

***Investigations into the Spatial Pattern of Annual and
Interannual Snow Coverage of Brøgger Peninsula, Svalbard,
2000 - 2007***

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- Introduction
- Data
- Methods
- Results
- Conclusion

- Major role of polar areas in the context of global warming
- Decrease of arctic snow cover: 10 % over the last 30 years
- Ongoing project at NPI: effect of global warming on polar areas
- Pillewizer (TU Dresden) expeditions in 1962 and 1964/65 on Brøgger Peninsula

Svalbard

- Circumjacent land area of the Polar Basin
- Franz Josef Land in the East
- Greenland and Ellesmere Land in the West



Svalbard

- All islands located between 74° and 81° N, and 10° and 35° E
- $\sim 61\,200\text{ km}^2$
- $\sim 2\,400$ residents



Brøgger Peninsula

- *Research metropolis*
Ny-Ålesund
- Total area of
~ 220 km²
- Maximum elevation:
1017 masl
- Glaciated area:
Total: ~ 55 km²
Studied: ~ 15 km²



Climate

- Gateway for air and water masses exchange between medium and high latitudes
- Local weather anomaly compared to elsewhere in the Arctic due to the Gulf Stream
- Brøgger Peninsula
 - Average annual temperature of -6°C
 - Numerous warm temperature anomalies in winter
 - Mean precipitation of ca. 400 mm per annum

Sounding

- Snow depth measurements from 2000 till 2007



Sounding

- Snow depth measurements from 2000 till 2007
- Lowlands
 - soundings with 200 m spacing along several tracks
- Glaciers
 - virtually regular grid with intervals from 150 to 200 m
- Not situated on consistent measuring points during the years

Ground Penetrating Radar (GPR)

- Snow depth measurements for 2000 and 2007 in lowlands



1800 MHz
antenna



GPR
control unit



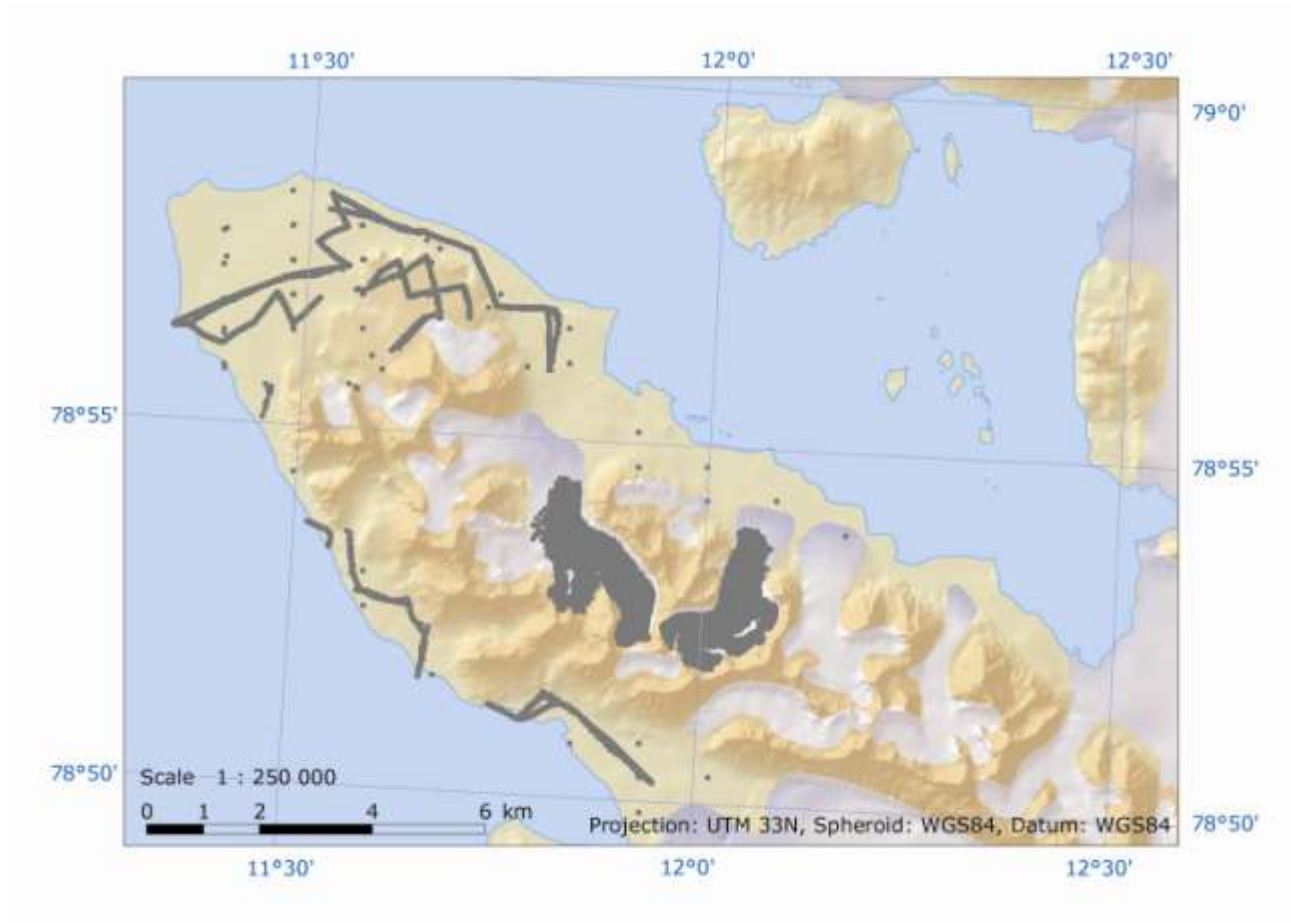
antenna sled &
trigger wheel

Ground Penetrating Radar (GPR)

- Manual digitalisation about every three to six traces along the separate profiles



In Situ Measurements Locations



Moderate Resolution Imaging Spectroradiometer

- Installed on the multi-instrument NASA Earth Observing System satellites Terra (02/2000) and Aqua (05/2002)



- MODIS Albedo Product
 - Black-sky and white-sky albedo for spectral MODIS bands 1 to 7 and three broadbands (VIS,NIR,SW)
 - ⇒ white-sky SW

QuikSCAT/SeaWinds Scatterometer

- NASA radar system to determine the backscatter of the Earth's surface in function of the incidence angle
- Launched in June 1999
- Normalised Radar Cross Section σ^0
 - Radar equation referred to a unit area on the horizontal ground plane
 - Horizontal and vertical polarisation at 46° and 54.1° nominal incidence angle
⇒ VV

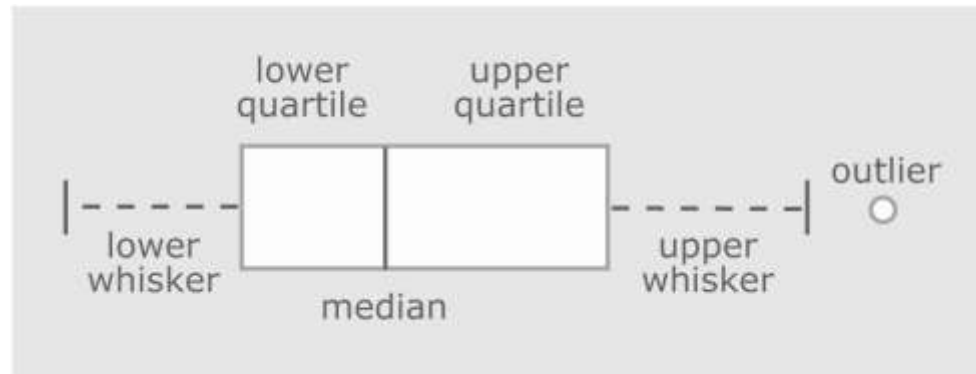


Meteorological Data from Ny-Ålesund

- Temperature and precipitation provided by the Norwegian Meteorological Institute
- Covering August 1999 to July 2007
- Snow accumulation derived from the snowmodel provided by Kohler and Aanes 2004

Correlating Relief Parameters

- Statistical evaluation by using box-and-whisker plots



- Data differentiated by year and location, i.e. lowlands and glaciers

Sounding versus Radar Measurements

- Analysis of the arithmetic mean snow depths of the particular profiles divided by type of measurement

Regional and Local Variability

- Assessment of measurement dispersion for each year using the standard deviation of the mean

- $\delta x = \sigma_{\bar{x}} = \frac{\sigma_x}{\sqrt{N}}$
- $x_i = \bar{x} \pm \delta x$

- Elevation intervals individually generated for lowlands and glaciers

Albedo Analysis

- Developing of extracted albedo mean values covering the period April till September for each year

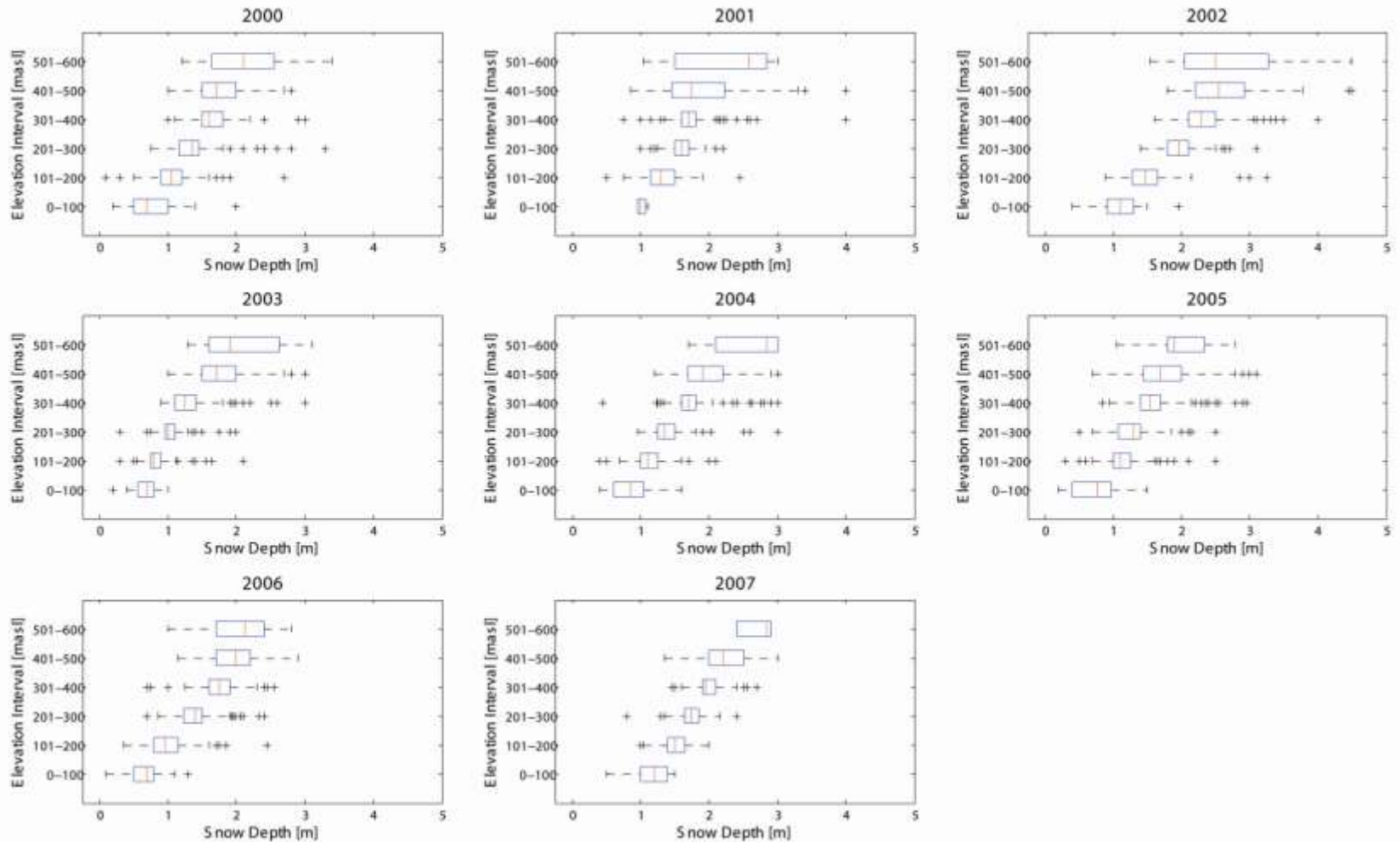
Analysis of Normalised Radar Cross Section

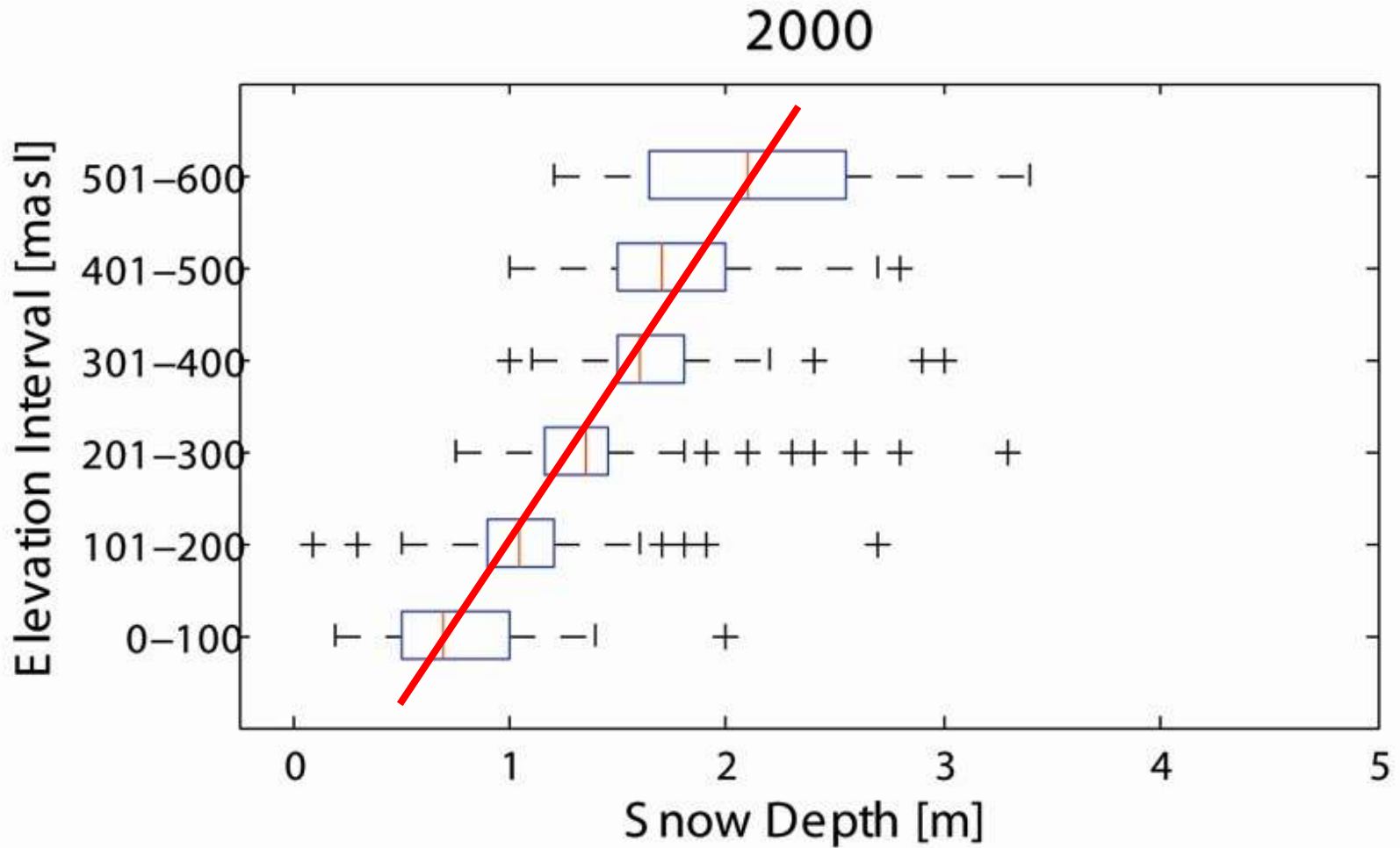
- Developing of σ^0 for VV-polarisation with the meteorological data covering 2000 till 2006

Processing

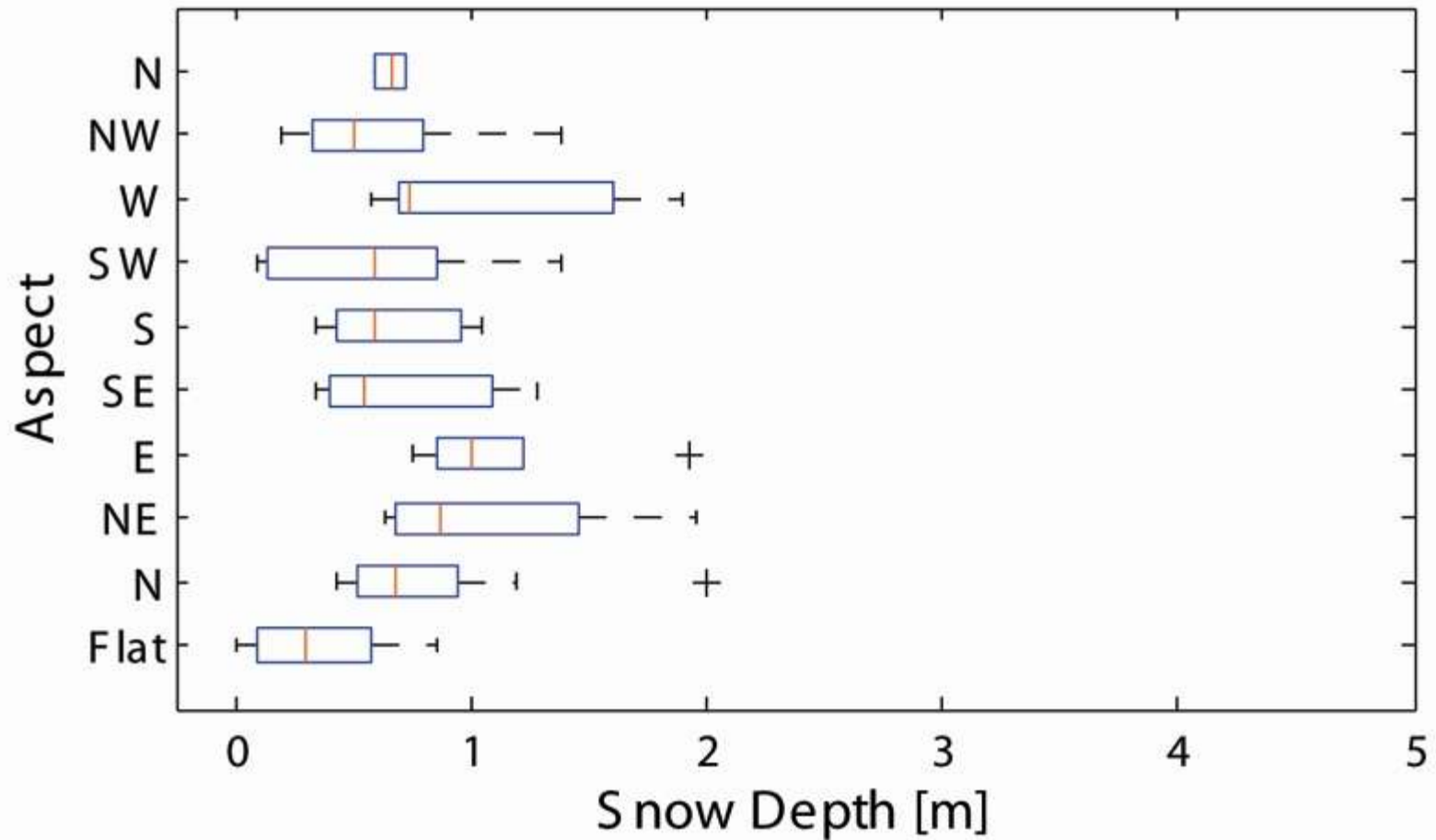
- Interpolation of MODIS data
- Scaling of snow depth measurements in three steps
- Preparation of the correlation matrices for MODIS and QSCAT using annual mean values per pixel
- Calculation of a robust regression per pixel resulting in a matrix containing a coefficient of determination R^2 for each pixel

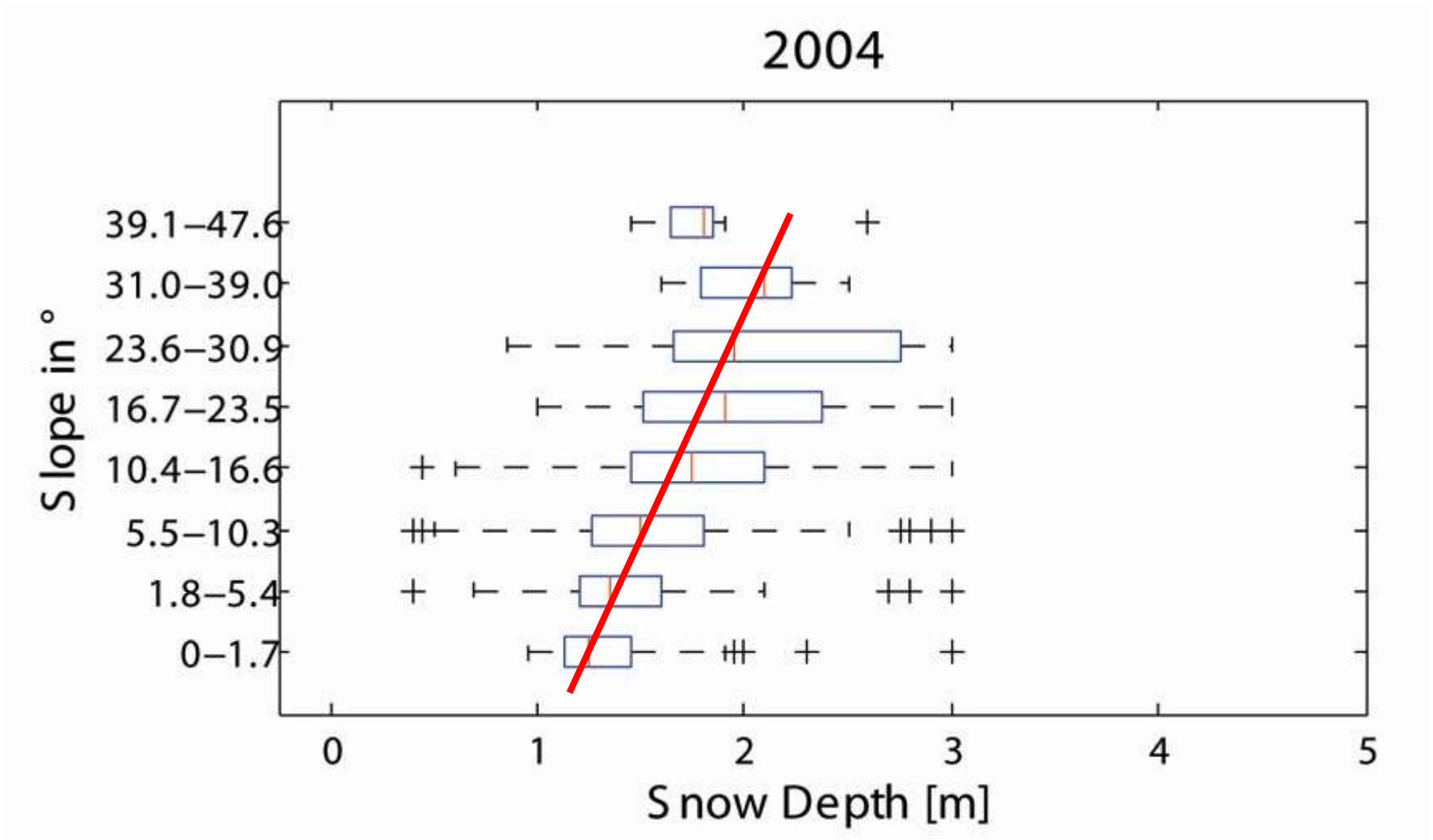
Relief Parameters



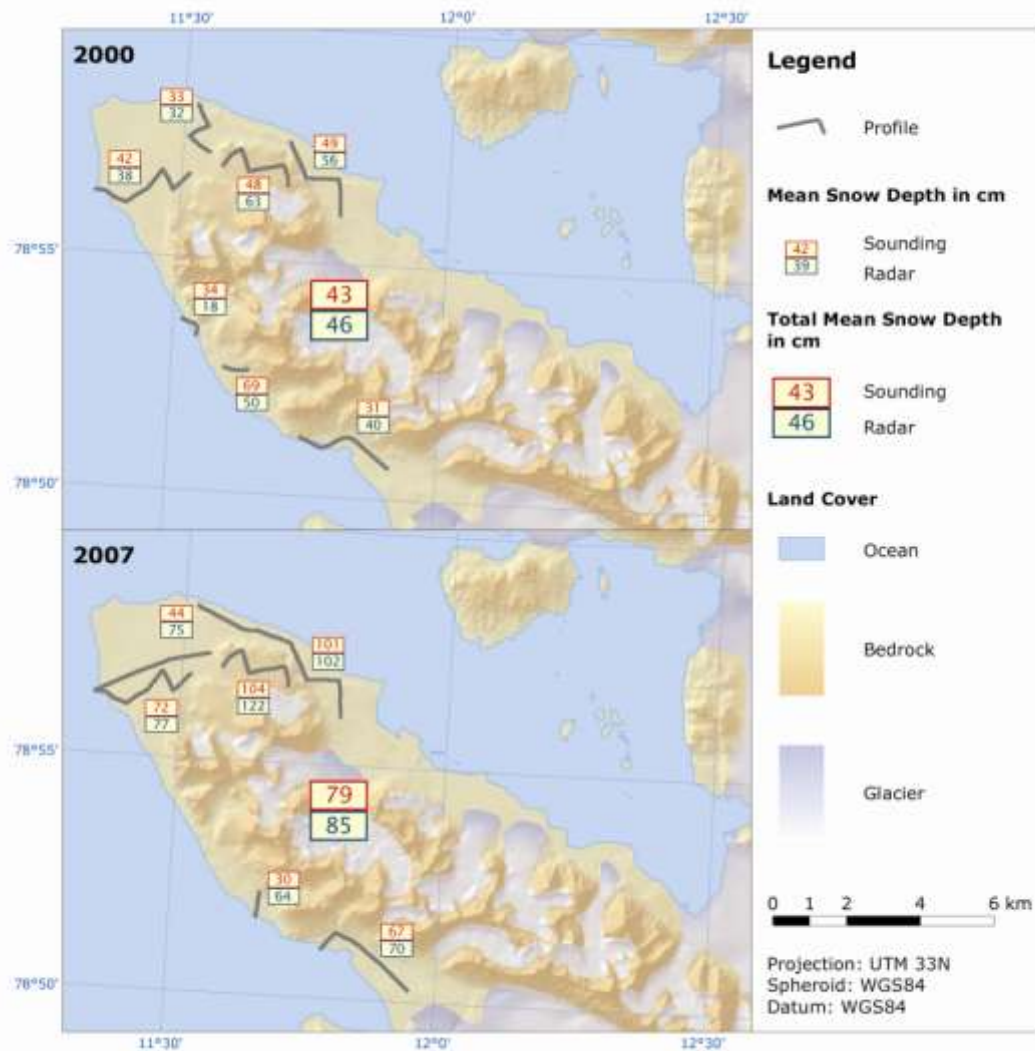


2007 – Sounding

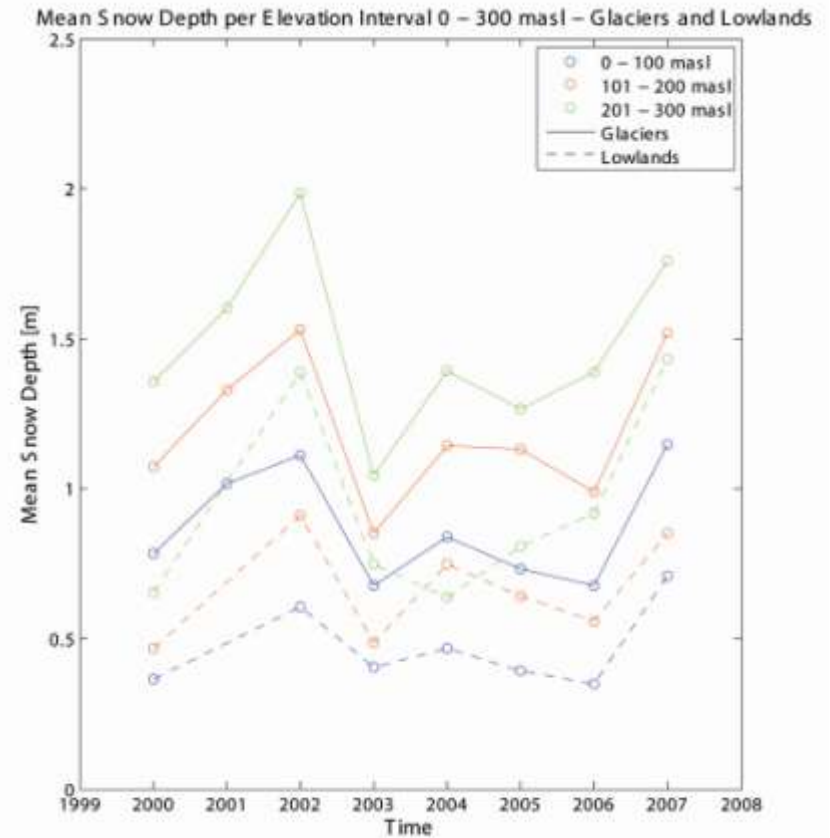
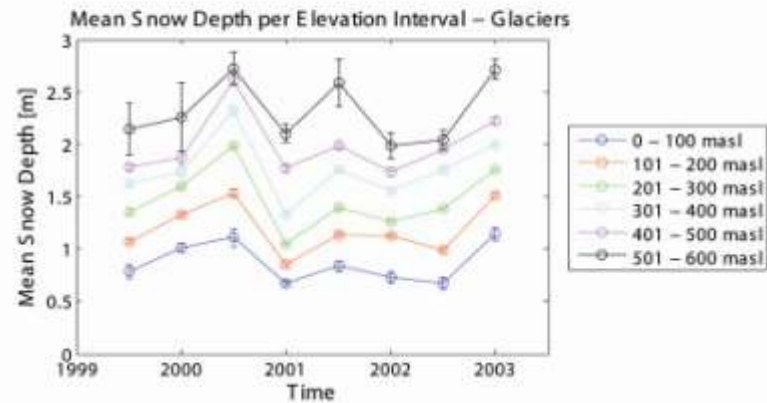
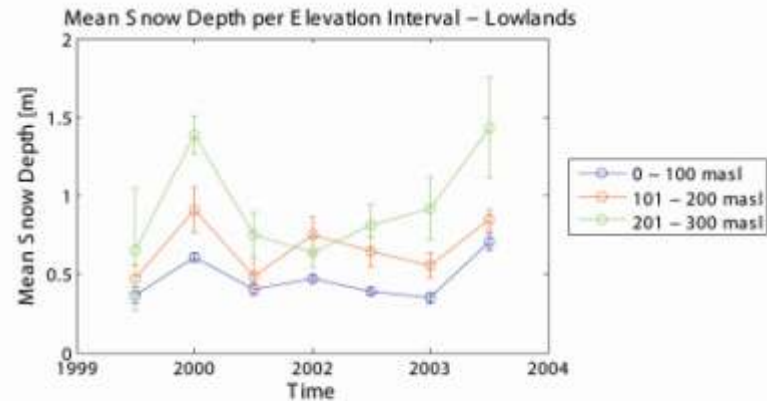




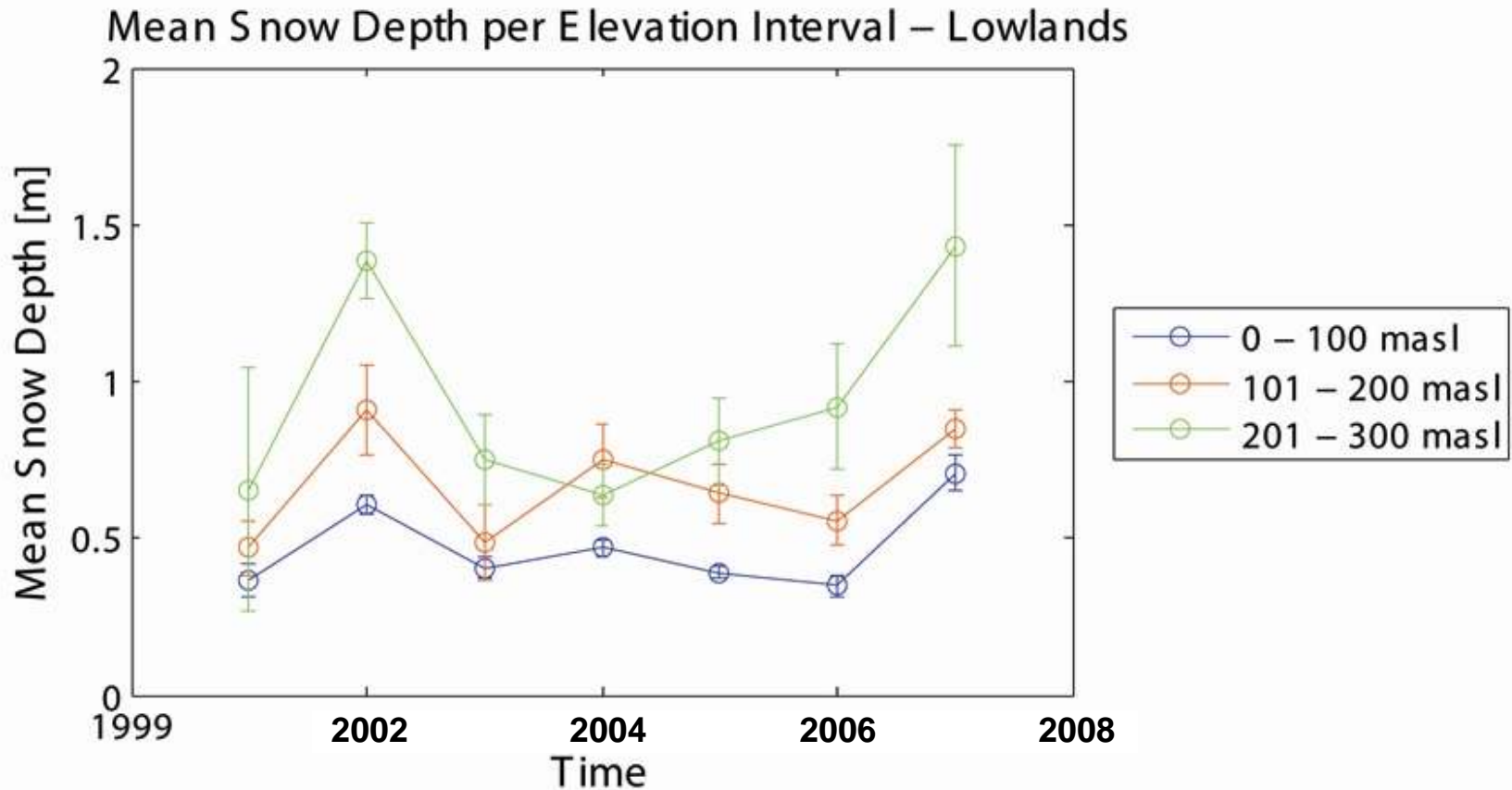
Sounding versus Radar Measurements

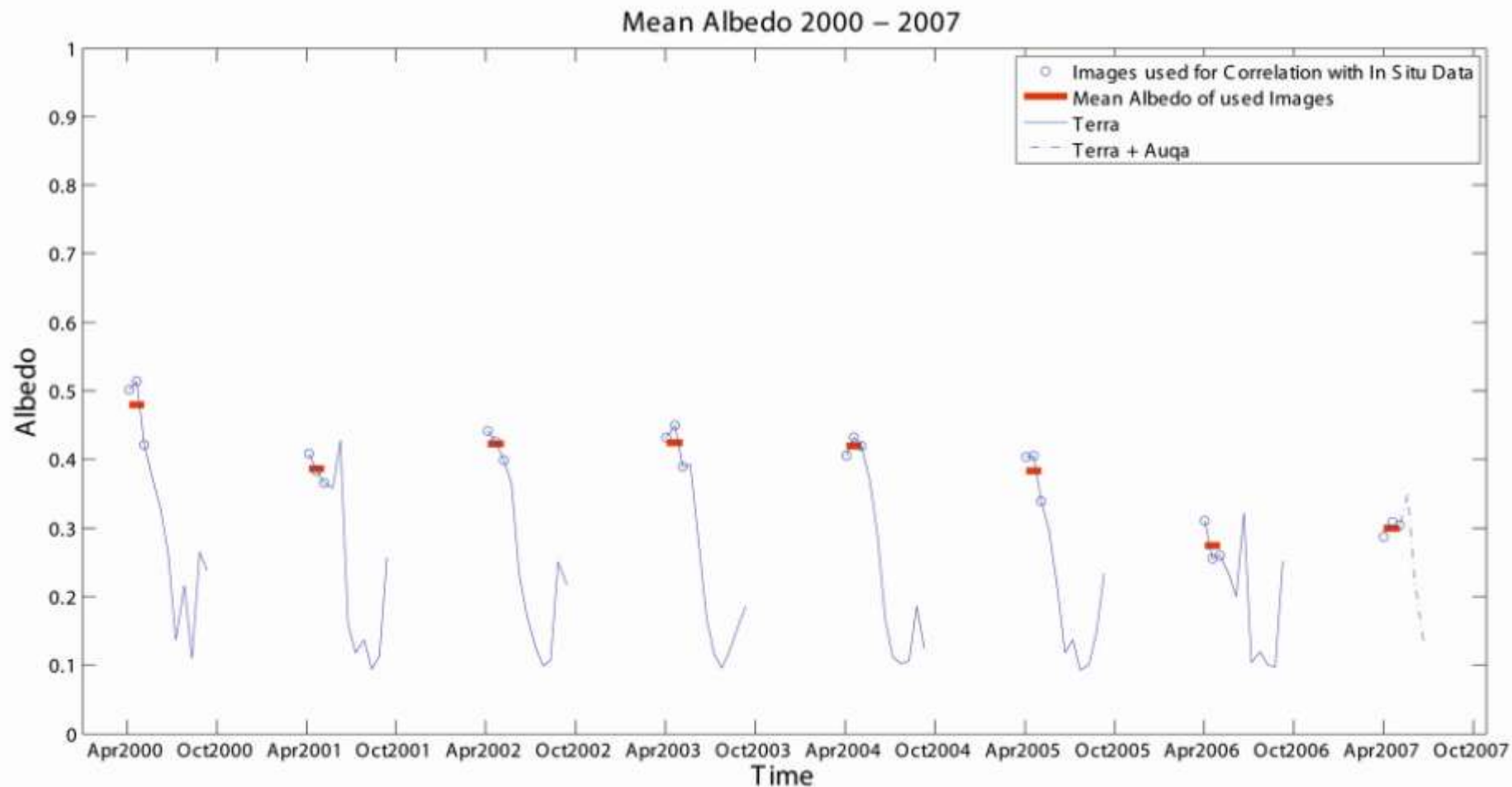


Regional and Local Variability

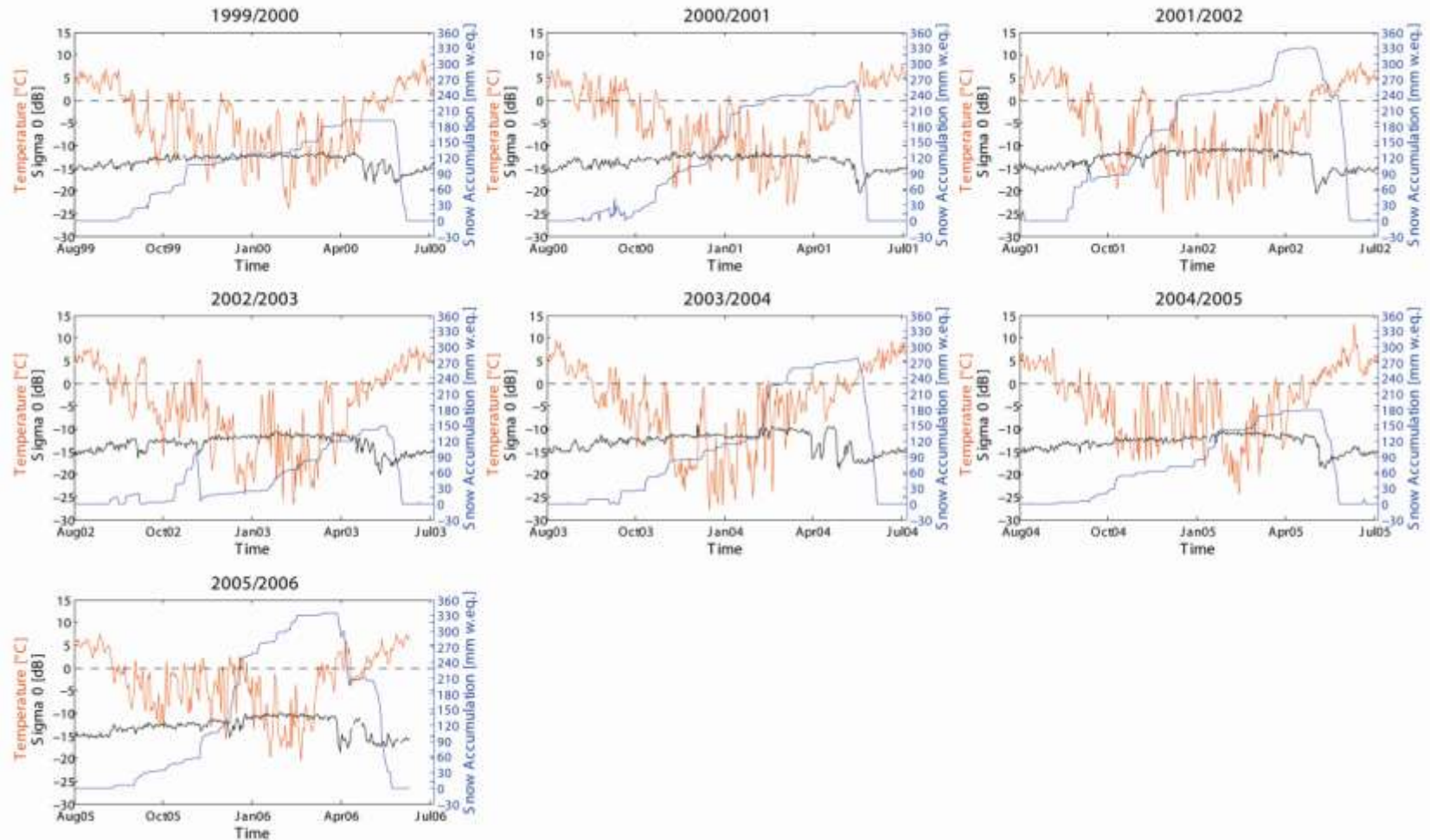


Regional and Local Variability

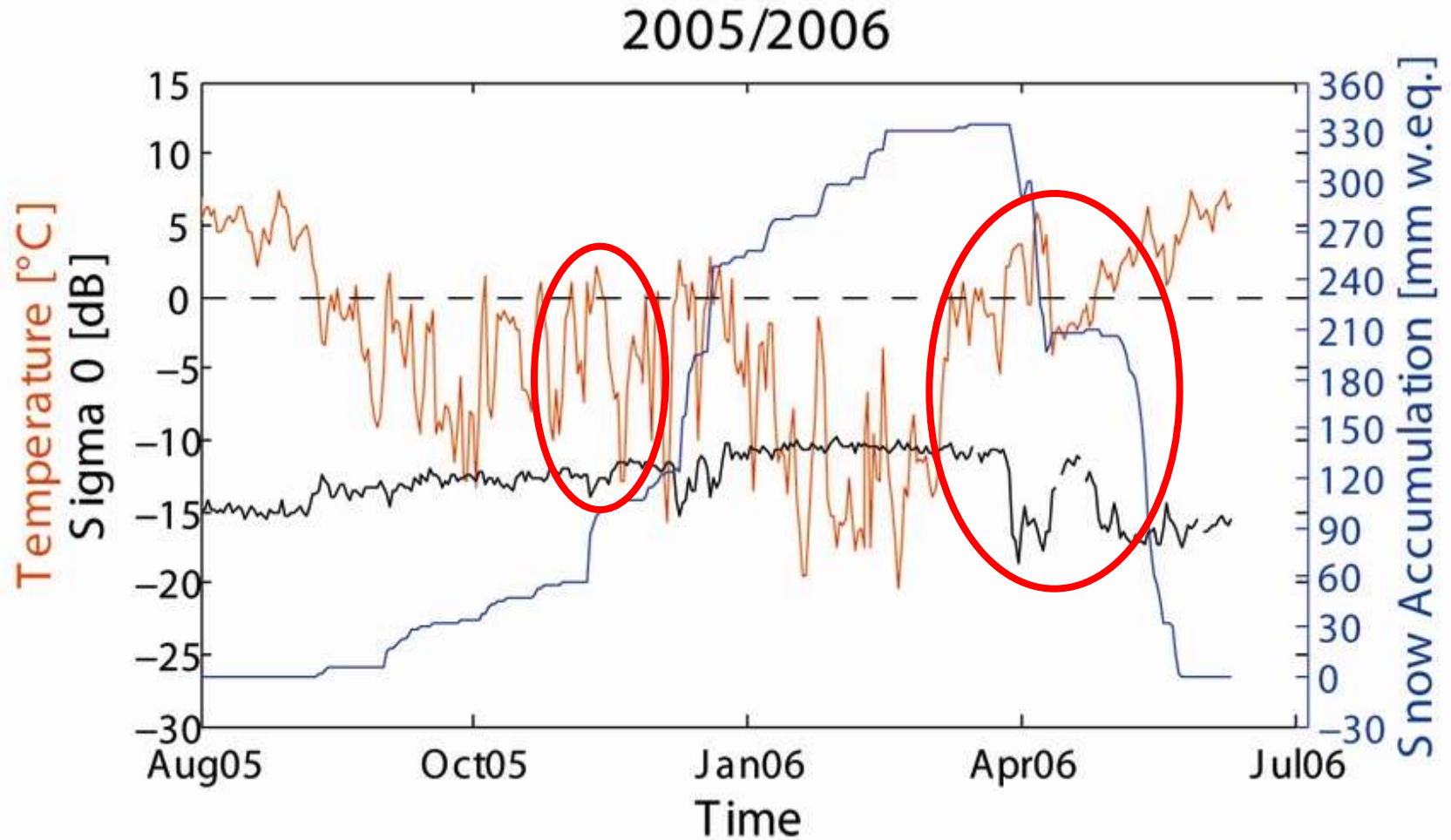




Normalised Radar Cross Section



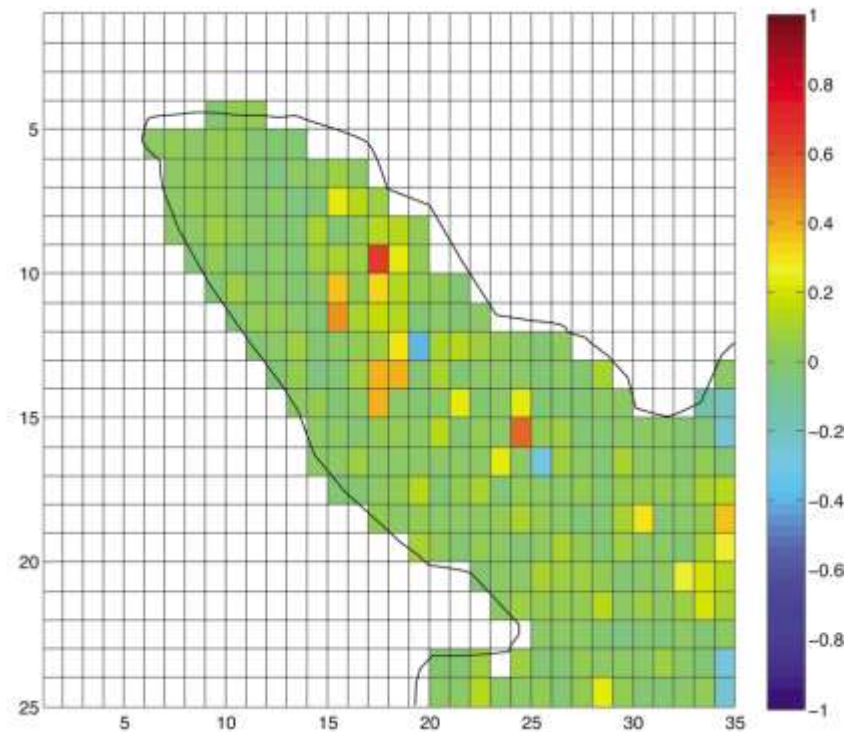
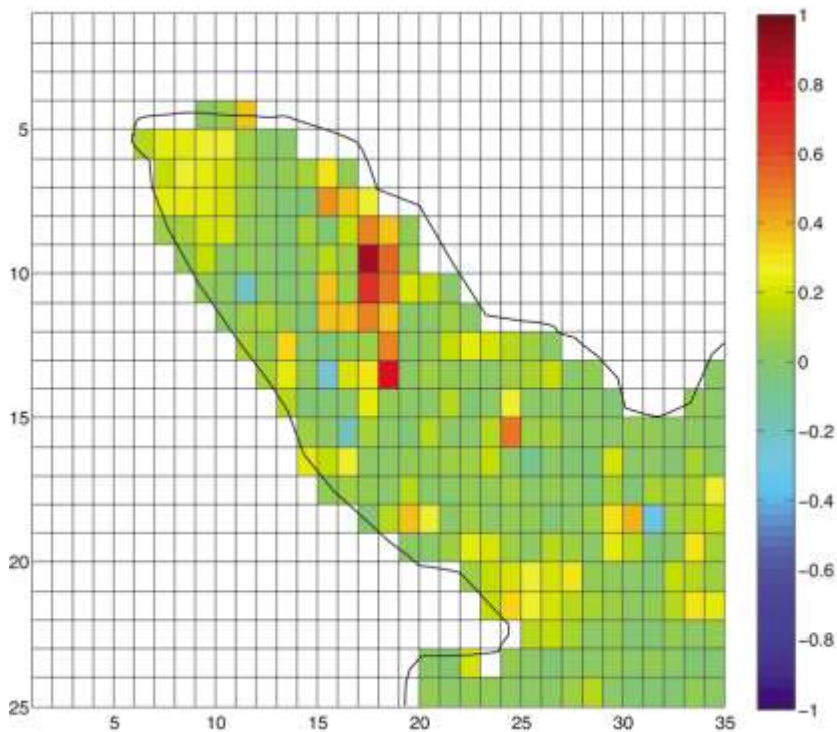
Normalised Radar Cross Section



Remote Sensing Data & In Situ Snow Depth

R^2 for MODIS and In Situ Snow Depth

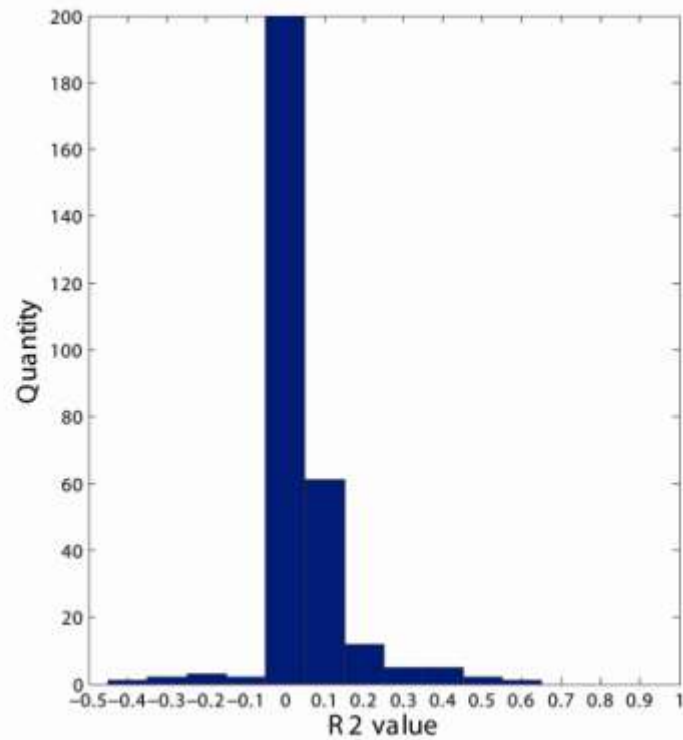
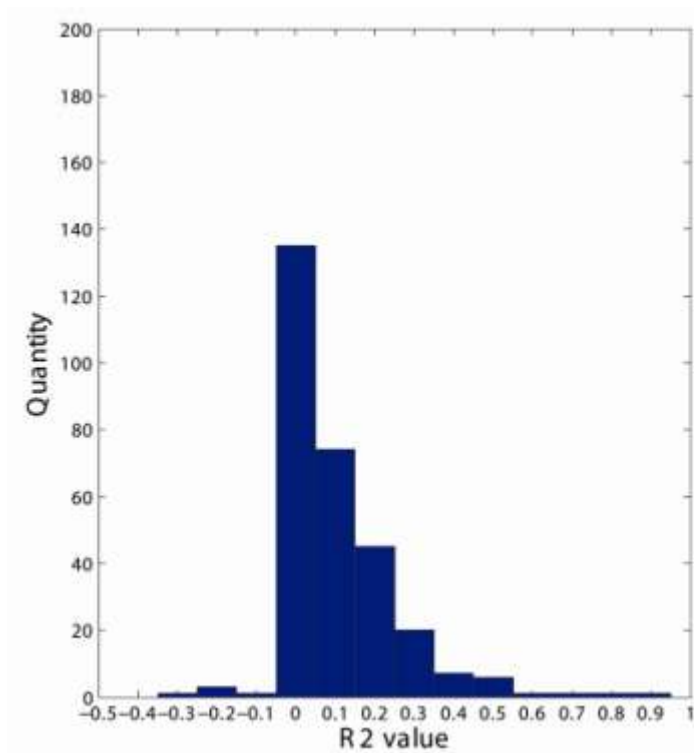
- Snow depth mean per elevation interval (left) and overall (right)



Remote Sensing Data & In Situ Snow Depth

Histogram for R^2 – MODIS versus In Situ Snow Depth

- Snow depth mean per elevation interval (left) and overall (right)



MODIS

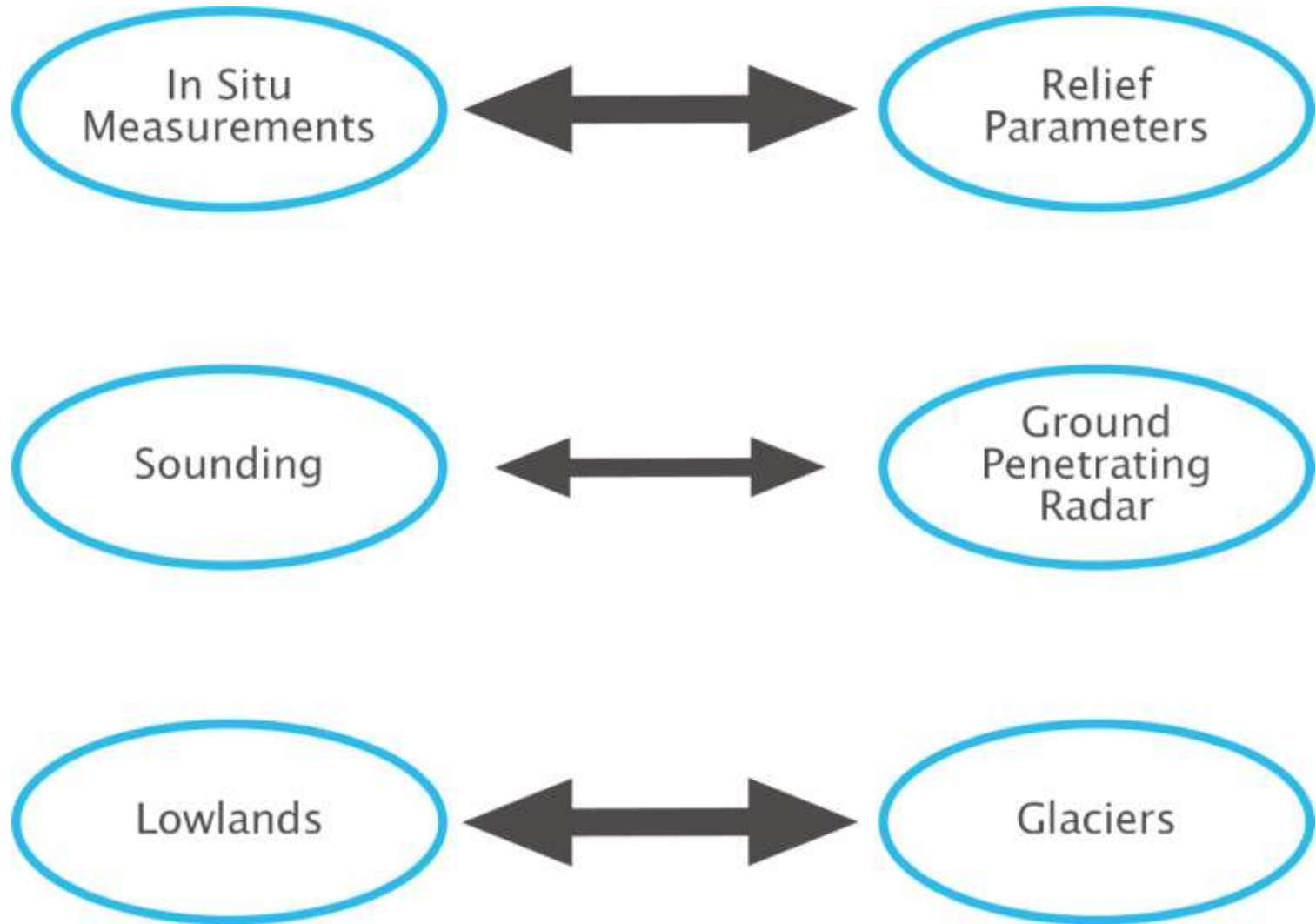
- Questionable relation between in situ snow depth and MODIS snow albedo
- Less than 5 % relatively good R^2

QuikSCAT

- No relation between snow accumulation and the QSCAT signal σ^0

In Situ Measurements

- Good relation between snow depth and relief parameters elevation, aspect and slope
- Reasonable accordance between the arithmetic means of radar and sounding for the individual profiles
- Good analogy for the interannual variability of glacier and lowland snow depths

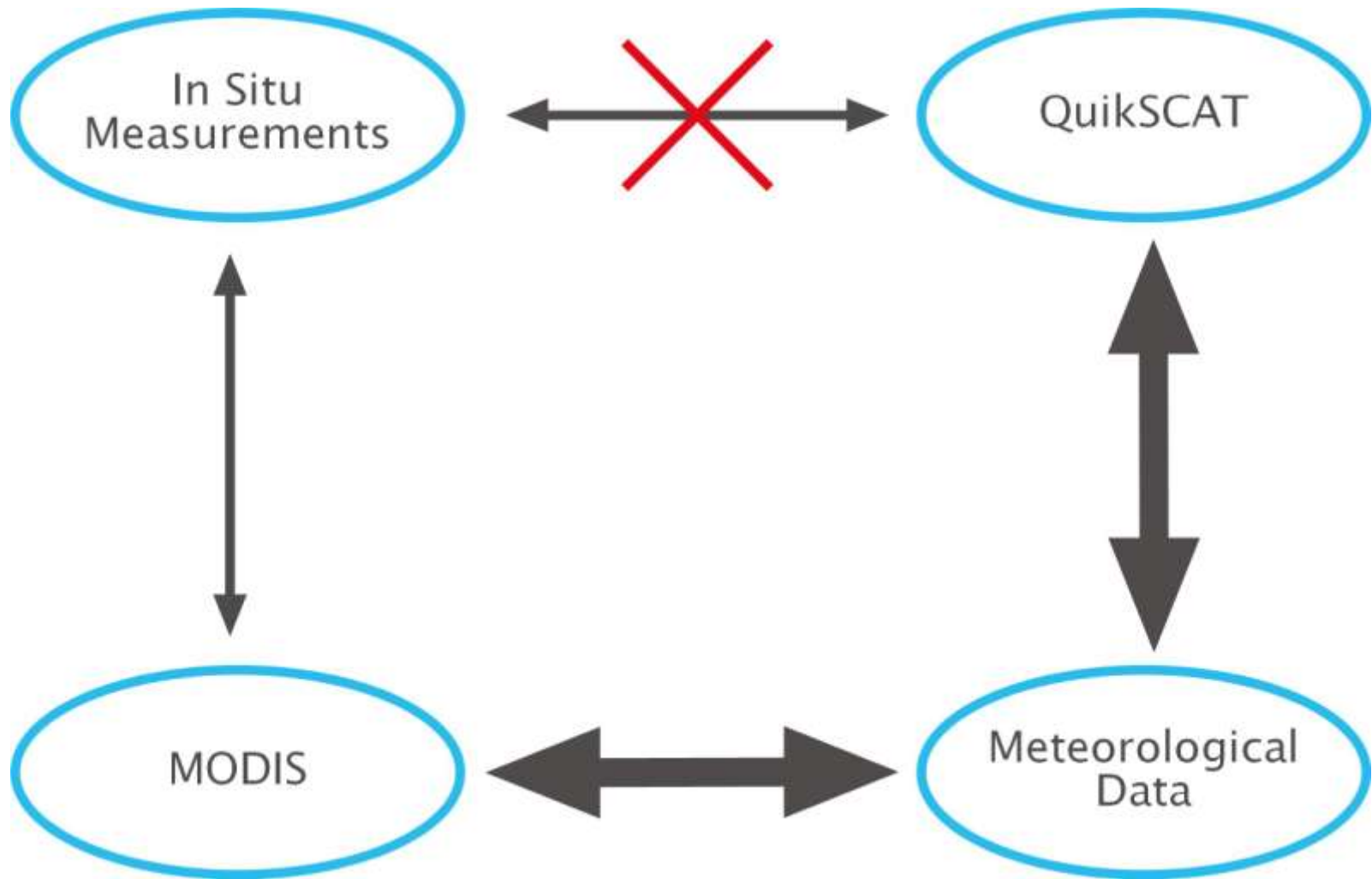


Albedo & Normalised Radar Cross Section

- Good perceptibility for snowmelt and snowfalls in summer
- Detection of warmer periods during snow accumulation as well as refreezing during the snowmelt using QuikSCAT

Remote Sensing Data & In Situ Snow Depth

- Restricted suitability for correlations between in situ snow depth measurements and remote sensing



Outlook

- In situ soundings on a regular grid covering the entire peninsula
- Gathering of in situ observations three times a snow period
- Inclusion of factors like snow density, grain size, liquid water content etc. for the correlation with remote sensing data
- Additional measurements of in situ albedo provide a reference for the MODIS albedo

Thank you!
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