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Mass balance and surface dynamics of Montasio Occidentale glacier (Eastern Italian Alps) investigated by Terrestrial Laser Scanner

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Both Terrestrial Laser Scanner (TLS) and Airborne Laser Swath Mapping technology (ALSM), using LiDAR (Light Detection And Ranging) technology, provide high resolution topographic data with notable advantages over traditional survey techniques. This technology found increasing application on glaciers in the last decade, since it provides detailed information for geomorphological mapping, mass balance investigations and multi-temporal analyses. In this work we present an application of TLS to a small, low-altitude glacier of the Julian Alps (Eastern Italian Alps), with the aim of assessing its mass balance and its surface velocity.
The Montasio Occidentale glacier was surveyed in three different dates by means of a TLS, in order to evaluate the winter balance, the summer balance and the annual net balance by differencing Digital Terrain Models (DTM). Surveys were carried out on 23 September 2010, 31 May 2011 and 29 September 2011. At the same time we did density measurements in snowpits, in order to convert the surface elevation changes into water equivalent quantities. The TLS was integrated by a high-resolution digital camera, that provided RGB values to the surveyed point cloud, thus enabling the automatic classification of substrata (snow, firn, ice and debris).
In may 2011 the glacier was completely covered by seasonal snow, with an average depth of 7.5 m (4.1 m w.e.). This remarkable snow depth is due to the concentration of snow by avalanches, and explains how an active ice mass like Montasio Occidentale glacier can survive at an average altitude of only 1940 m a.s.l. in the European Alps. However, the average elevation change from September 2010 to September 2011 was -0.7 m (0.6 m w.e.), indicating a negative annual mass balance, due to a long a warm ablation season. At the end of summer 2011 the glacier was still covered by snow in its upper part, but in the middle area firn from previous years emerged and strongly melted. The lower part of the glacier was completely buried by debris, as was observed in previous years. The high resolution DTMs acquired by TLS enabled the detection of the small surface velocities which characterize this area (few decimeters per year), by measuring the displacement of debris from September 2010 to September 2011. This rate of displacement is more typical of rock glaciers than of glaciers, and testify the present low activity of the Montasio glacier.