Supporting Information for "Bounds on the calving cliff height of marine terminating glaciers"

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1. Table S1

Additional Supporting Information (Files uploaded separately)

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1. Table S1 lists the detailed information of all the observational data points we extracted from the MCoRDS data set and plotted in Fig. 3 (grey dots), including location, date of measurement, latitude and longitude, ice thickness, water depth, ice bottom error, etc.

The observational data provided by IceBridge flights span from 2006 to 2014 and include measurements of over 30 outlet glaciers across Greenland, most extensively the Helheim, Jakobshavn, Petermann, and Hayes glaciers. These measurements were taken from Multichannel Coherent Radar Depth Sounder (MCoRDS). The MCoRDS data set contains L1B Geolocated Radar Echo Strength Profile Images, L2 Ice Thickness, Ice Surface, and Ice Bottom elevations, and L3 Gridded Ice Thickness, Ice Surface, and Ice Bottom elevations over Greenland, Canada, and Antarctica taken with the CReSIS Radar Depth Sounders (RDS) [*Gogineni et al.*, 2012]. The terms elevation, bottom and surface used in Table S1 are defined as: elevation of the radar, distance from the bottom of the glacier to the radar, and distance from the surface of the glacier to the radar, respectively. The water depth and ice thickness values used in Fig. 3 are derived from the provided data, either a single radar measurement at the terminus or, more desirably, an average of the data over the span of 3 seconds at the terminus. Radar data in which the transition from ocean to outlet glacier is not clear, or inaccurate, are omitted from this study.

According to IceBridge data descriptions, there are two types of "errors": spatial resolution (or location error) and depth error (due to radar measurement). Spatial Resolution varies by surface characteristics and aircraft flown. And the primary error sources for ice penetrating radar depth measurement are system electronic noise, multiple reflectors also known as multiples, and off-nadir reflections. Each of these error sources can create spurious reflections in the trace data leading to false echo layers in profile data. Multiple reflectors arise when the radar energy reflects off three surfaces, back-and-forth in the vertical dimension, and then returns to the receive antenna. Reflections occur in situations when multiple surfaces are present with high impedance, such as the upper surface (air/ground), the base of the ice or an ice-water interface, and the aircraft body which is also a strong reflector. The radar receiver only records time since the radar pulse was emitted, so the radar energy that traveled the additional path length appears later in time, apparently deeper in the ice or even below the ice-bedrock interface. Note that multiples of a strong continuous reflector have a similar shape but all slopes appear magnified, that is, doubled in the simplest geometric cases, relative to the main reflection. Off-nadir reflections can result from crevasse surfaces, water, rock outcrops, or metal structures. Beam structure and processing of the MCoRDS system are designed to reduce these off-nadir reflected energy sources. (Source of reference: http://nsidc.org/data/docs/daac/icebridge/irmcr2/index.html)

Representative spatial resolutions provided on NSIDC IceBridge data page are

1. Smooth surface, across-track: 323 m where height above the air/ice interface = 500 m and ice thickness = 2000 m;

2. Rough surface, across-track: 651 m where height above the air/ice interface = 500 m, and ice thickness = 2000 m.

3. Along-track: about 25 m and a sample spacing of about 14 m.

4. Depth: 4.5 m resolution. Actual target location is ambiguous for a rough surface since the off-nadir returns in the antenna footprint can hide the nadir return. The ice thickness is still close to correct, but may not be for the nadir return.

The errors calculated in Table S1 are ice bottom errors (those related to radar depth measurement) and are much smaller than the spatial resolution. The documentation suggests depth errors of the order of 10 m.