



Royal Meteorological
Institute of Belgium
(RMIB)

&

Belgian Climate Centre
(BCC)

From Manual to Operational : Towards sustainable homogenization

Monthly Temperature and Precipitation in Belgium

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Budapest – 4-6 May 2026

Context - Homogenization in Belgium

Project NOISELESS – Developing long-term homogenised climate series

Partners RMIB, BCC, VITO – Funded by Copernicus C3S NCP

- Temperature (minimum and maximum) - From 1880-1954 to 2024
- Precipitation - From 1880-1951 to 2024
- Monthly scale, previously homogenized up to 2015

- Annual future **updates**
- **Access** from summer 2026 through C3S Climate Data Store and open data platforms RMIB, BCC

Purpose - Implement realistic processes

From Manual to **Operational**

→ Research ≠ Practical operation

Operable by data scientists (non-statisticians, non-researchers)

Accounting for limited time & staff resources

Towards **sustainable** homogenization

→ « Easily » updatable series, maintainable scripts

Approach – Choice of software

- **Leverage existing work**

Build on operational solutions to avoid duplicated or isolated efforts

- **Free & Open Source**

Supports transparency, reproducibility and open science

- **Operational standards**

Reliability, scalability, maintainability

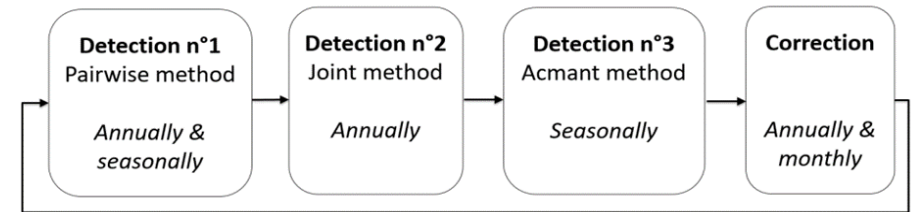
Approach – Choice of software

- **Semi-automatized HOMER¹** (HOMogenization software in R)

Iterative cycle

Detection: pairwise (PRODIGE²),
joint (cghseg³), ACMANT⁴

Correction: ANOVA approach²



- Adapted from the automatic setup **BART⁵**

Developed by Magnus Joelsson from Swedish Meteorological and
Hydrological Institute (SMHI)

Gradual automation

Re-introduction of scientist's expertise

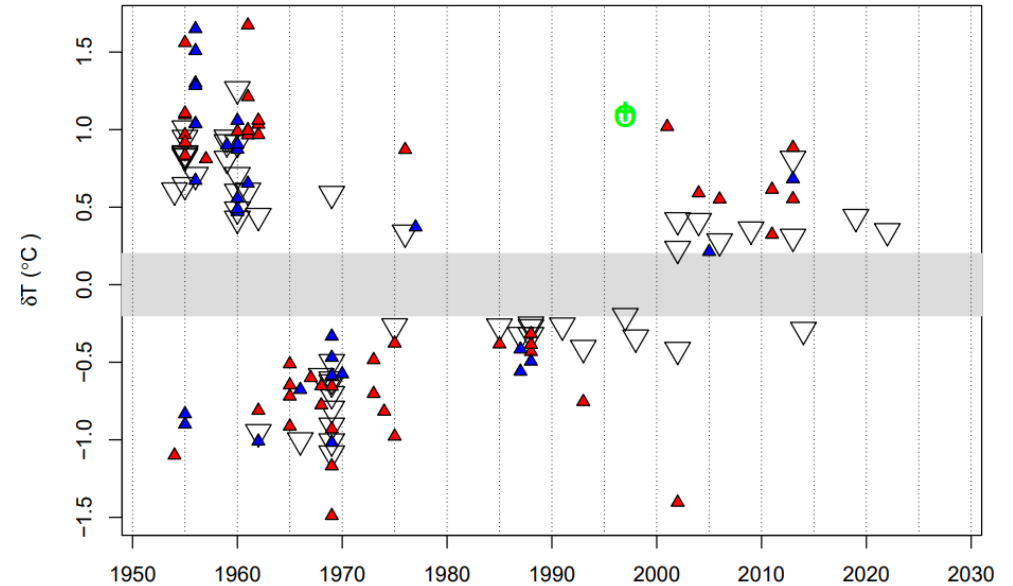
(Semi-)Automation of HOMER

- **Break evaluation**

Scoring system - From BART

Weighted sum of 'evidences'
(detection & metadata)

Threshold for break acceptance



(Semi-)Automation of HOMER

- **Procedure standardization**

- Highly iterative procedure (>5 correction rounds)

- Top-to-bottom approach

- Varying break acceptance threshold

- Analysis of breaks interdependence

- Optimization of breaks unsupported by metadata

→ Significant time gains & reduced risks of over-homogenization

(Semi-)Automation of HOMER

- **Selection of reference series**

Multi-criteria selection of reference series - From BART

Remove the evidences of a break from poorly correlated reference series
& threshold for minimum detectable amplitude (pairwise detection)

→ Thresholds easily adaptable by the user

- **Integration of metadata**

Into the scoring system

Challenge – Metadata management

- Bottleneck : **Upstream collection and selection of relevant metadata**
 - AI assistance: Large language model summarizes each report, email, table in less than 30 words
 - Scientist filter and assign metadata events
 - Still requires manual filtering and scientist's insight
-
- Scope larger than the project – Data management

For one station

Subject: stations automatiques: observations a verifier
From: "XX YY" <XX.YY@na.be>
Date: Fri, 03 Jun 2005 11:55:28 +0200
To: ana@meteo.be
CC: lbb@na.be,
Chers collègues,
Concerne: Statist
Re: 2005
J'utilise des calculs (pas de données utilisées
+ sous abri: g
sur le mât:
disponibilité:
+ rayonnement:
Incident (le
Calculs:
situation de la
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AWS Intervention Report

Prepared by:

AWS Privatif/anderbeed AWS

Date of interv: Station: Bottem

Date of interv	Station	Type	Description
01/06/2005	Bottem	1	reduce of ventilator for temperature 2m
08/06/2005	Bottem	3	Replacement of ventilator for temperature 2m
21/06/2005	Bottem	2	Malfunction of P100 sensor for temperature 2m
11/04/2006	Bottem	3	Replacement of sensor for temperature 2m
14/12/2008	Bottem	5	Malfunction of P100 sensor for temperature under shelter at 1.5m, affecting Tmax and Tmin
10/03/2009	Bottem	6	Change of the position of the temperature sensor on the multiplexer in order to locate the problem on Tdry shelter
20/05/2009	Bottem	4	Tdry shelter in the past. Repaired the temperature failure by connecting the second input of the same multiplexer
29/08/2014	Bottem	5	Two motor ventilator malfunctioning
26/11/2014	Bottem	3	Replacement of two-motor ventilator
09/06/2015	Bottem	3	Replacement of datalogger + replacement of concrete foundation under concrete valley of the pluvis
10/05/2016	Bottem	6	Malfunction of ventilator causing malfunction of temperature dry 2m
26/05/2016	Bottem	3	Replacement of ventilator for temperature 2m

From 217 texts...

doc_id	station_found	date	Home #	comment HOMER
Bottem_20050601_rep.doc	Bottem	01/06/2005	1	reduce of ventilator for temperature 2m
Bottem_20050608_rep.doc	Bottem	08/06/2005	3	Replacement of ventilator for temperature 2m
Bottem_20050621_rep.doc	Bottem	21/06/2005	2	Malfunction of P100 sensor for temperature 2m
Bottem_20060411_rep.doc	Bottem	11/04/2006	3	Replacement of sensor for temperature 2m
Bottem_20081216_req.txt	Bottem	14/12/2008	5	Malfunction of P100 sensor for temperature under shelter at 1.5m, affecting Tmax and Tmin
Bottem_20090310_rep.doc	Bottem	10/03/2009	6	Change of the position of the temperature sensor on the multiplexer in order to locate the problem on Tdry shelter
Bottem_20090520_rep.doc	Bottem	20/05/2009	4	Tdry shelter in the past. Repaired the temperature failure by connecting the second input of the same multiplexer
Bottem_20140829_req.txt	Bottem	29/08/2014	5	Two motor ventilator malfunctioning
Bottem_20141126_rep.txt	Bottem	26/11/2014	3	Replacement of two-motor ventilator
Bottem_20150609_rep.txt	Bottem	09/06/2015	3	Replacement of datalogger + replacement of concrete foundation under concrete valley of the pluvis
Bottem_20160510_req.txt	Bottem	10/05/2016	6	Malfunction of ventilator causing malfunction of temperature dry 2m
Bottem_20160526_rep.txt	Bottem	26/05/2016	3	Replacement of ventilator for temperature 2m

...to 12 relevant events

Operationalizing

- Statistical research
- Process optimization
- Standardization
- Implementation
- Maintenance
- Capacity building

Beyond an homogenization project

- **Holistic approach at institute scale**
 - Balance project vs long-term needs
 - Data engineering
- **Knowledge transfer & Collaboration**
 - Build on documented practical work
 - Document the operationalization process itself
 - Facilitate method accessibility for non-researchers
 - Better operationalization comes from dialogue among practitioners and with researchers

Thank you for your attention

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References

- 1 - Mestre, O., Domonkos, P., Picard, F., Auer, I., Robin, S., Lebarbier, E., Böhm, R., Aguilar, E., Guijarro Pastor, J.A., Vertacnik, G. and Klancar, M., 2013. HOMER: a homogenization software—methods and applications.
- 2 - Caussinus, H. and Mestre, O., 2004. Detection and correction of artificial shifts in climate series. *Journal of the Royal Statistical Society Series C: Applied Statistics*, 53(3), pp.405-425.
- 3 - Picard, F., Lebarbier, E., Hoebeke, M., Rigaille, G., Thiam, B. and Robin, S., 2011. Joint segmentation, calling, and normalization of multiple CGH profiles. *Biostatistics*, 12(3), pp.413-428.
- 4 - Domonkos, P., Poza, R. and Efthymiadis, D., 2011. Newest developments of ACMANT. *Advances in Science and Research*, 6(1), pp.7-11.
- 5 - Joelsson, L.M.T., Sturm, C., Södling, J., Engström, E. and Kjellström, E., 2022. Automation and evaluation of the interactive homogenization tool HOMER. *International Journal of Climatology*, 42(5), pp.2861-2880.