Monitoring Bioclimatic Indicators in Southwest Alaska National Parks

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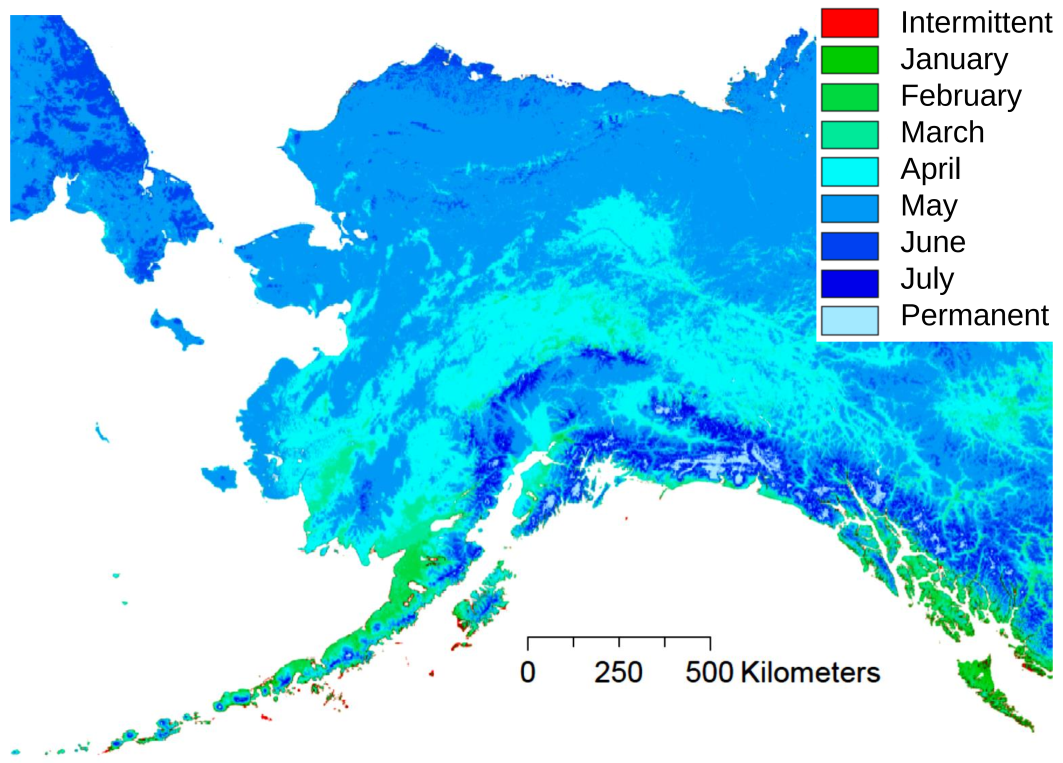
Introduction

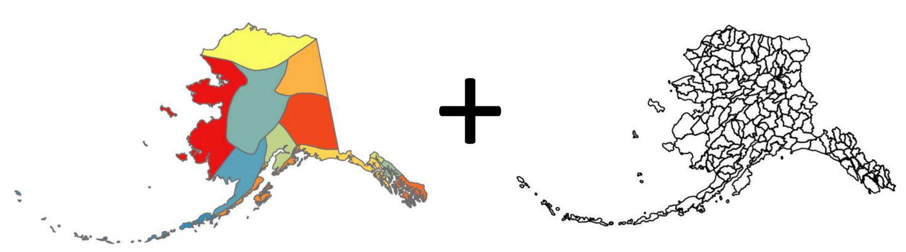
Southwest Alaska is a dynamic landscape experiencing rapid regional climate warming resulting in changes to ecosystem processes. These changes are most profound in locations where small increases in temperature shift precipitation regimes from snow to rain, melt snow earlier, and alter soil temperatures resulting in changes to active layer properties. The Southwest Alaska Network of the National Park Service Inventory and Monitoring program (SWAN) monitors long term trends and dynamics in ecosystem process and supports research in National Parks. Our data include satellite observations for 16 years of semi-polar snow phenology and in-situ observations from climate station networks and vegetation monitoring plots over a 3° latitudinal gradient. These data are being used to support intensive field studies, modeling and remote sensing calibration and validation activities for the NASA Arctic Boreal Vulnerability Experiment (ABoVE).

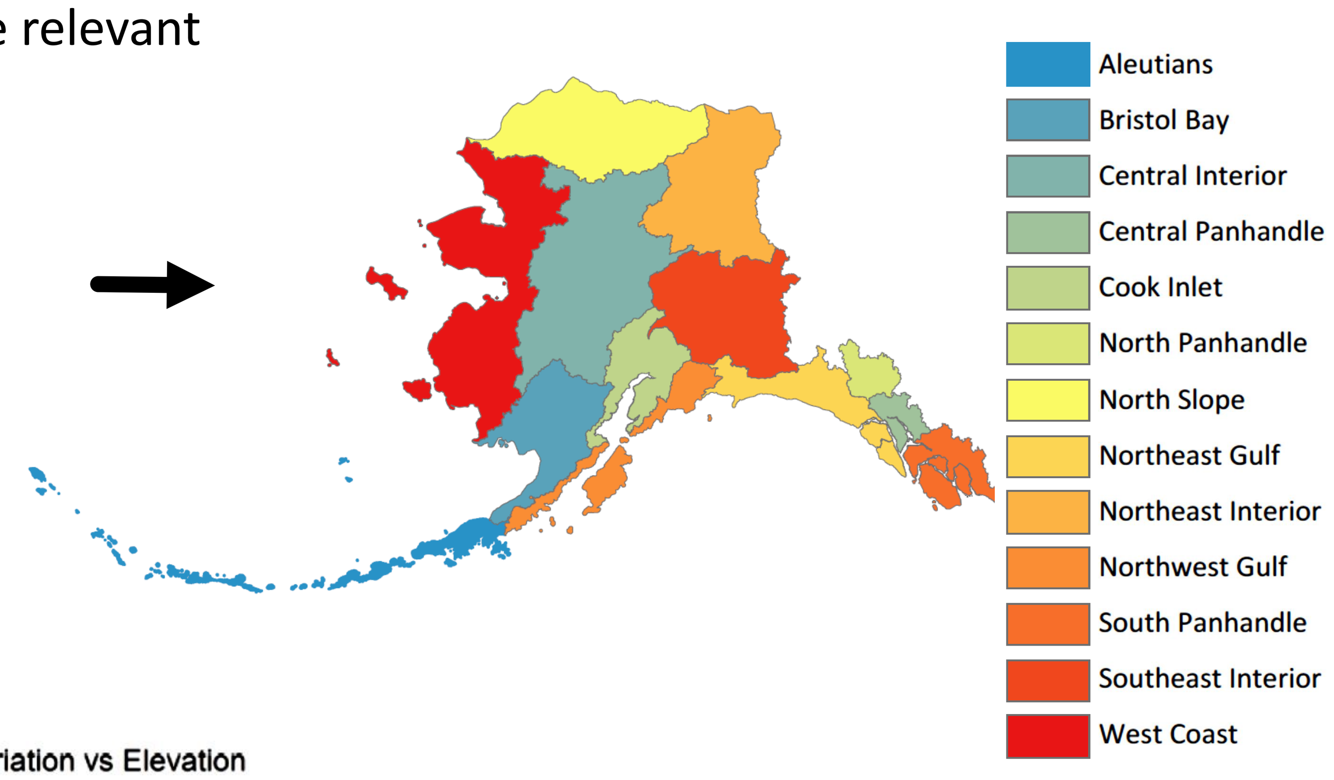
Snow

We used MODIS daily snow cover to generate annual metrics for 2001 to 2016 snow years to describe the onset of snow accumulation, melt and the variability of the snow season (Lindsay et. al. 2016). To create regionally coherent snow climatology we combined the recently developed Climate Divisions for the Alaska region and the level 8 Watershed Boundary Dataset, at the sub-basin level, to capture the hydroclimactic influences of topography (Bieniek et.al. 2012, Watershed Boundary Dataset 2016). By using this method features such as latitude, proximity to seas and seasonal sea ice and topography help define relevant climatic boundaries.

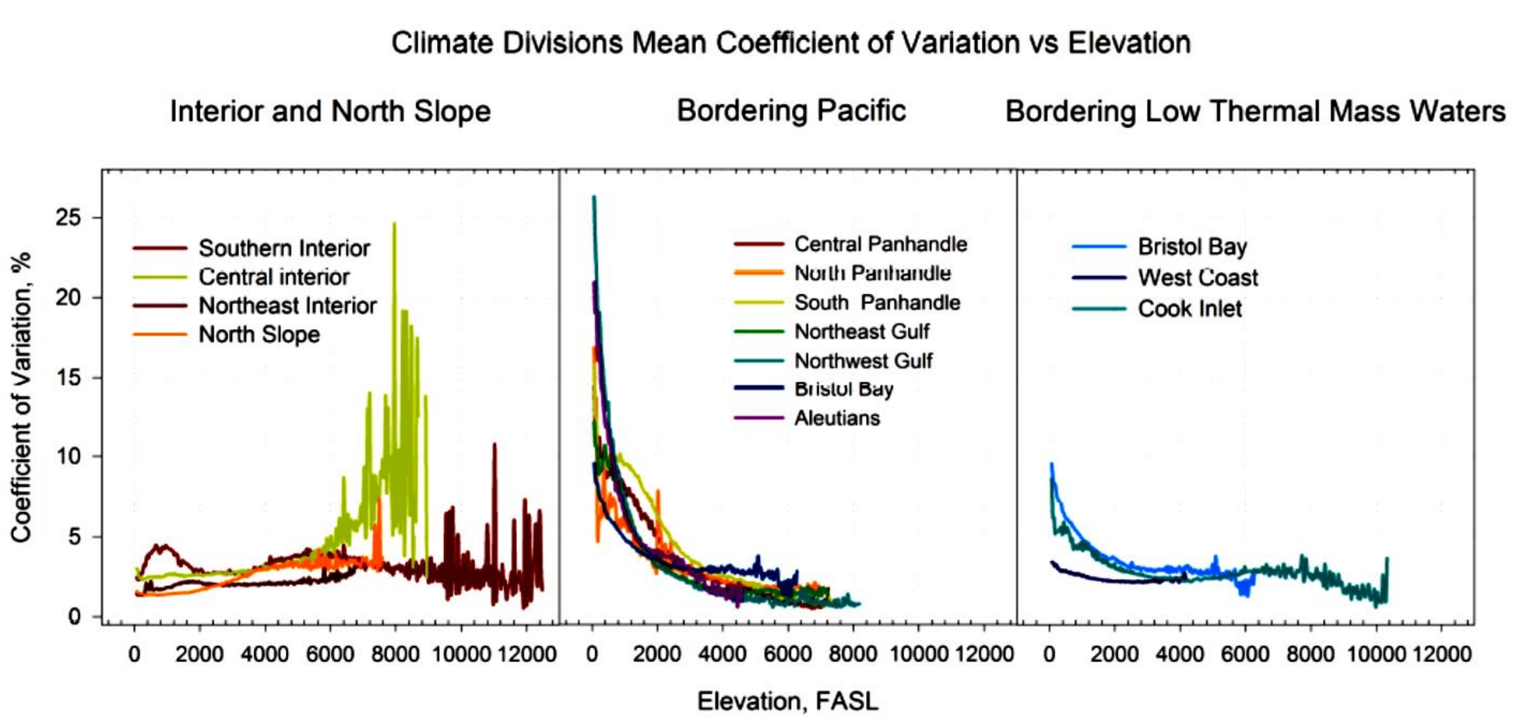


12 snow metrics were generated from MOD10A1 for the 16 year time series. The figure above is the median last day of continuous snow cover for 2001-2016, aggregated by month.

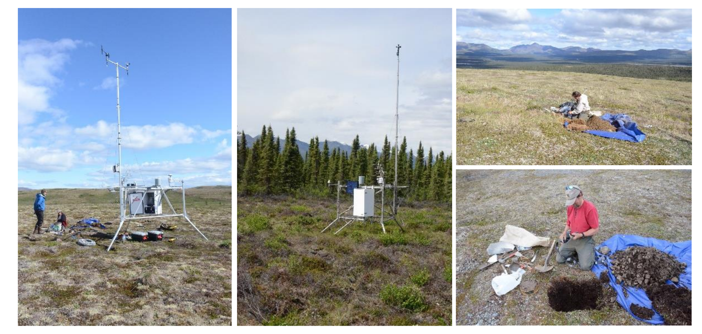




Using climate divisions (left) with hydrologic unit boundaries (center) creates coherent regions (right) for spatial analysis (Bieniek et.al. 2012, Watershed Boundary Dataset 2016).

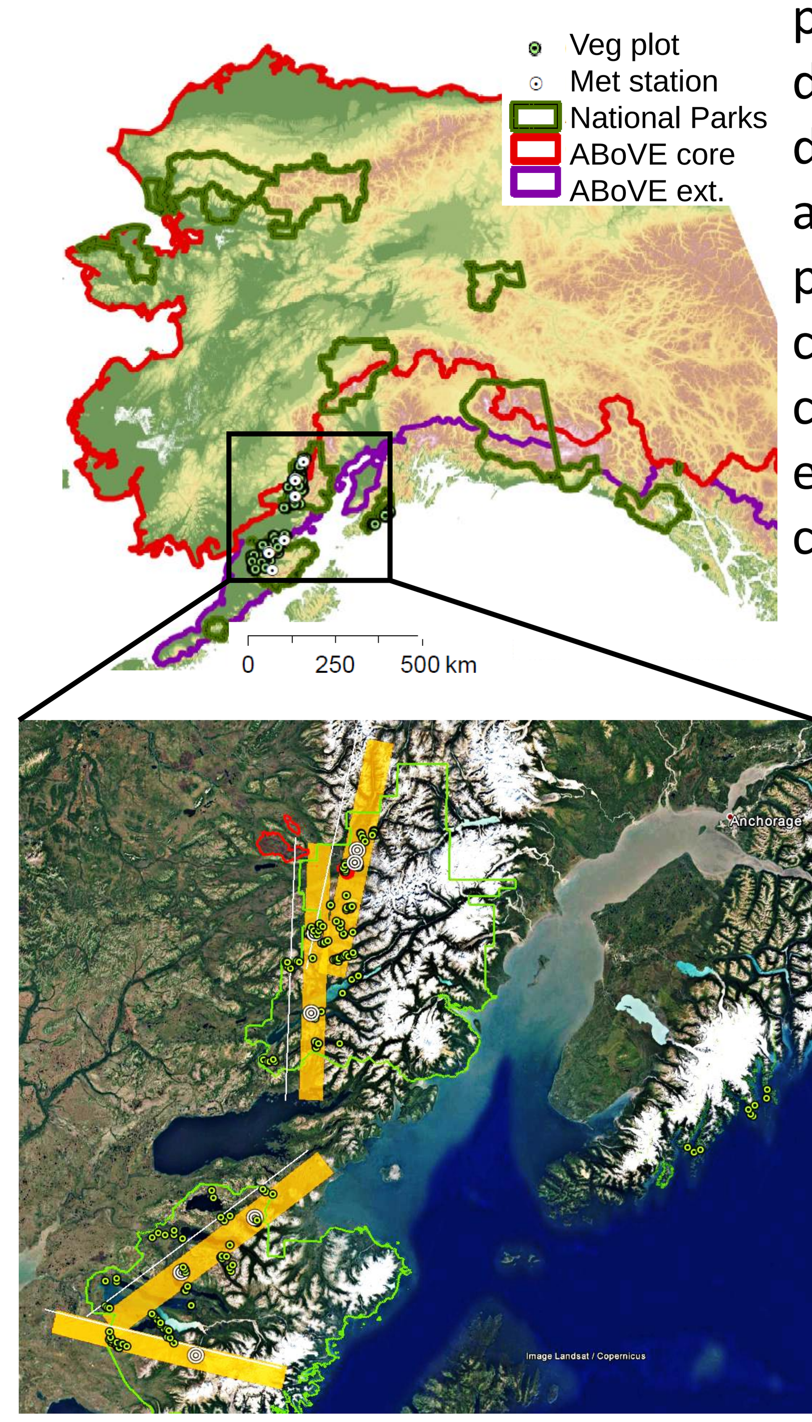


The coefficient of variation for 16 years of daily time series for the last day of continuous snowcover is plotted for each of the above climate divisions by elevation (left). The interannual variability demonstrates three patterns where: i.) interior and North Slope divisions show greater variability at higher elevations, ii.) divisions bordering the Pacific show variability dropping exponentially with rising elevation and iii.) divisions bordering shallow, low-thermal-mass seas show low interannual variability in length of snow season.



Measurement	Location	Metric
air temp, C	2 m	mean, min, max
RH, %	2 m	mean
wind speed, m/sec	6 m	mean, max, time
wind direction, deg	6 m	mean, max, time
rain total, mm	2 m	total
snow depth, cm	soil pit surface ~2 sq m	mean
surface IR, C	soil pit surface ~2 sq m	mean
incoming shortwave, w/m^2	2m	mean
soil temperature, C	5, 10, 20, 30, 50 cm	mean
soil moisture, VWC	5, 20, 50 cm	mean
soil conductivity, µS/cm	5, 20, 50 cm	mean
matric potential, kpa	10, 30 cm	mean

A transect of met stations have been established to monitor the listed meteorology and soil properties.

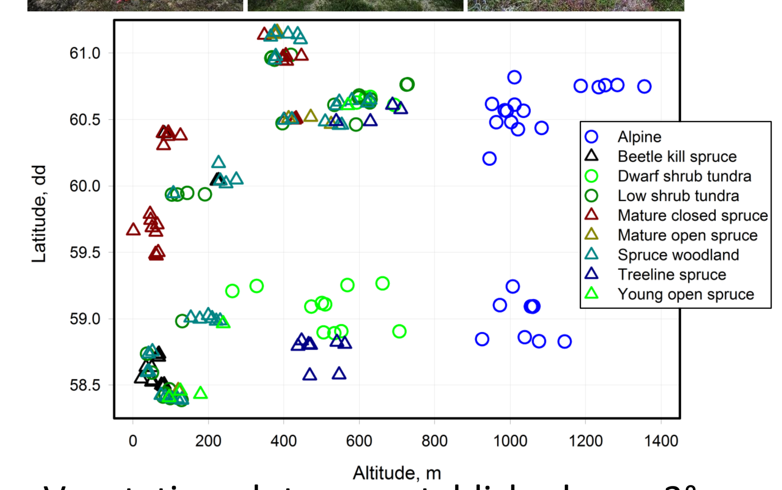


Met stations and veg plot locations with park and ABoVE core and extended boundaries (top). Proposed flight paths in Katmai and Lake Clark National Parks with 2015 fire outlines (bottom).

In-situ Observations

SWAN, (science.nature.nps.gov/im/units/swan/) maintains a network of 12 met stations and 172 vegetation monitoring plots for inventory and monitoring of natural resources in Southwest Alaska's 5 National Parks. Six met stations are configured in a latitudinal transect and monitor soil properties and the active layer. Together these observations provide a robust method to monitor current conditions and trends in bioclimate.

Established vegetation plots monitor a broad range of spruce forest, shrub and tundra ecosystems. At each plot soil characteristics and topography have been inventoried and repeat data is collected to estimate long-term changes in species richness, cover, diversity, physiognomy and changes in the demography of woody species. These data provide a basis for establishing above and below ground biomass, plant functional types and species composition which serves to characterize and spatially distribute ecosystem structure, function and carbon dynamics to landscape scales.



Vegetation plots are established over 3° latitude and 1400 m in elevation and cover a range of forested (top photos, triangles) and shrub and tundra ecosystems (bottom photos, circles).

Airborne Science

Landscape level (~50m resolution) low frequency (P-band) Radar observations are being obtained using the Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS) and (L-band) Unmanned Aerial Vehicle Synthetic Aperture Radar (UAVSAR) instrument. Primary permafrost soil properties to be examined include soil active layer moisture profile and freeze-thaw state variability, and depth to permafrost table. The AirMOSS retrievals will be guided and validated by the Southwest Alaska Network in situ measurements of soil temperature, soil moisture, vegetation properties and forward model simulations of radar backscatter properties and parameter retrieval uncertainty analyses. These data will be used to inform a succession of land surface hydrology and terrestrial carbon (CO_2 and CH_4) flux model simulations to investigate the impacts of permafrost soil dynamics and surface hydrology on vegetation growth and the ecosystem carbon budget.

References

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