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Intra-annual velocity variability extracted from multi-sensor and multi-temporal datasets produced by different processing chains

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Ice velocity products with a sub-annual resolution are needed to better understand subglacial hydrology, glacier instabilities and glacier response to short-term events, such as calving or increased melt. Different processing chains are now releasing scene-pair velocities worldwide (ITS_LIVE, GOLIVE, RETREAT, PROMICE, MEaSUREs, Millan et al., 2019). Their temporal resolution is up to 2 days and their spatial sampling up to 50 m. However, analysing the sub-annual variability of glacier dynamics on a global scale remains challenging. Indeed, the amplitude of the velocity at high temporal resolution is frequently smaller than the uncertainty in many areas. In addition, the available datasets are complex to use because the velocities span different temporal baselines, are derived from images from different sensors, and are computed using different correlation and post-processing parameters. The methods developed to post-process ice velocities usually select only a subset of the datasets, require strong a priori knowledge of glacier velocities, remain sensitive to systematic errors and/or have not been validated for different glacier dynamics. Therefore, there is a need to develop and validate an operational method able to fully exploit the available ice velocity datasets in order to provide homogeneous and robust sub-annual velocity time series.

Here, we propose a method based on the temporal closure of the displacement measurement network. To be robust to both systematic and random errors (e.g., temporal decorrelation and random noise), we invert the system using an iterative reweighted least square with a robust downweighting function. We propose a regularisation strategy that can account for different glacier dynamics (e.g., normal vs. surge flow). The performance of the method is evaluated using GNSS stations in the Yukon (Canada) and the European Alps. The resulting velocity time series have a homogeneous temporal sampling and reduced uncertainty (up to 60%). Annual velocity peaks are retrieved with a Mean Absolute Error in the order of 10 to 30 days, and 1 to 40 m/y. The results reveal the spatio-temporal propagation of annual velocity peaks and glacier surges along glacier centerlines. This method can be applied to any available dataset. The code will be published in a github repository.