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

Jessica Cartwright (PhD student) [1,2], Maria-Paola Clarizia[2], Chris Banks[1], Paolo Cipollini[1], Andrew Shaw[3]

[1] National Oceanography Centre, Southampton, UK
[2] University of Southampton, UK
[3] SKYMAT Ltd., Southampton, UK

SPITFIRE Southampton Partnership for Innovative Training of Future Investigators Researching the Environment

UNIVERSITY OF Southampton

National Oceanography Centre NATURAL ENVIRONMENT RESEARCH COUNCIL

noc.ac.uk

NERC SCIENCE OF THE ENVIRONMENT

Introduction

Jessica Cartwright

PhD student (as of October 2016)

National Oceanography Centre, UK

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)

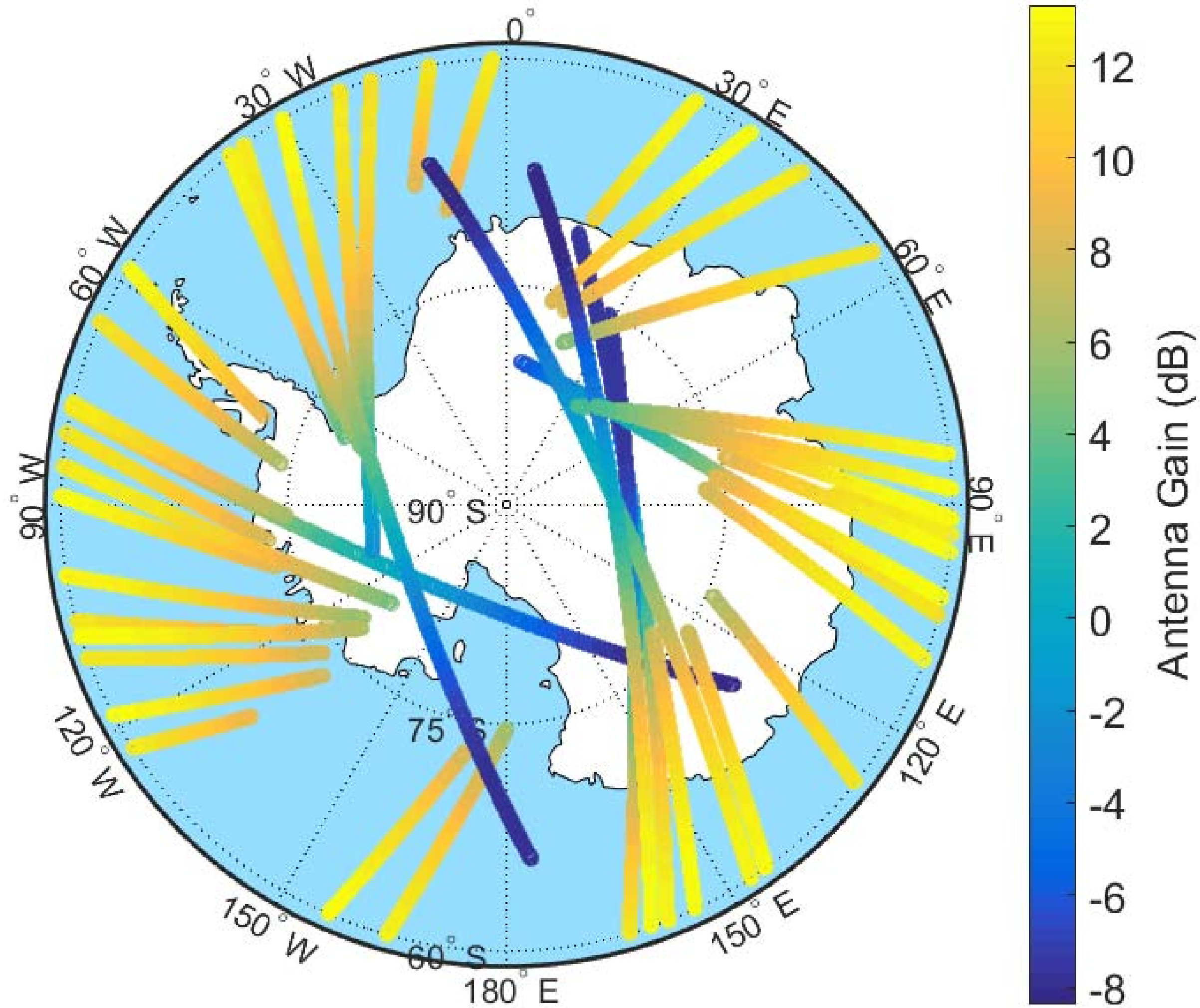
Acquired from MERRByS database (merrbys.co.uk)

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

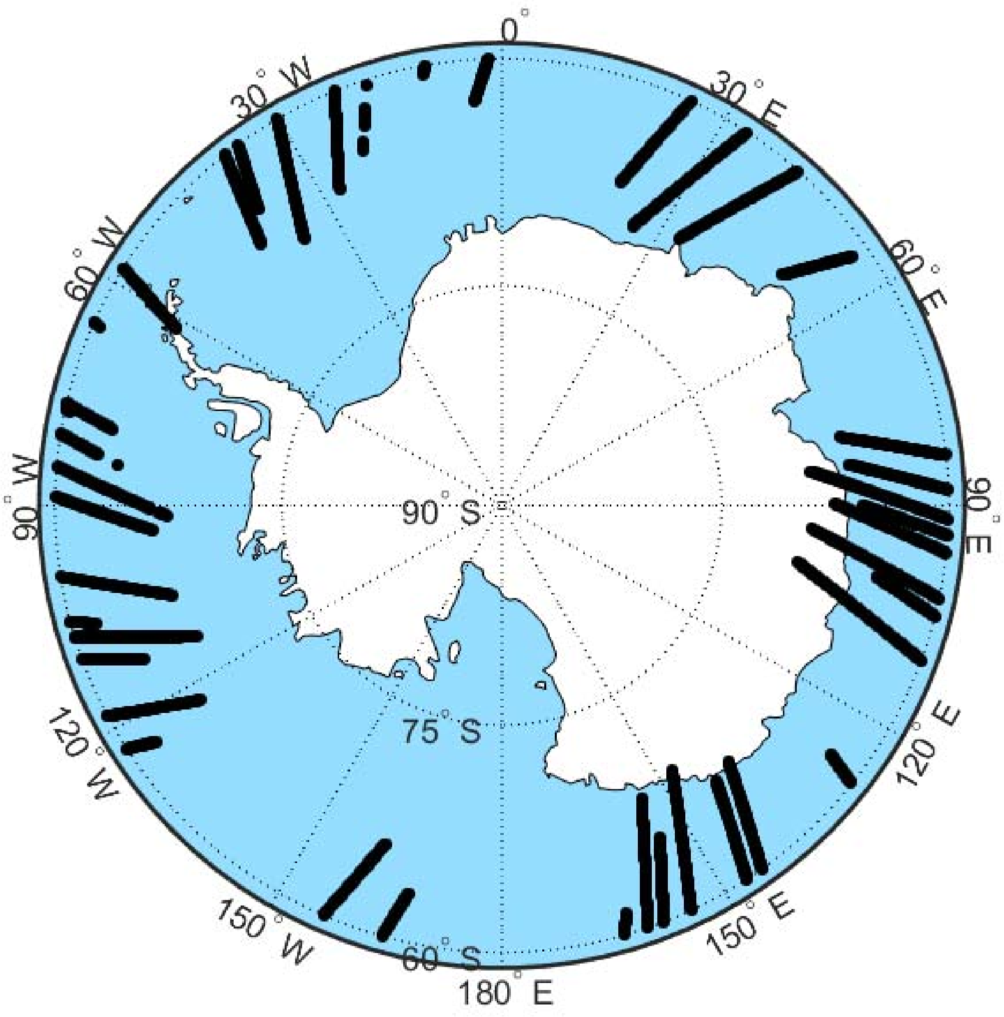
- 43 tracks in total



- 43 tracks in total

- Antenna Gain

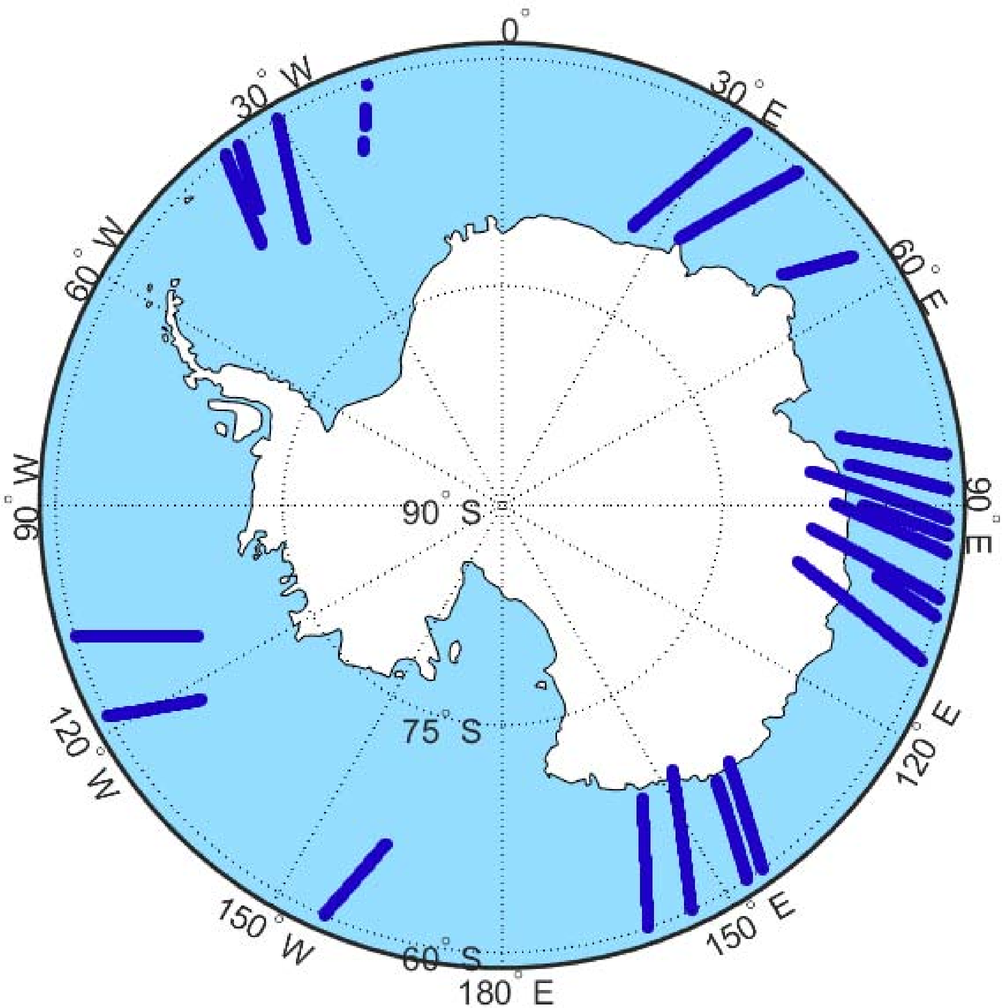
  >12 dB



- 43 tracks in total
- Antenna Gain

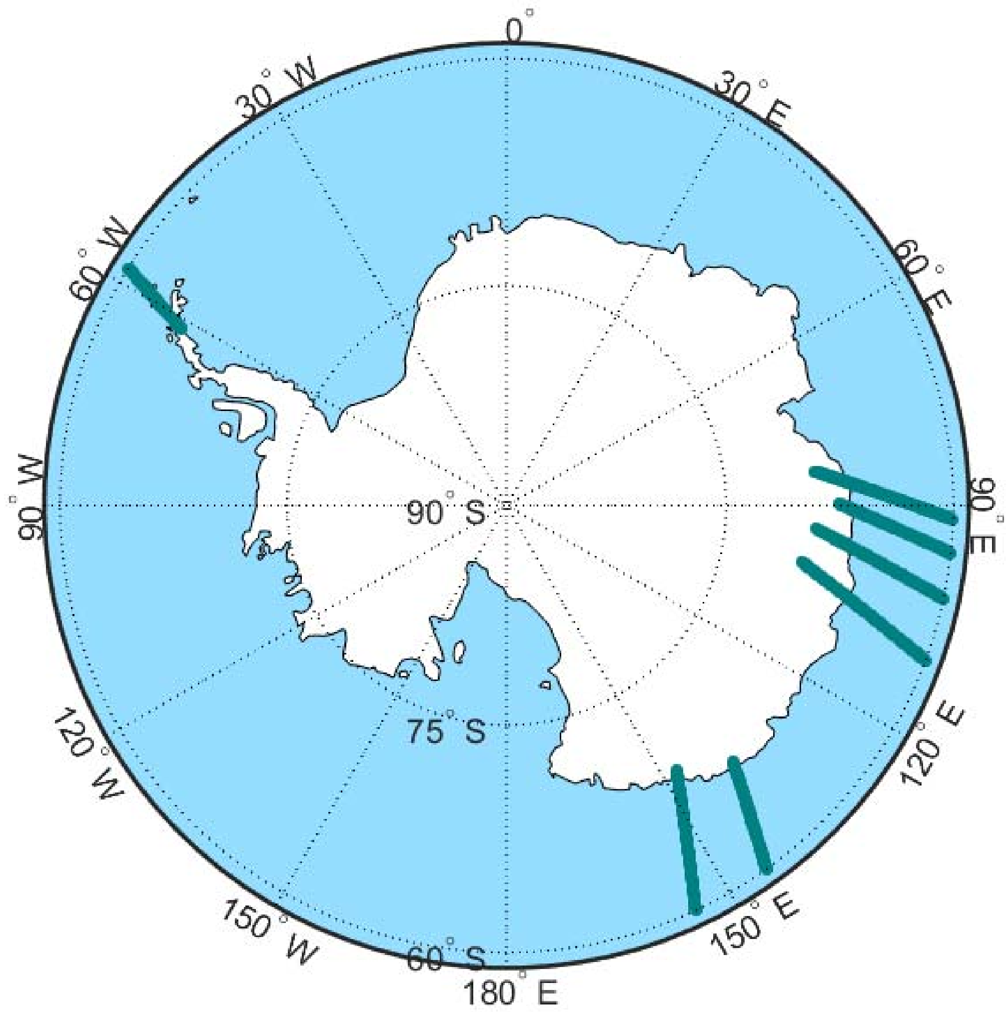
  >12 dB

- 23 – Sea ice



- 43 tracks in total
- Antenna Gain

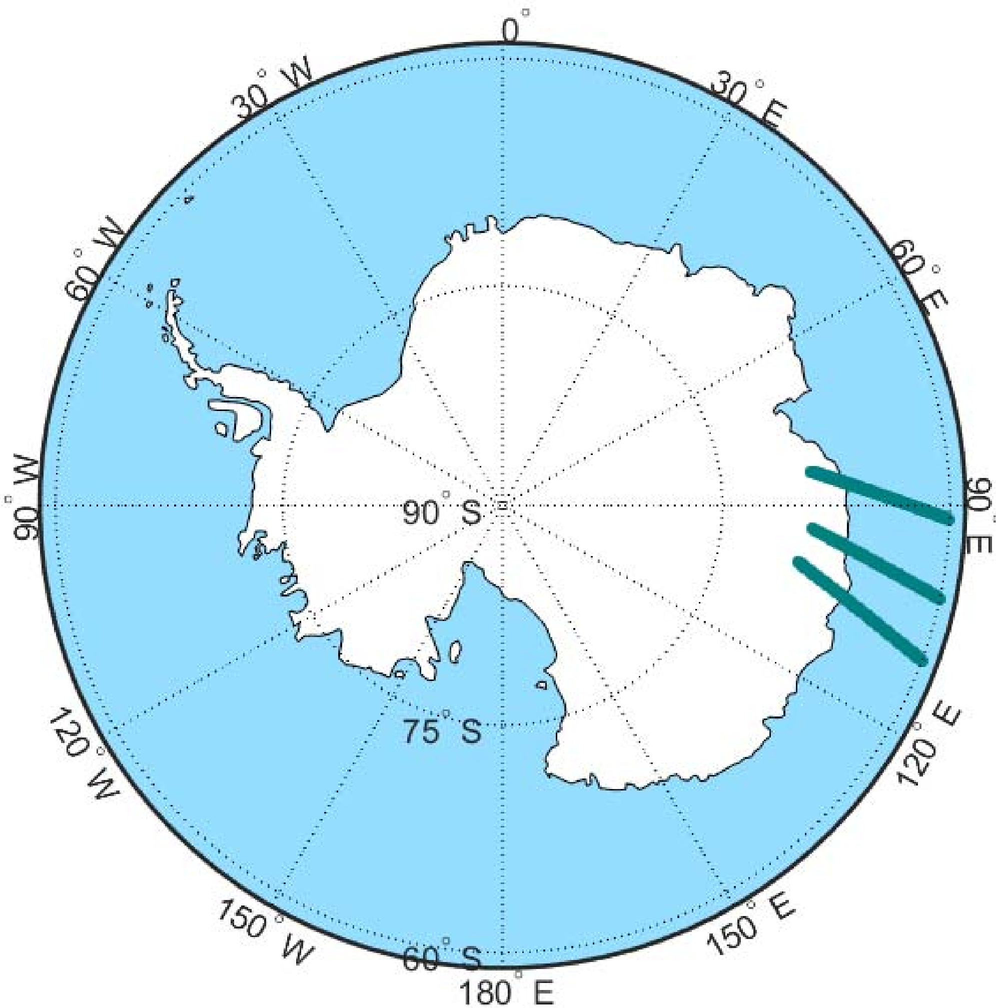
  >12 dB
- 23 – Sea ice
- 7 – Glacial Ice



- 43 tracks in total
- Antenna Gain

  >12 dB

- 23 – Sea ice
- 7 – Glacial Ice

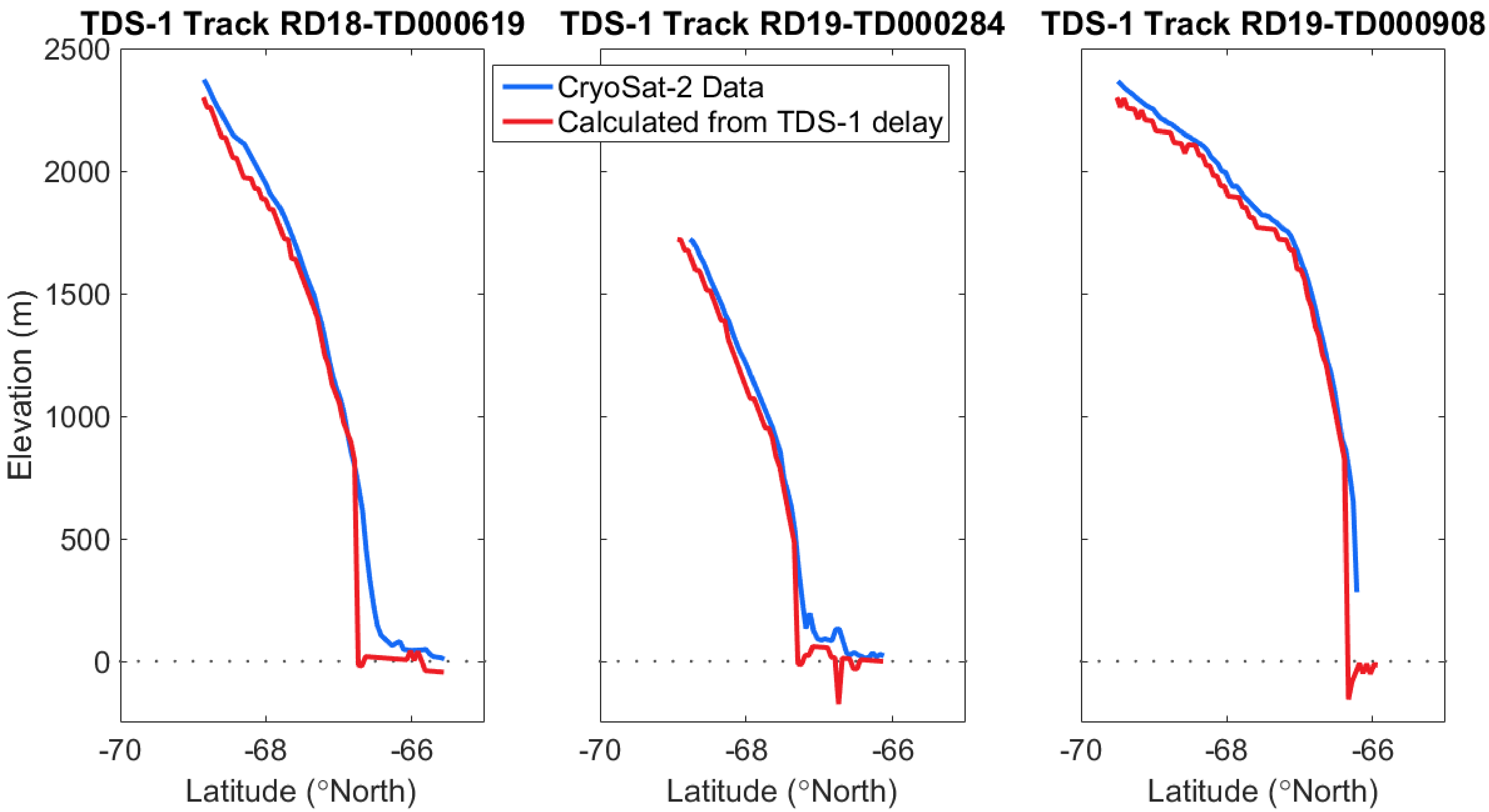


3 Altimetry tracks - RD18_TD000619, RD19_TD000284, RD19_TD000908

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

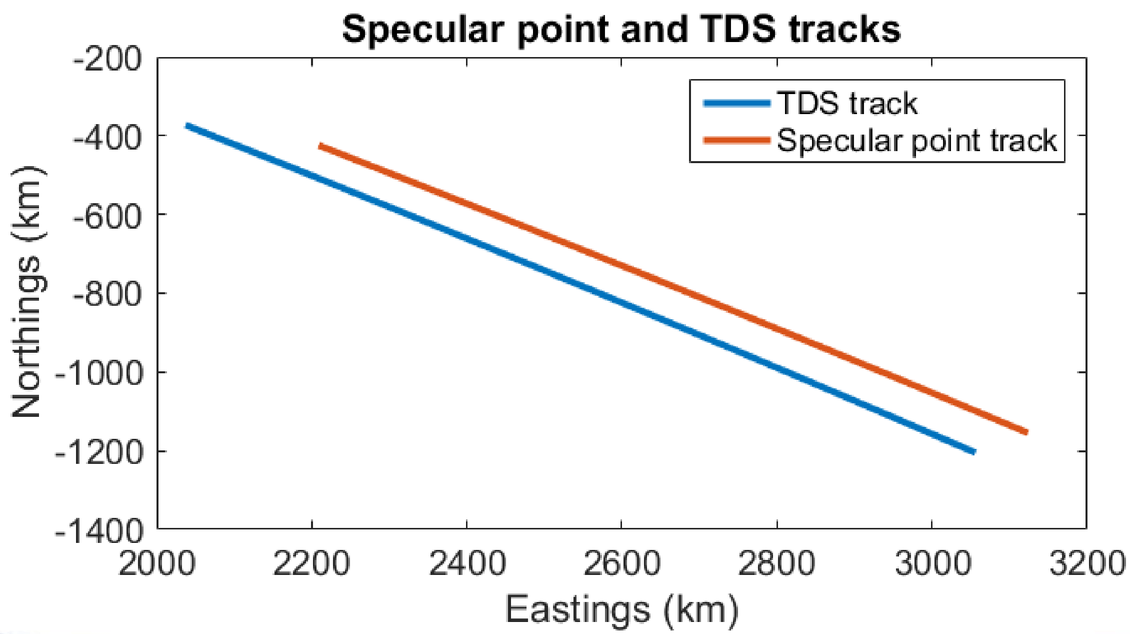


GNSS-R as altimetry – Glacial Ice

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

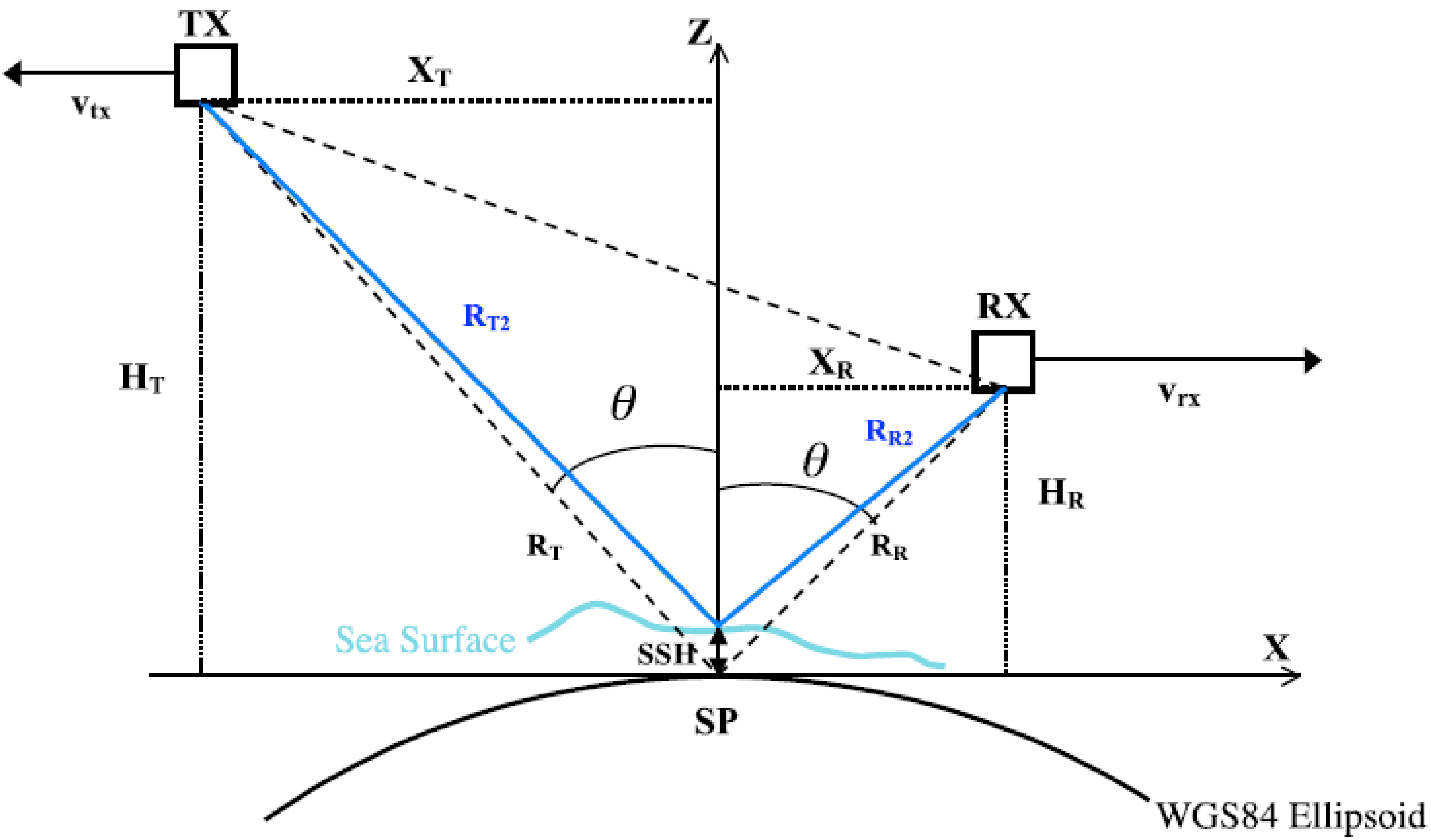
Height calculations

- offset of specular point from TDS nadir
- slope of glacial ice

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

Sources of uncertainty

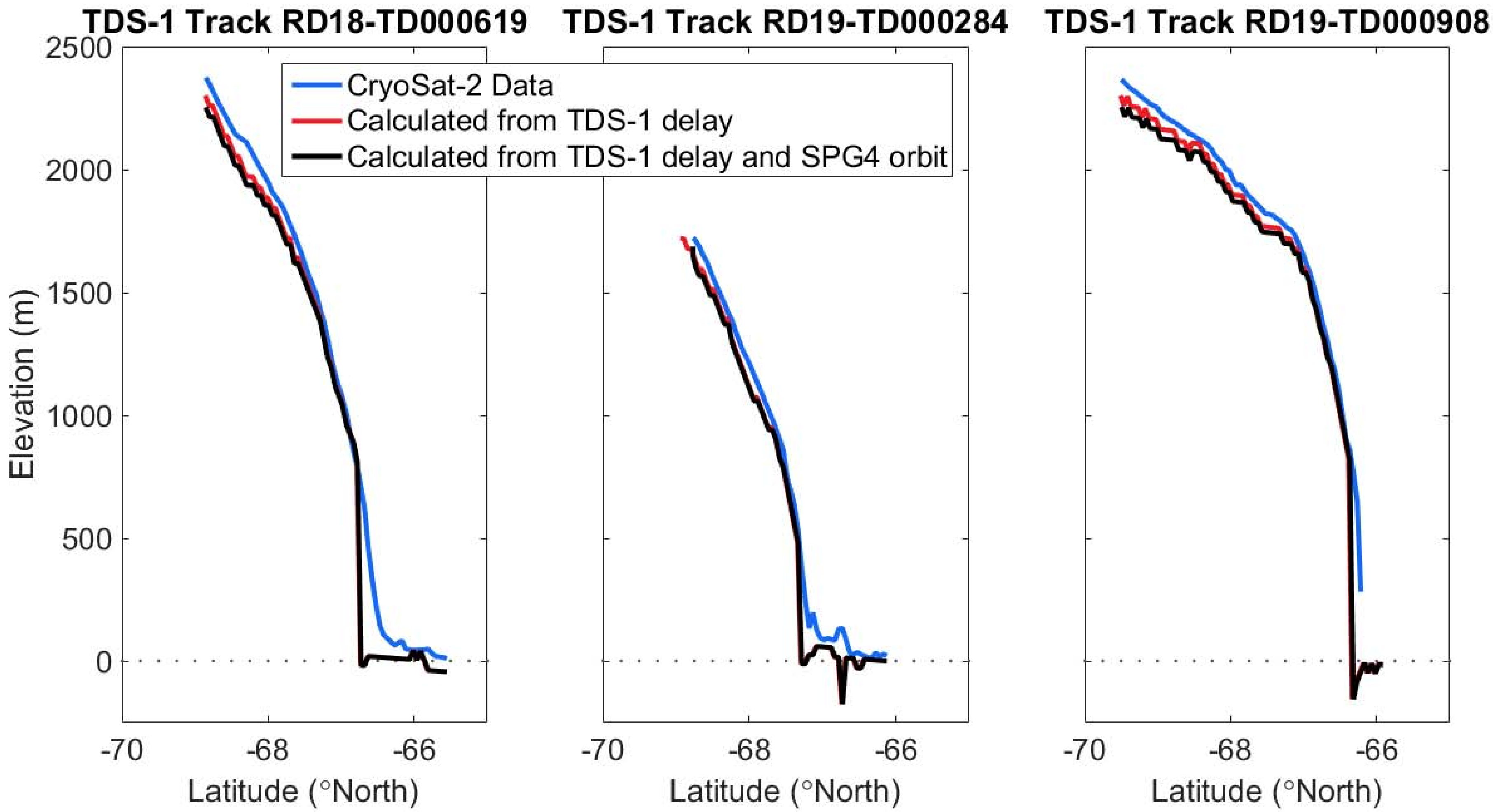
Height calculations

- offset of specular point from TDS nadir
- slope of glacial ice

Specular Point Positioning

- Height from ellipsoid
- Specular point calculation

GNSS-R as altimetry – Glacial Ice



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

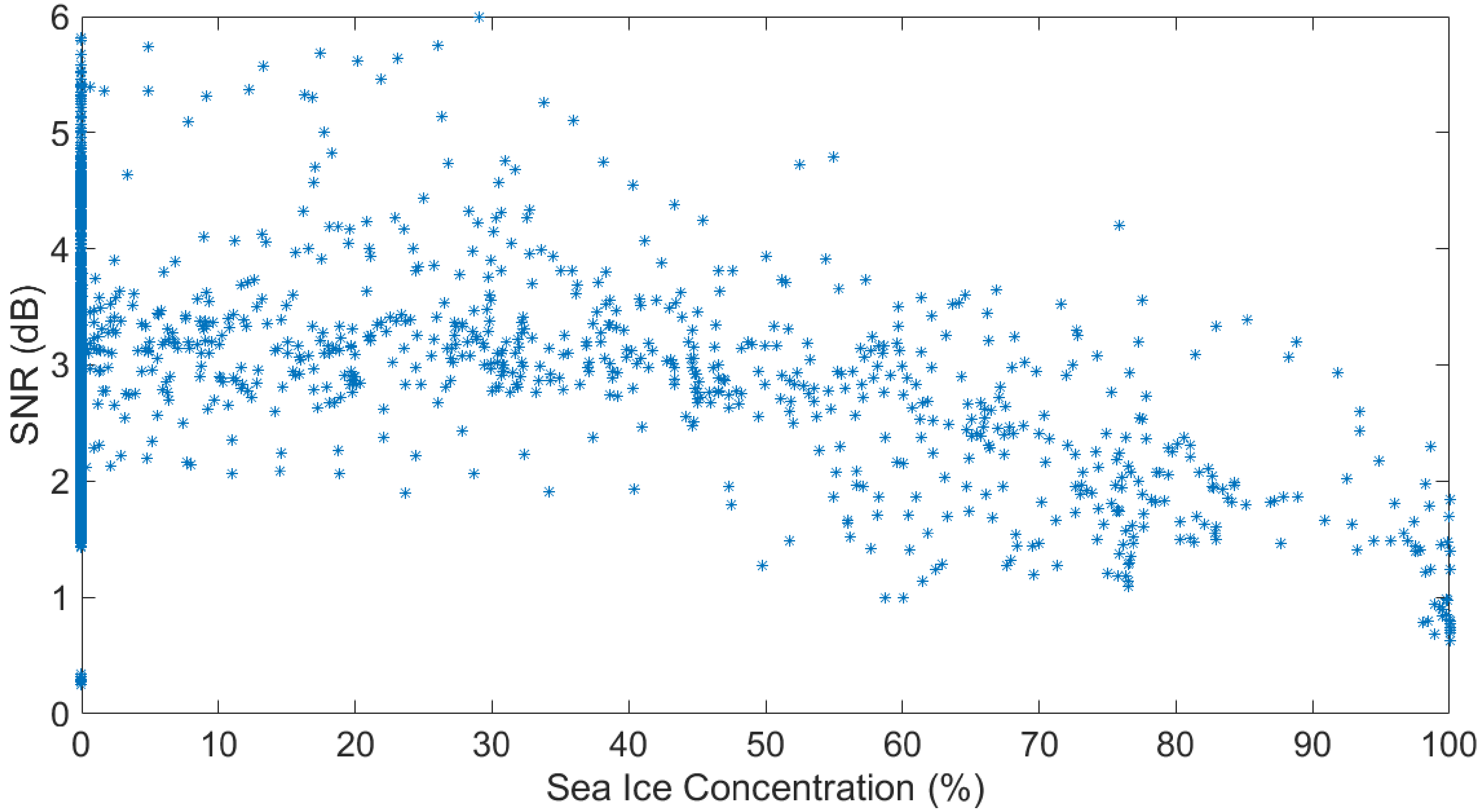
- Sea ice vs. Glacial Ice

- First year / Second-year / Multi-year ice
- Health and longevity of ice
- Monitoring of ice dynamics

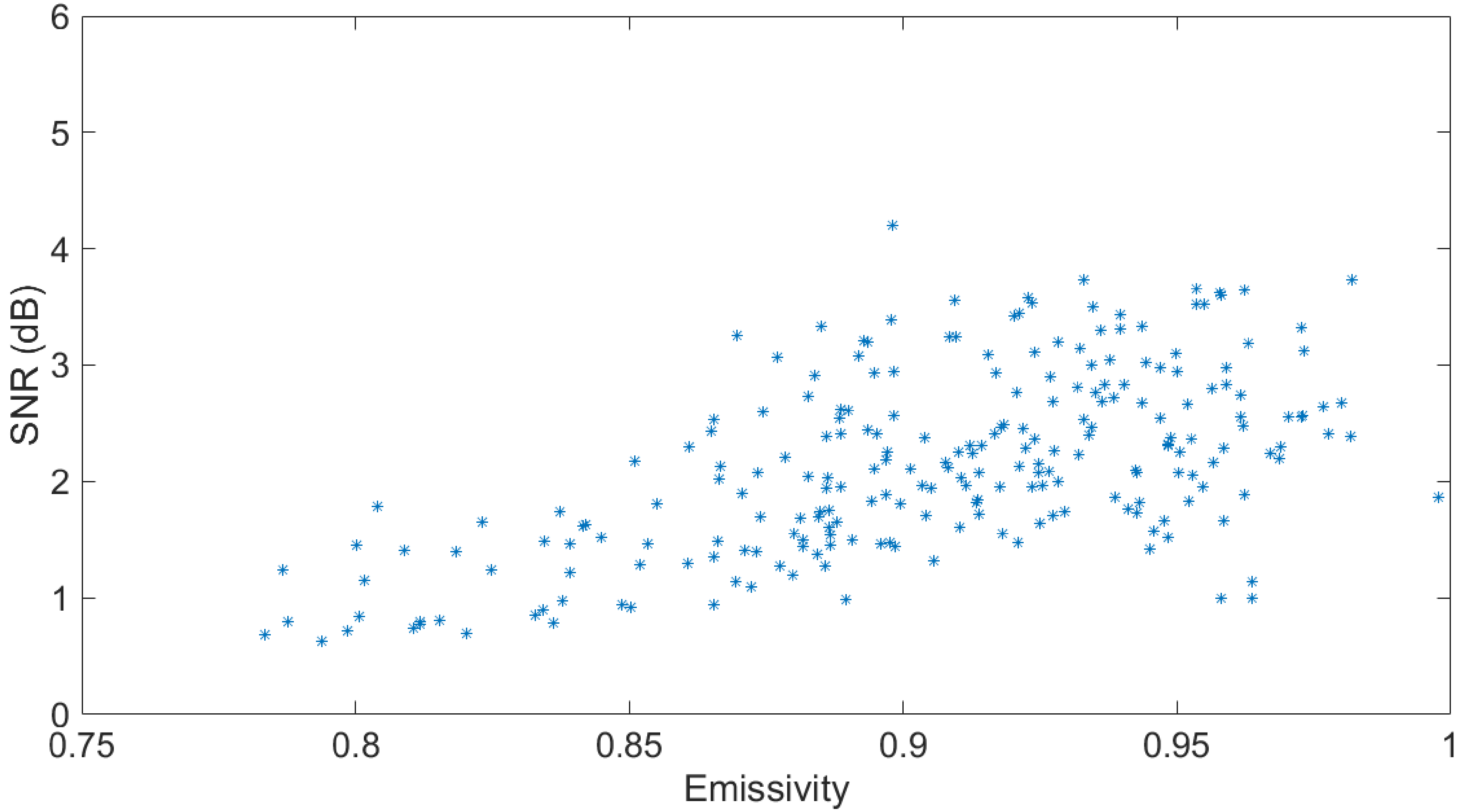
- Signal to noise ratio calculation

$$SNR = \frac{98th\ percentile\ of\ DDM\ amplitudes}{median(DDM\ noise\ rows)}$$

SNR vs. Sea Ice Concentration



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

- 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

- jc1n15@noc.soton.ac.uk