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

R. Drews (1), W. Rack (2), C. Wesche (1), D. Steinhage (1)

(1) Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, (2) Gateway Antarctica, University of Canterbury, Christchurch, New Zealand
Objectives

- Develop a new DEM via DinSAR
- Derive 3D – Flowfields
- Estimate Mass Flux into the Ekströmisen
- Map Accumulation

Ekströmisen, DML, Antarctica
**Data Set**

- **W - Dronning Maud Land, Antarctica**
  - 116 SAR scenes from ERS-1/ERS-2
  - 19 digital elevation models
  - area ~ 130 000 km²
Methodology

SAR Processors

• PAFs
• MSP (Gamma Remote Sensing)
• APP (EarthView)
Interferometric SAR

Introduction
Methodology
Accuracy Evaluation
Surface Elevation & Ice Dynamics

- RAW processing
- InSAR processing
- DInSAR processing

ERS-1
ERS-2

\( B_{12} \)
\( \alpha_{12} \)
\( \alpha'_{12} \)
\( \theta \)

\( R_1 \)
\( R_2 \)
Differential SAR Interferometry

**Introduction**

**Methodology**

**Accuracy Evaluation**

**Surface Elevation & Ice Dynamics**

**RAW processing**

**slc**

**InSAR processing**

**int**

**DInSAR processing**

**DEM**

**Flowfield**

**Icesat GCPs**

**1D - Disp.**

**3D - Disp.**

**DEM**

**Int**
Mosaic

(50x50) m grid

Introduction  Methodology  Accuracy Evaluation  Surface Elevation & Ice Dynamics
Mosaic

Introduction  Methodology  **Accuracy Evaluation**  Surface Elevation & Ice Dynamics
Introduction  Methodology  Accuracy Evaluation  Surface Elevation & Ice Dynamics
Processing Uncertainties

Introduction  Methodology  Accuracy Evaluation  Surface Elevation & Ice Dynamics
Processing Uncertainties

- $B_1 - B_2 [m]$ with lines $E1-E2$, $E1-G$, and $E2-G$
- $\phi - \phi_1 [rad]$ with lines $E1-E2$, $E1-G$, and $E2-G$
- $z - z_1 [m]$ with lines $E1-E2$, $E1-G$, and $E2-G$

slant range [km] from 0 to 40
\[ z - z' = \frac{\lambda r_0 \sin \Theta_0}{4\pi} \left( \frac{\Delta \phi_f B'_{\perp,0} - \Delta \phi'_f B_{\perp,0}}{B'_{\perp,0}B_{\perp,0}} \right) \]
Comparison with GCPs

- Airborne Laser Altimetry
- Kinematic GPS
Comparison with GCPs

Number of GCPs

ALS - DinSAR [m]

GPS - DinSAR [m]

\[ s = (2.9 \pm 4.1) \text{ m} \]

\[ s = (-1.2 \pm 8.0) \text{ m} \]
Mass flux: $3.45 \cdot 10^3$ Gt/a
Boxmodel
Boxmodel

\[ m_{f,\text{res}} = (2.128 - 2.214 - 0.077 - 0.047) \frac{\text{km}^3}{a} = -0.211 \frac{\text{km}^3}{a} \]

\[ \dot{a} = \rho \frac{m_{f,\text{res}}}{A} = 248 \frac{\text{kg}}{\text{am}^2} \]
Summary

- Generation of high resolution DEM for Interferometry
- Difference field reveals processing and other external errors
- Displacement maps have been used for mass flux estimates
- Mapping of accumulation with satisfactory prelim. results
Comparison GPS

- GPS
- DInSAR
- Glas/Icesat
- JBL97
- RAMPv2

Introduction  Methodology  Accuracy Evaluation  Surface Elevation & Ice Dynamics
Boxmodell

![Graphs showing residual mass balance and ice thickness vs. longitude.](image.jpg)
Mixed interferogramm with topography and displacement
Processing Uncertainties

\[ z - z' = \frac{\lambda r_0 \sin \Theta_0}{4\pi} \cdot \left( \frac{\Delta \phi_f B'_{\perp,0} - \Delta \phi'_f B_{\perp,0}}{B'_{\perp,0} B_{\perp,0}} \right) \]
Comparison with GPS

- kinematic GPS
  - traverse from Neumayer to Kohnen
  - vertical accuracy < 1 m
  - along track spacing ~ 3 m

Introduction  Methodology  Accuracy Evaluation  Surface Elevation & Ice Dynamics