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Climate fluctuation in the Alps during the last 250 years

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Abstract

Within EU-project Alp-Imp climate fluctuations in the Alps for the last 500 to 1000 years have been investigated. Beside climate proxy data (tree rings, ice cores) special weight is put on careful analyses of instrumental time series. These data series were quality checked, homogenised and interpolated to a 1°x1° lat/long spatial grid for monthly values (HISTALP data base). Longest series of the data base date back to 1750. However, not only the long time span and data quality makes this data base to a unique example of input data for assessment of both climate change and climate impact but also the vertical extent of climate station from low level sites to high mountain observatories offers the opportunity of three-dimensional evaluations. The high mountain observatory at Sonnblick with its multi-elemental series back to 1886 takes an especially important role for the HISTALP data base and related climate change assessment. On short term (inter-annual) time scale the climate of the Greater Alpine Region (GAR) can be described by five sub-regions (derived from principle component analyses of monthly values) which fits well with a subjective spatial clustering of mean annual course of station series. This sub-regionalisation holds for both air temperature and precipitation. On long term scale GAR air temperature series show a uniform trend for the last 250 years whereas precipitation trends are spatially diverse. Since 1890 GAR annual air temperature has increased by about 2°C. The investigation of changes in temporal variability of both air temperature and precipitation show a decreasing trend which coincide with a decreasing thermal continentality of the GAR.

Keywords

Climate change, Alps, HISTALP, homogenisation, air temperature, precipitation

The HISTALP data base

The HISTALP data base (Auer a.o., 2005) stands for high quality (homogenised, outlier-corrected, gap-filled) long-term instrumental time series covering the Greater Alpine Region (GAR), both in a station and gridded mode. The spatial coverage (which covers the transition zone between three most important climate regions of Europe: Mediterranean - Atlantic - Continental) is shown in Figure1 for the example of air temperature and precipitation. HISTALP includes not only air temperature and precipitation but also several other climate elements like air pressure, sunshine duration, humidity and vapour pressure. For the present release of HISTALP temporal resolution is mostly monthly values but increase of temporal density to daily values is planned for the future. Both the long time span back to 1750 as well as the altitudinal coverage from low level sites up to 3500m a.s.l. for the entire GAR make the HISTALP data set to a unique contribution to climate change assessment and impact studies. Whereas the gridded mode of instrumental series is 1°x1° (relative series) reconstruction methods offer spatially high resolution (10 minute lat-long) long term data sets of absolute values for air temperature and precipitation which are also part of HISTALP.

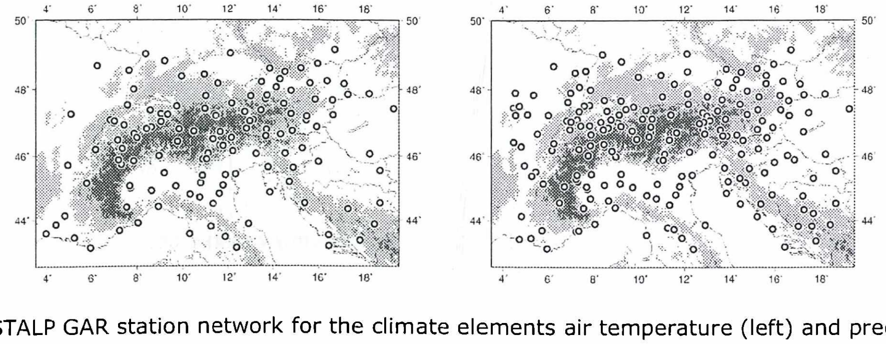

Fig. 1: The HISTALP GAR station network for the climate elements air temperature (left) and precipitation (right)

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Air temperature trends in the Greater Alpine Region

On short term scale the GAR can be regionalised (rotated principle components of normalised monthly series of air temperature) into five different sub-regions. The long term trends of air temperature for these five sub-regions are spatially homogenous not only for annual values but also for seasonal values (but long term trends are seasonally different). Figure 2 shows the long term trend of air temperature of the GAR for the example of two different sub-regions, GAR low-elevation and GAR high-elevation, respectively. The time series show a common increase of about 2.0°C since about 1890 for annual values which is much higher compared to the global warming of about 0.6°C for the same period (BÖHM a.o., 2004). Beside other effects this difference becomes clearer if one takes into account that 2/3 of the earth surface is covered by ocean water which has a higher capacity of heat compared to continental land masses and therefore results in damped temperature variability on global scale.

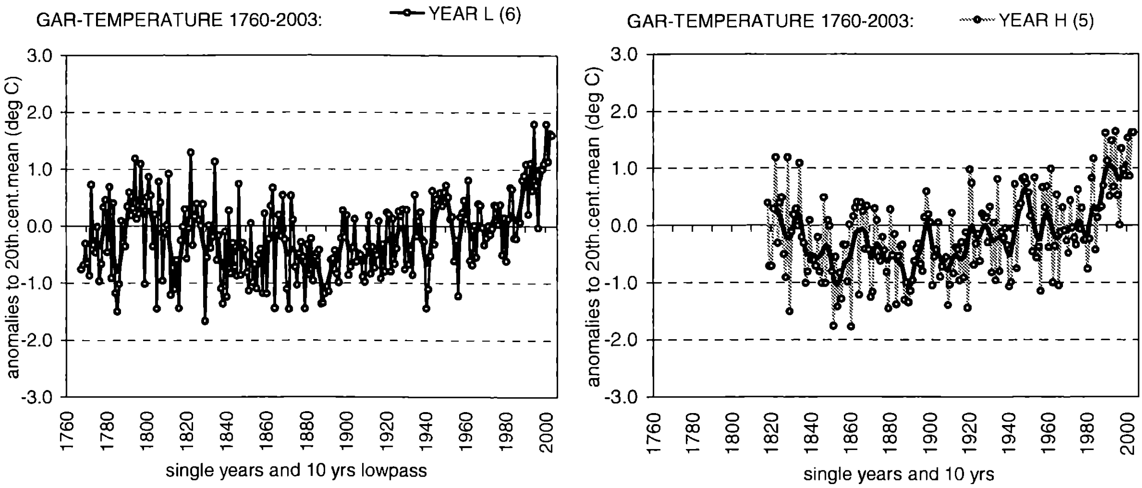

Fig. 2: Long term trends of air temperature for GAR sub-regions low-elevation (left) and high-elevation (right)

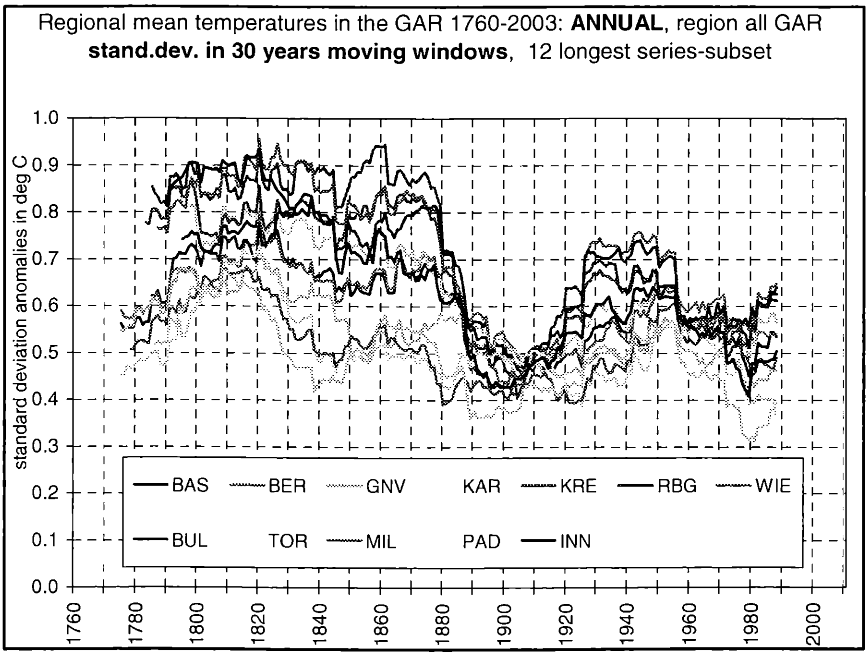

Fig. 3: Time series of annual air temperature variability (30 years moving window technique) for the GAR within the last 200 years for the 12 longest series-subsets

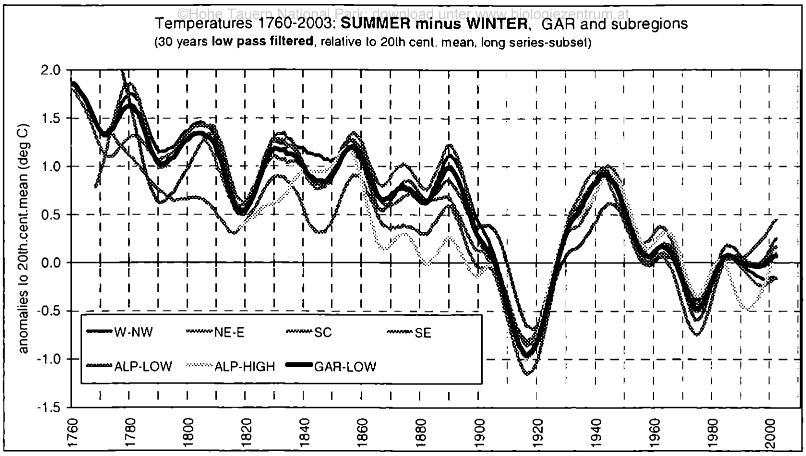

Fig. 4: Low-pass filtered time series of thermal continentality (summer air temperature minus winter air temperature) for different sub-regions of GAR

Another matter of high interest in climate change research is the investigation of changes in variability of climate elements – which could answer the question if the climate has become more variable or not. Figure 3 shows the temporal evolution of the standard deviation of annual values of air temperature for the 12 longest series subsets. It can be seen from the figure that temperature variability is in general decreasing within the 200 years period. This decreasing trend coincides very well with the decreasing thermal continentality within GAR as shown in Figure 4.

Precipitation trends in the Greater Alpine Region

Whereas on the time scale of inter-annual variability GAR precipitation coincides with the 5 air temperature sub-regions on the long term scale precipitation trends are quite spatially different. Figure 5 shows the example of two different sub-regions (NW and SE) which show in general an opposite trend within the 200 years period (increasing for NW and decreasing in SE for about the last 100 years).

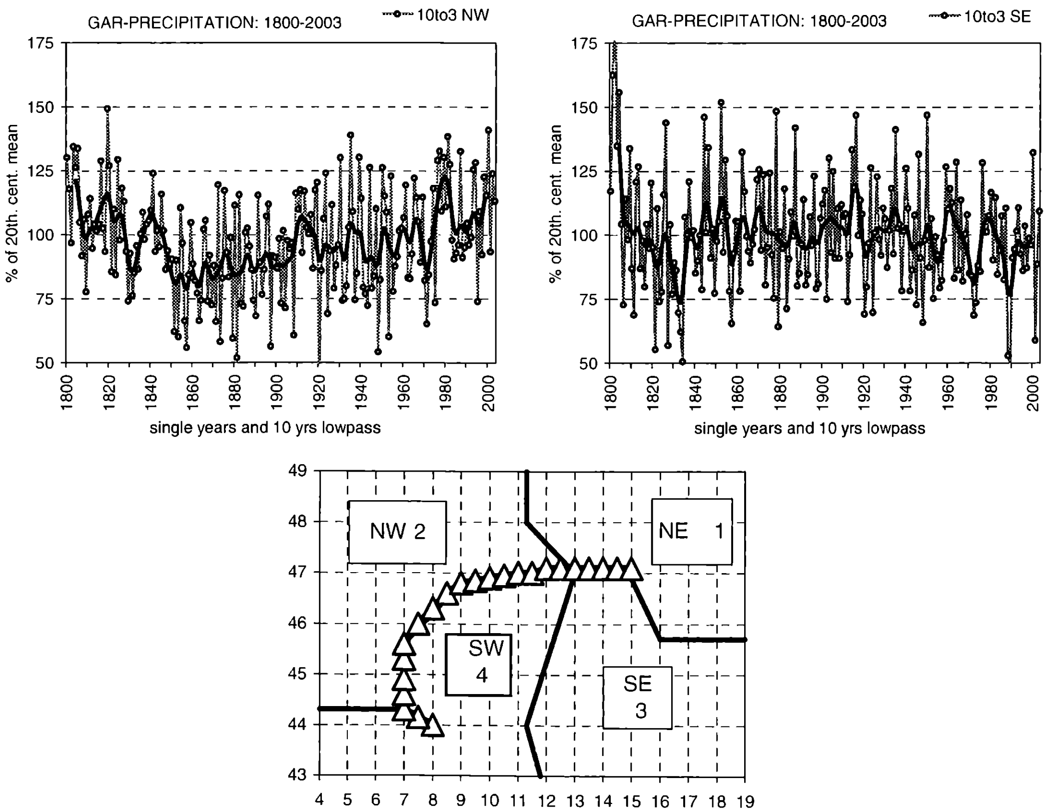

Fig. 5: Example of different long term trends of annual values of precipitation for sub-regions NW (left) and SE (right) of GAR

Conclusions

- For investigation of short term scale (inter-annual variability) the Greater Alpine Region has to be divided into five sub-regions for both air temperature and precipitation
- Long term trends (decades to centuries) of air temperature and precipitation are different for individual seasons within the Greater Alpine Region
- Spatial differences of long term trends of air temperature are not existent and the computation of a GAR temperature trend is useful and representative for all sub-regions
- For precipitation sub-regional trends show different in some cases even opposite behaviour (the computation of a GAR precipitation trend is not useful and therefore sub-regional trends have to be used for climate trend analyses)
- For monthly values of both air temperature as well as precipitation the temporal trend of variability is rather decreasing than increasing within the last 200 to 250 years and coincide with a decreasing thermal continentality

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