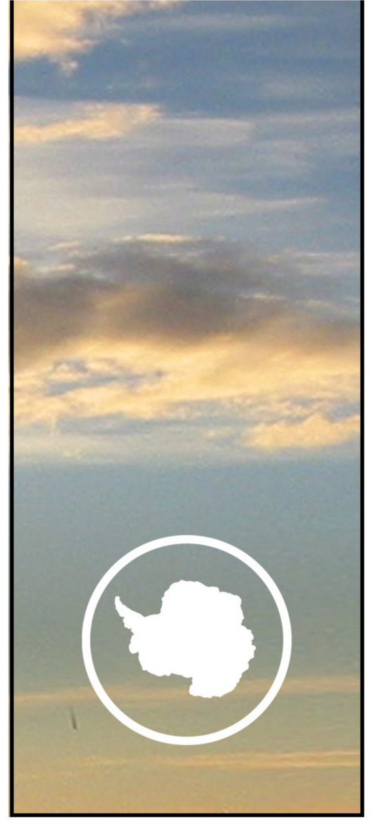
Atmosphere-Cryosphere Interaction over the Larsen Ice Shelf, Antarctica – the OFCAP Project



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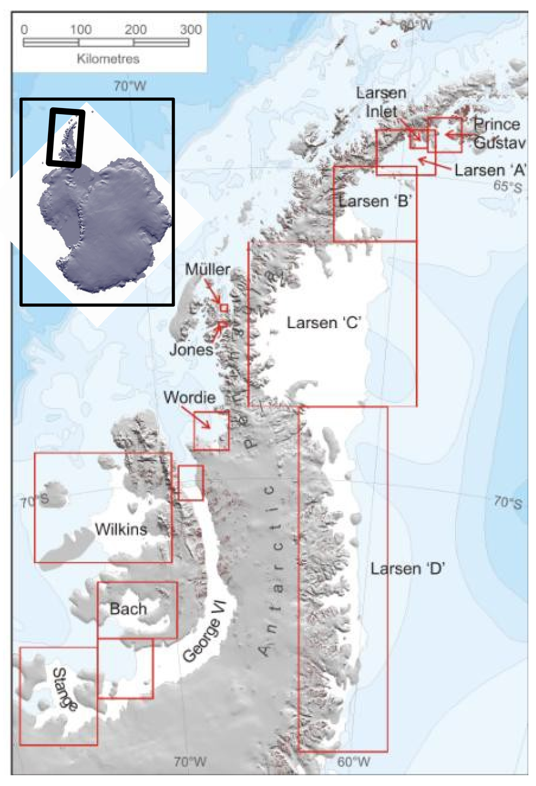
Introduction

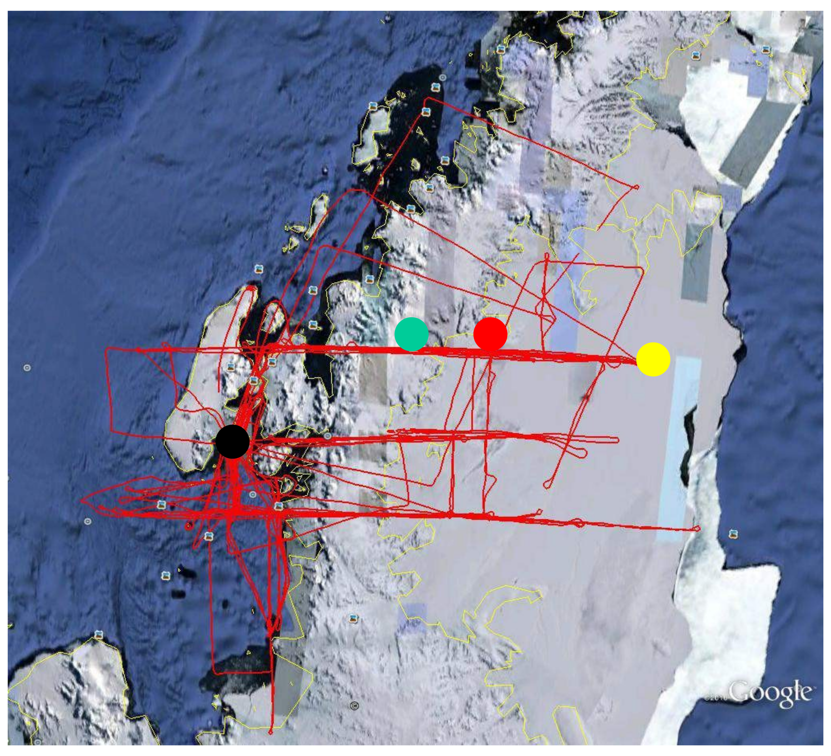
The Antarctic Peninsula is one of the most rapidly warming regions on Earth and has experienced dramatic environmental change in recent years. Ice shelves in the northern part of the Peninsula have retreated rapidly or even completely collapsed. The Prince Gustav and Larsen A ice shelves broke up in 1995 while Larsen B disintegrated over two months in 2002. The larger Larsen C ice shelf is currently stable but may be threatened if current warming continues. Associated with warming over these ice shelves has been an increase in the strength of the circumpolar westerly winds that blow across the ~2000 m – high mountain chain of the Antarctic Peninsula. The goal of the Orographic Flows and the Climate of the Antarctic Peninsula (OFCAP) project was to investigate the hypothesis that warming and increased melt over the ice shelves was a result of an increased frequency of occurrence of warm föhn winds on the eastern side of the Antarctic Peninsula mountains in response to strengthened westerlies. The centrepiece of the project was a month-long field campaign during early 2011, which was complemented with studies using high-resolution regional atmospheric models.



Location of ice shelves in the Antarctic Peninsula. The photograph shows Larsen B after its spectacular collapse in early 2002

The OFCAP field campaign: January-February 2011

An instrumented Twin Otter aircraft operating out of Rothera Research Station (●) made free atmosphere and boundary-layer measurements. A total of 78 hours were flown over 22 flights (tracks shown in red), which included two strong föhn events.

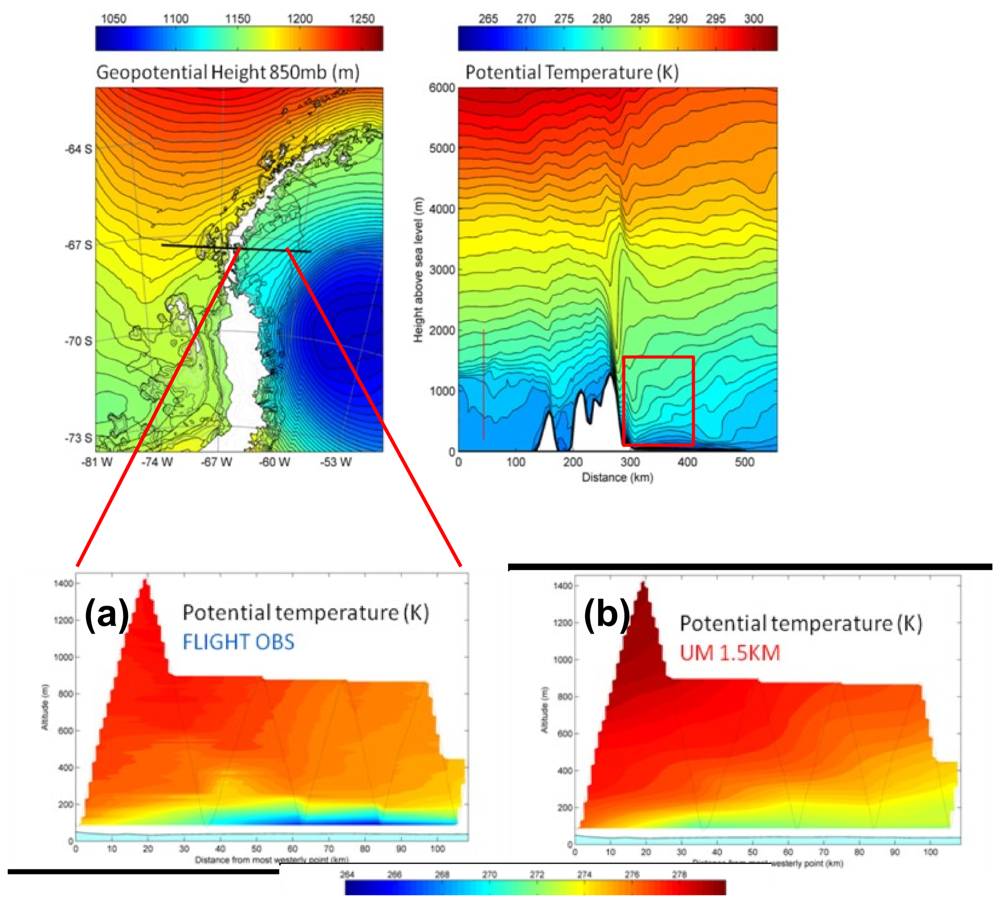


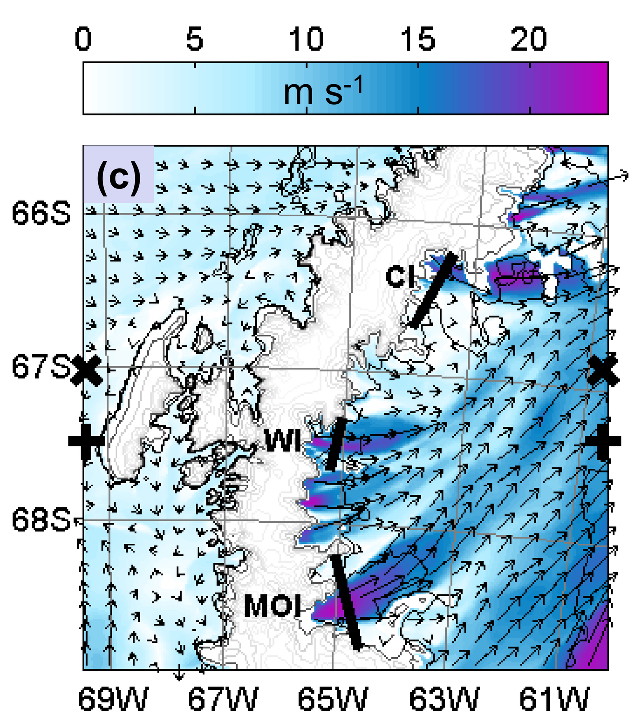
Radiosondes were launched and surface energy balance measurements made from a camp on Larsen C Ice Shelf (●).

Automatic Weather Stations were deployed on the summit of the Peninsula (●) and at the western edge of Larsen C Ice Shelf(●)

Modelling, Analysis and Interpretation

A westerly föhn event – 5 February 2011





Elvidge et al (2014) "Foehn jets over the Larsen C Ice Shelf, Antarctica", *Q. J. R. Met. Soc., doi:* 10.1002/qj.2382

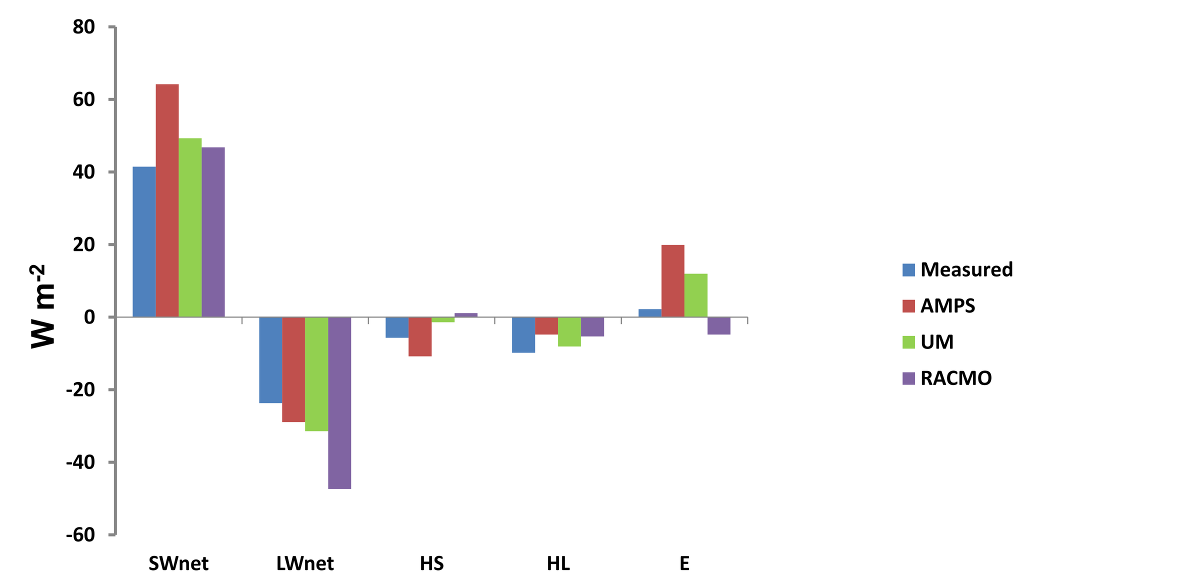
• Föhn event modelled using the UK Met Office Unified Model (UM) run at a resolution of 1.5 km.

•Observed (a) and modelled (b) cross-sections show warm föhn air reaching the surface of the ice shelf just downwind of the foot of the mountains, with cold air persisting further east.

• "Föhn jets" emerge from embayments at the foot of the mountains and blow across the ice shelf (c). Trajectory analysis shows that these are gap winds that have originated at relatively low levels on the upwind side of the Peninsula. The air within these jets is thus generally both cooler and moister than the bulk of the föhn flow.

Validation of the surface energy balance at Larsen Camp in three high-resolution atmospheric models

The rate of surface melting is determined by the surface energy balance (SEB) We have compared SEB components measured at Larsen Camp during OFCAP with values computed by three regional atmospheric models: (i) The Antarctic Mesoscale Prediction System (AMPS, implemented using the WRF model), (ii) the UK Met Office Unified Model (UM) and the Regional Atmospheric Climate Model (RACMO). All three models ran at a horizontal resolution of about 5 km. Over 8 January – 8 February 2011, all three models calculate excessive net shortwave heating (SWnet) of the surface which is partially compensated for by excessive modelled net longwave cooling (LWnet). Averaged over the month, modelled turbulent sensible (Hs) and latent (HL) fluxes are small and in reasonable agreement with observations. The biases in the radiative components are most likely due to a poor representation of cloud coverage and cloud properties in all three models.



Mean SEB components at Larsen Camp, 8 Jan – 8 Feb 2011, from measurements and from three high-resolution models