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Geodetic glacier mass balancing on ice caps - inseparably connected to firn modelling?

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Observed melting of glaciers and ice caps in the polar regions contribute to the ongoing global sea level rise (SLR). A rising sea level and its consequences are one of the major challenges for coastal societies in the next decades to centuries. Gaining knowledge about the main drivers of SLR and bringing it together is one recent key-challenge for environmental science. The high arctic Svalbard archipelago faced a strong climatic change in the last decades, associated with a change in the cryosphere.

Vestfonna, a major Arctic ice cap in the north east of Svalbard, harbors land and marine terminating glaciers, which expose a variability of behavior. We use high resolution remote sensing data from space-borne radar (TanDEM-X, TerraSAR-X, Sentinel-1a), acquired between 2009 and 2015, to estimate glacier velocity and high accurate surface elevation changes. For DEM registration we use space-borne laser altimetry (ICESat) and an existing in-situ data archive (IPY Kinnvika). In order to separate individual glacier basin changes for a detailed mass balance study and for further SLR contribution estimates, we use glacier outlines from the Global Land Ice Measurements from Space (GLIMS) project.

Remaining challenges of space-borne observations are the reduction of measurement uncertainties, in the case of Synthetic Aperture Radar most notably signal penetration into the glacier surface. Furthermore, in order to convert volume to mass change one has to use the density of the changed mass (conversion factor) and one has to account for the mass conservation processes in the firn package (firn compaction). Both, the conversion factor and the firn compaction are not (yet) measurable for extensive ice bodies. They have to be modelled by coupling point measurements and regional gridded climate data.

Results indicate a slight interior thickening contrasted with wide spread thinning in the ablation zone of the marine terminating outlets. While one glacier system draining to the north west shows re-advance and possibly surge evidence, the majority of the outlets draining south- and eastwards are in stable or retreating dynamic conditions. Only two southern outlet glaciers speeded up between 2009 and 2015.

We target measurement uncertainties by using in-situ missions as well as further comparable space-borne sensors. The mass conversion factor ('dhdt-problem') and the compaction processes are estimated by an pythonic offline firn compaction model (FCM) which is forced with Regional Climate Model (RCM) data. The RCM data and the FCM output are validated against an in-situ data archive.