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Temporal Stacking of Cross-Correlation for Glacier Offset Tracking

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Offset tracking is one of the most widely applied methods for measuring glacier flow velocities using remote sensing data. It uses the pair-wise cross-correlation of images acquired at two different times to detect offsets between image templates of a certain size. Despite the simplicity and reliability of the method, accurate estimations of glacier velocities are limited by the accountability of features and the noise, e.g. radar speckles in synthetic aperture radar (SAR) images. One way of gaining robust estimations is to increase the size of image templates, but the resolution of obtained velocity field is inevitably depreciate. Furthermore, for templates that only contain extremely weak features with respect to the noise, increasing the size of templates is not helpful as the noise is boosted more than the features.

To overcome these issues, we propose a temporal stacking algorithm that first averages a time series of local cross-correlation functions calculated from a series of consecutive image pairs, and then estimates the averaged velocity from the stacked cross-correlation functions. Assuming the flow velocity of a glacier is constant during a certain time span (e.g. a season), the offsets between consecutive image pairs in the time series ought to be equal. Therefore, the cross-correlation functions can be considered as a time series of signals that record the identical offsets and thus are temporally coherent. Hence, we can temporally stack the signals to enhance the signal-to-noise ratio (SNR) of cross-correlation functions and better estimate offsets from the stacked cross-correlation functions.

The proposed algorithm is assessed by mapping the flow velocity of the Aletsch Glacier using a time series of about 10 SAR images acquired by TanDEM-X in 2017 with constant revisit time of 11 days. The results show that temporal stacking of cross-correlation functions significantly enhances the spatial coverage and resolution of the obtained velocity fields compared to standard offset tracking using only pair-wise cross-correlation functions. This algorithm promotes the ability of mapping glacier velocities to a new extent with larger spatial coverage and higher spatial resolution, and provides a new perspective of measuring glacier velocities through exploiting the emerging time series data from recent high resolution space-borne imaging sensors.