Glacier calving front extraction from TanDEM-X DEM products of the Antarctic Peninsula

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The Antarctic Peninsula (AP) is one of the most dynamic Polar regions and is experiencing fast mass loss. In order to quantify the mass changes of the AP and the associated sea level rise, an accurate estimate of its contemporary mass change is essential. The calving front location (CFL) is one important parameter to measure the geodetic mass balance or the dynamic mass loss of outlet glaciers. In order to quantify the mass change of Antarctic Peninsula glaciers on regional or individual glacier scales, the CFL with high spatial resolution is required. Because the Antarctic Peninsula has long, narrow coastlines, it is extremely time-consuming to delineate the detailed CFL from optical or SAR remote sensing images manually. Furthermore, it is also challenging for automatic algorithms to detect the whole glacier calving front line of AP considering the similarity of spectral and backscattering response of sea ice, grounded ice and mélange. Currently the most up-to-date coastal product covering the entire AP, which is provided by the Antarctic Digital Database (ADD), is manually delineated with all of the available remote sensing imagery acquired in various years. A frequently updated CFL product for the entire AP coastline is not available.

Therefore, we propose an efficient method to extract the current coastline of AP from bi-static TanDEM-X DEM products, including the 12 m TanDEM-X global DEM and newly processed RawDEMs with a precise time stamp. The CFL between grounded ice or ice shelves and the ice mélange or open water is characterized by strong elevation gradients. Besides, the grounded ice and the ice shelf show smoother and more continuous elevation values in the TanDEM-X DEM while the ice mélange and open water are noisier. Hence the ice mélange at the CFL may look similar to grounded ice or ice shelves in optical and SAR images but can be distinguished in the TanDEM-X interferometric DEM. In our work, we combine elevation and elevation gradient information to separate grounded ice/ice shelves and ice mélange. Afterwards, terrain analysis and morphological operations are applied to remove the residual ice mélange pixels in the segmented image.

The TanDEM-X global DEM covering AP is a consistent, timely and high-precision DEM, which was generated from the bistatic InSAR data acquired by the TanDEM-X mission during austral winters 2013 and 2014. Thus our coastline of AP extracted from the 12 m TanDEM-X global DEM will correspond to the CFL of outlet glaciers of years 2013/2014. Furthermore, the CFL extracted from
TanDEM-X RawDEMs with a particular time stamp can be used for geodetic mass balance calculation during different time periods. The extracted glacier calving front line reveals the potential of the high resolution height information in assisting the separation of grounded ice/ice shelf and ice mélange. The resulting glacier calving front line product of AP will be validated with the geocoded TanDEM-X backscattering amplitude images acquired at the date closest to the time stamp of the DEM tile and with the Antarctic coastline provided by the ADD.