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Abrupt decay of underground cryosphere driven by increasing extreme weather events in the Southeastern European Alps

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In 2011 a long term mass balance monitoring of ground ice deposits located in the Italian Julian Alps (Southeastern Alps, Europe) has been initiated. Fixed benchmarks allow measuring the congelation ice floor and collecting information about surface ablation in a karstic cave interested by permanent ice deposits. The ice surface in the ice cave remained rather undisturbed until it was deeply engraved by a number of single severe weather events that occurred in the late fall of 2012 and 2014.
A rather constant annual cycle characterized by Autumn minima and Summer maxima, with variation in the order of 2-3 cm, was observed in a site located in the most internal part of the cave. A general slight increase trend was observed until 2014 when a dramatic ice surface decrease of 9 cm was recorded between 22 July and 20 November. In 2015, during a Summer visit, a further ice surface decrease of 1.4 cm was measured despite the usual positive mass balance observed at that period of the year.
The most external benchmark showed a similar pattern compared to the inner one, but a general decrease trend was already observed since 2013. Between 22 July and 20 November 2014 the same decrease was measured (9 cm), but 4.2 cm of lowering were also detected between 12 July and 30 October 2013. These events produced a melting hole considerably deepened by the late-fall-2014 event and a bedières 0.8 m to 1.0 m deep and 15 cm to 35 cm wide formed. The total ice decrease since 1 September 2011 is equal to 11 and 18.4 cm at the internal and close-to-the-entrance benchmarks, respectively.
A close influence of global and local climate change in the evolution of such ice deposits is pointed out in this work. Over the last three decades (1981-2010), a thermally driven moisture increase has significantly contributed to the global intensification of extreme rainfalls and MAAT in the Julian Alps increased by about 1.4°C between 1983 and 2012.
Indeed, heavy precipitation events in Autumn are common in the area, but a higher than average melting level produces heavy rainfalls at altitudes normally interested by snowfalls.
The natural feedback of the ice cave's mass balance in a warming climate and the forecasted increase of extreme weather events in the following decades, especially in regards to warmer and more intense rainfalls caused by higher 0°C isotherm, will be crucial in the future mass balance evolution of permanent ice cave deposits in the alpine area.