



Snowpack measurements in the Catalan Pyrenees for avalanche forecasting

Carles García

carles.garcia@icgc.cat



ICGC
Institut
Cartogràfic i Geològic
de Catalunya

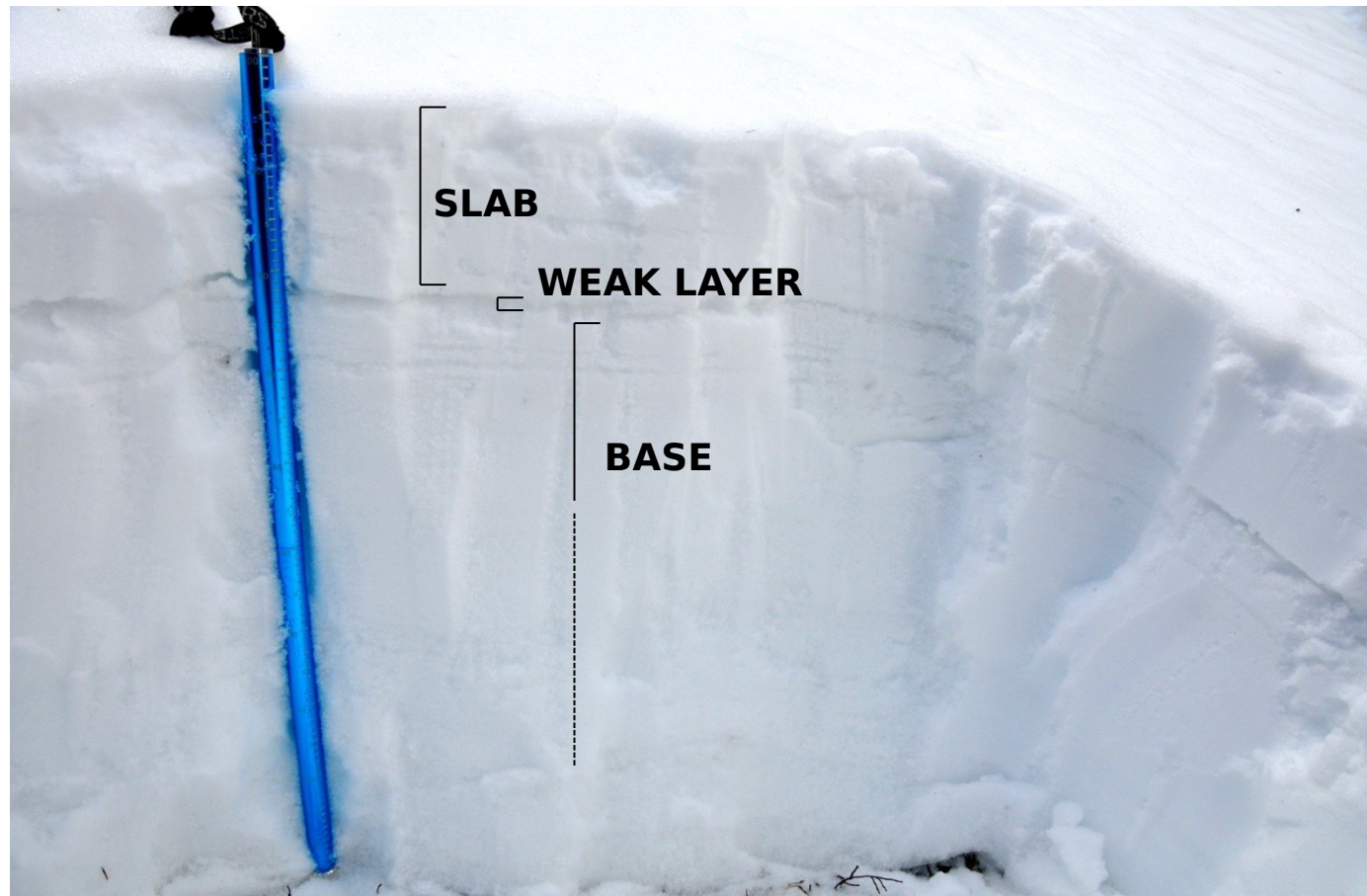


Generalitat
de Catalunya

Snowpack measurements

To look for unstable conditions into the snowpack STRUCTURE:

- ❑ Collapses between layers
- ❑ Level of bonding among the snow grains



Snowpack measurements

ON GROUND MEASUREMENTS

- Procedures of «International Classification for Seasonal Snow on the Ground» UNESCO – IACS
- Harmonisation questions: European Avalanche Warning Services
- Coherency with USA and Canadian Snow and Weather Observation Guidelines
- Local working groups: Pyrenees Inter-regional meeting (Aragon-Navarra-Catalunya, Andorra-France).

Daily Snowpack measurements

FRACTURES AND PROPAGATION

SNOWPACK STRUCTURE



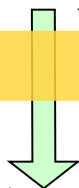
Fracture?

Mechanical instability

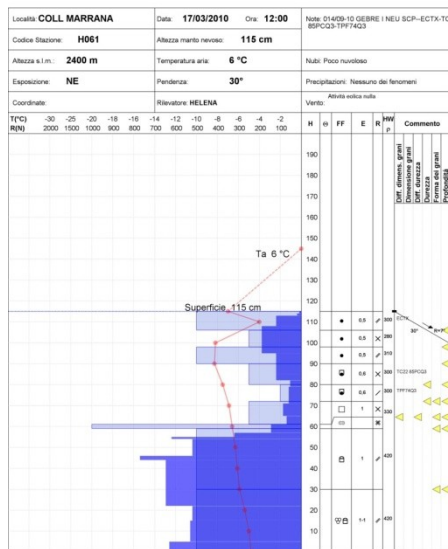
Propagation?

Structural instability

Snowpack measurements



Snowpit and ram profile



Stability tests



What?
Why?
How?

Mechanical conditions

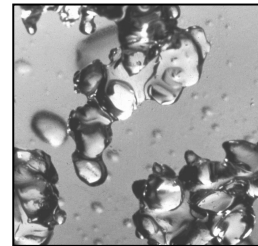
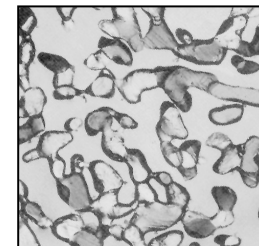
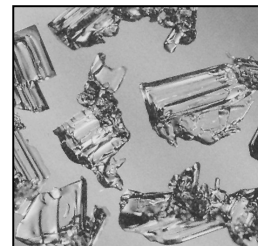
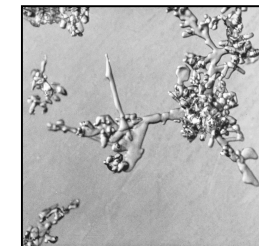
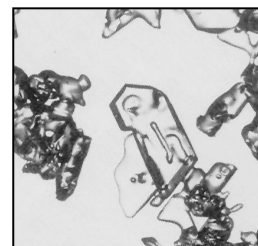
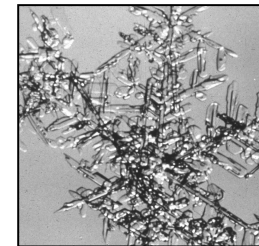
- **Resistance** (N), cm by cm
- To detect weak layers and crusts
- Haefeli ram penetrometer, mobile weight



What?
Why?
How?

Mechanical conditions

- Individual layers, **snow grain type** (IACS) , Ø
- Grain type determines unfavourable conditions
- 8x to 25x loupe



What?
Why?
How?

Layer properties

Snowpack **thermal gradient**, surface and 10 by 10
It rules the metamorfismes of the snowpack
Thermometer sonde



- Snow **density** of each layer
- Loading and stress supported
- Horizontal sampling (200 cm³), dynamometer (300 gr, 5 gr resolution)



Foto: Ramon Baylina



Foto: Ramon Baylina

What?
Why?
How?

Layer properties

- **Hand hardness**
- Cohesion among grains
- Qualitative approach

- Liquid water content

- Probability of wet avalanches

- Qualitative approach, gently squeezing a snow sample

Penetration		Hardness	Value
Fist		Very soft	1
Four-finger maximum		Soft	2
One-finger maximum		Quite hard	3
Pencil maximum		Hard	4
Knife maximum		Very hard	5

Class	Definition	Water content (by volume)	Symbol	Data code
Dry	Usually the snow temperature (T) is below 0 °C, but dry snow can occur at any temperature up to 0 °C. Disaggregated snow grains have little tendency to adhere to each other when pressed together, as in making a snowball.	0 %	None	D
Moist	T = 0 °C. Water is not visible even at 10x magnification. When lightly crushed, the snow has a distinct tendency to stick together.	< 3 %		M
Wet	T = 0 °C. Water can be recognized at 10x magnification by its meniscus between adjacent snow grains, but water cannot be pressed out by moderately squeezing the snow in the hands (pendular regime).	3 - 8 %		W
Very wet	T = 0 °C. Water can be pressed out by moderately squeezing the snow in the hands, but there is an amount of air confined within the pores (funicular regime).	8 - 15 %		V
Slush	T = 0 °C. The snow is flooded with water and contains a relatively small amount of air.	> 15 %		S

What?
Why?
How?

Structural instability

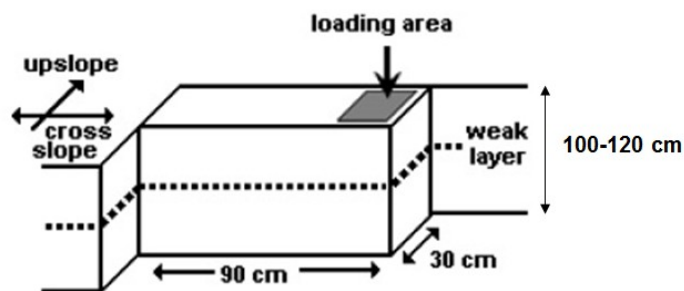
- **Is it possible for a fracture to propagate once started?**
- Compression test (CT test): Stress required to initiate a fracture
- Qualitative approach: “nº tips + position WL + quality shear”



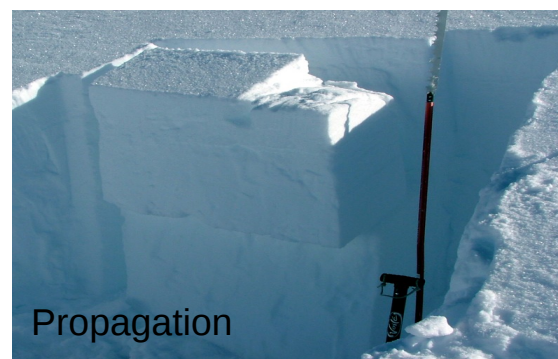
What?
Why?
How?

Structural instability

- **Is it possible a fracture to propagate once started?**
- Extended Column test (ECT test) / Propagation Saw test (PST test): Propagation capacity
- Qualitative approach: “nº tips + propagation ratio + position WL + quality shear”



No propagation

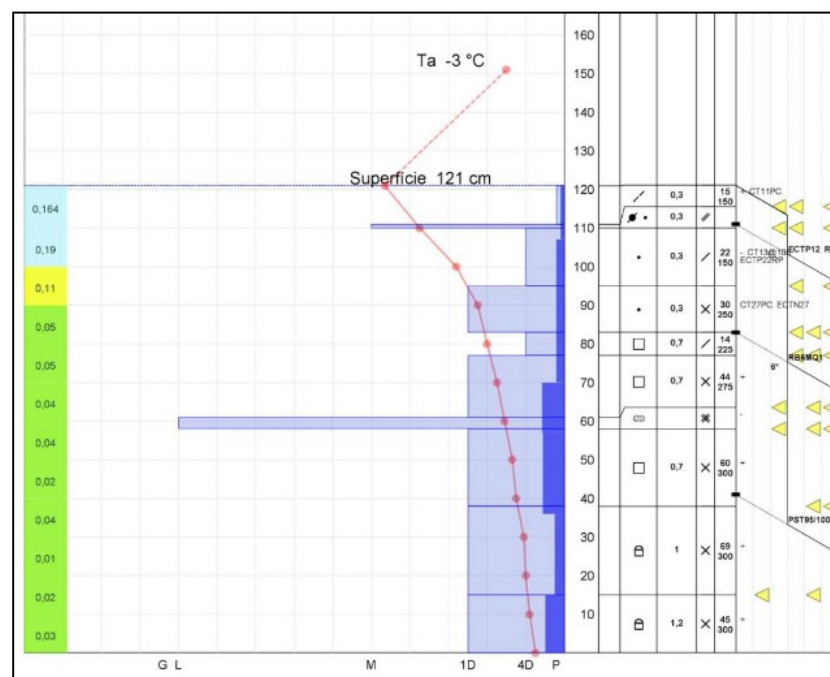
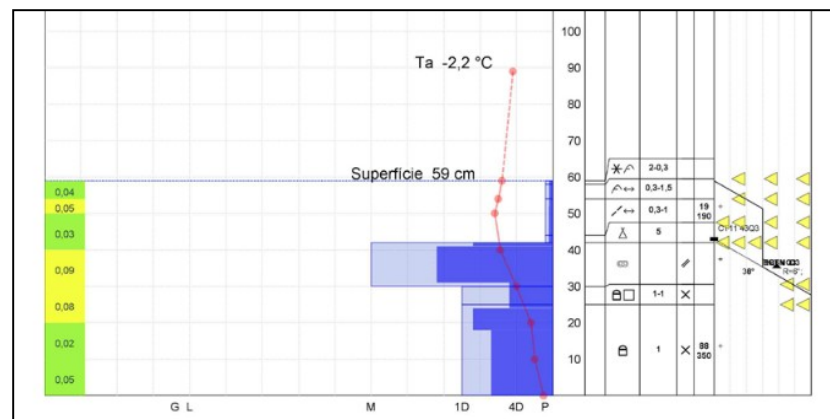


Snowpack measurements

Avalanche problems

INSTABILITY SNOWPACK PATTERNS

- New snow
- Wind-drifted snow
- Persistent weak layers
- Wet snow
- Gliding snow



Snowpack measurements

Avalanche warnings

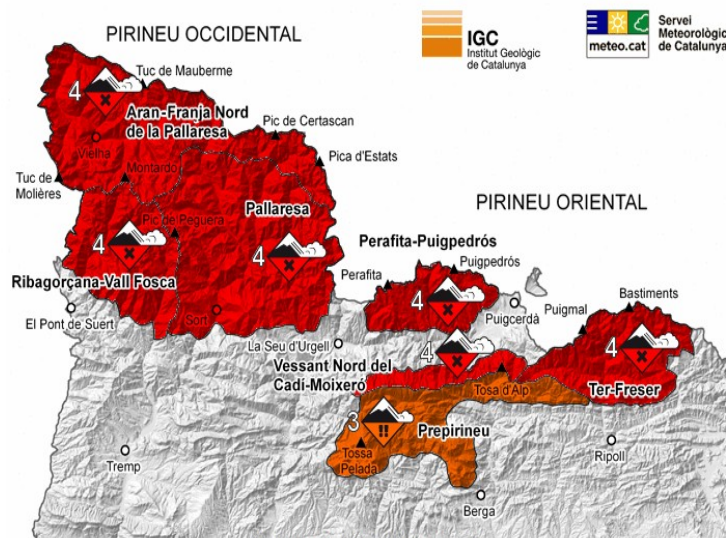
- Eastern Pyrenees: Daily avalanche warnings, 7 regions, cat + cast + eng

Butlletí de Perill d'Allaus - BPA

Butlletí de Perill d'Allaus actualitzat el 08/01/10

[Heu observat una allau?](#)

Zones del Pirineu de Catalunya amb informació sobre el Perill d'Allaus



Mapa sensible. Cliquen sobre una zona.



PIRINEU OCCIDENTAL
Aran - Franja nord Pallaresa
Ribagorçana - Vall Fosca
Pallaresa

PIRINEU ORIENTAL
Perafita-Puigpedrós
Vessant Nord Cadi-Moixeró
Prepirineu
Ter-Freser

PIRINEU OCCIDENTAL

! Allaus de placa de vent que en sectors sobreacumulats poden ser de grans dimensions.

- [Llegenda de símbols](#)
- [Guia d'utilització del BPA Gràfic](#)
- [Escala europea de perill d'allaus](#)

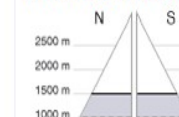


Aran - Franja nord de la Pallaresa

! Allaus de neu recent de mida mitjana i de placa de gran conforme vagi nevant i acumulant-se neu pel vent.



Distribució del mantell



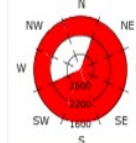
Efectes del vent: Sobreacumulacions en vessants S

Perill d'allaus de neu recent i de placa

Tipus allaus i mida



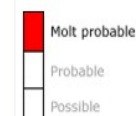
Localització més probable



Sobrecàrrega (plaques)



Probabilitat de desencadenament



Tendència



Predicció meteorològica

	Temps previst	Temperatura màxima i mínima	Vent
24h:			
			Cota neu: 0 m

Snowpack measurements

Available data

SNOWPITS AND PROFILES

- Database: 1990-91 / 2015-16
- $\pm$ 6.000 profiles (50.000 layers):
 - Ram penetration
 - Snow grain type and $\emptyset$
 - Snow thermal gradient
 - Density
 - Hardness
 - Humidity
 - Stability tests

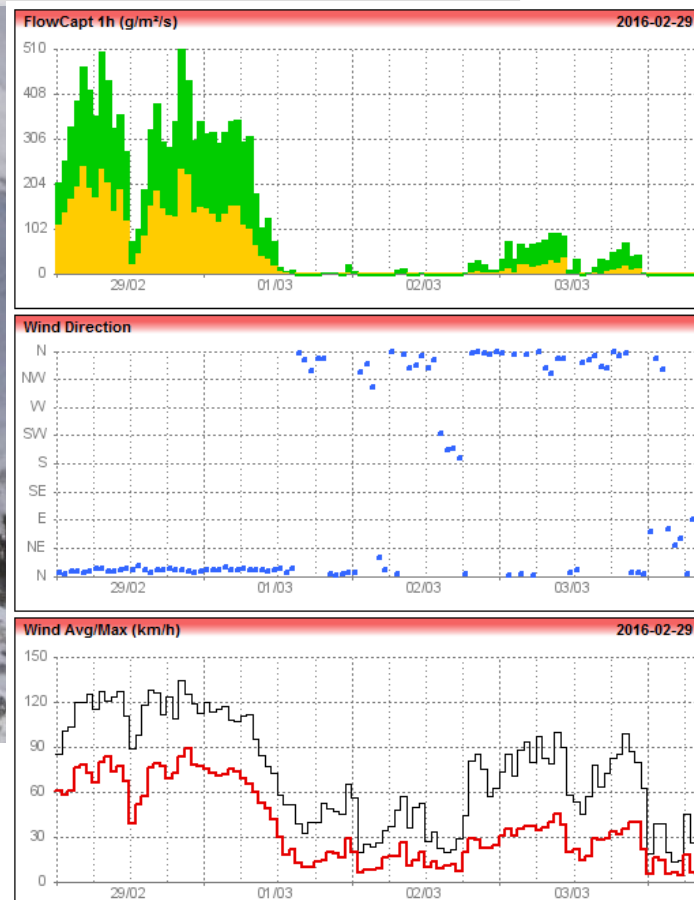
Snowpack measurements

Automatic Weather Stations

AWS

Snow variables:

- Snow depth
- Snow precipitation
- Snowpack thermal gradient
- Snow drift transport (Flow-cap)



Availability:

- 1996-97 / 2015-16

Snowpack measurements

FLOODS DUE TO RAIN ON THE SNOW

- How deep can rain percolate?
- How much mass of snow can melt?

WHICH OBSERVATIONAL METHOD???



Other scopes



THANK YOU FOR YOUR ATTENTION



**Institut Cartogràfic i Geològic
de Catalunya**

Parc de Montjuïc,
E-08038 Barcelona

41°22'12" N, 2°09'20" E (ETRS89)

🌐 www.icgc.cat

✉ icgc@icgc.cat

🐦 twitter.com/ICGCat

📘 facebook.com/ICGCat

Tel. (+34) 93 567 15 00

Fax (+34) 93 567 15 67