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The Cryosphere Discussions

Interactive comment on "Monte Carlo ice flow modeling projects a new stable configuration for Columbia Glacier, Alaska, by c. 2020" *by* W. Colgan et al.

Dr. Colgan

william.colgan@colorado.edu

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Copied below is an abridged chronological summary of Cryolist postings regarding the high elevation accumulation rate at Columbia Glacier. This discussion focused primarily on the reliability of high elevation accumulation rate measurements, and secondarily on constraining a characteristic high elevation accumulation rate at Columbia Glacier. The Cryolist thread was initiated by Dr. Wendell Tangborn on 2-May-2012. The unabridged thread is available at: http://cryolist.org/archives.

I'm responding In regards to suspicion about the accuracy of the 1978 balance mea-

surements at the two highest sites at Columbia Glacier: 2640 m and 2220 m elevation, 2 km and 8 km from the head of the glacier. The balance measurements of about 5 mwe at these sites would translate into pit depths of about 10 m, not 5 m, and that is certainly too deep for a snow pit. Measuring snow/firn depths of about 10 m is extremely difficult and hence suspicion is reasonable. I was not involved with making these measurements myself though am one of the authors of the report this data appeared in:

Columbia Glacier stake location, mass balance, glacier surface altitude, and ice radar data, 1978 measurement year; 1979; OFR; 79-1168; Mayo, L. R.; Trabant, D. C.; March, Rod; Haeberli, Wilfried (not available online at this time)

The report is a pretty stripped down data report with minimal text and no specifics about the methods used for these high balance measurements.

I was able to look up the notes for these measurements and can provide you with some information about how they were made. Stakes were install at both sites with 2 strong magnets (roughly 1" diameter by 1' long each) installed in the tops of both stakes in August 1977. The height of the 1977 summer surface was identified on the stakes at the time of the stake installations. In August 1978 both sites were revisited and the stakes were buried and not directly observed. Magnetometer surveys were conducted by a tech of Will Harrison's, to locate the stakes and determine the depth to the magnets from mapping the field strength. Will has published a report about the technique of using magnets and magnetometer surveys to determine snow depths. The depth to the magnets was added to the height of the magnet above the 1977 summer surface when the magnets and stakes were installed to get the depth of snow/firn remaining at the end of the 1978 balance year. It was assumed that the height of the 1977 summer surface on the stake did not change significantly over the year. Snow pits were dug to about 1.5 meter for partial density and coring was done from the pit bottom to determine the density down to about 10 m at each site. I don't know what the accuracy of the magnetometer depth surveys is or how it might be

affected by a leaning stake (and magnet) without looking up Will's paper but I think it is suppose to be pretty good and not too sensitive to leaning unless the lean is fairly severe. I have not taken the time recheck all the interpretations of the coring and magnetometer surveys and stake readings.

Making balance measurements this deep is challenging and it is reasonable to be suspicious of them. Though I can't guarantee their accuracy, from a quick review of the notes, these appear to be pretty good measurements for snow this deep. And they do not depend on the visual identification of the summer surface in a core, as was suggested, which admittedly can be difficult this high in the Chugach Mts where accumulation occurs year round.

Rod March, United States Geological Survey rsmarch@usgs.gov Posted on Cryolist 2-May-2012

I am not sure if this will help, but Valdez Heli Skiing keeps accurate snowfall records in the Chugach just 50 km east of Columbia. They report an average of 25 m of annual snow accumulation at an elevation of about 7,500 feet (so about 5-8 m.w.e.). Annual accumulation at Columbia at an elevation of 2000 m shouldn't differ much from 5 m.w.e.

Santiago de la Peña, Byrd Polar Research Center delapena.5@osu.edu Individual response to Cryolist discussion 2-May-2012

How snow accumulation is measured makes a great difference. Is it 25 meters deep at the end of the season or is daily accumulation summed throughout the winter to total 25 m? At the Mt Baker ski resort here in Washington they have reported as much as 90 feet (27 m) of accumulation by totaling the daily measurement throughout the winter. The actual depth in the spring is much less of course.

Wendell Tangborn, HyMet Inc. hymet01@gmail.com Posted on Cryolist 3-May-2012

I didn't understand these messages until I read Rod's comment. The issue seems to be the correct measurement of accumulation and/or winter balance when it is too large to caught by a conventional snow pit. It would be a great shame if our global knowledge of observed glacier balance would be biased to low-accumulation glaciers. Indeed, some of us would argue that high-accumulation glaciers ought to be the ones that are more sensitive to climate variations.

Roger Braithwaite, The University of Manchester r.braithwaite@manchester.ac.uk Posted on Cryolist 3-May-2012

I assume you want to know if we believe 5.5 m w.e. of winter snowfall? I haven't looked at your paper, Liam, but if that's the question, I'm in the "believe it" camp. At Yahtse Glacier, ESE down the coast from Columbia, we had some of our instruments at $\sim$1500 m get buried beneath 2 m of snow just between a July and an early September site visit. So that's 0.6 - 0.8 m w.e. before the winter has even begun? For what it's worth, 5-6 m w.e. by the end of the winter passes my "sniff test."

Tim Bartholomaus, University of Alaska tbartholomaus@gi.alaska.edu Individual response to Cryolist discussion 3-May-2012

Interactive comment on The Cryosphere Discuss., 6, 893, 2012.