamic series of daily processes of partial pressure of carbon dioxide in a small river catchment in Scotland, it can be applied to any dynamic FTS. The performance of our novel FPCs has been compared to other FPCs approaches in the literature through an extensive simulation study. Current work involves the assessment of these smooth dynamic FPCs in interpolating missing data as well as their extension to approximate spatio-temporal non-stationary processes.