

# Interactive Mapping and Geospatial Analysis with Leafmap and Jupyter

Qiusheng Wu  
Department of Geography  
University of Tennessee  
Knoxville, TN, USA  
qwu18@utk.edu

## ABSTRACT

Leafmap is a Python package for interactive mapping and geospatial analysis with minimal coding in a Jupyter environment. It is built upon several open-source packages, such as ipyleaflet and kepler.gl (for creating interactive maps), WhiteboxTools (for analyzing geospatial data), and ipywidgets (for designing interactive graphical user interface). Leafmap provides many convenient functions for loading and visualizing geospatial data with only one line of code. Users can also use the interactive user interface to load geospatial data without coding. Anyone with a web browser and Internet connection can use leafmap to perform geospatial analysis and data visualization in the cloud with minimal coding. This workshop will introduce the key features of leafmap for interactive mapping and geospatial analysis in a Jupyter environment. Attendees will learn how to leverage open-source Python packages and free cloud computing platforms for geospatial analysis and data visualization.

## CCS CONCEPTS

• Software and its engineering → Software notations and tools → Software libraries and repositories

## KEYWORDS

mapping, geospatial, open-source, Python, Jupyter

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## 1 INTRODUCTION

Leafmap is a Python package for interactive mapping and

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geospatial analysis with minimal coding in a Jupyter environment (Wu, 2021). It is a spin-off project of the geemap Python package (Wu, 2020), which was designed specifically to work with Google Earth Engine (GEE) (Gorelick et al., 2017). However, not everyone in the geospatial community has access to the GEE cloud computing platform. Leafmap is designed to fill this gap for non-GEE users. It is a free and open-source Python package that enables users to analyze and visualize geospatial data with minimal coding in a Jupyter environment, such as Google Colab, Jupyter Notebook, and JupyterLab. Leafmap is built upon several open-source packages, such as folium (Filipe et al., 2021) and ipyleaflet (Renou et al., 2021) (for creating interactive maps), WhiteboxTools (Lindsay, 2018) and whiteboxgui (for analyzing geospatial data), and ipywidgets (Grout & et al., 2021) (for designing interactive graphical user interface). Leafmap has a toolset with various interactive tools that allow users to load vector and raster data onto the map without coding (see Figure 1). In addition, users can use the powerful analytical backend (i.e., WhiteboxTools) to perform geospatial analysis directly within the leafmap user interface without writing a single line of code. The WhiteboxTools library currently contains 460+ tools for advanced geospatial analysis (see Figure 2), such as GIS Analysis, Geomorphometric Analysis, Hydrological Analysis, LiDAR Data Analysis, Mathematical and Statistical Analysis, and Stream Network Analysis.

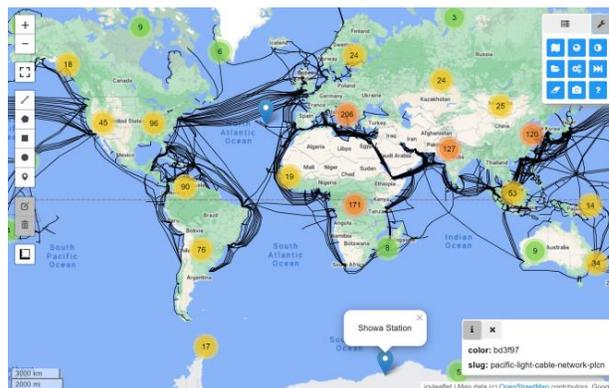
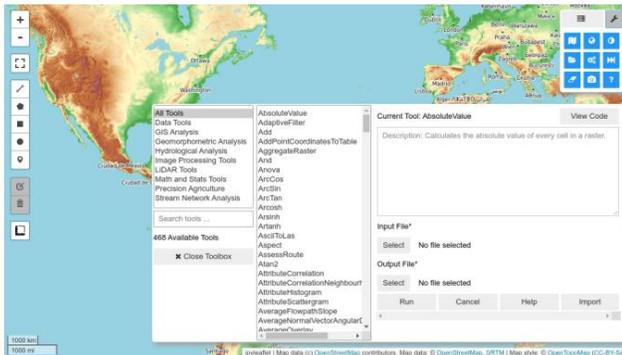


Figure 1: The leafmap user interface built upon ipyleaflet and ipywidgets.

It should be noted that leafmap is very different from desktop GIS software packages (e.g., QGIS, ArcGIS), which require a decent computer for the installation of a large program. Although QGIS can be used across platforms (e.g., Windows, Linux, Mac), ArcGIS Desktop is only available on Windows. ArcGIS Online can be used across platforms, but it is a proprietary product and requires a paid account for accessing its web services. In contrast, leafmap is a lightweight open-source Python package that can be used across platforms. It can also be used in the cloud (e.g., Colab, JupyterHub) without installing anything on a local computer. Users just need a web browser to get started, requiring minimal hardware configuration. Leafmap makes geospatial technologies and cloud computing more accessible to the scientific community.



**Figure 2: The WhiteboxTools graphical user interface integrated into leafmap.**

## 2 PREREQUISITES

The attendees are expected to have a basic understanding of Python and the Jupyter ecosystem. Familiarity with Earth science and geospatial datasets is useful but not required. More information about leafmap can be found at <https://leafmap.org>.

## 3 TUTORIAL PLAN

The topics that will be covered in this tutorial include: (1) a brief introduction to leafmap and relevant web resources; (2) creating interactive maps using multiple plotting backends (e.g., folium, ipyleaflet, heremap, kepler.gl); (3) changing basemaps; (4) loading and visualizing vector/raster data; (5) using Cloud Optimized GeoTIFF (COG) and SpatialTemporal Asset Catalog (STAC); (6) downloading OpenStreetMap data; (7) creating custom legends and colorbars; (8) creating split-panel maps and linked maps; (9) performing geospatial analysis (e.g., hydrological analysis) using WhiteboxTools; (10) discussion and Q&A. Each topic takes about three minutes, with a total of 30 minutes. The materials will be made available on GitHub. Attendees will be able to follow the tutorial using Google Colab or Binder without installing anything on their computer.

## 4 EXPECTED LEARNING OUTCOMES

Upon completion of this tutorial, attendees will be able to:

- Use Jupyter Notebook and JupyterLab on mybinder.org for geospatial analysis in the cloud.
- Use leafmap to create interactive maps with multiple plotting backends.
- Load various XYZ/WMS basemaps interactively or programmatically.
- Add vector (e.g., Shapefile, GeoJSON) and raster (e.g., GeoTIFF) datasets to the map.
- Design custom legends and colorbars.
- Create split-panel maps and linked maps for visualizing multiple geospatial datasets.
- Perform geospatial analysis using WhiteboxTools.

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