

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

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<https://wetlands.io>



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AGU Fall Meeting
December 7, 2020

Slides: <https://gishub.org/AGU>

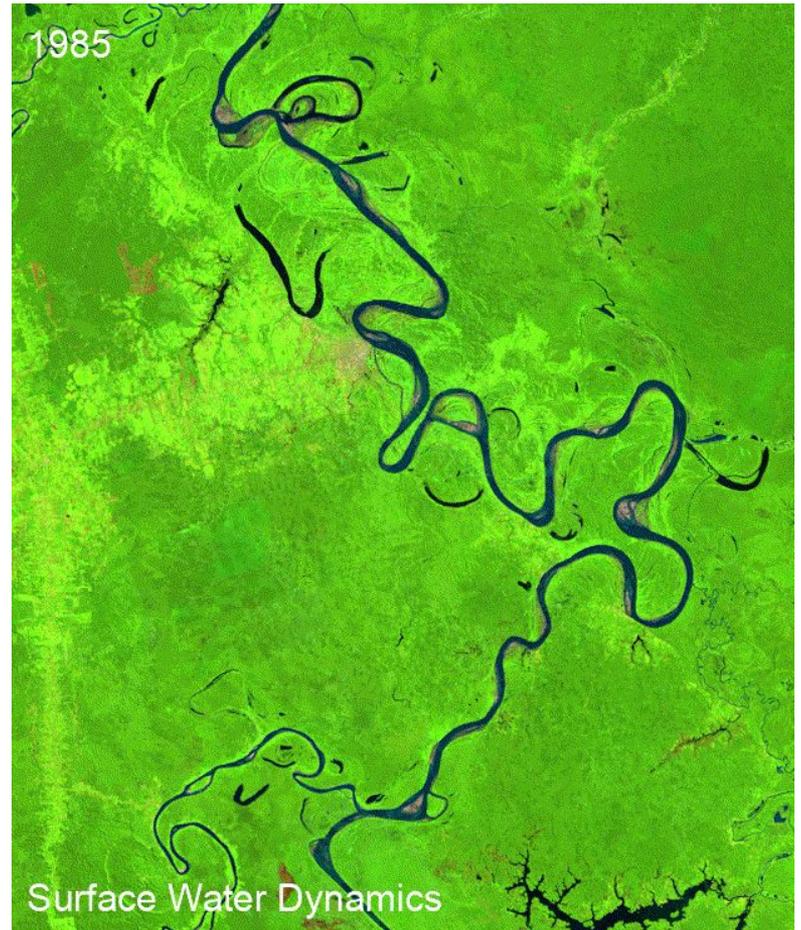


slides

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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 km²

Five states:

- North Dakota
- South Dakota
- Minnesota
- Montana
- Iowa



Median size:

1,600 m²
< 2 Landsat pixels

Depth:

< 1 m

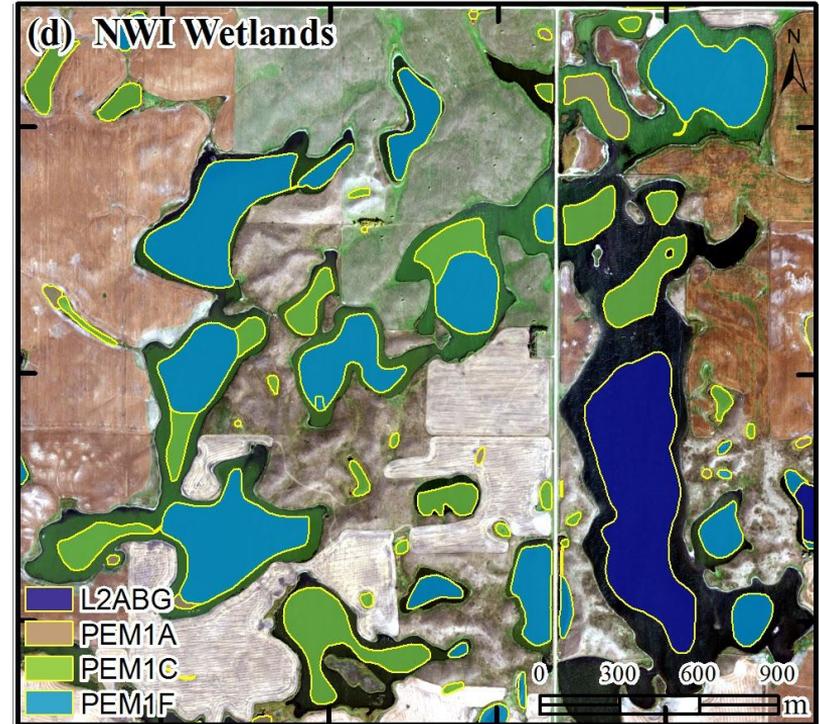


Water supplies:

- Rainfall
- Snowmelt
- Upland inflow
- Groundwater seepage

National Wetlands Inventory (NWI)

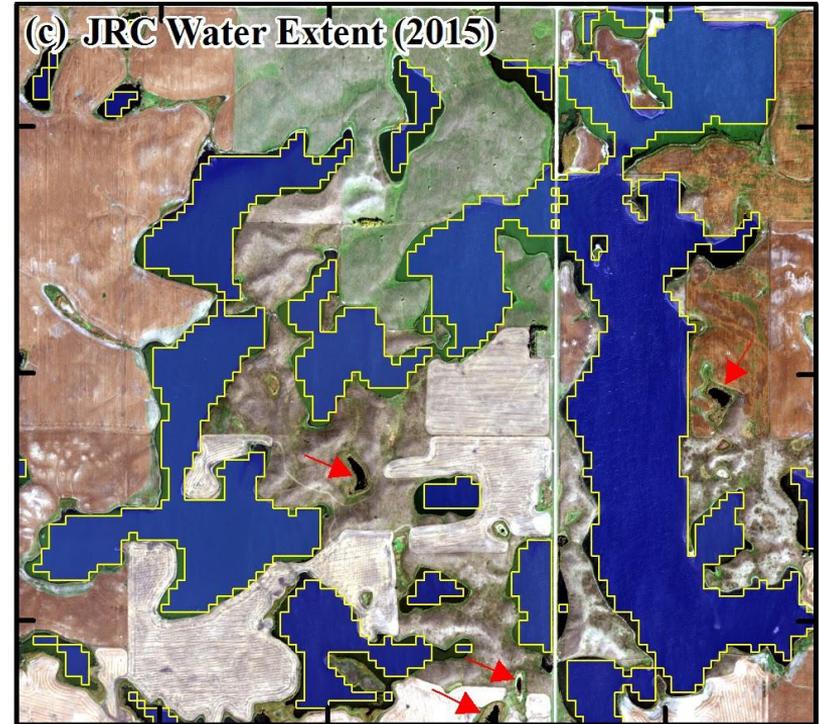
- NWI is the **most spatially and categorically detailed wetland inventory** available for the contiguous U.S.
- **Water regimes**
 - Temporarily flooded (PEM1A)
 - Seasonally flooded (PEM1C)
 - Semi-permanently flooded (PEM1F)
 - Seasonally saturated (PEM1B)
- **Limitations**
 - Manual interpretation 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



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)
- **How can we better utilize fine-resolution NAIP imagery for mapping (small) wetlands at large geographic scales?**

What is Earth Engine?

Google Earth Engine

<https://earthengine.google.com/>

Datasets

FAQ

Timelapse

Case Studies

Platform

Blog

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An aerial satellite-style image of a river delta, likely the Amazon, with a topographic overlay in shades of green and blue. The text is overlaid on the left side of the image.

A planetary-scale platform for Earth
science data & analysis

Powered by Google's cloud infrastructure

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RSE Paper

Remote Sensing of Environment 228 (2019) 1–13



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journal homepage: www.elsevier.com/locate/rse



<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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ARTICLE INFO

Keywords:

Wetland hydrology

Inundation

Topographic depressions

Surface water

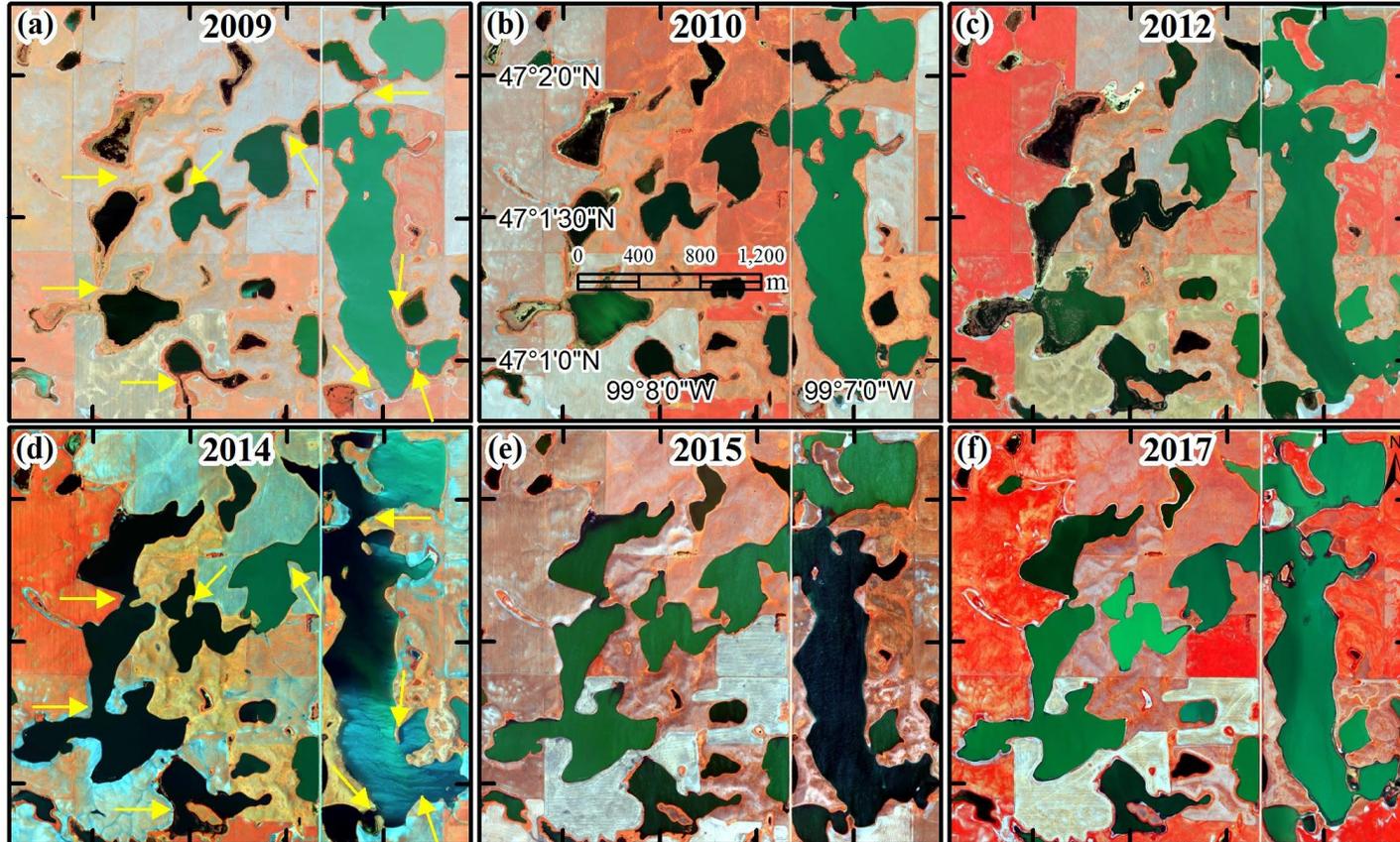
LiDAR

Google Earth Engine

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 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

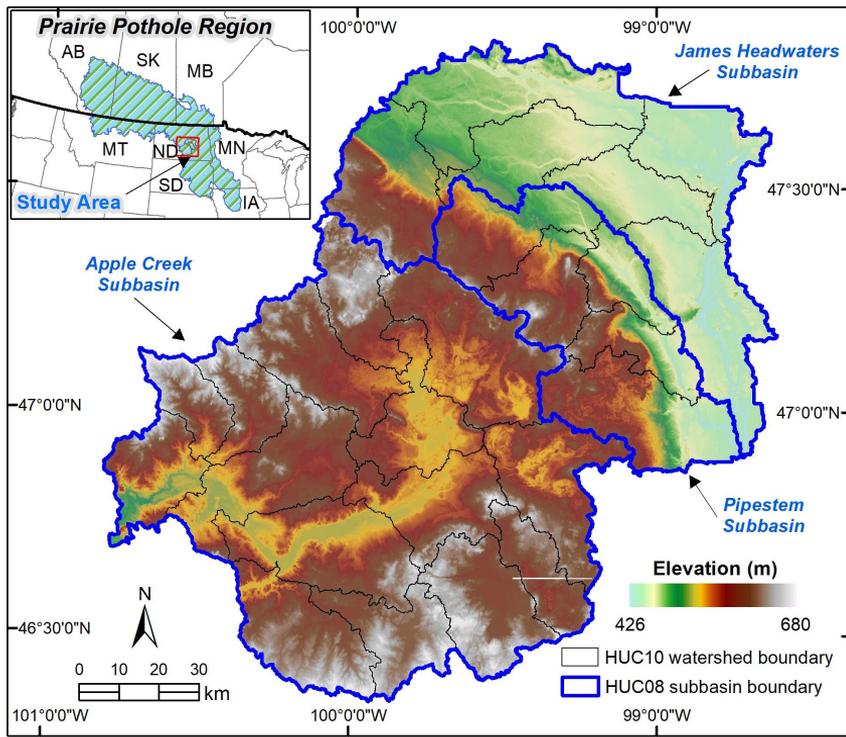
Inundation Dynamics of Prairie Wetlands



1-m
Resolution
USDA
NAIP
Imagery

National
Agriculture
Imagery
Program
(NAIP)

Study Area and Geospatial Datasets

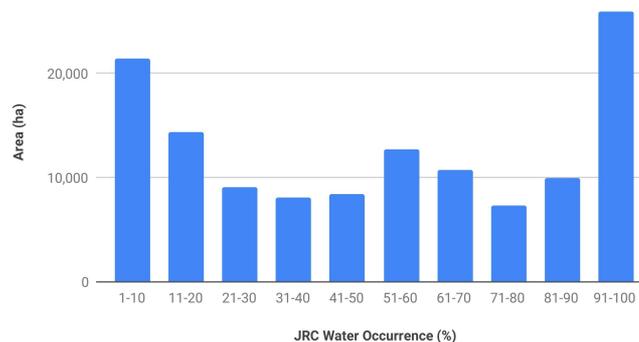


Study Area

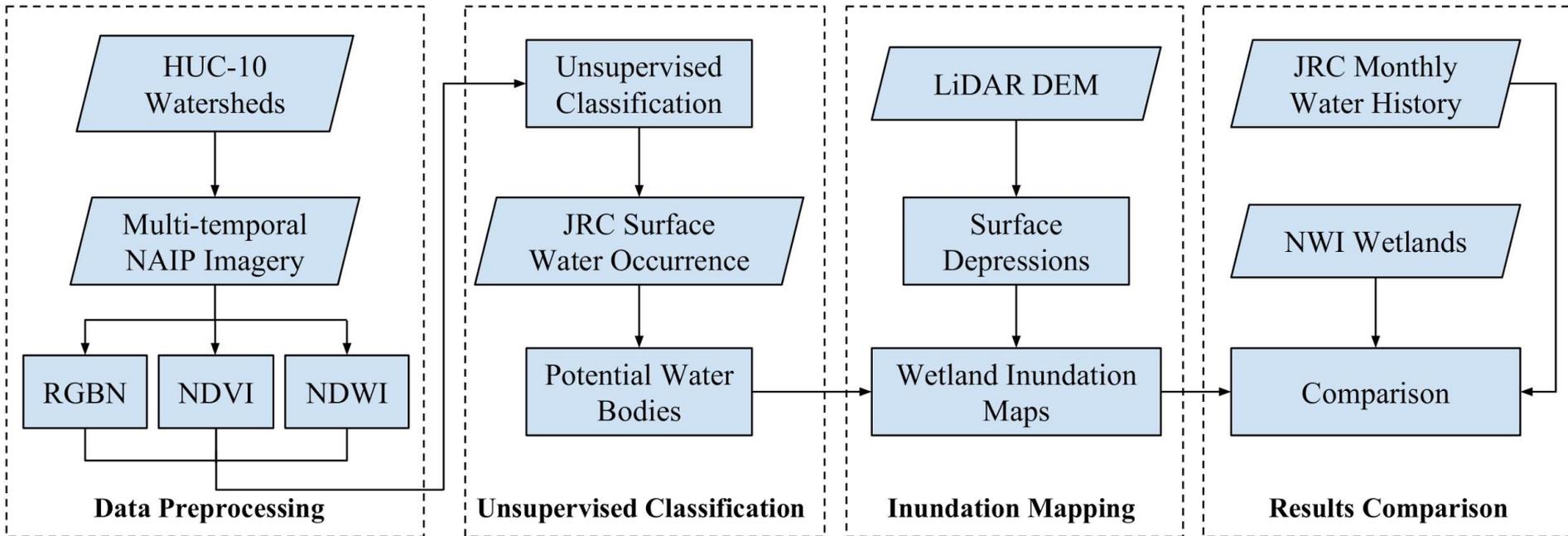
- 3 HUC-8 subbasins (16,576 km² in total)
- 26 HUC-10 watersheds (318 ~ 998 km²)

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)

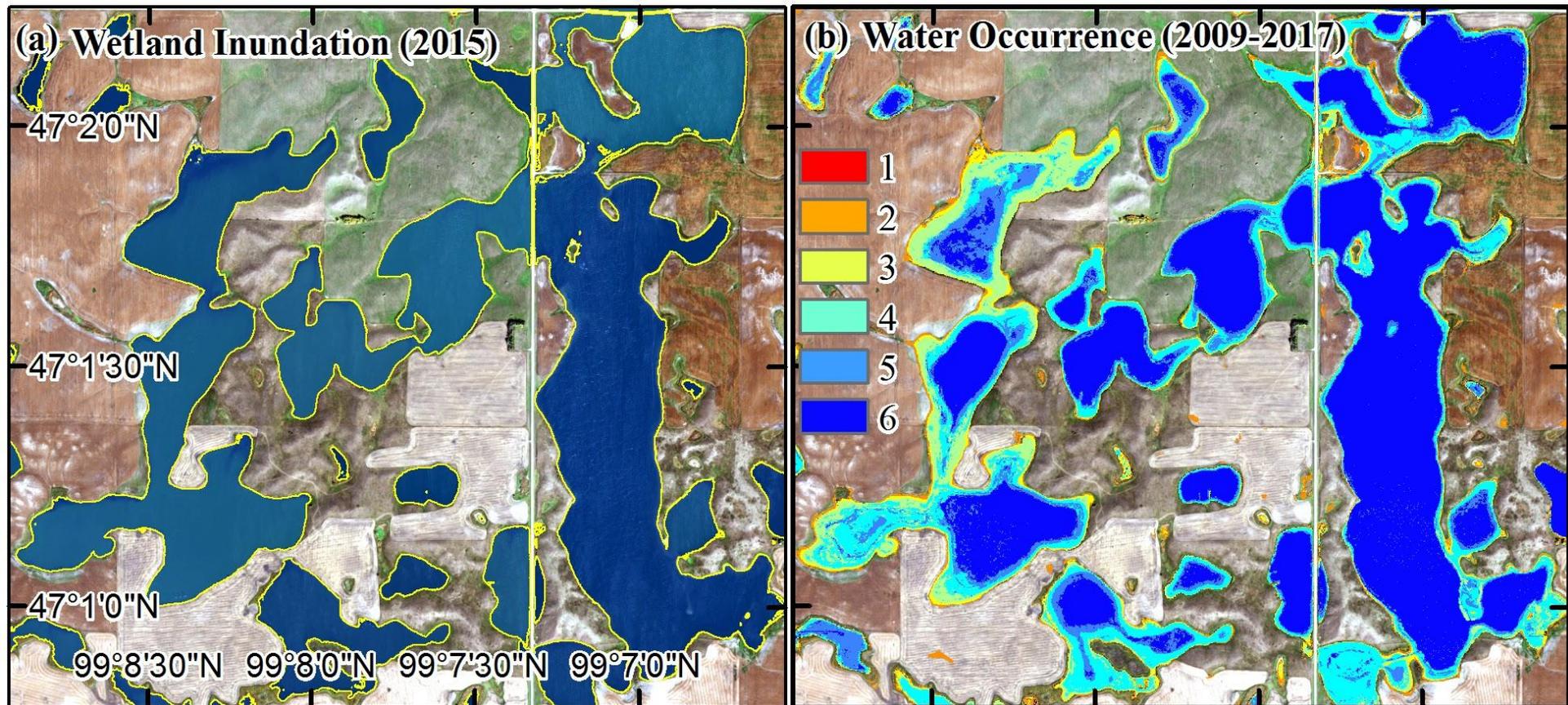


GEE Algorithm for Automated Inundation Mapping

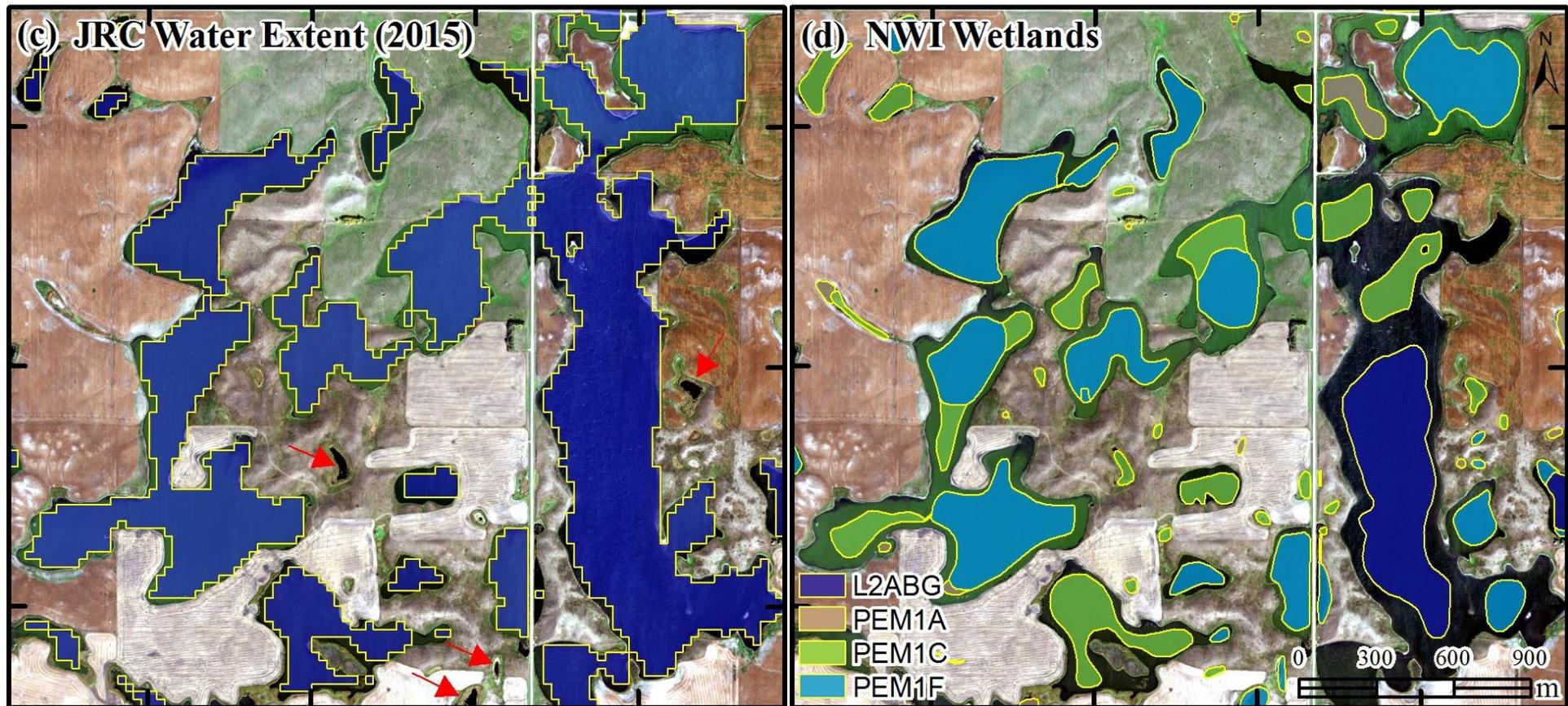


- **Wu, Q.,** Lane, C. R., Li, X., Zhao, K., Zhou, Y., Clinton, N., DeVries, B., Golden, H. E., & Lang, M. W. (2019). Integrating LiDAR data and multi-temporal aerial imagery to map wetland inundation dynamics using Google Earth Engine. *Remote Sensing of Environment*, 228, 1-13. <https://doi.org/10.1016/j.rse.2019.04.015>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

NAIP-derived Wetland Inundation Maps



Landsat-derived JRC Surface Water Extent vs. NWI



JavaScript-based Interactive Web App

Google Earth Engine Search places and datasets... Help giswqs

Wetland Hydrology Analyst

Mapping wetland hydrological dynamics in the Prairie Pothole Region using LiDAR data and aerial imagery.

Select the year of NAIP aerial imagery (1-m RGBN) to display on the map.

2017

Activate the inspector to click a watershed on the map to inspect its properties and map wetland inundation extent.

Activate inspector Deactivate inspector

Watershed id: 1016000202
Watershed name: Little Pipestem Creek
Watershed area: 50,532.05 ha (1 ha = 10,000 m²)
GLCF Landsat water area (2000): 4,396.44 (ha)
JRC max water extent (1984-2015): 5,167.59 (ha)
NWI wetlands count: 8570
NWI wetlands total area: 6,276.19 (ha)
NWI wetlands average size: 0.73 (ha)

National Wetlands Inventory (NWI)

Wetland Type	Area (ha)
Freshwater Emergent...	~5,000
Freshwater Forested/...	~100
Freshwater Pond	~100
Lake	~1,000

Layers

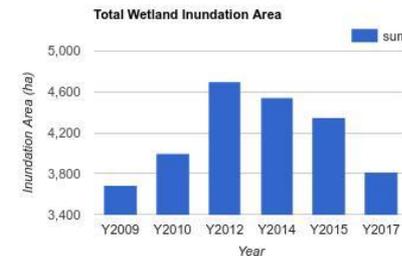
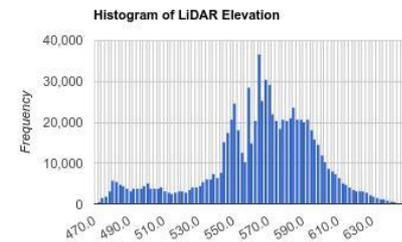
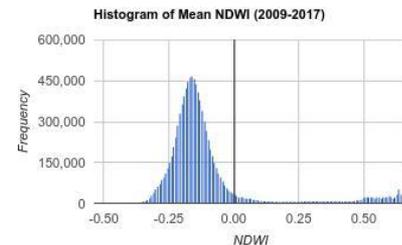
- Training Samples
- NWI Wetlands
- GLCF Water (2000)
- JRC Water (1984-2015)
- LiDAR Depressions
- CLSA Hillshade
- LiDAR DEM
- Water Occurrence
- Vectors Year 2017
- Water Year 2017
- Refined Year 2017
- Label Year 2017
- Cluster Year 2017
- NAIP Year 2017
- Mean NDWI (2009-2017)
- WUE 1016000202

Map Satellite

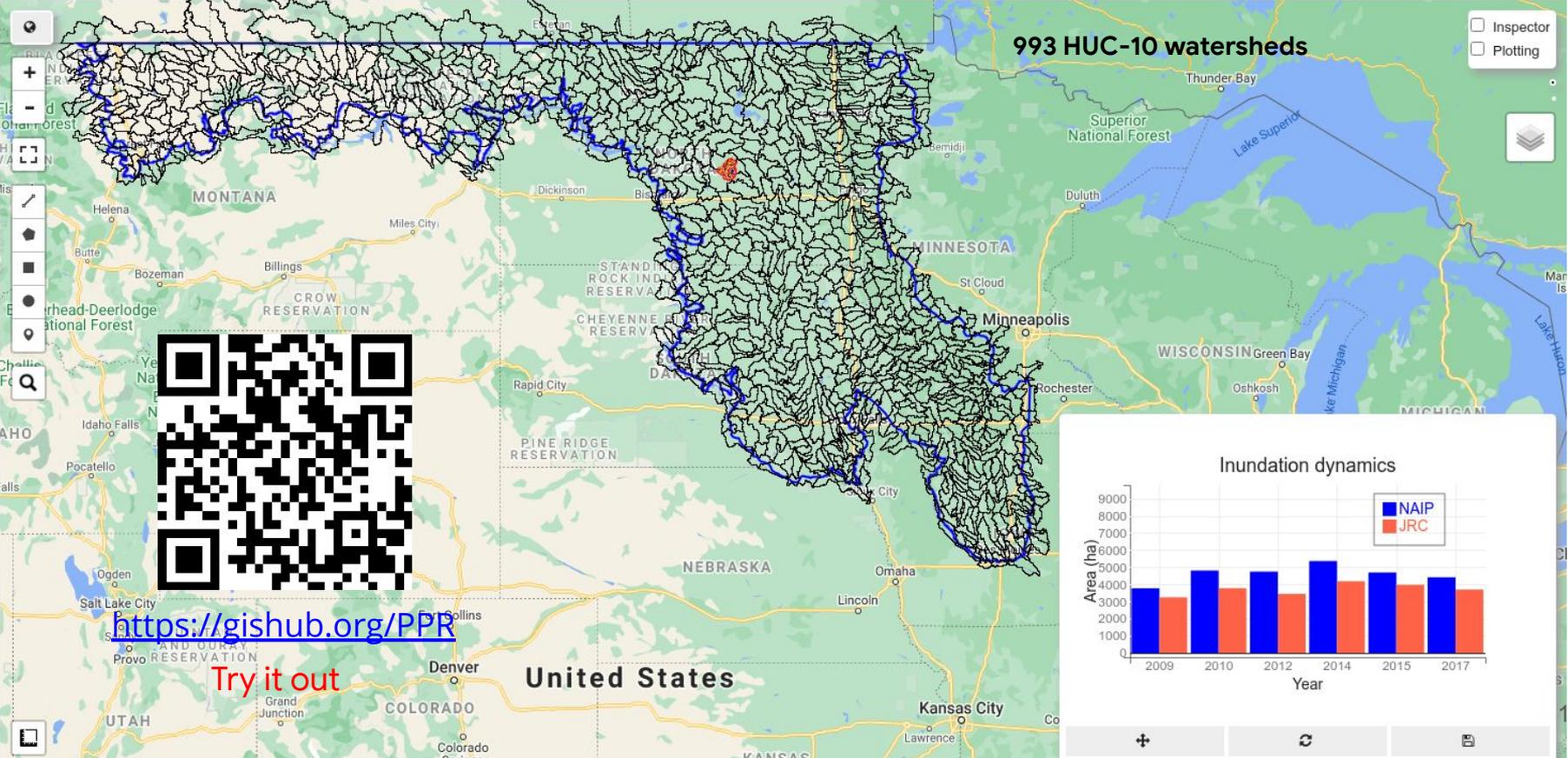
Map data ©2018 Google

Demo: <https://gishub.org/AGU20-GEE>
Code: <https://gishub.org/AGU20-Code>

NDWI thresholding using Otsu method: 0.1601



Python-based Interactive Web App





Introducing geemap

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



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](#)



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Welcome to geemap



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](#)

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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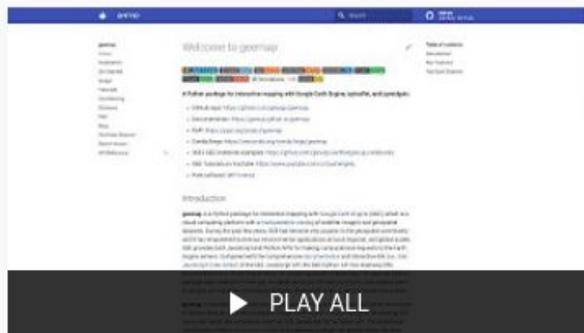
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Introducing the geemap Python package for interactive mapping with Google Earth Engine and ipyleaflet. More information about the geemap

1



New website for geemap user guide and API reference

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2



01 Introducing the geemap Python package for interactive

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3



02 Using basemaps in geemap and ipyleaflet for interactive

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4



03 Introducing the Inspector tool for Earth Engine Python API

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5



04 Creating a split-panel map for visualizing Earth Engine data

Thank you!
Any questions



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