AWI

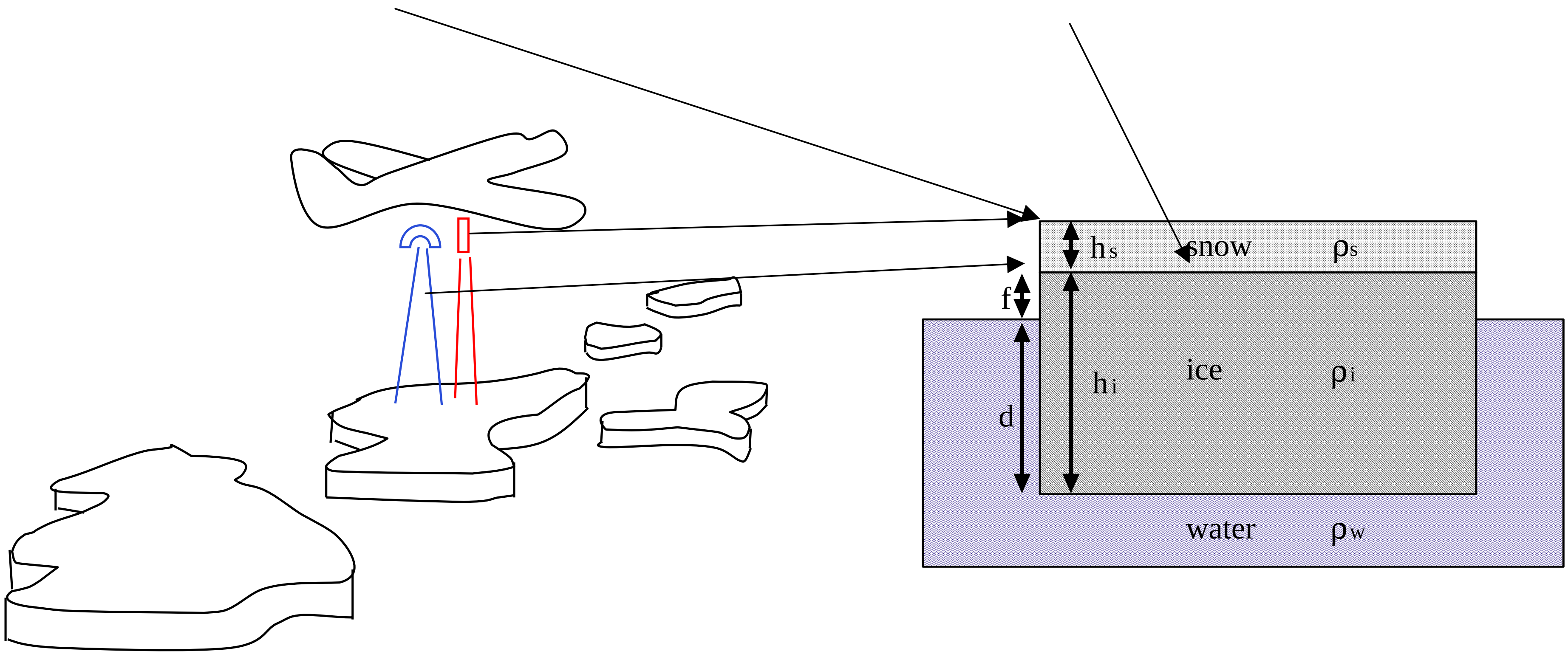
Stiftung Alfred-Wegener-Institut
für Polar- und Meeresforschung
in der Helmholtz-Gemeinschaft

ASIRAS Pre Report

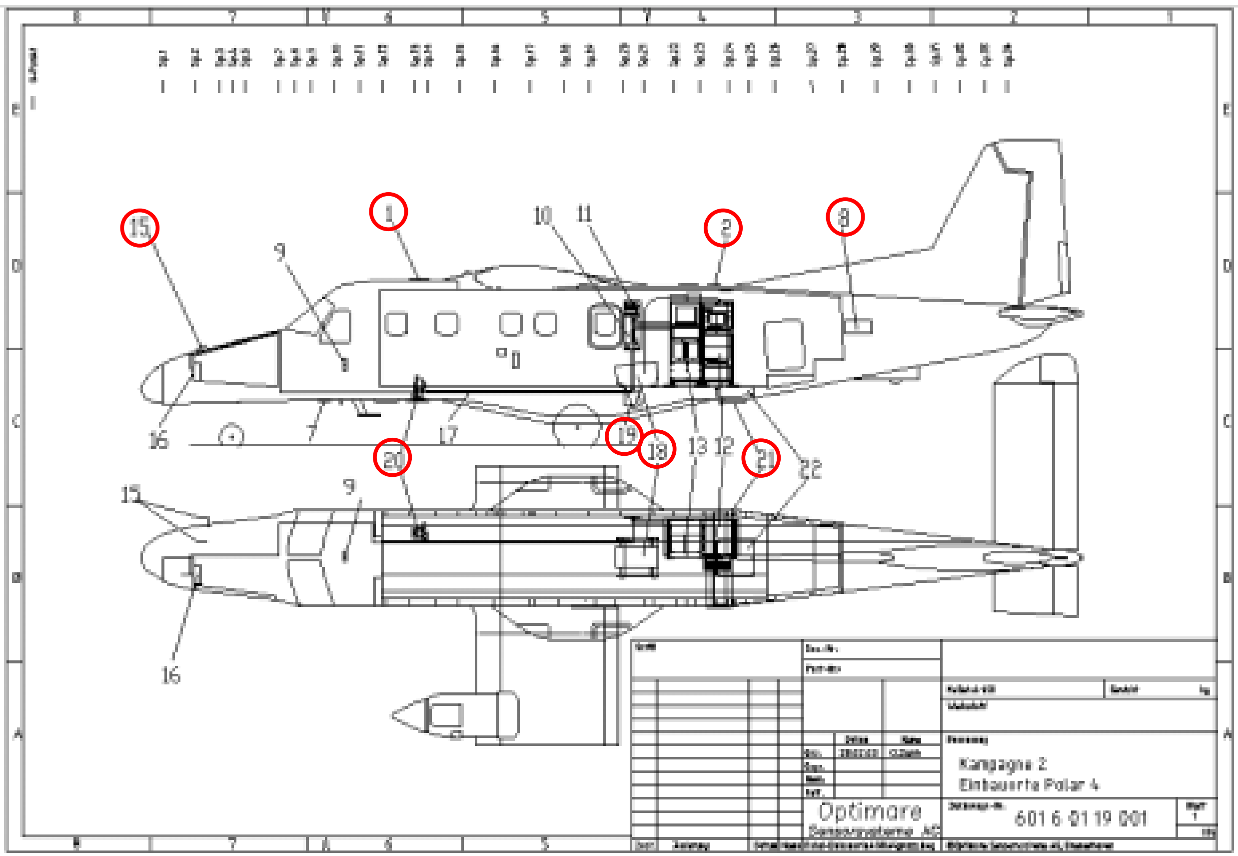
- Part 1: ASIRAS campaigns 2004
    - System characteristics
    - Data acquisition
- Part2: preliminary data processing report
    - GPS processing
    - 1st results of the comparison of Laser and Radar
    - INS correction
    - Summary and Questions
    - Future prospects

Cal/Val – ASIRAS and Laser Scanner as main tools

ASIRAS: Airborne synthetic interferometric radar altimeter system



Summary description of system



1 + 2 GPS Antennen für Trimble

7 Radar Altimeter

8 INS

9 GNS-X

10 Power Distribution Module

11 Data Distribution Module

12 Rack I

13 Rack II

15 Basis Meteorology Sensors

16 BMET I/O Module

17 Fiber Optic

18 Riegl Laser Scanner LMSQ280

19 Riegl LD90 Laser Altimeter

20 Sony Video Camera

21 RST - ASIRAS Antenna

22 Antenna Cable Slot

System characteristics

ASIRAS:

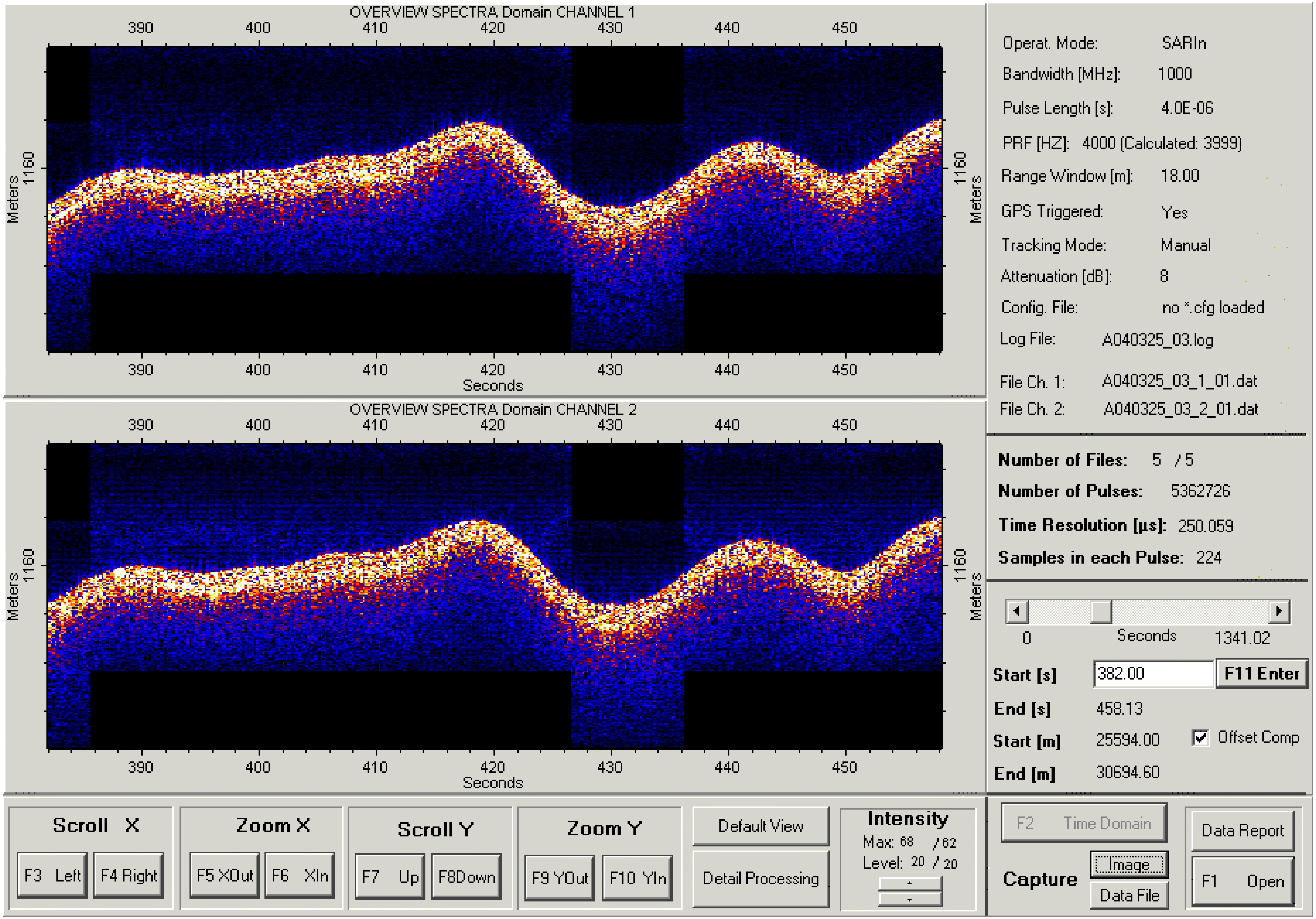
altitude:	Minimum altitude: 1090m,
angle of beam:	
	- along track: 10°
	- across track: 2.5°
footprint:	38 meter (1150 meter flight altitude)

Laser scanner:

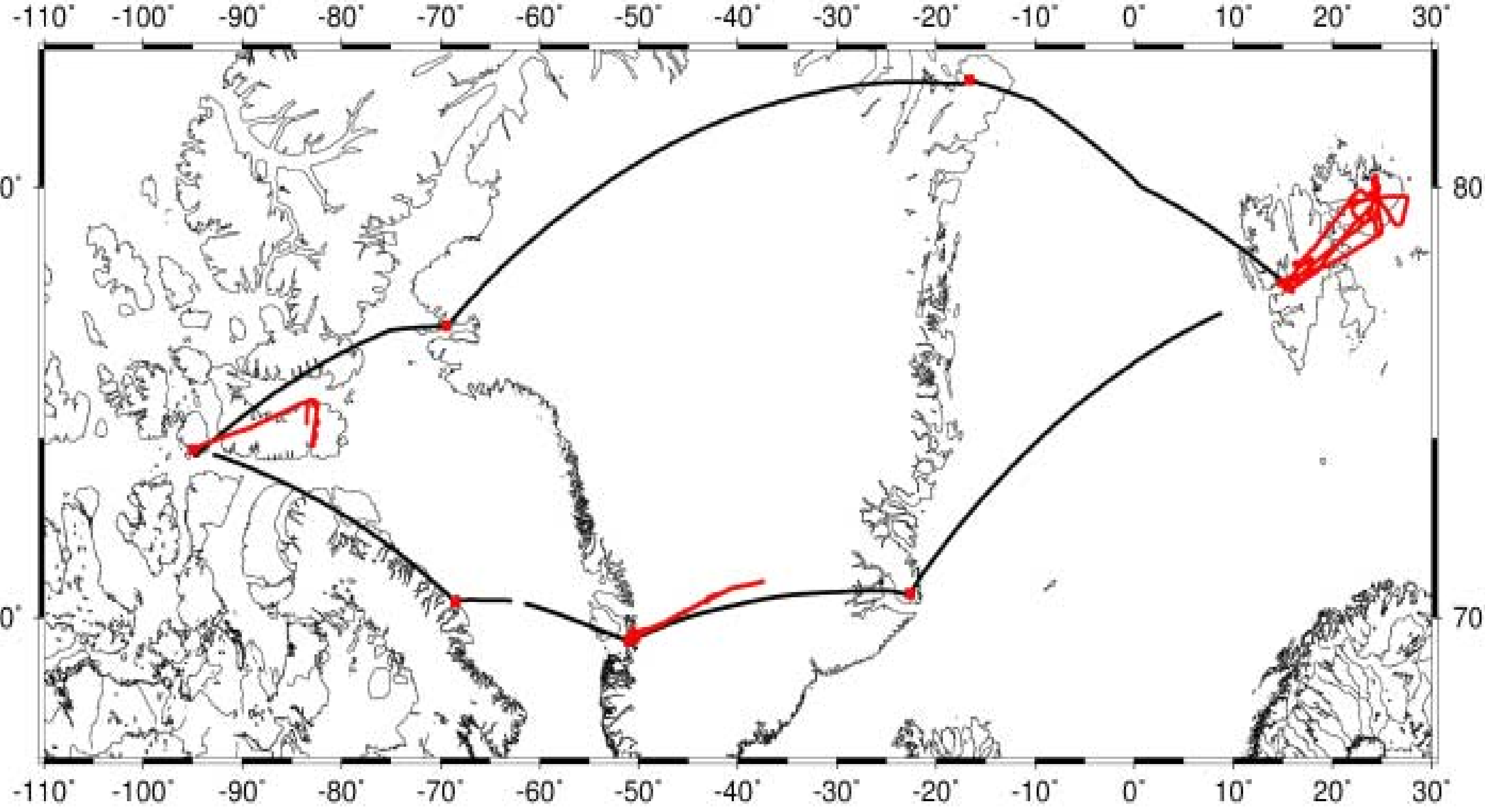
altitude:	Maximum altitude: 1200m,
scanning range:	+/- 22.5 ° = 45 ° total
footprint:	880 meter (1150 meter flight altitude)
	270 meter (350 meter flight altitude)

Consequence: fly each track twice in low (laser scanner, 350 m) and high altitude (ASIRAS + laser scanner, 1150 m)

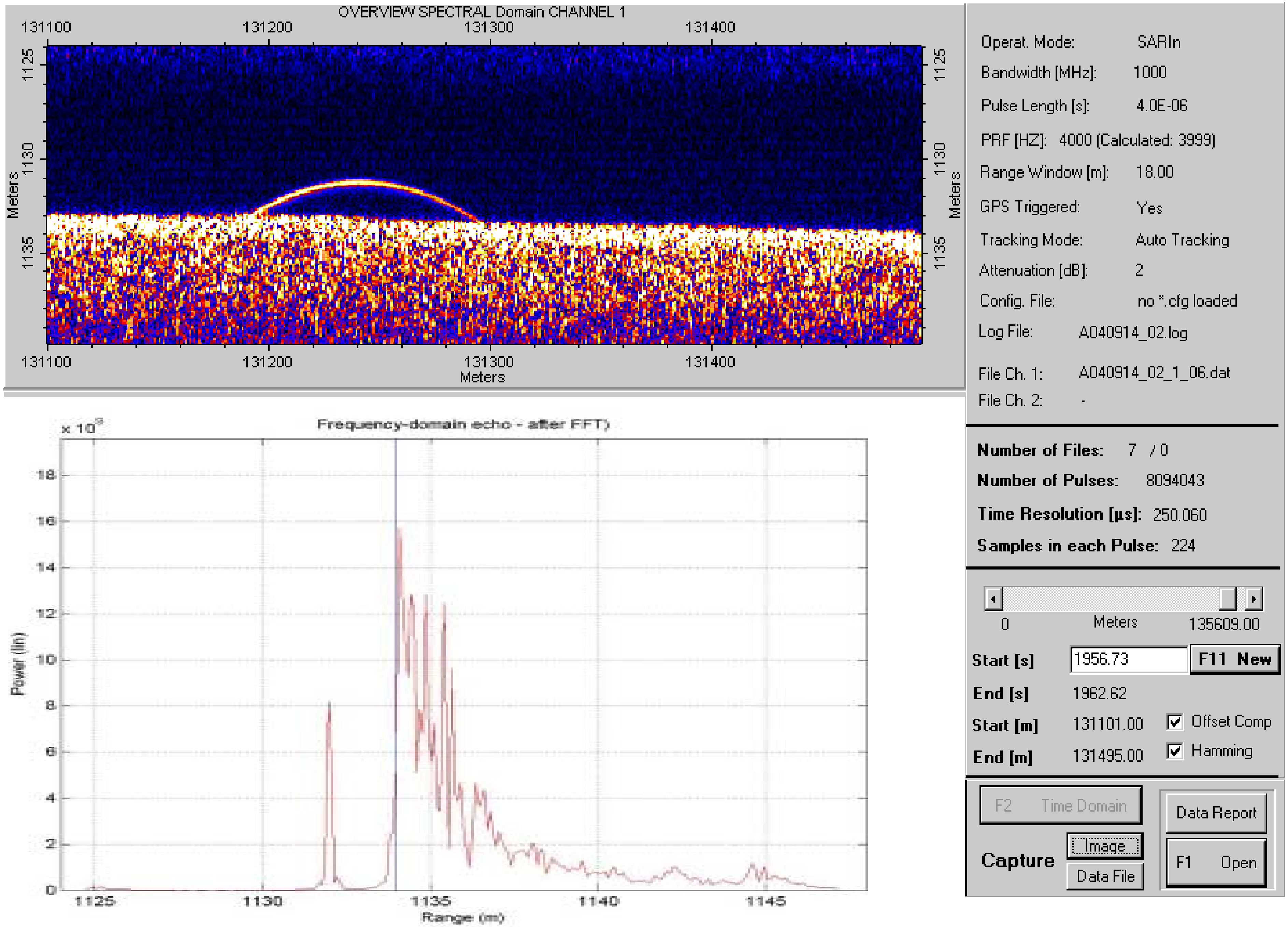
Tracking Success



Grand Tour ASIRAS



Corner reflector seen from the radar

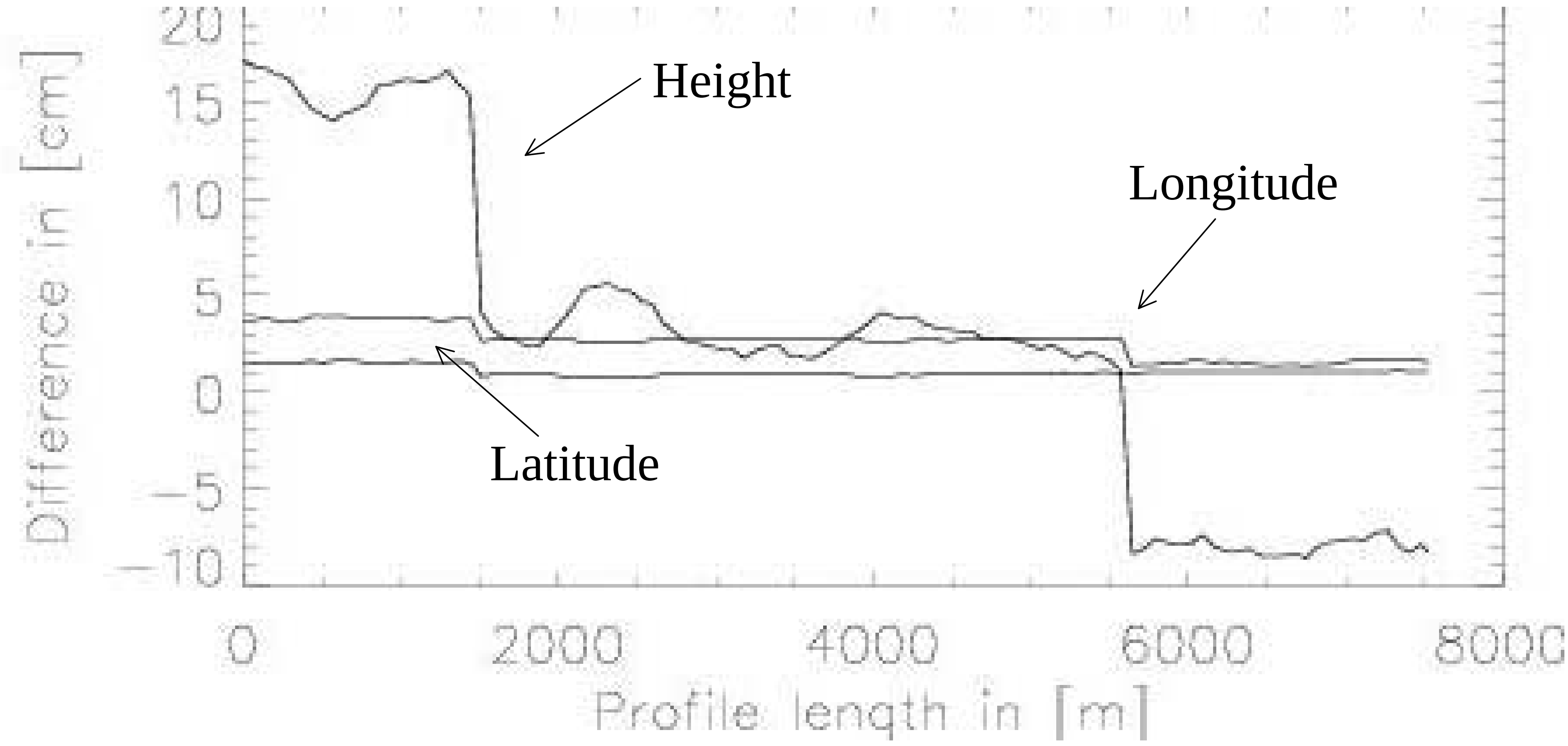


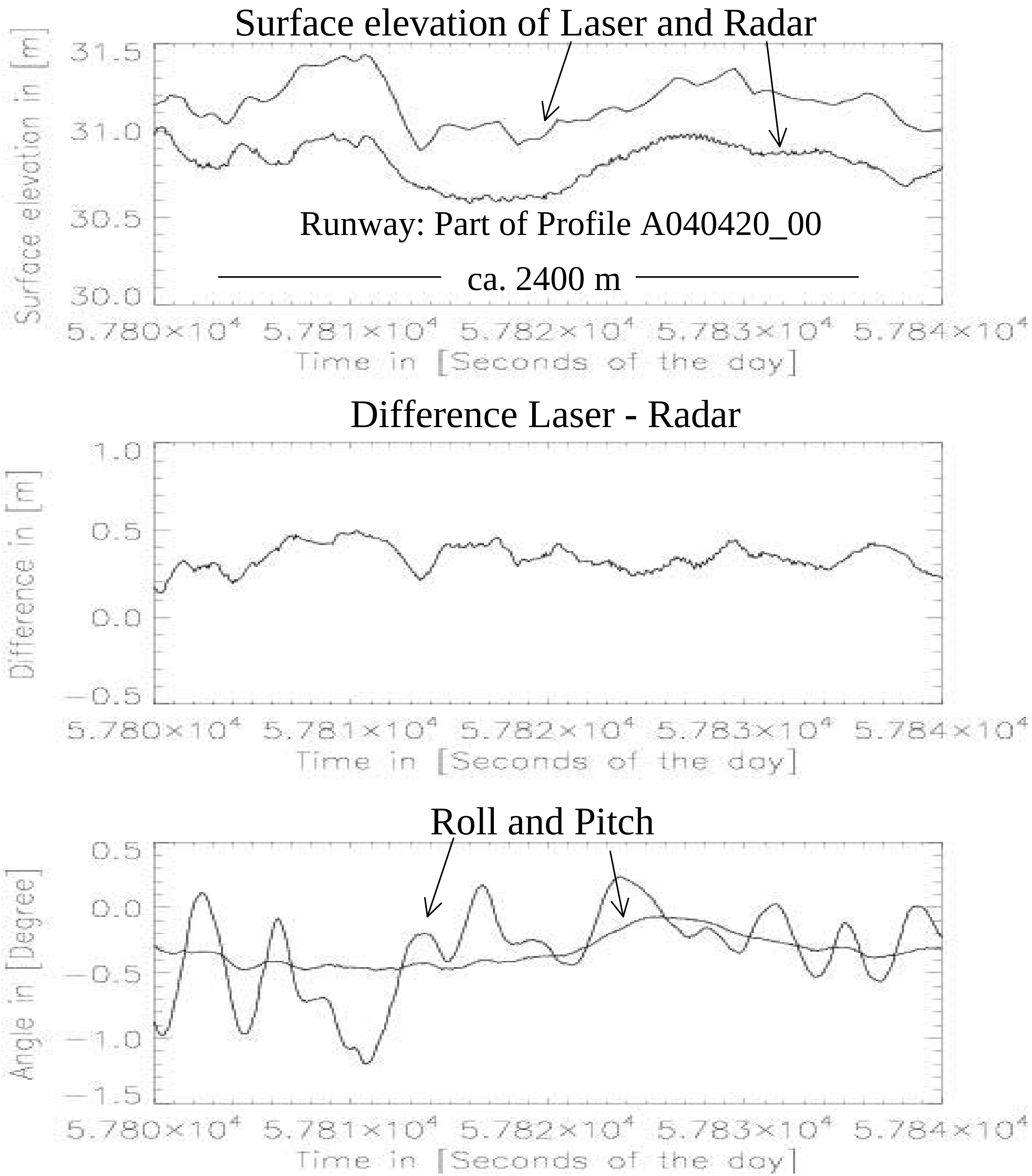
State of data processing

GPS Processing

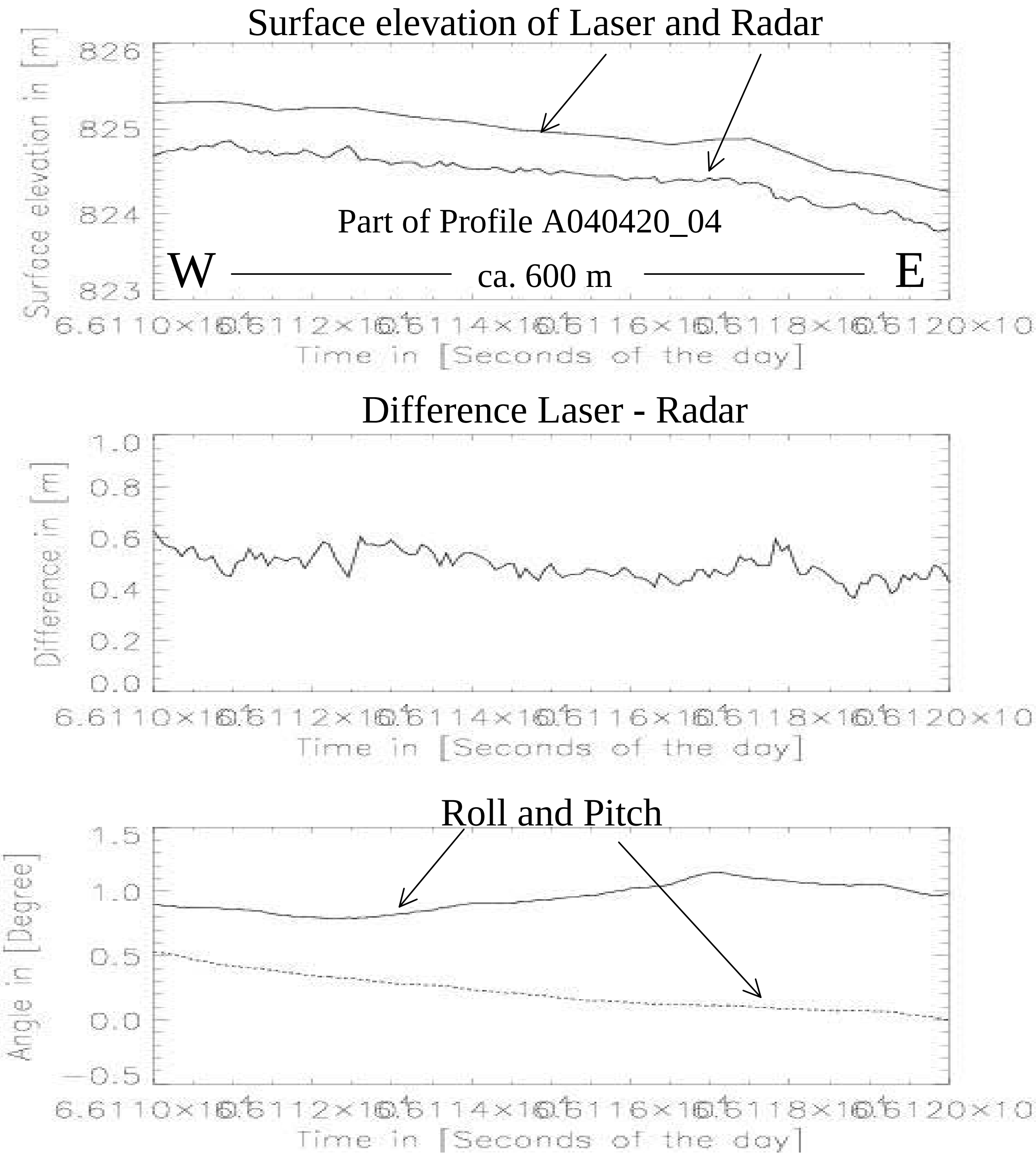
Difference of pre and final processed GPS data

Profile A040420_04 (Austfonna)





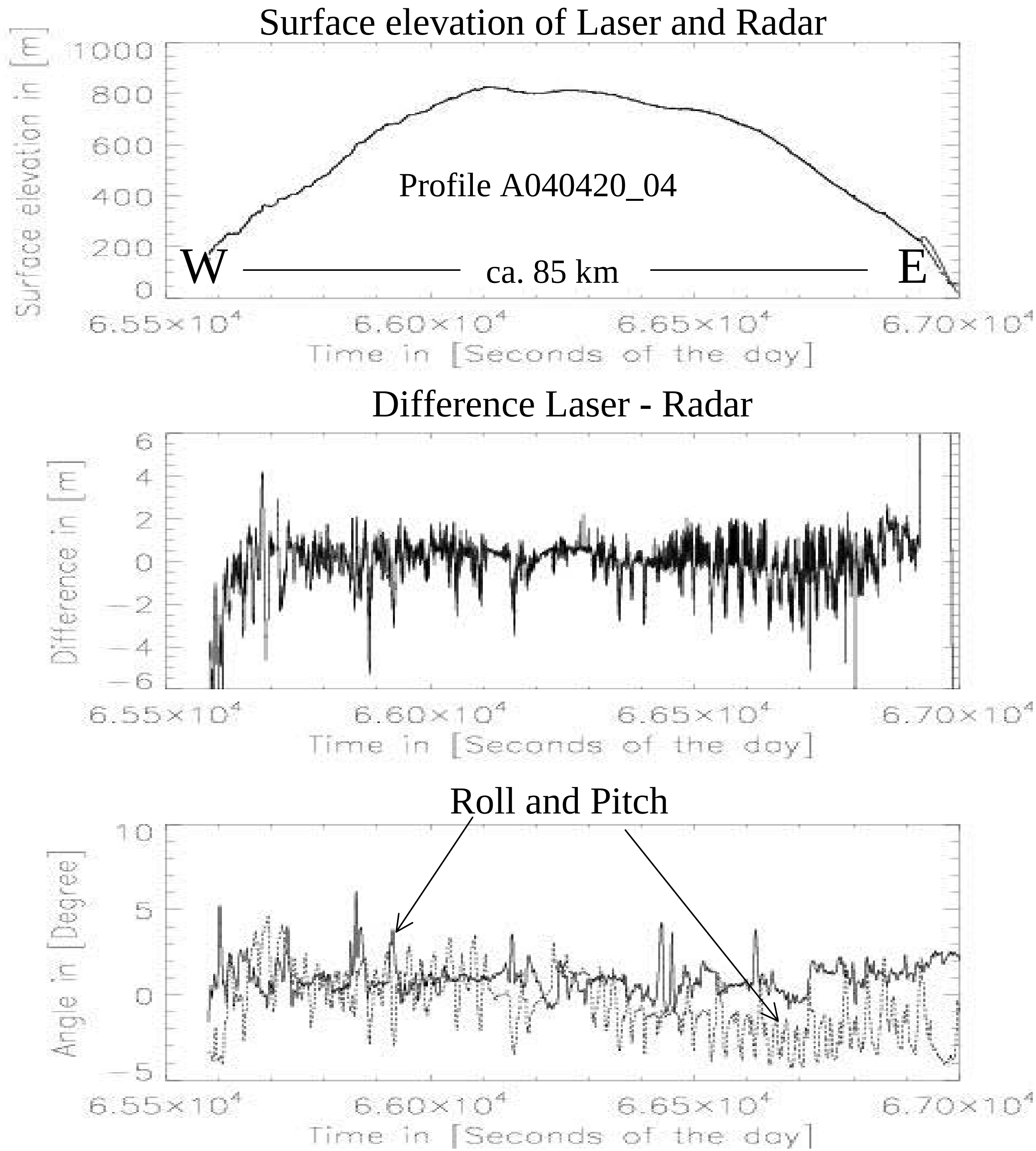
Surface elevation of Laser and Radar
Surface elevation in [m]
31.5
31.0
30.5
30.0
Runway: Part of Profile A040420_00
ca. 2400 m
5.780×10^4
5.781×10^4
5.782×10^4
5.783×10^4
5.784×10^4
Time in [Seconds of the day]
Difference Laser - Radar
Difference in [m]
1.0
0.5
0.0
−0.5
5.780×10^4
5.781×10^4
5.782×10^4
5.783×10^4
5.784×10^4
Time in [Seconds of the day]
Roll and Pitch
Angle in [Degree]
0.5
0.0
−0.5
−1.0
−1.5
5.780×10^4
5.781×10^4
5.782×10^4
5.783×10^4
5.784×10^4
Time in [Seconds of the day]


Surface elevation of Laser and Radar
Surface elevation in [m]
826
825
824
823
Part of Profile A040420_04
W
ca. 600 m
E
6.6110×10^4
6.6112×10^4
6.6114×10^4
6.6116×10^4
6.6118×10^4
6.6120×10^4
Time in [Seconds of the day]
Difference Laser - Radar
Difference in [m]
1.0
0.8
0.6
0.4
0.2
0.0
Time in [Seconds of the day]
Roll and Pitch
Angle in [Degree]
1.5
1.0
0.5
0.0
−0.5
Time in [Seconds of the day]

1st results of the comparison between Laser and Radar

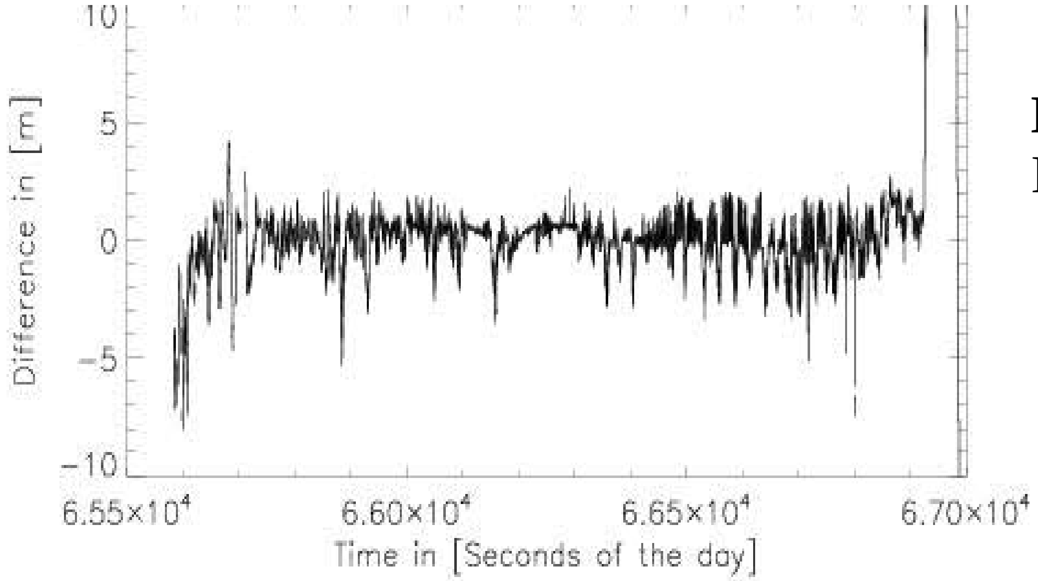
- Profile N-S: A040420_01
- Profile W-E: A040420_04

Pic. from Norwegian ground operating team

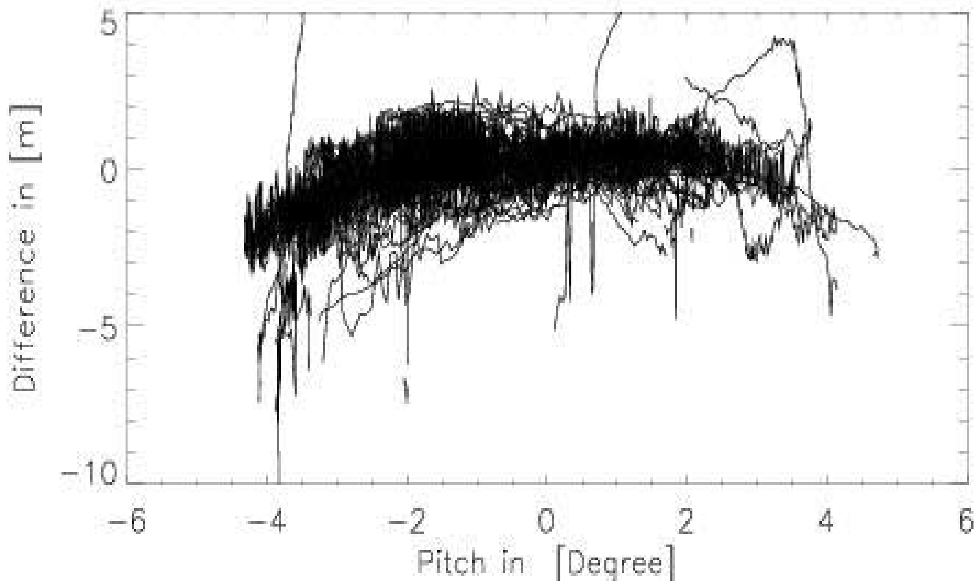


Surface elevation of Laser and Radar
Surface elevation in [m]
Profile A040420_04
W
ca. 85 km
E
Time in [Seconds of the day]
Difference Laser - Radar
Difference in [m]
Time in [Seconds of the day]
Roll and Pitch
Angle in [Degree]
Time in [Seconds of the day]

1st results of the comparison between Laser and Radar

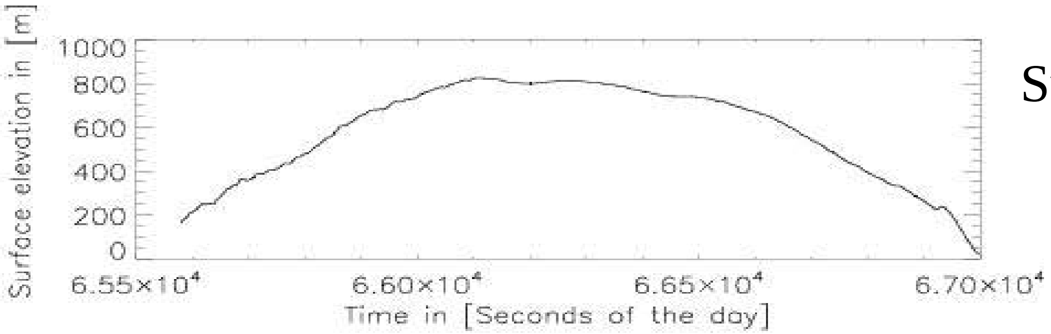


Difference between INS corrected Laser and INS corrected Radar Surface elevations

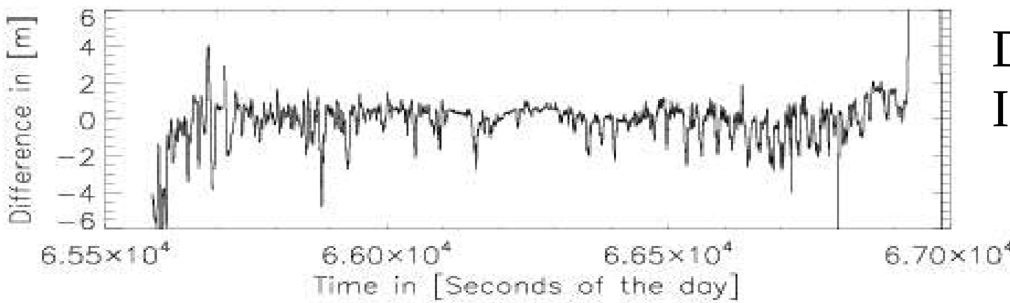


Difference between INS corrected Laser and INS corrected Radar Surface elevations
as a function of Pitch

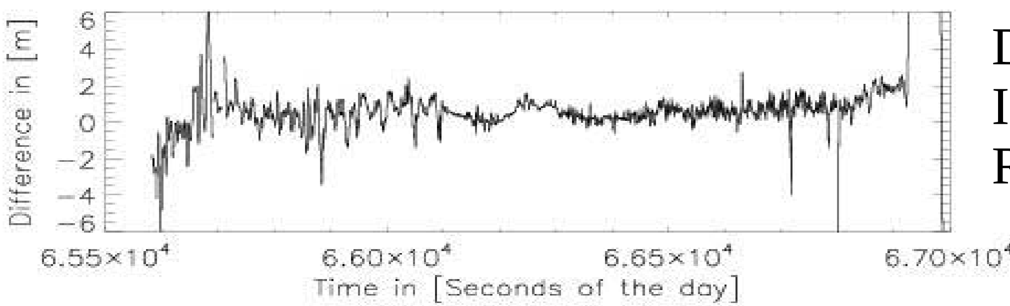
1st results of the comparison between Laser and Radar



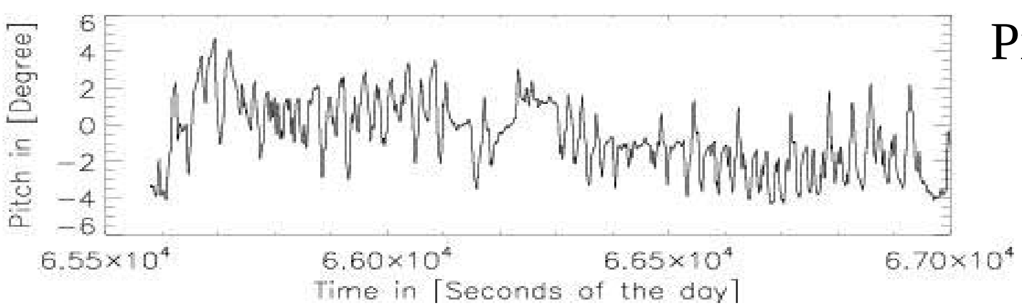
Surface elevation - Profil A040420_04



Difference between INS corrected Laser and INS corrected Radar Surface elevations



Difference between INS corrected Laser and INS (**without Pitch correction**) corrected Radar Surface elevations

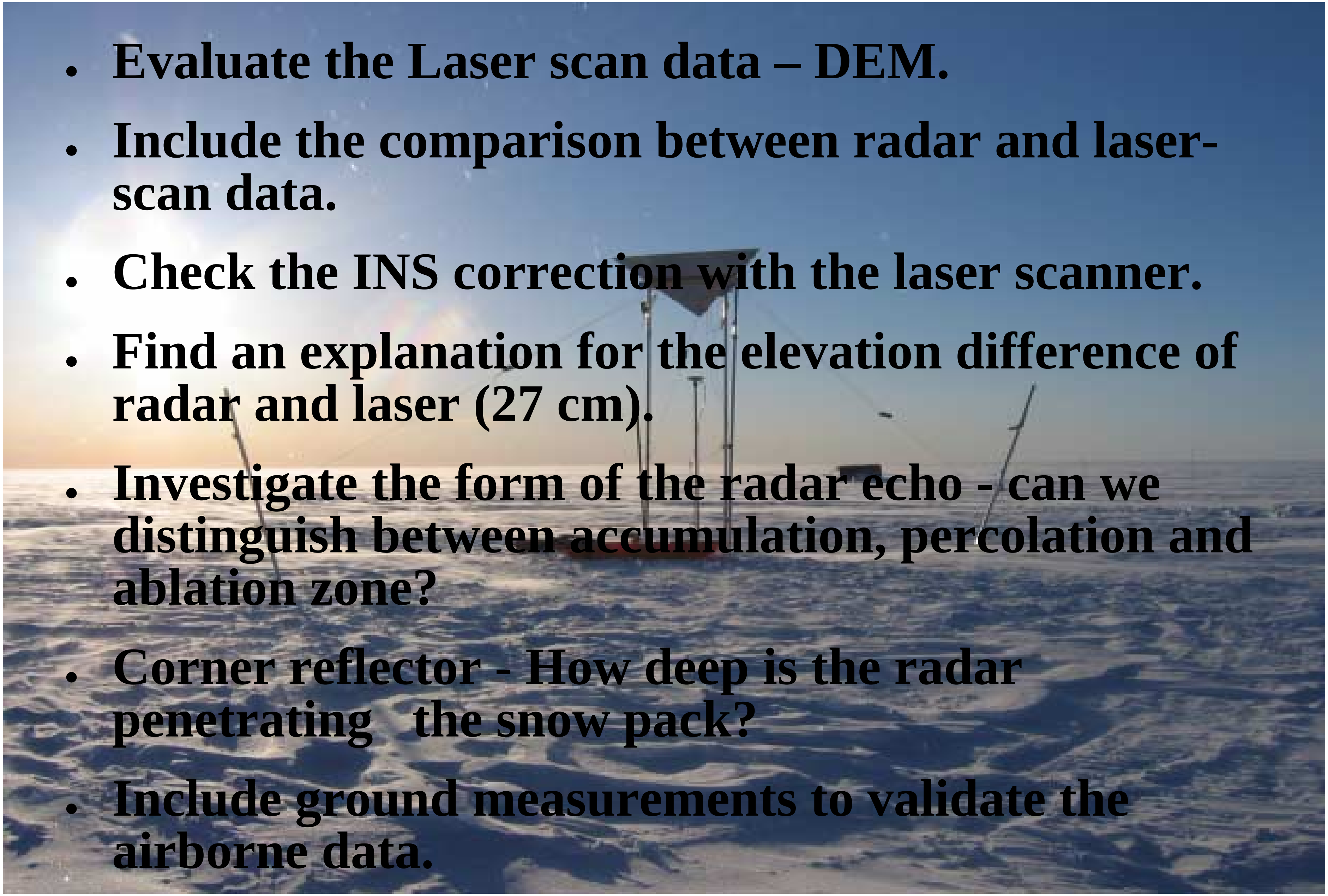


Pitch

Summary and Questions

- Difference between Laser and Radar over a runway is ca. 27 cm:
  - Q: Is this created by a static shift (eg. Cable length are different) or is the Radar squinting? (27 cm ---> squint angle: 1.24 degree (1150 m flight altitude over ground)
  - Q: If the radar is squinted along track, how is this effecting the Laser-Radar difference and how can this be corrected?
- Difference between Laser and Radar over flat snow surface is ca. 45cm
  - Q: Does this imply a penetration of radar waves into the snow pack of ca. 20 cm?
- Sensitivity of Laser and Radar to the pitch is different.
  - Best results for profile A040420_04 when:
    - Laser is corrected for roll, yaw and pitch.
    - Radar is corrected for roll and yaw without pitch
  - Q: Where is the high variability (about 1-2 m) of the difference between laser-radar surface elevation coming from?
  - Q: Why do we see penetration of laser instead of radar in some parts of the profile?

Future prospects



- **Evaluate the Laser scan data – DEM.**
- **Include the comparison between radar and laser-scan data.**
- **Check the INS correction with the laser scanner.**
- **Find an explanation for the elevation difference of radar and laser (27 cm).**
- **Investigate the form of the radar echo - can we distinguish between accumulation, percolation and ablation zone?**
- **Corner reflector - How deep is the radar penetrating the snow pack?**
- **Include ground measurements to validate the airborne data.**


Thank you

DGPS and INS Navigation

Post-processing DGPS

2 Trimble GPS on board with up to 5 base stations
L1/L2 code, phase, doppler observations

data:	latitude, longitude, ellipsoidal height
data rate:	1 Hz
online data:	1 Hz

typical errors for the height solution:

static solutions	± 25 mm
kinematic solution:	± 50 mm

accuracy depending from baselines

Honeywell LaserNAV INS and Wulfsberg GNS-X

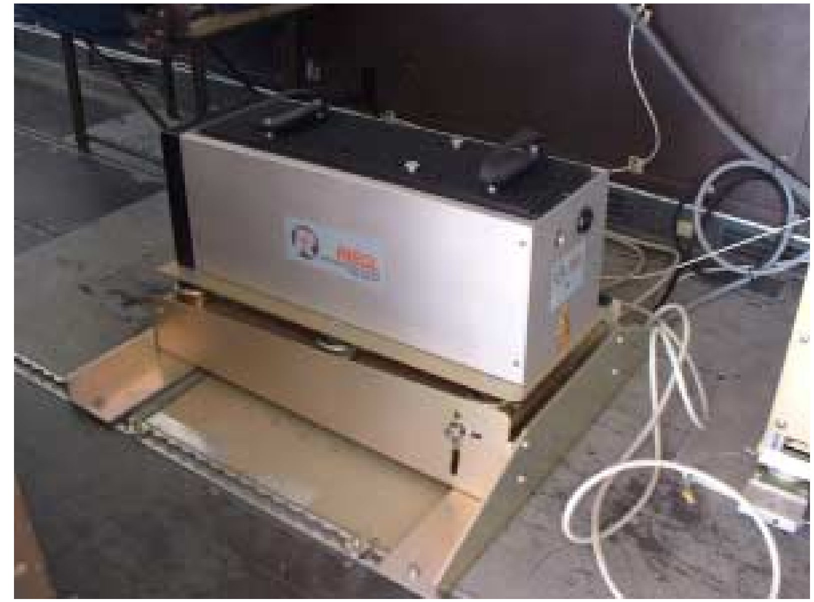
high speed ARINC 429 data interface logged to NAVP Sensor Processor

Primary Data:	Rate	Res.
yaw rate, pitch rate, roll rate	50 Hz	0.0054 °
true heading, pitch, roll	50 Hz	0.0039 °/s
x-, y-, z-, acceleration	50 Hz	0.0001 G

Secondary Data:

66 labels configurable like:
ground speed, track, wind direction, magnetic variation, true airspeed ...

Laser-Scanner LMS-Q280



Specifications:

measurement range:	30 m up to 1280 m
measurement resolution:	20 mm with typ. ± 25 mm acc.
data channels:	range, amplitude, true color
measurement rate	PRR=18.5 kHz, data=9250 Hz
beam divergence	0.5 mrad
scanning range	nominal 45° up to 60°
scanning rate	4 Hz to 80 Hz

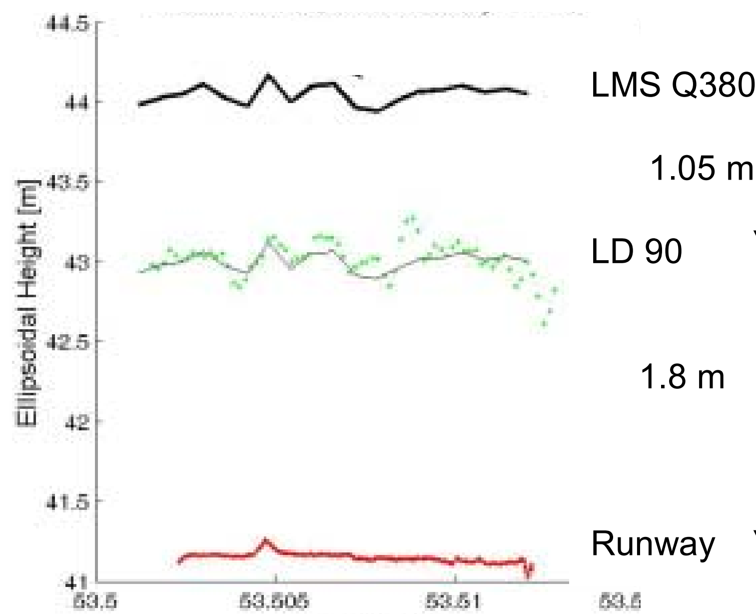
System integration:

electrics: <100 Watts @ 28 VDC

data: serial communication and
parallel data interface (ECP)
MEDUSA via LS sensor processor

timesync.: 1 PPS sync. input
sensor processor

First Data:



Measurements

DGPS and INS Navigation

Post-processing DGPS

2 Trimble GPS on board with up to 5 base stations
L1/L2 code, phase, doppler observations

data:	latitude, longitude, ellipsoidal height
data rate:	1 Hz
online data:	1 Hz
typical errors for the height solution:	
static solutions	± 25 mm
kinematic solution:	± 50 mm

Litton INS

Primary Data:	Accuracy	Res.
yaw rate, pitch rate, roll rate	0.1 °/sec	0.0039 °/sec
Pitch / roll angle	0.05 °	0.0054 °
true heading	0.4 °	0.0054 °

Recommended: IGI flight guidance system with gyroscope
(includes recording of GPS and attitude data)

Primary Data:	accuracy
pitch / roll	< 0.05 ° rms
heading	< 0.1 ° rms
Position	5-10 m, without real time GPS (TX ground stations)

Laser-Altimeter LD90

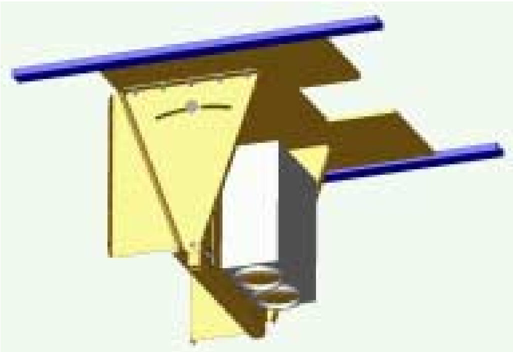
Specifications

measurement range:	up to 2500 m for ρ≥80% („good target“) >800 m for ρ≥10% („bad target“)
minimum distance:	10 m
measurement resolution:	2 mm with typ. ± 25 mm accuracy
data channels:	range, amplitude, quality, true color
measurement rate	PRR=2000 Hz, data=4 Hz
beam divergence	1.2 mrad

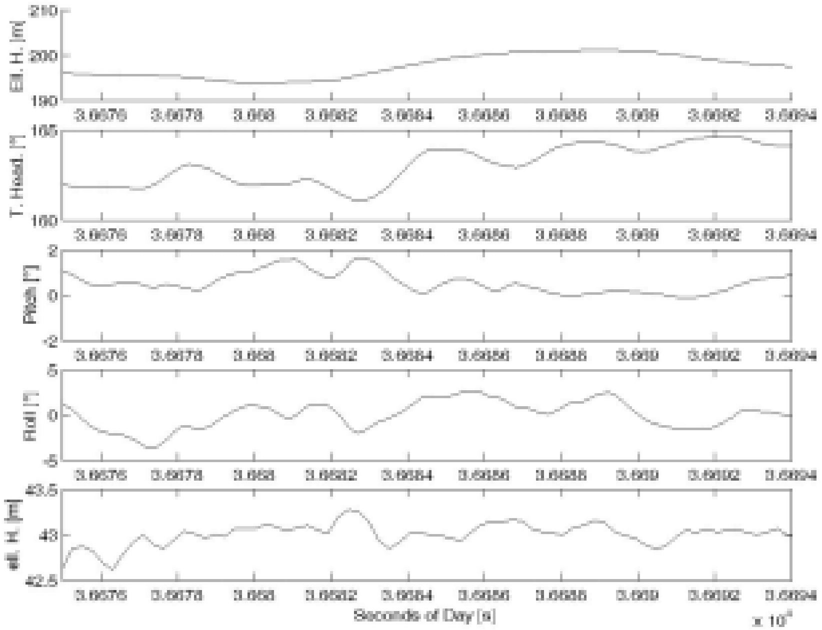
System integration

electrics:	10 Watts @ 28 VDC
data:	serial communication and data interface integration to Medusa-P via NAVP sensor processor
timesync.:	1 PPS sync. input

mechanics:



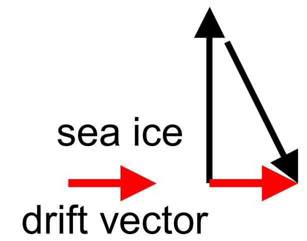
First results from test flights




POLAR 6

Campaign Objectives

Instrument performance	➢Stability of ASIRAS (daily repeated CAL experiments) ➢Roll Experiments ➢Long runs over open ocean
Test of validation concept	➢Sea ice drift removal experiment
Surface type related performance	➢Dry inland ice at min/max flight altitude ➢Sea ice north of Greenland ➢Effect of penetration into dry ice ➢Decorrelation of interferometric looks ➢Angular dependence of reflectivity ➢Identification of ice surface types ➢Influence of humidity
Previous Campaigns	➢Acquisition of comparable data sets ➢Optimization of data processing



Objectives

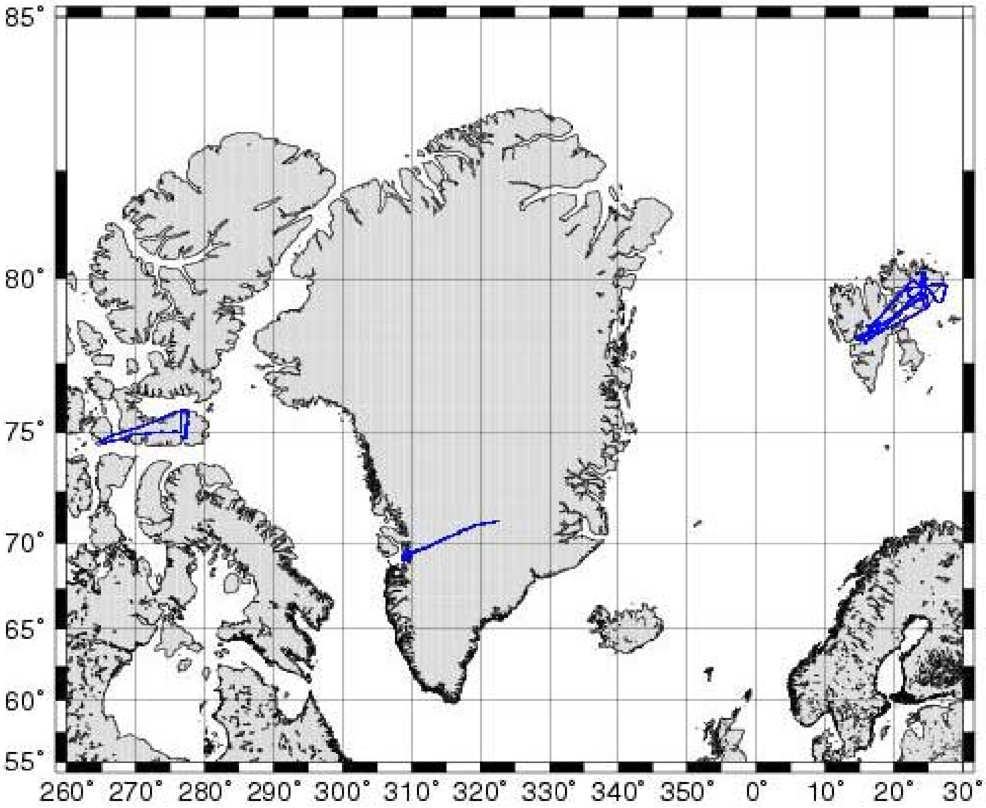
Key elements for CryoSat Validation:

- overflights over main ground-based experiments
- airborne logistical support to/from ground teams

ASIRAS Objectives:

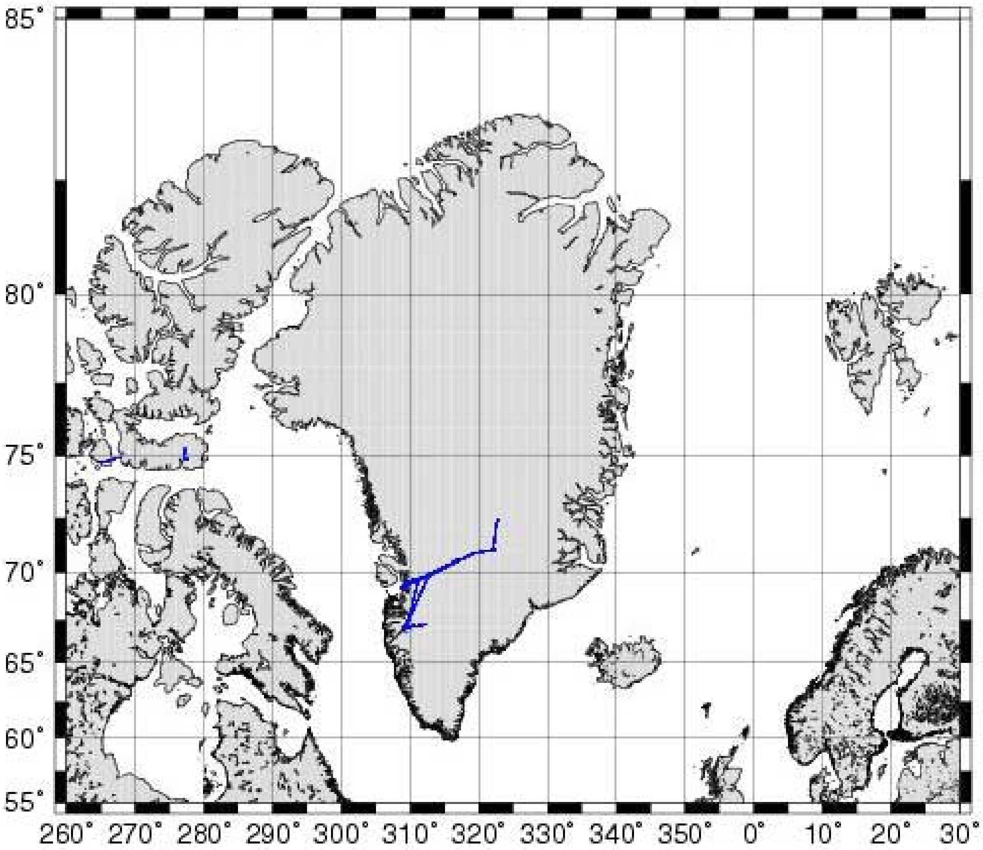
Instrument performance	➢Stability of ASIRAS (daily repeated CAL experiments)
Validation concept	➢Dry inland ice ➢Effect of penetration into dry ice ➢Decorrelation of interferometric looks ➢Angular dependence of reflectivity
Surface type related performance	➢Identification of ice surface types ➢Influence of humidity
Previous Campaigns	➢Acquisition of comparable data sets

ASIRAS 2004 A



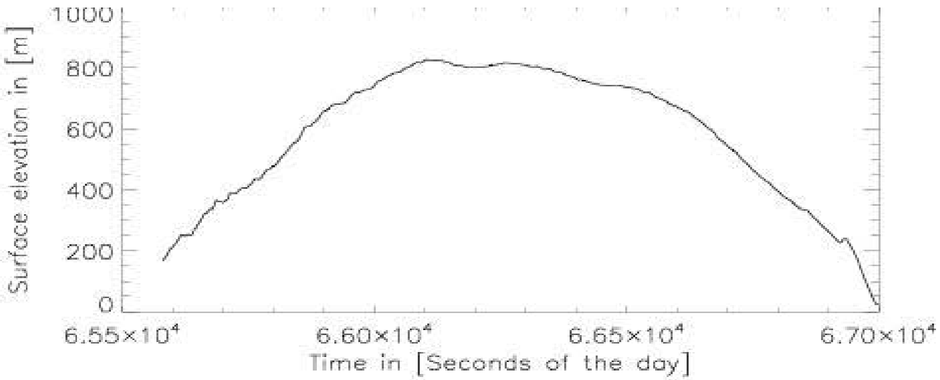
- ASIRAS campaign in spring 2004
- Overflights in Austfonna, Devon Island and West Greenland
- Hard disk problems over the Greenland Icesheet caused by the high flight altitude

ASIRAS 2004 B

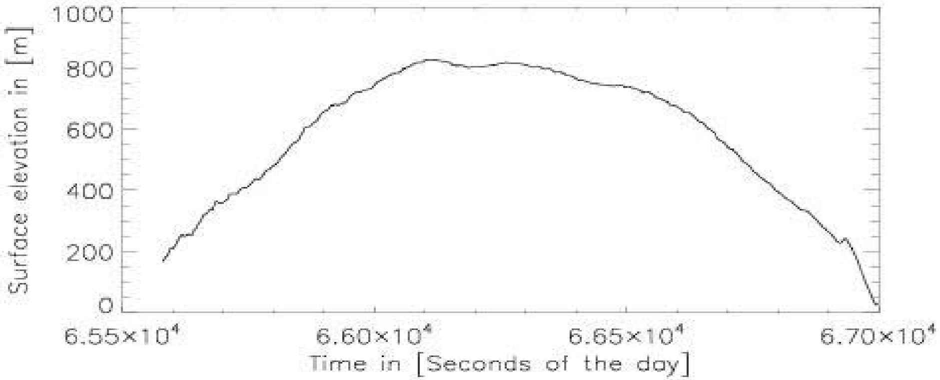


- ASIRAS campaign in autumn 2004
- Overflights in Devon Island and West Greenland
- No GPS ground station for Devon Island

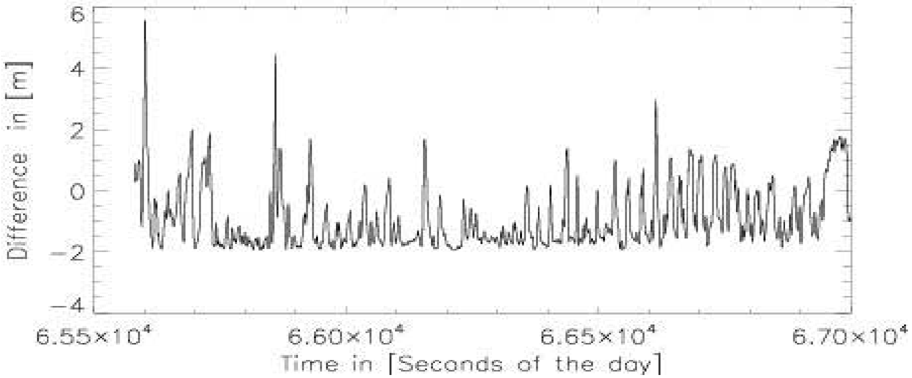
1st results of the comparison between Laser and Radar



Laser Surface elevation – raw data

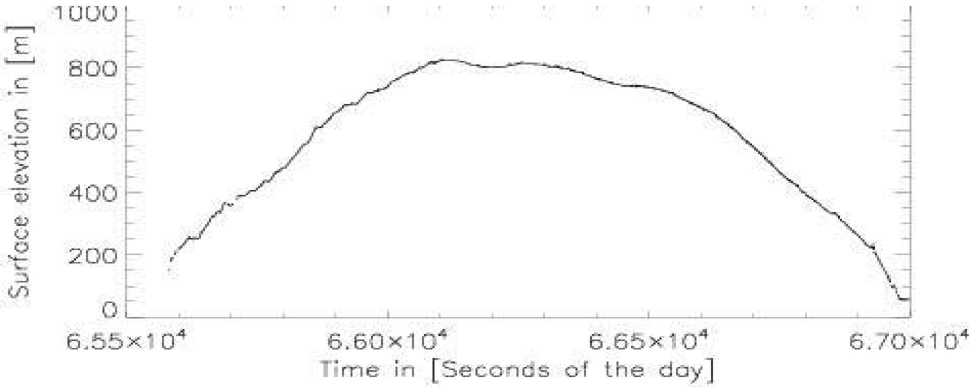


Laser Surface elevation – INS corrected data

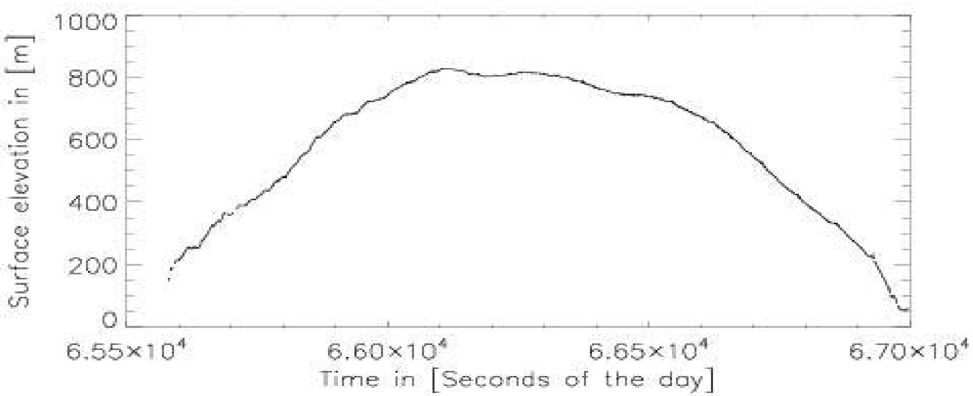


Difference between uncorrected and INS corrected Surface elevations

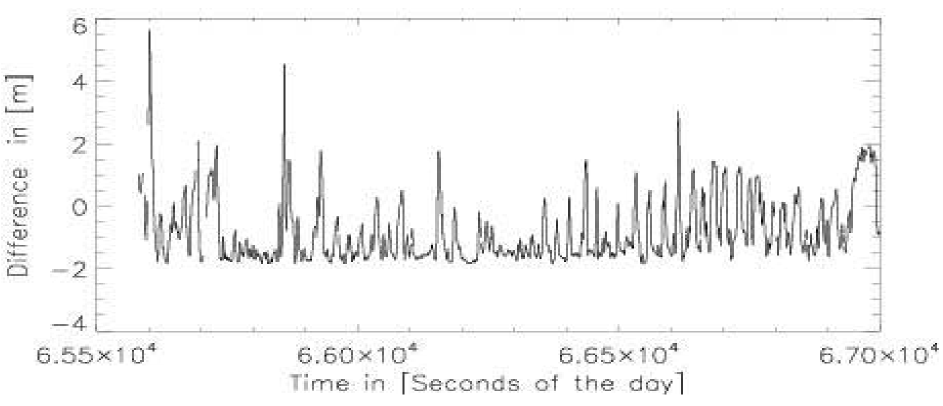
1st results of the comparison between Laser and Radar



Radar Surface elevation – raw data

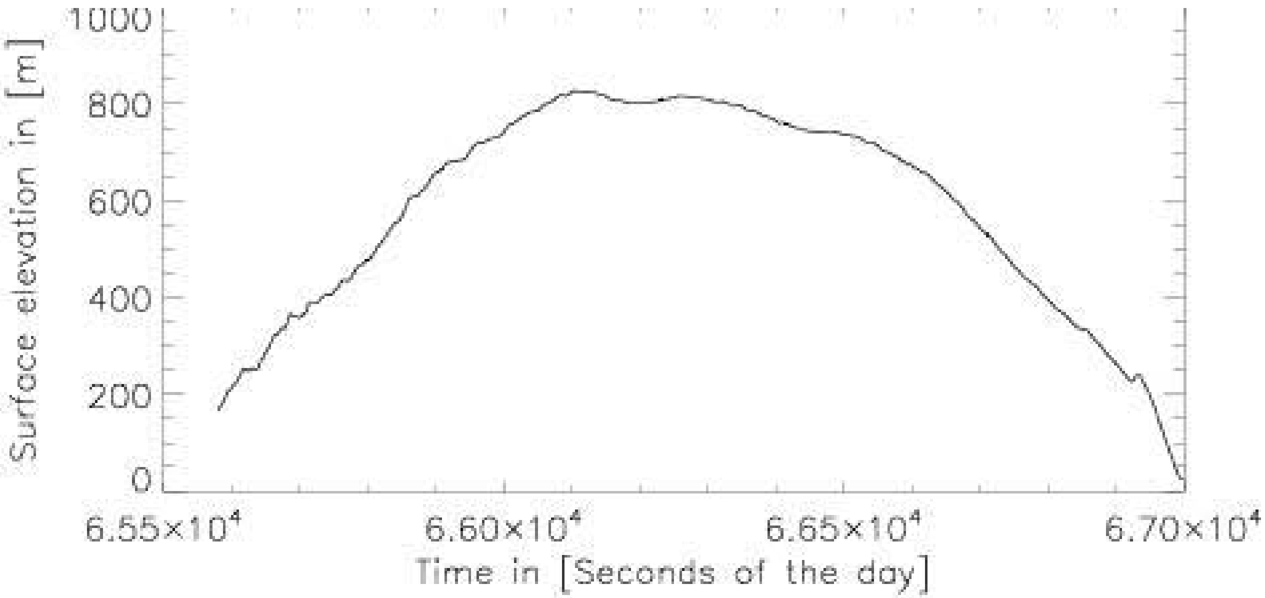


Radar Surface elevation – INS corrected data

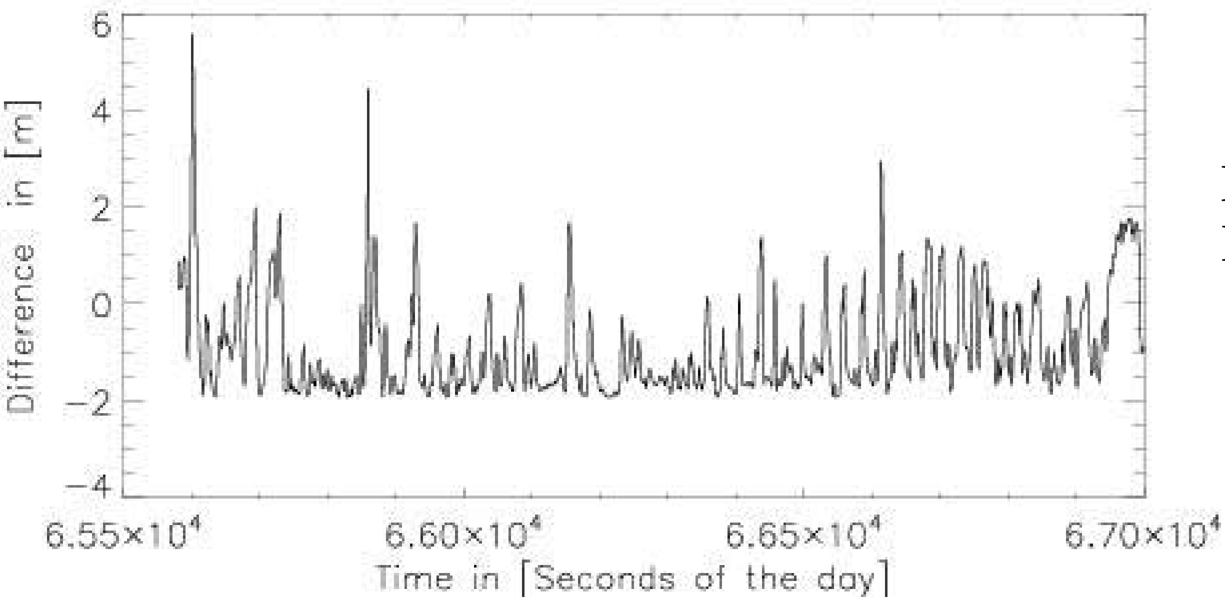


Difference between uncorrected and INS corrected Surface elevations

1st results of the comparison between Laser and Radar

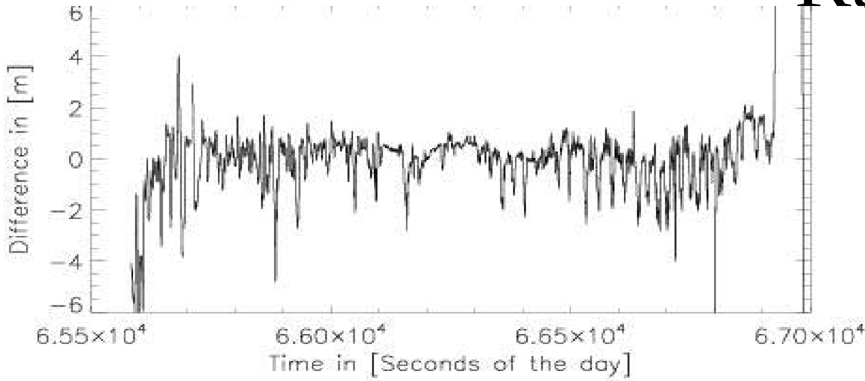


Laser Surface elevation

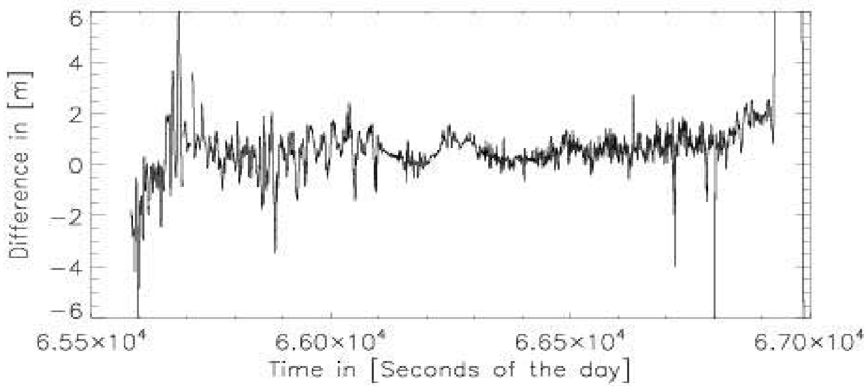


Difference between uncorrected and INS corrected Surface elevations

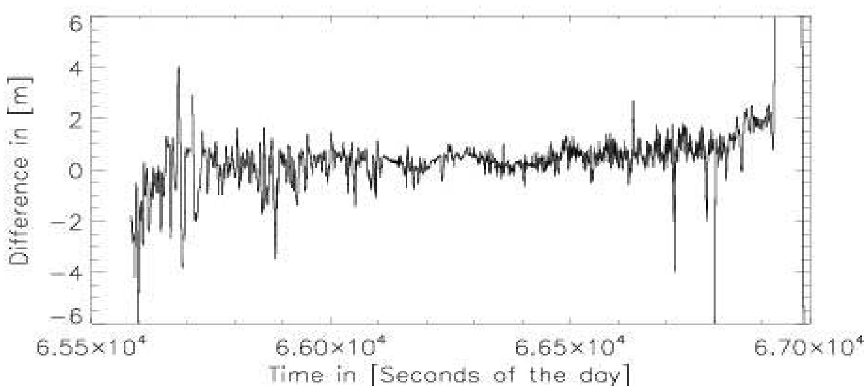
1st results of the comparison between Laser and Radar



Difference between INS corrected Laser and
INS corrected Radar Surface elevations

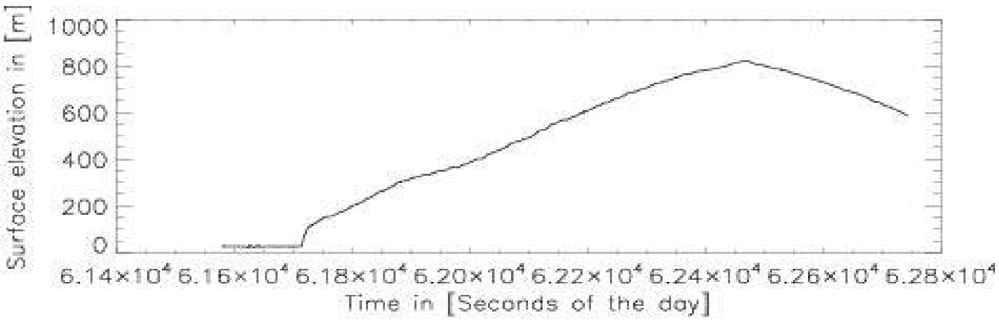


Difference between INS corrected Laser and INS
(**without Pitch correction**) corrected Radar Surface elevations

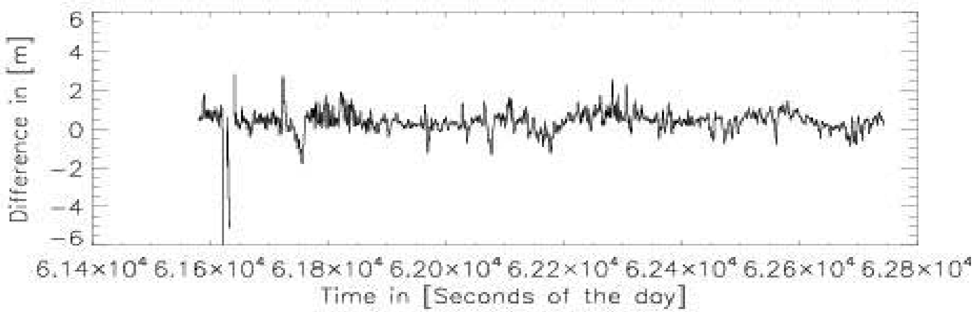


Difference between INS corrected Laser and INS
(**Pitch correction for Pitch > 0°**) corrected Radar Surface elevations

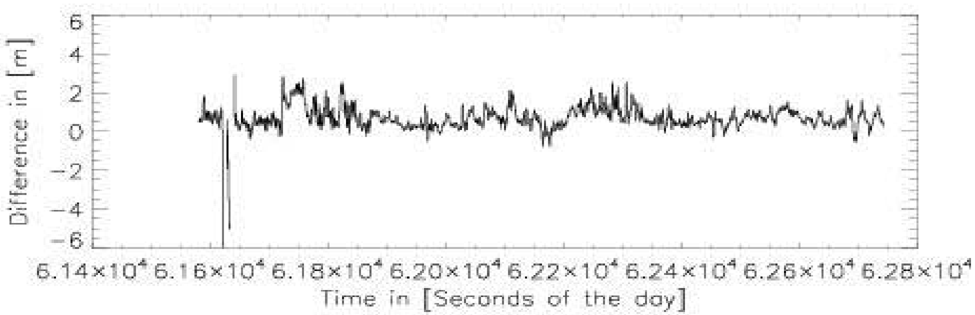
1st results of the comparison between Laser and Radar



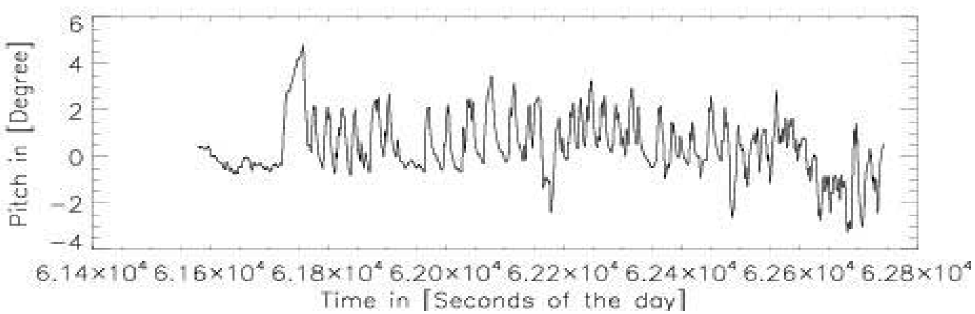
Surface elevation – Profile A040420_01



Difference between INS corrected Laser and INS corrected Radar Surface elevations



Difference between INS corrected Laser and INS (**without Pitch correction**) corrected Radar Surface elevations



Pitch

Examples of Radar echoes