



# A Web Architecture to Geographically Interrogate CHIRPS Rainfall and eMODIS NDVI for Land Use Change

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## Motivation

- Two programs at NASA Marshall Space Flight Center are engaged in supporting end-users by providing unique NASA observations and research data sets for various applications.

The NASA Short-term Prediction Research and Transition (SPoRT) Center, which integrates unique NASA satellite and weather forecast modeling capabilities for the weather forecasting community.

NASA's SERVIR Program, which integrates satellite observations, ground-based data, and forecast models to improve disaster response in Central America, the Caribbean, Africa, and the Himalayas.



Monitoring of rainfall and vegetation over the continent of Africa is important for assessing the status of crop health and agriculture, along with long-term changes in land use change. These issues can be addressed through examination of long-term precipitation (rainfall) data sets and remote sensing of land surface vegetation and land use types. However, these datasets can be difficult for users to investigate due to several factors:

- Size of the datasets both for download and processing
- Processing capabilities of the end-user
- Complex imagery slicing and comparisons

In order to facilitate assessment of land-use change a web architecture has been built to allow users, requiring only a web browser, to perform complex interrogations of precipitation and vegetative index from remotely sensed data. The web architecture needs to be scalable to accommodate a large number of users and deployable within a cloud architecture to ensure that it is flexible to meet future demands.

## Input Datasets

### Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)

CHIRPS is a 30+ year rainfall dataset that is global in coverage. CHIRPS provides the daily precipitation input dataset.

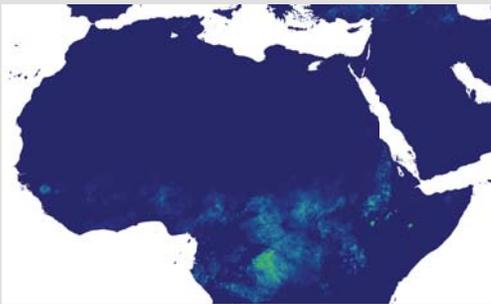


Figure 1: CHIRPS daily rainfall for a given day over Africa.

### eMODIS NDVI

eMODIS are multi-day composites of Normalized Difference Vegetation Index (NDVI) from FEWS NET. The data is acquired by using multiple remote sensing instruments. NDVI provides information regarding the green-ness of the vegetation.



Figure 2: eMODIS NDVI Imagery for a given day for West Africa.

**30+ Years**  
**1980-Present**  
**Daily, Monthly, Yearly**

## Architecture

The architecture consists of two parts: web client based graphical user interface, and the processing server architecture.

30 years of data from CHIRPS and eMODIS NDVI have been ingested into the system and provide the means to determine relationships between NDVI trends and precipitation for a given area.



Figure 3: General architecture of the system.

### Client Architecture:

Client system is built on OpenLayers and D3, both well-established Javascript libraries. OpenLayers is a web mapping library, and D3 is a graphing library. Using these base libraries custom software was developed to interact with the Server Web Application Programming Interface (API) and provide the methods to choose the area of interest, submit query and visualize and export the result.

### Server Architecture:

The server main interface is a Web API that allows users to submit queries into the system. The system then divides the tasks of requesting the data into discrete data requests. Those data requests are concurrently processed through iPython. The data associated with a discrete part of a data request is processed using image array processing techniques using Numpy. Numpy is a Python library to perform complex multi-dimensional queries in relatively short time frames. Numpy coupled with iPython's concurrency allows fast query returns for large time samples.

Custom geometries that the end-user creates through the interface are rasterized and applied across the 3-D arrays using Numpy.



Figure 4: Rasterized custom geometries provide mask for slicing data. End resultant has mathematical operation applied as requested by end-user.

## Workflow

Upon visiting the website the user is presented with a workflow to allow defining the area and time frame to perform their inquiry. The steps involved in the workflow are shown Figure 5.

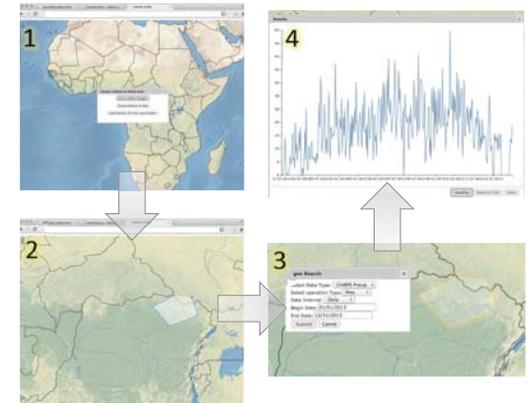


Figure 5: End-User Workflow using the system.

The system can be used to generate daily, monthly and yearly averages over a geographical area and range of dates of interest to the user. It also provides analysis of trends in precipitation or vegetation change. The general workflow is the following:

- 1) User Chooses to upload custom geometry in GeoJSON format, select area using predefined geopolitical boundaries, or by defining a custom geometry.
- 2) If the user needs to define custom geometry they performs this by clicking on the map interface. Or they can select the geopolitical area of interest from existing geopolitical features.
- 3) The end-user selects the type of parameter to interrogate (currently CHIRPS rainfall, or eMODIS NDVI), selects the mathematical operation on the data such as max, or min, etc. The user then selects the method to aggregate the data in the time dimension, daily, monthly or yearly. Lastly, the user selects the start and end dates for the interrogation and submits the request.
- 4) The request returns with the display of the desired data in graph format. The data can then be exported in Comma Separated Values (CSV) for use in external programs, or the graph can be saved as an image.

## Conclusions

The data provided back to the end-user is displayed in graphical form and can be exported for use in other, external tools. The development of this tool has significantly decreased the investment and requirements for end-users to use these two important datasets, while also allowing the flexibility to the end-user to limit the search to the area of interest.