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Design of frequency selective filters for non-equispaced data

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Modern sensors and satellite missions deliver huge data sets and long time series of observations.
In the most cases equispaced time series are collected. Filtering of time series is a standard task in data analysis. Therefore a large variety of methods is already established to deal with equispaced time series. Discrete digital filters can be individually designed in the time as well as in the frequency domain. Often a priori information in the frequency domain is used to extract the signal of interest from the remaining part. These well established strategies presume equispaced samples to get access to the frequency domain behaviour.

In this presentation we focus our attention on non-equispaced time series, which often appears in satellite geodesy and remote sensing. Again we assume that a special behaviour in the frequency domain characterizes the desired part of the signal. To extract exactly this part of the signal we construct frequency limited base functions, which are able to provide a strict cut-off in the frequency domain. A linear combination of these base functions can be applied in an approximation procedure. Thus, it is possible to extract the desired band-limited signal also for non-equispaced data sets.

Our presentation is focused on the construction of these frequency limited base functions. Starting with piecewise given polynomial base functions with finite support (Splines), we construct by the inversion of an infinite band Toeplitz system tailored base functions, which are mutually independent (sampling splines). These sampling splines can be transformed into the spectral domain and because of the finite support of the original base functions a closed form representation in the spectral domain is possible (finite sums). Detailed studies on the filter characteristic in the frequency domain allows then a simple access to design low pass filters for non-equispaced data with a predefined transit region.

Synthetic examples as well as the time-wise filtering of a DInSAR-SBAS image stack collected from ERS1 and ERS2 demonstrate the capability of this approach in practice.