**WET Water Resources**

*A Google Earth Engine Python API Tool to Automate Wetland Extent Mapping Using Radar Satellite Sensor for Wetland Management and Monitoring*

**Project Team**

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**Project Overview**

***Project Synopsis:***

The Wetlands Water Resources Team developed a new tool for mapping the extent of wetlands globally using Google Earth Engine (GEE) Python API. The tool, which utilizes optical and radar satellite sensors, is open-source and can monitor changes in wetland ecosystems threatened by climate change, pollution, urbanization, and population increase. The tool uses high-resolution imagery and SAR data, which is not affected by cloud cover and light availability, making it an ideal solution for monitoring wetland changes during critical times like the rainy season. The team calibrated and validated the tool through a historical change and sensitivity analysis of the Sudd watershed in central Sudan and anticipates its widespread use in wetland monitoring and management.

***Abstract:***

Wetland ecosystems are annually or seasonally wet transition zones between land and water. They provide a range of ecosystem services such as water filtration, flood mitigation, and carbon sequestration, as well as hosting biodiversity hotspots. Although they fulfill fundamental physical and natural processes, wetland extent and health are threatened by anthropogenic influences related to urbanization, population increase, pollution, and climate change. Recognizing the need to quantitatively monitor changes in these recently threatened ecosystems in a timely and cost-effective way, we developed a Google Earth Engine (GEE) Python API tool for automated wetland extent mapping using optical and radar satellite sensors that can be applied globally. The tool will significantly improve wetland change analysis and monitoring as SAR data provides high resolution (5-10 m) imagery, unaffected by cloud cover and light availability (day vs. night), common limitations for other remotely sensed sensors. The tool utilizes Copernicus Sentinel-1 C-band and NISAR L-band (once operational and available on the GEE repository) synthetic aperture radar (SAR) imagery. During image preprocessing, we applied a Terra Moderate Resolution Imaging Spectroradiometer (MODIS) snow product to determine regional snow coverage, which affects land classification sensitivity. Calibration and validation were conducted through a historical change and sensitivity analysis of the Sudd watershed located in central Sudan. The tool was the first of its kind, as it enables NISAR data processing through an open-source GEE repository, further expanding and improving the utility of NASA Earth observations and contributing to NASA Open Science initiatives. We anticipate the tool will be used by researchers and practitioners interested in wetland monitoring and management.

***Key Terms:*** Inundation, land cover classification, machine learning, NISAR, remote sensing imagery, SAR, Sentinel-1

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

***Study Location:*** Sudd Wetland, Nile River Basin- South Sudan, Africa

***Study Period:*** October 2021

***Project Objectives:***

* Develop tool to quantify wetland extent on a global scale using Google Earth Engine in the Python API
* Create user-friendly interface for visualizing and analyzing wetland extent.
* Improve remote sensing applications for water resources using optical and SAR sensors.
* Establish a methodology that can easily integrate NISAR products upon launch.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Sentinel-1 C-SAR** | Backscatter | Backscatter values for inundation classification. |
| **Terra MODIS** | Snow/ice | Snow/ice detection for annual timeseries of snow cover. |
| **Sentinel-2 MSI** | Land cover | Dynamic World land cover classification for reference in selecting training polygons for classification. |
| **Suomi-NPP VIIRS** | Floodwater fraction | Floodwater fraction for validation of classification tool. |

***Ancillary Datasets:***

* Brandi Downs et al., October 2021 VIIRS Floodwater Fraction Daily Composite – Surface water binary classifier of South Sudan used to test the tool’s accuracy

***Software & Scripting:***

* Google Earth Engine Python API – Upload satellite imagery from the GEE data repository to analyze and classify Sentinel-1 imagery using GEE and Python modules
* Jupyter Notebooks – Create a user interface using the GEE Python API to increase usability and streamline how users input parameters interact with the tool

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Benefit & Use** | **Software Release Category** |
| **WET 3.0 GEE Python Tool:**   * User Interface * Wetland Classifier * Validation Imagery * Accuracy Assessment | Sentinel-1 C-SAR  Sentinel-2 MSI  Terra MODIS  Suomi-NPP VIIRS | This tool, accessible through the GEE Python API, will support in the increased timeliness and accuracy of wetland cover classification | IV |
| **Sudd Wetland Case Study:**   * Classified Dataset/ Image * Accuracy Assessment Results | Sentinel-1 C-SAR  Sentinel-2 MSI  Terra MODIS  Suomi-NPP VIIRS | This case study provides insight into the extent of changing wetlands in the Sudd, South Sudan. Results support future time series analyses of other wetland ecosystems | N/A |

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

The objectives of this project were to develop a high accuracy classifier tool that is easily accessible and intuitive to the user, compatible with NISAR imagery, and will have long-term functionality with the GEE Python API interface. It is critical that end users have the ability to openly access tools such as this one, to get accurate results in a timely and cost-effective way. Future users will need to have access to results such as these to make effective land management decisions to ensure the conservation of wetlands. Beyond this, our project and tool has developed a new methodology of land cover classification using SAR imagery that will support future development of highly accurate and automated classifications.

**References**

Downs, B., Kettner, A. J., Chapman, B. D., Brakenridge, G. R., O’Brien, A. J., & Zuffada, C. (2023). Assessing the relative performance of GNSS-R flood extent observations: Case study in South Sudan. *IEEE Transactions on Geoscience and Remote Sensing*, *61*, 1–13. <https://doi.org/10.1109/TGRS.2023.3237461>

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Wu, Q. (2020). geemap: A Python package for interactive mapping with Google Earth Engine. *Journal of Open Source Software*, *5*(51), 2305. <https://doi.org/10.21105/joss.02305>