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NatRisk - LNSA

DISAFA
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LNSA

NatRisk
università di torino
centro interdipartimentale sui rischi naturali in ambiente montano e collinare

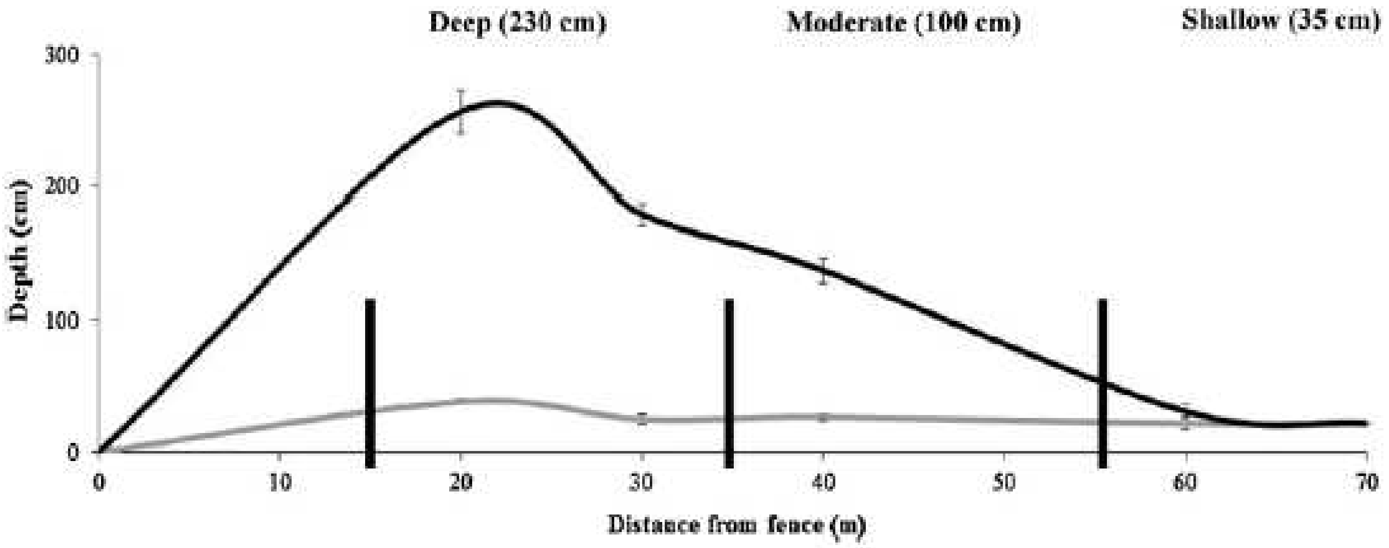
Snow cover duration/soil nutrient cycling

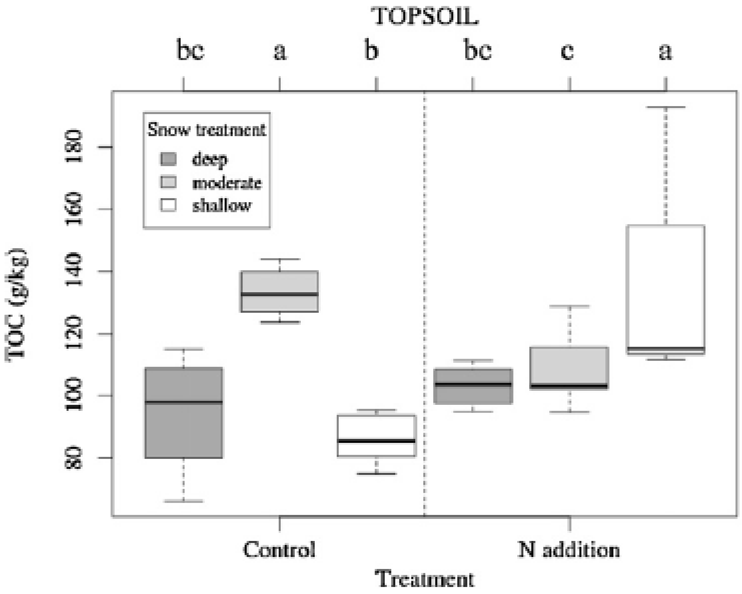
Istituto Scientifico Angelo Mosso, 2901 m slm

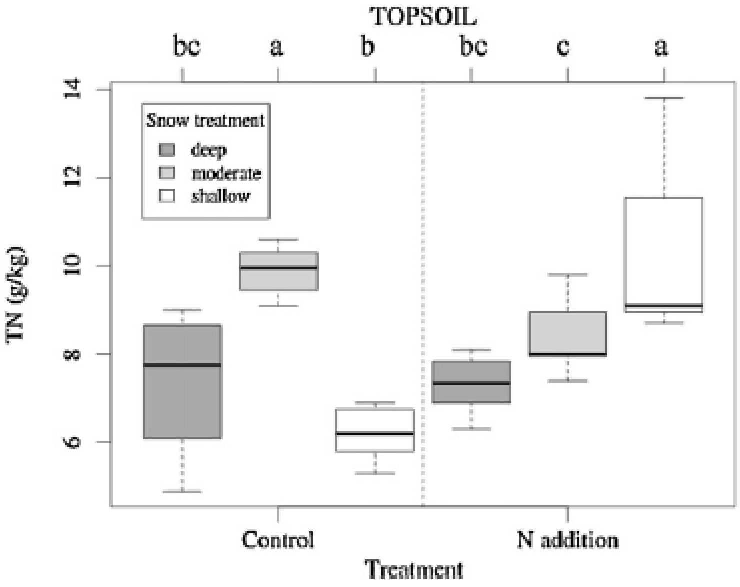
LTER Europe LTER Italia

Snow cover duration/soil nutrient cycling

M. Freppaz et al. / Applied Soil Ecology 62 (2012) 131–141

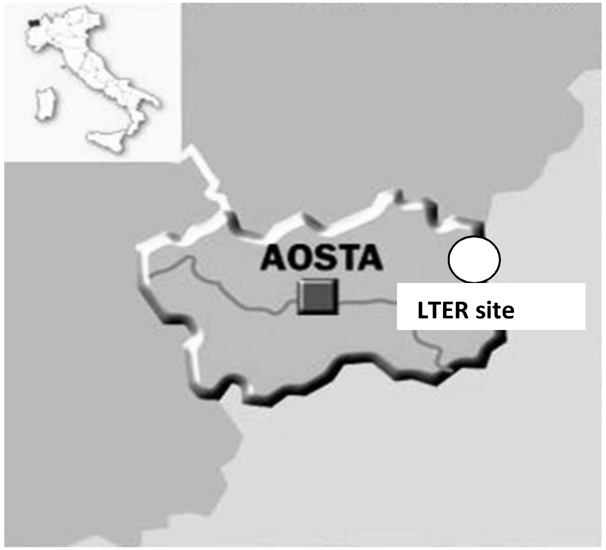


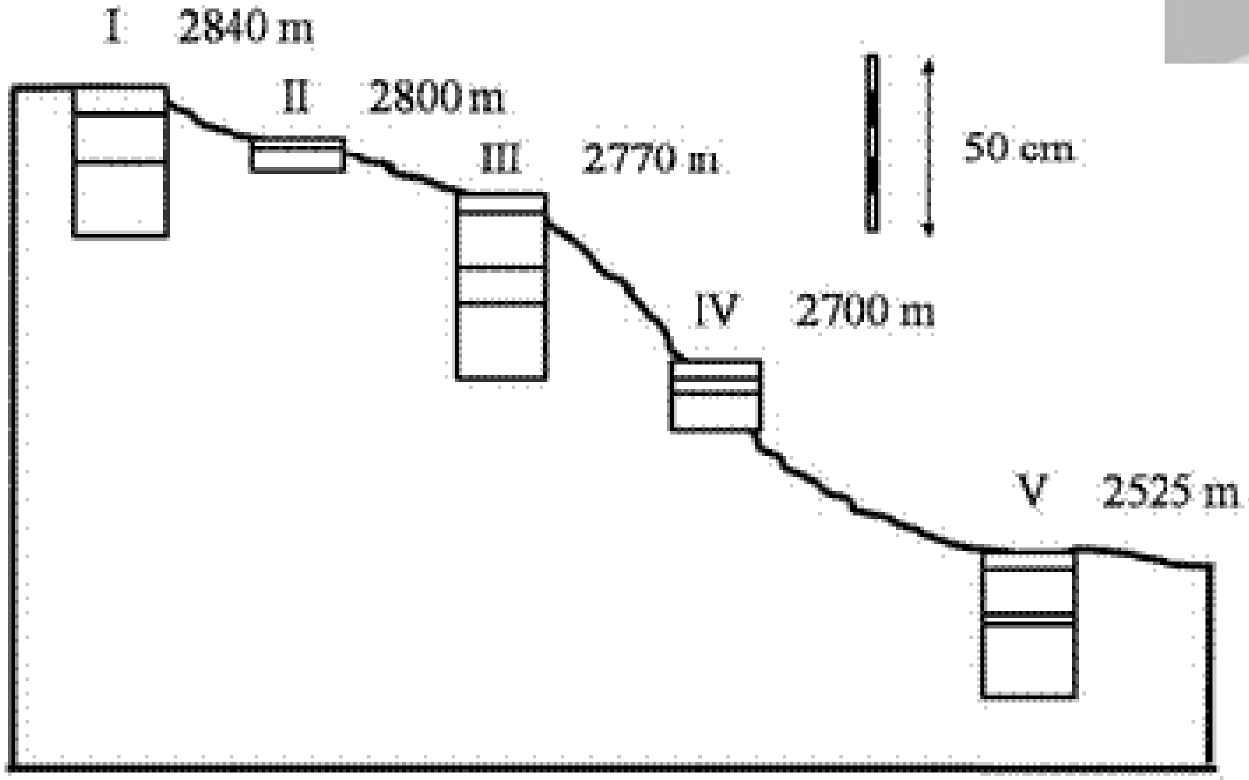




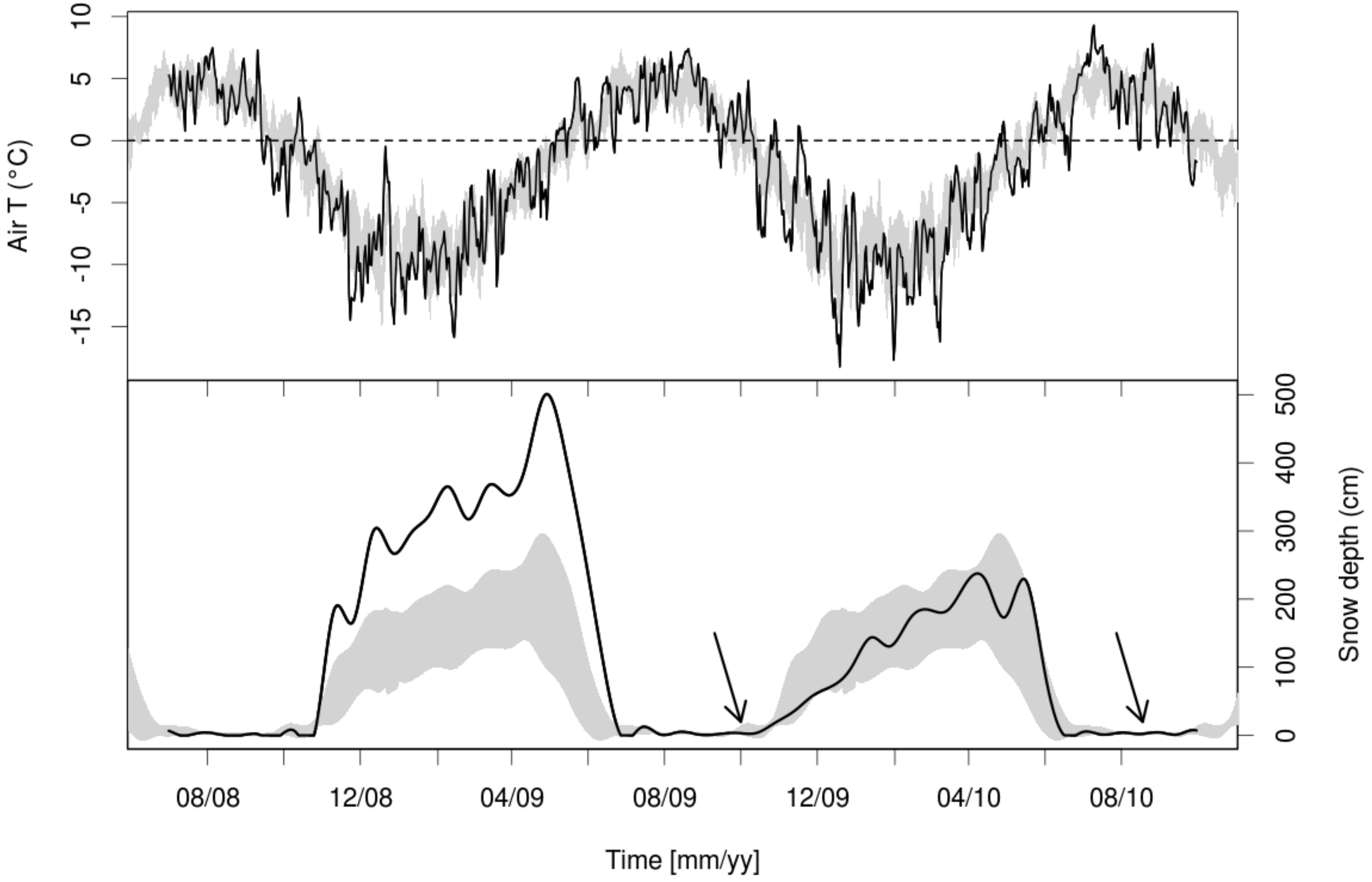
M. Freppaz et al. / Applied Soil Ecology 62 (2012) 131–141

Snow cover duration/soil nutrient cycling

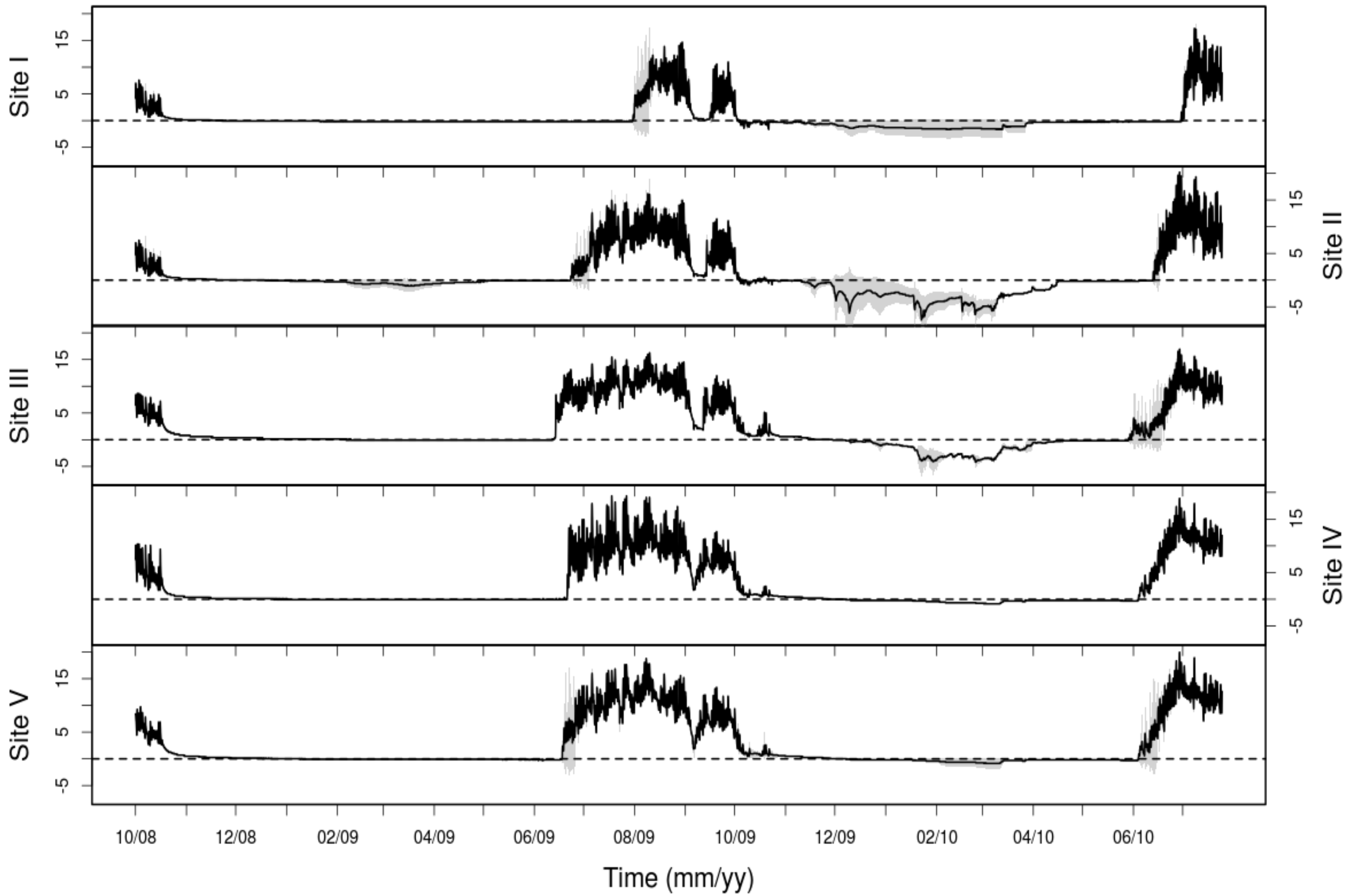

AOSTA
LTER site


I 2840 m
II 2800 m
III 2770 m
IV 2700 m
V 2525 m
50 cm

Freppaz et al., 2010



Freppaz et al., submitted

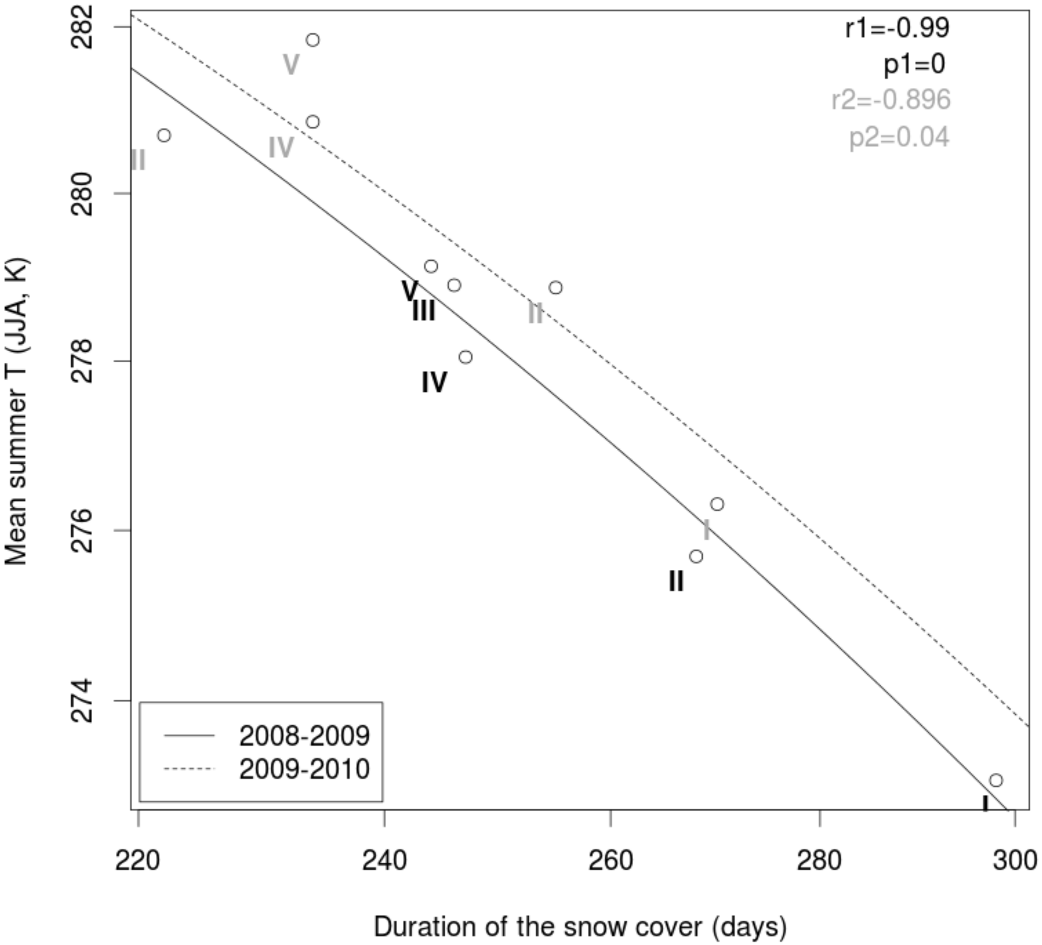


Freppaz et al., submitted

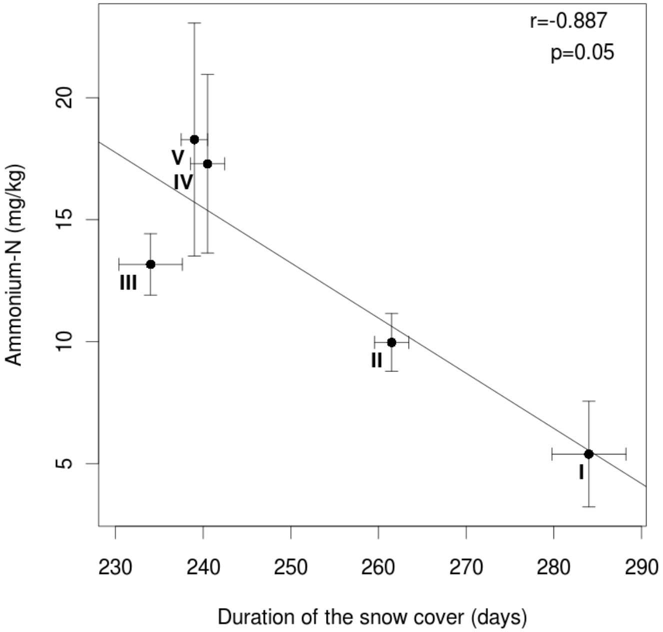
Daily soil temperature amplitude

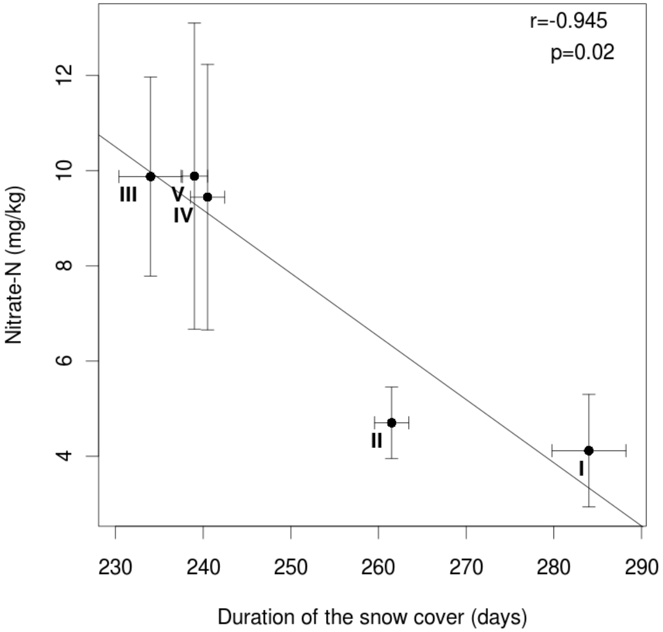
< 1-2 °C

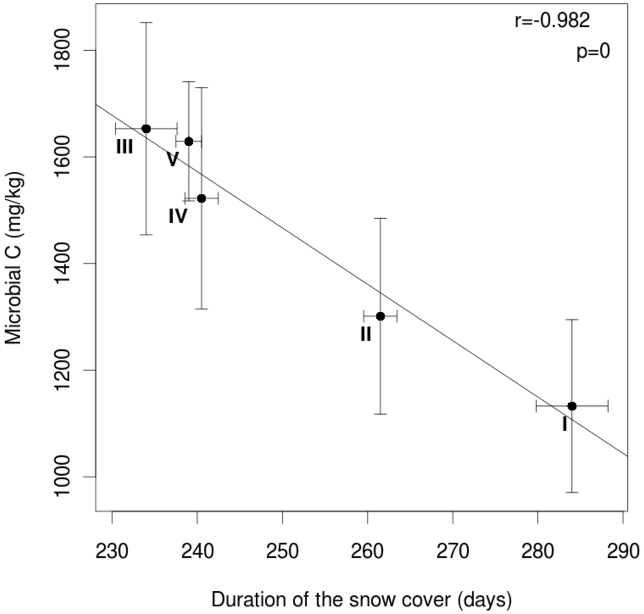
Snow cover on the ground



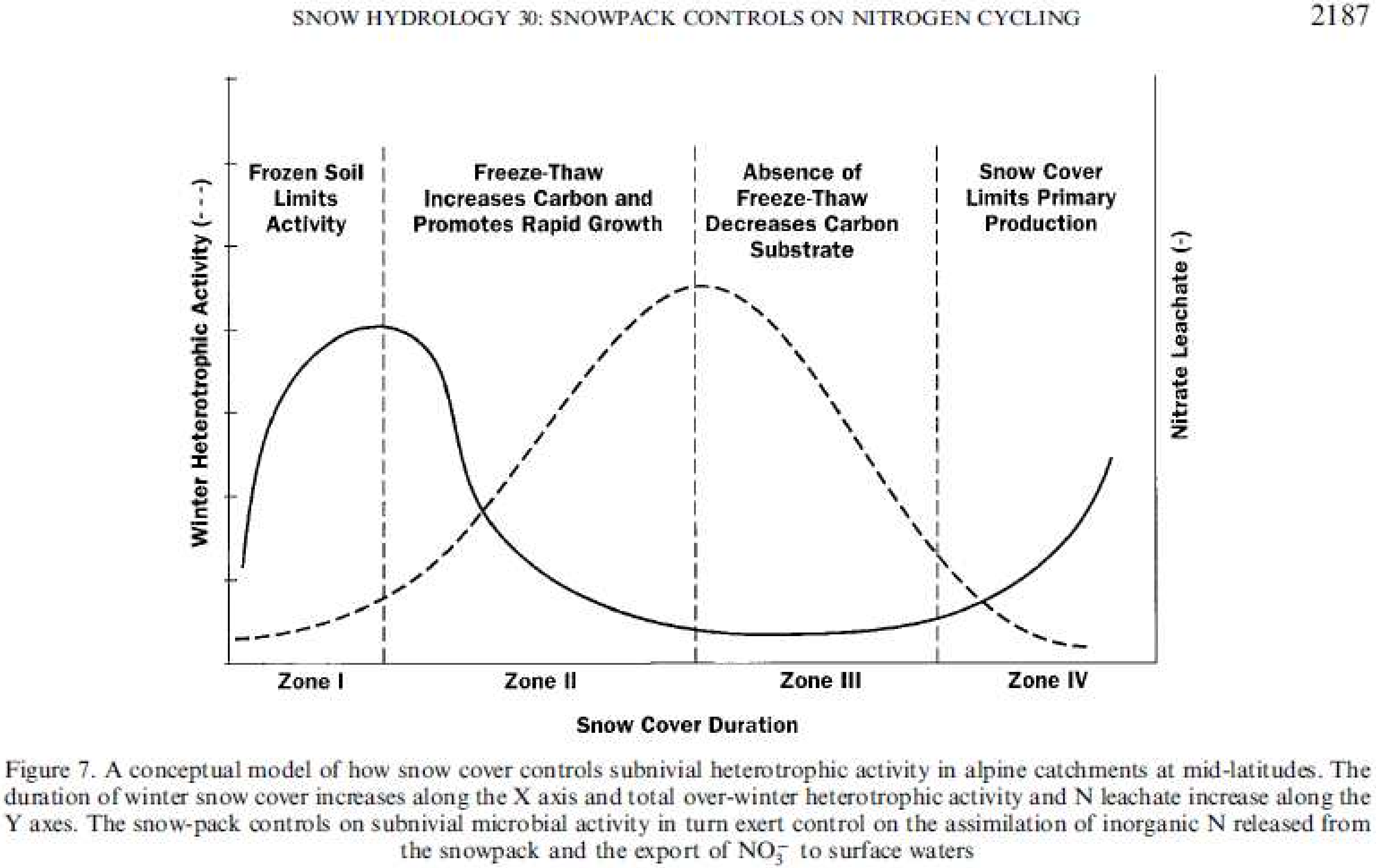
Freppaz et al., submitted







Freppaz et al., submitted

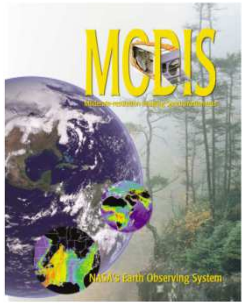


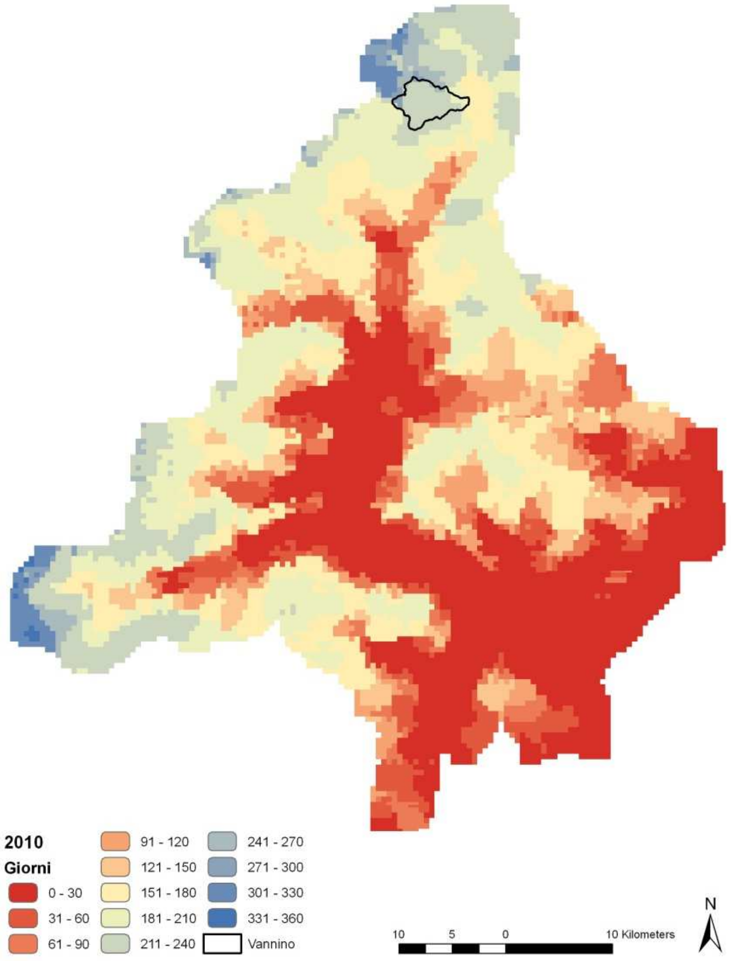
SNOW HYDROLOGY 30: SNOWPACK CONTROLS ON NITROGEN CYCLING 2187

Figure 7. A conceptual model of how snow cover controls subnivial heterotrophic activity in alpine catchments at mid-latitudes. The duration of winter snow cover increases along the X axis and total over-winter heterotrophic activity and N leachate increase along the Y axes. The snow-pack controls on subnivial microbial activity in turn exert control on the assimilation of inorganic N released from the snowpack and the export of NO_3^- to surface waters

Brooks and Williams, 1999

Snow cover duration

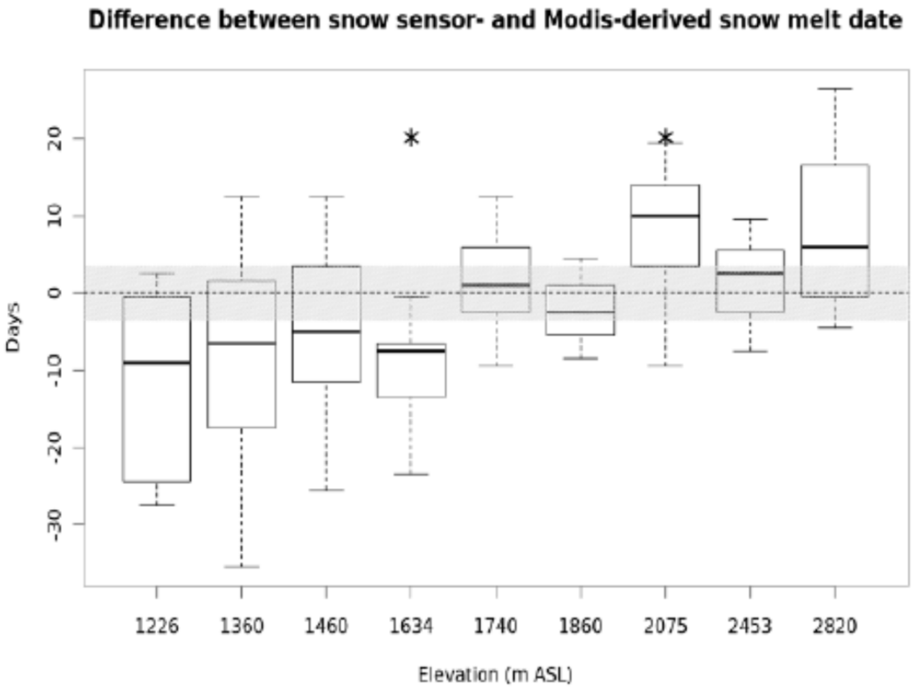

MODIS
NASA's Earth Observing System


2010
Giorni
0 - 30
31 - 60
61 - 90
91 - 120
121 - 150
151 - 180
181 - 210
211 - 240
241 - 270
271 - 300
301 - 330
331 - 360
Vannino
10
5
0
10 Kilometers
N

211-240 giorni

2010

Validazione con nivometri a terra



International Journal of Environmental Protection *IJEP*

Snow Cover Extent and Duration in MODIS Time Series: a Comparison with In-Situ Measurements (Provincia Verbano Cusio Ossola, NW Italy)

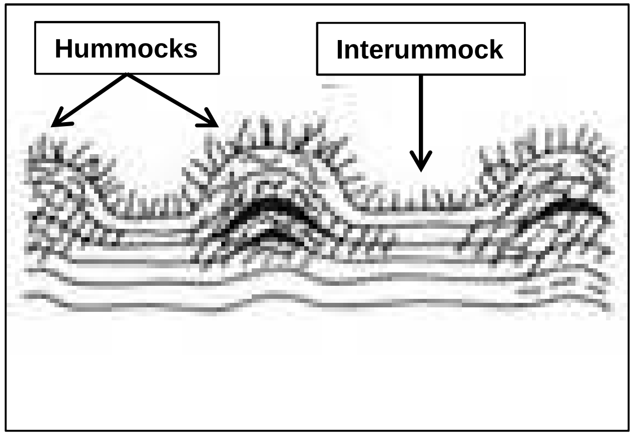
Danilo Godone[#], Gianluca Filippa[#], Silvia Terzago[+], Enrico Rivella[°], Alessio Salandin[°], Secondo Barbero[°], Gabriele Garnero[#], Michele Freppaz[*]

- 2000-2010
- 506 scene MODIS
- 9 stazioni della Rete ARPA Piemonte
- **Data di scomparsa della neve**: ad alta quota i nivometri sembrano sovrastimare, a bassa quota sottostimare

I nivometri e la fenologia delle specie erbacee

Plants as ecosystem engineers

Microtopografia:
i suoli a cuscinetti erbosi
(Earth Hummocks)



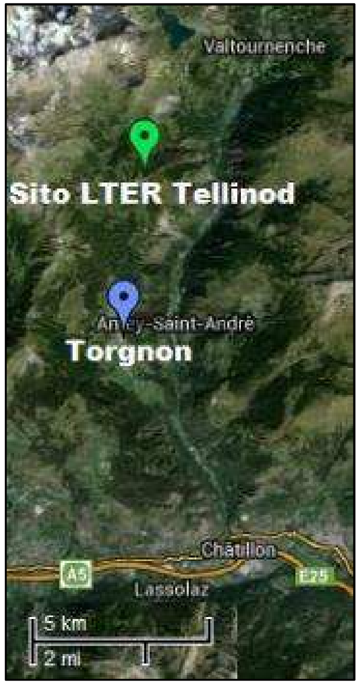
- Sollevamenti differenziali da gelo
- Cryoespulsione di clasti
- Accumulo di lettiera e materiale vegetale

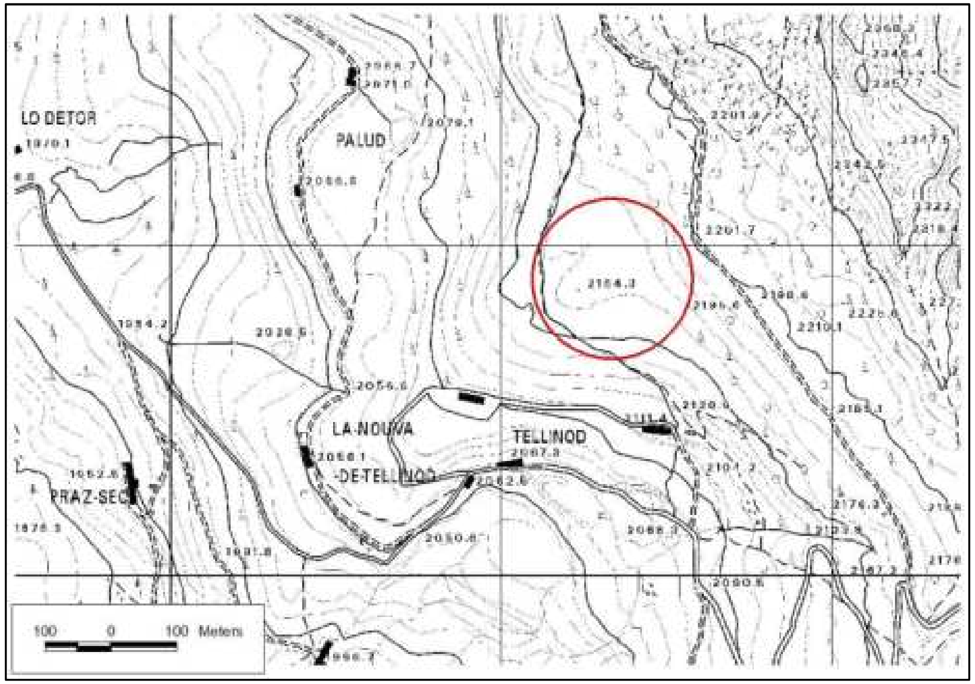
Tesi Laurea Pintaldi, 2014

Obiettivi

- Determinazione delle principali caratteristiche chimico-fisiche dei suoli a cuscinetti erbosi in corrispondenza di *hummocks* (*“**up**”*) *e interhummocks* (*“**down**”*)
- Valutazione delle caratteristiche della soluzione del suolo e andamento stagionale (primavera-estate-autunno)

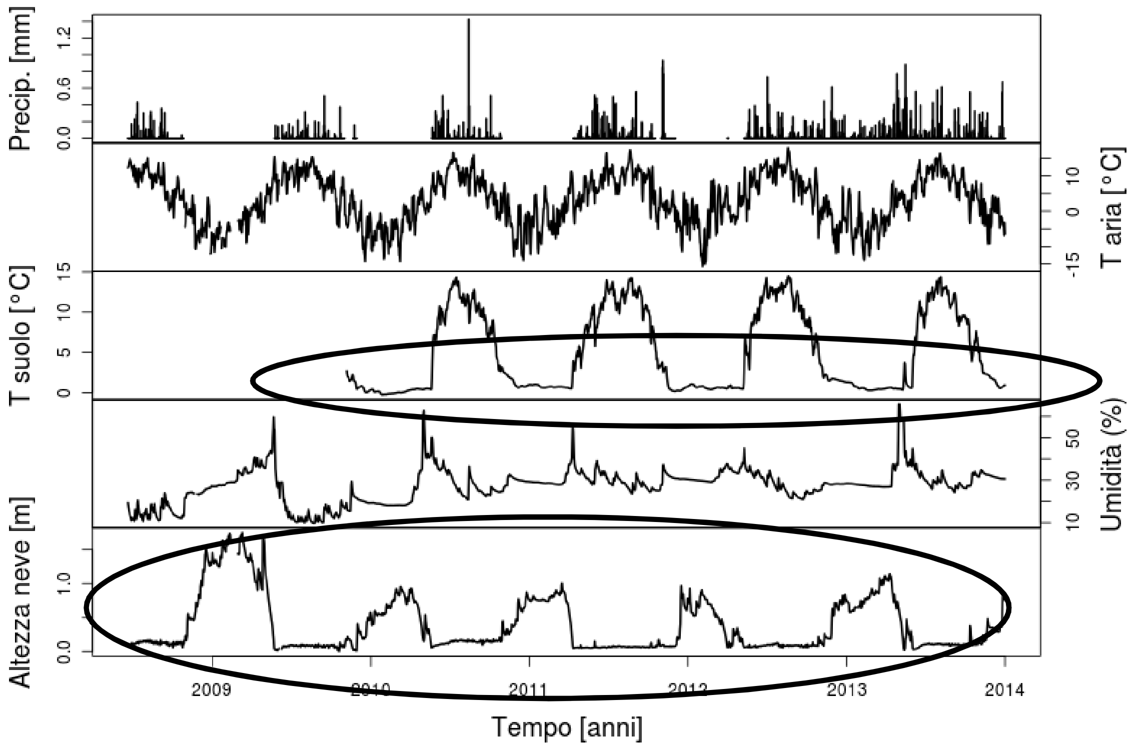
Inquadramento geografico


Valtournenche
Sito LTER Tellinod
Antey-Saint-André
Torgnon
Châtillon
A5
E25
Lassolaz
5 km
2 mi


LO DETOR
PALUD
LA NOUVA
-DE TELLINOD
TELLINOD
PRAZ-SEC
2164.3
100
0
100 Meters

- Quota: 2160 m.s.l.m.
- Comune di Torgnon, Loc. Tellinod
- Esposizione Sud
- T media annua aria: 3.1 C°
- Precipitazioni medie annue: 880 mm/anno

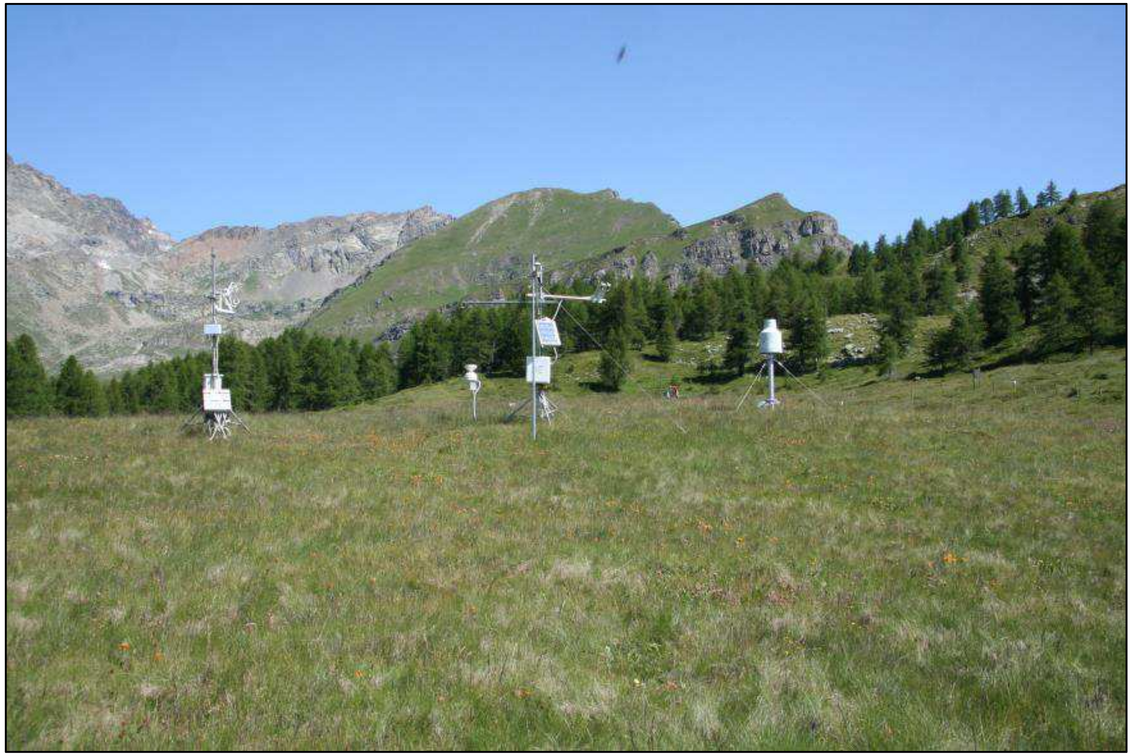
Inquadramento meteo-nivologico



- Altezza manto nevoso: 90-120 cm
- Durata media manto nevoso: 6 mesi
- Temperatura invernale suolo: ~ 0 C°

Tesi Laurea Pintaldi, 2014

Sito LTER di Tellinod



- Monitoraggio flussi CO_2
- Monitoraggio dinamiche stagionali e processi funzionali vegetazione
- Effetto dinamiche stagionali (durata innevamento e fusione) del manto nevoso

Tesi Laurea Pintaldi, 2014

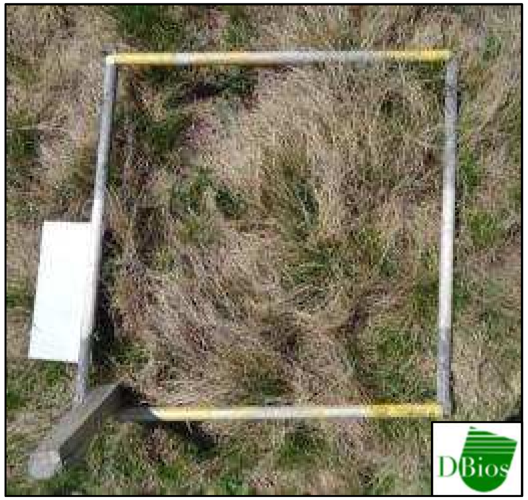
Materiali e metodi

Inquadramento morfologico

Inquadramento vegetazionale

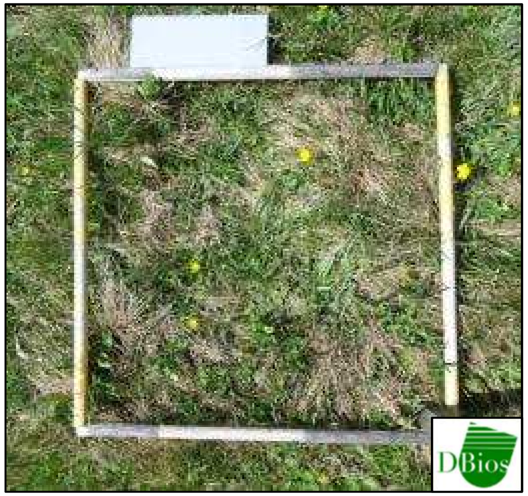
Zone UP:
Nardus Stricta

95-99%



Zone DOWN:
Crocus vernus, *Geum montanum*,*Trifolium alpinum*, *Arnica montana*, *Polygonum bistorta*…

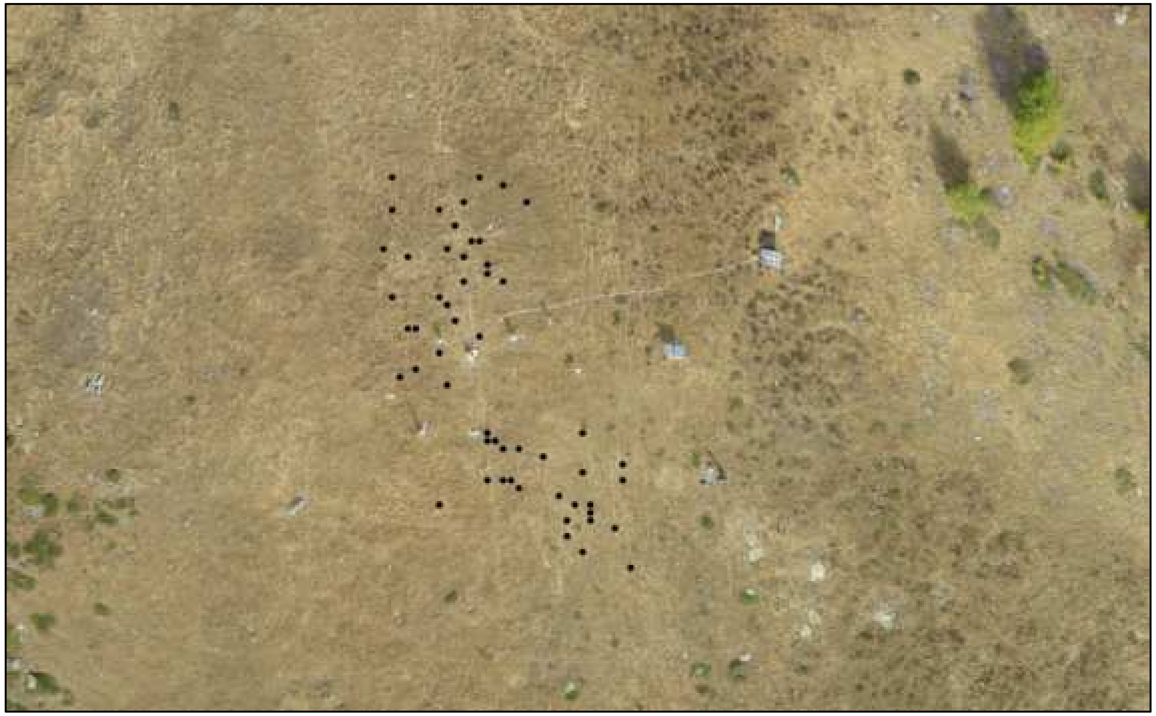
45-75%



Tesi Laurea Pintaldi, 2014

Immagini e rilievi Prof.ssa Siniscalco

Campionamento del suolo



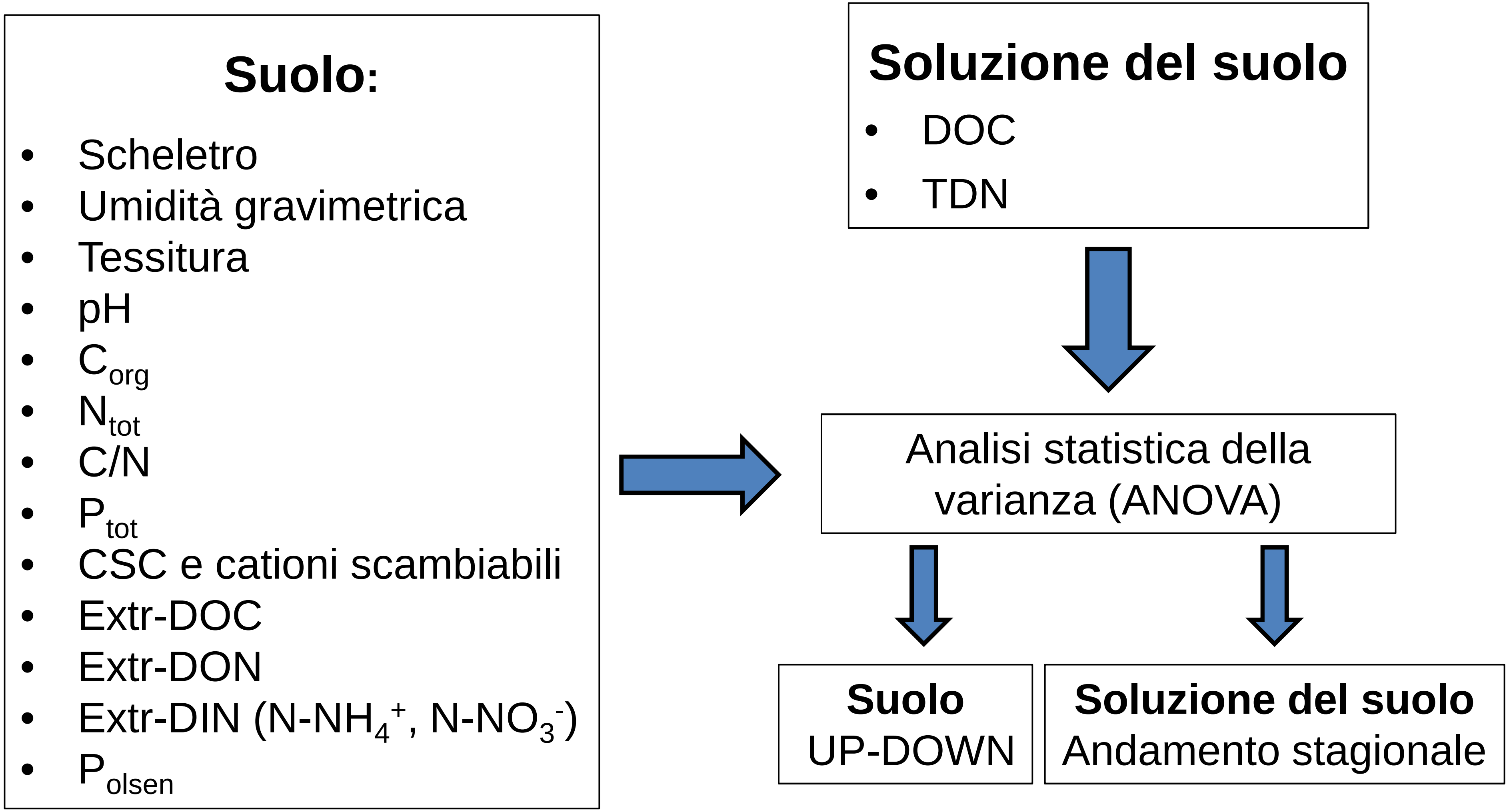
- Data campionamento: 8/11/2013
- Prelievo del *topsoil* (0-10 cm)
- 60 campioni (30 *up*-30 *down*)

Campionamento soluzione del suolo

- Lisimetri (prelievo 20 e 40 cm di profondità)
- Prelievi da giugno a dicembre 2013

N°PRELIEVO	DATA
1	06/06/2013
2	14/06/2013
3	26/06/2013
4	04/07/2013
5	24/07/2013
6	22/08/2013
7	08/11/2013
8	10/12/2013

Analisi di laboratorio



Suolo:

- Scheletro
- Umidità gravimetrica
- Tessitura
- pH
- C_{org}
- N_{tot}
- C/N
- P_{tot}
- CSC e cationi scambiabili
- Extr-DOC
- Extr-DON
- Extr-DIN ($N\text{-}NH_4^+$, $N\text{-}NO_3^-$)
- P_{olsen}

Soluzione del suolo

- DOC
- TDN

Analisi statistica della varianza (ANOVA)

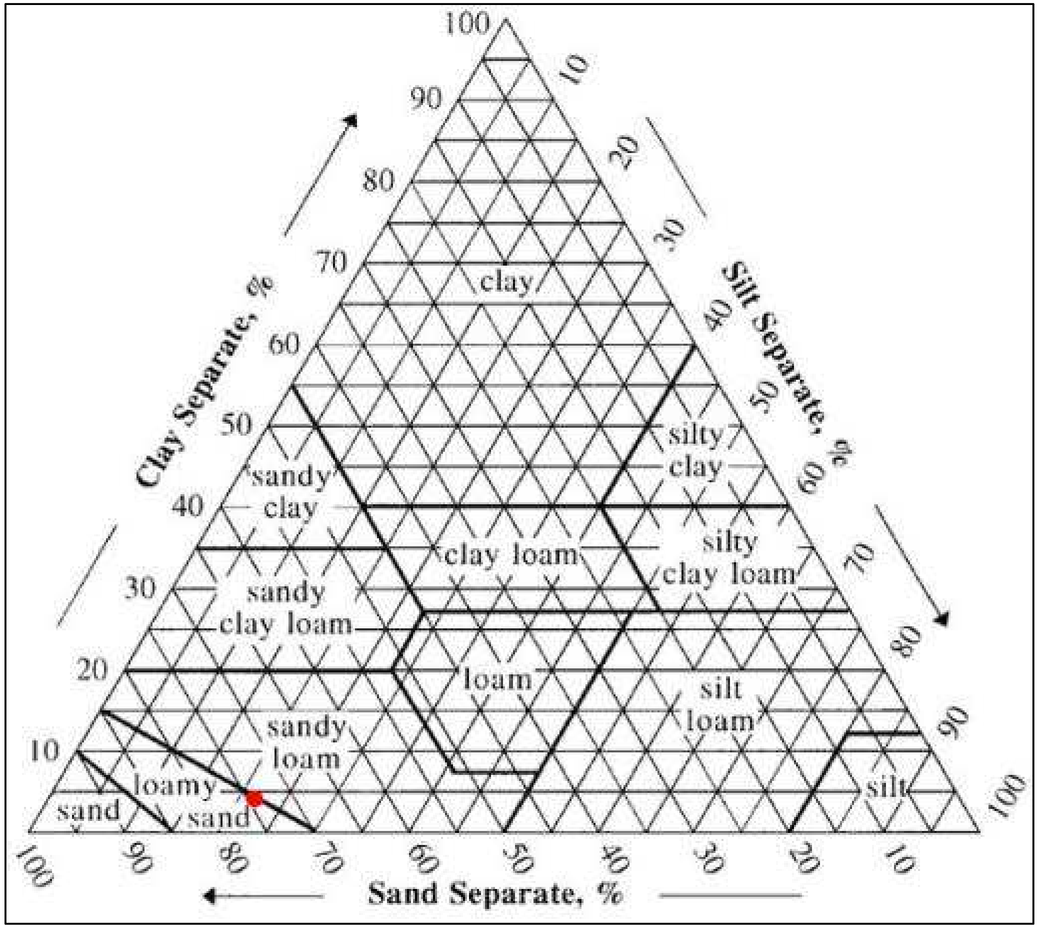
Suolo
UP-DOWN

Soluzione del suolo
Andamento stagionale

Tesi Laurea Pintaldi, 2014

Risultati suolo

Tessitura

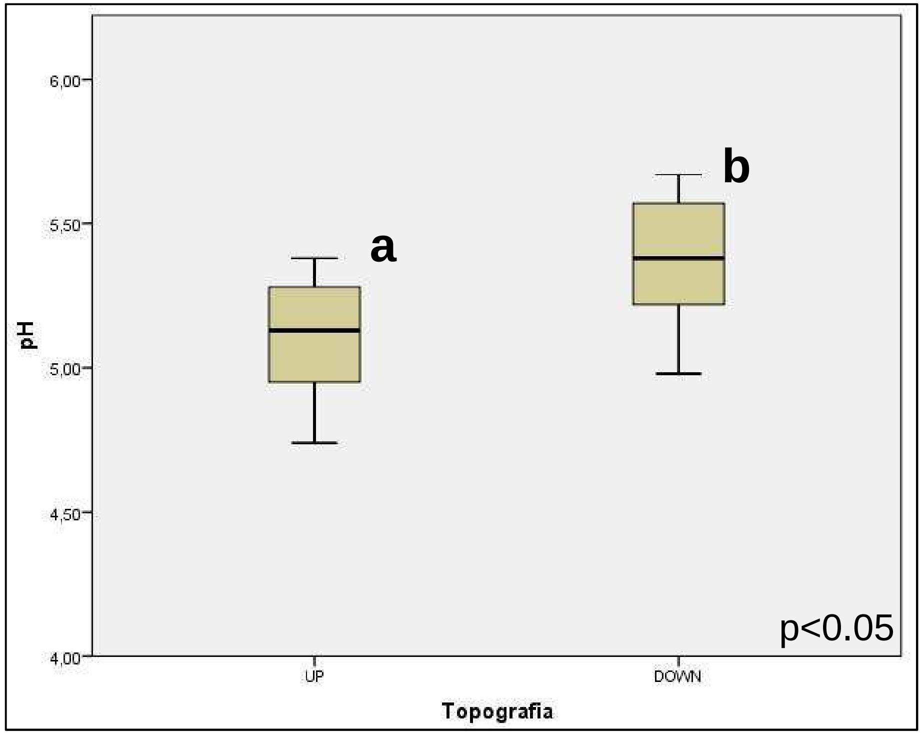

Clay Separate, %
Silt Separate, %
Sand Separate, %
clay
silty clay
sandy clay
clay loam
silty clay loam
sandy clay loam
loam
silt loam
sandy loam
silt
loamy sand
sand
100
90
80
70
60
50
40
30
20
10

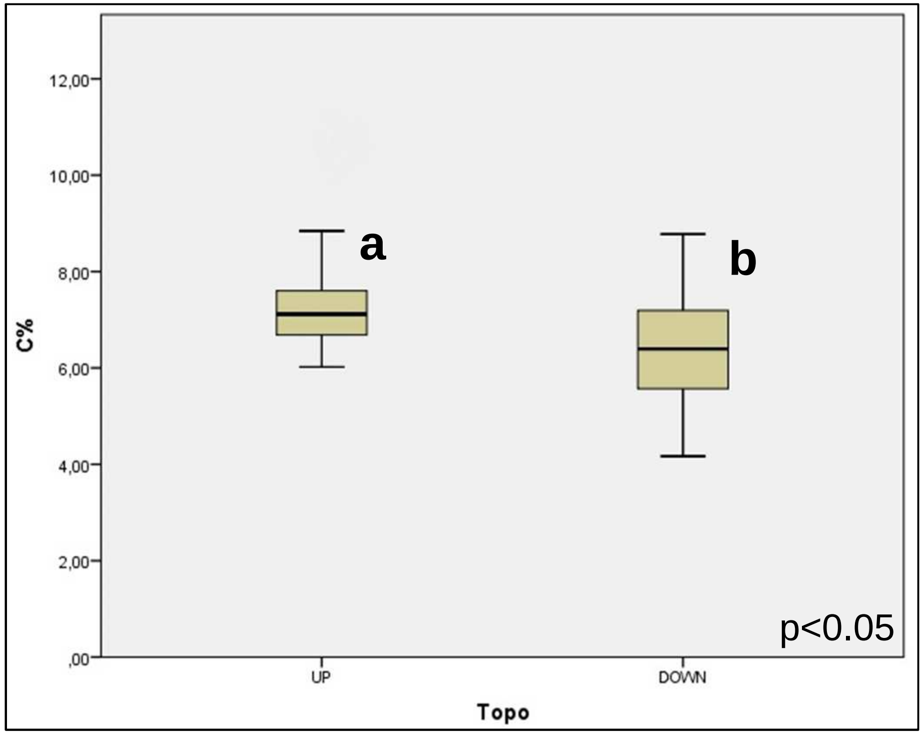
- Sabbiosa-franca (75% sabbia- 21% limo- 3.7 % argilla
- Limo grossolano (0.05-0.02 mm)*

* Differenza significativa $p<0.05$

Risultati suolo

pH, C_{org}

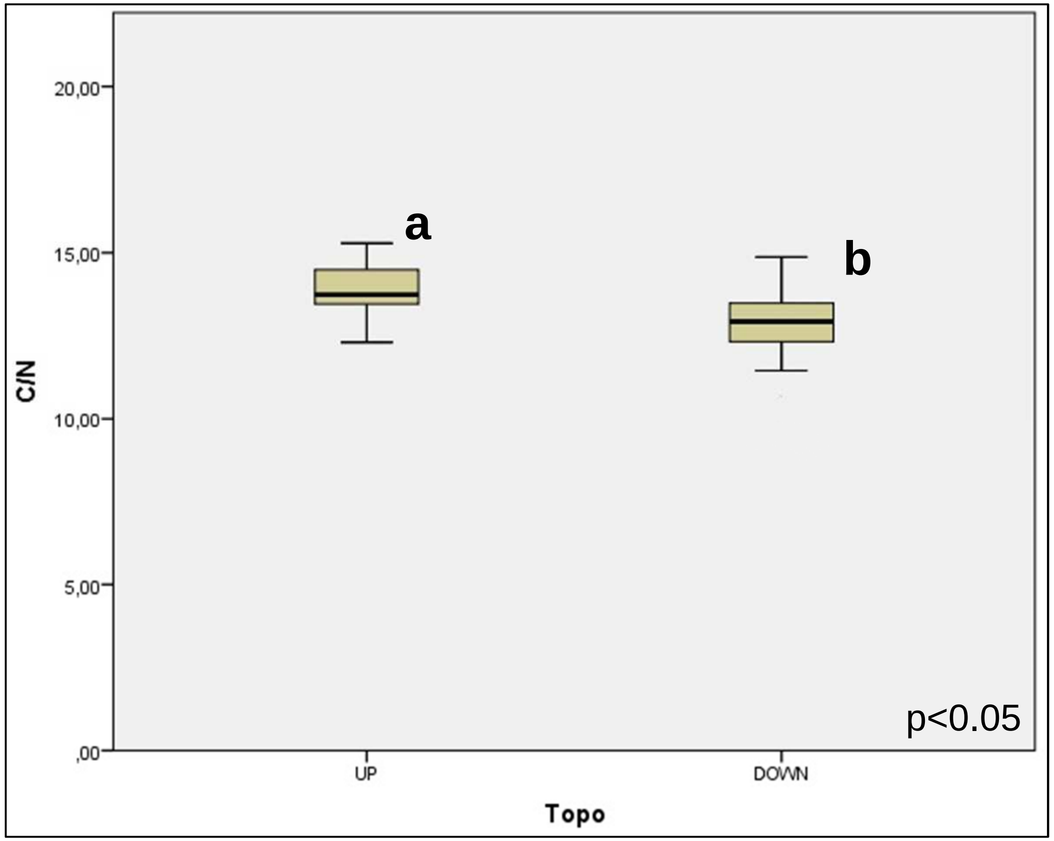




Tesi Laurea Pintaldi, 2014

Risultati suolo

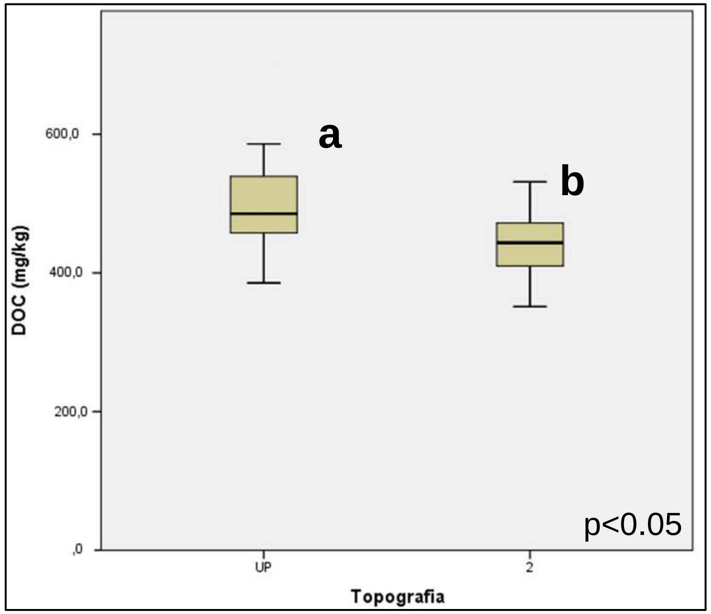
C/N

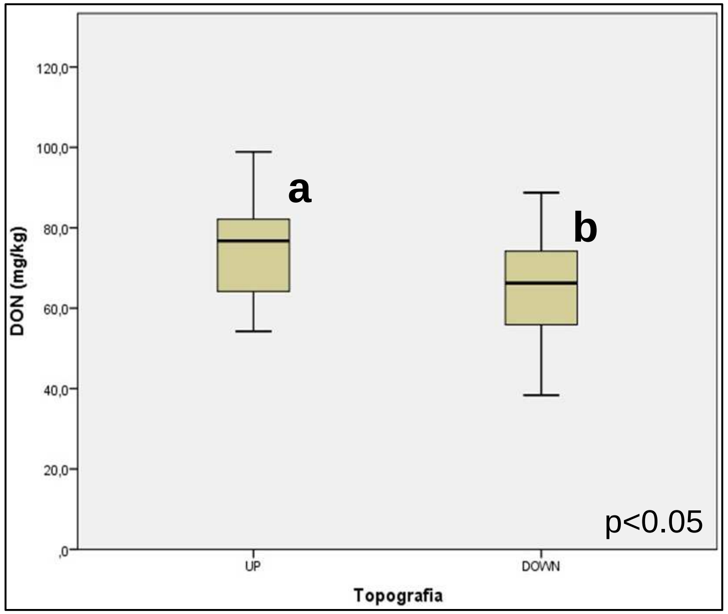


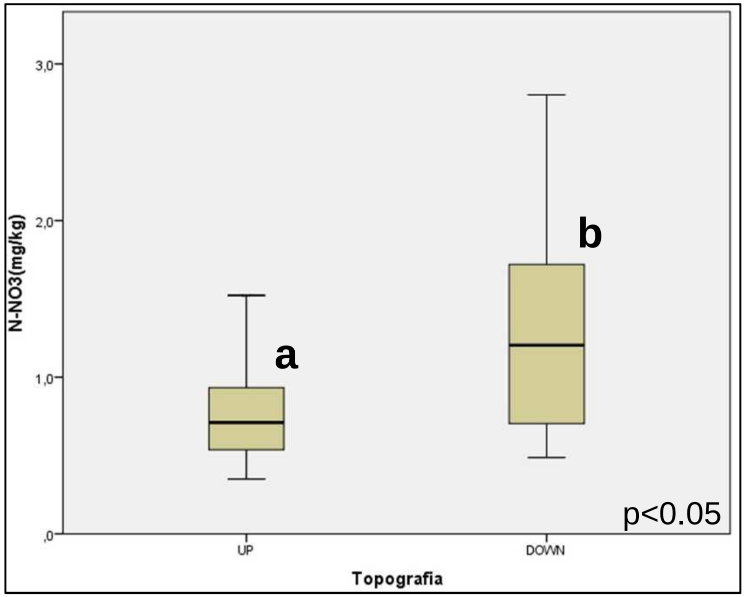
Tesi Laurea Pintaldi, 2014

Risultati suolo

Extr-DOC,DON,DIN







Tesi Laurea Pintaldi, 2014

Risultati suolo

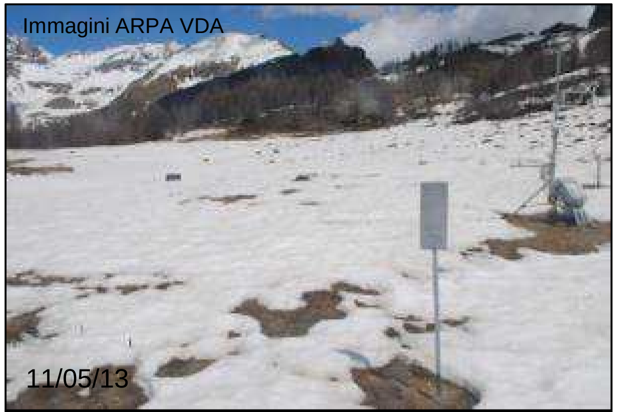
Microtopografia

Pattern distribuzione manto nevoso

Data di fusione manto nevoso

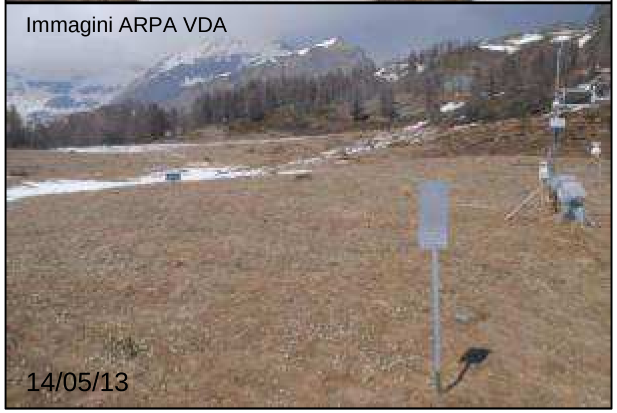
Regime idrico e termico del suolo

Mineralizzazione SOM



Immagini ARPA VDA

11/05/13

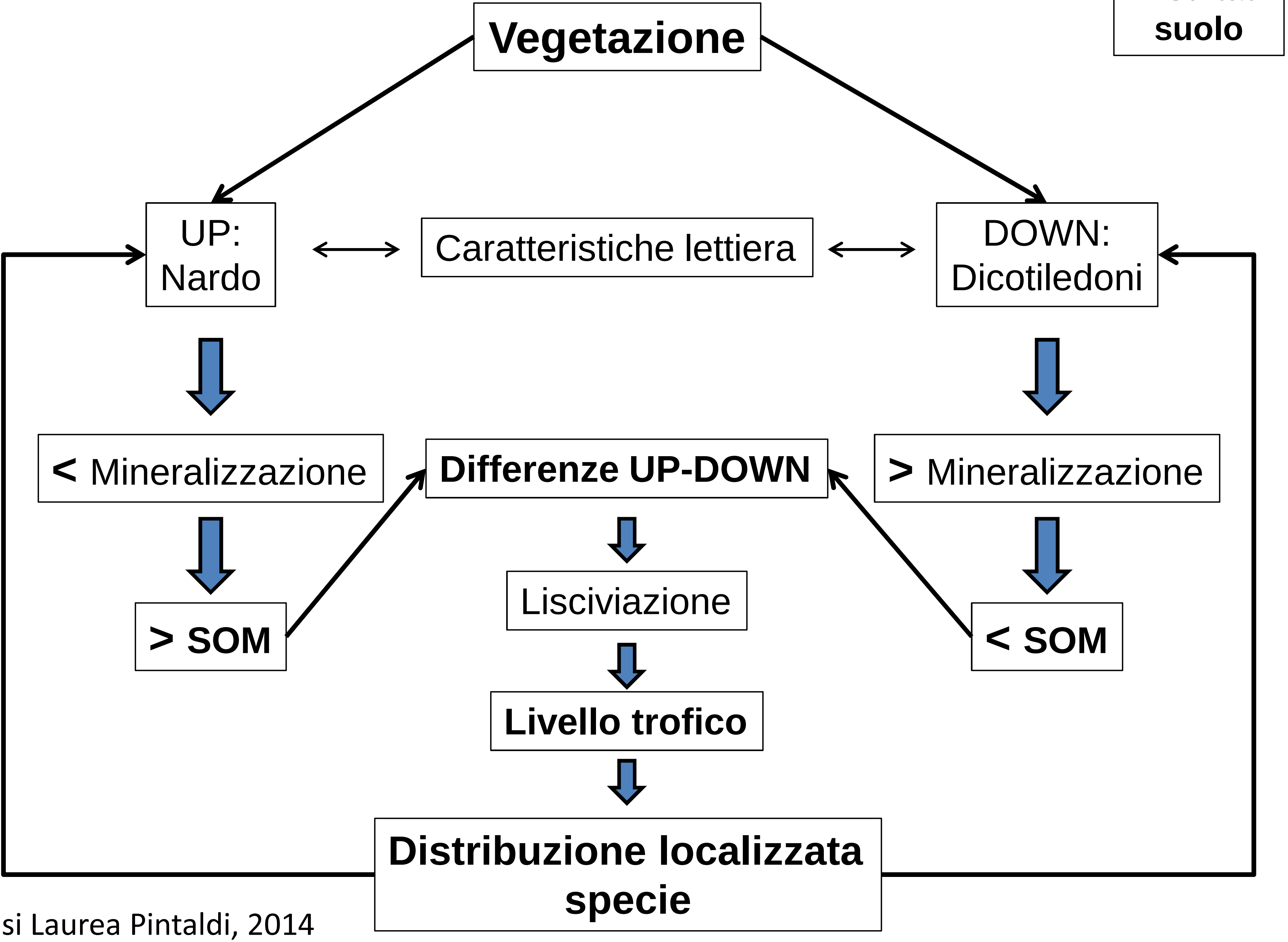


Immagini ARPA VDA

14/05/13

Tesi Laurea Pintaldi, 2014

Risultati suolo



Vegetazione

UP: Nardo

Caratteristiche lettiera

DOWN: Dicotiledoni

< Mineralizzazione

Differenze UP-DOWN

> Mineralizzazione

> SOM

Lisciviazione

< SOM

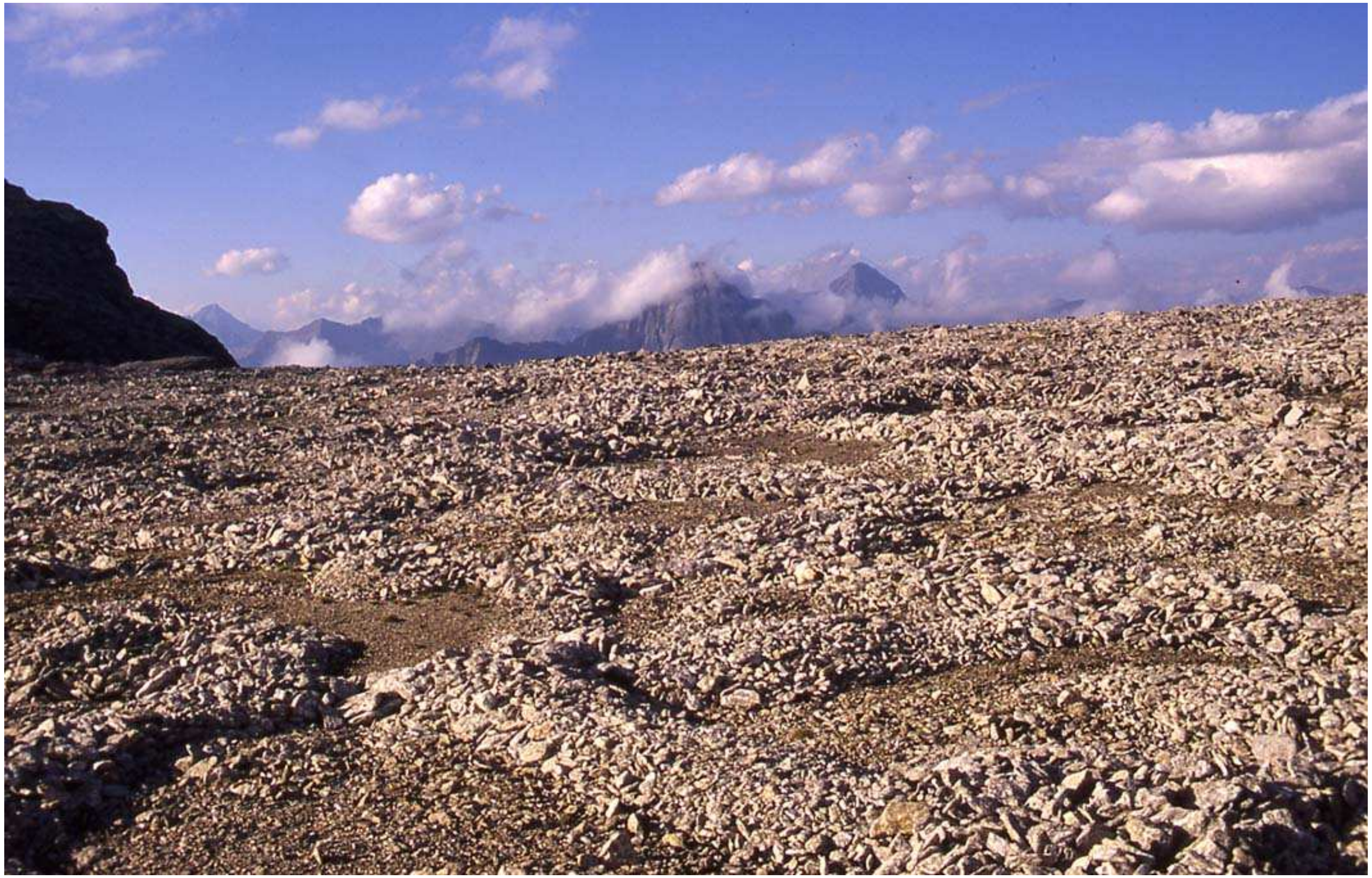
Livello trofico

Distribuzione localizzata specie

Tesi Laurea Pintaldi, 2014

Frost as ecosystem engineer

Suoli con morfologia superficiale a *patterned ground* nel Parco Nazionale Gran Paradiso (Piata Lazin - Valle Soana)

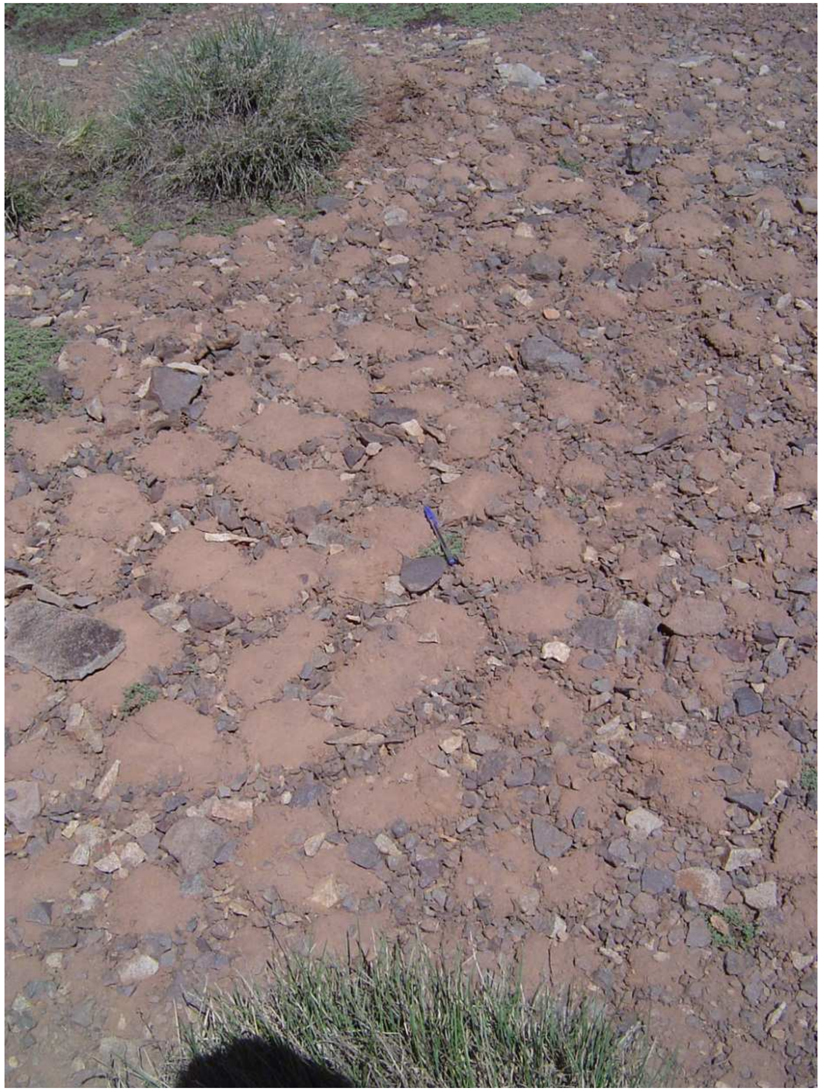


D’Amico et al., submitted

- In ambienti caratterizzati da basse temperature, il *patterned ground* è una delle manifestazioni più spettacolari dell’azione del gelo.
- Il *patterned ground* è classificato sulla base di:

a) Forma geometrica (es. cerchi, poligoni, strisce)

b) Presenza o assenza di segregazione (sorted o unsorted)



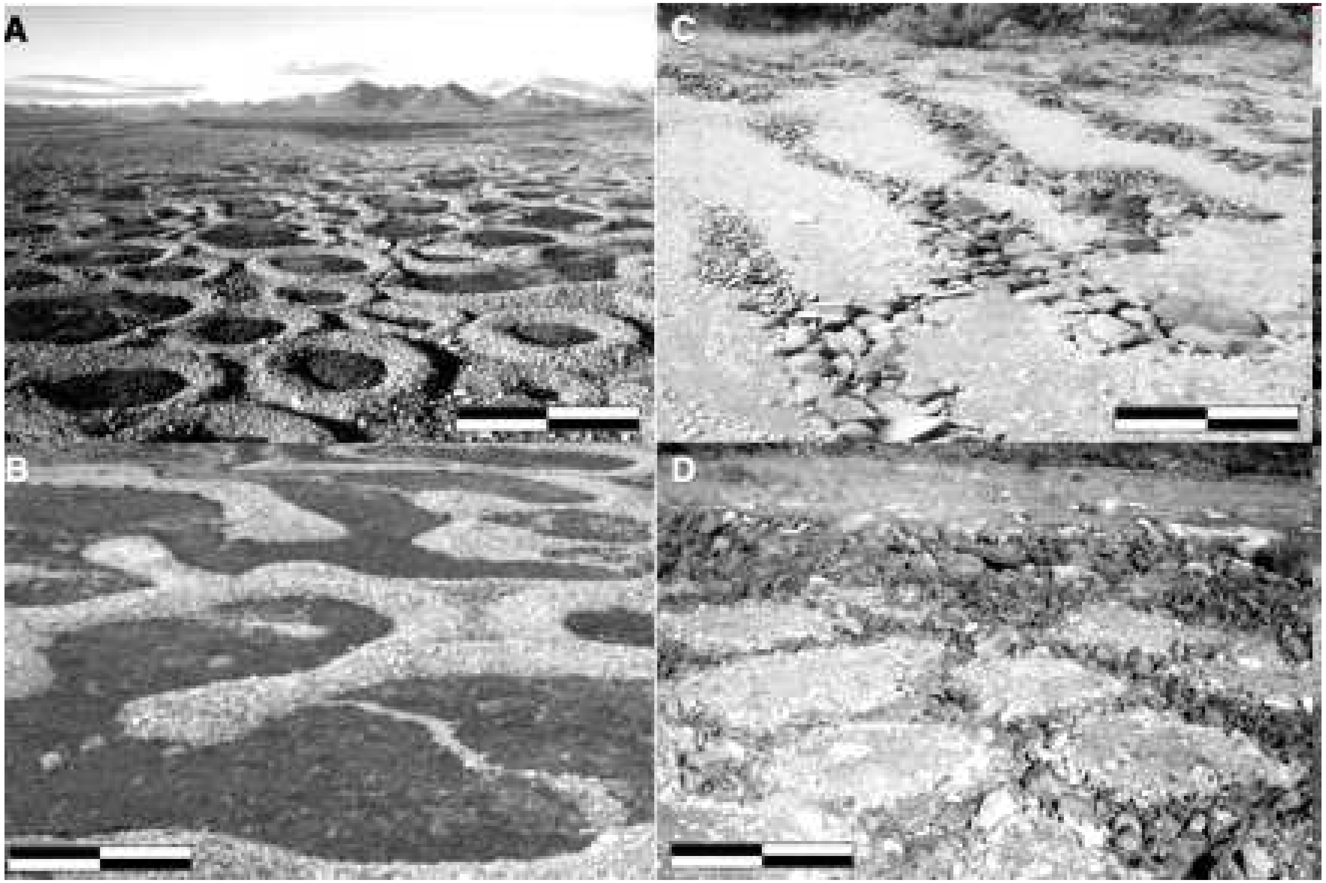
Aconcagua, Argentina (32°45’ S, 3428 m slm)

D’Amico et a., submitted

Alcuni esempi

Sorted circles

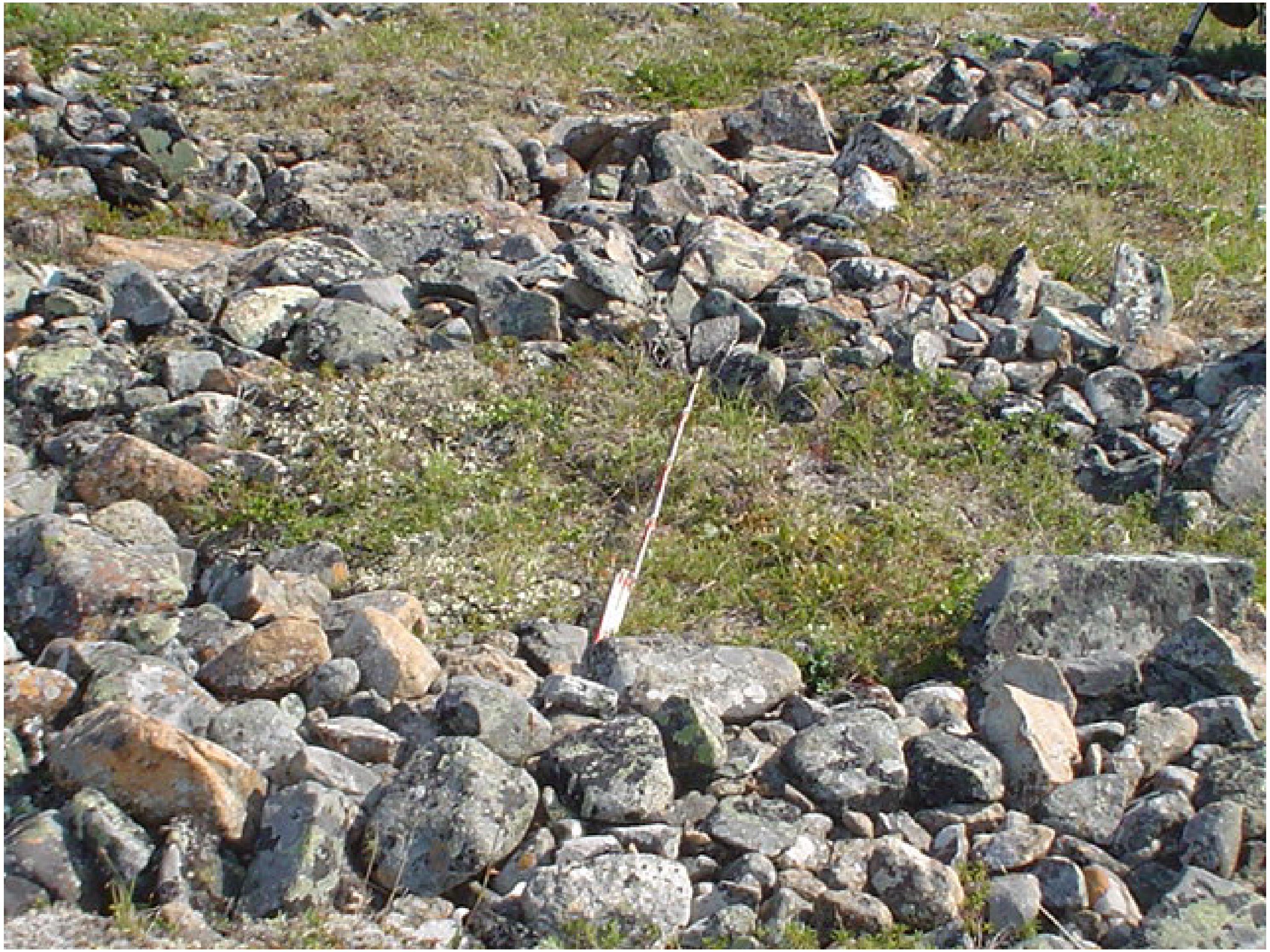
Sorted labyrinths



Sorted stripes

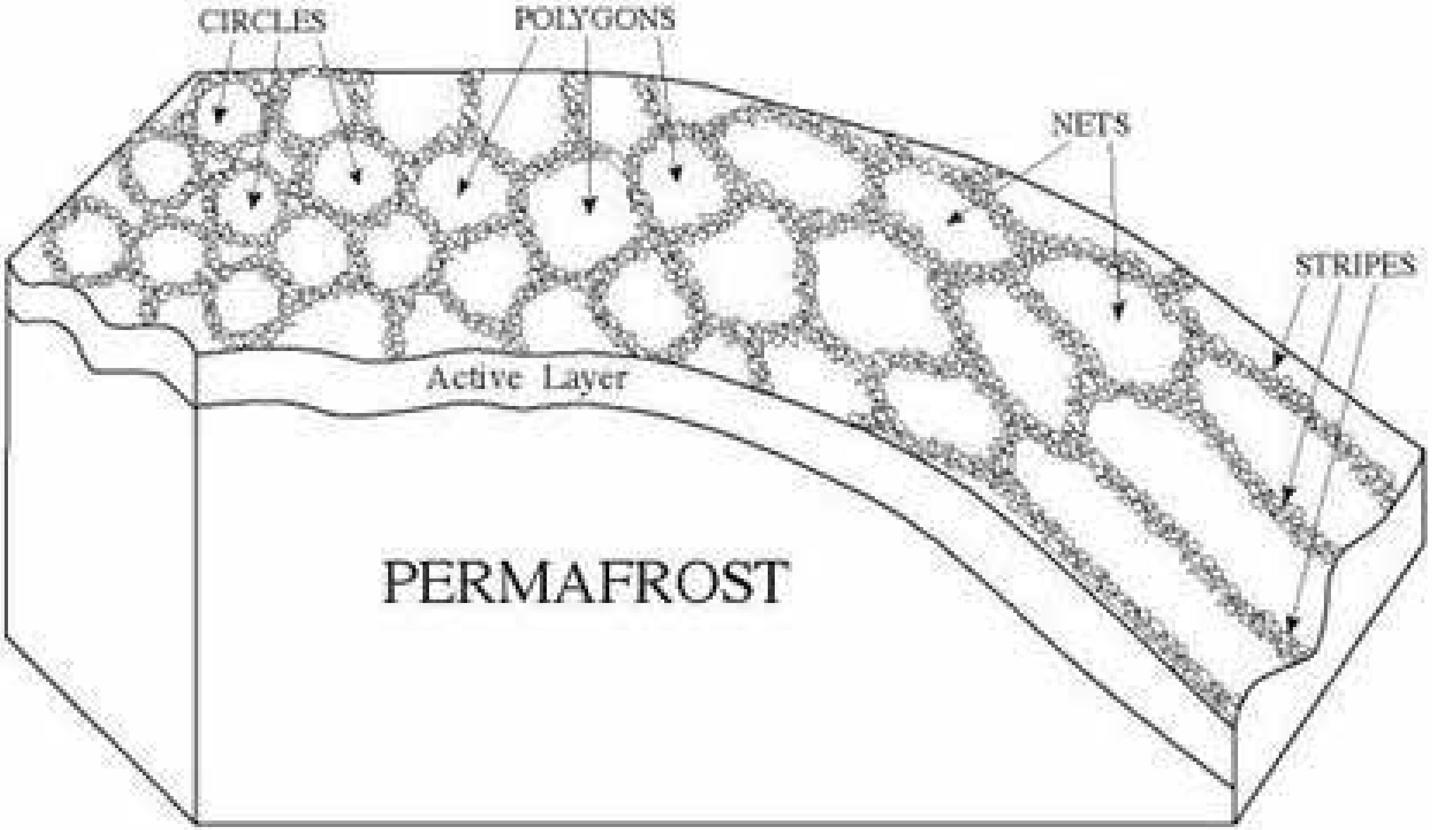
Sorted polygons

Kessler e Werner *(2003)*



Vorkuta (67°30’ N; 64°10’ E, 180 m slm), settembre 2004

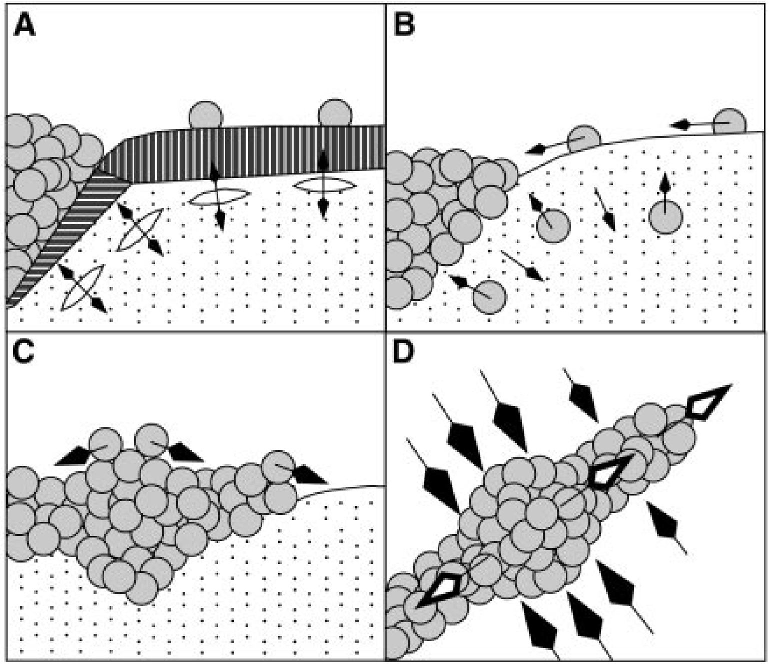
PATTERN TYPE AND SLOPE ANGLE


CIRCLES
POLYGONS
NETS
STRIPES
Active Layer
PERMAFROST

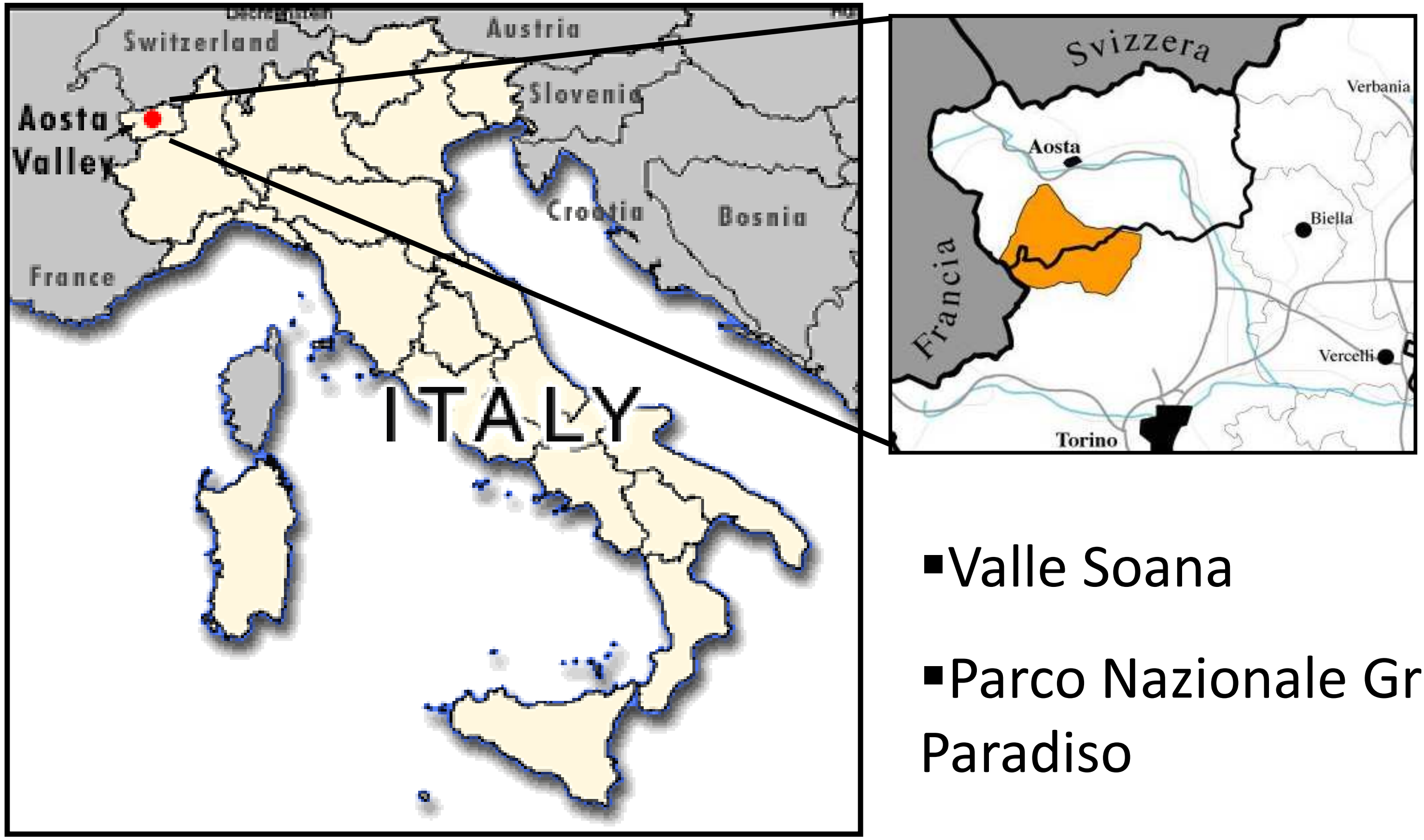
- I processi responsabili dell’origine dei *sorted patterned ground* non sono ancora completamente noti. Recentemente Kessler e Werner (2003) hanno sviluppato un modello, secondo il quale i cicli gelo/disgelo:

1) Inducono la separazione del materiale grossolano e la concentrazione del materiale fine in aree separate;

2) Favoriscono il trasporto del materiale grossolano lungo l’asse maggiore.



Area di Studio


Switzerland
Austria
Slovenia
Aosta
Valley
Croatia
Bosnia
France
ITALY
Svizzera
Verbania
Aosta
Biella
Francia
Vercelli
Torino

- Valle Soana
- Parco Nazionale Gran Paradiso
- Piata Lazin

D'Amico et al., submitted

Area di Studio

- Plateau Sommitale (3028 m slm)
- Dislivello: 2000 m circa
- Gneiss occhiadino
- Temperatura media annua: -4°C
- Precipitazioni medie annue: 1600 mm

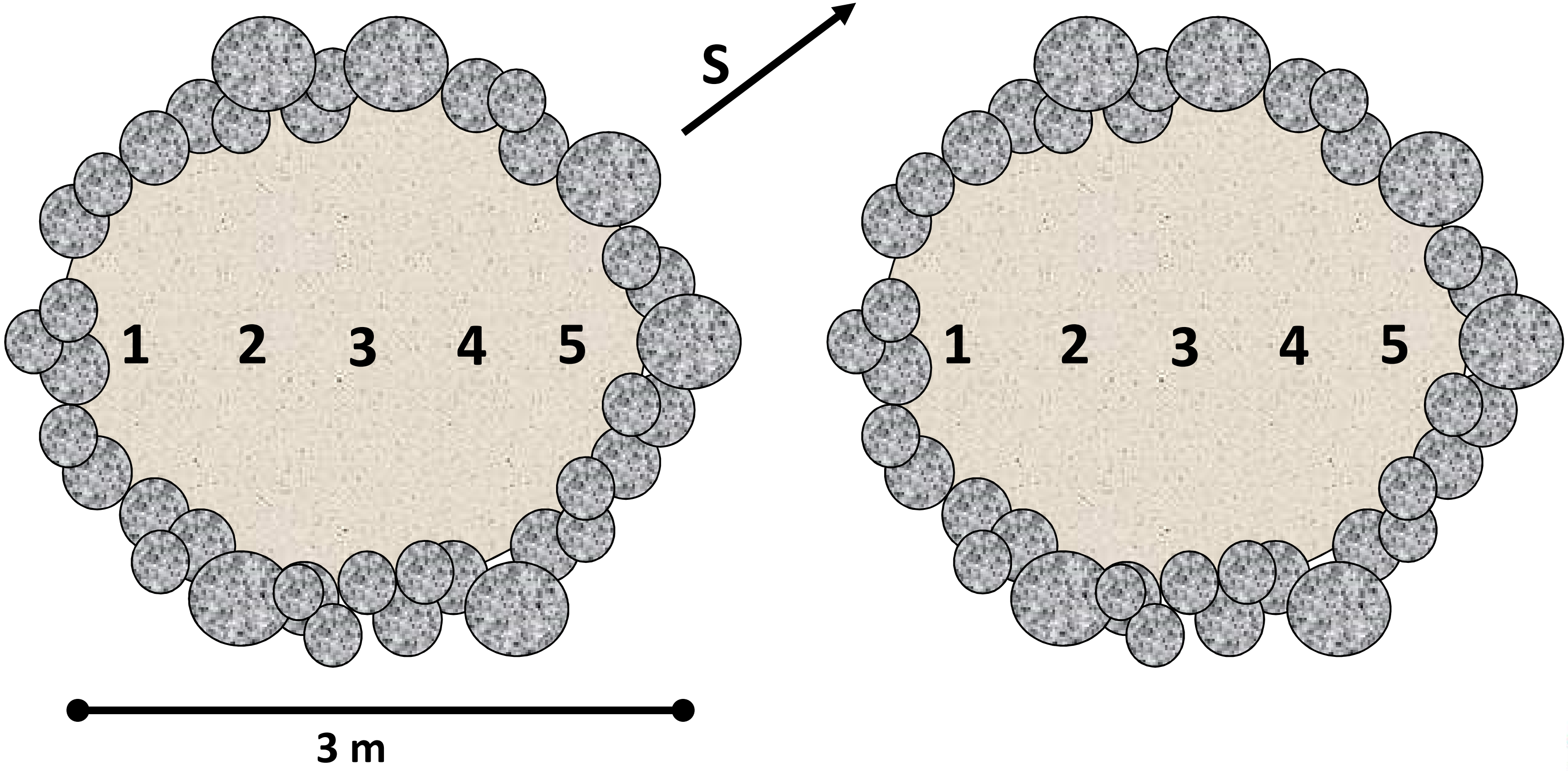
D’Amico et al., submitted

Area di Studio

D’Amico et al., submitted

Attività di campo ed analisi di laboratorio (1)

- Mappatura sorted circles
- Prelievo tospsoil in 2 sorted circles: pH, colore, Corg, Ntot, tessitura apparente, indice COLE



D'Amico et al., submitted

Attività di campo ed analisi di laboratorio (2)

- Misura temperatura suolo: ottobre 2007-ottobre 2008 (data loggers UTL-1)
- Stazione nivometeorologica Lago Valsoera (SMI)

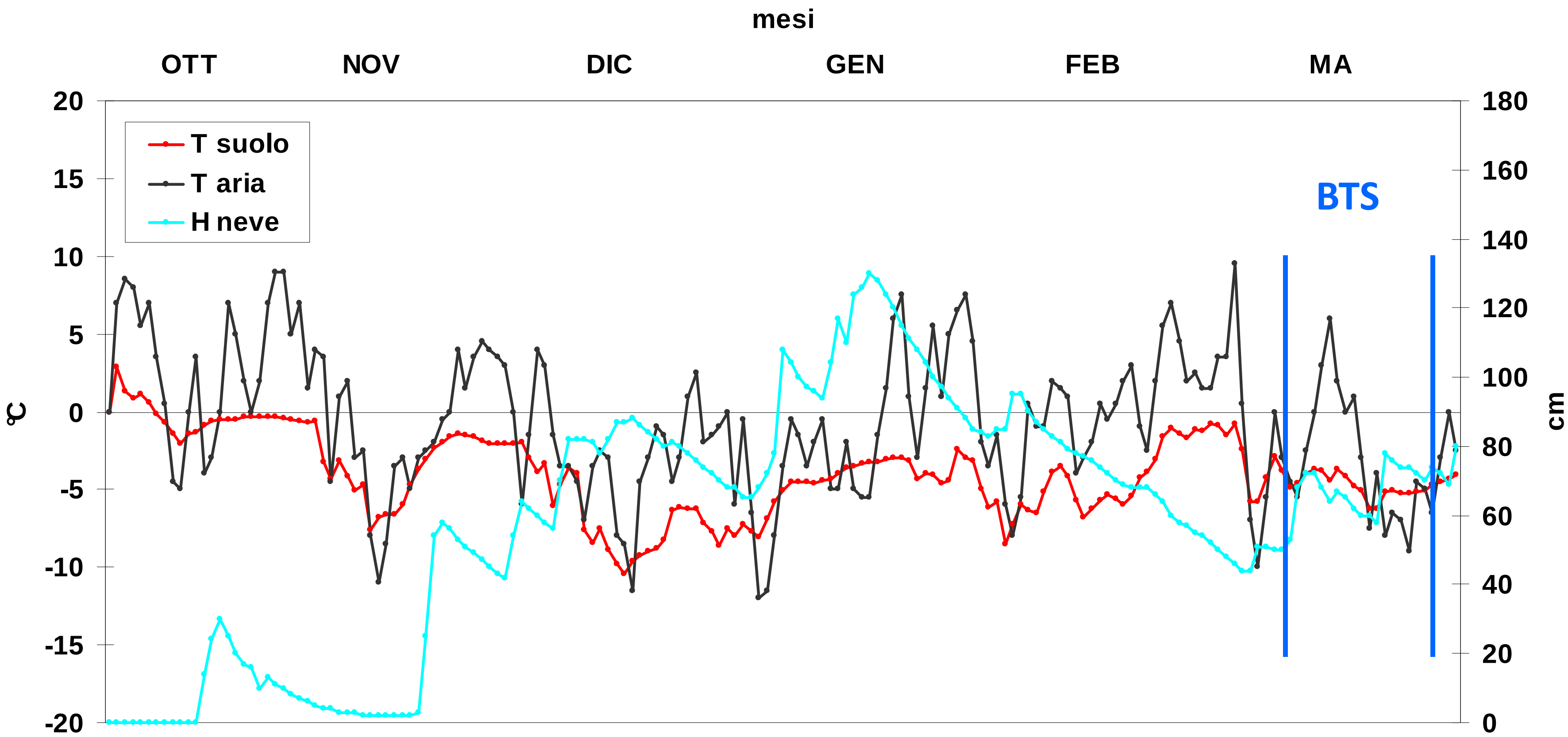
D'Amico et al., submitted

Mappatura sorted circles

- Numero sorted circles/ha: 233
- Diametro sorted circles: 0.5-5m
- Dimensione clasti sui bordi: 5-25 cm
- H bordi: 6-12 cm

D'Amico et al., submitted

Piata Lazin (3085 m slm)

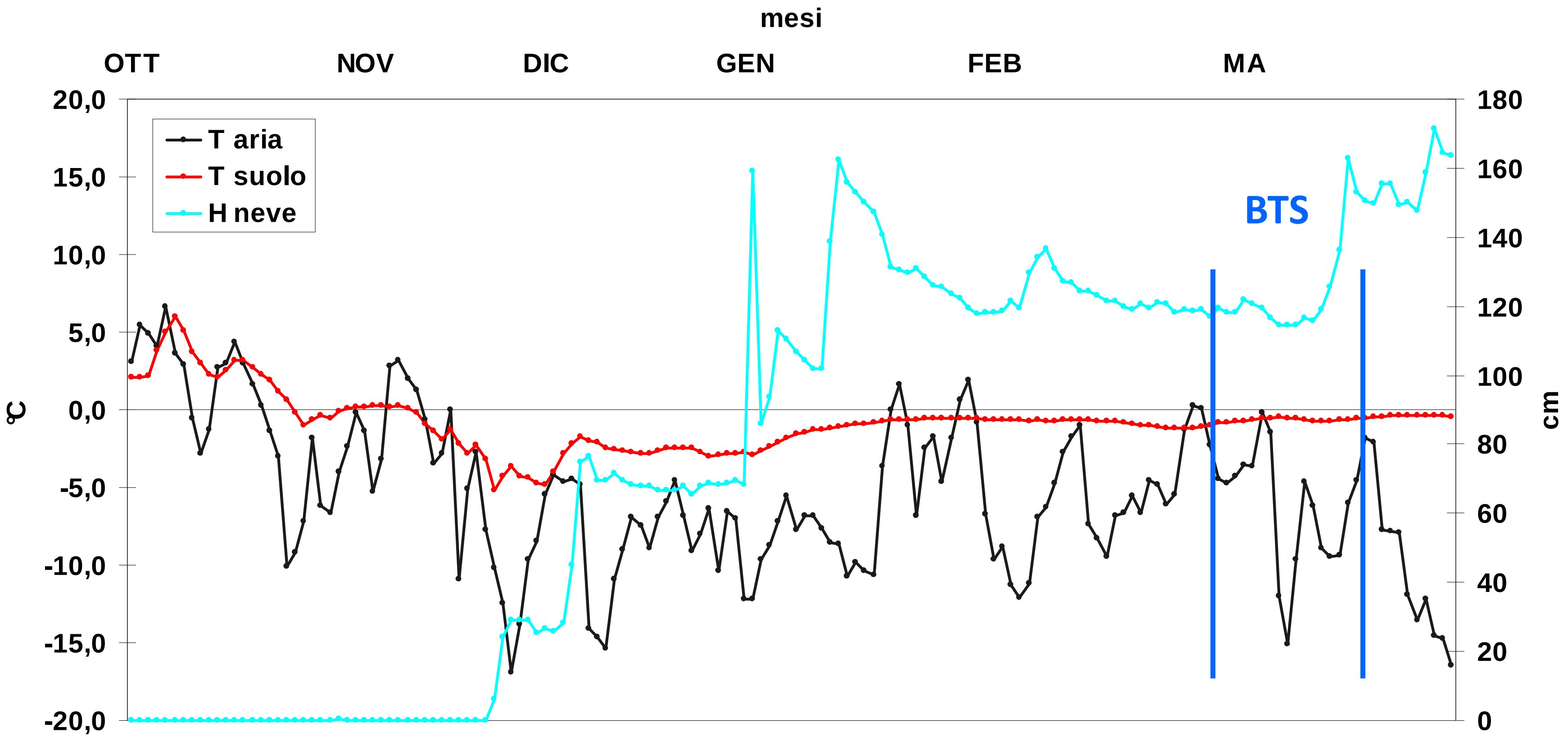


BTS: -3.9 °C

Probabilità presenza di permafrost: ALTA

D’Amico et al., submitted

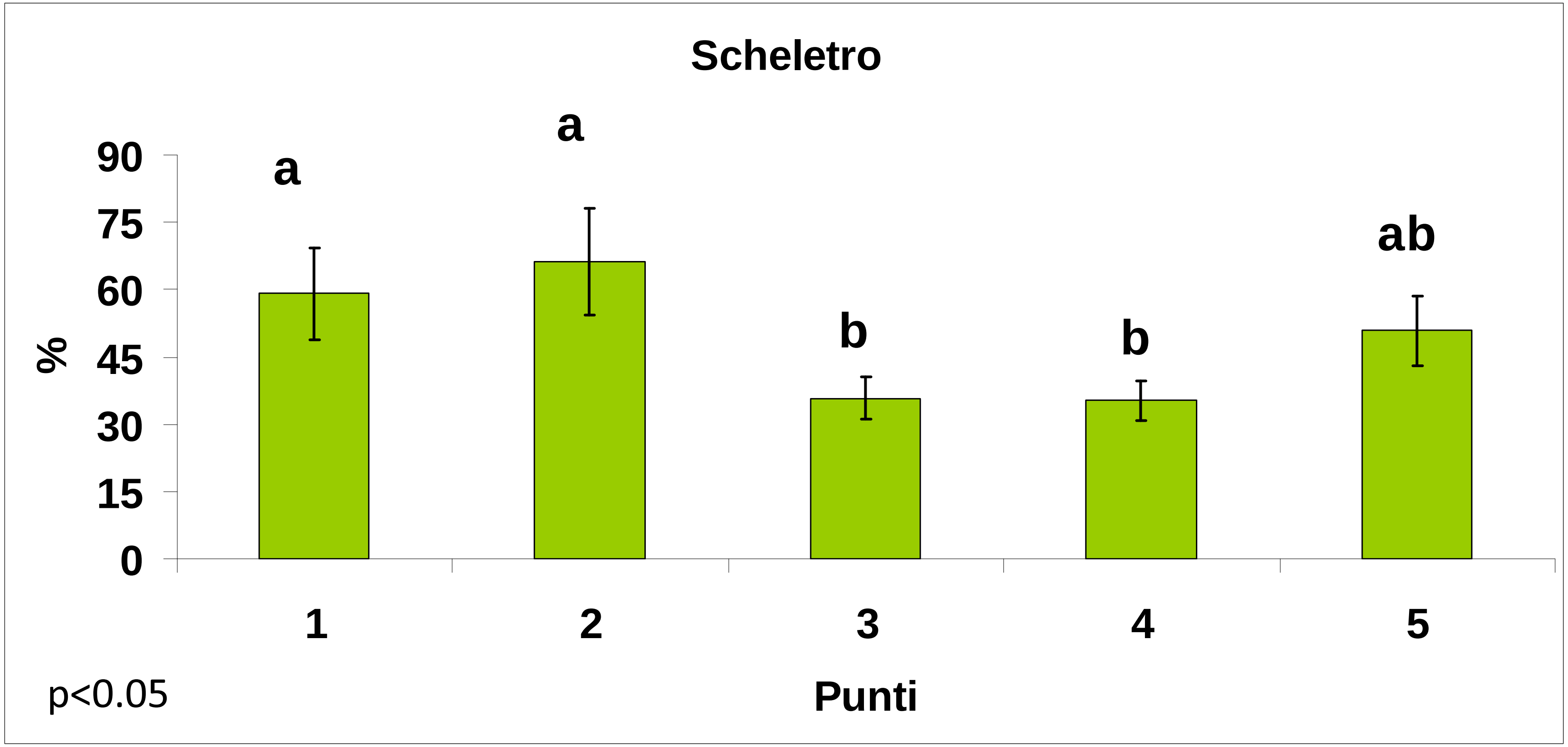
Col d’Olen 2901 m slm



BTS: -0.5 °C

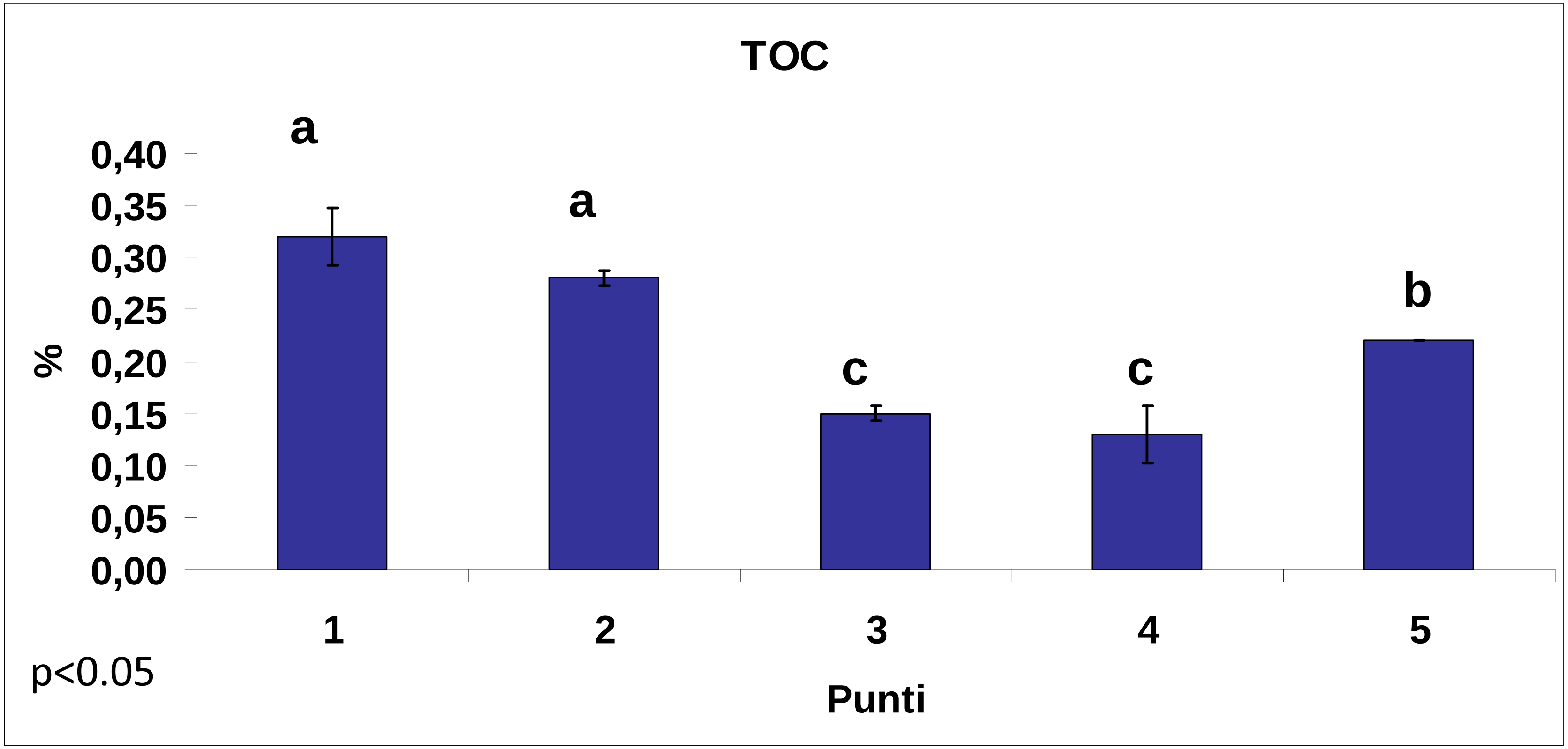
Probabilità presenza di permafrost: BASSA

D’Amico et al., submitted



Ghiaia grossolana (20-75 mm), di forma angolare

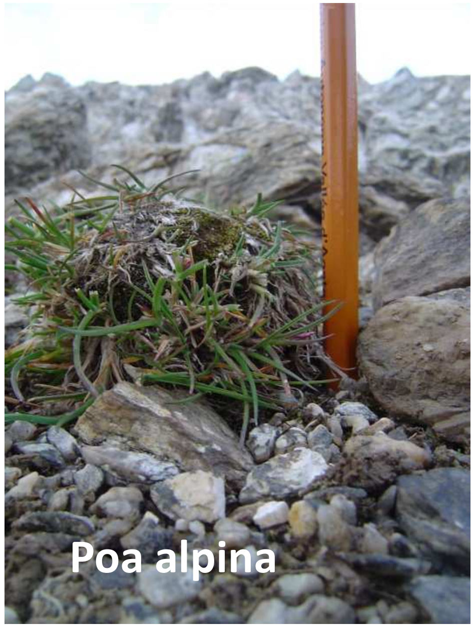
D’Amico et al., submitted



Sostanza organica: 0.19 - 0.58 g100g^{-1}

D'Amico et al., submitted

- La presenza di vegetazione solo sui bordi esterni evidenzia come il fenomeno non sia più così espresso.
- In accordo con numerosi studi la presenza di specie vegetali indica condizioni relativamente stabili.

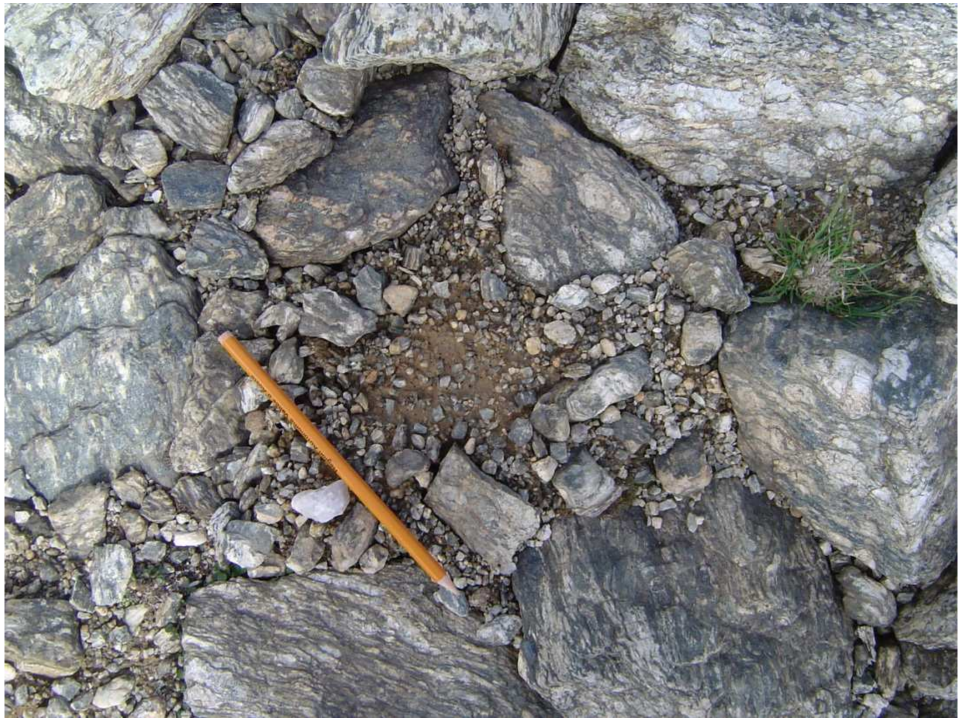


Poa alpina

Cerastium uniflorum

D’Amico et al., submitted

- La presenza di sorted circles più piccoli (5-10 cm) all’interno delle figure di maggiori dimensioni evidenzia però che i processi sono almeno in parte attivi.

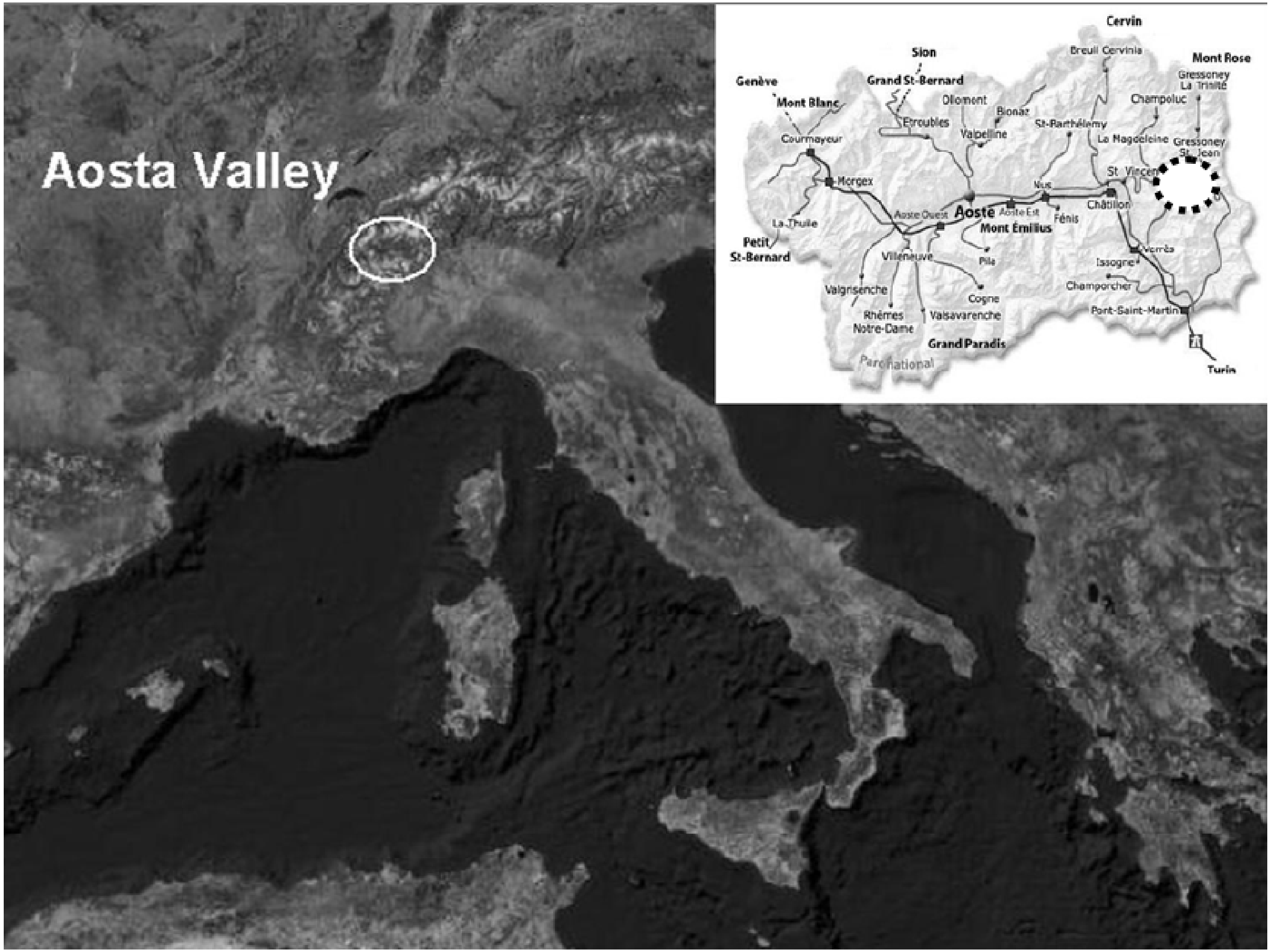


D’Amico et al., submitted

- **Nel sito oggetto di studio la presenza del permafrost è probabile.**
- **L’organizzazione spaziale del materiale fine e del materiale grossolano determina una discontinuità nella distribuzione delle caratteristiche dei suoli e delle piante.**
- **Il processo di segregazione del materiale sembra ancora parzialmente attivo, con la formazione di forme “miniaturizzate” nelle porzioni centrali dei cerchi più grandi, che invece sembrano parzialmente stabilizzati.**

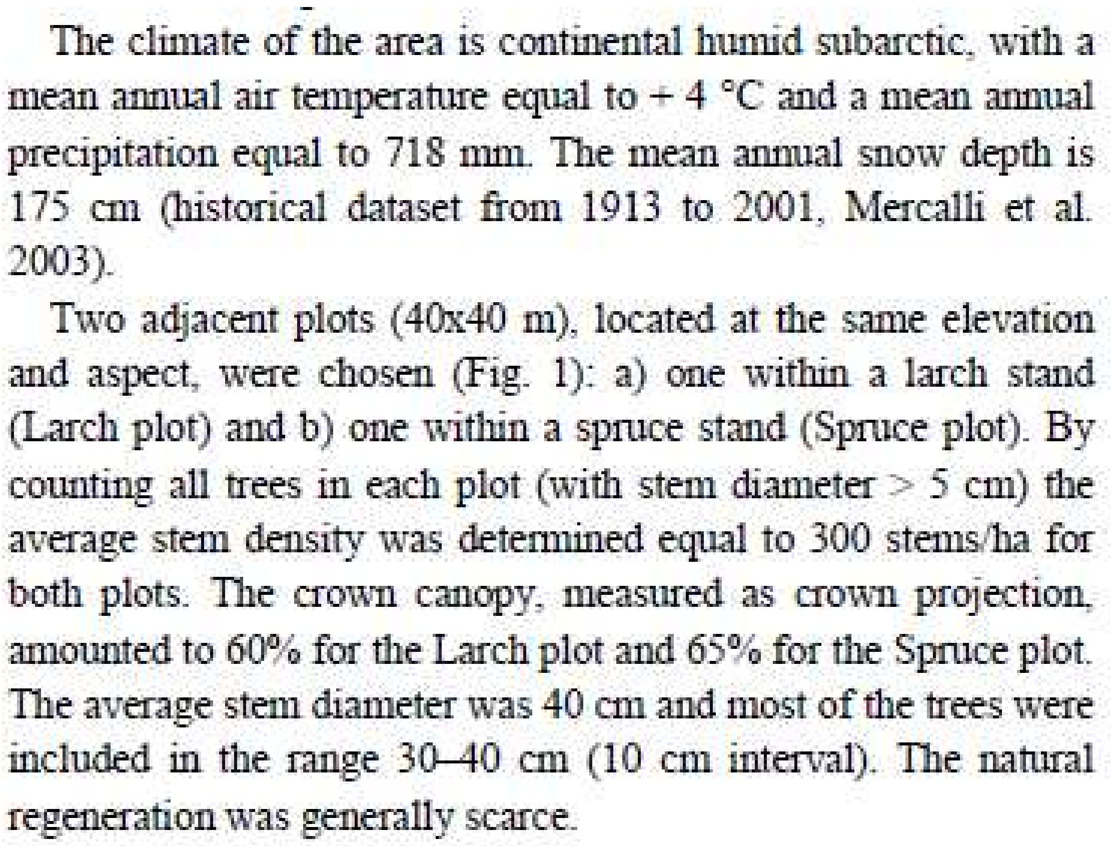
D’Amico et al., submitted

Snow gliding and loading under two different forest stands: a case study in the north-western Italian Alps


Aosta Valley
Cervin
Breuil Cervinia
Mont Rose
Gressoney La Trinité
Sion
Grand St-Bernard
Genève
Mont Blanc
Ollomont
Bionaz
Champoluc
Etroubles
St-Barthélemy
Valpelline
La Magdeleine
Gressoney St. Jean
Courmayeur
St. Vincent
Morgex
Nus
Châtillon
Aoste Ouest
Aoste
Aoste Est
Fénis
La Thuile
Mont Émilius
Petit St-Bernard
Verrès
Villeneuve
Pila
Issogne
Valgrisenche
Champorcher
Cogne
Rhêmes Notre-Dame
Valsavarenche
Pont-Saint-Martin
Grand Paradis
Parc national
Turin

2 STUDY PLOTS

Larix decidua *Picea Abies*

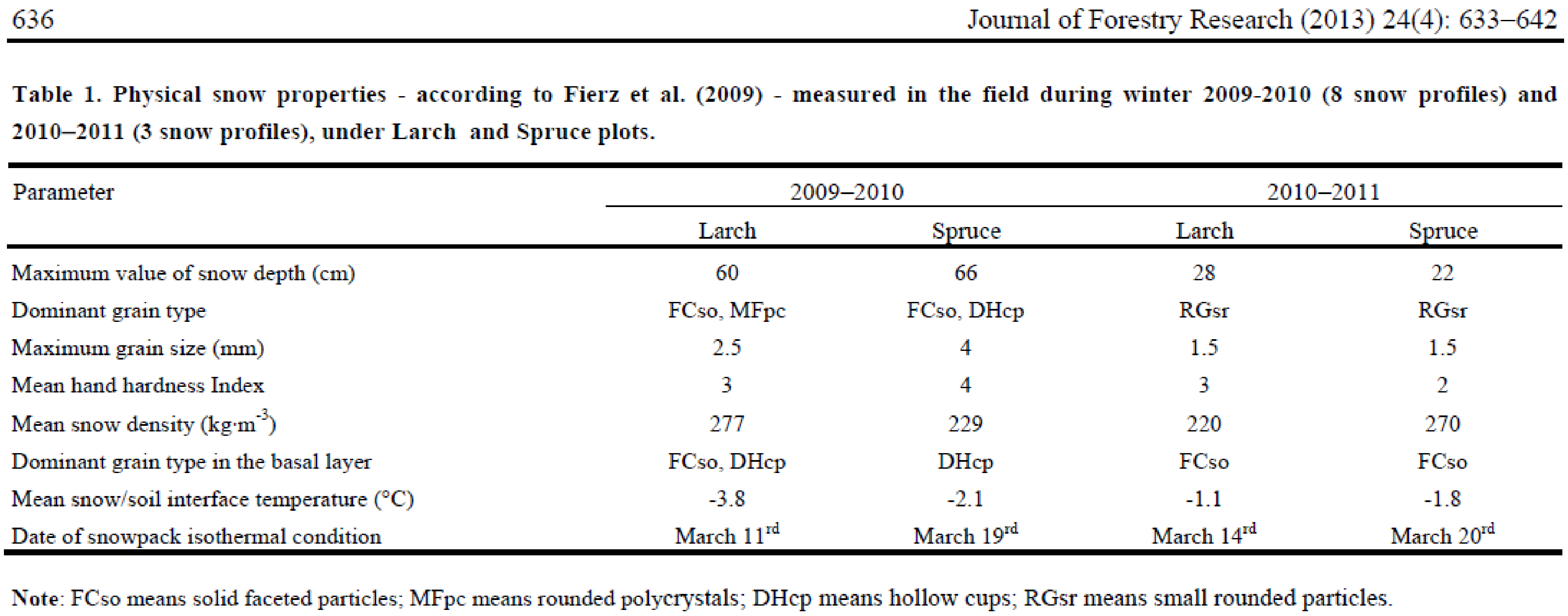


The climate of the area is continental humid subarctic, with a mean annual air temperature equal to + 4 °C and a mean annual precipitation equal to 718 mm. The mean annual snow depth is 175 cm (historical dataset from 1913 to 2001, Mercalli et al. 2003).

Two adjacent plots (40x40 m), located at the same elevation and aspect, were chosen (Fig. 1): a) one within a larch stand (Larch plot) and b) one within a spruce stand (Spruce plot). By counting all trees in each plot (with stem diameter > 5 cm) the average stem density was determined equal to 300 stems/ha for both plots. The crown canopy, measured as crown projection, amounted to 60% for the Larch plot and 65% for the Spruce plot. The average stem diameter was 40 cm and most of the trees were included in the range 30–40 cm (10 cm interval). The natural regeneration was generally scarce.

Viglietti et al., 2013

Physical snow properties



636 Journal of Forestry Research (2013) 24(4): 633–642

Table 1. Physical snow properties - according to Fierz et al. (2009) - measured in the field during winter 2009-2010 (8 snow profiles) and 2010–2011 (3 snow profiles), under Larch and Spruce plots.

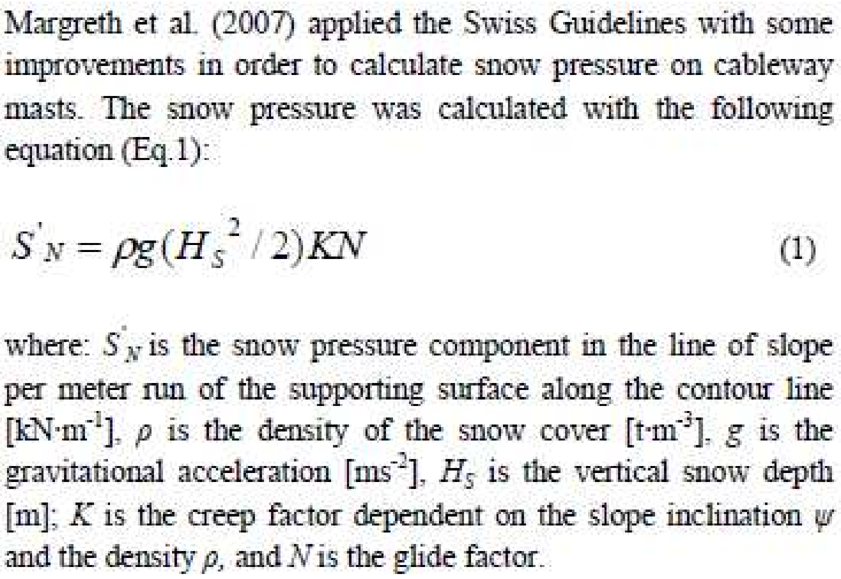
Parameter	2009–2010		2010–2011	
	Larch	Spruce	Larch	Spruce
Maximum value of snow depth (cm)	60	66	28	22
Dominant grain type	FCso, MFpc	FCso, DHcp	RGsr	RGsr
Maximum grain size (mm)	2.5	4	1.5	1.5
Mean hand hardness Index	3	4	3	2
Mean snow density ($kg \cdot m^{-3}$)	277	229	220	270
Dominant grain type in the basal layer	FCso, DHcp	DHcp	FCso	FCso
Mean snow/soil interface temperature (°C)	-3.8	-2.1	-1.1	-1.8
Date of snowpack isothermal condition	March 11rd	March 19rd	March 14rd	March 20rd

Note: FCso means solid faceted particles; MFpc means rounded polycrystals; DHcp means hollow cups; RGsr means small rounded particles.

Viglietti et al., 2013

Snow pressure on trees

Swiss guidelines

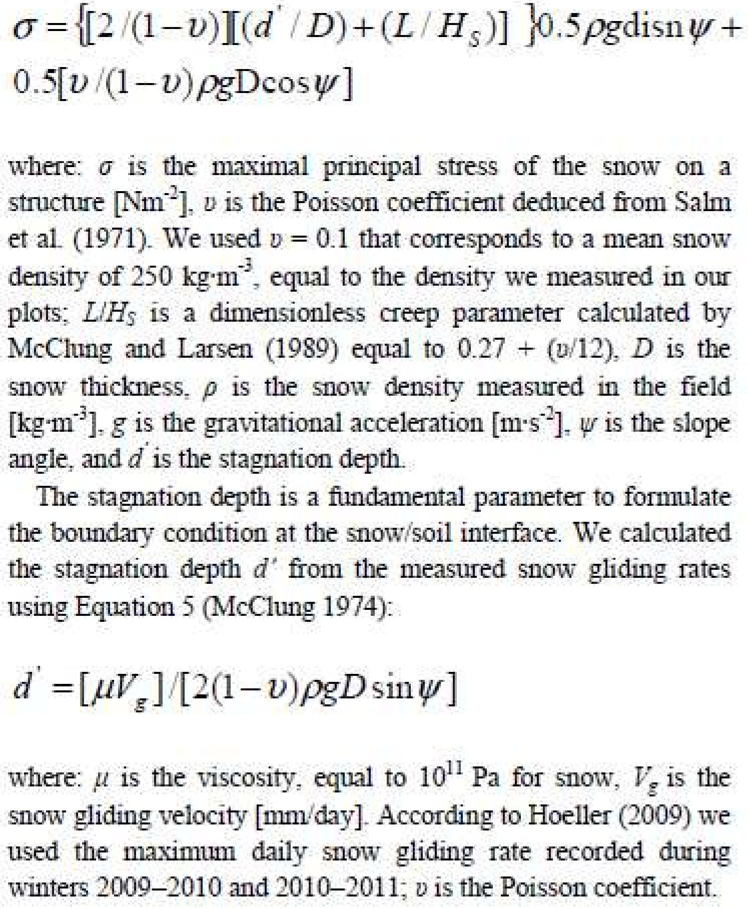


Margreth et al. (2007) applied the Swiss Guidelines with some improvements in order to calculate snow pressure on cableway masts. The snow pressure was calculated with the following equation (Eq.1):

$$S'_N = \rho g (H_S{}^2 / 2) KN \qquad (1)$$

where: S'_N is the snow pressure component in the line of slope per meter run of the supporting surface along the contour line [kN·m^{-1}], ρ is the density of the snow cover [t·m^{-3}], g is the gravitational acceleration [ms^{-2}], H_S is the vertical snow depth [m]; K is the creep factor dependent on the slope inclination ψ and the density ρ, and N is the glide factor.

Mc Clung and Larsen (1989)



$$\sigma = \{[2/(1-\upsilon)][(d'/D)+(L/H_S)]\}0.5\rho g \mathrm{disn}\psi + 0.5[\upsilon/(1-\upsilon)\rho g \mathrm{D}\cos\psi]$$

where: σ is the maximal principal stress of the snow on a structure [Nm^{-2}], υ is the Poisson coefficient deduced from Salm et al. (1971). We used $\upsilon = 0.1$ that corresponds to a mean snow density of 250 kg·m^{-3}, equal to the density we measured in our plots; L/H_S is a dimensionless creep parameter calculated by McClung and Larsen (1989) equal to $0.27 + (\upsilon/12)$, D is the snow thickness, ρ is the snow density measured in the field [kg·m^{-3}], g is the gravitational acceleration [m·s^{-2}], ψ is the slope angle, and d' is the stagnation depth.

The stagnation depth is a fundamental parameter to formulate the boundary condition at the snow/soil interface. We calculated the stagnation depth d' from the measured snow gliding rates using Equation 5 (McClung 1974):

$$d' = [\mu V_g]/[2(1-\upsilon)\rho g D \sin\psi]$$

where: μ is the viscosity, equal to 10^{11} Pa for snow, V_g is the snow gliding velocity [mm/day]. According to Hoeller (2009) we used the maximum daily snow gliding rate recorded during winters 2009–2010 and 2010–2011; υ is the Poisson coefficient.

Viglietti et al., 2013

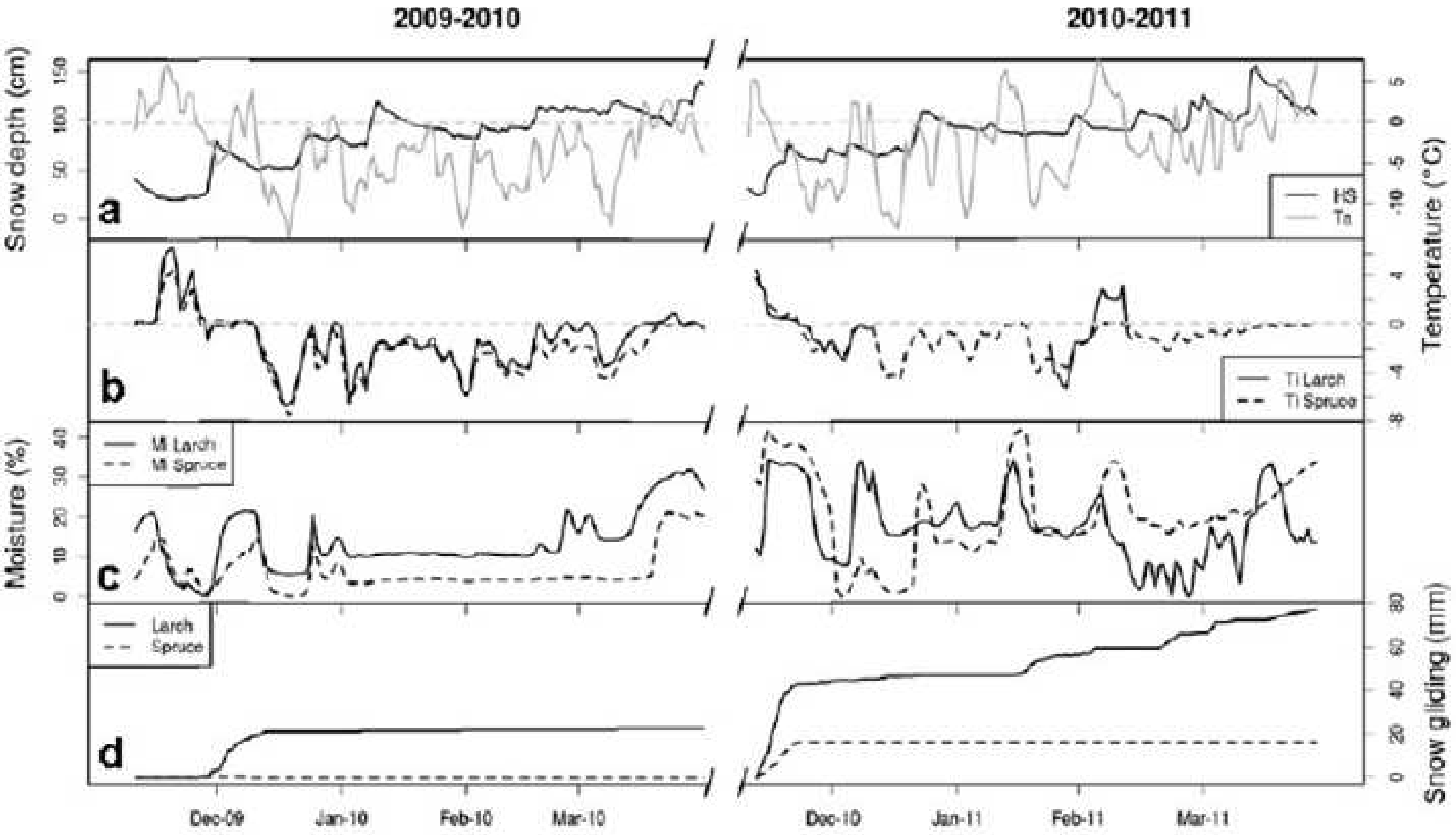


Fig. 3 Snow depth and air temperature measured by the automatic snow and weather station (a); *Ti* (b) *Mi* (c) and snow gliding (d) in each plot recorded in both winters (2009-2010 and 2010-2011) when the study site was snow-covered.

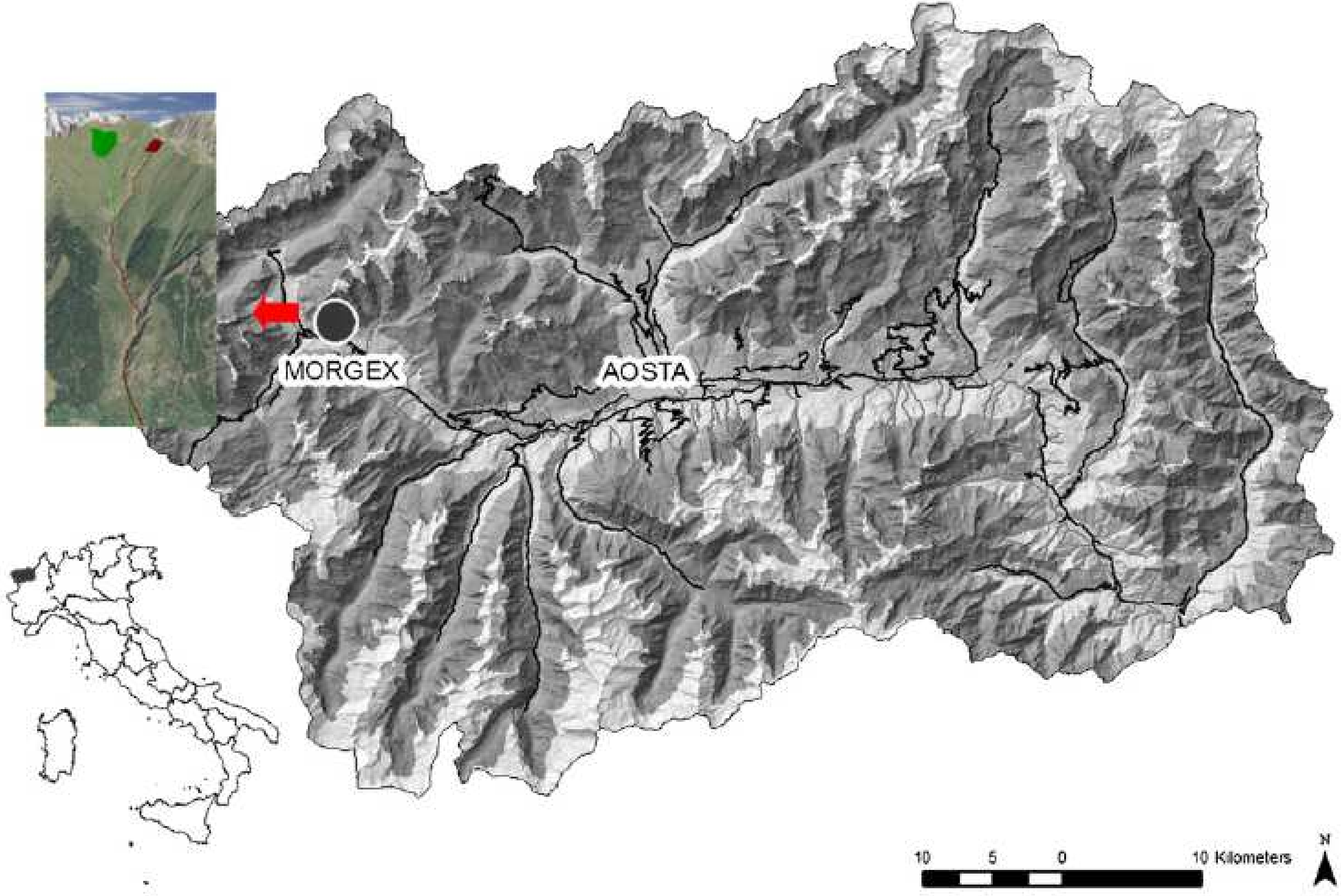
Viglietti et al., 2013

From our results, the snow/soil interface moisture significantly influenced the snow gliding processes. In particular, soil moisture at the snow/soil interface was related to the snow/soil interface temperature and both parameters (Mi and Ti) were strongly regulated by air temperature.

The volumetric moisture increase of a relatively dry snow/soil interface (10%−20%), seemed to be the most important factor influencing the snow gliding rates: in particular snow gliding was observed with wetting rates higher than 1.2%/day.

Viglietti et al., 2013

Modelling soil removal from snow avalanches: A case study in the North-Western Italian Alps


MORGEX
AOSTA
10
5
0
10 Kilometers
N

Confortola et al., 2012

Load: 25 t/ha

Superficial deposit: 1.8 mm

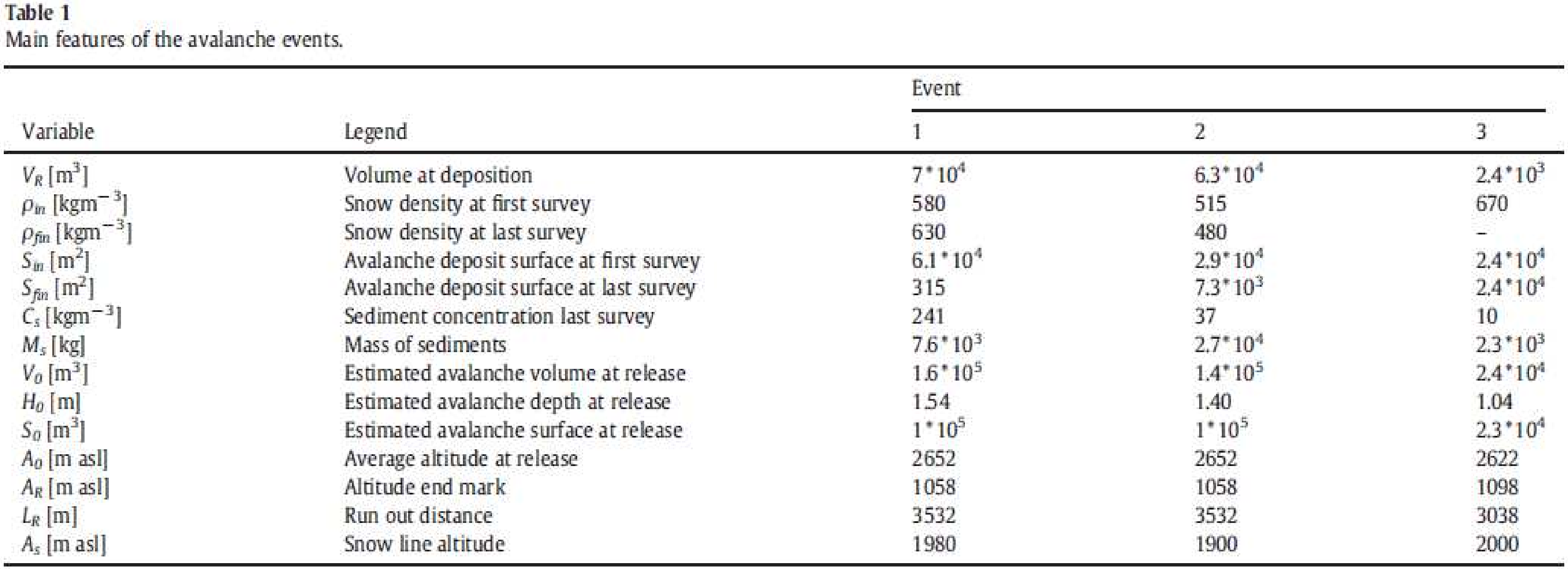
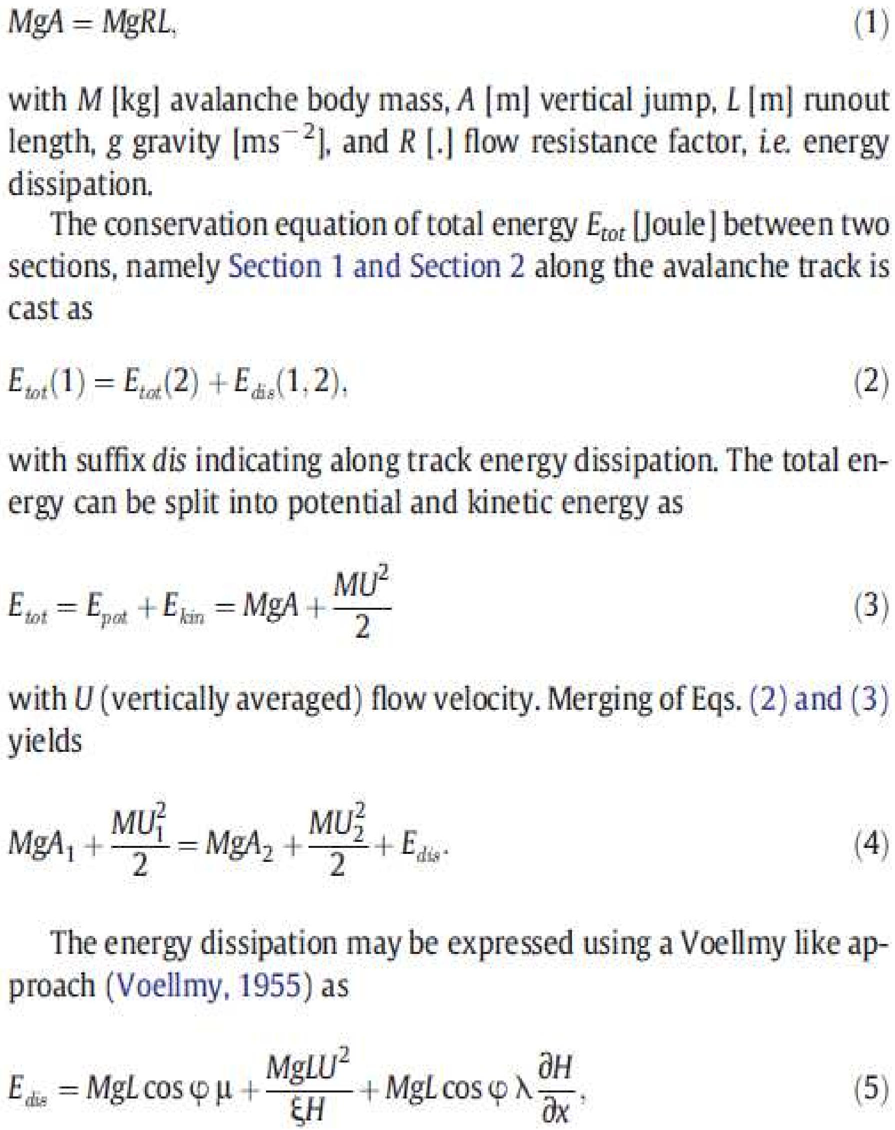


Table 1

Main features of the avalanche events.

Variable	Legend	Event 1	2	3
V_R [m^3]	Volume at deposition	$7*10^4$	$6.3*10^4$	$2.4*10^3$
ρ_{in} [kgm^{-3}]	Snow density at first survey	580	515	670
ρ_{fin} [kgm^{-3}]	Snow density at last survey	630	480	–
S_{in} [m^2]	Avalanche deposit surface at first survey	$6.1*10^4$	$2.9*10^4$	$2.4*10^4$
S_{fin} [m^2]	Avalanche deposit surface at last survey	315	$7.3*10^3$	$2.4*10^4$
C_s [kgm^{-3}]	Sediment concentration last survey	241	37	10
M_s [kg]	Mass of sediments	$7.6*10^3$	$2.7*10^4$	$2.3*10^3$
V_0 [m^3]	Estimated avalanche volume at release	$1.6*10^5$	$1.4*10^5$	$2.4*10^4$
H_0 [m]	Estimated avalanche depth at release	1.54	1.40	1.04
S_0 [m^3]	Estimated avalanche surface at release	$1*10^5$	$1*10^5$	$2.3*10^4$
A_0 [m asl]	Average altitude at release	2652	2652	2622
A_R [m asl]	Altitude end mark	1058	1058	1098
L_R [m]	Run out distance	3532	3532	3038
A_s [m asl]	Snow line altitude	1980	1900	2000

AVALANCHE MODEL



$$MgA = MgRL, \tag{1}$$

with M [kg] avalanche body mass, A [m] vertical jump, L [m] runout length, g gravity [ms^{-2}], and R [.] flow resistance factor, *i.e.* energy dissipation.

The conservation equation of total energy E_{tot} [Joule] between two sections, namely Section 1 and Section 2 along the avalanche track is cast as

$$E_{tot}(1) = E_{tot}(2) + E_{dis}(1,2), \tag{2}$$

with suffix *dis* indicating along track energy dissipation. The total energy can be split into potential and kinetic energy as

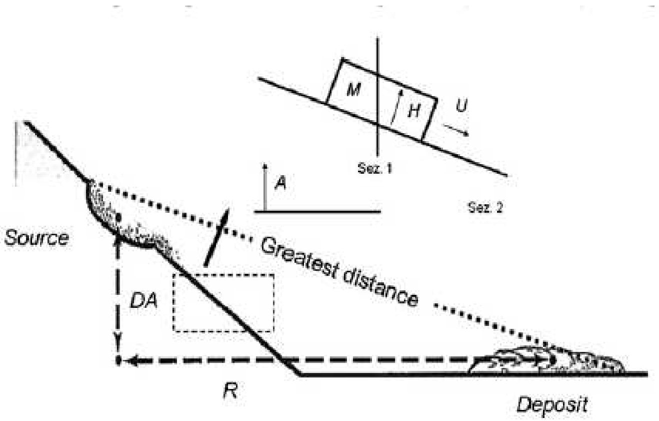
$$E_{tot} = E_{pot} + E_{kin} = MgA + \frac{MU^2}{2} \tag{3}$$

with U (vertically averaged) flow velocity. Merging of Eqs. (2) and (3) yields

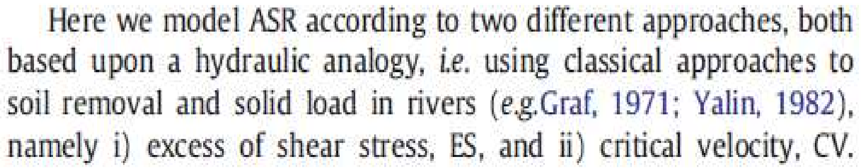
$$MgA_1 + \frac{MU_1^2}{2} = MgA_2 + \frac{MU_2^2}{2} + E_{dis}. \tag{4}$$

The energy dissipation may be expressed using a Voellmy like approach (Voellmy, 1955) as

$$E_{dis} = MgL\cos\varphi\,\mu + \frac{MgLU^2}{\xi H} + MgL\cos\varphi\,\lambda\frac{\partial H}{\partial x}, \tag{5}$$

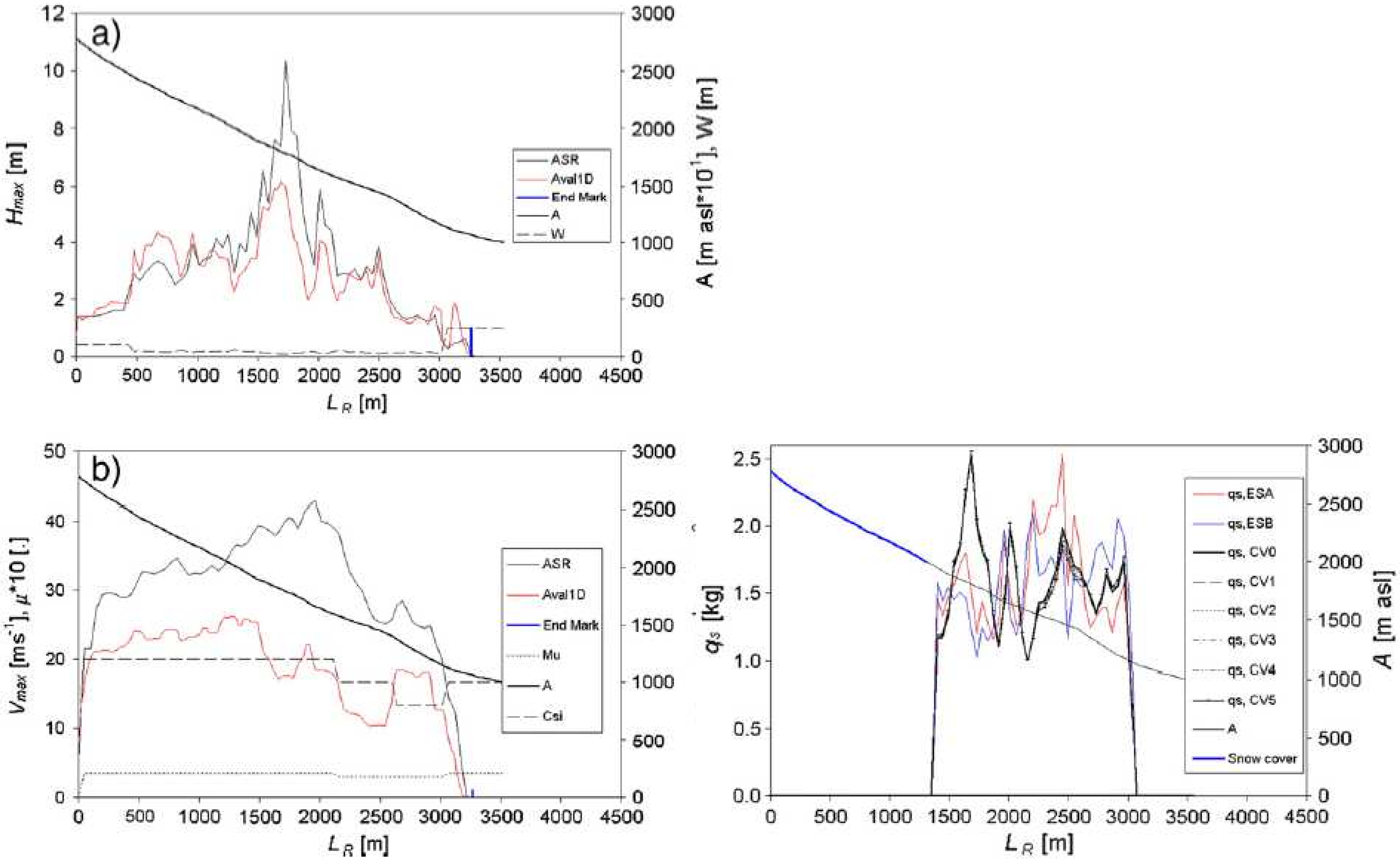


SOIL EROSION MODEL



Here we model ASR according to two different approaches, both based upon a hydraulic analogy, *i.e.* using classical approaches to soil removal and solid load in rivers (*e.g.*Graf, 1971; Yalin, 1982), namely i) excess of shear stress, ES, and ii) critical velocity, CV.

Confortola et al., 2012



Confortola et al., 2012

SNOW GLIDING PARAMETERS:
snow depth, density, gliding factor (vegetation, topography, etc,.)

AVALANCHE PARAMETERS:
fracture depth (DH3gg), friction parameters, erodible snow cover,

→ MODEL INPUTS

CLIMATE CHANGE
???