Innovations in Snow Cover Mapping for Dall Sheep

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Satellite remote sensing from the Moderate Resolution Imaging Spectroradiometer (MODIS) provides valuable snow cover information. Snow Cover Frequency (SCF) is a new metric that can serve as a proxy for snow water equivalent and snow depth. Here, we map differences in springtime SCF over the Wrangell-St. Elias study area as part of a Dall Sheep study for NASA's Arctic Boreal Vulnerability Experiment (ABoVE). We use a cloud-computing approach with Google Earth Engine to compute SCF globally for any user-specified time period within the MODIS record (2000-present).

Dall sheep populations have been declining over the past several decades. Their populations are sensitive to habitat and snow cover. This project aims to characterize changes in snow that may affect Dall sheep populations, especially during the lambing season. We have developed a suite of snow metrics to augment ground-based measurements from stations whose spatial distributions are sparse and not necessarily representative snow spatial distributions.
We use an innovative cloud-computing approach to developing and distributing snow cover products. Here, we present maps of Snow Cover Frequency (SCF), which are produced via an application running on Google Earth Engine.

Snow Cover Frequency (SCF) uses daily observations of snow cover from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS, MOD10A1) at 500-m spatial resolution.

$$SCF = \frac{\text{\# of snow observations in a pixel}}{\text{\# of valid observations in a pixel}}$$

We apply an adjustment for cloudy days when those days are bounded by clear-sky observations of snow cover.
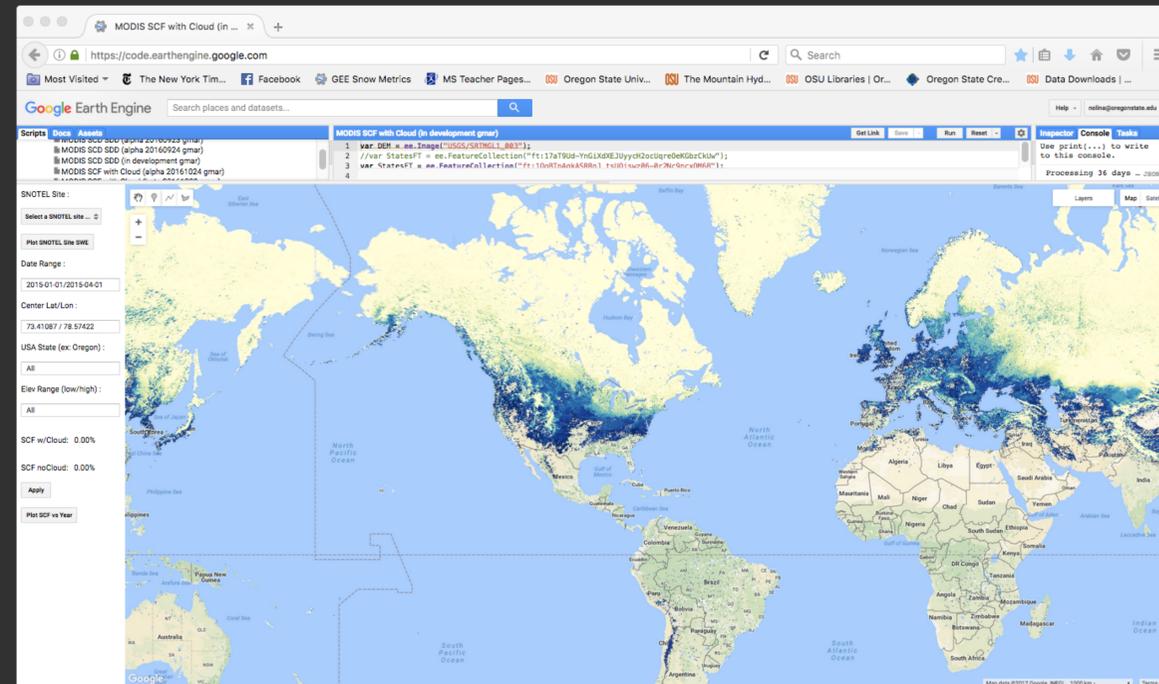
Figure 2. Snow Cover Frequency for the period January – April, 2015

Google Earth Engine offers a new paradigm for data analysis, visualization, and distribution. Satellite data are stored on the EE cloud and developers can create applications (in JavaScript or Python) that run on the EE cloud (Figure 2.)
MODIS snow cover data are processed on the EE cloud using the SCF algorithm running.
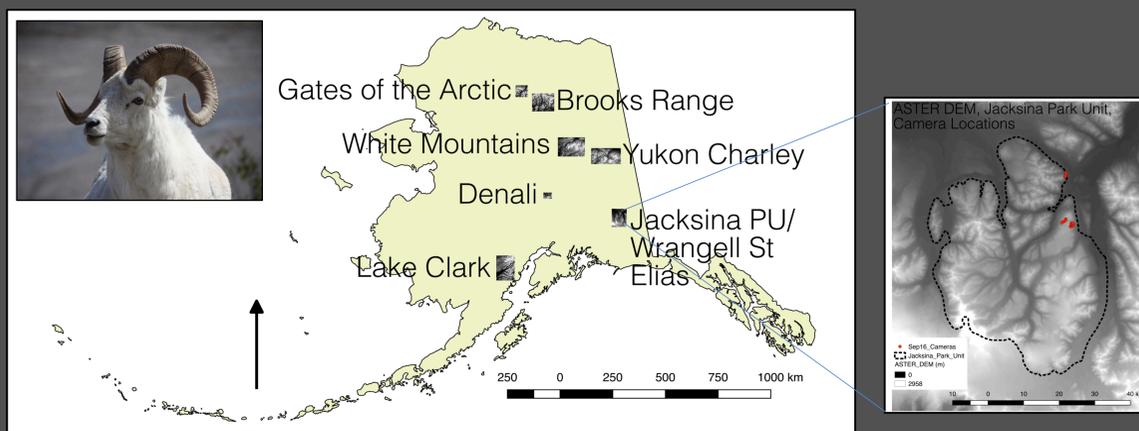SCF is computed globally usually less than 20 sec.

Figure 1. Map of National Park study areas and the Jacksina Park Unit

Our ABoVE Dall Sheep study area is the Wrangell-St. Elias National Park/Jacksina Park Unit (Figure 1). We are modeling and measuring snowpack properties and comparing with remotely sensed snow cover data and Dall sheep GPS location information.

In addition to processing data for our study area, SCF is produced globally. Users can subset by polygon, shapefile, US state, and/or elevation range.
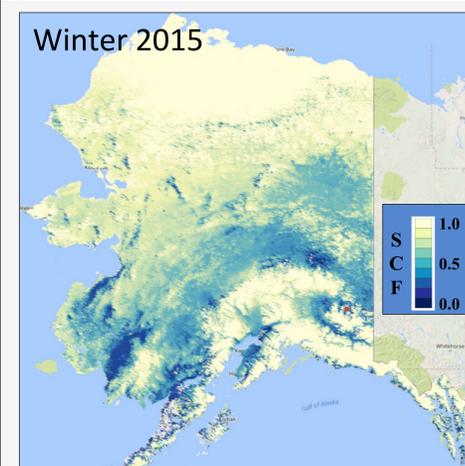
Figure 3. Users can subset by polygon, shapefile, US state, and/or elevation range.
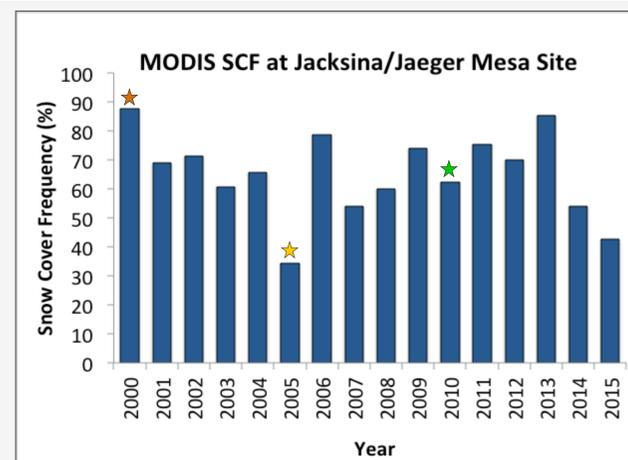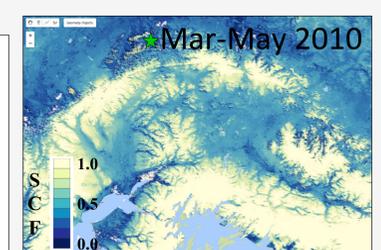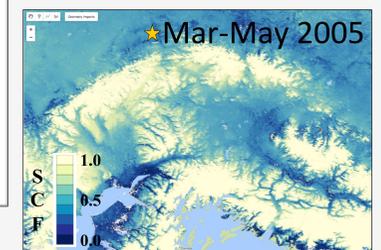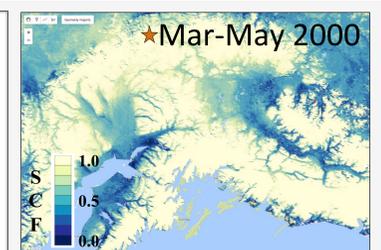
Figure 4. SCF data can be easily exported to a csv file or an image file for further analysis.

We computed SCF for winter (Jan-Mar) 2015 and subset results for the state of Alaska (Figure 3). We also looked more closely at spring (Mar-May) conditions in the Jacksina PU and specifically at one of our Jaeger Mesa sites for the period 2000-2015 (Figure 4). Data indicate that spring 2000 was a high snow year (SCF=87%), spring 2005 was a low snow year (SCF=34%) and spring 2010 was roughly average snow year (SCF=62%). Next we will be comparing snow conditions with Dall sheep population data and SnowModel output.