Geophysical Research Abstracts
Vol. 16, EGU2014-5142-3, 2014
EGU General Assembly 2014

Glacier monitoring by a dense network of single-frequency GPS receivers

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The measurement of temperate glaciers surface deformations using GNSS provides crucial data for the understanding of the dynamics of those glaciers. The amplitude of the movements makes the observation theoretically easy, but the field conditions are often difficult. A dense network of stations is necessary to measure the spatial heterogeneities of the displacements, with also a sufficiently high sampling rate to precisely detect velocity variations. Moreover the sensors need to be sufficiently rugged to overcome the harsh meteorological conditions.
During the autumn 2013, we installed on the downstream of the Argentière glacier, in the the Mont-Blanc massif (French Alps), an array of eleven single-frequency GPS receivers developed by the French National Mapping Agency (IGN) called "Geocubes". The glacier covers a 19 km^2 area and has a length of 10 km but our array was limited to a 600 m * 400 m area about 1 km upstream of the Lognan serac fall marking the lower end of the main glacier. Two additional reference receivers were located on the stable bedrock near the glacier shores.
Here is presented the methodology for data processing and the way to achieve high rate and high spacial resolution thanks to a kinematic computation at sub-centimeter level precision. It includes a Kalman filtering allowing epoch by epoch coordinates determinations. We found a mean velocity of the stations on the glacier of around 15 cm/day with variations that can take place in a few hours and reach 50% of the magnitude of the average velocity. The velocities appear to be strongly correlated with meteorological parameters, especially rainfall and air temperature. Moreover a deformations map derived from the heterogeneous measured displacements shows a clear correlation between extension areas and the crack areas edgeways the glacier.