CReSIS Student Organization Mentoring Award

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Developing a method for estimating accumulation rates using CReSIS airborne Snow Radar from West Antarctica

For more than 50 years, scientists have retrieved ice cores from the world's ice sheets to study ice dynamics as well as past and present climatic and atmospheric conditions, including the accumulation rate. The ice-sheet accumulation rate is not only an important climate indicator but also a significant component of ice-sheet mass balance, which is the total mass gained or lost over a prescribed period of time [1]. Snow accumulation is the primary mass contributor while ice flux into the ocean and surface melting are the primary mass loss mechanisms. As concern over sea-level change and ice-sheet stability increases, more accurate and spatially complete estimates of the accumulation rate are required. Therefore, the sparse point estimates of the accumulation rate (i.e., ice cores) no longer give sufficient data for regional mass balance estimates because of their limited spatial coverage, but remain important paleoclimate records due to their exceptional temporal resolution. In order to constrain current mass balance estimates at the regional scale, improvement in the spatial resolution of accumulation rate estimates is necessary [2].

West Antarctica in particular is seriously lacking in point based measurements of the accumulation rate, whether through snow pit or ice core analysis. Climate models show the region along the Amundsen Coast receives snowfall amounts unprecedented across most of the continent, yet these models lack any ground-truthing and are limited in their spatial resolution [3]. Thus, any estimates of mass balance over this region are ill-constrained and are in need of much better estimates of the snow accumulation rate. For this project, the student will work on developing a method to improve our knowledge of the spatial pattern of accumulation in West Antarctica using the CReSIS developed Snow Radar data collected during the summer 2009 field season. The Snow Radar is capable of imaging near surface layers in the uppermost part of the ice sheet at a very fine vertical resolution. Using this dataset, the student will estimate very recent accumulation rates over the Thwaites glacier along the Amundsen Coast of West Antarctica.

Specifically, the student will map and date the imaged subsurface layers using both the airborne Snow Radar and ice cores. Using the radar echograms, the student will manually digitize the firn layers, which are then dated where they intersect a dated core site. Because these layers are within the firn column, density variations will be considered as well. The process is equivalent to taking several ice core measurements of the accumulation rate along the radar flight lines with a very coarse temporal resolution but at a very high spatial sampling frequency. The student will generate accumulation rates for Thwaites glacier at an unprecedented spatial frequency.

While the student works on his research, we will undoubtedly investigate several routes to accumulation rate estimation and appropriate method creation including, but not limited to:

- **How to date mapped layers?** Not all of the Snow Radar flight lines intersect an ice core which means we will get creative about alternative dating methods. This might involve using a very simple model [4] for estimating the depth-age scale or a more creative route of trying to "tie" dated layers through flight intersections. Generally, if we date one layer at a core site, and it intersects a flight line that does not intersect a core, can we "tie" the dated layer to the undated flight line?
- **Can we make the process easily repeatable?** There already exists several flights worth of Snow Radar just for West Antarctica, and many more flights will be collected this field season. If we can automate most of this process outside of the layer digitization, future estimates of the accumulation rate using Snow Radar will require much less time and effort.

By the end of the summer, the student will have worked through much but perhaps not all of this research problem and will have a greater understanding of not only scientific process and collaboration, but also provide an important contribution to the field of polar science.

References

[1] K.M. Cuffey and W.S.B. Paterson. *The Physics of Glaciers*. Elsevier, Inc., 4th edition, 2010.

[2] R.H. Thomas *and 6 others*. Mass balance of the Greenland Ice Sheet at high elevations. *Science,* 289: 426-428, 2000.

[3] A. J. Monaghan *and 15 others*. Insignificant change in Antarctic snowfall since the International Geophysical Year. *Science,* 313: 827-831, 2006.

[4] M.M. Herron and C.C. Langway. Firn Densification: an empirical model. *Journal of Glaciology,* 25: 373-385, 1980.