Surface velocities in the vicinity and hinterland of the Neumayer III station (Antarctica)

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GATEWAY ANTARCTICA

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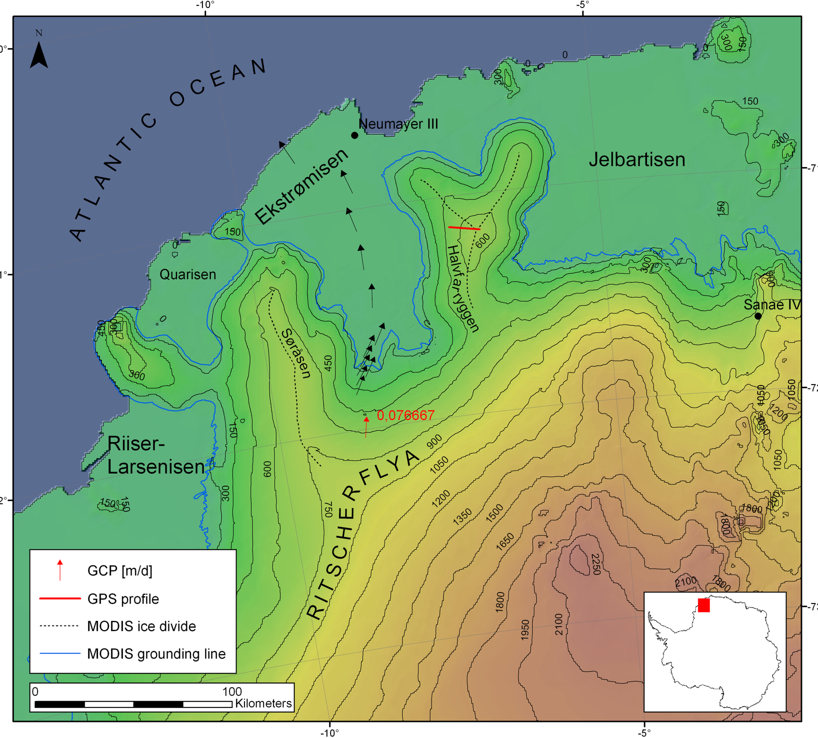

Figure 1: Region of interest, hinterland of the German overwintering station Neumayer III. The red arrow marks the GCP which was used for velocity adjustment.

Introduction: Surface velocities of grounded ice are an important input parameter for mass flux calculations and ice-sheet modelling. As on-site measurements in remote areas are sparse, satellite-based measurements have to be used to obtain area-wide surface velocities. For this purpose synthetic aperture radar data from various sensors are routinely employed. Depending on the availability of adequate SAR image pairs, the surface velocity can be derived by radar interferometry. The accuracy of the applied method heavily depends on external input parameters (e.g. elevation model) and the processing history. In this case study ERS satellite data from the ERS Tandem Mission and the Second Ice Phase was used to derivate three-dimensional surface velocities. The study focuses on the hinterland of the German overwintering station Neumayer III (Antarctica). We analyse the dependency of external elevation models for the interferometric approach by comparing surface velocities based on Antarctic-wide elevation models with surface velocities based on local elevation models (Drews et al. 2009). The main goal is to point out the inaccuracy/accuracy of surface velocity fields. As a geophysical product a preliminary map of surface velocities next to the German overwintering station Neumayer III is presented.

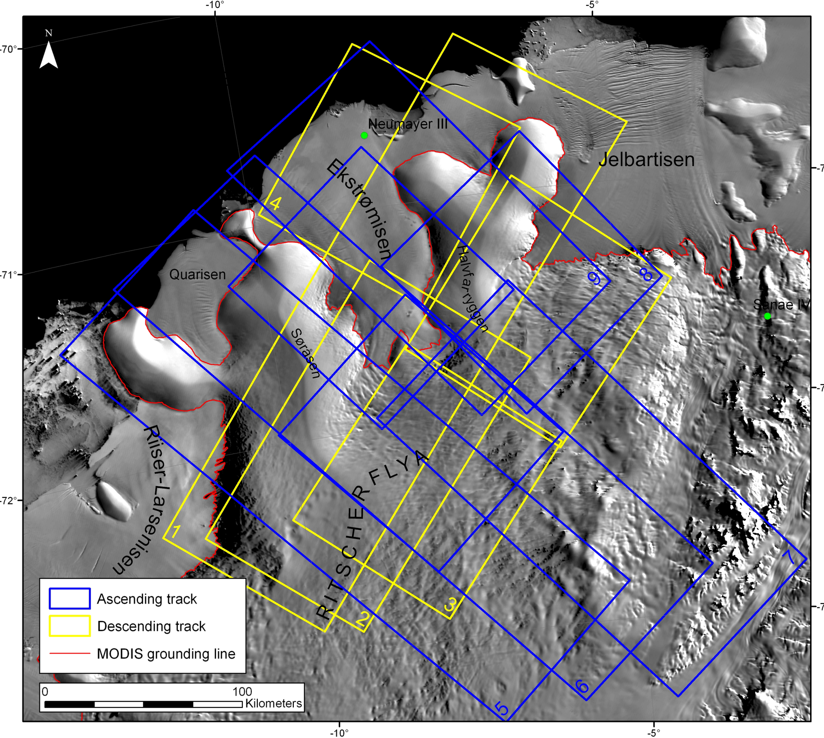

Figure 2: Available ERS satellite tracks for InSAR processing in the region of interest. Tracks and frames are listed in table 1.

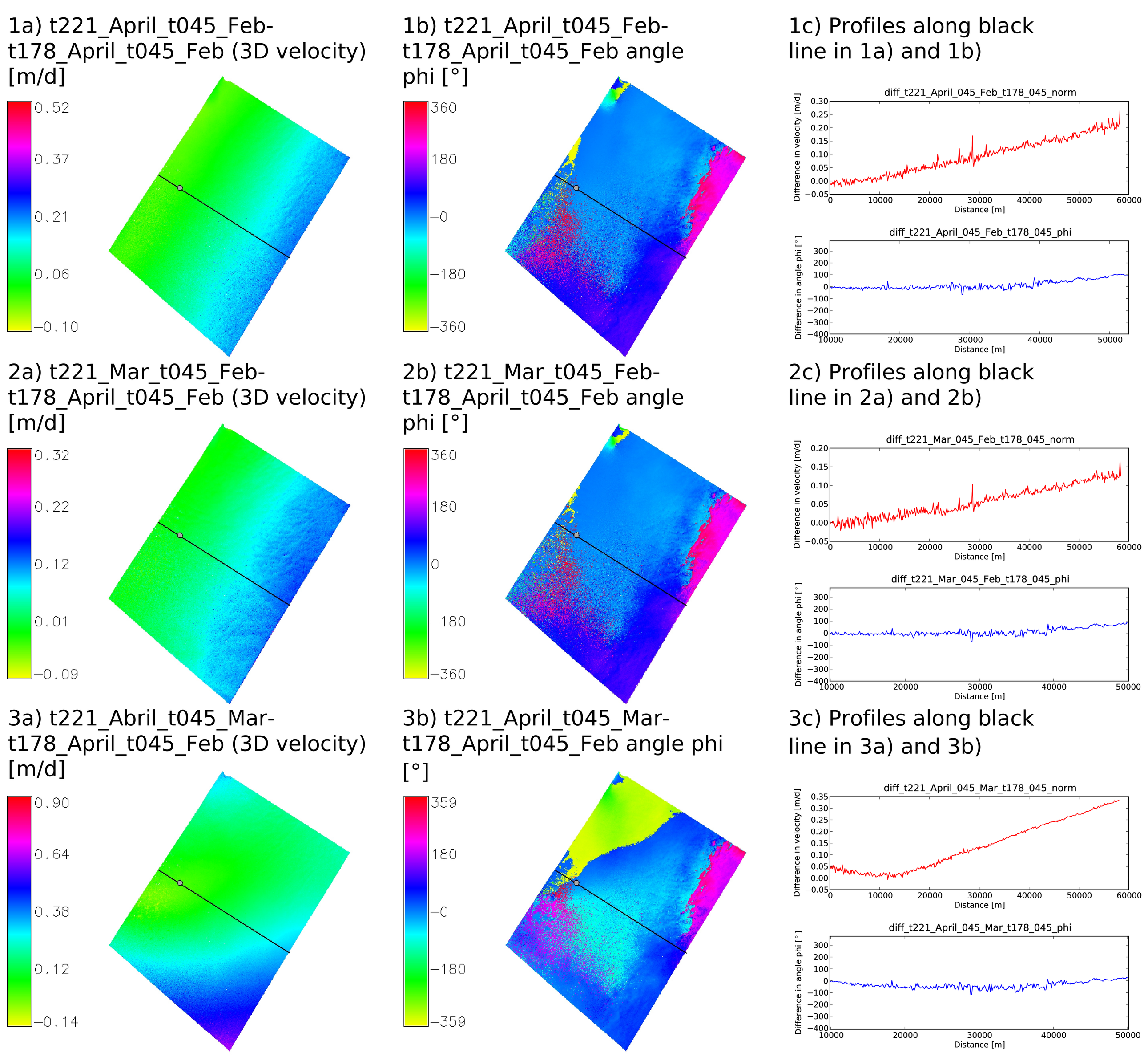

Figure 3: Deviation of ice flow in overlapping areas of three-dimensional velocity fields, as well as the deviation in angle ϕ, which represents the angle between the north direction and the calculated ice flow.

Method: The first step towards a three-dimensional velocity field is the generation of two interferograms, one from a descending satellite path and one from an ascending satellite path. An interferogram is created by differencing two SAR images holding information about the phase and the amplitude of the backscatterd signal. The generated interferogram holds information about the topography depending on the spatial baseline and the surface velocity depending on the temporal baseline. Once two interferograms are created they need to be isolated from topography by substracting a simulated 'topography-only' interferogram from external height data. As a 1D-velocity field only represents the velocity along the satellite's line-of-sight, the descending and ascending 1D-velocity fields are combined to form a three-dimensional velocity field after unwrapping the pure velocity interferograms. It turns out that the created velocity fields need to be corrected. In order to do this, the unwrapped phase was set to the X or Y component of the GCP point shown as red arrow in figure 1. The same GCP is shown as grey dot in figure 3. Figure 3 shows the differences in the overlapping area of two three-dimensional velocity fields as well as the differences in angle ϕ which is the angle between the north direction and the flow direction. As shown in table 1 the used SAR imagery is available for two time periods. In a first aproach the three-dimensional velocity field with the smallest deviation was taken for mosaicing three-dimensional velocity data as shown in figure 5.

Table 1: Available ERS satellite tracks as shown above.

Id	Track	Frame	Date	Pass
1	493	5121,5103,5085	18/19 Feb 1996	Descending
2	221	5121,5103	05/06 Mar 1996, 09/10 Apr 1996	Descending
3	178	5121,5103	06/07 Apr 1996	Descending
4	035	5085	12/13 Mar 1997	Descending
5	031	5661,5679,5697	06/09 Mar 1994 (2nd Ice Phase)	Ascending
6	045	5661,5679,5697	13/14 Mar 1997, 22/23 Feb 1996	Ascending
7	002	5661,5679,5697	15/16 Jan 1996	Ascending
8	188	5697	03/04 Mar 1996	Ascending
9	460	5697,5715	22/23 Mar 1996	Ascending

DEM comparison: For the simulation of the 'topography-only' interferogram the 'Antarctic wide 1 km DEM from combined ERS-1 radar and ICESat laser satellite altimetry' (Bamber 2009) and a local InSAR DEM (Drews et al. 2009) were taken into account. The preliminary results are shown in figure 5. Figure 4 illustrates the comparison of the two DEMs along a GPS measured elevation profile (Wesche, pers. communication) which is plotted as red line in figure 1. The local InSAR DEM leads to better results in this region, which can also be seen in the three-dimensional velocity fields in figure 5. The photoclinometry data which is plottet in figure 4 looks promissing, but is only available for small coastal areas as a lack of contrast is observed in more continental areas.

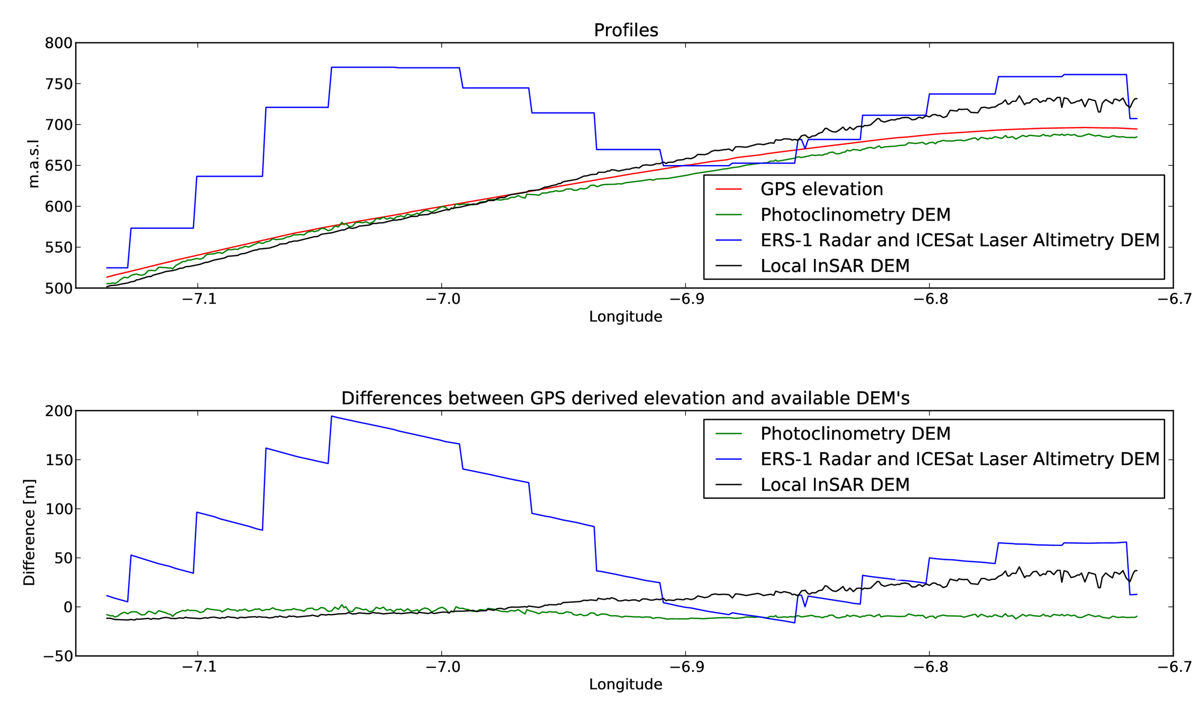

Figure 4: Comparison of available digital elevation data in the region of interest with GPS measured elevations.

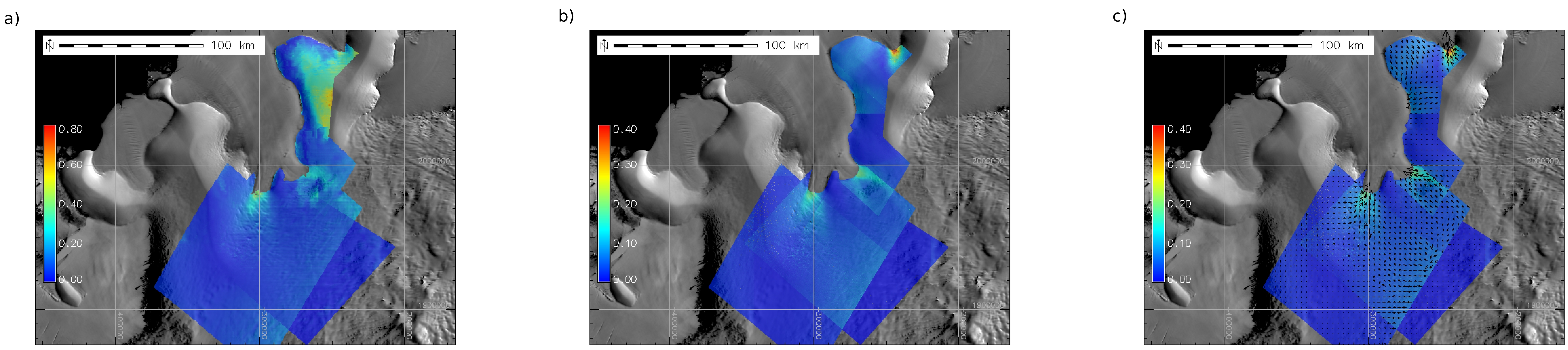

Figure 5: Preliminary results of example data. a) shows the mosaiced three-dimensional surface velocity field in m/d, calculated with the 'Antarctic wide 1 km DEM from combined ERS-1 radar and ICESat laser satellite altimetry'. b) is calculated with the local InSAR DEM and c) points out the direction of the ice flow shown in b). Used ERS tracks: 493, 460, 221, 045, 031 (see table 1 and figure 2).

Summary and outlook:

InSar or SAR interferometry appears to be a good method for the derivation of area-wide surface velocities, but is rather dependend on accurate external data, such as digital elevation data and groundtruth data. **-> Quality of surface velocities depends strongly on the external DEM.** Unfortunately, most of the available groundtruth data is located on the floating shelf ice and can not be used for the adjustment of grounded ice because of tidial effects. **-> Adjusting the flowfields with a single GCP is often not enough. Sytematic errors due to inaccurate processing remain!** The preliminary results are giving a first impression of the regional ice dynamics, but need to be adjusted in a second step. A solution would be an approximation to the fall line under the assumption of downhill ice flow. **-> Solution: Application of an optimisation procedure to minimize differences between flow direction and the downhill direction.**

References:

Drews, R., Rack, W., Wesche, C., and Veit, H. (2009). A spatially adjusted elevation model in Dronning Maud Land, Antarctica, based on differential SAR interferometry. IEEE Transactions on Geoscience and Remote Sensing, 47:2501-2509.

Joughin, I. R., Kwok, R., and Fahnestock, M. A. (1998). Interferometric estimation of three-dimensional ice-flow using ascending and descending passes. IEEE Transactions on Geoscience and Remote Sensing, 36:25-37.