

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

Project leader and team:

---

Prof. Heinz W. Gäggeler  
Dr. Margit Schwikowski  
Dr. Sönke Szidat  
Theo Jenk

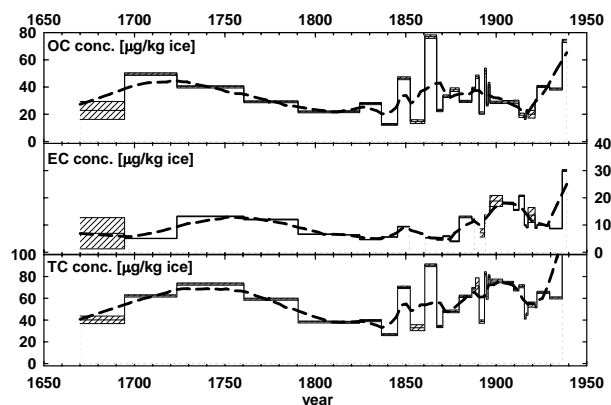
Project description:

---

VITA (Varves, Ice cores and Tree rings – Archives with annual resolution), the subprogram of the National Center of Competence in Research on Climate (NCCR Climate) aims to compare proxy climate records obtained from trees, lakes, peat bogs and glaciers (<http://www.nccr-climate.unibe.ch/>). The site selected for ice coring was the Fiescherhorn glacier in the Berner Oberland (FH, Swiss Alps, 46°33'3.2''N, 08°04'0.4''E; 3900 m asl.), close to the Jungfrauoch. Samples from this ice core were analysed to obtain a first long-term record of the two main fractions, organic carbon (OC) and elemental carbon (EC) of carbonaceous particle concentrations in ice along with the fraction of modern carbon derived from <sup>14</sup>C analysis. Long-term concentration records of carbonaceous particles are of increasing interest in climate research due to their not yet completely understood effects on climate. We analysed 33 samples of 0.4 to 1 kg ice, covering the time period ~1670-1940. Details of sample preparation and analysis can be found elsewhere (Jenk et al., submitted).

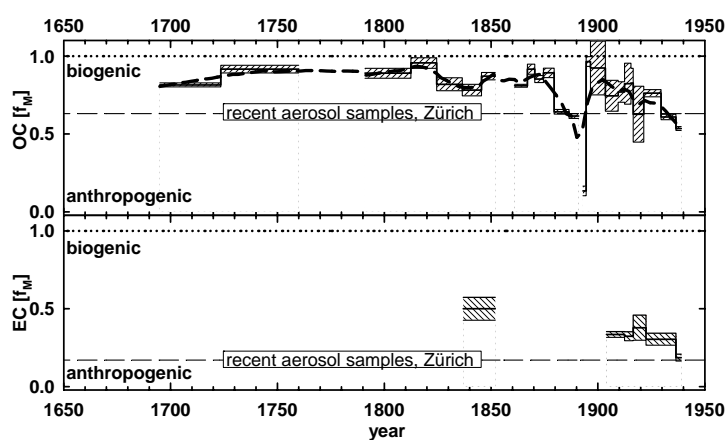
Since analysis of standard parameters like stable isotopes ( $\delta^{18}\text{O}$ ,  $\delta\text{D}$ ) and chemical species, e.g. ammonium, used for dating of ice cores by annual layer counting (ALC), is not completed yet for the Fiescherhorn glacier core, dating of the presented samples was performed by ALC back to 1880 (uncertainty:  $\pm 2$  years) and by a Nye ice flow model for the time before ( $\pm 10$ , rising to the end). Ice samples were obtained by cutting slices along the recovered core sections of about 70 cm length and were prepared as described in (Jenk et al., submitted).

Concentrations of OC, EC and total carbon (TC) in  $\mu\text{g}/\text{kg}$  ice are presented in Fig. 1, representing the water insoluble amount. OC, as a tracer of biogenic emissions, shows a high variability in concentrations. An influence from anthropogenic emissions is not obvious for the examined time period, since high concentrations were already observed around 1700. The relatively low levels during the early 19<sup>th</sup> century are unexpected. A possible explanation might be a change in bioactivity due to colder conditions around 1800. EC concentrations, as a tracer of anthropogenic emissions show less variability. In contrast to OC, the anthropogenic influence due to industrialisation and the use of fossil fuels (hard coal, later oil and gasoline) is clearly reflected in EC concentrations, which began to increase around 1880.



**Fig. 1:** OC, EC and TC concentrations as  $\mu\text{g}/\text{kg}$  ice from 1670 to 1940 (solid lines) with measurement uncertainties ( $1 \sigma$ , shaded areas). The dashed line was obtained by smoothing of the data.

$^{14}\text{C}$  analysis has shown to be a powerful tool for source apportionment of carbonaceous particles (Szidat et al., 2006). In Fig. 2, results of  $^{14}\text{C}$  analysis are presented for OC and EC as fraction of modern carbon ( $f_M$ ) corrected for the decay by accounting for the age of the sample. The  $f_M$  thus indicates the level of biogenic/anthropogenic contribution to the sample. Accordingly, a sample with a  $f_M = 1$  originated to 100% from biogenic sources. The record for the  $f_M$  of OC shows - similar to the EC record in Fig. 1 - a rising of anthropogenic emissions after 1880. The level for 1940 is already comparable to recent aerosol samples with an anthropogenic contribution of around 40% [3]. A very strong peak of anthropogenic emissions between 1880 and 1900 is interesting for further investigation. Before 1850, OC was almost purely of biogenic origin. This is an important finding as we intend to use OC for radiocarbon dating of the oldest sections of ice cores. The  $f_M$  of EC reflects a more and more dominating contribution of anthropogenic sources after 1900 until reaching about 80% of the total EC emissions in 1940, comparable to what is observed in recent aerosol samples (Szidat et al., 2006). Interesting but without explanation yet is the  $f_M$  for the sample from around 1850. EC seems to be influenced by  $^{14}\text{C}$  extinct sources even around 1850.



**Fig. 2:**  $f_M$  of the OC and EC fractions derived from  $^{14}\text{C}$  AMS analysis (solid lines) with measurement uncertainties ( $1 \sigma$ , shaded areas). The dashed line was obtained by smoothing of the data. The dotted line represents 100% biogenic origin.

Acknowledgements:

---

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

References:

---

Jenk, T.M., S. Szidat, M. Schwikowski, H.W. Gäggeler, D. Bolius, L. Wacker, H.-A. Synal, M. Saurer, Microgram level radiocarbon ( $^{14}\text{C}$ ) determination on carbonaceous particles in ice, submitted to Nucl. Instr. Meth. Phys. Res. B.

Szidat, S., T.M. Jenk, H.-A. Synal, M. Kalberer, L. Wacker, I. Hajdas, A. Kasper-Giebl, U. Baltensperger, Contribution of fossil fuel, biomass burning and biogenic emissions to carbonaceous aerosols in Zürich as traced by  $^{14}\text{C}$ , J. Geophys. Res. Atmos., in press.

Key words:

---

carbonaceous particles, radiocarbon, aerosol effect

Internet data bases:

---

<http://lch.web.psi.ch/>

<http://www.nccr-climate.unibe.ch/>

Collaborating partners/networks:

---

Brigitta Ammann, Institute of Plant Sciences, University of Bern

Martin Grosjean, Jürg Luterbacher, Heinz Wanner, Geographical Institute, University of Bern.

Lukas Wacker, Hans-Arno Synal, Martin Suter, ETH Zürich.

Scientific publications and public outreach 2005:

---

**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. Discuss. 5, 7497-7545 (2005).

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](mailto:margit.schwikowski@psi.ch)  
URL: <http://lch.web.psi.ch/>

