**NASA DEVELOP National Program**

**2018 Fall Project Proposal**

**California – JPL**

**Alaska Ecological Forecasting**

*Automated Wetland Hydroperiod Mapping Integrating Optical Satellite Imagery and Synthetic Aperture Radar*

**Project Overview**

***Project Synopsis*:** The provision of ecosystem services from Alaska’s wetlands, including nutrient retention and water purification, are vital in providing a robust habitat for fish and shorebirds. Wetland inundation is the most important factor controlling wetland extent and function in general, and partners at the US Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) have not completely mapped wetland extent in Alaska. In order to better map and manage these wetlands, this project will produce and review inundation end products created from Landsat 8 OLI, Sentinel-1 C-SAR, Sentinel-2 MSI, and SMAP. A forecasted wetland extent map will also help partners better understand areas at risk of wetland loss due to habitat change. The end results will support the development and refinement of NWI wetland maps in Alaska, and build the capacity of operational federal programs to use Synthetic Aperture Radar (SAR).

***Community Concern:*** Wetlands are one of the most important ecosystems in the world that provide numerous benefits for humans and wildlife, such as providing vital habitats for various species, storing water and maintaining water flow, protecting and improving water quality, and alleviating floods. People have noted the importance of wetlands as the “kidneys of the Earth,” and research institutions and government organizations have worked on maintaining these semi-aquatic systems. The partners at the NWI have created a Wetlands Mapper to disseminate maps of America’s wetlands to resource managers and the public. The NWI maps have not been produced for some parts of Alaska, and the partners would like to distribute inundation and soil moisture products to their stakeholders in Alaska for evaluation to determine if these products could assist in generating or refining wetland map products.

***Source of Project Idea:*** This project idea came from initial conversations between NASA Jet Propulsion Laboratory (JPL) scientist Bruce Chapman and Megan Lang from the USFWS NWI. Bruce approached the California – JPL Center Lead to propose the project and discuss its feasibility.

***National Application Area Addressed:*** Ecological Forecasting

***Study Location:*** AK

***Study Period:*** May2016 – September 2018; Forecasting to 2025

***Advisor:*** Bruce Chapman (NASA Jet Propulsion Laboratory, California Institute of Technology)

**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 | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The NWI is tasked with providing the public with the status and locations of wetlands in the United States. The NWI is a congressionally mandated resource developed by the USFWS to provide detailed information on wetlands – resource managers use the site heavily across the states. The NWI currently use very fine resolution optical remote sensing imagery to manually delineate wetlands and field technicians to validate wetland boundaries. The NWI geospatial products represent the most accurate, as well as categorically and spatially detailed, wetland maps available for the US. However, due to the relatively intensive mapping process used to create the dataset, the NWI products are only available for approximately one third of Alaska.

***End User’s Capacity to Use NASA Earth Observations:***

*US Fish and Wildlife Service, National Wetlands Inventory* – The partner has used fine resolution optical imagery, both aerial and satellite, but has not used the NASA Earth observation suite to build their classified wetland maps. Since their maps are created manually through imagery interpretation, they hope to build their capacity in using a more automated approach for their classification methods. The project will build capacity for the partner by displaying the use and application of radar data, which would give them a better idea of what the NASA-ISRO Synthetic Aperture Radar Mission (NISAR) can provide to them in the future.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Alaska Satellite Facility* – The ASF has the Hybrid Pluggable Processing Pipeline, or HyP3, which provides on-demand processed SAR imagery. The ASF will work on providing inundation products derived from calibrated algorithm thresholds on Sentinel-1 data, and the DEVELOP team will work closely on fine-tuning these products.

***Dissemination by Boundary Organizations*:**

*US Fish and Wildlife Service, National Wetlands Inventory* – Megan Lang plans to distribute the project results to outside groups and individuals for their evaluation of the project end products. If the products meet the needs of the stakeholders, these data could be used to develop or refine NWI wetland maps. These groups and individuals include other NWI specialists in Alaska (Regional Wetland Coordinators), the Alaska Geospatial Council (Wetlands Working Group), and other sub groups within the USFWS.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with partners at the NWI on a biweekly basis via teleconference and will routinely send emails to inform the partner on the project’s status. The Center Lead and Project Lead will be the primary points of contact with the NWI.

***Transition Plan*:** The team will hand off the preliminary end products to the partner for their feedback via email and will host a video conference presentation explaining how the products were created. A tutorial will be provided for the partners’ convenience. The final decision support tool hand off is planned after the proposed second term. A software release is expected to be included in the hand off, depending on the programming language or platform the automated tool is created in. The team will provide the partner a walkthrough of the tool for when software release is complete.

***Letters of Support*:** Megan Lang,Chief Scientist, US Fish and Wildlife Service, National Wetlands Inventory.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Sentinel-1 C-SAR** | Backscatter values, surface roughness | SAR data will be used to develop a methodology for deriving soil saturation and wetland inundation |
| **Sentinel-2 MSI** | Surface reflectance | Sentinel-2 will complement the Landsat sensors and will be used for mapping wetland inundation. |
| **SMAP** | Soil moisture | SMAP’s 1-3km L-band SAR will be used to map soil moisture and inundation. |
| **Landsat 8 OLI** | Surface reflectance, panchromatic sharpening | Landsat 8 OLI is a 30 meter resolution dataset that will be used to delineate wetland features. Image enhancement techniques will be developed and fine-tuned to delineate those features. |

***Ancillary Datasets:***

USFWS National Wetlands Inventory database – Data from the Wetlands Mapper will be used to assess the general wetland functions and cover types

***Modeling:***

TerrSet Land Change Modeler (LCM) (POC: Dr. Kenton Ross, NASA Langley Research Center)

***Software & Scripting:***

Esri ArcGIS – create quality maps for presentations and reports

Python – batch process imagery, derive soil saturation and inundation

Exelis ENVI – raster manipulation and analysis, image enhancement, image classifications

ESA Sentinel Application Platform (SNAP) – preprocess Sentinel-1 and Sentinel-2 raster imagery

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Wetland Inundation and Soil Saturation Tool** | The partner will use the tool to replicate the inundation maps on their own and will apply the tool (or algorithm) to create an ancillary dataset that would be shared with stakeholders. | The team will create a validated inundation product derived from calibrated algorithm thresholds (from the ASF) on Sentinel-1C-SAR data. A similar product will also be produced from SMAP for comparison. A tool is planned to automate this process once it is validated. | IV |
| **2025 Forecasted Wetland Coverage** | The partner will use the forecasted coverage map to bring awareness about the changing climate’s impact on wetland extent, and to get a better understanding of the wetland areas that are more at risk for loss. | The Landsat 8 OLI, Sentinel-1 C-SAR, and Sentinel-2 MSI historic record will be used to document wetland inundation trends to predict possible future conditions. The Land Change Modeler will be used to assess land change and model the future extent. | I |

***End-User Benefit*:** The end products will help improve the NWI’s automated wetland mapping capacity by using SAR to map inundation and soil saturation. This project will also assist with the future production of a coarser scale wetland types map product for Alaska. The partner’s current geospatial dataset has various classifications in which each class supports characterization of various levels and types of ecosystem functions and habitat. The automated tool will also help them save money as they pay their contractors by the hour to manually create the images.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2018 Fall to 2019 Spring

***Multi-Term Objectives:***

* **Term 1 (Proposed Term):** 2018 Fall (California – JPL) – Alaska Ecological Forecasting
  + The first term will focus on the augmentation of the algorithm for detecting inundation extent that is being developed at ASF, including tailoring the algorithm to address soil saturation. The term will involve creating preliminary inundation and soil saturation time-series maps (coarse and less categorically detailed) that will be used to forecast inundation extent using TerrSet, as well as comparing Landsat, SMAP, Sentinel-1 and Sentinel-2 products. The initial end products will be presented to the stakeholders for their feedback so the algorithm could be fine-tuned for the second term.
* **Term 2:** 2019 Spring (California – JPL) – Alaska Ecological Forecasting II
  + During the second term, the team will work on validating the inundation and soil saturation products from the Sentinel-1 imagery and using SAR and optical time-series products to map wetland presence and absence at study sites. The team will also work on comparing the results with Landsat. The team will work on creating a forecasted map of wetland extent, as opposed to the forecast of inundation extent produced in the previous term. Software release is anticipated this term when the methods have been more established and validated.

***Related DEVELOP Work:***

2017 Spring (UGA) – Eastern India Ecological Forecasting II: A Multi-Sensor Approach to Enhance the Prediction of Mangrove Biophysical Characteristics in Chilika Lagoon and Bhitarkanika Wildlife Sanctuary, Odisha, India

2016 Fall (LaRC) – Everglades Ecological Forecasting II: Utilizing NASA Earth Observations to Enhance the Capabilities of Everglades National Park to Monitor and Predict Mangrove Extent to Aid Current Restoration Efforts

2014 Fall (LaRC) – Great Lakes Climate: Monitoring the Impacts of Climate Change and Decreasing Water Levels on Wetlands in the Great Lakes Region of North America

**Notes & References:**

***Notes*:** Since this project proposes ambitious end products and a collaboration with the ASF, Bruce Chapman will see whether ASF can have a student intern work remotely at their location with the DEVELOP team at JPL. The DEVELOP team will work with ASF to test the different thresholds for various land cover types within the Alaska region and the partner will work on gathering validation sites.

NWI’s Wetland Mapper can be accessed here: <https://www.fws.gov/wetlands/Data/Mapper.html>

***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.

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