The Beardmore Basal Body: Tracing Basal Features of the Ross Ice Shelf (C15D-0612)

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I. The Ross Ice Shelf – Surface Level

The **Ross Ice Shelf (RIS)** at ~500,000 sq. km. is Antarctica's largest ice shelf. The RIS is fed by **tributary ice streams** from the **West Antarctic Ice Sheet (WAIS)** and **Trans-Antarctic Mountain (TAM)** glaciers that drain the **East Antarctic Ice Sheet (EAIS)**. The vertical structure of the ice shelf depends on individual inputs of ice sheet ice, basal melt & freeze-on and surface accumulation. Together with the flow history these processes leave a permanent trace throughout the ice shelf.

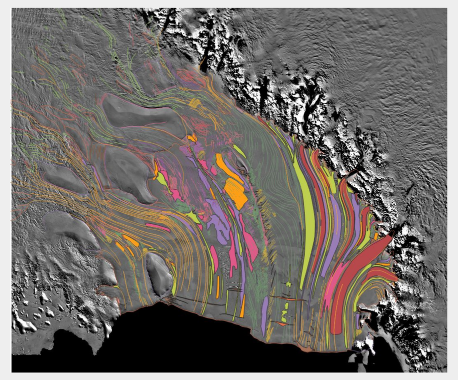


Figure A. Ledoux (2017) digitized RIS surface features from MODIS-MOA in color, superimposed upon greyscale MODIS-MOA.

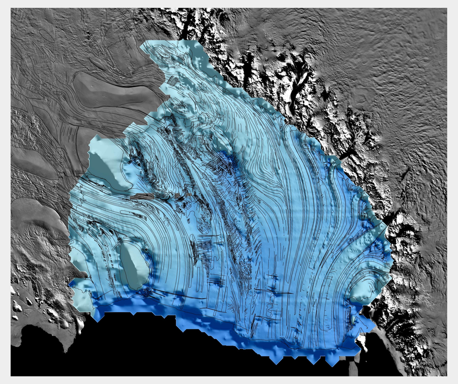


Figure B. Ledoux (2017) digitized RIS surface features (black), ROSETTA LiDAR surface elevation grid (blue), MODIS-MOA (grey)

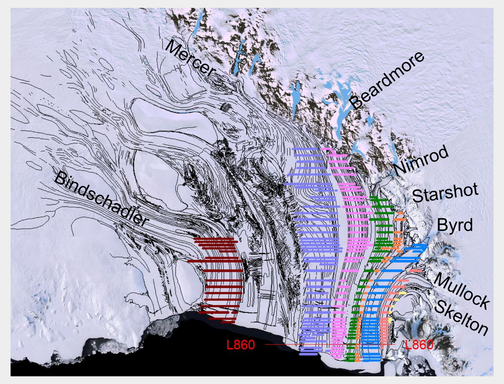
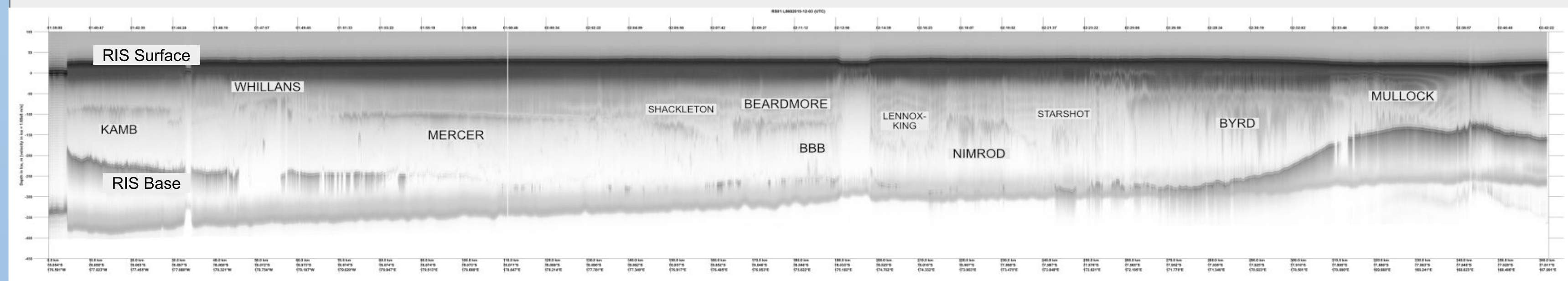


Figure C. Landsat-7 LIMA w/ Ledoux digitised RIS surface features (black), line path of RS L860, & color coded locations of isolated CMI picks:
Bindschadler (maroon), Mercer (lilac), Beardmore (pink), Nimrod (green), Starshot (orange), Byrd (blue), Skelton (yellow), Mulock (peach).

Shallow Ice Radar (SIR) from the ROSETTA-Ice Project captures a distinct horizon across the RIS called the **Continental Meteoric Ice (CMI)** reflector. This reflector is not continuous from West to East but marks the top of the packet of ice that streams into the shelf from the continent(Figure C).



West Antarctica ← → East Antarctica

Figure D. (Above) ROSETTA-Ice Shallow Ice Radar (SIR) L860 with CMI reflectors labeled with associated glacier streams.

II. The Ross Ice Shelf – Internal Structure

Lateral discontinuities within the CMI delineate the outflow from individual outlet glaciers. The CMI is just one of the internal reflectors within the RIS and defines the interface between two major ice layers:

- **Local Meteoric Ice (LMI)**
  - Ice between the RIS surface and the CMI reflector
- **Continental Meteoric Ice (CMI)**
  - Ice between the CMI reflector and the RIS ice base.

Change in the along-flow thicknesses of the continental meteoric ice has been used together with present-day surface velocities to calculate ice shelf basal melt rates over multi-decadal timescales (Das et al., 2020).

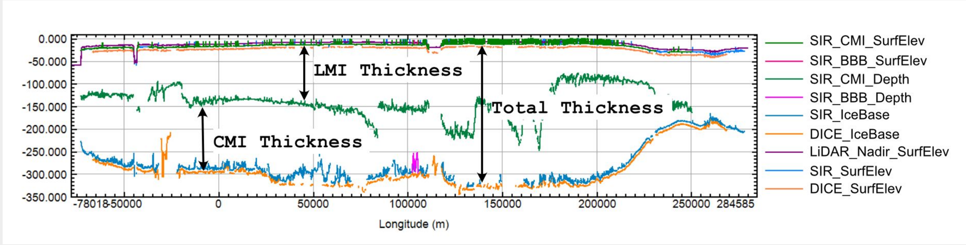


Figure E. (Top-Left) Line Profile [RS L860] example of digitized thickness measurements from ROSETTA-Ice SIR and DICE radargrams, used for Das, et.al., (2020) calculations for the below Figure F (a), (b), and (c).

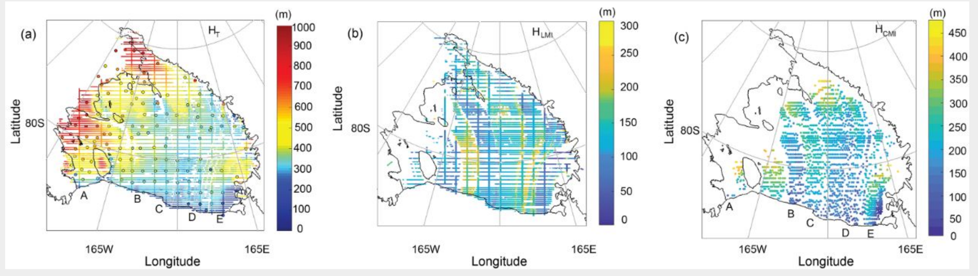


Figure F. (Bottom-Left) Das, et.al., (2020) calculations of RIS thicknesses. (a) H_T = Total thickness of the ice shelf, calculated from digitized ice base measurements from ROSETTA-Ice DICE. (b) H_{LMI} = Thickness of LMI across the ice shelf, calculated from digitized CMI reflector measurements from ROSETTA-Ice SIR. (c) H_{CMI} = Thickness of CMI across the ice shelf, calculated from digitized CMI reflector measurements from ROSETTA-Ice SIR.

The LMI thickness increases steadily along flow as snow accumulates on the ice shelf. The CMI thickness decreases along flow as the ice shelf stretches.

The Beardmore Basal Body (BBB) is a basal feature whose thickness is variable along flow, indicating changing basal processes beneath the grounded ice or a record of changes within the ice shelf.

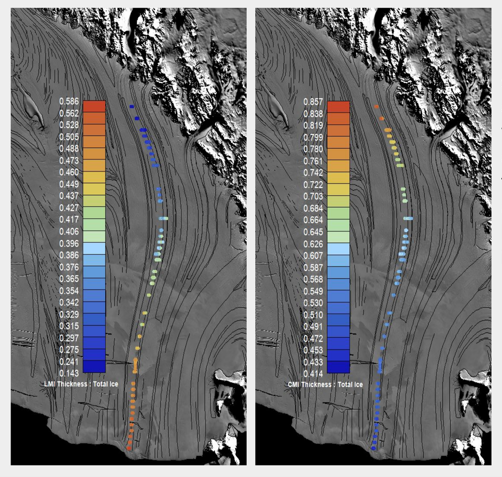


Figure G. (Left) Linear color plots showing Ratio of LMI and CMI Thicknesses to Total Ice Thickness along the BBB feature, which appears along Beardmore Glacier ice stream.

III. The Beardmore Basal Body

The Beardmore Basal Body (BBB) is a persistent **near-basal reflector** found below the CMI reflector packet associated with ice from Beardmore Glacier ice stream (Figure D).

The BBB characteristically has **three consecutive peaks with stratigraphy** within each rounded peak. The BBB was digitized in an isolated picking campaign, which found the feature **persisted** with its extremely distinct shape **for ~547 km** across the ice shelf, back to front.

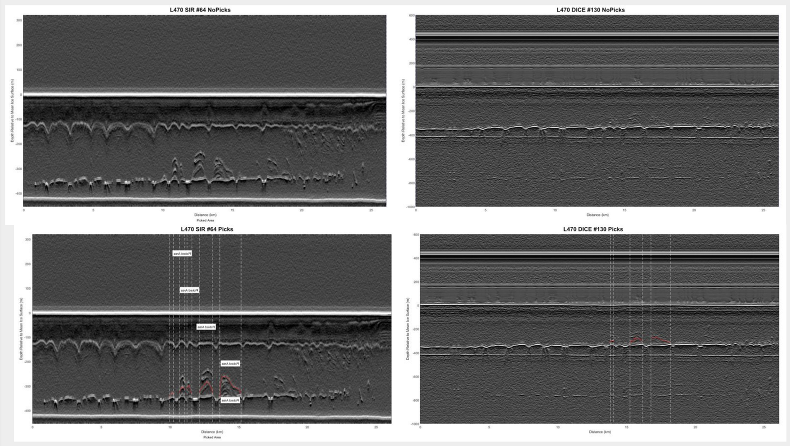


Figure H. (Above) Four ROSETTA-Ice radargrams with high contrast "diff" filter applied, showing BBB feature: three rounded peaks w/ straigraphy. Top-Left, SIR L470 No Pick. Bottom-Left, SIR L470 with Pick. Top-Right, DICE L470 No Pick. Bottom-Right, DICE L470 with Pick.

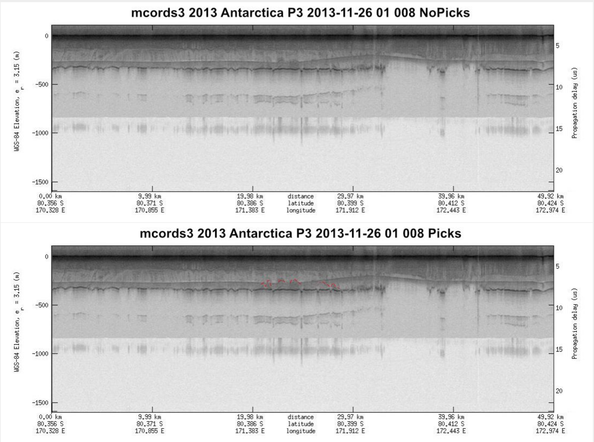
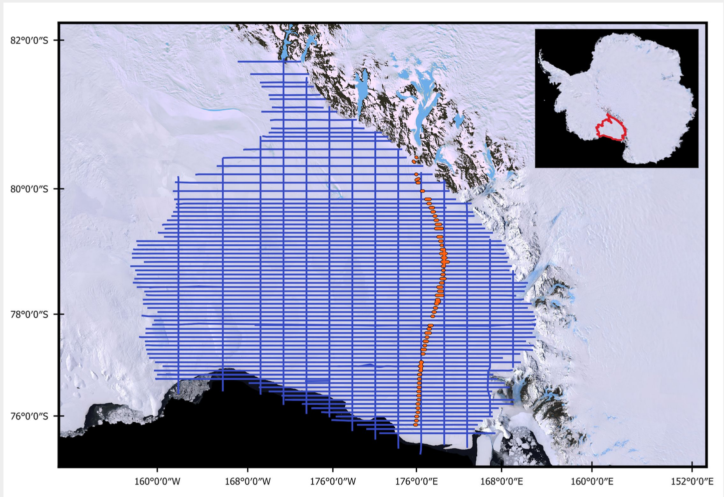


Figure I. (Above) Two Operation IceBridge Antarctica radargrams showing the BBB feature: three rounded peaks. Top image, shows No Pick. Bottom image, shows with a reflector Pick. The stratigraphy of the BBB cannot be seen.

The BBB Thickness varies along the flowline, but does not follow the changes in CMI thickness.

The BBB stratigraphy varies in brightness along flow. Its 3 main peaks vary in thickness. Understanding the 3D structure of the BBB requires knowledge of the angle of radar capture, sensor power, and potential deformation of the feature.



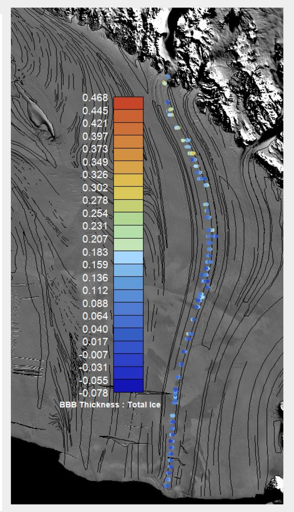
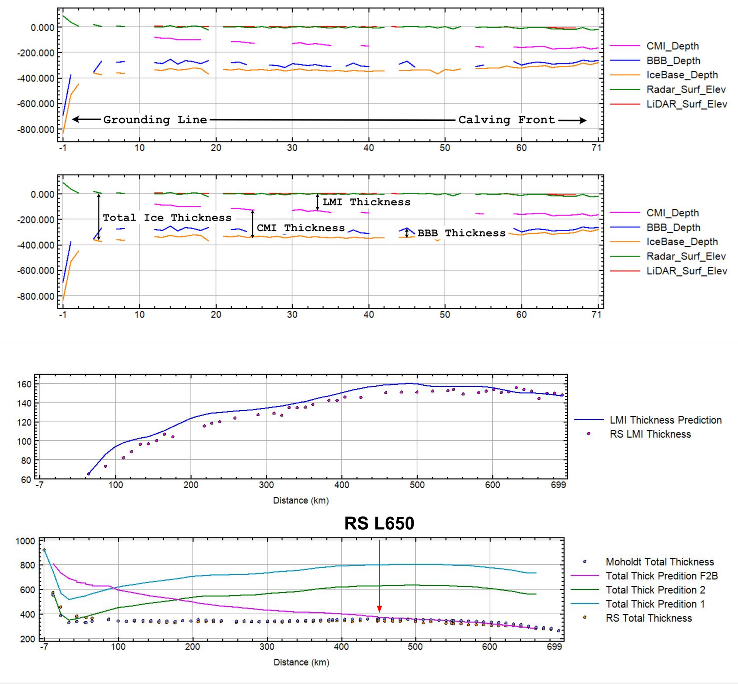


Figure J. (Left) A map with Landsat LIMA Imagery of the RIS with the ROSETTA-Ice survey grid superimposed, and each digitized instance of the BBB feature from ROSETTA and OIB radargrams.

Figure K. (Right) A linear color plot of the Ratio of BBB Ice to the Total Ice Thickness, along the Beardmore Glacier flow line.

We tracked the center of the BBB, defining a flowline of the feature from the grounding line to the calving front. Using ice-shelf flow and mass balance from Moholdt et al., 2014, and extracting a timeline from the MEaSURES velocity grid, we calculated predicted thicknesses of the ice shelf structure by starting with the upstream-most observed thickness measurement and recursively applying Moholdt's rates of change. This method was successful in predicting LMI thicknesses along the flowline, but was unable to predict full ice-shelf thicknesses. When applying this method in reverse (starting at the front of the shelf) reconstructed full ice-thicknesses matched present-day observations for the past ~300 years of ice flow.



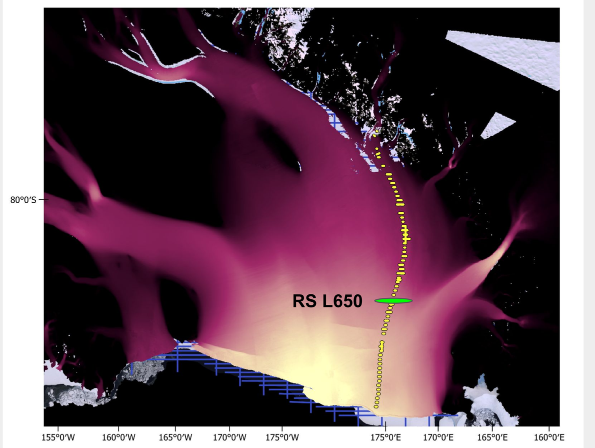
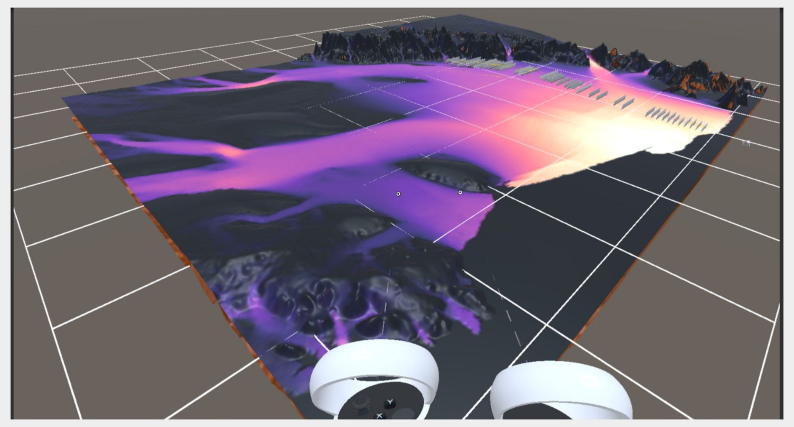


Figure L. (Top-Left) Two color line depth profiles of the along-flow pseudo-streakline developed using the midpoints of digitized BBB features.

Figure M. (Mid-Left) Along-Flow profile showing the LMI observed (circles) and predicted (line) thickness from upstream-most measurement to calving front.

Figure N. (Bottom-Left) Along-Flow profiles: Moholdt Thickness and observed thickness measurements (circles); Predicted thicknesses (lines). From grounding line to calving front. Break point indicated

IV. Datasets & Visualization



AntARctica

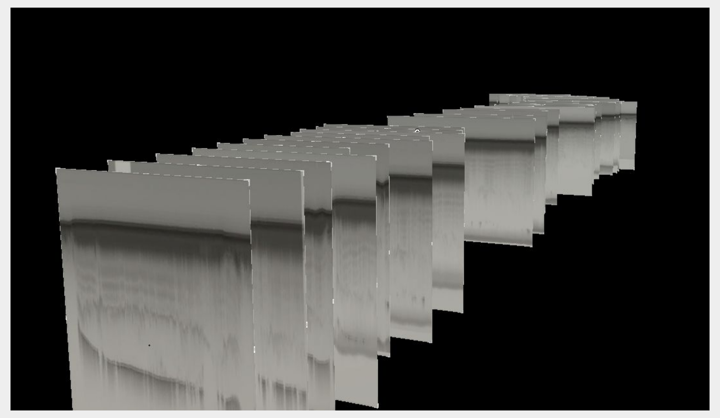
This **Virtual Reality (VR)** and **Augmented Reality (AR)** application was developed by the **POL-AR/VR Team** from Columbia University and Lamont-Doherty Earth Observatory. **AntARctica** combines surface and bedrock DEMs, MEaSUREs velocity grid, and a subset of ROSETTA-Ice SIR radar imagery along the Beardmore Glacier ice stream and the BBB.

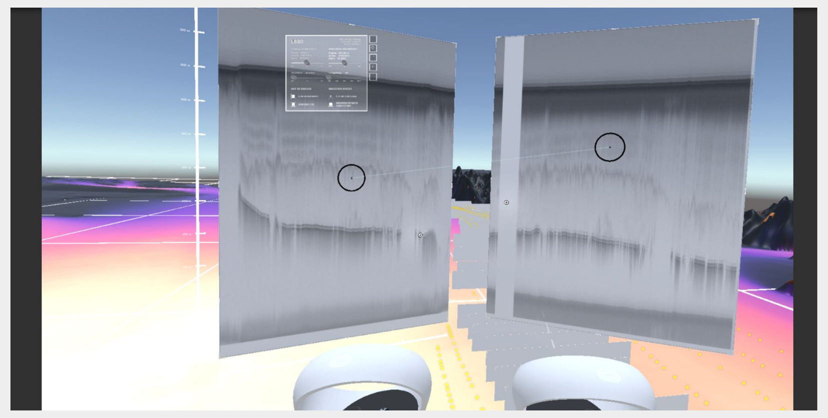
The application includes: stretching, real-time strain calculations, distance measurement tools, and more.

Try AntARctica! **Wednesday 14 Dec., 09:00-12:30 CST in Poster Hall A**
[IN32B-0394] AntARctica: An Immersive 3D Look into Antarctica's Ice Using Augmented Reality and Virtual Reality

OR

See POL-AR/VR Members, Benjamin Yang and Shengyue Guo
Wednesday 14 Dec., 12:30-14:30 CST at NASA Booth 1937
AGU Michael H. Freilich Student Visualization Competition
Grand Prize Winner Presentations

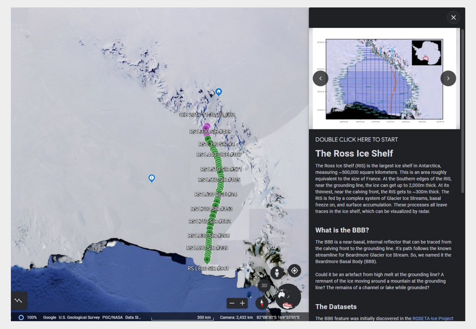




Explore the BBB on Google Earth:

"Hmm, that thing is pretty cool!"
Take a look for yourself! On Google Earth!

bit.ly/3AY4BuV



All Datasets Acquired From:

ROSETTA-Ice Project
Operation IceBridge
Center for Remote Sensing and Integrated Systems
United States Antarctic Program Data Center

References:

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V. Acknowledgements

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I would also like to thank my family, my partner, and my friends for everything. I am less without you and better for you.

This poster is dedicated to my father, Edgar Cordero, who passed away on October 21st, 2022. He was the coolest and best dad he could be. Growing up, he thought going into science meant you had to be a medical doctor, and instead found happiness in economics and coffee. However, his passion and interest for science and technology lives on in his two daughters, and this poster is for him.