Radar Ice Thickness Near Repeat Comparison

CReSIS 2009 Kangerdlugssuaq Data

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Introduction

I investigated near repeat ice thickness measurement reported by CReSIS for Kangerdlugssuaq (Kanger) data. I sought to determine consistency of ice thickness estimates made at flight line intersections.

Data

I used CReSIS 2009 data for Kanger Glacier posted on the CReSIS web site at:

https://www.cresis.ku.edu/data/greenland?quicktabs_5=2#quicktabs-5

Jakobshavn and Helheim Glacier data are also posted at this site but the Kanger data contained the most crossing flight lines. I used all of the matlab files for April 21-23, 2009. Location of data measurements are shown in figure 1.

Approach

I concatenated the matlab files into a single file containing an index, latitude, longitude, and ice thickness. I concatenated the data files sequentially assuming that the individual data points would sequentially follow the flight tracks (see below for an issue on this point). Next, I transformed the latitude and longitude data into a polar stereographic projection and removed no data values. I found near repeat points using the following algorithm:

1) Select a reference point with sequential index n
2) Compare n to the index value of all other data points.
3) Avoid selecting adjacent points along a flight path. If the index value of the reference point is at least 750 values different from the sample data point, then continue, else end.
4) Using the polar stereographic x and y coordinates, compute the distance between the reference and sample point. If the distance is less than 10 m, identify the point as a near repeat. Compute the difference in ice thickness.

This brute force technique is tedious at several levels but seems to work reasonably well. The disadvantages are that first, the program has to run through the entire data set twice. The second disadvantage is that the program estimates the thickness difference at the near repeat point twice (once with a positive and then with a negative difference). Finally, if there are clusters of
observations around a near repeat point, several differences can be computed in the 10 m search radius.

Results
The locations of all near repeat points found by the algorithm are shown in the figure 1. Notice that there are bunches of points at a few locations. The algorithm assumes that the data are serially ordered in the data files so as to follow the flight track. This may not always be the case as sometimes data along the same stretch are reported in more than one file (figure 2). This results in very high spatial sampling and also a break in the index values for the adjacent points. I suppose it is possible that these are in fact exactly repeated flight line segments but the geographic coincidence argues against that interpretation. Consequently, I removed these near repeats from the analysis.

Figure 1. CReSIS 2009 flight lines for Kangerdlugssuaq Glacier. Flight path (black), measured ice thickness (green), near repeat points (red).
Figure 2. Sequential data points in concatenated file are not always time sequential. It is unclear whether these are actual exact repeat flight lines or if there is duplication in the data set.

The edited data set is shown in figure 3 which displays the original flight lines (yellow), the locations where ice thickness data are reported (green), the near repeat thickness differences (filled circles), and a SAR base map. I chose presentation of the data in map overlay for two reasons. First, a histogram is biased by the multiple samples in the vicinity of any near repeat point and also by the double counting of each point. Second, the map overlay gives context to why some near repeat differences may be larger or smaller than others.

As figure 3 illustrates, most of the near repeat differences are less than 50 m. The largest differences (130 m) are located in crevasse zones. Some of the crevasse zones are shear margins and at least one zone seems to be a central patch located within the main flow band of the glacier.
Figure 3. Near repeat thickness differences (filled circles).

Conclusions

Figure 4 shows the near repeat differences superimposed on a thickness map. The thickness map was prepared by converting the point data to a raster using simple inverse distance weighting. In
general the percent difference in near repeat measurements is less than 10% of the total ice thickness. These seems like very good results. However there are some places where the number is closer to 30%. Even that seems like a good result given the lack of any other information. Indeed where radar ice thickness measurements are available, they will likely be better than any other airborne measurement. A key issue as our modeling colleagues have illustrated is how these uncertainties propagate in predictive models and whether there are trades between model algorithms and observational accuracy that can maximize predictive confidence.

Figure 4. Cross over differences overlaid on a thickness map