

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

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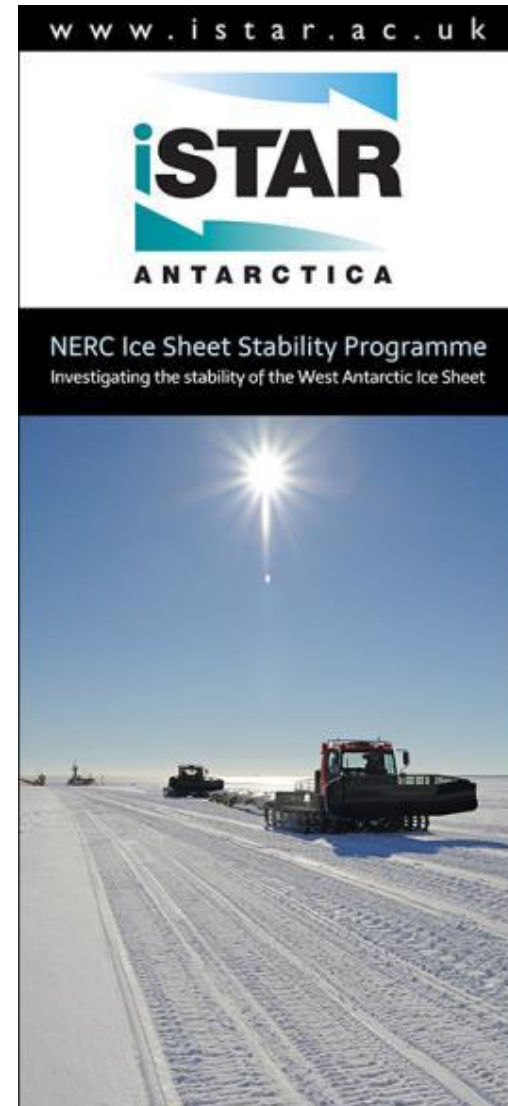
See also poster  
that complements  
this presentation!



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)

# 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

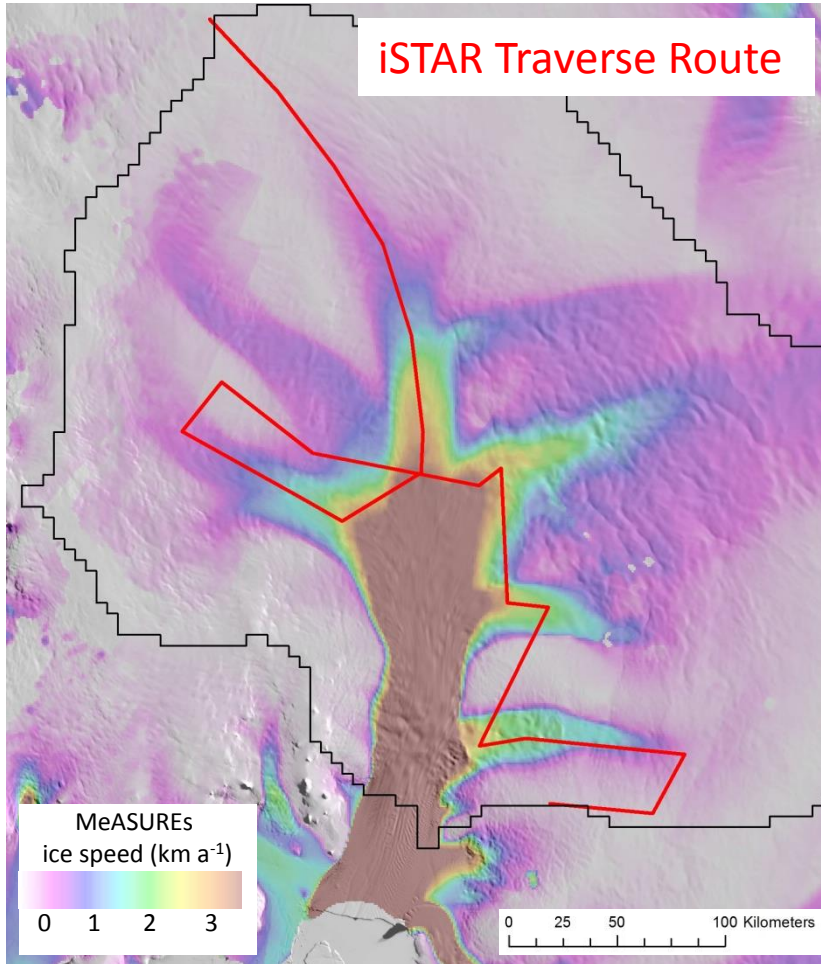


BG photo: Anna Hogg

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# iSTAR Traverse 2013/14

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

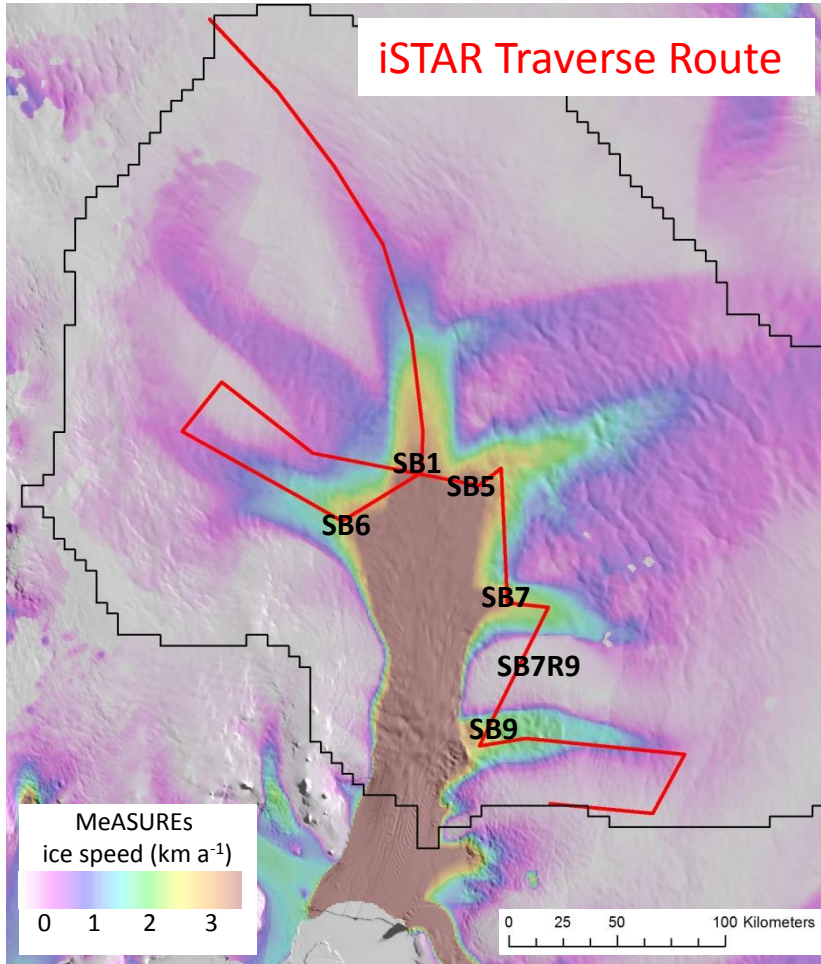


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# Radar surveys



- 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

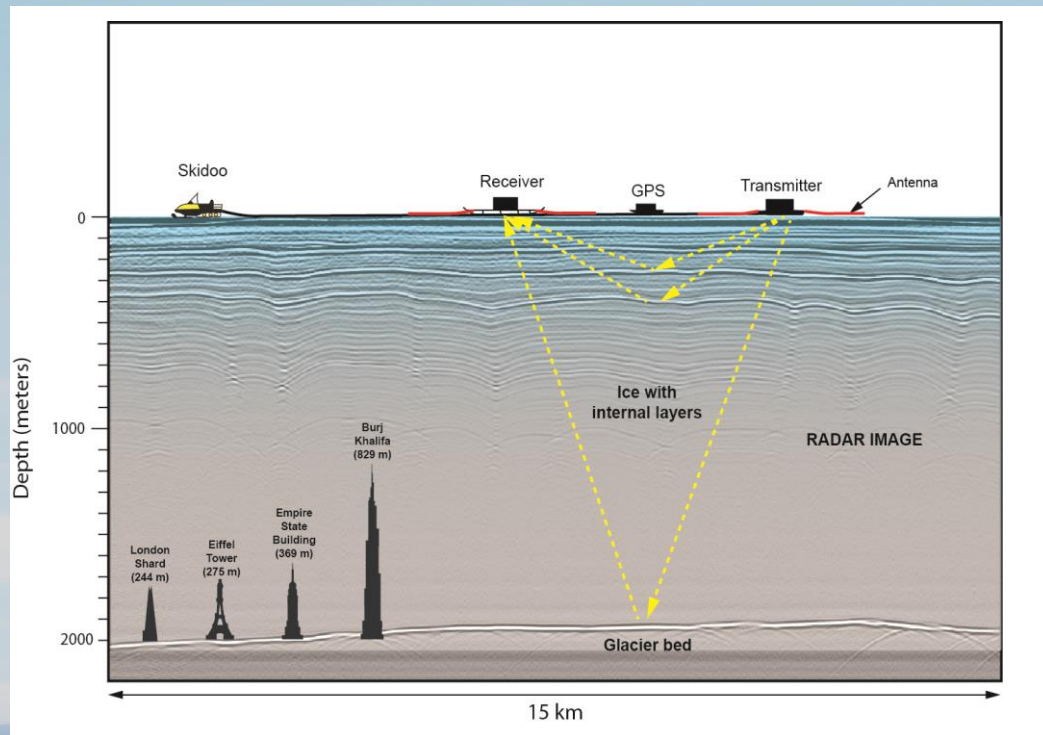
Sleep-deprived scientists...



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# DELORES radar



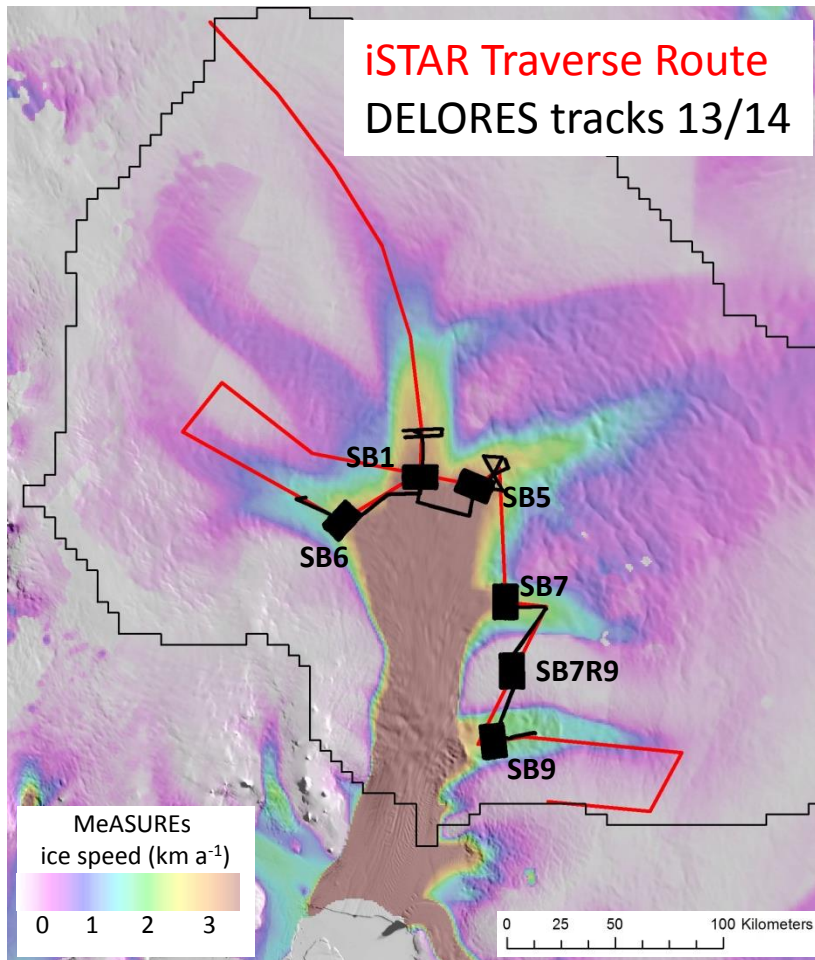
Central frequency 3 MHz  
Sampling interval  $\pm 1$  metres  
Vertical resolution  $\pm 3$  metres



BG photo: Anna Hogg

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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.

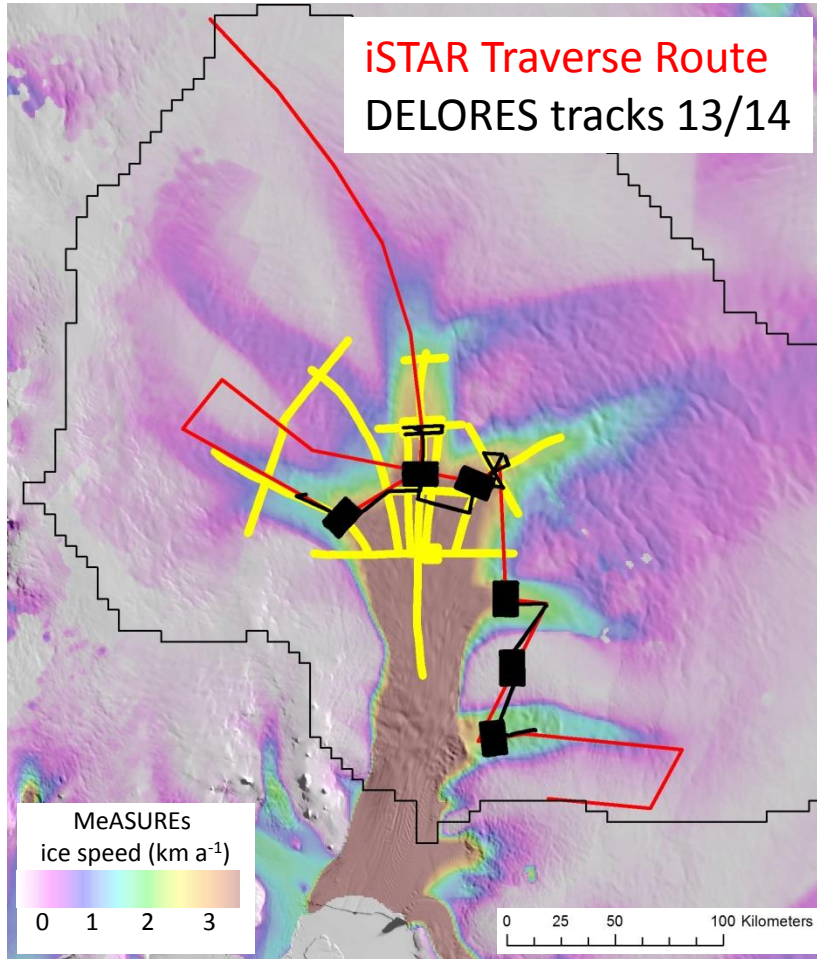


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## “Repeat” DELORES surveys

- 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 km<sup>2</sup> “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)

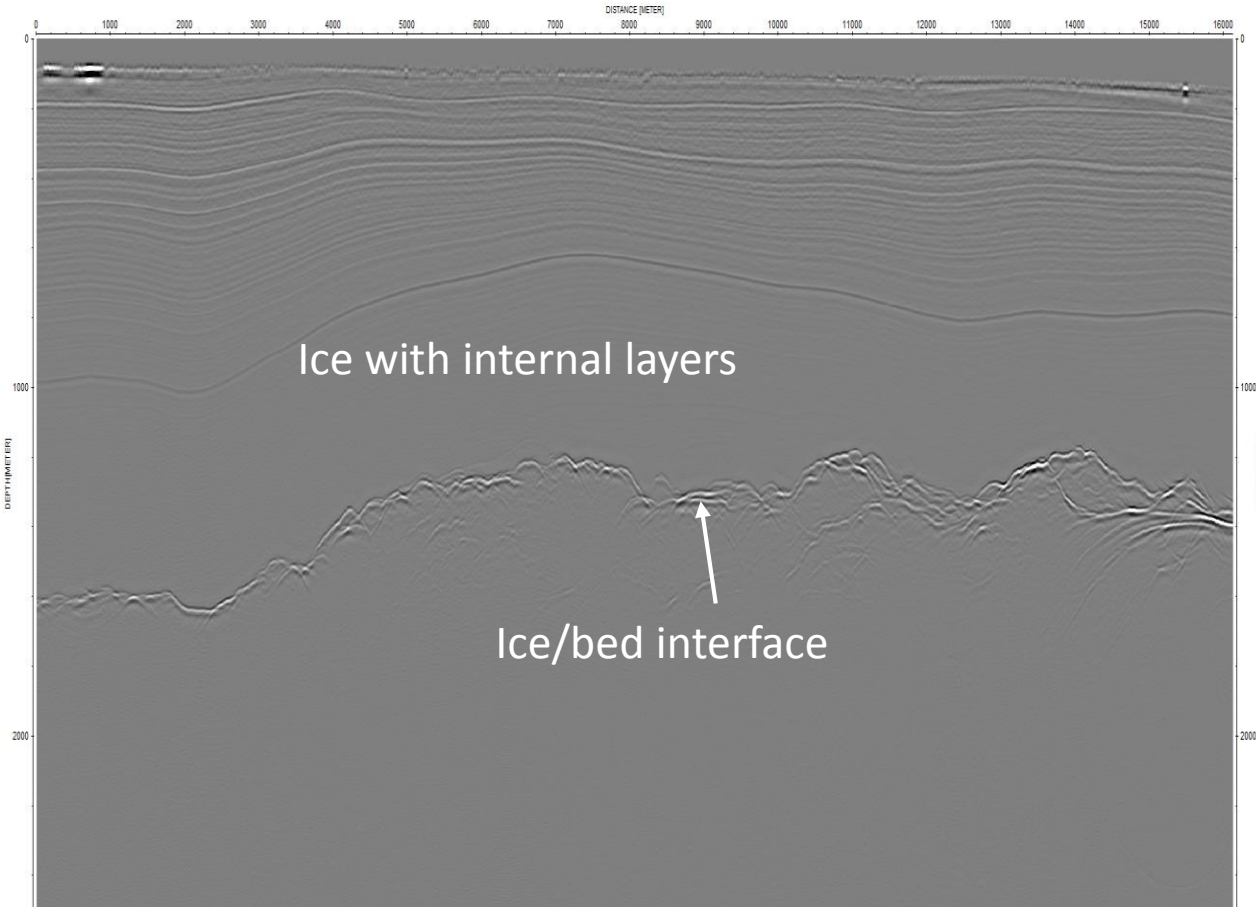


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# Results

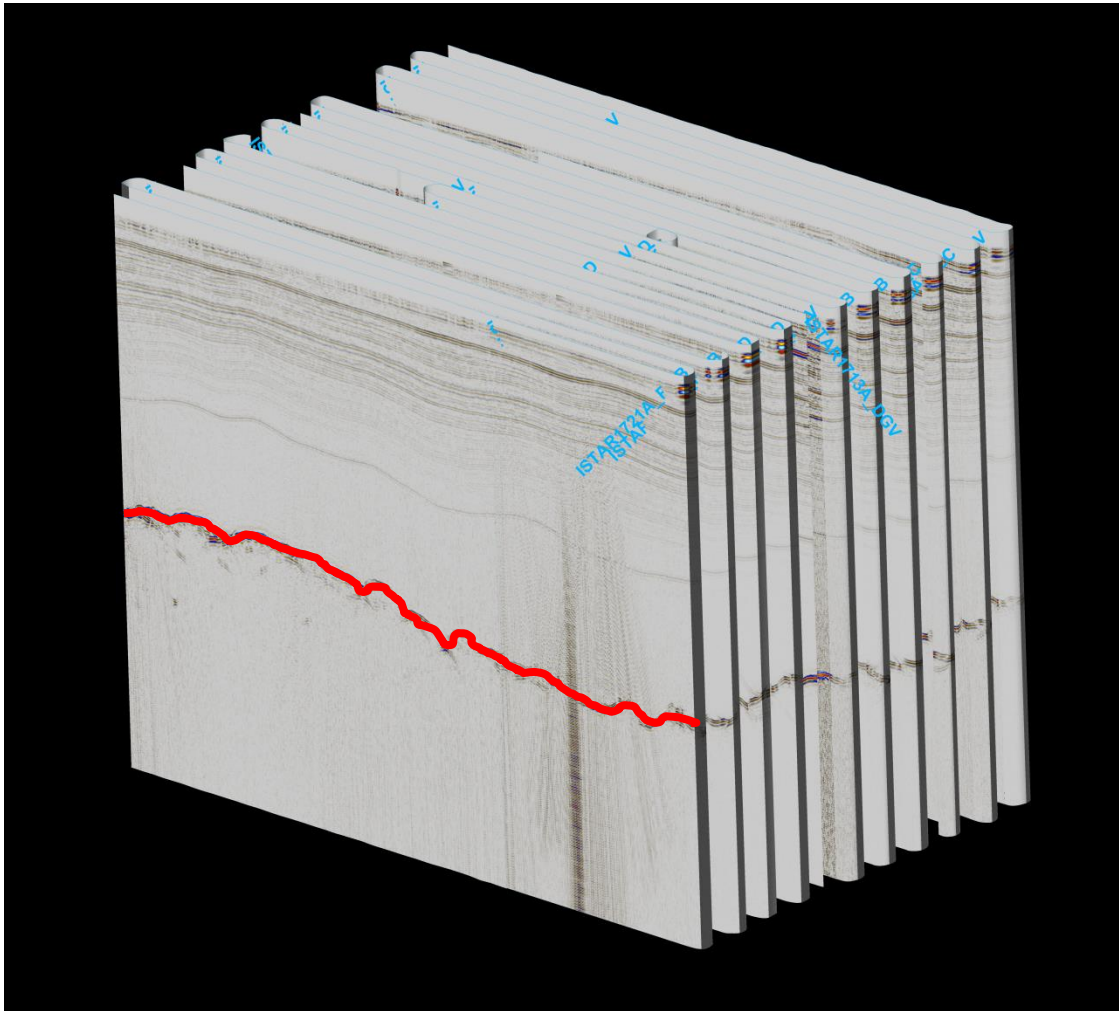
1. Radargram processing:
  - bandpass filter, gain, migration



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# Results

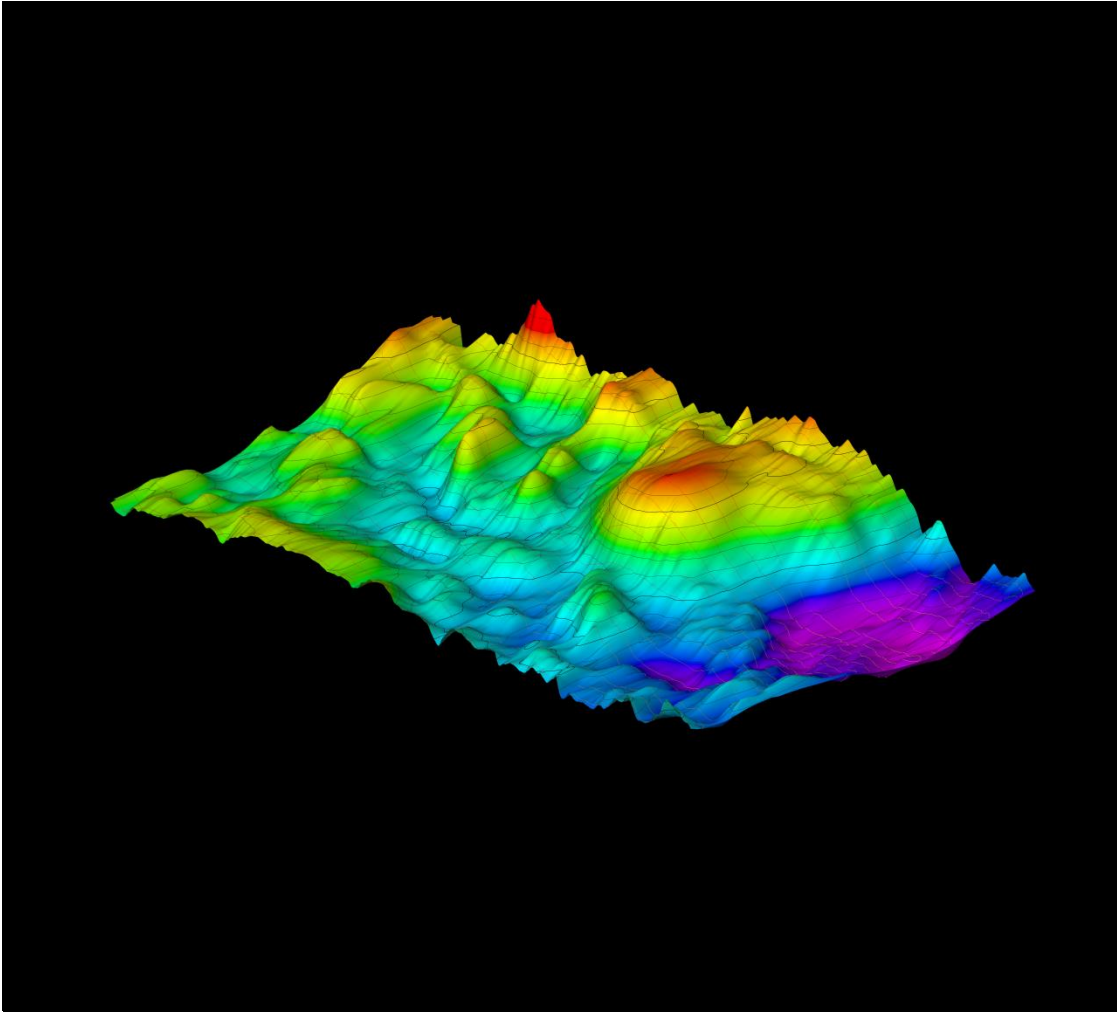
1. Radargram processing:
  - bandpass filter, gain, migration
2. Import SEGY to Schlumberger Petrel™
3. Pick bed (semi-automatic)



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# Results



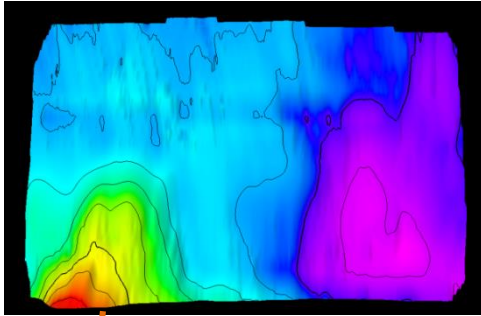
1. Radargram processing:
  - bandpass filter, gain, migration
2. Import SEGY to Schlumberger Petrel™
3. Pick bed (semi-automatic)
4. Create mesh of bed picks
5. Derive DEM  
50 m x 50 m

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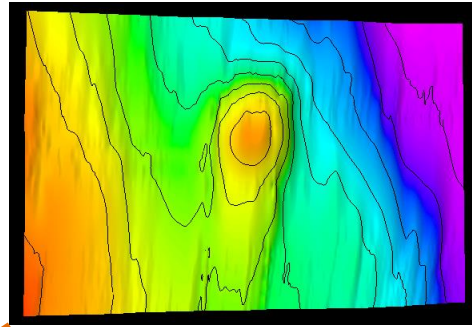
Ve x5

## Results

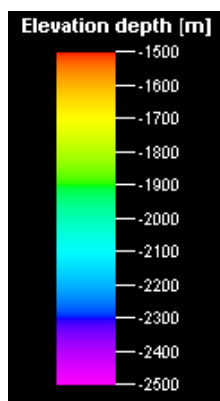
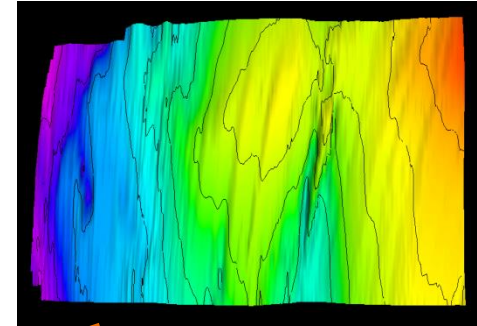
SB6 (Tributary,  $v \sim 250 \text{ m a}^{-1}$ )



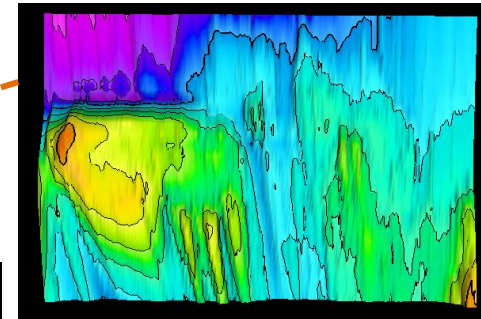
SB1 (Central trunk,  $v \sim 375 \text{ m a}^{-1}$ )



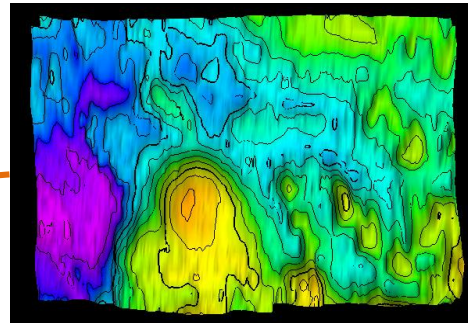
SB5 (Tributary,  $v \sim 365 \text{ m a}^{-1}$ )



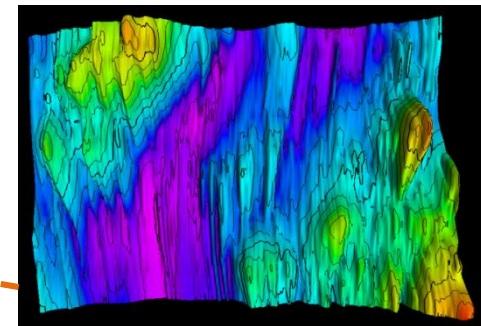
SB7 (Tributary,  $v \sim 285 \text{ m a}^{-1}$ )



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

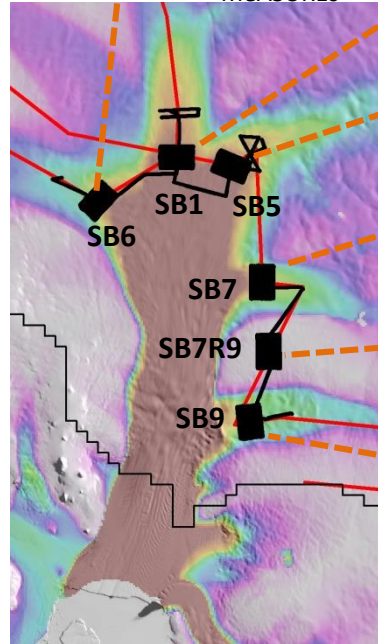


SB9 (Tributary,  $v \sim 225 \text{ m a}^{-1}$ )



ICE FLOW

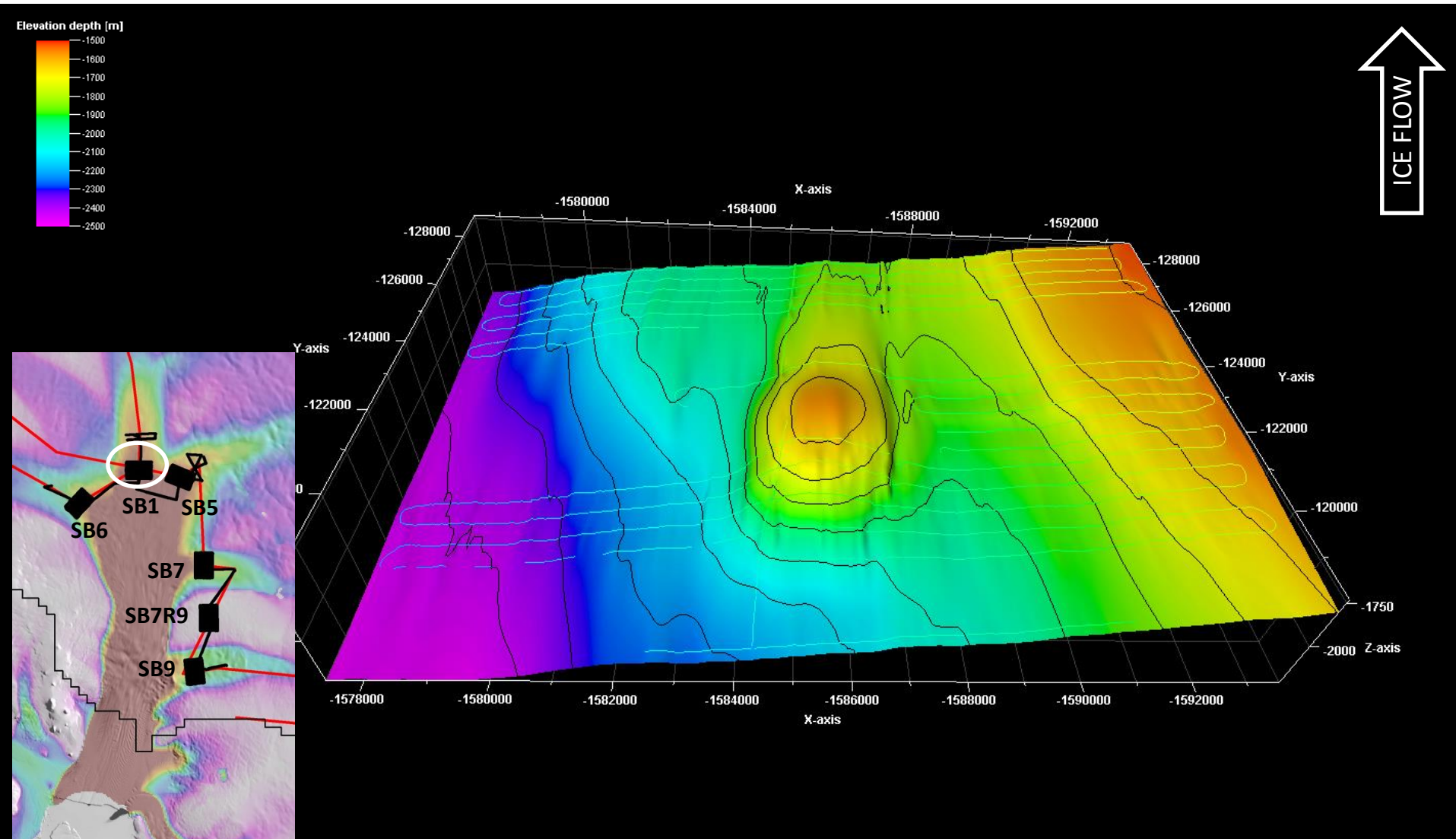
MeASURES



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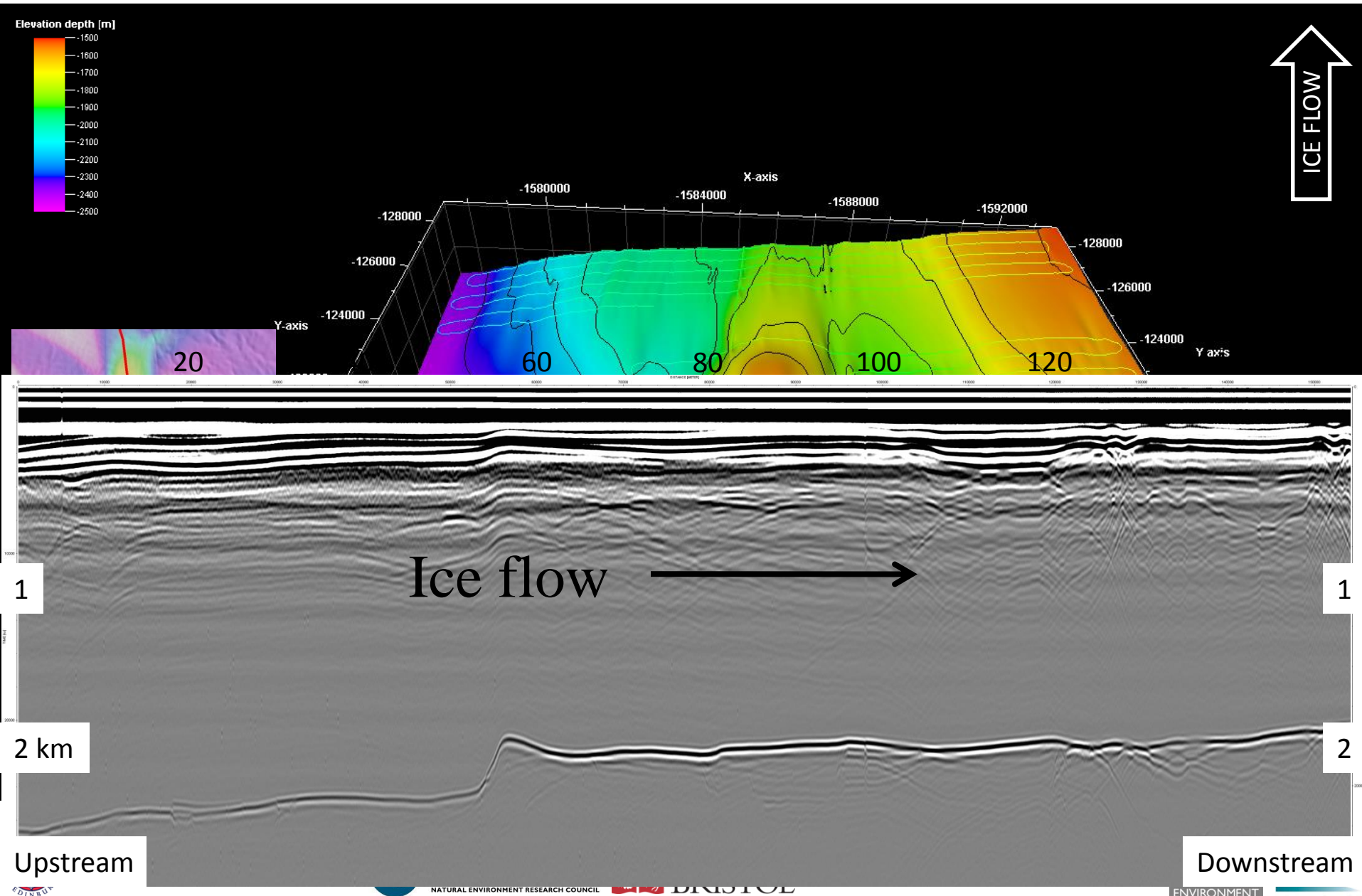


# Results: Main trunk - Site SB1 (istar07)



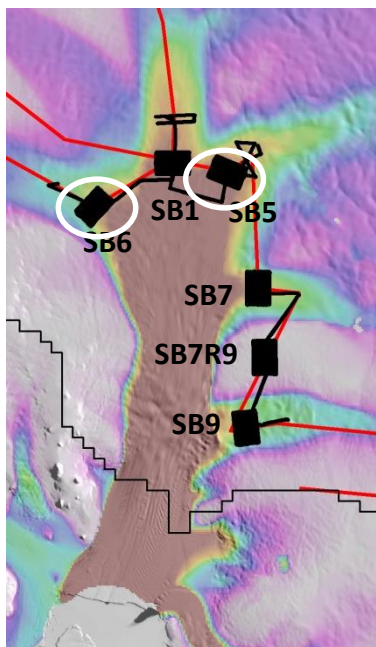
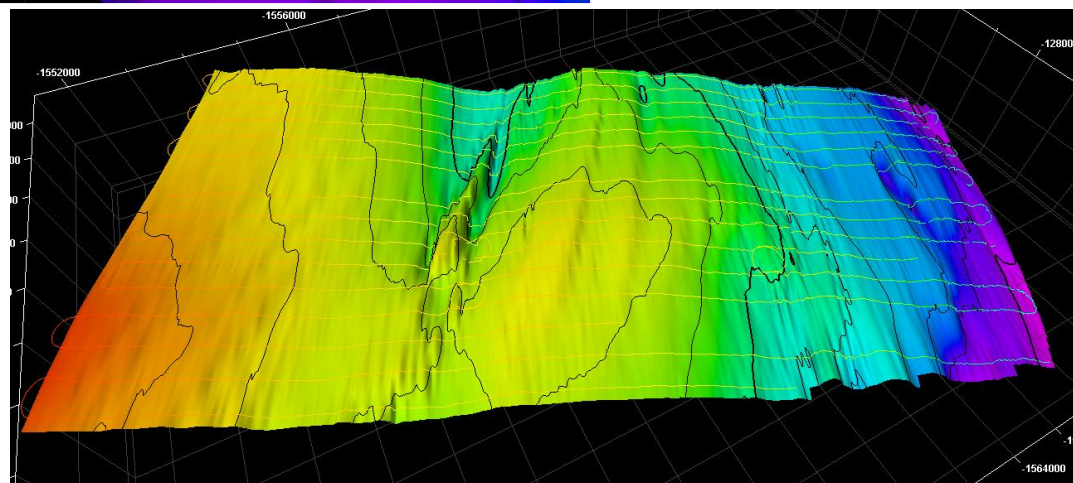
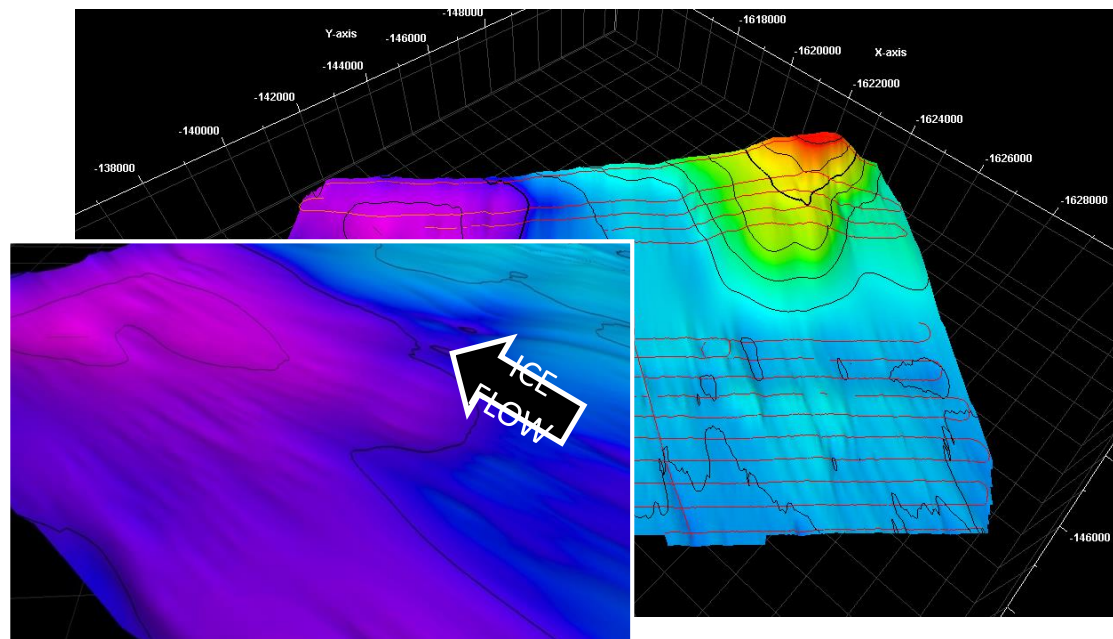
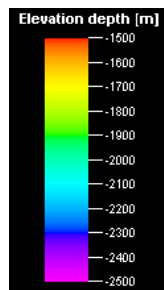
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# Results: Main trunk - Site SB1 (istar07)





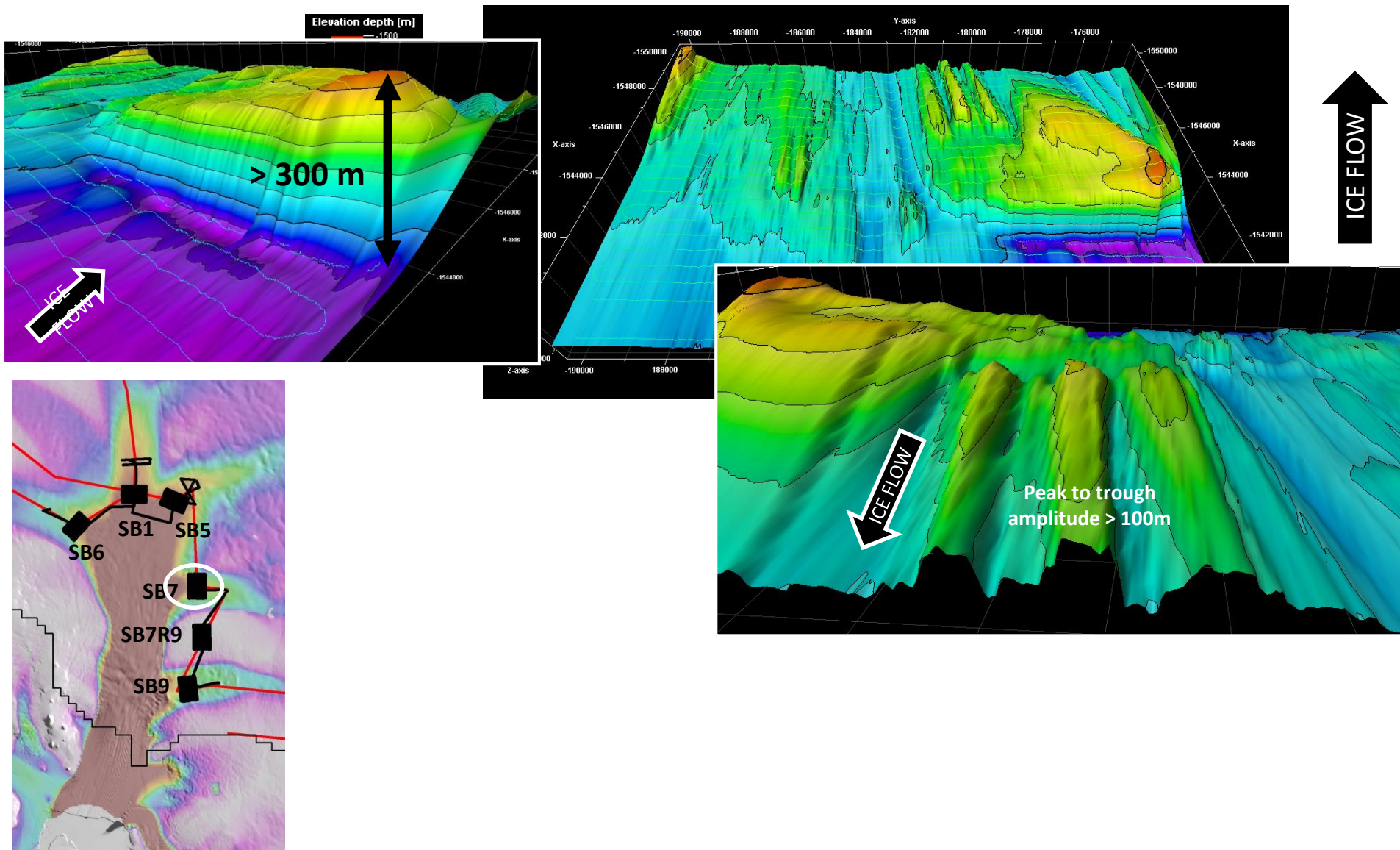
# Results: Upstream tributaries - Sites SB6 & SB5 (istar08 & istar13)



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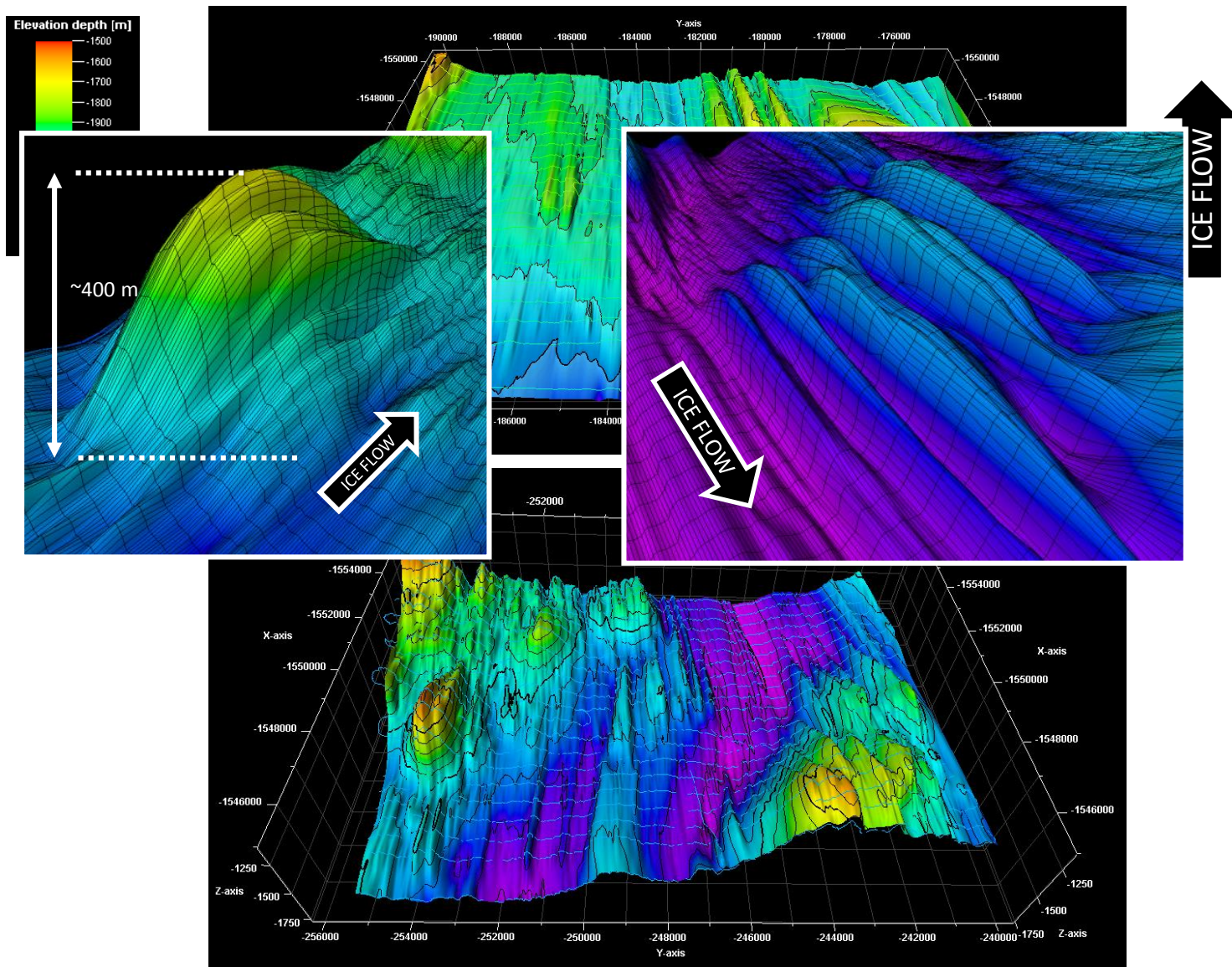
# Results: Downstream tributaries - Sites SB7 & SB9 (istar15 & istar18)



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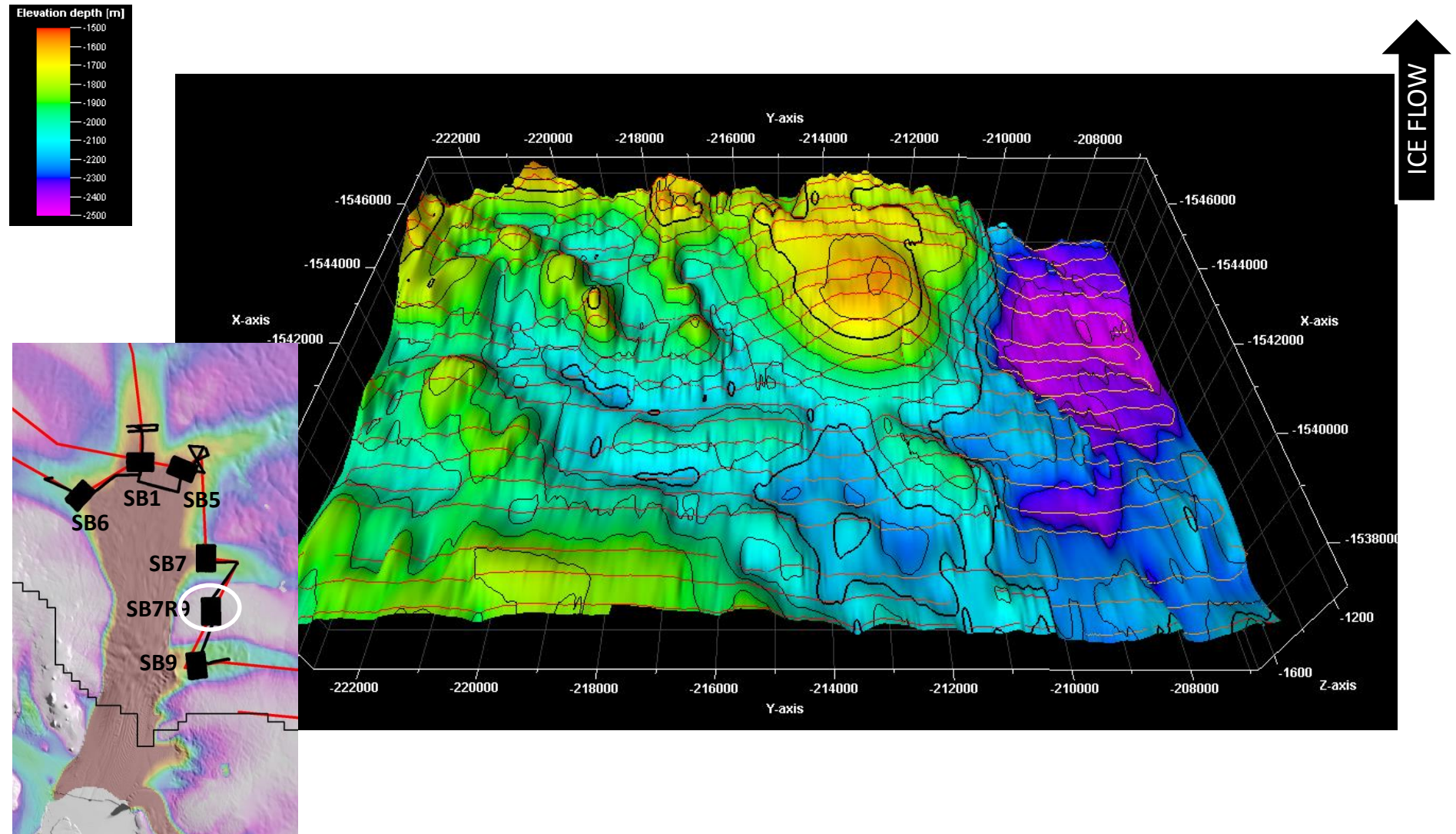
# Results: Downstream tributaries - Sites SB7 & SB9 (istar15 & istar18)



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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 deglaciaded terrains
  - Input to modelling exercises: basal drag; change at the bed.

See also poster  
that complements  
this presentation!

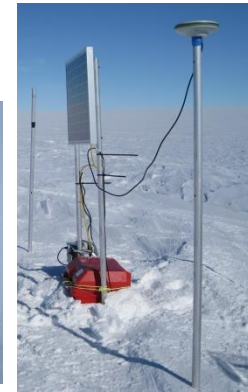
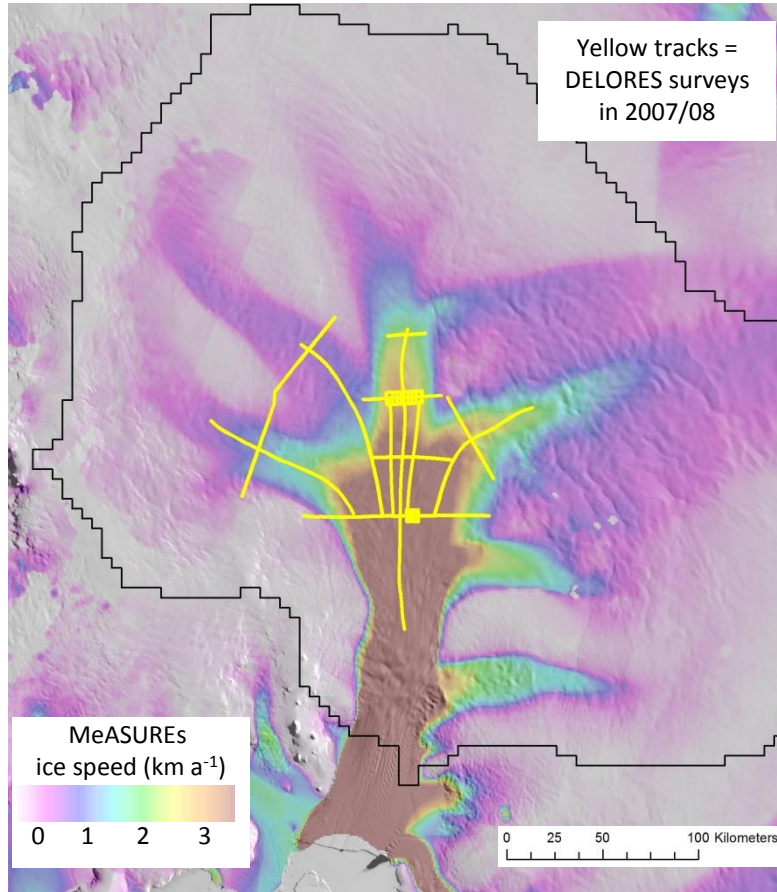


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## Methods: 2. Pine Island Glacier

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



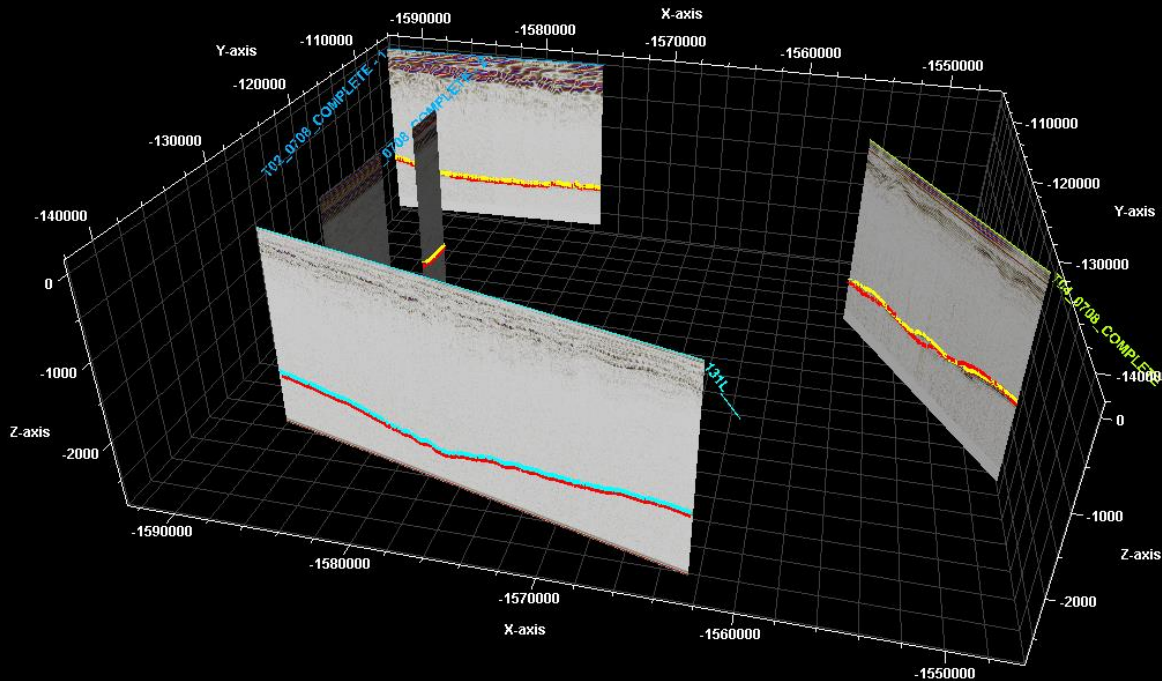
iSTAR traverse of 2013/14 allowed considerably greater efficiency of data acquisition through facilitating larger field party  
Operation of tried and tested methods in “siege campaign”!

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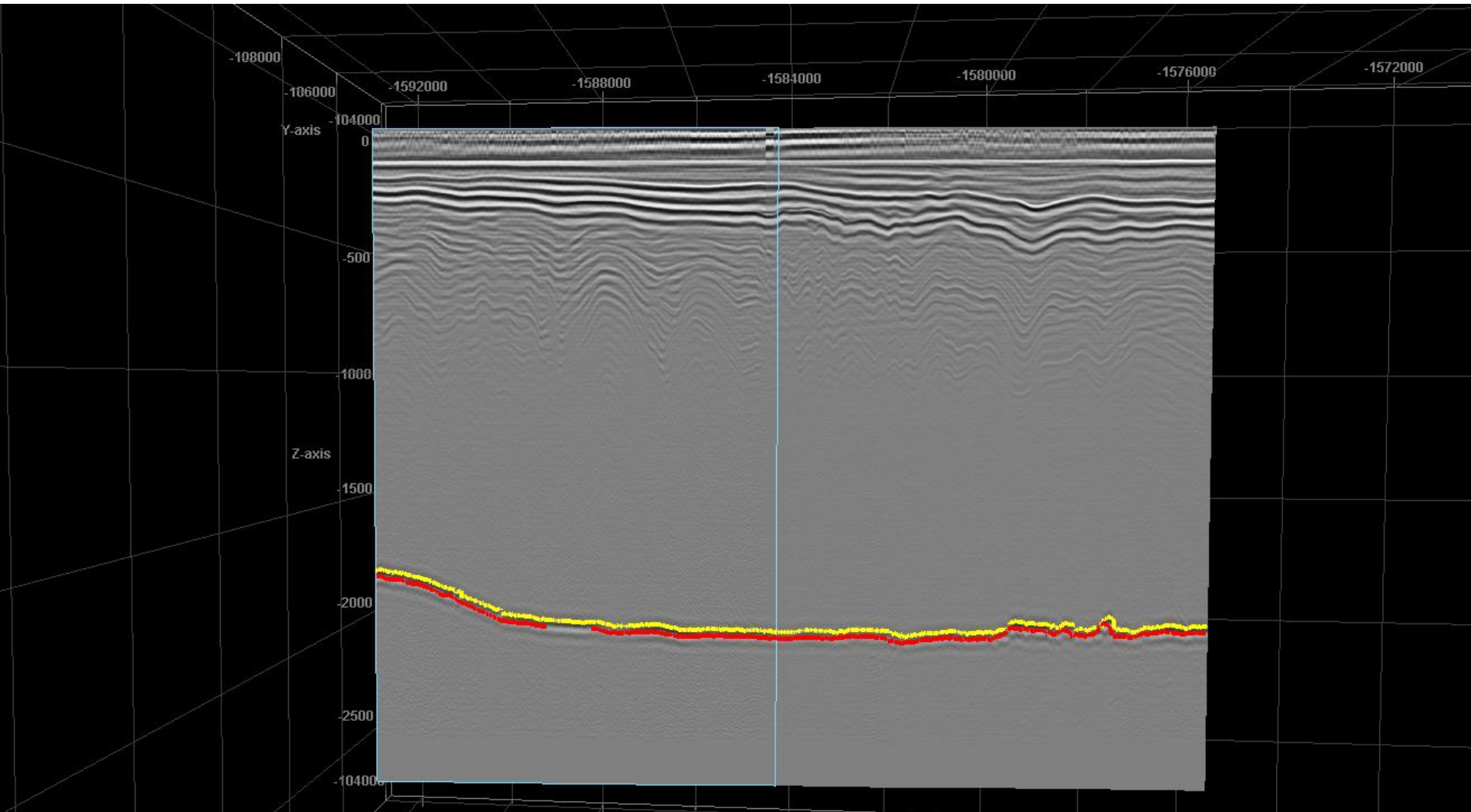
## V. Preliminary – early work on “repeat surveys”

Repeats with bed picks: T02, L01, T04, T05. looking upstream.  
1314 = red pick, 0708 = yellow, 201011 = blue

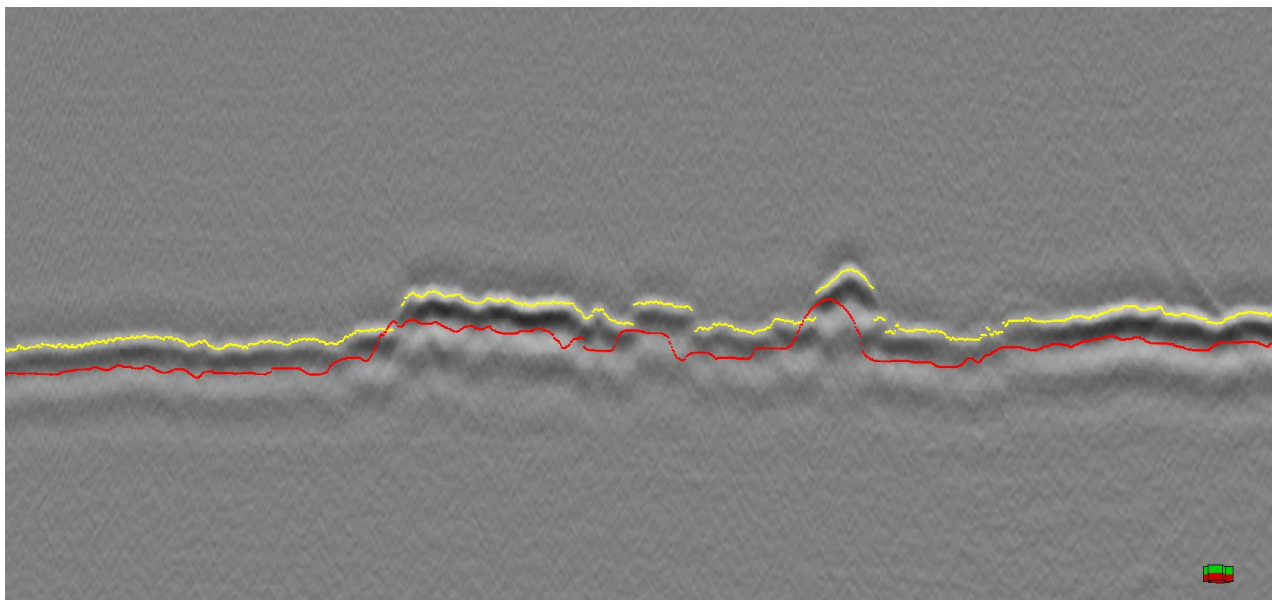


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Close up of T02 (background radargram is 2007/08 data)



Close up of bed bump on T02 (07/08 radargram)



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

