Characterizing Mountain Snowpack for Dall Sheep

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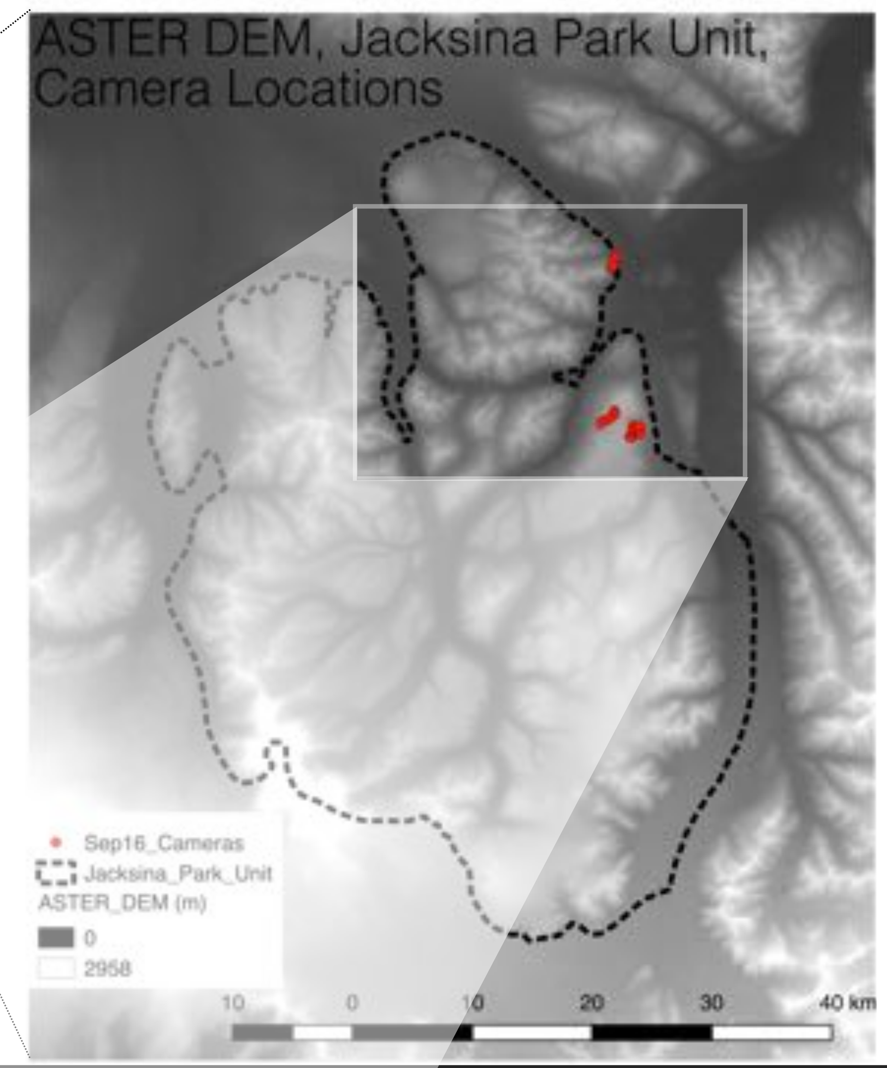
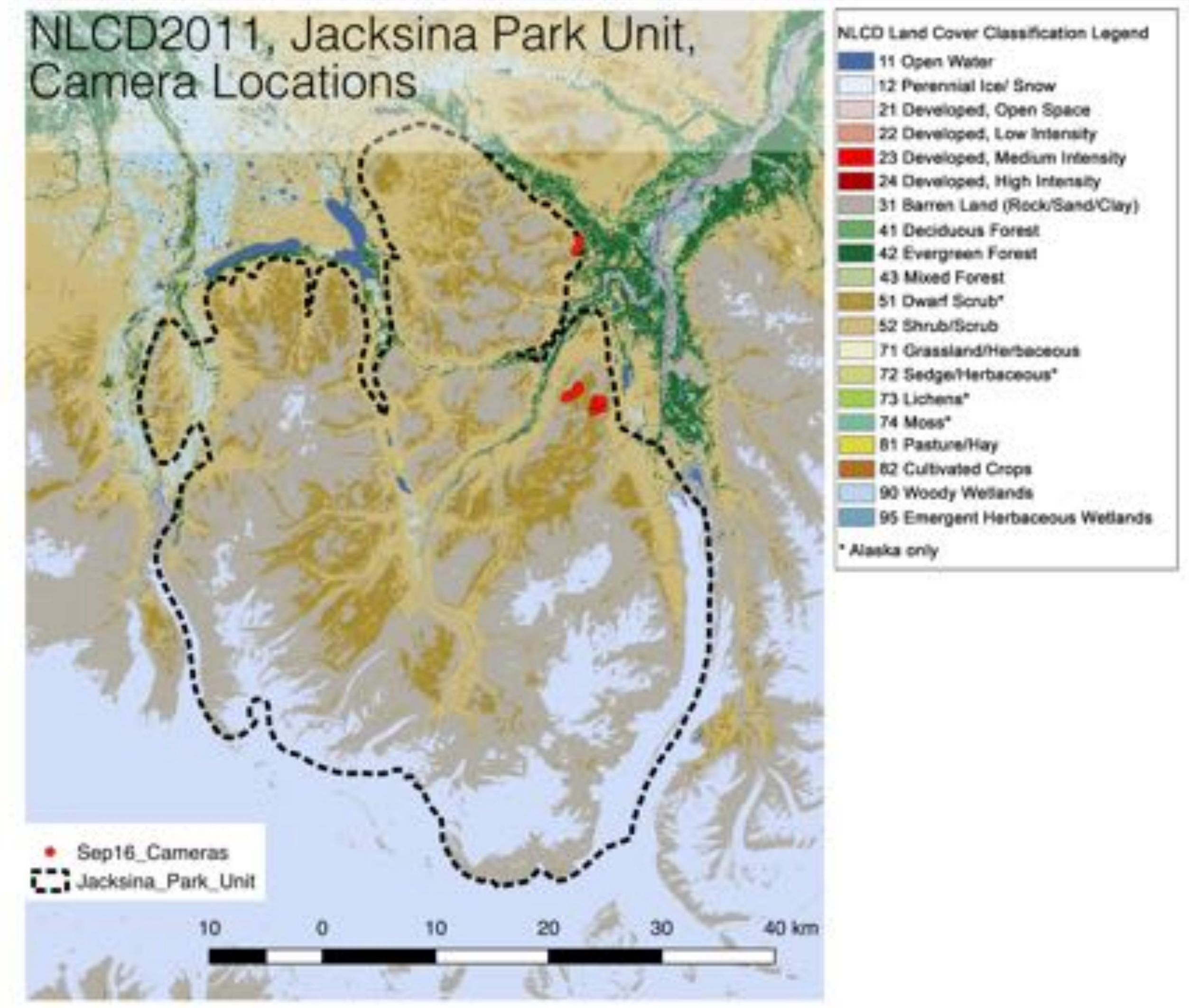
Dall Sheep are an iconic species of the mountainous Arctic and boreal North America. Their populations are highly sensitive to snowpack conditions, especially during the lambing season in spring. Through tourism, subsistence and trophy hunting, Dall Sheep offer a crucial ecosystem service in the region. As part of the Arctic Boreal Vulnerability Experiment's (ABoVE) "Assessing Alpine Ecosystem Vulnerability to Environmental Change Using Dall Sheep as an Iconic Indicator Species", we are characterizing snowpack changes in the Wrangell-St. Elias National Park using a combined modeling, field, and remote sensing approach.

STUDY REGION

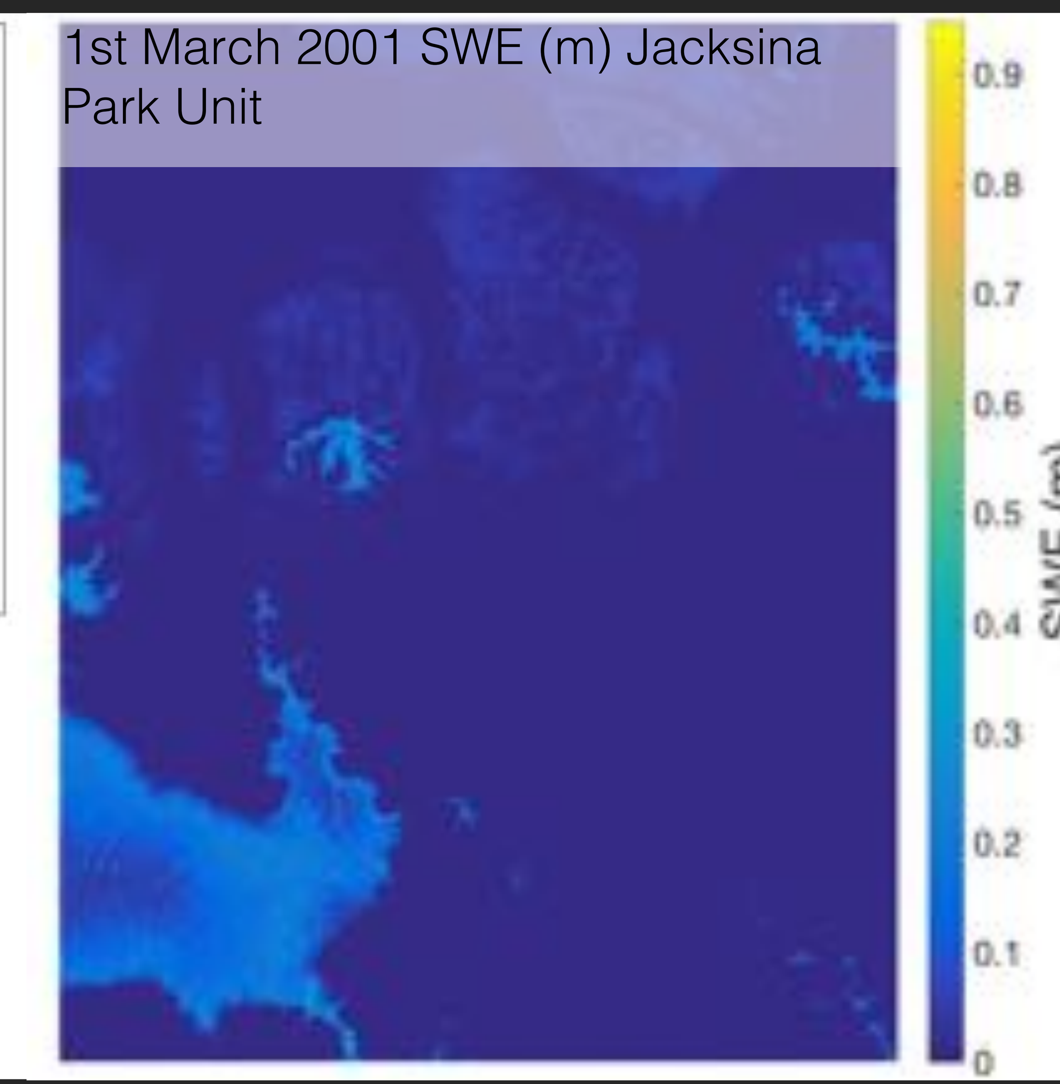
The National Parks in the above map comprise the areas where we will run SnowModel, a spatially-distributed snow-evolution model (Liston & Elder, 2006). We use the the Jacksina Park Unit (PU) of the Wrangell-St-Elias for model calibration (see figs beginning right, and 'Field Site' figs below). SnowModel requires topographical data (90-m ASTER DEM, see right), vegetation data (NLCD2011, see mid-right), and meteorological forcing data (NASA Modern Era Retrospective-Analysis for Research and Applications; MERRA-2). Snow-survey and weather station data will be assimilated into the model as available. Simulation periods are determined by historical Dall Sheep observations.

MODEL INPUTS





CALIBRATION RUN

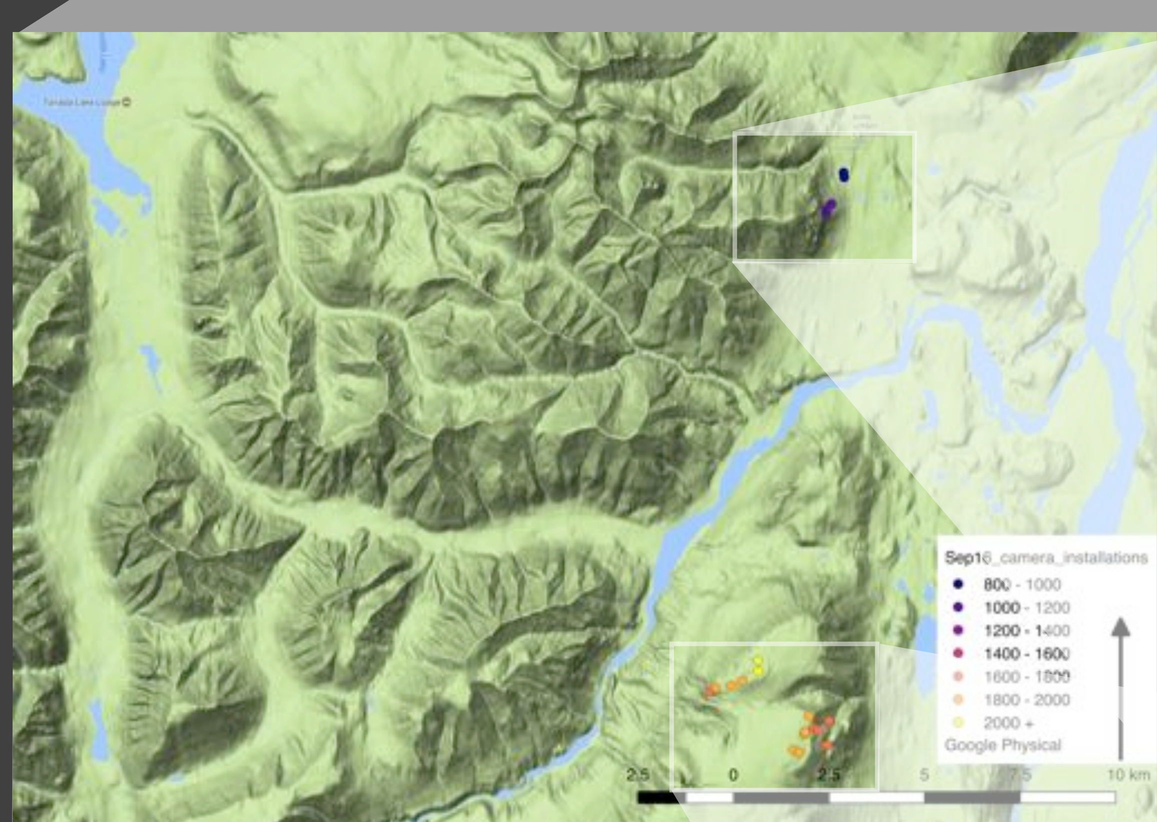


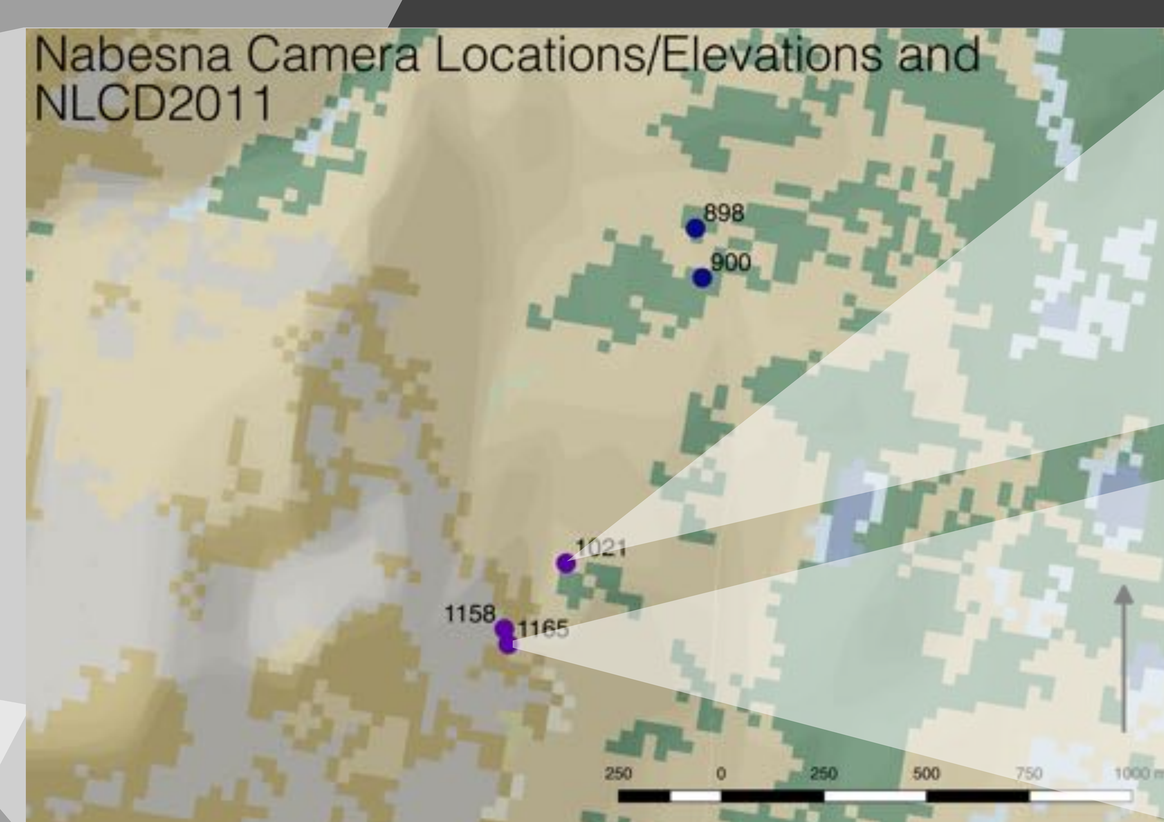
MODEL NOTES

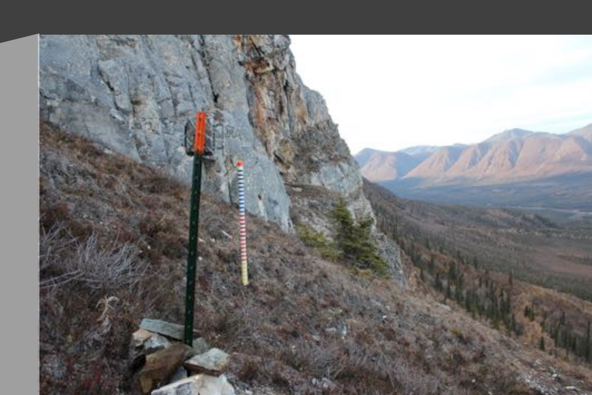
- 90m by 90m cells
- 781 by 969 grid
- 1 September 2000 to 1 June 2001
- 3hr time-step
- Wind increase with elevation implemented 25% per 1 km elevation gain
- Precipitation lapse rate reduced to 1/10th

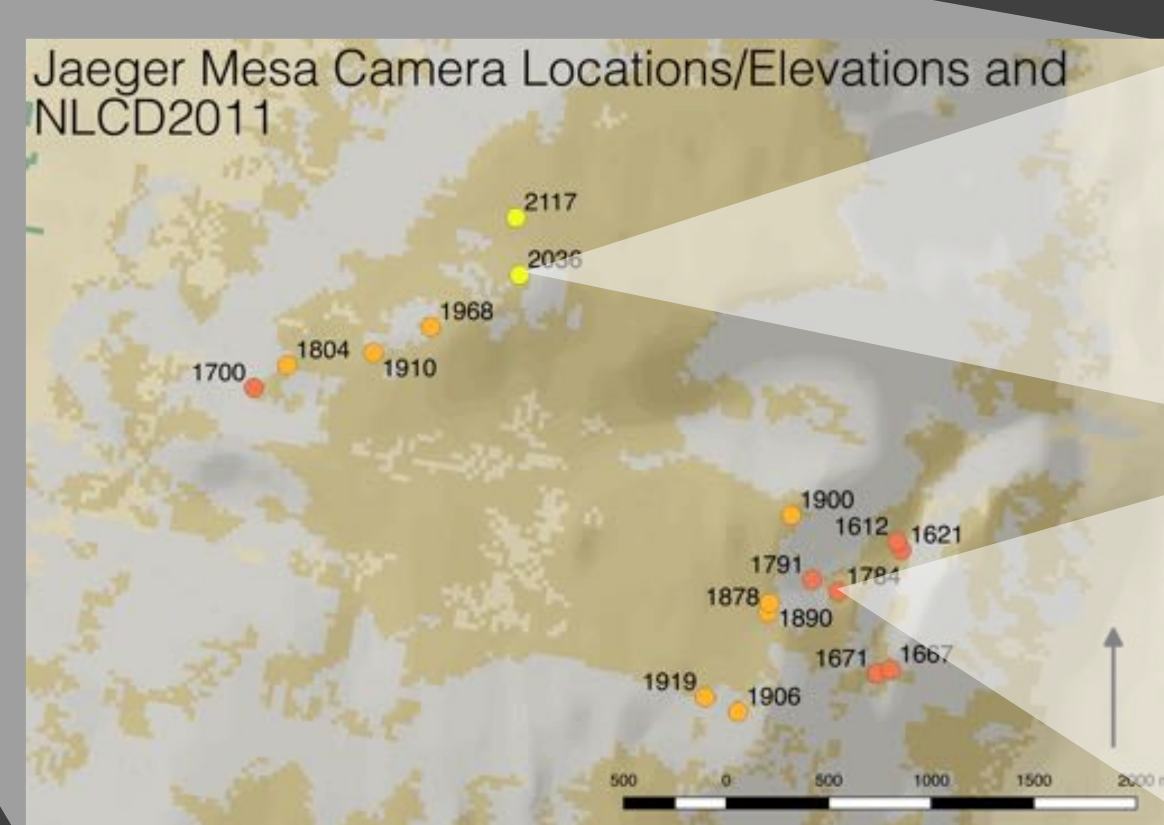
These parameters follow simulation for Lake Clark NP by Glen Liston for the Dall Sheep project. Very low simulated SWE shown in the left figure indicates the need for locally determined parameters

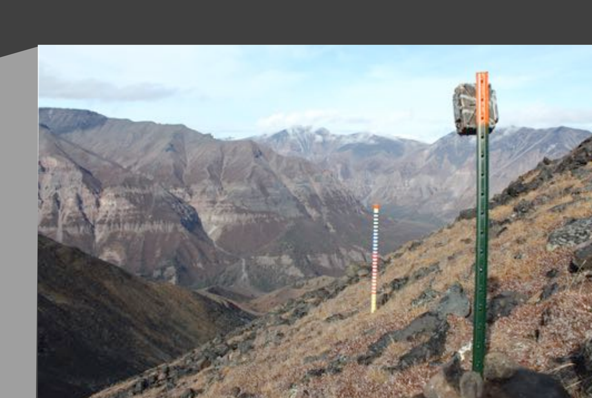
FIELD SITE











The figures above, above-right, and right, show the locations of 22 Reconyx PC900 wildlife cameras paired with a 10 cm demarcated snowstake (see photographs far right) installed in September 2016. The cameras are programmed and equipped to take hourly photographs throughout the winter; this allows us to determine snowpack evolution (see far right text panel) and, we hope, spy a few sheep.

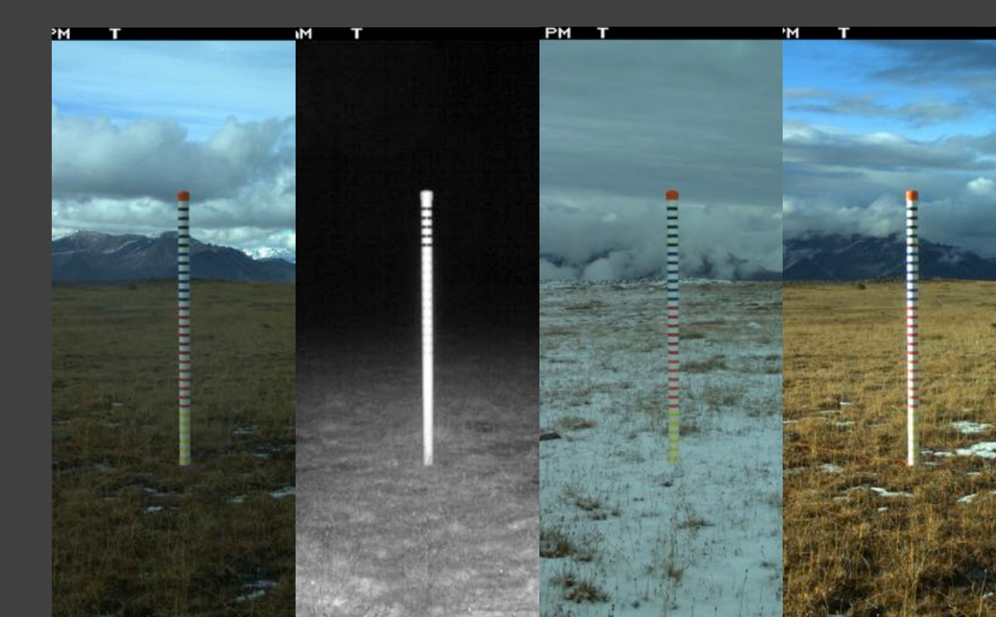
Cameras were located subjectively whilst in the field to best capture a range of elevations from alpine to boreal forest (~800 to ~2100 m), varying aspects and slope angles in complex terrain, and changing vegetation cover (see photos right). Two camera sites were established, the first near the small community of Nabesna (above-right figure), and the second in the northern part of Jaeger Mesa (right figure). These two locations represent a balance between accessibility, the above landscape variables, and preferable sheep terrain.

In March 2017 we will return to collect the cameras and conduct detailed surveying of snow depth and density. Use of a Snowhydro GPS Magnaprobe will enable an extensive coverage of snow depth measurements, which alongside snow depths derived from our camera sites, will inform future model parametization.

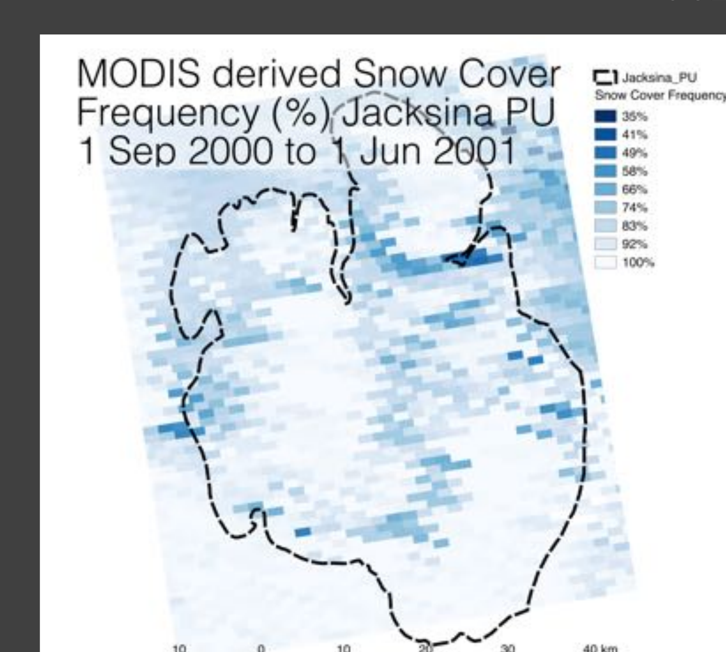
SNOW STAKE IMAGE ANALYSIS

The photographs to the right show a snow stake as photographed by a Reconyx PC900 at ~5 m distance. These images are from camera 1, located at 2117 m atop Jaeger Mesa and were taken on during field installation; from left to right 9/17/16 4PM, 9/18/16 1AM, 12PM, 6PM.

Calculation of snow depth will be conducted by automated image analysis following Garvelmann et al., (2013). Challenges include weather conditions obscuring camera lenses and/or snow stakes, disturbance by animals/weather, determination optimal daily lighting conditions, and volume of images; ~75,000 images recorded by 22 cameras in a 6 month deployment period.



REMOTE SENSING



The following remote sensing products will be investigated for use in combination with field and model data;

- Snow Cover Frequency (SCF) (see example at left) a MODIS/Terra daily snow cover product built in Google Earth Engine. SCF gives the percentage of snow-covered days within a given period per pixel
- Fractional Snow Covered Area (fSCA) product at 30-m resolution, from Landsat Thematic Mapper (TM), Enhanced Thematic Mapper (ETM+), and Operational Land Imager (OLI)
- MODSCAG - MODIS Snow Covered-Area and Grain size retrieval (Painter et al., 2009), a daily fSCA product at 500-m resolution for the period 2000-present
- A new enhanced resolution passive microwave product to detect snow melt/freeze events (http://nsidc.org/pmesdr/)

REFERENCES

Garvelmann, J., Pohl, S. and Weiler, M., 2013. From observation to the quantification of snow processes with a time-lapse camera network. Hydrol. Earth Syst. Sci, 17(4), pp.1415-1429.
Liston, G.E. and Elder, K., 2006. A distributed snow-evolution modeling system (SnowModel). Journal of Hydrometeorology, 7(6), pp.1259-1276.
Painter, T. H., Rittger, K., McKenzie, C., Slaughter, P., Davis, R. E. & Dozier, J. 2009)Retrieval of subpixel snow covered area, grain size, and albedo from MODIS. Remote Sensing of Environment 113(4), 868–879
Prugh, L., 2016. Camera and stake photographs used with permission