Temporal Analysis of Ice Thickness at Byrd Glacier's Grounding Zone

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Introduction

- Glacier stability is often attributed to ice thickness and properties at the grounding zone. A glacier with ice that is thinning at the grounding zone is more susceptible to rapid retreat and acceleration.
- The grounding zone is defined as the region bounding the transition from grounded ice to floating ice (Van Der Veen,2013). Figue 2 shows a schematic cross section of the grounding zone.
- In this study we investigate whether ice thickness at the grounding zone of Byrd Glacier, Antarctica changed over a 36-year period. We compare airborne radar echograms collected in 1975 (SPRI) and 2011 (CReSIS) to assess changes in ice thickness.

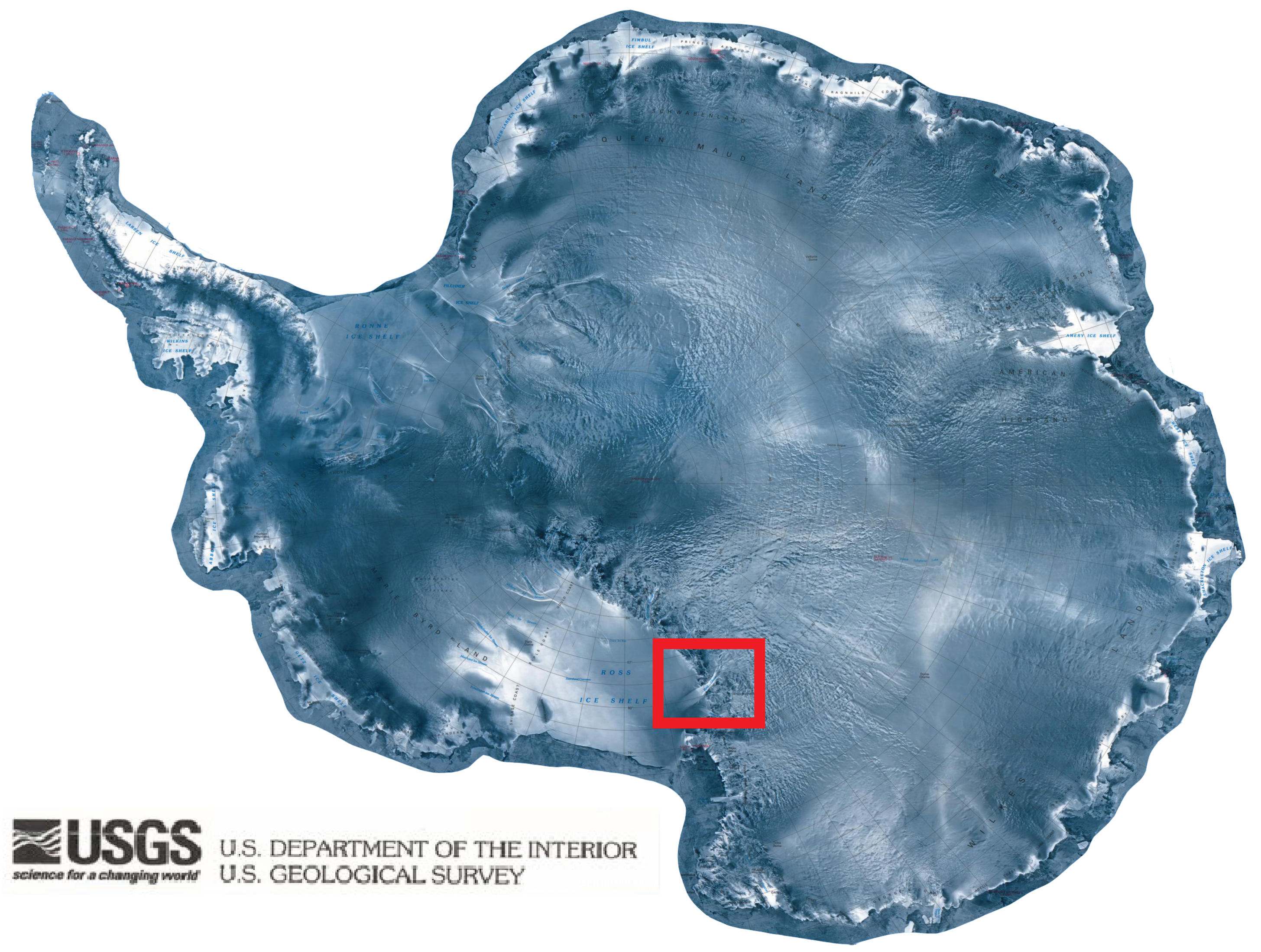

Figure 1. USGS radar map of Antarctica indicating location of Byrd Glacier

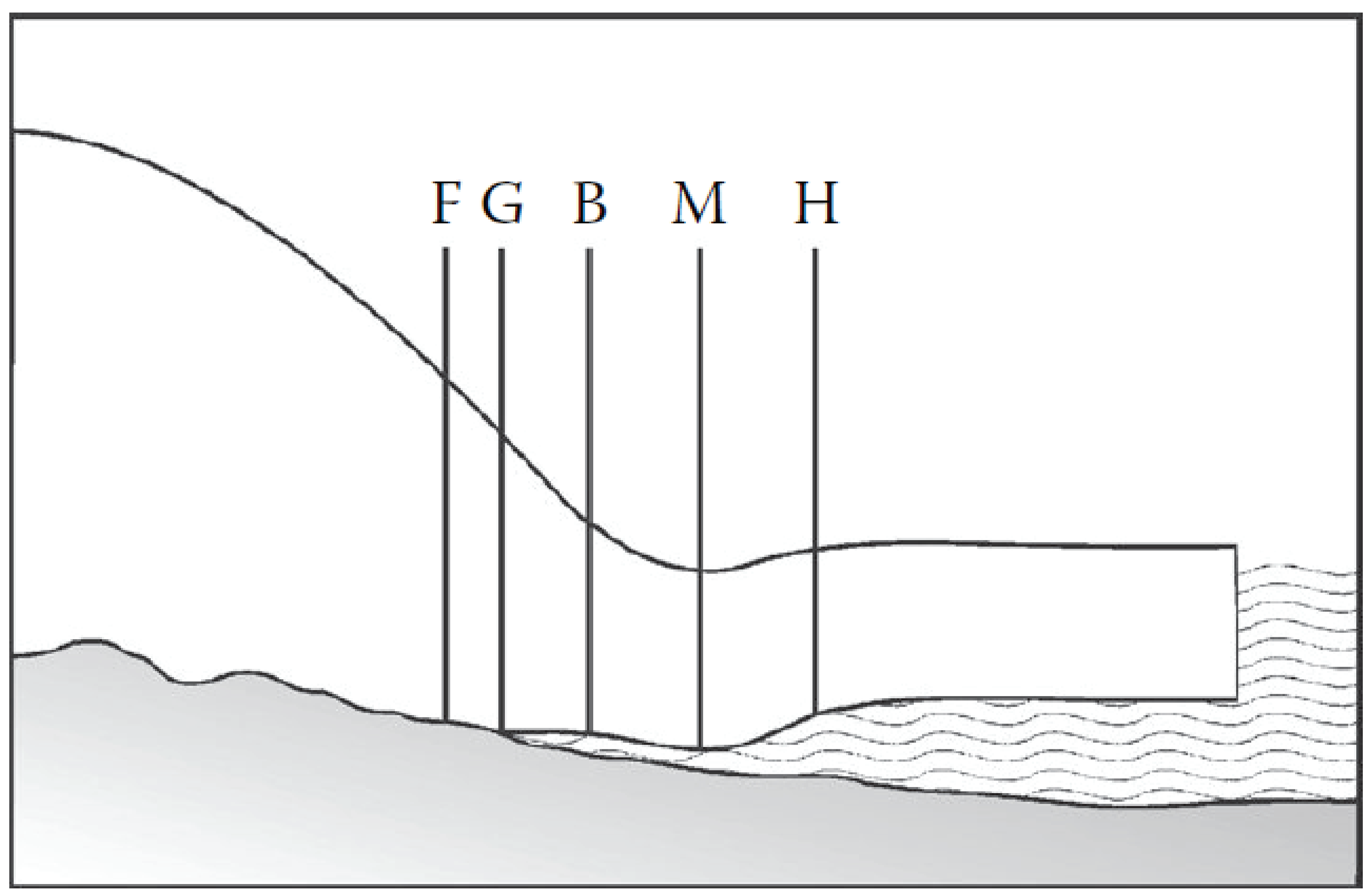

Figure 2. Schematic cross-section of the grounding zone showing the inland position of tidal flexure (F), the grounding line (G), the break in slope (B), the local minimum in surface elevation (M), and the hydrostatic point (H) where ice is in hydrostatic equilibrium. The grounding zone is defined as the region between points F and H (From Van Der Veen, 2013).

Methods

- Radio Echo Sounding (RES) methods obtain rapid, accurate, and detailed data from a remote platform, in our case an air plane.
- The radar return signal differs for grounded vs floating ice, allowing us to use radar echograms to classify the location of the grounding zone (Figure 3). In Figure 3, the following features are visible:
  - o The surface of the ice is the strongest reflector, and is highlighted by the solid black line near the top of the image.
  - o Grounded ice appears as the smooth, clear signals visible on the left side of the image.
  - o Basal crevasses, which are characteristic of floating ice, appear as hyperboles. These basal crevasses initiate at the grounding zone and persist in floating ice.
  - o The grounding zone is the transition zone between grounded and floating ice, appearing moderately smooth or "fuzzy."
- We compare the ice thickness extracted from a 1975 SPRI radar echogram with data from a 2011 CReSIS echogram. The 1975 flightline followed a single flight path and only intersects with a CReSIS flightline in a few discrete points.
- We interpolate between the two datasets using kriging techniques on the CReSIS data over the grounding zone. The resultant grid of 2011 ice thickness allows us to compare the 2011 data with the 1975 data.

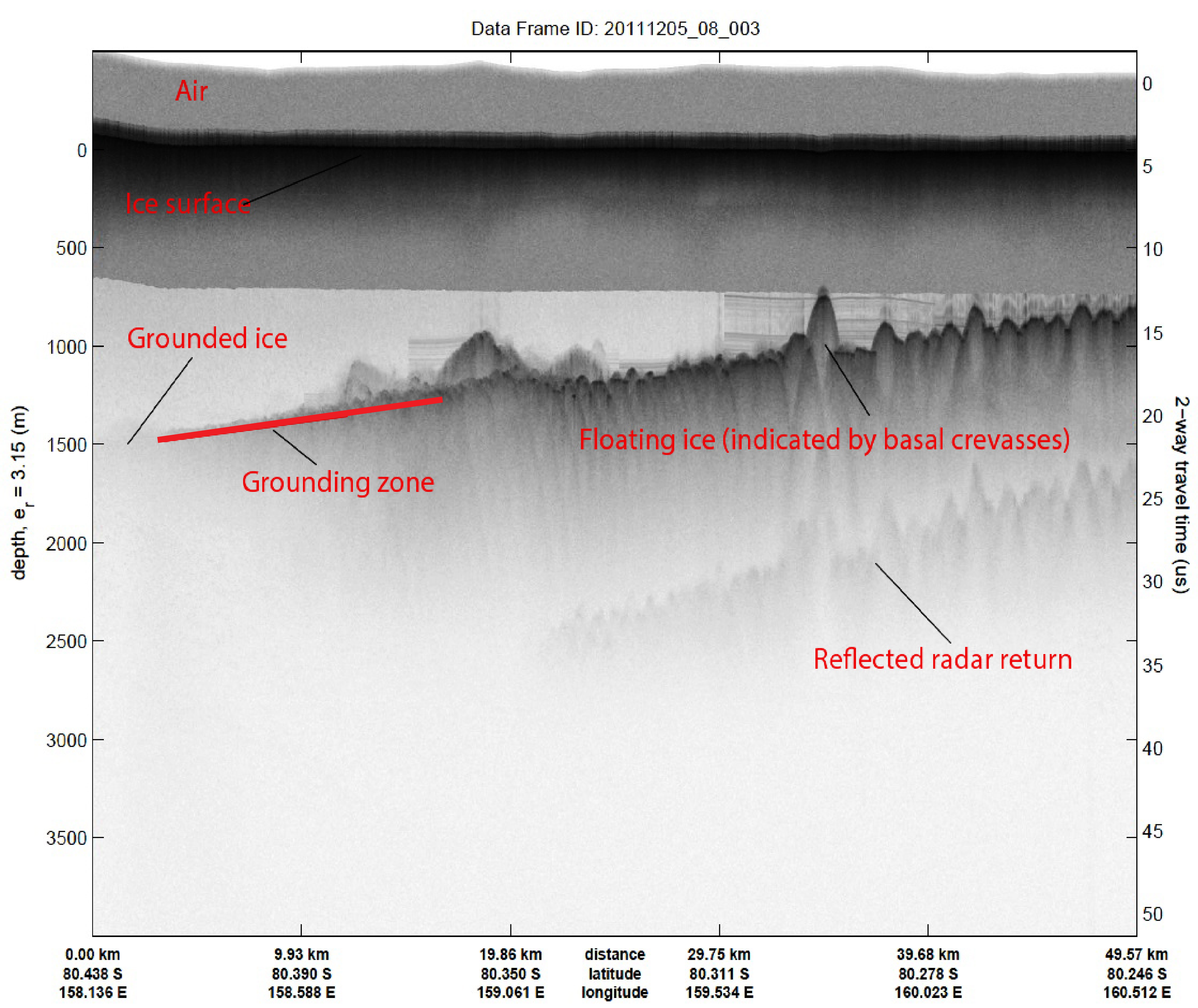

Figure 3. CReSIS 2011 radar echogram with radar return features labeled.

Results and Discussion

- Figure 4 is a map created in ArcGIS that shows the interpolated thickness values from the 2011 CReSIS radar data relative to the location of the grounding zone. The grounding zone boundary was created by picking data from each of the radar echograms with flight paths crossing over the area near the apparent grounding line.
- Possible sources of error within this project that should be taken into account include the extremely interpretive nature of evaluating radar echogram data to determine the grounding zone. The features seen in the radar return can be inter preted with different meanings dependent on the evaluator's background and level of experience with picking data.
- The outcome of this and future research is aimed at gaining a better understanding of the long-term behavior and complex dynamics involved in the behavior of glacial ice, as well as the driving forces behind this behavior. The mechanisms controlling variations in glacial ice thickness and the advance and recession of grounding lines include a number of potential forcings, such as oceanic temperatures, sea level changes, air temperatures, ocean tides, subglacial bathymetry, geomorphological features, subglacial meltwater, thermodynamics, and the size of the drainage basin (Davies, 2014).

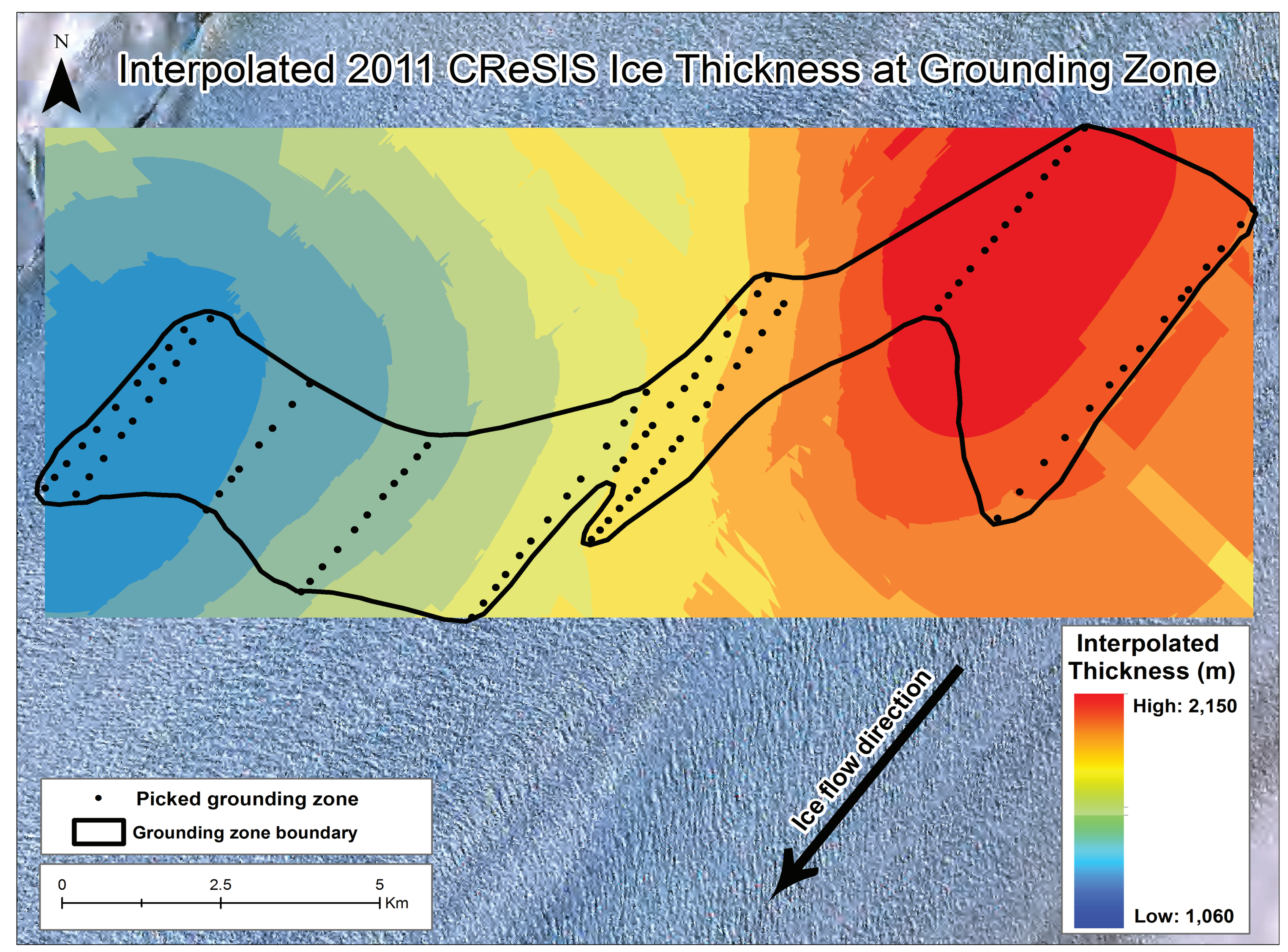

Figure 4. ArcGIS Map showing kriging interpolation of ice thickness values near estimated grounding zone area, original values from 2011 CReSIS data.

References

Davies, Bethan. "Why Study Antarctic Glaciers?" AntarcticGlaciers.org.14 Feb. 2014.
CReSIS Radar Depth Sounder. 2011. Raw data. Antarctica
Van Der Veen, C. J. "Chapter 10 Dynamics of Glaciers and Ice Sheets." Fundamentals of Glacier Dynamics. 2nd ed. Bosa Roca, FL: CRC, 2013. 329-31. Print.