The nature and dynamics of the bed beneath Pine Island Glacier, Antarctica

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With thanks to the Operations and Logistics staff of British Antarctic Survey, and the other members of the 2013/14 iSTAR traverse: Tim Gee, James Wake, Jonny Yates (BAS), Thomas Flament, Anna Hogg (Leeds), Peter Lambert (Reading)

See also poster that complements this presentation!
Introduction: iSTAR

• iSTAR: Ice Sheet Stability Research programme

• 6-year £7.4M NERC programme aiming to understand and predict future of ice in Amundsen Sea Embayment (where Antarctic ice loss greatest since 1990s).

• Simultaneous acquisition of ice stream, ice shelf and ocean measurements around Pine Island Glacier and Amundsen Sea Embayment.

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Motivation for project “Dynamic Ice”

• Central question: What controls the dynamic response of Pine Island Glacier?
• Overall goal: development of models that can emulate the recent response with realistic physical processes, and can then be used to project future response (next 200 years)

• Although there have been several surveys of Pine Island Glacier over the last decade (e.g. Vaughan et al., 2006, GRL; Operation IceBridge), there are few data on smaller scale bedforms and bed properties – which may be (most?) critical for controlling basal motion.

• Radar and seismic surveys of bed therefore designed to improve knowledge of “smaller” - but critical! - bed features
iSTAR Traverse 2013/14

- Overall 900 km route designed for complementary science projects from November 2013 to January 2014
- 12 participants

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Radar surveys

- At six of the sites along the route, iSTAR would “pitch camp” for 2-3 days, allowing the four radar operators to radar-survey the site continuously.

Sleep-deprived scientists...

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Central frequency 3 MHz
Sampling interval ± 1 metres
Vertical resolution ± 3 metres
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**DELORES surveys**

- At each main “radar site”, we acquired 22 15-km radar profiles orthogonal to ice flow.
- 0.5 km spacing between profiles
- Along track, after stacking etc., bed soundings were acquired every 4-5 m.

![iSTAR Traverse Route and DELORES tracks 13/14](image)

![MeASUREs ice speed (km a^{-1})](image)
“Repeat” DELORES surveys

- NB - Where iSTAR route was close to 2007/08 DELORES surveys, opportunity taken to “repeat-survey” some radar tracks.

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The data

• **6 x 150 km² “grids”**
  - Each consisting of 22 15-km profiles across flow, spaced by 500 m
  - 1 in central trunk, 4 in tributaries, 1 in intertributary slow-flow zone
  - 1965 km of radar tracks

• **8 x “repeat profiles”**
  - 154 km worth of tracks
  - 5 x profiles orthogonal to ice flow
  - 3 x profiles along flow
  - 7 are repeats from 2007/08 (6 year acquisition gap); 1 is a repeat from 2010/11 (3 year acquisition gap)
Results

1. Radargram processing:
   - bandpass filter, gain, migration
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2. Import SEGY to Schlumberger Petrel™

3. Pick bed (semi-automatic)
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4. Create mesh of bed picks

5. Derive DEM
   50 m x 50 m
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MeASUREs

SB6 (Tributary, $v \sim 250$ m a$^{-1}$)

SB1 (Central trunk, $v \sim 375$ m a$^{-1}$)

SB5 (Tributary, $v \sim 365$ m a$^{-1}$)

SB7 (Tributary, $v \sim 285$ m a$^{-1}$)

SB7R9 (Inter-tributary ridge, $v \sim 10$ m a$^{-1}$)

SB9 (Tributary, $v \sim 225$ m a$^{-1}$)
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Results: Main trunk - Site SB1 (istar07)

Ice flow
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Results: Upstream tributaries - Sites SB6 & SB5 (istar08 & istar13)
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Results: Downstream tributaries - Sites SB7 & SB9 (istar15 & istar18)

- Sites SB7 & SB9 (istar15 & istar18)
- Downstream tributaries
- Elevation depth 300 m
- Peak to trough amplitude > 100 m
Results: Downstream tributaries - Sites SB7 & SB9 (istar15 & istar18)

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Results: Intertributary ridge - Site SB7R9 (istar17)

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Conclusions

• 6 x hi-res “bedmaps” recovered from PIG
• ~150 km of “repeat”-surveyed profiles, mostly comparing 2007/08 with 2013/14

Next steps:
• This season, active seismic surveys will be undertaken at the same sites
• Reflectivity of the bed to be calculated using both radar and seismic data – for further improved understanding of bed composition & conditions
• Detailed comparison of bed geomorphology with offshore marine geophysical data and onshore deglaciated terrains
• Input to modelling exercises: basal drag; change at the bed.

See also poster that complements this presentation!
Methods: 2. Pine Island Glacier

- 4 x reconnaissance field campaigns by BAS since 2006:
  - Preliminary ground-radar surveys
  - GPS measurements
  - Active seismic surveys at selected sites

MeASUREs

- Ice speed (km a⁻¹)

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Yellow tracks = DELORES surveys in 2007/08

iSTAR traverse of 2013/14 allowed considerably greater efficiency of data acquisition through facilitating larger field party
Operation of tried and tested methods in “siege campaign”!
V. Preliminary – early work on “repeat surveys”

Repeats with bed picks: T02, L01, T04, T05. looking upstream. 1314 = red pick, 0708 = yellow, 201011 = blue
Close up of T02 (background radargram is 2007/08 data)
Close up of bed bump on T02 (07/08 radargram)

Close up of bed bump on T02 (13/14 radargram)