Temporal Variation in Land Surface Temperatures of Lambert Glacier-Amery Ice Shelf System (LGAISS)

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EXTENDED ABSTRACT

Data collected by state-of-the-art satellite technologies provide a convenient way to explore the dynamic surface variations of the Antarctic ice sheets. The Lambert Glacier and the adjacent Amery Ice Shelf (LGAISS) comprise the largest glacier-ice shelf system in east Antarctica. Mapping and analyses of the LGAISS since 2008 have been conducted using 1 km daily Moderate Resolution Imaging Spectroradiometer (MODIS) land surface temperature (LST) and Sea Ice Temperature (IST) products. “Melt” occurrences were identified from the land and sea ice temperature images at the pixel level on days where MODIS observed temperatures were above 273.15°K (0°C). A geographical and statistical analysis approach was developed and implemented to evaluate the number of melting days on the LGAISS. Cloud contamination and other data gaps have an effect on the record, but the combined data set does enable examination of spatial and temporal ‘melt’ periods. Work is underway to extend and improve the time series for successful comparison to lower resolution time series of surface melting developed from passive microwave instruments.

Keywords: land surface temperature, ice surface temperature, MODIS, Antarctica

DATASETS

Two MODIS level-3 products are combined to study daily variations in surface temperature across the LGAISS (Figure 1) over the period from September 1st, 2008 to March, 1st, 2009. The first dataset is the level-3 MODIS global LST product (MOD11A1) (Wan, 2007) that has both day and night time temperatures for Earth’s land areas. The second product is a sea ice surface temperature (IST) product MOD29P1N (Riggs *et al*., 2006), that also has day and night observations. Combining the two products is necessary because the Amery Ice Shelf is not considered land in the LST product. An obstacle to integrating the two products over the LGAISS is that they are in different map projections. The LST is produced in the standard MODIS Global Equal Area Sinusoidal Projection while the IST product is in a polar centric Lambert Azimuthal Equal Area Projection which is compatible with the National Snow and Ice Data Center (NSIDC) EASE-GRID projections.

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METHODOLOGY

Using IDL7.0.2 (Interactive Data Language) and ArcGIS9.3, the two data sets are processed following the workflow illustrated in Figure 2. To avoid the influence of cloud cover, all "cloud-contaminated" pixels are removed in the data preprocessing and, therefore, not utilized in subsequent analysis. This is done by screening all pixels in the two input products by the following criteria for quality control: 1) average emissivity error is not greater than 0.04; 2) average LST error is not greater than 3°K; 3) quality is either 'good' or 'other'; 4) Difference in temperature between neighboring pixels is not greater than 10°K. Only pixels where LSTs meet 1) to 4) and ISTs meet 3) to 4) are used.

For all pixels meeting the quality control, 'melt' is identified when the surface temperature (IST or LST) is 0°C or warmer. Since, the MODIS sea ice product has a known bias of -2.1°K (Hall, *et al*., 2004), a bias correction is performed prior to the identification of melt. Finally, the LST is reprojected to be consistent with the projection of IST, Lambert Azimuthal Equal Area Projection. Once the melt pixels have been identified for each day, a daily map of melt pixels is created and projected.

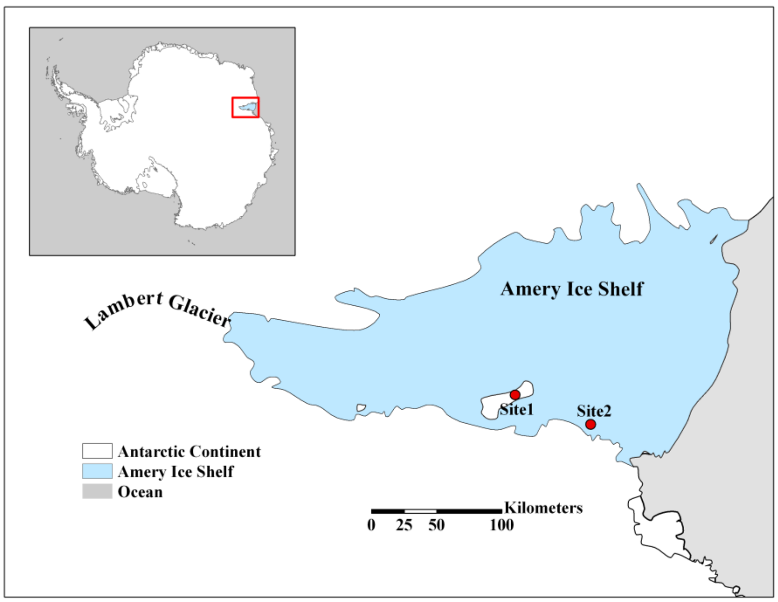

Figure 1. Map of sample Site 1 and Site 2

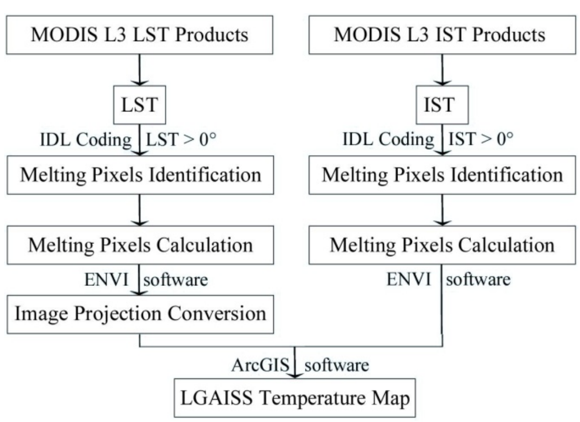

Figure 2. Data processing workflow

RESULTS

To illustrate a portion of the time series, two sample locations are selected from areas where temperatures are determined from the LST (Site 1) and IST (Site 2) datasets. The location of these two relatively low elevation sites is shown in Figure 1. Figures 3 and 4 illustrate the developed time series. In these plots, linear interpolation is used to fill in data gaps of less than two sequential days. No attempt is made to fill longer data gaps. Figures 3 and 4 illustrate that daytime melting is observed from mid December to mid January, with a singular melt day identified in late January of 2009 at Site 2. At no point in the time series do observed nighttime temperatures reach the melting point. Overall, the two products appear to be in agreement, allowing for an integrated view of surface melting for the entire LGAISS using these two MODIS products. During the time period from Sep 1st, 2008 to Mar 1st, 2009, the mean LSTs were 249.11K and 249.07K for daytime and nighttime, respectively, while the mean ISTs were 254.81K and 247.34K.

In addition to examining these time series, an initial attempt is made to compute the duration of observed daytime and nighttime melting on the LGAISS from MODIS as illustrated in Figures 5 and 6, respectively. It is important to note that these maps only show the sum of the number of observed melt occurrences. No attempt is made to adjust for observations missing due to cloud cover and other factors. Even though this initial analysis only includes clear sky observations, during the period between Sep 1st, 2008 and Mar 1st, 2009, more than 16.9% of the Amery Ice Shelf had over seven days of daytime melting, while approximately 8.5% of the area experienced at least one day of nighttime melting.

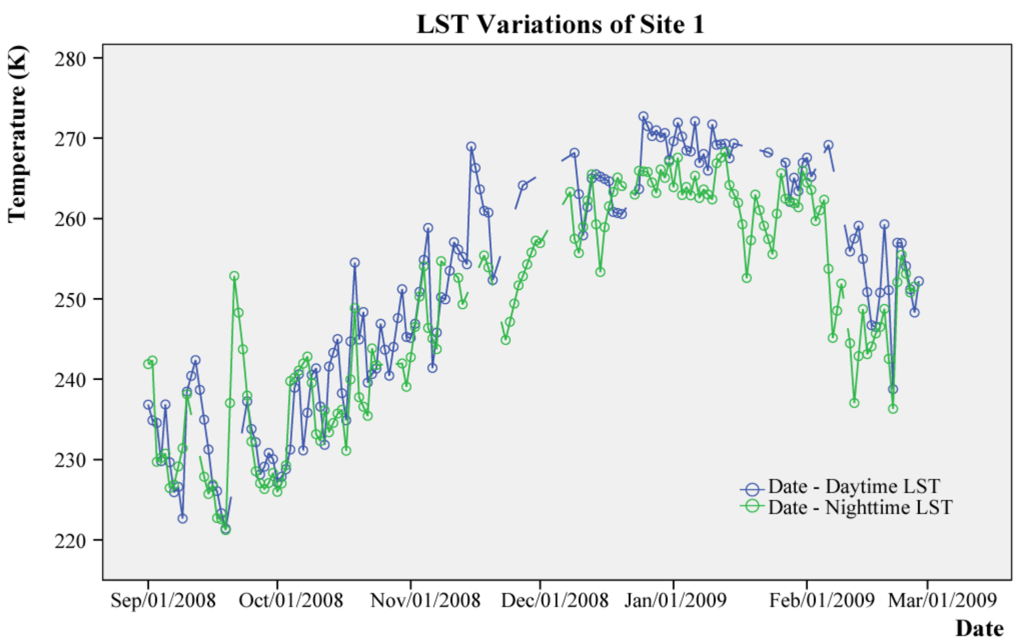

Figure 3. LSTs for sample Site 1 for the September 1st, 2008 – March 1st, 2009 period, retrieved from MOD11A1 daytime and nighttime products. The elevation of Site 1 is 64.12 m.

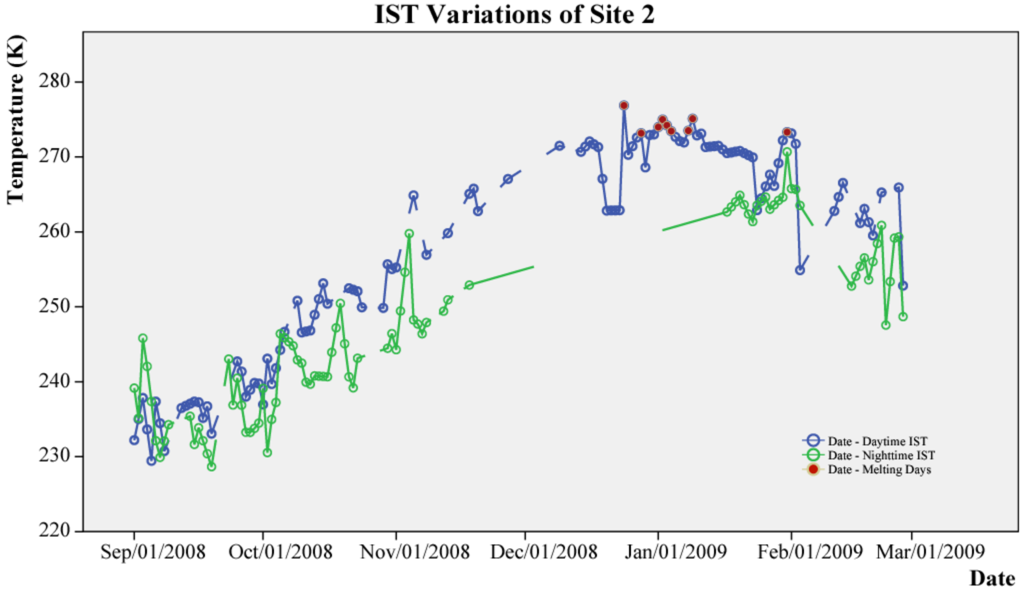

Figure 4. ISTs for sample Site 2 for the September 1st, 2008 – March 1st, 2009 period, retrieved from MOD29P1D and MOD29P1N daytime and nighttime products. The elevation of Site 2 is 98.78 m.

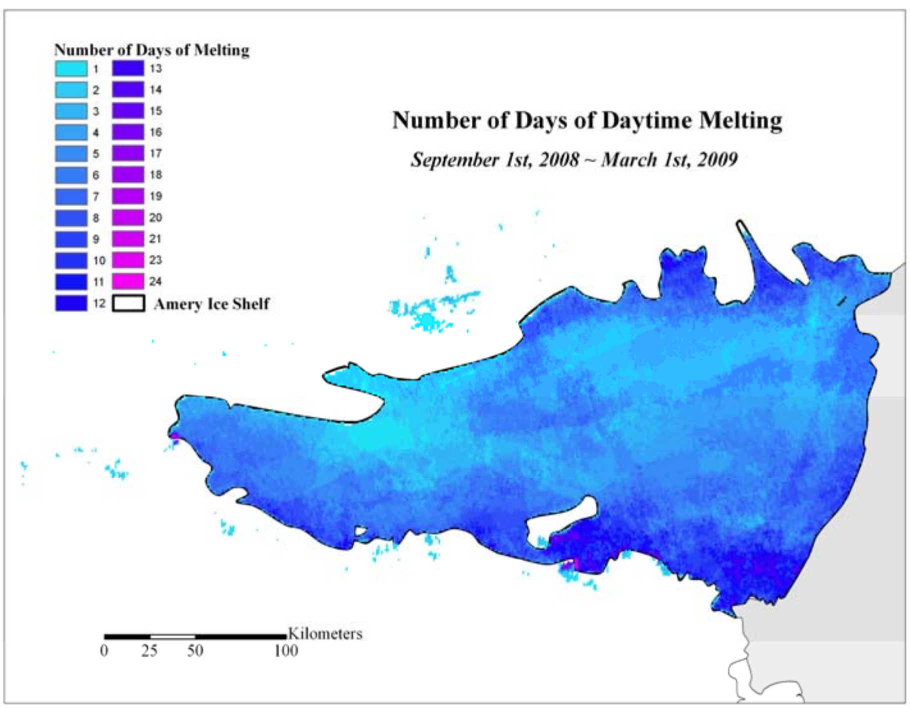

Figure 5. Map of the number of daytime "melting" occurrences derived from MODIS.

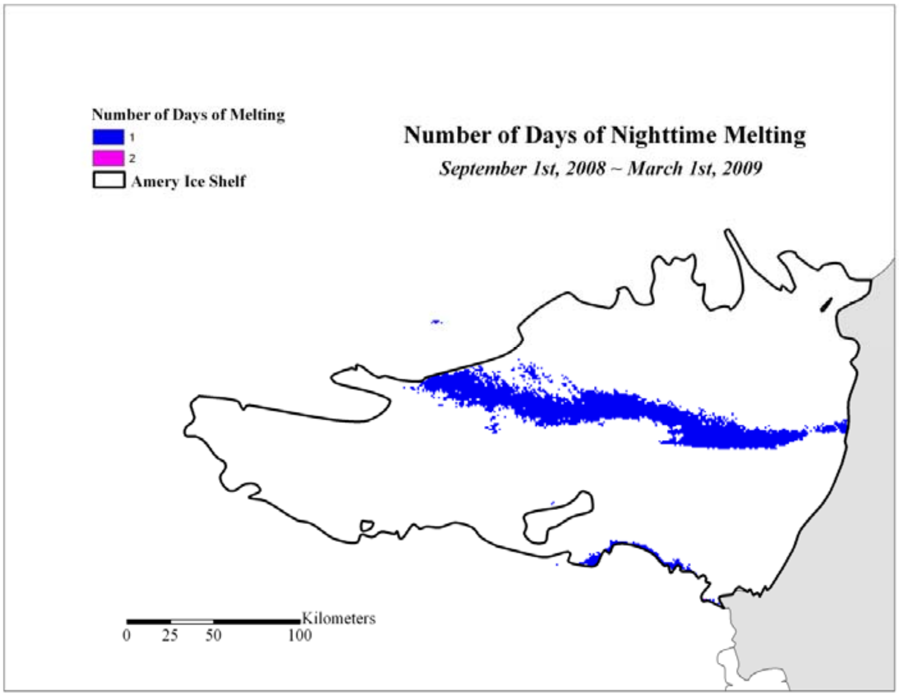

Figure 6. Map of the number of nighttime "melting" occurrences derived from MODIS.

CONCLUSIONS

MODIS Land and Sea Ice Surface Temperature products are merged to determine days of 'melting' on the Lambert Glacier- Amery Ice Shelf system where temperatures met or exceeded 0° C during the 2008-2009 austral summer. While the combined IST and LST melt time series does suffer from data gaps due to cloud cover and other factors, the temperature variations observed in the two products for single pixels generally match the expected pattern of increasing temperatures in the summer season and decreasing temperatures in the winter season. The similarity gives confidence that the combined product can be used to examine melt over the LGAISS. The combination of MODIS LST products and Sea Ice products contributes to exploring and understanding the temperature variations of LGAISS as an integrated system and will be compared to a time series that is more temporally complete but with a lower spatial resolution.

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