Name of research institute or organization:

Alfred Wegener Institute for Polar and Marine Research, Bremerhaven
Institute for Environmental Studies, University of Heidelberg

Title of project:

Linking micro-physical properties to macro features in ice sheets with geophysical techniques (LIMPICS)

Project leader and team:

Project leader: PD Dr. Olaf Eisen
Team: Pascal Bohleber, Anja Diez, Reinhard Drews, Günther Druivenga, Dr. Coen Hofstede

Project description:

In the middle of August 2010 a one-week geophysical field survey was carried out in the accumulation region of Grenzgletscher at Colle Gnifetti. The campaign was part of the DFG-funded junior research group LIMPICS. Aim was the application of geophysical measurements to derive physical properties of the glacier surrounding the location of an existing borehole. Previous to the actual measurements the five-people team of the Alfred Wegener Institute Bremerhaven, the Institute for Environmental Physics at the University of Heidelberg and GEOSYM Hannover spent the nights from 6-9 August 2010 in the Kulmhotel Gornergrat.

Photo 1: Deployment of the geophone line along a profile marked with bamboo poles towards East. The camp is in the background. Photo: Anja Diez, AWI

Photo 2: Deployment of the geophone line along a profile marked with bamboo poles towards East, Lago Maggiore is in the background. Photo: Anja Diez, AWI

The selection of Gornergrat as the location for accommodation has several reasons: located at a high altitude for acclimatisation, easy and fast accessibility via the Gornergratbahn, access to the Findelgletscher, insight of Grenzgletscher and Zermatt. For working at Colle Gnifetti (4450 m), with overnighting in the Capanna Margherita (4550 m), a good acclimatisation is mandatory. Two overnightings on Gornergrat on 3100 m represents a necessary step. The good accessibility is important in case problems occur for transport of cargo by Air Zermatt's helicopter to Colle Gnifetti and a quick descent to Zermatt is required. Likewise, the Gornergratbahn makes a fast access to the accomodation on the day of arrival easier, leaving enough time for preparation of the cargo flights as was necessary on 7 August. For the actual transportation of personnel from Gornergrat or Rothenboden to Colle Gnifetti by helicopter it is important to have direct insight of the upper part of Grenzgletscher and to Zermatt. In the case of bad weather this enables the usage of even short fine weather windows for transportation, or to cancel planned flights from Zermatt in time, if the weather conditions in the Monte Rosa-region do not permit a safe flight.

After the first night from 7 to 8 August three people of the team made a hike from Kulm to the accumulation region of the Findelgletscher for acclimatisation exercise.

Two other members of the team went down to Zermatt to finish preparing the cargo for the flights envisaged for the 8 August. However, because of bad weather conditions all flights to Colle Gnifetti except for one cargo transport were delayed until Monday, 9 August. Despite a fully booked hotel, the necessary additional overnight stay at Kulm could be provided.

After arriving at Colle Gnifetti on the late morning of the 9. August, set-up of the camp and the measurements were carried out immediately. Achieved goals were :

- extension of an existing net of ground-penetrating radar (GPR) profiles to map the internal structure of the glacier,

- borehole radar and borehole-surface tomography measurements in the existing hole,

- reflection seismic measurements with a pressure-wave and shear-wave source (vibroseis),

- position and elevation measurements with the global positioning system (GPS).

The first three days at Colle Gnifetti allowed for sufficient measurements under fair weather conditions. Due to a predicted worsening of weather conditions the freight was packed for return flights on 11 August. The team descended on 12 August on foot all the way to Zermatt. The cargo flights were carried out by Air Zermatt during a short period of fine weather on the morning of 13 August. The campaign thus finished successfully and without any incidents with three flights on 13 August in Zermatt.

Photo 3: The ElViS vibroseis source with additional weight on top to increase pressure at the base. Photo: Anja Diez, AWI

A preliminary data analysis indicates that this field campaign was able to achieve several important results and provides significant progress:

- From the borehole radar data (the first measurements carried out there) it is probably possible to determine the amount of ice still present underneath the existing borehole and the bedrock. This is important as this ice is older than the one retrieved so far and contains further information of the past climate. Depending on the detailed outcome further ice-core drilling is envisaged.

- The GPR and GPS profiles at the surface extended the coverage of existing data from the glacier saddle, connecting several ice-core sites, and will allow for a better understanding of the age-depth distribution for kinematic and dynamic analysis of the ice regime.

- Vibroseis reflection measurements with the employed minivibrator ElViS were carried out for the first time on firn and glacier ice. The results show that the obtained data quality for both, pressure- and shear-waves, vibroseis is significantly superior to conventionally employed seismic sources (e.g. explosives or hammer sources). This will have a considerable impact on the future investigation of ice masses world-wide, both Alpine and polar, for determining the properties of ice as well as the geological structures underneath.

- The shear-wave vibroseis measurements indicate several internal reflectors in the ice. This was one of the actual goals of the LIMPICS project. Whether these reflectors are caused by changes of the bulk crystal orientation fabric, as expected, requires further analysis and remains to be seen.

We cordially thank the Hochalpinen Forschungsstationen and the Kulm Hotel Gornergrat as well as the staff of the Cpn. Margherita for their support, as the realization of this campaign and all results would have been difficult to achieve otherwise.

Photo 4: Deployment of the geophone line along a profile marked with bamboo poles towards West, Zumsteinspitze in the background. Photo: Anja Diez, AWI

Key words:

Colle Gnifetti, ice core, glacier, climate change, physical properties, geophysical techniques, ground-penetrating radar, borehole, seismic vibrator, vibroseis

Internet data bases:

http://www.awi.de/en/go/limpics

Collaborating partners/networks:

Dr. M. Zemp, University of Zurich, Prof. Dr. M. Hoelzle, University of Fribourg

Scientific publications and public outreach 2010:

Refereed journal articles and their internet access

Heilig, A., Schneebeli, M., Eisen, O. Upward-looking ground-penetrating radar for monitoring snowpack stratigraphy, Cold Regions Science and Technology, 59,(2-3), 152-162., doi:10.1016/j.coldregions.2009.07.008, 2009.

Theses

Heilig, A. The search for and location of inhomogeneities in seasonal snowpacks utilizing ground-penetrating radar technology, Ruprechts-Karl-Universität, Heidelberg, 157pp., PhD thesis, Institute of Environmental Physics, University of Heidelberg, 2009.

Address:

AWI, Alfred Wegener Institute for Polar and Marine Research
Postfach 120161
27515 Bremerhaven, Germany

Contacts:

Olaf Eisen
Tel.: +49 471 4831 1969
e-mail: oeisen@awi.de
URL: http://www.awi.de/en/go/limpics