

Project AFI 7/22 (2008/9)

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 Nicholls (British Antarctic Survey)

Location: Larsen C and Filchner Ronne ice shelves

Field Personnel: Matt Balmer, Celine Nyhan (BAS)

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).

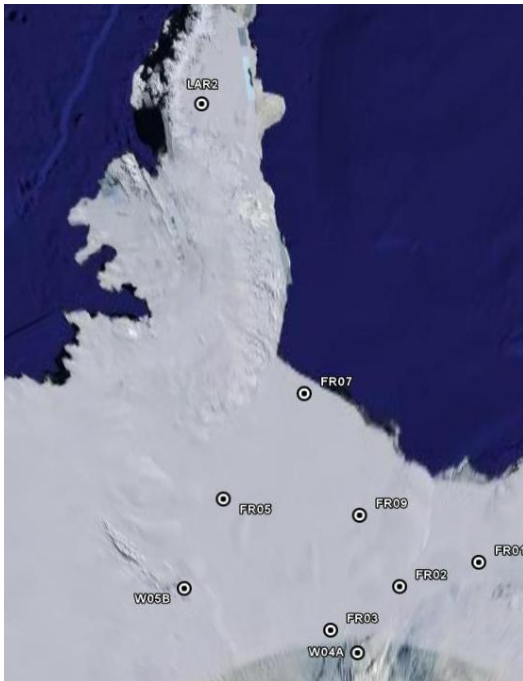


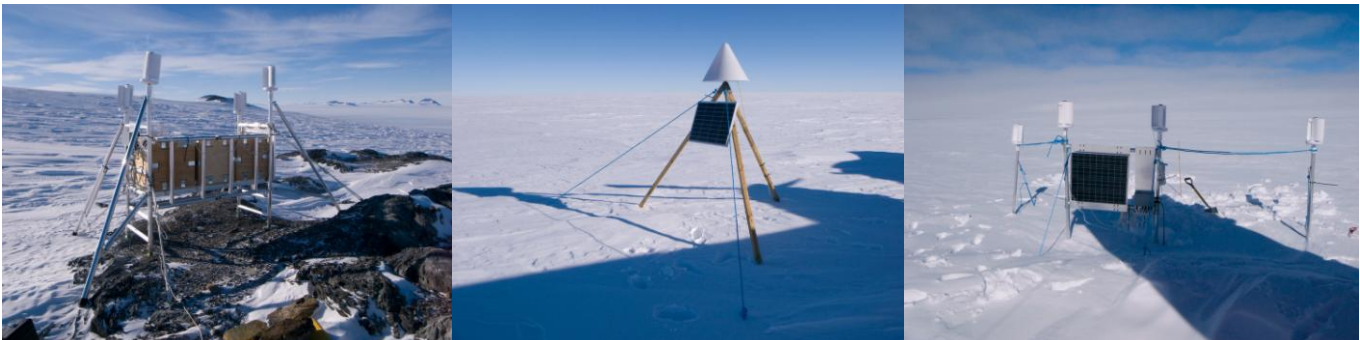
Figure 1: Sites left for winter 2008 and retrieved during 2008/9

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. The sites left for the winter are shown in Figure 1. Sites LAR2 (Larsen C ice shelf), FR05, FR07, FR09, W04A and W05B had power systems designed to power the instruments through the winter using either solar+wind or lithium batteries. The other sites had solar only power and would only run until the autumn, and then perhaps again in the spring.

The 2008/9 field season was planned as a retrieval season. The scientific investigators at home in the UK awaited news of the sites with some trepidation. On 28/12/08 Matt Balmer (Rothera PSD Engineer) and Nico Inderberghe (Pilot) set out from Rothera (routing through Sky Blu) with the intention of uplifting the two prioritised GPS systems, FR05, FR09, then returning to Rothera.

Upon arrival at site FR09 a scheduled radio call with Rothera took place and due to good weather on the Ronnie and poor weather at Sky Blu, it was decided that as many GPS stations would be uplifted as possible. With some hard work, including substantial digging in snow, and long days sites FR02, FR03, FR05, FR09, W04A, and W05B were retrieved in a single trip. Initial inspection revealed good amounts of

data at all sites. A wind turbine was found dented at W05B (Wilson Ntk).



Sites W05B (left), FR02 (middle) and FR05 (right) on retrieval

On Jan 27, 2009, Celine Nyhan (BAS) visited site LAR2 and found it to be in good working order despite substantial accumulation. The GPS and pressure sensor for this site was downloaded and the site reset and left for another year. Site FR01 was subsequently recovered via Halley.



Site LAR2 on download (left) and after being reset for the 2009 winter

The data were examined back in the UK with very satisfying results. One of the big challenges of this project was to run GPS receivers through the winter. Of the 6 sites with winter power systems, 5 had run largely without break. One (W05B) stopped during the winter, recommenced for a few days in spring then failed again. It is not yet clear if this is a power generation (possibly related to the wind turbine being bent) or due the GPS receiver not switching on due to a low voltage cut-off (or a combination of the two). The latter is perhaps more likely. Site FR01 and FR03 were found to have corrupt compact flash cards. These were the only two Leica GPS receivers to over-winter (the rest being Trimble). The data from FR03 was fully recovered using specialist partition recovery software. The data on the FR01 card is unrecoverable. These corruptions may have been related to receiver firmware issues although this remains unclear at the time of writing. Despite these losses, the total data return was >90% and nearer 100% of that which was hoped for given the challenges involved.

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. As the raw GPS data are turned into position time series, this project will provide the most comprehensive time series of ice flow and tide data for the Ronne/Larsen ice shelves ever collected. Indeed, these data have now been processed and they yield very interesting data that will bear fruit for many years to come. Improving and developing models of these observations is the next step.

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 has been a very successful and enjoyable field project.