

Table S1. Comparison of homogenization methods (CLIMATOL, PHA, and BART), including methodological setup, data characteristics, and breakpoint detection and adjustment procedures.

	CLIMATOL	PHA	BART (HOMER)
GENERAL PROPERTIES AND SETUP			
Documentation	Manual and user guides	Plain text notes.md	Basic user guide
References	Guijarro (2018)	Menne et al. (2009)	Mestre et al. (2013) & Joelsson (2022)
Open source	Yes	Yes	Yes
Availability	https://cran.r-project.org/web/packages/climatol/index.html	https://www1.ncdc.noaa.gov/pub/data/ghcn/v3/software/52i/	https://climatol.eu/pub/HOMER2.6.zip mail to Magnus Joelsson
Version	3.1.2	Fortran + Python data readers and converters	BART V0.17.20
Operating System	Most	Linux	Linux
Programming environment	R package	Python	R source
Software	R	Fortran + Python data readers and converters	R (3.5.3)
Dependencies	Requires R (≥ 3.6)	PHA executables are UNIX Bash and source code has been compiled with Fortran v4.1.2. Python readers and writers are required to load and convert raw data (e.g., SEF data) into GHCNm-v3 format.	R ($\leq 3.5.3$) cghseg, maps, mapproj
Operation type	Automatic	Automatic	Automatic (Interactive)
Input format	ASCII	ASCII	ASCII
APPLICATION IN THIS STUDY FOR THIS PROJECT (marked bold)			
Data basis	HCLIM	HCLIM	HCLIM
Area	Regions	Regions	Regions
Number of networks	30	18	30
Climatic variables	Temperature (any)	Temperature , pressure	Temperature (any)
Resolution	Annual, Monthly , daily	Monthly , daily	Annual, Season, Monthly
Metadata usage	No	No (optional in some configurations)	No (optional in some configurations)
Network size characteristics	3490	3632	2892
Period	1757-2020	1895-2020	1758-2020
Operation	Automatic	Automatic	Automatic
Breakpoint detection method	Relative homogenization approach: Standard	Relative homogenization approach: Standard	Relative homogenization approach

	Normal Homogeneity test (SNHT) (Alexanderson, 1997)	Normal Homogeneity test (SNHT) (Alexanderson, 1997 & Peterson et al. 1998)	(Penalized Likelihood)
Station distance constraints	Maximum geographical distance between stations: 1000 km	Not available	Optional parameter
Internal option for reference stations	Geographical or correlation	Correlation (Optional)	Geographical or correlation (Optional)
Missing data tolerance	Very high	Very high	Minimum record length: 15 years
Minimum number of series	10	7 (correlate > ~0.3)	8
Max. number of series	No limit	7000	300
Network size characteristics	Biggest network: 628 records (Northeast USA (NW: 8))	Biggest network: 628 records (Northeast USA (NW: 8))	Biggest network: 628 records (Northeast USA (NW: 8))
	Smallest network: 9 records (Alaska (NW: 11))	Smallest network: 14 records (Greenland (NW: 12))	Smallest network: 14 records (Greenland (NW: 12))
Station with the highest number of observations	CET (4200)	Paris (4063)	CET (4200)
Data availability (number of observations) (for whole years) (number of months)	255277 3387350	259311 3449188	249915 3305279
Mean length of series (years)	79	77	93
BREAKPOINT DETECTION			
Step 1	Initial checks and standard deviations (reference)	Pairwise Comparison	Pairwise detection (annual)
Step 2	SNHT (Standard Normal Homogeneity Test) 1 Reference (distance)	Serial	Pairwise detection (seasonal)
Step 3	SNHT (Standard Normal Homogeneity Test) 2	Simulations	Joint detection
Step 4	-	-	ACMANT-style detection*
Metadata used	No	No	No
Correlation threshold			
1. Step	0.25	0.7	0.9
2. Step	0.5	0.5	
3. Step	0.5		
Clustering before selection of reference series	Yes	No	Yes
Interpolation of gaps	Yes	No	No
Reference used	Composite (1:1)	Pairwise	Pairwise, joint

BREAKPOINT CORRECTION			
Correction method	ANOVA	Hierarchic, binary segmentation	Pairwise
OUTPUTS			
Homogenized series	Yes	Yes	Yes
Corrected outliers	Yes	Optional / User-defined	Yes
Corrected breaks	Yes	Optional / User-defined	Yes
Graphics	Yes	Optional / User-defined	Yes

* ACMANT includes detection of inhomogeneities in the seasonal cycle range (Mestre et al., 2013).

SNHT: Standard Normal Homogeneity Test.

Bold text indicates elements applied in this study.

Supplementary Table S2. Stations excluded from the homogenization analysis (BART)

Reason for exclusion | Number of stations

All excluded stations had insufficient record length (<15 years). A complete list is provided below:

qc/qctmmAG02_Tegerfeldend.txt removed from the list: less than 15 years of data
qc/qctmmAR01_Herisau_Merzd.txt removed from the list: less than 15 years of data
qc/qctmmAR02_Gaisd.txt removed from the list: less than 15 years of data
qc/qctmmBE01_Bern_Kochd.txt removed from the list: less than 15 years of data
qc/qctmmBE01_Bern_Lombachd.txt removed from the list: less than 15 years of data
qc/qctmmBE01_Bern_Taveld.txt removed from the list: less than 15 years of data
qc/qctmmBE04_Beatenbergd.txt removed from the list: less than 15 years of data
qc/qctmmBE05_Buerend.txt removed from the list: less than 15 years of data
qc/qctmmBE08_Utzenstorfd.txt removed from the list: less than 15 years of data
qc/qctmmBE09_Gottstatd.txt removed from the list: less than 15 years of data
qc/qctmmBE10_Burgdorfd.txt removed from the list: less than 15 years of data
qc/qctmmFR01_Fribourgd.txt removed from the list: less than 15 years of data
qc/qctmmGR01_Chur_Buold.txt removed from the list: less than 15 years of data
qc/qctmmGR01_Chur_Herold.txt removed from the list: less than 15 years of data
qc/qctmmGR01_Chur_Wehrlid.txt removed from the list: less than 15 years of data
qc/qctmmGR02_Bevers_Bovelind.txt removed from the list: less than 15 years of data
qc/qctmmGR05_Disentis_Condraud.txt removed from the list: less than 15 years of data
qc/qctmmGR11_Nufenend.txt removed from the list: less than 15 years of data
qc/qctmmLU01_Luzern_Ineichend.txt removed from the list: less than 15 years of data
qc/qctmmSO01_Solothurnd.txt removed from the list: less than 15 years of data
qc/qctmmTI01_Gotthard.txt removed from the list: less than 15 years of data
qc/qctmmTI02_Bellinzonad.txt removed from the list: less than 15 years of data
qc/qctmmVD04_Morgesd.txt removed from the list: less than 15 years of data
qc/qctmmZH01_Zurich_Hirzeld.txt removed from the list: less than 15 years of data
qc/qctmmZH01_Zurich_Meyerd.txt removed from the list: less than 15 years of data
qc/qctmmZH01_Zurich_Ottid.txt removed from the list: less than 15 years of data
qc/qctmmZH02_Ellikond.txt removed from the list: less than 15 years of data
qc/qctmmZH03_Winterthur_Furrerd.txt removed from the list: less than 15 years of data
qc/qctmmZH03_Winterthur_Unknownd.txt removed from the list: less than 15 years of data
qc/qctmmZH08_Kuesnachtd.txt removed from the list: less than 15 years of data
qc/qctmmGCOS_Basel_Fuerstenbergerd.txt removed from the list: less than 15 years of data
qc/qctmmGCOS_Bern_Taveld.txt removed from the list: less than 15 years of data
qc/qctmmGCOS_Zurich_Escherd.txt removed from the list: less than 15 years of data

qc/qctmmGCOS_Zurich_Hirzeld.txt removed from the list: less than 15 years of data
qc/qctmmGCOS_Zurich_Hirzeld.txt removed from the list: less than 15 years of data
qc/qctmmGCOS_Zurich_Hofmeisterd.txt removed from the list: less than 15 years of data
qc/qctmm_Dove-268d.txt removed from the list: less than 15 years of data
qc/qctmm_Dove-359d.txt removed from the list: less than 15 years of data
qc/qctmm_Dove-409d.txt removed from the list: less than 15 years of data
qc/qctmmPalatine-Society_Genevad.txt removed from the list: less than 15 years of data
qc/qctmmPalatine-Society_Zagand.txt removed from the list: less than 15 years of data

qc/qctmmGlobal-Datasets_SRM-091d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-4d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-235d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-236d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-237d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-239d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-241d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-242d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-245d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-247d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-248d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-251d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-253d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-254d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-256d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-257d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-261d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-301d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-596d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-598d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-599d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-602d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-608d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-613d.txt removed from the list: less than 15 years of data

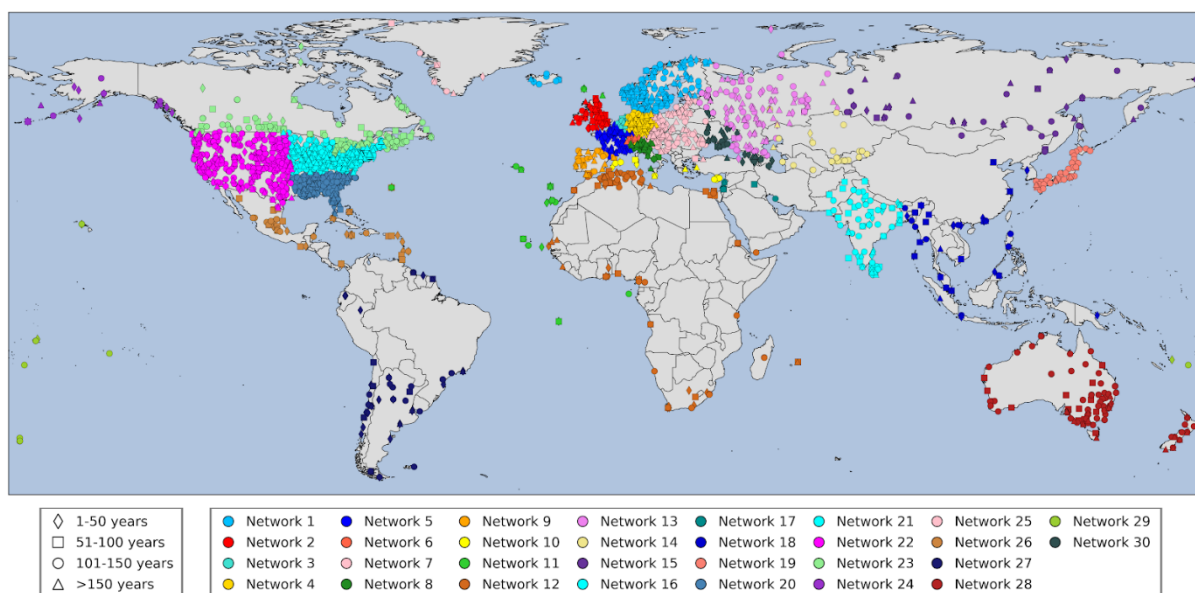
qc/qctmm11900d.txt removed from the list: less than 15 years of data
qc/qctmm18652d.txt removed from the list: less than 15 years of data

qc/qctmm20250d.txt removed from the list: less than 15 years of data
qc/qctmm3020d.txt removed from the list: less than 15 years of data
qc/qctmm41350d.txt removed from the list: less than 15 years of data
qc/qctmm6650d.txt removed from the list: less than 15 years of data
qc/qctmm68152d.txt removed from the list: less than 15 years of data
qc/qctmm96200d.txt removed from the list: less than 15 years of data
qc/qctmmEurope_Russia-14d.txt removed from the list: less than 15 years of data
qc/qctmmGHCN_NON00050541d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-265d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-293d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-346d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-401d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-417d.txt removed from the list: less than 15 years of data
qc/qctmmGlobal-Datasets_Dove-665d.txt removed from the list: less than 15 years of data
qc/qctmmPalatine-Society_Spydebergd.txt removed from the list: less than 15 years of data

Table S3. Number of absolute temperature records per network before (original number of stations), during (manual pre-selection and software pre-processing), and after breakpoint detection (records with detected breakpoints) using the BART, CLIMATOL, and PHA homogenization methods.

	Networks	Original number of stations	Manually pre-selection	Software pre-processed records from the nHom-part			Number of records with detected breakpoints with the Hom-part		
				<i>BART</i>	<i>CLIMATOL</i>	<i>PHA</i>	<i>BART</i>	<i>CLIMATOL</i>	<i>PHA</i>
1	Africa	93	90	74	82	90	73	49	16
2	Alaska	17	17	6	9	17	0	1	1
3	Asia	216	214	178	192	214	156	86	85
4	Atlantic	30	28	19	20	28	15	10	9
5	Australia	117	116	106	109	116	83	65	49
6	Canada	225	216	172	201	216	148	84	83
7	CentralAm	66	66	44	52	66	41	29	29
8	Europe	633	602	283	514	601	316	240	180
9	Greenland	13	12	11	11	12	4	0	2
10	Mediterr	18	17	15	16	17	12	6	6
11	Pacific	16	16	10	13	15	0	4	4
12	Russia	291	224	144	204	287	55	30	32
13	Scandinavia	184	180	157	173	180	120	43	53
14	South-Am	71	69	40	50	68	34	25	26
15	UK	88	88	63	80	88	50	18	19
16	US-NE	648	626	497	569	626	489	361	365
17	US-SE	458	434	397	394	437	394	256	261
18	US-W	447	437	365	410	437	354	208	213
	Not assigned	1							
	Total records	3632	3452	2581	3099	3515	2344	1489	1433

Table S4. The B network used of the homogenization software *BART*, *CLIMATOL*



	Sjekket med kartet Networks	Networks	Number of stations before homogenization	Number of stations after homogenization with Climatol	Number of stations after homogenization with Bart
1	Scandinavia	Scandinavia	184	173	157
2	UK	UK	88	80	63
3	Be-Ne-Lux Countries	Be-Ne-Lux Countries	21	20	16
4	Germany	Germany	294	183	154
5	France	France	106	86	28
6	Switzerland	Switzerland	88	73	38
7	East-Europe	Italy	54	51	49
8	Italy	Istria-peninsula	28	28	28
9	Istria-peninsula	East-Europe	75	73	68
10	Mediterranean Sea	Mediterranean Sea	17	16	15
11	Atlantic Ocean	Atlantic Ocean	28	20	19
12	Africa	Greenland	12	11	12
13	West-Russia	Middle East	20	59	19
14	Sentral-Asia	Eastern-Asia??	40	34	33
15	East-Russia	Western-Asia	19	19	18
16	India and Sri Lanka	India and Sri Lanka	85	80	82
17	Middle East	Japan	47	35	44
18	Eastern-Asia	East-Russia	97	54	39
19	Japan	West-Russia	116	100	87
20	Southeast-US	South-Russia	78	50	22
21	Northeast-US	Africa	90	82	74
22	Western US	Northeast-US	632	626	497
23	Canada	Southeast-US	440	434	365
24	Alaska	Western US	437	410	397
25	Greenland	Canada	217	201	172

26	Central America	Alaska	17	9	-
27	South America	Central America	66	52	44
28	Australia	South America	69	50	40
29	Pacific Ocean	Pacific Ocean	16	13	-
30	Western-Asia	Australia and New Zealand	116	109	106