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Ice flow dynamics and mass balance of Vatnajökull outlet glaciers observed by X-band SAR Data

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Several outlet glaciers of the major ice caps in Iceland are affected by sub-glacial outburst floods, so-called jökulhlaups. Sources of these outbreaks are water accumulations beneath the glacier due to geothermal or volcanic activity. One component of the project NorthHydrology, carried out within the ESA STSE (Support to Science Element) programme, addresses techniques and applications of satellite data for studying drainage mechanisms and water outbreaks of sub-glacial lakes in Iceland. Such events are usually related to surface deformation and changes in ice velocities, sometimes occurring already well ahead of the peak of the flood wave. High resolution repeat pass SAR data are able to deliver spatially detailed information on surface motion and displacement, which are highly relevant for advancing the understanding of glacier hydraulics and jökulhlaup processes.
A template matching technique is applied to data stacks of TerraSAR-X and Cosmo-SkyMed amplitude images acquired between summer 2008 to summer 2010 in order to study the ice dynamics and mass balance of outlet glaciers of Vatnajökull in Iceland. This technique requires distinct and stable surface features, as usually available on ice surfaces of glaciers. Main outlet glaciers, investigated in the project, are Breidamerkurjökull and Skeiderarjökull, with the fronts terminating close to the coast. The lower terminus of these glaciers exhibits significant melting during summer, and sometimes even during winter. At these glaciers in-situ data on ice velocity and surface elevation changes have been recorded at in situ GPS stations, operated by University of Iceland. The ice motion field was derived using ascending and descending repeat pass SAR images. In order to retrieve the 3D ice motion vector, effects of surface melt are taken into account by modelling the ablation. Combining maps of displacement shifts from ascending and descending passes and compensating for surface lowering due to melt, maps of the vertical elevation changes and the horizontal ice velocity are obtained. Ice velocity maps and ice elevation changes supply key information on the dynamic response to changing boundary conditions related to subglacial water accumulations and outbreaks, as well as to glacier mass balance.