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Seasonal frost conditions and permafrost regime distribution in the high lands of Sierra Nevada (Spain)

Marc Oliva (1), Antonio Gómez-Ortiz (2), Ferran Salvador-Franch (2), Montserrat Salvà-Catarineu (2), David Palacios (3), Luis Miguel Tanarro (3), and Miguel Ramos (4)

(1) University of Lisbon, Institute of Geography and Spatial Planning - Centre for Geographical Studies, University of Lisbon, Lisbon, Portugal, (2) Department for Physical and Regional Geography, University of Barcelona, Spain, (3) Department for Regional and Physical Geography, Complutense University of Madrid, Spain, (4) Department of Physics, University of Alcalá, Spain

Sierra Nevada, Southern Spain (37ºS, 3ºW), is the massif including the southernmost permafrost remnants in Europe. Over the last decades the distribution of permafrost in this massif has been examined through a combined approach including geomorphological, geophysical and monitoring studies. The purpose of this communication is to summarize all the studies relating to soil thermal regime in the high lands of Sierra Nevada.

A 114.5 m deep borehole was drilled in 2000 in the Veleta summit (3380 m) in order to monitor soil temperatures in the summits of the massif. No permafrost regime was detected, with average temperatures stabilizing at 20 m depth at 2 ºC.

Seasonal frost conditions were also detected in periglacial landforms such as solifluction lobes and sorted-circles. In the Rio Seco cirque the mean annual temperatures in a solifluction lobe located in a southern glacial cirque of the massif (3005 m) were 3.9 ºC at 1 m depth between 2006 and 2012; in the north-exposed San Juan valley, soil temperatures in another solifluction landform (2864 m) were 3.9 ºC at 1 m depth between 2003 and 2012. In a sorted-circle located in the high plateau of Cerro de los Machos (3297 m) soil temperatures recorded an average of 1.7 ºC at 50 cm depth between 2003 and 2011.

The only place where temperatures were permanently negative was inside of the only active rock glacier distributed in the Veleta cirque, on the northern slope of the Veleta peak. Here, the remnants of a small glacier that existed during the Little Ice Age (LIA) are still present in the form of buried ice and permafrost buried under the boulders of this rock glacier. Temperatures averaged 0.2 ºC at 1 m depth between 2006 and 2013, with permanently negative temperatures below this level until, at least, 10 m depth.

Consequently, seasonal frost is widespread nowadays in most of the Sierra Nevada, with permafrost conditions strongly conditioned by the geomorphological setting and the recent environmental history. Therefore, only small areas in the highest northern cirques where small glaciers existed during the LIA show now patchy permafrost occurrences.