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## Time series homogenization with the ACMANT software

**Peter Domonkos**

Tortosa, Spain (dpeterfree@gmail.com)

The development of ACMANT homogenization software started during the European COST HOME project, around 2010. Due to its excellent results in method comparison tests, the development of ACMANT has been being continuous since then. While its first version was applicable only to the homogenization of monthly temperature series, the later versions are applicable to a wide range of climatic variables and either for monthly or daily time series.

The operation of ACMANT is fast and automatic, and it is easy to use that even for large size datasets. The method can homogenize together time series of varied lengths, well tolerate data gaps, includes outlier filtering and infilling of data gaps (optional). ACMANT includes modern and effective statistical tools for the detection and removal of inhomogenities, such as step function fitting, bivariate detection for breaks of annual means and seasonal amplitudes (where applicable), ANOVA correction method and ensemble homogenization with varied pre-homogenization of neighbour series. For these properties, ACMANTv4 was the most accurate homogenization method in most method comparison tests of the Spanish MULTITEST project (<https://doi.org/10.1175/JCLI-D-20-0611.1>). In these tests, one important exception occurred, namely network mean trend errors were removed with significantly higher certainty by the Pairwise Homogenization Algorithm when approximately a half of the time series were affected with quasi synchronous breaks imitating concerted technical changes in the performance of climate observations. The most recent developments aiming the release of ACMANTv5 include the elimination of this drawback of ACMANT.

For ACMANTv5, a new break detection method has been developed, in which the combination of two time series comparison methods is applied. The new method contains both the use of composite reference series and pairwise comparisons, and in the detection with composite reference series the step function fitting is forced to include the breaks detected by pairwise comparisons. Another novelty of ACMANTv5 is that it gives options to use metadata in the homogenization procedure. The default operation mode of ACMANTv5 is still fully automatic, with or without the automatic use of a prepared metadata table. ACMANTv5 uses every date of the metadata list as a break indicator, and they are evaluated together with other indicators obtained by pairwise comparisons. Optionally, ACMANTv5 gives access to users to edit the list of detected breaks based on the pairwise detections of the first homogenization round. In the later steps of ACMANTv5 user intervention is not possible, but metadata may be considered by the automatic procedure also in the final estimation of break positions.