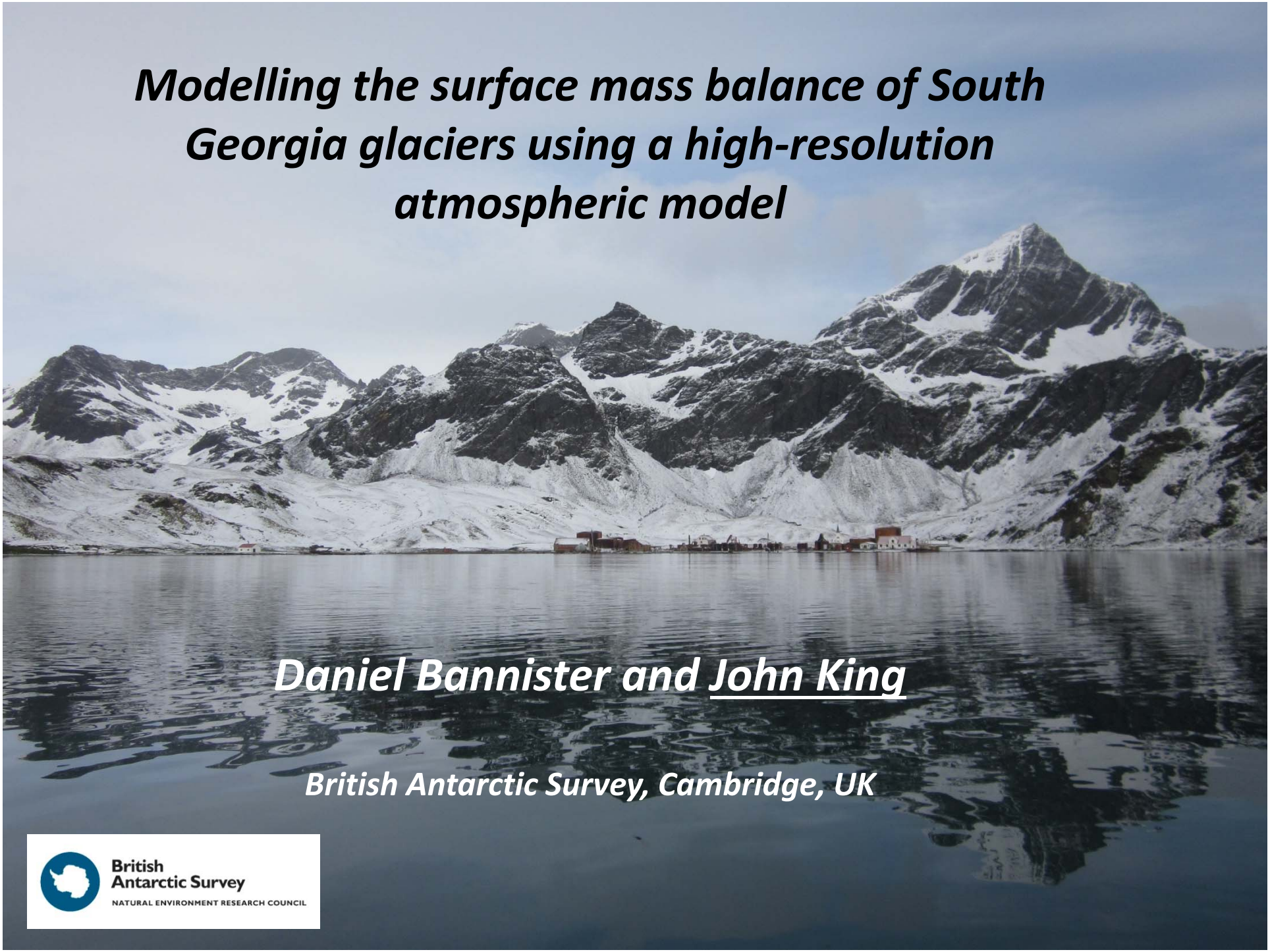

Modelling the surface mass balance of South Georgia glaciers using a high-resolution atmospheric model

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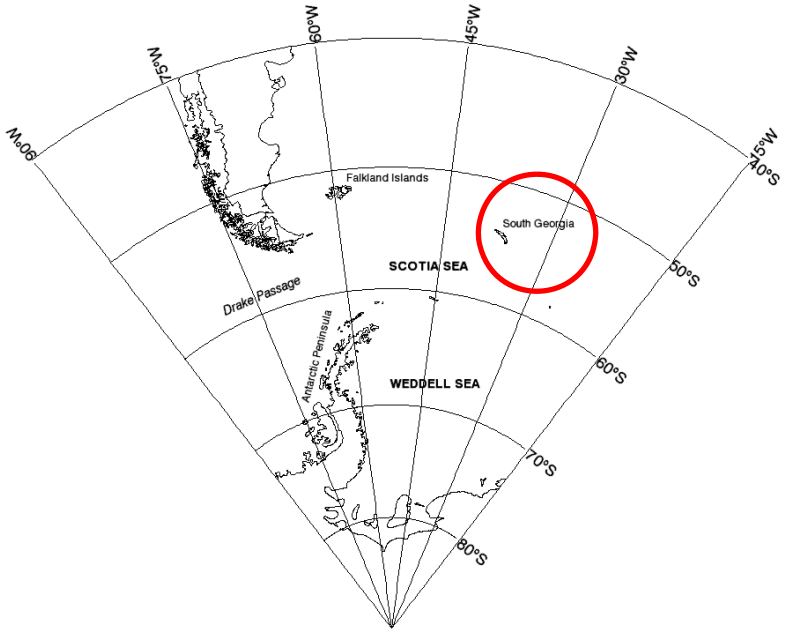
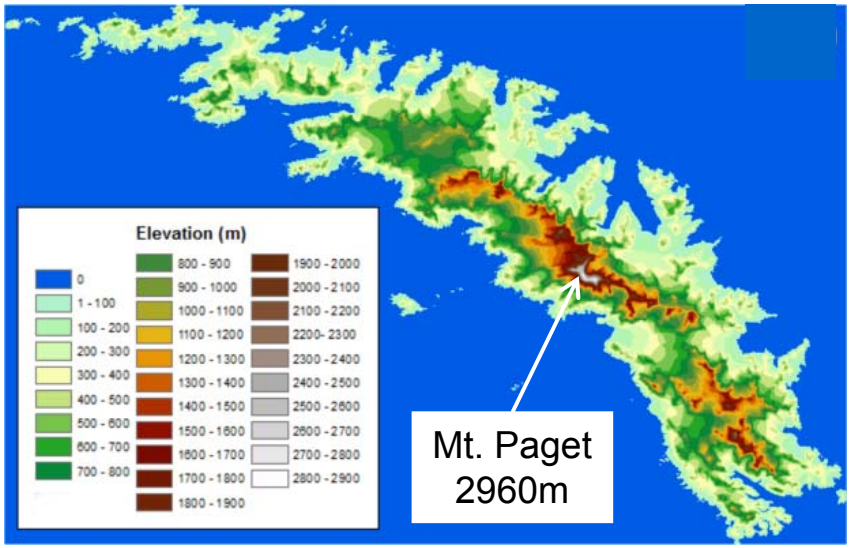
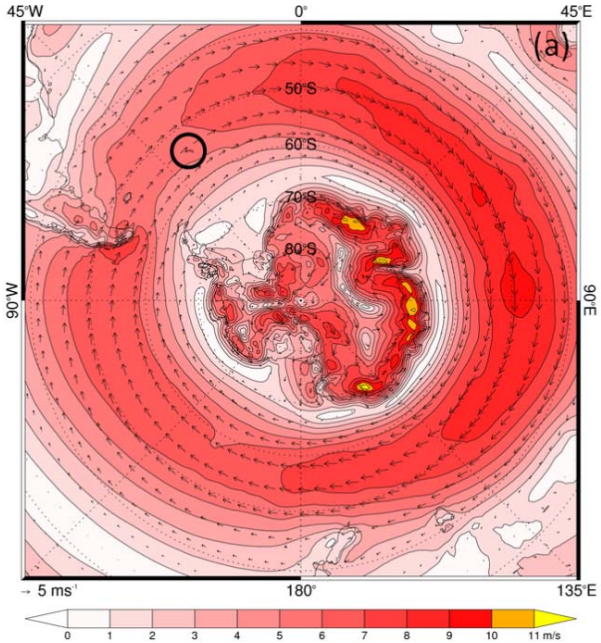
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

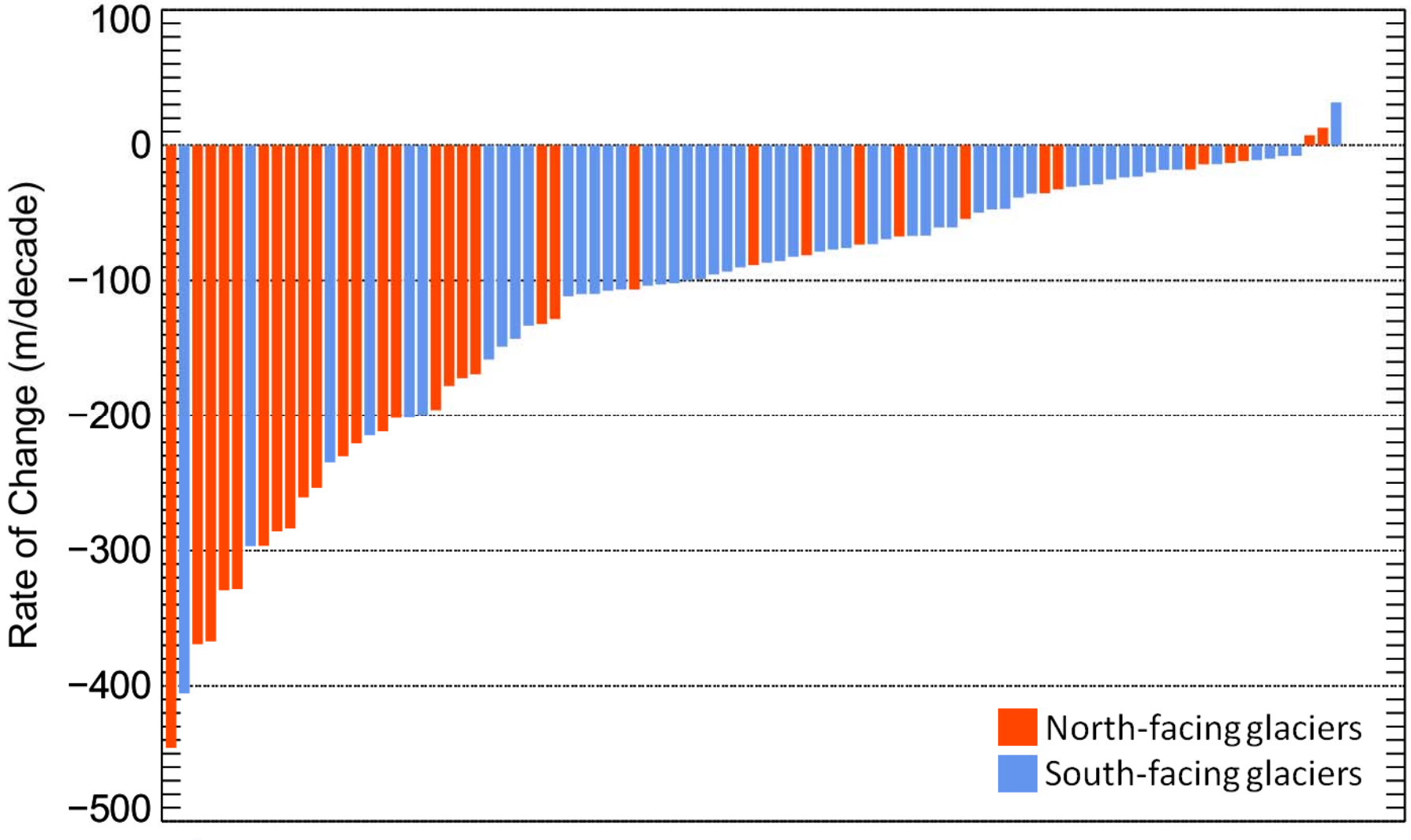

60°W
45°W
30°W
15°W
75°W
90°W
40°S
50°S
60°S
70°S
80°S
Falkland Islands
South Georgia
SCOTIA SEA
Drake Passage
Antarctic Peninsula
WEDDELL SEA


Elevation (m)
0
1 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1300
1300 - 1400
1400 - 1500
1500 - 1600
1600 - 1700
1700 - 1800
1800 - 1900
1900 - 2000
2000 - 2100
2100 - 2200
2200- 2300
2300 - 2400
2400 - 2500
2500 - 2600
2600 - 2700
2700 - 2800
2800 - 2900
Mt. Paget
2960m


45°W
0°
45°E
(a)
50°S
60°S
70°S
80°S
90°W
90°E
→ 5 ms⁻¹
180°
135°E
0
1
2
3
4
5
6
7
8
9
10
11 m/s

Glacier length changes on South Georgia

(40+ years of observations)



Data from Cook *et al.*, 2010

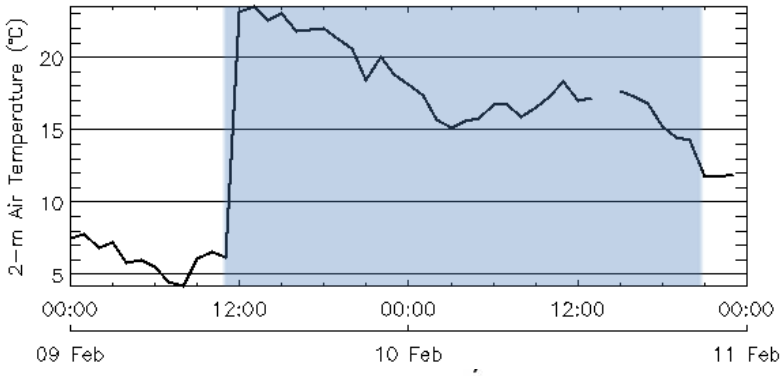
Hypothesis: Asymmetric glacial retreat on South Georgia is a result of more frequent/stronger **föhn winds** on the downwind side of the island in response to strengthening westerly winds

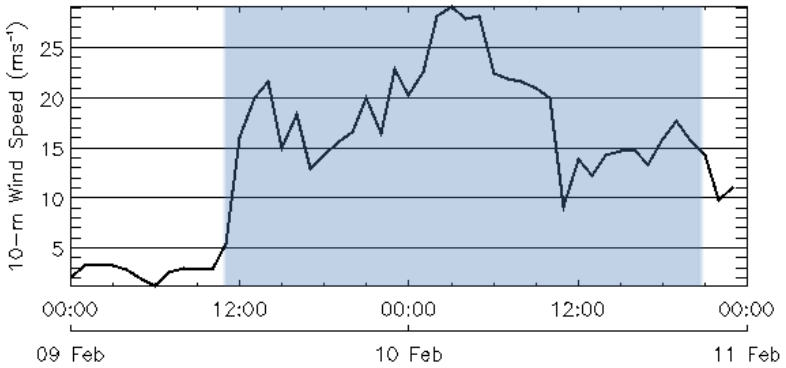
Questions to answer:

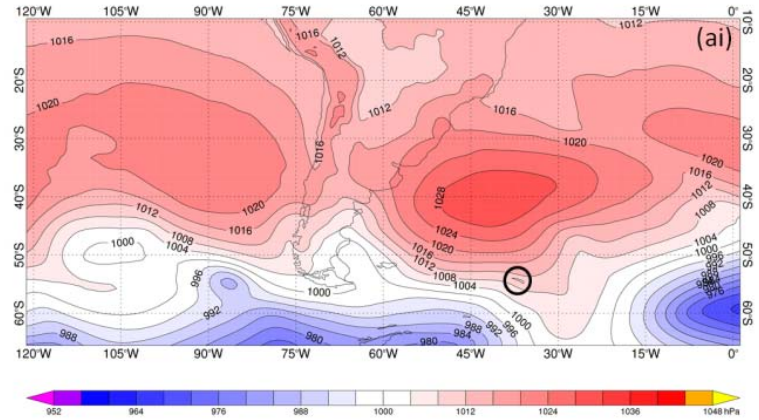
- [How have the westerlies changed?]
- [How do föhn winds respond to changes in the westerlies?]
- *What is the impact of föhn winds on South Georgia's glaciers?*

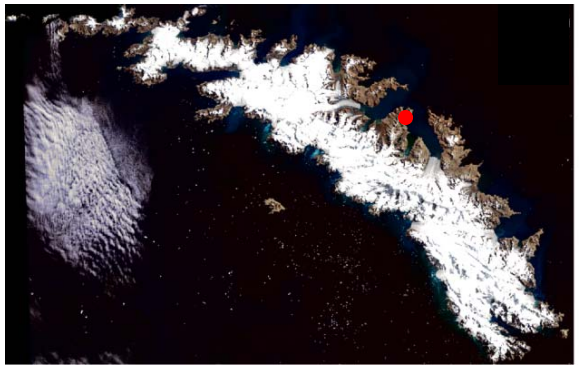
Few *in situ* observations available – use high-resolution atmospheric modelling to study the impact of föhn on the surface mass balance of South Georgia's glaciers

Strong föhn event, King Edward Point (●), 9-10 Feb 2004









Föhn conditions observed at KEP for ~30% of the time, 2003-2012

The Weather Research and Forecasting (WRF) model

- Non-hydrostatic, regional atmospheric model
- Freely available, large user community
- Wide range of options available for representing surface and atmospheric processes
- Adapted for use over polar surfaces (Hines & Bromwich, 2008, *Mon. Wea. Rev.)*
- WRF version 3.4.1 used in this study

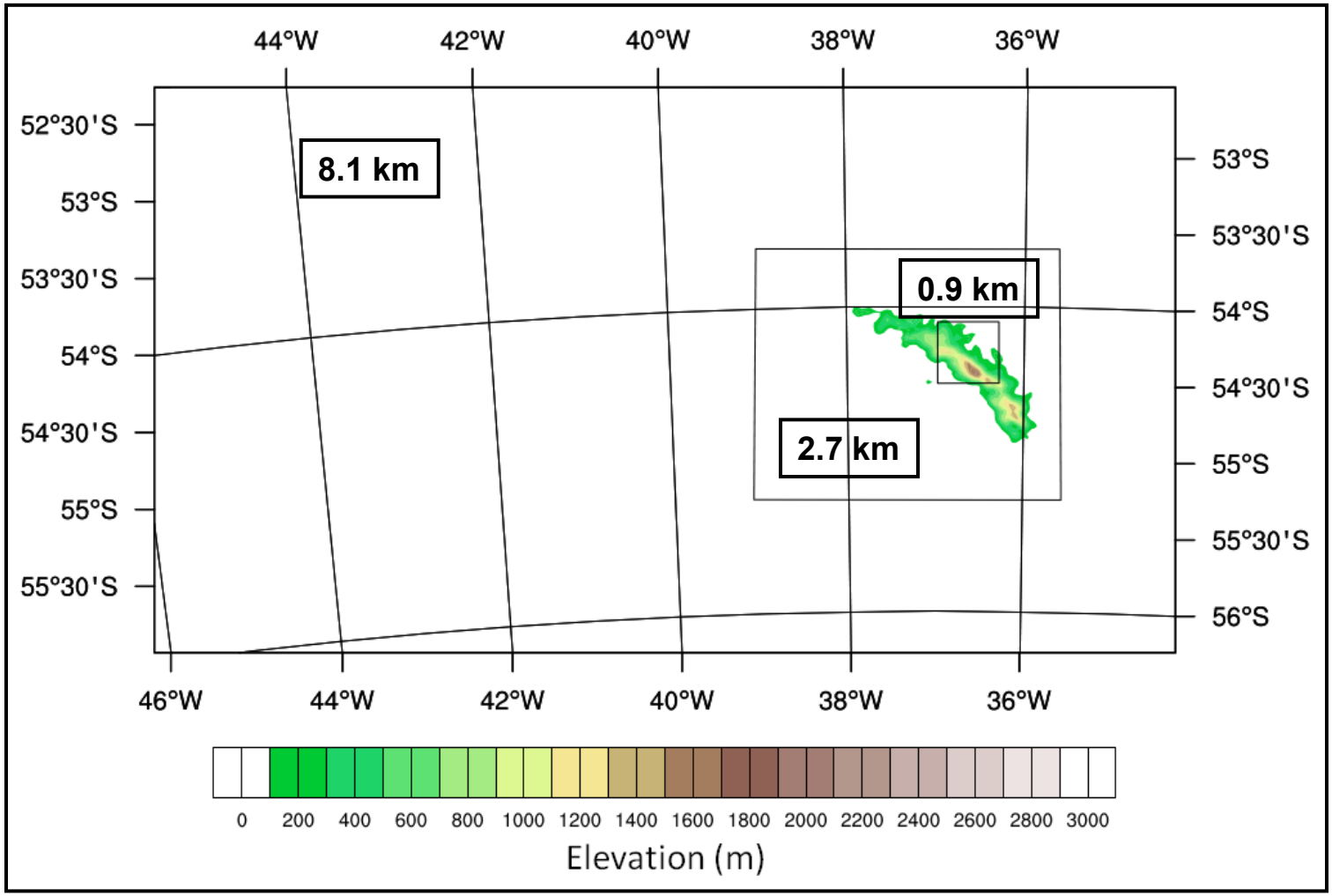
WRF setup for South Georgia

- 3 nested domains, innermost with 0.9 km resolution
- 70 vertical levels, 17 in lowest 2km, model top at 50 hPa (~20 km)
- SG orography from Shuttle Radar Topography mission (100m resolution)
- SG land surface type (snow/ice or bare rock) from Landsat (90m resolution)
- Physics options chosen to give best model validation against KEP observations

(AWS 2001-2013, intensive campaign with radiosondes, Feb. 2013)

- Slope aspect and topographic shading options switched on
- Model run from 1 June 2011 – 1 March 2013
- Objective scheme for detecting föhn conditions in model output

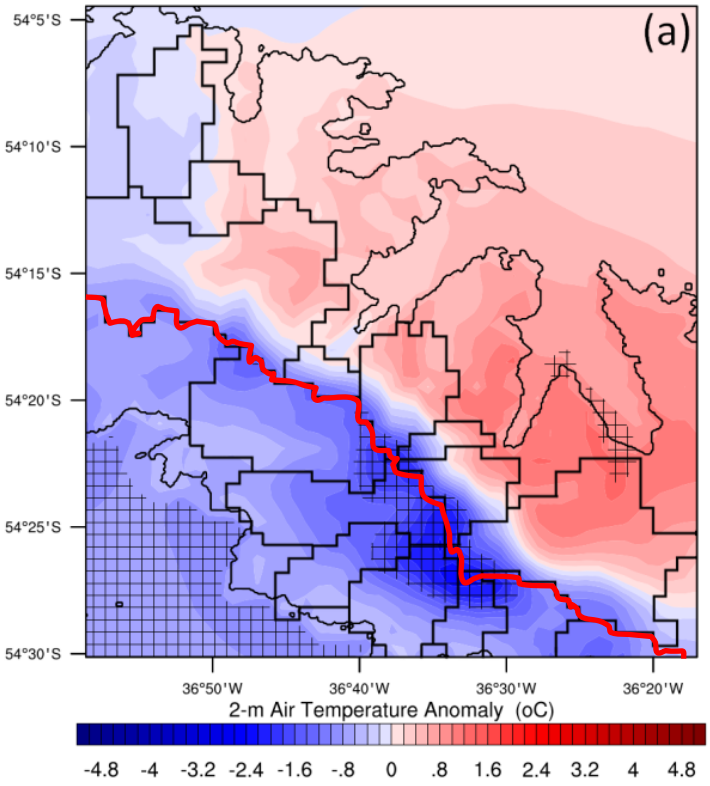
WRF model domains



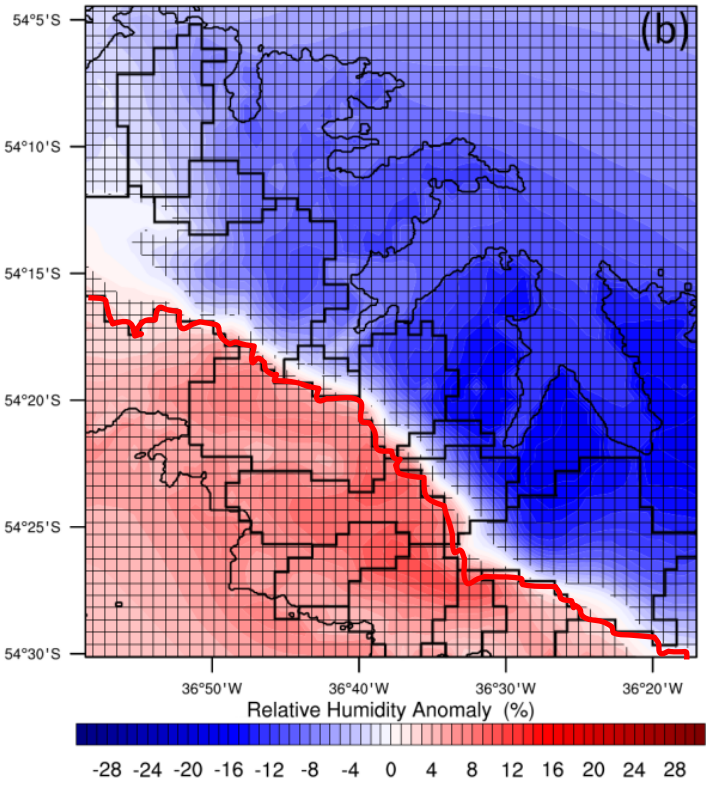
Föhn composite anomalies

i.e. mean (föhn times) – mean (all times)

Air temperature

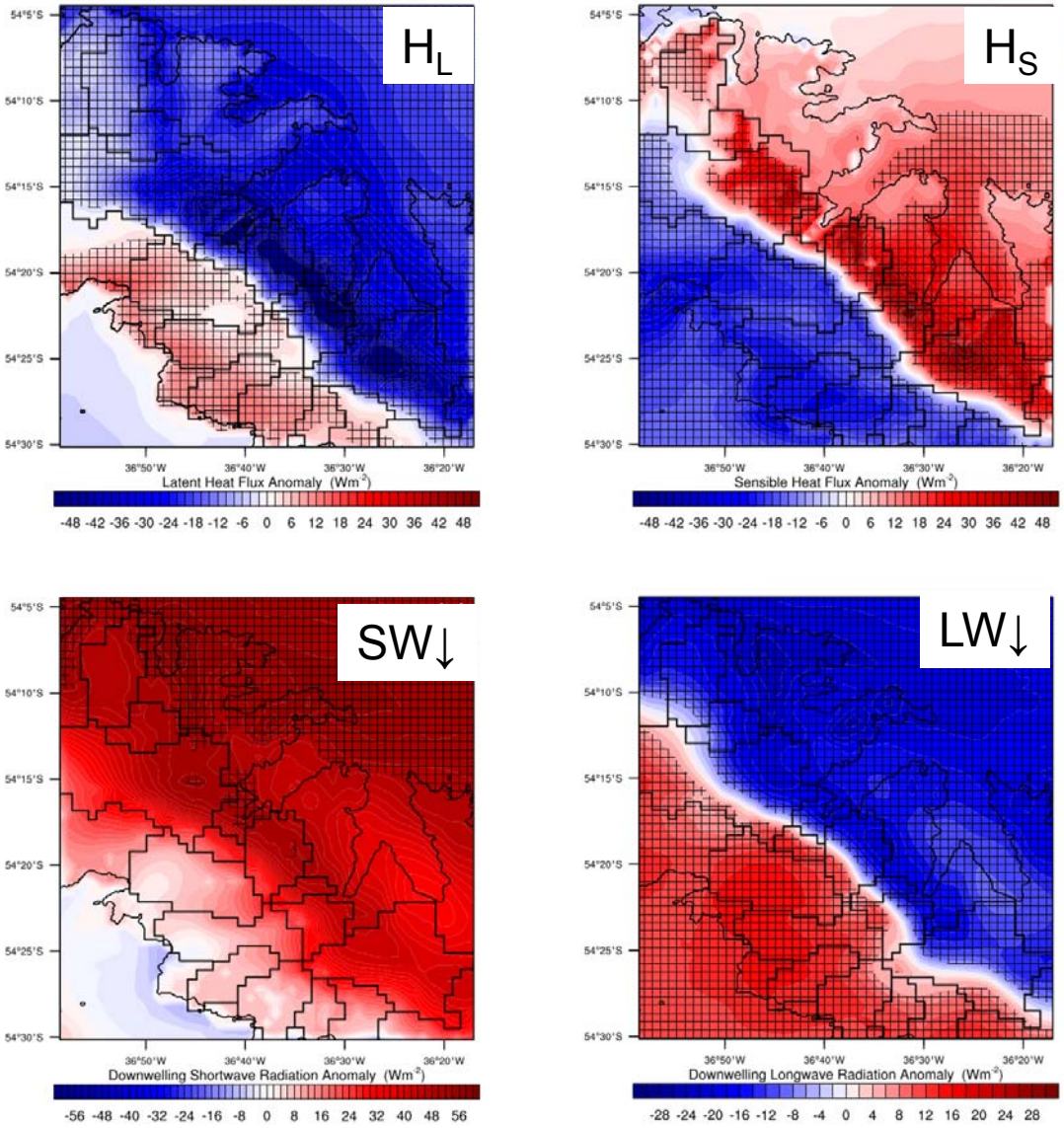


Relative humidity

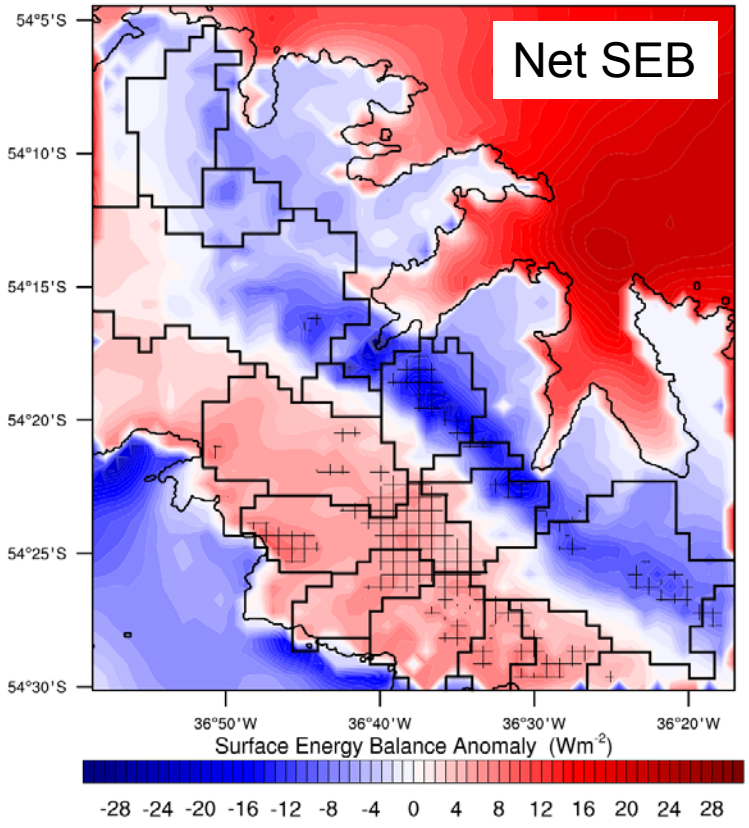


Foehn T & RH anomalies, fig 6.7

Föhn composite anomalies

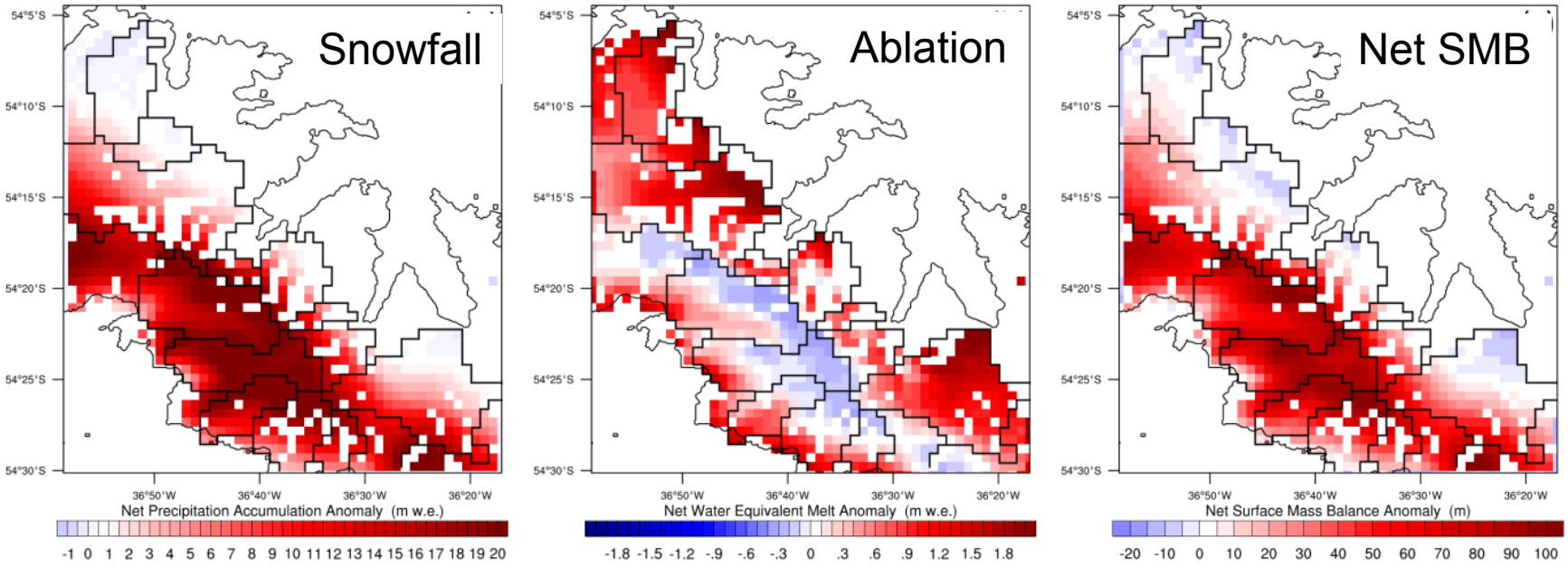


Foehn SEB anomalies, fig. 6.9



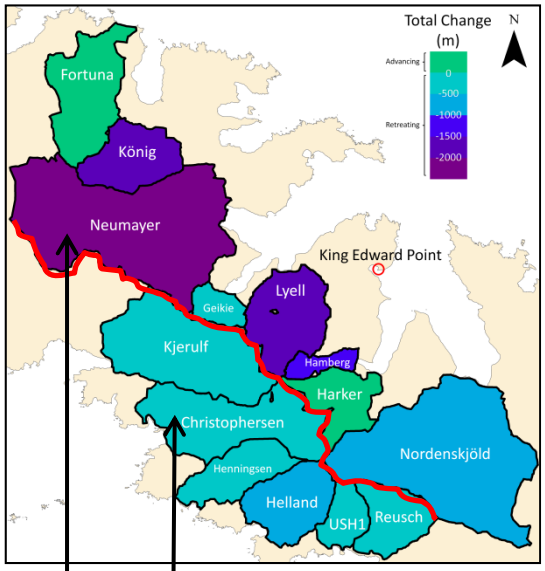
Foehn netSEB anomaly, fig. 6.10

Föhn composite anomalies



Modelled surface mass balance

- two contrasting glaciers



Glacier	Neumayer	Christopherson
Aspect	NE	SW
Rate of retreat (m/decade)	328	87
Area (km^2)	162	75
Mean elevation (m)	596	1085
No. of WRF points	123	94
Modelled annual SMB (m.we)	3.1	9.0
Modelled annual föhn SMB (m. we)	8.8	28.5
$\Delta_{föhn}$(SMB) (m.we)	5.7	19.5

Conclusions

• A high-resolution atmospheric model has been used to produce the first-ever description of South Georgia's regional climate and surface mass balance at glacier catchment scale.

• Föhn winds have a clear asymmetric impact on the surface energy and mass balances but, for all glaciers, increased modelled accumulation during föhn outweighs increased ablation.

• Modelled SMB is positive and unrealistically large for all glacier catchments, suggesting that there may be biases in modelled accumulation and/or ablation (WRF known to have SEB biases in the polar regions).

• Urgent requirement for *in situ* measurements (meteorology, surface energy balance, surface mass balance) at catchment scale to validate and improve models.

With thanks to: Ian Renfrew, Scott Hosking, Andrew Orr, Barbara Brooks, Alan Gadian and Ralph Burton