**NASA DEVELOP National Program**

2024 Work Plan

**Massachusetts – Boston**

**Alaska Ecological Conservation**

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

**Project Overview**

***Project Synopsis*:** In Northwestern Alaska, pronounced seasonal differences prompt caribou (*Rangifer tarandus)* herds to migrate to and from their wintering grounds to calving areas each year. Warming temperatures and associated shifts in river-ice phenology have the potential to challenge the caribous’ ability to cross large rivers along their migration routes. Partners at the National Park Service (NPS) are interested in assessing if observed changes in the timing of river ice formation have contributed to changes in observed caribou migration patterns since 2017. Using Landsat 7 ETM+, Landsat 8 and 9 OLI, and Sentinel 2A/B MSI imagery, the timing of annual river ice formation and melting will be determined through the creation of mapped time-series and compared to observed caribou migration patterns. NPS is interested in understanding shifts in migrations to help mitigate the continuing decline of caribou populations in Northwestern Alaska, in addition to informing hunting regulations in areas of cross-river migration.

***Study Location:*** Northwestern Alaska

***Study Period:*** September 2017 - December 2023

***Advisor(s):*** Dr. Cedric Fichot (Boston University), cgfichot@bu.edu

***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. The first part of this project will identify changes in river ice phenology since 2017, while the second will analyze vegetation phenology within the same time period.

***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, including cross-river migration, since 2017. One initiative the NPS is currently working on is monitoring caribou harvesting. Since local hunters use rivers for hunting, there is a nexus between hunting regulation, hunting timing, and the potential need to adjust regulations. By understanding river ice phenology patterns, the NPS can help inform future hunting regulations in areas of cross-river migration to help better protect this species and understand the causes of migration deflection.

**Partner Overview**

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** | **Sector** |
| **National Park Service** | Kyle Joly, Wildlife Biologist | End User | Non-profit |

***End User’s Current Decision-Making Process & Capacity to use Earth Observations:***

The National Park Service (NPS) currently studies the interactions between wildlife in Northwestern Alaska, including caribou, and their habitat, through fieldwork, GIS, and remote sensing. One initiative NPS is currently involved in is managing caribou harvesting. The Western Arctic Herd in Alaska has declined from 490,000 caribou in 2003 to 152,000 in 2023. With expectations that this count will continue to decrease, NPS is interested in learning more about the timing of caribou migration and the deflections and delays significantly impacting migration. Research investigating such phenomena can inform future hunting regulations. Currently, the partners at NPS use Earth Observations in their research and analysis and are interested in further applying it to river ice phenology studies.

***Partner Interest/Demand***: The NPS is interested in identifying the timing of river ice formation and melting in Northwestern Alaska. River ice phenology timeseries maps and plots will be able to assign estimated dates to these phenomena for rivers that the partners will help the team identify early on in this term.

***Partner Communications***: Conversations with Kyle Joly (NPS) have been ongoing since last fall. The first partner meeting is planned for 1/30 at 11AM EST and will occur at that same time every other week for the remainder of the term. Christian will be the primary point of contact for the team.

***Partner Experience:*** Kyle has extensive knowledge of caribou migration and the different phenomena, including river ice, that impact migration patterns. He has performed research in the same study region and has conducted projects studying the Western Arctic Herd and their cross-river 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 7 ETM+** | Spectral Ice Indices | Landsat 7 TM data will be analyzed in Google Earth Engine to identify areas and dates of river ice formation and melting. |
| **Landsat 8 OLI** | Spectral Ice Indices | Landsat 8 OLI data will be analyzed in Google Earth Engine to identify areas and dates of river ice formation and melting. |
| **Landsat 9 OLI** | Spectral Ice Indices | Landsat 8 OLI data will be analyzed in Google Earth Engine to identify areas and dates of river ice formation and melting. |
| **Sentinel-2 A/B MSI** | Spectral Ice Indices | Sentinel-2 data will be analyzed in Google Earth Engine to identify areas and dates of river ice formation and melting. |
| **Sentinel-1 A/B SAR** | Spectral Ice Indices | Sentinel-1 data will be analyzed in Google Earth Engine to identify areas and dates of river ice formation and melting. |

***Software & Scripting:***

* Google Earth Engine (GEE) JavaScript API – acquire data and perform river ice detection using an ice index and thresholds
* ESRI ArcGIS Pro – process data and visualize river-ice timeseries maps

***Modeling:***

* Continuous Change Detection Classification (Curtis Woodcock, Boston University) -- CCDC algorithm to in GEE to identify river ice formation timing

**Decision Support Tools & End Product Overview**

***End Products:***

|  |  |  |
| --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** |
| **River-Ice Phenology Timeseries Maps** | Timeseries Maps will provide partners with data to identify annual trends and gradual shifts in river ice formation and melting. Analysis of these maps can help determine the influence of river ice phenology on recent shifts in the deflection of caribou migration.  | Landsat 7 ETM+, Landsat 8 OLI, and Sentinel-2 data will be used to create time series maps using the visible bands to produce maps in ArcGIS Pro. |
| **River-Ice Phenology Timeseries Trends** | Timeseries trends will plot river ice phenology at specified locations to provide NPS with data on annual trends of both ice formation and melting. Analysis of these plots can be used by NPS to compare with caribou migration dates and locations. | Landsat 7 ETM+, Landsat 8 OLI, and Sentinel-2 data will be used to determine dates of river ice formation and melting using an ice index and thresholds.  |
| **Identification of Ice Formation Date** | Plots identifying the day of ice formation at specified locations each year to convey long-term trends. Plots can be compared with NPS’s caribou tracking data to find correlations with migration dates. | Landsat 7 ETM+, Landsat 8 OLI, and Sentinel-2 data will be applied in Google Earth Engine using the Continuous Change Detection and Classification algorithm to identify the annual date of river ice formation. |
| **Social Media Series** | A short series of Twitter and Facebook posts describing shifts in river ice phenology and the potential impacts it can have on the timing of caribou migration. | N/A |

***End-Product Priorities***:

* **Timeseries of river ice** formation (top priority) and melting in 3-5 specified locations throughout the study period. These can be used to identify trends that can then be related to how caribou move in that area.
	+ **Timeseries plots** of river ice phenology at these specified locations can complement the timeseries maps

**Project Timeline & Previous Related Work**

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

***Multi-Term Objectives:***

* **Term 1 (Proposed Term):** 2024 Spring (MA) – Alaska Ecological Conservation I
	+ 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 aims to identify changes in annual river ice formation and melting using Earth Observations. While this term investigates one threat to caribou populations, the partner has expressed interest in looking at another potential determinant: vegetation phenology in calving zones. Investigating vegetation phenology will provide a more holistic view of how climate change and human involvement in northwestern Alaska impact caribou migration and overall resilience.
* **Term 2:** 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. At the conclusion ~~t~~of this project, this, in conjunction with results on river ice phenology, will help managers to understand how changes in ecological trends have shifted caribou behavior.

***Similar Past DEVELOP Projects***:

* 2023 Spring (NC) – Northeast Alaska Climate: <https://www.devpedia.developexchange.com/dp/index.php?title=Northeast_Alaska_Climate_NC_Spring_2023>
* 2017 Summer (ARC) – Chile Water Resources II: <https://www.devpedia.developexchange.com/dp/index.php?title=Chile_Water_Resources_II_ARC_Summer_2017>
* Potential (need Tech Paper access): 2015 Fall (UGA) – Antarctica Climate: <https://www.devpedia.developexchange.com/dp/index.php?title=Antarctica_Climate_UGA_Fall_2015>

***Related to other NASA work?*** No

**Resources & Trainings**

***Key Papers & Resources to Read***:

* Joly, K., Gunn, A., Côté, S., Panzacchi, M., Adamczewski, J., Suitor, M. & Gurarie, E. (2021). Caribou and reindeer migrations in the changing Arctic. *Animal Migration*, *8*(1), 156-167. <https://doi.org/10.1515/ami-2020-0110>
* Li, H., Li, H., Wang, J., & Hao, X. (2021). Identifying river ice on the Tibetan Plateau based on the relative difference in spectral bands. *Journal of Hydrology*, *601*, 126613. <https://doi.org/10.1016/j.jhydrol.2021.126613>
* U.S. Department of the Interior. (n.d.). *Using satellite imagery to detect the changing seasonality of river ice (U.S. National Park Service)*. National Parks Service. <https://www.nps.gov/articles/000/aps-22-1-7.htm>

***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**

*In this section, the team, with the guidance of the Center Lead, will brainstorm how to best approach this project. Included is a first draft of a project workflow and additional datasets needed to complete the project. This section may be modified.*

***Project Workflow:***

***Additional Datasets:***