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Surface topography and massflux of the Antarctic ice sheet in western Dronning Maud Land, derived by differential SAR interferometry

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Considerations on mass balance in Antarctica are of high interest in recent debates about the influence of the cryosphere and its response to climate change. Antarctica plays an important role in the earth's overall radiation budget, the development of the mean sea level, and, as an excellent climate archive, it enables paleoclimatic research and improved understanding of the climate system. In order to address those questions, a detailed knowledge of the ice sheet's topography and its dynamics is crucial.

Space borne interferometric synthetic aperture radar (InSAR) offers high resolution mapping of displacement fields with large spatial coverage. For this process, a detailed digital elevation model (DEM) with both vertical and horizontal resolution is needed. Since the existing DEMs in the study area of western Dronning Maud Land have a relatively crude resolution, we derived a new DEM through a differential InSAR approach (DinSAR) in combination with new IceSAT laser altimeter data. For the processing we used a commercial software package. The calculated displacement fields were combined with ice thickness maps from an airborne Radio Echo Sounding system to measure the mass flux into the Ekströmisen ice shelf as well as to estimate the accumulation rate on the higher elevated areas by means of mass conservation.

The newly deduced DEM was compiled from acquisitions of the European Remote Sensing Satellites ERS-1 and ERS-2 from 1994 to 1996, where 116 scenes have been used. The spatial extent is approximately 135 thousand square kilometres. In large areas of the mosaicked DEM stacking of up to 19 independently derived DEMs was possible in order to reduce noise. The concurrently received difference field does not show systematic deviations apart from the south-eastern area, where we believe that atmospheric conditions are responsible for a larger error. The comparison of the DEM with additional IceSAT data and available GPS measurements on a 50x50 meter grid revealed the accuracy to be approximately 7 meters in areas of high coherence, which makes it a high quality DEM in both vertical and horizontal dimension. We allocated errors both due to physical parameters, as for example a varying penetration depth and an unknown atmospheric contribution, and errors due to an imprecise processing. The latter becomes evident when comparing overlapping parts of adjacent frames originating from the same raw data.

By a combination of ascending and descending orbit, fully 3D-velocity fields were used for the mass flux estimate. An estimate for accumulation was derived by calculating the divergence of mass flux in a closed box within the velocity field. A positive divergence is attributed to accumulation, a negative to ablation in the respective area. Limiting factors are the unknown horizontal velocity profile with depth and the availability of highly resolved ice thickness maps. However, a comparison of our results with a new accumulation map from in situ data shows good agreement.