Here Today, Gone Tomorrow: How and why glaciers are changing in Iceland

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Abstract

Temperate glaciers such as those seen in Iceland experience high annual mass flux, thereby responding to small scale changes in Earth's climate. Decadal changes in the glacial margins of Iceland's ice caps are observable in the Landsat record, however twice daily AMSR-E Calibrated Enhanced-Resolution Passive Microwave Daily EASE-Grid 2.0 Brightness Temperature (CETB) Earth System Data Record (ESDR) allow for observation on a daily temporal scale and a ~3.125 km spatial scale, which can in turn be connected to patterns seen over longer periods of time. Passive microwave data allow for careful observation of melt onset and duration in Iceland's glacial regions by recording changes in emissivity of the ice surface, known as brightness temperature (TB), which is sensitive to fluctuations in the liquid water content of snow and ice seen during melting in glaciated regions. Results show that Iceland glaciers have a bimodal distribution of brightness temperature delineating when the snow/ice is melting and refreezing. Ground based temperatures have increased on a decadal trend. Clear glacial boundaries are visible on the passive microwave delineating strong features, and we are working to understand their variability and contribution to glacier evolution. The passive microwave data set allows connections to be made between observations seen on a daily scale and the long term glacier changes observed by the Landsat satellite record that integrates the overall glacier changes.

Introduction

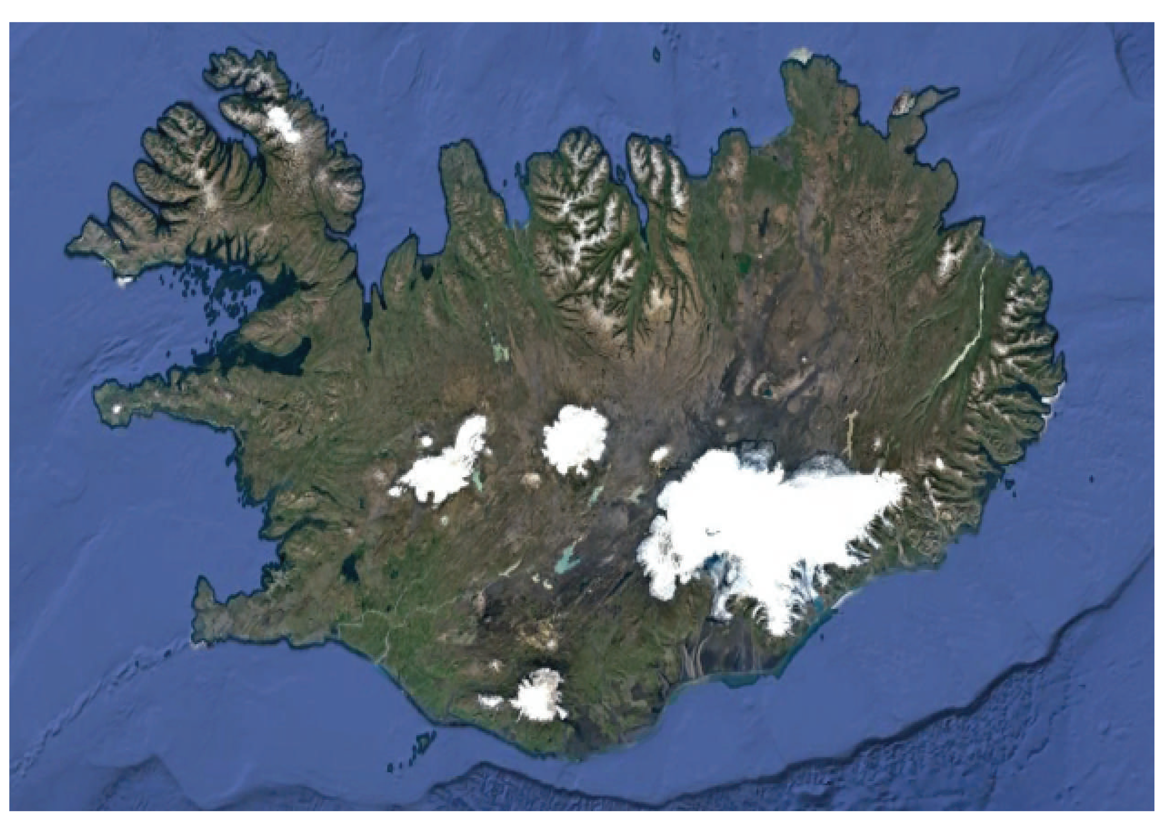


Figure 1. Google Earth image of Iceland, which was the main study area.

The goal of this study was to combine CETB passive microwave data with temperature and discharge data to determine variability in glacial melt on a daily scale combined with long term changes seen in the Landsat record. This summer I worked with just the year 2004 as I familiarized myself with the processors dataset.

What is Brightness Temperature?

Brightness temperature (T_B) is a measure of the emissivity of a surface. Due to sensitivities between dry snow, wet snow and ice, it is useful for the study of melt and freeze timing, as well as snow extent (Paget *et al.* 2016). The greater resolution of this data set allow for more careful and exact measurement along margins.

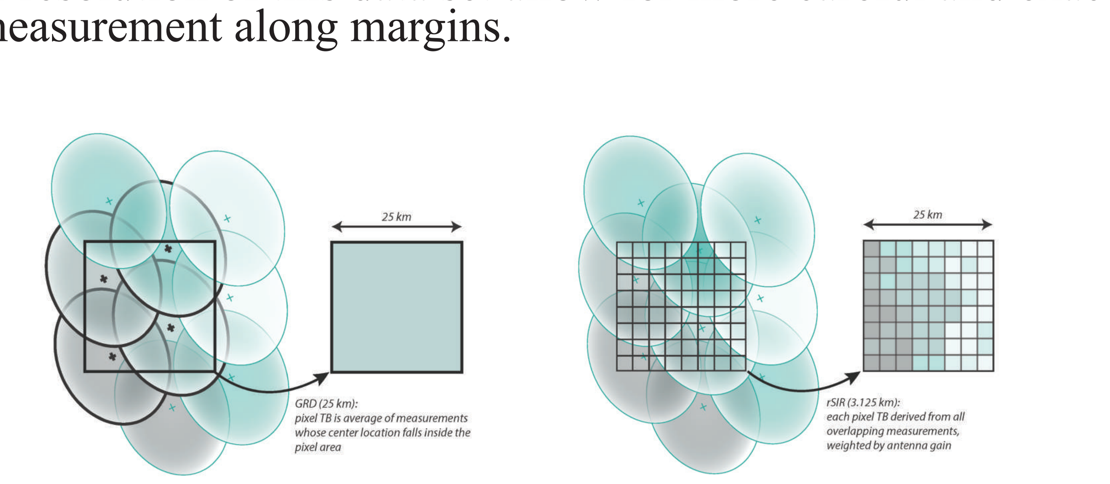
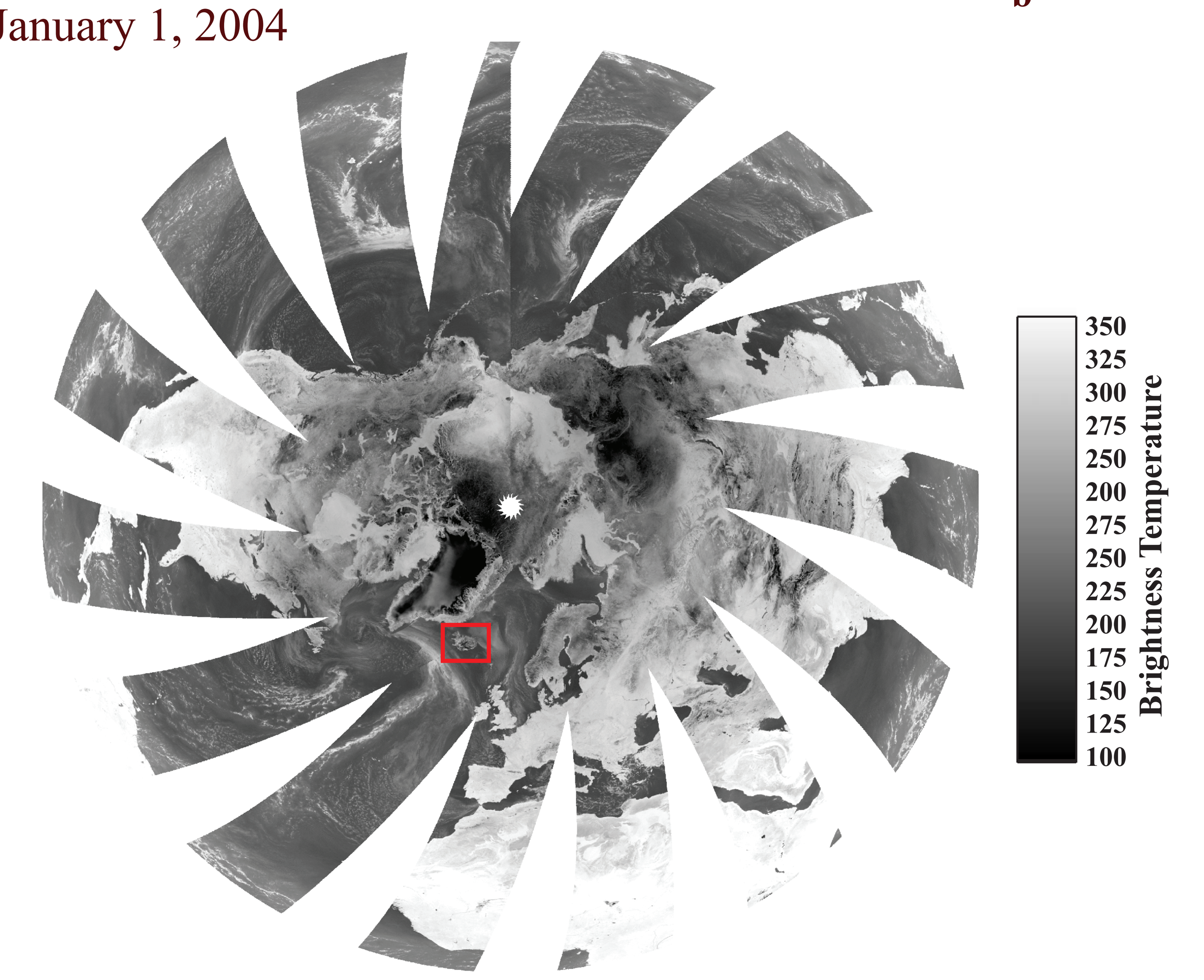


Figure 2. Graphical representation of the increased resolution allowing for more detailed study of margins and smaller areas of interest (Brodzik *et al.* 2016).

Example of Northern Hemisphere T_b Data

January 1, 2004



Morning vs. Evening

January 1, 2004

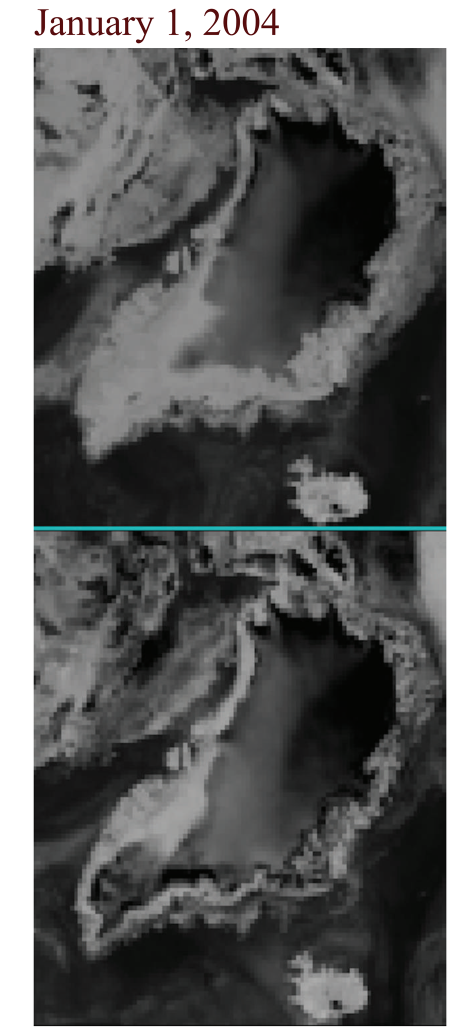


Figure 3. CETB brightness temperature from a Northern projection. (A) shows the entire data set on January 1, 2004. Red box indicates Iceland. (B) is more focused on the study area, and shows a comparison from the morning (top) to the evening (bottom) image that shows how the CETB refelcts changes in T_B on July 18, 2004.

Understanding the Dataset:

Dataset contains extensive metadata

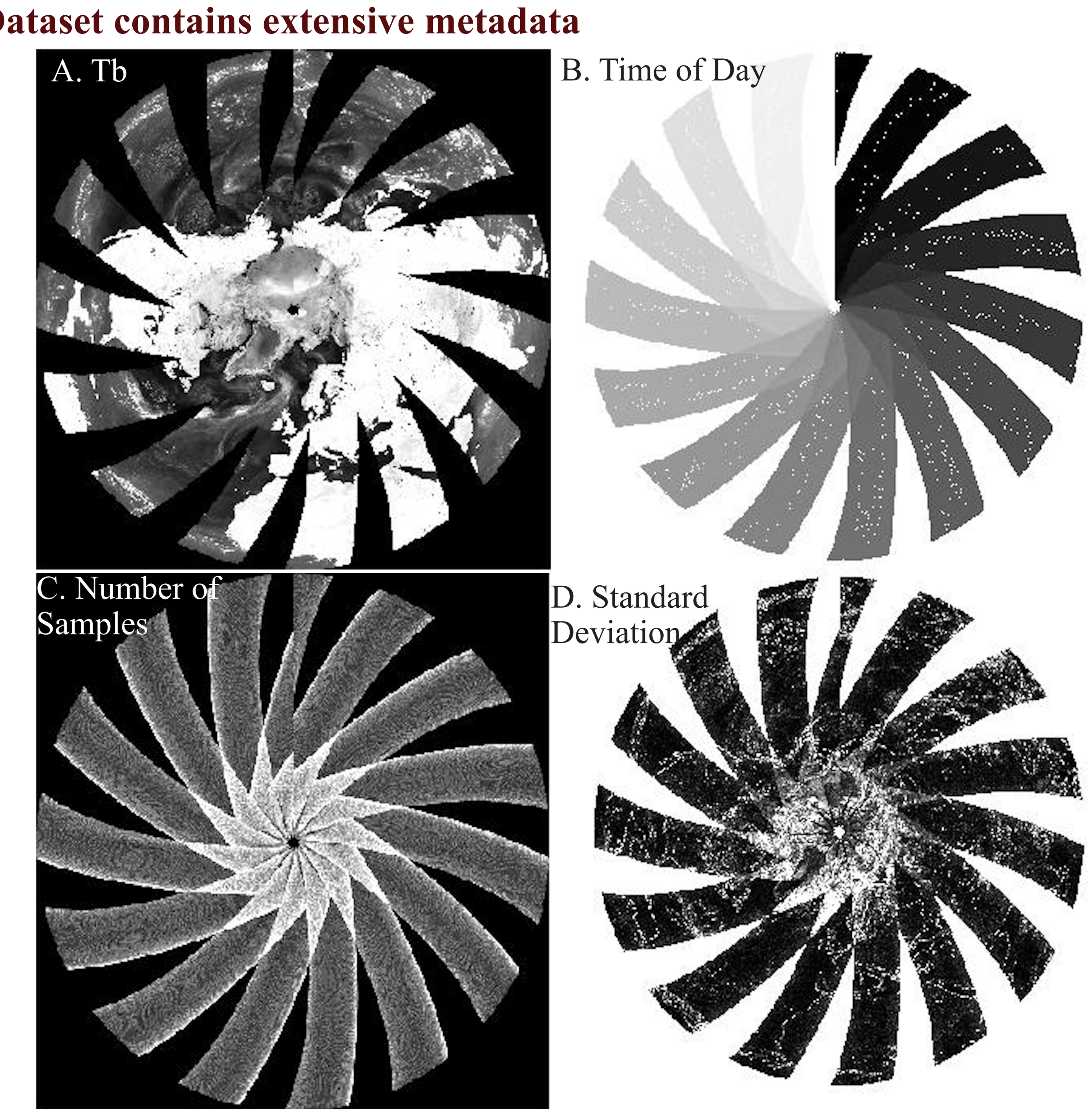


Figure 5. Projection of the northern hemisphere on June 12, 2004 depicting (A) the brightness temperature, (B) local time of day for each path of the satellite, (C) the number of samples for each path, and (D) the standard deviation. An algorithm is used to split the northern hemisphere into twice daily images referred to as local time of day based on averaging the times for each image. This varies by the number of samples, with poles seeing up to 8 values decreasing to 2 on the edge of the path.

Histogram Representing Bimodal Distribution

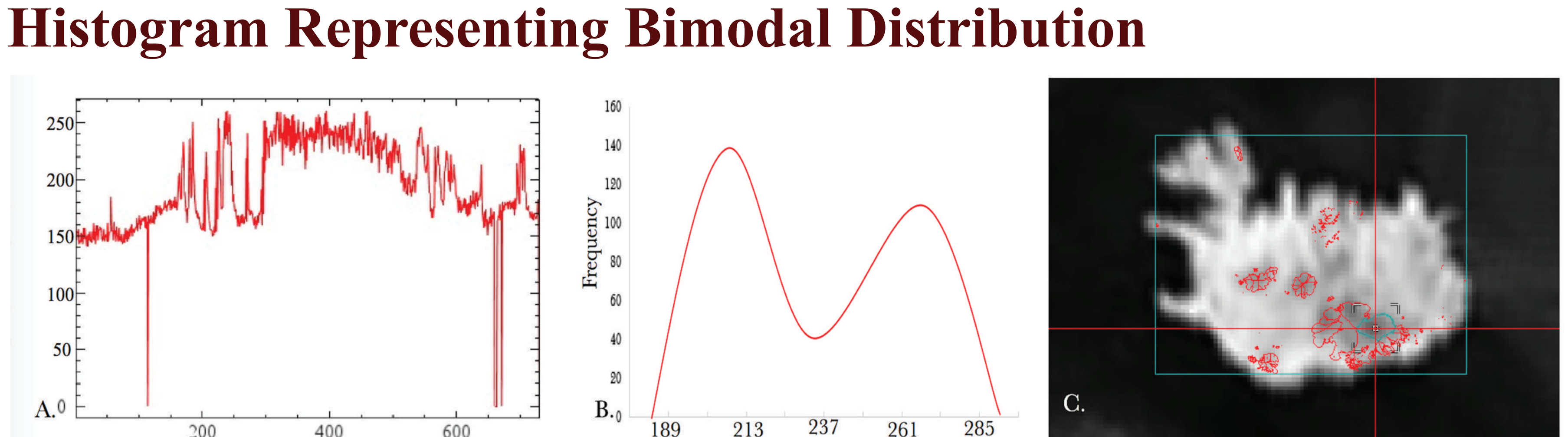


Figure 4 (above). An example of the TB indexes collected from a 2004 time series. (A.) shows the half Julian Day on the x-axis and the brightness temperature in K on the y-axis. The line represents the changes in TB during days of melt. (B.) is a histogram generated for the shown pixel showing a bimodal trend with a slightly greater amount in the frozen category. (C.) uses crosshairs to represent the location of the data selection. Glacial outlines are overlain on the map in red to make it easier to distinguish margins. Points that go to zero are points of no data.

ArcticDEM and Iceland Glaciers

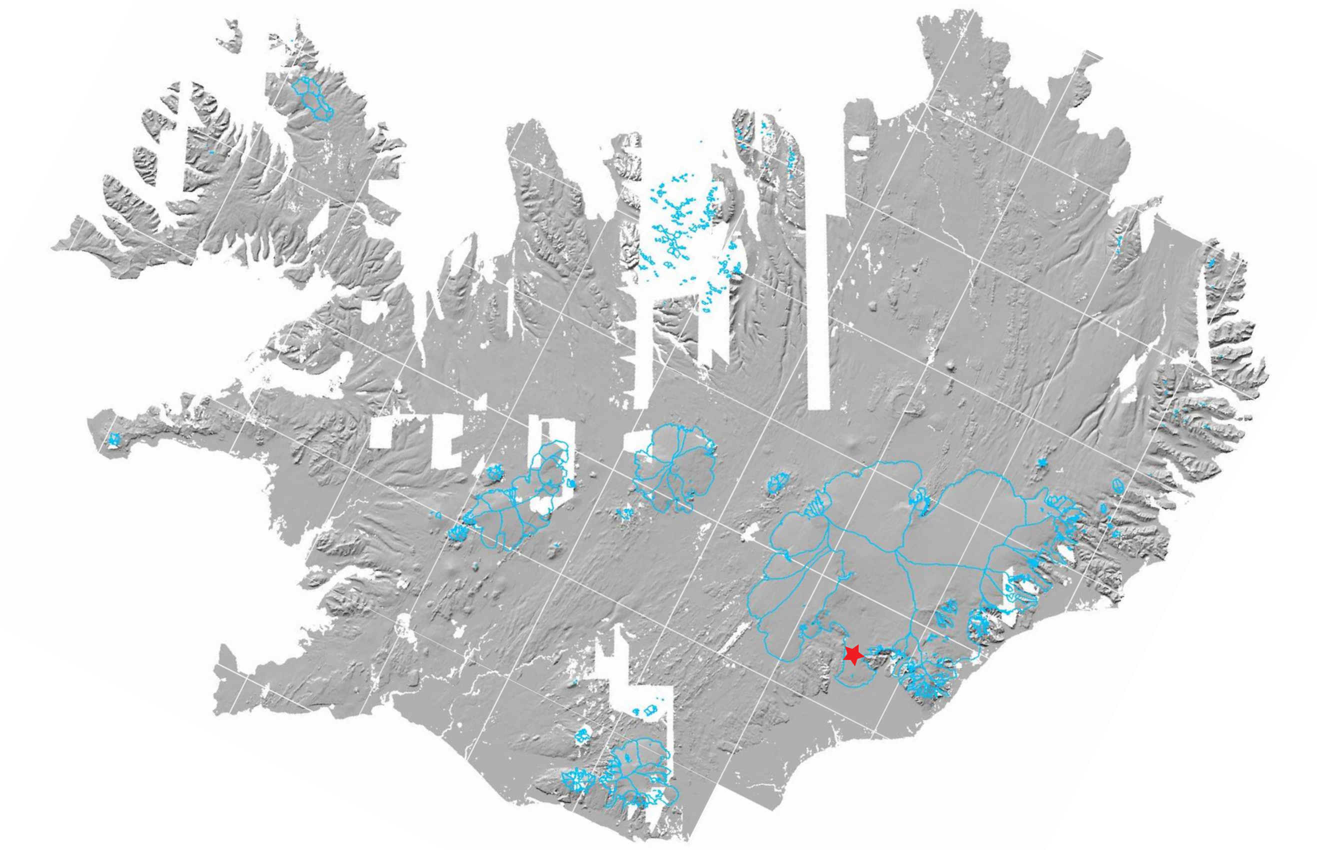


Figure 6. DEM of Iceland showing hillshade from ArcticDEM. Downloaded in a 5m resolution tile mosaic. Blue outlines are glacial margins. Elevation derived from the DEM can be used to determine sensitivities at different heights on the icecap in relation to air temperature.

Time Series at Location on Vatnajokull Icecap, 2004

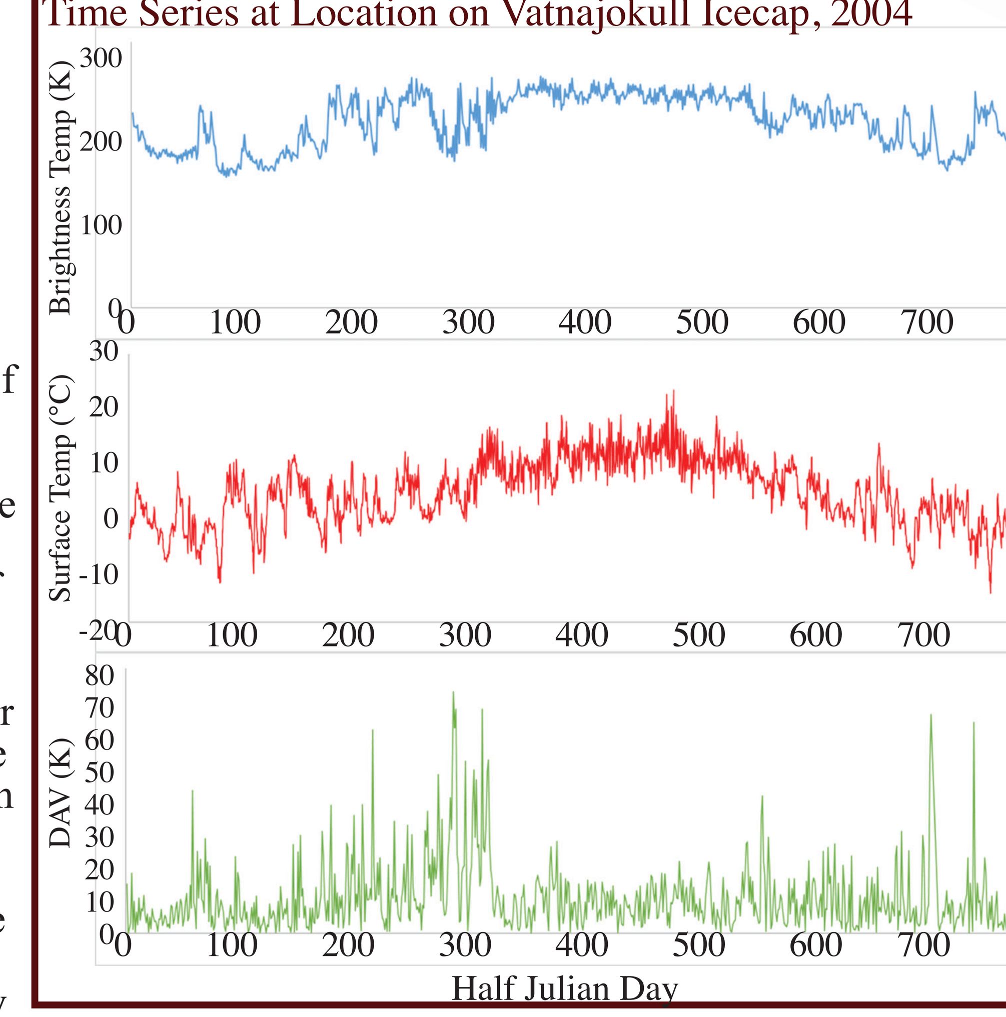
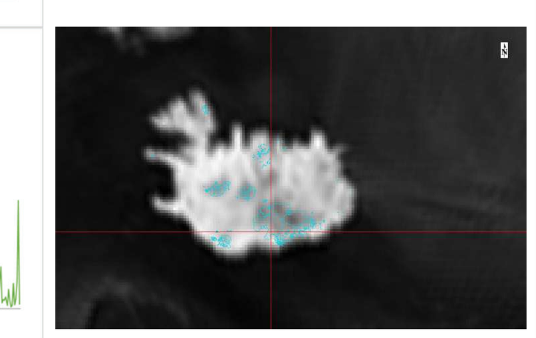


Figure 7. Comparison of Brightness Temperature, surface temperature and running difference between morning and afternoon values (DAV) for one location on the Vatnajokull Icecap, indicated on the image below. Sensitivities in the DAV allow determination of the onset of melting.



Preliminary Conclusions and Further Study

- Glacial boundaries are clearly visable on CETB data
- Focusing attention on one area (Vatnajokull ice cap) as an original area of interest that can later be expanded
- matching air temperature data with the morning and evening images
- determine the start of melting for each year and look at decadal trends
- Use the DEM downloaded from ArcticDEM (Figure 6) to study volu metric changes in ice in conjunction with mass balance
- Overlay river discharge data from various stations
- Apply XPGR snowmelt algorithm originally presented by Abdalati and Steffen (1995) is used as a comparison with the diurnal amplitude variation (DAV) values on Iceland's Vatnajokull ice cap
- Refine melt algorithm for Iceland glaciers

References and Acknowledgements

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Surface Temperatures provided by the NNDC CDO by the NOAA.

Brodzik, M. J., D. G. Long, M. A. Hardman, A. Paget, and R. Armstrong. 2016. MEaSUREs Calibrated Enhanced-Resolution Passive Microwave Daily EASE-Grid 2.0 Brightness Temperature ESDR, Ver sion 1. AQUA_AMSRE. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: http://dx.doi.org/10.5067/MEASURES/CRYO SPHERE/NSIDC-0630.001. January 2017.

Paget, A.C., Brodzik, M.J., Long, D.G., and Hardman, M.A. (2016). Bringing Earth's Microwave Maps into Sharper Focus. *Eos, 97,* https://doi.org/10.1029/2016EO063675

"Iceland". 62 40'09.52" N and 18 01'26.77" W. **Google Earth.** December 13, 2015. April 15, 2017.