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Inferring snow cover duration from the measurement of soil temperature in the alpine tundra (NW-Italy, LTER site “Istituto Mosso”)

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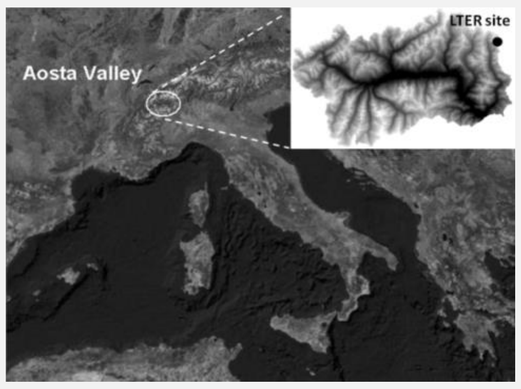
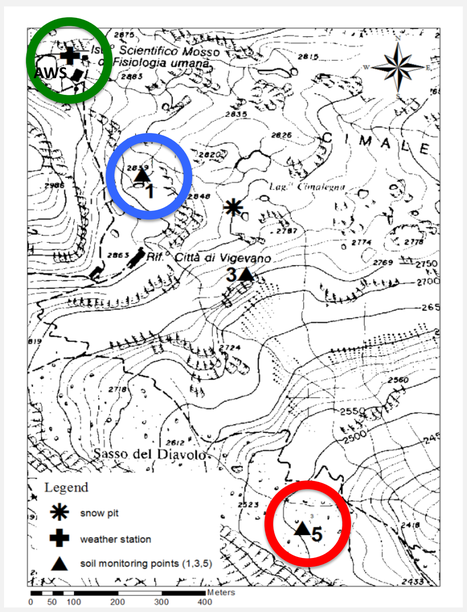
Snow plays a key role on the ecology of much of Earth’s surface, especially in circumpolar and high altitude regions and is a factor of paramount importance in terms of soil development and temperature due to its distinctive characteristics of soil thermal insulation (Jones et al., 1994).
Changes in soil temperature induced by the annual snow cover influence the subnivial processes which are one of the major controls on the leaching loss of N from soil during snowmelt (Brooks and Williams, 1999).



The study area (LTER site “High elevation areas in the Northwestern Alps”) is located in North West Italy, close to the Monte Rosa Massif (4634 m asl).



From 2005 the **Automatic Weather Station** (AWS, 2901 m asl) *Col d’Olen* of the Italian Army (Comando Truppe Alpine Servizio Meteomont) has recorded:

- Snow depth;
- Topsoil temperature;
- Air temperature;
- Snow temperature;
- Wind speed.

From 2008 topsoil temperature at 2 different study sites located at 2525 m asl (**Site 5**) and 2840 m asl (**Site 1**) were also recorded (UTL-1). In these sites the soil C and N dynamics were investigated by periodical soil sampling.

Two main purposes:

I. Infer the snow cover duration (SCD) from the topsoil temperature;
II. Detect if some snow still remains on the ground when the daily soil temperature amplitude (D.A.) was larger than 1°C.

Since the sharp change in the amplitude of the daily soil temperature is used to detect the first and last day of snow on the ground and consequently the SCD, we used as suggested by Danby and Hik (2007) a threshold of 1°C.

Water Year	SCD (days)
2005-2006	260
2006-2007	235
2007-2008	256
2008-2009	271
2009-2010	266
2010-2011	256
2011-2012	256
2012-2013	281
2013-2014	299
Mean	264 (s=18)

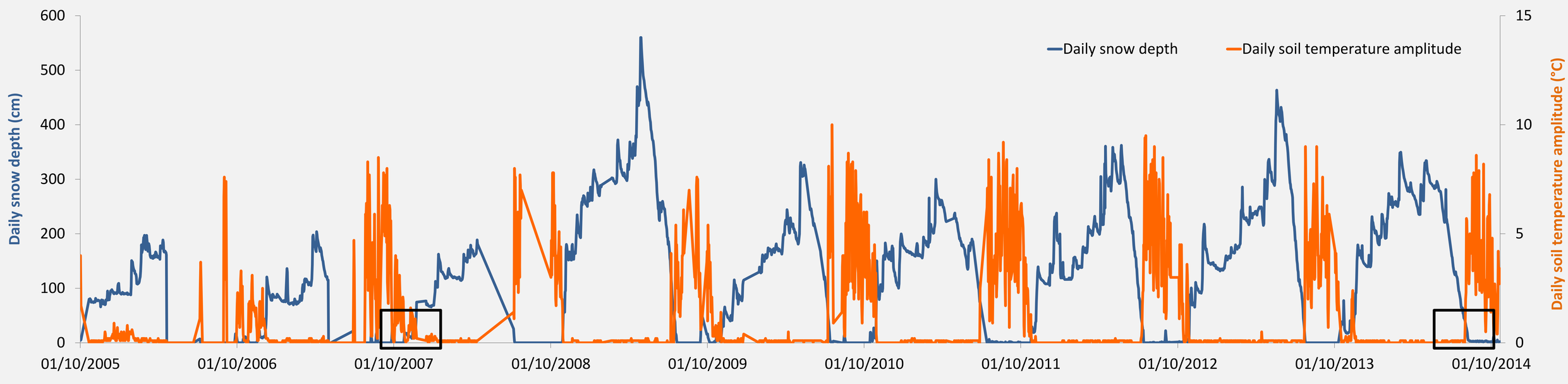
AWS *Col d’Olen* (2901 m asl), time span 2005-2014:

- mean SCD: 264 days;
- minimum of 235 days in water year 2006-2007 (unusually warm spring of 2007);
- maximum of 299 days in water year 2013-2014.

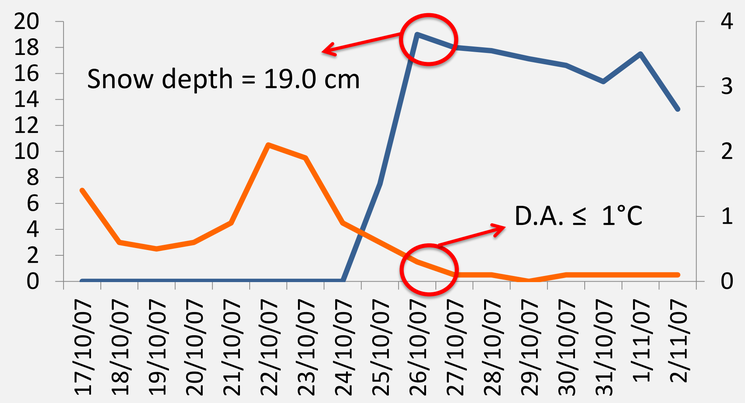
Considering the other study plots:

- at 2840 m asl the mean SCD was equal to 260 days and at 2525 m asl was 229 days;
- maximum at 254 days in site 5 in water year 2012-2013 (cold spring at 2013).

Water Year	SCD site 1	SCD site 5
2008-2009	272	244
2009-2010	271	235
2010-2011	255	219
2011-2012	241	216
2012-2013	284	254
2013-2014	287	238
Mean	260	229

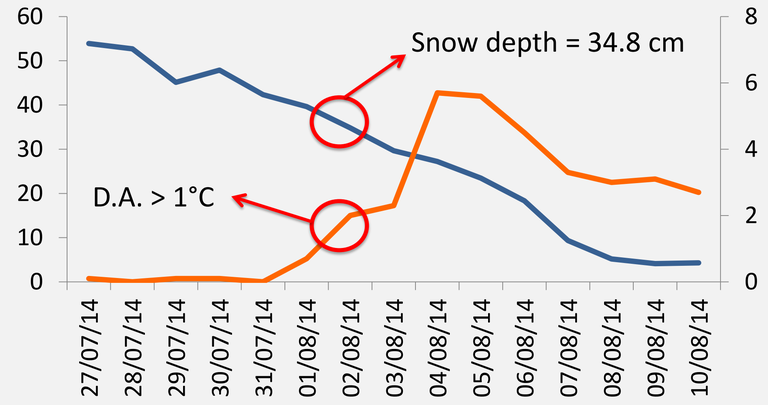


FALL SNOWFALL



By comparison of the snow cover duration detected by the daily soil temperature amplitude and the ultrasonic snow depth sensor, it resulted that: a) during fall ~ 20 cm of snow are necessary to decouple the soil temperature from the air temperature and b) during summer ~ 35 cm of snow are still on the ground when the D.A. is larger than 1°C.

SUMMER SNOW MELTING



Long-term soil surface temperature monitoring can provide a cost-effective method for detecting changes of snow cover duration, a key parameter for soil development and soil nutrient cycling in the alpine tundra, even if it could be affected by uncertainty.

References: Brooks, P. D. & Williams, M. W. , 1999. Snowpack controls on nitrogen cycling and export in seasonally snow-covered catchments. Hydrological Processes, Vol. 13, 2177-2190.
Danby, R.K., Hik, D.S., 2007. Responses of white spruce (Picea glauca) to experimental warming at a subarctic alpine treeline. Glob. Chang. Biol. , Vol. 13, 437–451.
Jones, H.G., Pomeroy, J.W., Walker, D.A., Wharton, R.A., Walker, S., 1994. Snow Ecology: A Report on a New Initiative. Bulletin of the Ecological Society of America, Vol. 75, No. 1, 29-31.

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