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Ground thermal regime in the atlantic high mountain. The central massif of Picos de Europa (Spain)

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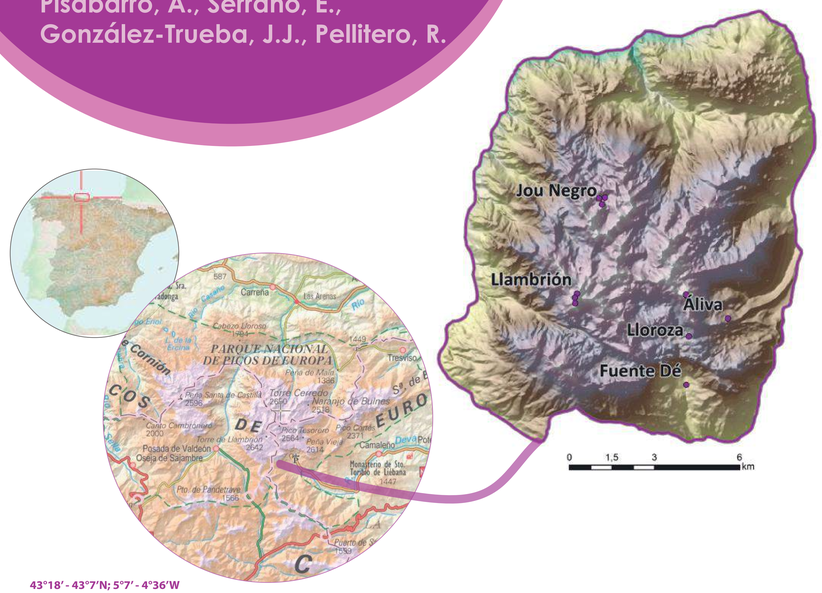


43°18' - 43°7'N; 5°7' - 4°36'W

CENTRAL MASSIFF OF PICOS DE EUROPA

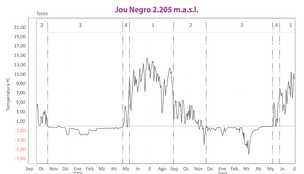
The central massiff of Picos de Europa (NW of Spain) is the most elevated massiff in the Cantabrian Mountains. It is a rugged mountain with a surface of 150 km2 isolated by deep gorges. The massiff is shared between Cantabria, Asturias and León provinces. The steep relief is composed by huge towers and deep holes called "jous" in the asturian language. The towers are aligned in groups. Lithology is calcareous with thickness of limestone upper 2000 meters. Precipitation is strong over 1900 mm because the sea is very near. The snow is the most important climatic factor and starts karstic process. The snow in combination with thermal phenomena like gelifraction erode the ancient glaciar surface. The result is a landscape of naked rock.

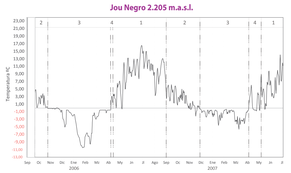
TERMOMETERS LOCATION

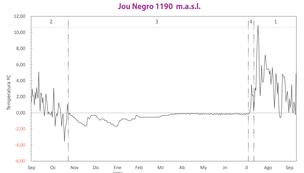
	LLAMBRIÓN	JOU TRASLLAMBRIÓN	JOU TRASLLAMBRIÓN
ALTITUDE (m.a.s.l.)	2.535	2.490	2.360
COORDINATES	43º 10' 24.97" N | 4º 51' 18.65" W	43º 10' 33.27" N | 4º 51' 14.65" W	43º 10' 44.73" N | 4º 51' 11.72" W
PERIOD	20/9/05-14/5/2007	20/9/05-14/5/2007	20/9/05-14/5/2007
DEPTH	10 cm	10 cm	10 cm
ORIENTACIÓN	N	N	N
LITHOLOGY	Limestone	Limestone	Limestone
SHAPE	Threshold with moraine sediments	Threshold with moraine sediments	Debris slope
SEDIMENT	Till dispersed	Till dispersed	Coarse sediment
	JOU NEGRO	**JOU NEGRO**	**JOU NEGRO**
ALTITUDE (m.a.s.l.)	2.205	2.155	2.190
COORDINATES	43º 12' 10.05" N | 4º 50' 59.68" W	43º 12' 7.84" N | 4º 51' 7.59" W	43º 12' 7.43" N | 4º 51' 9.17" W
PERIOD	20/9/2005-14/7/2007	20/9/2005-14/7/2007	13/9/2006-25/12/07
DEPTH	10 cm	10 cm	10 cm
ORIENTACIÓN	N	N	N
LITHOLOGY	Limestone	Limestone	Limestone
SHAPE	Debris slope	Moraine	Moraine with ordered ground
SEDIMENT	Heterometric sediment	Till	Till
	JOU NEGRO (Surface)	**PEÑA VIEJA**	**PEÑA VIEJA**
ALTITUDE (m.a.s.l.)	2.190	2.510	2.325
COORDINATES	43º 12' 7.43" N | 4º 51' 9.17" W	43º 10' 29.23" N | 4º 48' 38.09" W	43º 10' 31.21" N | 4º 48' 43.82" W
PERIOD	13/9/2006-25/12/07	21/09/03-29/10/04	21/09/03-10/05/2005
DEPTH	0 cm	10 cm	10 cm
ORIENTACIÓN	N	NW	NW
LITHOLOGY	Limestone	Limestone	Limestone
SHAPE	Moraine with ordered ground	Top debris cone	Small sinkhole
SEDIMENT	Till	Homometric thin texture	Heterometric debris slope
	LLOROZA	**ÁLIVA**	**FUENTE DÉ**
ALTITUDE (m.a.s.l.)	1.865	1.735	1.115
COORDINATES	43º 9' 35.4" N | 4º 48' 43.32" W	43º 11' 39.71"N | 4º 46' 17.06"W	43º 8' 56.76" N | 4º 48' 35.27" W
PERIOD	20/9/2005-14/7/2007	20/9/2005-14/7/2007	20/9/2005-14/7/2007
DEPTH	10 cm	10 cm	10 cm
ORIENTACIÓN	N	N	N
LITHOLOGY	Limestone	Shales	Limestone
SHAPE	Moraine	Regularized slope	Debris cone
SEDIMENT	Till	Thin texture	Debris sediment

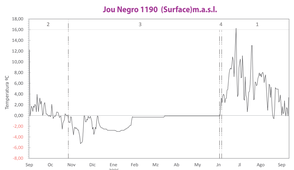
THERMAL REGIME PHASES

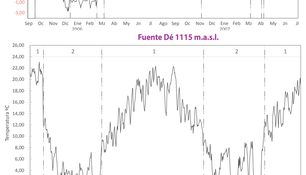
1. High temperature phase in summer and start of Autumn Ground in contact with atmosphere T> 0ºC always
2. Inestability and high thermal oscilation. First snowfalls but atmospheric influence. Freeze & thaw cycles
3. Isothermal phase. The snow cover isolate the ground and the daily thermal oscilation is hardly null. T<0ºC always
4. Thaw phase. Quick episode (end Spring/ beginning summer). The snow cover disapears quickly and T increase in a few days











JOU NEGRO

JOU TRASLLAMBRIÓN

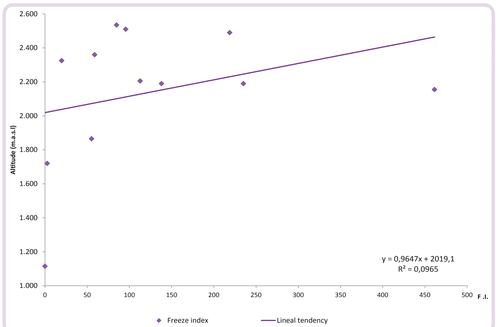
PEÑA VIEJA

ÁLIVA

LLOROZA

FUENTE DÉ

ALTITUDE - FREEZE INDEX RELATION, DURATION AND DEPTH OF FREEZE



There is no correlation between altitude and Freeze Index

$$F.I. = \int_{t0}^{t1} |T|\,dT\,|;Ti < 0^{\circ}C = \sum_{i=1}^{n} |Ti|;Ti < 0^{\circ}C$$

(Fengquing and Yangwei, 2011)

The freeze depth in Jou Negro with 461,34 (Freeze Index) according the Washburn (1979) equation and heterometric sediment of till is aproximately 0,5 meters.

$$x(m) = \sqrt{\frac{2 * K * I_h}{C_L}}$$

K (Kcal*h-1*m-1*ºC-1);
CL (Kcal *m-3); Ih (ºC).

Location	Altitude	Year	Days T < 0ºC	%	Days Tª <-2ºC	%	Freeze index	T°C (Phase 3)	Seasonal Frozen Ground
Llambrión	2.535	2006	217	59,5	0	0,0	84,77	-0,5 to 0	Posible
Peña Vieja	2.510	10/2003- 10/2004	146	40,0	17	4,7	95,62	-1 to 0	Posible
Jou Trasllambrión	2.490	2006	234	64,1	2	0,5	218,71	-1,5 to -0,3	Yes
Jou Trasllambrión	2.360	2006	238	65,2	0	0,0	58,83	-0,5 to 0	Posible
Peña Vieja	2.325	2004	230	63,0	0	0,0	19,74	-0,2 to 0,2	Posible
Jou Negro	2.205	2006	121	33,2	2	0,5	112,75	-1,5 to -0,5	Yes
Jou Negro (Surface)	2.190	11/2005-11/2006	277	75,9	1	0,3	138	-2,5 to -0,1	Yes
Jou Negro	2.190	11/2005-11/2006	238	65,2	65	17,8	235	-1,1 to -0,1	Yes
Jou Negro	2.155	2006	176	48,2	63	17,3	461,34	-8,5 to 0	Yes
Lloroza	1.865	2006	79	21,6	2	0,5	55,17	-0,7 to 0,5	Posible
Áliva	1.720	2005	34	9,3	0	0,0	2,64	0 to 0,5	Posible
Fuente Dé	1.115	2006	0	0,0	0	0,0	0		Imposible

FREEZE & THAW DAILY CYCLES

	Alt	Jan	Feb	Mar	Apr	May	Jun	Jul	Ago	Sept	Oct	Nov	Dec	Total	year useful
Llambrión	2.535							1		1	2	2	9	15	2006
Peña Vieja	2.510					5						3	1	9	10/2003- 10/2004
Jou Trasllambrión	2.490							1			1	6		8	2006
Jou Trasllambrión	2.360							1	2					3	2006
Peña Vieja	2.325	13		1				1						15	2004
Jou Negro	2.205					5						3	2	10	2006
Jou Negro (Superficie)	2.190							1	2	5	8	14	4	34	11/2005-11/2006
Jou Negro	2.190	4							4	4	10	14	4	40	11/2005-11/2006
Jou Negro	2.155				4	4						6	4	18	2006
Lloroza	1.865			7									1	8	2006
Áliva	1.720	1	1	3	1									6	2005
Fuente Dé	1.115													0	2006
Total		**18**	**2**	**10**	**5**	**14**	**0**	**5**	**8**	**10**	**21**	**48**	**25**		

CONCLUSIONS

1. Temperature regime depends on thickness and duration of snow cover. The snow stops the thermal oscilation during 4 to 8 months according to topoclimatic conditions in each location
2. Above 1700-1800 m.a.s.l. was imposible to determinate altitudinal gradient of minimun temperature. The freeze index is high in some locations where is sure the seasonal freeze soils. Mean minimun temperature in winter below -2ºC in Jou Negro and -1ºC in Jou Trasllambrion. The existence of permafrost is unlikely.
3. The month with more freeze and thaw cycles is November. In second place is December. The reason is that the Northeast Artic Cold without big snow cover produce the highest daily oscilations. The autumn is the period of the year with more periglaciar activity.
4. The study of thermal conditions in stepped locations can be useful in the deglaciated rocky mountain where the cold and the snow are the key to understand the morphodinamic. This study is a basical research that pretend to serve to future thermal map of massiff and researchs about risk of rockfalls.