USING AWS AND MERRA-2 DATA TO ESTIMATE THE CLIMATOLOGY AND EFFECTS OF POLAR NIGHT FOEHN WIND ON LARSEN C ICE SHELF

Matthew K. Laffin[1*], Charles S. Zender[1,2]

[1]Department of Earth System Science, University of California, Irvine

[2]Department of Computer Science, University of California, Irvine

[1*] Corresponding Author: Matthew K. Laffin
ESS, UC Irvine, Irvine, CA
E-mail: mlaffin@uci.edu

1. OVERVIEW

Larsen C Ice Shelf (LCIS) is experiencing increased melt due to anthropogenic increases in atmospheric temperature. Mechanisms called hydrofracture and firn densification caused by surface melt are thought to be a major contributor to the disintegration of the Larsen A, B, and C ice shelves off the eastern slopes of the Antarctic Peninsula. Ice sheet surface melt is traditionally thought to be dominated by a positive net shortwave radiation flux causing surface melt and runoff. This implies that surface melt only occurs in the summer when solar radiation and air temperatures are at their peak. Recent work discovered that polar night foehn winds are a large (up to 25%) contributor to ice sheet surface melt during polar night (Kuipers Munneke et al., 2018).

Foehn winds are warm and dry downslope winds that can induce turbulent downward sensible heat fluxes. Surface melt during polar night on the LCIS has not been well-studied or quantified.

Here we present preliminary results to quantify the spatial and temporal extent of foehn wind melt events during polar night and their contribution to the total annual melt experienced on LCIS. We created a foehn detection algorithm (FonDA) using both Automated Weather Station (AWS) and Modern-Era Retrospective analysis for Research and Applications (MERRA-2) data products to identify foehn events. FonDA is used in combination with estimated surface energy budgets to quantify melt on the LCIS.

2. FOEHN DETECTION ALGORITHM

Our Foehn Detection Algorithm (FonDA) uses variable thresholds for wind speed, air temperature, and relative humidity to identify foehn wind melt events (Figure 1a). The air temperature threshold is air temperature greater than zero degrees Celsius. Relative humidity and wind speed thresholds are more dynamic because high winds and low relative humidities do not guarantee melt, they only aid in identifying foehn winds. A quantile regression approach is used to identify these variable thresholds. Wind speeds have to rise above the 75th percentile and relative humidity has to be below the 50th percentile to cross the thresholds. If all three of these variables surpass the threshold identified, the algorithm will identify the event as foehn.

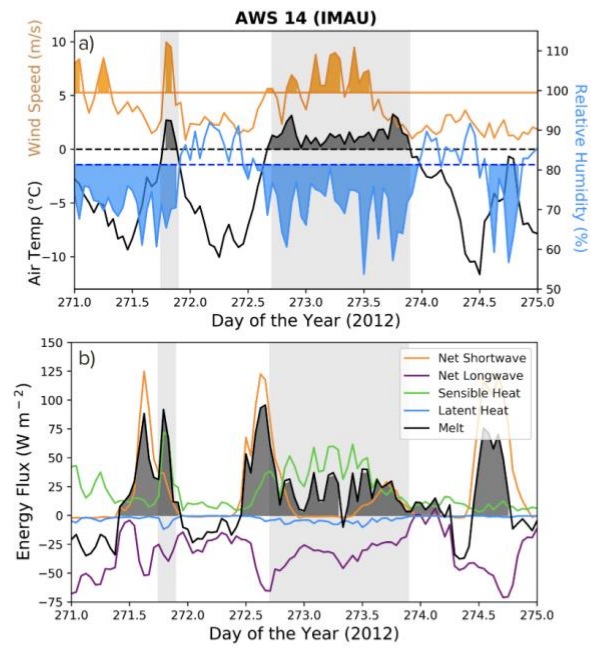

Figure 1: a) Two foehn events were identified by FonDa at AWS 14, indicated by light grey shading. b) The ice surface energy budget with corresponding energy for melt shaded in dark grey, with sensible heat dominating the surface energy budget during foehn events.

3. ICE SURFACE ENERGY BUDGET

The estimated energy budgets for the AWS that provide radiation fluxes are compared to the corresponding grid cell of MERRA-2 energy budgets. This provides a diagnostic evaluation of how well MERRA-2 data are able to resolve surface energy budgets at the surface, despite the large grid cell size. During polar night foehn wind events the ice surface energy budget is dominated by turbulent fluxes of sensible heat, inducing surface melt (Figure 2b).

4. DATA SOURCES

We use current and past weather stations situated on LCIS for direct in-situ weather measurement (Figure 2). These data provide accurate data for a limited geographic region. With only 5 stations on LCIS it's difficult to extrapolate these data to the entire LCIS. These AWS data are used to calibrate MERRA-2 data, which is satellite derived, but helps to broaden our surface melt understanding to a greater geographic region.

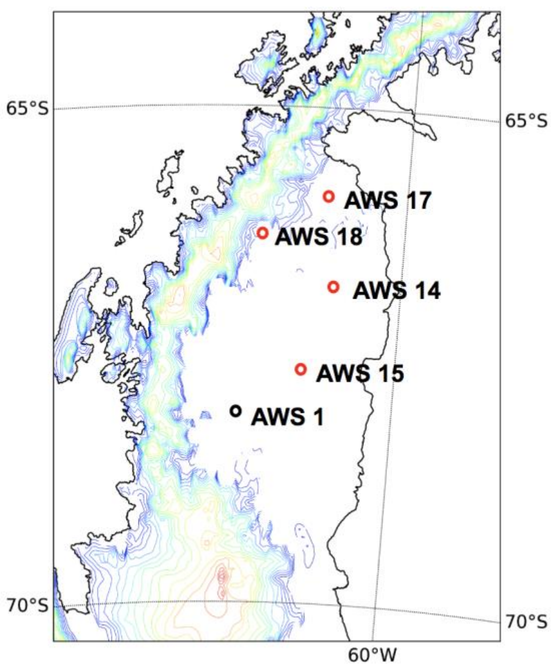

Figure 2: Automatic Weather Stations (AWSs) on LCIS. Red circles indicate IMAU AWSs. Black circle indicates AMRC AWS.

5. PRELIMINARY RESULTS

LCIS experiences surface melt during polar night caused by foehn winds, which form when relatively moist air travels eastward over the Antarctic Peninsular Mountain range. The ice surface energy budget during these foehn events is dominated by turbulent sensible heat fluxes at the surface. Temporal surface melt is highly variable due to the variability of yearly atmospheric circulation which ultimately drives foehn wind formation. The northern portion of LCIS is affected most by foehn, likely due to the the increased temperatures at lower latitudes. Preliminary surface melt results show a strong foehn signature just east of the Antarctic Peninsular Range due to topographic funneling of foehn winds and a change in topographic relief which concentrates sensible heat on the surface (Figure 3).

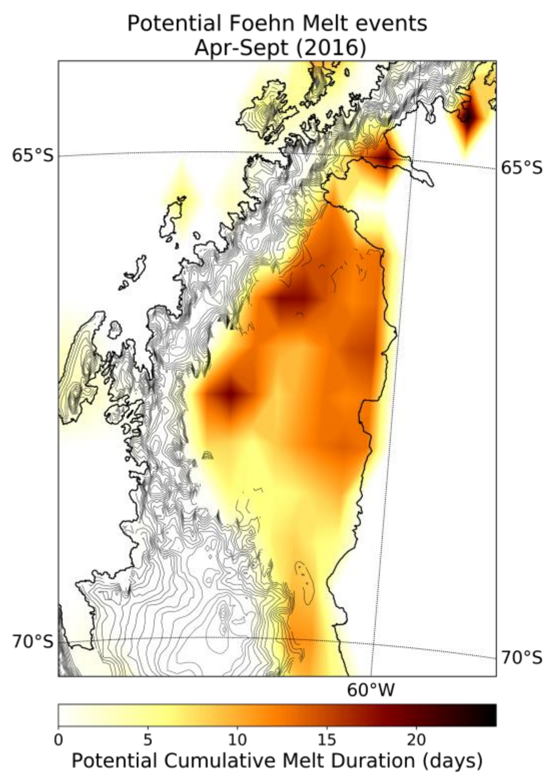

Figure 3: Spatial distribution of polar night (April-September) surface melt on LCIS caused by foehn wind. Black contour lines indicate topography of the Antarctic Peninsula Range.

6. FUTURE

Current research has focused only on the LCIS mainly due to its vulnerability to disintegration and known foehn events. Future research will expand beyond LCIS to the Antarctic and Greenland Ice Sheets, aiming to provide new information about polar night surface melt caused by foehn winds.

7. ACKNOWLEDGEMENTS

We thank the Institute for Marine and Atmospheric Research (IMAU) at Utrecht University and the Antarctic Meteorological Research Center (AMRC) at the University of Wisconsin-Madison for providing Automatic Weather Station data. We also thank the NASA Global Modeling and Assimilation Office (GMAO) for providing MERRA-2 reanalysis data.

8. REFERENCES

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