Mapping the tidal motion of an Antarctic ice shelf from space

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**Methodology**

- The satellite measures the phase value of the radar signal returned from Earth’s surface.
- The difference in the phase values collected from 2 different satellite passes can be displayed as an image (interferogram).
- The phase signal has components due to topography & surface displacement.
- We difference 2 interferograms to remove the phase component due to steady ice flow, leaving only displacement due to tidal motion (plus noise).
- We then use a DEM to remove the topographic component of the phase signal, leaving a ‘tide-only’ interferogram (main figure).

**Comparison to tide models**

Accurate tide models are required to remove unwanted signals from some space-borne estimates of ice shelf elevation and flow velocity, yet no field measurements are available in this region to constrain or validate these models.

We compared multiple tidal predictions from interferometry to the displacements predicted by the tide models TPX07.1 and FES2004 (right, error bars indicate spatial variation over the ice shelf of interferometric tidal displacement).

We found:

1. FES2004 predictions must be taken seaward of the ice shelf front to correlate with interferometric predictions.
2. FES2004 gave a better fit to our data (RMS deviation of 7.5 cm, compared to a TPX07.1 RMS deviation of 9.0 cm).

We conclude that estimates of ice shelf elevation / velocity that rely on tide model predictions to remove the tidal signal are likely to be contaminated by a residual tidal signal.

**Monitoring glaciological change in West Antarctica.**

Ice flowing into the Amundsen Sea has sufficient volume to raise sea level by ~ 1.3 metres.

Recent changes to Amundsen Sea glaciers:
- glacier & ice shelf thinning.
- glacier acceleration.
- grounding line retreat.

Satellite-based interferometric synthetic aperture radar (InSAR) can map glaciological change in remote areas, with no reliance on good weather, daylight or field studies.

Here we use satellite-based differential InSAR to:
1. Identify the grounding line of the Dotson Ice Shelf.
2. Assess the suitability of tide models to simulate the tidal motion of the Dotson Ice Shelf.

The phase (colour) cycles represent the difference in tidal motion occurring during the acquisition of each interferogram.

A “Bulls-eye” pattern indicates a region where the ice shelf is grounded on an elevated portion of sea-floor. The series of adjacent “bulls-eyes” suggests a ridgeline is running under the ice.

**Grounding line**

Densely-spaced colour cycles mark the transition from floating to grounded ice. The seaward limit of these dense fringes (together with an elastic beam model) can be used to map the limit of tidal flexure - a close approximation of the grounding line (the boundary between grounded and floating ice).

**Mapping tidal displacement**

The phase cycle map (centre figure) can be converted into a map showing variations in the vertical displacement of the ice surface (below). Here, a displacement close to 0 (turquoise) indicates that the ice is grounded, whilst a displacement close to 0.3 metres (orange) indicates that the ice is freely floating.

**Loss of clarity of phase cycles (noise)**

- likely due to changes on the ice surface occurring during the period in which the images were acquired.

**Travelling from A to C:**

The ice is initially grounded, then briefly begins to float, before it is re-grounded again on a ridge running underneath the ice (B). The ice then becomes freely floating as it reaches the main ice shelf.