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Homogenization of GNSS IWV Time Series with R-Package GNSSseg

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Long records of observational data are essential to climate research for understanding the condition of environmental evolution on the planet. Ground-based networks of Global Navigation Satellite System (GNSS) receivers provide observations of tropospheric delay and integrated water vapour (IWV) for more than 20 years. However, GNSS time series show breakpoints due to changes in the instruments, in measurement conditions, or in processing software. Such artificial shifts can introduce spurious trends which can be erroneously interpreted as climate variations.

We propose a relative segmentation algorithm that consists in detecting the abrupt changes in the IWV differences between GNSS observations and the ERA-Interim reanalysis. The underlying statistical model assumes that the IWV difference time series are independent and identically distributed random Gaussian variables and accounts for two specific features observed in the GNSS – ERA-Interim differences: i) the variability is month-dependent rather than homogeneous and ii) the differences contain a periodic signal at a number of sites because the GNSS observations and ERA-Interim reanalysis do not represent perfectly consistent (in amplitude and phase) seasonal variations.

The proposed estimation procedure consists in 2 steps. In the first one, we estimate iteratively (i) the variance (using a robust estimator) and the breakpoints and (ii) the periodic signal, the number of breakpoints being fixed. In the second step, the number of breakpoints is chosen using model selection criteria (three criteria are adapted).

A simulation study is performed to evaluate the performance of the proposed method. Application to real data is also presented using daily IWV data from 120 GNSS stations globally distributed for the period from January 1995 to December 2010.

This proposed method is implemented in the GNSSseg R package, which will be available on the CRAN.