MILESTONES FOR THE ASSESSMENT OF REGIONAL CLIMATE VARIABILITY DURING THE 20TH CENTURY IN THE EASTERN ALPS

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Abstract: A high quality climate data set of sufficient length and temporal and spatial resolution is the indispensable requirement to assess climate variability and extremes on regional scale. Supported by the Interreg III Alpine Space Programme the Zentralanstalt für Meteorologie und Geodynamik (ZAMG) has set up a data recovery and rescue initiative to extend the sparse and patchy long-term daily climate data set of Austria: Electronic imaging via a digital camera is applied to all existing original climate sheets available at ZAMG. However, additional data search became necessary due to the nearly complete Austrian climate data loss during World War II. External data archives have been contacted for data recovery. Recently a very fruitful collaboration has been established with the Regional Hydrographical Centres in Austria and the Hydrographical Service of Austria (HZB). A great number of daily temperature, precipitation and snow data for the provinces of Lower Austria, Burgenland, Styria, Carinthia and Salzburg were provided by those data centres and digitised at ZAMG. However, the interpretation of old historical data highlighted the necessity of a high level quality data control and homogeneity checks. Climate time series analyses must not be applied before the homogeneity status of a series has been improved.

Keywords: *data recovery, data rescue, quality control, time series analyses, climate change indices*

1. INTRODUCTION

Climate Change Indices derived from daily temperature and precipitation measurements have found wide acceptance and dispersion in the climate change community. The Interreg III Project FORALPS with the intention to contribute to climate change assessment on regional scale will benefit from the freely available software RClimDex (http://cccma.seos.uvic.ca/ETCCDMI/). However, for an Alpine country like Austria, snow variables belong to the list of climate elements which should be included into the analyses. Snow conditions are highly affected by changes in the temperature and precipitation regime and contain a certain potential of danger (e.g. avalanches, traffic accents, snow load damages, etc.) – however snow is one of the natural resources for winter tourism in Austria.

2. DATA AND METADATA

The quality of climate change studies is highly influenced by the quality of the available climate basic data. Therefore, FORALPS WP5 (http://www.unitn.it/foralps/) intends to create and provide a high quality data set for further climate change studies.

For each series station history and relevant metadata have been excerpted from ZAMG's paper archive containing old station protocols, photos and routine correspondence. Additional sources for metadata have been recovered in the annual year books of ZAMG and HZB (Hydrographical Service of Austria), as well as other published sources (e.g. Lauscher et al., 1977 for the later discussed series of Rauris). Figure 1 displays exemplarily relevant metadata of the station Rauris. Rauris' first weather station was established in 1875 and has been in operation up to now, however several relocations and data gaps necessitated careful data quality checks, homogeneity testing, data completion, and adjusting procedures.

Homogeneity has been tested and adjustments have been applied on monthly level due to the principles of HISTALP (Auer et al., 2007). For daily values a further 30days smoothing of the discrete monthly adjustments has been applied to avoid breaks over months-ends. All in all, in the 137 years of the Rauris series 8 breaks have been detected, six of them could be assigned to metadata, two breaks are caused by unknown reasons up to now.

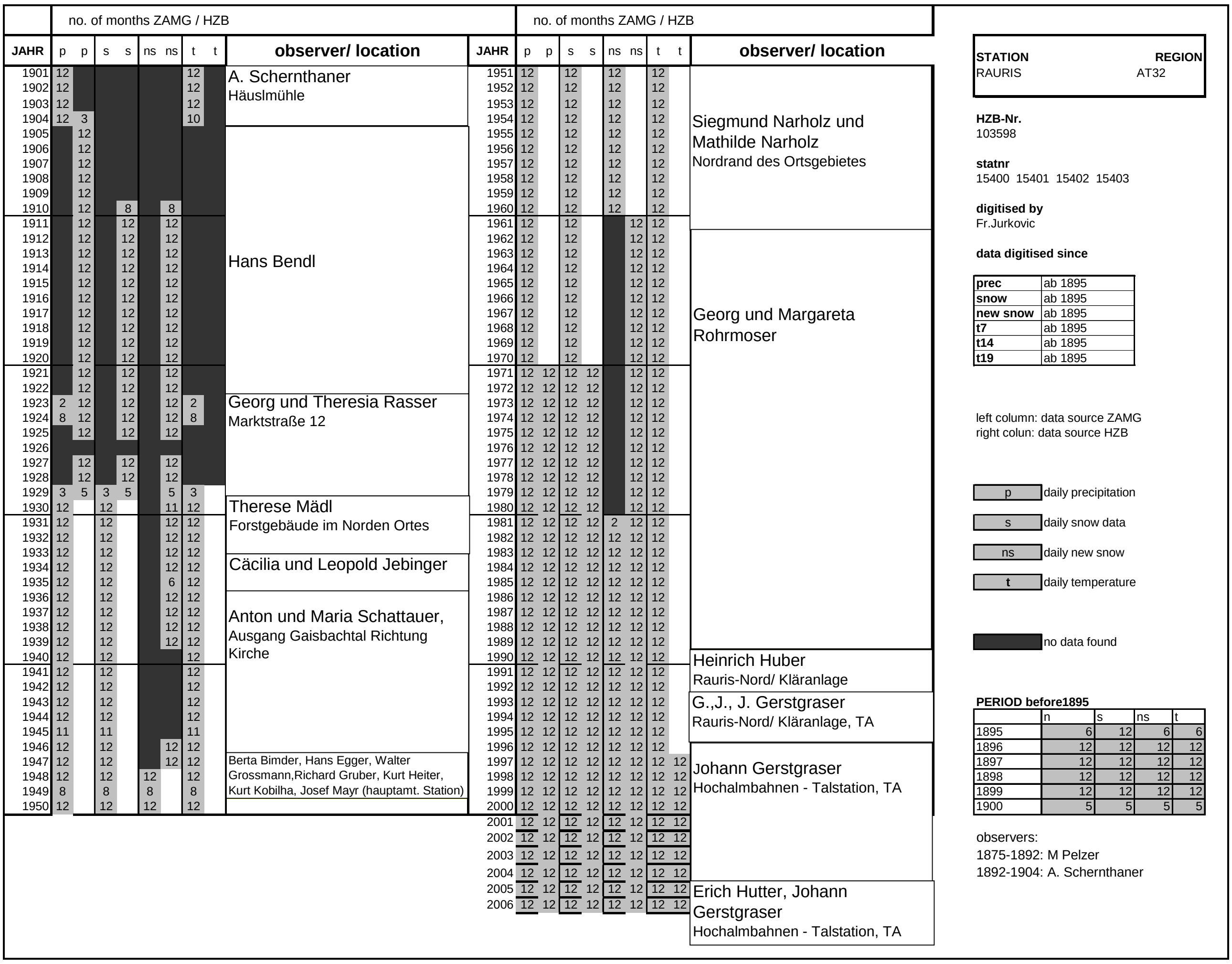

Figure 1: Daily data availability, locations and observers of the inner-alpine station Rauris (long. 12°59’33’’, lat. 47°13’25’’, alt. 941 m a.s.l.)

3. RESULTS

Up to now our results are single station results only, regional conclusions will have to be confirmed by some more stations which are under construction. The necessity to study climate variability on regional scale can be demonstrated by looking at climate impacts e.g. snow fall amount, heat waves, dry spells, etc..

For the **winter season**, beside its climatological relevance, the amount of snowfall turned out to be of highest practical and economic importance for the European Alps. Figure 2 displays temperature, precipitation and snowfall variability at Rauris und Sonnblick, a very close station pair, however located in different altitudes. Rauris represents an inner-alpine valley station north of the Alpine main crest in about 950 m asl, whereas Sonnblick is a high mountain observatory above 3100 m asl. The two stations show a quite similar temperature increase since the beginning of the 20th century (1.1 K on Sonnblick, 1.4 K in Rauris) and during the same time both stations display a negative precipitation as well a negative snowfall trend. However, the high Alpine decrease for precipitation and snowfall has been taken place to nearly the same extent whereas at the inner-alpine low elevation station the snowfall decrease exceeded the total precipitation decrease per 10%.

Out of the long list of Climate Change Indices (e.g. used in Moberg et al., 2006) for the **warmer season** changes in growing season lengths, no. of tropical nights, of summer days and hot days, and some others may turn out to be typical objects to be studied. Derived from daily precipitation measurements several indices more can contribute to assess regional climate change.

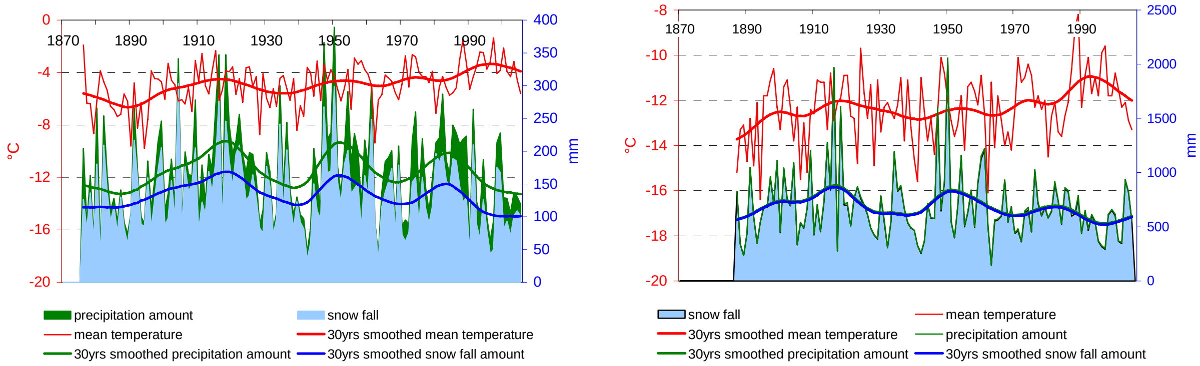

Figure 2: Time series of temperature (scaled on the left y-axis), precipitation* and snowfall amount (scaled on the right y-axis) during winter (DJF): left graph: at the inner-alpine station Rauris (long. 12°59’33’’, lat. 47°13’25’’, alt. 941 m a.s.l), right graph at the high Alpine station Sonnblick (long. 12°57’29’’, lat. 47°03’16’’, alt. 3105 m a.s.l). *Due to the various problems of precipitation measurements at Sonnblick (comp. Auer, 1992) the high Alpine precipitation sums were derived from Efthymiadis et al. 2006.

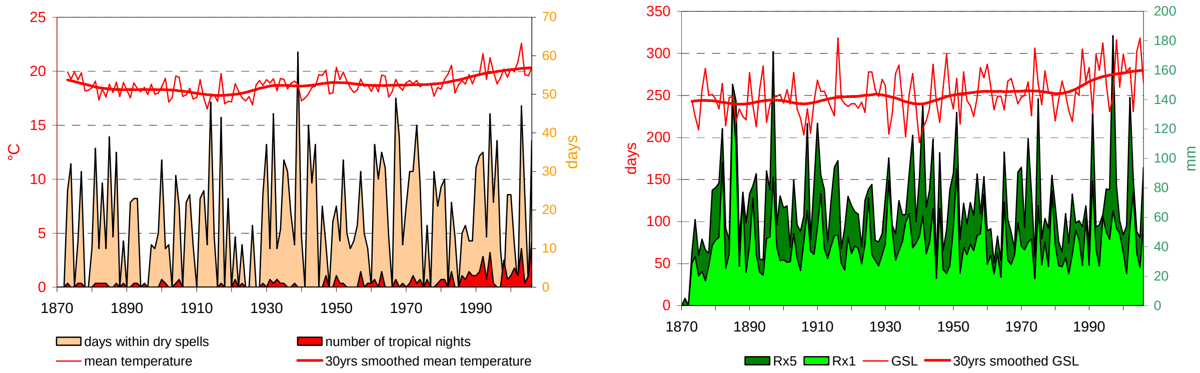

Figure 3: Time series of selected climate change indices calculated for the warm season at Wien Hohe Warte (long.16°21’23’’, lat. 48°14’55’’, alt. 198 m a.s.l.). Left panel: days within dry spells (sum of all days during dry spells of at least 10 days), number of tropical nights (Tmin > 20°C), mean temperature and 30yrs smoothed mean temperature calculated over summer (JJA). Right panel: Rx5 (Maximum consecutive 5-days precipitation), Rx1 (Maximum 1 day precipitation), GLS (Growing Season Length) and 30yrs smoothed GSL calculated over the warm season (April to September).

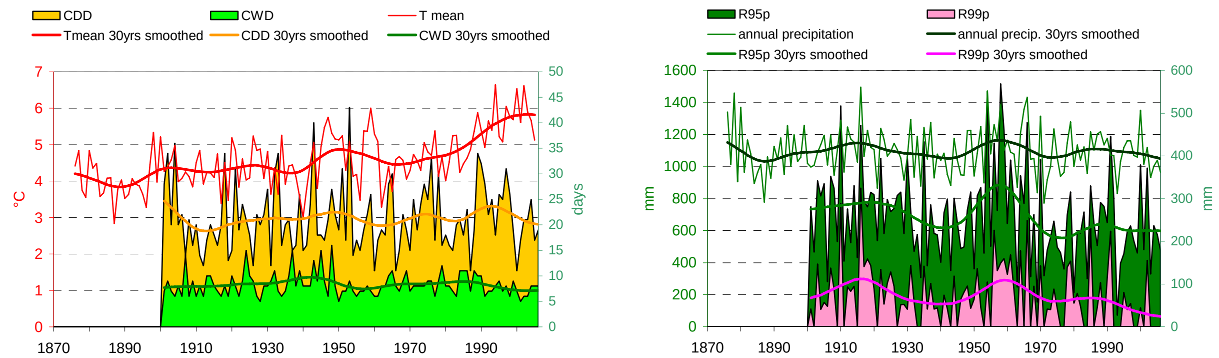

Figure 4: Time series of selected climate change indices calculated for the year at Rauris (long. 12°59’33’’, lat. 47°13’25’’, alt. 941 m a.s.l), single values and 30 years smoothed. Left panel: mean temperature, scaled on the left y-axis, maximum number of consecutive dry days with RR < 1 mm (CDD), maximum number of consecutive wet days > 1mm (CWD) scaled on the right y-axis. Right panel: annual precipitation sum (PRCP) scaled on the left y-axis, R95p (PRCP when RR>95[th] percentile) and R99p (PRCP when RR>99[th] percentile) scaled on the right y-axis.

Figure 3 provides insight into the climate characteristics during the warm season derived from the daily temperature and precipitation data of Wien Hohe Warte, in sub-urban environment in the flat East of Austria. Since 1901 summer mean temperature (Jun – Aug) has increased by about 2 K accompanied by a remarkable increase of tropical nights, particularly pronounced since the 1980ies. Growing season lengths has been extended by about 1 month since the beginning of the 20th century, also with the strongest increase since the 1980ies. Climate change indices related to precipitation are not so clear to interpret. Days within dry spells show a great variability from year to year (between 0 in several years and 61 in 1939), the maximum daily precipitation amount as well the maximum 5days precipitation amount point at a trend of near to 0.

Figure 4 again reflects the **annual** precipitation variability in Rauris in more detail. Since 1901 the total precipitation amount has decreased only slightly, but the 1910th as well as the 1960ies turned out to be the two wettest periods. Comparing with R95p and R99p the three curves display some parallelism, but there are no hints for an increase of extreme events at all. Both, R95p and R99p have decreased by 67 mm or 46 mm respectively. Changes in CDD and CWD turned out to be less than +/- 1 day, and again the overall feature is a high year to year variability.

4. CONCLUSIONS AND OUTLOOK

During FORALPS more than a hundred thousand Austrian daily and sub-daily data have been digitised. The time consuming procedure of quality control and homogenising is under way, thus the number of useful stations will increase in the near future. A higher number of centennial daily series will raise the representation of our up now only single station results. Together with our partners from Italy (APAT the Italian Agency for Environmental Protection and Technical Services, ARPALombardia the Regional Agency for Environmental Protection – Lombardia, PAB the Hydrographic Office of the Autonomous Province of Bolzano, PAT Meteotrentino of the Autonomous Province of Trento) and Slovenia (EARS the Environmental Agency of the Republic of Slovenia) we will be able to look into regional East Alpine climate variability beyond any political borders.

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