Gap filling based on EOF analysis of temporal covariance of offset tracking displacement measurement time series

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Abstract

Last decades have seen huge amount of satellite data being made available by space agencies to the scientific community and to general public. As an example, Synthetic Aperture Radar (SAR) images products from European Space Agency (ESA) Sentinel-1 satellites are ready for use through the Copernicus program, which allows an new form of data sharing, diffusion and analysis. One application among many others is offset tracking of SAR images, which is widely used for measurement of large ground displacement as landslides, earthquakes or glacial flow. However, spatio-temporal measurement gaps exist because of surface changes of the observed targets from one acquisition to another. These measurements gaps hinder a full exploitation of the displacement measurement time series which provides useful information about the spatio-temporal evolution of the target under observation. On the other hand, there is a substantial lack of studies that are adapted to reconstruct missing data in displacement measurement time series with embedded error analysis. Therefore, we propose a data-adaptive interpolation method based on the Empirical Orthogonal Function (EOF) analysis of the temporal covariance of a displacement measurement time series to retrieve missing data. This EOF-based method decomposes temporal covariance in different EOF modes corresponding to different variations, from which coherent spatial patterns whose magnitudes vary over time can be obtained. The latter is used for data denoising and reconstruction by selecting a relevant number of EOF modes. In this method, data gaps are initialized by appropriate values and then modified after the EOF analysis of temporal covariance in an iterative process. The convergence criterion is based on the root mean square error between the reconstruction and the data for validation. The proposed method is first applied to a synthetic displacement time series containing missing data in order to 1) investigate some tuning parameters such as gap initialization value, noise characteristics, data gaps quantity and distribution, number of iteration, etc. and 2) to highlight the efficiency of the method. Then, the proposed method will be applied to a displacement measurement time series, issued from offset tracking of 65 Sentinel-1 SAR images acquired between October 2016 and December 2017 over the Argentière glacier. The results will be evaluated by InSAR measurement when they are available, otherwise by cross validation with offset tracking measurements.

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