Second periodic report for RTD-project

ALP-IMP

Multi-centennial climate variability in the Alps based on

Instrumental data, Model simulations and Proxy data

EVK-CT-2002-00148

Period covered by the report: May 1st 2004 to April 30th 2005

Contents (public parts in bold):

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project homepage: http://www.zamg.ac.at/ALP-IMP

SECTION 2:

EXECUTIVE PUBLISHABLE SUMMARY, RELATED TO REPORTING PERIOD 1

(MAY 2004 TO APRIL 2005)

Contract n°	**EVK-CT-2002-00148**	Reporting period:	**2004-04 to 2005-04**
Title	**ALP-IMP: Multi-centennial climate variability in the Alps based on Instrumental data, Model simulations and Proxy data**		

Objectives:
The main tasks of the second reporting period were
- to fialize the four data activities of worktask 1
- to execute most o the consistency worktask 2
- to start the concluding synthesis worktask 3

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Scientific achievements:
In general all objectives have been fulfilled. Some elongations have been due to extensions versus the originally planned work in terms of data quantity and quality. Only a small part of the proposed schedule could not (yet) be obtained – but is more than counterbalanced by additional results obtained. All produced data (WT-1) have been subject to analysis in terms of consistency (WT-2) and of comparative synthesis (WT-3. From this, some useful fedbacks of analysis on data quality topics have appeared – therefore WT-1 has not been competely closed. A typical respective example is the production of a HR-grid which arose from the findings of consistency WP-5
The instrumental data activity has produced a dense network of carefully quality improved (homogeneity breaks and outliers removed, gaps filled) monthly climate time series of 5 climate elements (pressure, temperature, precipitation, sunshine, cloudiness) covering the entire GAR and two (relative humidity, vapour pressue) covering three of the 5 main subregions (CRS – coarse resolution subregions detected via objective statistical methods). All in all the 3 main and the 2 second order elements are represented now by a total of near to 72400(869000) station-years (-months). They cover an area of approximately 7% of Europe, altitudes from 0 to 3500m asl. and time spans of 1 to 2 centuries: maximum length temperature and air pressure series back to the 18th century, precipitation back to the 1810s, cloudiness back to the 1840s and sunshine back to the 1880s. Several 1000s of breaks and outliers were removed thus avoiding errors and also large area-biass of the original data – equal to larger as the true long-term climate signal. The data are kept in station-mode (original and quality improved) and in three grid-modes (5 CRS- means, 112 MRS-1deg-lat-lon grid-series, 4042 HRS-10' lat-long grid series). All CRS-series are visible, explained and downloadable on the public part of the homepage, all other instrumental gridded data will appear there during year 3.
The treering data activity
During this period, the cooperation between the WP partners has led to the development of a GAR tree ring network with a dense spatial and extensive temporal resolution.. Combined investigations from selected high elevation sites, have yielded detailed local and wider regional temperature reconstructions on annual to multi-decadal time scales. Effort has focused on the development and analyses of millennial length chronologies, with sufficient sample replication for the application of age-related standardization techniques to be applied, so that multi-centennial scale variations can be preserved and reconstructed. Investigations on precipitation changes are more challenging because of the more spatially heterogeneous nature of precipitation. Nevertheless, first analyses from Austrian dry sites prove the potential for precipitation/drought reconstruction at least on a local to regional basis. A started respective collaboration with Italian corresponing project partnershas a promising potential. In Switzerland, a combined data set (recent and historical wood) for nearly 1000 low elevation samples has been provided by Swiss dendro-archeologist M. Schmidthalter.
The isotopic ice core records activity as confined in the Alps to "cold glaciers" of the highest summit ranges continued to explored the Monta Rosa and Mont Blanc regions for past isotope-temperature changes.
New experimental findings on the influence of upstream effects identifyed bergschrund an dome crevasses to petubate the isotope deph profiles, though only very locally or resticted to the core bottom sections . Almost finalyzed isotope analyses of two new Mt. Blanc cores, to a good deal performed at seasonal resolution, allowed now to contrast several cores of both key regions. At all sites particularly clear recent warming trends are seen over the late 20th-century. For yet unresolved reasons, both sites exhibit a significantly higher isotope/temperature sensitivity, than expected,. The first long term isotope record obtained from the Mt.Blanc region at an unique dome position shows, different to its counterparts of Monte Rosa flank cores, a systematic increase of the apparent isotope-temperature towards mediaevel times. This preliminary finding again questions the significance of single, long term isotope records, calling for the multi-site approach as deployed and critical revisited in ALP-IMP
The glacier variability data activity started the second project year with the completion of the database revision and the completion of data control and correction. All the data can now be ordered via the World

Glacier Monitoring Service (WGMS). An online glacier meta-information browser gives an overview on available data. Subsequently, we focused on the spatio-temporal analysis of the collected glacier fluctuation data and its representativity with respect to the entire Alpine glacierisation (as documented in the World Glacier Inventory). The growth of Alpine glacier monitoring over time has resulted in an unprecedented dataset with excellent spatial and temporal coverage. The summary of all national inventories provide complete Alpine coverage for the 1970's. This new inventory is used together with the new Swiss Glacier Inventory (SGI2000) to extrapolate Alpine glacierisation in 1850 and 2000. Multispectral satellite data and corresponding techniques for the processing of digital glacier inventories, as applied in the SGI2000, can also be used for (Alpine-wide) inventories. While inventory data contains information on spatial glacier distribution at certain times, fluctuation series provide temporal information at specific locations. Continuity and representativity of fluctuation series are thus, most relevant for the planning of glacier monitoring.

Consistency WP "observed versus observed data" has produced a basic comparative description of all instrumental CRS-mode series which can be regarded also a starting point for the comprehensive description of the general GAR climate variability features of the past 200 years (WP-8). intercomparisons of GAR with regional to global data were continued. These inter-comparisons highlighted the spatially varying character of the GAR climate (mainly due to the Alpine orography) and indicated the need for highly spatially resolved descriptions of the major climate fields and variability in the region. To date, this has only been achieved to a limited extent, for time periods within the 20th Century. After some discussions between the project partners it was decided that the bi-centennial station series dataset for precipitation (detailed in the paper of Auer et al., 2005) could form the basis for the generation a new high-resolution precipitation dataset, expressed on a regular geographical grid. Thus an additional objective was set within the WP-5 activities: The construction of a 10-min-gridded precipitation dataset for the Greater Alpine Region, 1800–2003 (VHR-precip-grid) The 'HISTALP precipitation grid-2' dataset construction is intended to facilitate grid-based multi-parameter studies of the GAR climate, to validate numerical models, and to calibrate climatic proxies which are not always located near to meteorological stations.

Consistency WP "observed vs. modelled": A simulation for the Greater Alpine Region (GAR) on 1/6 degree resolution was performed with the REMO regional model during the last report period. During the second reporting period, this simulation, and the ERA40 reanalysis, have been compared with observed temperature and precipitation. The period October 1989-present was re-run, because of an error in setting the solar constant in the original simulation for this period. Comparisons with the HISTALP temperature dataset, and the 0.5 degree CRU temperature dataset indicate spatially varying relationships, with better performance of REMO compared to ERA40 in the Central Alpine high and low elevation regions. Comparisons on the monthly timescale with a 1/6 degree daily precipitation dataset produced for ALP-IMP based on the dataset of Frei and Schär (1998) revealed that REMO precipitation is too high in spring, and too low in summer and autumn. The physics of fractionation of stable water isotopes has been built into REMO. To allow a direct comparison between simulated and observed isotope values a two-step approach has been developed. Firstly the global GCM ECHAM4ISO was nudged to meteorological reanalysis wind fields. REMO was then forced at its boundary with the climate and water isotopes from this former simulation. Comparison with station data from Saclay (near Paris) shows that the model captures well features of the temperature evolution over the course of a selected year.

The 3 final integrative workpackages have started in the reporting period and promise highly interesting descriptions and findings. The wealth of new data material elaborated so far in the project and some already performed preliminary studies can be expected to produce new and/or better proved material and understanding of regional climate variability in the GAR. Typical for research, also some new questions will be formulated at the end, most of them dealing with consistency among different climate elements (physical understanding) and consistency among different data sources (proxies-instrumental-model).

Socio-economic relevance and policy implications: will take effect by the end of the project and will be argued then

Conclusions: With a few exceptions (counterbalanced by not planned additional activities), the project is well on its way. The data WPs have produced more than expected and are a challenge worth to deal with for the last project period devoted to integrated analysis.

Keywords: instrumental datasets, homogeneity, tree-ring datasets, isotopic ice-core records, glacier variability, Greater Alpine Region, regional modelling, isotope modelling

Publications (cumulative list): annex 2.1. (ALP-IMP publications list, table 1

SECTION 3:

DETAILED REPORT ORGANIZED BY WORK PACKAGES INCLUDING DATA ON INDIVIDUAL CONTRIBUTIONS FROM EACH PARTNER

RELATED TO THE REPORTING PERIOD (MAY 2004 TO APRIL 2005)

According to the project plan (page 20 of “Description of Work”) also WPs 7, 8 and 9 have started in the reporting period. Due to major extensions of the data WPs of the project in terms of volume and data quality (argued in section 1) all nine WPs of the project have been active in the reporting period.

3.1. WP-1: INSTRUMENTAL RECORDS (reported by partner 1)

WP-1 is a common activity of partners 1 and 5, continuously supported (without costs) by the network of "corresponding project partners" and linked national projects (described in the first project report). Lead and reporting partner is partner 1. Activities of WP-5 (responsible partner 2, CRU) has provided additional instrumental data products and thus contributed to WP-1 as well.

The planned deliveries have been produced and WP-1 can be regarded as successfully closed. Only two activities (not initially planned but recognised as feasible and necessary) will go on: the snow-activity and one to produce a very-high-resolution (VHR) gridded long-term temperature dataset Most modifications have been argued in the first activity report already. In general, WP-1 produced more than was initially planned, mainly in terms of data quality. There were some reductions in terms of included climate elements (due to availability). But those were more than counter-balanced by quality, spatial density and length of the produced datasets.

3.1.1. WP-1 OBJECTIVES

1. Collect all available monthly long-term instrumental climate data from the GAR
2. Reanalysis in terms of general quality and homogeneity
3. Standardized re-procession and description for further internal and external use

3.1.2. METHODOLOGY AND SCIENTIFIC ACHIEVEMENTS RELATED TO WP-1 INCLUDING CONTRIBUTION FROM PARTNERS

The working capacity in WP-1 was spent on objectives 2 and 3 (described in the following sections of 3.1.2) mainly. The data collecting activity (objective 1) was mostly finished in the 1st reporting period already. Only updates and the respective data-activities related to the two additional topics (VHR-temperature and snow) have been (and will be) necessary further on (until the end of the project and beyond).

3.1.2.1. Objective 1 (data collection)

Snow activity: Scanning and quality control of daily snow series 1895-1916 for more than 800 sites (Austria, Slovenia plus parts of Italy, Croatia, Czech Republic) from Austrian hydrographic yearbooks. Additional (full coverage of 20th century) daily snow series from Valle d'Aosta (some 20 series) and from Tyrol (some 50 series), 1971-2003 daily series from recent Austria's Hydrographic Service (some 200), 1948-2003 daily series from ZAMG (some 200) integrated. The still existing gap between the 2 wars has been started fill by manual digitising. Contacts with Swiss data holders had positive results to allow for an extension to the Western Alps. The final goal within ALP-IMP will be a daily dataset of (quality improved) approximately 100 continuous snow-sites covering the entire 20th century and a respective analysis in terms of long-term trends and extreme events. For the non

Austrian parts the ALP-IMP snow activity shall serve as a starting-impulse for a respective international activity to create and analyse a pan-Alpine snow variability dataset. The necessity of such an activity was discussed already in the first ALP-IMP report.

VHR-temperature dataset activity: Respective needs formulated by different project partners from the proxy communities hinted at a second eligible additional project data activity – a very high resolution (VHR) absolute temperature dataset. The successful creation of a similar dataset for precipitation within WP-5 (details see there) was an additional argument to start such an activity. Unlike precipitation (for which the necessary pre-condition, high resolution GAR-wide monthly climatologies was already available) such basics turned out not to be existing for temperature. Therefore a respective data collection activity was successfully executed. Thanks to the existing (and additional new) contacts to the multitude of respective data-holders in the region and in the future also based on a formal collaboration within an initiated EUMETNET-ECSN project (AlpineTmap, coordinated by I. Auer) it produced more than 1700 single station datasets for the normal period 1961-1990. They were already quality controlled and gap-filled. Currently a homogenisation of the different means-calculations is on the way plus an adjustment of the station coordinates to a 1km-resolution elevation model. First feasibility analyses (lat-long-alt-coastline regressions) encouraged us to continue this activity. The high-resolution monthly CLINO-climatologies 1961-90 will be a value for itself. Merged with the ALP-IMP (coarser resolution) monthly long-term series it will finally result in a GAR-VHR-absolute temperature dataset 1760-2003. The VHR-climatologies will have 1km resolution, for the VHR-longterm dataset a resolution between 1 and 5 angular minutes is envisaged (plus an additional algorithm for subgrid-corrections in steep terrain).

3.1.2.2. Objective 2 (reanalysis in terms of general quality and homogeneity)

As already indicated in the first ALP-IMP report, the accumulate experience within the project and also in related activities of the WP-1 partners advised to completely re-analyse all existing and newly produced time series with the new tools and methods, described in 3.1.2.2 of the 1st project report. Mainly this caused to the already discussed elongation of WP-1. In the reporting period a great part of the working capacity was used to finalise the outlier-detection and elimination of the temperature series and to apply it also on the air pressure series. Thus, the 3 “first order climate elements” (temperature, precipitation and air pressure) are present now in the form of (131, 192, 72) homogenised and outlier corrected monthly series of average lengths of 147, 137, 142 years. Outlier detection was performed using the interactive GIS-based procedure histalp-05-v33.apr. All single 8064 monthly pressure, temperature, and precipitation fields were studied and used for respective corrections. Nearly 2000 real outliers were detected and removed. In addition to that an even larger number of “overshooting adjustments” (due to not exactly localised beak-points and to remaining uncertainties in adjusting) could be removed as well. Specifically the time-consuming outlier removing significantly increased the quality of the projects database and allows makes it applicable now also for extreme event studies.

The remaining “second order elements” (details in section 3.1.2.3) sunshine duration and cloudiness were also re-analysed with the new HOCLIS procedure. The vast amount of work was to a large extent provided by the Austrian funded project CLIVALP (see respective explanation in section 1). In the 75(55) single station series of an average length of 120(89years 265(366) single breaks were detected and removed. For both elements “near to total” spatial coverage could be obtained (only France provided no cloudiness data, in Italy there exists no sunshine network). All in all the 3 main and the 2 second order elements are represented now by a total of near to 72400(869000) station-years (-months). They cover an area of approximately 7% of Europe, altitudes from 0 to 3500m asl. and time spans of 1 to 2 centuries: maximum length temperature and air pressure series back to the 18th century, precipitation back to the 1810s, cloudiness back to the 1840s and sunshine back to the 1880s.

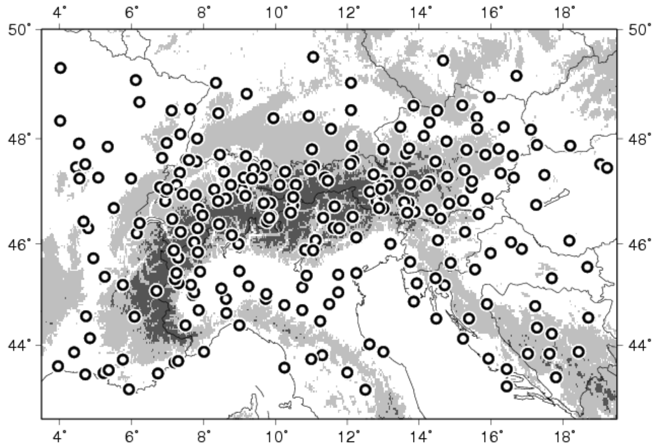


Figure 3.1.1. Network of available and homogenised 1st- and 2nd order station mode series in the GAR

For the two remaining "third order elements" relative humidity and vapour pressure 20(21) single station series from the eastern part of the GAR could be quality improved (121/105 inhomogeneities removed), updated and included in the project's dataset. Data availability at the different providers did not allow for total GAR coverage (as already announced in the first report). First analyses of the 3rd order elements (WP-8) showed their value, in spite of reduced spatial coverage and density.

3.1.2.3. Objective 3 (standardised re-procession and description for further internal and external use)

The great number of data products afforded a final standardised systematic to allow for easy use and exchange of data within and outside the project. This final system was developed within Austrian project CLIVALP, was filled with data in close cooperation of ALP-IMP, CLIVALP and several other formal or informal cooperations with national data-holders (details in section 1). The system operates under the name **HISTALP**. In the post-project future (after CLIVALP is finished) it will be continuously maintained by ZAMG. Within ZAMG it is technically implanted as a mySQL databank in connection with the ZAMG-KLIMVIS derivate histalp-05-v33.apr for visualisation. Data access outside ZAMG works over the project homepage. The respective data-part of the project-data will be continuously accessible after the end of the project via the website of ZAMG, linked with such of other voluntary project members.

The data are present in **HISTALP** in different modes, **station-mode**, **grid-mode and CRSM-mode**:

Station mode:

stands for the monthly climate time series as **"originals" (ori)** with restricted access based on respective agreements with the data providers and as **"homogenised" (hom**, standing for: homogenised, outlier removed and gap filled) with free access within the project. External access on station-mode series will be negotiated with the original providers for the post project period. As much project working-time has been spent on them, the project coordination aspires free access on hom-series.

Grid mode:

Grid-mode series have been generated within the project and thus are PU-deliverables without restrictions by the end of the project.

The first order elements are present also in the form of **“grid-1”**. Grid-1 stands for monthly anomaly series (relative to 20th century means) interpolated on a regular grid at 1 deg lat-long. For air pressure and temperature the grids are provided for two altitude-bands: HIGH (>1500m) and LOW (<1500m) elevation. For precipitation a high elevation grid was not achievable due to the well known measuring difficulties at high elevation sites.

A WP-5 activity has successfully developed a **grid-2** product for precipitation. It consists of high resolution (10’ spatial resolution) monthly absolute (mm) grid-fields with GAR-wide coverage back to 1800. It is described more in detail in section 3.5 of this report and may be regarded as a breakthrough in long-term past climate variability datasets in complicated terrain. The success of the grid-2 precipitation activity has caused also a respective (already mentioned) extension of the WP-1 activities to produce a similar dataset also for temperature. For air-pressure an envisaged grid-2 will have a lower spatial resolution and will consist of absolute monthly SLP-fields. The feasibility of such a SLP-dataset (based on reduction to z=0m calculated for monthly means) is currently studied within WP-8.

CRSM-mode:

Stands for **“coarse resolution subregional mean”** mode. Due to the more severe homogenising problems for 2nd and 3rd order climate elements, it increasingly turned out that a comparable resolution of the grid-1 fields will not be achievable with sufficient data quality. Experience with WP-8 analysis on the other hand pointed at the possibility to gain sufficient quality at coarser resolution. Again first WP-8 results suggested the feasibility to use a common sub-division of the GAR into 4 horizontal low elevation climatic sub-regions and one additional high-elevation one. The definition of these subregions (roughly outlined in Figure 3.1.2) is based on a compromise between objectively performed regionalisations (for analysis applications in WP-8, details see there) for temperature and precipitation.

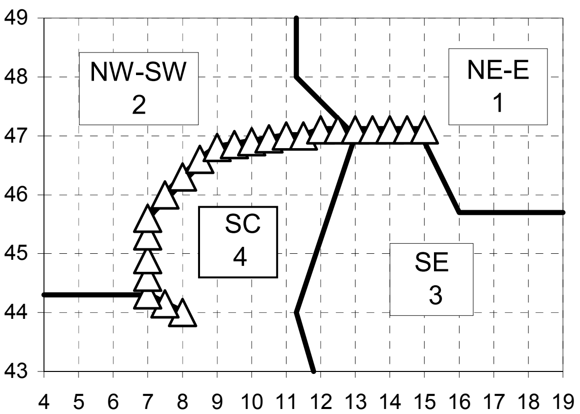


Figure 3.1.2. Outline of the CRSM-mode coarse resolution sub-regions in the GAR. Four low elevation groups (1 to 4) plus 1 high-elevation group (visualised here through the line of triangles along the main ridge of the Alps)

Thus it seemed to make sense to calculate CRSM-series for each 2nd- and 3rd-order climate element which can be expected to be representative for the 4 (5) sub-regions. For means of comparison also the first order elements were condensed to CSRM-series. CSRM-series are monthly anomaly-series. First analyses (WP-8) validated the feasibility and the quality of the 2nd- and 3rd-order CRSM-series.

3.1.3. SOCIO-ECONOMIC RELEVANCE AND POLICY IMPLICATION

The socio-economic value of the deliverables of the WP-1 - climatic datasets in yet unknown length, density and quality in a region highly sensitive and vulnerable to climate variability, climate extremes and climate change – has been already discussed in the respective chapter of the first project report. During project year 2 maybe two new topics of high practical value have newly emerged:

- The new coarse-grid CRSM-series may be easier be explained and transdisciplinarily transported also to non scientists

- The finally envisaged temperature and precipitation VHR-grid-2 fields have direct application potential in the fields of all kinds of energy demand estimations, agricultural and forestry vulnerabilities (PDS-indices and similar products can be directly derived for single small scale locations,…). Specifically these new VHR-products quantify climate variability - for the first time in the complicated terrain of the Alps – directly on-site, where climate impacts happen and where society and economy are vulnerable.

3.1.4. DISCUSSION AND CONCLUSION

WP-1 fully approved it’s necessity to set a solid instrumental database for the project. The applied methods turned out to be scientifically clean, quickly to handle and well usable – they significantly improved the basis for further ongoing within the project during the integrative consistency- and analysis- workpackages.

3.1.5. PLAN AND OBJECTIVES FOR THE NEXT PERIOD

In general the workpackage is closed. Only the two additional activities (snow and VHR-temperature) will be carried on. Experience already gained through intensive cooperation with other proxy-data WPs, as well as the consistency- but also the analysis WPs (all already active) makes it probable anyway that a dataset never reaches a final state. Data are never 100% correct and a flexible and innovative research initiative must always allow for additional respective revisions, updates and re-analyses based on the information from data-analysis. Specifically the final integrative WP-9 is expected to produce not only definite and binding climate reconstructions. It will also provide valuable information on still existing problems among the different data sources. But a clearly defined and objectively described problem is sometimes of greater value than a “result” based on a concealed foul compromise.

3.2 WP-2: TREE-RING RECORDS (reported by partner 8)

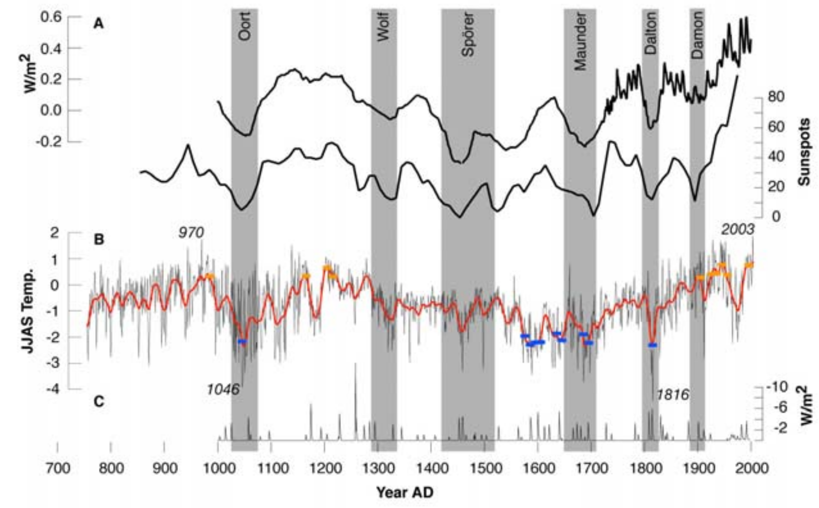
WP 2 is a common activity of partners 2, 8, 9 and 10, with partner 8 as the lead and reporting partner. The Universities of Padua and Ancona (both Italy) act as collaborators.

Objectives

- Assemble best possible ‘optimum’ set of existing and new tree-ring data for the Greater Alpine Region (GAR) with a focus on identified key regions and tree-growth variables
- Screen, quality control, and reprocess raw measurement data to form standardized multi-century to millennial site and regional chronologies for different species, using recently developed/improved statistical techniques
- Undertake systematic detailed identification of climate signals in the chronology data, with emphasis on quantifying time-dependent changes

3.2.1 Methodology and scientific achievements related to WP-2 including contribution from partners

Within the second project year a June-August temperature proxy series for GAR high elevation environments is developed back to AD 951 utilizing 1500+ ring width measurements from living trees and relict wood (own samplings from the Lötschental, and existing recent and historical ring width data from K. Nicolussi, M. Schmidthalter and M. Seifert). The reconstruction is composed of larch data from four Alpine valleys in Switzerland and pine data from the western Austrian Alps. Sampling regions are situated above 1,500 m asl where a spatially homogenous summer temperature signal exists (see also results from the project’s first year: Frank and Esper 2005a, 2005b). In an attempt to capture the full frequency range of summer temperature variations over the past millennium, from inter-annual to multi-centennial scales, the Regional Curve Standardization technique is applied. Correlations of 0.65, and 0.86 after decadal smoothing, with high elevation meteorological stations (provided by WP 1) since 1864 indicate an optimal response of the RCS chronology to June-August mean temperatures. The proxy reveals warm conditions from before AD 1000 into the 13th century, followed by a prolonged cool period, reaching minimum values in the 1820s, and a warming trend into the 20th century. This latter trend and the higher frequency variations compare well with the actual high elevation temperature record (WP 1). The new GAR proxy suggests that summer temperatures during the last decade are unprecedented over the past millennium. Comparisons with Frank and Esper (2005a, 2005b) provide similar (different) temperature variations (amplitude) back to AD 1600. We also find similarity at inter-decadal to



Comparison between estimates of **A** solar activity (Crowley 2000), sunspot numbers (Usoskin et al. 2003), **B** the Alpine June-September temperature reconstruction (Büntgen et al. 2005), and **C** estimates of the radiative forcing of volcanic eruptions (Crowley 2000). Orange and blue boxes denote the 10 warmest and coldest decades. Grey shadings denote the timing of great solar minima (Stuiver and Braziunas 1989). The smoothed red line is a 20-yr low-pass filter. The temperature reconstruction compiles 180 LBM corrected high elevation MXD series from the Swiss Alps. For calibration, single regression against high elevation June-September mean temperatures - equal the vegetation period - was applied back to 1818. Although the proxy mimics natural forcing over the past 1250 yr, recent anthropogenic forcing is not excluded.

multi-centennial frequencies with large-scale temperature reconstructions. However, deviating trends during certain periods are seen in H.H. Lamb`s European/North Atlantic temperature history. Discrepancies between this tree-ring reconstruction and the early instrumental data (WP 1) are detailed.

We further reconstructed annual resolved Alpine summer (June-September) temperatures over the AD 755–2004 period (fig. 1). This reconstruction is composed of 180 recent and historic high elevation tree-ring maximum latewood density series. With these data, we also address the noise introduced by periodic larch bud moth defoliation cycles, detect this ecological signal, and provide a detailed history of the frequency and magnitude of bud moth population dynamics over the past millennium. After correction for larch bud moth induced negative outliers, RCS preserves high to low frequency information from the dataset. Instrumental temperature and precipitation data (provided by WP 1) reveal a distinct growth/climate response to current year June-September temperatures. For calibration/verification statistics, various models are applied including different periods, seasonalities, and wavelength. The final reconstruction explains 60% of Alpine temperature variations back to 1818, with a clear weighting towards high frequency variations. Extra-verification using low elevation temperatures back to 1760 proves the reconstruction's inter-annual skill, however describes a substantial trend offset between (warmer) instrumental and (colder) proxy data (see also Büntgen et al. 2005, Frank and Esper 2005a, 2005b). High temperatures in the 10th and 13th century, comparable to those of the last decade, confirm the putative Medieval Warm Period. A prolonged cooling from ~1300–1820, relative to the 20th century, reflects to the so-called Little Ice Age. With 2003 being the warmest summer over the past 1250 years, the proxy captures the full range of the instrumental measurements, and provides an annual (decadal) temperature amplitude of 6.4 (3.1)°C. The new MXD-RCS reconstruction is compared with radiative forcing series derived for volcanic eruptions and solar activity, and the North Atlantic Oscillation. Warmest summer temperatures coincide with periods of high solar and low volcanic activity, and coldest temperatures vice versa. However, no relationship with the NAO is found. As this study and other regional- and large-scale proxy records share common variability, evidence of the timing of the MWP, LIA and recent warming is provided, however the amplitude of temperature variations is not fully understood.

These results are promising for a detailed view on long-term climate trends, including early instrumental measurements. The offset between (colder) proxy records developed in project years 1 and 2, and (warmer) early low elevation temperature measurements will be explored in year 3 of ALP-IMP. Therefore, a close collaboration with WP 1 is scheduled.

To understand climatic extremes and their temporal distribution, we further analyzed a larger Alpine network of high elevation temperature sensitive tree sites (Frank and Esper 2005a, 2005b), which has been processed to preserve the relative frequency and magnitude of extreme events. In so doing, temporal changes in year-to-year tree-ring width variability were found. These decadal length periods of increased or decreased likelihood of extremes coincide with variability measures from a long instrumental summer temperature record, representative for high elevation conditions in the Alps (WP 1). Intervention analysis, using an F-test to identify shifts in variance, on both the tree-ring and instrumental series, resulted in the identification of common transitional years. The study demonstrates that the annual growth rings of trees can be utilized to quantify past frequency and amplitude changes in extreme variability. The approach addresses the role of external forcing, ocean-atmosphere interactions, or synoptic scale changes in determining patterns of observed extremes prior to the instrumental period.

Millennium chronologies in Austria:

The temperature reconstruction of the existing 3474 year long spruce/larch-chronology from the mountain Dachstein (Austria) is ongoing in collaboration with partner 2. The sampling at

two lakes (Riesachsee, Schwarzer See) in Austria (October 2003) ended up in a 1384 year long – but not closed - chronology.
Additional sampling was done at a bog in Hallstatt (Austria) in August 2004. It was possible to extract more than 300 samples. These samples in combination with existing historical samples will set up a chronology of minimum 3500 years. The measurements of this site are finished, the crossdating is ongoing and will be finished in July 2005. The data of all three millennium sites will be used within the project to calculate long term temperature variations.

Analysis of dry sites (five new sites with low number of tree-rings) in eastern Austria was started. A possible combination with the existing dry-site-network of Austrian pine (more than 400 years long) will be evaluated.

All data sets have been centralized, including raw measurements of single series in Tuscon-format and the corresponding metadata, at the institute of partner 8 on a newly created ALPIMP tree ring data bank. This database is currently accessible for the WP-2-partners via the WSL server.

3.2.2 Socio-economic relevance and policy implication

The existing GAR tree-ring records and their explained local and regional climatic sensitivity currently allow initial interpretation of climate before, at the transition to, and during unprecedentely intense anthropogenic activity. Thus, the millennium long temperature reconstruction points to the summer AD 2003 being the warmest over the whole period, but followed by the pre-industrial, medieval summer AD 970. Although, reconstructed temperature variations mimic natural forcings reasonably well, anthropogenic impact during the industrial period cannot be excluded (Bauer et al. 2003; Crowley 2000). Moreover, the obtained Alpine temperature history shows significant similarities with reconstructed NH decadal scale variations and longer-term trends. These findings suggest that Alpine climate is of larger-scale importance.

In future, these data will hence be useful to quantify natural (e.g., solar and volcanic) vs. anthropogenic (e.g., CO_2 and manmade aerosols) forcing in the highly sensitive Greater Alpine Region in a long-term context. Moreover, the data sets will help enable quantifying long-term spatial and temporal changes of GAR biomass. This will yield information to aid in future valuation of forest resources, and can provide data to help shape, and/or assess compliance with policies seeking regulate the flux and sequestration of carbon.

3.2.3 Discussion and conclusion

During this period, the cooperation between the WP partners has led to the development of a GAR tree ring network with a dense spatial and extensive temporal resolution.. Combined investigations from selected high elevation sites, have yielded detailed local and wider regional temperature reconstructions on annual to multi-decadal time scales. Effort has focused on the development and analyses of millennial length chronologies, with sufficient sample replication for the application of age-related standardization techniques to be applied, so that multi-centennial scale variations can be preserved and reconstructed. Investigations on precipitation changes are more challenging because of the more spatially heterogeneous nature of precipitation. Nevertheless, first analyses from Austrian dry sites prove the potential for precipitation/drought reconstruction at least on a local to regional basis. In Switzerland, a combined data set (recent and historical wood) for nearly 1000 low elevation samples has been provided by Schmidthalter. Recent efforts are going to explore the possibility of reconstructing precipitation and drought metrics, such as the Palmer Drought Severity Index (PDSI, provided by Briffa et al.), and finally search for teleconnections with Austrian results.

3.2.4. Plan and objectives for the next period

WP 2 will be active as planned. Future activities are going to include studies of supra-long chronologies, drought reconstructions of precipitation sensitive sites on local to regional scales, investigations on the early instrumental period and their homogenization in comparison to proxy data, and more detailed local analyses on different altitudinal gradients. Moreover, combined studies on millennium scales will be intensified.

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Usoskin, I. G., S. K. Solanki, M. Schüssler, K. Mursula, and K. Alanko, 2003: Millennium-scale sunspot number reconstruction: evidence for an unusually active sun since the 1940s. Phys. Rev. Lett., 91, 211101.

3.3. WP-3: ISOTOPE ICE CORE RECORDS (reported by partner 4)

The ice core WP 3 comprises joint experimental work covered by partners 4&6 as well as joint evaluation/modelling work to which in addition partners 1, 3, 6 and 7 contribute. These activities are supplemented by substantial, external co-operation, at no project costs, which includes: the Universities of Berne (field work, trace gase analyses) and Vienna (^{14}C-AMS), the LGGE-CRNS (sample sharing ,field work, stratigraphical dating), and the German Polar Research Institute–AWI (GPR, CFA, field work). In charge of the WP-3 lead and reporting is partner 4

3.3.1. WP-3 OBJECTIVES

1) retrieve first multi-centennial isotope profiles in the Mt. Blanc in addition to the Monte Rosa region

2) interlink the long term isotope records by appropriate ice core chronologies

3) identify periods of abrupt changes and long-term trends in isotope summer precipitation signature, representative for high elevation Alpine areas, and

4) provide recent and long term isotope records ready for use in WP6 and WP9

3.3.2. METHODOLOGY AND SCIENTIFIC ACHIEVEMENTS RELATED TO WP-3 INCLUDING CONTRIBUTION FROM PARTNERS

Basic methodology :

The isotope ratios ($\delta^{18}O$) or δD) of ice recovered from ice sheets and non-temperated glaciers are well recognized proxys, which eventually reflect the local temperature variability. While polar ice core studies have extensively deployed this isotope- thermometer back into the past glacial(s), much less studies focussed on the near past (e.g. last millenium) and on mid-latitude glaciers.The latter ice bodies are however subject to a series of shortcomings (as fragmentary snow depositon, ice flow effects and highly non-linear depth/age relationships), which still deserves basic investigation to reliably explore these climate archives.

Selected target regions for the ALP-IMP ice core studies are the Monte Rosa and Mt. Blanc summit ranges, which offer the most suitable Alpine drill sites for recovering long term and high resolution isotope records, respectively. To enhance and to confirm the climate significance of Alpine isotope records, their spatial and temporal coverage needs to be substantially improved. This attempt is accomplished by establishing isotope records from specifically selected new ice cores: two ones from the Mt. Blanc region (Col du Dome area) with one of them uniquely located at a dome position and one from Monte Rosa (Colle Gnifetti) complementing existing long term records.

3.3.2.1.Objective 1 (additional Mt.Blanc records)

The Mt.Blanc dome core could be quasi-continously analysed for its isotope variability down to bed rock at appropriate time resolution. In contrast, analyses of isotope records in the second, 100m deep flank core needed to be maintained at seasonal resolution to a much larger depth than hitherto planned, since, for yet unknown reasons, its thinning rate abruptly decreased. Thus, due to the extra work, bedrock is not actually reached by the isotope profile, which is however scheduled within the next month. The establishment of new and mostly complementary ice core redords in WP 3 is thus mostly done. However,drilling to bedrock at an outstanding Colle Gnifetti site had to be again postponed (drilling equipment over extended period not at disposal). Evaluation of extensive areal ground penetrating radar(GPR) soundings by partner 4 indicating a promising drill position(i.e. optimized time resolution for long term records), where core drilling based on collaboration with external groups (KUP-Berne, LGGE-Grenoble and AWI- Bremerhaven) is now definitly scheduled to late summer 2005.

3.3.2.2.Objective 2 (ice core chronologies)

In order to allow for preliminary comparisons of the isotope changes seen in the various ice cores, working chronologies has been established for the two new Mt.Blanc cores by stratigraphical dating (mainly for the flank position) , backed up by a simple ice flow consideration (mainly for the dome position). Activities to refine these chronologies are ongoing, which includes inter-and intrasite matching via stratigraphical markers. Nevertheless, new insights(especially for the more recent periods) of the spatio-temporal isotope variability could already be gained through the new, complementaryl Mt. Blanc records (see below). Revisiting the existing Colle Gnifetti long term chronologies suggested, that the core nearest to the bergschrund is incosistently dated in the lower section as too young. It is envisaged to solve this important (likely glaciological) phenomenon based on the awaited new core, which will be recovered at comparable bergschrund distance, but on a lateral flow line. Establishing age constraints via radiocarbon are now on the way (Steier et al. submitted) in order to reduce the basic uncertainties of the mult-centennial core chronologies.

3.3.2.3.Objective 3 (representativ isotope variability)

Aimed at reconciling the influence of systematic up-stream effects (which are a key obstacle in obtaining net atmospheric signals of isotope changes), intensive reconaissance studies via GPR tracking of internal isochrones (partner 4) along with isotope analyses of a new series of shallow firn cores are performed at Colle Gnifetti in accordance with the WP 3 schedule. Respective effects (including the first depth profiles of the bergschrund walls) are shown to strongly depend on the selected accumulation period and distance from the bergschrund (imposing an apparent isotope-temperatur changes of up to some degree C). New evidence came up here, that dome and bergschrund crevasses may significantly add temporally and seasonally disordered ice to the lower core sections.

Evaluations of relatively recent isotope records (not much affected by glaciological bias or dating problems) of now 6 deep drill sites allowed to contrast the two main ice core regions, revealing: recent warming trends seen at both regions, though at varios extent.Common to the isotope changes of both regions are the considerably higher temperature sensitivity than expected. Preliminary intersite comparison suggests the 20th century trend and well known temperature excursion (back to into the LIA era) are more clearly recorded in the Monte Rosa cores

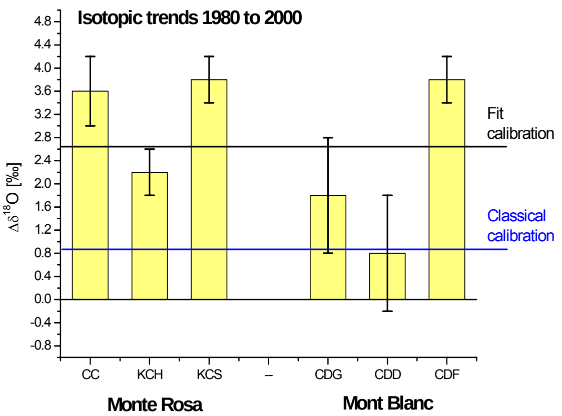


Fig.1: Late 20th-century warming trends, as reflected by ice cores from Monte Rosa and Mt.Blanc regions. All cores are drilled at flank positions, except the CDG dome one. Note also the preference of summer snow contribution, except at CDD. Horizontal lines refer to a temperature trend of 1.2 °C depicted from the GAR dataset, which is transferred to a respective $\delta^{18}O$ trend by the common and by a regression based $\Delta\delta^{18}O/\Delta T$ relationship, respectively.

3.3.2.4.Objective 4 (master records of isotope-temperature)

Monte Rosa cores, having been the only ones covering the last millenium, shown in their stacked isotope changes broad agreement with the general trend seen in the longest instrumental GAR temperatur time series. They exhibite, however an odd long term trend towards lower isotope values towards mediaevel times. This yet unsolved and surprising pecularity, is not reflected in the new Mt.Blanc dome core. Here, a downcore increase of the apparent isotope-temperature is seen over the period in question, but in contrast no warm period in the late 18th (see Figure 2). Common to all deep cores is, however the obvious lack of a prominent LIA feature

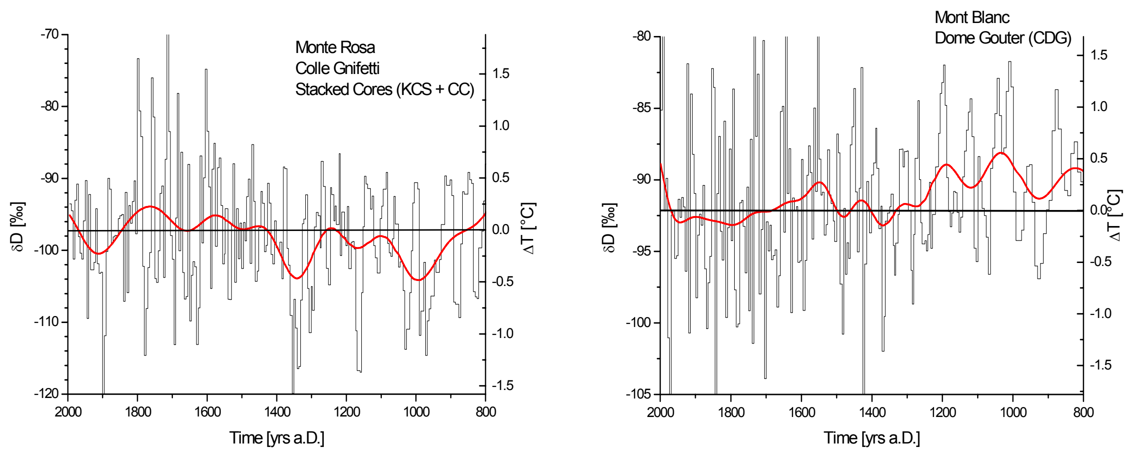


Fig. 2 : Comparison of low pass filtered Alpine Deuterium records, covering the last millenium. Left: stacked record from two flank cores at Monte Rosa , right: new Mt. Blanc core drilled at a dome position. Note, that the the dome core chronology is still preliminary, since essentially based on a

simple ice flow estimate. The temperature scales of both panels refer to regression result of a Monte Rosa master record using long term instrumental temperatures data of the GAR.

3.3.3. SOCIO-ECONOMIC RELEVANCE AND POLICY IMPLICATION

Climate proxies derived from high altitude cold glaciers of the Alps offer outstanding means to better assess the climate variability in Central Europe. Related activities may thus supplement the commonly deployed paleo-climate archives of the European realm in an unique way. The dedicated prospection of these high altitude glacier archives, otherwise available in the less climatically explored polar regions or sub-tropical mountains only, constitutes an innovative enterprise within the European climate research community.

3.3.4. DISCUSSION AND CONCLUSION

In approaching the central objective of WP 3 most essential achievments concerne the now setteled experimental base for considering up-stream effects and the almost finalized extension to a deep ice core array in the Mt. Blanc region, which complements the Monte Rosa one. Despite rather strong depositional and meteorological noise, substantial trends and climate exursions appeared to be faithfully and uniformally recorded by the isotope data at almost all sites (Pettinger et al. 2005). Significant intersite and temporal differences in the climate sensitivity seen in the isotope-thermometer needs however to be still tackled. In this respect establishing a solid, scientific base for the empirical calibration strategy of the isotope signals would be essential in assessing the climate significance of the pre-instrumental isotope records.

3.3.5. PLAN AND OBJECTIVES FOR THE NEXT PERIOD

Experimental activities will finally concentrate on: 1) the establishment of age constraints by radiocarbon and trace gase analyses, 2) isotope analyses of the final in the Mt. Blanc flank core section and of the upcoming Monte Rosa core (at low resolution), 3) routine stratigraphical dating of the Mt. Blanc dome and the upcoming Monte Rosa cores.

In evaluating the more recent isotope variability(i,e.on the decadal time scale), which would serve as test floor for the long term isotope records , emphasis will be on assessing the spatial significance of the observed isotope changes in terms of recent warming trends. During that period, upstream effects are of minor importance, which would allow seasonal dissection of the records as to obtain isotope temperature signals representative for the European 4000m level. The central problem in quantifying the observed isotope changes arises from the much higher isotope/ sensitivity as expected. This basic calibration question will be mainly tackled based on the above reduced isotope dataset and:1) by dedicated comparison with instrumental records of partner 1 (including time series of seasonal dissected temperature, precipitation, laps rate and circulation indices). and 2) by modelling attempts of partner 7 via a mesoscale 25 years simulation aimed at deconvoluting the isotope signal into local (surface and consensation temperature) and remote (sourcee temperature, trajectoties) factors, respectively. To promote this evaluation attempts, two dedicated meetings between the involved partners are already scheduled.

On the longer time scale, final evaluation of the upstream influence considering ice flow patterns and related firn core datasets will be cruical in obtaining a reliable long term master record of isotope-temperature changes. To ensure an appropriate deployment of this WP 3 key deliverable the precision of the underlying long term chronologies will be be thoroughly assessed as well.

3.4. WP-4: GLACIER PROXIES

3.4.1 OBJECTIVES

3.4.1.1 WP 4 aims

- dense and long term set of glacier variability data within the Greater Alpine Region (GAR)
- uniform structure in terms of data quality
- glacier as an integrated proxy for air temperature, precipitation, radiation, snow cover, atmospheric circulation and its representativity for GAR
- climate impact study on glaciers (use of glaciers as key indicator of climate change)

3.4.1.2 WP 4 deliverables & milestones

Month 13: A quality checked dataset of glacier variability within the GAR (mass balance, front position changes, area changes, volume changes, historical/geomorphological evidences)

Month 16: Representativity of glacier variability data within the GAR

Month 18: Complete GAR glacier dataset plus description ready for use on the project homepage and for transfer to the existing dataset of World Glacier Monitoring Service (WGMS) and World Data Center-A for Glaciology

3.4.2 METHODOLOGY AND SCIENTIFIC ACHIEVEMENTS OF 2ND REPORTING PERIOD

3.4.2.1 Summary

We started the second project year with the completion of the database revision and the completion of data control and correction. All the data can now be ordered via the World Glacier Monitoring Service (WGMS). An online glacier meta-information browser gives an overview on available data. Subsequently, we focused on the spatio-temporal analysis of the collected glacier fluctuation data and its representativity with respect to the entire Alpine glacierisation (as documented in the World Glacier Inventory).

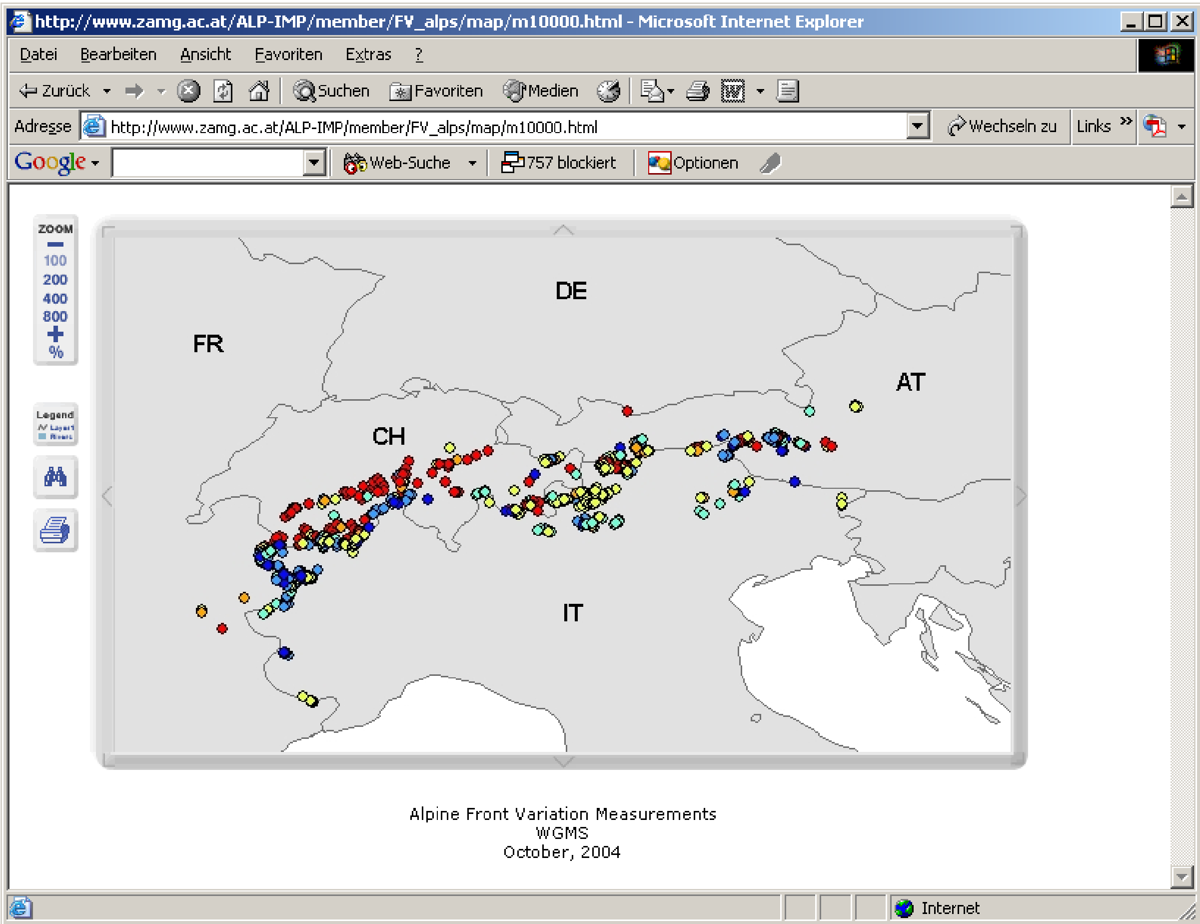
3.4.2.2 Database revision, data collection, data control and correction

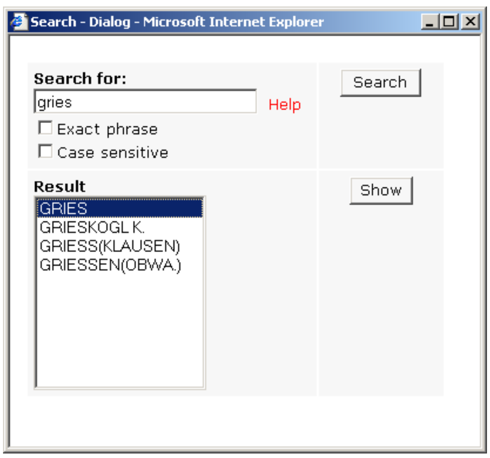
The revision and expansion of the WGMS database, to fulfil the requirements of ALP-IMP, is almost completed. The revised Austrian front variation dataset is completed and currently prepared for upload into the database. Within the framework of ALP-IMP, an unprecedented Alpine glacier dataset was collected, checked and, if necessary, corrected. The new dataset contains almost all available glacier fluctuations series in the European Alps. WGMS ensures update and public availability of the data. Further on, WGMS integrates and coordinates the continuation of the historically grown Alpine glacier network within the Global Terrestrial

Network for Glaciers (GTN-G) of the Global Climate/Terrestrial Observing System (GCOS/GTOS) according to the Global Hierarchical Observing Strategy (GHOST).

3.4.2.3 Public data access

All data collected within the framework of ALP-IMP is available via the World Glacier Monitoring Service. Meta-information on available data can be found on the project homepage (http://www.zamg.ac.at/ALP-IMP/member/alpimp_glacierdata.htm) as well as on the official website of WGMS (www.geo.unizh.ch/wgms).





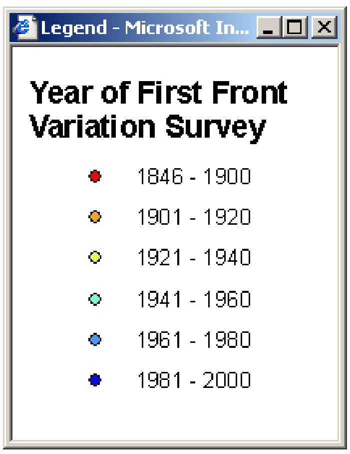


Figure:

Online glacier meta-information browser. Example of Alpine front variations: internet user is able to browse and search for glaciers with available front variation data according to their geo-graphical location, name or year of first survey.

3.4.2.4 Spatio-temporal analysis of Alpine glacier fluctuations and its representativity

The growth of Alpine glacier monitoring over time has resulted in an unprecedented dataset with excellent spatial and temporal coverage. The summary of all national inventories provide complete Alpine coverage for the 1970's. This new inventory is used together with the new Swiss Glacier Inventory (SGI2000) to extrapolate Alpine glacierisation in 1850 and 2000. Multispectral satellite data and corresponding techniques for the processing of digital glacier inventories, as applied in the SGI2000, can also be used for (Alpine-wide) inventories. While inventory data contains information on spatial glacier distribution at certain times, fluctuation series provide temporal information at specific locations. Continuity and representativity of fluctuation series are thus, most relevant for the planning of glacier monitoring.

Increasing mass loss, rapidly shrinking glacier areas and spectacular tongue retreats are clear warnings of the atmospheric warming observed in the Alps during the last 150 years and the acceleration observed during the past two decades. However, in the short-term or at a regional scale, glaciers show a highly individual variability. Glacier behaviour depends not only on the regional climate but also on local topographic effects which complicate the extraction of the climate signal from glacier fluctuations.

The results of this study are submitted for publication:

Zemp, M., Paul, F., Hoelzle, M. and Haeberli, W. (submitted):

Alpine glacier fluctuations 1850-2000: overview and spatio-temporal analysis of available data and its representativity. Proceedings of the International and Interdisciplinary Workshop on Mountain Glaciers and Society, Wengen, Switzerland, October 6-8, 2004.

Paul, F., Machguth, H., Hoelzle, M., Salzmann, N. and Haeberli, W. (submitted): **Alpine-wide distributed glacier mass balance modelling: a tool for assessing future glacier change?** Proceedings of the International and Interdisciplinary Workshop on Mountain Glaciers and Society, Wengen, Switzerland, October 6-8, 2004.

Frauenfelder, R., Zemp, M., Haeberli, W. and Hoelzle, M. (in press):

Worldwide glacier mass balance measurements: general trends and first results of the extraordinary year 2003 in Central Europe. In: Data of Glaciological Studies, 98, Russia.

3.4.2.5 The new satellite-derived Swiss Glacier Inventory

Within the framework of the ALP-IMP project we have completed the digitisation of reconstructed glacier outlines from around 1850. As the entire variability of glacier change in the Alps during the past 2000 years occurred (more or less) within the 1850 extent, these outlines provide a valuable proxy to confine the climate change variations within this period. We presently try to connect the 1850 outlines to the WGI database to facilitate assessment of glacier change. A publication of all data (1850-1973-2000) on a glacier individual basis is planned for the next year.

3.4.2.6 Reassessment of the length measurements in Switzerland and development of related GIS-based tools

In a diploma thesis project we currently compare cumulated in-situ length change measurements for the period 1973-1998/99 with data obtained form the digitised 1973 inventory and satellite data. Thereby, we also have eliminated some errors in the in-situ series. A particular problem is the continuation of the length measurements at a separated body of dead ice. We also developed a GIS-based approach for fast assessment of glacier length changes from glacier outlines of two times. We hope that this method will allow us to enlarge the sample of length change measurements (in the Alps or worldwide) considerably.

3.4.3 SOCIO-ECONOMIC RELEVANCE AND POLICY IMPLICATION

Glaciers are recognized as high-confidence climate indicators and as a valuable element of early detection strategies in view of possible man-induced climate change by several international assessments such as the periodical reports of the Intergovernmental Panel on Climate Change (IPCC). Past and present glacier fluctuations do indeed provide important information on ranges of natural variability and rates of change with respect to long-term energy fluxes at the earth's surface. The spectacular loss in length, area and volume of mountain glaciers during the 20th century is a major reflection of the fact that rapid secular change in the energy balance of the earth's surface is taking place at a global scale. However, glacier change not only has implications on the water cycle at global scale (e.g. sea level rise). Increased impacts are also expected on economic aspects (e.g. tourism, energy production, water irrigation) and natural hazards (e.g. glacier lake outbursts). It is expected that they will increase on a regional to local scale. Such impacts show the strong socio-economic relevance of the glaciers especially on the local and regional scale within GAR.

3.4.4 DISCUSSION AND CONCLUSION FOR THE SECOND PERIOD

An unprecedented dataset of glacier fluctuation information back to 1850 was collected, quality checked and integrated in the revised and expanded database of World Glacier Monitoring Service (WGMS).

Results from spatio-temporal analysis of glacier fluctuation data and its representativity were presented at international meetings and are submitted for publication.

Full and open access to all data collected within the framework of ALP-IMP is guaranteed by the World Glacier Monitoring Service. Online glacier variability dataset description and exemplary fluctuation series can be found on the websites of ALP-IMP and WGMS.

Consequently all deliverables of Workpackage 4 (glacier proxies) are satisfactorily fulfilled.

3.4.5 Plan and objectives for the next period

In the 3rd project year we will focus on the remaining project aims, i.e. modelling glacierisation for the entire Alps. In order to use the glacier as a integrated climate proxy, to predict the impact of climate change to glaciers and to compare Alpine glacier fluctuations with worldwide glacier data we will follow four major approaches, which are all based on modelling:

- Model I: This model approach is based on a relationship between precipitation and temperature at the glacier equilibrium line altitude (ELA_0). This relationship will be used to quantify the precipitation field over the Alps for the period around 1850 (UNIZH-Group).
- Model II: This model is a process model, which is based on the calculation of the energy balance at the glacier surface. Here, the distributed mass balance of individual mountain regions within the Alps will be investigated and simulations back to the 18th century are possible (UNIZH-Group).
- Model III: A statistical model relating climatic variables (temperature - and precipitation fields) and mass balance will be developed to reconstruct past mass balances for the Alpine area (ZAMG-Group).
- Model IV: A simple parameterisation for inventory data will be applied for the Alps and compared to other mountain ranges (UNIZH-Group).

3.5.WP-5: CONSISTENCY: Observed versus Observed Data

Workpackage 5 is a common activity of partners 1, 2 and 5. Leading and reporting partner is partner 2.

3.5.1. OBJECTIVES

- Inter-comparisons between variables within the GAR
- Comparison of principal variables for the GAR with their counterparts in gridded hemispheric variables

Inter-comparisons between the HISTALP station-mode datasets, for temperature and precipitation, and other gridded datasets with regional to global extent were conducted in the first year of the ALP-IMP project and continued in the second year, with special emphasis on precipitation. These inter-comparisons highlighted the spatially varying character of the GAR climate (mainly due to the presence of the Alps) and pointed the necessity of a high-as-possible spatially resolution description of the principal climate fields of the area. Up to now, this has been achieved only for parts of the GAR, for time intervals within the 20th Century. After some discussions between the project's partners it was decided that the bi-centennial station series dataset for precipitation (detailed in the paper of Auer et al., 2005) could form the basis of a new high-resolution precipitation dataset on a regular geographical grid. Thus an additional objective was set within the WP-5 activities:

- Construction of a 10-min-gridded precipitation dataset for the Greater Alpine Region, 1800–2003

The 'HISTALP precipitation grid-2' dataset construction is intended to facilitate grid-based multi-parameter studies of the GAR climate, to validate numerical models, and to calibrate climatic proxies which are not always located nearby meteorological sites.

3.5.2. CONSTRUCTION OF A 10-MIN-GRIDDED PRECIPITATION DATASET

The gridding scheme follows the "anomaly approach" (e.g., Jones et al., 1982; Jones and Hulme, 1996) which is based on the characteristics of the two components of the field: the long-term time-mean component (the "climatology") and the temporal deviations from this (the "anomalies"). The climatology, being characterized by small-scale spatial patterns, has been calculated, at high resolution, for the period 1971–1990, when the station network is dense (Schwarb, 2000; Schwarb et al., 2001). The climatology dataset was provided by the Swiss Federal Institute of Technology (ETH) at Zurich and was geographically augmented, using additional station data, to cover central Italy and the eastern parts of the GAR. The anomaly field consists of comparatively large-scale patterns. The grid-based anomaly field was estimated by interpolating the station-based anomaly data (expressed as per cent deviations from the 1971–1990 mean field). An angular-distance-weighted (ADW) interpolation is applied using the data for the three nearest stations to each grid-point. These data are based either on observations or reconstructed values (by means of local EOFs) based on nearby station observations. Finally, the (full) gridded field in mm units was derived by merging the gridded climatology and the gridded anomaly field.

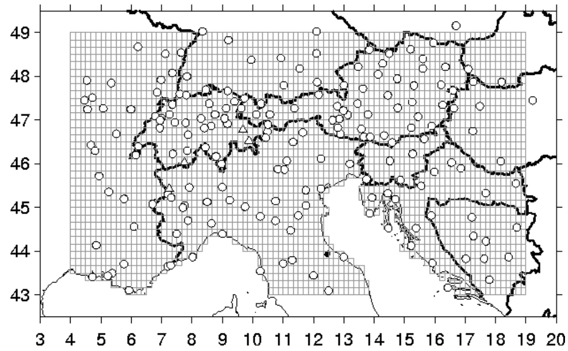
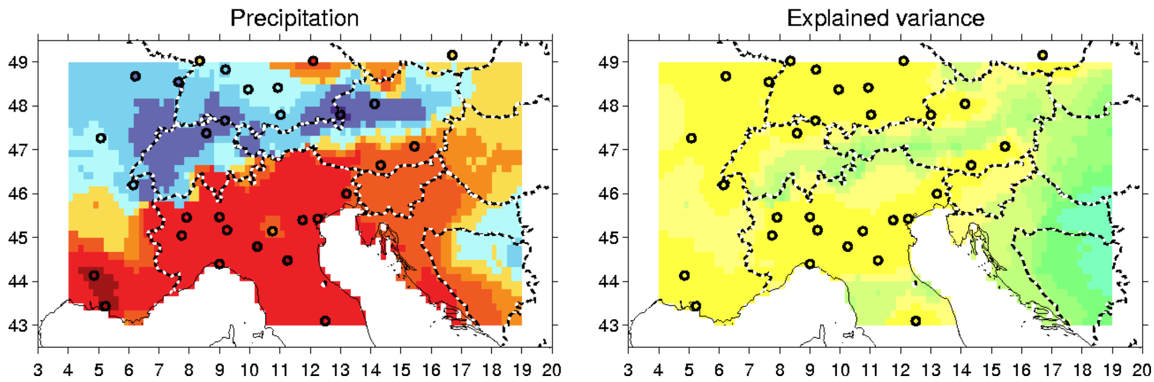


Figure 3.5.1a. The HISTALP station network for precipitation and the 10-min grid of the new dataset

Since the station network declines progressively back to the early 19th Century, the accuracy of the interpolated field diminishes. To quantify the effect of sparse network, the accuracy relative to the 1931–2000 (maximum data availability) period was calculated. The explained variance was selected as the quality score, expressed on a per cent scale (with 100% assigned to the 1931–2000 period). For the relative explained variance calculation, weights, used for interpolation in each month and year, were also applied to the 1931–2000 data and the resultant interpolated series were compared with the original 1931–2000 series. Higher scores are found in winter months, whereas the lowest scores characterize the June and July time series (Figure 3.5.1b). In particular regions the scores are locally low: in mountains (where the precipitation field has low spatial coherence) and southeast GAR (where the observational data are unavailable for most of the decades of the 19th Century).



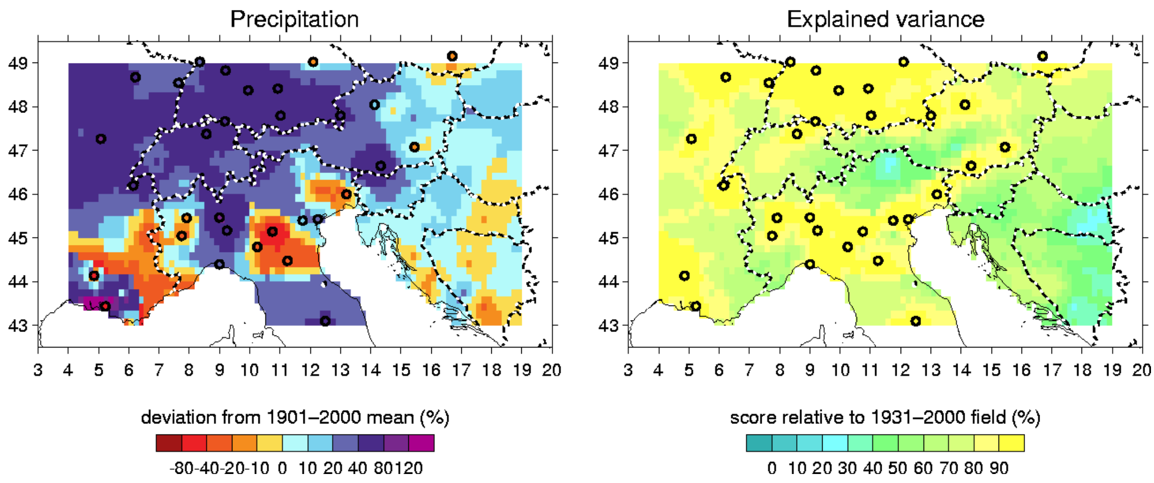


Figure 3.5.1b. HISTALP 10-min-grid precipitation (overlain with HISTALP station-mode precipitation, in circles), and the associated explained variance for January (upper panel) and July (lower panel) of 1840.

The HISTALP precipitation grid-2 dataset has been preliminary evaluated through comparisons with other, independently-developed, datasets. Correlation of interranual variability, multidecadal trends, and extreme precipitation cases were examined within the 20th Century. A general consistency was found across the GAR, but less over the Alpine mountain chain. Some local discrepancies were also identified where the station networks used for developing the various datasets differed substantially.

3.5.3. PLAN AND OBJECTIVES FOR THE NEXT PERIOD

The WP-5 is formally finished. However, the conclusions drawn and the analyses of the instrumental datasets produced (within WP-1 and WP-5) will contribute to the Synthesis Worktask of the project (WP-7 and WP-8). In particular, regional patterns of temperature and precipitation variability will be identified (WP-7) and compared with their counterparts in gridded hemispheric variables to seek links between regional and continental-scale climate variations (WP-8).

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3.6.WP-6: CONSISTENCY OBSERVED VS. SIMULATED DATA

This workpackage is a common activity of partners 3, 4, 5, and 7, supported without costs by partner 1. The lead and reporting partner is partner 3.

3.6.1. OBJECTIVES

- Perform a high-resolution (approx. 17 km) simulation for the greater Alpine region (GAR) with a regional atmospheric model for the last few decades.
- Identify regions, variables, and periods where the simulation and the observations agree and where they do not, and analyze reasons for inconsistencies.
- Identify water vapor sources for the Alps and their influence on water isotopes.
- Deconvolute the isotope signal in a part affected by local climate parameters and in a part affected by large-scale circulation and varying vapor sources.

3.6.2. METHODOLOGY AND SCIENTIFIC ACHIEVEMENTS RELATED TO WP-6 INCLUDING CONTRIBUTION FROM PARTNERS

3.6.2.1. High-resolution simulation for the last decades and temperature validation

In the first report period at GKSS (partner 3) the high-resolution regional simulation performed with the REMO regional model has been conducted, which provides multi-variable hourly output with a horizontal resolution of about 17 km (1/6 deg. on a rotated grid) on 20 vertical levels in the troposphere and lower stratosphere. It is driven by the approximately 1.12 deg. resolution ERA40 reanalysis through prescribing the values at the lateral boundaries and through forcing the large-scale wind field within the model domain by the spectral nudging technique (von Storch et al. 2000).

In the second report period, this simulation has been compared to observations from the Greater Alpine Region. During the analysis it became evident that in the simulation, which was completed in May 2004, the solar constant has been reduced drastically by mistake in October 1989, which caused a temperature drop of approximately 10 K. Therefore, the simulation had to be repeated for the period October 1989 to the present and will be completed in the next few weeks. The simulation has thus been compared so far to the observations for the period 1958 to 1988.

As part of the third WP6 deliverable (6/3) the monthly mean 2m temperatures simulated in REMO have been analysed by calculating correlations and biases between simulated and observed timeseries. For comparison 2m temperatures from the ERA40 reanalysis have also been analysed. The observed timeseries are the HISTALP dataset derived in WP1 and the ½ deg. resolution temperature dataset of the Climatic Research Unit (CRU, Mitchell et al. 2003). The HISTALP temperature data contain a station dataset and two gridded anomaly datasets of 1 deg. resolution; one derived from low- and one from high-elevation stations. The simulations and observations were regridded to different resolutions (1/6 deg., ½ deg., 1 deg., 2 deg., and 3 deg.) to allow for a scale-dependent analysis. The HISTALP station records have also been directly compared to the REMO and ERA40 temperatures. Correlation and bias maps at the different resolutions have been calculated separately for each month of the year based on monthly means from 1958 to 1988. In order to summarise the results, the values at the grid cells or at the stations have been averaged over the whole Alpine area (4 to 19 deg. west, 43 to 49 deg. north) and over six subregions, namely West (Maritime), East (Continental), South (Adriatic), Po Plain, Central Alpine Low Level and High Level (>1400 m a.s.l.) (Fig. 1, Böhm et al. 2001).

For both REMO and ERA40 the Alpine area mean correlations are very high with values around 0.9 and the correlations increase continuously with spatial scale. But REMO has slightly higher monthly mean temperature correlations than ERA40 for all datasets and resolutions during most of the year. The bias averaged over the whole Alpine area is for both simulations largest in summer, where REMO is too warm and ERA40 is too cold (Fig. 2).

The correlations averaged over the six subregions (Fig. 3) are lowest for the Po plain for both REMO and ERA40, especially in summer and winter when weather phenomena occur that are difficult to simulate, such as heavy convection or fog. For the Central Alpine Low Level and the High Level subregions ERA40 has lower correlations than REMO. The higher resolution of REMO therefore leads to an added value in the mountainous region (Prömmel et al. 2005).

While this report was written, the German Climate Computing Centre (DKRZ) announced that the ERA40 temperatures on the DKRZ-CERA database, which have been used for our comparison, were erroneously calculated only from temperature at 0 UTC. This explains the apparent cold bias of ERA40 in summer. Our entire analysis of ERA40 temperatures will be recalculated.

3.6.2.2 Validation of the REMO precipitation simulation over the Alps 1971 – 1988

At ZAMG (partner 1) the precipitation simulated in REMO has been compared to observations from Alpine Region. The basis for a first estimation of the quality of the REMO precipitation simulation is the ETHZ observational precipitation data set from 1971 – 1988 with a monthly time resolution (Frei and Schär 1998). A special version of the dataset with elevation correction and on the REMO grid was agreed with, and provided by Christoph Frei from the ETH in Zürich (the original, publicly available dataset has a spatial resolution of about 25km and has no altitude correction). Both versions of the dataset are based on time series from a high density network of about 6700 rain gauges.

The mean measured annual precipitation sum over the 1981 grid cells common to the REMO and ETHZ data sets amounts to 1053 mm and the respective simulated value is 1123 mm, which indicates a average overestimation of the precipitation by the REMO model by 9%. However, it should be noted that the ETHZ data are not corrected for potential systematic undercatch. The common variance between the mean yearly REMO and ETHZ precipitation fields is 0.26. The model is fairly well able to depict the general seasonally varying precipitation climatology along the NS profile across the Alps.

From the work of Frei et al. (2003), where REMO has been run on a 50 km grid, it becomes evident that REMO underestimates precipitation in the Mediterranean. With an increased spatial resolution of a 1/6th degree this underestimation remains as a general feature, but a more complex spatial pattern of over- and underestimation appears, which can be related to the topography. The upwind – downwind exaggeration of the precipitation profile over the topography through REMO becomes specifically evident during winter. Particularly in spring the precipitation is overestimated, whereas in summer and autumn the precipitation sums of the model are too low.

In order to quantify the skill of the model, the variability of the observed precipitation fields has been compared with the modelled precipitation fields. With respect to the common variance and the mean squared error the model is as good as the climatology during June, July and August, but much better than the climatology during the other months, particularly during autumn.

Comparing the monthly time series of mean precipitation sums over the total available area one finds a linearly decreasing trend in the modelled precipitation sums of –11 mm and a trend to increasing precipitation values of +5.7 mm in the ETHZ observations over the 18 year period. At the beginning of the time period (1971) the model overestimates the mean precipitation sums over the total area. The diverging precipitation trends result in a decrease of this overestimation and a good match of the values around 1988.

A first comparison of the temporal ability of the REMO precipitation simulation involves the total time series of 216 monthly precipitation sums at each of the 1981 grid elements (Fig. 4, bottom panels). The common variance (RSQ) between REMO and ETHZ grid point time series was calculated (the mean seasonal variation was first subtracted). The spatial variability of the RSQ values is large (Fig. 4, bottom left). The values span a range from near 0 to about 0.8. Highest values can be found at the rims of mountains, at mountain fringes and lowest in the centre or downwind of mountains. In mountainous areas the grid to grid gradient is also large. The absolute difference between the time series expressed by the Mean Square Error (MSE) shows a spatial pattern different to that of the RSQ. The absolute differences in precipitation amounts between the model and the observation, as depicted by the ratio in the top right of Fig. 4 top, seem to dominate the MSE distribution, because the dark blue and dark red areas in Fig. 4 top right come out dark red in Fig. 4 bottom right.

3.6.2.3 Isotope modelling

At CEA/LSCE (partner 7) the physics of fractionation of the stable water isotopes has been built into REMO in order to allow a direct evaluation of the model on a longer ”paleo” time scale in the GAR. In addition the global atmospheric general circulation model (GCM) ECHAM4 has been run with a module for calculating stable water isotopes. The temperature/isotope relation which is key for the use of the water isotopes as paleo-thermometer in high-latitude ice core records is the result of highly variable synoptic systems. These systems transport water vapour from low to high latitudes and form clouds and condensate, thereby fractionating the stable water isotopes. Global GCMs are capable of reproducing the statistical correlation between local climate parameters, in particular temperature and precipitation, and the water isotopes, but it is difficult to test if these model are doing this for the right reason, that is if they are correctly simulating the isotope signal of individual air masses within storms or passing fronts.

A direct comparison between a GCM and observations for specific storms is not possible as long as the global model is run in a climatological (that is forced by long term mean ”climatological” SSTs) mode or even forced by observed SSTs of a specific year. Internal atmospheric variability dominates the water isotope signal entirely. Therefore we developed a two-step model approach specifically aimed at analysing high frequency isotope records from high altitude Alpine sites. In a first step, the global GCM ECHAM4ISO was nudged to meteorological re-analysis wind fields provided by the European Center, ECMWF, Reading. These re-analysis data sets, here we use the ERA15 data set, guarantee both a close correspondence to the observations and a physically consistent three-dimensional flow field. The term ”nudging” here means a continuous but small modification of the computed wind field of the ECHAM4 to achieve a close similarity with the ERA15 data.

The global nudging procedure provided us with the necessary meteorological and isotopic boundary conditions for the second step of our approach. The regional climate model REMO is forced at its boundary with the climate and water isotopes previously simulated by the

ECHAM4 model. Moreover, within the model domain (here Central Europe where the largest number of high-frequency water isotope records are available) the REMO model in the 0.5° standard resolution is again nudged to the re-analysis data. It is important that the water isotopes as part of the hydrological cycle are freely computed by both models, ECHAM4 and REMO, and there is no direct influence on the water isotopes by the nudging procedure.

As a first test in simple terrain and flow conditions, a comparison for Saclay (near Paris) shows that the model captures even second order features of the temperature evolution for this particular year (Fig. 5). We point particularly to the persistently very cold period in the second half of February 1983. Precipitation distribution of the grid point including the Saclay measuring site is in fair agreement with the observation. Small-scale land surface features probably are responsible for differences between simulated and station precipitation amounts.

The REMO results are a logical consequence of the different spatial correlation length of temperature and precipitation. In this respect, the water isotopes (Fig. 6) are situated in between the ”large-scale” temperature field and – as part of the hydrological cycle – the ”small-scale ” precipitation field. Timing of most of the peaks and lows in the d18OVap record is correctly captured, though sometimes with a slightly underestimated amplitude. The February cool period is even much more intense in the observed isotope record. The model isotope signal at that time is the most-depleted, in the sense of the isotope/temperature relation ”isotopically coldest”, and long lasting period. The model however underestimates by a factor of two the isotope amplitude. Obviously, when comparing with the temperature record from Fig. 5, the isotope signal is not only influenced by local temperature (the temperature signal is clearly less strong than the isotope signal) or by local precipitation (the corresponding period is very dry) but is also affected by the advection of very depleted air masses. The corresponding wind fields of February 10, 1983 (not shown), show a strong anomalous westward flow and clearly confirm this hypothesis. The Paris area is under the influence of a strong anomalous east circulation advecting cold and isotopically depleted air masses westward.

Furthermore, a number of model diagnostics have been developed which quantify the relative importance of various local and non-local controls upon the temporal isotopic variability of precipitation.

(1) For the purposes of calibrating the ^{18}O-temperature relationship, it was found to be crucial to employ a diagnostic for in-cloud condensation temperatures rather than surface temperatures, since the former vary independently of the latter.

(2) A tracer permitting the determination of vapor source properties has been implemented, and source variations were found to have a significant impact upon isotopic variability within Europe.

(3) To understand isotopic variability at continental interior locations (that is in particular at the Alpine ice core site of ALP-IMP), it is necessary to take into account the degree of upwind "prefractionation" of the vapor condensing in such areas, and a tracer method was constructed which can quantify this upwind influence even for areas like the Alps which have complex flow patterns.

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Frei, C., J. H. Christensen, M. Déqué, D. Jacob, R. G. Jones and P. L. Vidale, 2003: Daily precipitation statistics in regional climate models: Evaluation and intercomparison for the European Alps. *J. Geophys. Res.* **108** (d3), pp. ACL 9-1, CiteID 4124, DOI 10.1029/2002JD002287.

Frei, C., Schär, C, 1998: A precipitation climatology of the Alps from high-resolution rain-gauge observations. *Int. J. Climatol.* **18**, 873-900.

Mitchell, T.D., T.R. Carter, P.D. Jones, M. Hulme, M. New, 2003: A comprehensive set of high-resolution grids of monthly climate for Europe and the globe: the observed record (1901-2000) and 16 scenarios (2001-2100). *J. Climate*: submitted.

Prömmel, K., B. Müller, M. Widmann, and J. M. Jones, 2005: Comparison of a high-resolution regional simulation and the ERA40 reanalysis over the Alpine region. Proceedings of the 28th international conference on Alpine Meteorology, Zadar, 23rd-27th May 2005.

Sturm K, Hoffmann G and Stichler W, 2005. Simulations of $\delta^{18}O$ in precipitation by the regional circulation model REMOiso. *Hydrological Processes*, submitted

von Storch, H., H. Langenberg, F. Feser, 2000: A spectral nudging technique for dynamical downscaling purposes, *Mon. Wea. Rev.* **128**, 3664-3673.

3.6.3. SOCIO-ECONOMIC RELEVANCE AND POLICY IMPLICATION

The ERA40 driven high-resolution REMO simulation for Europe performed within ALP-IMP provides a four-dimensional, multi-variable meteorological dataset for the period 1958-2002 of unprecedented resolution. This simulation can substantially improve our understanding of the links between large-scale atmospheric states and regional weather and climate, in particular over areas where the regional weather can not be fully captured by the instrumental network, either due to a sparsity of observation sites, for instance over the sea or remote areas, or due to the complexity of the terrain, as is the case for parts of the Alpine region. A better understanding of the link between large and regional scales can improve our estimates for the past climate derived from local records, and thus help to discern natural climate variability from anthropogenic effects. It has also a potential for improving regional scenarios for future climate change. The fact that the model simulates not only meteorological variables, but also water isotope fractionation makes it also particularly suited for improving estimates of the past climate from isotope records from icecores.

3.6.4. DISCUSSION AND CONCLUSIONS

The considerable technical challenges associated with conducting a regional simulation that goes to the limit of what is feasible on the current supercomputer at the German Climate Computing Centre (DKRZ), and with implementing an water isotope fractionation module in the REMO model have been successfully mastered. The still ongoing validation of temperature and precipitation simulated in REMO provides a systematic assessment of the skill of the simulation. The unexpected difficulties with respect to the sensitivity of the isotope fractionation simulation to the constraints at the boundaries of the model domain have been successfully overcome through a newly developed double-nudging approach in which REMO is driven by the atmospheric GCM ECHAM4 and the wind fields in both models are nudged towards the ERA reanalysis.

3.6.5. PLAN AND OBJECTIVES FOR THE NEXT PERIOD

WP6 is scheduled to be finished by the end of April 2005. However, we have a delay of a few months for several reasons. As discussed above, unexpected scientific problems were related to providing boundary conditions for the REMO simulation with isotope fractionation and to the erroneous solar constant in the standard REMO simulation after 1989. Both problems are now solved, but took extra time. In addition we had problems at GKSS with filling the ALP-

IMP position. One of the people employed on ALP-IMP left GKSS in January 2004. We had planned to fill this position in May 2004 but for internal administrative reasons could not fill the position until September 2004. Thus activities related to WP6 will continue, and the deliverables and milestones for WP6 will be completed within the next months after some further analysis.

Concerning the consistency between the regional simulation and observations, several activities are planned. Temperature will be analysed on a daily timescale, if suitable daily datasets are found, as on this short timescale a higher added value can be expected. The simulated temperature may also be compared to the HISTALP high resolution temperature dataset that is in preparation (workpackage 1), however it is not clear when this dataset will become available because of the unexpected non-existence of a high resolution GAR-climatology the development which is currently being undertaken by ZAMG. The validation of the simulated precipitation will be complemented by a comparison with the HISTALP precipitation time series over the full time period from 1958 to 1999. The emphasis will be laid on identifying features of the precipitation data in the model simulation, such as wet and dry periods.

In WP7 the model output will be used to describe the influence of topography on circulation patterns as well as to reconstruct the climate of the GAR from long instrumental records.

Concerning the isotope modelling it is planned to extend the case study discussed above into a more systematic analysis of the relation between circulation patterns and isotope signals. Leading weather patterns are accompanied by typical isotope levels. The interpretation of inter-annual or decadal shifts in the water isotopic composition of precipitation can be based on such a weather pattern/isotope classification instead of using just empirical temperature/isotope relationships.

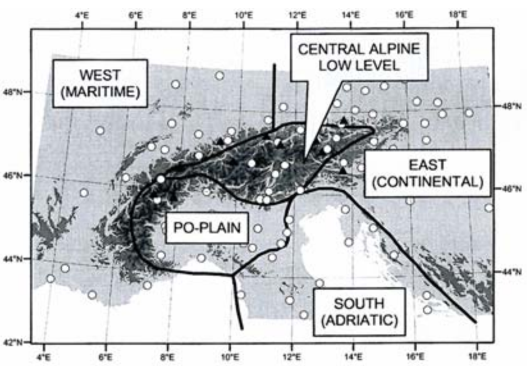


Fig 1: Map of the subregions 1 West (Maritime), 2 East (Continental), 3 South (Adriatic), 4 Po Plain, 5 Central Alpine Low Level and 6 ▲ High Level (>1400 m a.s.l.) (from Böhm et al. 2001).

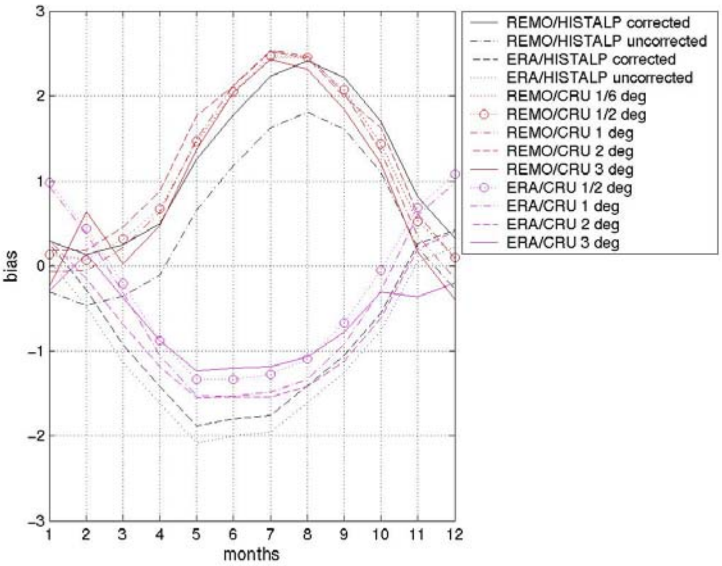


Fig 2: Monthly mean temperature bias between REMO and ERA40, respectively, and the instrumental datasets HISTALP stations and CRU, the latter on different resolutions. REMO and ERA40 were additionally adapted to the real HISTALP station altitude by a lapse-rate of 0.65 K/100 m.

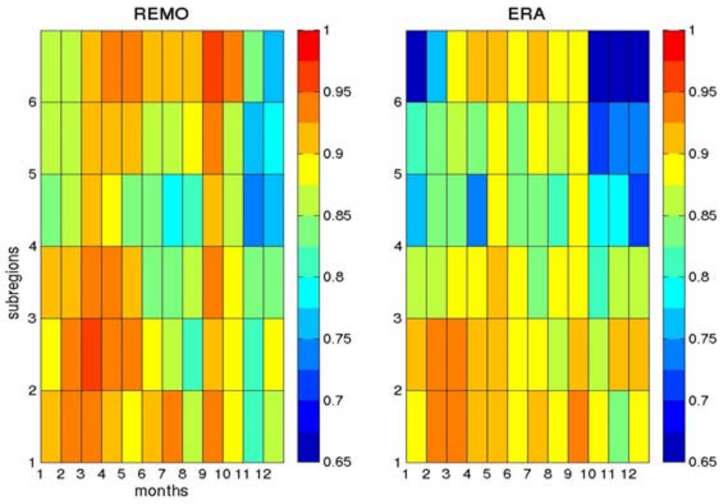


Fig 3: Monthly mean temperature correlations between REMO and the HISTALP station dataset and ERA40 and the HISTALP station dataset for each month for the six subregions (Fig. 1).

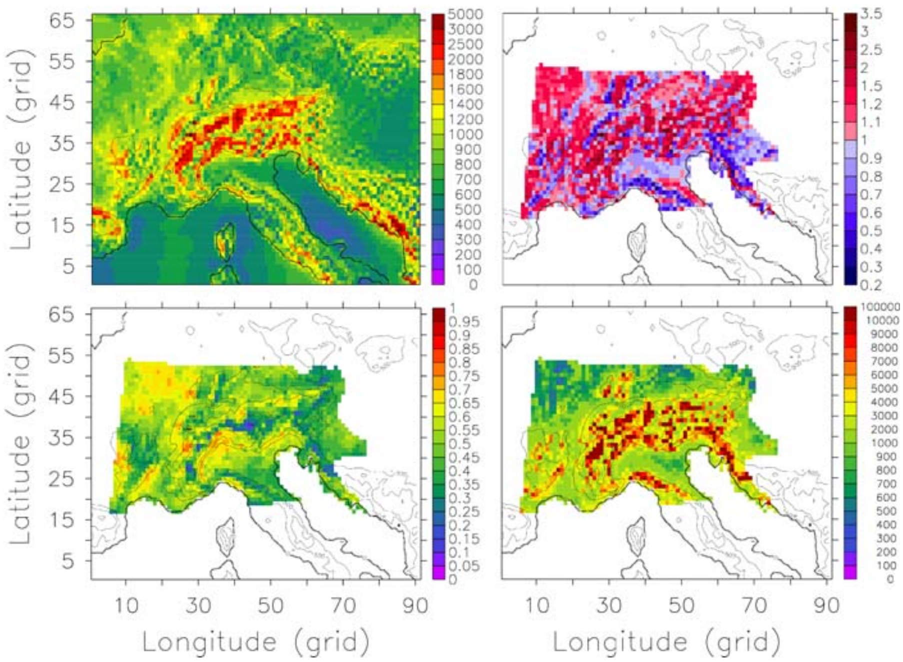


Fig. 4: Spatial distribution of the REMO mean yearly precipitation sums (mm/year, top left), ratio of the REMO modelled mean yearly precipitation sums / ETHZ observed mean precipitation sums (top right). Grid point wise comparison of the monthly precipitation time series are depicted in the lower plots, the common variance between the REMO and the ETHZ time series (bottom left) and the Mean Square Error (mm/year, bottom right). Time series cover the period 1971 – 1988.

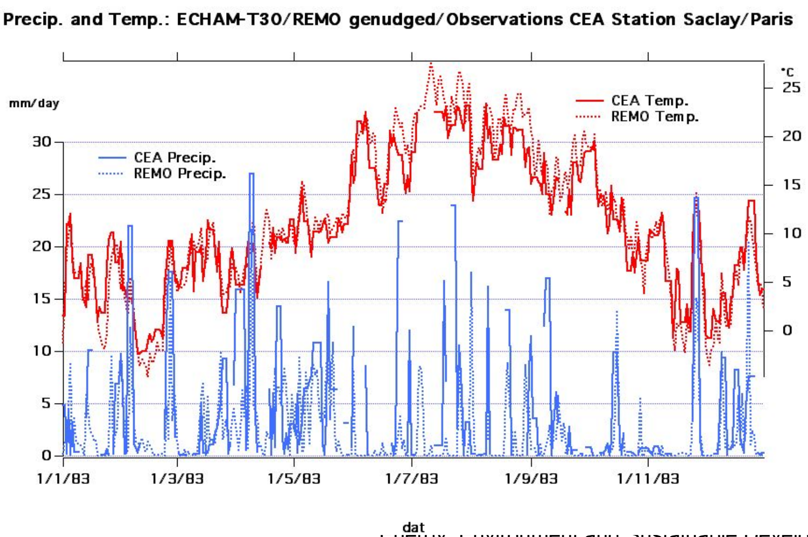


Fig. 5: Comparison of meteorological observations from the CEA Station at Paris with results of the nudged $REMO_{Iso}$ for the year 1983.

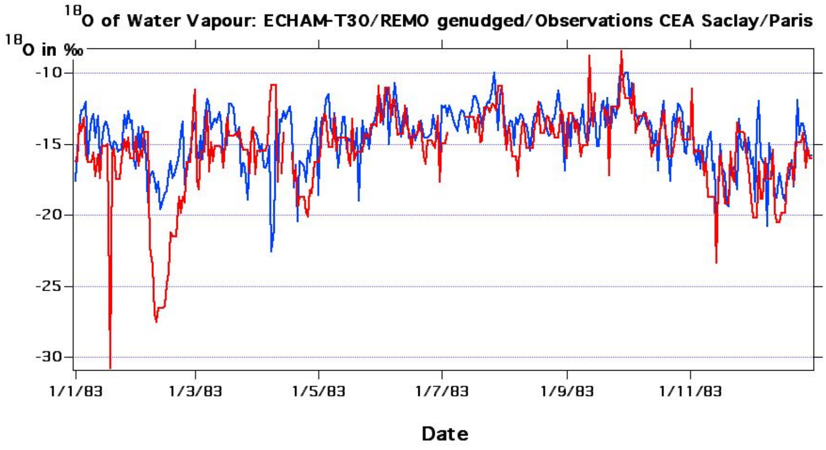


Fig. 6: Comparison of water vapour observations from the CEA Station at Paris with results of the nudged $REMO_{Iso}$ for the year 1983.

3.7.WP-7: CONSISTENCY OBSERVED VS. SIMULATED DATA

3.7.1. OBJECTIVES

This workpackage is a common activity of partners 3 and 5. The lead and reporting partner is partner 3. In the workpackage description in the proposal the following objectives are stated:

- Comparison of the 1/6 degree REMO, 0.5 degree REMO model runs, and the 2.5 degree reanalysis to determine the influence of topography on Alpine flow.
- To determine mesoscale circulation patterns within the GAR domain for the simulated period 1948-present from the 1/6 degree REMO run.
- Use mesoscale circulation patterns in conjunction with long instrumental records to produce a 4-dimensional reconstruction of climate for the GAR for the instrumental period.
- Investigate the mesoscale dynamical causes for decadal and longer-scale variability of surface temperature and precipitation.

3.7.2. METHODOLOGY AND SCIENTIFIC ACHIEVEMENTS RELATED TO WP-7, INCLUDING CONTRIBUTION FROM PARTNERS.

As explained in the 2004 annual report, due to the availability of the ERA40 reanalysis, the 1/6 degree REMO simulation has been forced with ERA40 for the period 1958-present (with the October 1989–present period currently being rerun as explained in workpackage 6 due to an error in the solar forcing). Thus as stated in the proposal, comparison with the 0.5 degree REMO run will not be undertaken, as this existing run was forced with the NCEP reanalysis. Comparison will therefore be undertaken between the ERA40 reanalysis and the aforementioned 1/6 degree REMO simulation.

None of the activities in this workpackage is scheduled as to be terminated already. Thus no final results can be yet expected. First analysis, to be begun in the near future, will be calculation of the EOFs of the REMO and ERA40 pressure and/or wind for the GAR. This will determine mesoscale circulation patterns over the GAR. Comparison of the EOFs from these two datasets will determine the influence of the higher-resolution REMO topography on the circulation patterns.

3.7.3. SOCIO-ECONOMIC RELEVANCE AND POLICY IMPLICATION

The analysis of the high-resolution REMO simulation in WP7 can substantially improve our understanding of the structure and temporal variability of mesoscale circulation variability in the GAR and its links to local climate. Understanding of these links may be important for understanding the dynamical causes of temperature and precipitation changes, and therefore for improving regional scenarios for future climate change. The three-dimensional reconstructions of past climate will help determine the magnitude of past climate variability over the GAR, and thus aid detection and attribution of climate change in this region.

3.7.4. DISCUSSION AND CONCLUSIONS

No final conclusions yet.

3.7.5. PLAN AND OBJECTIVES FOR THE NEXT PERIOD

Thus for the next period, work shall start on the aforementioned analysis of mesoscale circulation patterns. This work shall be followed by the investigation of the signal of the mesoscale circulation patterns determined during the first stage of the workpackage on temperature and precipitation. The final analysis of the workpackage will be statistical upscaling using the 1/6 degree REMO data and the long station records to reconstruct variables such as geopotential height throughout the troposphere.

3.8. WP-8: 200 YEARS GAR VERSUS GLOBAL

WP-8 is a common activity of partners 1 and 2, with (unscheduled) contributions of partner 5. Lead and reporting partner is partner 1. It has started its activities in time during the reporting period, mainly based on the deliveries of WP-1. WP-8 has concentrated in its initial phase on the first of the following objectives

3.8.1. OBJECTIVES

- to comprehensively describe the general climate variability features of the greater Alpine region (GAR) as a whole (what is *the* Alpine climate variability like)
- to analyze the representativity of the GAR climate variability features for larger parts of Europe (what tell us the Alps for larger parts of Europe?)
- to understand GAR climate variability in the context of large scale influences (what is the influence of continental to global scale climate variability on the Alps?)

3.8.2. METHODOLOGY AND SCIENTIFIC ACHIEVEMENTS RELATED TO WP-8 INCLUDING CONTRIBUTIONS FROM PARTNERS

Objective 1 will be met by an extensive paper which is already well on the way to be submitted for publication (ref: ALP-IMP-plan-2-16). It comprehensively and comparatively describes the short- and long-term climate variability features of the instrumentally measured climate elements (compare WP-1 report) air pressure, temperature, precipitation, sunshine duration, cloudiness, vapour pressure and relative humidity in the GAR. For means of data aggregation, the spatial variability has been reduced to the 5 leading "coarse resolution subregions". They are a necessary compromise of the objectively derived homogeneous sub-regions for the single climate elements. As the single series subregions do not differ substantially the general CR-subregions allow for statistically clean inter-elemental comparisons. The best solution for a general regionalization is outlined below. It resulted in four low-elevation sub-regions in the NW, NE, SW and SE of the GAR. They all cross in a "four corner region near 13deg E - 47degN, are sharply divided by the main chains of the Alps, but penetrate each into the Alpine valleys and basins. The 5th CR-subregion stands for the higher elevations from approximately 1500m asl (with some topographic exceptions like lower summit-stations or higher valleys)

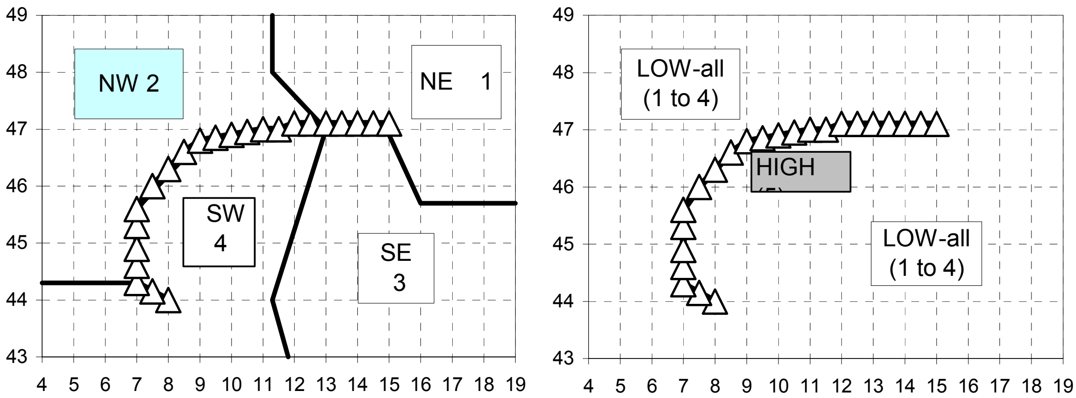


Figure 1: The four low elevation (left) and the high elevation (right) coarse resolution subregions of the GAR

For each element, all monthly, seasonal, half-annual, annual times series are visible at the public part of the homepage – together wit an extended summary of the HISTALP-paper. Only two examples may serve here to represent the wealth of new climate variability information in the HISTALP dataset.

Figures 2, 3 and 4 provide a first impression of the multitude of seasonally, subregionally, vertically different variation, trends and oscillations having happened in the past 1 to 2 centuries in relatively small region like the GAR.

The comprehensive HISTALP-paper will give a complete overview and thus officially fullfill the objective 1 plans. But it is clear right now that the new dataset will be continuously used for a lot of other studies concentrating on parts of it or also on the inter-elemental co-relations, dependencies, consistencies, physical correctness etc…within the project but also in the post project time.

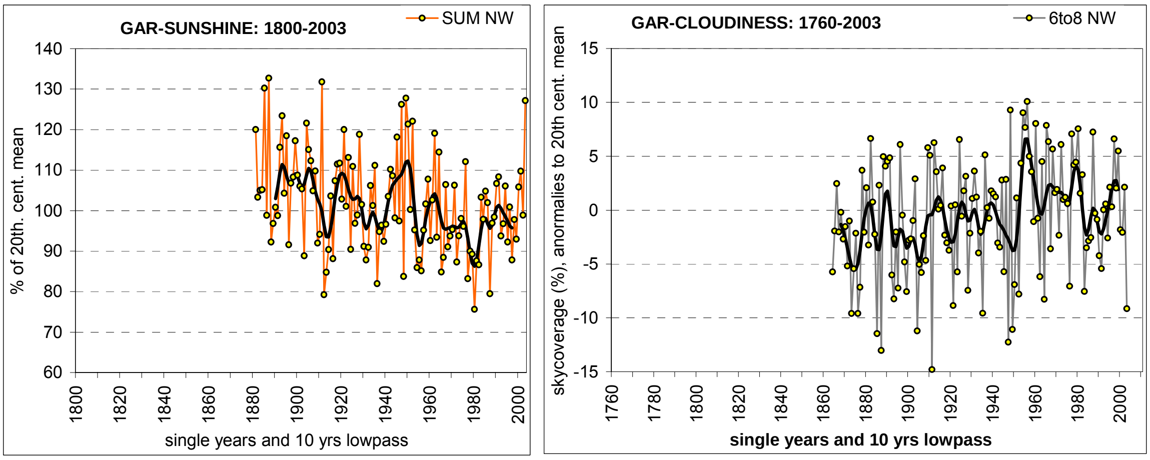


Figure 2: CR-Summer series (JJA) for subregion NW for sunshine (left) and cloudiness (right)

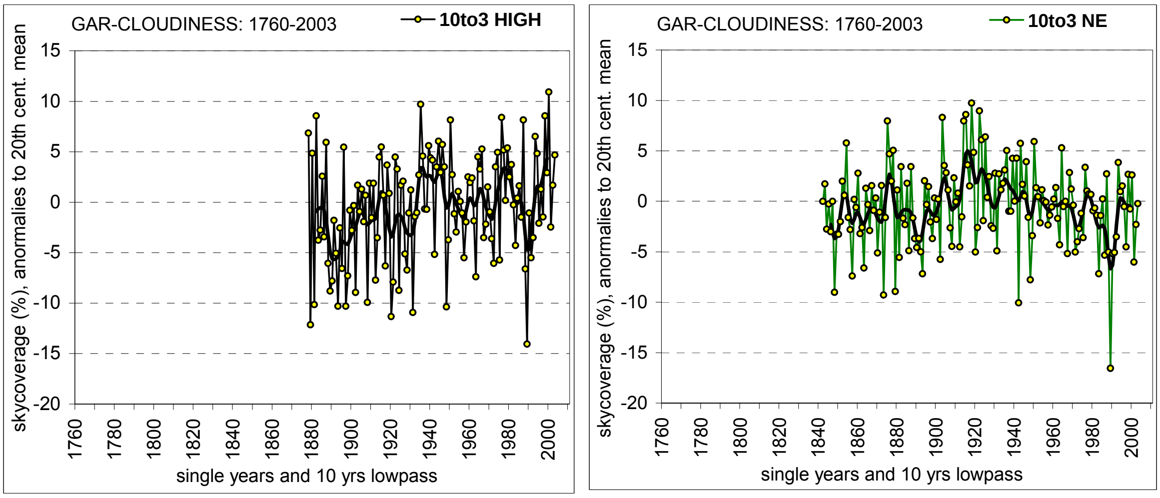


Figure 3: CR-Winter-Half-Year cloudiness-series (ONDJFM) for subregion NE-low and for subregion HIGH

Objectives 2 and 3

For the remaining objectives of WP-8 some preliminary studies have been performed (compare e.g. 1st report, 3.5.3).

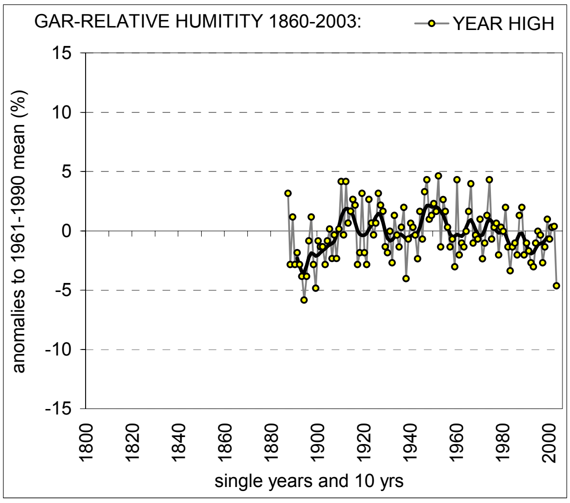
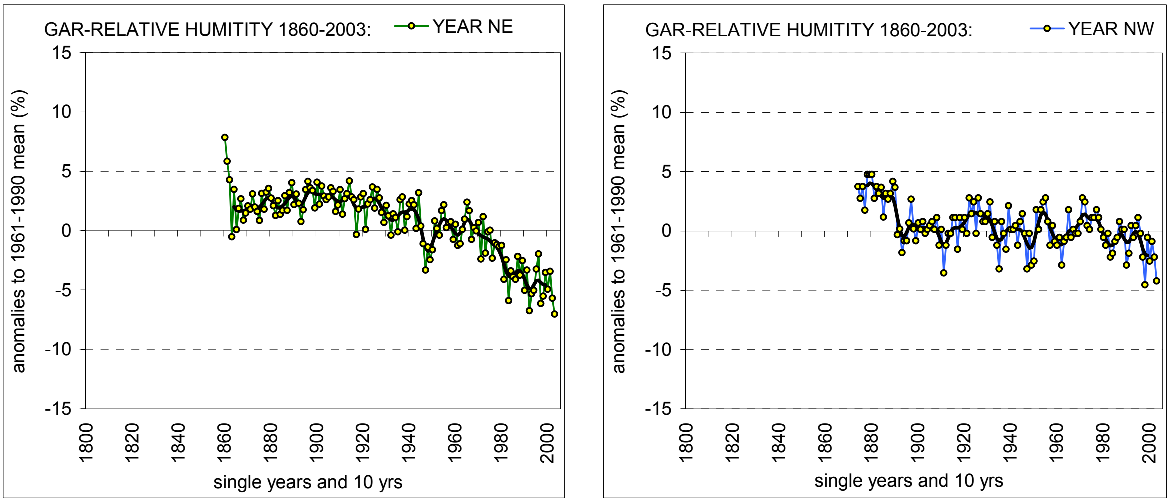


Figure 4: CR-annual relative humidity series for subregions HIGH (top), NW (bottom-left) and NE (bottom right)



3.8.3. SOCIO-ECONOMIC RELEVANCE AND POLICY IMPLICATION

The socio-economic value and the policy implications of the yet achieved deliverables of WP-8 – are given by a yet unknown real "climate"-variability description (climate to be understood as a linked multitude of different climate elements) of a region highly sensitive to climate impacts. The remaining work to be done in the WP will set the GAR-region's climate variability of the instrumental period in relation to that of larger scales. This is expected to help avoiding one of the major and most frequent biases of the recent discussion on climate change – the simplifying and often incorrect extrapolation of findings to other (larger or smaller) regions.

3.8.4. DISCUSSION AND CONCLUSION

As WP-8 is a workpackage just started, there are no final conclusions yet to be drawn.

3.8.5. PLAN AND OBJECTIVES FOR THE NEXT PERIOD

The worpackage is well on its way. After the finishing of the work on the first objective (publishing of ALP-IMP-plan-2-16) the two other objectives can be expected to be met without problems and in time.

3.9. WP-9: 1000 YEARS GAR VERSUS GLOBAL

WP-9 involves all partners, but partner 3. The lead and reporting partner is Partner 2. During the reporting period, work under several objectives was due to be virtually complete, while other areas of consolidation and syntheses of results arising from work on different palaeoclimate proxies was either in progress or just underway.

3.9.1. OBJECTIVES

- integrated analysis of tree-ring reconstructions
- extraction of climate signals from ice cores
- interpretation of climate forcing of glaciers
- proxy–proxy intercomparison reconciliation
- integrated analysis of GAR millennium climate
- GAR vs. global millennium climate
- description of ALP-IMP findings for public use

3.9.2. METHODOLOGY AND SCIENTIFIC ACHIEVEMENTS RELATED TO WP-9

Objective 1 is near completion. This has involved the development of both independent and integrated versions of millennial temperature reconstructions including combining ring-width and ring-density data, as described under section 3.2 (work between Partners 8 and 10). In addition, partner 2, along with partners 9 and 10 have explored methodological issues of long tree-ring chronology construction using separate and combined data sets. This work has identified potential bias issues affecting the magnitude of apparent recent tree growth changes, of relevance for chronology scaling against instrumental records and quantifying past temperature change. Several papers will describe this work. Though this aspect of the work is largely completed, final analyses and publication of results will continue into the third reporting period, but it is not envisaged that this will hinder the inter-proxy comparisons to be undertaken under Objective 4, or the wider integration of results involved in the other Objectives.

Objective 2: These aspects have been reported under Section 3.3.2.4—basically represented by two independent isotope-temperature series (for Monte Rosa and Mont Blanc) covering the last millennium. While the isotope determinations are available, further work is envisaged to explore the likely fidelity of the age scales, and uncertainty in ice flow properties at the different locations that could affect the practicality of integrating these records to provide an overall ice-core temperature history (see Section 3.3.2.2).

Objective 3: The work on interpreting the climate forcing of glaciers is virtually complete. Within the ALP-IMP project these aspects are described in two publications:

1. Zemp, M., Paul, F., Hoelzle, M. and Haeberli, W. Alpine glacier fluctuations 1850–2000: overview and spatio-temporal analysis of available data and its representativity. (In) *Proceedings of the International and Interdisciplinary Workshop on Mountain Glaciers and Society, Wengen, Switzerland, Oct. 6–8, 2004*. [In press]

2. Frauenfelder, R., Zemp, M., Haeberli, W. and Hoelzle, M. Worldwide glacier mass balance measurements: general trends and first results of the extraordinary year 2003 in Central Europe. (In) *Data of Glaciological Studies [Materialy glyatsiologicheskikh issledovaniy]*, 99, Russia.

To access these see: ftp://ftp.geo.unizh.ch/pub/mzemp/alpimp/

In the third reporting period, the glacier group will focus on modelling glacier behaviour over the entire Alps and compare this to other regions worldwide. The glacier movements in themselves represent a more integrated response to general climate forcing than is the case for other palaeoclimate proxies (e.g. individual tree-ring chronologies) that may have greater specific sensitivity to a narrower range of climate parameters (e.g. summer temperature at high elevation), whereas glacier volume will represent the combined influences of winter precipitation (accumulation) and summer temperature (ablation) over a number of years. During the final year of the project, the glacier modelling will, therefore, involve different and complementary strategies. These are described under 3.4.5. One outcome, the reconstruction of general (GAR) mass balance change, will form the basis for comparison of reconstructed climate change provided by the other proxies.

Objectives 4 to 7 are now underway, with Objectives 4 and 7 further advanced, in accordance with the projected time schedule outlined in the GANTT chart. Initial comparisons of ice temperatures and tree-ring reconstructions are problematic, in that they show mutual evidence of recent (i.e. during the last 2–3 decades) warming, but the ice temperatures show no evidence of the significant centennial-length cooling indicated in the 17th century in the tree-ring data. It should be stressed that, at present, no overall temperature curve (with quantitative estimates of uncertainty) are available for either the total tree-ring data set, or the ice temperatures, but the tree-ring estimates are in better agreement with the implied GAR tree-ring temperatures, and they are also in qualitative agreement, at least with the wider (N. Hemisphere) history of temperature change over the last millennium. When complete, independent precipitation estimates (~400 years long) will provide the basis for additional comparison (with expected negative correlation where these are primarily driven by summer rainfall, with limited influence of winter soil recharge or snow melt) with the temperature estimates. Over these 400 years, additional simple modelling of glacier mass balance, driven by temperature and precipitation change derived from the dendroclimatic reconstructions, will also provide independent support for the climate change inferred from the more sophisticated glacier modelling work undertaken by Partner 6. These findings will also feed into the wider comparisons of temperature changes (and limited precipitation evidence) on a Hemispheric scale.

Objective 8, relating to the description of ALP-IMP findings for public dissemination, though not due to start until month 30, has seen some progress through the ALP-IMP web site and individual partner websites. These efforts will be consolidated as envisaged during the final reporting period.

ANNEX 1 to THE ALP-IMP 2nd aanual report:

Cumulative PUBLICATION LIST

All publications listed below as pdf-files in the member area of the project homepage

(www-zamg.ac.at/ALP-IMP)
under the filenames indicated in column “ALP-IMP-ref-ID”

ALP-IMP PUBLICATION LIST			PEER REVIEWED ARTICLES		***Version June 2005***	
ALP-IMP ref-ID	**Reporting Period**	**Authors**	**Date**	**Title**	***Journal***	**Reference**
REPORTING PERIOD 1: 2003-03 to 2004-04						
ALP-IMP-rev-1-1	1	Aguilar E, Auer I, Brunet M, Peterson TC, Wieringa J	Dec. 2003	Guidlines on Climate Metadata and Homogenization	*WMO-TD* **1186** *WCDMP* **53**	51 pages
ALP-IMP-rev-1-2	1	Maugeri M, Brunetti M, Monti F, Nanni T	2004	Sea-level pressure variability in the Po-plain (1765-2000) from homogenized daily secular records	*International Journal of Climatology* **24**	437-455
REPORTING PERIOD 2: 2004-05 to 2005-04						
ALP-IMP-rev-2-1	2	Auer I, Böhm R, Jurkovic A, Orlik A, Potzmann R, Schöner W, Ungersböck M, Brunetti M, Nanni T, Maugeri M, Briffa K, Jones P, Efthymiadis D, Mestre O, Moisselin JM, Begert M, Brazdil R, Bochnicek O, Cegnar T, Gajic-Capka M, Zaninovic K, Majstorovic Z, Szalai S, Szentimrey T	2005	A new instrumental precipitation dataset in the greater alpine region for the period 1800-2002	*International Journal of Climatology* **25/2**	139-166
ALP-IMP-rev-2-2	2	Frank D, Esper J	2005	Characterization and climate response patterns of a high elevation, multi species tree-ring network for the European Alps.	*Dendrochronologia* **22**	107-121
ALP-IMP-rev-2-3	2	Zemp M, Kääb A, Hoelzle M, Haeberli W	2005	GIS-based modelling of glacial sediment balance.	*Zeitschrift für Geomorphologie N.F.*, Suppl.-Vol. **138**.	113-129
ALP-IMP-rev-2-4	2	Casty C, Wanner H, Luterbacher J, Esper J, Böhm R	Apr.05	Temperature and precipitation variability in the European Alps since 1500	accepted for: *International Journal of Climatology*	
ALP-IMP-rev-2-5	2	Büntgen U, Esper J, Frank DC, Nicolussi K, Schmidhalter M	2005	A 1052-year tree-ring proxy of Alpine summer temperatures.	accepted for: *Climate Dynamics*	
ALP-IMP-rev-2-6	2	Frauenfelder, R., Zemp, M., Haeberli, W. and Hoelzle, M.	Apr.04	Worldwide glacier mass balance measurements: general trends and first results of the extraordinary year 2003 in Central Europe.	accepted for: *Data of Glaciological Studies,* **98**	
ALP-IMP-rev-2-7	2	Böhm R	Apr.05	Reconstructing the Climate of the 250 Years of Instrumental Records at the Northern Border of the Mediterranean (The Alps)	accepted for: *Il Nuovo Cimento*	
ALP-IMP-rev-2-8	2	Frank D, Esper J	2005	Temperature reconstructions and comparisons with instrumental data from a tree-ring network for the European Alps	accepted for: *International Journal of Climatology*	
ALP-IMP-rev-2-9	2	Brunetti M, Maugeri M, Monti F, Nanni T	2005	Temperature and Precipitation Variability in Italy in the Last Two Centuries from Homogenized Instrumental Time Series	accepted for: *International Journal of Climatology*	
ALP-IMP-rev-2-11	2	Efthymiadis D, Jones PD, Briffa K, Auer I, Böhm R, Schöner W, Frei C,	Apr.05	Construction of a 10-min.gridded precipitation dataset for the Greater Alpine Region 1800-2003	submitted to: *Journal of Geophysical Research - Atmospheres*	
ALP-IMP-rev-2-12	2	Büntgen U, Bellwald I, Kalbermatten H, Frank DC, Freund H, Schmidhalter M, Bellwald W, Neuwirth B, Esper J	2005	700-years of settlement and building history in the Lötschental/Vallis.	submitted to: *Erdkunde*	
ALP-IMP-rev-2-13	2	Carrer M, Urbinati C	Apr.05	Long-term change in the sensitivity of tree-ring growth to climate forcing of *Larix decidua* (L.)	submitted to: *Global Change Biology*	
ALP-IMP-rev-2-14	2	Frank D, Wilson R, Esper J	2005	Synchronous variability changes in Alpine temperature and tree-ring data over the last two centuries	submitted to: *Boreas*	
ALP-IMP-rev-2-15	2	Zemp, M., Paul, F., Hoelzle, M. and Haeberli	Jan.05	Alpine glacier fluctuations 1850-2000: overview and spatio-temporal analysis of available data and its representativity.	submitted to: *Advances in Global Change Research.*	
ALP-IMP-rev-2-16	2	Paul, F., Machguth, H., Hoelzle, M., Salzmann, N. and Haeberli, W.	Jan.05	Alpine-wide distributed glacier mass balance modelling: a tool for assessing future glacier change?	submitted to: *Advances in Global Change Research.*	
ALP-IMP-rev-2-17	2	Paul, F., Machguth, H. and Kääb, A.	Feb.05	On the impact of glacier albedo under conditions of extreme glacier melt: the summer of 2003 in the Alps.	submitted to: EARSeL Workshop on Remote Sensing of Land Ice and Snow, Bern, 21.-23.2. 2005. *EARSeL eProceedings* **3**, *CD-ROM.*	
ALP-IMP-rev-2-18	2	Steier P, Drosg R, Fedi M, Kutschera W, Schock M, Wagenbach D, Wild EM	2005	Radiocarbon determination of particulate organic carbon in glacier ice from the Grenzgletscher (Monte Rosa)	submitted to: *Radiocarbon*	
ALP-IMP-rev-2-19	2	Brunetti M, Maugeri M, Monti F, Nanni T	2005	The Variability of Italian climate in the last 160 years	accepted for: *Il Nuovo Cimento*	
ALP-IMP-rev-2-20	2	Nicolussi K, Kaufmann M, Patzelt G, van der Plicht J, Thurner A	2005	Holocene tree-line variability in the Kauner valley, central eastern Alps, indicated by dendrochronological analyses of living trees and subfossil logs	submitted to: *Vegetation History and Archaeobotany*	

ALP-IMP PUBLICATION LIST		NON REFEREED ARTICLES				*Version June 2005*	
ALP-IMP ref-ID	Reporting Period	Authors/Editors	Date	Title	Event	Reference	Type*
REPORTING PERIOD 1: 2003-03 to 2004-04							
ALP-IMP-n-rev-1-1	1	Böhm R, Auer I, Ungersböck M, Schöner W, Huhle C, Nanni T, Brunetti M, Maugeri M, Mercalli L, Gajic-Capka M et al.	May 2003	Mesoscale patterns of long-term precipitation variability in the greater alpine region	ICAM-03: International Conference on Alpine Meteorology	Binder P, Richner H, Schär Ch (eds): ICAM-03 Extended Abstracts, *Publications of MeteoSwiss* **66** 555	abstract (of an oral presentation)
ALP-IMP-n-rev-1-2	1	Böhm R.,Auer I, Schöner W, Ungersböck M, Huhle C, Nanni T, Brunetti M, Maugeri M, Mercalli L, Gajic-Capka M, Zaninovic K, Szalai S, Szentimrey T, Cegnar T, Bochnicek O, Begert M, Mestre O, Moisselin JM, Müller-Westermeier G, Majstorovic Z	Sep. 2003	Der Alpine Niederschlagsdipol – ein dominierendes Schwankungsmuster der Klimavariabilität in den Scales 100 km – 100 Jahre *(The alpine precipitation dipole - a dominant climate variability pattern at the scales of 100 km - 100 years)*	6. Deutsche Klimatagung - Klimavariabilität, 22.9. - 25.9.2003, Potsdam (DE) *(6th German climate conference - climate variability)*	Negendank FW, Ristedt H (eds), 2003: *Terra Nostra* **2003/6**, 61-65	proceedings with extended abstracts (of an oral presentation)
ALP-IMP-n-rev-1-3	1	Scheifinger H, Böhm R, Auer I	Sep. 2003	Räumliche Dekorrelation von Klimazeitreihen unterschiedlicher zeitlicher Auflösung und ihre Bedeutung für ihre Homogenisierbarkeit und die Repräsentativität von Ergebnissen *(Spatial de-correlation of climate time series of different time-resolution and it's relevance for homogenization and spatial representation of results)*	6. Deutsche Klimatagung - Klimavariabilität, 22.9. - 25.9.2003, Potsdam (DE) *(6th German climate conference - climate variability)*	Negendank FW, Ristedt H (eds), 2003: *Terra Nostra* **2003/6**, 375-379	proceedings with extended abstracts (of a poster)
ALP-IMP-n-rev-1-4	1	Roswitha Drosg, Walter Kutschera, Martin Schock, Peter Steier, Dietmar Wagenbach, Eva Maria Wild	Sep. 2003	Radiocarbon determination of particulate organic carbon in glacier ice	18th International Radiocarbon Conference in Wellington, New Zealand, 1-5 September 2003	Proceedings of the 18th International Radiocarbon Conference (in Press)	abstract (of an oral presentation)
ALP-IMP-n-rev-1-5	1	Böhm R	Apr. 2004	Systematische Rekonstruktion von zweieinhalb Jahrhunderten instrumentellem Klima in der größeren Alpenregion – ein Statusbericht *(Systematic reconstruction of two and a half centuries of instrumental climate in the greater alpine region - a status report)*	54. Deutscher Geographentag, Bern (CH) 28.9.2003 bis 4.10.2003 *(54th German Geographer's Day)*	Gamerith, W., Messerli, P., Meusburger, P., Wanner, H. (Hrsg.) (2004): Alpenwelt – Gebirgswelten. Inseln, Brücken, Grenzen. Tagungsbericht und wissenschaftliche Abhandlungen, 121-131	extended proceedings with invited contributions (of an oral presentation)
ALP-IMP-n-rev-1-6	1	Böhm R, Auer I, Jurkovic A, Orlik A, Potzmann R, Schöner W, Ungersböck M, Brunetti M, Maugeri M, Nanni T, Jones P, Briffe K, Efthimiadis D	Apr. 2004	Die neuen ALP-IMP - CLIVALP Klimadatensätze - Neuerungen, Datenqualität unsd erste Ergebnisse *(The new ALP-IMP - CLIVALP datasets - news, data quality and first results)*	8. Österreichischer Klimatag, 19. und 20.Apr. 2004, Wien (AT) (8th Austrian Climate Day)	http://oegm.boku.ac.at/Veranstaltungen/klimatag08.html	Abstracts and ppt-files of presentations
ALP-IMP-n-rev-1-7	1	Paul, F., Kääb, A., Maisch, M., Kellenberger, T. W. and Haeberli, W.	2003	Das neue Schweizer Gletscherinventar: Anwendungen in der Gebirgskartographie. *(The new Swiss glacier inventory: Applications in mountain catography)*	*Kartographische Nachrichten,* **5**	212-217.	
ALP-IMP-n-rev-1-8	1	Haeberli, W., Paul, F., Gruber, S., Hoelzle, M., Kääb, A., Machguth, H., Noetzli, J., Rothenbühler, C.	2004	Effects of the extreme summer 2003 onglaciers and permafrost in the Alps - first impressions and estimations.	EGU 1st General Assembly, Nice, 25-30 April 2004	*Geophysical Research Abstracts* , **6,** 2004, CD-ROM (ISSN: 1029-7006)	abstract (of an oral presentation)
ALP-IMP-n-rev-1-9	1	Hoelzle, M., Zemp, M., Frauenfelder, R. and Haeberli, W.	2004	Integration of alpine glacier monitoring into the GTN-G network of the global climate observing system (GCOS) by applying the global hierarchical observing strategy (GHOST). A discussion report.	EGU 1st General Assembly, Nice, 25-30 April 2004	*Geophysical Research Abstracts* , **6,** 2004, CD-ROM (ISSN: 1029-7006)	abstract (of an oral presentation)
ALP-IMP-n-rev-1-10	1	Zemp, M. and Hoelzle, M.	2004	Revision and expansion of World Glacier Monitoring Service's database	EGU 1st General Assembly, Nice, 25-30 April 2004	*Geophysical Research Abstracts* , **6,** 2004, CD-ROM (ISSN: 1029-7006)	abstract (of an oral presentation)
ALP-IMP-n-rev-1-11	1	Machguth, H.; Paul, F.;Hoelzle, M. and Haeberli, W.	2004	Calculating distributed glacier mass balance over entire mountain groups.	EGU 1st General Assembly, Nice, 25-30 April 2004	*Geophysical Research Abstracts* , **6,** 2004, CD-ROM (ISSN: 1029-7006)	abstract (of an oral presentation)
ALP-IMP-n-rev-1-12	1	Paul, F.; Machguth, H.; Hoelzle, M.; Salzmann, N. and Haeberli, W.	2004	Application of a distributed glacier mass balance model to the western part of the Swiss Alps	EGU 1st General Assembly, Nice, 25-30 April 2004	*Geophysical Research Abstracts* , **6,** 2004, CD-ROM (ISSN: 1029-7006)	abstract (of an oral presentation)

ALP-IMP PUBLICATION LIST			**NON REFEREED ARTICLES**			***Version June 2005***	
ALP-IMP ref-ID	**Reporting Period**	**Authors/Editors**	**Date**	**Title**	**Event**	**Reference**	**Type***
REPORTING PERIOD 2: 2004-05 to 2005-04							
ALP-IMP-n-rev-2-1	2	Auer I, Böhm R, Scheifinger H, Ungersböck M, Orlik A, Jurkovic A	Sep. 2004	Metadata and their role in homogenising	Fourth Seminar for Homogenization and Quality Control in Climatological Databases, 6.-10.10.2003, Budapest (HU)	Szalai S, Szentimrey T (eds.), 2004: Proceedings of the 4th Seminar for... *WMO-WCDMP* **56**, *WMO-TD* **1236** 17-23	proceedings with extended abstracts (of an oral presentation)
ALP-IMP-n-rev-2-2	2	Büntgen U, Esper J, Frank DC, Nicolussi K, Schmidhalter M, Seifert M	2005	The effect of power transformation on RCS – case study from 3 millennial-length alpine chronologies	TRACE Dendrosymposium 2004 April 22nd-24th, Birmensdorf, Switzerland	*TRACE* **3** 141-149	extended abstract volume of invited contributions (of an oral presentation)
ALP-IMP-n-rev-2-3	2	Scheifinger H, Böhm R	2004	Räumliche Dekorrelation und Homogenisierbarkeit von Klimazeitreihen	DACH-2004 Meteorologen-Tagung, 7.-10.9.2004, Karlsruhe	Extended Abstracts CD, P12.21	proceedings with extended abstracts (of a poster presentation)
ALP-IMP-n-rev-2-4	2	Matulla C, Auer I, Böhm R, Ungersböck M, Schöner W, Wagner S, Zorita E	Apr.05	Outstanding past decadal-scale climate events in the Greater Alpine Region analysed by 250 years data and model runs		*GKSS-Report* **2005-04**, 1-115	
ALP-IMP-n-rev-2-5	2	Leal, S., Melvin T.M., Grabner, M., Wimmer, R., Briffa, K.R.	Sep.04	Tree-ring width variability in the Austrian Alps and its relation with climate	Eurodendro 2004, September 15.-19., 2004, Rendsburg, Germany	Proceedings of the EuroDendro 2004, September 15.-19., 2004, Rendsburg, Germany: 29-30	abstract of a poster
ALP-IMP-n-rev-2-6	2	Auer I, Böhm R, Matulla C, Ungersböck M, Nanni T, Maugeri M, Pastorelli R	Sep.04	Frost occurrence in the European Alps - A view into the future and into the past	4th Annual Meeting of the European Meteorological Society, 26-30 Sept. 2004, Nice	EMS Annual Meeting Abstracts CD Vol.1, 00167, 2004	abstract proceedings
ALP-IMP-n-rev-2-7	2	Böhm R, Auer I, Potzmann R, Schöner W, Ungersböck M, Brunetti M, Nanni T, Maugeri M	Sep.04	Homogenising 192 precipitation time series in the greater alpine region (GAR) - A field report on theoretical and practical problems and solutions	4th Annual Meeting of the European Meteorological Society, 26-30 Sept. 2004, Nice	EMS Annual Meeting Abstracts CD Vol.1, 00168, 2004	abstract proceedings
ALP-IMP-n-rev-2-8	2	Böhm R, Auer I, Schöner W, Brunetti M, Nanni T, Maugeri M, Jones PD, Briffa K, Efthymiadis D	Sep.04	4-dimensional precipitation patterns in the greater alpine region - re-analysed with the new HISTALP dataset	4th Annual Meeting of the European Meteorological Society, 26-30 Sept. 2004, Nice	EMS Annual Meeting Abstracts CD Vol.1, 00169, 2004	abstract proceedings
ALP-IMP-n-rev-2-9	2	Zemp, M., Paul, F., Hoelzle, M., Haeberli, W. and Frauenfelder, R.	Oct.04	Spatio-temporal analysis of 150 years of Alpine glacier fluctuations.	International and Interdisciplinary Workshop on Mountain Glaciers and Society, Wengen, October 6 - 9, 2004.	Proceedings volume not yet available	abstract (of a poster)
ALP-IMP-n-rev-2-10	2	Schöner W, Auer I, Böhm R, Briffa K, Efthymiadis D, Jones PD, Widmann M, Brunetti M, Nanni T, Maugeri M	Oct.04	Long-term gridded air temperature and precipitation for the Greater Alpine Region	Conference on Spatial Interpolation Techniques in Climatology and Meteorology, 25. to 29. October 2004, Budapest	Proceedings volume not yet available	abstract of an oral presentation
ALP-IMP-n-rev-2-11	2	Zemp, M., Paul, F., Hoelzle, M., Haeberli, W. and Frauenfelder, R.	Feb.05	Spatio-temporal analysis of 150 years of Alpine glacier fluctuations.	9th Alpine Glaciology Meeting, Milano, February 24 - 25, 2005.	http://users.unimi.it/glaciol/9agm/zemp.pdf	abstract (of an oral presentation)
ALP-IMP-n-rev-2-12	2	Zemp, M., Hoelzle, M., Paul, F. and Haeberli, W.	Apr.05	Distributed Modelling of Regional Equilibrium Line Altitude in the European Alps: First Results and Discussion Report.	EGU 2nd General Assembly, Vienna, 25-29 April 2005.	*Geophysical Research Abstracts* , 7, 2005, CD-ROM (ISSN: 1029-7006)	abstract (of an oral presentation)
ALP-IMP-n-rev-2-13	2	Zemp, M., Paul, F., Hoelzle, M., Frauenfelder, R. and Haeberli, W.	Apr.05	Spatio-temporal Analysis of 150 Years of Alpine Glacier Fluctuations.	EGU 2nd General Assembly, Vienna, 25-29 April 2005.	*Geophysical Research Abstracts* , 7, 2005, CD-ROM (ISSN: 1029-7006)	abstract (of a poster)
ALP-IMP-n-rev-2-14	2	Hoelzle, M., Chinn, T., Stumm, D., Paul, F., Zemp, M. and Haeberli, W.	Apr.05	Application of inventory data for estimating characteristics of and regional climate-change effects on mountain glaciers: a comparison between the European Alps and the New Zealand Alps.	EGU 2nd General Assembly, Vienna, 25-29 April 2005.	*Geophysical Research Abstracts* , 7, 2005, CD-ROM (ISSN: 1029-7006)	abstract (of a poster)
ALP-IMP-n-rev-2-15	2	Böhm R, Auer I, Jurkovic A, Orlik A, Potzmann R, Schöner W, Ungersböck M	Apr.05	Climate variability changes in the greater alpine region in the past two centuries	EGU General Assembly 2005, 24-29 April 2005, Vienna, Austria	*Geophysical Research Abstracts* **7** 06634 2005 Sref-ID: 1607-7962/gra/EGU05-A-06634	abstract proceedings
ALP-IMP-n-rev-2-16	2	Pettinger M, Keck L, Fischer H, Wagenbach D, Preunkert S, Böhm R, Hoelzle M, Leuenberger M Hoffmann G	Apr.05	Centennial scale isotope thermomentry from Alpine ice core records: shortcomings and challenges	EGU General Assembly 2005, 24-29 April 2005, Vienna, Austria	*Geophysical Research Abstracts* **7** 07941 2005 Sref-ID: 1607-7962/gra/EGU05-A-07941	abstract proceedings
ALP-IMP-n-rev-2-17	2	Arnold W	Jan-2005	Schwarzwild: Hintergründe einer Explosion		Waidwerk **1/2005** 8-11	

	ALP-IMP PUBLICATION LIST			**PLANs OF NEAR FUTURE PUBLICATIONS** **Version June 2005**
ALP-IMP ref-ID	**type**	**date**	**authors from partners (lead partner bold)**	**contents**
	REPORTING PERIOD 2: 2004-05 to 2005-04			
ALP-IMP-plan-2-1	per reviewed journal	2005	9, 2	Tree-ring growth varaibility at the Austrian Alps in relation with site altitude, tree species and climate.
ALP-IMP-plan-2-2	per reviewed journal	2005	9, 2 (and externals)	Extreme growth years in relation to climate in precipitation sensitive Pinus nigra Arn. Tress growing in Austria.
ALP-IMP-plan-2-3	per reviewed journal	2005	9, 2 (and externals)	Possible CO2 fertilization effects on tree growth at the Austrian Alps.
ALP-IMP-plan-2-4	peer reviewd journal	2005.6	9, 2	Temperature reconstruction at the mountain Dachstein, Austria
ALP-IMP-plan-2-5				
ALP-IMP-plan-2-6	proceedings Eurodendro 2005, Viterbo	Sep.05	**9**	New master chronologies from historical and archaeological timber in Eastern Austria.
ALP-IMP-plan-2-7	proceedings Eurodendro 2005, Viterbo	Sep.05	**9**	The bronzeage salt mine at Hallstatt, Austria - First dendrochronological results.
ALP-IMP-plan-2-8	proceedings Eurodendro 2005, Viterbo	Sep.05	**9**	Is there CO2 fertilization effect on tree growth at Austrain alpine sites?
ALP-IMP-plan-2-9	peer reviewed journal	2005	**8**	We describe annual resolved Alpine summer (June-September) temperatures over the AD 755–2004 period. The reconstruction is composed of 180 recent and historic high elevation tree-ring maximum latewood density (MXD) series. After correction for larch bud moth (LBM) induced negative outliers, the regional curve standardization (RCS) preserves high to low frequency information from the dataset. Instrumental temperature and precipitation data from nine high (low) elevation grid-boxes back to 1818 (1760) are used for comparison with the proxy. Distinct growth/climate response to current year June-September (JJAS) temperatures is revealed. For calibration/verification statistics, various regression models are applied including different periods, seasonality, and wavelength. The new reconstruction correlates at 0.69 with Alpine high elevation JJAS temperatures back to 1818, weighted towards high frequency variations. Extra-verification using low elevation temperatures back to 1760 proves the reconstruction's inter-annual skill, however, also shows a substantial trend offset between (warmer) instrumental and (cooler) proxy data.
ALP-IMP-plan-2-10			continuation of previous	High temperatures in the 10th and 13th century, comparable to those of the last decade, confirm the putative Medieval Warm Period (MWP). A prolonged cooling from ~1300–1820 reflects to the so-called Little Ice Age (LIA). With 2003 being the warmest summer over the past 1250 yr, the proxy captures the full range of the instrumental measurements, without splicing both records. We provide annual and decadal temperature amplitudes of 6.4°C (1816-2003) and 3.1°C (1810s-1940s), respectively. The MXD-RCS reconstruction is compared with radiative forcing series derived for volcanic eruptions and solar activity, and the North Atlantic Oscillation (NAO). Warmest summer temperatures coincide with periods of high solar and low volcanic activity, and coldest temperatures vice versa. However, no relationship with the NAO is found. Although, reconstructed temperature variations mimic natural forcings, anthropogenic impact cannot be excluded for the 20th century. As this study and other regional- and large-scale proxy records share common variability, evidence of the timing of the MWP, LIA and recent warmth is provided, however the amplitude of past temperature variations is poorly understood.
ALP-IMP-plan-2-11	peer reviewed journal	2005	**8**	A new Norway spruce [Picea abies (L.) Karst.] tree-ring width chronology based on living and historic wood spanning the AD 1108-2003 period is developed. This composite record combines 208 high elevation samples from three Swiss subalpine valleys, i.e., Lötschental, Goms and Engadine. To retain potential high to low frequency information in this dataset, individual spline detrending and the regional curve standardization are applied. For comparison, 22 high elevation and six low elevation instrumental station records covering the greater Alpine area are used. Previous year August-September precipitation and current year May-July temperatures control spruce ring width back to ~1930. Decreasing (increasing) moving correlations with monthly mean temperatures (precipitation) indicate instable growth/climate response during the 1760-2002 period. Crucial June-August temperatures before ~1900 shift towards May-July temperature plus August precipitation sensitivity after ~1900.
ALP-IMP-plan-2-12			continuation of previous	Numerous of comparable subalpine spruce chronologies confirm increased late-summer drought stress, coincidently with the recent warming trend. Comparison with regional-, and large-scale millennial-long temperature reconstructions reveal significant similarities prior to ~1900 (1300-1900 mean r =0.51), however, this study does not capture the commonly reported 20th century warming (1900-1980 mean r =-0.17). Due to instable growth/climate response of the new spruce chronology, further dendroclimatic reconstruction is not performed.
ALP-IMP-plan-2-13	peer reviewed journal	3rd project year	**6**	P-T-ELA0 Method Paper: GIS-techniques are used for a distributed modelling of the regional mean Equilibrium Line Altitude (ELA0) in the European Alps. An empirical relationship between mean summer temperature and annual precipitation at the ELA0 of 14 Alpine glaciers has been obtained, derived from high altitude temperature time series, gridded precipitation data (2 km resolution) and mass balance measurements over the period 1971-1990. Using GIS-techniques and a Digital Elevation Model (DEM; derived from SRTM3 and GTOPO30 data) the Alpine ELA0s for this period are modelled. Unlike other studies on Alpine ELAs or distributed mass balance models, this approach allows for computation of the regional ELA0s over the entire Alps at high horizontal resolution (100 m), using a minimum of data input (DEM, temperature and precipitation data).
ALP-IMP-plan-2-14	peer reviewed journal	3rd project year	**6**, 1	P-T-ELA0 Application Paper: The emp. relationship between precipitation and temperature at the glacier ELA will be used to reconstruct the Alpine precipitation pattern around 1850 from temperature data and glacier ELAs.
ALP-IMP-plan-2-15	peer reviewed journal	3rd project year	**6**	World Glacier Monitoring Service (WGMS) database revision and expansion.
ALP-IMP-plan-2-16	peer reviewed journal (planned for IJC)	2005	**1**, 2, 5 plus all corresponding instrumental project partners	HISTALP – **H**istorical **I**nstrumental **S**urface Climatological **T**ime Series of the **ALP**ine Region (a comprehensive description of the instrumental database in the Greater Alpine Region, to be used as basic reference for HISTALP data users). The paper has just been started by ZAMG (coordinator: Inge) CRU comment: we will contribute in the 'Introduction'. It is not clear what we are asked to do for the 'Data' section (as noted in the Inge's e-mail: 'high resolution: CRU Hompage?'
ALP-IMP-plan-2-17	peer reviewed journal	3rd project year	**1**, 3, 5	A barometric thermometer measuring 125 years air column temperature of the lower 3kms of the Alpine troposphere. (already discussed with ISAC-UNIML, REMO input from GKSS would be welcome, please GKSS comment GKSS-comment: OK, with contributions of REMO-temperatures, relative topographies,…
ALP-IMP-plan-2-18	peer reviewed journal	3rd project year	**1**, 2, 3, 5	Sunshine and cloudiness variability in the GAR for the past 50, 100, 200 years (analysis of the new "actinic" time series in the GAR checked against REMO results and discussed against the background of global climate - e.g. the new CRU-cloudiness gridded dataset,…?). we agree to participate. Data availability and quality will determine the objectives/extent of this study. ISAC-UNIMIL comment GKSS-comment: OK,
ALP-IMP-plan-2-19	peer reviewed journal	3rd project year	**2**, 1, 3, 5	The influence of circulation on multiple climate variability in the Greater Alpine Region. ("The" basic paper using all HISTALP-climate elements (temp, precip, sun, clouds, vapour pressure, relative humidity) and several methods to describe circulation (from NAO to evt. new indices derived from the new HISTALP air pressure fields) in the region and its potential to explain the "remaining residuals" (after subtracting the continental to global background). CRU comment: influence of circulation on GAR climate variability) is in progress. Temp, Precip & MSLP fields are analyzed at regional and hemispheric scales. The incorporation of sun, clouds, vapour pressure & relative humidity parameters will depend on data quality and length of record, ISAC-UNIMIL comment GKSS-comment: needs coordination with ALP-IMP-plan-2-26
ALP-IMP-plan-2-20	peer reviewed journal	3rd project year	1, ?	Long-term variability of the thermo-hygric climatic component in the northern and high elevation GAR (a first description of the HISTALP vapour pressure and relative humidity series for the GAR subregions NW, NE and HIGH) anybody interested in joining us?

	ALP-IMP PUBLICATION LIST			PLANs OF NEAR FUTURE PUBLICATIONS Version June 2005
ALP-IMP ref-ID	type	date	authors from partners (lead partner bold)	contents
ALP-IMP-plan-2-21	peer reviewed journal	2005	**1**, 5 plus a greater number of contributers	A high resolution monthly temperature climatology of the Greater Alpine Region (just going on, 1700stations collected, partly quality checked and some first analysis drafts done (see ALP-IMP-n-rev-3-3)
ALP-IMP-plan-2-22	peer reviewed journal	3rd project year	**2**, 1, 5	Construction of a high resolution gridded temperature dataset for the Greater Alpine Region 1760-2003 (using the HR-temperature climatology plus the long-term anomaly fields, CRU-comment: the high-resolution climatology (ALP-IMP-plan-2-21) will be needed. Findings from studies on temperature variability will assist on the development of a proper technique for gridding the temperature field. The ALP-IMP-plan-2-22 (temperature and precipitation variability during 19-20th Centuries) will have some common elements with the ALP-IMP-plan-2-19. Interchange of individual results will help both studies. Therefore we will participate in this study too. and GKSS comment) GKSS comment: not to be included here, but see comment in ALP-IMP-plan-2-27
ALP-IMP-plan-2-23	diploma thesis, Uni-Vienna	3rd project year	1	110 years snow variability in the Eastern Alps (Anita's diploma thesis)
ALP-IMP-plan-2-24	peer reviewed journal	3rd project year	**1**, 2	Climate variability changes of GAR temperature and precipitation in the past two centuries (anybody interested in joining?) CRU: The ALP-IMP-plan-2-2$ (temperature and precipitation variability during 19-20th Centuries) will have some common elements with the ALP-IMP-plan-2-19. Interchange of individual results will help both studies. Therefore we will participate in this study too.
ALP-IMP-plan-2-25	peer reviewed journal	3rd project year	**3**, 1, ETHZ (C.Frei)	Skill of simulations with different resolution for the Alpine climate from 1958 - present: - comparison of ERA40, REMO 1/6 deg, REMO 1/2 deg with observations on monthly and daily time scales - validation of simulated precipitation based on ETHZ precip data on REMO grid with elevation correction (Helfried Scheifinger) - validation of simulated temperature, maybe also of pressure, based on HISTALP and CRU data (Kerstin Proemmel)
ALP-IMP-plan-2-26	peer reviewed journal	3rd project year	**3**, 1	Alpine mesoscale circulation patterns derived from REMO and ERA40 and their relation to local temperature and precipitation: - determination of GAR mesoscale circulation patterns in terms of EOFs (WP7 deliverable) - analysis of effect of topography (how do the different representations of the topography in the different models alter the EOFs) (WP7 deliverable) - relation of temporal variability in the intensity of circulation patterns to temperature and precip variability, including cross-validation/stability analysis. (WP7 deliverable) - analogous studies for observations.
ALP-IMP-plan-2-27	peer reviewed journal	3rd project year	**3**, 1	Four-dimensional temperature and/or circulation reconstruction for the GAR for the last 200 years based on the HISTALP dataset for the GAR for the last 200 years and REMO-based predictands: - reconstruction based on HISTALP dataset as predictors and REMO mesoscale temperature and circulation patterns on multiple vertical levels as predictands (WP7 deliverable) note: This reconstruction can only be done if REMO has sufficient skill, which is currently being determined. additional GKSS-remark: comparative but no collision potential of ALP-IMP-2-27 and ALP-IMP-2-22
ALP-IMP-plan-2-28	peer reviewed journal	3rd project year	**4**, 6, 1,7	Significance of isotope records in Alpine ice cores in terms of recent warming trends. Encompass multi-site ice core data combined with evidences from englacial temperature, isotope precipitation networks and instrumental time series
ALP-IMP-plan-2-29	peer reviewed journal	3rd project year	**7**,**4**,1,6 optional 3	Basic interpretation of (recent) isotope changes in high Alpine precipitation and ice cores based on modelling and obsevational evidences. a) the question of isotope sensitivity from atmospheric physics view b) the question of realistic transfer functions from precipitation to ice core archive
ALP-IMP-plan-2-30	peer reviewed journal	3rd project year	**1, 6?**	Mass balance reconstruction for the Alps based on statistical glacier mass balance model and the HISTALP monthly precipitation and air temperature series (absolute values with high resolution in space) as well as series of snow precipitation derived from precipitation and temperature series. Comparison with glacier front position series to better understand the climatic causes of the period of LIA maximum and vanishing of glaciers since then.
ALP-IMP-plan-2-31	peer reviewed journal	3rd project year	corr.partner Arnold	The impact of climate on the recent explosive population increase of wild boars in Europe versus other potential forcing factors
ALP-IMP-plan-2-32	proceedings Eurodendro 2005, Viterbo	Sep.05	**10**	Holocene tree-line variability in the Kauner valley, central eastern Alps
ALP-IMP-plan-2-33	peer reviewed journal	3rd project year	**10, 1, 2**	Reconstruction of the temperature variability of the last 2000 years, based on dendroclimatological analysis of Pinus cembra tree-ring data from the central eastern Alps and by using the new Alpine temperature data set
ALP-IMP-plan-2-34	peer reviewed journal	3rd project year	**10, 1?**	Analysis of a multi-species tree-ring width data set, mainly historical samples from the eastern Alps, establishement of a record of synchronous extreme growth events, analysis of climatic forcing
ALP-IMP-plan-2-35	non refereed journal, submitted	3rd project year	**10, and others**	Zur Geschichte der Gletscher der nördlichen Ortlergruppe im 19. und 20. Jh.
ALP-IMP-plan-2-36	non refereed journal, submitted	3rd project year	**10**	Zur Bauentwicklung der Gebäude der Obermairalm am Fuchsberg, Fraktion Katharinaberg, Gemeinde Naturns, Südtirol. Ergebnisse dendrochronologischer Analysen.
ALP-IMP-plan-2-37	non refereed journal	3rd project year	**10**	Zur Bauentwicklung der Gebäude des Oberniederhofes, Unser Frau / Schnals, Südtirol. Ergebnisse dendrochronologischer Analysen