iSTAR

ANTARCTICA

iSTAR - NERC Ice Sheet Stability Research Programme

Investigating the stability of the West Antarctic Ice Sheet

Highlights: 2012 – 2018

NERC SCIENCE OF THE ENVIRONMENT

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Ice, ocean and iSTAR

Our Earth's ice sheets are increasingly affecting global sea levels and climate, and predictions show that this will continue in the future.

The West Antarctic Ice Sheet represents one of the largest potential sources of future sea-level rise and it contains approximately 2.2 million km^3 of ice. Its complete collapse could raise global sea levels by as much as four metres and it is already losing mass at a growing rate.

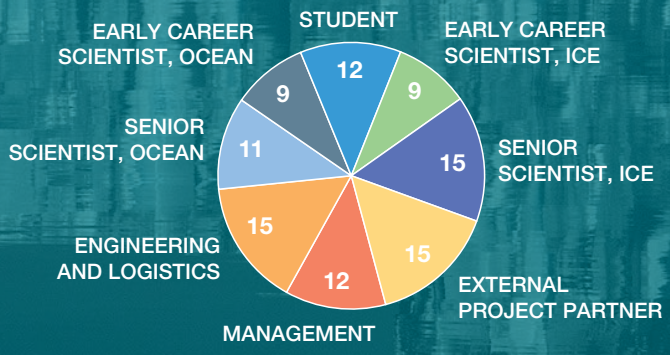
Of all the world's glaciers, the one currently causing the greatest sea-level rise is Pine Island Glacier in West Antarctica. The rate of ice loss in this area has doubled in six years and now accounts for 10% of all global sea level rise. Unfortunately, because of its irregular shape, Pine Island Glacier is one of the glaciers whose future behaviour is most difficult to understand.

Changes in the glacier are intimately linked with, and driven by, the ocean in the nearby Amundsen Sea.

iSTAR is the Ice Sheet Stability Research Programme of the UK Natural Environment Research Council (NERC).

iSTAR is a team of researchers led by the universities of East Anglia and Leeds and the British Antarctic Survey. It has researchers from eleven UK universities and two UK research centres, with international collaborators from the USA, South Korea, and Germany.

Our goal is to understand Pine Island Glacier, the Amundsen Sea, and the links between them, so that we can improve predictions of future sea level.



The ice sheet

The West Antarctic Ice Sheet is a vast inland ice reservoir that feeds ice into the surrounding glaciers and ice shelves. It is replenished by snow fall in the interior of Antarctica, but a net loss of ice contributes to global sea-level rise.

Because of its large scale, observations of the ice sheet are mainly done by satellite, measuring changes in elevation and motion. When combined with models of ice movement, these can quantify past, current, and future ice loss.

Measurements have also been made on the ice sheet through ambitious crossings with equipment pulled by tractors. During these iSTAR traverses, the snow and ice near the surface were measured using a variety of techniques, to help us better understand how the snow compacts, and interpret how the observed thinning relates to changes in ice mass.

Historic and current satellite measurements over the glaciers feeding into the Amundsen Sea have been analysed and compiled, enabling us to track how dynamical changes in the glaciers have propagated upstream to the ice sheet over the last 25 years.

To interpret the observed changes, we need models both for the behaviour of the ice surface and for the dynamical changes in the ice sheet, underpinned by observations on the ground and in the ocean.

The glacier

Pine Island Glacier is a vast river of ice, fed by smaller tributaries from the West Antarctic Ice Sheet, flowing into a floating ice shelf in the Amundsen Sea. When you are standing on it, you don't even realise that it is moving towards the sea at a rate of up to 4000 metres every year.

Together, Pine Island Glacier and the neighbouring Thwaites Glacier, have recently accounted for approximately 70% of the net ice loss from West Antarctica.

It is remote, hard to reach from all permanently occupied research stations, and difficult to work on.

Prior to the build-up to iSTAR, only one team had ever worked there on the ground: in 1960 a pioneering exploratory US traverse, the infant stages of modern Antarctic research, crossed the upper part of the glacier without even realising that they were on a glacier.

Over the ~10 years covering the iSTAR Programme, we have gradually unlocked the secrets of Pine Island Glacier, turning it from a blank area on the map into one of the most intensely studied of Antarctica's large glaciers.

Being supported by a tractor-towed traverse has enabled us to survey the tributaries and trunk of the glacier in unprecedented detail.

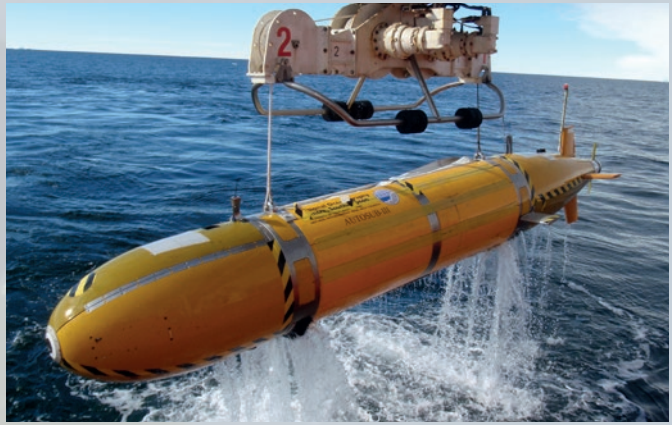
Our new insights into the past and present behaviour of the glacier and conditions at the base of the ice, in combination with high-resolution topography, have enabled us to build better models of the ice flow. This will in turn lead to better predictions of the ice loss from West Antarctica.

The ocean

The Amundsen Sea forms a key link between the World Ocean and the West Antarctic Ice Sheet. Warm Circumpolar Deep Water (CDW), which is unable to reach the continental shelf around most of Antarctica, flows onto the shelf through glacially carved troughs, all the way to the floating ice shelves. Here it is able to penetrate beneath the ice shelves to the grounding line, the point where the glacier goes afloat.

More warm water at the grounding line causes stronger melting, thinning the ice shelf, which in turn weakens the ice shelf's resistance to ice flow from the glacier upstream.

The key oceanographic question in iSTAR is how the ocean is forcing the ice shelf: what is driving the variability in deep warm water flow onto the continental shelf? And how, once this water reaches the ice shelves, does it melt the ice?



We have enlisted the help of Weddell and Elephant seals to carry miniaturised oceanographic instruments for a year, transmitting data back by satellite when they return to the surface. These seals have given us a unique distribution of measurements across the continental shelf throughout the winter.

Along with measurements from moored instruments that we have deployed across the shelf break and right up to the ice shelf fronts, we have gained new insights into the year-round variability of the deep warm water on the shelf not captured in previous summer snapshots of the ocean.

118,418 km
TRACKS FROM SEALS

63
OCEAN INSTRUMENTS

38
WEATHER BALLOONS

What has iSTAR learned?

iSTAR has delivered a step-change in our understanding of Pine Island Glacier, a key part the Antarctic Ice Sheet and a major contributor to global sea-level rise.

In particular iSTAR has:

- Developed satellite techniques to deliver more robust assessments of Antarctic ice loss.
- Delivered improvements in ice sheet models that provide more reliable forecasts of ice-sheet change and global sea-level rise.
- Established long-term measurements quantifying interactions between the ocean and ice that drive ice-sheet change.

- Revealed diverse landscapes under the ice, which both promote and limit fast glacier flow. This is the biggest factor affecting current ice flow and how the ice evolves in coming decades and centuries.
- Developed novel technology to deliver year-round measurements of the varying patterns of melt beneath the ice.
- Made precise measurements of the vertical movement of the Earth's crust. This signal records past changes in the ice sheet and provides the historical context to fully understand recent and future change.
- Established a clear link between local weather patterns and short time-scale changes in the waters of the Amundsen Sea.
- Measured for the first time the turbulent mixing taking place as water escapes from beneath the ice into the open sea.
- Quantified the winter-time seawater properties across the Amundsen Sea beneath the sea ice, using novel sensors on seals.
- Revealed the importance of changes in the tropical Pacific Ocean (e.g. El Niño) for long time-scale variations in the Amundsen Sea. We have shown that high year-to-year variability in these patterns currently prevents robust identification of long-term changes.
- Explored the extraordinary environment beneath the floating part of Pine Island Glacier, only accessible to advanced instrumentation. For the first time we have begun to understand the fundamental processes of ice-ocean interaction that affect the shape of the ice sheet and oceans across the world.

The iSTAR legacy

In addition to a large and growing contribution to the scientific literature and knowledge about the West Antarctic Ice Sheet, iSTAR has created a paradigm shift in how the UK conducts Antarctic field campaigns. Tractor trains have proven to be a reliable and efficient new mobile research platform and a method of moving large volumes of equipment and fuel to remote regions in support of science and logistics. This is a valuable new capability, extending the operational boundaries of UK Antarctic science.

Data from the iSTAR Programme are publicly available from UK data centres and can be found through a user-friendly, map-based Geographic Information System.

We have built a new academic community of oceanographers and glaciologists working together and, through PhD students and postdoctoral researchers, have initiated a new generation of polar scientists.

The future

The experience gained through the iSTAR Programme is now being applied to the Thwaites Glacier through a large joint UK-US research programme, co-funded by NERC and the US National Science Foundation (NSF). This $20M programme - the International Thwaites Glacier Collaboration - will seek to build on the success of iSTAR to further improve our projections of ice loss and sea-level rise from the West Antarctic Ice Sheet.

13 INSTITUTES

4 INTERNATIONAL COLLABORATORS

98 SCIENTISTS ENGINEERS & TECHNICIANS

The iSTAR Programme gratefully acknowledges the input and contributions from our many project partners and collaborators; particular thanks go to the Korea Polar Research Institute (KOPRI), the Alfred Wegener Institute (AWI) and the US National Science Foundation (NSF).

Useful links

iSTAR website: *www.istar.ac.uk*
Geographic Information System (GIS): *gis.istar.ac.uk*
The International Thwaites Glacier Collaboration (ITGC): *www.thwaitesglacier.org*

The iSTAR Programme comprises four projects:

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