



Ice Thickness in South Georgia from SRTM Elevation Data

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Introduction

- Background
- Method
 - Theory
 - Assumptions
 - Results
- Discussion of results
- Conclusions



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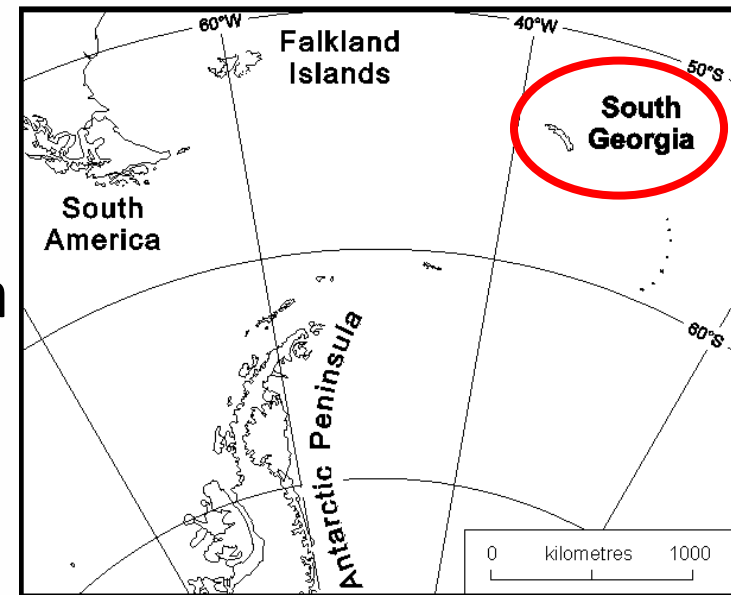
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Background

- South Georgia is an island in the South Atlantic
- Very remote:
 - 1500 km from Falklands
 - 2000 km from South America
 - 5000 km from South Africa
 - 1600 km from Antarctica
 - 15,600 km from Hong Kong!
- Largest island in the Southern Ocean



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- Main island 185 km long
 - Group is 500 km long
 - Mountains up to 2934 m
 - Heavily glaciated



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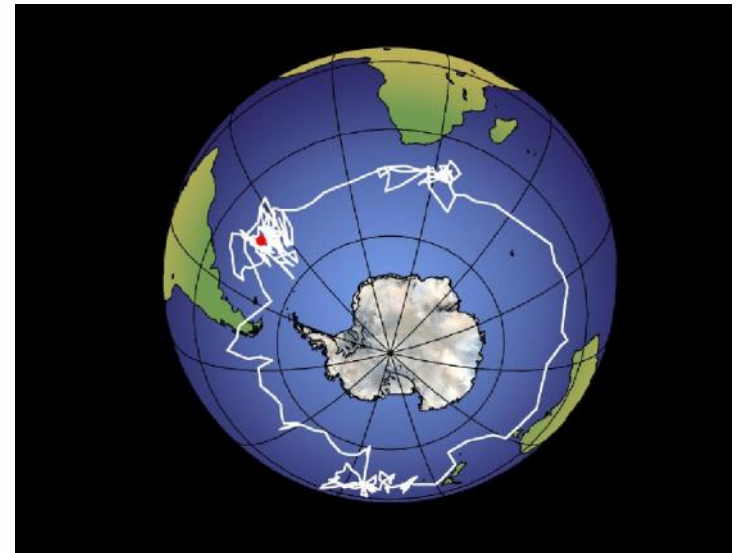
Background

- South Georgia is a vital breeding ground for many Southern Ocean Species
 - Albatrosses
 - Petrels
 - Penguins
 - Fur Seals
 - Elephant Seals
 - And many more!



Background

- Birds and seals from South Georgia are an important part of the ecosystem of the Southern Ocean



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Background

- Government of South Georgia signatory to the Agreement on the Conservation of Albatrosses and Petrels (ACAP)



“The objective of this Agreement is to achieve and maintain a favourable conservation status for albatrosses and petrels.”



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Background: The Problem

- South Georgia has several introduced species
- Rats (*Rattus norvegicus*) are a major threat to birds of South Georgia
- Rats not present everywhere
- Breeding success of birds higher in rat-free areas



Background: The Problem

- Migration of rats is blocked by glaciers
- Most glaciers are in retreat
- Continued glacier retreat would allow rats to occupy new areas
- Threat to areas where birds nest
- Need to evaluate threat so rat eradication schemes can be targeted effectively.



Background: Problem

- Glaciology of South Georgia poorly known
- Ice thickness a critical parameter
- No measurements of ice thickness
- This study uses indirect techniques for estimating ice thickness



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Method: Theory

- Surface slope (α) is related to ice thickness (h), the limiting shear stress (τ), the density of ice (ρ) and the acceleration due to gravity (g) by the following equation:

$$h = \frac{\tau}{\rho \cdot g \cdot \sin(\alpha)}$$

- Density of ice and acceleration due to gravity are constant
- Limiting shear stress is assumed to be constant.



Method: Theory

- Correction required for distance from the valley wall. $h = \frac{\tau}{\rho \cdot g \cdot \sin(\alpha) \cdot F}$
- Where F depends on distance from the valley wall.
- Valley wall delineated using a threshold slope of 17°
- Distance from valley wall computed using Euclidean distance function.



Method: Assumptions

1. The glacier is flowing by plastic deformation.
2. Ice motion is primarily horizontal.
3. The limiting basal stress is constant.
4. The value of limiting basal stress is 100 kPa.
5. The cross-section of the glacier is parabolic.



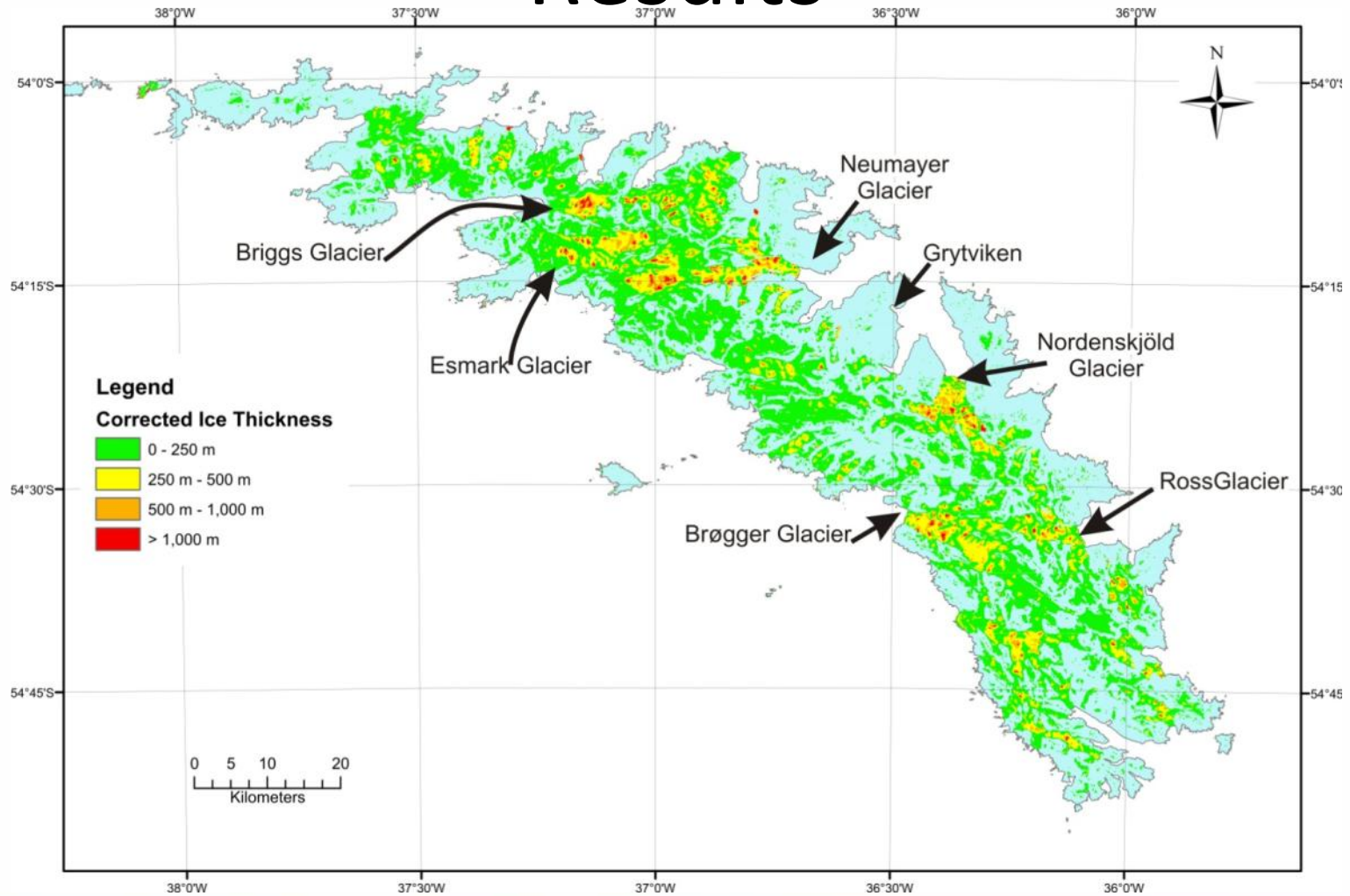
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Results



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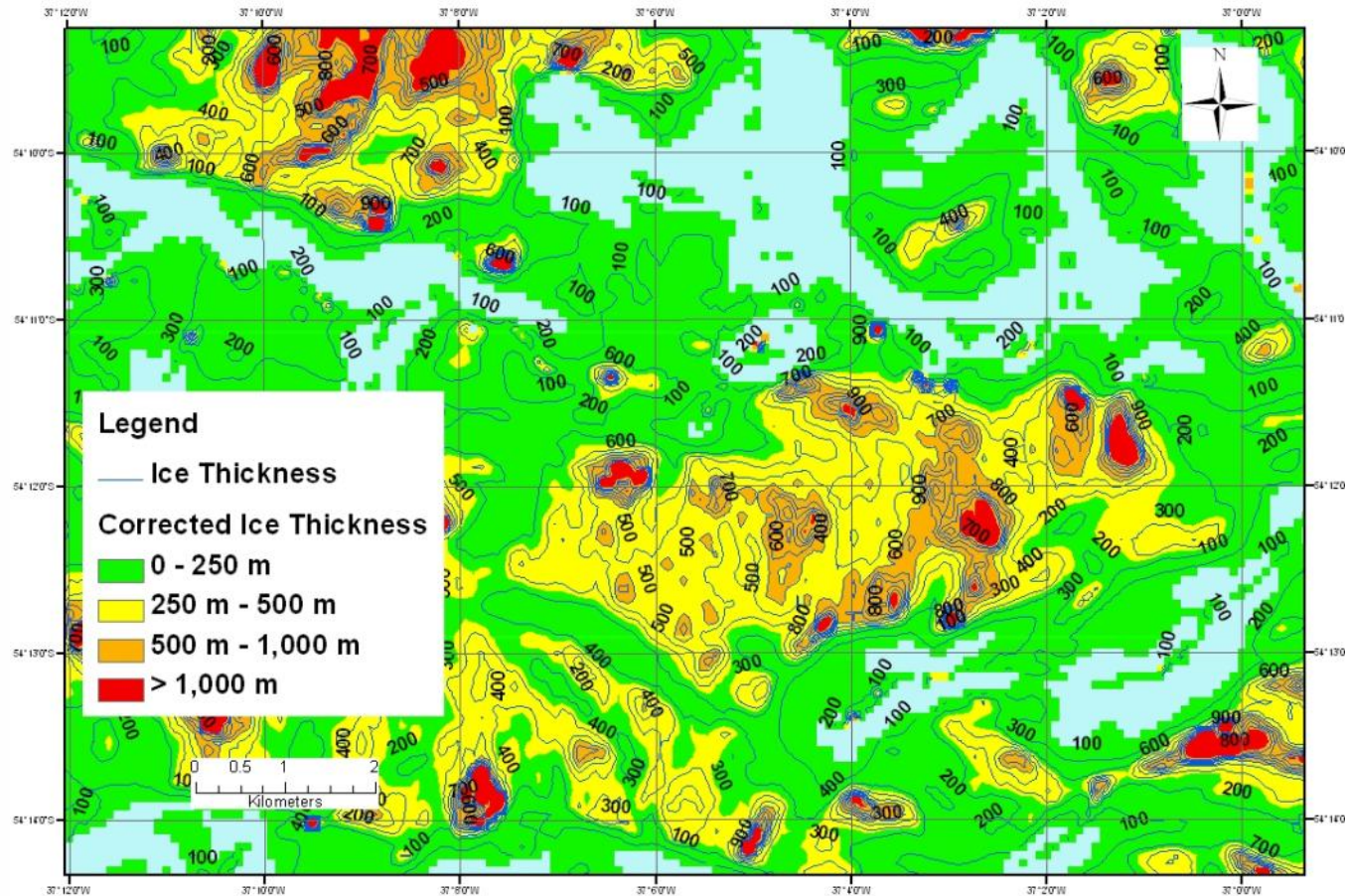
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Discussion of reliability of results

- Failure of the first two assumptions overestimates ice thickness.
 - 1 fails when ice is sliding over the bed
 - 2 fails in accumulation areas where ice motion has a substantial vertical component.
- Failure of other assumptions results in systematic errors in ice thickness.
- Estimated ice thickness is a good indicator of reliability.



Discussion of reliability of results



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Discussion of reliability of results

- 0 - 250 m: likely to be an accurate reflection of the actual ice
- 250 m - 500 m: probably subject to errors in some locations;
- 500 m - 1000 m: very likely to be incorrect
- > 1000 m: highly unlikely to be correct.



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Discussion of reliability of results

Thickness Band	Number of pixels	Area (km ²)	% of ice area
0-250 m	104861	849	74.57%
250-500 m	26321	213	18.72%
500-1000 m	7365	60	5.24%
>1000 m	2071	17	1.47%



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Discussion of Results

- Most results unsurprising
 - Comparable with measured ice thicknesses of similar sized glaciers in Svalbard (North of Norway)
- High errors concentrated in two regions:
 - Very low slopes at the upper end of glaciers
 - Rapidly moving ice at the end of some glaciers
- Errors in flat-lying areas unsurprising.



High thickness estimates and glacier retreat

- Failure of plastic flow assumption shows sliding at glacier bed
- Rapid motion in these areas confirmed by physical features on satellite images



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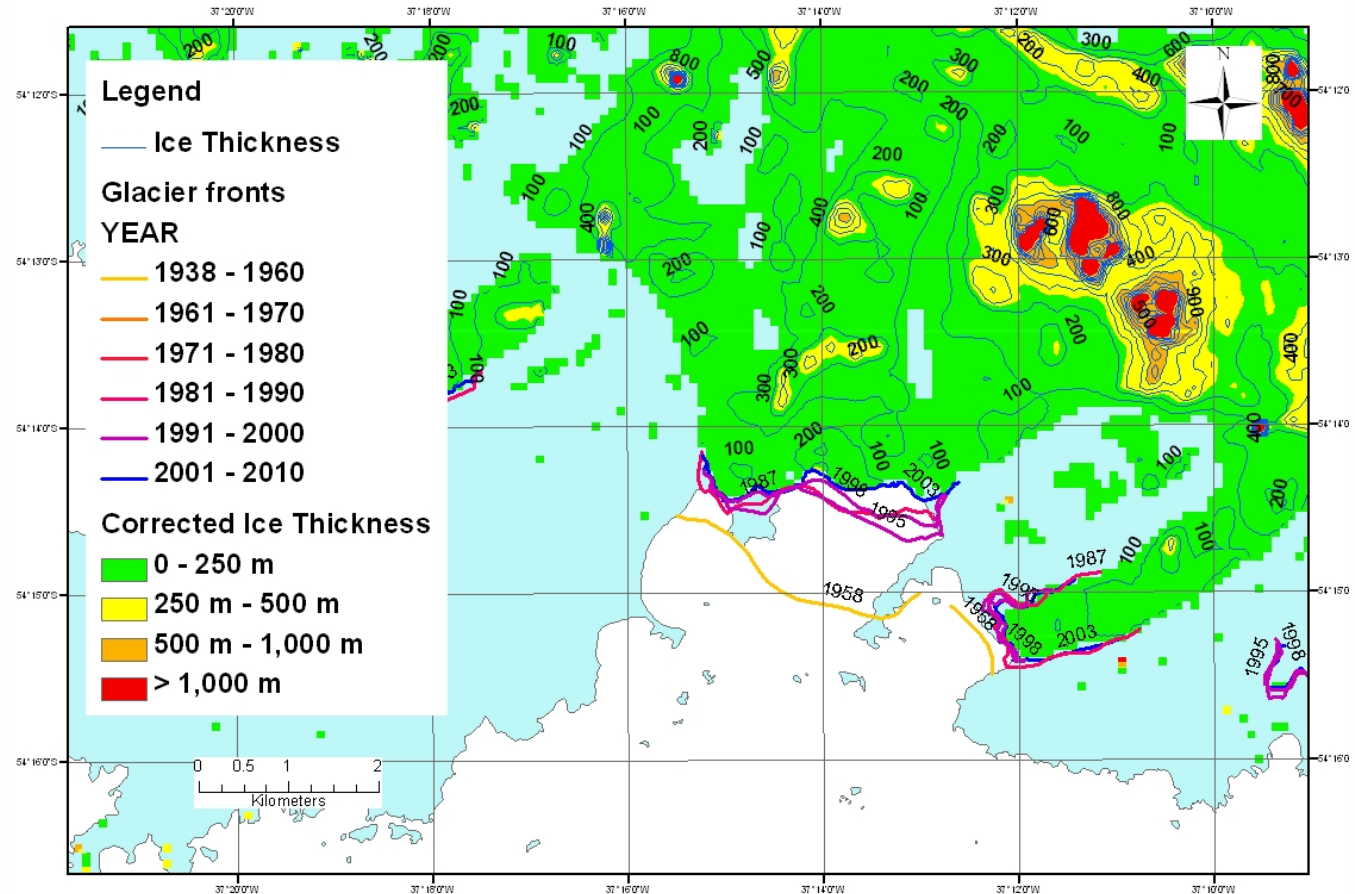
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Glaciers restricting movement of rats

- Briggs
- Esmark



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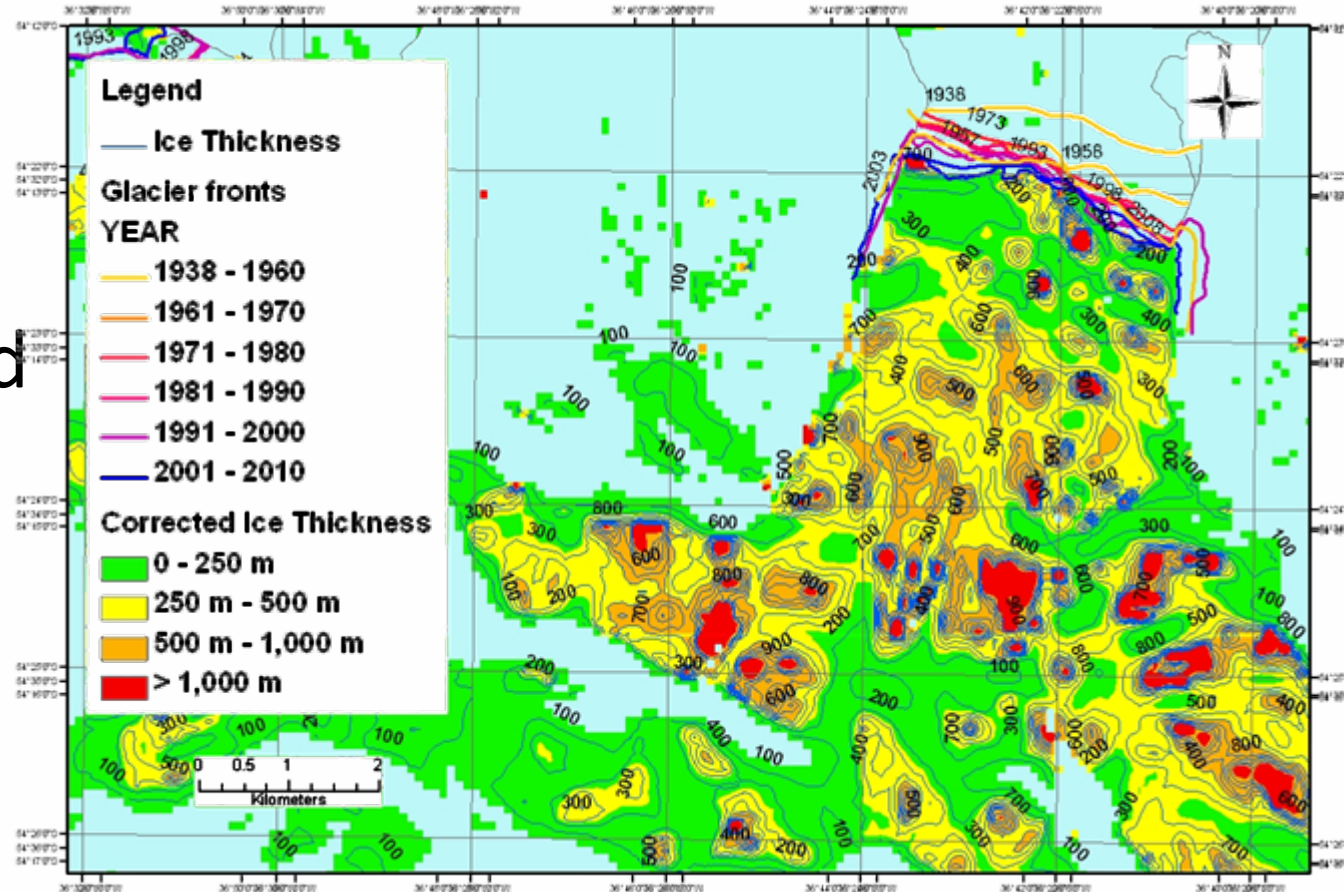
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Rapidly retreating glaciers

- Neumayer
- Ross
- Nordenskjöld



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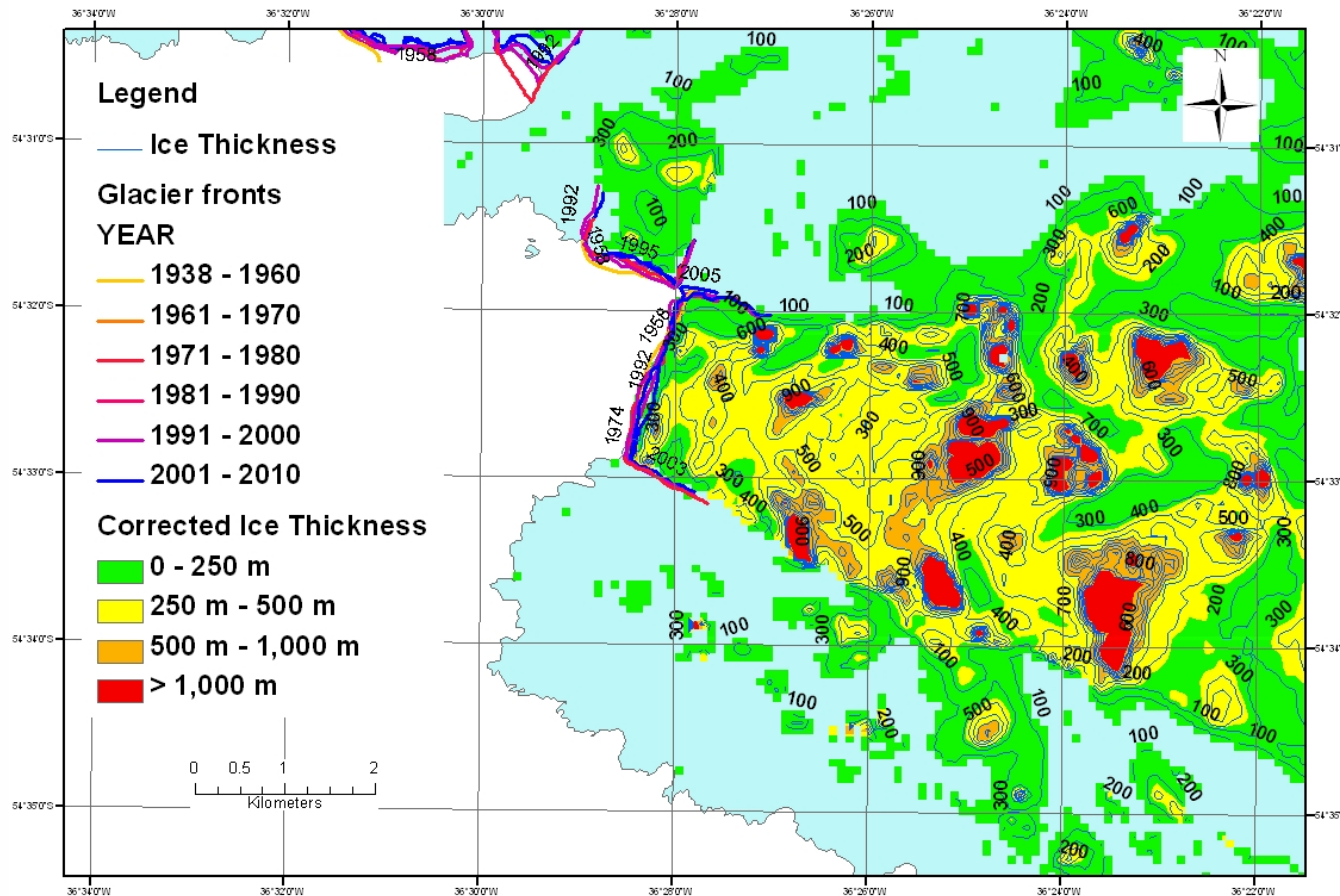
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Anomalous Glacier

- Brøgger



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Conclusions

- Analysis of precise surface elevation data provides a useful estimate of ice thickness
 - Data are of useful quality over more than 90% of the ice covered area.
- Anomalies provide insights into glaciological conditions
- This study assists environmental management of a vulnerable eco-system.



Thank-you.



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