NASA DEVELOP National Program

2024 Work Plan

Massachusetts – Boston

Alaska Ecological Conservation II

Using NASA Earth Observations to Identify Recent Changes in Vegetation Phenology and Its Impacts on Caribou Migration

Project Overview

***Project Synopsis*:**

In Northwestern Alaska, caribou (*Rangier tarandus)* herds migrate from their wintering grounds to calving areas each year. Research shows that the selection of calving zones is highly dependent on nutrient availability, therefore it is believed that patterns in vegetation phenology directly impact where caribou migrate for calving. Partners at the National Park Service (NPS) are interested in assessing if changes in vegetation phenology, including the timing of vegetation green up, peak, and senescence, correlate with observed shifts in caribou migration patterns. Using harmonized Landsat 8 and Sentinel-2 (HLS) imagery, patterns in vegetation phenology will be determined through time-series maps and plots that project partners can compare to observed caribou migration and calving patterns. NPS is interested in understanding the correlation between vegetation and calving zones as this information can inform National Petroleum Reserve – Alaska (NPRA) boundaries, some of which currently overlap with vegetated areas suitable for caribou calving.

Study Location: Northwestern AK
Study Period: 2000-2024, May 25th – June 15th

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Source of Project Idea: Collaboration with Kyle Joly from the National Park Service was first introduced by a professor at Boston University interested in collaborating on a project in the Northwest Territories and North Slope of Alaska. This conversation led to the idea of a multi-term collaboration studying different factors impacting caribou migration patterns. This is the second part of this study, following the Spring 2024 project that identified changes in river ice phenology since 2017. This project will analyze vegetation phenology within the same time period and help Kyle gain a better understanding of how changing patterns in vegetation impact where caribou choose to migrate to for calving.

Actionable Decision: The Western Arctic Heard in Northwestern Alaska has experienced significant decreases in population throughout the 21st Century. With these declines, the National Park Service (NPS) in Alaska has been making efforts to help sustain caribou populations by studying their habits, including having a better understanding of what has prompted changes in the timing of their migration since 2017. One initiative the NPS is currently working on is identifying where caribou calve and what vegetation factors impact these migration decisions currently and in the future. Currently, the National Petroleum Reserve – Alaska (NPRA) boundaries are being reviewed. Previous research suggests that the Western Arctic Herd's calving grounds extend further north than the suggested NPRA boundaries, so the partner I hopeful that this research can provide insight into where quality calving ground are located in order to inform future policy regarding these protected areas.

Partner Overview

Partner Organization:

Organization	Contact (Name, Position/Title)	Partner Type	Sector
National Park Service, National Park Service, Gates Of The Arctic National Park & Preserve	Kyle Joly, Wildlife Biologist	End User	Non-profit

End User's Current Decision-Making Process & Capacity to use Earth Observations:
The National Park Service currently studies the interactions between wildlife in Northwestern Alaska, including caribou, and their habitat, through fieldwork, GIS, and remote sensing. NPS is interested in observing how vegetation phenology impacts the location and timing of caribou calving. Understanding where caribou calve annually will help the NPS inform policy as the Bureau of Land Management revisits the location of the National Petroleum Reserve – Alaska (NPRA) boundaries. Currently, calving grounds overlap these boundaries, therefore products displaying trends in the location of calving zones can inform decision makers as they review and revise the NPRA boundaries. To date, partners at the NPS use Earth observations in their research and analysis and are interested in further applying it to vegetation phenology studies.

Partner Interest/Demand: The NPS is interested in analyzing different spatial and temporal trends in vegetation phenology in order to better understand where caribou may calve in the future. The information from this project can in turn help inform future policy regarding where the NPRA boundaries should be located.

Partner Communications: Conversations with Kyle Joly (NPS) have been ongoing since last fall. The first partner meeting is planned for 6/3_ at ___ EST and will occur at that same time every other week for the remainder of the term. Jackie will be the primary point of contact for the team.

Partner Experience: Kyle has extensive knowledge of caribou migration and the different phenomena that impact migration patterns. He has performed research in the same study region and has conducted projects studying the Western Arctic Herd and their annual migrations. Kyle is also familiar with the methods this study will use. He has used GIS, Landsat imagery, and remote sensing techniques in his previous research and has a good understanding of the different ways technology can be applied to projects such as this one.

Earth Observations Overview

Earth Observations:

Platform & Sensor	Parameter(s)	Use
Landsat 8 OLI	Spectral vegetation indices	Values derived from these sensors, via the Harmonized Landsat 8 OLI Sentinel-2 MSI Product, will be applied to the Multi-Sensor Land Surface (MS – LSP) algorithm to produce timeseries using the two-band Enhanced Vegetation Index (EVI). Results from this algorithm will be visualized through timeseries maps and plots.
Sentinel-2 MSI	Spectral vegetation indices	Values derived from these sensors, via the Harmonized Landsat 8 OLI Sentinel-2 MSI Product, will be applied to the Multi-Sensor Land Surface (MS – LSP) algorithm to produce timeseries using the two-band Enhanced Vegetation Index (EVI). Results

		from this algorithm will be visualized through timeseries maps and plots.
MuSLI Land Surface Phenology V1.1 Data Product	Spectral vegetation indices	This product will be used to retrieve phenological metrics and dates of phenophase transitions. Results will be visualized through timeseries maps and plots and compared to products derived from the Harmonized Landsat 8 OLI Sentinel-2 MSI Product.

Software & Scripting:

- Google Earth Engine (GEE) JavaScript API – acquire data and perform analysis on Landsat and Sentinel imagery to identify key vegetation phenology benchmarks
- ESRI ArcGIS Pro – process data and visualize vegetation phenology timeseries maps

Ancillary Datasets:

- National Park Service Calving Ground Shapefile – shapefile including the location of caribou calving zones in Northwest Alaska to delineate boundaries for study site analyses

Decision Support Tool & End Product Overview

End Products:

End Product	Partner Use	Datasets & Analyses
Vegetation Phenology Timeseries Charts	Plots will display the day of year for vegetation start of greenup, greenup midpoint, maturity, peak, senescence, senescence midpoint, and dormancy to gain information on vegetation phenology that can be compared with caribou calving data. Length of season as well!!	Data from the Harmonized Landsat 8 Sentinel-2 product will be applied to the Multi-Sensor Land Surface algorithm to produce daily EVI2 timeseries to determine key dates of vegetation phenology.
Vegetation Phenology Timeseries Maps	Maps will reflect the key information derived from the Vegetation Phenology Charts, mapping spatial variation in day of year for greenup, vegetation peak, senescence, etc. to identify temporal and spatial changes in vegetation phenology timing. This information will be compared with caribou calving location and timing data.	Data from the Harmonized Landsat 8 Sentinel-2 product will be applied to the Multi-Sensor Land Surface algorithm to produce daily EVI2 timeseries to determine key dates of vegetation phenology. This information will be visualized using GEE or ArcGIS Pro.
Social Media Series	A short series of Twitter and Facebook posts describing shifts in vegetation phenology and the potential impacts it can have on the timing of caribou migration and calving.	N/A

Project Timeline & Previous Related Work

Project Timeline: 2 Terms: (2024 Spring) to (2024 Summer)

Multi-Term Objectives:

- **Term 1:** 2024 Spring (MA) – Alaska Ecological Conservation
    - Caribou populations in Northwestern Alaska have decreased throughout the 21st Century as climate change and anthropogenic influence have increased in this region. Resulting shifts in river ice formation and phenology are believed to deflect caribou migration patterns, including cross-river travel. This project identified changes in annual river ice formation using Earth Observations, in addition to assessing the feasibility of using different Earth Observation products for this analysis. The team produced time series maps and plots depicting river ice phenology with true-color imagery, various spectral indices, and Sentinel-1 SAR C-Band backscatter values. After comparing these products' results, the team found that SAR data was more successful in analyzing river ice presence, while optical imagery better identified ice onset dates each year.
- **Term 2 (Proposed Term):** 2024 Summer (MA) – Alaska Ecological Conservation II
    - The second term will investigate vegetation phenology in caribou calving zones. After seasonal migrations, caribou aim to calve in areas with healthy, abundant vegetation that provides nourishment for their calves. Using Earth observations, this project will detect changes in vegetation phenology through time series analysis to see if caribou migrations target the time and areas of peak vegetation. This will help NPS further understand caribou migration and inform future policy for land protection in the National Petroleum Reserve – Alaska so that it includes calving grounds within its protected zones. As the conclusion to this project, this, in conjunction with results on river ice phenology, will help to understand how changes in ecological trends have shifted caribou behavior.

Similar Past DEVELOP Projects:

- 2021 Spring (MSFC) – Bhutan Water Resources II: https://appliedsciences.nasa.gov/what-we-do/projects/comparing_phenology_precipitation_and_temperature_data_in_bhutan_to_assist_the_himalayan_environmental_rhythm_observation_and_evaluation_system_heroes_project
- Spring 2021 (CO) – Colorado River Basin Water Resources: https://appliedsciences.nasa.gov/what-we-do/projects/pairing_phenology_citizen_science_observations_with_nasa_earth_observations_to_monitor_riparian_vegetation

Related to other NASA work? No

Resources & Trainings

Key Papers & Resources to Read:

Papers:

- Bolton, D. K., Gray, J. M., Melaas, E. K., Moon, M., Eklundh, L., & Friedl, M. A. (2020). Continental-scale land surface phenology from harmonized Landsat 8 and sentinel-2 imagery. *Remote Sensing of Environment*, *240*, 111685. https://doi.org/10.1016/j.rse.2020.111685
- LP DAAC. (n.d.). *LP DAAC - release of Musli Land Surface Phenology v1.1 data product*. Release of MuSLI Land Surface Phenology V1.1 Data Product. https://lpdaac.usgs.gov/news/release-of-musli-land-surface-phenology-v11-data-product/

- Post, E., Bøving, P. S., Pedersen, C., & MacArthur, M. A. (2003). Synchrony between Caribou Calving and plant phenology in depredated and non-depredated populations. *Canadian Journal of Zoology*, *81*(10), 1709–1714. https://doi.org/10.1139/z03-172
- Severson, J. P., Johnson, H. E., Arthur, S. M., Leacock, W. B., & Suitor, M. J. (2021). Spring phenology drives range shifts in a migratory Arctic ungulate with key implications for the future. *Global Change Biology*, *27*(19), 4546–4563. https://doi.org/10.1111/gcb.15682
- U.S. Department of the Interior. (n.d.). *New insights from an enduring tool: Using GPS data to detect calving events in Alaskan caribou herds (U.S. National Park Service)*. National Parks Service. https://www.nps.gov/articles/000/aps-20-1-9.htm

Technical Resources:
- ARSET – Fundamentals of Remote Sensing
- ARESET – Spectral Indices for Lands and Aquatic Applications (I wouldn't prioritize this one, may want to just look at EVI and NDVI)

Software Carpentry: Early in the term, coding workshops are offered. Participants are signed up for lessons based on the project methods and goals
- Google Earth Engine

Team Brainstorming

The team, with the guidance of the Center Lead, will brainstorm how to best approach this project during Week 1. During this time participants can ask questions about the work plan, data, methods, partner, etc.

Notes & References:

Notes: Make sure to review the first part of this project once it has gone through export control. The DEVELOPedia page for the project is linked here.

References:

List out any relevant content or websites; however, please note that citations should not be included in the text in the body of the proposal.

Bolton, D. K., Gray, J. M., Melaas, E. K., Moon, M., Eklundh, L., & Friedl, M. A. (2020). Continental-scale land surface phenology from harmonized Landsat 8 and sentinel-2 imagery. *Remote Sensing of Environment*, *240*, 111685. https://doi.org/10.1016/j.rse.2020.111685

LP DAAC. (n.d.). *LP DAAC - release of Musli Land Surface Phenology v1.1 data product*. Release of MuSLI Land Surface Phenology V1.1 Data Product. https://lpdaac.usgs.gov/news/release-of-musli-land-surface-phenology-v11-data-product/

Post, E., Bøving, P. S., Pedersen, C., & MacArthur, M. A. (2003). Synchrony between Caribou Calving and plant phenology in depredated and non-depredated populations. *Canadian Journal of Zoology*, *81*(10), 1709–1714. https://doi.org/10.1139/z03-172

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U.S. Department of the Interior. (n.d.). *New insights from an enduring tool: Using GPS data to detect calving events in Alaskan caribou herds (U.S. National Park Service)*. National Parks Service. https://www.nps.gov/articles/000/aps-20-1-9.htm