PROCEEDINGS

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TTL

technik tourismus landschaft

TU WIEN

TTL Conference

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Vienna University of Technology

Contents

1. Introduction to TTL

Landscape under Snow

As a first introduction and welcome to this conference these words will, I hope, serve to put the role of this department into the context of the event.
That landscape architecture represents a relatively small subject area within Vienna University of Technology is perhaps true, but that fact that small is not only beautiful, but can also be rich diverse and lively, is borne witness to by the initiation of this new interdisciplinary research initiative 'Technology Tourism Landscape' of which this first conference focussing on 'Snow' represents an international high-profile launch event.
What has snow to do with landscape architecture? In the normal case of events, a fall of snow obscures the landscape, but this conference is perhaps an opportunity to achieve the opposite and to cast some light on the discipline in its wider context, of which snow is but a part.
'Landscape architecture' is the generic title of the academic discipline and professional activity that is concerned with the conservation and development of landscape resources and values for the benefit of current and future generations through planning, design and management. The landscape is also where we all live and where a considerable proportion of mankind's technological innovations take place.
The name of this department reflects the breadth of fields covered by the discipline as a whole, from *'Gartenkunst'* – the history and conservation of parks and gardens at one 'extreme' to *'Landschaftsplanung'* concerned amongst other things with the issues of the landscape at the regional scale at the other – where here in Austria in particular snow plays such an important role. Between these two extremes, this department also focuses on contemporary landscape design, urban open space planning and landscape planning at the local level. This conference, and the development of the TTL initiative is taking place under the auspices of our larger scale focus of 'Regional Landscape Analysis' for which Dr. Meinhard Breiling, initiator of this conference is responsible within the department.
That the awareness of the policy importance of the landscape at the European level is growing has recently been clearly demonstrated by the coming into force in March of this year of the European Landscape Convention, the first international convention to be concerned with the landscape as a whole and the planning for its protection.
While the landscape and is planning and management is becoming a larger issue at the European level, it is still a relatively modest part of Vienna University of Technology. The sensible strategy for small but dynamic groups within larger organisations is to seek to establish larger networks and partnerships, which as a whole are able to have a greater impact that the sum of their parts, and through which smaller units can 'punch above their weight' within a wider context. This is, of course, part of what TTL is about.
But, such a strategy has also been behind the establishment of the LE:NOTRE Project by this department, a Thematic Network in Landscape Architecture, which is just entering its third year of funding by the European Union and now involves over 100 academic and professional institutions Europe-wide. This is the only thematic network of its type to be coordinated from Austria, and it has generated considerable interest, not just across Europe, but as far afield as the USA and China. The TTL Network is therefore in good company in this department.
So I would like to take this opportunity to welcome all those contributing to the conference and to this publication, both current colleagues and new collaborators, in the conviction that this new partnership will represent an important new initiative for all of us, and I am sure that this early fall of snow will throw the landscape into sharper relief and will provide an important inspiration for this planned new research focus of Technology, Tourism and Landscape.

Prof. Richard Stiles,
Head of Department "Urban Design and Landscape Architecture"
Vienna University of Technology

2. Short Presentations

Short Presentations by:

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Bacher, Michael/Hübl, Hannes - Vienna University of Natural Resources and Applied Life Sciences - AT
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Breiling, Meinhard - Vienna University of Technology - AT
Charamza, Pavel - Charles University in Prague- CZ
Farnleitner, Andreas/Mach, Robert - Vienna University of Technology - AT
Feilmayr, Wolfgang - Vienna University of Technology - AT
Jansa, Josef - Vienna University of Technology - AT
Kleemayr, Karl - Institute Of Natural Hazards and Alpine Timberline ,Innsbruck - AT
König, Martin – Austrian Bureau for Climate Change
Kostka, Zdeno/Holko, Ladislav - Slovak Academy of Sciences - SK
Krautzer, Bernhard - Federal Reseach Institute for Agriculture in Alpine Regions - AT
Mair, Rudolf - Avalanche Warning Service of the Tyrol - AT
Petrushina, Marina - Moscow State University - RU
Puxbaum, Hans - Vienna University of Technology - AT
Reichelt, Wolfgang - Provincial Government Carinthia / Regional Planning - AT
Rubinstein, Konstantin - Hydrometeorological Centre of Russia, Moscow - RU
Scheibl, Horst - Provincial Government Salzburg, Regional Planning - AT
Shmakin, Andrej - Russian Academy of Sciences - RU
Sokratov, Sergey - Swiss Federal Institute for Snow and Avalanche Research Davos - CH
Stiles, Richard - Vienna University of Technology - AT
Stolba, Petra - Austrian Federal Economic Chamber - AT
Svardal, Karl/Kroiss, Helmut - Vienna University of Technology - AT
Zins, Andreas - Vienna University of Economics and Business Administration - AT

3. Ammermann, Ansgar and Leitner, Wolfgang

IG Fahrrad Vienna / Vienna University of Technology - AT

"Bicycle Technology for Winter Time"

Bicycles exists in higher numbers than cars and have a big potential in future for enviromental friendly transport and for tourism.

The advantage of the bicycle is it's versatility. The use of the bike is possible throughout the year. Coldness and slippery ground is not the main reason for not using the bicycle in wintertime. The fear of being killed by cars. is justifiably higher. The reduction of the murderous car traffic is an political aim. The following described technology will be used more in future as car traffic will be reduced. Traffic conditions for cyclists should become much more safer.

All technologies for, reliable winter bicycles are ready available, but from different ends of the cycle industry.

Wide rims to flattening the tire profile for use on snow were first developed in Alaska. These rims led to super fat tires and were later copied for downhill racing. **Studded tires** and special tires for rain are available from different manufactures.
Completely enclosed **hubgears** have up to 14 troublefree gears and can be combined with enclosed chains. Comparison of production costs together with the costs for maintenance shows clearly that the use of a hub-geared bicycles is cheaper than a chain geared bicycle.

Windsreens for wether protection were first tested 1960 by Alex Moulton in England. He developed the first modern bicycle with suspension front and rear for universal use because the suez crisis caused oil shortage in Great Britain. About 25 years later prices for car fuel in the USA exploded which again led to windscreens for bicyles. Glen Brown founded Zipp-Design for the marketing of screens made from clear polycarbonat. Mountain-bikes with long travel **suspension** front and rear enables the riders to ride under conditions were they had to walk some years ago. The main problem with the current suspensions is expensive maintenance.

Winter-cyclists are no new species. The classic use of a racing bike included a second rear wheel without freewheel for winter training. The fixed gear provides direct contact between the rider and the slippery ground. With low gearing the winter bike was used mainly for endurance-training. The global warming with reduced snow in the alps will increase the popularity of cycling in all aspects. The impact on tourism and landscape will be enormous.
The internal combustion engine as a power source for human transport is no longer acceptable.

Ammermann, Ansgar and Leitner, Wolfgang

4. Arnberger, Arne and Brandenburg, Christiane

Vienna University of Natural Resources and Applied Life Sciences - AT

"Leisure and Recreation Activities in Protected Areas: Monitoring and Modelling Visitor Demands and Visitor Flows"

1 The need for monitoring and management of visitors in protected areas

Protected areas such as national parks are managed mainly for ecosystem protection and provide recreational and educational opportunities, all of which must be environmentally and culturally compatible (IUCN & EUROPARC 2000). In this challenging role, comprehensive park management generally requires application of monitoring processes. This the more, as Europe's protected areas have become a focus for people seeking rural holidays, outdoor activities and quality tourism opportunities. These areas will witness increasing pressure from tourists and day visitors. Quantifying visitor numbers and their distribution in time and space as well as the identification the behaviours and demands of visitors is an essential component of visitor impact management in protected areas, in particular for suburban and urban protected areas. Compared to remote national parks with low visitor numbers and a quite homogeneous visitor structure, national parks close to conurbations are faced with an excessive number of users living close to the area and day users from the city resulting in high use loads. User conflicts, crowding perception and use displacement might be prominent issues in such national parks (Arnberger & Brandenburg 2001/2002).

2 Monitoring methods

Over the past decades, numerous techniques and methods have been suggested for the purpose of monitoring visitor flows in recreational areas (Muhar et al. 2002, Hornback & Eagles 1999, Gasvoda 1999, Watson et al. 2000). Managers must decide on the most appropriate observation strategy and most suitable methods for identifying visitor use characteristics such as type and size of user groups, for estimating the total recreational use in an area, or for describing the short- and long-term temporal distribution of use (see Table 1). Consequently, comprehensive knowledge about the many technical and methodological options, their costs, and their respective advantages and disadvantages is fundamental for area management.

			visitor numbers	direction of motion	routes	distribution within area	group size	visitor charac- teristics (age, sex)	visitor characteristics (origin, expectations etc.)	behaviour
direct methods	interviews	oral interviews			x	x	x	x	x	x
		written interviews			x	x	x	x	x	x
	direct observation	roaming observers	(x)	(x)	(x)	(x)	(x)	(x)		(x)
		fixed counting stations	x	x		x	x	x		x
	indirect observation	automatic cameras	x	x		x	x	x		x
		time-lapse video	x	x		x	x	x		x
		arial, satellite imagery	(x)	(x)	(x)	(x)	(x)			
	counting of access permits	tickets sold	x							
		permits issued	x				x			
	counting devices	turnstiles	x	(x)			(x)			
		photoelectric counters	x	(x)			(x)			
		pressure sensitive mats	x	(x)						
		pneumatic tubes	x	(x)						
		inductive loop sensors	(x)	(x)						
	self-registration	trail registers	x	x	(x)		x			
		summit books	x	x	x		x			
		hut registers	x	x	x		x			
indirect methods	mapping of traces of use	garbage	x			(x)				
		trail deterioration	x			(x)				
		damage to vegetation	(x)			(x)				
		footprints	x	(x)		(x)				
		sandbed	x	(x)						

Tab. 1: Techniques for visitor monitoring and their fields of application (Muhar et al. 2002)

3 Long-term monitoring methods

Long-term collection of visitor count data in parks is a prerequisite for sound decision making. However, only few monitoring approaches allow a long-term monitoring of winter and summer recreation activities in an efficient manner. Video monitoring and automatic counters provide such information.

Time-lapse video monitoring (Arnberger et al. acc., Arnberger & Hinterberger 2003, Muhar et al. 2002) can be used to monitor different recreational activities over a longer period, daily from dawn to dusk. Each monitoring system consists of a weatherproof black-and-white video camera with integrated heating and a time-lapse video recorder. Consequently, this method can be used for year-round monitoring. The time-lapse video recorders capture single images at fixed intervals of 1.6 seconds over the entire day. With the type of video camera installed and its specific setting, it is impossible to identify individuals in the video images, ensuring anonymity of the subjects. The following data can be captured from the video tapes:

- Temporal distribution of the visitors (number of visitors over the entire year, by month or by season; daily visits, daily visits by season, peak days, minimum and average number of visitors per day).
- Spatial distribution of visitors (number of visitors at various entrance points, choice of direction at the intersection of paths etc.)
- Identification and quantification of user groups and their spatio-temporal distribution
- Recording and quantification of visitor behaviour (for example dogs not kept on leash etc.)

Automatic counters such as mechanical counters, seismic sensors, pressure pads, active light beam counters, passive IR sensors etc. provide use levels data over the entire day and over a longer period with low maintenance efforts. However, data about different recreational activities or visitor behaviour such as keeping dogs off leash cannot be recorded via such devices. For automatic counters a calibration process is necessary, as counts may be biased by wildlife, swaying grass and moving leaves, or curious visitors tampering with the device, in addition to properly passing visitors. Miscounts from a passive infra-red counter can be associated with visitors walking past in tight groups or can also be caused by certain colours of user clothing (Gasvoda 1999). Pressure pads did not allow an unbiased registration of winter activities due to snow cover and under freezing conditions.

4 Modelling visitor flows

Forecasts about visitor behaviour and visitor attendance levels allow a proactive visitor management. Long-term video monitoring data for example enables the modelling of visitor attendance levels by user types depending on the weather or the quantification of use displacement behaviour due to intolerable social conditions in an area.

Modelling visitor flows depending on the weather

Weather is one of the major factors that influence different outdoor leisure and recreational behaviour in a different way, and the relationship between weather and human leisure activities has been the subject of research for several decades. (De Freitas 1999, etc.). An additional factor that modifies visitor attendance levels is the day of the week, and especially whether it is a holiday or a working day (Brandenburg 2001).
Ploner and Brandenburg (2003) developed prognostic models of use levels as a function of the daily number of visitors and external factors such as weather and day of the week. The day of the week has the greatest influence upon the total number of visitors as well as for user groups (Table 1). Temperature as a meteorological feature appears in the models indirectly through the scale indices of thermal comfort and the development of the temperature during the day. The Physiological Equivalent Temperature (PET), defined as the air temperature at which in a typical indoor setting the heat budget of the human body is balanced with the same core and skin temperature as under the complex outdoor conditions to be assessed, has a major impact upon the number of visitors per day, in particular on cyclists and pedestrians. The usage patterns of joggers and dog owners were more complex to model, as they apparently are less dependent on weather related factors.

Choice models

Stated choice analysis has been applied to study public preferences concerning a range of recreation-related issues such as visitor preferences for wilderness management issues (Lawson & Manning 2002), tourism destination choice (Haider & Ewing 1990), and beach preferences of rafters (Stewart et al. 2003). One strength of choice models lies in their ability to predict how the public will respond to various policy and management alternatives, including arrangements of

resources, quality of visitor experiences, facilities, services and/or regulations that may not currently exist. In stated preference and stated choice models, alternatives are defined as combinations of attributes, and each set is evaluated as a whole (Louviere et al. 2000).
Such a multi-variate trade-off approach was applied to establish crowding norms for the main trail section of a recreation area in Vienna, Austria (Arnberger 2003). The stated choice model, combined with a variation of a conjoint approach, consisted of digitally calibrated images systematically displaying combinations of levels of crowding with different mixes of user types, group sizes, compliance behaviour, direction of movement, and placement within the image. Preferences were assessed by asking the visitors to choose the most and the least preferred scenario; the crowding norm was elicited by asking if each one of the chosen scenarios was so unacceptable that respondents would shift their use. The resulting model predicts that under specific situations the tolerance norms of a significant proportion of respondents are violated resulting in use displacement behaviour. The predictive capacity allows managers to explore the likely effects of several management options integrating recreation use data gained by video monitoring.

Figure 1: Example of a choice set with four digitally calibrated images– each image depicts different levels of six social setting attributes

Agent-based-modells

New advancements in recreation management using new technology that couples Geographic Information Systems (GIS) with intelligent agents to simulate recreation behaviour in real world settings. An autonomous agent is a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to affect what it senses (and acts on) in the future. Recreation behaviour simulators (Itami et al. 2002, Gimblett et al. 2002) enable recreation managers to explore the consequences of change to any one or more variables by generating statistics during the simulation. Based on the simulation results managers are able to identify points of over crowding, bottlenecks in circulation systems, and conflicts between different user groups etc.

5 Conclusion

Data on recreational use are essential for selecting appropriate visitor and area management strategies, for determining the effects of recreational activities on the fauna and flora, for monitoring visitor compliance with use regulations, for the scheduling of maintenance tasks, for allocating human and financial resources, and for developing appropriate marketing strategies to specific user groups (Cessford & Muhar 2003). The more reliable the data obtained from visitor counting techniques and monitoring systems are, the better are the resulting ecological and visitor management strategies.

Bicycles exists in higher numbers than cars and have a big potential in future for enviromental friendly transport and for tourism.

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"Snow Conditions in Austria - Basic Studies and Urgent Needs for Further Research"

INTRODUCTION:

Beside its meteorological and climatological relevance, the climate element snow is of highest practical and economic importance for Austria. On the one hand snow contains a certain potential of danger (e.g. avalanches, traffic accidents, snow load damages, etc.) – but on the other hand it is one of the natural resources for winter tourism in Austria. Thus, the knowledge about the regional snow distribution, its natural variability and its future prospective due to an enhanced green house forcing (sensitivity) is an indispensable necessity for the economic future planning.

SPATIAL SNOW DISTRIBUTION IN AUSTRIA

For a number of planning aspects information about the recent average snow conditions (CLINO 1961-1990 defined by WMO) and their extremes during this period is available. As appropriate examples for Austria the digital Climate Atlas of Austria ÖKLIM (Auer et al. 2001) or maps included in the Hydrographical Atlas of Austria (Schöner and Mohnl, 2003) may be mentioned. In addition a number of regional studies include spatial descriptions of various snow parameters (e.g. Auer et al. 2002, Umweltinstitut des Landes Vorarlberg, 2001). The latter ones as well as ÖKLIM contain snow information in form of digital maps, tables, figures and textual contributions.

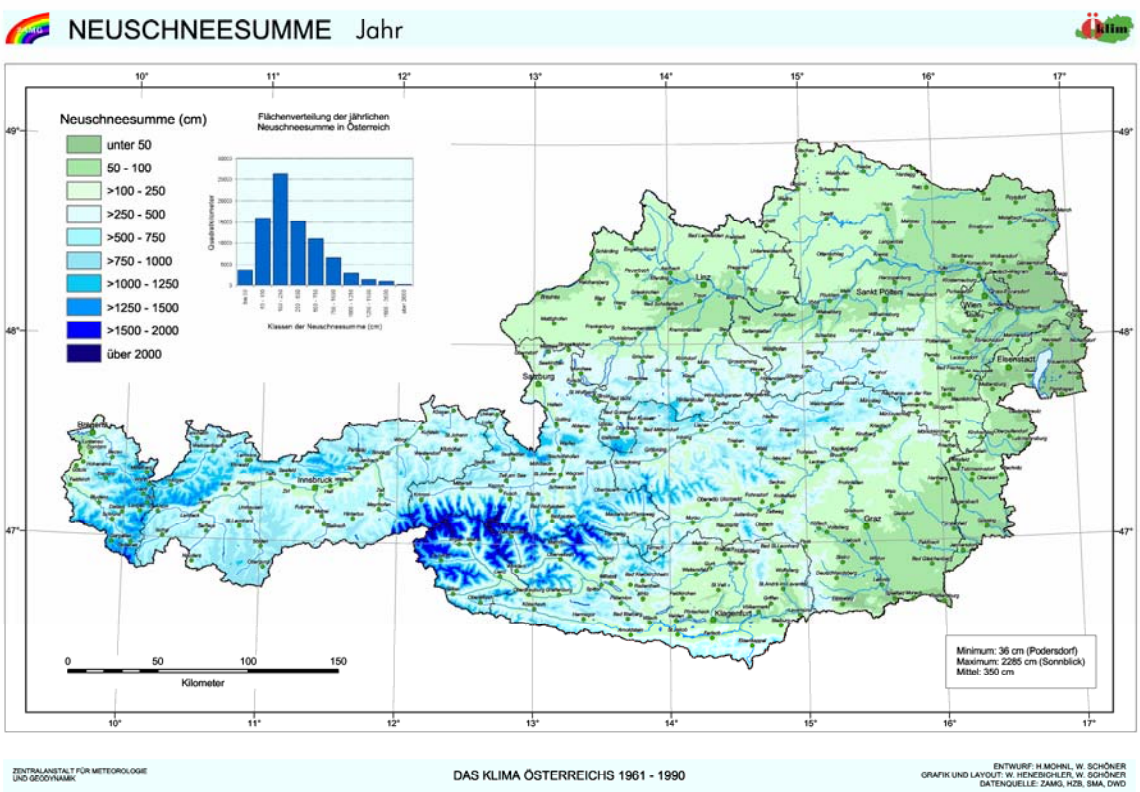

Figure 1: Map of the annual sum of fresh fallen snow in Austria for the period 1961-1990, data source ÖKLIM 2001.

Besides the map presented here the following snow parameters are available as digital maps for Austria: mean duration of snow cover, mean duration of winter cover, mean maximum of snow depth.

SNOW DATA- availabilty and quality

Snow measurements in Austria extend back to the end of the 19th century, mainly conducted by the Austrian Hydrographical Service (HZB) and later on by the Central Institute for Meteorology and Geodynamics (ZAMG). Unfortunately, only a minor part of the existing treasure of snow data is available for scientific studies, mainly as printed sources like yearbooks of HZB and ZAMG or the digitised more recent data. But, the bigger part of the existing material has been drowsing in archives for many years waiting to be excavated. The WMO (World Meteorological Organisation) has initiated the Programme DARE (Data Rescue, WMO 2004). Data Rescue is the ongoing process of 1.) preserving all data at risk of being lost due to deterioration of the medium and 2.) digitising current and past data into computer compatible form for easy access. This programme is strongly focused on the poor countries in the developing world, but what about Austria. How save are our archive data? Most of the snow data existing before 1961 have not been digitised yet, and there are only few centennial series available. However, the quality and homogeneity of these series is questionable. Unfortunately, the possibilities to apply quality and homogeneity checks to the data are limited, because the network of historical data is too sparse due the spatial variability of snow depth measurements. Therefore, opposite to other Alpine countries, a recent detailed study (e.g. for Switzerland: Laternser et al. 2003) of the natural snow variability is missing for Austria. The most current investigation on the centennial variability of snows refers to Mohnl, 1994 with about 50 single station results.

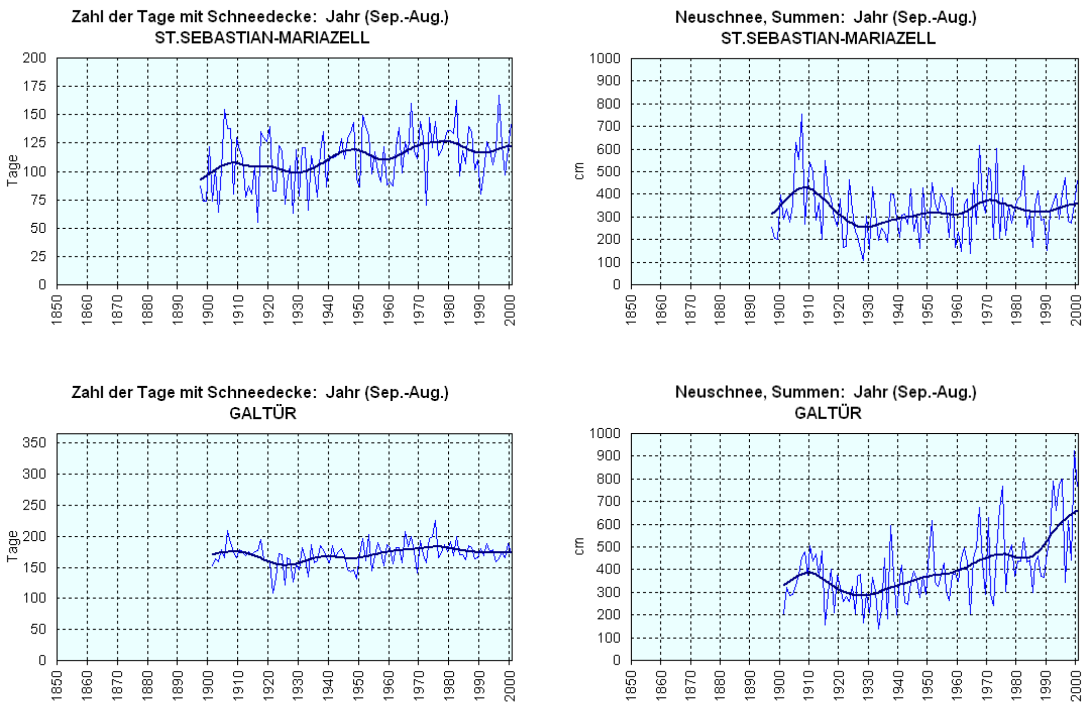

Figure 2: Time series of snow cover duration and annual sum of new snow for two locations in Austria (data source: ÖKLIM 2001)

WHO ELSE NEEDS SNOW DATA?

Climatologists and similar groups are not the only ones interested in snow data. Just, snow is of greatest economical and social importance for an Alpine country such as Austria. Out of a greater number of interested parties, profiting in a different way of years "rich of snow" and "poor of snow", only some examples can be mentioned here:

Much snow: traffic and transport, avalanches, short vegetation period, damages by snow load

Much snow: hydro-power (water storage), agriculture (frost protection)-winter tourism

FUTURE Snow and Winter Tourism

We pick out the sector of winter tourism. Especially the western part of Austria profits from winter season tourism and from double season tourism. Hantel et al. (2000) have studied the sensitivity of snow cover duration in Austria due to a prospected increase of the European mean temperature. They found out that in the maximum sensitive regions of Austria (575 m in winter, 1373 m in spring) the lengths of the snow cover period may be reduced by about four weeks in winter and six weeks in spring by a European temperature rise of 1 K. Snow cannons – in the meantime the normal but pitiable sight of our ski tracks - are only partly qualified to balance the snow deficiencies. Artificial snow production is not free of costs, and it is based on the availability of water and negative temperatures. Thus, the additional question concerning the sensitivity of frost occurrence due temperature increase has to be asked. Due to an investigation conducted by Auer et al., 2004 we have to take into account a reduction of frost additionally, depending on season and altitude. It turned out that among the investigated territory there is no region in Austria that will remain unaffected, thus limiting and shortening the possibilities of artificial snow production. The problem snow is linked to the problem frost.

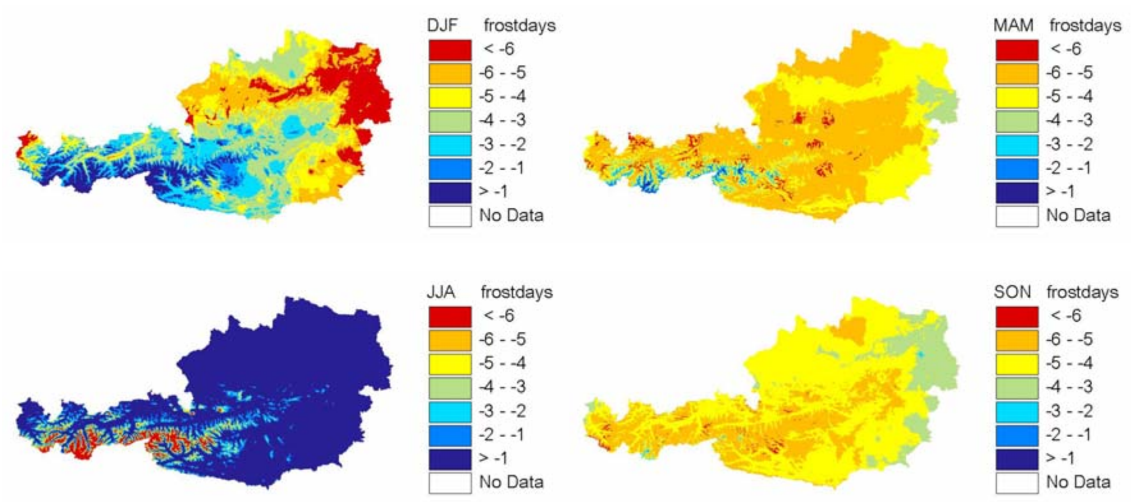

Figure 3: Seasonal sensitivity maps – upper row: winter (DJF) and spring (MAM); lower row: summer (JJA) and fall (SON) in Austria. Blue values indicate areas, which are not sensitive to temperature increases of 1°C (i.e. changes in frost days below 1 day); *Red* areas indicate high sensitivity (i.e. changes in frost days of more than 6 days).

OUTLOOK

How will the climate develop in Austria on the regional level and how will its impact be on natural systems like snow? To understand the complexity of the future connection between temperature and the hydrological cycle, we first have to know as much as possible about the natural variability (temporal and spatial) of the snow conditions in Austria. As a first step all data deficiencies have to be removed as soon as possible by creating a centennial snow database with daily resolution. The series have to be checked and improved by quality and homogeneity procedures. The analyses of the historical snow series should include the understanding of horizontal and vertical variability patterns, trend analyses and circulation studies in the snow variability. This knowledge would be the optimal basis for further socio-economic studies of winter tourism, studies of the danger potential of avalanches and landslides in the Alpine environment as well as studies of the hydropower potential.

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„Schnee - Auswirkungen auf die Raumplanung in Alpinen Siedlungsgebieten Lawinen und Gefahrenzonenplanung“

Einführung

Naturereignisse, wie Hochwasser oder Lawinen, ziehen immer die Aufmerksamkeit der Bevölkerung auf sich. Ein subjektives Empfinden über die Zunahme zerstörender Naturereignisse ist wahrscheinlich auch auf die gesteigerte Sensibilität zurückzuführen. Während der Wintermonate zählen besonders Lawinen zu einer bedeutenden Gefahr in Österreichs Alpentälern. Schadbringende Großereignisse sind hier noch in lebhafter Erinnerung. Der Umgang mit Naturgefahren in alpinen Siedlungsräumen und Möglichkeiten der vorausschauenden Planung werden im Folgenden vorgestellt.

Raumplanung

Zahlreiche schadbringende Naturereignisse in Österreich in den vergangenen Jahren haben vermehrt zu Diskussionen geführt, inwieweit die Raumplanung ihrer Aufgabe nachgekommen ist, vorausschauend und planmäßig an der Gestaltung der Siedlungsräume mitzuarbeiten. Die einzelnen Bundesländer in Österreich regeln in ihren Raumordnungsgesetzen den Umgang mit Naturgefahren unterschiedlich: Es stehen neun verschiedene gesetzliche Grundlagen für die Raumordnung im Allgemeinen und für den Umgang mit Naturgewalten in der räumlichen Planung im Besonderen zur Verfügung.

Die zentralen Anliegen der Raumordnung werden durch Raumordnungsgrundsätze und Raumordnungsziele bestimmt. Die Umsetzung dieser Ziele erfolgt über ein hierarchisches Planungsinstrumentarium, das unterschiedliche Raumpläne auf überörtlicher Ebene umfasst und in weitere Folge die örtliche Raumplanung bindet.

Maßnahmen in Bezug auf die Gefährdung durch Naturgefahren, mit denen die Ziele der Raumordnung erreicht werden, unterteilt man grundsätzlich in drei Gruppen:

* Maßnahmen, die den Ursachen der Naturgefahren entgegen wirken. (technische Maßnahmen, biologische Maßnahmen)
* Maßnahmen, die die Wirkung der Naturgefahren mindern oder ausschalten. (Objektschutz, aber auch Lawinenschutzbauten wie Dämme oder Bremsverbauungen)
* Maßnahmen, die eine den Naturgefahren angepasste Raumnutzung zum Ziel haben. (Ausweisung gefährdeter Bereiche in Siedlungsgebieten)

Als Steuerungsmittel im Umgang mit Gefährdungsbereichen sieht das Raumordnungsrecht vor allem Nutzungsbeschränkungen und Widmungsverbote vor. Aktive Maßnahmen, etwa das Vorschreiben von Schutzmaßnahmen zur Beseitigung der Gefährdung oder direkte Maßnahmen, die bestehende Bauten in Gefährdungsgebieten betreffen, sind nicht vorgesehen.

Gefahrenzonenplan

Die seit jeher bestehenden Bemühungen, bestimmte Nutzungsarten, insbesondere die Baulandnutzung, von gefährdeten Gebieten fernzuhalten, wird in Österreich mit dem Forstgesetz 1975 und der Gefahrenzonenplanverordnung 1976 auf eine einheitliche rechtliche Basis gestellt. Dies betrifft jene Flächen, die durch Wildbäche oder Lawinen bedroht sind. Auslöser waren die

Naturkatastrophen Mitte der sechziger Jahre, die das Fehlverhalten bei Bautätigkeiten in gefährdeten Gebieten aufzeigten.

Gefahrenzonenpläne zählen zu den umfassendsten und fundiertesten Grundlagen der Raumplanung, haben aber keinen Verordnungscharakter. Sie sind primär nur für den forsttechnischen Dienst im Rahmen des Sachverständigendienstes und der Projektierungstätigkeit bindend. Bei Gefahrenzonenplänen handelt es sich vielmehr um qualifizierte Gutachten. In den meisten Bundesländern bestehen aber gesetzliche Regelungen bzw. Erlässe, die gewährleisten sollen, dass Gefahrenzonenpläne in Bau- und Raumordnungsverfahren berücksichtigt werden.

Ausscheidung der Gefahrenzonen

Gefahrenzonenpläne enthalten die Einzugsgebiete von Wildbächen und Lawinen, Gefahrenkarten Gefahrenzonen, Vorbehaltsbereiche und Hinweisbereiche. Von zentraler Bedeutung sind rote und gelbe Gefahrenzonen und der daraus ableitbare differenzierte Gefährdungsgrad bei der Beurteilung von planerischen Maßnahmen.

* Rote Zone: Sie umfasst Flächen, die derart gefährdet sind, dass ihre ständige Benützung für Siedlungs- und Verkehrszwecke nicht oder nur mit unverhältnismäßig hohem Aufwand möglich ist. Die für die Abgrenzung maßgeblichen Lawinendrücke sind größer als 10 kN/m^2. Ablagerungen von mehr als 1,5 m bedingen in der Gefahrenzonenplanung ebenfalls eine Rote Zone.

* Gelbe Zone: Sie umfasst Flächen, die derart gefährdet sind, dass ihre ständige Benützung für Siedlungs- und Verkehrszwecke beeinträchtigt ist. Die für die Abgrenzung maßgeblichen Lawinendrücke liegen zwischen 1kN/m^2 und 10kN/m^2. Als Grenze der Ablagerungshöhe wird ein Bereich von 0,2 m bis 1,5 m angegeben.

Methodik

Im Sinne einer vorausschauenden Planung werden nicht nur erfahrungsgemäß häufige, also in Abständen von wenigen Jahren wiederkehrende Ereignisse zur Beurteilung des Gefährdungsgrades herangezogen, sondern auch jene mit einer Jährlichkeit, die bedeutend über der durchschnittlichen Lebenserwartung des Menschen liegt. Entscheidend für die Erstellung eines Gefahrenzonenplanes für Lawinen gefährdete Bereiche sind jene Ereignisse mit einer Wiederkehrdauer von 150 Jahren.

Die Grenzen für die rote und gelbe Zone werden bei der Erstellung des Gefahrenzonenplans nach den neuesten wissenschaftlichen Erkenntnissen ermittelt. Die Erfahrung der Experten in der Ausscheidung von Gefahrenzonen wird unterstützt durch verschiedene Modellansätze, welche den Prozess der Lawine bestmöglich beschreiben.

Solche Ansätze, die auch vom Forsttechnischen Dienst der Wildbach- und Lawinenverbauung in Österreich verwendet werden, sind z.B. die Lawinensimulationsmodelle ELBA und SAMOS.

Ablagerungshöhen und Ausdehnungsgrenzen der abgelagerten Schneemassen sowie Fließdrücke sind jene Parameter, die diese Lawinensimulationsmodelle als Entscheidungshilfe für die Gefahrenzonenplanung liefern. Stumme Zeugen und Chronikberichte vergangener Ereignisse dienen zur Evaluierung dieser Ergebnisse. Die endgültige Entscheidung über die räumliche Lage der Zonengrenzen wird vom Experten vor Ort getroffen.

Parameter

Modelle zur Simulation einer Lawine versuchen den komplexen Prozess mit Hilfe einfacher Annäherungen bestmöglich nachzubilden und die Ergebnisse zu visualisieren. Als Grundlage für eine realitätsnahe Simulation einer Lawine wird ein digitales Modell der Geländeoberfläche herangezogen, das z.B. mit Hilfe photogrammetrischer Luftbildauswertung gewonnen werden kann.

Lawinenbezogene Eingangsparameter für eine Simulation sind die Mächtigkeit der Schneedecke im Anbruchsgebiet, Rauhigkeitsparameter und die Dichte des Schnees.

* Anbruchsschneemächtigkeit: Die maßgebliche Schneehöhe für das Bemessungsereignis ist die 3-Tages Neuschneesumme im Anbruchsgebiet. Diese wird nach einer Korrektur für die Neigung, die Einwehung und gegebenenfalls für die Höhenlage zur Lawinensimulation herangezogen. Über die Definition einer Fläche für das Anbruchsgebiet wird das Anbruchsvolumen der Lawine bestimmt.

* Rauhigkeitsparameter: Im Simulationsmodell Samos ist die Geländerauhigkeit als Eingangsparameter wählbar. Beim äquivalenten ELBA Modell wird neben der Geländerauhigkeit noch ein geschwindigkeitsabhängiger Reibungswert in die Berechnung mit einbezogen.

* Dichte des Schnees: Bei den hier beschriebenen Modellen gelten als Richtwerte für die Dichte im Anbruchsbereich ein Wert von 200 kg/m³ und für die Fließende Lawine eine Dichte von 300 kg/m³.

Probleme

Die Beschreibung einer Lawine mit computergestützten Methoden liefert Ergebnisse, die stark von der Qualität der verwendeten Eingangsparameter abhängen. Berechnete Auslauflängen und Lawinendrücke variieren schon bei geringfügigen Änderungen dieser Parameter erheblich. Es ist unumgänglich, Simulationen an bereits beobachteten Auslauflängen und Ablagerungshöhen zu kalibrieren. Ein weiteres Potential zur Verbesserung der Simulationsmodelle und damit auch ihrer Ergebnisse beinhaltet die Verbesserung der derzeitig verfügbaren vereinfachten Annahme über das Verhalten fließenden Schnees.

* Abschätzung der Anrissschneehöhe: Die 3-Tages Neuschneesumme im Anbruchgebiet wird als Bemessungsereignis für eine Lawine mit einer Wiederkehrhäufigkeit von 150 Jahren angenommen. Es bleibt die Unsicherheit, ob die gesamte Neuschneesumme im Anbruchgebiet als Lawine abbricht. Weiters stellt sich die Frage, ob der bereits im Anbruchgebiet vorhandene Altschnee auch zur Lawinenmasse hinzuzuzählen ist.

* Stoff- und Fließgesetze: Die den Simulationsmodellen zugrunde liegenden Stoffgesetze zur Beschreibung von Fließlawinen orientieren sich an hydraulischen Modellen oder definieren die Lawine als Schneeblock, in dessen Schwerpunkt alle wirkenden Kräfte angreifen. Ein Konstitutivgesetz fließenden Schnees, welches die Reibung im Inneren der Lawine beschreibt, gibt es noch nicht.

* Rauhigkeitsparameter: Die Geländereibung und die ‚turbulente' Reibung (ELBA) wird in den Modellen entlang der Fließstrecke größtenteils konstant gehalten. Eine Messung der tatsächlichen Werte ist nicht möglich bzw. zu aufwendig.

* Dichte des Schnees: Die beschriebenen Lawinenmodelle können eine Dichteänderung entlang des Lawinenpfades noch nicht berücksichtigen. Derzeit beschränken sich die Experten auf die Definition einer konstanten Anbruchsdichte und einer entlang des Lawinenpfades konstanten Fließdichte.

Ausblick

Die Verfasser von Gefahrenzonenplänen in Lawinen gefährdeten Gebieten wünschen sich zuverlässige und anwenderfreundliche Hilfsmittel zur Abgrenzung der Gefahrenzonen. Simulationsmodelle können durch die Erarbeitung und Implementierung von Gesetzmäßigkeiten in Bezug auf das Verhalten fließenden Schnees erheblich verbessert werden. Eine solche Verbesserung impliziert nicht automatisch eine höhere Sicherheit.

Die Experten des forsttechnischen Dienstes der Wildbach- und Lawinenverbauung in Österreich sind durch ständige Evaluierungen bei der Erstellung der Gefahrenzonenpläne bemüht, die Qualität ihrer Arbeit sehr hoch zu halten.

Als Beispiel für die Wirksamkeit der Gefahrenzonenpläne sei hier eine Studie aus der Schweiz angeführt, welche nach dem Winter 1999 durchgeführt wurde. Daraus geht hervor, dass die Lawinenablagerungsbereiche in 97% der Fälle mit den ausgewiesenen Flächen in der Gefahrenzonenplanung übereinstimmen.

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7. Blöschl, Günther and Kirnbauer, Robert

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"Spatially Distributed Snow Estimation in Austria"

In this paper we will present results from two studies. The first study is set in the Schneealpe region in the Austrian Alps, 80 km south of Vienna. The purpose of the study was to estimate the spatial and temporal distribution of snow water equivalent in the water supply catchment of the Vienna Water supply Department. The estimation method is built around a comparison of simulated snow cover patterns with snow cover patterns derived from SPOT XS satellite data. The calibration to obtain optimum model parameters consists of three steps: Setting parameters based on auxiliary information; global calibration of spatially uniform parameters based on snow patterns; and spatially distributed calibration based on snow patterns which makes use of four-dimensional data assimilation techniques. The verification is based, again, on a comparison of simulated and observed snow patterns for an independent data set. For the case study area we demonstrate that the calibrated and verified model provides more reliable estimates of snow water equivalent and snow melt than is possible with a modelling procedure where no observed snow patterns are used. The implementation of this procedure in an operational water resources management context is under way.

The second study covers all of Austria. The main emphasis in this study was estimating the component of the water balance in area as physiographically heterogeneous as Austria. A conceptual water balance model was used for each catchment in Austria and parameters were estimated from observed snow depths and runoff data. The estimated parameters were more robust as if runoff only were used. The parameter sets are then used for estimating the water balance components for elevation zones in each basin. Input data for the water balance modeling include 27 years of daily streamflow (406 basins), precipitation and snow depth (900 stations), and air temperature (212 climatic stations). As a result, grid maps of the water balance components including snow water equivalent were constructed at a daily time step with a resolution of 1 x 1 km. Additional information derived from the simulations include days with snow cover.

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"Technology.Tourism.Landscape: Integration of Snow Research"

Introduction

In the last decades, integration and interdisciplinary research has become more important all over the globe. In an open, integrative research approach, the conceptual aspects turn out to be more significant and consume ever more time in the finding of new solutions. Team work with other professional groups and the resulting communication process becomes also more important. On the other side, the classical ideal of research with dividing a subject and going in depth with particular interests remains. An important question can be: what kind of integration is wanted, needed and possible. The amount of scientific findings doubles in only a few years, the number of combinations for integration and multidisciplinary research grows even exponentially to the findings. As a result, terms like integration and multidisciplinary might be good in principle, but could mean nothing in practice. In the following I will present my ideas why we choose the combination of technology, tourism and landscape and why snow has particular relevance for this topic. Further more, what rules are important to direct integration and multidisciplinary, so that a group of perhaps very different people could become a team in the future?

Technology

Describes "HOW". How we can explore and analyse the landscape or develop tourism? Technology changes over time, it depends on the availability of resources and it will change in the future. However, we can only anticipate the velocity and the direction of change in technology. Snow related technology actually refers to many and diverse technologies related to cold temperatures and numerous problems related to these technologies:

- Technologies to use snow, like skis, sledges, ski lifts, igloos, snow scooter and others.
- Technologies to adopt to snow, like the shapes of house roofs and particular materials to resist to snow
- Technologies to abate snow, like snowplough, soil surface heat exchange on roads and other more
- Technologies to increase snow, like artificial snow generating plants
- Technologies to protect from snow, like avalanche protection constructions
- Technologies to detect snow, for example remote sensing devices
- Technologies to modify physical properties and micro structures of snow, e.g. micro-organisms to increase melting point of snow.

An optimal control on the amount and the consistence of snow is wanted for many purposes, perhaps the most important out of them is winter tourism.

Tourism

Describes "WHAT". Tourism is a modern kind of land use, a service or an export product. Tourism is growing over the world and stagnating in Austria at a very high level. Here, tourism contributes to some 8% of GDP and is therefore in particular important for rural and mountainous areas, where it is the lead economy. Winter tourism is growing and could perhaps grow even more, if there would not be major problems related to the warming during the last decades. Snow safety can no longer be guaranteed, but snow remains a major success factor in winter tourism. The adaptation to warming was costly for the winter tourist regions of Austria. Practically all skiing resorts came into existence until 20 years ago. From then on an adaptation process started.

Landscape

Describes "WHERE". Not every place is suited for tourism or feasible for technological adaptation. Unsuitable, low altitude and less profitable ski resorts, went out of business, the remaining skiing areas had to manage expensive adaptations, collecting water in artificial ponds and building water canalisations in the mountains to collect it in ponds. Due to the conflict for scarce resources, the first user(s) may take the available water resources that are required for artificial snow making and winter tourism. Technology can help to use the resources more efficiently, but it not possible to overcome principle problems related to global environmental and economic change. Another phenomenon of Austrian tourism is, that it becomes ever more concentrated in the best suited landscapes, usually those in high altitudes with colder climate, while many other landscapes become less interesting for tourism.

Matching Space and Time

Each field of investigation is interesting for itself. However, the combination of all three of them together could support many people in particular those living in more periphery areas. However, choosing the right topic is only one part of a successful approach for integration and multidisciplinary. Overcoming and matching different borders of space and time contributes to other challenges. *Figure 1* describes the challenges related to various spatial (global, regional global, international regional, local regional, local, private) and temporal (centuries, decades, years, seasons, month, days, hours) scales.

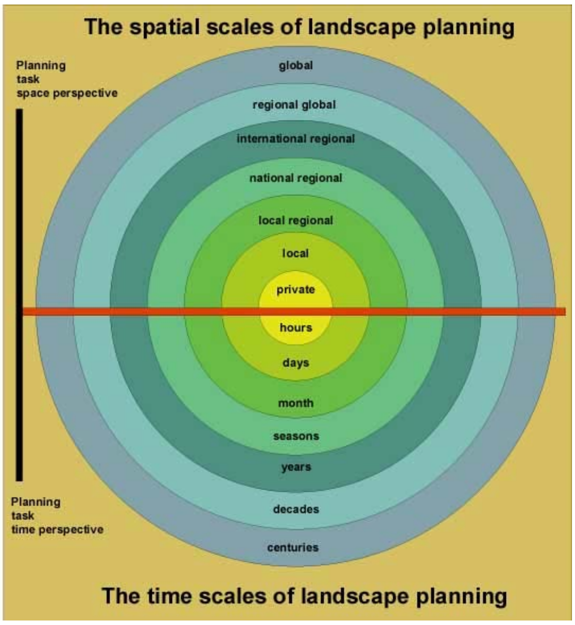

Figure 1: Definition of the space and time borders of a research task

What processes and what areas we consider with our task? Each research task has a particular space-time extension, symbolized by the black line on the left corner. By identifying the borders, we explain to others more about our way of thinking.

Motivation for Conference Technology.Tourism.Landscape

The many scales of technology, tourism and landscape and snow in particular are perhaps not entirely visible to specialists and practitioners dealing with a particular interest. Here we would like to make a contribution with our conference. You will not find the "common line" usual for many conference proceedings. There is no peer review, as people are no peers, but complementing each other. Perhaps this is the only time all these people meet under the common topic. But we rather hope that this will be the beginning of a series with a fruitful exchange and a stimulation for writing joint research proposals.

I would like to thank all our participants for sharing this idea and for contributing to the success of this venue. I hope that we will enjoy many and pleasant discussions.

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"Climate Sensibility of Austrian Winter Tourism: Winners and Losers at Different Degrees of Warming. Results from a Study for the Austrian Ministry of Economy/Section Tourism and Ministry of Environment"

Summary

In this paper we will introduce general approach for studying global warming impacts for snow cover in different areas. However, due to the differences in local data sources it can be sometimes difficult to follow this general idea and adaptations of this model have to be done. We introduce, as an example of one of these adaptations, the regional model for Austria. Concrete results and estimates of global warming impacts are given.

General Model description

The most straightforward idea is to express the snow cover using the temperature data. If there exists the relation between the snow and temperature we can estimate the influence of global warming on snow. Expressed more formally

(1) Snow situation = f_1 (temperature)

implies

(2) Snow situation after the global warming = f_2 (temperature + global warming effect).

Generally, it is very complicated, and even impossible to say something precise about the difference between f_1 and f_2 and we will assume that they are equal and we will denote it by f. It is quite clear that snow situation cannot be explained only by the temperature effect but also by other climate factors. The most natural ones to include into the model considerations are the precipitation conditions. Hence our symbolic equations can take the form of

(3) Snow situation = f (temperature, precipitation)

and

(4) Snow situation after the global warming =
= f (temperature + global warming effect, precipitation + global warming effect).

It is unrealistic to have only one function f for the whole globe and we have to consider our equations to be more localized. As the good spatial differentiator climate zone can be taken. By climate zone we understood without going into methodological details adjacent districts with the same or similar climate conditions. This means that for different climate zones we can have different functions f estimated and hence the relation (1) can be more formally described by

(5) Snow situation$_{\text{climate zone}}$ = $f_{\text{climate zone}}$ (temperature, precipitation).

Generally, our wish is to get global warming impacts for any concrete place in the climate zone (city, village, skiing area, concrete ski lift etc.). For being able to do this we must be able to estimate snow cover situation based on the concrete place through the covariates of temperature and precipitation. Hence we express the temperature and precipitation of the concrete place through spatial formulas

(6) temperature=ϕ(altitude, latitude, longitude)
(7) precipitation=ψ(altitude, latitude, longitude).

Summarizing above given ideas, based on the current data we try to estimate the current situation by

(8) Snow situation$_{\text{climate zone}}$ = $f_{\text{climate zone}}$ (ϕ(altitude, latitude, longitude), ψ(altitude, latitude, longitude))

And consequently predict the global warming impact as

(9) Snow situation after global warming$_{\text{climate zone}}$ = $f_{\text{climate zone}}$ (ϕ(altitude, latitude, longitude)+global warming effect, ψ(altitude, latitude, longitude)+global warming effect).

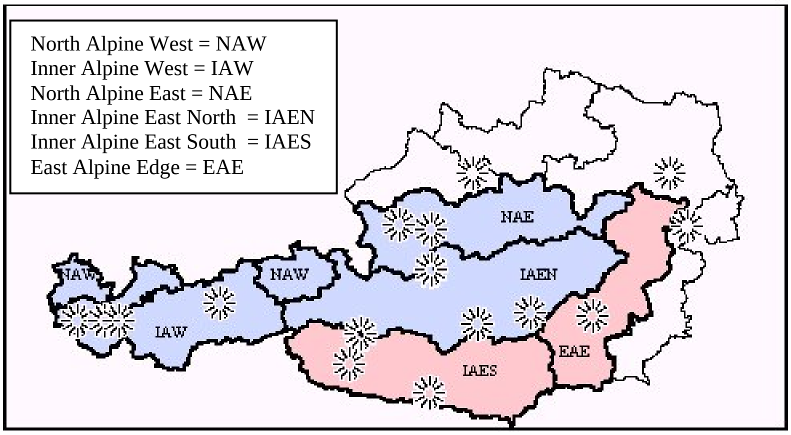
Local model – Austria

We tried to follow the general model ideas for Austria based on the available data sources. There are several climate zones in the Austria in each of which similar climate behaviour can be expected that are given in table 1 (see also Map! And see [20] for definition of these climate zones).

Table 1: Climate zones in Austria

NAW	NORDALPIN WEST
IAW	INNERALPIN WEST
IAON	INNERALPIN OST NORD
IAOS	INNERALPIN OST SÜD
AOR	ALPENOSTRAND
NAO	NORDALPIN OST
MWV	MÜHLVIERTEL-WALDVIERTEL
AAW	AUSSERALPIN WEST
AANO	AUSSERALPIN NORDOST
AASO	AUSSERALPIN SÜDOST

Map 1 Climate Regions with 16 Temperature Stations



Each climate zone consists of concrete Austrian districts. In each of these districts we had information collected from the three sources: temperature data, precipitation data and snow cover data. We have temperature data collected in three measurement stations. We will denote them as TP(y1) - the average month temperature in the lowest altitude place of the climate region, TP(y2) the average month temperature in the middle altitude place of the climate region and TP(y3) the average month temperature in the highest altitude place of the climate region. For each district we further had one precipitation station, denoting this information by PR(z) - the average month precipitation of the precipitation station z. Finally, we had data concerning snow cover in several places of one district, which we will denote by SC(x). The data were collected monthly in the years 1965-1995. Hence we have average temperature data, cumulative precipitation and cumulative snow cover in the given stations. We approximated the general function *f* by its linear approximation and we assumed that (8) takes the form of

(8‘) $SC(x)=t_1*TP(y1) + t_2*TP(y2) + t_3*TP(y3) + p*PR(z) + const+error.$

The parameters t_1, t_2, t_3, p, const are estimated using general linear model. For any snow station in the respective climate region we hence get a list of snow stations and the relevant models for these stations. These snow stations are situated in different altitudes. From the snow cover data of these snow stations and their altitude we estimate the relation between the altitude and snow cover for the climate region B in the form

(10) Snow cover=g (altitude)

and taking inverse of this relation we have

(11) Altitude = g^{-1} (snow cover)

To estimate the situation after global warming we use the relation (8') that we assume to be valid even after the global warming situation. Just we only substitute the temperature in (8') by the warmer one and get a new snow cover situations in all the snow stations of the given region. We did not assume changes in precipitation after global warming, however, for any concrete scenario of precipitation changes it would be easily possible to include them in final model as in the case of temperature effects. Concretely, we estimated new snow cover conditions for the snow station x NSC(x) as

(12) $NSC(x)=t_1*(TP(y1)+\text{warming effect}) + t_2*(TP(y2) +\text{warming effect}) + t_3*(TP(y3)+\text{warming effect}) + p*PR(z).$

We re establish the equation (9) and (10) for the new data getting

(13) snow cover after warming = h (altitude)

and

(14) . altitude = h^{-1} (snow cover after warming)

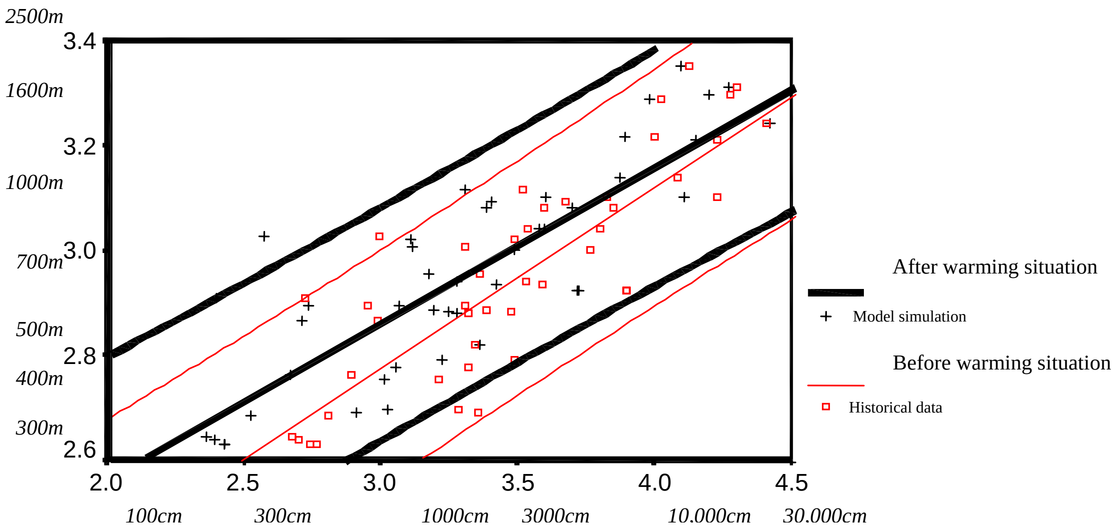
The relations (10), (11), (13) and (14) between the altitude and snow cover was estimated statistically based on the general relation

(15) Log(altitude(x)) =a* log (SC(x)) +const+error.

Results

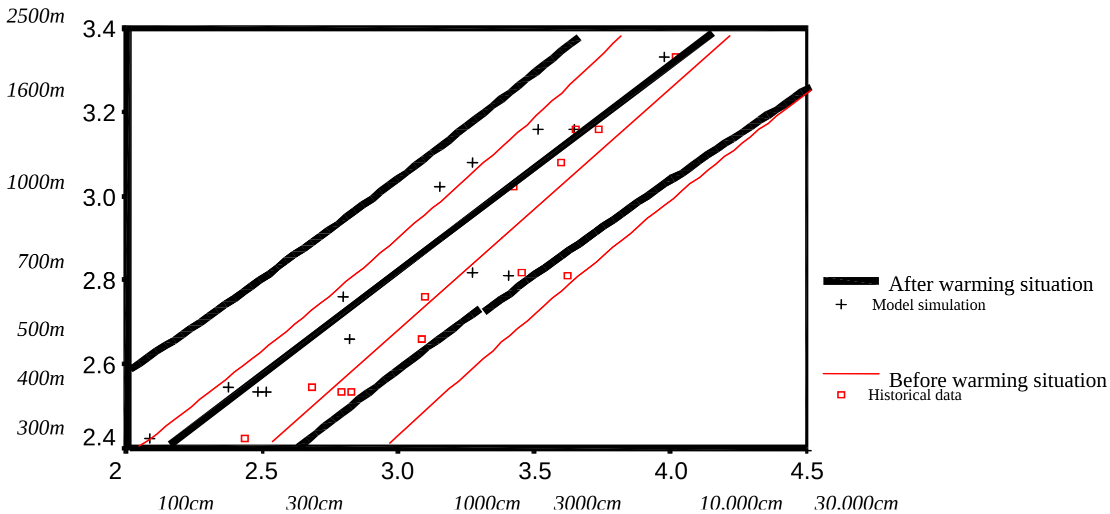
On Figure 1 we can see the output of the model. Climate zones IAEN, IAW, NAW and NAE were taken together since the estimation of parameters in (15) were similar.

Figure 1 Relation between log altitude and log snow cover in IAEN, IAW, NAW, NAE



The square points show the situation before warming, i.e. the current situation of snow at the measurement stations. The middle weak line is the least square fit of the data explaining the relation between the snow cover and altitude. The upper and lower weak lines are the 95% confidence limits for this least square fit. The bold lines have the same meaning for the situation after the 2°C warming. Cross points refer to snow data predicted by the model. The scale on both axes is logarithmic hence two scaling units are used. On the x axis the scale in cm means cumulative snow cover over the season, on the vertical axis altitude in meters si given. If we take e.g. the today situation in 1000 m altitude we see that the snow cover is 3728 cm (weak middle line). Taking the altitude of the warming situation in 1000 m we get 2712 cm seasonal snow depth after the 2°C warming (using the bold middle line). The corresponding altitude to this cumulative snow cover under the current situation is 895 m (using the weak middle line). So we get approximately 105 m decrease of altitude at the level of 1000 m. We can also observe approximately one quarter decrease of cumulative snow cover. This is true for the regions IAEN, IAW, NAW, NAE (figure 1). For the regions IAES and EAE (figure 2) we can follow the same method and get the results shown on figure 2.

Figure 2 Relation between log altitude and log snow cover in IAES, EAE



We can estimate other useful characteristics of global warming impacts. In [21] the notion of MARP (Mean Altitude of Residential Population) was introduced as the weighted average of altitude of Austrian districts. Average is taken over the communities with weights taken as the size of population in the respective community. Using the results of the introduced model it can be shown that the range of MARP which varies today from 305 to 1201 meters will sink to 195 – 1107 meters in the case of two degrees warming.

Direct impact to ski areas can be measured through MASPLS (Mean Altitude of Starting Points of Ski Lifts) which will sink from today range 689-1889 to 515-1879. See again [21] for more details about MASPLS.

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"Karst Research: Possible Conflicts Related to Water Protection and Winter Tourism"

Groundwater plays a major role for water supply in many countries throughout the world, although it comprises only a minute amount (< 0.5%, including low and high level groundwater) of the worlds total water reserves. For example more than 70% of the drinking water demand in Austria, Germany, Hungary, and Italy is covered by groundwater resources (Frimmel 1999). Contrasting to there importance for water supply, groundwater habitats are frequently endangered by chemical or biological contaminants (Berbenni, Cavallaro et al. 1993; Roux 1995; Piver, Jacobs et al. 1997; Halwani, Baroudi et al. 1999; Barrett, Howard et al. 2000; Chave 2000; Haakh 2000; Ibe, Nwankor et al. 2001). Thus, in order to maintain high level ground water quality sustainable management and protection of those natural resources is of outstanding importance. A thorough understanding of the complex nature of groundwater ecosystems is therefore an important pre-requisite.

Karst aquifers are particular types of groundwater ecosystems, showing unique characteristics in terms of hydrogeology, biogeochemistry and vulnerability (Ford and Williams 1996; Drew and Hötzl 1999). In this case vulnerability is defined as the intrinsic hydrogeological characteristics which determines the sensitivity of groundwater to contamination. As in contrast to porous media aquifers, karst aquifers with their discrete rock fractures and large conduits exhibits distinct and very dynamic discharge characteristics from their respective catchment areas (Clemens 1999; Labat, Abon et al. 2000; Baedke and Krothe 2001). Karst aquifers are thus particular susceptible to environmental impacts and changes (Ford and Williams 1996; Drew and Hötzl 1999). A lot of effort is therefore put into the development of protection strategies in order to maintain high water quality (Doerfliger, Jeannin et al. 1999; Drew and Hötzl 1999; Plagnes and Bakalowicz 2001). Nevertheless thorough understanding of karst-aquatic environments is a complex subject and demands for multiple disciplines (e.g. [Drew and Hötzl 1999; Dirnböck and Grabherr 2000; Loaiciga, Maidment et al. 2000; Simon, Gibert et al. 2001]).

In alpine areas like Austria, groundwater resources from alpine karst aquifers play a fundamental role for high quality public water supply. Consequently, alpine karst research has to provide the basic scientific understanding which will than allow to follow all necessary steps for long term maintaining the ecological integrity of the respective alpine catchment areas. Research on Austrian alpine karst ecosytems has a longstanding tradition and has primarily focused on geologic, hydrologic and vegetation sciences (see [Herlicka and Graf 1992; Dirnböck and Grabherr 2000; Kralik 2001] and references therein).

A recent survey (Kralik 2001), including different institutions and companies dealing with karst water research or practical water supply from alpine karst water areas, identified the following factors as main points of concerns for a potential negative influence on water quality within the catchments area (given in order of anticipated importance): a) mass tourism [e.g hotels, parking space, roads, cablecars, b) (intensive)agriculture [e.g. inappropriate fertilization, pesticides], c) intensive pasture farming [e.g. erosion, manure], d) road construction, e) refuge and mountaineering [e.g. waste disposal], e) contamination from atmosphere [e.g. acid precipitation], f) skiing (e.g. on glaciers), g) inappropriate sewage disposal, and h) construction activities (Kralik 2001). Form this survey it is obvious that tourism is considered to be one of the main potential influencing factor on water quality in the respective catchments as tourism is related to points a), d), m), f), g), h) given above. In general, this should be of relevance for summer as well as winter tourism, although detailed differences in the potential impacts are expectable. Furthermore, catchment protection as well as winter tourism is likely to coincide as both areas are often related to mountainous or alpine regions, thus making it a very sensitive subject. According to the mentioned survey on possible impacts on ground water quality form alpine karst areas, microbiological contamination is the main anticipated potential problem if catchments protection fails (Kralik 2001). Thus it was suggest to intensify microbiological research in order to provide a scientific understanding of alpine karst aquifer microbiology (Farnleitner 2002) and to develop efficient analytical techniques for microbial characterisation and source identification (Kralik 2001) (Farnleitner, Burtscher et al. 2002).

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"Winter Tourism in Austria: Basic Figures and Perspectives"

Key Data on Austrian Tourism

Compared to other countries tourism in Austria plays an outstanding economic role. In the year 2003 28,1 mio. arrivals and 118 mio. nights have been achieved. Alltogether 90.000 companies or businesses with more than 500.000 employees are engaged in tourism. More than 173.000 are directly employed in the hotel and gastronomy sector. The revenues of tourism in 2003 add up to more than 14,2 bil. € . The value added from tourism is about 18 % of the GDP. Worldwide Austria ranks eigth concerning the total revenues of tourism and first concerning the per capita revenues. Therefore in Austria tourism plays a central role covering income and employment as well as the adjustment of the balance of payments.

Key Data on Austrian Winter Tourism

Nights / winter season 2002 /2003 (1. Nov. – 30. Apr.)	56.792.814
Nights / summer season 2003 (1. May. – 31. Oct.)	61.096.483
Share of winter nights	48,2 %
Share of winter nights (Hotels)	48,9 %
Number of winter beds / hotels	583.389
Number of winter beds / santoriums and recreation homes	13.073
Number of winter beds / private accommodation	322.467
Number of winter beds / other accommodation	143.542
Occupancy rate hotels (winter)	34,2 %
Occupancy rate santoriums and recreation homes (winter)	57,8 %
Occupancy rate private accommodation (winter)	11,1 %
Occupancy rate hotels (other accommodation)	25,1
Occupancy rate summer (Hotels)	34,1 %
Winter nights „alpine regions"	51.152.962 (90 %)
Winter nights „other regions"	5.679.597 (10 %)
Summer nights „alpine regions"	50.948.256 (83,4 %)
Summer nights „other regions"	10.148.227 (16,6 %)
Daily expenses (winter)	€ 97,2
Daily expenses (summer)	€ 74,1
Sum of winter expenses	€ 5,5 bil.
Sum of summer expenses	€ 4,5 bil.
(4 bil. € are due to daily tourism (no overnight stays))	

With the exception of the two major cities Vienna and Graz the 50 communities with the most winter nights are situated in alpine regions. They account for more than 50 % of all winter nights.

18 of these 48 communities (38 %), which account for approx. 30% of the nights, lie below 1.000 m above sea level and their highest mountain station does not exceed 2.000 m. These communities may be severely affected by a further warming of the global climate. Furthermore we can assume, that the communities, which account for the rest of the winter nights, predominantly lie below 1000 m and their highest mountain station below 2.000 m.

Key Data on the Skilift Sector

The following types of skilifts are distinguished in Austria:

Main cable cars (MCC): all types of cable cars / railways, chairlifts, which are not permanently connected

Other chair lifts (OCL): chair lifts, which are permanently connected or coupled

T-bar lifts (TBL)

Number of lifts (Winter 2001 /2002)

MMC:	439
OCL:	433
TBL:	2246

In recent years the number of MMCs is increasing, wheras OCL and TBL are decreasing

Length:		**Capacity**	**Actual transport (pax)**
MMC:	839.305	448.608.450	265.200.539
OCL:	519.985	199.302.903	111.390.098
TBL:	1.088.352	---------------	179.454.934

Capacity here is defined as height difference x max. number of persons / h

Data from 2003 / 2004

Total Sales:	€ 901.300.000
Total Transport (pers):	591.200.000
Skier days:	49.900.000
Operation days:	30.900
Average Expenses per skier day:	€ 18,1 (02/03: 17,6)
Average LiftExpenses/operation day:	€ 25.996.-
Transports per person:	11,75
Transports per operation day:	17.358

Conclusions

Following recent media reports, the trend towards alpine skiing is unbroken. (DIE PRESSE, 22.10.2004). Ranking second are snowboard, followed by nordic skiing and cruising. So "Snow-Sports" are the central motivations for tourists spending their winter holidays in Austria. Other activities like wellness, tennis or other sports can be regarded as supplementary supplies but are not in grade to stimulate touristic demand out of their own.

This hypothesis is supported by the recent growth rates in Austrian winter and summer tourism:

WinterNights

1997/98	1998/99	%	1999/00	%	2000/01	%	2001/02	%	2002/03	%
49540083	52122540	5,2	53415883	2,5	55270892	3,5	56300480	1,9	56792814	0,9

Average growth rate: 2,8   Growth rate 1997/98 – 2002/03: 14,6

Summer Nights

1997/98	1998/99	%	1999/00	%	2000/01	%	2001/02	%	2002/03	%
61253216	61200921	-0,1	59645098	-2,5	59246385	-0,7	60296256	1,6	61096483	1,5

Average growth rate: -0,04 Growth rate 1997/98 – 2002/03: -0.04

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"Data Acquisition by Various Remote Sensing Techniques"

Introductory Notes

This presentation should give an overview of current remote sensing techniques. The used sensors may be carried on aeroplanes ("airborne sensing") or on satellite platforms ("spaceborne sensing"). We also want to show that remote sensing and photogrammetry are overlapping disciplines which complement each other although they use the same or similar equipment for data collection.

Remote Sensing

Remote Sensing, *the art and science of obtaining information on shape and physical characteristics of remote objects without getting in mechanical touch with it*, has reached a high level of standardization and reputation. Weather forecasting without observation from space, for example, would perhaps be considered as impossible by the great majority of people.

Photogrammetry

Aerial photographs have been the foundation for high precision mapping for more than half a century. The mapping technology from photographs is called photogrammetry. In order to distinguish between the discipline of photogrammetry and of remote sensing, the following definition has been given: Photogrammetry is the *art and science of obtaining information about the geometric shape of the object under investigation*.

Laser Scanning

A rather new acquisition technique uses the distance measurement through time-of-flight analysis of laser beams. Together with modern navigation equipment based on GPS (Global Positioning System) and IMU (Inertial Measurement Units), the Earth surface can be densely sensed from an airplane thus delivering a detailed surface model and elevation model with quite low effort. Nevertheless, the most interesting potential of laser scanning is given by its possibility to penetrate vegetation to a certain extent. New instruments are going to record a great many details of the signal so that a thorough analysis of the vegetation cover becomes feasible.

Remote Sensing Sensors

Many different sensors have been launched into space. The "major players" in the field of observation from space are USA, France, India and Europe. This list will certainly be extended in near future. Remote sensing sensors usually take images in more than three spectral bands and/or in regions of the wavelength that cannot be covered by traditional films, such as mid-range infrared, thermal infrared or microwaves.

Optical and Microwave Sensors

Optical Systems are those which mainly record radiation that has been reflected on or emitted from the Earth surface and can be imaged with the help of so-called optical systems, such as mirrors or lenses. The classical optical system is the film-based or digital frame camera. More important for remote sensing purposes is the multispectral scanner. Two basic principles are used: the whisk-broom and the push-broom sensor. In the meantime also microwave sensing plays an increasing role.

Multispectral and Hyperspectral Scanner

All instruments that record more than the traditional three colour channels of colour photography are called multispectral acquisition systems. The first multispectral scanner in Landsat 1 to 3, named MSS, was sensitive in green, red, and two bands in near infrared. The second generation of Landsat (4,5 and 7) had on board the so-called Thematic Mapper (TM) with 7 spectral bands from blue to red, near infrared, two bands in mid-range infrared and one in thermal infrared. The sensors on the well-known SPOT family, launched by France, had three to four spectral bands from the visible ranges to the mid-infrared range. Generally, there is no exact definition regarding the minimum or maximum number of channels a multispectral scanner has to have.

A new generation of sensors is known as hyperspectral instruments. Basically identical to multispectral sensors, hyperspectral scanners register a huge number of separate channels usually far beyond the 7 TM channels and may be able to register radiation in 128 to 256 and even more channels. They deliver a practically continuous spectrum of the sensed object and are mostly used for solving geological problems.

Microwave Systems

Microwave have their wavelength in the ranges of cm to meters. The sensor does not consist of optical elements. It uses antennas. Spaceborne microwave sensor are mostly active instruments with a so-called Synthetic Aperture. Active means, that the satellite itself generates the radiation whose backscattered echo is received and recorded. Microwave systems are generally known as RADAR (Radio Detection and Ranging).

Characteristics of Microwaves

Microwaves are sensitive to the dielectric properties of the object under investigation. As the dielectric constant of a surface varies with the water content, RADAR images can be used for sensing the moisture or water content of the Earth surface. Due to their relatively long wavelength many materials have smooth surfaces with respect to microwave and are likely to behave like mirrors. This effect can be used also for image interpretation. An often cited example is the detection of oil spills on water surfaces. Normal water tends to generate waves even at low wind speeds. The water surface is rough and behave as a diffuse reflector. A backscattered signal will be registered by the RADAR sensor. After an oil spill waves are suppressed, the water surface behave as mirror and no signal will be received by the sensor. Because of their sensitivity to moisture RADAR images are also used for investigations where snow cover and its melting process are to be investigated. One great advantage of microwave radiation is their capability to penetrate cloud cover without being seriously affected.

SAR Systems and Interferometry

As already mentioned above, synthetic aperture RADAR systems are common in spaceborne sensors. This special technology needs coherent radiation. The great advantage is the possibility to increase the spatial resolution dramatically independent of the flying height. The negative side-effect are interferences causing the so-called speckles, a disturbing image noise. On the other hand, a further advantage leads to a completely new and interesting field of applications. As the signal is generated as coherent waves, interferometric approaches render possible. The SAR sensors are, therefore, quite often used for motion analysis (such as detection of landslides, determination of speed of glaciers or sea ice, surface changes after earthquakes) or simply for the acquisition of digital terrain models. A famous example for the latter application was the Shuttle RADAR Topography Mission (SRTM) where a great part of the Earth's landmass could be covered with digital terrain data.

Global Acquisition vs. High Resolution

Many questions of today's scientists are focused on the system Earth and cannot be restricted to pure local problems. Global and local problems need different sensors. One often mentioned quality measure for a sensor its "resolution". It has to be emphasised that this specification is just one parameter of an acquisition system, which by the way is not adequate at all to characterise its quality, not withstanding the fact that the term needs a more accurate definition.

Definition of Resolution

This section focuses on the term "Resolution" which is commonly used for classifying Earth observation systems without bearing in mind, that several types of resolution exist which often depend from each other and are therefore not freely selectable by the developers of the sensing equipment.

Spatial Resolution

The spatial resolution defines the ability to distinguish between two neighbour objects. It is directly related to the footprint of a pixel in the digital image of the object. Today's satellite sensors are able to provide pixel sizes down to 0.6 m (e.g. QUICKBIRD panchromatic). On the other end of the scale is, for instance, METEOSAT with a pixel size 2.5 to 5 km at the equator.

Spectral Resolution

The spectral resolution is determined by the number of spectral band on the one hand and by their bandwidth on the other hand. A panchromatic image has the lowest spectral resolution, while the spectral resolution of hyperspectral scanners might be very high.

Temporal Resolution

The temporal resolution is defined by the number of revisits within a certain period. The European Remote Sensing satellite (ERS) is able to image a certain area of the Earth surface every 35 days. SPOT with its pointing capabilities may take pictures of from the same place every two days in our latitudes. METEOSAT's temporal resolution is 30 minutes, which, as the satellite is geostationary, may called re-acquisition time rather than revisit time.

Radiometric Resolution

The radiometric resolution is defined by the capability to distinguish between intensity levels. The measure for radiometric resolution of optical instruments is the "noise-equivalent reflectance change". An good (though not sufficient) indicator for the resolution is also the number of bits used for recording (or storing) the intensity values of one pixel. Traditionally 8 bits (256 levels) are used for storing a greyvalue, nowadays 10 and 12 bits, even 16 bits may be found.

Laser Scanning in More Detail

Laser scanning is currently used from airborne platforms. The main application is the derivation of high resolution digital terrain models and surface models. The greatest advantage of laser scanning is its capability to look through the vegetation cover to the earth surface. With laser scanning and appropriate processing techniques a high quality terrain model can be generated almost fully automatically even in densely forested areas.

Laser scanners measure the distance from the sensor to the surface by measuring the time difference between the transmission of a short laser pulse and the reception of the echo. When the pulse reaches the canopy of a forest a part of that pulse is reflected while a remaining part is able to go through the various gaps between leaves and branches and reaches the ground where eventually it is reflected, too. The receiver firstly registers the reflected pulse from the top of the tree and a bit later (maybe after some further reflections from branches) the last reflection from the ground. Systems which register both pulses are called first-pulse/last-pulse systems and are well suited for vegetation analysis and DTM generation in vegetated areas. Currently, a new type of instruments is being developed. The so-called full-waveform-scanners register a great number of pulses between the first and the last pulse. The signal describes in a certain way the structure of the entire path of the laser beam. As this technology is quite new, no state-of-the-art processing methods exist. The Christian-Doppler-Laboratory for "Spatial Data from Laser Scanning and Remote Sensing" in co-operating with the company RIEGL Laser Measurement Systems (Austria) investigates the system's behaviour and potential.

Conclusion

The above mentioned systems are currently heavily used and have become important data acquisition systems for today's life. Data are available either commercially (in most cases) or for free (in particular for scientific applications and for participants in certain research projects). Although the spatial resolution of spaceborne sensors is currently as good as 60 cm, airborne sensors still provide the best quality. Photographic film-based sensors are currently replaced by digital frame cameras. Several companies are already offering operational cameras for photo flights, although major improvements are expected for the near future. One must not forget, that an increasingly important data source are the various image archives. Archives of satellite images go back to the beginning of the seventies of the last century, while aerial photo of highest quality are available back to the fifties. They are an invaluable source for all investigations relating to monitoring climate change, urban dynamics and other projects of environmental developments.

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"Remote Sensing for Snow Classification"

Introduction

Vienna's drinking water supply depends on water from springs in the Karst area some 100 km south-west of the city. The snow melt behaviour is of great influence to the amount of water to be expected at the individual springs. Therefore, a prototype observation systems was planned where the snow conditions should be modelled mathematically. Input are continuous hydrometerological observations (see presentation by G. Blöschl). In order to be able to calibrate the model the actual snow pattern had to be observed by remote sensing techniques. Satellite data, in particular multispectral SPOT images and microwave SAR images seemed to provide ideal means.

Remarks relating to snow classification with optical images

SPOT XS images with is spectral band in the visible and near infrared range are not ideal for snow classification. Snow, clouds and bright lime stone can hardly be separated as the have almost the same spectral characteristics. This problem does not occur if SPOT XI images with their mid-infrared band are used. The planned classification is not intended to derive special snow characteristics, it should only deliver the following classes:

- No snow discernible
- Very patchy snow cover discernible
- Slightly patchy snow cover discernible
- Full snow cover discernible

Classification with the help of the commonly used multispectral classification approaches do not work properly for several reason, the most important is that the area of interest is a mountainous region with steep slopes, causing severe shading especially at low sun elevation angles.

Normalised Difference Indices

The utilisation of indices, i.e. ratios between different spectral bands, is a quite common approach in classification if shading effects should be eliminated. One well-known index is the NDVI (the normalised difference vegetation index) which is used for investigations of the vitality of plants. A similar constructed index is the normalised difference snow index, the NDSI. The value range of both indices is –1 to +1, indicating either "no vegetation" and "highly vital vegetation", or "no snow" and "almost certainly snow", respectively. SPOT XI images provide all information for both indices, the red and near infrared on the one hand and the red and mid infrared band on the other hand. By combining both indices an almost perfect data set for calibrating the snow model can be achieved quickly and with low effort.

Snow classification with microwave images

One of the great disadvantages of multispectral satellite images is their sensitivity to clouds. Clouds are obstacles which cannot be penetrated by the waves used in optical remote sensing. Unfortunately, frequent cloud cover is typical in the area of our investigation as thorough checks of the archives of satellite data showed. Microwave remote sensing is able to provide a work around. Microwaves penetrate clouds and can reach the Earth surface almost unaffected. In our project the Synthetic Aperture RADAR (SAR) sensor of the ERS satellite have been used. The sensing geometry requires careful geometric processing. SAR is a side-looking technology which means that the area is observed from one side of the satellite path only causing severe distortions and occlusions in mountainous areas. In order to cover the area of interest two satellite paths are necessary, one so-called ascending and one descending path.

Besides this geometric properties, also the radiometric backscattering behaviour has to be explained. Backscattering of microwaves depends on various factors, such as surface roughness and most importantly on the dielectric properties of the observed materials. Dry snow is almost transparent for microwaves, while surfaces with high water content cannot be penetrated easily and show a typical backscatter pattern in the images. Microwave images, therefore, are usually not used for snow classification in the same way as multispectral images. A common approach is the analysis of differences between images of different dates by calculating image ratios. Variations of the ratios indicate changes of the water content from one acquisition date to the other. During the melting period the melting process can be observed rather than the geometric extent of the snow cover.

Conclusion

This presentation should show that spaceborne remote sensing provides appropriate means for the determination snow cover, although a series of restrictions have to be considered. Many of the snow properties, such as grain size, density profiles, layer structure, thickness, etc cannot be derived or can be derived to a certain extent only under ideal circumstances and conditions. Another problem is snow cover in forested areas. Satellite sensors cannot look through the canopy of the trees. For instance, regions that appear totally snowless in the images may actually have a rather high snow cover hidden blow a snowless tree canopy. As the pilot project showed, observing the snow pattern in vegetation-free areas is more or less sufficient for the calibration of the snow model. Nevertheless, additional on-site observations are compulsory for reliable results and for a successful implementation in practice.

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"Projects Related to Snow and Mountain Hydrology in Slovakia"

Introduction

Slovakia is a mountainous country. About 78% of its area is situated above 300 m a.s.l. and the highest mountains exceed 2500 m a.s.l. Snow and mountains are important natural phenomena here.

The aim of this contribution is to provide an overview of current projects in mountain hydrology and snow reseach. For the purpose of this overview the research is divided into experimental and theoretical. **Experimental** hydrological and/or snow **research**, i.e. research based on field data collected in specifically equipped catchments or plots is performed only by a few research bodies - Slovak Academy of Sciences (Institute of Hydrology) and Technical University in Zvolen (Faculty of Forestry). Extended monitoring of mountain environment in the High Tatras, i.e. the highest part of the Carpathians, which covers also climatic monitoring, is carried out by the High Tatras National Park Research Station. Most research projects are devoted to **theoretical research**, i.e. the research based mostly on the data from the standard observation networks which are sometimes supplemented with the data from field campaigns. Such a research is performed at the Slovak Academy of Sciences (Institute of Hydrology, Institute of Geography), Slovak Technical University and Comenius University in Bratislava, Agricultural University in Nitra, Slovak Hydrometeorological Institute, Water Management Institute.

Research projects are typically covered by governmental funding through grant agencies or the end users (ministries, operationally oriented institutes). Majority of the projects is financed by national sources. These research projects are listed at http://www.vega.sav.sk and http://www.apvt.gov.sk. The transition from the former state-planned research to present grant system has led to a more competitive environment with higher responsibility of smaller research teams or even individuals. On the other hand, it has also lead to the atomisation of research.

More detailed overview of current projects performed in the field of (mountain) hydrology in Slovakia can be found in Szolgay (2003), Holubec (2003) and Holko and Miklánek (2004).

Mountain hydrology research

Most of the recent projects in the field of mountain hydrology in Slovakia have been devoted to the assessment of climate change impacts on hydrology and water management, rainfall-runoff relationships including floods and regionalisation. Other research projects have dealt with evapotranspiration, water quality, river morphology and sediment transport including hydrobiological issues.

Research on impacts of climate change on hydrology and water management addressed the following issues:

- Analysis of time series of precipitation, runoff, groundwater regime (groundwater runoff, spring yields) and evapotranspiration data with the aim of detecting climate change signals;
- Preparation of several analogous, incremental and GCM (General Circulation Model) based climate change scenarios for the 2010, 2030 and 2075 time horizons (monthly and annual time series of air temperature, precipitation and air humidity); preparation of scenarios of extreme monthly and daily precipitation totals for selected time horizons (2010, 2030, 2075);
- Estimation of climate change impacts on the mean annual flow, mean monthly flow, yields of the main water reservoirs and changes in the hydrological regime including snow cover in mountains;

- Proposal of basic strategies for the adaptation processes in water resources management to deal with climate change impacts.

The rainfall-runoff relationship is the central topic of hydrological cycle. It can be studied from various points of view, e.g. the estimation of areal precipitation in catchments, runoff formation, occurrence and causes of extreme events (floods, droughts). The practical aspect like flood protection, which originally initiated the research in this field, is still an important target. The long-term experimental research is performed only by the Institute of Hydrology SAS in the mountain catchment of the Jalovecký creek in the Western Tatra Mountains (catchment area of 22.2 km^2, mean elevation 1500 m a.s.l., mean slope 30º). Experimental research on the role of forests in runoff generation is performed by the Technical University in Zvolen. Theoretical research performed by various institutes addressed extremality of runoff conditions, occurrence of flash floods, weather conditions accompanying the floods, analysis of maximum rainfall, inventory of current flood protection measures, dynamics of floods in small streams and rivers, rainfall-runoff relationship and possible influence of climate change on the design values, influence of vegetation on runoff regime (runoff coefficient, temporal characteristics of the flood), management of mountain streams and its influence on catchment runoff characteristics, increase of retention capacity of groundwater storage, analysis of economical and ecological values of the inundation area and its protection against floods, design of protection measures based on computations of water levels during big floods, simulation of dynamics of floods on the tributaries of the main rivers, assessment of effects of water reservoirs and old river channels during floods, design discharge values for selected profiles, relationship between surface water and groundwater.

One of the tasks of operational hydrology is to provide the end users with various hydrological characteristics. Because the characteristics are often needed for ungauged basins, regionalisation remains an important research issue with clear practical outputs. Regionalisation research in Slovakia in the last years was focused on minimum and mean annual runoff regimes, extreme values using traditional as well as newer statistical approaches (multilinear regression, Hosking and Wallis method, regional frequency analysis, cluster analysis).

The water quality studies were focused on the impact of land use on stream water quality, balance of nitrates in the water cycle, variability of suspended sediment loads, modelling of pollutants loads, influence of water from urbanised areas on the quality of river water, identification of the main sources of diffuse pollution and management of water quality in several mountain catchments. Long-term research of the water quality of mountain lakes in the Tatra mountains was carried out by Czech scientists.

Snow research

Although the days with snowfall are registered at some meteorological stations in Slovakia since 1850, systematic research of snow cover from hydrological point of view started more than one hundred years later, in 1960-ies at the Institute of Hydrology of Slovak Academy of Sciences. This research evolved from the study of methodology of field measurements, variability of snow depth and water equivalents in the catchments, estimation of relationships between snow cover and vegetation, evaluation of measurements carried out in standard meteorological network to snow accumulation and melt modelling and qualitative aspects of snow cover. Some research results were successfully implemented in the water management praxis. The research was performed between 1960 and 1990-ties. After the break in the 1990-ties it started again recently. Recent work was devoted to processing of previous long-term field measurements carried out by the scientists from IH SAS in winters 1969-1992 (Holko, 2000), snow accumulation and melt modelling (Parajka, 2001, Parajka et al., 2001, Kostka et al., 2003, Holko et al., 2003), estimation of the climate change impacts on the snow (Kostka and Holko, 2000, Pecušová et al., 2004) and snow drift (Kostka, 2001). Most works were connected with the experimental catchment of the Jalovecký creek and the upper Hron river basin. Currently used tools include lumped and spatially distributed snow accumulation and melt models based on both index and energy approaches. Future research in snow hydrology will be focused on implementation of snow drift into simulations and utilization of ground photogrammetry in model validation. The role of vegetation should also be studied more carefully.

Except research preformed by the Institute of Hydrology SAS, regular measurements of snow characteristics are performed in the network of climatic stations of Slovak Hydrometeorological Institute. SHMI also organises field snow courses measurements in several mountain catchments. Evaluation of some snow characteristics from the point of view of meteorology (depth, number of days with snowfall, etc.) in selected regions is occasionally performed (e.g. Handžák, 1997, Vívoda, 2000). Avalanche protection service (APS), the operationally oriented unit provides avalanche forecasts, organises workshops for the rescue teams and mountaineers, installs protection measures, etc. The staff of APS in cooperation with the Mountain Rescue Service perform climatic and snow structure measurements related to avalanche formation at selected mountain sites. Several diploma and PhD theses supervised by the univerisites in cooperation with the Avalanche protection service appeared recently (e.g . Vojtek, 2002, Králik, 2003, Laučík, 2003, Bochníček, 2003).

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"Integrated Risk Management – Reality and Perspectives"

It is an ambitious target to bridge technological, tourist and landscape aspects (as indicated by the mission statement of the conference) concerning natural hazards like snow and avalanches. It is ambitious, because many different types of information and various scales in time and space have to be included. Integrated risk management is the key word regularly stressed upon this problem. But both, process knowledge as well as methodological knowledge and practices have to be appraised critically. Integrated risk management will need a change from deterministic to probabilistic risk assessment methods. Strongly simplified decision matrices with static hazard scenarios have to be enhanced by cost-efficiency based risk management methods with dynamic properties. The short presentation will give a draft overview of state of the art and perspectives.

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„StartClim – First Analyses of Extreme Weather Events and their Impact in Austria".

Abstract
In 2002, Austrian climatologists founded a research platform under the title AustroClim. Its goal is to meet the challenges that climate change poses to science and to support the necessary decisions that need to be made in the political and economic sectors and by each and every individual. This is to be achieved in an interdisciplinary approach that will provide the basis for the decision-making process. In light of AustroClim's call for a coordinated climatological research effort, and based on an initiative of the Austrian Federal Minister of the Environment, six funding partners[1] have commissioned the Start Project Climate Protection:
„**StartClim – First Analyses of Extreme Weather Events and their Impact in Austria**".
The BOKU - University of Natural Resources and Applied Life Sciences as representative of the AustroClim Research Platform agreed to act as the project leader for StartClim. The administrative tasks were assumed by the Federal Environment Agency.
Based on the contractor's specifications, three tasks were pursued in StartClim by a total of approximately twenty research facilities:

A Analysis of extreme weather events in the past, their impacts and economic dimensions as well as elements of future scenarios in Austria

B Synopsis of the weather factors that triggered the flood event in 2002 and their economic impacts

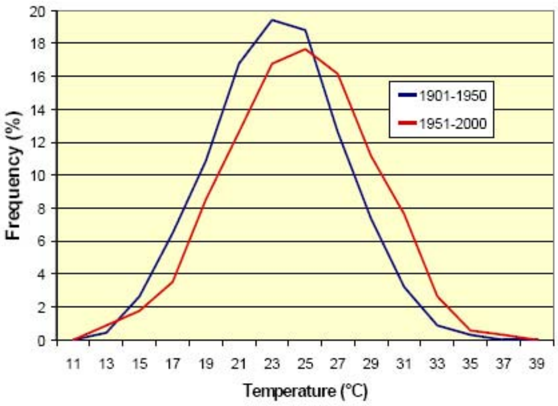
C Development of a draft concept for a long-term climate-climate change impact research program in Austria

The precondition for the analyses of extreme events as required in **Task A** is the availability of sufficiently long time series of meteorological data as well as chronicles of weatherinduced damages over a sufficiently long period, because such events are rare by definition.
The overview of available data and their accessibility was therefore an important part of StartClim.
An improved plausibility-tested data set of air temperature (mean and extremes), precipitation sum and snow height on a daily basis was prepared for 71 Austrian stations for the period 1948 to 2002. These 50-year time series are sufficient to describe single meteorological elements (e.g. daily temperature maximum and minimum) and their statistical measures, but for most parameters time series of at least 100 years are needed. The archive of daily meteorological data before 1948 was unfortunately lost during the second world war, but information relevant to extreme events can also be found in monthly data sets, e.g. monthly extremes of temperature, number of ice-, frost-, heat- and heat- days, maximum precipitation in each month, etc. These data sets were retrieved, subjected to a plausibility check and corrected where possible for 20 stations for periods extending before 1948. Methods to homogenize the inconsistencies of the data sets due to displacement of stations, changes in instrumentation, etc. are not yet available. Nevertheless, the data sets in their current state already open up a number of possibilities for analyses that are of interest to different disciplines. The analysis of the 50-year data set using extremal statistics shows e.g. for the station Vienna, Hohe Warte, a significant increase of extreme summer temperature within the last 50 years (see Figure). Note that the extremes of winter minimum temperatures in Vienna have not become correspondingly less frequent.

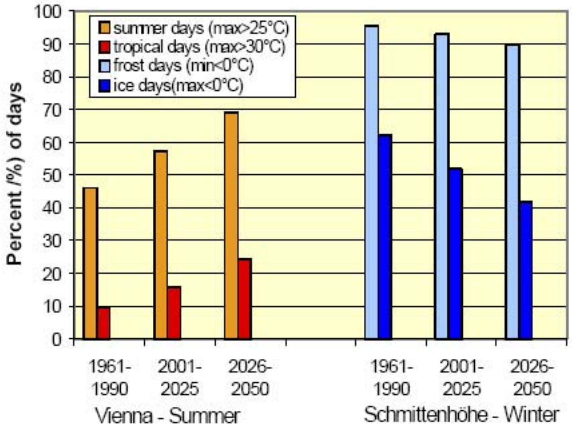
1) Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management
- Austrian Federal Ministry for Education, Science and Culture
- Austrian Ministry for Economics and Labour
- Österreichische Nationalbank
- Austrian Hail Insurance
- Federal Environment Agency

To determine potential future frequencies of extreme events, two methods were developed and tested to diagnose extreme events in different regions in Austria from global climate model (GCM) scenarios. One of these methods used a new clustering procedure to identify seven synoptic patterns which are characteristic for heavy precipitation events in Austria.
The patterns differ considerably with respect to frequency of occurrence and regional impacts. This new method, which takes weather development prior to the extreme event into account, also shows promise for storm and drought events.
The second method relies on classical statistical downscaling methods, which have not been applied to extreme events so far. Canonical Correlation Analysis (CCA) and the Analogue technique used on monthly and daily scales, respectively, lead to robust results for the temperature, while uncertainties in precipitation are much larger. For the selected global climate change scenario, the frequency of days with temperature extremes above 30°C (heat days) doubles within the next 25 – 50 years, while in about 2000 m a.s.l. (e. g. Schmittenhöhe, 1964) the warming leads to a decrease in the number of days with temperature continuously below 0°C (ice-days) by about one third (see Figure).

Frequency distribution of daily temperature maximum; Vienna – summer (Observations)



Frequency of days with temperatures above 25 and 30°C in summer (Vienna) and extremes below 0°C (Schmittenhöhe 1964 m) (Model results)



Closely linked to extreme weather events are floods, mud slides, avalanches, droughts, etc.
These events are determined not only by the weather, but also by human interventions (land use, protective measures, etc.). The survey, documentation, analysis and evaluation of the impacts of weather-induced extreme events for selected regions and sectors in Austria was one of the foci of StartClim.
An information system (MEDEA - Meteorological extreme Event Data information system for the Eastern Alpine region) was developed to eventually bring together from different scientific fields a wide range of data on extreme weather events and weather-induced events in Austria. The system has been successfully tested with a first set of data. An overall picture of an extreme event and the complete chain from weather event to possible long-term economic impacts can only be gained through the simultaneous availability of information ranging from meteorological data to data on damage, impacts, etc. Systematic inclusion of information on data uncertainty is a necessary step towards improved uncertainty and risk estimations in the evaluation of extreme events.
Two types of extreme events were studied in detail: The time series gained from the data base on torrents, set up in 1972 by the Austrian Federal Office and Research Centre for Forests (BFW) in Vienna, can be significantly enlarged by data from chronicles available at the district level, e.g. for the districts Landeck and Imst in the Tyrol (Institute for Forest and Mountain Risk Engineering– WLV), that registered events beginning in the year 1274. Methods were suggested on how the collection, administration and processing of data should be documented in the future in order to ensure largely uninterrupted records. Quantitative data on precipitation or run-off are missing in the chronicles. Sediment deposits and the number of damaged objects are only partially recorded quantitatively. In some cases the monetary value of the damaged objects is documented in the form of an overall damage estimate. The torrent database of the BFW also does not include figures on damage, apart from the reconstruction costs

of destroyed or damaged control and protection measures. The registration of damage costs is not centrally organised, and data are therefore not readily available.
MEDEA could integrate these data and make them available, e.g. for cost-effectiveness considerations for the planning of precautionary and protective measures.
The second area studied was agriculture: for seven agricultural crop species in three regions of Austria, the kinds of extreme weather causing bad harvests were analysed. The database consisted of area-based agro-statistical surveys and the monthly means of meteorological parameters from 1869 to 2002. Selected results include:

- Milder winters are especially advantageous if no extreme temperatures occur in February.This is beneficial mainly for winter cereals and grapevine.
- Dry weather in spring is especially disadvantageous for spring cereals.
- Cereals require dry weather in the harvest months to avoid yield losses.
- Dry, hot summers are unfavourable for sugar beet and corn, to a lesser extent for potato.

Insurance policies are intended to protect against excessive losses due to extreme events.
The flood event 2002 and unsuitable measures taken by the Austrian "Katastrophenfonds", a national fund for damage compensation after natural catastrophes, triggered a study that discusses reforms affecting the entire system of risk transfer from natural catastrophes in Austria. In a comparison of risk transfer systems for catastrophes in six countries, ineffective or even counterproductive elements of the Austrian system are analysed; better solutions that have been implemented elsewhere are presented.
With a focus on the specific problems of individuals, insurance companies and public authorities that face the general problem of flood risk, a proposal is made for re-designing certain elements of the risk transfer mechanism in Austria that would cope better with the issues of incentive compatibility, efficiency and social acceptability.
For five economic sectors expert knowledge was gathered on the specific impacts of various extreme weather events, the availability of data for in-depth studies, the perception of vulnerability within the sectors and on current and planned adaptation and mitigation measures.
The result indicates that insufficient awareness is often coupled with data insufficiencies; moreover, past efforts have often been restricted to technical protective measures. Integrated adaptive strategies comprising a package of technical, spatial planning, organizational, economic, and climate- and education policy measures are rare exceptions. Policy suggestions for these sectors include general political measures (e.g. enhancing public risk awareness), fiscal and regulatory measures (e.g. integrated spatial planning) and measures to ensure that basic needs can be met after natural disasters.
The second major topic of StartClim (**Task B**) dealt with the meteorological situation and the economic repercussions of the flood event in August 2002; it represents a contribution to the ongoing research program FloodRisk.
The potential of improving the accuracy of areal precipitation values elicited from a network of irregularly spaced stations by the use of the objective analytical method "VERA" was shown for the flood events 2002. Areal precipitation is an important input into hydrological run-off models and greater accuracy in real time operational services would help to obtain a better evaluation of the situation earlier on during an extreme event. A suitable incorporation of additional information, such as satellite and radar data, could boost the performance of VERA-analyses even further.
A detailed verification of meteorological forecast models with regard to the August 2002 flood event is a necessary requirement for the development of effective early warning systems. In the framework of StartClim it was quantitatively shown that the forecast skill strongly depends on the temporal and spatial scale, as well as on the observational data used, and the area under consideration. In general, forecasts for alpine areas affected by orographic upslope precipitation are more reliable than those for lowland regions because, in the latter, convective processes make a larger contribution to heavy precipitation events. The relative forecast error can be significantly reduced by increasing the duration for which a forecast (precipitation sum) is made. This is because forecast errors partially compensate each other over the duration of an event A reduction of the relative forecast error by increasing area size can be achieved only when one approaches the typical scale of a province. It is not merely the size of the catchment area but also the size of the synoptic disturbance itself that determines forecast skill. Compared to other events of the last 4 years, precipitation amounts during the first part of the August 2002 flood were forecasted poorly, whereas forecasts during the second part were better than average. Hourly maxima are still unpredictable and generally underestimated. Probability forecasts based on ensemble predictions can contribute to improved pre-warnings (or 'watches') in the sense that they yield the potential spectrum of precipitation scenarios.

An improvement in short term forecasts for extreme events might also be achieved by combining the spatial and temporal dimensions through the analytical tool VERA, as this would permit investigating small-scale flow characteristics and displacements. Key numbers to improve nowcasting of extreme weather events and to evaluate climatological time series could be developed.
Regarding the economic impact of the flood event 2002 a consistent data set of damages in Austria was collected, that has been checked for plausibility, completeness and internal consistency.
It is based on the notifications of losses to the state authorities, on additional information given by the states, the communities and municipalities, public and commercial entities and results of additional investigations.
By feeding this information into a geographic information system (GIS) visualisation of space related data and interactive queries along selected search criteria at different levels of aggregation have become possible. The geoinformation system (Database and GIS) is a valuable tool for problem oriented analysis and representation of the collected information. In case of general application for the documentation of the notification of losses after flood events (e.g. through the WEB) all data required by the different stakeholders, applicants, municipalities, state and federal administrations, auxiliary organsiations and other NGOs etc. should be included in one database and readily available. Rapid accessibility and unified documentation across district and state borders would be guaranteed and at the same time, a sound base for scientific analyses would be laid.
This database was used to run conventional model calculations in order to estimate the economic effects of the 2002 flood event. The results show that the macro-economic impacts were small and that the positive effects of the investment demand in 2002 can be interpreted as a transitory shock. The slightly negative consumption effects reflect the reduced available income of the affected households.
Adequately depicting the economic repercussions of extreme events requires going beyond traditional analyses involving the overall political economy. A concept was therefore developed to expand conventional economic models to include the key role of the interplay between stock and flux factors (e.g. possessions and money flow).
Using a Kamptal community as a case study, the disturbances the 2002 flood event triggered in the social metabolism as well as the social response patterns to these disturbances were investigated. Resource consumption rose by approximately 60% and energy consumption by 11% compared with a reference site. Opportunities to utilize potential energy-savings were largely not taken due to the restructuring measures during the reconstruction phase; the reconstruction was directed solely at re-establishing the original situation. The surveyed material and energy flows therefore exclusively represent supplementary burdens that are not balanced by significant long-term reductions.
Only few of the queried persons were fully aware of the influence that economic activities have on global ecological cycles. Although more than half of those polled considered such flood events to be a possibility, only few households had actually made contingency plans.
More information and additional incentives are apparently necessary to better utilize the inherent opportunities in such flood events.
StartClim was also involved at the interface between science and education. One group of students used questionnaires to interview about 100 relatives and family acquaintances on the issue of extreme weather events. The gathered information was compared to data from meteorological stations. This process familiarized the students with data collecting and quality control methods and at the same time confronted them with the issue of climate, climate change and extreme weather events. The data gathered by the students were integrated into the database MEDEA, making them available to the climate change research community.
Another group of students from higher grades developed their own questionnaires on the consequences of the 2002 floods. This type of cooperation between scientists and educational institutions raises the awareness of a large group of people of different ages for climate change issues. It also provides valuable information on public perception of extreme weather events and the questions that citizens are interested in when confronted with climate change. This could be helpful to decision makers in policy decisions, crisis management or insurance issues. Last but not least this adds value to scientifically gathered data because it broadens the scope by incorporating the aggregate perspective of the affected population.
StartClim projects have supplied a wealth of new data and understanding that are also of practical relevance. They have also made important contributions to the evaluation of data availability, data quality and of methods in view of their potential to help answer questions related to extreme events in a changing climate.
This work was essential for the development of a long-term research programme on climate

change in Task C of StartClim; it takes national needs and research developments into account and is embedded in the pertinent international research landscape. In cooperation with the research community, a programme was developed that is application oriented in its topics, but will also require a certain amount of basic research as well. The main questions to be addressed:

- How will the climate develop on the regional level and what will its impact on natural systems be?
- What risks and opportunities for the economy and for society can be expected through climate change and climate change policies?
- Can the understanding of alpine climates, their changes and impacts gained in Austria be of help in Africa, South America and Asia?

were broken down into a number of research activities that provide the necessary information on climate change in the strict sense of the word, and that analyse the sensitivity, adaptation potential, vulnerability or mitigation potential of individual economic sectors.

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17. Kostka, Zdeno and Holko, Ladislav

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Expected Impact of Climate Change on Snow Cover in a Small Mountain Catchment

Introduction

Snow cover is an important hydrological and water management phenomenon. Due to spring snowmelt Slovak rivers exhibit maximum discharges during spring months. It is therefore doubtless that the assessment of spatial and temporal distribution of snow cover under expected different climatic conditions is an important hydrological and water management issue. While the existence of climate change is still discussed, increase of the air temperature in the catchments are doubtless. The assessment of snow cover changes therefore remains an important task.

Mathematical modelling as a useful tool in the study of hydrological regime of the catchments can help also in the assessment of climate change impacts. Mathematical models used in such an assessment range from spatially distributed physically based models.

The distributed hydrological model WaSiM (Water Balance Simulation Model, *Schulla*, 1997) was used in this study. The simulations were performed in the mountain catchment of the Jalovecký potok creek (Západné Tatry mountains, north Slovakia). The model was calibrated to measured runoff data and snow water equivalent data from hydrological years 1989-1993 and verified with data from hydrological years 1994-1999. Calibrated model was run with the input data (precipitation, air temperature) from the period 1989-1999 adjusted according to climate scenarios CCCP and GISS for time horizons 2010, 2030 and 2075 according to *Lapin et al.* (2000). The results were then evaluated with respect to changes of the snow cover duration and the snow water equivalents in the catchment as a whole and in four elevation zones (800-1150, 1150-1500, 1500-1850 and 1850-2200 m. a.s.l.).

The Jalovecký creek catchment is situated in the Západné Tatry mountains. Catchment area is 22.2 km^2. The elevation ranges from 816 to 2178 m a.s.l. (mean 1500 m a.s.l.), mean slope is 30°. The catchment is southwest oriented. Forests (mainly spruce) cover 44% of catchment area. Dwarf pine occurs on 31% of the area, meadows and bare rocks cover the rest.

Hydrological model WaSiM was developed to simulate hydrological balance and runoff for daily or shorter time steps. It is capable to represent fast hydrological response typical for alpine and subalpine catchments (*Grabs*, 1997). The model can utilise distributed catchment characteristics and parameters. Raster maps of digital elevation model, landuse and soils were used as basic spatial information. Snow accumulation and melt was calculated by the combined method of *Anderson* (1973).

Except for the above mentioned basic raster data, model inputs consist of precipitation and air temperature data. Air temperature was measured at three stations in the catchment and its vicinity. Precipitation was measured at 6 stations in the catchment. Elevation gradients of air temperature and precipitation were used to calculate their spatial distributions in the catchment (*Kostka and Holko*, 2000).

Climate change scenarios used to change the input precipitation and air temperature data are shown in Tables 1 and 2. Monthly scenarios were recalculated to give daily input data for the model. Basically, the scenarios expect slight increase of precipitation and a more pronounced increase of air temperature.

Table 1. Scenarios of monthly average air temperature changes [ºC] for the whole territory of Slovakia with respect to the 1951-1980 normal.

Horizon	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
CCCMprep													
2010	0.5	0.7	0.9	0.7	0.4	0.6	0.9	1.0	1.0	0.9	0.6	0.4	0.7
2030	0.9	1.2	1.4	1.1	0.8	1.1	1.4	1.5	1.6	1.2	0.7	0.7	1.1
2075	2.2	2.9	2.8	2.3	2.3	2.9	3.4	3.6	3.6	3.0	2.0	1.8	2.7
GISSprep													
2010	0.3	0.3	0.5	0.7	0.7	0.6	0.6	0.4	0.3	0.5	0.6	0.5	0.5
2030	1.2	1.0	0.8	0.8	0.9	0.8	0.8	0.7	0.7	0.9	1.2	1.2	0.9
2075	2.7	2.4	2.3	2.2	1.9	1.8	2.1	2.4	2.3	2.3	2.6	2.8	2.3

Table 2. Quotients of monthly precipitation totals for Štrbské Pleso with respect to the 1951-1980 normal.

Horizont	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
CCCMprep													
2010	0.976	0.967	1.016	0.969	1.050	0.988	0.929	0.999	1.045	1.109	1.092	0.981	1.004
2030	1.003	0.992	1.052	1.026	1.094	0.996	0.925	0.999	1.052	1.131	1.132	1.012	1.026
2075	1.190	1.131	1.095	1.012	1.054	0.917	0.878	0.990	1.019	1.116	1.206	1.163	1.041
GISSprep													
2010	1.042	1.021	1.030	1.064	1.073	1.051	1.032	1.081	1.125	1.078	1.043	1.051	1.054
2030	1.017	1.055	1.077	1.075	1.082	1.074	1.049	1.088	1.148	1.117	1.052	1.015	1.067
2075	1.236	1.217	1.152	1.127	1.103	1.047	1.025	1.041	1.075	1.114	1.124	1.124	1.106

Results

As expected, increase in the air temperature lead to decrease of snow water equivalent. This decrease was caused mainly by decreased snowfall and more frequent or earlier increase of air temperature above the melting threshold. The most pronounced decreases of the snow water equivalent were simulated for the CCCM2075 and GISS2075 scenarios. Compared to present values the simulated snow water equivalent dropped almost by one half.

Snow cover duration was characterised by number of days with snow water equivalents higher than 5 mm. While at present the snow cover lasts for 181-288 days (depending upon elevation), under the changed climate it could last for 156-214 days only. The difference between the present snow cover duration and the GISS2075 duration that represents the most unfavourable conditions is typically about 1 month.

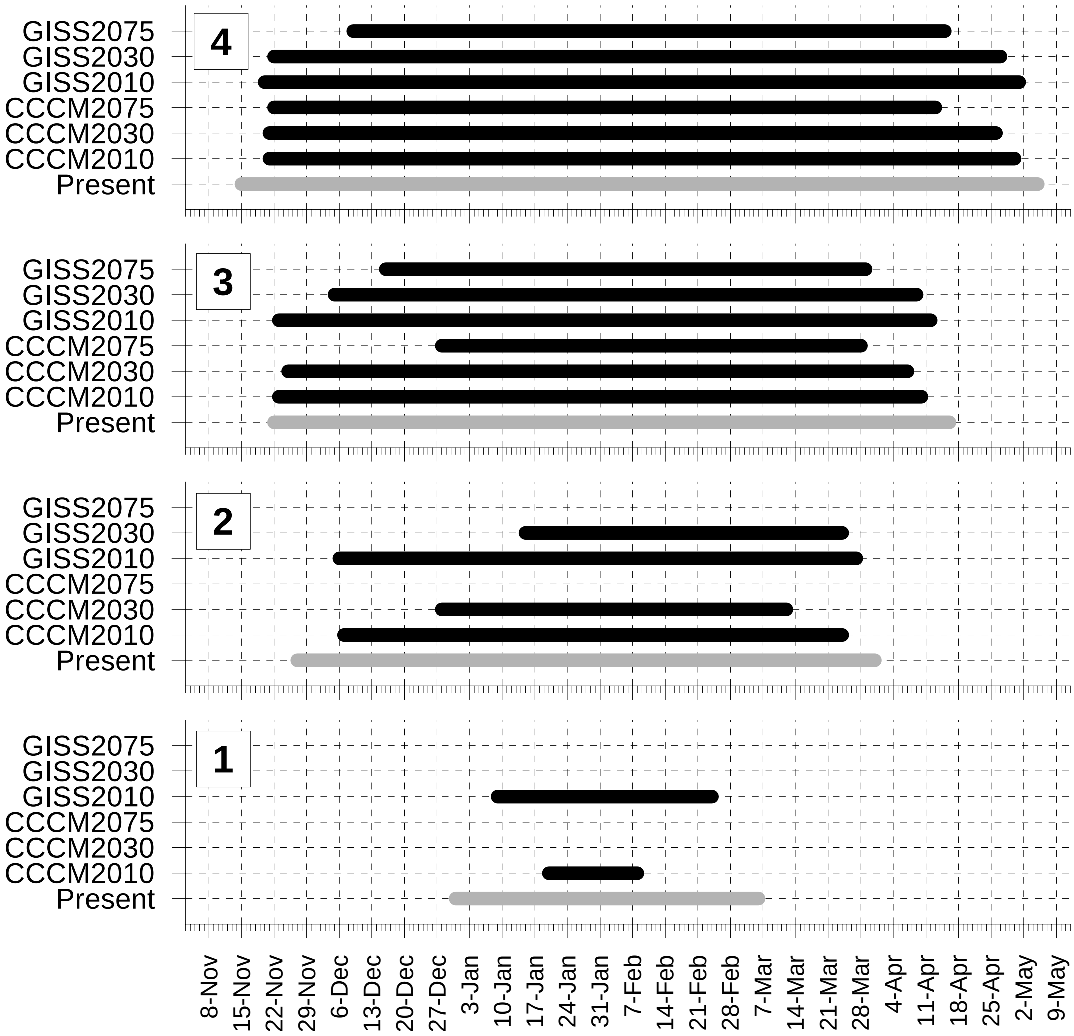

Fig. 1. Snow cover duration (snow water equivalent above 100 mm) in particular elevation zones in the Jalovecky potok creek catchment; (1) zone 800–1150 m a.s.l., (2) zone 1150–1500 m a.s.l., (3) zone 1500–1850 m a.s.l., (4) zone 1850–2200 m a.s.l..

Winter tourism and skiing are important activities performed in mountains. They depend directly on the amount of snow. Research performed in the Alps (*Abegg*, 1996) has shown that the snow cover duration of at least 100 days is necessary for economic management of winter sport facilities. Minimum snow water equivalent for the downhill skiing is 100 mm, for Nordic skiing 50 mm (*Abegg*, 1996). Figure 1 represents the duration of snow cover with snow water equivalent higher than 100 mm for the particular elevation zones. The results indicate that in the future the economically suitable conditions for the Alpine skiing at the studied territory might occur only at the highest elevations (above 1850 m a.s.l.).

Conclusions

In the paper we discuss probable changes of snow water equivalent that may result from expected change of precipitation and air temperature in the mountain valley of Jalovecký potok creek in the Tatra mountains in Slovakia. Snow water equivalents were modelled with a distributed hydrological rainfall-runoff WaSiM model. The model was calibrated and verified by field measurements carried out in hydrological years 1989-1999. Expected changes of precipitation and air temperature were taken from CCCM and GISS scenarios for horizons 2010, 2030 and 2075. Simulated duration and water equivalent of snow cover decreased for all scenarios. This decrease was simulated for catchment as a whole as well as for the particular elevation zones we have delineated in the catchment (800-1150, 1150-1500, 1500-1850, 1850-2200 m a.s.l.). The results indicate that climate change can hamper economic utilisation of winter sports facilities situated below 1500 m a.s.l.

Application of mathematical modelling in the assessment of climate change impacts is a classical approach. In this paper we concentrated only on one aspect of hydrological cycle in mountains, namely the snow cover. Though there are always many uncertainties in the modelling (model structure and parameters, input data, etc.), the effects of increased air temperature on the duration and amount of snow in the mountains are rather clear. Winter sports may directly be influenced by the change of the snowpack. However, other consequences of different snow accumulation and melt like the change of runoff regime may have more serious economical and ecological impacts.

Acknowledgment

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"Ecological Restoration of Ski Runs"

Introduction

Permanent changes took place in the entire region of the Alps during the course of the last 50 years. Wide areas used for agrarian purposes were reduced or abandoned. On the other hand, the widespread opening of power stations and intensive road building, torrent and avalanche barriers, as well as extensive infrastructural measures especially for winter tourism. 40,000 ski runs amounting to 120,000km in length were built in the last decades in the Alps and used annually by 20 million tourists (Veit, 2002).

All of the measures described lead to intensive building each year, which then requires the restoration of the areas burdened by the intrusion. But at an increasing altitude restoration is increasingly more difficult due to the rapidly worsening climatic conditions. Due to cost, restoration continues to be relinquished in some areas of the Alps, but a combination of almost always cheap restoration procedures and cheap and alien seed mixtures are turned to. The resulting ecological and often economic damage is comprehensive: soil erosion, increased surface drainage, inadequate vegetation cover, the high costs of ecologically dubious fertilisation measures and management, and flora falsification are some of the resulting effects that follow.

For fifteen years, intensive research has been carried out by various institutes to break this negative circle of events. In various research projects (e.g. Urbanska, 1986; 1997; Wittmann & Rücker, 1999; Wild & Florineth, 1999; Florineth, 2000; Krautzer *et al.,* 2003) could be proved that a combination of high quality application techniques and site-specific vegetation or seed, lead to stable, sustainable and ecologically adapted populations of high value for nature protection. Fertilisation and management measures can be clearly reduced, which make these methods useful in the medium term, as well as being economical.
The following depictions should offer a brief overview of the restoration problems in alpine environments as well as the possibilities and the necessity of ecological restoration measures, but also the necessary respect given to the limits of what is possible.

Concepts and terms

The following depictions of the ecological restoration of alpine ecosystems relate to the subalpine and alpine zones and are thus limited to the zones between altitudes of 1,300 and 2,400 metres (Ellenberg, 1996). In lower zones, the overcoming of the power of erosion is by degrees easier. At extreme altitudes over 2,400 metres, satisfactory restoration is no longer possible according to the current state of technical awareness.
In the "Guidelines for Site-Specific Restoration" (Austrian grassland federation, 2000) the important terms relative to restoration measures are exactly defined; and means accordingly: vegetation is site-specific when after generally extensive agricultural use or non-use it is enduringly self-stabilising, and when the manufacturing of agricultural products is not a prime target for this plant society. This site-specific vegetation, with the exception of finishing and development management, or possible intensive agricultural use, requires no further management measures.

Vegetation created by humans is then site-specific when the following three criteria are fulfilled:

Site adapted: the ecological amplitudes (the "demands") of the applied plant species are in accord with the characteristics of the site.

Indigenous: the plant varieties used are to be seen as "indigenous" when they are found in the geographical region (e.g. Val d'Aosta, Hohe Tauern), but at least in the same region in which restoration takes place, and are evident, or have been evident, at appropriate natural sites.

Regional: the seed or plant material used originates from the immediate surroundings of the project area and from the habitats, which in respect of essential site factors, are appropriate to the type of vegetation to be produced. Due to a lack of availability of regional seed, the "regional" criteria should be aimed at, but is not obligatory.

Ski runs and slope areas

Ski runs are emphasised as an independent focus because above all the re-cultivation of bare terrain following the erection of skiing facilities has been and is very often insufficiently carried out. Due to this situation, the important economic and tourism policies have fostered a somewhat negative image. Numerous terrain corrections at high altitudes are recognisable as extensive vegetation-free areas with a high erosion potential after decades of operation, and despite some "restoration attempts" are seen as "wounds" in the landscape. Above all in relation to the re-cultivation of such technological skiing areas is the lack of a definition relative to the latest advances in the field, and the lack of contractual and realisable legal nature-protection criteria and guidelines is especially flagrant. In numerous cases, permanent ecological restoration was brought to agreement in decisions supporting legal nature-protection as well as in tenders, but were never realised. We have unfortunately all too often been satisfied with the argument "We have tried everything, it simply doesn't work better". In this respect, it is to be maintained that there where the sites are beyond restoration, according to the latest advances in the field, terrain-changing measures are to be relinquished. This is above all true at altitudes over 2400 metres and for plant societies that are found within exposed alpine grasslands (e.g. those comprising curved sedge, horst sedge, etc.). Interception in these plant communities, of which there are no seeds currently available, and according to the latest advances in the field cannot be manufactured similar or identical to nature, is to be generally relinquished.

An area used as a ski run in winter is subject to the following special site factors:

- Extended snow cover, generally longer than is natural at the given altitude.
- A relatively dense snow cover, in some cases with deposits of ice layers, which in the six months of winter hinders the exchange of oxygen between the plant cover, the ground and the atmosphere.
- The effect of mechanical disturbance factors, such as the effect of steel edges and the chains on ski-run preparation machinery. These effects can have a destructive influence on vegetation, above all on rounded hills and steep slopes.
- Increased drainage response of surface waters. Because precipitation increases with altitude, a relatively high drainage rate is to be reckoned with in ski run areas, which compared to forests and areas stocked with shrubs, only on runs based on herbal vegetation can disposal take place without danger through appropriate technical measures (diagonally running and open drainage channels).

These points place additional stress factors on the vegetation cover. Above all at increasing altitudes, with the related shortened vegetation period, this is to be taken into consideration in connection with other stress factors (such as grazing). Thus in some high-altitude areas the double burden of skiing and grazing is only possible after several years when the vegetation cover is fully stabilised. There are also cases in which this double burden is to be excluded; that means that before construction begins, one must choose either the construction of ski runs and appropriate re-cultivation measures, or agricultural grazing. Appropriately considerate re-cultivation planning agreements are to be seen as an indispensable part of the project.

General criteria for ecological restoration

For ecological restoration the following general criteria, which are to be adapted to respective individual cases, are to be given.

1. A state of acceptance is given when restoration shows a condition of development that ensures the achievement of the restoration aims or is appropriate to the same.
2. The sown or planted vegetation must have survived two rest periods and frost phases before being accepted at high altitudes. The acceptance date during restoration must therefore be set for the early summer of the next year but one. In the special case of high altitudes, acceptance should take place following two summer periods and two frost periods. Special agreements are to be made for special cases (e.g. a rehabilitation project).
3. Additional fertilisation should take place only in relation to the nutritional supply of the substrata and the desired restoration aims. Overly rich and thus divergent vegetation created by over fertilisation has no acceptance capacity.
4. Restoration created by seeding should form a uniform cover, which in an uncut state, unless otherwise agreed, must show at least 70% of the projected ground cover. In cases where restoration has taken place, a divergent ground cover can be brought to agreement. Vegetation-free patches of over 20 x 20cm are not permitted, whereby vegetation in this sense is to be seen as comprising only vascular plants. The stock must comprise up to 60% of the projected

cover with those species given in the seed mixture, or laid down as a restoration target (type of vegetation). The annual state of the plants, according to species, is to be taken into account when mediating the degree of cover. Nursery or alien vegetation does not count among the desired degree of cover. Divergent cover values or acceptance conditions, above all in the restoration of difficult sites, are to be contractually agreed and taken into account during acceptance.

5. The available topsoil should be carefully removed and stored before building begins. The diaspora material it contains, as well as the remaining pieces of vegetation, makes rehabilitation possible with vegetation from the original site. A further possibility is the lifting of grass turf or larger pieces of vegetation for reapplication to the levelled area. The intermediate patches should be restored with a mulch seed. The introduction of a grass sward of forest vegetation is generally not suitable for ski runs cleared within nature.
6. Exclusively re-cultivation techniques are to be used in most cases because they guarantee sufficient protection of the topsoil. This included seed processes combined by means of covering the topsoil with a layer of mulch, net or seed mat, as well as hay-mulch seed. When using hay-mulch seed and threshed-hay seed, it is necessary for an expert to make the decision for extra cover.
7. Planted pieces of vegetation must be firmly rooted. In the fringe areas of the planted grass swards, no appearance established of drying out or erosion should be apparent.

Seed mixtures

The conventional "high-zone mixtures" available on the market mainly comprise high-growing non-site-specific lower plants originally bred for grassland economy in valley locations or as grasses for sporting events. These species are adapted to lower, warmer locations and are generally not suitable for restoration in high zones (Florineth, 1992). The high nutritional needs of these species require long-term, expensive fertilisation measures to achieve the necessary grass density. Also relative is a high biomass production, which again requires regular cutting, grazing or removal of the materials arising because in the short vegetation period, no sufficient decomposition of the additional growth of biomass takes place and the chocking of the vegetation stigma would be the result. In many cases, further use or management of the restored areas is also no longer wished for or possible.

Site-specific subalpine and alpine plants are adapted to an optimum degree to the high-zone climate. They produce little biomass, but with an appropriate choice of species, they do produce high-quality feed. Seeding with site-specific seeds generally require only slight amounts of nutrition, and short-term management measures lead quickly to natural, generally extensive self-maintaining grass, which has high persistency against subsequent uses for tourism and agriculture. With the use of site-specific seed mixtures, the required sowing volumes commonly used in practice can be lessened from 200 to 500kg per hectare to 80 to 160kg per hectare. Grasses and leguminosae were selected within the sphere of several international research projects, which are suitable for seed production in valley locations and can be used in various site-specific alpine seed mixtures (Krautzer *et al.*, 2003). In the meantime, the ecological species suitable for high zone restoration will multiply over a broad area, graded according to altitude, original rock and usage in high-quality restoration mixtures and brought to the market. The use of such site-specific seed mixtures (e.g. www.saatbau.at) should be obligatory when sowing in high zones.

Fertilisation

Restoration in the area of ski runs is generally only successful with the use of seeds or plants interacting with proper fertilisation. A poor volume of minerals available to plants is mostly shown in areas after levelling. Rapid development of the seeding to a full grass cover is also necessary in site-specific restoration for rapid erosion protection at such sites. A single fertilisation of such areas is generally sufficient with a suitable fertiliser for establishment. If in the second year of vegetation an insufficient vegetation cover is achieved, further fertilisation measures to achieve a sufficient grass density is necessary. These measures can also be combined with seeding-over with a site-specific seed mixture. With the achievement of relatively dense grass cover, the measures can be limited to unsatisfactory patches of the area.

Fertiliser of a slow and permanent effect should be used, and which promotes the build-up of humus and has good plant tolerance. Attention should be given to achieving a balanced nutritional relationship. To be avoided is the use of roughage-promoting or unhygienic fertiliser. Where possible such organic fertiliser as well-rotted farmyard manure, composted fertiliser or certified biological compost (according to the existing legal regulations) should be used. The use of fluid and semi-solid sewage is to be avoided. The use of organic-mineral fertilisers with the appropriate characteristics (slow, permanent release of nutrition) is possible. Their use should be limited to the necessary degree in relation to the positive additional effects of the organic fertiliser (multiple effect, deposit effect, herb tolerance, build-up of humus).

Fertilising measures should only be carried out to achieve a sufficient degree of cover. Only slow, permanently effective and ecologically safe fertiliser that promotes the build-up of humus is to be used for restoration. This requirement is above all fulfilled by organic fertilisers (home-produced commercially available fertilisers), which are also authorised for biological farming. To be especially recommended is well-rotted farmyard manure. The use of fluid and semi-fluid sewage as fertiliser is unsuitable and to be avoided.

Utilisation

Constant utilisation is not obligatory or necessary following the use of site-specific seed mixtures. With the appropriate composition of the seed mixtures or the use of appropriate plant materials, a restoration area can be left to itself, which is greatly desired for the restoration of areas prone to erosion, constructions for the regulation of torrents and avalanches, etc.

Utilisation of ski run restoration is in most cases also necessary in areas not used predominantly for farming. Utilisation takes place in the form of extensive grazing or annual mowing, with or without the removal of organic material (in only slight amounts of biomass).
Above all, in the first years of seeding accompanied with fertilisation, cultivation of ski areas must take place. Until the achievement of sufficient grass density, at least over the first two vegetation periods, no grazing is to take place on the areas. Annual mowing is necessary following the achievement of appropriately lush growth. This mowing removes biomass and thus hinders the stifling of the growth in winter. Sprouting of the plants is also stimulated and the grass density is promoted. On steep and footfall-sensitive areas, grazing is to be hindered by fencing, if necessary, in favour of mowing.
With a slight degrees of cover (< 50%) the year following restoration, further necessary measures are to be laid down, such as reseeding with a site-specific seed mixture (30 to 50kg per hectare). When necessary, appropriate improvement work must be undertaken in small areas.

Techniques for establishing site-specific vegetation at high altitudes

Simple dry seeding

This method may only be used when combined with a covering of the topsoil by means of a layer of mulch, netting or seed matting. One sees simple dry seeding as the introduction of seeds and fertiliser in a dry state with no additional support substances. It is very suitable for level terrain (use of diverse sowing machines), but can also be used on banks with a rough topsoil.

Degree of seeding: up to 10g/m² on level areas
up to 18g/m² on steep areas

Cover-crop seeding

This method may only be used at high altitudes when combined with a covering of the topsoil by means of a layer of mulch, netting or seed matting. For this seeding method winter rye, oats or barley (the latter is only suitable in the spring and summer) is worked into the soil and the remaining seeds sown over them. Due to the rapid accumulation of the cover crop in the soil, a rapid covering of the open areas of earth takes place. Nevertheless, this effect is strongly inhibited by severe climates at high altitudes. The actual restoration seed develops between the cover crop and finally forms the site-specific vegetation. This method is above all suitable for steep ski runs or banks strongly exposed to the sun. At lower altitudes the cover crop must be mowed and cleared on time (at a max. height of 30cm) or it will oust growing and enduring vegetation when dying-off leaves large patches.

Seed volumes: 5 - 10g/m² winter rye/oats/barley
10 - 15g/m² seed

Wet seeding or hydro-seeding

This method can only be used at high altitudes when combined with a covering of the topsoil by means of a layer of mulch, netting or seed matting. In this seeding method seeds, fertiliser, mulch material, soil adjuvant substances and gluten are mixed with water in a special spray container and sprayed over the areas to be restored. Even steep banks with a smooth surface can be restored in this way, whereby the rapid emergence of the seeds has above all proved to be advantageous against erosion processes. On steep slopes, the seed-fertiliser mixture can be sprayed over an affixed jute net. In extreme cases, this method can also be undertaken with a helicopter.

Material expenditure: to a maximum of 25g/m² of seeds

100g/m²	organic fertiliser
80g/m²	cellulose, peat-substitute material, very short straw
100g/m²	algae products as gluten
(10 - 30g/m²	chemical gluten)

Because peat can be replaced in the hydro-seeding method with alternative materials, use of this ecologically questionable raw material is to be avoided for site-specific restoration.

Mulch seeding

In the mulch seeding process, soil and seeds are covered and protected with various organic material. For optimum growth the depth of the layer of mulch should not be more than 3-4cm and pervious to light. The most common mulch materials are hay and straw.

With the simple hay or straw seeding methods, a 3-4cm straw or hay cover is applied over the seeding. The prerequisite for this restoration method are sites that are protected against the wind and are not too steep. The material expenditure is 300 - 600g/m² in a dry state.

The hay mulch seeding method is perfectly appropriate for site-specific restoration. Through the application of well-matured hay from the immediate vicinity, seeding with commercial seed can be avoided insofar a slow vegetation development is possible. The hay cover also acts as additional erosion protection.

At steep points, especially above the tree line, the bitumen straw-cover seeding method is suitable. Seeds and fertiliser are applied into the 3-4cm straw layer and an unstable bitumen emulsion sprayed over it (not to be used in drinking-water protected areas). Hay is not as suitable for spraying with bitumen because it is compressed; due to thinner stalks and better cohesion, hay cover seeding alone is more stable than straw. Hay and straw can also acquire sufficient cohesion through light organic gluten.

Seeding techniques with the use of netting and seed matting

A number of geological textiles are commercially available. This netting of jute, coconut fibre, synthetic fibres or wire can be used for all previously described restoration processes. When possible, use of synthetic fibres and wire netting as a planting aid in site-specific restoration should be avoided. Geological textiles are used predominantly where there is a clear danger of erosion or extreme site conditions (e.g. on very steep ridged banks). They offer the possibility for stronger surface protection and, according to the materials used, are more or less stable in the face of natural forces such as falling rock, snowdrifts, precipitation, etc. According to the material, site conditions and altitude, the netting rots within one to four years with no residue. Galvanised iron and synthetic fibre netting have a lifespan of around 30 years and are not biologically degradable. The danger of residue exists.

Seed matting is filled with wood-wool, coconut fibres, hemp, straw or other natural fibres, which is sewn into finely stepped jute netting. The seeding is mostly contained in the seed matting. This seed matting requires full contact with the soil and can therefore only be attached to flatter and smooth earth surfaces.

Combined seed-sward process

In this special restoration technique, the covering with grass swards, or other pieces of vegetation, is combined with dry or wet seed. The grass swards used must be appropriate to the desired, site-specific type of vegetation and are generally acquired in the project area at the beginning of building work or in the immediate vicinity. There can therefore be cases of an interception in the vegetation sphere beyond the immediate project area to achieve optimum success through the "division" of available vegetation. The area to be restored is therefore often larger than the original project sphere.

The grass swards (02 - 05m²) are placed in groups in dry locations to prevent them from drying out and grid-like in areas subject to high precipitation in the area to be restored. Site-specific seed is applied to sparse patches between the swards. This seed has a stabilising effect on the vegetation-bearing layer. Due to the short distances between the covered grass swards, it is possible for well-established vegetation to move into the intermediate spaces. In this way, these patches will also be restored and inhabited in a natural way by species not available as seeds.

The conception of this restoration technique, and above all the selection of grass-donor areas, is only to be undertaken by appropriate experts. In steeper areas (over 30% slope gradient), and in terrain endangered by erosion, the use of geological textile matting or similar is planned for securing the covered vegetation or for the protection of the topsoil against erosion.

Ready made sward (sod rolls)
Sod rolls with site specific vegetation are already available in small amounts for differing starting substrates. Sod rolls are produced at specialised firms over a period of around 12 months until the sufficient development of site-specific altitude species is ensured. According to need and restoration aims, certain grass mixture can be produced beforehand. The grass is then harvested to order and transported to the restoration area. Thus is the shortest possible time a complete cover of restoration areas is possible. Especially interesting is this method in restorations following small-area interception and in extreme locations.

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"Avalanche Bulletin and Hazard Scale: a Basis for Modern Safety Strategies in Alpine Regions"

1.) In the winter of 1993/94, the European Avalanche Hazard Scale was introduced in France, Switzerland, Italy, Germany and Austria.

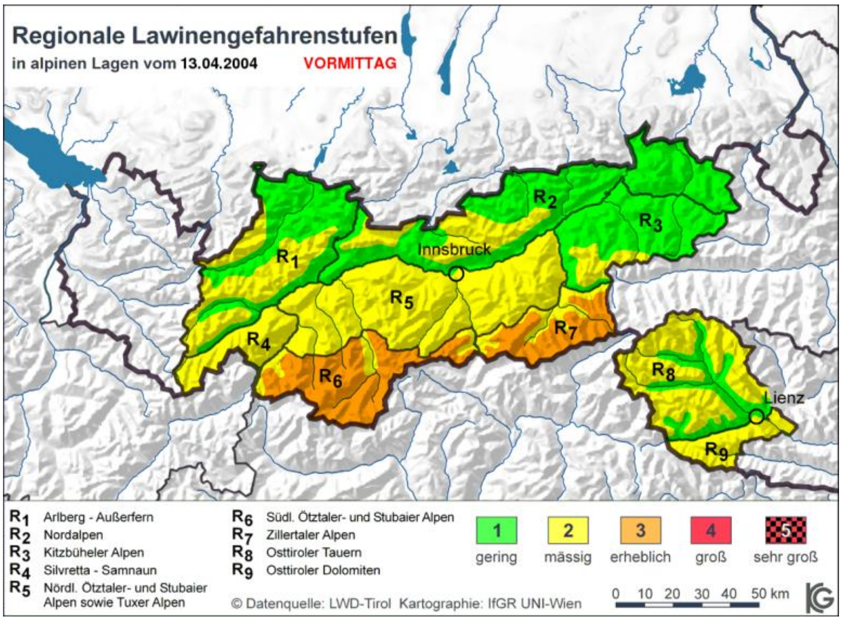

Fig.1 Map displaying Avalanche Hazard Scale Applied to Tyrol

2.) The degree of hazard is determined by a combination of the distribution of hazard sites and the probability of an avalanche release.

Lawinenwarnzentrale

Probability of Avalanche Release

Distribution of Hazard Sites	generally only with large surcharge	particularly with large surcharge (possibly also with small surcharge)	already with small surcharge **possible**	with small surcharge **probable**	or	Spontaneous release of medium, in some cases large avalanches **possible**	Spontaneous release of many medium, in several cases large avalanches **probable**	Spontaneous release of many large avalanches **probable**
single hazard sites (specifiable in avalanche report *)	1	2	2	2		2		
hazard sites on **some steep slopes** (specifiable in avalanche report *)	2	2	3	3		3		
hazard sites on **many steep slopes** (specifiable in avalanche report *)	2	2	3	4		3	4	
hazard sites on many steep slopes **)	2	3	4	4		4	4	5
Hazard sites **also in moderately steep slopes**				5			5	5

*) specifiable with respect to altitude, exposition and/or relief
**) the hazard sites are too numerous or too diffusely distributed to be specifiable with respect to altitude, exposition and/or relief

Auxiliary matrix for the avalanche report
27.05.2003

Fig.2 Probability of Avalanche Release

3.) Every day, the Avalanche Warning Service of the Tyrol creates an Avalanche Bulletin, which includes the actual degree of hazard and an up-to-date weather forecast as well as information about snowpack stability and various dangerous zones.

4.) Tyrol is divided into 9 regions, for each of which a specific degree of hazard is determined. It is also possible to specify a different degree of hazard according to the time of the day (morning/afternoon) or different height levels.

5.) The most important parameter in evaluating the avalanche danger is the steepness of the slopes: the steeper the slope, the more dangerous it is. Excellent information on this is available on the internet: www.lawine.at

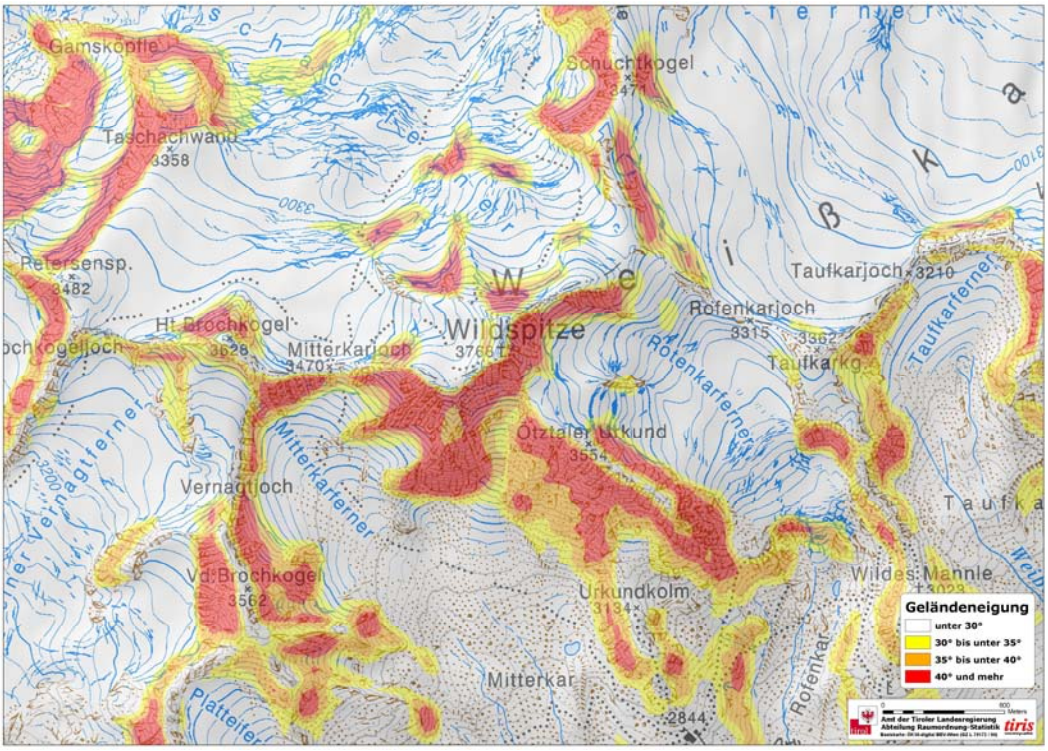

Fig.3 Map Displaying Steepness of Slopes

6.) If modern safety strategies with basic limits had been used, 85% of all avalanche accidents in the Tyrol since the introduction of the European Avalanche Hazard Scale in 1993 could have been avoided! Therefore an avalanche bulletin specifying the degree of hazard as accurately as possible, combined with a consideration of basic limits regarding slope steepness is a very suitable tool for the prevention of most avalanche accidents.

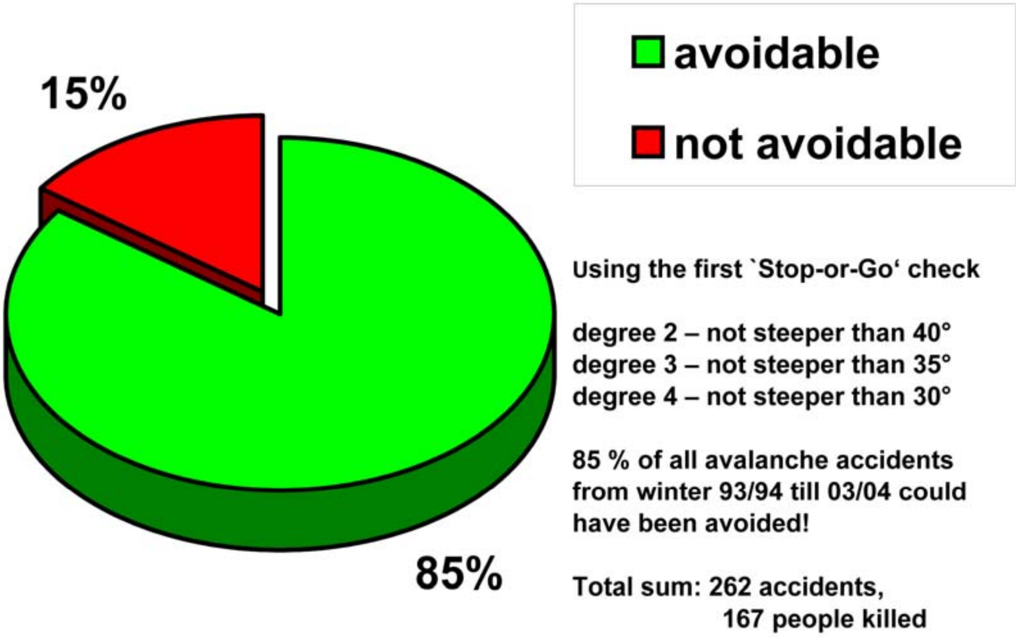

Fig.3 Avoidable Avalanche Related Accidents

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"Landscape Approach In Study Of Snow"

Introduction

Snow is a specific component-factor, usually sezonal one, of the majority landscapes of different hierarchic levels – from the elementary landscapes to the complex one. We regard landscape as a geosystem with interaction between its components – relief, soil, water, air mass, biota (plants and animals) on the certain area and of similar genesis. Snow plays a vital role in the functionality and dynamics of nature and in the life of the people, particularly in the Northern Eurasia. It determines the character of all components of landscapes, the activity of exogamic processes, such as nival, erosion, avalanches and so on, causing changes in the most stable component of landscapes – lithogenic basis (relief and rocks) (Richter, 1948; Yashina, 1960; Geography of avalanches, 1992 and etc.). It was ascertained that even the areas of some species of animals correlate with isolines of certain snow depth (Formozov, 1990).

The spatial and temporal variability of snow cover also depends on the features of other components of landscapes and of the character of the whole landscape (Kolomyts, 1976; Nefedieva, 1977 and etc). As snow reflects changes in nature, firstly of meteorological parameters it can be regarded as a very informative indicator of climatic changes, of winter state and functionality of landscapes. That is why landscape approach must be used in the study of snow cover.

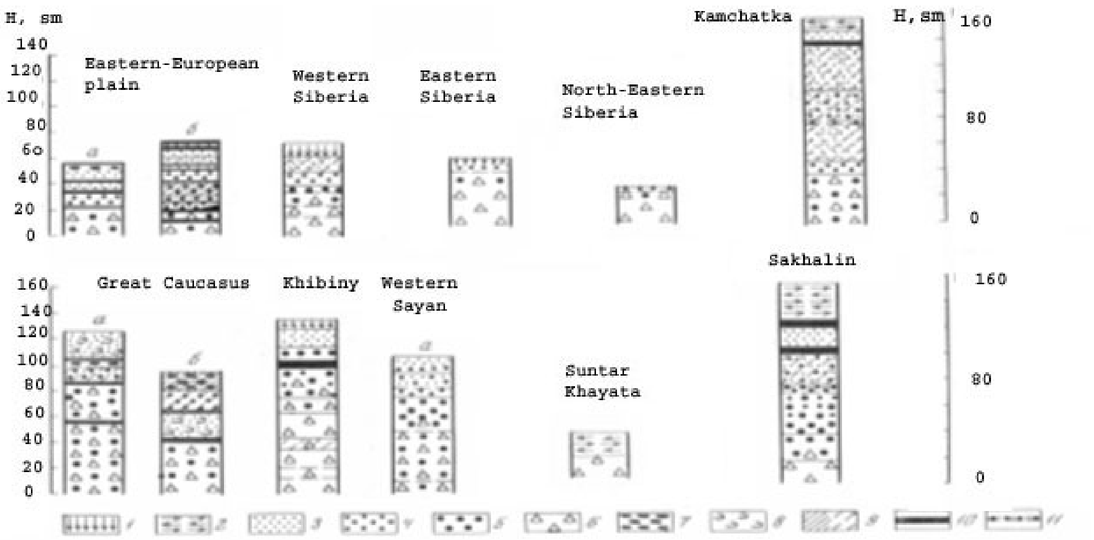
Results and discussion

Landscape approach we used in the study of snow cover of Russia, which is characterized by most complex spatial and temporal variability of snow in the Northern Eurasia due to the geographical position, large territory and diversity of landscape structure. The whole territory of Russia in winter has snow cover of different depth -- from 10 sm to 80 sm and more. The time of its existing increases from few days in the south-west of the country to more than 240 days in the north-west (Atlas of snow-ice resources, 1987).

Our field study in some regions of Russia and analysis of published data (Yashina, 1972; Revyakin, Varganova, 1973; Kolomyts, 1976; Kopyl, Nikolaev, 1993; Drevilo, 2000 and etc.) showed that spatial and temporal variability of snow cover depends on the features of nature landscapes of different hierarchic levels in what it forms. It can be mentioned that different changes of snow structure parameters are typical for regional and local levels. The changes on the regional level appear: 1/ in the different physical-geographical countries – mountain and plain, for example, in the Eastern European plain, Western Siberia, Caucasus and so on; 2/ in different zonal and sub zonal types of landscapes – tundra, taiga, steppe and so on; 3/ in different meridian sectors – oceanic, moderate continental, continental, extreme continental and so on; 4/ in different physical-geographical provinces – of low plains, high plains and etc, for example, in Middle-Russian high plain or Oksko-Donskaya low plain; 5/ in different concrete landscapes. On the local level the vertical structure of snow depends on the features of elementary landscapes and microlandscapes.

The snow cover on the regional level firstly reflects different climatic conditions of their formation and than the character of the surface – the relief, the combination of vegetation, soils and so on.

The longitude-sector differentiation of snow cover from the west to the east reveals more clearly due to the climatic changes in this direction in winter. Different types of snow vertical structure are typical for these sectors (Fig. 1).



Stratigraphy of snow: 1 - new snow, 2 - wind snow, 3,4,5 - different snow grains, 6 - depth hoar, 9 - dense snow, 10 - ice layers, 11 - firn layers

Fig.1 Change of vertical structure of snow in plains and mountanous regions of Russia from west to east

More complex columns of snow with high depth, with sharp stratigraphy of different layers form in the oceanic and moderate continental sectors, for example for Eastern European plain, Kamchatka, due to the more rapid changes in the meteorological parameters in winter with several periods of snowfalls and melting.

The simple vertical structures appear in the continental sectors. The decreasing of snow depth and density, increasing of depth hoar layers, prevailing of wet snow during the whole winter are distinguished features of continental types of snow vertical structures. The snow structure forms in the continental regions according to the epigenetic type, while in moderate continental conditions - to the singenetic one. The spatial variability of snow becomes less complex with increasing of the degree of continental climate. The simplest structure is typical to the regions with extra continental climate.

Zonal types of landscapes are also characterized by different snow structure. The zonal vegetation which is closely connected with climatic features play very important role in changes of snow cover. In tundra as an afforest zone the snow cover is characterized by rather high variability in depth due to the typical strong winds, particularly on the sea coasts. Thus the average volumes of snow migration in this zone reach 550-907 t/m^2, increasing near the coast to 907 t/m^2 (Snow, 1986).

The increase of the snow variability on the regional level is typical for forest-steppe and forest-tundra types of landscapes, which are specific regional ekotons, due to the complex combination of forest and open land territories as well as for the forest boundaries on the site level. Taiga zone is characterized by lower spatial variability of snow, particularly in the typical sub zone of taiga with high density of trees. The depth of snow here is rather low. In the zone of mixed forests the snow variability is more complex.

Every zonal type and subtype of landscapes is characterized by specific internal landscape structure, reflecting also in the changing of snow structure. Thus in the forest zone the density of snow and it depth is usually larger on the open lands of plakors than in the forest geosystems, determining different snow-water equalants. Study of forest landscapes of mixed type showed that the lower snow-water equalants are typical for forests, particularly to the coniferous forests of continental sector of the Eastern European plain. The snow depth in the leaved forests is higher than in the coniferous forests as well as in the forest geosystems on the plakors in comparison with open lands due to the winds. The snow melting in the meadow geosystems in the forest zone in the south of the Moscow region begins for 10 days earlier than in the coniferous forests. Maximum of the spring floods is often correlated with the last days of snow melting on the open lands of water catchments (Kuzmin, 1968). The snow-water storage in the taiga landscapes is 2-3 times lower than in the mires. Rapid melting and run-off in the permafrost regions cause the increasing of erosion processes and formation of erosion landforms as well as high floods.

It was ascertained that snow structure on the local level in the plain landscapes is most closely connected with humidity of geosystems (Kolomyts, 1976), for example with mires, which are also typical for different zones; mainly for tundra, forest-tundra and taiga. The intense recrystallization of snow pack occurs in the humid regime of soils and ground.

In the mountains regions the spatial and temporal variability of snow structure (snow depth, stress, density, thermal characteristics, stability of snow) are closely connected with morphology of the slopes. Thus, the density of snow varies on the gentle slopes in the high mountain .landscapes of the Caucasus from 417 kg/m^3 to 345 kg/m^3 on the convex slopes and to 397 kg/m^3 on the concave sites of slopes. In such landscapes in more continental Eastern Siberia this parameter varies from 227 kg/m^3 to 219 kg/m^3 and 255 kg/m^3 accordingly (Golubev, Sokratov, 2004). More favorable conditions for formation of layer of a depth hoar are typical for steep slopes composed of detrial rocks.

The variability of snow cover mountain regions is very complex due to the complexity of landforms, vegetation, rocks, and climatic conditions and so on. The remarkable feature of mountain regions, which is closely connected with snow structure, is the activity of snow avalanches. Landscape approach had been undertaken in their study in the Central Caucasus, which is characterized by extreme activity of avalanching.

Landscape mapping and profiling were used while study. It was turned out that the majority of avalanches are typical for the subnival, alpine and sub alpine landscapes with postglacial landforms, steep slopes and ability of snow cover (Fig. 2).

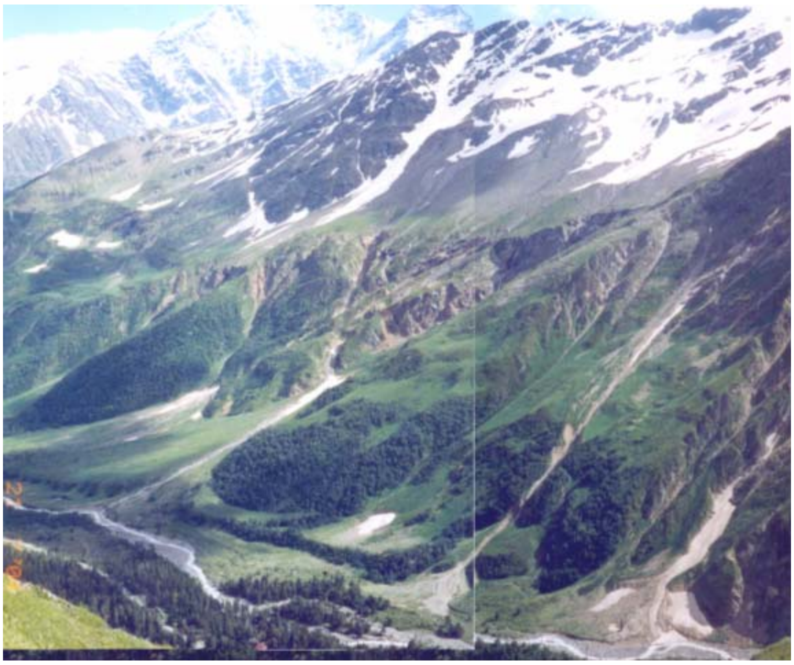


Fig. 2. The northern slope of high mountain range in the Elbrus region with a lot of avalanche geosystems

Different landscape changes occur in the zones of avalanching, depending on the type of avalanches, their activity, the internal features of affected landscapes. The wet avalanches usually destruct the whole elementary landscape, while powder ones change vegetation, mainly forests only. Geosystems with coniferous forests are more affected than those with leaved forests or meadows. As a result of prolonged avalanche impact, a series of elementary landscapes or microlandscapes with different vertical structure (different vegetation and soils firstly) appear. We can use these series as an indicator of frequency and duration of avalanches. The extreme patterns of dynamic sequence are geosystems with coniferous forests, on the one hand, and with sub alpine meadows, azonal for the forest landscapes, on the other. Subalpine geosystems exist on the territories with regular avalanching, usually under the action of powder avalanches. The geosystems with sparse subalpine or even alpine meadows and willow stand indicate also the annual avalanching. The geosystems with mature birch-pine forest indicate the action of avalanches approximately once in 30-50 years and with pine forests – not more often than once in 50 years or even rare. Different landscape spatial patterns indicate the zones of avalanches of different type and frequency. The complex one is typical for the cascade systems, forming on the slopes (Fig. 2).

Conclusions

The snow cover reflects in it structure the main features of landscapes and their components. The most common features of snow structure correlate with regional (zonal, longitude-sector and altitude belts) characteristics of winter climatic conditions. Several types of vertical snow structure can be revealed on the regional scale of investigation. The complex ones are typical for the regions with moderate continental climate, simple - to the extra continental areas. The mountain landscapes are characterized by very diverse snow cover. The spatial and temporal variability of snow structure on the local level are closely connected with relief, vegetation, humidity of soils and ground. The snow structure can be used as an indicator of landscape state and functionality in winter conditions and as informative component of landscape.

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"Relationships of Major Ions and H_2O_2 in Snow Fall and Rime at Sonnblick Observatory (SBO, 3106 m) and Implications for Scavenging Processes in Mixed Clouds"

Abstract

According to the processes in the seeder-feeder mechanism the composition of snowfall is determined primarily by the amount of attached rime droplets (in the supercooled liquid region of the cloud system) to originally unrimed sublimation grown ice crystals. In our experiment we determine the composition of snow fall and rime and infer information about the composition of the unrimed ice crystals.
Snow fall and rime samples have been collected at the Sonnblick Observatory (SBO, 3106 m) during a four year time period and have been analyzed for major ions (Cl^-, NO_3^-, SO_4^{2-}, H^+, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}) as well as for S(IV) and H_2O_2. The seasonal variations of the concentrations of the "anthropogenic" major ions (NH_4^+, H^+, NO_3^-, SO_4^{2-}) exhibit spring maxima for rime as well as for snow samples. Crustal elements (Ca, Mg, Na, K) as well as chloride showed no pronounced seasonal variation in snow, however, spring maxima for rime samples.
The spring maxima of the crustal elements and chloride in rime originated from a couple of Saharan dust events, during which no snow fall was observed. The maximum of the H_2O_2 concentration in snow was observed in summer. In rime the H_2O_2 concentration was elevated above the annual average in spring and summer. The S(IV) concentration exhibited maxima in snow and rime during winter and spring. We applied the Brantner et al. (1994) snow/cloud mass balance model for estimating the relative mass of rime droplets attached on ice crystals. The rimed mass fraction on the yearly average is in the range of 20 - 30% - depending on the method of calculation.
There is little seasonal variation except for fall with a slight increase of the rimed mass. There is indication for considerable gas phase scavenging of SO_2, NH_3, HNO_3 and H_2O_2 directly on the ice crystals. Crustal elements (Ca, Mg, Na, K) as well as chloride appear to become scavenged predominantly via ice nucleation. Our tentative estimates indicate that as a lower limit NO_3^- in snow fall is derived to more than 35% from direct gas phase scavenging onto ice crystals and crustal elements in snow are derived more than 60% from ice nucleation scavenging. The estimated contribution from the ice crystals to the "free H_2O_2" determined in snow is even around 90%.

These results are lower limits as for sulfate the ice crystals concentration was assumed to be zero. If sulfate (presumably in low concentration) is also present in the ice phase, the fractions derived for the other components would increase.

Key word index: Snow, rime, supercooled cloud droplets, mixed clouds, precipitation scavenging, nucleation scavenging, ice nucleation, snow chemistry, chloride, nitrate, sulfate, calcium, magnesium, sodium, potassium, sulfur dioxide, ammonia, nitric acid, Sonnblick, ALPTRAC.

INTRODUCTION

In simultaneous studies of cloud and precipitation chemistry it has been generally observed that sulfate and nitrate concentrations in suspended cloud droplets are enriched relative to the respective concentrations in precipitation such as falling snow or rain (e.g. Borys et al., 1988; Mitchell and Lamb, 1989; Weathers et al., 19xx; Collett et al., 1993; Brantner et al., 1994; Kalina and Puxbaum, 1994a; Dixon et al., 1994; Baltensperger??). This effect has been explained as a result of the seeder-feeder mechanism, which is the dominant precipitation-forming process in continental clouds (Pruppacher and Klett, 1980). In this process sublimation-grown ice crystals, which contain very minor amounts of sulfate, fall through layers of supercooled cloud droplets, which contain sulfate from nucleation scavenging of sulfate aerosols and from reactive gas scavenging of SO_2. The amount of cloud droplets which become attached to the falling crystals due to impaction freezing ("riming") determine the concentration of sulfate in the crystal in and below the cloud respectively in the rain drop after falling through the melting zone.
Brantner et al. (1994) have proposed a first order approximation of estimating the mixing ratio between cloud water from supercooled droplets and ice phase in the riming process. As a first order approximation the concentration of a compound in snow (C_S) can be described as a mixing process of the mass fraction ‘a’ of ice phase of the concentration C_I and the mass fraction ‘b’ of cloud droplets of the concentration C_R (eq 1):

$$C_S = a*C_I + b*C_R \qquad \text{(eq 1)}$$

with C_I concentration of a component in unrimed ice phase (unrimed snow)
C_R concentration of a component in cloud droplets (rime droplets)
C_S concentration of a component in snowfall (ice phase after riming)
a relative mass fraction of ice phase
b relative mass fraction of cloud droplets
with (a+b)=1

Assuming a negligible concentration of sulfate in the ice phase (C_I=0) then the ratio C_S/C_R for sulfate can be used to estimate the relative mass of cloud droplets in the resulting rimed snow (according to Dixon et al., 1994; b is called the "rimed mass fraction", or "RMF"):

$$C_S/C_R=b$$

The validity of the "snow/rime mass balance" approach has been assessed in two comparative studies using microscopic observations of the "degree of riming" of snow flakes for estimating the relative contribution of rime droplets to the total mass of snow flakes and measurements of C_S and C_R in precipitating clouds (Brantner et al., 1994; Kalina and Puxbaum, 1994a). Similar results were obtained independently by Dixon et al. (1994) from field experiments at Mt. Rigi (1798 m a.s.l., Switzerland).
The above mentioned results were campaign-type studies from a few observation days in each campaign and did not include the fractionation behavior of "crustal components" (e.g. Ca, Mg).
Here we report about C_R and C_S data from a long term study over four years and include observations in addition to sulfate and nitrate about chloride, ammonium, sodium, potassium, calcium, magnesium, ammonium, sulfite and H_2O_2. The data allow to derive seasonally averaged "rimed mass fractions". By comparing C_S/C_R ratios from other compounds in relation to sulfate we obtain information about the scavenging behavior of predominantly gas phase (nitrate, sulfite, H_2O_2), respectively aerosol (sodium, potassium, calcium, magnesium) derived species. Rearrenging the Brantner et al. (1994) mass balance (eq 1) we obtain the relative fractional mass contributions of the individual compounds from rime droplets and from unrimed ice in rimed (fallen) snow. Thus we report for the first time tentative estimates for ion concentrations in unrimed ice phase and show that crustal components are scavenged predominantly via the ice phase most likely via the ice nucleation process (see e.g. Parungo et al. xx).

EXPERIMENTAL

SITE DESCRIPTION

Sonnblick (3106 m) is a mountain peak located in the main ridge of the Austrian Alps at 12°57' East and 47°03' North. The Sonnblick Observatory (SBO), a meteorological station which is operated all year, is located on the summit. A description of the site is given in Kasper and Puxbaum (1997, this issue), additional details are given in Kromp-Kolb et al. (1993) and in Brantner et al. (1994).

SAMPLING

Temperatures at SBO are below zero most of the year, so that snow-fall is the most frequent form of precipitation. Only from June to September the temperatures may rise above zero, but even in these months snowfall and rime ice may occur, however, much less frequent than during the other seasons.

All samples were taken at the platform of the SBO. Sampling surface for rime was the railing of the instrument platform of the observatory. The railing consists of a L-shaped profile with 5 cm width on both flanks of the profile. The material is galvanized steel. The deposition properties of cloud droplets are not well defined on such a surface. For typical wind speeds at the site in the range of 5 - 30 ms^{-1} the aerodynamic diameter for particles with a 50% impaction probability is estimated to lie in the range of 12 - 30 µm. This estimate is based on calculations of particle deposition with a 'body-impactor' (Lehtimaeki et al., 1993). However it was observed with cloud sieves for larger supercooled droplets (using cylinders with 7.9 and 20 mm diameter) that feathery rime deposits are formed which act as collectors also for smaller droplets (e. g. about 10 µm diameter at wind speeds of 5 ms^{-1}) (Hindman et al., 1992). As it was the purpose of our study to check wether during different seasons of the year the ratio of the concentrations of ions in rime vs. snow is changing and we assume that the deposition conditions for rime droplets were similar throughout the year on our sampling surface we conclude that the analytical data from the rime samples can be used for such a comparison. Baltensperger et al. (this issue) report a similar frequency distribution of the LWC at JFJ during the different month of a year. Our assumptions are particularly valid, if no large concentration differences of the ions of interest exist between the different sizes in the droplet spectrum. Thus though the deposition of cloud droplets to our sampling surface is not well defined, we can take it as a fact that a predominant sampling of larger droplets (>10µm diameter) occurs. This however is also the case for falling ice crystals. The typical cutoff size for collected cloud droplets by dendritic ice crystals is around 10 µm diameter (Harimaya 1975). For hexagonal plates a cut-off in the range of 20-25 µm diameter has been reported (Kajikawa 1974). Kalina and Puxbaum (1994a) observed droplets with diameters between 10 and 60 µm impacted on dendritic ice crystals.

As we are only interested in the concentrations of major ions in rime ice, the collection rate is not of importance. However the concentration measured in rime ice should reflect the respective concentrations in the cloud droplets which became attached to falling ice crystals in the riming process. The information about size dependence of chemical constituents in cloud droplets is quite controversial. According to a modeling study of Bott and Carmichael (1993) smaller cloud drops are enriched in major ions relative to the larger ones. Collett et al. (1993) found experimentally an enrichment of sulfate and nitrate in cloud droplets < 10 µm diameter compared to droplets > 10 µm. The eventual enrichment of major ions in cloud droplets < 10 µm diameter is however not of importance for the considerations in our study.
Therefore we assume, that the concentrations of major ions we determine in rime ice is representative for the volume weighed average concentration of the cloud droplets impacted on the ice crystals.

The snow samples were taken out of a snow sack, which was mounted moveable similar to a wind bag. As the opening of the sack acts as a virtual impactor, collection of rime droplets is neglegible (Borys et al., 1988)

All samples were collected on a daily basis with a sampling time at 8 a. m. The samples were kept deep frozen until the analyses at the Vienna University of Technology. There the samples were melted carefully. The analyses were performed within 72 hours. The sampling period was from December 91 - April 95. We collected 210 snow and 129 rime samples with 83 paired events.

ION ANALYSES

The samples were analyzed for cations (Na^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+}), anions (Cl^-, NO_3^-, SO_4^{2-}), for pH, and conductivity. For anion analyses we used a DIONEX IC-system equipped a AG4A-precolumn, an AS4A analytical column, a self-regenerating suppressor ASRS-I and a conductivity detection. The eluent was 1.8 mM Na_2CO_3 / 1.7 mM $NaHCO_3$. Beginning with the samples from May 1994 we used another DIONEX IC-System. This system was equipped with an AG12-guard-column, an AS12 separation column, a self-regenerating suppressor (ASRS-I), a DIONEX GPM-2 gradient pump, a DIONEX CD-20 conductivity detector. The step gradient was 10 mM NaOH (0 to 5.5 min) and 47 mM NaOH (5.6 to 20 min) allowing the separation of F^-, acetate, formiate, Cl^-, NO_3^-, SO_4^{2-}. The eluent flow was 1.2 $mlmin^{-1}$. Cation analyses were also performed on a DIONEX-IC system using a CG12A precolumn, a CS 12 analytical column, a cation self-regenerating suppressor CSRS-I, and a conductivity detection. The eluent was 17 mM Methanesulfonic Acid (Fluka 64280). For pH-measurements we used an INGOLD glass-electrode for low ionic strength samples. Conductivity was determined with a PHILIPS PW 9510 conductivity cell.

Quality control was performed on the analyzed samples by plotting calculated versus measured conductivities and by ion balances. The correlation coefficient for the ion balances was above 0.93. The sum of Na^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+}, H^+ versus the sum of Cl^-, NO_3^-, SO_4^{2-} was for most samples on or close to the 1:1 slope, although organic acids and CO_3^{2-}, which is the main counter ion for Ca^{2+} and Mg^{2+}, were not analyzed For the conductivity of these ions is rather low the conductivity balances have a better correlation (0.97).

SULFUR (+IV) ANALYSES

SIV was determined with a chemoluminescence monitor (UD 8802) basing upon a chemoluminescence-reaction of SIV and Ce^{4+} (Jaeschke 1990). This method allows to determine free SIV ($SO_2.H_2O$, HSO_3^-, SO_3^{2-}) with detection limit of 2 μgL^{-1}. Details of this method are described in Tscherwenka et al. (this issue).

HYDROGEN PEROXIDE ANALYSIS

The H_2O_2-content of the samples was determined using a HPLC-method with a postcolumn derivatisation with p-Hydroxyphenylacetic acid in presence of Peroxidase (Hellpointer and Gäb, 1989). The system was equipped with two opposed-piston pump (Merck LiChroGraph modell L-6000), a precolumn (Merck 250 * 4 mm LiChrospher 100 RP-18, 5 µl), a separation column (Alltech 250 * 4.6 mm Adsorbosphere HS C18 5 micron), a Nafion-mebrane reactor and a fluorescence detector (Merck LIChroGraph F-1050).

The eluent was 10^{-3}m H_2SO_4) with a flow of 0.6 $mlmin^{-1}$. The samples were injected into the eluent-flow via a 6-port valve (Rheodyne 9125) with a 20 µl-sampling loop. The other pump pumped 0.06 ml reagens-solution (11.5 mmol Potassium hydrogen phthalate, MERCK 4874) per liter, 0.13 mmol p-Hydroxyphenylacetic acid (SIGMA Chemical Co., H-4377) per liter and 68 mg peroxidase (Sigma Chemical Co. P-8250) per liter at a pH of 5.8 (NaOH)) per minute via the precolumn (to damp the pulsation of the pump) to the T-peace, where the two flows were combined. After a mixing coil the pH-value was set to about 10 in a membrane reactor. The reactor was out of semipermeable Nafion tube through, which the solution is pumped. The Nafion tube was put into a 30% NH_4OH-solution (Hwang and Dasgupta, 1986). After the reactor the analyte came to the flourescence cell. The exitation-wavelength was 330 nm, the detection wave length was 400 nm.

The instrumentation was calibrated using solutions of H_2O_2 prepared by serial dilution of a stock solution titrated with standard $KMnO_4$. The detection limit of the system was 50 nmol H_2O_2 L^{-1} (1.7 μgL^{-1}).

RESULTS AND DISCUSSION

Average concentrations and seasonality

For this study a total of 129 rime ice and 210 snow fall samples were collected from Oct. 92 to April 96. In these samples we determined the major ions as well as S(IV) and H_2O_2. The average concentrations (means and medians) of the determined species for snow and rime ice samples are given in Table 1.

The mean concentrations of the snow samples were for most of the analyzed species around two to four times lower than for the rime ice samples. Higher ratios were found for potassium (0.76) and H_2O_2 (1.0). The higher ratio for K might be an artefact due to the low concentrations - frequently below the detection limits - in snow. The ratio around 1 for H_2O_2 is an indication that the unrimed ice phase contains a H_2O_2 concentration comparable to that in the rime droplets. Scavenging of H_2O_2 by ice crystals has been observed in laboratory experiments (Mitra et al., 1990, Conklin et al., 1993). Under conditions of H_2O_2 scavenging also SO_2 is readily scavenged on ice crystals (loc. cit.). Data from field experiments, however, show that unrimed snow exhibits very low concentrations of sulfate (Scott, 1981; Borys et al., 1988). Kalina and Puxbaum (1994) estimated the sulfate content of unrimed snow at SBO to lie below 1 $\mu molL^{-1}$. As in the liquid phase (supercooled rime droplets) H_2O_2 will react with SO_2; only for cases when H_2O_2 is in excess an analytical signal is expected. Thus the snow/rime ratio of around 1 for H_2O_2 is a result of a) scavenging of H_2O_2 into the liquid as well as ice phase and b) depletion in the liquid phase by reaction with SO_2. The lowest snow/rime ratio (0.24) is found for sulfate, which is taken as indication that scavenging from the aerosol and via reactive scavenging of SO_2 from the gas phase proceeds preferentially in the rime droplet phase (see also Kalina and Puxbaum, 1994a).

In the seasonal variation the "anthropogenic" major ions (NH_4^+, H^+, NO_3^-, SO_4^{2-}) exhibit a spring maximum in rime as well as snow samples (Table 1). Spring maxima for sulfate are a common feature in wet precipitation at European sites (Meszaros 1974, Rodhe and Granat, 1984). For SBO wet precipitation also secondary maxima during late summer have been reported (Puxbaum et al., 1991). Secondary summer maxima in rime and snow for sulfate and ammonium were observed also in our data set.

Crustal elements showed no pronounced seasonal variation in snow, however a spring maximum for rime (Table 1). The spring maximum for rime originated from a couple of events with Saharan dust occurrence (01 and 02 March 94). During the Saharan dust events, however, no snow fall was observed at SBO.

Seasonality of the rimed mass fraction

One goal of this study was to investigate wether the rimed mass fraction exhibits a seasonal variation. To this end we calculated C_S/C_R for sulfate (=b_{SO4}) for paired samples from the four seasons. The calculations were performed from C_S/C_R ratios for the individual pairs and then averages and medians were formed. Due to the considerable scatter of the individual data and the not normally distributed data different results were obtained for averages and medians (Table 2). A common feature of the individual results however is evident: There is no indication of an enhanced riming activity in spring (as observed in campaign type experiments at SBO (Brantner et al. 1994, Kalina and Puxbaum, 1994a) and Rigi (Dixon et al. 1994; discussed in Kalina and Puxbaum, 1994b). However it appears from our data that riming is somewhat enhanced during the fall period, which is indicated by the above the annual average b_{SO4} values independly of the calculation procedure (Table 2). Baltensperger et al. (1997) have investigated the cloud liquid water content (LWC) at Jungfraujoch (3450 m, Swiss Central Alps) during a full year. They report no significant seasonal variation of the LWC, though in April, August and December the LWC appeared to be above the annual average. In all, however, the LWC during fall was not above the annual average, which means, that there are no indications for conditions enfavouring enhanced riming in fall in the high Alpine region from the LWC experiments.

The frequency distributions of the C_S/C_R ratios for sulfate during the four seasons are shown in Figures 1a-d. The winter and spring distributions of the C_S/C_R ratios (Figures 1b, c) appear bimodally distributed, with a dominant mode in each of the two seasons centered in the 0.11-0.20 class. A small, secondary mode in both cases is centered in the 0.61-0.70 class. We refer to the first mode (C_S/C_R < 0.40) as to "moderately rimed" cases and to the second mode (C_S/C_R > 0.40) as to "heavily rimed" cases. While in winter and spring "moderately rimed" cases dominate, during fall the "moderately" and "heavily rimed" cases occur with comparable frequency (Figure 1a), leading to a higher seasonal average for b_{SO4} than the annual average. The number of summer events (N = 5) is too low to draw firm conclusions, although arithmetically the calculated average for b_{SO4} is comparable to the winter and spring situation (Figure 1d, Table 2). As in summer during most of the precipitation events SBO was in the melting zone for the snow flakes, no assessment about the magnitude of riming for these cases could be performed.

Estimate of unrimed ice phase (C_I) concentrations

When comparing the C_S/C_R ratios of all paired samples (N = 77) for the different analysed components (Table 3) one can see that the ratios of all other components exhibit higher values than for SO_4^{2-} (0.20). This effect is interpreted in terms of more efficient scavenging of the "enriched" components by the unrimed ice phase as compared to SO_4^{2-}. The "enriched" components can be divided into the following groups: The components (in brackets C_S/C_R ratios) SIV (0.34), NH_4^+ (0.24), NO_3^- (0.41) and H_2O_2 (1.75) have potential gas phase sources (SO_2, NH_3, HNO_3 and H_2O_2) which might lead to gas phase scavenging of the ice phase. Gas scavenging of SO_2 and H_2O_2 on ice phase has been experimentally observed by Mitra et al., (1990); and Conklin et al., (1993). Indirect evidence for ice phase scavenging of HNO_3 from field observations has been reported by several groups (e.g. Raynor and Hayes, 1983; Huebert et al., 1983; Chang, 1984; Baltensperger et al., 1993; Brantner et al., 1994). Also in laboratory experiments nitric acid sorption on ice crystals has been demonstrated to be an effective process (Diel et al., 1995).

The crustal elements Ca, Mg, Na and K exhibit a C_S/C_R ratio (for averages) in the range of 0.47 - 0.75, which indicates a considerable enrichment in the ice phase. Crustal aerosol particles are generally in the coarse size range. Background crustal aerosol at a glacier site in Switzerland (Colle Gnifetti, 4450 m) exhibited an average volume mean diameter of around 2.5 µm (Wagenbach and Geis, 1989). Such aerosols can be scavenged by ice crystals by nucleation scavenging (the mineral aerosol might act as ice condensation nuclei) or by impaction scavenging (falling ice crystals might collide with mineral aerosol particles). Impaction scavenging will be effective only for the larger particles in the size distribution (e.g. > 10 µm, see discussion in chapter 2), which are generally not frequent (Wagenbach and Geis, 1989), but have been observed spuriously at high Alpine glacier fields (Wagenbach and Geis, 1989; De Angelis and Gaudichet, 1991). Minerals and alkaline halides are known to initiate ice nucleation (Pruppacher and Klett, 1980). Also soil particles with high organic content respectively due to bacteria associated with the soil particles may act as ice nuclei (Götz et al., 1991). Thus it appears feasible, that crustal elements become scavenged into ice crystals to a certain extent. Kasper (1994) reported for SBO snow/aerosol washout ratios for SO_4 and Ca during different seasons of the year. Generally, in the monthly averages, washout ratios for Ca were around a factor of 2-10 higher than for SO_4 which can be taken as indication that the more efficient scavenging of Ca by snow is a result of a different (respectively additional) scavenging mechanism as compared to sulfate.

The different scavenging behavior of the "gas phase" and the "crustal" components becomes evident from the different distribution functions of the respective C_S/C_R ratios (Figures 2a-f). Figure 1a shows the distribution function of C_S/C_R for all paired cases (N = 77) for sulfate. The function is bimodal with a primary maximum in the 0.1-0.2 class and a secondary maximum in the 0.4-0.7 range. The corresponding distribution function for ammonium (Figure 2b) shows again a maximum in the 0.1-0.2 class, but with indications of a shift of the median towards higher values. We think that this shift originates from a contribution of NH_3 gas phase scavenging onto ice crystals. The maximum of the nitrate distribution (Figure 2c) is found in the 0.2-0.3 class, which indicates as for NH_3 gas phase scavenging of HNO_3 on ice particles in addition to the scavenging by riming. The distribution functions for the components Ca and Na (Figures 2e, f) are considerably different from the three cases mentioned above as virtually no maxima appear in the graphs. This means that the composition of snow with respect to crustal elements (e.g. Ca, Na) is not dependent from the concentration of these components in the rime droplets. We interpret this behavior as a result of predominant scavenging of these elements by the unrimed ice phase. The distribution of C_S/C_R ratios for chloride (Figure 2d) exhibits an intermediate behavior between the groups of the "gas phase" and the "crustal" compound. This behavior can be explained by the fact that chloride in snow has a gas phase as well as a coarse mode aerosol source. The occurrence of Cl in gas and aerosol phase has been observed at a site in eastern Austria, where in the annual average around 70% of the Cl was present in gas and 30% in aerosol phase (Puxbaum et al. 1993). The size distribution of aerosols was determined at SBO during a sampling campaign in 1993. Chloride was found in the coarse mode with a mass median aerodynamic diameter of 2.5 µm (Kasper 1994), which equals the size of the crustal elements.

When the coefficients a and b in the "snow/rime mass balance" equation (equ. 1) have been determined for sulfate (under the limiting assumption C_I [SO_4] = 0), a tentative assessment of the ice phase concentrations (C_I) of the other components is possible by applying equ. 1, using a and b as determined for sulfate and C_S and C_R of the substance under consideration. The results for C_I for the various compounds determined from averages and medians of C_S and C_R are shown in Table 3. While ice phase concentrations of NH_4^+, S(IV) and H^+ are below or close to 50% and of NO_3^- is around 60% of the respective concentrations in snow, ice phase concentrations of the crustal elements as well as of chloride are in the range of 75-90% of the snow concentrations. The estimate for the ice phase concentration of Ca is 1.7 (from medians) and 2.8 $\mu molL^{-1}$ (from averages) (Table 3). For H_2O_2 the concentrations in the ice phase are higher than in the snow phase. The derived average H_2O_2 concentration in the ice phase is around 1.2 $\mu molL^{-1}$ while the averaged (measured) snow phase was around 1.1 $\mu molL^{-1}$.

To check wether the concentration of the crustal element Ca in the ice phase might have originated from ice nucleation scavenging we performed the following first order estimate: The average diameter of a dendritic ice crystal is 2.0 mm, which yields a volume of around 0.04 mm^3 (Pruppacher and Klett, 1980). In a long term study of aerosols at an Alpine site (Wank, 1780 m), in about 150 km distance to SBO, the relative content of soluble Ca of the total crustal aerosol was around 10% (Reiter et al., 1976). Assuming a soluble Ca content of the crustal aerosol at SBO of 10%, a mean diameter of a crustal aerosol particle of 2.5 µm (Wagenbach and Geis 1989) and a density of the mineral aerosol of 2.7 tm^{-3}, a concentration of 1 $\mu molL^{-1}$ of Ca in the ice phase is obtained. In the study by Kalina and Puxbaum (1994) of snow crystals at SBO a median diameter of around 0.65 mm was observed. Using the conversion in (Pruppacher and Klett, 1980) a volume of 0.004 mm^3 is obtained for a single crystal, leading to an estimated concentration of 10 $\mu molL^{-1}$ of Ca in the ice phase. Thus we expect a Ca concentration of 1 - 10 $\mu molL^{-1}$ in the ice phase. From the snow/rime relationship we derived a concentration of around 2-3 $\mu molL^{-1}$ (Table 3), which is in the range expected. Parungo et al. (1976) observed ice nuclei forming mineralic particles by electron microscopy examination of ice crystals quite frequently in snow fall samples in Colorado. Thus it appears likely, that the Ca concentration estimated for the ice phase originates predominantly from ice nucleation scavenging. The same assumption is also valid for the other crustal elements such as Na, K, and Mg as well as for chloride.
From these data the relative contribution of an individual component (E_i) to the concentration in snow from riming [$\%R(E_i)_S$] and from the ice phase [$\%I(E_i)_S$] can tentatively be assessed via equ. 3a,b. We start from eq.2 where the split of the water fractions from cloud water and unrimed ice phase contributing to the resulting rimed snow is determined tentatively by a_{SO4} and b_{SO4}. The concentration of a component Ei in ice phase is then determined by the measured concentrations of $C_{S(Ei)}$ and $C_{R(Ei)}$. (a_{SO4} + b_{SO4}) $C_{S(Ei)}$ is the concentration of a component Ei in a unit mass of

rimed snow (water equivalent). Normalizing to $(a_{SO4} + b_{SO4})\ C_{S(Ei)}$ (and $a_{SO4} + b_{SO4} = 1$) yields the relative mass contributions of Ei's from rime droplets (eq 3a) and unrimed ice phase (eq 3b) to the mass of Ei in rimed snow.

$$(a_{SO4} + b_{SO4})\ C_{S(Ei)} = a_{SO4}{*}C_{I(Ei)} + b_{SO4}{*}C_{R(Ei)} \qquad \text{(eq 2)}$$

$$\%R(E_i)_S = 100 \times b_{SO4} \times C_{R(Ei)}/C_{S(Ei)} \qquad \text{(eq 3a)}$$

$$\%I(E_i)_S = 100 \times a_{SO4} \times C_{I(Ei)}/C_{S(Ei)} \qquad \text{(eq 3b))}$$

The results of these calculations are shown in Figure 3: While our limiting assumption is that sulfate in snow originates exclusively from the rime phase, NH_4^+, S(IV), H^+ and NO_3^- in snow originate to around 20-50% from the ice phase. For the crustal elements Ca, Mg, Na and K as well as for chloride the contribution from the ice phase to the amount of the respective element in snow is around 60-70%. The estimated contribution from the ice phase to the "free H_2O_2" determined in snow is even around 90% (Figure 3). These results are lower limits as for sulfate the ice phase concentration was assumed to be zero. If sulfate (presumably in low concentration) is also present in the ice phase, the fractions derived for the other components would increase.

SENSITIVITY

CONCLUSIONS

- The seasonal variations of the concentrations of the "anthropogenic" major ions (NH_4^+, H^+, NO_3^-, SO_4^{2-}) exhibit spring maxima for rime as well as for snow samples. Crustal elements (Ca, Mg, Na, K) as well as chloride showed no pronounced seasonal variation in snow, however, spring maxima for rime samples. The spring maxima of the crustal elements and chloride in rime originated from a couple of Saharan dust events, during which no snow fall was observed. The maximum of the H_2O_2 concentration in snow was observed in summer. In rime the H_2O_2 concentration was elevated above the annual average in spring and summer. The S(IV) concentration exhibited maxima in snow and rime during winter and spring.

- Applying the snow/rime mass balance for SO_4^{2-} yields a first order estimate for the "rimed mass fraction" (the relative amount of supercooled cloud droplets attached to the snow crystal in the riming process). We find that about 20 - 30% of the mass of snow flakes is derived from riming of supercooled cloud droplets. The analysis of our 4-year data set of snow and rime samples from SBO gave no indication for an enhanced riming activity in spring - in contrast to observations from campaign type experiments at SBO (Brantner et al. 1994, Kalina and Puxbaum, 1994a) and Rigi (Dixon et al. 1993; discussed in Kalina and Puxbaum, 1994b). However, it appears from our data that riming is somewhat enhanced during the fall period. For spring, winter and summer cases the derived rimed mass fraction was in a similar magnitude.

- From the shapes of the distribution functions of the C_S/C_R ratios of the analyzed components we derived the following information about the scavenging behavior of the individual components with respect to their occurrence in snow: SO_4^{2-}, NH_4^+ and H^+ are scavenged primarily via riming (impaction of supercooled rime droplets by falling ice crystals). There are also indications for considerable gas phase scavenging of SO_2, NH_3, HNO_3 and H_2O_2 directly on the ice phase. Crustal elements (Ca, Mg, Na, K) as well as chloride appear to become scavenged predominantly via ice nucleation. For chloride also an additional contribution from gas phase scavenging onto ice phase was derived.

- Our tentative estimates indicate that as a lower limit NO_3^- in fallen snow is derived to more than 35% from direct gas phase scavenging onto ice crystals and crustal elements in snow are derived more than 60% from ice nucleation scavenging. The estimated contribution from the ice phase to the "free H_2O_2" determined in snow is even around 90%. These results are lower limits as for sulfate the ice phase concentration was assumed to be zero. If sulfate (presumably in low concentration) is also present in the ice phase, the fractions derived for the other components would increase.

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Caption of figures:

Figure 1a: Frequency distribution of the C_S/C_R ratios for sulfate during fall (N=18)
Figure 1b: same as figure 1a for winter (N=31)
Figure 1c: same as figure 1a for spring (N=25)
Figure 1d: same as figure 1a for summer (N=5)

Figure 2a: Frequency distribution of the C_S/C_R ratios for sulfate for all paired cases with C_S/C_R <1 (N=77)
Figure 2b: Frequency distribution of the C_S/C_R ratios for ammonium for all paired cases (with C_S/C_R <1 for sulfate and ammonium) (N=72)
Figure 2c: Frequency distribution of the C_S/C_R ratios for nitrate for all paired cases (with C_S/C_R <1 for sulfate and nitrate) (N=71)
Figure 2d: Frequency distribution of the C_S/C_R ratios for chloride for all paired cases (with C_S/C_R <1 for sulfate and chloride) (N=52)
Figure 2e: Frequency distribution of the C_S/C_R ratios for calcium for all paired cases (with C_S/C_R <1 for sulfate and calcium) (N=42)
Figure 2f: Frequency distribution of the C_S/C_R ratios for sodium for all paired cases (with C_S/C_R <1 for sulfate and sodium) (N=51)

Figure 3: relative mass contributions (%) of individual compounds in snow fall from rime droplets and from the unrimed ice phase (calculated over the means and medians from table 01)

Table 01: average and median concentrations of all snow and rime ice samples $\mu molL^{-1}$

snow samples			rime ice			
substance	mean	median	substance	mean	median	R/S (Median)
Na^+	2.93	1.91	Na^+	5.56	3.04	1.6
NH_4^+	14.42	7.79	NH_4^+	44.38	21.51	2.75
K^+	0.73	0.49	K^+	0.96	0.64	1.3
Ca^{2+}	3.23	2.15	Ca^{2+}	8.78	3.52	1.6
Mg^{2+}	0.63	0.45	Mg^{2+}	1.47	0.95	2.1
H^+	14.99	10.72	H^+	45.49	35.48	3.3
Cl^-	2.69	2.12	Cl^-	6.09	3.27	1.6
NO_3^-	12.26	8.52	NO_3^-	29.14	22.20	2.6
SO_4^{2-}	6.95	4.51	SO_4^{2-}	29.29	19.20	4.3
S(IV)	0.091	0.068	S(IV)	0.319	0.224	3.1
H_2O_2	1.182	0.670	H_2O_2	1.119	0.347	0.5

Table 2: Seasonal variation of b_{SO4} (averages and medians) from the snow/rime experiments 1992 - 1996 at SBO and comparison with data from cloud campaign experiments at SBO (compiled in Kalina and Puxbaum, 1994b) and Rigi (Dixon et al., 1994; calculations of average RMF /"rimed mass fraction" for Rigi data see Kalina and Puxbaum, 1994b)

	This work - snow/rime experiment			Literature data	
Season	N	b_{SO4} (from averages)	b_{SO4} (from medians)	Campaigns: RMF Rigi	Campaigns: b_{SO4} SBO
Fall	18	0.27	0.41	n.d.	0.29
Winter	31	0.21	0.17	0.35	n.d.
Spring	23	0.18	0.14	0.43	0.52
Summer	5	0.27	0.15	n.d.	0.24
I - XII	77	0.20	0.22	-	-

n.d. no data: N number of paired samples in the snow/rime experiment
b_{SO4} data based on C_S/C_R ratio for SO_4;
RMF data based on microscopical evaluations of individual snow flakes

Table 03: Concentrations of the individual componds in the unrimed ice phase (C_I) calculated from data in table 01 using eq (1)

	c_S	c_R	b	c_I
Na^+	3.31	5.22	0.63	2.82
NH_4^+	12.65	62.80	0.20	-0.20
K^+	0.80	1.13	0.71	0.72
Ca^{2+}	5.79	7.82	0.74	5.26
Mg^{2+}	1.00	1.64	0.61	0.84
H^+	17.86	43.18	0.41	11.38
Cl^-	3.61	4.54	0.80	3.38
NO_3^-	11.98	25.22	0.47	8.58
SO_4^{2-}	6.72	32.92	0.20	0.00
S(IV)	99	143	0.69	88
H_2O_2	1853	696	2.66	2150

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„Das Kärntner Wintererschließungskonzept (WEK)"

Evaluierung und Aktualisierung 2004

Das Kärntner Wintererschließungskonzept wurde in den 80er Jahren erarbeitet und hatte folgende Ziele:

- Stärkung des Wintertourismus zur Verringerung des saisonalen Ungleichgewichtes; Erhöhung des Anteiles der Winternächtigungen von damals 15% auf über 25 %;
- Sicherung und Ausbau der Wettbewerbsfähigkeit der führenden Wintersportzentren durch
  - ⇨ Beseitigung von Angebotsschwachpunkten
  - ⇨ Abstimmung von Transportkapazitäten auf die Gesamtinfrastrukturen
  - ⇨ Ausbau von Winterergänzungsangeboten etc.

In diesem Zusammenhang wurden mehr als 100 wintertouristische Ausbauideen und Projekte hinsichtlich ihrer

- ⇨ räumlichen Eignungsvoraussetzungen
- ⇨ seilbahntechnischen Aspekte
- ⇨ erforderlichen Infrastruktureinrichtungen
- ⇨ Raumauswirkungen etc. untersucht.

Aus den Ergebnis wurde ein von der Landesregierung akzeptierter Prioritätenkatalog erstellt, aus dem ersichtlich ist, welche Projekte

- ⇨ mit sehr hoher bzw. hoher Realisierungspriorität einzustufen sind,
- ⇨ welche Vorhaben vor ihrer Realisierung noch auf ihre Raumauswirkungen und Effekte abzuklären sind,
- ⇨ und welche Ausbaupläne aufgrund ihrer negativen Raumauswirkungen nicht realisiert werden sollten.

Projekte, die in das WEK aufgenommen wurden, erhielten Förderungen bzw. ihnen wurde im Rahmen der verschiedenen Bewilligungsverfahren ein „öffentliches Interesse" zugebilligt. Wurden zu einem späteren Zeitpunkt Projekte zur Realisierung vorgeschlagen, die im WEK nicht aufgelistet waren, so mussten im Rahmen einer Raumverträglichkeitsprüfung (RVP) Fragen

- der Machbarkeit
- der regionalwirtschaftlichen Effekte,
- der Raumauswirkungen etc. geprüft werden.

Die Ergebnisse einer RVP wurden jeweils dem Regierungskollegium vorgelegt. Bei positiven Ergebnissen wurden die vorgeschlagenen Maßnahmen nachträglich in das WEK aufgenommen.

Die wintertouristischen Rahmenbedingungen und Erfordernisse für die Kärntner Schigebiete haben sich in den letzten Jahren zum Teil deutlich geändert
(Schneesicherheit, Gästeverhalten, Konkurrenzverhältnisse, etc.).

Es wurde daher im Jahr 2002 mit der Evaluierung des WEK begonnen, um zum einen die Zielerfüllung der bisherigen Maßnahmen zu überprüfen, und zum anderen

Entscheidungsgrundlagen für eine Aktualisierung des WEK zu erhalten.

Die Arbeitsschwerpunkte betrafen

- eine Evaluierung der Position Kärntens im Österreichvergleich hinsichtlich
  - ⇨ die Entwicklung des Seilbahn und Pistenangebotes
  - ⇨ die übrige wintertouristische Angebotspalette
  - ⇨ die Nachfrageentwicklung;
- die Durchführung von standort- und strukturspezifischen Trendanalysen für die Kärntner Schigebiete;
- Detaillierte SWOT Analysen betreffend die 27 Schigebiete bzw. Standorträume mit Hilfe eines 54 Kriterien umfassenden Bewertungskataloges.
  Verwendet wurden
  - ⇨ 27 infrastrukturelle Indikatoren (betreffend die Pisten, Seilbahnanlagen, Betteninfrastrukturen, ergänzende Infrastrukturen etc.)
  - ⇨ 15 regionalwirtschaftliche Indikatoren / Winter (betreffend Betriebstage, Anlagen- und Bettenauslastung, Wertschöpfung etc.)
  - ⇨ 5 regionalwirtschaftliche Indikatoren / Sommer (betreffend Betriebstage, Anlagen- und Bettenauslastung, Wertschöpfung etc.)
  - ⇨ 7 betriebswirtschaftliche Indikatoren (betreffend Umsatz, Cash flow, öffentlicher Mitteleinsatz, Verschuldungsrate etc.).

Die SWOT Analyse wurde sowohl quantitativ anhand der vorhandenen Datengrundlagen als auch qualitativ auf Basis von verbalen Beschreibungen der Stärken / Schwächen / Chancen und Risken sämtlicher Schigebiete durchgeführt. Insgesamt wurden 1.458 Indikatoren aufbereitet bzw. berechnet.
Als Ergebnis lässt sich festhalten, dass die Kärntner Schigebiete aufgrund ihrer derzeitigen nationalen bzw. internationalen Wettbewerbsstärke, ihrer natur-räumlichen Gegebenheiten (z.B. Schneesicherheit, räumliches Entwicklungs-potenzial), infrastruktureller Rahmenbedingungen und damit auch hinsichtlich ihrer weiteren Entwicklungschancen zwei unterschiedlichen Typen zugeordnet werden können:

- ⇨ Tourismusgebiete (durchschnittlich 153 ha Pistenfläche, mehr als 100.000 Winternächtigungen im unmittelbaren Einzugsbereich); in diesen Gebieten wird der überwiegende Teil der regionalen Wertschöpfung erzielt;
- ⇨ Regionalgebiete (durchschnittlich 47 ha Pistenfläche und 47.400 Winter-nächtigungen im unmittelbaren Einzugsbereich); diese Gebiete sind für den zielgruppenspezifischen Regionalbedarf von Bedeutung.

Daraus folgen unterschiedliche Zielsetzungen, die bei der Aktualisierung des Kärntner Wintererschließungskonzeptes berücksichtigt werden sollten:

1) **in Tourismusgebieten**:
Stärkung der nationalen und internationalen Wettbewerbsfähigkeit zur

nachhaltigen Steigerung der Wertschöpfung im Wintertourismus.

Lediglich in diesen Schigebieten ist vom Potenzial her mit einer Steigerung der Wertschöpfung zu rechnen. Da in den nächsten 10 Jahren laut internationaler Prognosen nur ein Marktwachstum von 1% pro Jahr zu erwarten ist, muss mit einem beträchtlichen Verdrängungswettkampf gerechnet werden. Um diesbezüglich die Marktposition in Kärnten halten oder gar ausbauen zu können, sind noch massive Anstrengungen in den Tourismusgebieten zur Verbesserung des Benchmarks erforderlich.

2) **in Regionalgebieten**:
- ⇨ Zielgruppenspezifische Weiterentwicklung der regionalen Winter / Freizeit-infrastruktur,
- ⇨ oder Aufrechterhaltung der erforderlichen Strukturen für den spezifischen örtlichen Bedarf,
- ⇨ oder Förderung von Umstiegsszenarien für innovative Alternativen.

Die regionale Versorgung hat in Kärnten gegenüber den anderen Bundesländern bereits ein weit überdurchschnittliches Niveau erreicht. Die regionalen Schigebiete sind Spezialisten, die regionale und zielgruppenspezifische Bedürfnisse (Familie, Anfänger, Renn / Training, Events ...) abdecken. Darin liegen ihre Entwicklungschancen für die Zukunft.

Die Vergabe von Fördermittel sollte auf der Ebene eines „Wettkampfes der Ideen" erfolgen, wobei anzudenken ist, nur jene innovativen Entwicklungsideen und Projekte zu unterstützen, die

- zielgruppenspezifisch sind,
- und die in der Lage sind, die tatsächlichen spezifischen Schwachstellen des jeweiligen Schigebietes im Sinne der Erhöhung des Benchmarks zu beseitigen (somit nicht lediglich die Maximierung einzelner Infrastrukturen z.B. die Förderleistung).

Die Ergebnisse der Untersuchungen sowie die daraus ableitbaren Schlussfolgerungen werden zur Zeit in Kärnten einer politischen Diskussion unterzogen, wobei in absehbarer Zeit mit entsprechenden Festlegungen zu rechnen ist.

Nach der politischen Annahme des überarbeiteten Wintererschließungskonzeptes ist vorgesehen, die Studie im Internet unter der Adresse www.ktn.gv.at zu veröffentlichen (Pfad: Abteilungen ⇨ Abt. 20).

Anlage: Indikatoren für die SWOT Analyse

Infrastrukturelle Indikatoren:

- Höhenlage des Ausgangspunktes in das Schigebiet
- Pistenfläche in ha
- beschneibare Pistenfläche in %
- Pistenfläche über 1500 m SH in %
- Seilbahnanlagen insgesamt
- Schlepplifte in % der Gesamtanlagen
- Frequenz der Schlepplifte in % der Gesamtanlagen
- Komfortanlagen in % der Gesamtanlagen
- Transportkapazität 2002 insgesamt in PersHm/h
- Entwicklung der Transportkapazität von 1992 -2002 in %
- Durchschnitt der Transportkapazität der Hauptseilbahnen
- erschlossene Höhenmeter im Schigebiet
- Summe der Höhenmeter aller Anlagen
- Durchschnitt des Alters aller Seilbahnen
- Transportkapazität pro Winterbett
- Transportkapazität pro ha Pistenfläche
- Tagesaufnahmekapazität an Schifahrern pro ha
- Verhältnis Angebotskapazität zu Nachfragepotenzial
- Winterbetten gesamt
  - Qualitätsstruktur der Hotellerie (3/4/5-Sterne) in %
  - Qualitätsbetten in % von Betten insgesamt
- Sommerbetten gesamt
  - Qualitätsstruktur der Hotellerie (3/4/5-Sterne) in %
  - Qualitätsbetten in % von Betten insgesamt
- Anzahl von Winterergänzungseinrichtungen
- Anzahl von nicht winterspezifischen Einrichtungen
- Anzahl von Unterhaltungseinrichtungen

regionalwirtschaftliche Indikatoren / Winter:

- durchschnittliche Auslastungsstunden der Anlagen 99 - 02
- Vollauslastungstage in % der Betriebstage 99 - 02
- durchschnittliche Betriebstage 99 - 02
- Winternächtigungen 2002 pro 100.000 PersHm/H
- Winternächtigungen 01/02
- Winter Nächtigungsanteil in % 01/02
- Entwicklung der Winternächtigung von 1992- 02 in %
- Belegstage der Betten im Winter ½
- Entwicklung der Winterbelegstage der Betten von 92 - 02

• Entwicklung der Wohnbevölkerung von 91 - 01 in %
• Winternächtigungen pro Einwohner 2000/01
• Einnahmen Winternächtigungen 2001/02 in Mio. Euro
• Entwicklung der wintertouristischen Einnahmen von 91/92 - 01/02 in %
• Wintertouristische Wertschöpfung in 1.000 Euro 01/02
• Wertschöpfung pro Einwohner in Euro

Regionalwirtschaftliche Indikatoren / Sommer:
• Sommernächtigungen 2002
• Sommer Nächtigungsanteil in % 2002
• Entwicklung der Sommernächtigung von 1991 - 2002 in %
• Belegstage der Betten im Sommer 2002
• Seilbahnfrequenz im Sommer, Durchschnitt von 2000-02

Betriebswirtschaftliche Indikatoren:
• Umsatz in 1.000 Euro
• Cash flow in % der Betriebsleistung
• Cash flow in % des Anlagevermögens
• Verschuldungsgrad in %
• Schuldentilgung in Jahren (fiktiv)
• Investitionen in 1.000 Euro pro 100.000 PersHm/H von 1991 - 2002
• öffentlicher Mitteleinsatz in % der Investitionskosten von 1991- 2002

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"Simulation Of Snow Chararistics By Over Eurasia In Russian Gcm Experiments"

Introduction

The hydrological cycle on the Earth surface is considered to be very important in climatic system, especially from the viewpoint of energy transformations. All global climate models (GCMs) include a parameterization of land hydrology. Description of some of hydrological processes (snow, evapotranspiration, soil water transformations, etc.) in a detailed manner is too complicated for global scale, because it requires too many specific soil and vegetation parameters. Snow cover plays significant role in the global hydrological balance and in cryosphere dynamics. To great extent, the snow influences soil wetness and surface albedo. So, it is especially important to describe snow processes in hydrodynamic models close to observed data.

1. Physical parameterizations of processes connected with snow for climate models

1.1 Snow precipitation of different kinds

There are several kinds of precipitation parameterizations in climate models, as well as several approaches to snow precipitation. Some models consider precipitation as snow only by ground temperature below 0°C like in the models of HMC and INM (Diansky, Volodin, 2002). In other models like in MGO (Shneerov, 1997) this is done taking into account both soil and air temperature. Another approach is used in ECHAM (Report, 1993) and Hadley Centre (Hansen, 1997) GCMs: the precipitation is considered as snow if the temperature is below 0°C in the layer of air where the precipitation is generated. There it can melt or evaporate, which depends on the temperature around it.

1.2 Thermoinsulation of ground by snow

To describe the heat flux in snow, we use the equation:

$$\rho_{sn} C_{sn} \frac{\partial T_{sn}}{\partial t} = \frac{\partial}{\partial z} \lambda_{sn} \frac{\partial T_{sn}}{\partial z},$$

where T is the temperature of snow. On the upper snow boundary air temperature, precipitation, and water vapor pressure are given. The heat capacity is considered as dependent from snow depth by empirical equation (without using the structure). In HMC and MGO models, there are no equations of this type. In INM, ECHAM and Hadley Centre – equations like this.

1.3 Snow melting

Most of models consider that temperature of snow is not higher than 0°C (in ECHAM – 2°C), and the snow melts if its temperature is to exceed the critical value.

1.4 Changes of snow depth

The snow depth is measured in meters of equivalent liquid water, and obeys the equation:

$$\frac{\partial Sn}{\partial t} = C_{Sn} \frac{J_q}{\rho_{H_2O}} + P_s - M_{Sn}$$

where P_s is the amount of solid precipitation. The area fraction covered by snow is defined as

$$C_{Sn} = \min\left(\frac{Sn}{Sn_{cr}}, 1\right)$$

with Sn_{cr} = 0.015 m.

1.5 Influence of snow cover on surface albedo

The background land albedo A_{sL} is modified by snow cover Sn to give the value used in the radiation scheme:

$$A_s = A_{s_L} + (A_{s_{snow}} - A_{s_L}) \frac{Sn}{Sn + Sn^*} \quad (9)$$

where the albedo of the snow $A_{s_{snow}}$ is 0.8 and Sn* is 0.01 m of equivalent liquid water. The sea points all have an albedo of 0.07, while sea ice is assigned an albedo of 0.8. This is only a background climatological field that the model alters when running, while over the snow-covered areas, albedo values are closer to 0.8.

1.6 Influence of snow cover on surface roughness

Roughness length depends on snow depth and is equal to 0.5 cm for the snow depth exceeding critical value.

2. Results of experiments

2.1 Analysis of mean snow characteristics

We begin the analysis from snow, as snow is a particularly good diagnostic element, which reflects general ability of the model to reproduce the real climate. In Figs.1 and 2, we show comparison of snow cover and snow mass over Eurasia as represented by 11 GCMs (including 3 Russian). All data except Russian models were taken from (Foster, 1996). Our interest is not to say which model performs best, but to investigate what are the reasons of disagreement, and to develop better snow descriptions.

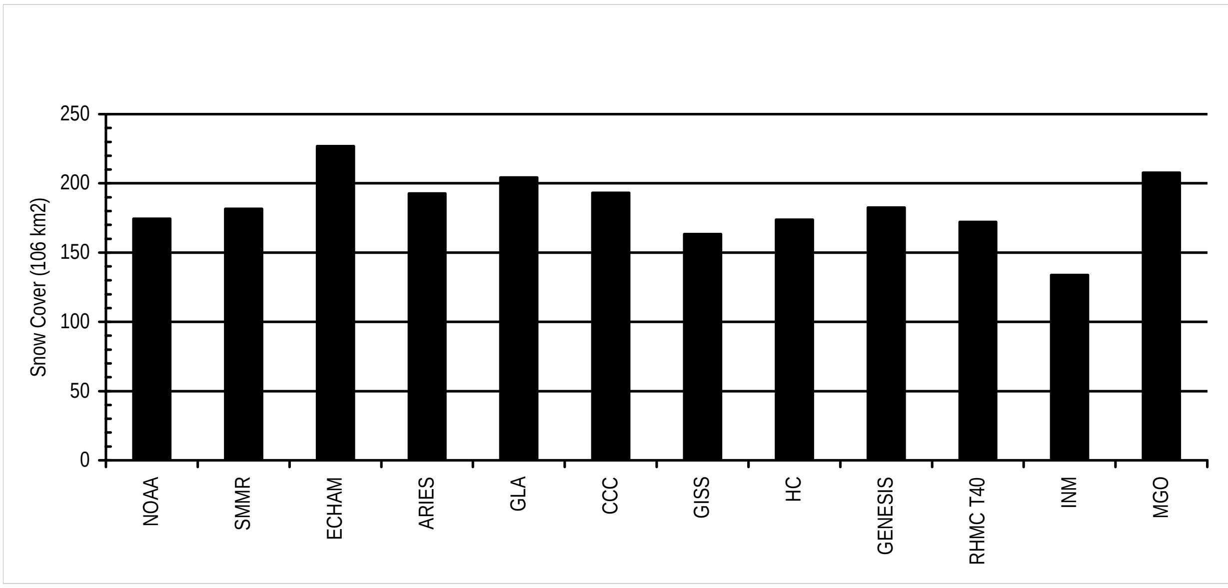


Fig. 1 Eurasian average area of snow cover in 11 GCMs participating in AMIP experiments, and satellite NOAA data

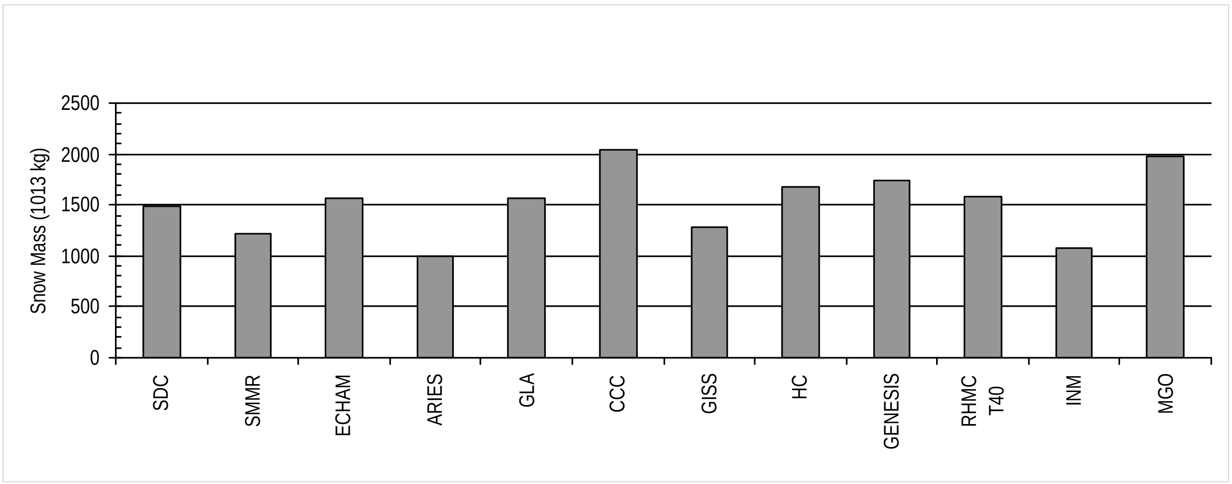
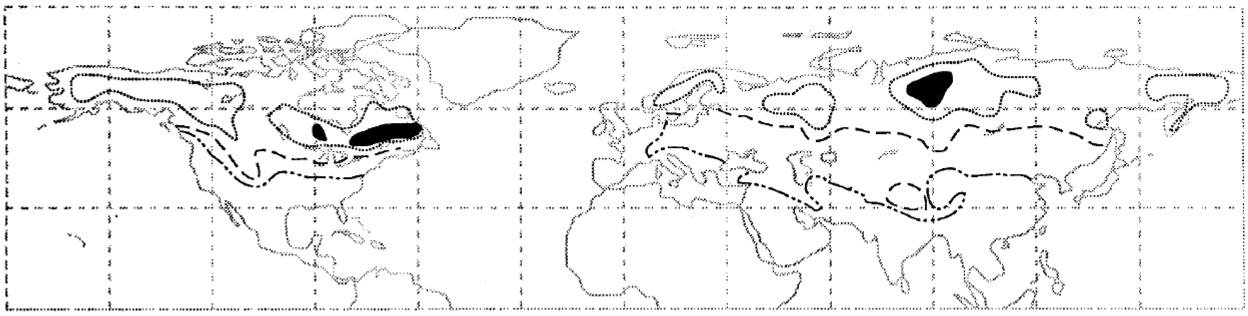


Fig. 2 Eurasian Average Snow Mass for 11 GCMs in AMIP experiments and observed snow SDC data

Before analyzing Figs. 1 and 2, it is important to note that there are no high-quality standards for modeled snow validation because differences between modeled and measured snow characteristics not always can be called as errors. We can see that Russian models, first of all HMC model, represent the main snow characteristics quite closely to the standards. We plan to analyze the reason of difference in these characteristics between models and observations in a special issue, as it needs detailed analysis of snow parameterization, structure of models and results of temperature and precipitation simulation.

In Fig. 3, one can see geography of the snow depth in Northern Hemisphere in February (averaged for experiment years) for the standard (SDC) and three of the Russian models. In central Asia (the Tibet Plateau, the Himalayas and the Caucasus), the snow extends till 40°N. In Europe, the snow line is closer to 50°N. The SDC data shows the same patterns.

SDC



RHMC

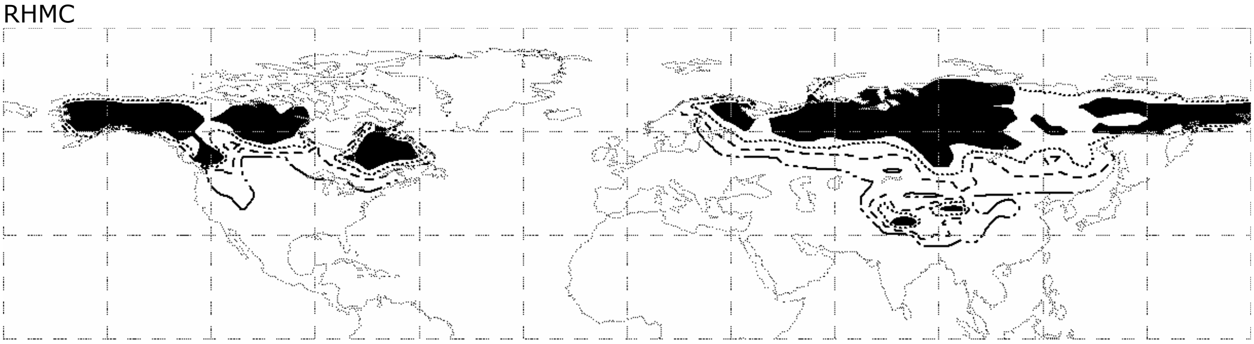


Fig 3 Mean February Snow Depth (contours are at 2, 25, 50, 75 cm) for SDC (Snow Depth Climatology, USAF/ETAC) and 3 Russian GCMs in AMIP experiment. The RHMC and MGO models show more snow in Siberia and Far East than we can see in SDC data or in INM results.

Conclusions

1. Mean snow characteristics can be simulated by GCMs quite realistically.
2. Several GCMs were tested for their ability to reproduce extremes of monthly snow parameters for November, February and April in 1979-1996. Maximum snow in November and February was simulated in NCAR reanalysis and HMC model. No one model could simulate properly monthly minimum and extremes in April.

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„Entwurf für RICHTLINIEN für Schierschließung im Bundesland Salzburg“

Einleitung

Das Bundesland Salzburg ist durch eine außergewöhnliche landschaftliche Vielfalt und damit bedingt hohe touristische Attraktivität gekennzeichnet. Schönheit und Abwechslungsreichtum der Landschaft sowie eine reichhaltige Tier- und Pflanzenwelt zeichnen das Land ebenso aus, wie unterschiedliche geologische und klimatische Gegebenheiten. Der hohe Alpenanteil von 94,7 % der Landesfläche ermöglicht es in weiten Teilen Salzburgs, schisportliche Aktivitäten zu setzen. Der Alpenraum Salzburgs hat als Lebens- und Wirtschaftsraum für die einheimische Bevölkerung ebenso große Bedeutung, wie als unverzichtbarer Rückzugs- und Lebensraum vieler gefährdeter Pflanzen- und Tierarten und weist geländebedingt regional unterschiedliche Gefährdungen im Zusammenhang mit Hochwasser, Murenabgängen und Lawinen auf. Die ständig wachsende Beanspruchung durch den Menschen kann den Alpenraum und seine ökologischen Funktionen im zunehmenden Maße gefährden, weshalb wirtschaftliche Interessen mit den ökologischen Erfordernissen in Einklang zu bringen sind.

Der Wintertourismus hat eine vorrangige Bedeutung für das Tourismusland Salzburg und steht in enger Verbindung mit sinnvollen und notwendigen schitechnischen Verbesserungen, Verbindungen und Erschließungen.

Aufgabe der Planung muss es in Zukunft sein, die ökonomischen Notwendigkeiten in Einklang mit der sensiblen Ökologie des alpinen Raumes zum Schutz des Naturhaushaltes zu bringen. Die Tourismuswirtschaft als einer der wichtigsten Wirtschaftszweige des Landes Salzburg ist in zunehmendem Maße auf einen intakten Naturraum und ein ansprechendes Landschaftsbild angewiesen. Ökologische Probleme und naturräumliche Erfordernisse müssen daher weiterhin Berücksichtigung bei der Schierschließung finden.

Die bisherigen Erfahrungen mit der Arbeitsgruppe "Raumverträglichkeitsprüfung/Schierschließung" haben gezeigt, dass eine umfassende Prüfung und Beurteilung der Projekte notwendig ist, um eine sinnvolle Entwicklung im Schianlagenbau gewährleisten zu können.

Die weitere Erschließung von Naturräumen für den Pistenschilauf ist in ihrer Wirkung auf Naturraum, Wirtschaft und Infrastruktur einer ganzheitlichen Prüfung (Raumverträglichkeits-prüfung) zu unterziehen.

1. Grundsätzliche Rahmenbedingungen für die Errichtung von Schianlagen

1.1 *Die Beurteilung von Schigebietsabgrenzungen erfolgt nach naturräumlichen Gegebenheiten wie Talräumen, Geländekammern, Wassereinzugsgebiet sowie betrachtbaren Landschaftsraum. Die Neuerschließung von weiteren Naturräumen wird abgelehnt.*

1.2 Der Modernisierung bzw. der Komfortverbesserung von bestehenden Aufstiegshilfen, der Ergänzung, Erweiterung, Abrundung, Anbindung oder Verbindung bestehender Schigebiete kann unter folgenden Voraussetzungen zugestimmt werden:

1.2.1 Die bestehenden Anlagen und Schipisten weisen in hydrologischer und biologischer Hinsicht keine Mängel auf und allfällig eingetretene Schäden, auch in den vorflutenden Gerinnen, wurden beseitigt.

1.2.2 Schianlagen, die aufgrund ihrer Lage und Exposition aus klimatischen Gründen zum überwiegenden Teil nur mit Kunstschnee betrieben werden können, dürfen nicht mehr errichtet werden. Die Schneesicherheit ist bei der Planung besonders zu berücksichtigen.
Eine Ausnahme stellen lediglich Zubringerbahnen dar, die ein bestehendes Schigebiet von einem Talraum aus erschließen, wobei in derartigen Fällen keine reguläre Abfahrt ins Tal hinunterführen muss.

1.2.3 Entsprechende Infra- bzw. Suprastrukturen, wie Verkehrsverbindungen, Parkflächen, Bettenkapazitäten und Restaurationsbetriebe müssen bereits als Grundlage vorhanden sein.

1.2.4 Die angestrebten Projekte müssen sinnvolle Vorhaben darstellen, die zu einer erheblichen Verbesserung des Gesamtschigebietes führen. Diese Maßnahmen müssen mit den räumlichen Entwicklungskonzepten der jeweils betroffenen Gemeinde übereinstimmen und dürfen bei Verbindungen, Anbindungen oder Erweiterungen den Programmen laut ROG 1998 nicht widersprechen.

1.2.5 Positive Erledigung dieser Raumverträglichkeitsprüfung gemäß Punkt 2.

1.2.6 Bei der Erweiterung, Abrundung, Anbindung oder Verbindung sind besonders strenge Maßstäbe an die naturräumliche Verträglichkeit anzulegen.

1.3 Kleinstanlagen werden von der Raumverträglichkeitsprüfung ausgenommen.

1.4 Vorhaben im Sinne von Pkt. 1.2 für Schierschließungen können sein:

1.4.1 Optimierung des Gesamtschigebietes, Neuorganisation der Anlagen

1.4.2 Erhöhung der Sicherheit für Wintersportler

1.4.3 Verbesserung der Fahrkomforts

1.4.4 Verkürzung von langen Wartezeiten sowie schnellere direkte Erreichbarkeit des Hauptschigebietes

1.4.5 Verbesserung, Ergänzung oder Abrundung des Wintersportangebotes

1.4.6 Sinnvolle Verbindung oder Anbindung von bestehenden Schigebieten

1.4.7 Verbesserung der örtlichen bzw. überörtlichen Verkehrssituation durch die Errichtung von Seilbahnanlagen

1.4.8 Verbesserung der naturräumlichen Situation durch Neusituierung von Anlagen bzw. durch Auflassung von Schleppliften bzw. standortgemäße Aufforstung und Rekultivierung von bestehenden, nicht entsprechend genützten Schiabfahrten. *Auch durch extensive Grünlandnutzung kann eine Verbesserung der naturräumlichen Situation (Offenhalten der Landschaft) erreicht werden.*

1.4.9 Errichtung von Flutlichtanlagen für homologierte Rennstrecken entsprechend den technischen Notwendigkeiten.

2. Raumverträglichkeitsprüfung durch die Arbeitsgruppe Schianlagen

Die Raumverträglichkeitsprüfung der Arbeitsgruppe "Schianlagen" wird unter Berücksichtigung folgender Bereiche durchgeführt:

2.1 Erhebung der Relation der bestehenden Aufstiegs- und Pistenkapazitäten mit dem vorhandenen Bettenangebot, dem zu erwartenden Tagestourismus und dem gegebenen Verpflegungssektor.

2.2 Schisporttechnische Eignung (Geländebeschaffenheit, Schneesicherheit, usw.)

2.3 Naturräumliche Auswirkung (wie z.B. mögliche Störung von schützenswerten Natur- und Lebensräumen, wildökologische Raumplanung, Gefährdung von Schutzwäldern, Landschaftsbild, usw.)

2.4 Wildbach- und Lawinensicherheit im Bereich der Aufstiegstrasse bzw. der dazu gehörigen Abfahrten

2.5 Veränderung der hydrologischen Verhältnisse sowie der *Hangstabilität*

2.6 Zustand der Pistenbegrünung bei bestehenden Anlagen

2.7 örtliche und überörtliche Verkehrserschließung sowie Verkehrssituation (Parkplätze, Zufahrtsmöglichkeit, mögliche Verkehrsüberlastung)

2.8 Gefährdung von Wasservorkommen

2.9 Energieversorgung

2.10 Abwasserentsorgung

2.11 Übereinstimmung mit dem Räumlichen Entwicklungskonzept der jeweiligen Gemeinde(n) und den Entwicklungsprogrammen laut ROG 1998

3. Mitglieder der Arbeitsgruppe "Schianlagen"

Forsttechnischer Dienst für Wildbach- und Lawinenverbauung
Fachabteilung 4/3, *Landesforstdirektion*
Fachabteilung 6/6, Wasserwirtschaft
Abteilung 7, Referat 7/01, Landesplanung und SAGIS (Vorsitz) und schisporttechnischer SV
Abteilung 13, Referat 13/02, Naturschutzfachdienst
Abteilung 15, Wirtschaft, Tourismus u. Energie, Ref. 15/04, Tourismus

Die Arbeitsgruppe hat bei ihren Beratungen Vertreter der jeweils betroffenen Gemeinde(n) sowie der Abteilung 5, Ref. 5/05, *Seilbahn*-, Luft- und Schifffahrtsangelegenheiten beizuziehen. Bei Bedarf können jederzeit weitere Experten zu den Beratungen beigezogen werden.

4. Organisatorischer Ablauf

4.1 Der Projektwerber reicht formlos die Unterlagen (4-fach) an das Amt der Salzburger Landesregierung, Arbeitsgruppe "Schianlagen" ein. Dazu ist notwendig:

– Kurzbeschreibung des Vorhabens (Art des Liftes, Länge, Höhenunterschied, Förderleistung)

– Übersichtsplan über die Lage des Projektes im Gesamtschigebiet (Situierung Tal- und Bergstation, Trassenführung), 1:25.000 (eventuell Flugaufnahme, *Orthofoto)*

– Grobabschätzung von möglichen Rodungsflächen

– Gesamtfläche der zum Projekt dazugehörigen Schipisten

– Kurzdarlegung der Aufgabe des Projektes in Zusammenhang mit dem Gesamtschigebiet, bei größeren Erschließungsvorhaben auch zukünftige Gesamterschließungskonzeption

4.2 Allfällige Durchführung eines Augenscheines (Einladung erfolgt durch die Arbeitsgruppe "Schianlagen"), bei dem die einzelnen Fachbereiche überprüft und eventuell zu erwartende Probleme für eine allfällige Genehmigung aufgezeigt werden.

4.3 Anhand dieser Vorprüfung wird festgelegt,

– ob die Realisierung des Schianlagenprojektes möglich ist

– *ob eine Erheblichkeitsprüfung oder Einzelfallprüfung durchzuführen ist, damit genauere Daten für die Beurteilung erarbeitet werden, oder*

– ob von weiteren Schritten zur Realisierung dieses Projektes aufgrund von erheblichen grundsätzlichen Problembereichen abgesehen werden soll.

4.4 Das Ergebnis dieses Augenscheines bzw. der Beratungen werden in Form eines einvernehmlichen Resümeeprotokolls zusammengefasst.

4.5 *Eine Umweltverträglichkeitsprüfung nach UVP-G 2000 ist durchzuführen,*
- *bei einer Neuerschließung von Gletscherschigebieten sowie*
- *bei einer Neuerschließung von Schigebieten, wenn damit eine Flächeninanspruchnahme mit Geländeveränderungen (dazu zählen u.a. auch Rodungen) durch Pistenneubau oder durch Lifttrassen von mindestens 20 ha verbunden sind.*

Eine Einzelfallprüfung zur Feststellung, ob ein UVP-Verfahren im vereinfachten Verfahren durchzuführen ist, kann notwendig werden
- *bei einer Flächeninanspruchnahme mit Geländeveränderungen von mindestens 5 ha.*
- *bei einer Flächeninanspruchnahme von 2,5 ha (Richtwert lt. UVP-G gültig), wenn schutzwürdige Gebiete der Kategorie A nach Anhang 2 UVP-G 2000 (das sind z.B. Vogelschutzgebiete, Bannwälder, Nationalparks, Landschaftsschutzgebiete, Naturschutzgebiete, ausgewiesene Biotope, etc.) betroffen sind.*

Eine UVP-Pflicht kann auch durch andere Tatbestände wie Rodungen (ab 5 ha bzw. ab 2,5 ha in schutzwürdigen Gebieten) und Parkplätze (ab 375 Stellplätzen bzw. ab 188 Stellplätzen in schutzwürdigen Gebieten) ausgelöst werden. In den beschriebenen Fällen oder bei Zweifeln ist eine endgültige Abklärung zu empfehlen. Dazu stehen auch Checklisten, die in der Abt. Umweltschutz des Landes Salzburg erarbeitet wurden, zur Verfügung.

4.6 *Bei notwendigen Flächenwidmungsänderungen für die Errichtung von Pistenflächen bzw. Aufstiegstrassen ist ab 10 ha in geschützten Gebieten sowie ab 20 ha in sonstigen Bereichen eine Umweltprüfung verpflichtend erforderlich (SUP-Richtlinie). Für Änderungen unterhalb dieser Schwellwerte ist im Einzelfall die Erheblichkeit der Umweltauswirkung zu prüfen. Bei erheblichen Auswirkungen kann im Einzelfall ebenfalls eine Umweltprüfung erforderlich sein. Diese Erheblichkeitsprüfungen fallen in den Zuständigkeitsbereich der Gemeinden.*

Die notwendige Erheblichkeitsprüfung laut SUP-Richtlinie wird ab Erreichung der Schwellwerte der Einzelfallprüfung bzw. der Vorprüfung, ob eine Kumulierung gegeben ist, im UVP-Verfahren gemeinsam abgewickelt. Durch eine derartige Vorgangsweise kann die Erheblichkeitsprüfung, welche bei Erweiterungen von Schianlagen im wesentlichen naturräumliche Probleme umfasst, im Rahmen der Einzelfallprüfung abgehandelt werden. Der notwendige Umfang für die Einzelfallprüfung wird im Rahmen einer Koordinationsbesprechung entweder unter Leitung der Abteilung 5 (wenn davon Seilbahnbauten und Schiflächen betroffen sind) oder der Abteilung 16 (wenn es sich um die ausschließliche Erweiterung von Schiflächen handelt), festgelegt. Dabei legen die Experten des Amtes der Salzburger Landesregierung sowie der WLV und der Landesumweltanwaltschaft den notwendigen Untersuchungsrahmen fest. Im Rahmen dieser Koordinationsbesprechung wird auch die Gemeinde und der Ortsplaner eingebunden werden, damit eventuell notwendige zusätzliche Fachbereiche für die Erheblichkeitsprüfung abgedeckt werden können. Die Bereiche der Erheblichkeitsprüfung im SUP-Verfahren, welche unterhalb der angegebenen Schwellwerte liegen, werden im Rahmen der Tätigkeit der Arbeitsgruppe Schianlagen (Ortsaugenschein, Prüfung der Unterlagen, usw.) geprüft, ob möglicherweise erhebliche Auswirkungen auf die Umwelt durch das geplante Vorhaben vorliegen. Diese Prüfung erfolgt für die notwendige Flächenwidmung, wie sie im Naturschutzgesetz (2 ha) derzeit vorgesehen ist. Für Erweiterungen von bestehenden Schipisten ab 2 ha und bei Neuerrichtung von Schipisten ist eine Flächenwidmung ab 0,5 ha erforderlich. Die Bewertung durch die Arbeitsgruppe wird im Rahmen eines Protokolls festgehalten und der Gemeinde zur weiteren Verwendung übermittelt.

4.7. Die Protokolle der Alpenkonvention sind direkt bei der Beurteilung von Schierschließungsvorhaben im Bundesland Salzburg zu berücksichtigen.

4.8. Bei Vorhaben, die Auswirkungen auf Natura 2000-Schutzgebiete haben könnten, ist eine Naturverträglichkeitsprüfung gem. § 22a Salzburger Naturschutzgesetz notwendig.

In den behördlichen Genehmigungsverfahren können die Protokolle, Einzelgutachten und das Ergebnis der Erheblichkeits- bzw. Einzelfallprüfung vorgelegt werden und diese sind von den Dienststellen des Landes zu berücksichtigen. Diese Erheblichkeits- bzw. Einzelfallprüfung ersetzt aber nicht die notwendigen rechtlichen Verfahren (Forst-, Naturschutz-, Seilbahn- und eventuell auch Wasserrecht).

5. Begriffsdefinitionen

5.1 Modernisierung und Komfortverbesserung bestehender Lifte oder Seilbahnanlagen

Ersetzen einer bestehenden Anlage durch die Errichtung einer Aufstiegshilfe mit verbessertem, technischen System bei gleichzeitiger Abtragung der bestehenden Anlage. Im Fall einer Kapazitätserweiterung muss eine genügend große Pistenfläche vorhanden sein.

5.2 Ergänzung oder Abrundung von bestehenden Schigebieten

Die Errichtung von Aufstiegshilfen und/oder Pisten im Bereich eines bestehenden Schigebietes, ohne dass die Außengrenzen davon überschritten werden.

5.3 Erweiterung vom bestehenden Schigebieten

Die Errichtung von Aufstiegshilfen und/oder Pisten über die Grenzen des bestehenden Schigebietes hinaus (Beurteilungsrahmen UVP-G und Abgrenzung nach naturräumlichen Gegebenheiten).

5.4 Verbindung von bestehenden Schigebieten bzw. Anbindung von Orten im Talraum an bestehende Schigebiete

Errichtung von für die Verbindung bzw. Anbindung notwendigen einzelnen Aufstiegshilfen oder Schipisten, um bereits bestehende, benachbarte Schigebiet zusammenzuschließen oder eine Verbindung aus dem Talraum zu bestehenden höher liegenden Schigebieten zu ermöglichen (Beurteilungsrahmen UVP-G und Abgrenzung nach naturräumlichen Gegebenheiten).

5.5 *Schigebiete und Schiräume*

Schiräume sind in einem sogenannten organisierten Schiraum und in den freien Schiraum unterteilt. Der organisierte Schiraum umfasst Pisten, Routen und Aufstiegshilfen, der freie Schiraum umfasst nur sogenannte Variantenabfahrten.
Im Bereich des organisierten Schiraumes ist eine Absicherung gegen alpine Gefahren, eine tägliche Kontrolle der Abfahrten mit einer Schlusskontrollfahrt sowie eine regelmäßige Pistenpflege gegeben. Im freien Schiraum ist kein Schutz vor alpinen Gefahren gegeben und es wird auch keine Pistenpräparierung oder Kontrolle durchgeführt.
Pisten und Routen werden markiert und bewusst angelegt. Pistenflächen im organisierten Schiraum sind allgemein zugängliche Flächen, welche zur Abfahrt mit Schiern oder anderen Wintersportgeräten vorgesehen sind. Diese werden präpariert, markiert, kontrolliert und vor alpinen Gefahren gesichert. Diese Pistenflächen sind durch technische Aufstiegshilfen erschlossen.
Ein Schigebiet umfasst einzelne oder zusammenhängende technische Aufstiegshilfen und dazugehörige präparierte oder gekennzeichnete Schipisten. In diesem Bereich ist ein durchgehendes Befahren mit Wintersportgeräten möglich, wobei die Pisten in der Regel zu den Aufstiegshilfen zurückführen. Einem Schigebiet ist weiters eine Grundausstattung mit den notwendigen Infra- und Suprastrukturen (wie z.B. Verkehrserschließung, Versorgungsbetriebe, Übernachtungsmöglichkeiten, Wasserversorgung, Kanalisation, usw.) zuzurechnen.
Ein Schigebiet besteht dabei aus mindestens zwei technischen Aufstiegshilfen mit einer Länge von mindestens jeweils 600 m sowie den dazugehörigen notwendigen Pistenflächen.
Ein Großschiraum bzw. eine Schiarena ist ein Gebiet, welches mehrere bestehende eigenständige Schigebiete schitechnisch und organisatorisch umschließt. Die einzelnen Schigebiete sind naturräumlich in der Regel voneinander getrennt und sind nur durch schitechnische oder verkehrstechnische Verbindungen miteinander verbunden.

5.6. *Abgrenzung nach naturräumlichen Gegebenheiten*

<u>Talräume und Geländekammern</u>
Bei Talräumen handelt es sich um geschlossene, durch markante natürliche Geländelinien und Geländeformen (Grate, Kämme, Rücken, Bäche, usw.) abgrenzbare Landschaftsräume, die in sich eine topografische Einheit darstellen. Darin befindliche Geländekammern können

diese Talräume unterschiedlich strukturieren und unterteilen. Bei der Neuerrichtung von Schianlagen über bestehende Talräume hinaus sind auch andere betroffene Talräume (konkret die betroffenen Geländekammern) mit zu berücksichtigen.

Wassereinzugsgebiet
Dies betrifft die Einzugs- bzw. Teileinzugsgebiete der Fließgewässer, welche zum großen Teil in Form der durch Verordnung der Landeshauptleute festgelegten Wildbacheinzugsgebiete vorliegen. Diese sind im Wildbachkataster dargestellt und werden laufend aktualisiert. Dieses Wassereinzugsgebiet soll im Regelfall bis zum vorhandenen Talsammler berücksichtigt werden. Mögliche notwendige hydrologische Maßnahmen bzw. Rückhaltemaßnahmen werden bei Pistenneubauten auf dem tatsächlichen Einzugsbereich berechnet und im notwendigen Ausmaß bei der Pistenerrichtung mitgeplant und realisiert.

Betrachtbarer Landschaftsraum
Dabei gilt die Beurteilung über die Einsichtigkeit aus dem Talraum oder anderen umgebenden Bereichen.

5.7 Kleinstanlagen

Einzelne Schlepplifte mit einer Trassenlänge von höchstens 300 m mit den dazugehörigen Schipisten, die in Siedlungsnähe als Schul- und Übungslifte dienen. Ein Zusammenhang mit Schigebieten ist in der Regel nicht gegeben. Diese stellen kein Schigebiet dar.

5.8 Neuerschließung

Alle Maßnahmen der Schierschließung, die nicht als Modernisierung und Komfortverbesserung bestehender Lifte und Seilbahnanlagen, als Ergänzung, Erweiterung, Abrundung, Verbindung oder Anbindung bestehender Schigebiete sowie als Kleinstanlagen im Sinne der Richtlinien definiert sind.

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"Regular Network Snow Observations in Russia in 20th Century and Beyond"

Since the very beginning of the regular meteorological observations in Russia, great attention was paid to snow feature recordings. The snow was recognized as a special issue for meteorological observations, and as early as 1881 the first snow depth data were registered on daily basis (at not so many stations yet). Since that time, more and more attention was paid to snow by the Russian hydrometeorological service, and after 1930s relatively dense network of more than 150 stations existed in ex-USSR already.

Then, in 1966 the new unique program of regular observations has been established. It includes the so-called transects: routes about 1-2 km long, with regular (about every 10-15 minutes) probing of the snow along the route. The routes are designed to cross land cover types usual for the area: field, forest or gullies. Then, the measured parameters are averaged for each of the land cover type. The transects are normally done every 10 days, and during the melting period – every 5 days.

The observed parameters include:
- Snow coverage (% of the territory),
- Snow depth,
- Snow water equivalent,
- Presence of ice and/or water saturated layers,
- General characteristics of the snow structure ("fluffy", or "crumbly"),
- Number of snow days within a month.

In Fig.1, typical coniferous forest in Moscow region is shown, and one can imagine how the snow cover features here are different from those at the meteorological stations, which are located on fields. The transects program allows one to overcome the forest data shortage, and many other problems.

Fig.1. Snow cover view in boreal forest around Moscow.

Totally, more than 1300 stations in USSR were included in the transects program.

Now about 700-800 of them in ex-USSR states are operating, with about 500-550 of them in Russia. Not every station had observations every 10 days, and usually not more than 700-800 of them are available for any of the days of observations. In Fig. 2, the distribution of all stations involved in the transects program is shown. Although the main part of ex-USSR territory is covered with observations pretty well, there are some areas without stations at all.

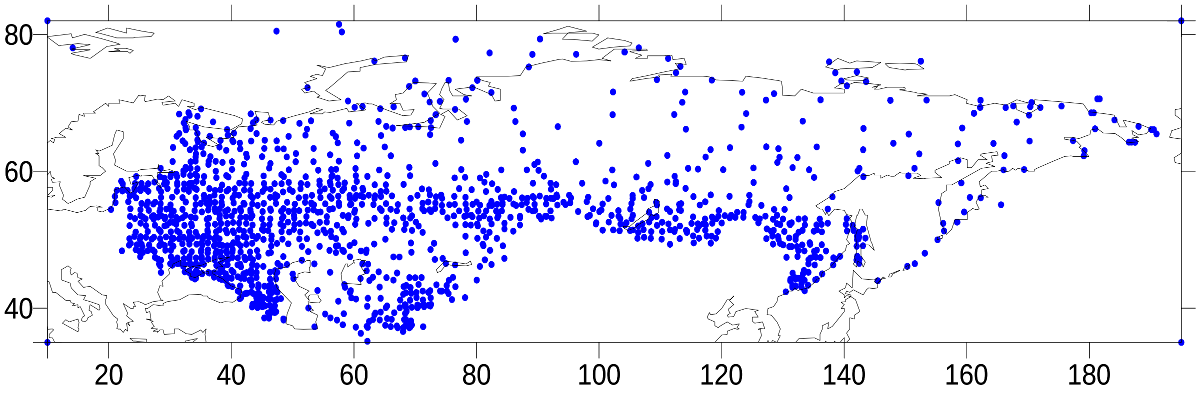

Fig.2. Geographical distribution of the observation stations involved in the snow transects program.

As an example of really available data on a certain day, the Fig.3 shows the distribution of stations which provided data on March 31, 1990. The areas without data mean either absence of data or absence of snow cover, and the latter is probably true for the south-western part of the territory. There are some other gaps in the data, for example in the very north-eastern part of Siberia, where the snow definitely existed at that time.

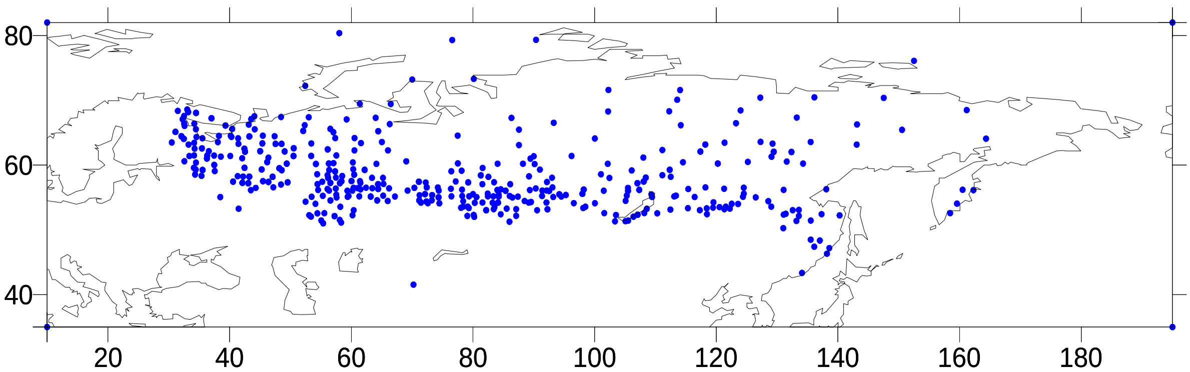

Fig.3. Stations provided snow transects data on March 31, 1990.

The data for 1966-90 are available from Internet (from NSIDC website in Colorado), and the data until 2001 are to be available in 2005. Also, the snow depth data from regular meteorological stations (without transects), as well as meteorological data, will be available next year. Relatively dense network of these stations exists since 1936, and daily data will be available. Nowadays, about 180-200 stations of this kind provide the snow depth data for the ex-USSR territory. Their geographical distribution is shown in Fig.4.

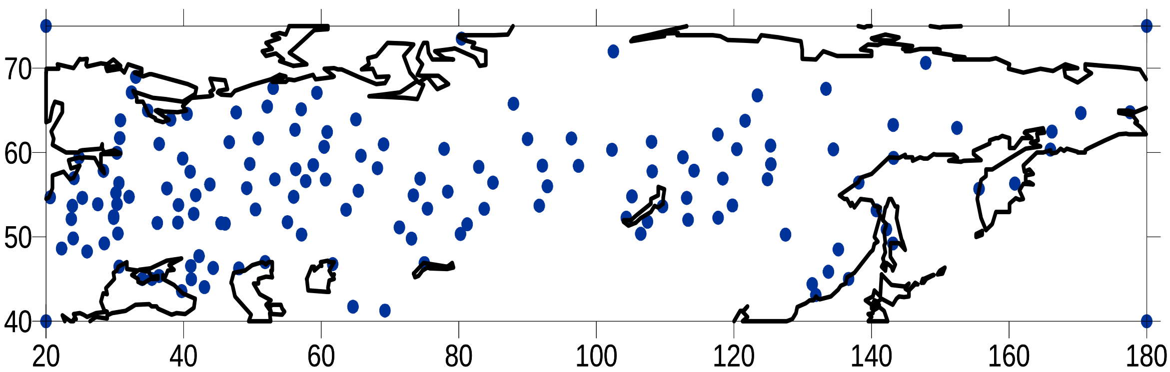

Fig.4. Regular WMO meteorological stations with daily observations of snow depth.

In the 21st century, the program of snow observations continues, with somewhat less stations providing information than in 1980s. This gives one a hope that the information on main snow cover features on the large part of Eurasia will give us new clues on the winter climate processes on the continental scale.

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"Modelling of Snow Cover and Permafrost Features in Northern Eurasia for Some Climate Change Scenarios"

Background and motivation

The changes of phenomena typical for cold environment, such as snow cover and permafrost, under the future climate changes are of great interest for many specialists. They are especially important as the projected climate changes are the strongest in the polar and subpolar latitudes. Also, the permafrost thawing could be critical for many aspects of economy in these regions. The study is aimed to evaluation of the regime of snow cover formation and melting, as well as permafrost thawing, in contemporary climate and under certain climate change scenarios in 21st century. The numerical experiments were carried out for the period from 1991 till 2070 in a transient mode.

Model

For the study, the SPONSOR scheme with full description of the local energy/water exchange processes was used. The model belongs to the SVAT (soil-vegetation-atmosphere transfer) class, and allows for quick calculations over large territories rather than detailed study at certain points. The scheme has been involved in numerous international projects for intercomparison of such models since 1994 (Luo et al., 2003; Slater et al., 2001; and others). For this study, the model was used together with the original radiation scheme (Shmakin, 1998). The following processes are included in the SPONSOR model:

- Accumulation, densening, evaporation and melting of snow;
- Interception of precipitation by plants and its evaporation;
- Infiltration of water into the soil;
- Surface and subsoil runoff;
- Transpiration and bare soil evaporation;
- Turbulent fluxes in the surface air layer;
- Variations of albedo and absorption of incoming radiation;
- Heat transfer in the snow and soil;
- Freezing and thawing of the soil water.

A set of landscape parameters describing the vegetation (leaf area index, height, etc.) and soil (heat conductivity, hydraulic conductivity, etc.) is specified for each of the experimental sites. There were 5 Russian sites selected for the study: Narian-Mar (67.65°N, 53.02°E), Turukhansk (65.78°N, 87.95°E), Olekminsk (60.40°N, 120.50°E), Yakutsk (62.08°N, 129.75°E), and Tiksi (71.35°N, 128.55°E), with each one in this row characterised by colder climate and thicker permafrost layer than the previous one. For each of the sites, the numerical experiments were carried out for two types of land cover: tundra or marsh with thick peat layer and shallow saturated (with ice rather than water) ground layer; and forest or bush with only a thin peat layer and relatively deep saturated ground. Basically, the tundra/marsh parameters represent wetter conditions for each of the regions, while the forest/bush case characterise dryer environments.

Atmospheric forcing parameters

For 1991-2000, 6-hourly data (air temperature, air humidity, cloudiness, wind speed, precipitation rate, atmospheric pressure), observed at regular meteorological stations, were used as forcing parameters.

For 2001-2070, the atmospheric forcing variables were obtained from the 1991-2000 data, repeated 7 times, with gradual change of the air temperature and precipitation in each month according to the results of integration of ECHAM and Hadley Centre coupled GCMs until 2070. The approach is similar to the "modulation" technique of combining high- and low-resolution atmospheric variables (Shmakin et al., 2002), and guarantees their physical interrelations and enough meteorological variability.

The GCM integrations have been done for the scenario of 1% annual increase of CO_2 concentration. The ECHAM model generally predicted larger warming in the 21st century, while the HadCM model obtained moderate warming. An example of air temperature in July of 1992 (observed) and 2062 (synthesised) is shown in Fig.1.

The deep ground temperature at 5 m (i.e. the lower boundary condition for the SPONSOR model) was suggested to be equal to the average air temperature during the last 10 years before the current model date. The 10-year lag was chosen as the typical relaxation time of the ground temperature at 5 meters depth.

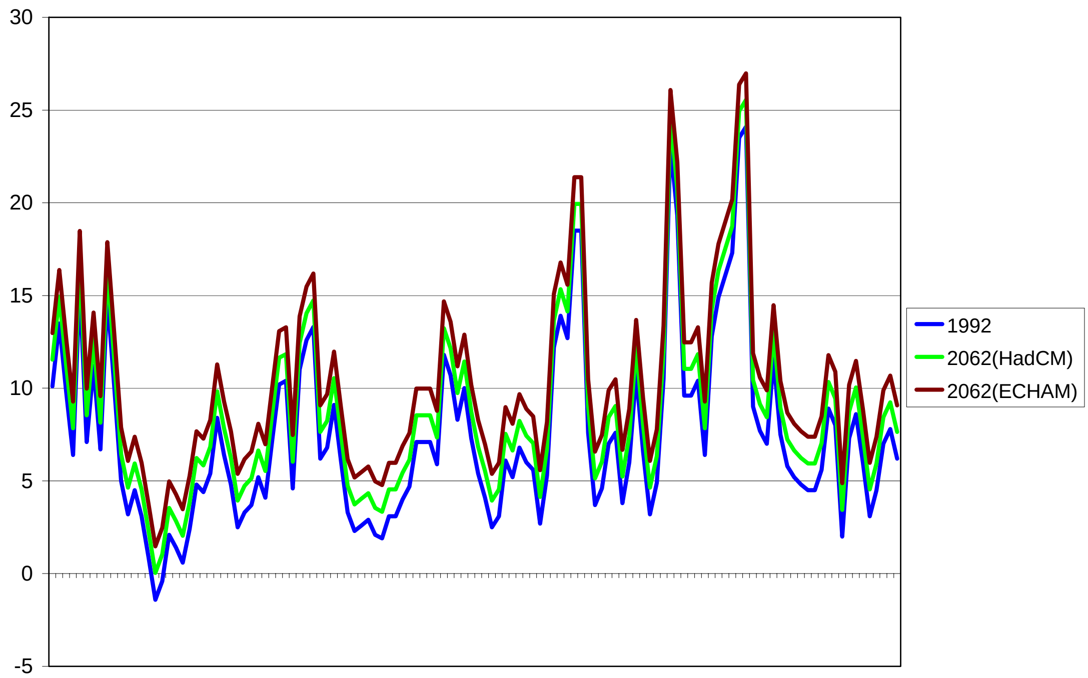
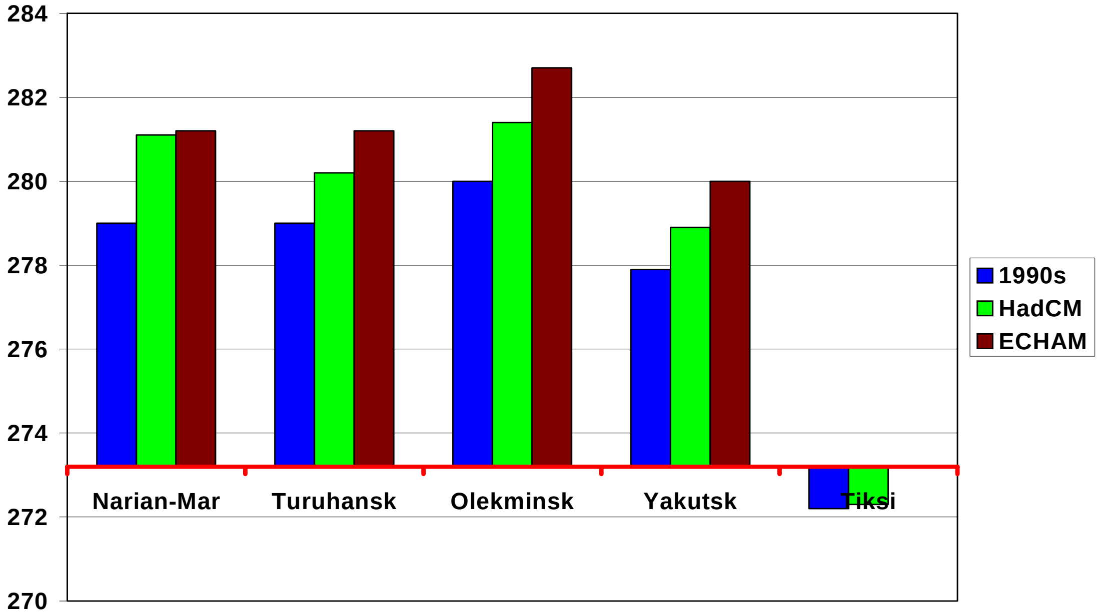


Fig.1. Air temperature in Tiksi for July of 1992 (observed) and 2062 (projected from GCM scenarios)

Results

The most informative results of the soil temperature calculation for contemporary and future conditions at forest/bush are shown in Figs.2 and 3. For the analysis, the maximum soil temperatures at the corresponding depths for each year from the last 10 years of calculations (i.e. 1991-2000 for contemporary conditions, 2061-2070 for future climate) were chosen, and averaged. In wetter environments, the soil temperature, while increasing due to the climate warming, doesn't exceed the melting point in the locations where the thawing takes place already, and doesn't reach the melting point in the layers which are frozen now. The main reasons for only slight thawing of the permafrost under the projected climate warming are low heat conductivity of the peat layer overlying the soil, as well as large heat capacity of the model layers, especially in the wetter landscapes. Moreover, according to both ECHAM and HadCM scenarios, the warming in summer is not so significant as in winter, and this prevents the permafrost from considerable thawing too. As to the snow cover, its maximum water equivalent in winter decreases slightly during 2000-2070 at all sites, although by not more than 15%. The snow duration decreases too, although by not more than 10%.

Fig.2. Average of annual maximum soil temperature at 0.7 m during the last 10 years of



calculations, forest / bush

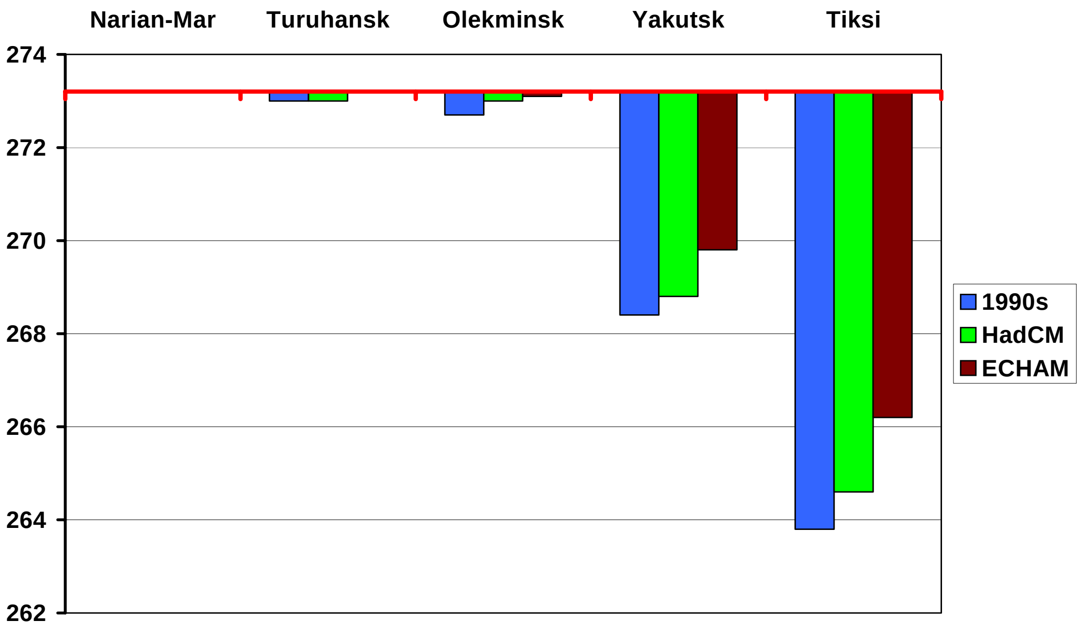


Fig.3. Same as Fig.2, but for 2 m depth

Conclusions

- At the tundra/marsh (wetter) sites, no qualitative changes in the permafrost changes take place in the coming 70 years under the suggested climate change scenarios.
- At the forest/bushes (dryer) sites under the ECHAM scenario, the permafrost will start to thaw in 2060s at 0.7 m in Tiksi and at 2 m in Turukhansk; the thawing is about to start at 2 m in Olekminsk in several years after 2070.
- Due to considerable soil heat capacity and low soil heat conductivity, as well as low temperature growth in summer during 2000-2070, the rate of soil temperature increase under the climate

change scenarios is quite low: not more than 1.5°C in 70 years at tundra/marsh sites, and 2.5°C at forest/bush sites.
- The maximum snow water equivalent at the sites decreases to some extent under the climate change scenarios, although not critically.

Acknowledgement

The work is supported by the Russian Foundation for Basic Research (grant No. 03-05-64745), and INTAS (grant 03-51-5296).

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"Snow: Macroscale and Microstructure"

Introduction

The necessity to account for snow cover characteristics in climate and hydrological models of local, regional, and global scales, if a studied territory is seasonally covered by snow, is widely accepted [*Liston*, 2004]. It is also expected that the more advanced is a description of a snow cover layering/microstructural features in a model of a snowpack, the higher, in general, is the accuracy of the models' output [*Etchevers et al.*, 2004]. There is, however, great distance between the expectations from an introduction of a snow cover in spatially-distributed surface properties for climate and hydrological models and the output from modelling the temporally-varying snow layers' properties in physical models of snowpack evolution. In first case the required characteristics are averaged per areas corresponding to a model's resolution effective characteristics of snow cover, such as albedo and effective heat conductivity of snow cover. For the snowpack models the characteristics of interest are mainly related to depth-variability of the effective properties of snow constructing the snowpack.

There is certain progress in development of both the approaches. It is shown that the profiles of snow layering in seasonal snow cover do correlate with climate and landscape zoning [*Sturm et al.*, 1995]. On the other hand, the energy balance of a snowpack, despite very complex interaction between the ice matrix and the pore space resulting in snow metamorphism, does correspond to certain type of equilibrium (though not always to the steady state) [*Bartelt et al.*, 2004]. Thus, it must be possible to estimate both the spatial (at a scale of interest) and temporal intraseasonal variability of some effective characteristics of snow cover by combination of a climate and a snowpack model, though one has to keep in mind that both these routines are of similar degree of numerical complexity with all the corresponding range of uncertainties in input and output parameters.
However, the task can be simplified if the following consideration would be taken into account.

Intraseasonal variability of snow cover effect on energy balance of a snow-covered landscape

Analysis of interrelation between an observed heat flow beneath a snow cover and the temperature conditions above it shows interesting features: Normally, a snow cover is considered to behave as thermoinsulating layer suppressing the energy exchange between soil and atmosphere [*Zhang et al.*, 1996]. This understanding is correct in general, but there are additional faces in introduction of the "low" heat conductivity of snow into a description of the energy balance. Firstly, the seasonal temperature variation corresponds to change of the direction of the heat flow. In early winter a soil is loosing heat, while close to spring season the heat flow is directed from the atmosphere to the soil. Snow cover does affect the energy balance in both cases, however, the effect is different. Not many studies were focused on such kind of the snow cover effect variability, but those results available suggest that [*Sokratov and Barry*, 2002] it is possible, instead of involving a detailed physical model of snow–soil interaction, to represent the variability in terms of a limited number of stages (numbered from a beginning of a winter season):

I. The duration of loosing the energy gathered by soil in previous summer correlated with the average snow depth at this stage;
II. The effective heat conductivity of snow cover is proportional to snow depth, but still complex temperature distribution in soil due to not completely equilibrated effects of phase changes in previous stage make the dependence weaker than at the next stage;
III. The heat flux through soil is almost uniform with depth, and the effective heat conductivity of snow cover is proportional to its depth;

IV. The energy balance of soil is proportional both to the mean air temperature during the stage and to the maximal for the stage (normally corresponding to maximal for the season Snow Water Equivalent) snow depth.

The time-boundaries between the stages are linked to certain seasonal climate events, such as complete active layer freezing between stage I and II (the analyzed by *Sokratov and Barry* [2002] site was in permafrost region), and zero heat flux between soil and snow cover between stages III and IV. They vary in time relative to the beginning of winter season from year to year and evidently would be at different time moments from site to site. Moreover, not all the stages can be expected in all landscapes and in any winter season, but they can be related to either modelled or observed climate and thus can be used as a parameterization scheme of intraseasonal variability of at least the effective heat conductivity of snow cover.

Effective heat conductivity of snow cover

The detailed profiles of various snow properties provided by physical models of snow cover evolution are valuable tool for such applications as snow avalanche forecasting and small-scale variability of snow cover. However, for scales and uncertainties of large scale climate and hydrological models, the information provided by these models can hardly be consumed and verified. Moreover, accepting the conclusion of *Sturm et al.* [1995] on rather certain snow profiles in certain climate conditions, a parameterization scheme for spatial large-scale variability of snow cover properties allows further simplification:

Taking as an example heat conductivity of individual snow layers, the effective heat conductivity of their combination (k_{eff}) is nothing else but a combination of the heat conductivities (k) of layers in the well-known construction of *Maxwell* [1891]: $k_{eff} = \frac{(l_1 + l_2)k_1k_2}{l_2k_1 + l_1k_2}$, where subscripts 1 and 2 correspond to one and the other layer and l is thickness. Practically, for a limited number of snow types involved, the estimation of the effective heat conductivity does not depend on distribution of these types inside a snowpack, but on percentage of a certain type in overall depth of the snow cover. The latter is the base for the classification of the snow cover as those of *Sturm et al.* [1995]. Thus, the accuracy of the effective heat conductivity of snow cover incorporation into a spatially-distributed model would be determined by accuracy of determination of the class of snow at certain geographical (climate) position, either in model or in interpretation of observational data, and by accuracy of the effective heat conductivity of the types of snow constructing this class. The latter determined by snow microstructure.

Microstructural properties of snow

The ideas expressed above provide a new view on importance of experimental investigations of the relation of snow properties to snow microstructure. Taking again the effective heat conductivity of snow as an example, the accepted for now empirical and theoretical constructions consider the snow density as the leading parameter determining the effective heat conductivity despite the fact that empirical data vary up to 5 times for the same snow density [*Sturm et al*., 1997]. Recently obtained experimental results show that the process of snow metamorphism can change the effective heat conductivity of snow with constant density at almost same degree as it would happen with snow density change [*Schneebeli and Sokratov*, 2004]. Construction of a physical model of snow metamorphism only recently started due to appearance of high resolution non-destructive experimental methods of laboratory observation of the snow recrystallization process [*Schneebeli and Sokratov*, 2004]. And in relation to the heat conductivity of the types of snow, required for large-scale snow cover parameterization schemes, the reported data provides very promising results: The effective heat conductivity of snow, despite continuous recrystallization, remains constant after reaching some limiting value determined by snow density [*Schneebeli and Sokratov*, 2004]. It means that considering a type of snow at the time scale of the stages of the snowcover effect on the energy balance of a snow-covered landscape described above, the effective heat conductivity with high accuracy can be accepted as a certain value. The answer, which value it is, can be given experimentally [*Schneebeli and Sokratov*, 2004] and would have solid theoretical base [*Bartelt et al.*, 2004]. But the experimental work with required types of snow can only be possible after the necessary for large scale models classes of snow cover would be defined.

Conclusions

Success in linking the results of microstructural studies of snow metamorphism and large scale climate and hydrological modelling depends on joint effort from both the sides. The difference in aims of snow-related investigations at different scales makes difficult close collaboration between groups working in these two directions. However, without such linkage the microphysical studies of snow unnaturally limit applicability of their results, while large scale models lose accuracy in modelled snow-related interrelationships and thus in overall outcome from the models.

The study is related to the INTAS 03-51-5296 project "Influence of snow vertical structure on hydrothermal regime and snow-related economical aspects in Northern Eurasia" and to the Swiss National Science Foundation project 200021-100294 "Crystal growth in the multi-element system snow".

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„Betriebsnachfolge im Tourismus als heißes Eisen“

In den nächsten zehn Jahren steht in der Wirtschaft ein großer Generationenwechsel bevor: Mehr als 30 Prozent der heimischen Unternehmer gehören zur Generation "50 plus", womit rund 54.000 Betriebe zur Übergabe anstehen werden.

Die Sparte Tourismus und Freizeitwirtschaft ist davon überdurchschnittlich stark betroffen. Nach den Daten der Wirtschaftskammer Österreich und der Statistik Austria gibt es etwa 9.000 bis 10.000 Unternehmer im Tourismus, die über 55 Jahre alt sind und deren Betrieb bis 2007 übergeben werden dürfte.

Wichtige Voraussetzung für einen reibungslosen Wechsel ist die Übernahmetauglichkeit. Dies bedeutet, dass ein Betrieb strukturell
und finanziell geeignet sein sollte, übernommen zu werden.
Tatsächlich gelten im Tourismus nach einer Untersuchung des Instituts für Gewerbe- und Handwerksforschung (1999) rund 31 Prozent der in Frage kommenden Betriebe nicht als übernahmetauglich. Angesichts der bekannt niedrigen Eigenkapitalquote und des hohen Verschuldungsgrades dürften diese Angaben durchaus realistisch sein, befürchtet der
Obmann der Bundessparte Tourismus und Freizeitwirtschaft, Komm.Rat Johann Schenner.

Eine besondere Rolle spielen im Gastgewerbe allerdings die stillen Reserven. Werden diese einbezogen, so verbessert sich das Gesamtbild sowohl für die Gastronomie als auch für die Hotellerie entscheidend.

Im allgemeinen ist die Betriebsübergabe bei KMU leichter als bei Großunternehmen, da es sich um überschaubarere Einheiten handelt. Vorteile sind das Aufrechterhalten der familiären Tradition, ein leichter kalkulierbares Risiko, sowie das Vorhandensein von Infrastruktur, Kundenstock und Mitarbeiter, stellte Schenner am Wochenende im Rahmen der "Tourismustage Alpbach" in einem Expertengespräch zum Thema Betriebsübergabe fest.

Probleme bereiten die oft mangelnde Rücktrittsbereitschaft des Unternehmers, der sich in der Regel stark mit dem Unternehmen identifiziert, das Verharren in altbewährten Strukturen, der Mangel an Managementkenntnissen und ein hoher Aufwand bei der Modernisierung veralteter Infrastruktur. Tatsache ist, dass nur etwa die Hälfte der Unternehmen den Sprung von der ersten zur zweiten Generation "überlebt" und weniger als drei Prozent den Weg in die dritte Generation schaffen.

Als Lösungsansätze nennt Schenner die Heranziehung externer Berater für strategische Maßnahmen - wodurch sich die Entscheidungsspielräume erweitern -, die Einbeziehung leitender Mitarbeiter in wichtige Entscheidungsprozesse, die rechtzeitige Planung und professionelle Vorbereitung der Übergabe (Dauer 3 bis 5 Jahre!) und die Ausarbeitung
eines Stufenplans für die Unternehmensnachfolge.

Als wichtigste politische Forderungen nannte Schenner im Rahmen des Expertengesprächs vor Teilnehmern aus ganz Österreich die Streichung der Erbschaftssteuer bzw. Erhöhung des Freibetrages bei Übergabe von bisher 365.000 auf eine Million Euro sowie die Gleichstellung von Betriebsnachfolgern und Unternehmensgründern bei Förderungen.

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"Sewage Treatment Plants for Winter Use in Austrian Mountains – a Full Case Study"

INTRODUCTION

Particularities of WWTP´s in winter tourism areas

Wastewater treatment in winter tourism areas is a challenging task since sudden load increases – in the range of double to triple of the median load of the non-tourism season – are combined with low wastewater temperatures. These two boundary conditions are especially critical for the nitrification process. The growth rate of nitrifiers at a temperature of 8 °C is only 0.25 d-1, which means that even under optimum growth conditions the nitrifying population would only grow by approx. 20 % per day considering autotrophic decay. Of course, such optimum growth conditions cannot be maintained within the entire aeration tank, subsequently there is simply no operational means to increase the nitrifying population to the increased load demands within the time span it actually occurs.

Instead, operational precautions have to be taken in order to maximise the nitrifying population well in advance of the occurrence of the load step change. The nitrification capacity of an activated sludge system is mainly determined by the nitrified load over the course of the SRT.

Basically two measures can be taken:

First, to operate the plant at maximum nitrification in the period before the load increase.

Second, to manage ammonium sources - i.e. storage of sludge dewatering filtrate water - and controlled dosing of the stored high ammonium load water over one SRT before the load increase.

The specific load situation has to be considered already in the plant design phase. Conventional single stage plants do not seem to be the most appropriate solution, since they need to be built very large to be able to handle the increased load, which corresponds to aeration tank over capacities during the low loaded season.

Two stage plants can be considered a better choice for such load characteristics, but conventional two stage plant often encounter problems due to an insufficient substrate supply to the nitrifying stage for nitrogen removal. Designing the plant for nitrification only during the high load season can lead to alkalinity (pH) related nitrification inhibition due to low buffer capacity of the wastewater – which is the case in some of the main skiing regions in Austria.

A possible solution can be found in a special two stage concept – the Hybrid®-concept – which combines some of the advantages of single and two stage activated plants.

Case study: WWTP Saalfelden

WWTP Saalfelden was put into operation in 1986 with a capacity of 50,000 PE serving the communities of Saalfelden, Maria Alm, Maishofen and Leogang. The plant load is characterized by substantial variations over the course of the year due to winter skiing tourism. Especially around Christmas and New Year and later in February the load to the plant almost doubles within a few days, at times when the temperature in the aeration tanks is usually in the range of 8-10 °C. Another characteristic is that during snow melting season, the influent temperature can drop significantly to a minimum of 6 °C.

The initial plant was designed for carbon removal and included a mechanical pre-treatment stage, primary clarification, aeration tanks and circular secondary clarifiers. For sludge treatment a sludge digestion stage was installed.

Due to new legislation issued in 1991 – requiring nutrient removal – and load increases an extension of the plant became necessary. Initially, a single stage activated sludge plant for nutrient removal with a capacity of 50,000 PE was envisaged. Due to the inclusion of a dairy factory a

capacity increase to 80,000 PE was needed, which initiated a re-design of the initial planning. As it turned out, with the Hybrid®-concept the capacity increase could be accommodated with almost the same volumes as planned for the 50,000 PE single stage plant. Additionally, the entire existing plant was integrated into the extension concept.
Table 2 gives the design load and effluent requirements for the extension of WWTP Saalfelden.

Table 2: Design load (left) and effluent requirements (right) of WWTP Saalfelden

Design flow	m³/d	16,000
Maximum wet weather flow	m³/h	1,800
BOD5-load	kg/d	4,800
Total nitrogen load	kg/d	880
Total phosphorous load	kg/d	160
Design temperature	°C	8

		8 < T < 12 °C	T ≥ 12 °C
BOD5 concentration	mg/l	15	15
BOD5 removal	%	95 %	95 %
COD concentration	mg/l	75	75
COD removal	%	85 %	85 %
NH4-N concentration	mg/l	5	5
Total nitrogen removal	%	-	70 %
Total phosphorous concentration	mg/l	1	1

THE HYBRID®-CONCEPT

The Hybrid®-concept combines the advantages of single and two stage activated sludge plants achieving extensive nutrient removal. The main advantages of the concept are the small space demand, the robustness against substantial load variations, great operational flexibility and the great potential of integrating existing plant structures into an extension concept in case of upgrading to nutrient removal is required.
The first stage removes around 85 % of the incoming organic load, subsequently the nitrifying second stage can be built comparative small. Additionally, the high loaded first stage has a great potential for buffering and equalisation of load increases resulting in only moderate load variations in the more sensible nitrifying stage. The second stage is a low loaded stage for nitrification/denitrification operated at a SRT above ten days. For denitrification sludge from the first stage is transferred into the second stage for substrate supply. Thus, the operational mode of the second stage can be adopted to the actual conditions.
It has to be mentioned, that the two Hybrid®-sludge-lines do not impose a considerable hydraulic load, usually they are operated in a range of 3-5 % of the influent flow. If these lines are shut off, the plant is operated as a classic two stage plant. In case the lines are operated at maximum, the two stage plant increasingly behaves like a single stage plant.

Case study: WWTP Saalfelden – Plant description

The implementation of the Hybrid®-concept at WWTP Saalfelden allowed the continued use of the existing plant structures (Geyer, 2001):
For increasing the hydraulic capacity of the plant, of the existing primary clarification (3 parallel lines) only one tank remained in operation as primary clarifier, while the other two tanks are now used as storm water tanks.
The existing aeration tank (3 parallel lines) is now used as first stage aeration tank (2 of the existing tanks) and for treatment of high ammonium loaded sludge dewatering filtrate water (1 of the existing tanks), which is carried out in a sequencing batch reactor mode. The existing circular settling tanks, previously used as final clarifiers, now serve as intermediate settling tanks.
For the second stage new aeration tanks and new final clarifiers had to be constructed. The aeration tanks were built as oxidation ditch type tanks with fine bubble aeration, with the blower building situated on top of the aeration tanks which contributes to efficient use of the available plant area.
The final clarifiers have been constructed as rectangular vertical flow through type tanks, due to the following reasons:

- Approx. 6 m less foundation depth (compared to circular type tank)
- Less complex measures for securing the tanks against buoyancy
- Reduction of the total required area which allowed to locate the final clarification outside of the 'restricted construction zone' which is imposed by a 110 kV-power line crossing the plant area

The existing sludge digestion stage remains in operation, in an earlier construction phase the digesters were equipped with new mixers.
For sludge dewatering a screw press was installed, which essentially consists of a cylindrical sieve which contains a slowly rotating (1.5 rpm) conical screw. The achieved dry substance content of the sludge cake is predominantly in the range of 30-35 %.
One of the existing aeration tanks was reconstructed to accommodate two sequencing batch reactor type tanks, which are used for treatment of the digested sludge dewatering filtrate water.

OPERATIONAL RESULTS

Plant performance considering seasonal load variations

During the Christmas holiday season 2002 the plant performance was investigated. This period imposes the most critical conditions onto the plant since a low wastewater temperature is combined with a step change of the load, approximately by a factor two. Figure 3 shows the load - expressed in PE - to WWTP Saalfelden during the period of week 48/02 through week 02/03. The load increases significantly after Dec 24 with a peak value above 80,000 PE on Dec 28 which was the first Saturday after the Christmas, the main arrival day of the skiing tourists. An additional load peak was caused by heavy rainfalls on Dec 22/23 just before the start of the Christmas holiday period. During the rainfalls on 22/23 Dec the hydraulic load increases significantly up to a peak value of 3.8 relative to the median load, while the organic and nitrogen load doubles.
At the Christmas holiday period the load remains in a range of 1.8 –2.6 of the median load and starts to decrease after 04 Jan 03, which was the first Saturday after the holidays, the main departure day of the skiing tourists. Another interesting observation is that the relative COD-load is lower than the relative N-load during the entire Christmas holiday period, while it is higher or equal in the period before. It is assumed the a reduced production of the dairy factory between 24 Dec and 31 Dec caused this effect.

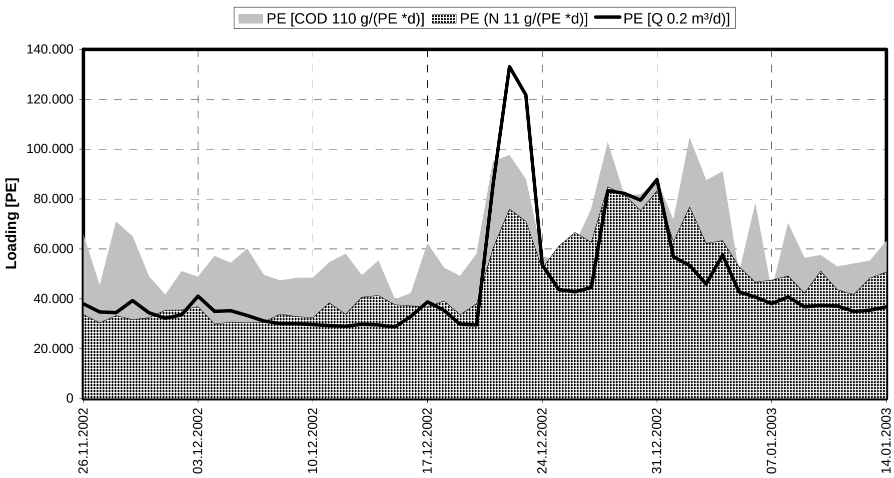

Figure 3: Hydraulic, organic and nitrogen load expressed in PE of WWTP Saalfelden during the period of week 48/02 through week 02/03

The temperature during this period was always below 12 °C with a minimum value of 7 °C during the rainfalls on 22/23 Dec. According to Austrian law only nitrification (NH4-Neff ≤ 5 mg/l) is required for the temperature range 8 °C ≤ T < 12 °C.
During the last three weeks before Christmas the nitrogen removal rate was always well above 70 %, which is the legal limit for temperatures above 12 °C. During the wet weather period on 22/23 Dec the nitrogen removal rate decreased, but immediately recovered after the hydraulic load returned to an average level.
The nitrogen effluent concentrations as ammonium (NH_4Neff), nitrate (NO_3Neff) and organic nitrogen (NorgEFF) are shown in Figure 4. The NH_4-N effluent concentration was mostly below 2 mg/l, with the exception of the period in week 02/03 when the temperature in the second stage dropped below 7 °C. The nitrate effluent concentration varied in a range of 2-16 mg/l depending on how much anoxic volume could be operated under the given load and temperature conditions. Finally, it is important to notice that the organic nitrogen effluent concentration did not rise

significantly during the wet weather period of 22/23 Dec which is an indication that no noteworthy increase of solids loss under high hydraulic load conditions occurred.

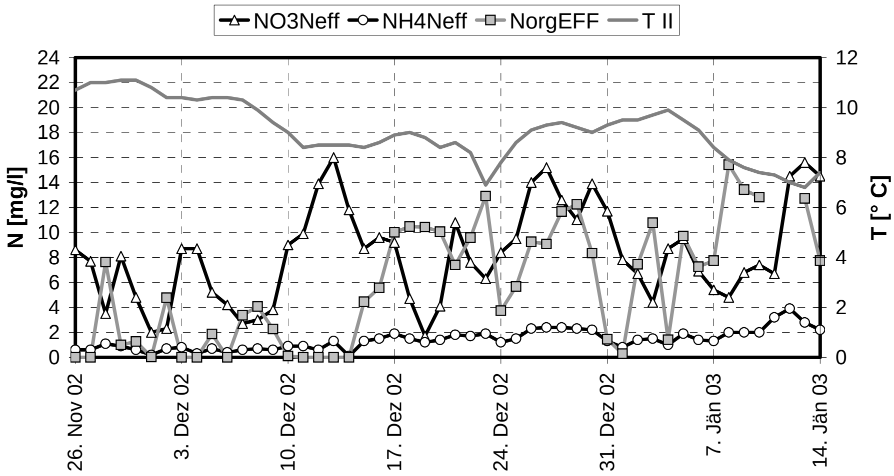

Figure 4: Nitrogen effluent concentrations and temperature in the aeration tank of the second stage (T II) of WWTP Saalfelden

CONCLUSIONS

A full scale study at a WWTP (80,000 PE) located in one of Austria´s main skiing tourism areas has been carried out. It could be shown that a load increase up to a factor of 2.5 could be managed maintaining complete nitrification and nitrogen removal rates up to 80 % at a wastewater temperature of 7 – 10 °C. In the investigated period the conditions were even more demanding since heavy rainfalls occurred just before the start of the holiday season on 22/23 Dec. The results are a strong evidence that the two stage HYBRID®-concept is capable of buffering considerable load variations in the first stage minimizing the impact onto the low loaded nitrifying second stage while extensive nitrogen removal can be maintained. Further it was shown that bulking sludge did not occur at the investigated plant, even so it receives a dairy wastewater load of approx. 15,000 PE/d.

ACKNOWLEDGEMENTS

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Appendices

A. Programme TTL Conference November 3rd – 5th

BLOCK 1 Chairperson: M.Breiling — **Day 1: November 3rd 2004**

9.00	**Registration**	Welcome, Delivering of Printed Proceedings to Registered Participants
9.30	**F.G.Rammerstorfer** Vice-Rector for Research / TU Vienna	Welcome Note
9.35	**R. Stiles** Head of Department of Urban Design and Landscape Architecture	Welcome Note
9.40	**Christian Smoliner**	Ministry of Science, Welcome Note
9:45	**M. Breiling** E261 / TU Vienna	The combination of Technology, Tourism and Landscape. Intended Projects
10:00	**A. Shmakin** Russian Academy of Sciences	Regular Network Snow Observations in Russia in 20th Century and Beyond
10:20	**K. Rubinstein/S. Gromov /V.Khan** Russian Hydrometeorological Institute	Snow Simulations by Russian Climate Models
10:40	**I. Auer** ZAMG	Snow Research in Austria: An Overview
11:00	**Coffee Break**	
11:20	**M. Petrushina** Moscow State University, Dep. of Geography	Landscape Approach in Study of Snow
11:40	**S. Sokratov** Snow and Avalanche Research, Davos	Snow: Macroscale and Microstructure
12:00	**General Discussion Block 1**	General Discussion to Presentations in Block 1
12:20	**Lunch Break**	

BLOCK 2 Chairperson: K.Rubinstein

14.00	**M. Bacher Michael** BOKU Vienna	Hazard Zoning in Austria: Legal Provisions in Austria
14.20	**H. Scheibl** Planning Division of Federal Province of Salzburg	Recent trends in Downhill Skiing: Analysis, Strategies and Trends
14.40	**Continuation H. Scheibl /K.Erlmoser**	How to restore the environment along a skiing slope: slide show from good and bad examples
15.00	**W. Reichelt** Planning Division of Federal Province of Carinthia	The new concept for winter tourism in Carinthia/ Austria
15.20	**I.Seinova/M. Petrushina** Moscow State University, Dep. Of Geography	Glacier Debris Flow of the Caucasus Mountains: Experiences of July 2000 (incl. Film Presentation)
15.40	**Coffee Break**	
16.00	**J. Jansa et al.** E166 / TU Vienna	Data Acquisition by Various Remote Sensing Techniques.
16.20	**P.Charamza/M. Breiling** Charles U Prague/TU Vienna	Climate Sensibility of Austrian Winter Tourism: Winners and Losers at Different Degrees of Warming
16:40	**General Discussion Block 2**	General Discussion to Presentations in Block 2
18:00		Evening Event for all Speakers / Media Attendance possible

BLOCK 3 Chairperson: A.Shmakin — **Day 2: November 4th 2004**

9.00	**Pre-Conference Gathering**	Ad-hoc messages
9:30	**W. Feilmayr** E-280 / TU Vienna	Winter Tourism in Austria: Basic Figures and Perspectives
10:00	**A. Zins** Dep. For Tourism and Leisure Research, Economic Univ. Vienna	Discussant to Lecture: an Overview of Winter Tourism in Austria: Future Prospects?
10:10	**A. Ammermann/W. Leitner** IG-Fahrrad,TU Vienna	Bicycle Techniques for Winter Season
10:30	**H. Puxbaum** TU Vienna, Research Group for Environmental Analytical Chemistry	Snow Chemistry in the Austrian Alps
10:50	**B. Krautzer** Federal Research Insti tute for Agriculture in Alpine Regions	Seed Propagation of Indigenous Species at Re-cultivation of Ski Slopes and Their Impact on Snow Cover
11:10	**Fruit Break**	
11.30	**M. König** Austrian Bureau for Climate Change	StartClim – First Analyses of Extreme Weather Events and their Impact in Austria
11.50	**A Amberger/C.Brandenburg** BOKU - Institute for Landscape Develop ment, Recreation and Conservation Planning	Leisure and Recreation in Protected Areas: Monitoring and Modelling of visitor demands and visitor flows.
12.10	**General Discussion Block 3**	General Discussion to Presentations in Block 3
12:30	**Lunch Break**	

BLOCK 4 Chairperson: M.Petrushina

14.00	**K. Kleemayer** Austrian Federal Office and Research Centre for Forests. Department of Natural Hazards and Timberline Regions	Avalanches and Avalanche Monitoring in Austria: Recent Research Activities and Open Questions Related to Snow Consistency
14.20	**R. Mair** Planning Division, Federal Country Tyrol	Avalanche Bulletin and Hazard Scale: a Basis for Modern Safety Strategies in Alpine Regions
14.40	**L. Holko** Slovak Academy of Sciences, High Tatra Division, Mountain Hydrology	Projects related to Snow and Mountain Hydrology in Slovakia
15.00	**Z. Kostka** Slovak Academy of Sciences, Inst. for Mountain Hydrology	Expected Impact of Climate Change on Snow Cover in a Small Mountain Catchment.
15.20	**A. Shmakin** Russian Academy of Sciences	Modelling of Snow Cover and Permafrost Features in Northern Eurasia for some Climate Change Scenarios
15.40	**General Discussion Block 4**	General Discussion to Presentations in Block 4
16.00	**Coffee and Farewell**	Room 32 / 4th Floor

BLOCK 5 Chairperson: Z.Kostka — **Day 3: November 5th 2004**

10.00	**Pre-Conference Gathering**	Ad-hoc messages
10.10	**J. Jansa et al.** E-166 / TU Vienna	Remote Sensing for Snow Classification
10.30	**G. Blöschl/R. Kirnbauer** E-222 / TU Vienna	Spatially Distributed Snow Estimation in Austria
10.50	**K. Svardal/H.Kroiss** E-226 / TU Vienna	Sewage Treatment Plants for Winter Use in Austrian Mountains
11.10	**Coffee Break**	
11.30	**P. Stolba** Austrian Chamber of Commerce, Section Tourism	Winter Tourism in Austria: What Kind of Research is Needed by Practitioners?
11.50	**M. Breiling** E-226 / TU Vienna	Technology.Tourism.Landscape: Summary of Project Ideas Related to Snow
12.10	**Ad hoc statements**	
12.30	**Final discussion**	Coming Research Ideas for "Technology.Tourism.Landscape", Related to Phase Two of TU Cooperation Centre

Conference Location

Seminarraum 1/3, Operngasse 11 (3rd Floor)
Entrance Resselgasse / A-1040 Wien
(Next to TU Main Library)

B. EU INTAS Project: Snow and Landscape

EU INTAS PROJECT: SNOW AND LANDSCAPE

INFLUENCE OF SNOW VERTICAL STRUCTURE ON HYDROTHERMAL REGIME AND SNOW RELATED ECONOMICAL ASPECTS IN NORTHERN EURASIA

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Project outline

Seven teams from five countries (RU, US, SK, CH, AT) with 32 project participants with different backgrounds in economical modelling, geography, geology, hydrology, meteorology, mathematics, physics, social sciences and landscape planning are expected to jointly work on this project for 20,000 hours or 12 years in total. The first project leader meeting will take place in Kaprun/Austria during Oct. 27th and 30th, 2004. Other meetings are scheduled for Moscow (2006) and Slovakia (2007).

Fig. 1: Area around Vladivostok

Project duration: May 2004 to April 2007.

Expectations of Project

Expectations are high to discover new findings in the relation snow and climate change. Numerous studies have demonstrated that the climate models are in particular sensitive to snow cover parameters, primarily due to its high albedo and the ability to store water seasonally. Due to data availability reasons, snow cover is described in a simplified way by snow height, variable snow water equivalent and a constant albedo. It is believed that more snow properties are necessary to describe snow cover in a

Fig. 2: Melting ice surface at Lake Bajkal (Source: www.bajkal.irkutsk.com)

satisfying way.
Furthermore the complex pattern of different kinds of snow with a manifold of different and

inhomogeneous snow layers should be classified according to more practical major snow types. Having major snow types better scenarios for future appearance of snow cover in the landscape can be anticipated.
However, we do not know the pace and magnitude of change and the project shall bring upon new ideas in what way this change is likely to go. A major effort is to explore in how far human life patterns and land uses in Northern Eurasia - our region of concern, which is the entire former Soviet Union with 15 nations and perhaps 50 ethnical groups amounting for more than 280 million inhabitants and stretching over 22 million km² - depends on snow. The region includes some of the highest settlement areas of the world with mountain peaks higher than 7,000 m altitude and huge lowland planes and deserts. The current and future availability of snow and water is crucial for many economic activities and any change in the pattern will modify the economic situation as well.

Tasks

The project is divided into seven tasks:

1) Observed data set creation. This includes the creation of a data base with the observed characteristics of snow cover and meteorological conditions during several decades. The regularly observed data from stations and special data from field campaigns will be systematized and organized. Special attention will be paid to the difference of natural conditions in which the snow has been formed. Coordination by Institute of

Fig. 3: Map of project region (Source: www.lib.utexas.edu)

Geography, Russian Academy of Sciences.

2) Snow cover types classification. This includes the development of snow cover types determined by its vertical structure. Analysis of the observed data on snow stratigraphy, structure and properties at key sides in combination with snow cover modelling. Coordination by Moscow State University.

3) Considering snow vertical structure in parameterisation scheme. The results of task 1 and 2 will become inputs to major global circulation models (GCM). This requires testing of the parameterisation scheme against the created data set of snow cover physical characteristics. Coordination by Russian Hydro Meteorological Centre, Moscow.

4) Climate model control running. The impacts of snow structure characteristics onto simulated contemporary climate will be discovered. The experiments with GCM realisations for contemporary climate conditions are planned to estimate the effects of snow cover structural features onto the hydrothermal regime in Northern Eurasia. Local models will be used for more detailed studies in snow-related and other cryospheric processes such as soil and permafrost freezing/thawing. Coordination by Russian Hydro Meteorological Centre, Moscow.

5) Scenario experiments with climate models. The transformation of the snow cover properties under certain

Fig. 4: Siberian farm house (Source: www.bajkal.irkutsk.com)

scenarios of climate change will be analysed. Several series of scenario experiments associated with greenhouse gases concentration increase will be carried out with global and local climate models to study the climatic processes connected with snow cover. Coordination by Institute of Geography, Russian Academy of Sciences.

6) Estimates of snow extreme events. The probability of extreme events, floods, permafrost thaw and the related avalanche activity in dependence of snow cover characteristics will be explored. It is expected that geographical distribution and seasonality, as well as occurrence and intensities of extreme events will change

considerably. Coordination by Swiss Federal Institute of Snow and Avalanche Research, Davos.

Fig. 5: Snowflakes under different environment conditions (Source: www.snowcrystals.com)

7) Snow related economical aspects. This task includes an estimation of economic effects of the snow cover spatial and temporal variability in Northern Eurasia and its projection related to a certain future climate change. How much snow melt water will be available for agriculture and irrigation purposes? Vast territories are forest and a change in water supply will show certain impacts. Transportation in swampy territories in the Northern part of our region is only possible when soils are frozen. Alternative ways of transport should be developed. What are the likely costs of an increase in extreme climate events? The region consists of higher altitudes than Western Europe with the Alps. Could winter tourism shift towards these regions in future and what would be the economic benefits?

Photo 1: Kyrgyzstan Memorial of Salomon

Photo 2: Russian Railways

Photo 3: Estonian lake

Photo 4: Fish from Lake Bajkal

Photo 5: St. Petersburg impression

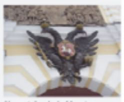

Photo 6: Symbol of Russian emperors

Photo 7: Open Landscape near St. Petersburg

Photo 8: Milk supply for urban people

Photo 9: Area map of Tashkent

Photo 10: Forest dynamics in relation to snow

Photo 11: Land use (Turkmenistan)

Photo 12: Irrigation system in Uzbekistan

Photo 13: Member of environmental scientists network

Photo 14: Map of the Russian Empire 1820

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ECLAS European Council of landscape architecture schools

Conference 2004, NLH Agricultural University of Norway

LANDSCAPE www.landscape.tuwien.ac.at TU WIEN