**Northeast Alaska Climate**

*Using Earth Observations to Evaluate Snow Variability through a Climatological Analysis to Support Ecological Monitoring in Northeast Alaska*

**Project Team**

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**Project Overview**

***Project Synopsis:***

In recent decades, variability in snow cover has altered the ability of the northeastern Alaskan landscape to support resident and migratory wildlife in the Arctic National Wildlife Refuge (ANWR) and National Petroleum Reserve - Alaska. This project utilizes Earth observations to evaluate historic snow variables including snow depth, snow cover fraction, snow season duration, and snow water equivalent (SWE) from 2000 to 2022. This supports refuge managers’ efforts to monitor changes in snow conditions and proactively prepare for the ecological, cultural, and landscape impacts that changes in snow variability will cause in the future.

***Abstract:***

Alaska is experiencing climate change at an unprecedented rate, with temperatures increasing twice as fast as the national average. The resulting changes to the landscape and ecosystems are significant, including shorter winters, declining snow depth, thawing permafrost, and rapidly receding glaciers. These changes are not only exacerbating the negative impacts of oil exploration but also affecting the food security of indigenous communities that rely on resident wildlife as a subsistence food source. With the US Fish and Wildlife Service managing a potential tundra travel season for the first time in its history, adequate data on historic snow variables is essential to protect the unique habitat of the area. This project used NASA satellite and assimilation system data to inform and improve current understandings of snow patterns in the Arctic National Wildlife Refuge and the National Petroleum Reserve – Alaska. The DEVELOP team used MODIS Normalized Difference Snow Index data to determine snow season duration, snow change frequency, and first and last day of snow. The team also utilized the 2.1 Global Land Data Assimilation System and Daymet V4 products to study climatological trends in snow depth and snow water equivalent (respectively) across the study areas. This supports refuge manager and stakeholders’ efforts to increase public awareness of the effects of snow variability in Alaska that are caused by changing climactic patterns.

***Key Terms:***

Remote Sensing, MODIS, GLDAS, Snow Products, Alaska, Snow Water Equivalent, Snow Cover Fraction, Snow Depth

***Study Location:*** Arctic National Wildlife Refuge and National Petroleum Reserve – Alaska, AK

***Study Period:*** January 2000 to December 2022

***Community Concerns:***

* In recent decades, the rise in Arctic temperatures has been almost twice as large as the global average. Shifting patterns of snow variables affect the migration of caribou in the region, which in turn affects the food security of the communities that depend on these herds as a food source.
* Due to the increasing global demand for oil, seismic exploration is expanding in the arctic and poses a threat to areas with sensitive tundra vegetation and underlying permafrost soils. With high snow variation, managers lack the necessary resources to take proactive measures in order to address areas that may be involved in oil and gas exploration.

***Project Objectives:***

* Utilize NASA Earth observations to fill the gaps in current data used by project partners
* Run time series analyses on snow cover fraction, snow depth, and snow water equivalent
* Highlight variation in snow cover fraction presence based on first and last days of snow cover and the length of the continuous snow season
* Study and document climatological trends in seasonal snow cover to provide insight on changes in snow season duration

**Partner Overview**

***Partner Organization(s):***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **US Fish and Wildlife Service, Arctic National Wildlife Refuge** | Dr. Paul Leonard, Supervisory Wildlife Biologist | End User |
| **Alaska Climate Adaptation**  **Science Center** | Dr. Jessica Garron, Deputy University Director | Collaborator |

***Decision-Making Practices & Policies:***

The US Fish and Wildlife Service (USFWS) manages ANWR. As a whole, its responsibilities focus on stewardship of wildlife and landscapes, preserving their wilderness values, and ensuring the public uses available at the refuge can continue. USFWS deploys a host of management tools to address biological changes, including conducting surveys to determine distribution and population trends for a variety of wildlife species and studying plant communities and snow conditions to monitor changes over time associated with disturbance and climatic conditions. However, at the time of the study, USFWS is faced with managing a potential tundra travel season on ANWR for the first time in its history. Although refuge managers have invested in remote sensing, *in situ* measurements, and long-term monitoring, long-term data sets of the areas have not been summarized into a unified visualization or tool that can be used to inform tundra travel.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Terra MODIS** | Normalized Difference Snow Index (NDSI) | Snow cover fraction (estimated snow cover in percent) was measured from the Snow Cover Daily L3 Global 500m Grid Collection 6 at a 500m resolution from 2000 – 2022. |

***Ancillary Datasets:***

* To access snow depth, the team used the NASA model-based 2.1 Global Land Data Assimilation System (GLDAS-2.1) snow depth product. GLDAS-2.1 is forced with a combination of observation and model data from the NOAA/GDAS (Global Data Assimilation System), GPCP (Global Precipitation Climatology Project), and the AGRMET (Air Force Weather Agency’s AGRicultural METeorological modeling system).
* To access SWE, the team used the Daymet Version 4 SWE product. Daymet is a data product derived from a collection of algorithms and computer software designed to interpolate and extrapolate from daily meteorological observations to produce gridded estimates of daily weather parameters. Daymet V4 covers the period from January 1, 1980, to December 31, 2021, and has a 1 km x 1 km spatial resolution and a daily temporal resolution.

***Software & Scripting:***

* Python 3.9 (Anaconda) – Data acquisition and processing
* Google Earth Engine API – Data acquisition, preprocessing, and analysis
* ESRI ArcGIS Pro 3.0.0 – Data visualization and map creation

***End Product(s):***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Snow Time Series Analyses** | **Terra MODIS** | Project partners will use this product to quantify climate variables and temporal trends to understand historical snow fluctuations. | N/A |
| **Snow Variability Maps** | **Terra MODIS** | Snow variability maps will be used to calculate climatological normals and variability of each snow measurement in order to visualize areas with historical snow fluctuations. | N/A |
| **Snow-on and Snow-off Maps** | **Terra MODIS** | Snow-on and snow-off maps will help partners identify high snow seasonality across the study period in order to aid in the management of tundra travel. | N/A |
| **Snow Season Duration Maps** | **Terra MODIS** | This product will give partners contextual information on the duration of the snow season so they can tailor their Management Practices for areas with a shorter winter. | N/A |

***Product Benefit to End User:***

USFWS received maps of the study area showing the change in historic snow variables through ANWR and NPR-A. In order to identify areas where climatological variation occurred between 2000 and 2022, the team constructed maps that display snow cover fraction variability, average snow depth and SWE, season duration, and first and last day of snow. These maps will support the USFWS to manage ANWR based on future oil exploration and shifts in the ecology and migration patterns of resident wildlife based on snow variability. Partner organizations can also use the maps and end products created through this project to increase public awareness of the effects of snow variability in Alaska that are caused by changes climactic patterns.

**References**

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