Characterisation of the Cryosphere with GNSS-R Data from TechDemoSat-1

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Introduction

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Sea Ice Characterisation and Monitoring using GPS-Reflectometry data from TechDemoSat-1

Step one: Get to know your data…
Getting to know the data

Evidence of surface characteristics in signal
Causes of changes in
  • Delay
  • Amplitude
  • Doppler spread

Effect of surface characteristics, eg.
  • Roughness
  • Thickness of ice – signal penetration depth
  • Snow cover
  • Melt water overlay
  • Sea ice concentration
Data

TechDemoSat-1 data
Surrey Satellite Technology, UK
Southern Ocean and Antarctica
October 2014 – February 2015 (First release)
Acquired from MERRByS database (merrbys.co.uk)

All data used in initial investigations
- specular points south of 60°S
- Antenna Gain > 12 dBi

Control data from satellite observations, CryoSat-2, NSIDC, OSI SAF, EUMETSAT
- 43 tracks in total
- 43 tracks in total
- Antenna Gain
  \[ >12 \text{ dB} \]
• 43 tracks in total
• Antenna Gain
  >12 dB
• 23 – Sea ice
• 43 tracks in total
• Antenna Gain
  >12 dB
• 23 – Sea ice
• 7 – Glacial Ice
• 43 tracks in total

• Antenna Gain
  >12 dB

• 23 – Sea ice

• 7 – Glacial Ice

3 Altimetry tracks - RD18_TD000619, RD19_TD000284, RD19_TD000908
GNSS-R as altimetry – Glacial Ice

- Tracking movement of maximum amplitude in delay
- Previously applied to SSH (Clarizia et al., 2016)
- Uses difference between expected delay (SP on ellipsoid) and delay in data (above ellipsoid)
- Compared with monthly CryoSat-2 data
- Median across 3 months to remove anomalies
GNSS-R as altimetry – Glacial Ice

TDS-1 Track RD18-TD000619

TDS-1 Track RD19-TD000284

TDS-1 Track RD19-TD000908

[Graphs showing elevation vs. latitude for different tracks]

CryoSat-2 Data

Calculated from TDS-1 delay
GNSS-R as altimetry – Glacial Ice

Sources of uncertainty
Height calculations

- offset of specular point from TDS nadir
- slope of glacial ice
GNSS-R as altimetry – Glacial Ice

**Sources of uncertainty**

Height calculations
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Specular Point Positioning
- Height from ellipsoid
- Specular point calculation
GNSS-R as altimetry – Glacial Ice

Clarizia et al., 2016
GNSS-R as altimetry – Glacial Ice

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TDS-1 Track RD18-TD000619  TDS-1 Track RD19-TD000284  TDS-1 Track RD19-TD000908

![Graphs showing elevation vs latitude for different tracks and methods]

- Blue line: CryoSat-2 Data
- Red line: Calculated from TDS-1 delay
- Black line: Calculated from TDS-1 delay and SPG4 orbit

Elevation (m)

Latitude (°North)
GNSS-R as altimetry – Glacial Ice

**Sources of uncertainty**

Height calculations
- offset of SP from TDS nadir
- slope of Glacial Ice

Specular point Positioning
- Specular point miscalculation
- Height from ellipsoid

Cryosat Data
- median of 3 months
- interpolation of scattered points
Sea ice characterisation

- Sea ice vs. Glacial Ice
- First year / Second-year / Multi-year ice
- Health and longevity of ice
- Monitoring of ice dynamics
- Signal to noise ratio calculation

\[
SNR = \frac{\text{98th percentile of DDM amplitudes}}{\text{median(DDM noise rows)}}
\]
SNR vs. Emissivity
Summary

- GNSS-R as altimetry
  - Height uncertainties
  - Uncertainty in location of specular point
  - Uncertainty in comparison
- Importance of monitoring sea ice
- SNR calculation
- SNR interaction with
  - Sea ice concentration
  - Emissivity
- Necessary to repeat analyses with later releases of TDS data and DDMs of normalized bistatic radar cross section
Data Used

**CryoSat-2 Elevation** - Level-2 Geophysical Data Record, height of surface above reference ellipsoid.
ftp://science-pds.cryosat.esa.int

**NSIDC Sea Ice Concentration** - Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS Passive Microwave Data
http://nsidc.org/data/NSIDC-0051

**EUMETSAT OSI SAF Emissivity** – The near 50GHz global sea ice emissivity
ftp://osisaf.met.no/archive/ice/emis/

**SPG4 Orbit Simulator** – Andrew Shaw, Skymat Ltd., UK
Thank you for listening

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