

Project AFI 7/22

Tidal dynamics of the Filchner-Ronne and Larsen C ice shelves, Antarctica

Principal Investigator: Professor Peter Clarke (Newcastle University)

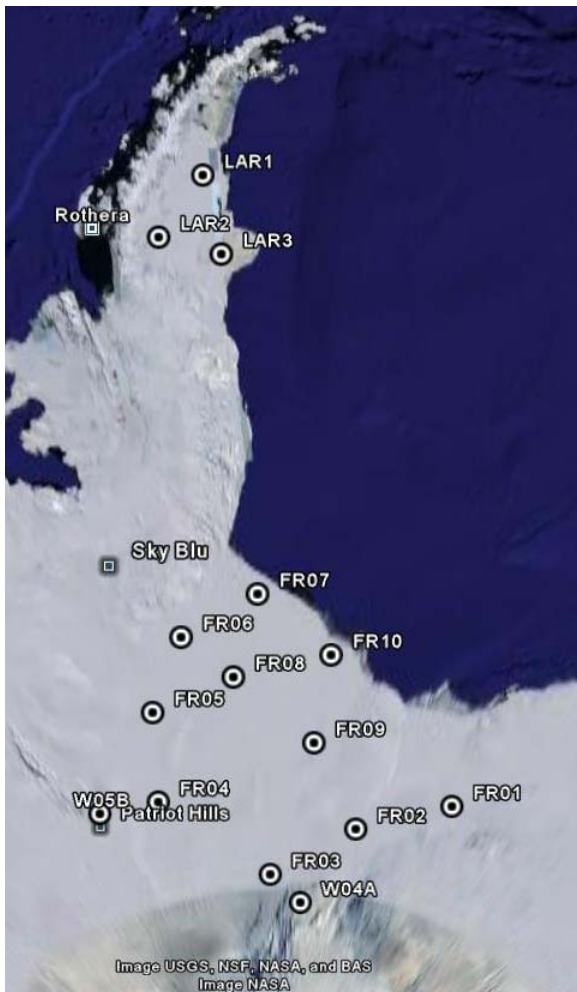
Co-Investigators: Dr Matt King (Newcastle University), Dr Keith Nichols (British Antarctic Survey)

Location: Larsen C and Filchner Ronne ice shelves

Field Personnel: Dr David Barber (Newcastle University)

Rationale: Some of the largest tides in the world are found along the eastern coast of the Antarctic Peninsula and southern extent of the Filchner-Ronne ice shelf where the peak-to-peak spring tidal range can exceed 7 m. At present, however, our knowledge of the tides under these ice shelves is the most limited of any comparably-sized region on Earth. Mismodelled ocean tides and ocean tide loading propagate into satellite based measurements, with present tide model uncertainties suggesting possible biases well above the measurement noise of these instruments. Recent exciting measurements have also demonstrated large tidally-driven modulations of ice shelf flow near the Rutford Ice Stream similar in appearance to those previously identified on the Brunt Ice Shelf over 1000 km away, suggesting such modulations may be widespread features and that ice shelves may play a larger role in ice stream flow modulation than previously thought. We are studying the tidal dynamics of the major Weddell Sea ice shelves, namely the Filchner-Ronne and Larsen C ice shelves, through direct GPS measurements and assimilation into an Antarctic numerical tide model. Our results will significantly reduce the tide-induced systematic error component in geodetic data used for key studies of post-glacial rebound, ice shelf thinning and ice sheet mass balance, and improve understanding of the intriguing tidal modulations of ice flow and their driving mechanism(s).

Highlights: During the 2007/08 summer field season 15 GPS receivers, recording position observations every 15 seconds for 24 hours a day, were successfully deployed over the Larsen C and Filchner-Ronne ice shelves. Six of these stations were uplifted at the end of the field season with the remaining stations left to operate over the 2008 Antarctic winter and then downloaded or retrieved during the 2008/09 field season. All stations were deployed via BAS Twin Otter aircraft and, in most cases, just two personnel (the pilot and the project's field technician).



The deployed GPS sites and the Antarctic Peninsula

Whilst modern GPS receivers are very compact, providing sufficient power at remote locations to ensure they operate over an extended period (including in the cold and darkness of an Antarctic winter) is not a trivial requirement. Three separate power systems were, therefore, required to meet the needs of this project. Summer only stations, sufficient for a 60 day deployment, were relatively simple, consisting of a single 12V battery and solar panel. Winter stations, intended for a minimum deployment of one year, required a more substantial design consisting of a solar panel, four wind turbines, six 12V batteries and a bespoke BAS-designed power management system. Finally, at two sites where the airlifting of large amounts of equipment would be difficult, expensive yet lightweight lithium battery packs sufficient to last for 12 months were selected.

Deployment of the GPS receivers and their associated power systems began on 21st November with a visit to the Larsen Ice Shelf. Operating directly from Rothera, two summer stations (LAR1 and LAR3) and one winter station (LAR2) were installed at three locations in a single day.

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Due to the larger number of stations designated for the Filchner-Ronne, deployment was performed over two fieldwork periods during the first and third weeks of December. The first deployment included visits to eight of the GPS sites, including four winter sites and four summer sites. Fieldwork was conducted via the BAS summer field depot at Sky Blu and the ALE operated base at Patriot Hills, close to the Ellsworth Mountains.

In the second deployment, the four remaining sites were tasked for installation. Given their remoteness from any manned depot/camp, this deployment required a one night stay on the Ronne ice shelf and a further night's camp at the Pillow Knob fuel depot at a latitude of over 83 degrees South. Unfortunately, equipment designated for site FR03 had to be swapped for faulty equipment intended for site FR01, preventing FR03's deployment on this trip. Also, battery packs for site W04A were found to be operating incorrectly and only half the available power system at this site could be deployed at this time.

Following the deployment of all but site FR03, an all-year GPS site located at Breckner peaks on the Antarctic Peninsula (of the same design as the one we had recently installed at site W05B) was visited by BAS field staff operating out of Rothera. On arrival it was discovered that this station had been blown over and destroyed during the winter of 2007. In response it was decided that the site at W05B needed to be secured with rock bolts and chain/rope guys to ensure it survived the 2008 winter. Therefore, on the 12th January, and with the use of an aircraft tasked to collect an ITN news crew from Patriot Hills, site W05B was revisited and this small but vital task completed. Also at this time, given its proximity and upcoming season end, summer site FR04 became the first station to be uplifted after an observation period of roughly 50 days.



Winter GPS stations at sites W05B (left) and W04A (middle), and a summer station at LAR1 (right).

On the 25th January, stations LAR1 and LAR3 were retrieved from the Larsen ice shelf, and data downloaded from over-winter station LAR2. Over the last week of January, we then launched a final mission over the Ronne Ice Shelf aimed at revisiting as many of the GPS sites as possible to download data and, where necessary, retrieve summer sites. This also presented an opportunity to deploy station FR03 after its repair at Rothera and to revisit station W04A to install its now working second battery pack. Persistent low cloud in the vicinity of station FR01 unfortunately meant it could not be retrieved and, likewise, station FR02 could not be revisited due to low cloud rendering contrast to nil over the area (although we were able to confirm it was still intact when overflying it). An overnight camp in the back of the aircraft at South Dome on Berkner Island allowed us to be in position the next day to visit and download data from station FR09, and then retrieve summer stations FR08 and FR06. Station FR10, located at the New Ronne depot, was not uplifted at this time, again due to bad weather, although it was later collected by a flight from Halley to Rothera at the beginning of February 2008.

This has been referred to as one of the most logistically challenging projects undertaken by BAS. Despite this, all 15 intended GPS stations were successfully deployed. Data downloaded this season had already undergone preliminary processing in the field, and initial results show the magnitude of the tidal range and the flow rates of ice shelves at the observed stations. With the revisit and retrieval of these GPS stations next year, this project will provide the most comprehensive time series of ice flow and tide data for the Ronne/Larsen ice shelves ever collected.

The success of the project and relative ease which the fieldwork was completed was, in no small part, due to the skill and enthusiasm of the BAS pilots and operations team involved. The project team thanks the BAS team for its support in what, to date, has been a very successful and enjoyable field project.