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Coupling GB-SAR and visual photography for 3D modelling of an Alpine glacier surface kinematics

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We present the 3-dimensional modelling of a glacier kinematics, obtained by coupling the results of two monitoring campaigns, simultaneously collecting data from two different and independent remote sensing devices, focused on the surface deformation of the Planpincieux glacier, on the Italian side of the Mont Blanc massif.
The analysed period lasted 25 days and occurred in correspondence of the beginning of the Alpine cold season. The unstable weather conditions, affecting both the monitored surfaces and the signal propagation, demanded an accurate understanding of the atmospheric effect and the development of a specific correction procedure for radar data.
The considered devices are a low-cost optical photography station (OPS) and a ground-based synthetic aperture radar (GB-SAR).
The OPS is placed frontally to the glacier surface and measures the daily motion components orthogonal to the line of sight (LOS). The processing is performed through spatial cross-correlation between consecutive images, acquired at the same hours to limit shadow effects. The images are orthorectified on a 1 m-resolution digital surface model (DSM) of the glacier and a pixel-to-metric conversion is performed.
The GB-SAR acquires data every 16 minutes. The GB-SAR location is decided aiming at maximising the parallel condition to the LOS and the estimated direction of the main flow.
The main processing steps include i) a coherence-driven pixel-selection criterion to identify glacier areas, ii) 2D unwrapping algorithm, iii) atmosphere phase screen (APS) filtering with a newly 2D polynomial model, function of the elevation. The radar maps are also georeferenced on the DSM.
Finally, from the 3 different components of the glacier surface motion it is possible to reconstruct the actual deformation vector. The results are mapped on the DSM.
The proposed method allows to determine the evolution of the 3-dimensional kinematics of the observed surface; it can be applied in general to the gravitational processes.