Long-term (climatological) to short-term (intensive campaigns) field investigations of meteorological and snow conditions at the experimental site Col de Porte

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ABSTRACT: The Col de Porte field station located in the mountains at 1325 m altitude near Grenoble, France, performs snow and meteorological monitoring for over 50 years. This contribution to the "Workshop on snow and avalanche test sites" within ISSW 2013 provides an overview on how the data are collected and used for several applications such as climatology of snow and meteorological conditions, development of detailed snowpack models, instrumental development and in-situ snow physics investigations. Examples of these different applications are shown and discussed with a particular focus on the integration of the various time scales covered at Col de Porte. Indeed, long-term continuous ancillary and snow observations provide crucial background for shorter-term experiments, while the latter have often transformed into unique multi-year records of some key physical properties of snow (settling, SWE, snowmelt etc.). The three main current intensive campaigns are:
- The contribution of the site, gathering several local groups (CNRM-GAME/CEN, LTHE, LGGE, EDF-DTG) to the ongoing WMO-SPICE Intercomparison (Solid Precipitation Inter-Comparison Experiment).
- Current developments on continuous monitoring of the optical properties of snow, spectrally resolved both in terms of reflectance and light penetration (mainly LGGE).
- Measurements of the physical properties of snow with newly developed instrumentation based on optical or micro-mechanical investigation means, collocated with conventional snowpit measurements (CNRM-GAME/CEN, LGGE).

KEYWORDS: snowpack observations, meteorological observations, physical properties of snow

1 INTRODUCTION

Research on the physical properties of snow and their relationship with the meteorological and wider environmental conditions requires experimental sites featuring co-located measurements of snow and meteorological variables, preferably spanning long time periods. The research station Col de Porte (CDP) lies among the few sites displaying a large suite of such measurements. It is located at 1325 m altitude in the Chartreuse mountain range, close to Grenoble, France (45.30°N, 5.77°E).

While the series of observations was started in the early 1960s with mostly daily meteorological and weekly snowpit records, the site performs hourly observations since 1993 in terms of meteorological and some essential snow and ground variables (snow height, snow surface temperature, internal snow temperature, ground temperature at various depths). Long-term snow and meteorological data gathered from 1993 to 2011 have recently been compiled and released publicly (Morin et al., 2012), allowing multi-year evaluation of snowpack models of various levels of complexity.

2 INSTRUMENTS AND EXPERIMENTS

Figure 1 provides an overview of the site from above, including instruments which are permanently deployed there. In addition to this suite of instruments and measurements described in detail by Morin et al. (2012), several shorter-term experiments are currently ongoing at CDP.

2.1 Contribution to the WMO-SPICE project

The World Meteorological Organization Solid Precipitation Inter-Comparison Experiment (WMO-SPICE) seeks to compare manual and automated methods for snow precipitation and observations of snow on the ground (height and snow water equivalent).

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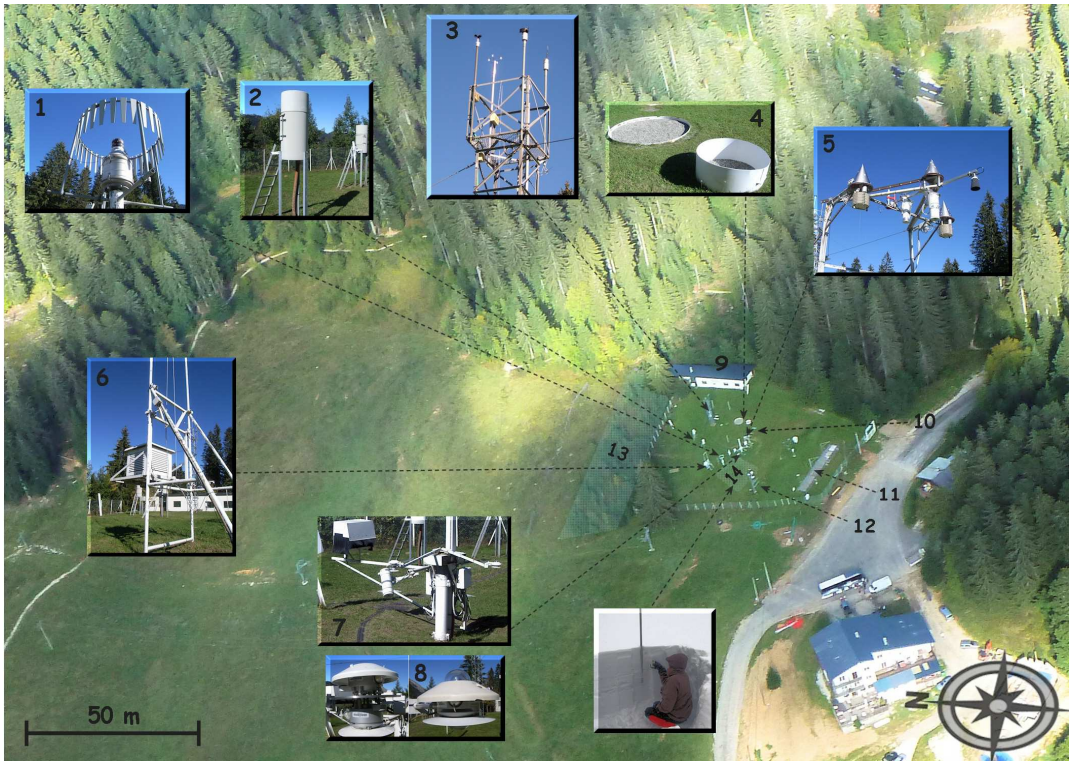

Figure 1: *Overview of the experimental research site at col de Porte, and close-up on some of the instruments used, such as : precipitation sensors (2: the two PG2000 ,1 : GEONOR), anemometers (10m mast, 3), lysimeters (used to measure basal runoff) (4), snow depth gauges and instruments measuring the vertical profile of height and temperature of snow layers (5), air temperature and relative humidity sensors (6), radiation sensors (7 and 8), snow water equivalent through cosmic rays counting (10), webcam (11) and automatic weather station « Nivose » (12). Weekly snow pit observations are carried out in a dedicated area (14).*

It is based on a series of over 10 sites around the world spanning a wide range of climate conditions (Qiu, 2012). CDP has been approved to participate in WMO-SPICE starting from the winter 2013-2014. In addition to the instruments deployed permanently (1 GEONOR and 3 PG2000 instruments with various heating configurations, see Morin et al., 2012, for details), the site will host for at least two winter seasons the following instruments:

- 2 GEONOR automated gauges (one shielded, the other not) to serve as a local reference to other precipitation gauges,
- 2 OTT Pluvio2 sensors with different shielding methods, to check their influence on the measurements,
- various disdrometers (Biral VPF 730, Campbell Scientific PWS100) and hotplate sensor (YES TPS-3100 Hotplate)
- additional anemometers to monitor the wind field near the gauge orifices / sampling volumes.

Also, the site will host two types of snow height sensors provided by manufacturers (Campbell Scientific SR50A and Jenoptik SMH30), in addition to existing sensors (ultrasonic and laser) and manual measurements.

More information about WMO-SPICE can be found at the following url :

http://www.wmo.int/pages/prog/www/IMOP/intercomparisons/SPICE/SPICE.html

2.2 Continuous monitoring of the optical properties of snow

Making continuous measurements of light penetration in snow is challenging for various reasons including the disturbance induced by the sensors themselves. CDP serves as a testbed for currently developed instrumentation at LGGE within the ANR project MONISNOW led by G. Picard. The retrieval of not only total light but also spectrally resolved light penetration and reflection (albedo) are seeked with encouraging results from the first year of operation (2012-2013). A companion system is also deployed at Dome C, Antarctica, where issues related to phase change and large precipitation events are absent. In this regard, making measurements at a low altitude site in the Alps often proves more difficult than in the remote Antarctic plateau.

2.3 Measurements of the physical properties of snow with new instrumentation

The ability of traditional snowpit observations to provide an objective description of the vertical properties of snow is often questioned due to the large impact of visual observations, inherently observer-dependent, on the retrieved profile. Alternative high-resolution methods based on optical or mechanical sounding of the snow have emerged over the past years. CDP has served as a test location where conventional snowpit observations, carried out every week, were complemented by new snow profiling techniques. This concerns mainly the retrieval of the optically equivalent grain radius, directly related to the specific surface area, by means of near infrared light reflection at 1310 nm (Gallet et al., 2009, Arnaud et al., 2011, Morin et al., 2013). A SnowMicroPen (Schneebeli et al., 1999) has also been purchased and tested at the same snowpit sites. Figure 2 shows an overview of vertical profiles of specific surface area and a variable derived from the SMP using the Poisson shot-noise algorithm developed by Löwe and van Herwijnen (2012), carried out at CDP over the snow season 2011-2012. This shows that physical properties of snow can be measured using modern instrumentation with high potential to describe the high-resolution vertical profile of the snowpack.

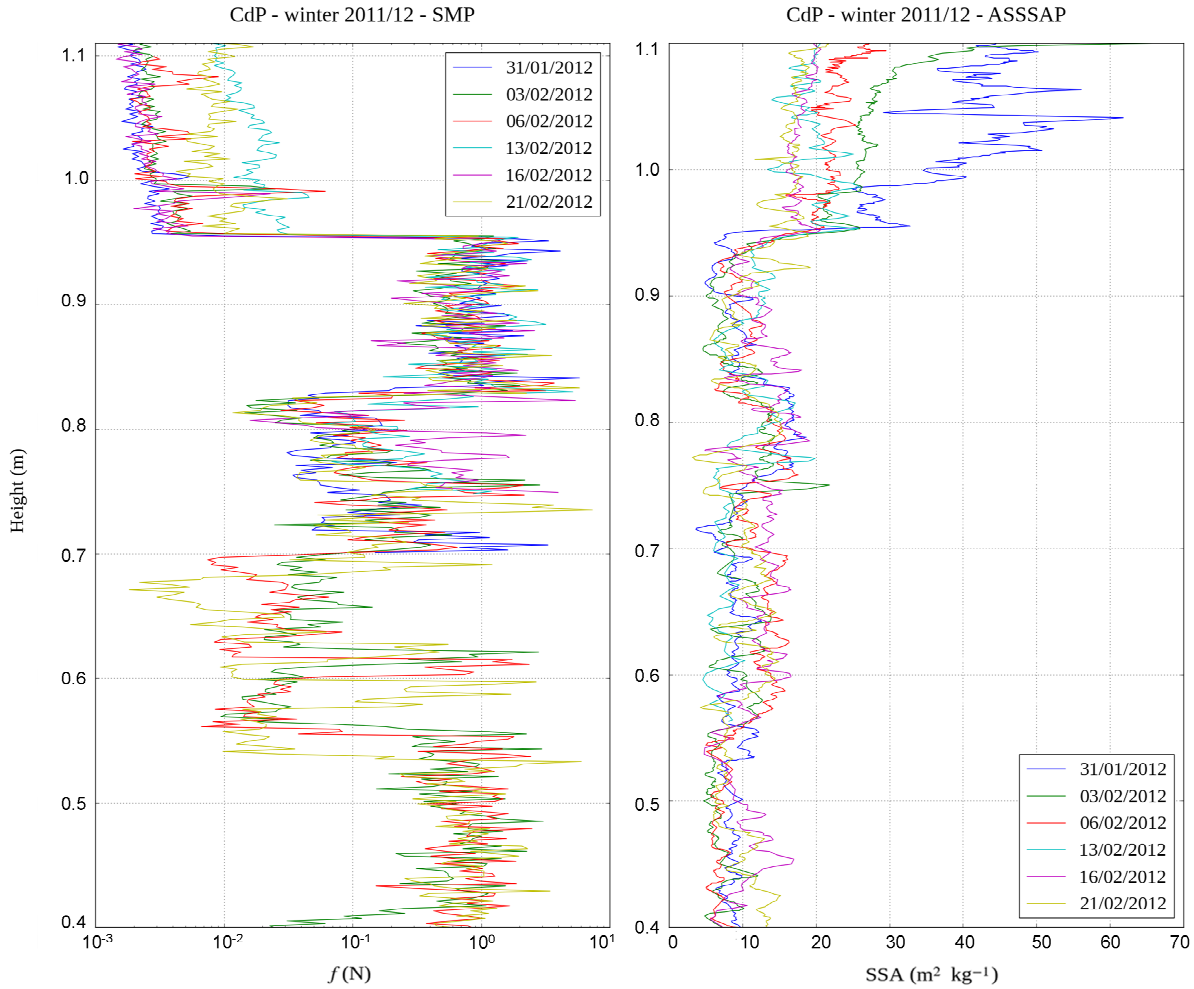

Figure 2: *Examples of vertical profiles of the force at rupture (f) deduced from SMP measurements (left) and the specific surface area (SSA) (right) within a few cm horizontal distance at 6 dates during the snow season 2011-2012 at CDP (from Carmagnola, in prep.)*

3 CONCLUSIONS

The experimental site CDP has a long history of snow and meteorological observations. The dataset gathered there has been instrumental in the development and evaluation of snowpack models of varying complexity. In several occasions, short-term experiments were converted into long term unique records of some key physical properties of snow. It is crucial to maintain such sites in operational state in different climate and snow conditions, to advance our knowledge of snow/atmosphere/environment interactions and our ability to monitor it.

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5 REFERENCES

Arnaud L., Picard G., Champollion N., Domine F., Gallet J.-C., Lefebvre E., et al. Measurement of vertical profiles of snow specific surface area with a 1 cm resolution using infrared reflectance: instrument description and validation. J. Glaciol., 57(201):17–29, 2011.

Carmagnola, C. M., Mesure, analyse et modélisation des processus physiques du manteau neigeux sec, PhD dissertation (in French), Univ. Grenoble-Alpes, in prep.

Gallet J.-C., Domine F., Zender C. S., Picard G. Measurement of the specific surface area of snow using infrared reflectance in an integrating sphere at 1310 and 1550 nm. The Cryosphere, 3, 167–82, 2009.

Löwe, H., and A. van Herwijnen (2012), A Poisson shot noise model for micro-penetration of snow, *Cold Reg. Sci. Technol.*, *70*, 62–70, doi:10.1016/j.coldregions.2011.09.001.

Morin, S.**,** Lejeune, Y., Lesaffre, B., Panel, J.-M., Poncet, D., David, P., and Sudul, M.: An 18-yr long (1993–2011) snow and meteorological dataset from a mid-altitude mountain site (Col de Porte, France, 1325 m alt.) for driving and evaluating snowpack models, *Earth Syst. Sci. Data*, 4, 13-21, doi:10.5194/essd-4-13-2012, 2012.

Morin, S., F. Domine, A. Dufour, Y. Lejeune, B. Lesaffre, J.-M. Willemet, C. M. Carmagnola and H.-W. Jacobi, Measurements and modeling of the vertical profile of specific surface area of an alpine snowpack, *Adv. Water Resour.*, 55, 111–120, doi :10.1016/j.advwatres.2012.01.010, 2013.

Qiu, J., Snow survey hopes for avalanche of data, Nature, 491, 312–313, doi:10.1038/491312a, 2012.

Schneebeli, M., C. Pielmeier, and J. B. Johnson, Measuring snow microstructure and hardness using a high resolution penetrometer, *Cold Reg. Sci. Technol.*, *30*(1-3), 101–114, doi:10.1016/S0165-232X(99)00030-0, 1999.