Name of research institute or organization:

Labor für Radio- und Umweltchemie der Universität Bern und des Paul Scherrer Instituts

Title of project:

VITA (Varves, Ice cores and Tree rings – Archives with annual resolution) and VIVALDI (Variability in Ice, Vegetation, and Lake Deposits — Integrated), both within the frame of NCCR Climate

Project leader and team:

PD Dr. Margit Schwikowski
Theo M. Jenk
Manuel Schläppi
Leonhard Tobler
Edith Vogel
Michael Sigl
Beat Muther

Project description:

VITA (Varves, Ice cores and Tree rings – Archives with annual resolution) and the follow-up subprogram VIVALDI (Variability in Ice, Vegetation, and Lake Deposits — Integrated) of the National Center of Competence in Research on Climate (NCCR Climate) aim to compare proxy climate records from natural archives (http://www.nccr-climate.unibe.ch/). The sites selected for ice coring were the Fiescherhorn glacier in the Berner Oberland (FH, Swiss Alps, 46°33'N, 08°04'E; 3900 m asl.), close to the Jungfraujoch and the Colle Gnifetti glacier in the Monte Rosa massif (CG, Swiss Alps, 45°56'N, 7°53'E; 4450 m asl).

As an example of the results obtained the Fiescherhorn ice core concentration records of NH_4^+, SO_4^{2-}, F^- and NO_3^- are discussed. They show a significant contribution from anthropogenic emission sources after the beginning of the industrialisation (~1850) (Fig. 1). The observed increase in i) NH_4^+ (~1850) concentrations is attributed to an extension in the agricultural production (fertilizers and animal manure), ii) SO_4^{2-} (~1860): the enhanced combustion of fossil fuels, iii) F^- (~1890): the aluminium production (starting 1890 in Switzerland) and iv) NO_3^- (~1950): increasing traffic. Also in the Cl^- record, a contribution from anthropogenic emissions, i.e. from the combustion of hard coal and from the chemical industry, was detected after ~1850. The relatively low and constant concentrations before the observed increase in the above discussed ions reflect their emissions from natural sources. These are emissions from biomass burning and vegetation for NH_4^+ and NO_3^-, whereas mineral dust is a natural source for F^- (e.g. fluorspar) and SO_4^{2-} (e.g. gypsum) which also originates from sea-salt. The industrial maximum (1970-2000) to pre-industrial (1750-1850) mean concentration ratio is highest for F^- (14.0). This ratio is 4.2 for SO_4^{2-}, 3.4 for NO_3^- and 3.0 for NH_4^+. In the SO_4^{2-} and F^- records, decreasing concentrations after 1970 are attributed to air pollution control measures, aiming at reduction of emissions to the environment.

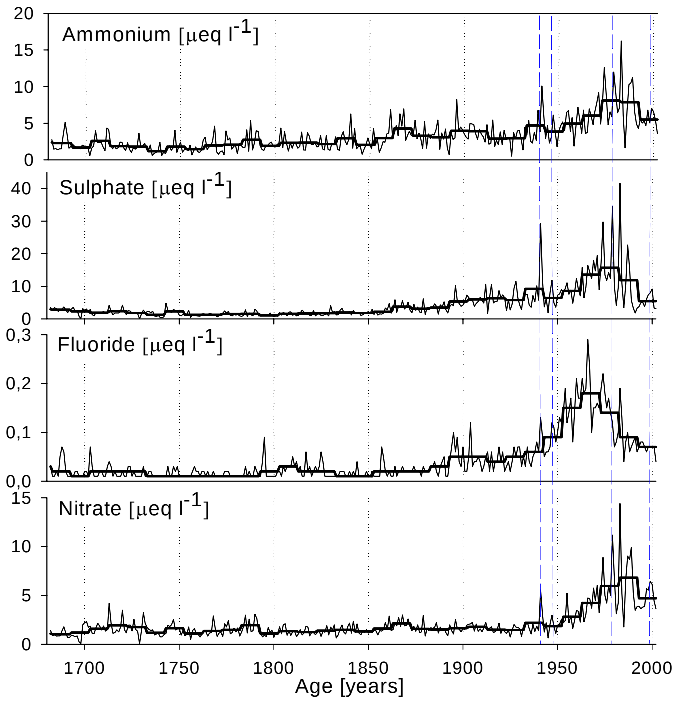

Fig. 1: Annual average concentrations (thin line) superimposed by the 10-year average (thick line) of NH_4^+, SO_4^{2-}, F^- and NO_3^-. The blue, dashed lines mark the sections influenced by percolating melt-water.

In addition to the ice core investigation, two snow pit/shallow firn core studies were conducted at Jungfraujoch. One was aiming to improve the understanding of the behavior of mercury (Hg) in snow. Hg is the only metal, whose elemental form has a natural cycle. Due to its high vapor pressure it is extremely toxic. However, there are still large uncertainties about atmospheric Hg-fluxes and Hg-concentrations. Also the chemical behavior of mercury after deposition is not well known. In this study Hg-concentrations in snow samples from Jungfraujoch were analyzed with cold vapor atomic fluorescence spectrometer (Mercur, Analytik Jena). Snow samples were collected on Jungfraujoch from a 63 cm and a 35 cm deep snow pit on 11 May and 12 May 2006, respectively (Fig. 2.). The upper 35 cm consisted of homogenous low-density snow, whereas the deeper layer from 35-63 cm was more compact but still homogenous. In the first snow layer Hg concentrations decreased from 2 ng/L to just above detection limit of about 0.14 ng/L. The agreement between the samples from the two consecutive days is good. There is no indication of a loss of Hg by evaporation. Interesting is also the second snow layer: An increase of Hg-concentrations with depth was detected, suggesting highly variable deposition conditions or concentrations in the atmosphere. However, the experiment was too short to fully understand mercury deposition and conservation in snow and a more detailed study is needed.

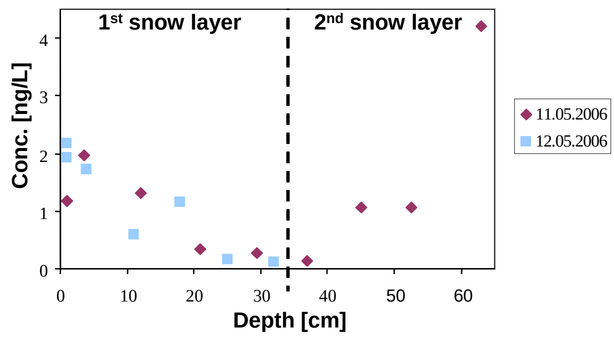

Fig. 2: Mercury concentrations against depth in the two snow pits from Jungfraujoch.

The shallow firn core study was conducted to test a new approach for dating of recent snow samples. The radioactive decay of ^{210}Pb with a half-life of 22.8 years is often used for dating of environmental archives like ice cores. ^{210}Pb activity is normally measured with α-spectroscopy through its granddaughter ^{210}Po, which has to be in radioactive equilibrium with ^{210}Pb. In this work the new approach was tested to apply this method for dating of snow/firn samples presumably younger than two years in which the two nuclides are not in equilibrium yet. Samples from the Jungfraujoch were collected by drilling a 6.8 m long shallow core on 11 May 2006. From the snow cores two aliquots per 20 cm long sections were prepared for the ^{210}Po α-spectroscopic measurements. Separation of ^{210}Po in the first aliquot was conducted between 5 and 28 days after sampling. Separation of the second aliquot took place 150 days resp. 180 days after sampling. From the two measurements the sample age was calculated (Fig. 3). A steady increase in age was observed until 400 cm depth, when the snow from the last autumn was reached (age about 200 days). Below that depth, ^{210}Po activities and ages show higher variability, which might be the effect of melting at this temperate glacier. Nevertheless, the resulting accumulation of 400 cm of snow for seven month seems reasonable for this site.

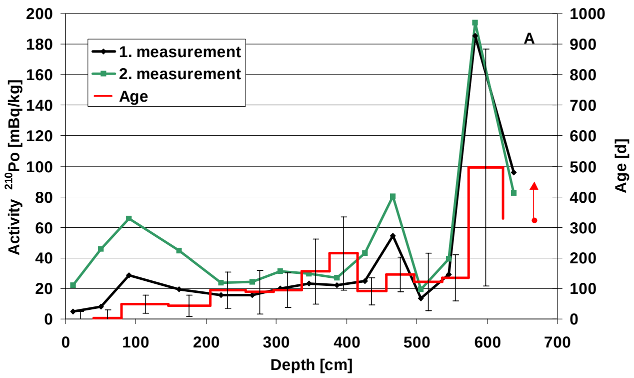

Fig. 3: ^{210}Po activities of the two measurements and the calculated sample age of the Jungfraujoch shallow core.

Acknowledgements

This study on the Fiescherhorn ice core was conducted in the frame of NCCR-Climate. Financial support from the Swiss National Science Foundation is acknowledged. The possibility to use the High Alpine Research Station Jungfraujoch as base camp is highly acknowledged.

Internet data bases:

http://lch.web.psi.ch/
http://www.nccr-climate.unibe.ch/

Collaborating partners/networks:

Markus Leuenberger, Luca Panno, KUP, University of Bern.
Harald Sodemann, ETH Zürich.
Martin Grosjean, Heinz Wanner, Geographical Institute, University of Bern.
Aurel Schwerzmann, Martin Funk, VAW ETH Zürich.

Scientific publications and public outreach 2006:

Refereed journal articles

Sodemann, H., A.S. Palmer, C. Schwierz, M. Schwikowski, H. Wernli, The transport history of two Saharan dust events archived in an Alpine ice core, Atmos. Chem. Phys. 6, 667-688 (2006).

Schwerzmann, A., M. Funk, H. Blatter, M.P. Lüthi, M. Schwikowski, A.S. Palmer, Reconstruction of past accumulation rates in an alpine firn region: Fiescherhorn, Swiss Alps, J. Geophys. Res. Earth Surface, 111, F01014, doi:10.1029/2005JF000283 (2006).

Schwikowski, M., Paleoenvironmental reconstruction from Alpine ice cores, PAGES News Vol. 14, N°1, 16-18 (2006).

Reithmeier, H., V.Lazarev, W.Rühm, M.Schwikowski, H.W.Gäggeler, E.Nolte, Estimate of European ^{129}I releases supported by ^{129}I analysis in an Alpine ice core, Environ. Sci. Technol., 40, 5891-5896 (2006).

Jenk, T.M., S. Szidat, M. Schwikowski, H.W. Gäggeler, S. Brütsch, L. Wacker, H.-A. Synal, M. Saurer, Radiocarbon analysis in an Alpine ice core: Record of anthropogenic and biogenic contributions to carbonaceous aerosols in the past (1650-1940), Atmos. Chem. Phys. 6, 5381-5390 (2006).

Address:

Paul Scherrer Institut
Labor für Radio- und Umweltchemie
CH-5232 Villigen
Switzerland

Contacts:

Margit Schwikowski
Tel.: +41 56 310 4110
Fax: + 41 56 310 4435
e-mail: margit.schwikowski@psi.ch
URL: http://lch.web.psi.ch/