Fine-Resolution Mapping of Wetland Inundation Dynamics in the Prairie Pothole Region of the United States

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Abstract

The Prairie Pothole Region of North America is characterized by millions of depressional wetlands, which provide critical habitats for globally significant populations of migratory waterfowl and other wildlife species. Due to their relatively small size and shallow depth, these wetlands are highly sensitive to climate variability and anthropogenic changes, exhibiting inter- and intra-annual inundation dynamics. Moderate-resolution satellite imagery (e.g., Landsat, Sentinel) alone cannot be used to effectively delineate these small depressional wetlands. By integrating multi-temporal (2009-2018) NAIP aerial imagery and ancillary geospatial datasets, a fully automated approach was developed to delineate wetland inundation extent at watershed scales using Google Earth Engine. Machine learning algorithms were used to classify aerial imagery with additional spectral indices to extract potential wetland inundation areas, which were further refined using ancillary geospatial datasets. The wetland delineation results were then compared to the U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) geospatial dataset and existing global-scale surface water products to evaluate the performance of the proposed method. The results showed that the proposed method can not only delineate the most up-to-date wetland inundation status, but also demonstrate wetland hydrological dynamics, such as wetland coalescence through fill-spill hydrological processes. The proposed automated algorithm provides a practical, reproducible, and scalable framework, which can be easily adapted to delineate wetland inundation dynamics at broad geographic scales.

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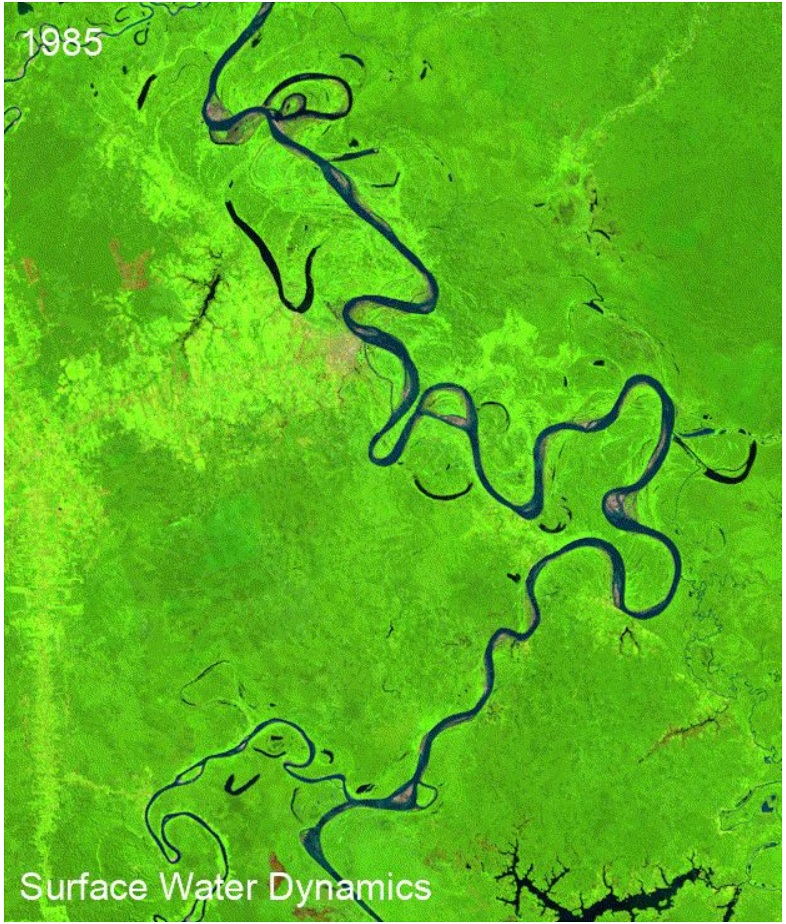
Outline

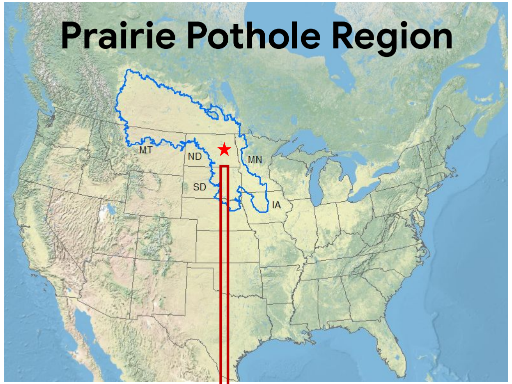
- Wetlands in the Prairie Pothole Region
- Existing wetland datasets
- Research challenge
- GEE for wetland inundation mapping
- More GEE resources
- Q&A



Wetlands in the Prairie Pothole Region (PPR)

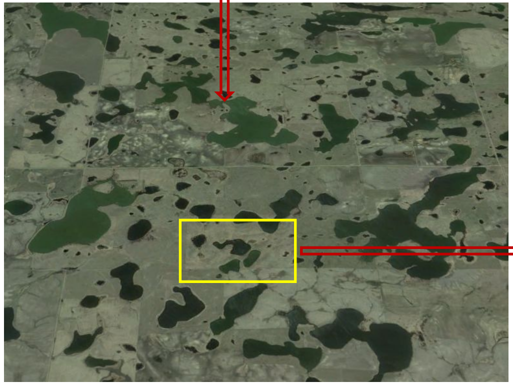
Area = 715, 000 km^2

Five states:
- North Dakota
- South Dakota
- Minnesota
- Montana
- Iowa



Median size:
1,600 m^2
< 2 Landsat pixels

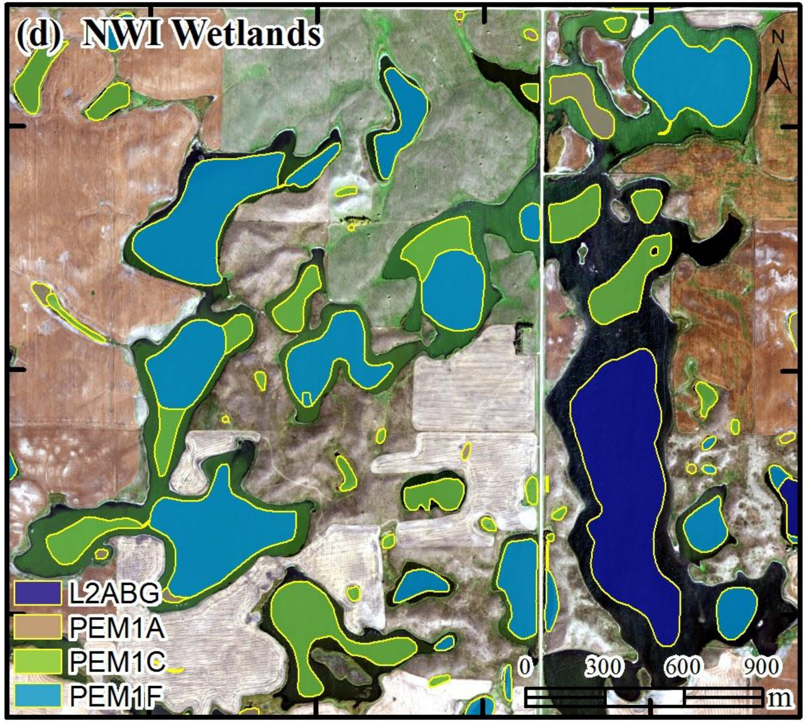
Depth:
< 1 m



Water supplies:
- Rainfall
- Snowmelt
- Upland inflow
- Groundwater seepage

National Wetlands Inventory (NWI)

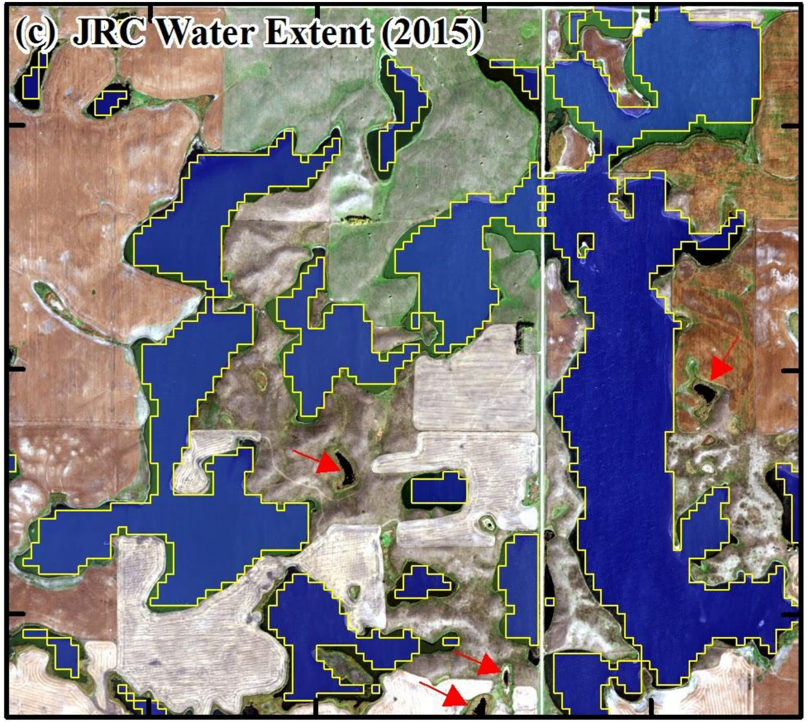
- NWI is the **most spatially and categorically detailed wetland inventory** available for the contiguous U.S.
- **Water regimes**
  - Temporarily flooded (PEM1A)
  - Seasonally flooded (PEM1C)
  - Semi-permanently flooded (PEM1F)
  - Seasonally saturated (PEM1B)
- **Limitations**
  - Manual interpretation and digitization of single-date aerial imagery
  - BW aerial imagery acquired in the 1980s
  - Inundation status may not be current



https://www.fws.gov/wetlands/data/Mapper.html

Global Surface Water Explorer (GSWE)

- GSWE was jointly developed by the European Commission's Joint Research Centre (JRC), UN Environment Programme and Google
- Based on 30-m **Landsat** data (1984-2018)
- GSWE provides the location and temporal distribution (**monthly**) of global water surfaces over the past **35 years**
- **Limitations**
    - Largely failed to capture small **sub-hectare** wetland features
    - Omission of inundation pixels around the **edges** of wetland features



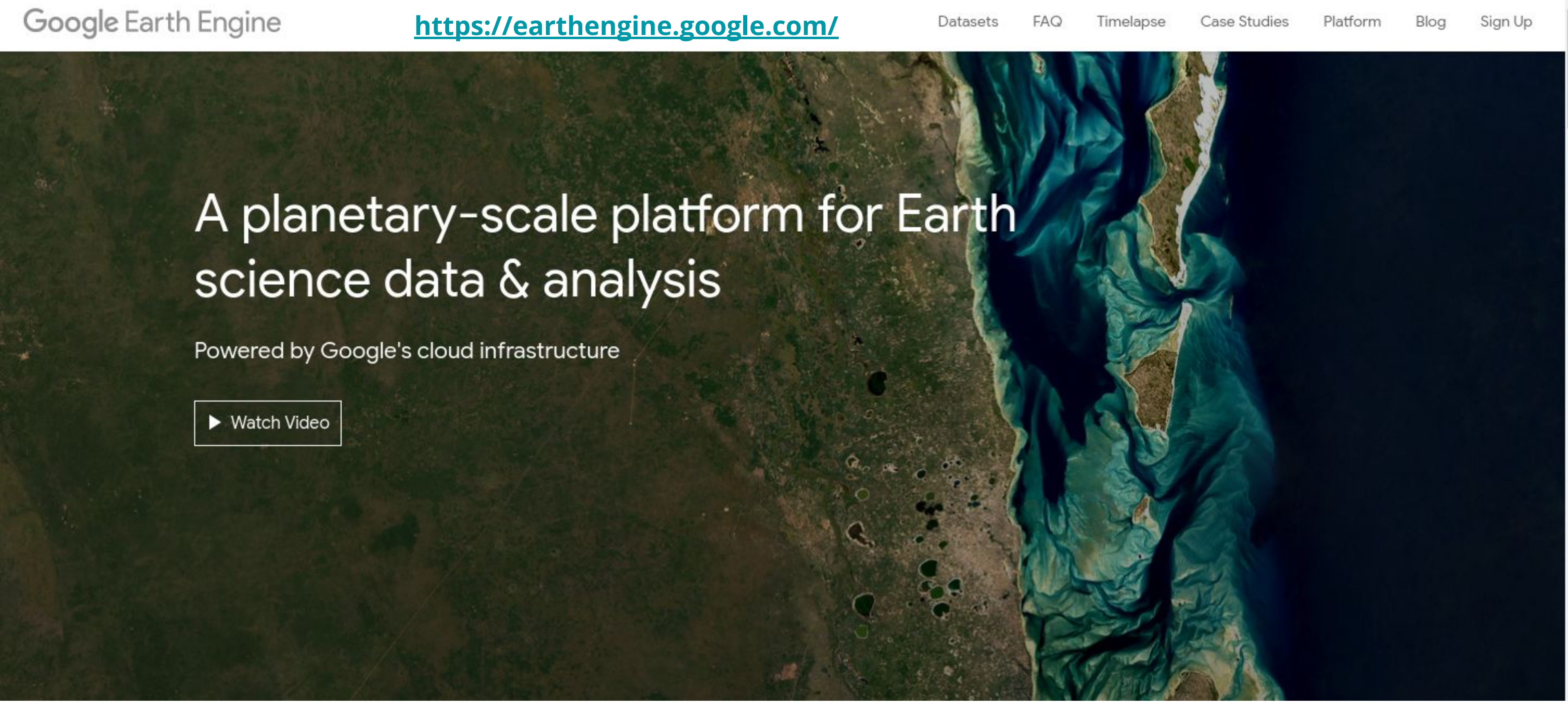
https://global-surface-water.appspot.com

Research Challenge

- To effectively manage wetlands, we need **contemporary information** about their location, extent, inundation dynamics, and drivers of change
- The NWI dataset provides the most spatially and categorically detailed wetland inventory for the contiguous U.S., but it has traditionally relied on **costly manual interpretation** of aerial imagery to generate data.
- Some regions (e.g., PPR) have **outdated** NWI. Automated workflows to enable **more rapid, cost effective updates** to the NWI dataset are highly desirable.
- Previous studies on mapping wetland inundation dynamics largely used **moderate spatial resolution** satellite images (e.g., Landsat, Sentinel)
- Massive computing power is needed to process large-volume datasets (e.g., NAIP)
- **<u>How can we better utilize fine-resolution NAIP imagery for mapping (small) wetlands at large geographic scales?</u>**

What is Earth Engine?

https://earthengine.google.com/



RSE Paper

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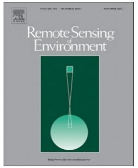

https://doi.org/10.1016/j.rse.2019.04.015

Integrating LiDAR data and multi-temporal aerial imagery to map wetland inundation dynamics using Google Earth Engine

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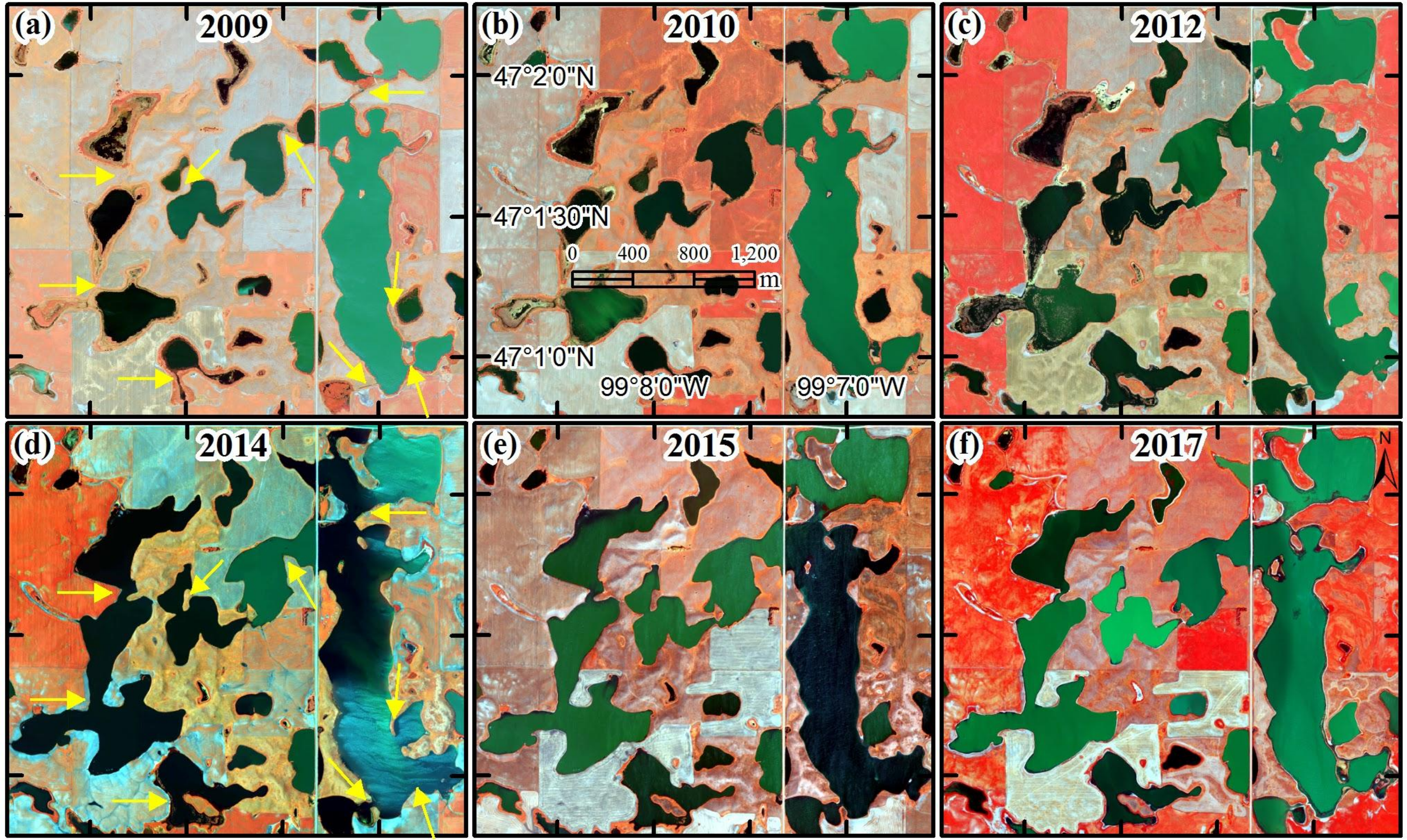
A R T I C L E I N F O

Keywords:
Wetland hydrology
Inundation
Topographic depressions
Surface water
LiDAR
Google Earth Engine

A B S T R A C T

The Prairie Pothole Region of North America is characterized by millions of depressional wetlands, which provide critical habitats for globally significant populations of migratory waterfowl and other wildlife species. Due to their relatively small size and shallow depth, these wetlands are highly sensitive to climate variability and anthropogenic changes, exhibiting inter- and intra-annual inundation dynamics. Moderate-resolution satellite imagery (e.g., Landsat, Sentinel) alone cannot be used to effectively delineate these small depressional wetlands. By integrating fine spatial resolution Light Detection and Ranging (LiDAR) data and multi-temporal (2009–2017) aerial images, we developed a fully automated approach to delineate wetland inundation extent at

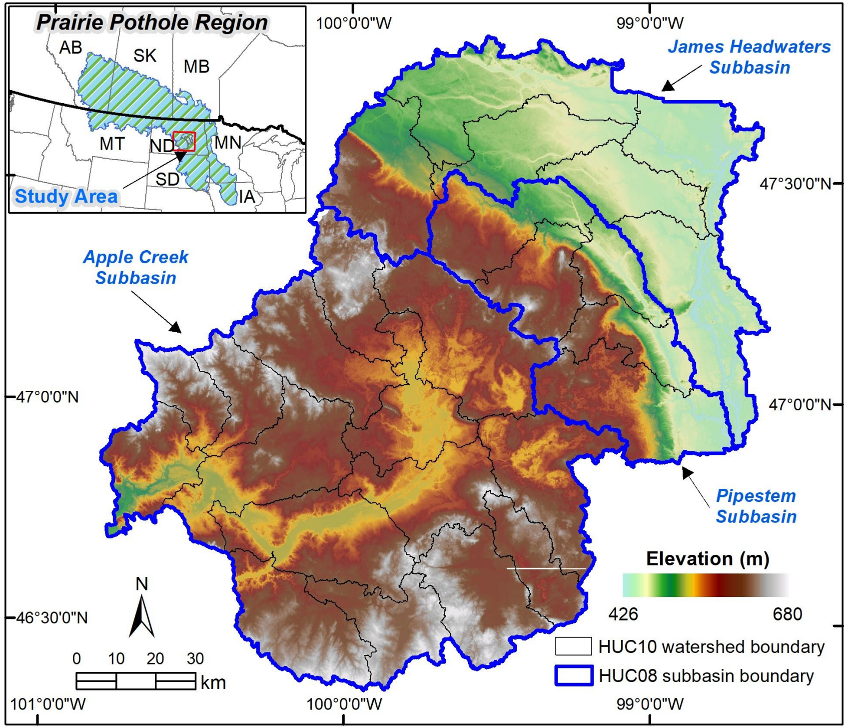
Inundation Dynamics of Prairie Wetlands



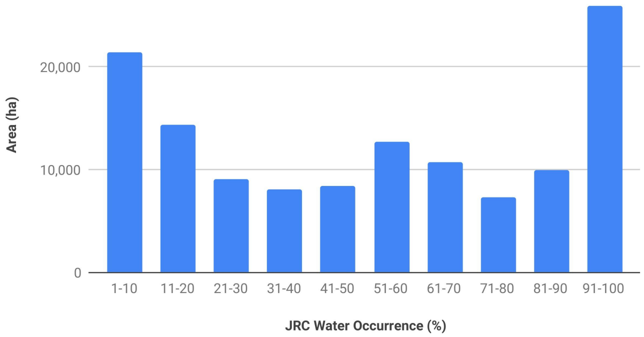
1-m Resolution USDA NAIP Imagery

National Agriculture Imagery Program (NAIP)

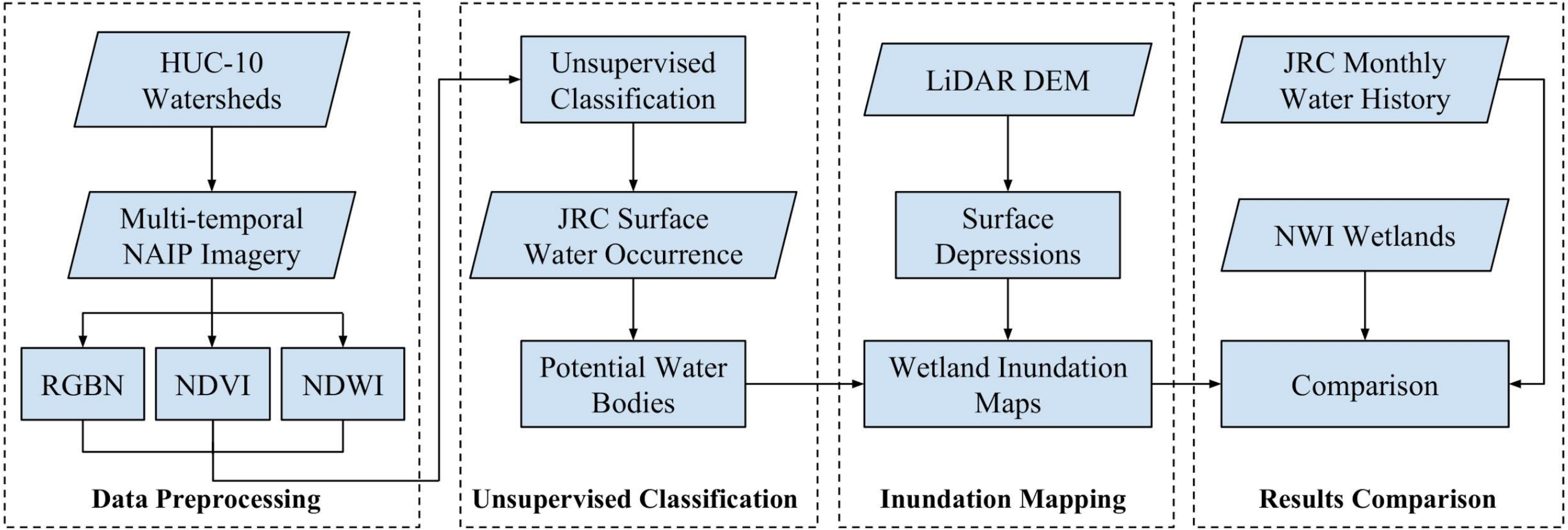
Study Area and Geospatial Datasets



- **Study Area**
  - 3 HUC-8 subbasins (16,576 km^2 in total)
  - 26 HUC-10 watersheds (318 ~ 998 km^2)
- **Datasets**
  - LiDAR data (2011-2016) - *107.65 GB*
  - NAIP imagery (2009, 2010, 2012, 2014, 2015, 2017)
  - National Wetlands Inventory [NWI] (1980s)
  - JRC Global Surface Water (1984-2018)

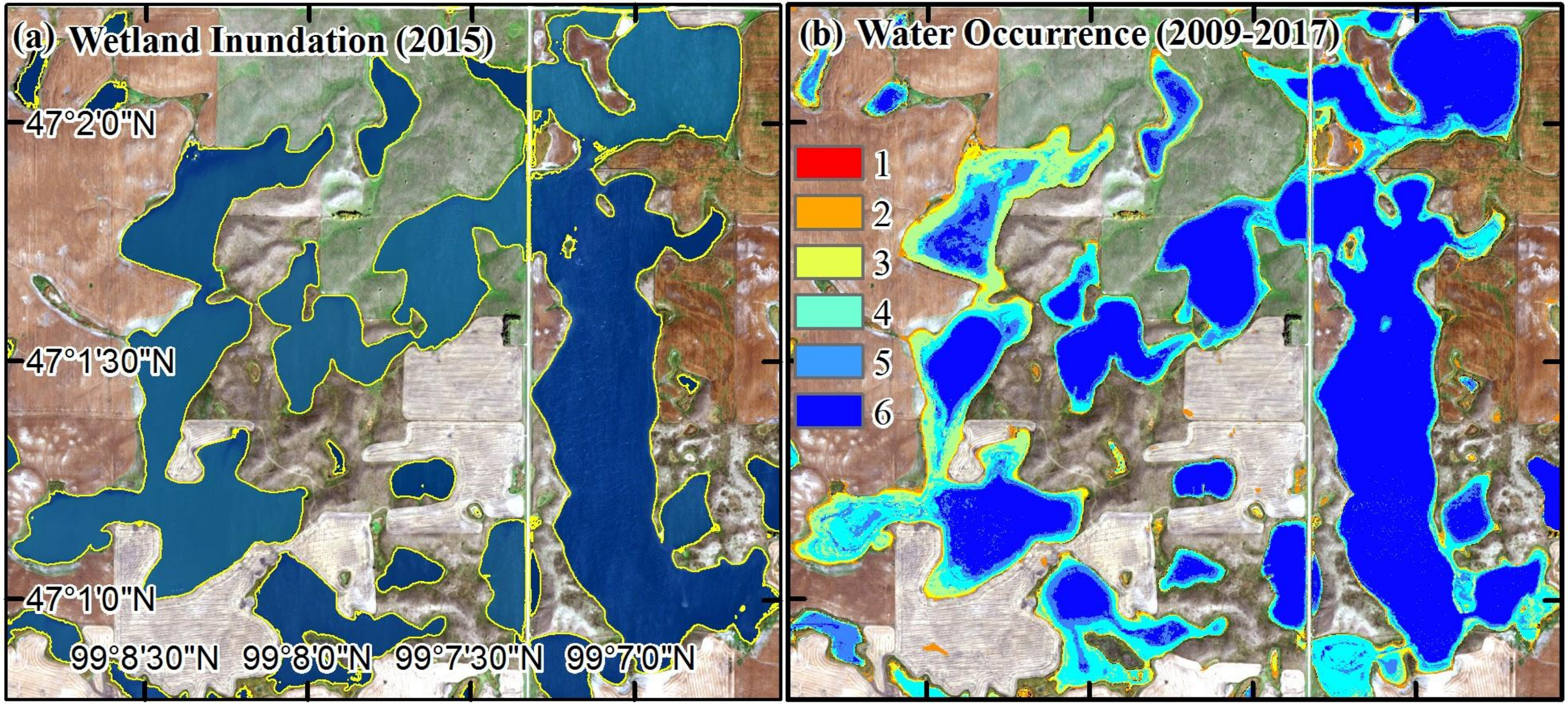


GEE Algorithm for Automated Inundation Mapping

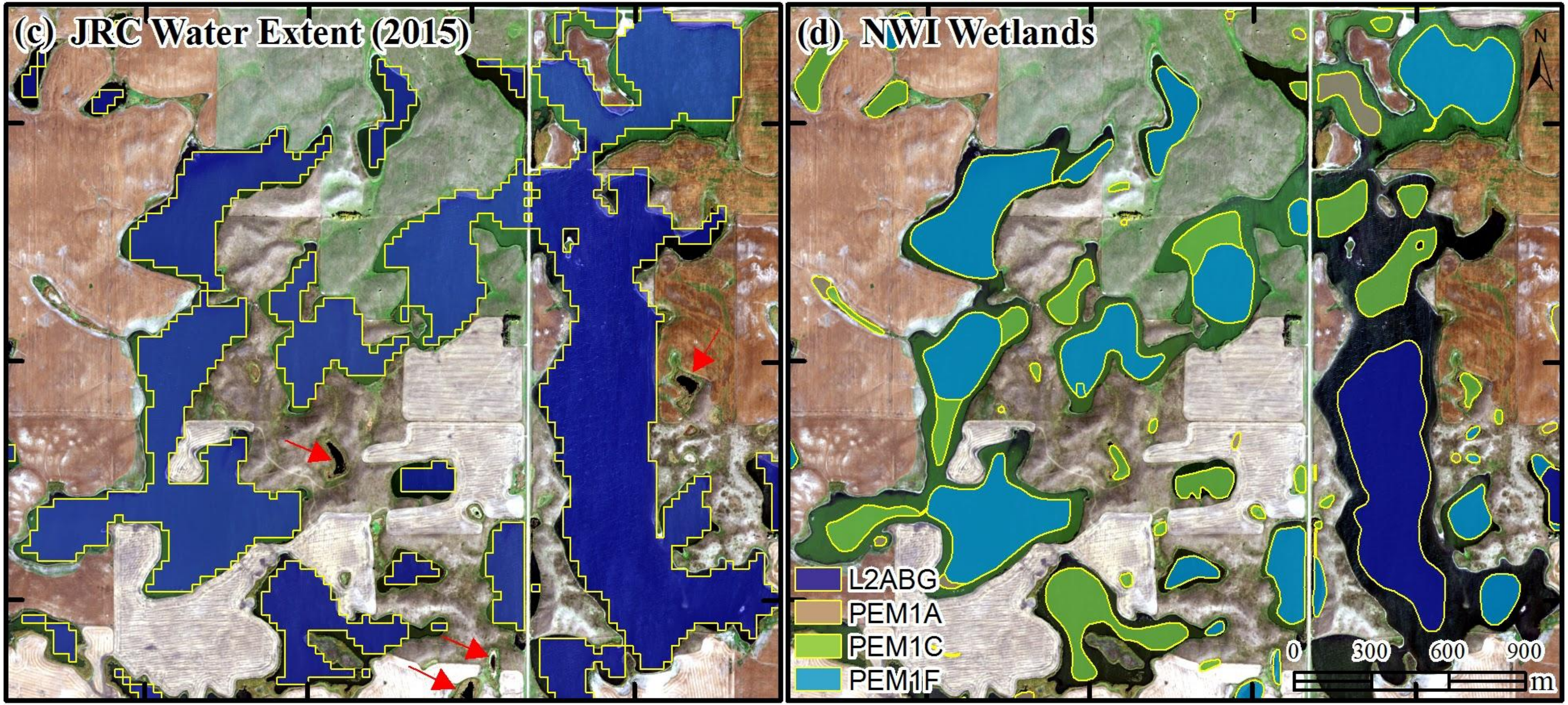


- **Wu, Q.**, Lane, C. R., Li, X., Zhao, K., Zhou, Y., Clinton, N., DeVries, B., Golden, H. E., & Lang, M. W. (2019). Integrating LiDAR data and multi-temporal aerial imagery to map wetland inundation dynamics using Google Earth Engine. ***Remote Sensing of Environment***, 228, 1-13. https://doi.org/10.1016/j.rse.2019.04.015 (PDF)

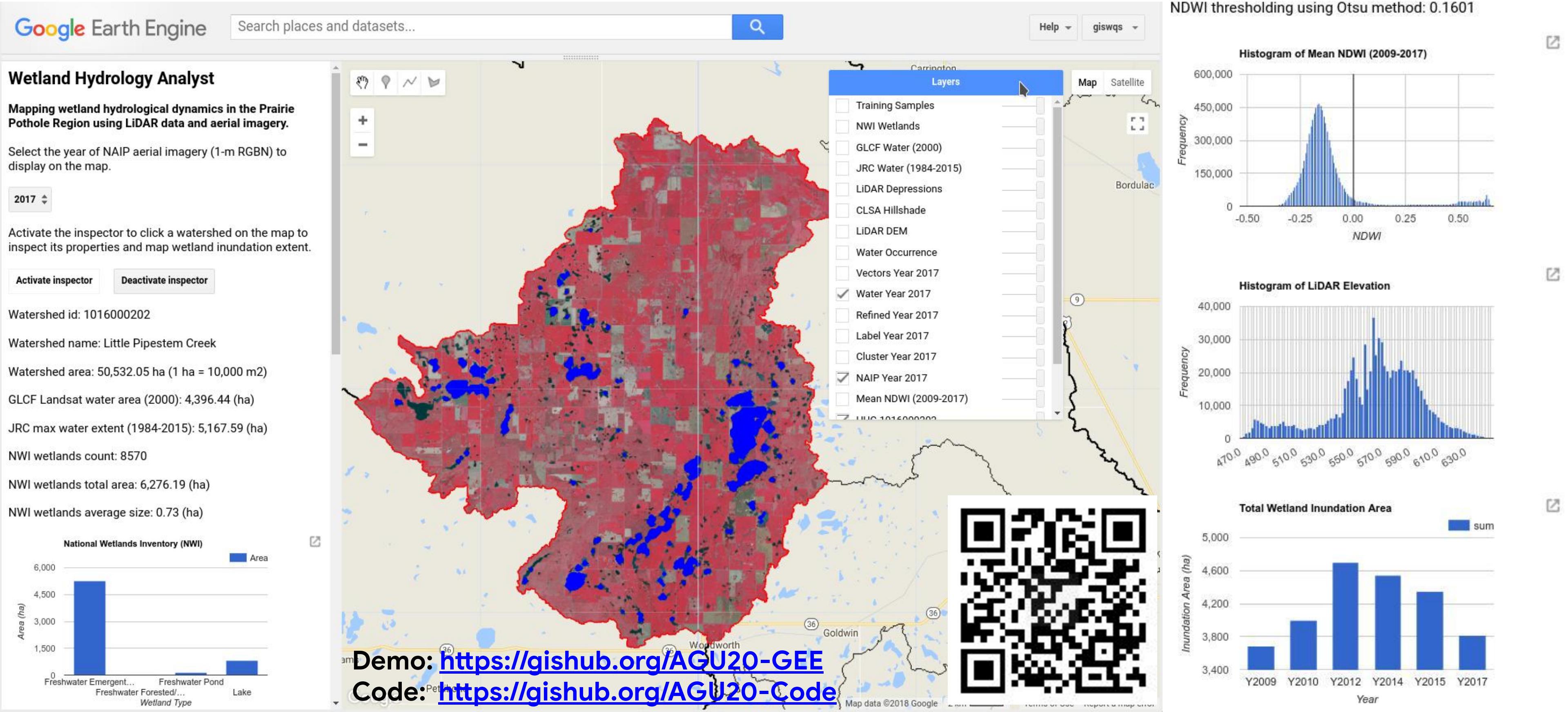
NAIP-derived Wetland Inundation Maps



Landsat-derived JRC Surface Water Extent vs. NWI



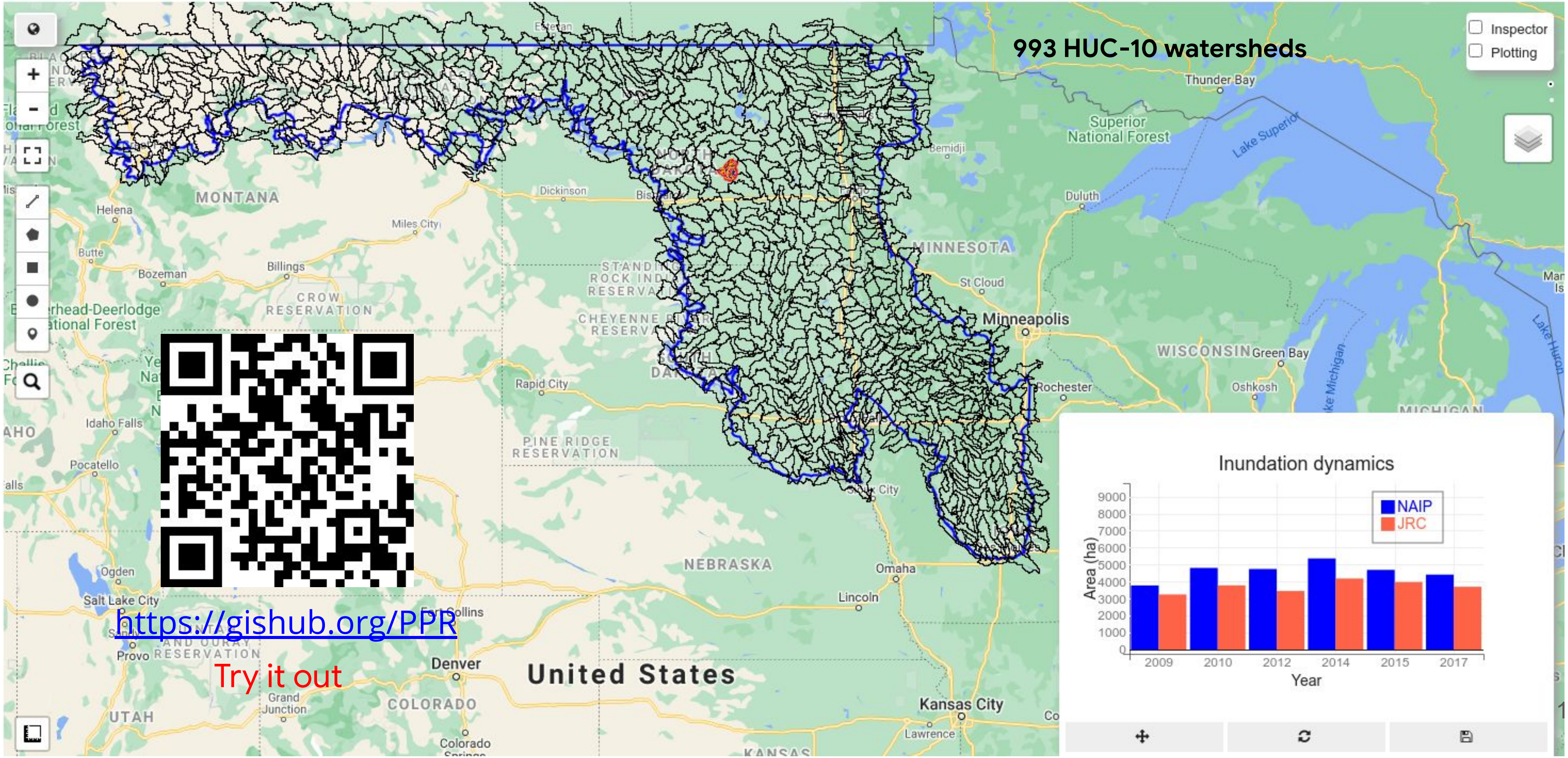
JavaScript-based Interactive Web App



Demo: https://gishub.org/AGU20-GEE

Code: https://gishub.org/AGU20-Code

Python-based Interactive Web App



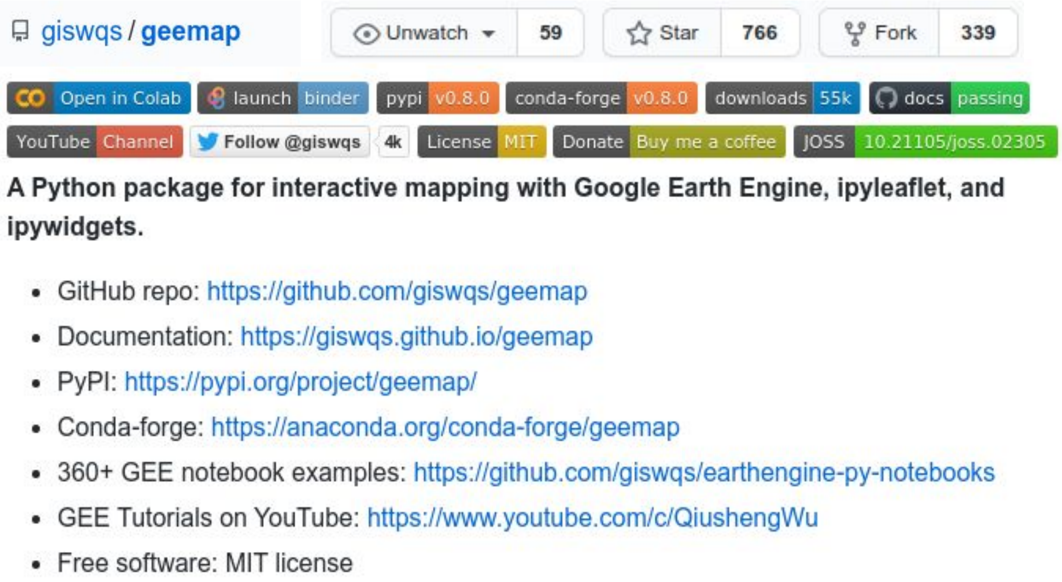
https://gishub.org/PPR

Try it out


United States

Introducing geemap

- A Python package for interactive mapping with Google Earth Engine, ipyleaflet, and ipywidgets.
- GitHub: https://github.com/giswqs/geemap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A Python package for interactive mapping with Google Earth Engine, ipyleaflet, and ipywidgets.

- GitHub repo: https://github.com/giswqs/geemap
- Documentation: https://giswqs.github.io/geemap
- PyPI: https://pypi.org/project/geemap/
- Conda-forge: https://anaconda.org/conda-forge/geemap
- 360+ GEE notebook examples: https://github.com/giswqs/earthengine-py-notebooks
- GEE Tutorials on YouTube: https://www.youtube.com/c/QiushengWu
- Free software: MIT license

- Key dependencies:
  - earthengine-api
  - ipyleaflet
  - folium
  - ipywidgets
  - bqplot
  - voila

geemap
Home
Installation
Get Started
Usage
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Welcome to geemap

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- Documentation: https://giswqs.github.io/geemap
- PyPI: https://pypi.org/project/geemap
- Conda-forge: https://anaconda.org/conda-forge/geemap
- 360+ GEE notebook examples: https://github.com/giswqs/earthengine-py-notebooks
- GEE Tutorials on YouTube: https://www.youtube.com/c/QiushengWu
- Free software: MIT license

Introduction

geemap is a Python package for interactive mapping with Google Earth Engine (GEE), which is a cloud computing platform with a multi-petabyte catalog of satellite imagery and geospatial datasets. During the past few years, GEE has become very popular in the geospatial community and it has empowered numerous environmental applications at local, regional, and global scales. GEE provides both JavaScript and Python APIs for making computational requests to the Earth Engine servers. Compared with the comprehensive documentation and interactive IDE (i.e., GEE

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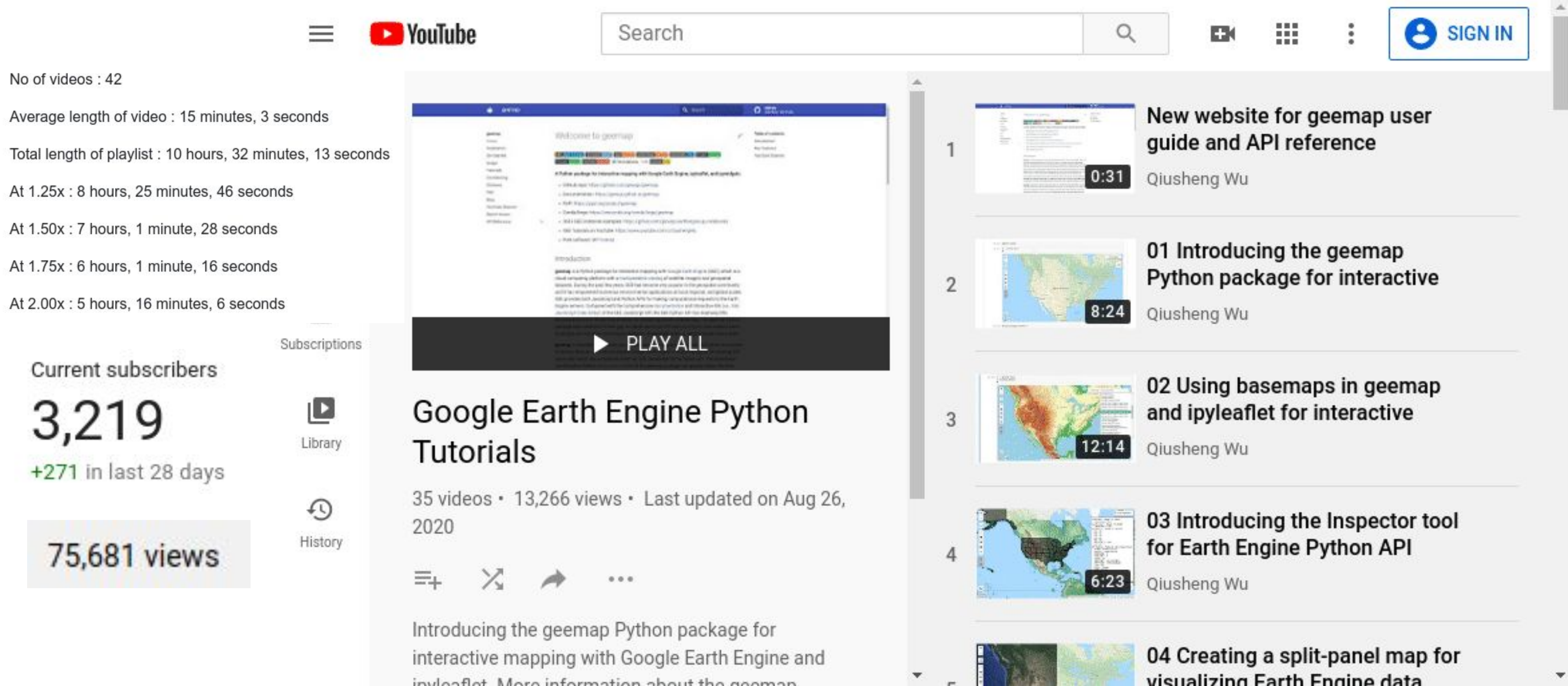
Tutorials

https://www.youtube.com/c/QiushengWu



Thank you!

Any questions

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