NASA DEVELOP National Program
California – JPL

Project Summary – Fall 2018

Alaska Ecological Forecasting
Automated Wetland Hydroperiod Mapping by Integrating Optical Satellite Imagery and Synthetic Aperture Radar

VPS Title: Under the Radar: Where the Wetlands SAR

Project Team

***Project Team*:**
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Project Overview

***Project Synopsis*:** Alaska's wetlands provide important ecosystem services, including nutrient retention, water purification, and habitat. In order for the US Fish and Wildlife Service (USFWS) to better map and manage Alaska's wetlands for the National Wetlands Inventory (NWI), the DEVELOP team worked with the Alaska Satellite Facility (ASF) to produce and review inundation products created from radar and optical imagery. Wetland inundation is the most important factor controlling wetland function and extent, and a tool to detect inundation will support the development and refinement of NWI wetland maps in Alaska, while also enhancing the capacity of operational federal programs to use Synthetic Aperture Radar (SAR).

***Abstract*:**
Alaska's wetlands cover approximately one third of the state and provide a multitude of ecosystem services, including nutrient retention, water purification, and provision of habitat for fish, wildlife, and vegetation. The temporal variation in wetland inundation affects these ecosystem functions, and for effective wetland policy and management, it is important to track patterns and changes in inundation. In collaboration with the US Fish and Wildlife Service (USFWS), Alaska Satellite Facility (ASF) and the University of Alaska Fairbanks (UAF), the Fall 2018 NASA DEVELOP Alaska Ecological Forecasting team produced a inundation tool to detect and classify inundation extent in Alaska's wetlands from C-band Synthetic Aperture Radar (SAR) data. The team used earth observation products, including Sentinel-1 C-SAR, Landsat 8 Operational Land Imager (OLI), PlanetScope, and RapidEye satellite imagery, to create the tool's thresholding algorithm and to generate land cover classifications for validation. The inundation tool effectively mapped wetland inundation due to SAR imagery's sensitivity to water and reliable data collection on cloudy days. The optical datasets, Landsat 8 OLI and high-resolution Planet Labs imagery, were limited by cloud cover and detection of inundation below vegetation and canopy cover, but were helpful for visual validations of Sentinel-1 C-SAR classifications. The tool's ability to map wetland inundation, can support the development and refinement of National Wetland Inventory (NWI) wetland maps in Alaska, and build the capacity of operational federal programs to use SAR.

Keywords: Remote sensing, wetlands, Alaska, Synthetic Aperture Radar, inundation

National Application Area Addressed: Ecological Forecasting
Study Location: Alaska (AK)
Study Period: January 2017 – December 2017; Forecasting to 2025

Community Concern:

- Wetlands provide crucial ecosystem services for both humans and wildlife, such as the provision of habitats, water storage, maintenance of water flow, improvement of water quality, and alleviation of flooding.
- Partners at the NWI have created the Wetlands Mapper, an online platform to disseminate digital maps of America's wetlands that help the public and resource managers understand, conserve, and restore wetlands. However, this map is completed for only one third of Alaska.
- Wetland inundation dictates wetland extent and function, and a tool to detect inundation in Alaska's wetlands will assist in generating or refining wetland map products.

Project Objectives:

- Implement an algorithm to detect inundation extent in Alaska's wetlands from C-SAR data
- Integrate the tool with ASF's Hybrid Pluggable Processing Pipeline (HyP3)
- Augment the NWI's mapping capability
- Create time series maps of inundation
- Validate inundation products from Sentinel-1 imagery using optical and ground data

Partner Overview

Partner Organizations:

Organization	POC (Name, Position/Title)	Partner Type	Boundary Org?
US Fish and Wildlife Service, National Wetlands Inventory	Megan Lang, Chief Scientist	End User	Yes
Alaska Satellite Facility	Jeremy Nicoll, Deputy Director; Franz Meyer, Chief Scientist	Collaborator	No
University of Alaska Fairbanks	Anna Liljedahl, Research Associate Professor	Collaborator	No

Decision Making Practices & Policies:
The NWI is a congressionally mandated resource developed by the USFWS to provide the public with detailed information about wetlands in the United States, including their location and classification type. Resource managers use this inventory to advance wetland understanding, conservation, and restoration. The NWI manually delineate wetland boundaries with very fine resolution optical remote sensing imagery and validation from field technicians. The NWI geospatial products represent the most accurate and spatially detailed wetland maps available for the United States. However, due to the intensive mapping process used to create the dataset, the NWI products are only available for approximately one third of Alaska.

Project Benefit to End User:
The wetland inundation tool developed with SAR data will help improve the NWI's automated wetland mapping capacity. The increased automation of this process will reduce mapping costs, as NWI pays their contractors by the hour to manually create the images. Currently, the USFWS classifies wetland areas

depending on levels and types of ecosystem functions and habitat. This tool and project will assist with producing maps of wetland classifications for Alaska.

Earth Observations & End Products Overview

Earth Observations:

Platform & Sensor	Parameter(s)	Use
Sentinel-1 C-SAR	Backscatter values, surface roughness	SAR data was used to develop a methodology for deriving soil saturation and wetland inundation
RapidEye	Surface Reflectance, Top of Atmosphere Reflectance	PlanetScope is a 5 meter resolution optical dataset that was used to validate SAR inundation classifications..
Landsat 8 OLI	Surface reflectance, panchromatic sharpening	Landsat 8 OLI is a 30 meter resolution dataset that was used to delineate wetland features. Image enhancement techniques were developed and fine-tuned to delineate those features.
PlanetScope	Surface reflectance	PlanetScope is a 3 meter resolution optical dataset that was used to validate SAR inundation classifications.

Ancillary Datasets:

US Fish and Wildlife Service National Wetlands Inventory – assess the general wetland functions and cover types

Modeling:

Water Balance Simulation Model (WaSiM) (POC: Anna Liljedahl, University of Alaska Fairbanks) – models spatial and temporal hydrological changes in river basins

Software & Scripting:

Esri ArcGIS – create quality maps for presentations and reports
Exelis ENVI – raster manipulation and analysis, image enhancement, image classifications
Python 2.7.15 – scripting language to batch process and classify imagery
Jupyter Notebook – programming platform
Geospatial Data Abstraction Library (GDAL) 2.3.1 – geoprocessing library
Rasterio 1.0.4/1.0.5 – python geospatial raster data abstraction tool

End Products:

End Products	Earth Observations Used	Partner Benefit & Use	Software Release Category
Wetland Inundation Tool	Sentinel-1C-SAR SMAP Landsat 8 OLI PlanetScope	The partner will use the tool to replicate their inundation maps and apply the algorithm to create an ancillary datasets.	IV
Water Balance Model Validation Products	Landsat 8 OLI Sentinel-1C-SAR	The WaSiM model was run on Crea Creek and Goldstream Valley in Alaska. Our inundation tool served as	I

		validation to the modeled hydrological processes.	

Project Handoff Package

Transition Plan:

The team handed off the preliminary end products to the partner for their feedback via email and hosted a video conference presentation explaining how the tool's products were created. A tutorial was provided for the partners' convenience on the tool's functionality. The final decision support tool hand off is planned after the proposed second term. A software release was completed to be included in the hand off. The team will also provide the partner with a walkthrough of the tool upon the software's completion.

Software Release Plan:

In our first partner meeting, the team communicated the necessary software release process and anticipated a six month delay for delivery of the inundation software and its source code. The team will provide tutorials and software documentation upon delivery of the software release. After the software release process is completed, the code will be shared to project partners.

Project Continuation Plan:

The team tracked and recorded methodology and saved downloaded data on an external hard drive. All codes were annotated thoroughly and have corresponding ReadMe files. The technical paper and project summary were included in the handoff for reference of methodology to assist the second term, which will involve validation of the inundation products and further forecast modeling of wetland extent.

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Partner POC: Megan Lang, megan_lang@fws.gov

Handoff Package:

- Wetland Inundation Tool
- Inundation tool tutorial
- Water Balance Model Validation Products
- Project Poster
- Project Video
- Technical Paper
- Study Area Shapefiles

References:

Huang, C., Peng, Y., Lang, M., Yeo, I.-Y., & McCarty, G. (2014). Wetland inundation mapping and change monitoring using Landsat and airborne LiDAR data. *Remote Sensing of Environment*, *141*, 231-242. https://doi.org/10.1016/j.rse.2013.10.020

Lang, M. W., Kasischke, E. S., Prince, S. D., & Pittman, K. W. (2008). Assessment of C-band synthetic aperture radar data for mapping and monitoring Coastal Plain forested wetlands in the Mid-Atlantic Region, U.S.A. *Remote Sensing of Environment*, *112*(11), 4120-4130. https://doi.org/10.1016/j.rse.2007.08.026

Lang, M. W., & McCarty, G. W. (2008). Remote sensing data for regional wetland mapping in the United States: trends and future prospects. In R. E. Russo (Ed.), *Wetlands: Ecology, Conservation and Restoration* (pp. 1-4). Hauppauge, New York: Nova.