HOMOGENISATION OF MONTHLY TEMPERATURE AND PRECIPITATION

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Introduction
Climatological analyses require long, complete, and homogeneous time series. Homogeneity in climate series is defined as :

A numerical series representing variations of a climatological element is called "homogeneous" if the variations are caused only by variations of weather and climate.

To ensure homogeneity, homogeneity tests are applied on the observation series. If homogeneity breaks are found, data are adjusted. HOMER (HOMogenisation softwarE in R) detects and adjust for homogeneity breaks (Mestre et al., 2013).

HOMER is a manual tool which require an operator which is impractical when large networks are to be homogenised regularly. The software Bart is an approach to automate HOMER (Joelsson et al., 2022).

The Swedish monthly temperature data set (1860–2021) was homogenised in 2022 using Bart (Joelsson, 2022; Joelsson et al., 2023). In 2023, the monthly mean data set was updated and extended. Also monthly averages of daily extreme temperatures was homogenised. The main application of the homogenised data sets thus far is the climate indicator: temperature.

Homogenisation of the Swedish monthly precipitation (1880–2022) is currently under progress.

Merging of time series
The temperature observational data set consist of over 1 000 time series from different weather and climate stations, the precipitation data set of over 2 000 time series. Very few of these are complete from 1860, when the first observational network was set-up in Sweden. In order to use the time series in climatological analyses, the time series must be gap-filled and extended to cover the entire period. To limit the use of gap-filling and extensions, time series can be merged.

An automatic method is developed to merge the time series in the observational data set (Joelsson, 2022; Joelsson et al., 2023), see Figure 1 and Figure 2.

Monthly average temperature data (daily mean, minimum, and maximum) data from over 800 stations are merged into over 400 time series. Monthly precipitation data from over 1 800 stations are merged into over 1 200 time series.

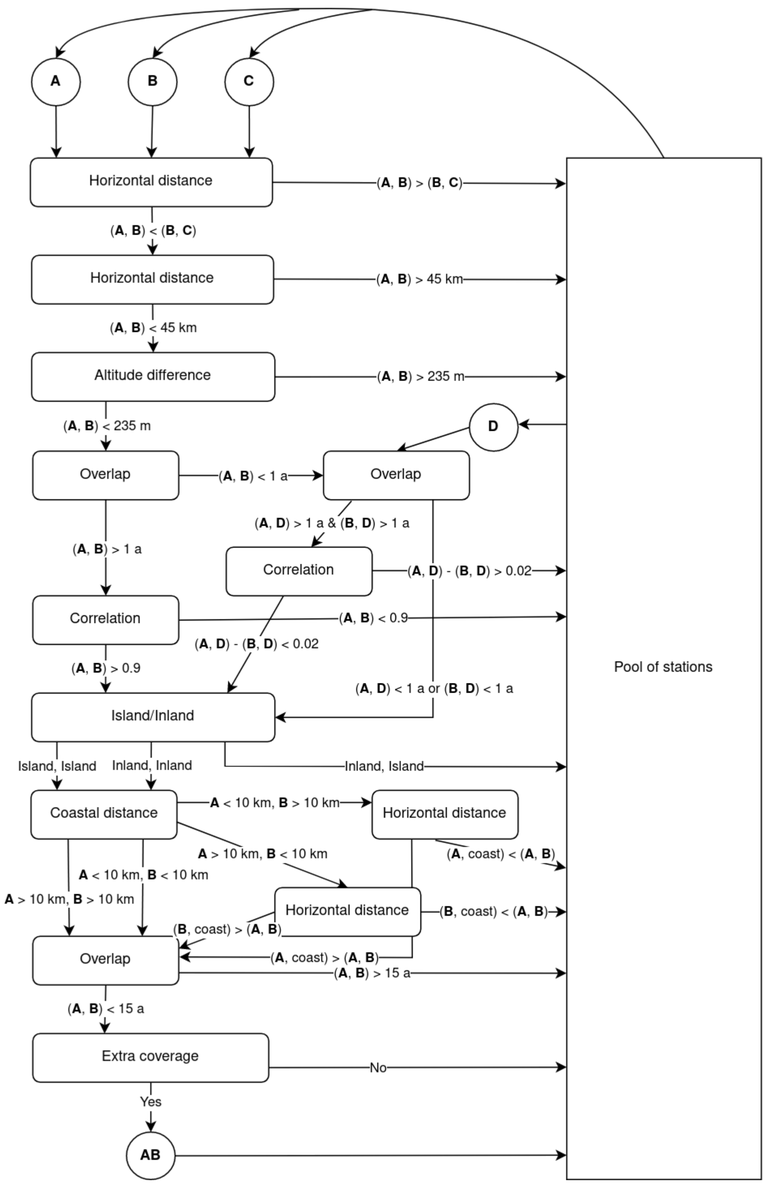

Figure 1: The process of grouping stations in the automatic merging scheme

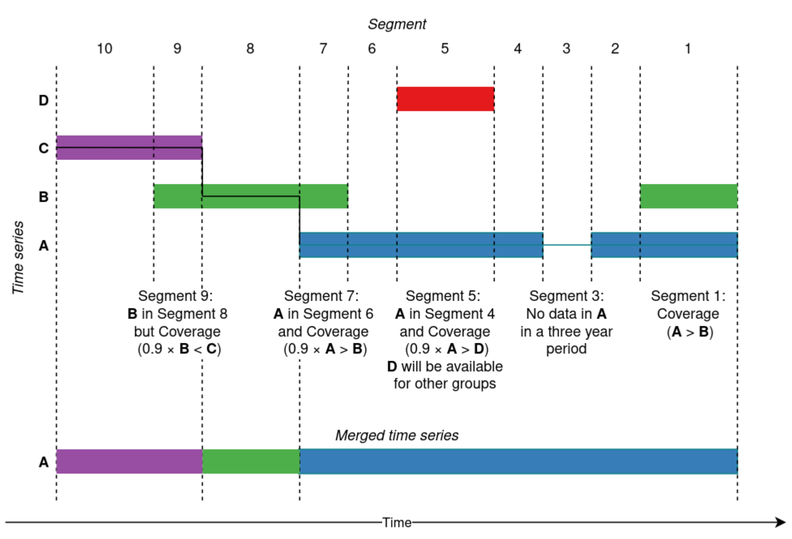

Figure 2: Example of a merged time series from a group of stations

Homogeneity break detection
HOMER is a maximum likelihood method which uses differences between two time series to detect homogeneity breaks. The difference series is segmented such that the total inner variance is minimized, see Figure 3. The placement of the transitions between segments indicate potential homogeneity breaks.

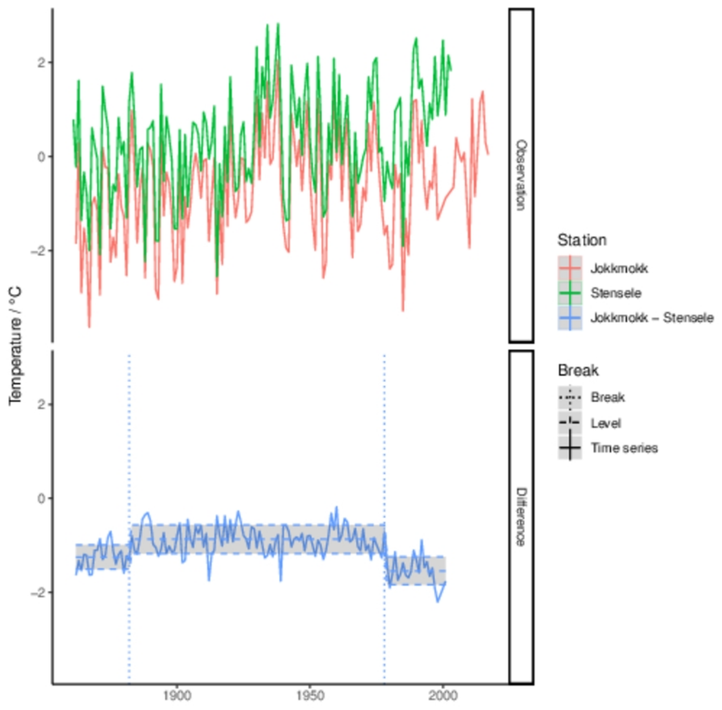

Figure 3: Example of homogeneity break detection between Jokkmokk and Stensele

The homogeneity for each series is tested against a number of climatologically similar series (*reference series*), see Figure 4 and Figure 5. If a potential homogeneity break in detected in a sufficient number of references, the homogeneity break is accepted.

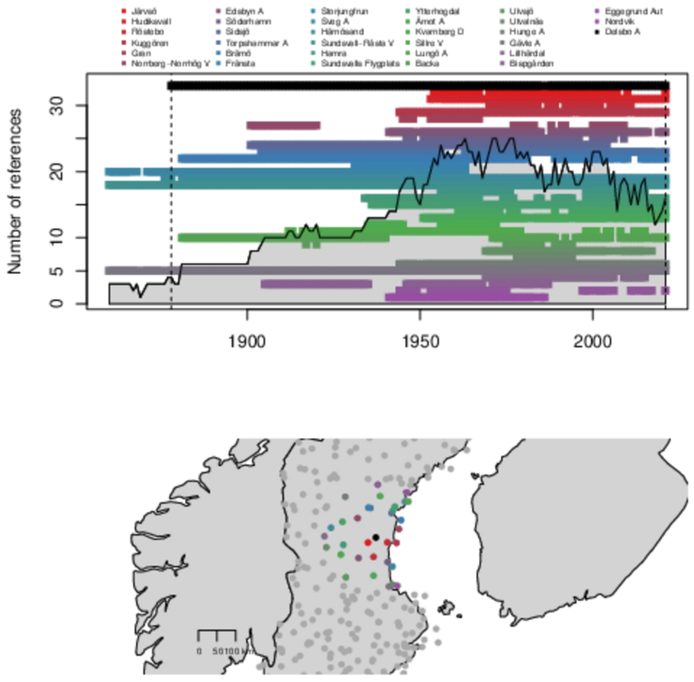

Figure 4: Selection of references used for the homogenisation of monthly mean temperature series of Delsbo

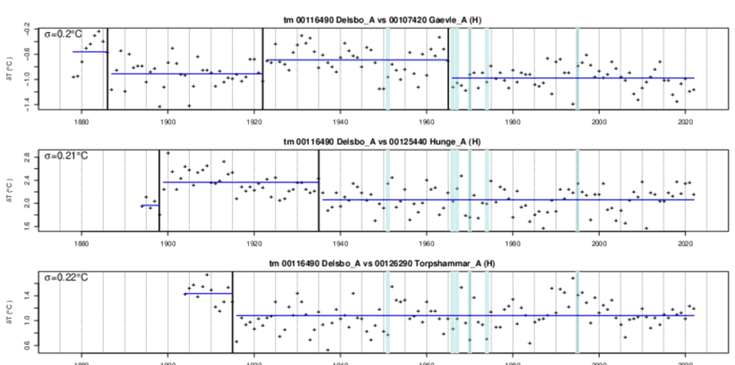

Figure 5: Homogeneity break detection in the monthly mean temperature series of Delsbo against four of the references

Adjustment and gap-filling
Adjustment of time series according to the accepted homogeneity breaks and gap-filling of the series is performed with the ANOVA correction method (Caussinus and Mestre, 2004; Domonkos and Joelsson, n.d.). The method is based on the assumption that a climate variable can be decomposed into a climate term (variable in time, but common for a subset of the station network), a station term (variable across the network, but constant in time), and random noise. Missing values can be approximated by combining the these terms

Homogenisation of temperature
Over 400 merged temperature time series 1860–2022 (daily mean) and 1882–2022 (daily extremes) were homogenised and gap-filled automatically with the homogenisation tool Bart. In total, 1 800–2 100 homogeneity breaks are found over the entire time periods and networks. There are on average 12–18 years between two homogeneity breaks. The network average of monthly mean homogenisation is presented in Figure 6.
The main application of the homogenised data sets are the the climate indicators, three climate indicators are presented in Figure 7.

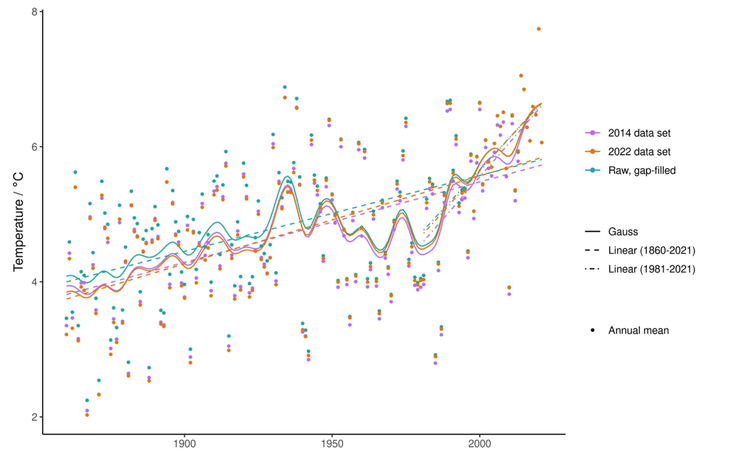

Figure 6: Annual mean temperature, averaged over of 35 selected stations, current homogenised data set (2022), previous homogenised data set (2014), and raw gap-filled data

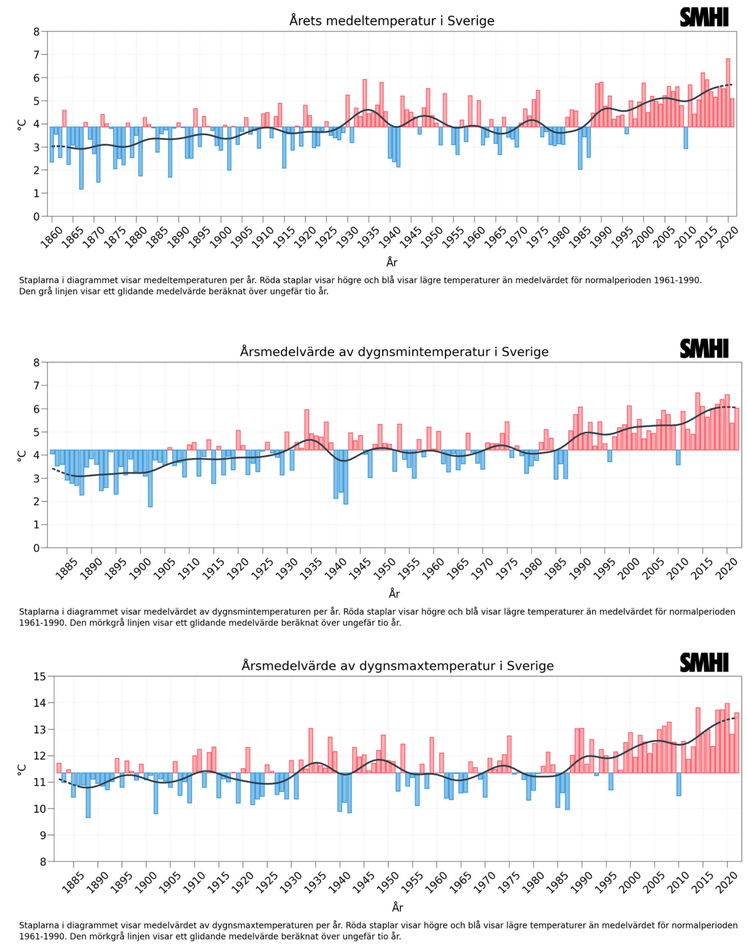

Figure 7: Climate indicators: Annual mean of daily mean (top), minimum (middle), and maximum (bottom) temperature

Homogenisation of precipitation
Homogenisation of monthly precipitation is under progress. In preliminary results about 1 000 homogeneity breaks are found across the network of over 1 200 series.

References
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Meste et al. (2013): HOMER: a homogenization software – methods and applications. *Időjárás*, 117(1), 1–158

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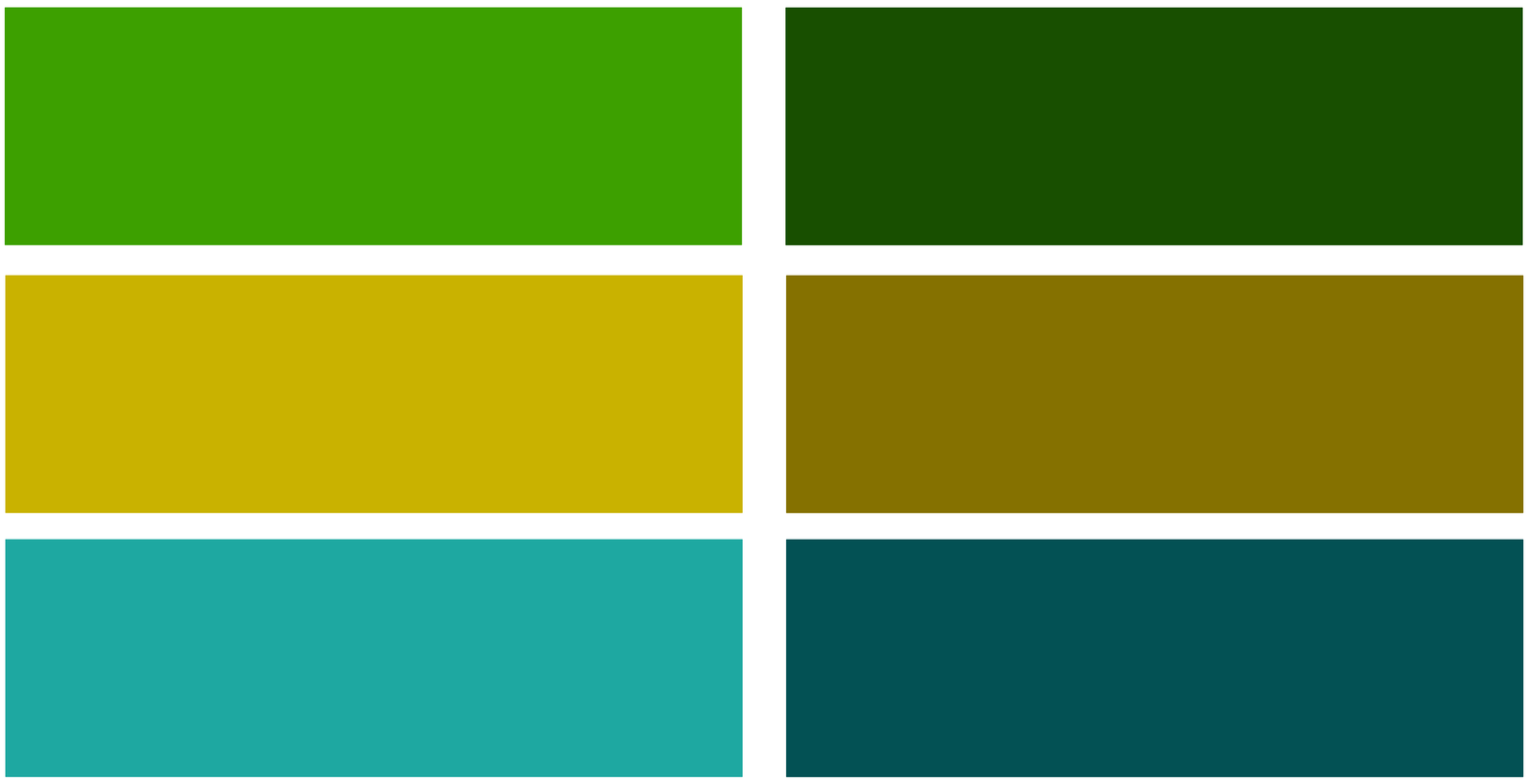

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