## Report for short visit at SLF

ESF Activity: Micro-DICE
Applicant: Polona Vreča, Jožef Stefan Institute, Ljubljana, Slovenia
Title of the project**: Physical properties of seasonal snow for snow hydrology applications**
Reference number: 5198
Host institution: WSL Institute for Snow and Avalanche Research SLF, Flüelastrasse 11, 7260 Davos Dorf, Switzerland
Mentor at host institution: Martin Schneebeli
Period of visit: 24. 2. – 2. 3. 2013

### 1) Purpose of the visit

In temperate humid catchments the storage of precipitation in snowpack, and the subsequent melting, both highly variable in space and time, substantially impact the water cycle. An accurate snow balance study is therefore necessary for 1) determination of size of the catchment area and 2) assessment of water residence times, which are crucial for protection of alpine water resources and assessment of their stability.

Isotopes of O and H offer a broad range of possibilities for studying processes within the water cycle and have also been used to study snow deposition and the subsequent alteration of snowpack and its influence on runoff. The isotopic content of near-surface snow is the result of effects of numerous processes taking place after deposition (e. g. Sokratov and Golubev, 2009). Preliminary detail isotopic investigations of snowpack performed in 2011 in Slovenia showed considerable changes in isotopic composition of snow that could be related to different processes occurring after the deposition (Vreča et al., 2012). Observed changes in isotopic composition indicated that in future snow investigations appropriate determination of physical properties could enable better understanding of the alteration of seasonal snowpack important also for understanding of water cycle. In addition, the isotopic fractionation in snow should be considered more in detail, especially based on vapour flux and recrystallization investigations of Pinzer et al. (2012) who estimated average residence time that an ice volume stays in place before it sublimates as relatively short (i. e. 2–3 days), meaning that most of the ice changes its phase from solid to vapour and back many times in a seasonal snowpack.

Therefore, the main objective of this first short visit at SLF was to gain basic knowledge on physical properties of snow, with emphasise on grain shape and size determination.

PINZER, B. R., SCHNEEBELI, M.KAEMPFER, T. U., 2012. Vapor flux and recrystallization during dry snow metamorphism under a steady temperature gradient as observed by time-lapse micro-tomography, *The Cryosphere 6*, 1141-1155.
SOKRATOV, S.A., GOLUBEV, V.N., 2009. Snow isotopic content change by sublimation. Journal of Glaciology 55, 823–828.
VREČA, P., BRENČIČ, M., SINJUR, I., SOKRATOV, S. A., 2012. Detail isotopic stratigraphy of snowpack - case study from Julian Alps (Slovenia). Geophysical Research Abstracts, vol. 14, 5893, European Geosciences Union General Assembly 2012.

### 2) Description of the work carried out during the visit

The work during the visit at SLF included:
- On-site characterisation of snow profile with emphasize on determination of different snow layers, snow hardness, grain shape and grain size using snow crystal card and a magnifying glass (10 x magnifications). Location was selected close to the institute, in the shade.
- Collection of ten snow samples from snow profile for further microscope investigations in cold laboratory (-15°C). Grain shape and grain size of crystals were determined using UNESCO-IHP International classification for seasonal snow on the ground (Fierz et al., 2009). Photos of each sample were taken for further classification of grains. Finally, oxygen isotopic composition of collected samples was determined at Jožef Stefan Institute after return from Davos.

- Photos of investigated snow samples were again compared with UNESCO-IHP International classification for seasonal snow on the ground (Fierz et al., 2009) and inspected together with dr. Charles Fierz.
- Comparison of in-situ, microscope and photo observations.
- Presentation of SnowMicroPen (SMP) instrument, which is capable of measuring the penetration resistance of snow with a high resolution. SMP provides measurements that enable determination of snow density and structure. With the SMP it is possible to detect very thin layers.

During the visit work and facilities of the research group Snow Physics were presented to me by dr. Martin Schneebeli, dr. Henning Löwe, Stefan Schleef and Sebastian Hortz. Visit of SLF was also a great opportunity to meet dr. Charles Fierz, the head of the research group Snow Cover and Micrometeorology, and dr. Tobias Jonas, the head of the research group Snow Hydrology.

**3) Description of main results obtained**

Grain shape comparison of in-situ, microscope and photo observations gave slightly different results, which can be attributed mostly to lack of experience. Photos with final classification and isotopic composition of oxygen in 10 analysed samples are presented in Figure 1. In surface layer, stellar grains were observed in-situ but under the microscope also partly decomposing and fragmenting of these particles was visible. In the second sample we observed prevailing decomposed and fragmented precipitation particles in combination with rounded grains and in the third sample a combination of rounded grains and faceted crystals. The fourth sampled layer was melting form, which was clearly identified. The fifth, sixth and seventh sample were classified as rounding faceted particles after detail inspection of photos. During microscopy observations they were classified as combination of large rounded and solid faceted particles. The eighth sample was again melting form and ninth and tenth sample were again rounding faceted particles.

Changes of isotopic composition of oxygen with depth of the profile are shown in Figure 2. The upper 3 samples have similar isotopic composition and show only slight enrichment in $^{18}O$ with depth. Samples 4 and 8 represent very thin melt forms, which are clearly determined also by shift in $\delta^{18}O$ values. Both samples collected below the melt forms (5 and 9) are distinctly enriched in $^{16}O$. Samples 6, 7 and 10 were all classified in the same group (FCxr) but their isotopic composition varies considerably indicating different processes in the snow pack. Obtained results represent the first attempt of comparison of crystal characteristics and their isotopic composition.

**4) Further collaboration with host institution and projected publications**

In Slovenia no cold laboratories with facilities for detail snow physical properties are available, therefore collaboration with SLF in future is of great importance. Knowledge gained at SLF will be applied in in-situ investigations of snow in Slovenia in the frame of ongoing projects related to water cycle investigations.

We envisage without yet clear funding a joint project, investigating in more detail the effects of metamorphism on isotopic composition. The different climates between the Alps in Eastern Switzerland and the Slovenian Alps, as well as the different source areas of the precipitation, could give a very interesting natural laboratory to understand better these effects.

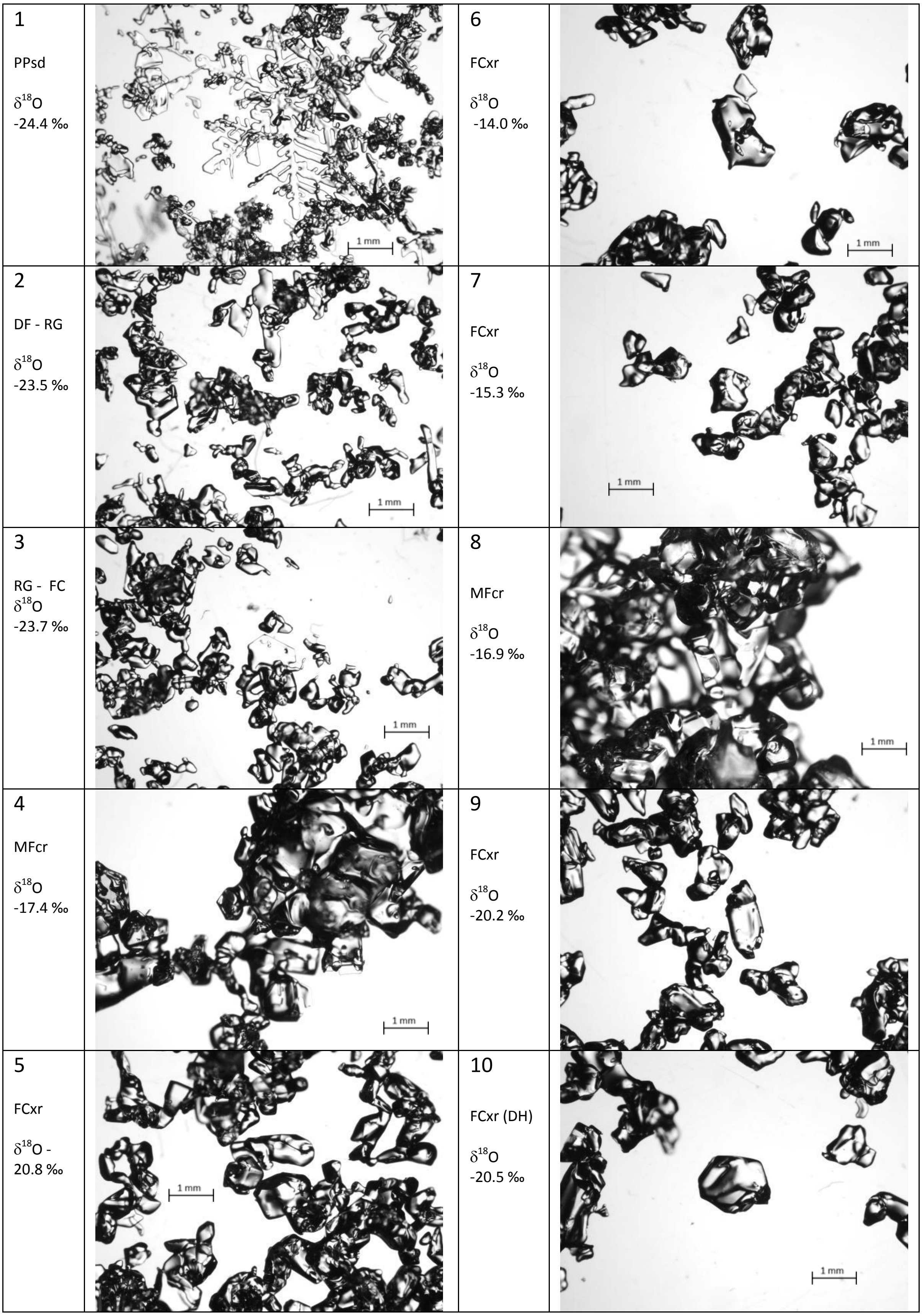


Figure 1. Selected snow crystal photos with determined grain shape classes and their oxygen isotopic composition.

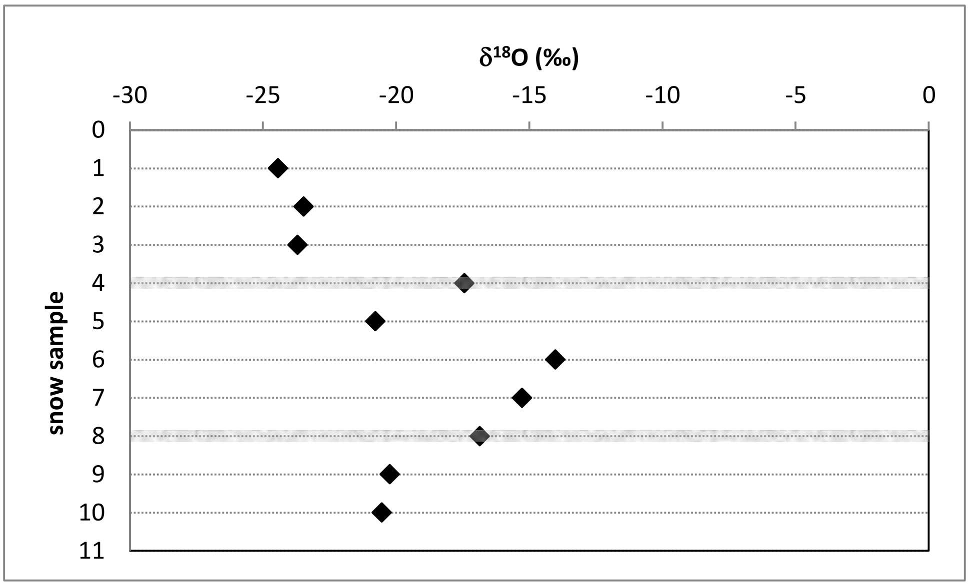

Figure 2. Changes of isotopic composition of oxygen in collected samples. Grey lines represent the layer with observed melt forms.