The ACMANTv6 homogenization method

Peter Domonkos

Tortosa, Spain, e-mail: dpeterfree@gmail.com

web: https://acmant.eu

Supporter: Servei Meteorologic de Catalunya

22 years with time series homogenization

- The development of ACMANT was in the centre. ACMANT is a relative homogenization method, each candidate series is homogenized with at least 3 (but preferably much more) neighbour series

- ACMANTv4 was found to be the most accurate method in the MULTITEST tests. Its advantage over the other methods was notable in all aspects. The MULTITEST results should be taken seriously, for the size and quality of the test dataset and the high variety of homogenization problems tested.

- ACMANTv4 is free, but its usability has limitations:
  - only automatic mode
  - no metadata use option
  - only section means are homogenized

Post-MULTITEST period (2019-2025)

Two main aims:

- Further development of ACMANT
- Boost the practical use of accurate methods on international level

Four possible lines of development in practical homogenization:

- Wider use of the homogenization method with best test results
- Wider use of units of the best performing methods in other homogenization methods
- Creating new homogenization methods with competitive test results
- Creating and using new test datasets of comparable quality to MULTITEST

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ACMANTv6 – main properties

- homogenizes: temperature, precipitation amount, relative humidity, wind speed, wind gust, sunshine duration, radiation, atmospheric pressure
- daily or monthly resolution
- input dataset: 4 to 5000 time series
- automatic selection of sets of neighbour series
- homogenizes both the section means and the probability distribution (PDF)
- removes physical outliers and spatial outliers
- input time series may cover varied periods and may include data gaps
- infills data gaps with spatial interpolation; repeatedly performed with improving homogeneity of the neighbour time series

ACMANTv6 – main properties

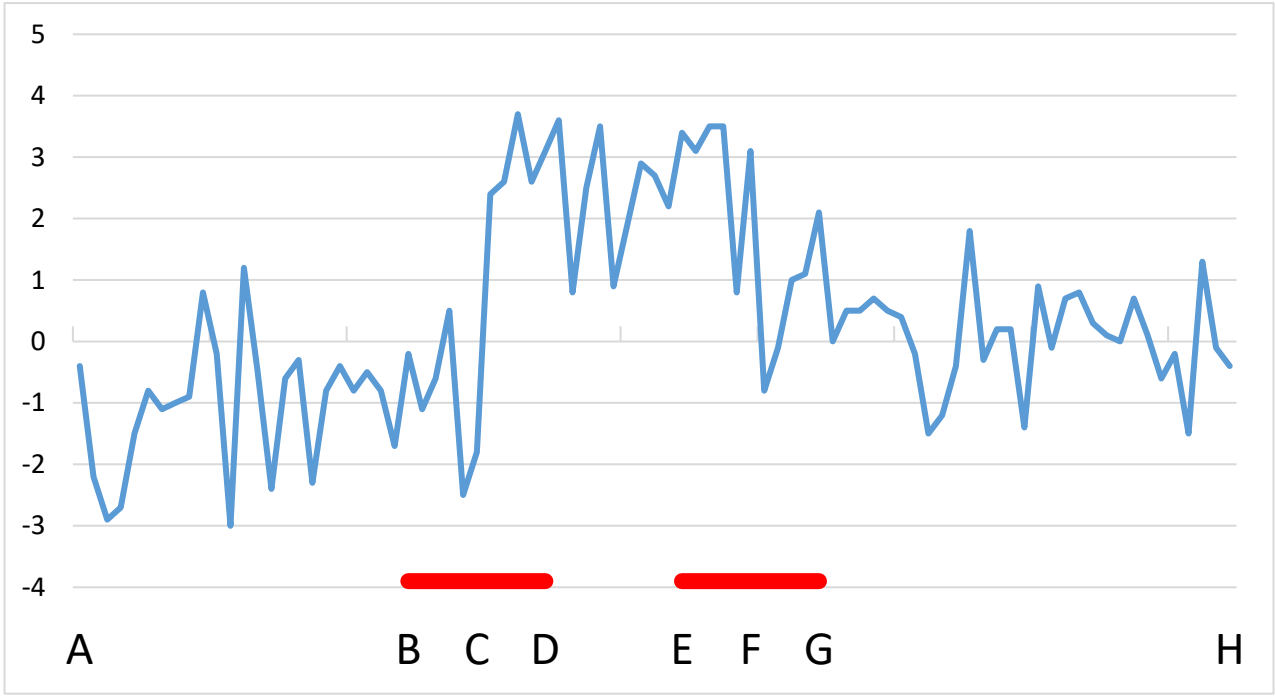
- annual means are homogenized in 3 homogenization cycles
- jointly considers possible multiple inhomogeneities in all parts of the procedure
- most important statistical methods:
    - break detection with composite reference series
    - break detection with combined time series comparison
    - fitting optimal step function with penalizing growing number of steps
    - Benova model for the calculation of adjustment terms
    - bivariate homogeneization for sinus-shaped inhomogeneities
    - ensemble homogenization
    - **New:** homogenization of PDF with the HPDTS procedure
- uses metadata in statistical procedures

ACMANTv6 – homogenization of PDF

- HPDTS: **Pre-defined percentile-ranges** of the PDF, then the first results are smoothed. In this respect it is similar to the known QM methods.
- HPDTS is performed only when the input data has daily resolution
- Precipitation not treated by HPDTS
- PDF of **absolute values for wind, humidity, and atmospheric pressure**, while **anomalies** from seasonal means **for temperature and sunshine**. When anomalies are used, seasonal division in applying HPDTS
- Statistically detected breaks of the previous steps and metadata are considered, with additional significance test
- **HSP means** (calculated by earlier steps of ACMANT) **are preserved**

Limitations of traditional QM

Traditional QM methods (HOM, SPLIDHOM, DAP…) select neighbour series according to the positions of the detected breaks in them, and use their limited sections. It is good for case studies, but the trend estimations might fail.



ACMANTv6 – homogenization of PDF

- Principal difference of HPDTS from QM methods:
  - the best correlating neighbour series are used, and they are completed to the period of the candidate series (when data gaps occur)
  - **all of the pre-selected neighbour series and all pieces of data** in them are used
  - correction terms are calculated with **Cenova**, which is a Benova-type equation system
- Both in Benova and Cenova models: (i) the observed data are composed from a climate signal and a station effect; (ii) the climate signal is characteristic for a group of time series; (iii) the station effect is a step function with presumed positions of the steps.

Benova and Cenova: references

Benova is the optimal model
Domonkos and Joelsson, Int. J. Climatol, 2024,
https://doi.org/10.1002/joc.8594,
but Benova needs continuous time series.

In Cenova, section averages substitutes the original observed values:
Atmosphere, 2025, https://doi.org/10.3390/atmos16050616.

Low frequency climate variability is removed when Cenova is applied.
Performance of Cenova was tested: Climate, 2025,
https://doi.org/10.3390/cli13100199.

ACMANTv6 – users' interactions

Obligatory:

- Selection of the model seasonal cycle of inhomogeneity biases

Optional:

- Setting minimum threshold of spatial correlation
- Setting thresholds for climatic outliers
- Modification of ACMANT-constructed networks of time series
- Edition of the break list of the first homogenization cycle
- **Selection of the reference HSP in the HPDTS procedure**

ACMANTv6 – Accessibility

From January 2028 every ACMANT version will be free

Before that time ACMANTv6 or ACMANTv5 can be purchased from the developer:

Peter Domonkos, dpeterfree@gmail.com

Further information: https://acmant.eu

Thank you for your attention!