6th Austrian Stable Isotope User Group Meeting

Thursday 3rd November 2005 (afternoon)
Friday 4th November 2005 (whole day)

Vienna Ecology Centre, Althanstrasse
University of Vienna

STABLE ISOTOPE NETWORK AUSTRIA
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Organizers:

Wolfgang Wanek and Andreas Richter
Department Chemical Ecology & Ecosystem Research

universität wien

6th Austrian Stable Isotope User Group Meeting

Thursday, 3. November 2005

17:15-18:15	P. HÖGBERG	Soil C and N dynamics in boreal forests: insights from isotopic studies (KEYNOTE)
19:30	Come-together at a **Heuriger** (traditional Viennese wine-house) [Heuriger Diem, Kahlenberger Strasse 1, 1190 Wien]	

Friday, 4. November 2005

08:30-08:40	**Welcome & Introduction**	
Session 1	Chair: P. Högberg	
08:40-09:30	H. ŠANTRŮČKOVÁ	Isotopic (^{13}C) fractionation in carbon transformation processes in soils (KEYNOTE)
09:30-09:50	C. KAISER	Conservation of soil organic matter through cryoturbation in arctic soils in Siberia
09:50-10:10	S. GÖTTLICHER	Dependence of soil microorganisms on recent photosynthates from trees
10:10-10:40	**Coffee Break**	
Session 2	Chair: H. Šantrůčková	
10:40-11:00	W. WANEK	Nitrogen isotope composition of forest soil N pools as a measure to short-term soil N cycling
11:00-11:20	M. WATZKA	Species-specific responses of plant nitrogen isotope composition to management of permanent grasslands
11:20-11:40	X. XU	Nitrogen retention in alpine meadows across an altitudinal gradient on the Tibet plateau, China
11:40-12:00	R. HOOD-NOVOTNY	Use of ^{13}C as a population and resource marker for *Anopheles arabiensis* mosquitoes in the context of the Sterile Insect Technique (SIT)
12:00-14:00	**Lunch Break**	

6th Austrian Stable Isotope User Group Meeting (continued)

Friday, 4. November 2005

Session 3	Chair: C. Spötl	
13:40-14:30	T. PROHASKA	Tracing the origin by isotope signatures analysed by ICP-MS (KEYNOTE)
14:30-14:50	S. BERGS	New Applications by Isotope Ratio Monitoring LC/MS
14:50-15:10	A.-V. BOJAR	Arid lacustrine development, Western Qaidam, China: mineralogical and stable isotope constraints
15:10-15:40	**Coffee Break**	
Session 4	Chair: A.-V. Bojar	
15:40-16:00	C. SPÖTL	Toward a high-resolution record of groundwater discharge: a case study from western Tyrol
16:00-16:20	D. RANK	What is the hydroclimatic meaning of deuterium excess in Alpine precipitation?
16:20-16:40	A. LIEBMINGER	Stable isotopes in precipitation: ^{18}O models based on correlations with local climate
16:40-17:00	E. EISINGER	Determination of water loss and change in δD an $\delta^{18}O$ isotope composition of meat water during cool storage of chunks and ground samples of beef/pork
17:00-17:10	**Closing Statement & Outlook** R. Hood-Novotny	

SINA Award

We are highly grateful to Gerhard Zinsberger, Spectronex GmbH, Vienna, for donating the **SINA Award** for the best student´s presentation (oral or poster). The award of € 300,- is dedicated for scientific literature and congress expenses.

List of participants

No	Name		Institution
1	Bergs	Sylveer	Thermo Electron Bremen
2	Boch	Ronny	Inst Geol Paleontol, Univ Innsbruck
3	Bojar	Ana-Voica	Inst Earth Sci, Geol Paleontol, Univ Graz
4	Bondar	Elisabeth	Dep Limnol, Univ Vienna
5	Eisinger	Elisabeth	Environ Sci, ARC Seibersdorf
6	Göttlicher	Sabine	Dep For Ecol, Swedish Univ Agric Sci, Umea
7	Groening	Manfred	Isotope Hydrol, IAEA Headquarter, Vienna
8	Högberg	Peter	Dep For Ecol, Swedish Univ Agric Sci, Umea
9	Hood-Novotny	Rebecca	IAEA, Agency Lab, Seibersdorf
10	Horacek	Micha	Environ Sci, ARC Seibersdorf
11	Inselbacher	Erich	Dep Chem Ecol Ecosys Res, Univ Vienna
12	Jandl	Robert	Fed Res Inst For Sci, Vienna
13	Kahmen	Ansgar	Inst Plant Sci, ETH Zürich
14	Kaiser	Tina	Dep Chem Ecol Ecosys Res, Univ Vienna
15	Kralik	Martin	UBA Environ Agency, Dep Groundwater, Vienna
16	Liebminger	Andreas	Biogen-Nat Res, ARC Seibersdorf
17	Mader	Dieter	Inst Geol Sci, Univ Vienna
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20	Papesch	Wolfgang	Environ Sci, ARC Seibersdorf
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24	Rank	Dieter	Inst Geol Sci, Univ Vienna
25	Richter	Andreas	Dep Chem Ecol Ecosys Res, Univ Vienna
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30	Spötl	Christoph	Inst Geol Paleontol, Univ Innsbruck
31	Trinidad	Trinidad P.	Dep Nucl Appl, IAEA, Vienna
32	Varmuza	Kurt	Inst Chem Engineer, Vienna Univ Technol
33	Wanek	Wolfgang	Dep Chem Ecol Ecosys Res, Univ Vienna
34	Watzka	Grete	Dep Chem Ecol Ecosys Res, Univ Vienna
35	Xu	Xingliang	Inst Soil Sci Land Eval, Univ Hohenheim
36	Zechmeister-Boltenstern	Sophie	Fed Res Train Centre Forests (BFW), Vienna
37	Zinsberger	Gerhard	Spectronex GmbH, Vienna

Sources of nitrous oxide emitted from European forest soils

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Forest ecosystems may provide strong sources of nitrous oxide (N_2O), which is important for atmospheric chemical and radiative properties. Nonetheless, our understanding of controls on forest N_2O emissions is insufficient to narrow current flux estimates, which still are associated with great uncertainties. In this study, we have investigated the quantitative and qualitative relationships between N-cycling and N_2O production in European forests in order to evaluate the importance of nitrification and denitrification for N_2O production. Soil samples were collected in 11 different sites characterized by variable climatic regimes and forest types. Soil N-cycling and associated production of N_2O was assessed following application of ^{15}N-labeled nitrogen. The N_2O emission varied significantly among the different forest soils, and was inversely correlated to the soil C:N ratio. The N_2O emissions were significantly higher from the deciduous soils (13 ngN_2O-N cm^{-3} d^{-1}) than from the coniferous soils (4 ngN_2O-N cm^{-3} d^{-1}). Nitrate (NO_3^-) was the dominant substrate for N_2O with an average contribution of 62% and exceeding 50% at least once for all sites. The average contribution of ammonium (NH_4^+) to N_2O averaged 34%. The N_2O emissions were correlated with gross nitrification activities, and as for N_2O, gross nitrification was also higher in deciduous soils (3.4 μg N cm^{-3} d^{-1}) than in coniferous soils (1.1 μg N cm^{-3} d^{-1}). The ratio between N_2O production and gross nitrification averaged 0.67% (deciduous) and 0.44% (coniferous). Our study suggests that changes in forest composition in response to land use activities and global change may have implications for regional budgets of greenhouse gases. From the study it also became clear that N_2O emissions were driven by the nitrification activity, although the N_2O was produced per se mainly from denitrification. Increased nitrification in response to accelerated N inputs predicted for forest ecosystems in Europe may thus lead to increased greenhouse gas emissions from forest ecosystems.

New Applications by Isotope Ratio Monitoring LC/MS

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With the introduction of compound specific isotope analysis by isotope ratio monitoring GC/MS (irm-GC/MS) the immediate demand for similar applications using HPLC was created. Many compounds of biological, medical, pharmaceutical and environmental interest are not volatile or too polar. Consequently, they cannot be directly analyzed by gas chromatography.
In irm-GC/MS the carrier is helium, which does not interfere with the essential combustion step prior to isotope ratio mass spectrometry (IRMS). In opposite the LC mobile phase has inhibited a similar direct conversion up to now. All earlier irm-LC/MS approaches were based on the removal of the liquid phase prior to combustion risking fractionation of the isotope ratios of the eluted compounds.
The LC IsoLink uses a new concept for isotope ratio monitoring LC/MS. The liquid phase is not removed from the sample prior to oxidation. The sample is oxidized still in the aqueous, mobile phase followed by on-line separation of the CO_2 from the liquid phase and transfer into the isotope ratio MS. In marked contrast to former approaches the processes in the LC IsoLink are quantitative and fractionation-free.

This new approach opens up a whole new world in the application of gas isotope ratio mass spectrometry. The $^{13}C/^{12}C$ ratios of organic acids, amino acids, carbohydrates and nucleotides can now be measured. These components, typically within a complex matrix, are separated by liquid chromatography followed by on-line determination of the isotope ratios. The drawbacks of using derivatization and off-line preparation procedures can now be overcome.
The new access allows studying biochemical cycles, running tracer experiments and determining the origin of components.
Applications from different scientific areas such as biogeochemistry, molecular biology, and pharmacy as well as authenticity control of foods will be presented. Sensitivity, linearity and precision of the LC IsoLink have been evaluated and will be discussed.

Arid lacustrine development, Western Qaidam, China: mineralogical and stable isotope constrains

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Lacustrine deposits have been largely investigated in order to constrain paleoenvironmental parameter. In this study we investigated a very particular arid lacustrine succession from the Western Qaidam, China. Stable isotope analyses on carbonates from lake evaporites collected from the non-marine western Qaidam basin yield a positive excursion from Pliocene to Quaternary times. At Dafeng Shan, the Quaternary sequences are composed of alternating layers of celestine/ dolomite and aragonite/calcite/barite with distinct isotopic compositions. The sequence described at Dafeng Shan formed in a low energy, hypersaline lacustrine environ-ment as indicated by the microstructures, evaporitic minerals as well as by the absence of lithoclasts.
Fluid inclusion studies from different facies are in progress. The oxygen isotopic compositions of carbonates vary between +34.4 and +39.8 ‰ (SMOW), representing the higher oxygen isotopic values measured until now. The $\delta^{18}O$ and the $\delta^{34}S$ isotopic composition of celestine range between 20.1 to 22.3 ‰ (SMOW) and +19 to +22 ‰ (CDT) respectively, suggesting sulfur recycling via sulfide oxidation.. The carbon isotopic compositions of carbonates show a large negative excursion of up to –30 ‰. Microstructures, mineralogy, isotopic compositions as well as the geological context suggest oxidation of methane from a deep source.

Determination of water loss and change in ^{2}H and ^{18}O isotope composition of meat water during cool storage of chunks and ground samples of beef and pork samples

Elisabeth Eisinger, Michael Horacek

ARCS Forschungszentrum Seibersdorf, IVA Tulln

According to EU regulations the traceability of food has to be available along the entire production chain. A potent tool to determine the provenance of food is the analysis of its stable isotope composition. As for δD and $\delta^{18}O$ determination the water from meat sample is analyzed, it is imperative to have a control on possible changes of the primary isotope composition.
After slaughtering both beef and pork meat are stored for ripening in freeze halls for a few days. After that it is further processed. During the storage and freezing/cooling some of the meat water evaporates and affects the isotope composition of the remaining meat water. Thus the magnitude of this change has to be evaluated. In this project, we investigate sub-samples from two pieces (about 2kg) of beef and pork meat from two different slaughterhouses. One piece of meat is ground before freezing and the other one is frozen whole. Every hour one sub-sample (about 50 – 70g) is taken both from the whole piece of meat (a slice of meat) and from the ground meat. The accumulated meat sap is then transferred into small vials. If they have not accumulated enough meat sap, the ground samples have to be centrifuged and the slices of the whole piece of meat have to be cubed and squeezed. The meat saps are analyzed for their D/H and $^{18}O/^{16}O$ isotope compositions. Additionally, the weight loss of the samples during the freezing and storage is determined in order to calculate the amount of water evaporation.

Dependence of soil microorganisms on recent photosynthates from trees

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It remains a challenge to quantify and asses the importance of the photosynthate based carbon(C) flux to soil microorganisms. A girdling experiment conducted in a boreal forest showed a drastic decrease in soil respiration rate (*c.* 50%)(Högberg *et al.* 2001) and in microbial biomass C (Högberg and Högberg 2002) shortly after (weeks to months) the flux of photosynthates to roots and associated microbes was terminated. We studied further the importance of labile C input through tree belowground allocation by comparing the response of endogenous C_3-soil respiration to additions of C_4-sucrose in tree-girdled plots with that of non-girdled control plots. The plots had been girdled 3 to 4 years previously. The basal respiration was *c.* twice that of the girdled plots. The respiration rate after sucrose application was on average *c*. two times higher than the basal respiration rate in both girdled and non-girdled plots. However, the C_4-induced increase in C_3-respiration was significantly less in girdled plots. Calculation of the C_3-respiration as a percentage of induced respiration showed that in girdled plots, C_3-respiration even decreased after sucrose addition. Considerable positive priming was found only in non-girdled plots with an intact rhizosphere where there was a presence of labile C_3-C in the microbial biomass or in soil organic matter. Terminating the C-flux from the canopy to the root-soil systems does not only reduce the root and mycorrhizal respiration immediately, it also influences the soil microorganisms on a long-term basis.

References

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Högberg, P., A. Nordgren, N. Buchmann, A. F. S. Taylor, A. Ekblad, M. N. Högberg, G. Nyberg, M. Ottosson-Löfvenius, and D. J. Read. 2001. Large-scale forest girdling shows that current photosynthesis drives soil respiration. Nature **411**:789-792.

Use of ^{13}C as a population and resource marker for *Anopheles arabiensis* mosquitoes in the context of the Sterile Insect Technique (SIT).

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Monitoring of sterile to wild insect ratios in field populations can be useful to follow the progress in control programmes integrating the Sterile Insect Technique (SIT). There are numerous methods for marking insects but some are clearly not suitable for use in mass rearing. Methods which are suitable include dye marking, genetic marking and chemical marking.
In these studies we tested the feasibility of using the stable isotope of carbon ^{13}C, as a potential chemical marker for the malaria mosquito *Anopheles arabiensis*. Labelled ^{13}C glucose was incorporated into the larval diet in a powder or liquid form. Larvae were reared to adults and fed *ad libidium* with an unlabelled sucrose solution. Enrichment in the adult was monitored by destructive sampling of the whole mosquito and analysed using isotope ratio mass spectrometry.
It was possible to "fix" the isotopic label in the adult mosquito and to detect the label at an appropriate concentration in 21 day old adults. The optimum labelling treatment would cost around 150 USD per million mosquitoes.
Enrichment of the male adult mosquitoes decreased with time reflecting the switch from labelled larval to unlabelled adult diet. It was possible to calculate the proportion of the adult carbon derived from the adult sugar diet over the life span of the mosquito and to determine the ratio of structural to non structural carbon.

Niche complementarity for nitrogen: An explanation for the biodiversity - and ecosystem functioning relationship?

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The relationship between plant diversity and productivity has largely been attributed to niche complementarity which assumes that plant species differ in their resource requirements and that consequently an increasing number of species should result in more efficient resource exploitation. For nitrogen (N), different forms of N strategy such as symbiotic N fixation, internal N recycling or soil N uptake have been shown for different plant species in grasslands. Also, it has more recently been suggested that different plant species in grasslands occupy different ecological niches with respect to their spatial, temporal and chemical N uptake patterns. In the study presented here, we tested the complementarity of such N uptake patterns and N strategies among 20 different grassland species

from five functional groups (Legumes, Tall herbs, Small herbs, Spring herbs and Grasses) using ^{15}N labeled N species in three semi-natural grasslands. The investigated plant species showed little chemical, spatial and temporal differences with respect to N uptake. However, the different plant species showed significant differences with respect to N strategy. The observed differences were consistent for the individual functional groups and across different grasslands. Our data therefore suggest that plants within functional groups have distinct N strategies so that the loss of a functional group from an ecosystem would result in declined resource use and thus ecosystem functioning. This study is among the first that gives direct functional evidence of the much debated hypothesis of niche complementarity.

Conservation of soil organic matter through cryoturbation in arctic soils in Siberia

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Cryoturbation (mixing of soil layers due to repeated freeze-thaw processes) is a major soil forming agent in arctic regions that can lead to various soil features such as patterned ground and subduction of humic-rich top-soil horizons into the deep soil. We were interested in the effect of burying of organic soil layers on microbial decomposition. We examined 12 soil profiles at a study site at the Gdansky peninsula, West Siberian Arctic, and measured chemical and microbial properties and isotopic composition of buried and regular, undisturbed soil horizons. The soil profiles exhibited a buried organic-rich layer situated between 30-60 cm depth, with a C and N content and a C:N-ratio highly similar to A horizons. Radiocarbon dating of humic acids revealed, however, that the mean age of C in the buried layer was three times higher (~1,300 years BP) than in the A horizon (~400 years BP), suggesting that decomposition rates in the buried layer were delayed. The observed microbial properties support this result: microbial processes (C and N mineralization) and microbial biomass were substantially lower in the buried layers than in the respective A horizons. Decomposition delay was most likely caused by different abiotic conditions in the deep soil (e.g. temperature, moisture, freeze-thaw regime). However, since microbes are able to adapt well to cold and wet conditions, it is likely that at least some decomposition took place. A C isotope composition analysis showed a high enrichment in ^{13}C in the buried horizons compared to A horizons, which strongly indicates that some C turnover did take place (^{13}C in SOM enriches progressively with age). The amount of C stored in the buried layer doubles the amount of C stored in top-soil humic- rich horizons (O and A). Assuming that the buried layer originates from both, O and A horizons, this indicates that O and A horizon at time of burying (800-1300 years BP) must have been much thicker and present-day O and A horizon at this site may not have reached their capacity to accumulate C yet. Cryoturbation therefore lead to additional long-term storage of C in the system by (1) retarding decomposition processes of buried organic material and (2) enabling the soil to restart C accumulation in top soil layers.

Austrian Network of isotopes in precipitation (ANIP) as a tool for assessing good status in groundwater

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1. INTRODUCTION

The Austrian Network for Isotopes in Precipitation (ANIP) started in 1972. Some stations have already been sampled since the 1960s (IAEA/WMO, 2001). 72 stations are presently sampled all over Austria with some preference given to the Karst areas North and South of the Alpine mountain range. The network is a co-operation between the Austrian Environment Agency (64 stations) and the ARC Seibersdorf Research (Arsenal: 8 stations). In addition 17 large rivers and lakes are sampled once a month to record the outflow response.

The aim of the Austrian Network for Isotopes in Precipitation (ANIP) is to provide input data for hydrological and hydrogeological investigations and a data-base for climatological changes and trends in sensitive Alpine areas. This database helps to discern the origin of wet air masses, the mean altitude of the recharge areas and the residence time of water in groundwater bodies (KRALIK et al. 2003).

In accordance with the European Water Framework Directive (DIRECTIVE 2000/60/EC) this allows the further characterisation of bodies found to be at risk including the characteristics of superficial deposits and soils. In contrast to some polluted porous aquifers some Alpine

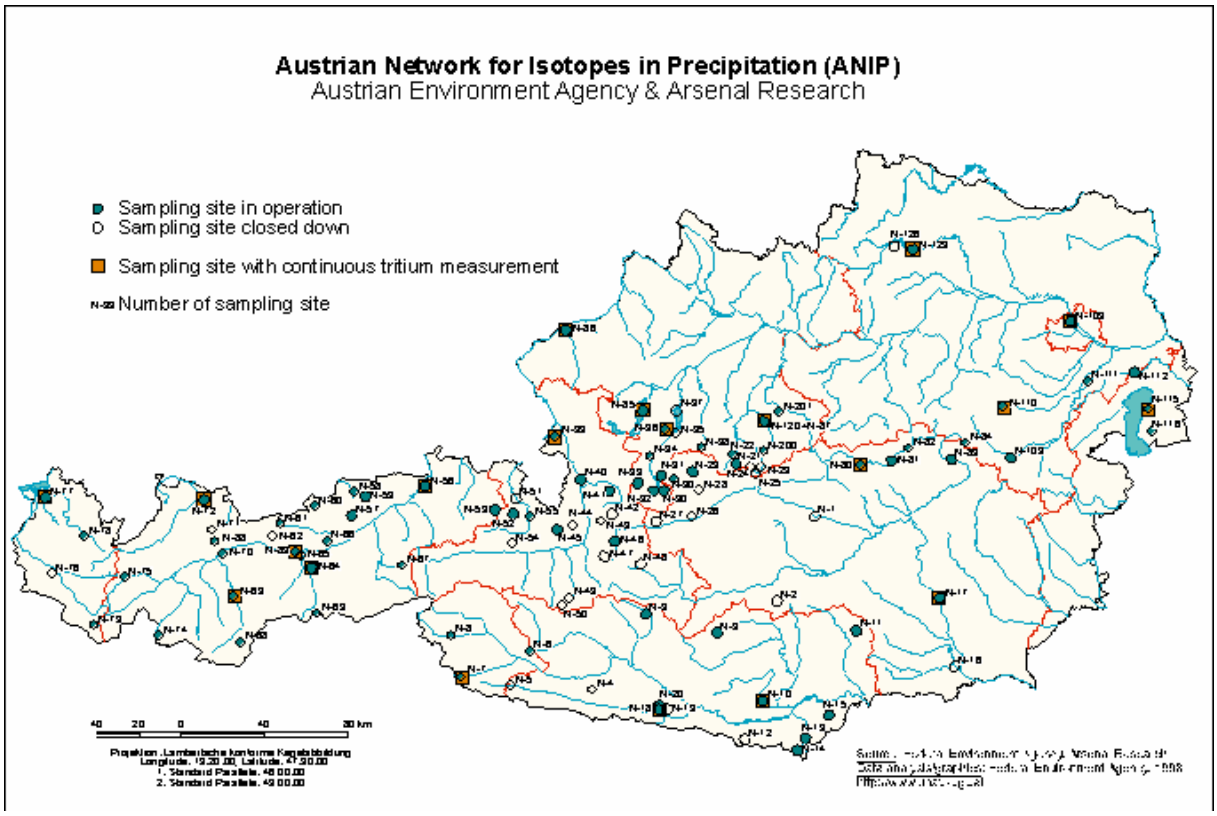

Fig. 1. 72 active sampling stations of the Austrian precipitation network.

springs show single parameters (e.g. nitrate, chloride) with an increasing trend despite general low concentrations. This indicates increasing manmade inputs which are in contrast to a good qualitative status.

2. MATERIALS AND METHODS

The precipitation is collected on a daily basis in ombrometers (500 cm2) and mixed to monthly samples at stations ranging from 120 to 2250 m in altitude (Fig. 1). So far about 15000 analyses of oxygen-18, deuterium and tritium have been made by the isotope laboratories of ARC (Arsenal, Vienna) and the Institute of Hydrology (GSF, Munich). All samples not measured immediately were stored in 1L bottles in a specially dedicated cellar (16000 samples) in Vienna and are available for analysis in the future.
Besides of the quality assurance of the analysing laboratories, which regularly take part at round robin tests of the IAEA, particular care has been taken for the quality control of the ANIP-Depot of the samples collected in 1 L polyethylene (PE) bottles and some of them stored in dark cellars up to 30 years. Mean temperatures (14° C) and relative humidity (70 %) data were recorded over time periods.

3. RESULTS AND DISCUSSION

The amount of precipitation in Austria is highly influenced by the Alpine mountain range (400-3000 mm/y). The amount of annual precipitation increases toward the mountain ranges, in particular at the high altitude regions. However, strong regional differences exist between the windward and the lee side of the Alpine ranges.
Wet periods are supposed to represent maritime phases. The Alps as a weather divide sharply distinguish precipitation events caused by different air flow directions. A study about the origin of the precipitating air masses in Austria showed that an Atlantic influence (moisture from NW) causes lower stable isotope values (e.g. Patscherkofel and Bregenz) than a Mediterranean one (e.g. Villacher Alpe and Graz) (KAISER et al., 2002). Due to the shorter distance the Mediterranean influence is characterised by lower tritium concentrations.

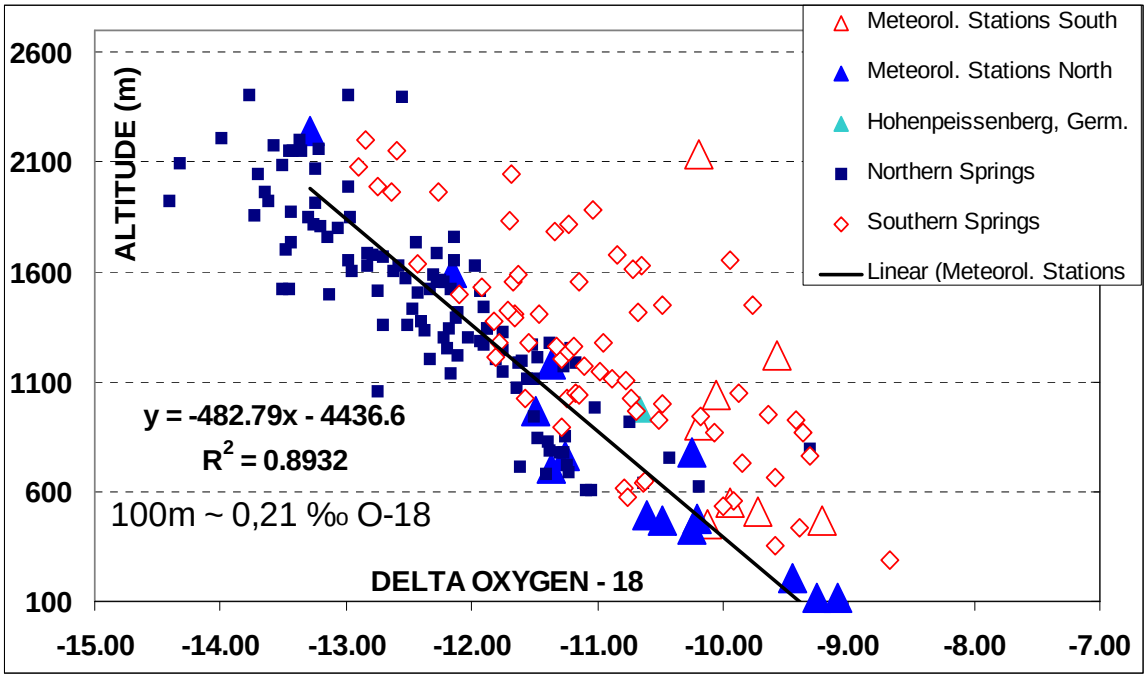

Fig. 2. Altitude effect at the northern front of the Eastern Alps in meteorological stations and springs (filled symbols) in contrast to a very steep or nearly no altitude effect at the inner-alpine mainly Mediterranean influenced stations and springs in southern part of Austria (open symbols).

In addition to the input measurements at the above mentioned meteorological stations 173 springs North and South of the weather divide were analysed for oxygen-18 and tritium four times a year in 1997/1998 in the framework of the Austrian Water Quality Network (AWQN). The mean O-18 values were plotted against the altitude of the recharge area calculated statistically as the half-height between the altitude of the spring and the potential maximum. It indicates an reasonable gradient of 0.21‰ oxygen-18 per 100 m altitude change. altitude of the recharge area. The correlation between the weighted mean of the O-18 values (1993-1997) and the altitude of the northern meteorological stations are in fairly good agreement with the spring trend in the North (Fig. 2).
However, most of the meteorological stations and the springs in the south of Austria show a significant Mediterranean influence. Also the altitude effect is small or not existing probably caused by the shielding effect of the Southern Alpine ranges in Northern Italy and Slovenia. As indicated by a recent study (KAISER ET AL., 2002) all stations and springs are influenced by Atlantic and Mediterranean origin to a variable degree and show therefore local mixtures, which may even vary in time.
The dense network of input stations allows to discern the origin of the wet air masses (far transported air pollution), the mean altitude of the recharge area and the mean residence time in the groundwater body. This helps in groundwater bodies at risk to estimates the percentage of the total groundwater is used by abstraction and how long it will take to observe a trend reversal after the source of contamination is removed.

4. CONCLUSIONS

A dense national network of precipitation sampling and some station of river outflow for isotope analysis allow a reasonable estimate of the origin of wet air masses, the altitude of the mean recharge area and the mean transfer time. This is even more important in mountainous areas and region with variable meteorological regimes. This is a crucial support for quantitative hydrological data. These data are important for the basic hydrological characterisation of groundwater bodies and they are essential for groundwater bodies at risk. Isotope data help to estimate the percentage of the total groundwater used by abstraction and how long it will take to observe a trend reversal after the source of contamination is removed.

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Stable isotopes in precipitation: Oxygen-18 models based on correlations with local climatic conditions

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Recent exploratory analysis of a data set from the Austrian Network of Isotopes in Precipitation (ANIP) together with climatic data revealed significant correlations between isotopic compositions in precipitation and climatic conditions. Based on these results multivariate models have been developed in order to predict the oxygen-18 concentration from local climatic and geographic parameters. The regression methods applied are ordinary least squares regression (OLS) and partial least squares regression (PLS). New features have been added as nonlinear transformations of the original variables (as for instance altitude, geographical longitude and latitude, monthly means of temperature, rain, snow, and wind speed). Feature selection methods used comprise forward selection combined with heuristic approaches. Monthly precipitation samples from about 30 locations all over Austria were collected over a time period of almost 40 years. The oxygen compositions have been analysed by Isotope Ratio Mass Spectrometry. Isotope data are reported as per mill (‰) relative to the V-SMOW (Vienna Standard Mean Ocean Water) standard. Local climate data were provided by the Central Institute for Meteorology and Geodynamics in Vienna.
The best two models are applied to 203 new locations for which long term climatic and geographic parameters are available. The modeled oxygen-18 values for these locations exhibit good compliance with known isotopic features of the concerned region such as correlations with temperature and altitude. The squared correlation coefficients between experimental and predicted oxygen-18 data exceeded 0.9, allowing sufficiently precise predictions for new climatic conditions and new locations. Isotope distribution charts lead to a reasonable picture of the distribution of oxygen-18 in Austrian precipitation and therefore will serve as a reference for subsequent studies in Austria intending the enhancement of stable isotope applications such as paleoclimatology from glacial ice or source determination of grown food. Additionally the inclusion of groundwater data will further be an important step forward to an overall understanding of the Austrian water cycle.

The isotope ecology of wireworms in arable land

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Wireworms are the larvae of elaterid beetles and contain several species which are facultative agricultural pests. The most important pest species belong to the genus *Agriotes*, which damage besides other crops especially maize and potatoes. Determining their dietary choice – crop or weed, for instance – under various environmental conditions is crucial for any pest control strategy. Stable isotope analysis can clarify feeding preferences in the field only after calibration of isotopic turnover rates and trophic shifts by laboratory experiments.
We performed diet switch experiments with laboratory reared larvae of *Agriotes obscurus* between diets which differed in $\delta^{13}C$ (wheat and maize) as well as between diets which differed in $\delta^{15}N$ (wheat from different locations). The isotopic signature of the new diet can be recognized in the wireworm within one week after the switch. After four months, only the fat component reached isotopic equilibrium with the new diet, but the all-components

sample lagged slightly behind. In general, isotopic variation among individual wireworms was surprisingly high. This experiment was repeated with individuals not raised in the laboratory but brought in from the field: The trends were the same, but isotopic variation was even higher. A subsequent random sampling experiment revealed that at least three individuals of one species have to be tested in order to avoid false-positive designations to two different trophic levels (type 1 error probability less than 5%). Application of above conclusions to field data showed that more *Agriotes* larvae feed more on weeds than on maize; mixed feeders, however, are most abundant. *Hemicrepidius niger*, also common in Central Europe and known from handbooks as an omnivore, was a generalist at the level of the population only: Mixed feeders were absent, most individuals were carnivorous or detritivorous or both, while some were strictly herbivorous and therefore a potential pest in arable land.

The extended ^{15}N isotope dilution method to estimate nitrogen fixation of different Lucerne stands

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The use of green manure legumes is the main agricultural practices on stockless organic farms in Eastern Austria providing the crops within the rotation with nitrogen assimilated from the atmosphere. In a field trial, performed from 1999 to 2001 located on the organically managed agricultural fields of the University of Natural Resources and Applied Life Sciences in Raasdorf, mulched Lucerne (Medicago sativa L.) stands were investigated with respect to their biological nitrogen fixation. To estimate symbiotic N2 fixation, the ^{15}N dilution method was used. A low-level application of ^{15}N enriched fertilizer (1 kg potassium nitrate ha-1, 10 at% ^{15}N) was conducted onto marked 2.25 m² subplots. When estimating the BNF of mulched legume crops, the uptake of mineralised N from the mulch material has to be taken into account. The remaining air-derived ^{14}N in the mulch implies that the $^{15}N/^{14}N$ ratio in the subsequent legume crop is reduced and the usual $\delta^{15}N$ method cannot be applied. Thus an extended ^{15}N dilution method was used to estimate BNF in mulched variants. The reference crops (grass-mixture: tall oat grass, red fescue, sheep´s fescue, meadow fescue) received the same kind and amount of legume mulch as the legume crops at the first and second harvest, accounting for the N mineralised from the mulch. The amount of total fixed N was 124-150 kg N ha-1 in 2000 and 178-197 kg N ha-1 in 2001. The proportion of N derived from the atmosphere (% Ndfa) ranged from 26 to 79%. The release of nitrogen from the legume mulch was inhibited due to unfavourable conditions (little precipitation) for mineralization in both years; the nitrogen fixation and the Ndfa of the mulched Lucerne crops were not decreased. To evaluate the extended isotope dilution method, we repeated a similar field trial in the wet year 2005 and compared reference crops treated by legume mulch with reference crops mulched by themselves. Results of this trial will be presented in the near future.

Tracing the origin by isotope signatures analysed by ICP-MS

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Main topic of the presentation is the application of isotope ratio analysis by using (multi collector) ICP-MS ((MC-)ICP-MS). The instrumentation allows the accurate assessment of a large variety of isotopic systems in combination with a high sample throughput. In addition, ICP-MS allows the direct assessment of elemental pattern and concentrations along with isotope ratios.
The combination of a laser ablation system and ICP-MS instrumentation allows moreover the direct analysis of isotope ratios or elemental pattern/concentrations with high spatial resolution (down to a few µm). The instrumentation is currently used for studying the origin and authenticity of samples within a multidisciplinary project conducted at the University of Natural Resources and Applied Life Sciences in collaboration with the University of Vienna and the Museum of Natural History, Vienna (VIRIS project). The fundamental research is directly transferred to three main pillars of applied research in food science, anthropology, archaeology and geochronology. Selected examples will underline the capability of the analytical approach: A new legislation, which is being implemented in the EU, aims at the traceability process along the production chain of food and feed in order to guarantee public health and consumer protection. One promising approach is the establishment of multi-isotopic pattern including e.g. Sr and Pb isotope ratios in addition to light isotopes. Moreover, isotope ratios can be easily be applied for nutrition studies using non radioactive enriched stable isotopes. Sr isotope ratios are widely used for studying the origin and migration of ancient human cultures or in living biological systems. Direct sampling by laser ablation allows the analysis of precious historical samples in a quasi non destructive way. In-situ LA-MC-ICPMS was applied for characterizing archaeological artefacts such as glass material and metal findings, mainly in combination with laser ablation in order to minimize the damage on the sample material.

What is the hydroclimatic meaning of deuterium access in Alpine precipitation?

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Deuterium excess has widely been used as an additional parameter to identify the source region of water vapour. However, it turns out that a simple relationship cannot be established due to secondary fractionation processes, like snow formation or partial evaporation of raindrops below the cloud base. Special investigations were performed to get more insight into the behaviour of the deuterium excess in precipitation over the Eastern Alps in the framework of the Coordinated Research Project (IAEA) on "Isotopic composition of precipitation in the Mediterranean Basin in relation to air circulation patterns and climate". The evaluation of long-term isotope records had shown a complete different seasonal pattern of the deuterium excess at mountain and valley stations. While the valley stations exhibit the expected minimum in summer, the mountain stations show a distinct maximum between June and October. These differences occur even if the horizontal distance between mountain and valley-station is only a few kilometers. From this we concluded, that the reason for the lower d-values at the valley-station is obviously evaporation and/or

isotopic exchange with air moisture during the falling of the drops. There is a slight increase of the yearly mean of the deuterium excess with increasing altitude of the sampling station. Backward trajectory calculations seemed then to be a suitable instrument to confirm the finding that high deuterium excess in precipitation at mountain stations is not necessarily a consequence of Mediterranean influence. As a first step, meteorological effects on the isotope patterns, the differences in the isotope content of precipitation water during July and August 1998 between the stations Patscherkofel and Villacher Alpe were studied with help of trajectory statistics. It came out that Mediterranean influence cannot be the reason for the high deuterium excess at Patscherkofel and at other mountain stations in the northern Alps. Referring to the interpretation of deuterium excess data in isotope-hydrological applications, the most important conclusions from these investigations are:

(i) The relatively big variations of the deuterium excess in precipitation in the Alps (higher values at the mountains, lower values in the valleys and forelands) is mainly "homemade" and not the result of a different origin of the air masses transported into the mountainous region. (ii) Therefore the deuterium excess is probably no reliable tool to trace the origin of air masses and moisture coming from farer away into the Alps. For this purpose – to distinguish between Atlantic and Mediterranean origin – $\delta^{18}O$ (or $\delta^{2}H$) values and especially ^{3}H data are a suitable instrument. (iii) The water of the rivers coming from mountainous regions is a mixture of mountain and valley precipitation, so that the resulting deuterium excess is more or less "normal", when the river leaves the mountainous region.

Toward a high-resolution record of groundwater discharge: an isotopic case study from western Tyrol

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A lot of attention is currently being paid to changes in air temperature and a trend toward higher values since the middle of the 19th century is undisputed. Although temperature is a major climatological variable, changes in the amount and intensity of precipitation - both annual and seasonal – are at least of equal importance in many regions. Records of precipitation in the Alps generally show a low signal-to-noise ratio and lack a clear-cut relationship to temperature over the instrumental period. Century-scale records of precipitation are virtually nonexistent. An archive that has shown to be sensitive to rainfall are chemical precipitates in caves and veins (speleothems). Albeit not recording rainfall directly, these formations "grow" as a function of shallow groundwater discharging into cavities of the subsurface. Depending on the thickness of the rock overburden and the permeability of the aquifer the signal arriving at the site of speleothem deposition will be variably low-pass filtered. We are currently exploring the usefulness of stable isotopes as a proxy for decadal to centennial variations in paleo-groundwater discharge and hence meteoric precipitation by examining in detail cores taken from a speleothem in a shallow cave in western Tyrol. The chronology of these records is provided by U-series ages taken at different depth. The advantage of this site is that the process of groundwater discharge and calcite formation is ongoing and can be monitored. Water analyses taken at regular intervals show a rather constant composition throughout the year, including the stable isotopes of carbon and oxygen, suggesting a well mixed aquifer. In the speleothem calcite, however, we observe a high-amplitude variability of covariant carbon and oxygen isotope values on a decadal time scale. The slope (C/O) of 1.5 indicates that kinetic fractionation in the cave as a result of fast degassing of carbon dioxide is the principal process causing this pronounced variability. As the rate of degassing is a function of the thickness of the water film and hence the rate of discharge these speleothems may provide a valuable and apparently uninterrupted record of precipitation in this alpine region.

Nitrogen isotope composition ($\delta^{15}N$) of forest soil N pools reflects short-term N dynamics

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A combination of natural ^{15}N abundance measurements and ^{15}N labelling experiments was used to investigate the potential of $\delta^{15}N$ signatures of soil N pools to reflect the short-term dynamics in the forest soil N cycle. Intact soil cores were collected from pure spruce (*Picea abies*) and mixed spruce-beech (*Fagus sylvatica*) stands on stagnic pseudogley in Austria. $\delta^{15}N$ values of the microbial biomass (mixed stand: 4.7 ± 0.8‰, spruce stand: 5.9 ± 0.9‰) and of dissolved organic nitrogen (DON; mixed stand: 5.3 ± 1.7‰, spruce stand: 2.6 ± 3.3‰) were not significantly different and represented the N pools of both stands which were most enriched in ^{15}N. Since all potential substrates for DON production were significantly more 15N depleted (soil organic matter, roots, plant litter, leaves, microbial biomass) only mineralization can account for such a ^{15}N enrichment of the DON pool, the isotope effect of gross mineralization, however, being much larger than previously anticipated. Denitrification was the main N_2O-producing process in the mixed forest stand: we detected a significant ^{15}N enrichment of its substrate NO_3^- (+3.6 ± 4.5‰) compared to NH_4^+ (-4.6 ± 2.6‰) and its product N_2O (-11.8 ± 3.2‰). For the spruce stand, nitrification contributed more to N_2O production than denitrification, as the ^{15}N flux in N_2O from $^{15}NH_4^+$ was higher than from $^{15}NO_3^-$. Moreover, the NH_4^+ pool was slightly ^{15}N enriched (-0.4 ± 2.0 ‰) compared to NO_3^- (-3.0 ± 0.6 ‰) and N_2O (-2.1 ± 1.1 ‰) in the spruce stand, indicating nitrification and denitrification operating in parallel to produce N_2O. The positive $\delta^{15}N$ values of N_2O points to extensive microbial N_2O reduction in the spruce stand. Inverse modelling of the transformation rates from $\delta^{15}N$ data by Rayleigh distillation and literature data on the reaction-specific isotope discriminations revealed good agreement with transformation rates in the spruce stand but not in the beach stand. Optimization of the isotope effects and of the fractions of each substrate that were consumed was performed. This demonstrated that pool dilution assays probably integrate over a shorter time interval than $\delta^{15}N$ of the respective pools since turnover rates of the pools ranged between days (NH_4^+) and weeks (NO_3^-).

The influence of meadow management on biomass, nitrogen partitioning and $\delta^{15}N$ of grassland plants belonging to different functional types

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Differences in nitrogen cycling resulting from different meadow management regimes are mostly due to the direct effect of N input in fertiliser and N output in harvest. However, fertilization and cutting frequency also influence (1) growth and nitrogen partitioning of individual plant species as well as (2) abundance of certain species and species composition, which in turn both may have a (secondary) effect on nitrogen cycling. To study these effects, we compared the responses in growth and nitrogen partitioning of a selection of common species with a wide ecological range to those of the sward as a whole. The selected species *Dactylis glomerata*, *Taraxacum officinale*, *Trifolium pratense*, *Trifolium re-*

pens are all valuable fodder plants. They represent the three main plant functional types in grassland (grass, forb, legumes) and they contribute a considerable proportion of biomass to the harvest in many European grassland systems, although none of them dominates in any plant association, except when sown. Total harvested biomass: increased with fertilization and was higher at plots that received mineral fertilizer. A similar effect was not observed in standing biomass of single plants in May. Only orchardgrass showed an increase in biomass with mineral but not with organic fertilization; growth of red clover plants was stimulated by small amounts of fertilizer but decreased at high fertilization levels.N in harvested biomass was not affected by fertilization, it was higher at plots with higher cutting frequency. In orchardgrass and dandelion N concentration in biomass increased with fertilization and was higher at plots that received mineral fertilizer, no clear effect was observed in red clover. δ^{15}N in harvested biomass was higher with organic fertilization (δ^{15}N of organic fertilizers = 6-11‰) and increased with the amount of applied fertilizer. δ^{15}N in orchardgrass and dandelion showed the same pattern as the total harvested biomass, no clear effect of fertilisation was observed in red clover - this species depends mostly on N_2 fixation by symbiotic rhizobia. White clover showed some increase in δ^{15}N at higher fertilization levels, especially when mineral fertilizer was applied. As a conclusion it can be stated that species differ in their reaction to meadow management from the whole stand. This indicates that adaptive plasticity of single species play a minor role in the response of the whole stand – and that shifts in the abundance of species and change of species composition are probably more important. Legumes (clover species and others) play an important role in N-cycling of meadows as they can contribute high amounts of N by N_2 fixation, especially in low input systems.

Nitrogen retention in alpine meadows across an altitude gradient on the Tibet Plateau, China

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^{15}N tracers were used to investigate N retention in alpine ecosystems across an altitude gradient with the same vegetation on the Tibet plateau. $^{15}NO_3^-$ and $^{15}NH_4^+$ retention was distinctly different in alpine meadows within two months following ^{15}N additions, and even after one year, but a similarity occurred after four years. Over short-term time scales (within two months) $^{15}NH_4^+$ retention in the soil increased with soil organic carbon content while $^{15}NO_3^-$ retention decreased with increasing soil organic matter content. Besides, increases in soil temperature enhanced $^{15}NH_4^+$ retention, but reduced $^{15}NO_3^-$ retention in the soil over short-term time scales. Soil moisture significantly affected ^{15}N recovered in soil organic matter and microbial biomass and aboveground parts, but had no significant influence on ^{15}N recovered in roots. These results indicate that environmental factors such as soil temperature and moisture and soil organic matter play an important role in N retention in alpine meadows.