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Abstract ID: 701

## **HISTALP – Historical Instrumental Time series for the Greater Alpine Region**

In reality long-term climate series are affected by a broad range of inhomogeneities, ranging from significant breaks to small nearly undetectable trends. Those effects bias the long-term series and hide the real climate signal. To make such series more useful for climate change studies homogenization procedures have to be applied, aiming at the detection and correction of artificial signals in long-term series. Homogenization belongs to the basic duties of NMSs; they are the holders of data and metadata. HISTALP is a data collection based on the following principles 1. Long-term (fully exploiting the potential of systematically measured data), 2. dense (network density adequate in respect to the spatial coherence of the given climate element), 3. quality improved (outliers removed, gaps filled), 4. homogenized (earlier sections adjusted to the recent state of the measuring site), 5. multiple (covering more than one climate element) and 6. user friendly (well described and kept in different modes for different applications). The proposed presentation focuses on the long way of the development of the HISTALP database with and its access via <http://www.zamg.ac.at/histalp>.



## HISTALP – Historical Instrumental Time Series for the Greater Alpine Region-

From HIST-ALP to HIST-EU

possibilities to study European long-term climate variability on regional scale

Zentralanstalt für Meteorologie und Geodynamik



Ingeborg Auer

## Overview

- The Greater Alpine Region and HISTALP – area, network, data requirements
- History of HISTALP
- HISTALP today  
web-site, applications – existing or in progress
- HISTALP tomorrow

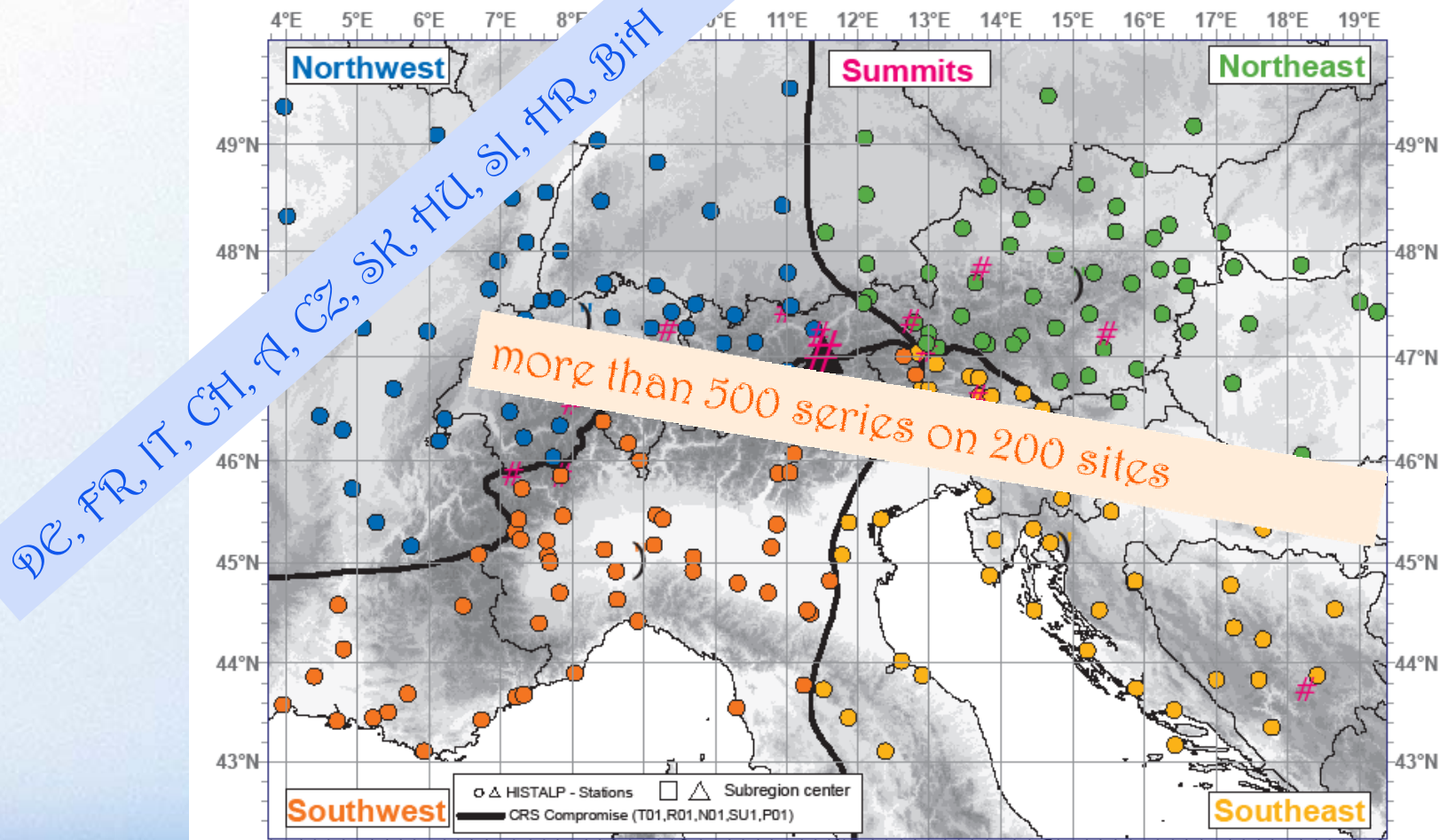




700.000 km<sup>2</sup>, 0 – 3500 m asl

Complicated terrain (littoral, mountain tops, valleys, cold air pools, urban sites, etc.)

### The Greater Alpine Region (GAR (4 to 19°E, 43 to 49 deg N))



Principal climatological regions: NW-SE, high level stations, climate divide between Atlantic, Mediterranean and continental influences

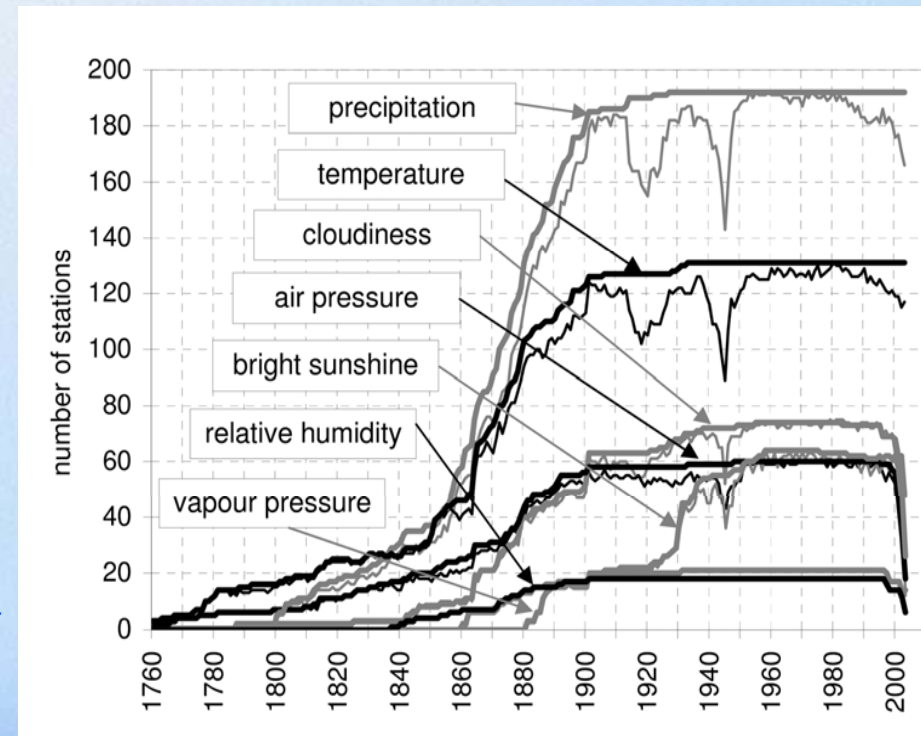


# Some HISTALP characteristics

## MULTIPLE

- Air temperature
- Precipitation
- Air pressure
- Sunshine duration - Cloudiness  
(relative humidity, vapor pressure)

## LONG-TERM



Source: Auer I, Böhm R, Jurkovic A, Lipa W, Orlik A, Potzmann R, Schöner W, Ungersböck M, Matulla C, Briffa K, Jones PD, Efthymiadis D, Brunetti M, Nanni T, Maugeri M, Mercalli L, Mestre O, Moisselin JM, Begert M, Müller-Westermeier G, Kveton V, Bochnicek O, Stastny P, Lapin M, Szalai S, Szentimrey T, Cegnar T, Dolinar M, Gajic-Capka M, Zaninovic K, Majstorovic Z, Nieplova E. 2007. HISTALP – Historical Instrumental Climatological Surface Time Series of the Greater Alpine Region. *Int. J. Climatol.* 27: 17-46 (2007).



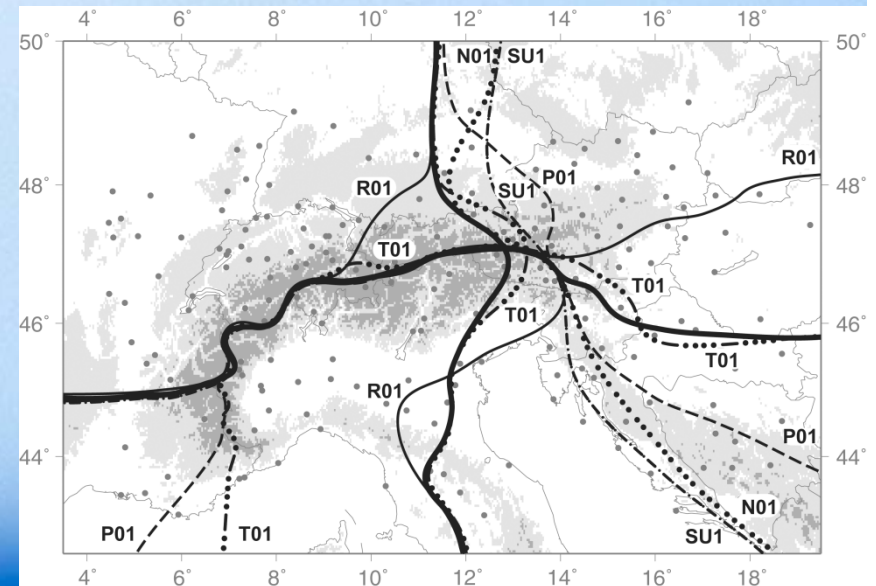


## Data overview

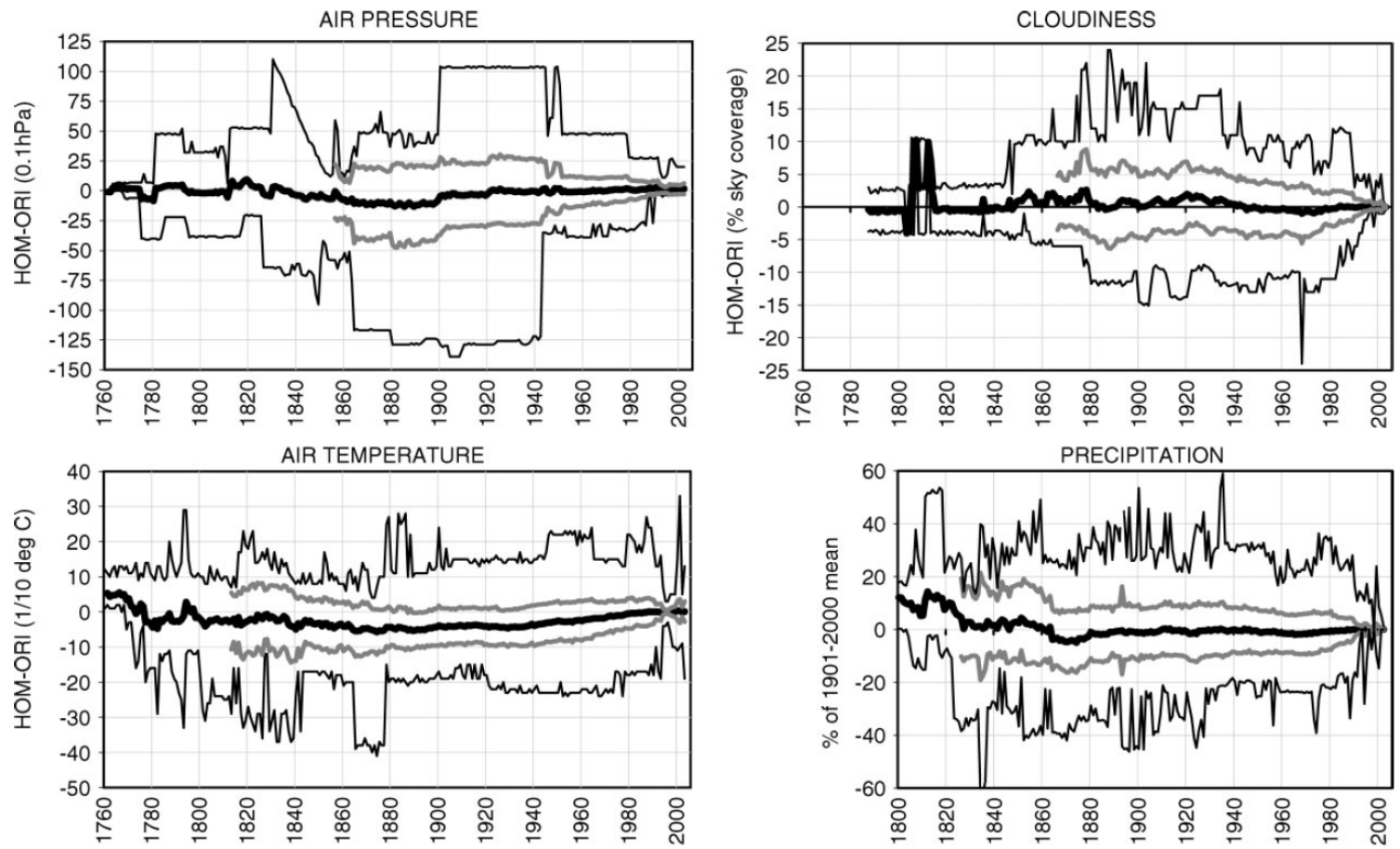
|                               | air pressure | temperature | precipitation | sunshine | cloudiness | all   |          |
|-------------------------------|--------------|-------------|---------------|----------|------------|-------|----------|
| no. of series                 | 72           | 131         | 192           | 55       | 66         | 516   | series   |
| available data                | 10215        | 19312       | 26063         | 7886     | 7669       | 71145 | years    |
| mean length of series         | 141.9        | 147.4       | 135.7         | 88.8     | 119.5      | 137.9 | years    |
| detected breaks               | 256          | 711         | 966           | 366      | 234        | 2533  | breaks   |
| mean homogeneous sub-interval | 31.1         | 22.9        | 22.7          | 11.6     | 26.3       | 23.4  | years    |
| detected real outliers        | 638          | 4175        | 529           |          |            |       | outliers |
| filled gaps                   | 4217         | 12392       | 14927         | 2011     | 3513       | 37060 | months   |
| mean gap rate                 | 3.4          | 5.3         | 4.8           | 2.1      | 3.8        | 4.3   | %        |

## HISTALP database, contents and outline statistics of breaks, outliers, and gaps

Leading horizontal climatological sub-regions of the Greater Alpine Region . Thin lines: Results of PCA (based on single element monthly anomalies) for P01 air pressure, T01 air temperature, R01 precipitation, SU1 sunshine, N01 cloudiness. Bold lines: The CRS (coarse resolution) compromise allowing for intra-elemental comparisons based on equal sub-regions for each climate element



quality improved (homogenized, outlier corrected, gaps completed)



Mean adjustments

$\pm 1$  standard deviation

total range of adjustments





## New: Early bias in instrumental series has been removed (systematic effect)

Prior to 1850-1870 thermometers were insufficiently sheltered from direct sunlight normally placed on north-facing walls or windows

temperatures recorded in the summer half of the year were biased warm and those in the winter half biased cold, with the summer effect dominating,

simultaneous measurements taken for eight recent years at the old and modern site at Kremsmünster, differences in the diurnal cycle depending on season, using metadata EI correction of 32 series



The historic measuring site for temperature and humidity, 6.9m above ground at the NNE-facing front of the historic astronomical tower of the Monastery Kremsmünster (48° 03' 21" N, 14° 08' 01" E , 380 m asl.)



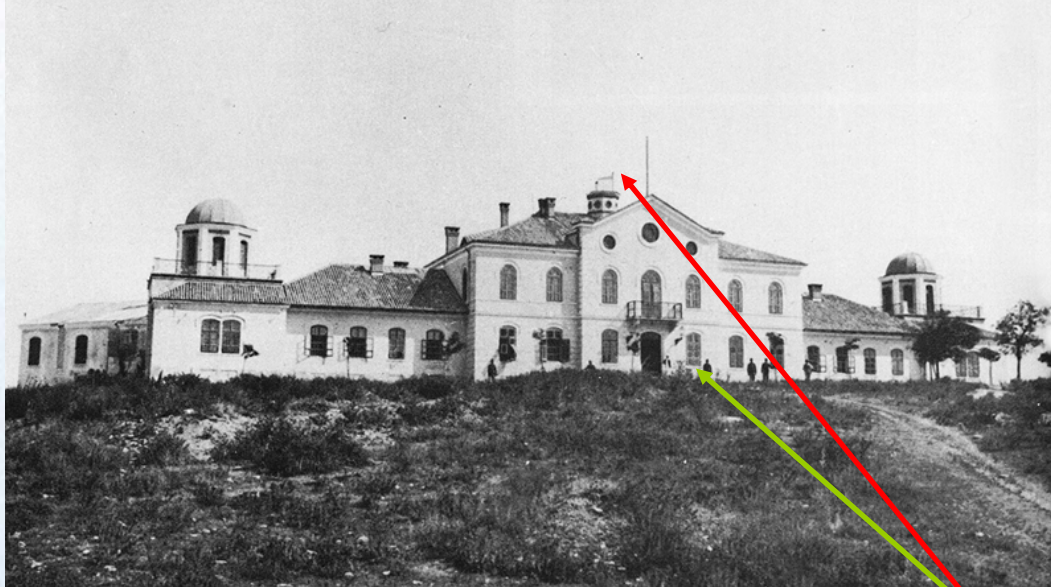
Source: Böhm R , Jones PD , Hiebl J , Frank D Brunetti , Maugeri M, The Early Instrumental Warm-bias: A Solution For Long Central European Temperature Series 1760-2007, accepted for CLIMATIC CHANGE special issue MILLENNIUM project





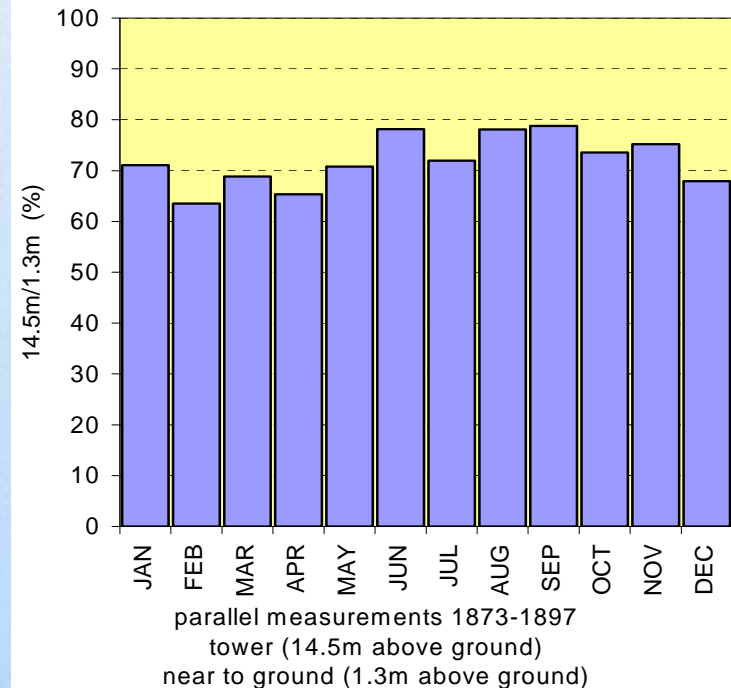
# Systematic effect: early rain gages, example: Precipitation in Pula – Pola,

complicated history (Austria-Italy-Yugoslavia-Croatia), a 30% break in 1897



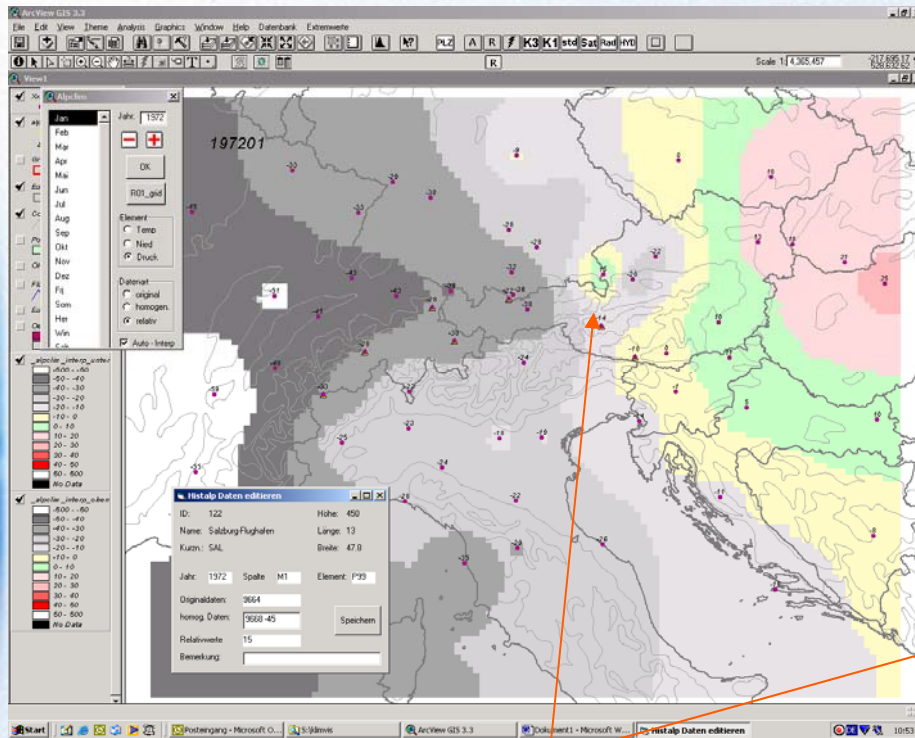
kk. Hydrographisches Amt: 2 sites  
(25 years of parallel measurements)

Comparison of mean monthly precipitation  
Pula (HR) 1873-1897:  
rooftop (14.5m) versus 1.3m near to ground

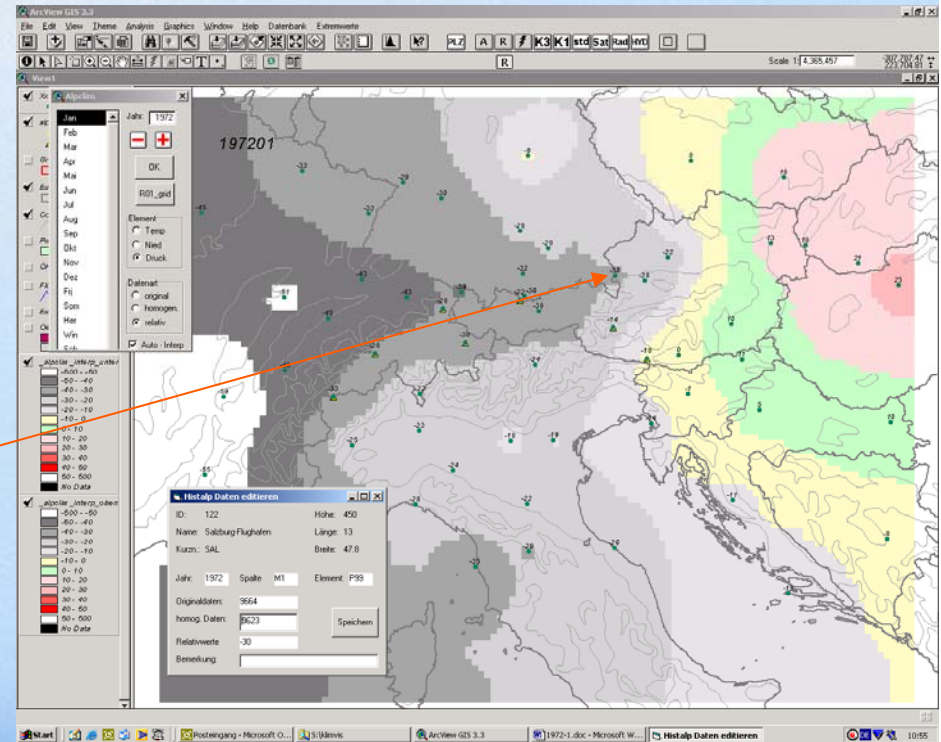


# Data quality: homogenized and outlier corrected:

Example of:  
Visual inspection of air pressure series



Salzburg-Outlier JAN-1972  
error: 4 hPa





## Brief history of HISTALP – how it developed

- Early 1990s: ~ 60 Austrian long-term temperature and precip. series (Böhm 1992, Auer 1993)
- 1994: Kirkkonummi (Majvik) WS on Climate Variations - Povl Frich (DMI) presented The Atlantic Climatological Dataset NACD, (Frich and Cappelen, 1992)- multiple, borderless, homogenized etc.
- Around 2000: start of extension to multiple and GAR (national and international funded climate change projects, „no data projects“)
- 2009: HISTALP goes on-line : [www.zamg.ac.at/histalp](http://www.zamg.ac.at/histalp)

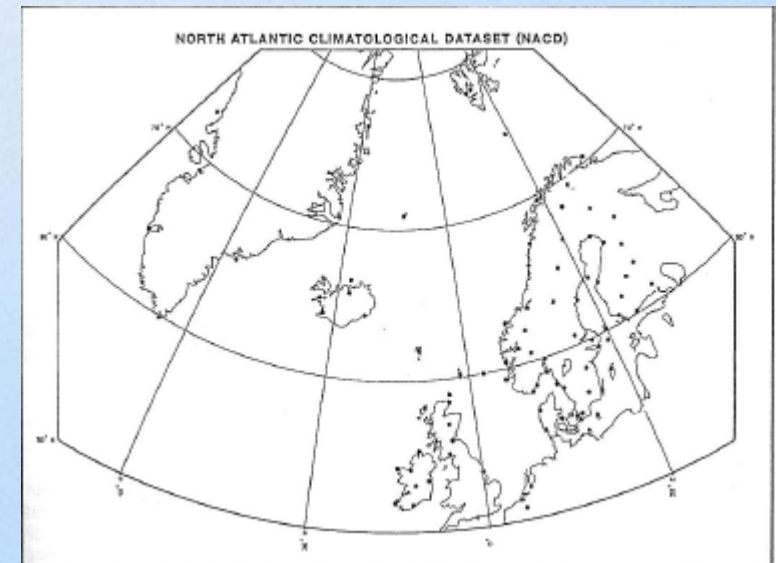


Fig. 1. Map with climatological stations which have been selected for the North Atlantic Climatological Dataset (NACD). After FRICH and CAPPELEN (1992).



# HISTALP on-line: <http://www.zamg.at/histalp>

HISTALP 2007 - Microsoft Internet Explorer provided by www.Sympatico.ca

http://www.zamg.ac.at/histalp/content/view/12/26/index.html

HISTALP

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**HISTALP HISTORY - Early 1990s**

**Early 1990s**

The idea for a collection of quality improved, longterm instrumental climate data in the realm of the European Alps emerged in the early 1990s. It started within the climate division of the Austrian weather service (ZAMG) with processing the respective sources for monthly temperature means and precipitation totals ([Bohm, 1992](#) , [Auer, 1993](#) ) for the territory of Austria. Those two attempts already considered the basic requirements to an adequate dataset for climate variability and change studies. They tried to produce data being:

**Histalp History**

- [Early 1990s](#)
- [1997-2001](#)
- [2002-2007](#)
- [2008](#)

- LONGTERM** (fully exploiting the potential of systematically measured data)
- DENSE** (network density adequate in respect to the spatial coherence of the given climate element)
- QUALITY IMPROVED** (outliers removed, gaps filled)
- HOMOGENISED** (earlier sections adjusted to the recent state of the measuring site)
- MULTIPLE** (covering more than one climate element)
- USER FRIENDLY** (well described and kept in different modes for different applications)

The initial attempts in the early 1990s already met 1, 2 and 4 of the "HISTALP commandments". In order to meet no.1 by extending the series back into the late 18th (temperature, later also air pressure) and in the early 19th century (precipitation, later also cloudiness) the decision was drawn to concentrate HISTALP on monthly data for the time being.

No. 2 was adequately fulfilled through 58 temperature and 62 precipitation series. They were homogenised (no.4) and existing gaps were completed (no.3). Systematic outlier detection was not done at this stage.

No.5 was partly met (2 climate elements), as well as No.6 by keeping the series as "original" and as "homogenised" – the former being quality improved data according to the requirements of met-services and their predecessors, the latter through the application of relative homogeneity testing and adjusting (e.g. [Peterson et al., 1998](#) , [Auer et al., 1999](#) ). Still in the "Austrian period" [Auer and Böhm, 1994](#) produced a first grid-mode through interpolation of the temperature and precipitation anomaly series to a regular 1x1 deg lat-long grid.

[read more...](#)





# Station Data, 1°x1° grids, Coarse Resolution Subregional Means

HISTALP 2007 - Microsoft Internet Explorer provided by www.Sympatico.ca

http://www.zamg.ac.at/histalp/content/view/full/18/36/index.html

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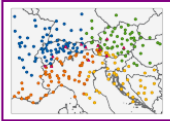



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**Datasets**

We have separated our datasets into two groups - station mode data and gridded datasets. In case of station data, we are not able to provide our complete collection due to restrictions of the original data providers - the gridded files include, of course all available data.

All HISTALP Data will be provided free of charge, provided the sources are acknowledged. Acknowledgement should preferably be by citing one or more of the appropriate papers (see [References](#)) and the source of the data: <http://www.zamg.ac.at/histalp>

The exact reference can be also found within the readme file provided with each dataset.

| GRID - MODE DATA                                                                                                                                    | STATION - MODE DATA                                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <a href="#">CRSM Files</a><br>coarse resolution subregional means | <br>here you can find, nearly all our homogenised <a href="#">Station-mode datasets</a> |
|  <a href="#">1x1 degree gridfiles</a>                             |                                                                                                                                                                             |
|  1/6 x 1/6 degree gridfiles (not finished yet)                   |                                                                                                                                                                             |
|  1km gridfiles (not finished yet)                                |                                                                                                                                                                             |

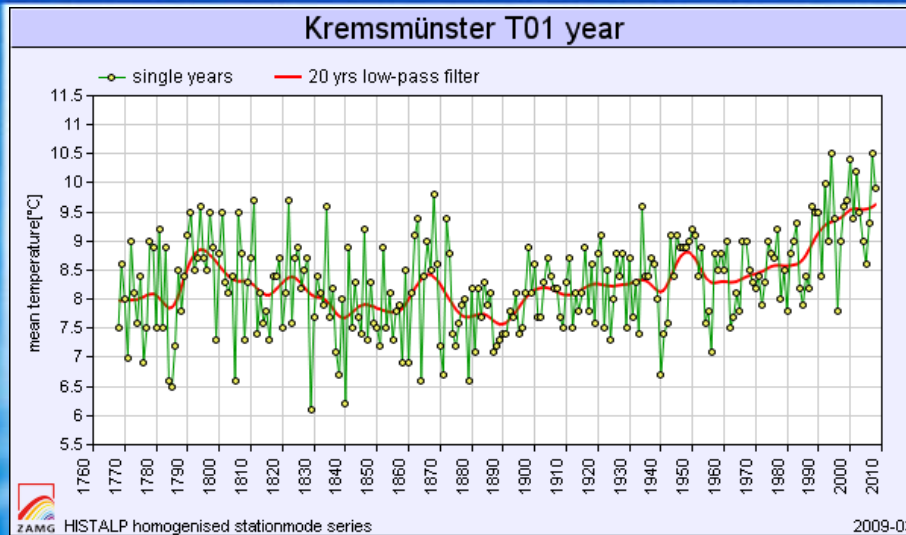
New datasets will be published infrequently so check this website every now and then for updates - if you like to receive an information please deposit your email address at the [HISTALP Management](#)

Start | Posteingang - Micr... | Windows Explorer | Veranstaltungen a... | KLFOR\_bericht\_20... | Microsoft Offic... | HISTALP 2007 - Mic... | Desktop durchsuchen | Internet | 100% | 13:41 Mittwoch 13.05.2009

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## Station-Mode Dataset



Example: T01 Mean temperature

Data download – data policy

Austrian series may be downloaded for non-profit research without restrictions

Files from Switzerland require the permission of MeteoSwiss,

Data of all other national subgroups require a respective short notice about the use

Seasonal and annual diagrams





# 1°x1° grids

**Grid mode 1**

Grid-mode-1 series are anomaly series interpolated to a regular grid of 1° latitude and 1° longitude ranging from 4° to 19°E and from 43° to 49°N. Like CRSM-series, also "grid-1" series intend to reduce still remaining undetected inhomogeneities/outliers through the process of averaging. They overcome any remaining inhomogeneities of the network in terms of spatial distribution of the sites and they allow for easier and more systematic use in many kinds of analyses. The method applied was a modified Gaussian weighted inverse distance interpolation. The filter width of the weighting function was set with respect to spatial decorrelation of the respective climate element (Auer et al. 2002, Fig.10, Fig.11). Some few existing steep climate gradients in the region like the alpine main chain for all elements, coastal versus inland for temperature and a few others were initially defined as barriers for any information transport. Also the search radius was set according to the specific spatial decorrelation. This is a measure to avoid transfer of information to a gridpoint over unrealistic long-distances especially in earlier times when network density was lower. For temperature, two such grid-1 datasets were produced. The version "high-elevation" is only present for grid-points in the direct alpine realm and was calculated from a selection of high-elevation or summit series. The version "low-elevation" comprises all grid points in the GAR.

For precipitation the series from the wind exposed summit sites had been excluded from the stmod-dataset already (Auer et al., 2005), due to the well known uncertainties of precipitation measurements at high elevated Alpine sites. Consequently, no high elevation grid-1 version was produced.

For air pressure only sites up to a maximum altitude of 650m asl were used for gridpoint-interpolation. These low elevation fields can be expected to mainly carry information usable for questions of circulation. Higher elevated sites were excluded due to their systematic bias originating from the temperature and humidity of the atmospheric layers beneath. However, respective studies targeting directly on such effects, have to remain on the respective low- and high elevation pairs of stmod series (e.g. Rohm et al 1998).

Currently the following grids are available (compressed as zip, size approx. 500kB)

| Description                                 | Download Grid File                            |
|---------------------------------------------|-----------------------------------------------|
| Temperature Grid from low elevation sites   | <a href="#">T01-hom-grid-11-2008-low.dat</a>  |
| Temperature Grid from high elevation sites  | <a href="#">T01-hom-grid-03-2009-high.dat</a> |
| Precipitation Grid from low elevation sites | <a href="#">R01-hom-grid-03-2009.dat</a>      |
| Air Pressure Grid from low elevation sites  | <a href="#">P01-hom-grid-03-2009-low.dat</a>  |
| Air Pressure Grid from high elevation sites | <a href="#">P01-hom-grid-03-2009-high.dat</a> |

A fourth grid-1 mode is envisaged for the future: it will be anomaly series of the climate parameter sunshine duration

- Temperature of low elevation sites
- Temperature of high elevation sites
- Air Pressure of low elevation sites
- Air Pressure of high elevation sites
- Precipitation of low elevation sites



# CRSM Data – Coarse resolution subregional means

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**CRSM Data**

CRSM-series are subregional mean series (CRSM = Coarse Resolution Subregional Means). They are arithmetic means of single station anomaly series for the five principal subregions in the Greater Alpine Region. The CRSs have been detected via EOF-based regionalisation for each of the 5 leading climate parameters present in HISTALP (Auer et al. 2007, chapt. 5). Single parameter regionalisation produced highly similar CRSs. Thus the decision was drawn to average them to one optimal version for all climate parameters (statmap-2).

Internal spatial decorrelation of the climatic fields within the CRSs compared to the diameters of the CRSs is such (Auer et al. 2007) that CRSM-series are the optimal choice for lower frequency analysis for all climate parameters. For higher frequency analysis (single months, seasons years, outliers, extreme events) higher resolution grids (grid-mode-1 or grid-mode-2 or station-mode are recommended. For the weakly decorrelating parameters air pressure and temperature CRSM-series may be the best choice also for such purposes. In CRSM-series eventually not yet detected inhomogeneities and outliers in single series are damped.

Monthly, seasonal and annual mean series of the leading climate parameters may be viewed in the [CRSM-time series gallery](#).

| Element                 | relative 1961-1990                        | relative 1900-2000                         | Size |
|-------------------------|-------------------------------------------|--------------------------------------------|------|
| mean sunshine duration  | <a href="#">SU1-rel1961-1990_CRSM.zip</a> | <a href="#">_SU1-rel1901-2000_CRSM.zip</a> | 24k  |
| mean precipitation sums | <a href="#">R01-rel1961-1990_CRSM.zip</a> | <a href="#">R01-rel1901-2000_CRSM.zip</a>  | 33k  |
| mean cloudiness         | <a href="#">N01-rel1961-1990_CRSM.zip</a> | <a href="#">_N01-rel1901-2000_CRSM.zip</a> | 27k  |
| mean temperature        | <a href="#">T01-rel1961-1990_CRSM.zip</a> | <a href="#">_T01-rel1901-2000_CRSM.zip</a> | 40k  |
| md5sum controlfile      | <a href="#">CRSM.md5</a>                  |                                            |      |

Somebody might be interested in coordinates of the center for each subregion, we have calculated them for each element under use of the station coordinates (longitude, latitude and height). The central point of each CRS is the result of an weighted average above all element dependend centers.

| Content | Download                             | Size |
|---------|--------------------------------------|------|
|         | <a href="#">CRSM-coordinates.csv</a> | 1k   |

[\[ Back \]](#)

**GAR-Temperature 1795-2007**  
AP Year | 1817

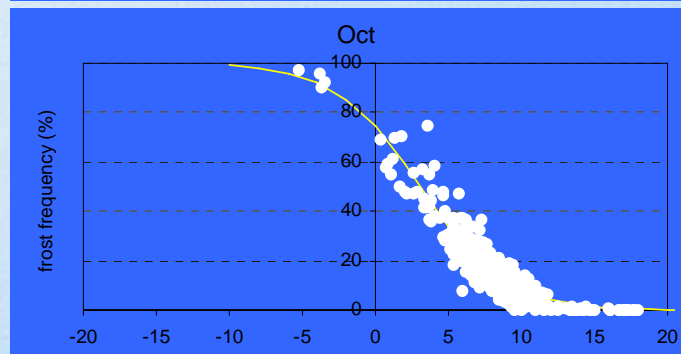
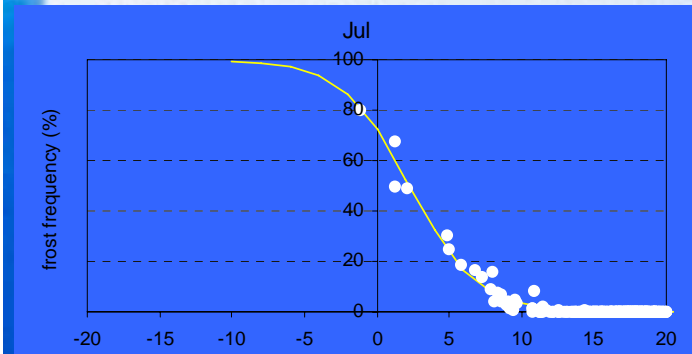
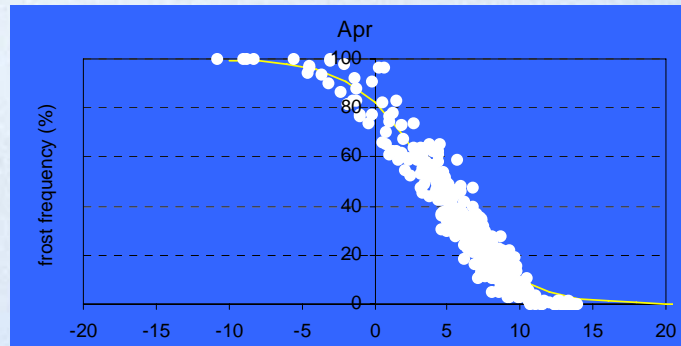
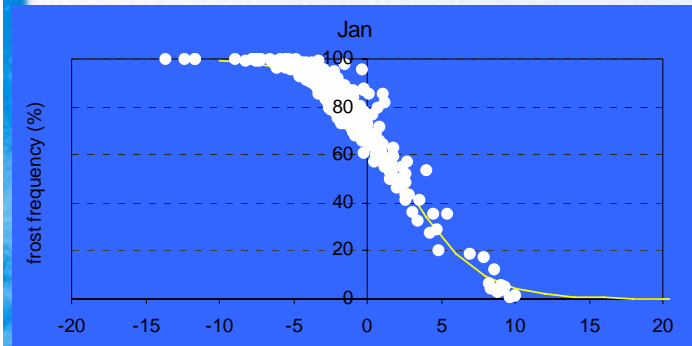
Element: relative 1961-1990  
relative 1900-2000  
Months, seasons and year





## Application: Derived elements based on HISTALP SENSITIVITY STUDIES :

Relationship between air temperature ( $t_m$ ) and frost days (% of month length) by tan h modelling  $FF(t_m) = p_{3,m} (1 - \tanh(p_{2,m} (t_m - p_{1,m})))$ ,  $m=1, \dots, 12$



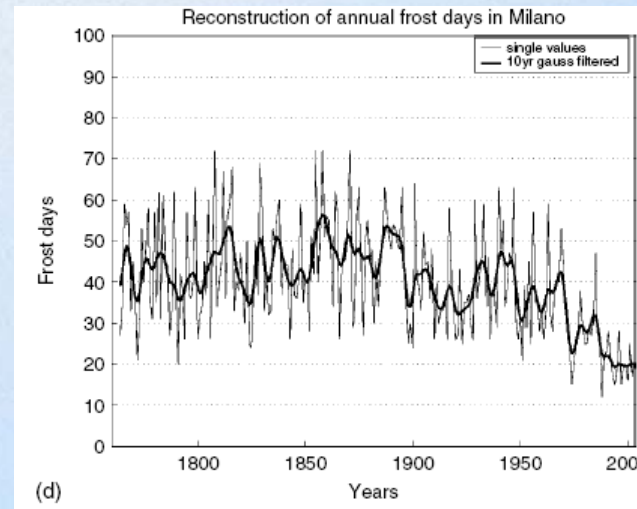
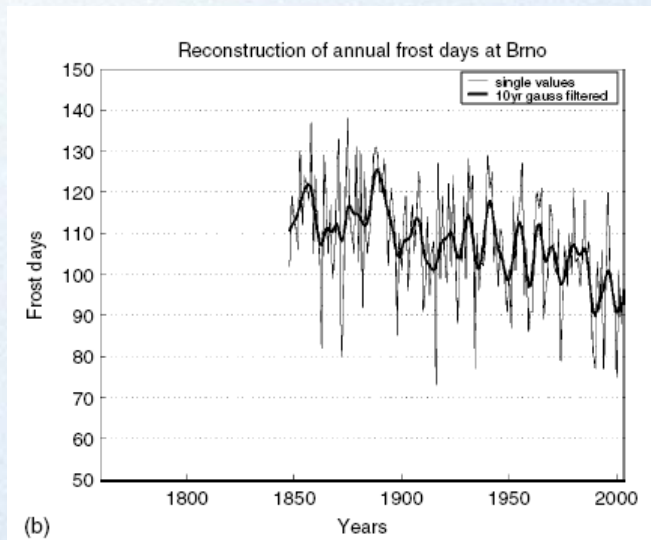
## FROSTDAYS

$$FF(t_m) = p_{3,m} (1 - \tanh(p_{2,m} (t_m - p_{1,m}))) , m=1, \dots, 12$$



## Application: Long-term series of frost days

To overcome deficiencies in frost days series  
when no minimum temperature measurements  
when series carry non removable inhomogeneities  
when series are too short

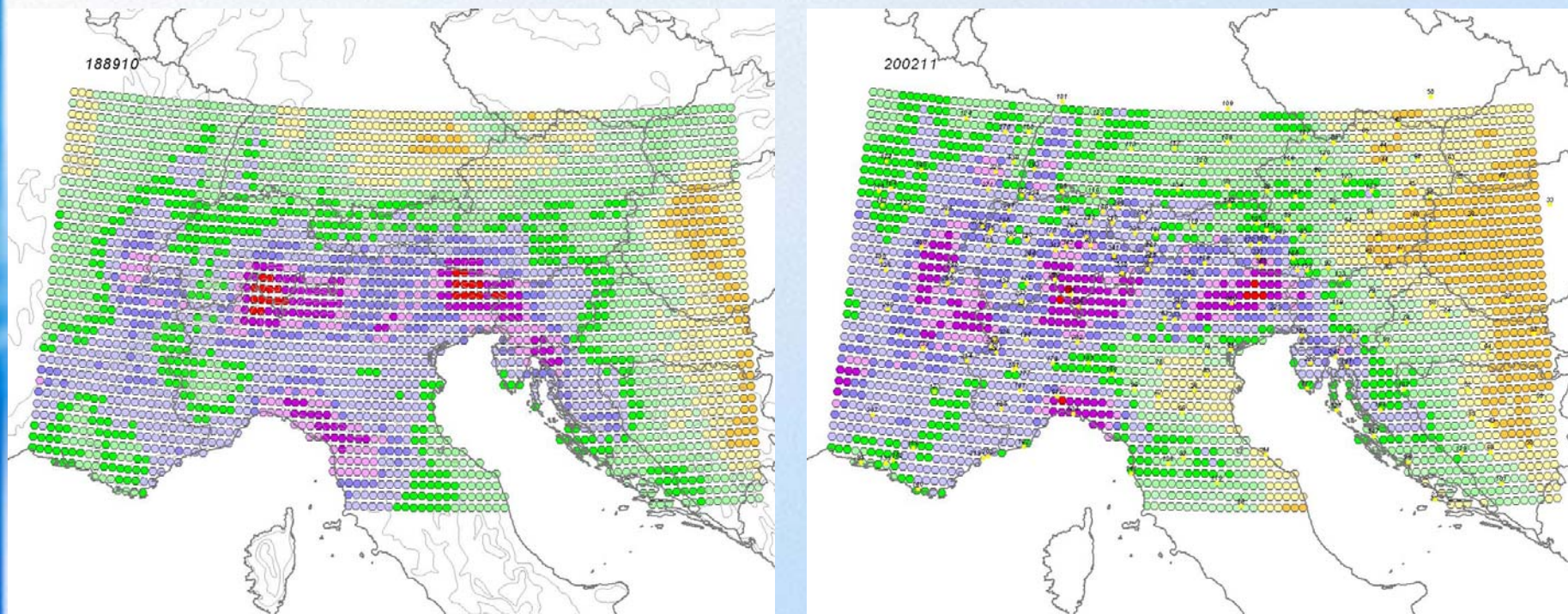


Source: Auer I, Matulla C, Böhm R, Ungersböck M, Maugeri M, Nanni T, Pastorelli R. 2005 Sensitivity of Frost Occurrence to Temperature Variability in the European Alps. [International Journal of Climatology 25: 1749-1766.](#)





## Application: reconstruction of high resolution precipitation fields

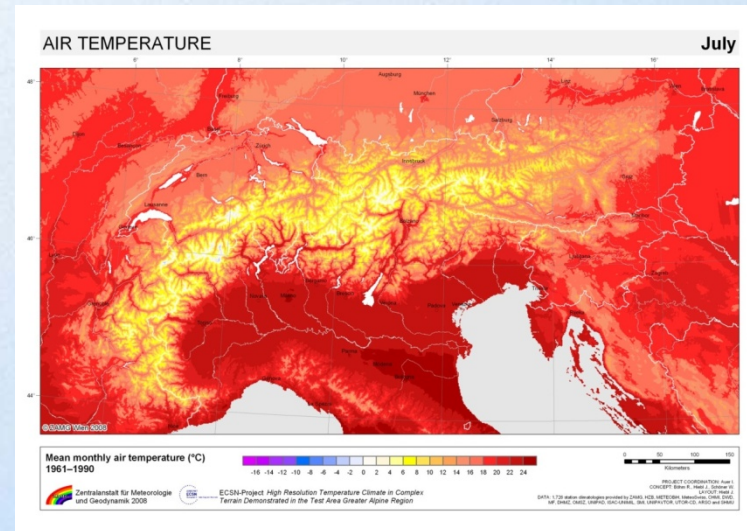
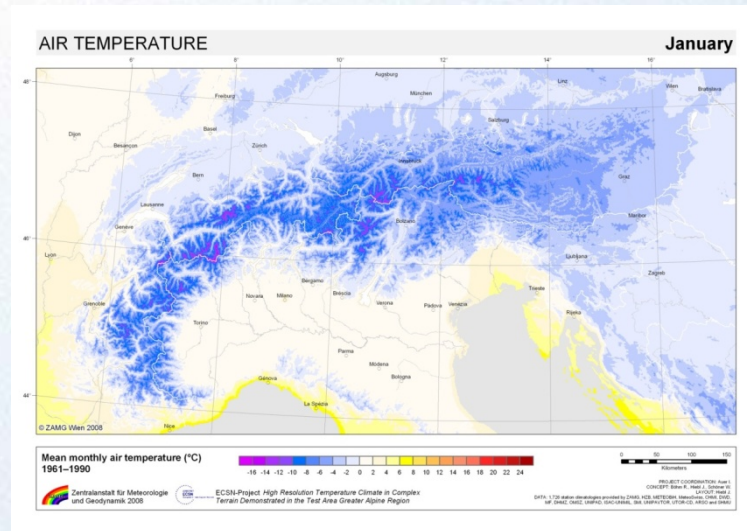


Source: Efthymiadis, D., P. D. Jones, K. R. Briffa, I. Auer, R. Böhm, W. Schöner, C. Frei, and J. Schmidli, 2006. Construction of a 10-min-gridded precipitation data set for the Greater Alpine Region for 1800–2003, *J. Geophys. Res.*, 111, D01105, doi:10.1029/2005JD006120





# Application in progress: reconstruction of high resolution temperature fields



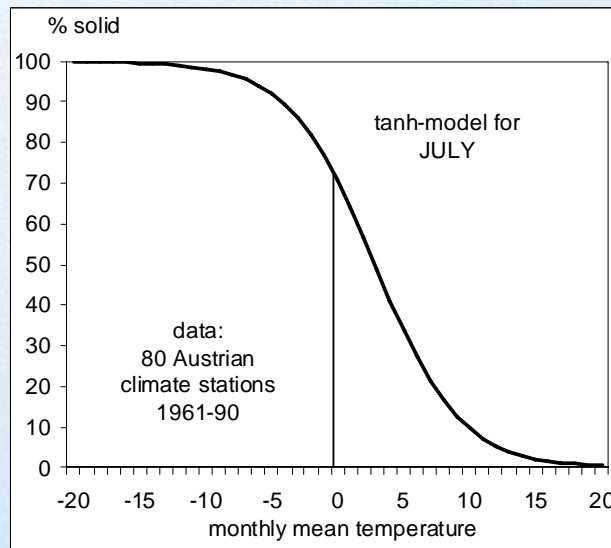
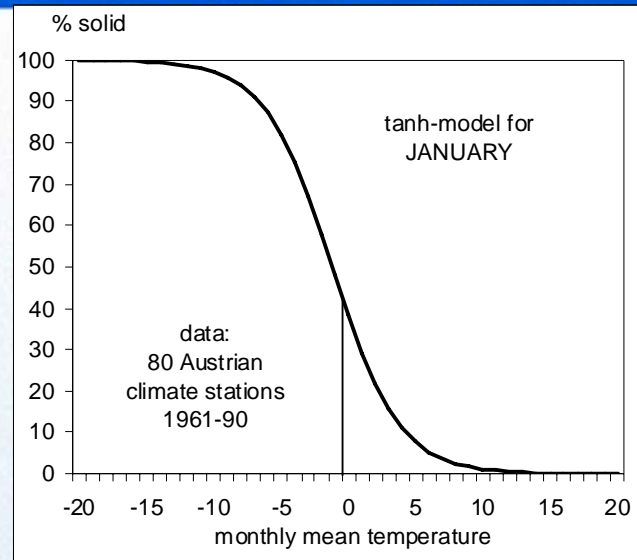
Construction of a new HR absolute grid-3 temperature dataset (high resolution-temperature climatology of ECSN GAR-HRT) merged with HISTALP-T01

merge the 12 monthly high resolution climatologies (based on 1700 stations in the GAR) with the available coarser resolution Alpine homogenized temperature series (132 stations) to a high resolution long-term temperature variability grid 1760-2003



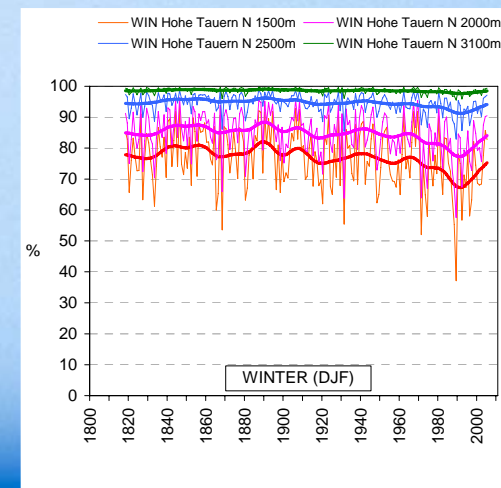


# Application in progress. Splitting HISTALP grid-3 precip into the solid and liquid components

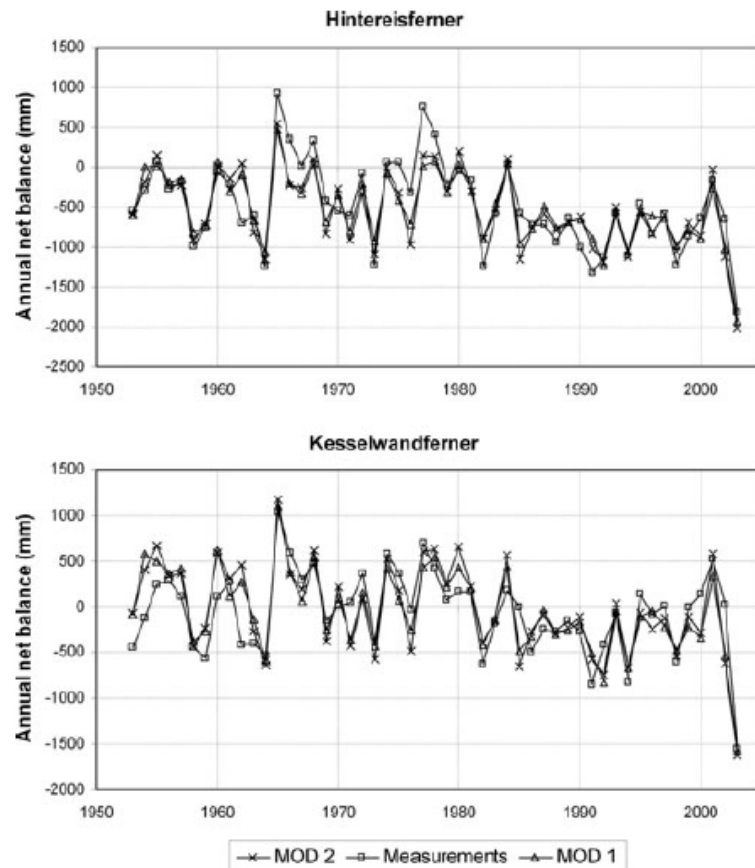


## Modeled solid precipitation

snow of special interest for the Alpine region: ecological importance, snow and water balance  
Economic importance – winter tourism



# HISTALP FOR GLACIER MB RECONSTRUCTION



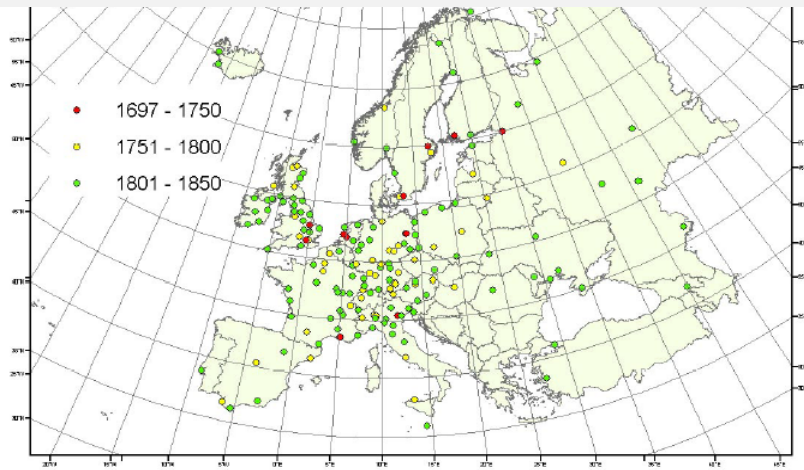
**Fig. 6.** Time series of measured and modelled annual net balance of Hintereisferner and Kesselwandferner. MOD 1: direct modelling approach; MOD 2:  $b_w + b_s$ .

Glacier mass balance model using HISTALP temperature and precipitation,

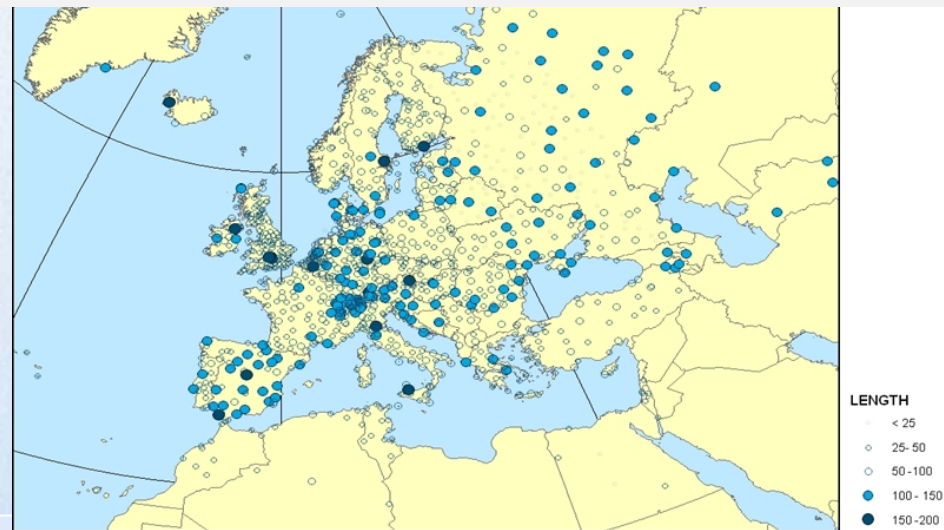
A statistical mass balance model for reconstruction of LIA ice mass for glaciers in the European Alps, Schöner et al., *Annals for Glaciology*, 2007



## FUTURE - continuing data search, data recovery, data rescue and digitization



Quick scan of the instrumental data potential in Europe for climate time series starting before 1850



### In Austria

Continuous improvements: up-dates, new stations, new elements, new grids:

Future: grid-1 mode series of sunshine duration (Jurkovic, Türk, 2009)

the step from monthly to daily series (HOCLIS / PRODIGE – SPLIDHOM/ INTERP, Gruber, Auer)

### In the GAR

Continuous improvement of network density (new data from Bosnia – Herzegovina)

In EUROPE – from HIST-ALP to ECSN HIST-EU



## HISTALP – POSSIBLE FUTURE OF HISTEU - OBJECTIVES

- in the framework of ECSN/EUMETNET
- network should cover (main parts) Europe
- Homogenisation on monthly basis
- software and recommendations delivered by COST ES0601
- software in use at NMSs (e.g. Hoclis (Auer et al., 2001), Prodiges (Caussinus et Mestre, 2004), SNHT (Alexanderson 1986, Alexanderson 1995), MASH (Szentimrey 1997, Szentimrey 1999))
- metadata to justify homogenisation
- Gap filling, outliers' detection

Thank you for listening

