AFI08/05 – Fieldwork Report, 2009/2010 Season

Present and Future Stability of Larsen C Ice Shelf (SOLIS)

Adrian Luckman[1], Daniela Jansen[1], Bernd Kulessa[1] (PI) Ed King[2], Peter Sammonds[3]

[1]School of the Environment and Society, Swansea University, Swansea SA2 8PP, UK.

A.Luckman@Swansea.ac.uk

[2]British Antarctic Survey, High Cross, Cambridge, UK.

[3]Department of Earth Sciences, University College London, UK.

1.0 Introduction

Early negotiations for the fieldwork component of this project resulted in planning for only one field visit during the 2008/2009 Antarctic season. However, circumstances during 2008/2009 prevented a complete achievement of all fieldwork objectives, most notably the transfer to Study Site II (Fig. 1) and subsequent radar and seismic measurements closer to the grounding line.

Fortunately, BAS logistics were willing to support a second field season and NERC subsequently committed modest additional funds to cover the costs of transfer flights and field assistant support. Adrian Luckman was chosen to lead this second field season and Catrin Thomas was selected as BAS General Assistant. It was agreed that passive and active seismic data collection at Field Site II was not necessary to achieve the main objectives of the project.

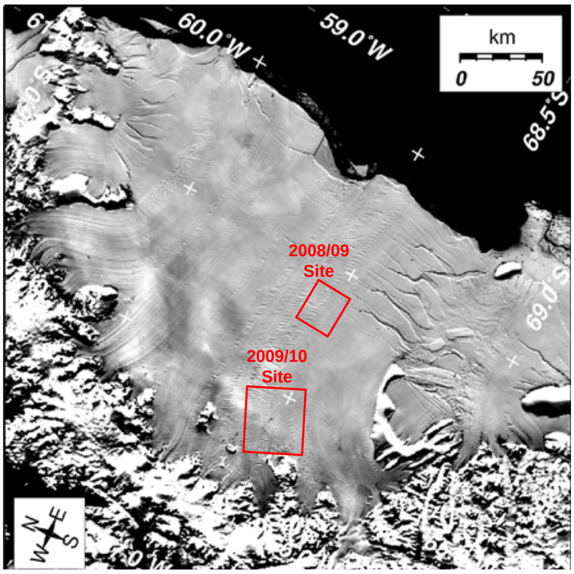


Figure 1: *MODIS MOA image of Larsen C showing field locations for the 2008/2009 and 2009/2010 seasons*

2.0 Aims

Objectives for Field Season 2 were devised to address the remaining needs of the project:

1) Use ground-penetrating radar (GPR) to map and characterise the thickness and internal ice structure across the transitions between flow bands.

2) Use GPR to investigate the nature of large (20km x 1km in MODIS imagery) cross-flow features thought to be the surface expression of bottom crevasses.
3) Use Common Mid Point (CMP) surveys to calibrate radar velocities in different flow units.
4) Deploy differential GPS (GEF Leica 1200) along with the GPR to fully characterise the surface height variation associated with different flow features and structural transitions.

3.0 Deployment details and setup

Adrian Luckman travelled via the Falkland Isles to Rothera in early November, arriving on 3rd November. Following field training, equipment testing and transfer of field equipment, final deployment to Larsen C was achieved on 15th November.

A short period of time was required to set up camp, install the Leica GPS base station and make final tests of the GPR equipment in the standard BAS linked-load travel configuration. To avoid contamination of the GPR signal by reflections from local metallic objects, the transmitter, receiver and antennas were mounted on a small metal-free man-hauling sledge while the console, laptop, GPS and battery was mounted on a half-Nansen sledge in front. This arrangement also emulated conditions of data collection from the earlier field season, to best allow data inter-comparisons. The two sledges were connected by fibre-optic cable, protected from damage using a 2m length of reinforced rubber radiator hose (normally used for making pyramid tent dongles) (Fig. 2)

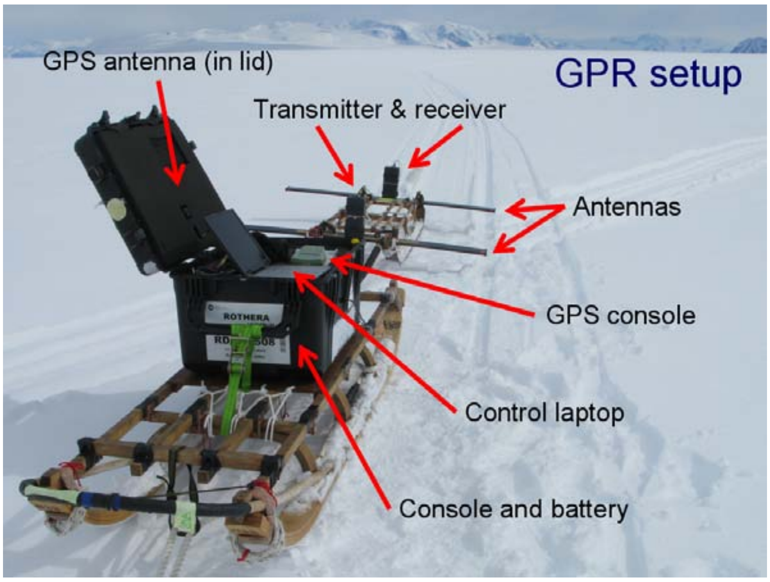


Figure 2: *GPS deployment behind second skidoo in linked travel arrangement*

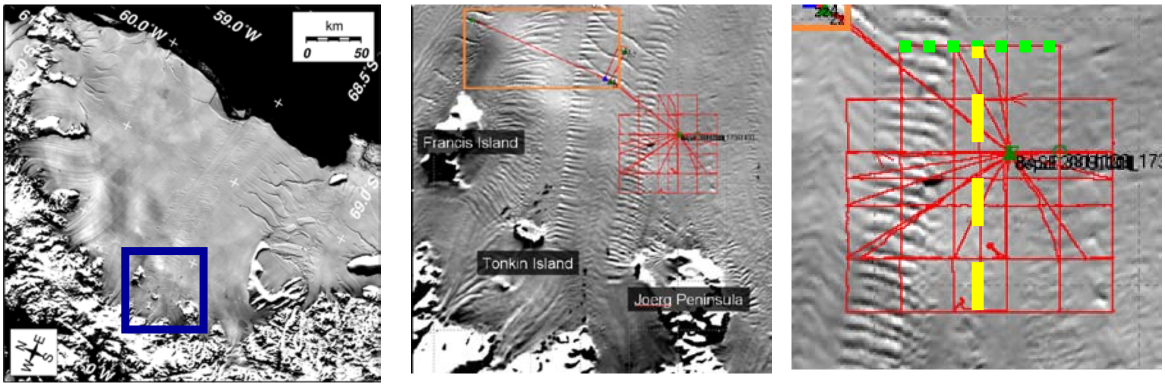
A coiled rope was dragged behind the rear radar sledge to act as a stabilising anchor.

Daily data collection involved planning which part of the survey grid to target, setting the GPS base-station to log at 1s intervals, driving to the required location, fixing the antennas to the rear sledge and collecting data (GPS and GPR). Spare GPR (camcorder) batteries, and lead-acid battery (car-type Gel-Cell) were carried to allow a battery change during the day. Battery life was approximately 3-4 hours depending on conditions, allowing a full day’s data collection away from camp.

Data were collected daily from 16/11/2009 to 8/12/2009 apart from two periods of lie-up days due to poor weather (17 collection days out of 26 days on the ice shelf). Three CMP surveys were carried out on foot at key locations within the survey grid during this period.

4.0 Field Data

Fig. 3 shows the pattern of data collected.



(a) **(b)** **(c)**

Figure 3: *Resulting grid of GPR data collection, as recorded by the on-board GPS. (a) overview map of Larsen C ice shelf; (b) GPR data collection lines consisting of 4km grid and northerly excursions, and (c) grid highlighting two GPR profiles shown in results*

The 20km grid was devised to sample ice thickness and structure across and along several ice shelf flow units (Objective 1). Initial data analysis suggested that a grid spacing of 4km was appropriate to sample the heterogeneity while 2km interval was employed close to the centre of the grid to focus on key flow using originating from the Joerg Peninsula and thought to be the origin of ice sampled in the previous field season.

In addition to the 20km grid, two forays were made further afield. The first was to local features to the North-East of the grid thought to be the surface expression of basal crevasses. Initial findings confirm that this is the case. The second was a radar line to the North of the grid designed to sample transitions between a number of different flow units.

All in all, approximately 2.4GB of GPS data and 2.0 GB or GPR data were collected during the 26 day deployment.

5.0 Initial findings

<u>20 km radar and gps grid:</u>

- Fig. 4a shows GPR profile highlighted with light green dashed line in Fig. 3, while Fig. 4b show profile highlighted in yellow on Fig. 3.
- Similar to the results in the first field season, the flow bands visible on remote sensing images are connected with irregular reflectors within the ice column, partly disrupted by normal depth basal reflectors (Fig. 4a).
- In Fig. 4b, the depth of the irregular reflector is increasing with distance to the grounding line, due to the accumulation of snow while moving downstream.
- The flow stripe features are also evident in the vertical component of the gps data as depressions. The vertical displacement relative to the adjacent flow unit of the ice shelf seems to level out downstream, an indication for further basal ice accretion due to freezing of sea water in the gaps. The change in surface elevation can be

also found in supplementary data like Ice-Sat and bedmap, but with a very sparse coverage.

Long profile

- The linear radar profile from the camp location to the north shows that also the other flowstripes detected on satellite imagery show similar patterns of their basal reflectors. The profile is perpendicular to the ice flow direction and clearly shows well defined basal reflectors in the flow units originating from glaciers feeding the ice shelf and diffuse, shallow reflectors within the suture zones in between. The findings derived from the higher resolution survey downstream of Joerg Peninsula might therefore be upscaled to other suture zones within the Larsen C ice shelf.

Basal crevasses

- The radar profiles across two large scale surface features downstream of Bills Gulch and Ahlmann Glacier (Fig. 4c) show that these surface features are the expression of large basal crevasses. The crevasses reach up to about 100 m depth, nearly the same for both crevasses, giving some information about the vertical stress distribution within the ice shelf in the region where the crevasses form.
- At one of the crevasses also a feature closer to the surface could be detected, maybe a buried surface crevasse due to the steepness of the slope on this side of the surface feature.
- These are valuable results for our model for vertical crevasse propagation, as the depth of the crevasse tips might be used for model validation.

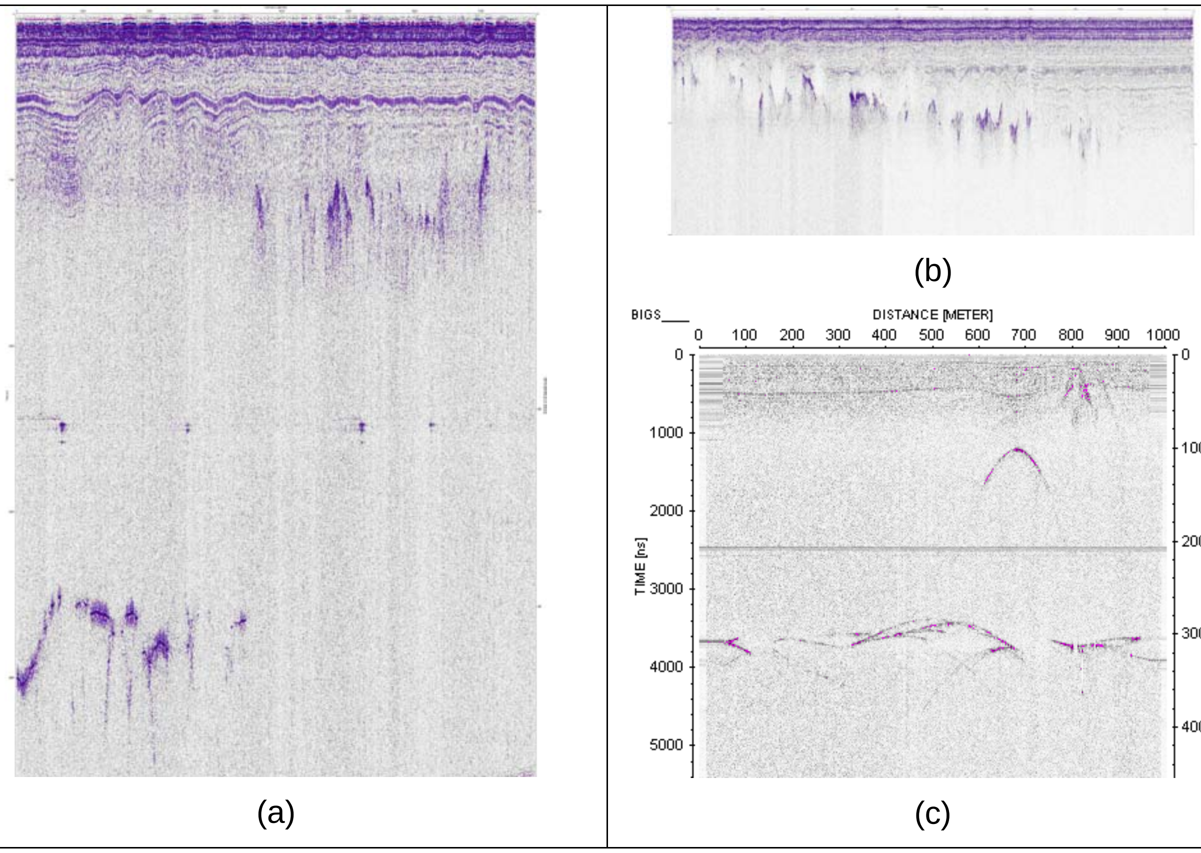


Figure 4: (a) Across-flow radargram (green dashes in Fig. 3), **(b)** along-flow radargram (yellow dashes in Fig. 3)and **(c)**, basal crevasse radargram