Surface velocities in the hinterland of the Neumayer III station (Antarctica) derived from SAR-Interferometry

Who? Niklas Neckel[1,2], Reinhard Drews[1], Wolfgang Rack[3]

When? September 30, 2011

[1]Alfred Wegener Institute for Polar and Marine Research
[2]University of Tübingen
[3]Gateway Antarctica, University of Canterbury, Christchurch

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Goals of this study

- identify critical steps in the interferometric processing.
- automate the processing chain.
- analyze the dependency of the interferometric approach on external elevation models.
- derive an area-wide velocity field with error estimates in the region of interest.
- derive an estimate of the grounding zone location in the region of interest.

Region of interest

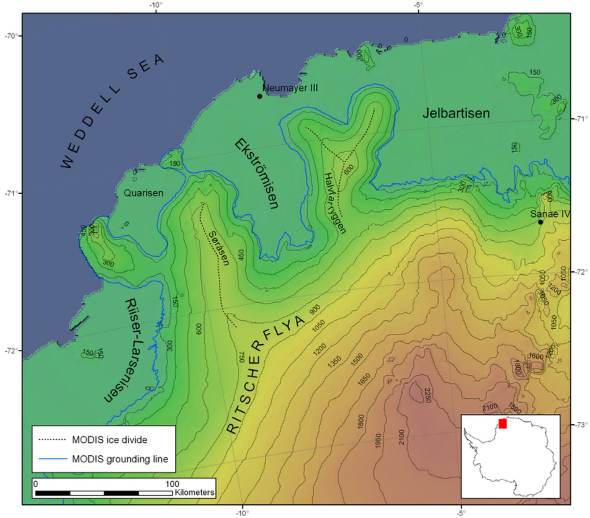


Figure: Hinterland of the German overwintering station Neumayer III.

Interferometric SAR

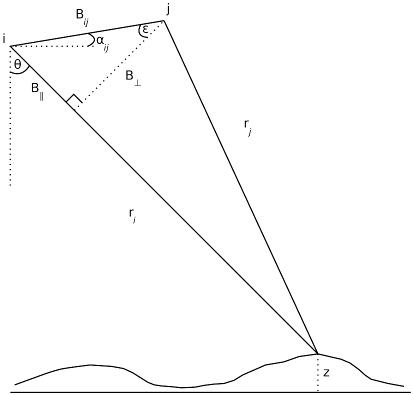


Figure: Setup for interferometric imaging.

$$\Delta\phi_{ij} = \Delta\phi_{orbit} + \Delta\phi_{topography} + \Delta\phi_{motion} + \Delta\phi_{atm} + \Delta\phi_{noise} \qquad (1)$$

Interferometric SAR

$$\Delta\phi_{ij} = \phi_j - \phi_i = \frac{4\pi}{\lambda}\Delta r \tag{2}$$

...if the random scattering is equal for ϕ_j and ϕ_i.

$$\Delta\phi_{ij} = \frac{4\pi}{\lambda} B_{ij} \cos(\theta_0 - \alpha_{ij}) \frac{z}{\rho_0 \sin(\theta_0)} + \frac{4\pi}{\lambda}\Delta\rho \tag{3}$$

Altitude of ambiguity:

$$z2\pi = \frac{\lambda}{2} \frac{r \sin(\theta)}{B_\perp} \tag{4}$$

Interferometric SAR

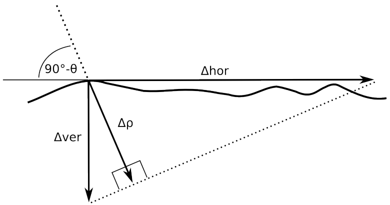


Figure: Sensitivity of ERS to vertical and horizontal motion.

For a 2π phase shift, this leads to

$$H2\pi = \frac{\lambda}{2\sin(\theta)} \approx 7.24cm \tag{5}$$

for horizontal motion and to

$$V2\pi = \frac{\lambda}{2\cos(\theta)} \approx 3.07cm \tag{6}$$

for vertical motion.

Interferogram

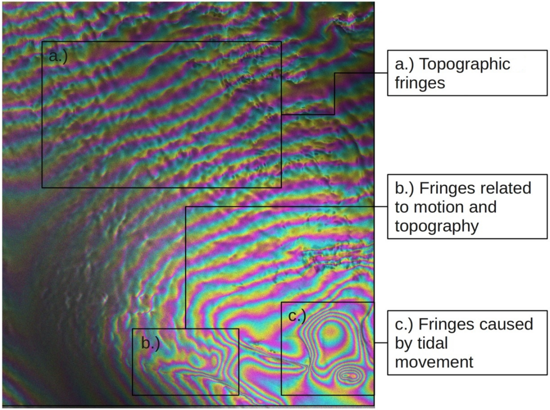
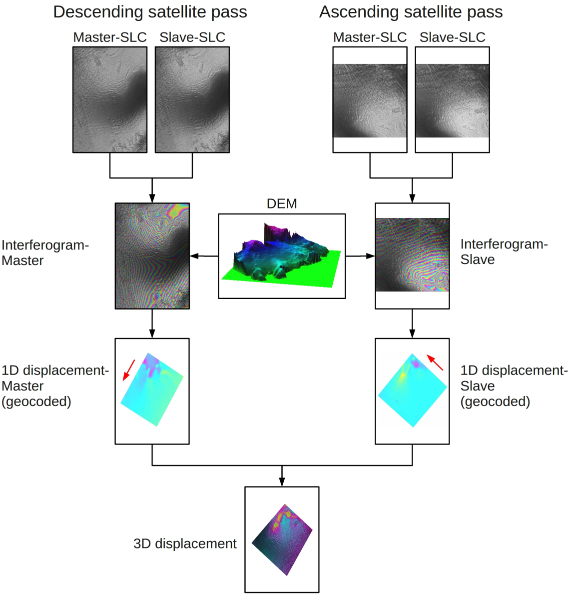


Figure: Interferogram. Fringes caused by topography, surface displacement and tidal movement.

Work flow

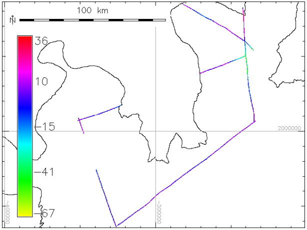


Descending satellite pass
Ascending satellite pass
Master-SLC
Slave-SLC
Master-SLC
Slave-SLC
DEM
Interferogram-Master
Interferogram-Slave
1D displacement-Master (geocoded)
1D displacement-Slave (geocoded)
3D displacement

DEMs

Table: Available DEMs for the region of interest.

Name	GRID	RMSE	Coverage
ASTER GDEM	30 m	894.9 m	World-wide
Bamber DEM	1 km	40.5 m	Antarctic-wide
Landsat DEM	20 m	-	Coastal areas
Local InSAR DEM	50 m	12.3 m	Local
RAMP DEM	200 m	177.3 m	Antarctic-wide
Wesche DEM	2.5 km	24 m	DML



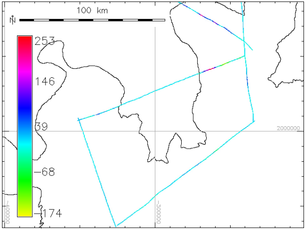


Figure: Elevation differences along airborne laser altimeter profiles.

Velocity field generation

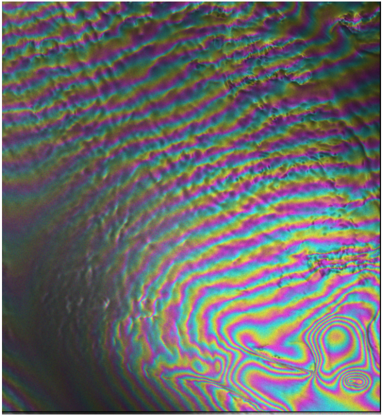


Figure: Fringes induced by surface displacement in the satellite's LOS and surface topography.

Velocity field generation

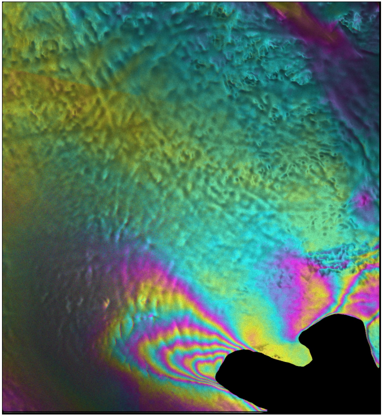


Figure: Interferogram after subtracting a simulated 'topography-only' phase trend.

Velocity field generation

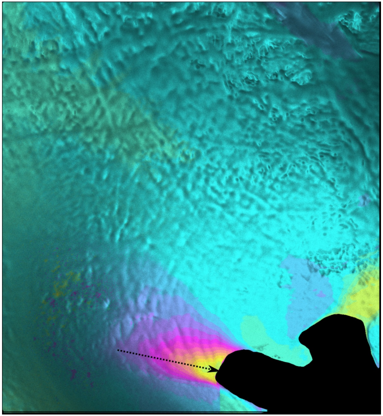


Figure: Interferogram after phase unwrapping with GAMMA's MCF algorithm.

Velocity field generation

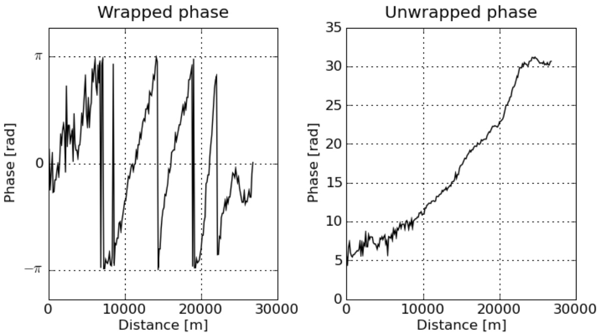


Figure: Profiles from wrapped and unwrapped interferogram.

Velocity field generation

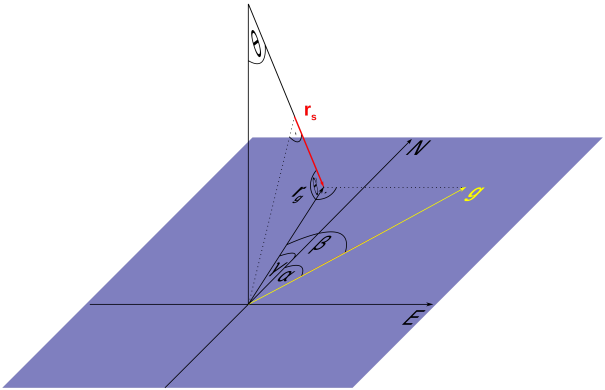
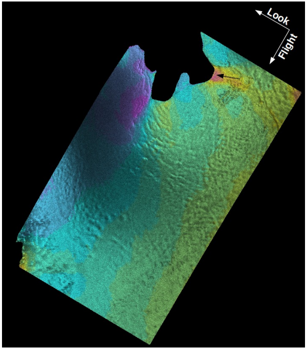


Figure: Relation between GPS-derived velocity (**g**, yellow) and the velocity along the satellite's LOS ($\mathbf{r_s}$ (slant range); $\mathbf{r_g}$ (ground range)).

Velocity field generation



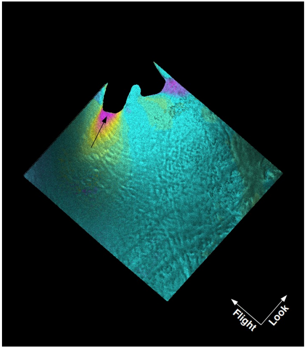


Figure: Left: One-dimensional flow field of a descending satellite track (geocoded). Right: One-dimensional flow field of the overlapping ascending satellite track (geocoded).

Velocity field generation

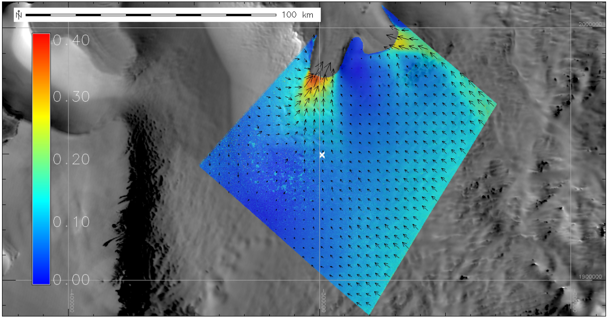


Figure: Three-dimensional velocity field in m/d. Composed from ascending and descending ERS tracks.

Errors

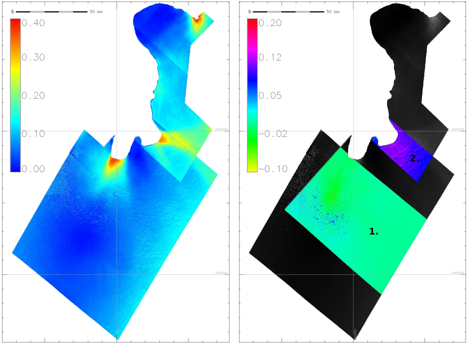


Figure: Mosaic of three-dimensional flow velocities of grounded ice in m/d.

$$\bar{x}_{overlap1} = 0.003\,\mathrm{m/d} \tag{7}$$

$$\bar{x}_{overlap2} = 0.098\,\mathrm{m/d} \tag{8}$$

Errors

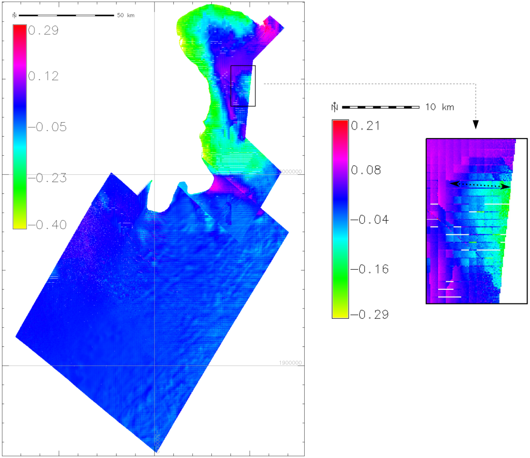


Figure: Differences between surface velocities based on the local InSAR DEM and the Bamber DEM in m/d.

Errors

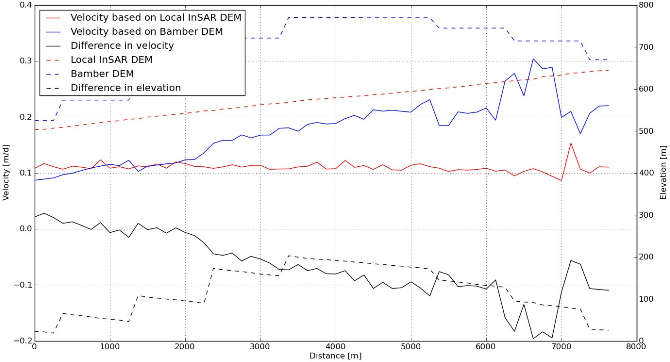


Figure: Differences in surface velocity calculated using various DEMs.

Final product

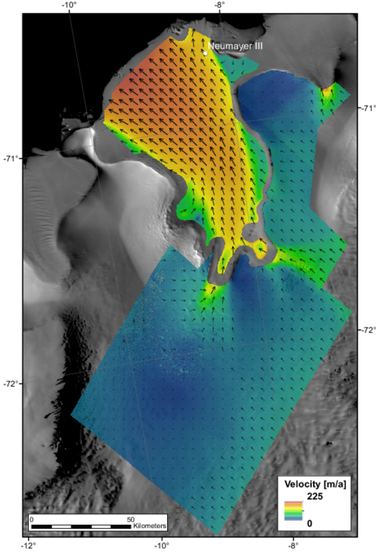


Figure: Ice flow in the Neumayer III hinterland.

Final product

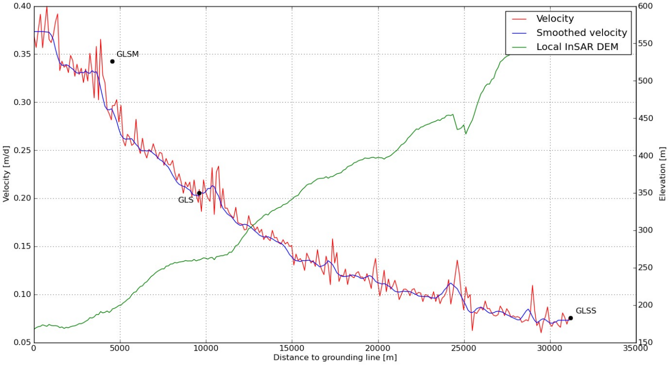


Figure: Profile in the region of the main ice flow. Black dots indicate the GCPs used for adjustment (*GLSS*) and comparison.

Field work

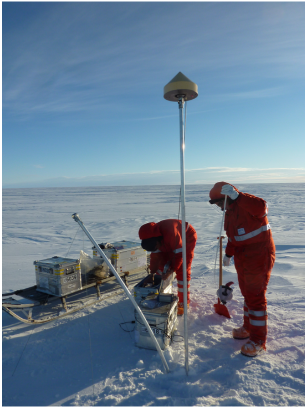


Figure: Ground Penetrating Radar and Global Positioning System measurements (LIMPICS ANT-Land campaign 2009/2010).

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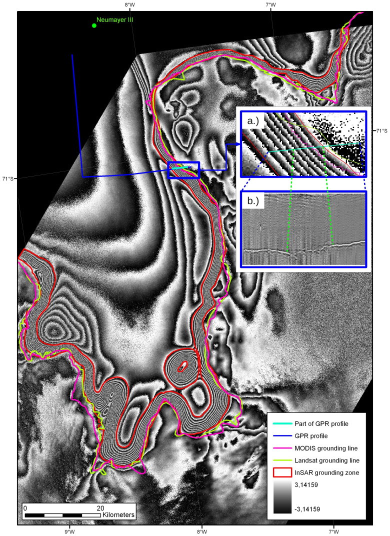

Figure: Grounding line detection from different satellite sensors.

Conclusion

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Thank you!

Contact:
Niklas Neckel
University of Tübingen
Institute for Physical Geography and GIS
Rümelinstr. 19–23
72070 Tübingen
Niklas.Neckel@uni-tuebingen.de