

## Field campaigns for demonstrating and comparing observation techniques, and identifying sources of variability of essential snow parameters

### **Includes the following deliverables of COST Action ES1404 (HarmoSnow):**

**D5** Assessment of measurement errors and inter-calibration of measurement techniques.

**D11** Measurement reports and manuals to standardize measurement protocols will be issued based on the field campaigns results.

### Description

The three extent field campaigns were organized by WG1 and WG2 in the context of HarmoSnow. The first campaign in Turkey addressed to demonstration of the snow height and snow water equivalent (SWE) measurement techniques used in the Europe. Total seven different SWE samplers were tested at the two field sites with different snow conditions. Additionally, stratigraphy, density and liquid water content observations were demonstrated at the third site. The second campaign in Iceland concentrated to identifying differences between the SWE samplers and identification of sources of variability. Total nine different sampler types were used at three field sites, where snow depth and ground cover type varied. In addition, spatial variability of snow height was studied by the students of Reykjavik University. The third field campaign in Finland included intercomparison of the SWE instruments at the three different field sites with low spatial variability of snow confirmed by SnowMicroPen observations. Accuracy of the scales was also studied at the inside temperature and the outside temperature, which is important to produce accurate observations. In addition, Short Term Scientific Mission (STSM) of Katalin Gillemot addressed to instrumental comparison of SWE samplers. Total three different samplers were applied. Those measurements includes also SWE observations by using two different scales for the weighing. In addition, a modest field campaign for demonstrating SWE measurements were organized together with the workshop on “*Snow Data Use*” in Slovakia in 2015.

The most important result from the field campaigns is that all samplers reaches maximum 10% variability if measurements are repeated adequately, which is usually accepted for the field observations in data assimilation. The 1<sup>st</sup> and 2<sup>nd</sup> campaigns proofed that instrumental variability or observer related variability are not possible to separate from high spatial variability of SWE. Therefore, it was aimed to have low natural variability of SWE and snow height in the 3<sup>rd</sup> field campaign to study closer instrumental variability and observer related variability. The observations resulted almost similar variability for experienced and novice observers. Variability was largest for the long and thin tubes, which are not typically used for taiga snowpack. During the three field campaigns was observed that all existing samplers are planned for certain environment and snow conditions typical to country where instrument is developed or typically used. Usually instruments are more difficult to use in other kind of field conditions. Therefore, it is not possible to choose one recommended instrument or method. Instead general recommendations for favorable instrument properties for different snow conditions are given, and basic guidelines to produce accurate results are stated.

In addition, two topical workshops addressed to intercomparison of measurement techniques and creating measurement protocols and recommendations. The workshop on “*In-situ snow albedo measurements: toward a snow albedo intercomparison experiment*” discussed on snow albedo measurement accuracy (presently achieved vs desired), best practices for calibration/characterization of instruments, protocol to minimize and

quantify measurement uncertainties due to measurement setup and environmental conditions, and recommendations concerning the use of auxiliary tools to measure/monitor ancillary snow properties. The workshop planned two upcoming activities, at first laboratory characterization and then field intercomparison. The workshop on *Integrated long-term Snow Chemistry Monitoring* had inter-comparison experiment on snow sampling strategy for monitoring the chemical composition, stable isotope content and snow stratigraphy of seasonal snow in mountain/arctic environment. Also in the workshop was started general discussion on the need for a protocol/guide on snow chemistry measurements for seasonal snow and its potential relevance and added value for the research community.

The results are presented in attached field campaign reports, STSM report, recommendations and workshop reports. In addition, a review paper based on the three HarmoSnow field campaigns is in progress. The European Snow Booklet (ESB) will have a chapter based on the HarmoSnow field campaigns. ESB is not published yet, but it will be available by the end of the year 2018.

#### Attachments

Lopez Moreno J I, Sensoy A, Leppänen L, Fierz C, **Report of the 1<sup>st</sup> HarmoSnow field campaign in Erzurum, Turkey, 2016**

[http://harmosnow.eu/dissemination/reports/Field\\_Campaign\\_Erzurum\\_2016.pdf](http://harmosnow.eu/dissemination/reports/Field_Campaign_Erzurum_2016.pdf)

Leppänen L, Lopez Moreno J I, Holko L, Fassnacht S, Dagsson-Waldhauserova P, Finger D, Luks B, **Report of the 2<sup>nd</sup> HarmoSnow field campaign in Reykjavik, Iceland, 2017**

[http://harmosnow.eu/dissemination/reports/COST\\_2nd\\_field\\_campaign\\_report.pdf](http://harmosnow.eu/dissemination/reports/COST_2nd_field_campaign_report.pdf)

Leppänen L, Lopez Moreno J I, Luks B, Holko L, Marty C, **Report of the 3<sup>rd</sup> HarmoSnow field campaign in Sodankylä, Finland, 2018**

[http://harmosnow.eu/dissemination/reports/Report\\_COST\\_Sodankyla.pdf](http://harmosnow.eu/dissemination/reports/Report_COST_Sodankyla.pdf)

Gillemot K, **STSM report** (*Snow measurement methods intercomparison and nature based solutions in avalanche prevention in Iceland*), 2018

[http://costsnow.fmi.fi/stsm/648\\_report\\_gillemot\\_iceland.pdf](http://costsnow.fmi.fi/stsm/648_report_gillemot_iceland.pdf)

Nejedlik, P. **Report of workshop on “Snow Data Use”**, 2015

<http://harmosnow.eu/dissemination/reports/Field%20campaign%20SK.pdf>

Leppänen L, Lopez Moreno J I, Gillemot K, Holko L, Luks B, **Recommendations from HarmoSnow field campaigns**, 2018

[http://harmosnow.eu/dissemination/reports/fc\\_Recommendations.pdf](http://harmosnow.eu/dissemination/reports/fc_Recommendations.pdf)

R. Pirazzini, G. Picard, M. Citterio, G. Hülsen, **Report on the “Workshop on In-situ snow albedo measurements: toward a snow albedo intercomparison experiment”**, 2016

<http://harmosnow.eu/dissemination/reports/Snow%20albedo%20workshop.pdf>

W. Schöner, O Meinander, C. Zdanowicz, B. Sattler, C. Larose, U. Nickus, T. Martma, P. Vreca, A. Spolaor, **Minutes from the workshop on “Integrated long-term Snow Chemistry Monitoring”**, 2018

<http://harmosnow.eu/dissemination/reports/Harmosonow-SnowchemistryWS-minutes.pdf>