**NASA DEVELOP National Program**



International Research Institute for Climate and Society (IRI)

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Malawi Disasters II

Applications of Flood Definitions and NASA Earth Observations to Create a Flood Forecasting Methodology

 **Technical Report**

Rough Draft – June 25, 2015

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# I. Abstract

[Placeholder - do not put anything here until the final draft submission. The abstract in the project summary is where the working draft of the abstract should “live”]

**Keywords**

Malawi, Floods, Inundation, Remote Sensing, Disaster Management, Soil Moisture, Precipitation, Early Warning

# II. Introduction

The African country of Malawi experiences a strong seasonal rainy season stretching from October to April, which provides about 95% of its annual precipitation. In addition to this high seasonality, about 20% of Malawi’s land cover is comprised of surface water from Lake Malawi, one of the Great African Lakes. These unique features contribute to a country-wide vulnerability to riverine floods and flash floods. In January 2015, extended periods of extreme rainfall caused a series of flood events throughout the Central and Southern Regions of Malawi, which resulted in the displacement of over 230,000 residents and left 276 dead. In order for local authorities and supporting humanitarian agencies to provide post-disaster relief, these organizations often rely on remotely-sensed satellite data to evaluate impact and design response programs. Furthermore, due to low density of in situ weather station data, satellite data is needed to expand spatial coverage of climatic, environmental and meteorological data, hence “filling in the gaps”.

A previous study of several inundation products provided insight into potential disparities between spatial distribution of flood signals relative to the specific type of flood. The current project builds on this analysis in numerous ways.

Disaggregating by flood type and isolating flash floods, this project aims to further assist our project partners, as well as other humanitarian agencies, to better monitor the spatial extent of different flood events and further improve flood early warning and disaster response activities.

This project falls under the NASA Applied Sciences national application area of Disasters. It will contribute to current disaster management practices in Malawi by building on previous analyses of various remotely-sensed flood detection products to better identify impacts of distinct flood events.

The project partners for this study are Erin Coughlan, Senior Climate Specialist of the Red Cross Red Crescent Climate Centre (RCRCC), and Hastings Kandaya, Director of Programmes and Development at the Malawi Red Cross (MRC) National Society. The most pressing concern in disaster risk management, as expressed by our project partners, is first the ability to locate affected areas in expedite fashion and second, to increase preparedness actions by development of a framework for flood early warning. Flash flood events present a unique challenge to disaster management, as they are exceedingly more unpredictable than traditional riverine floods as well as being more difficult to detect and document, thus posing difficulties to disaster response. By providing a framework for including flash flood-specific methodology into monitoring and forecasting, our partner organizations will have more spatially accurate information available for managing relief efforts.

# III. Methodology

Building off the initial Malawi disasters project, this term we will analyze the most recent, verified humanitarian data to determine skill of remotely sensed flood detection products. Further, we will incorporate long time series of remotely sensed environmental data into our analyses to explore potential for establishing a predictor-predictand relationship. First, we will process the most recent data on locations of shelters housing internally displaced people (IDPs).

The data recorded the following information:

- Shelter site ID

- Name of shelter

- Shelter location

- Site start date

- GPS coordinates of the site

- Site Status

- Name of flooded villages; origin of internally displaced person (IDP)

- Location of flooded villages; origin of internally displaced person (IDP)

- Type of shelter used

- Land Ownership of the site

- Survey date

- Total number of IDP families

- Total number of IDP individuals

Using this information, an enhanced, ground truth grade Shelter Location Layer was produced as a vector file in ArcGIS.

Furthermore, for each shelter, the dataset includes the name and location of the origin village that the majority of IDPs were forced to flee from. Unfortunately, the origin villages were not georefernced and there were difficulties in establishing their location, leading to challenges in the production of a Flooded Village Layer.

If the location of the origin village was in question, location was determined from an enhanced qualitative comparison with the Malawi Spatial Data Portal (MASDAP). As the village location is in question, the valid location will be determined by analyzing boundaries of political districts of descending influence (provided in the dataset); first the Region in which the flooded village was located would be matched, than the Traditional Authority Area, then Town, and finally, Village. After locations of the origin villages could be determined, they were georeferenced and processed as a vector file using ArcGIS. This layer, deemed the Flooded Village Layer, along with the new Shelter Location Layer, will replace the spatially coarse and temporally outdated layer from the previous term, affording the opportunity for a higher spatial resolution and more temporally recent analysis to be completed.

Next, both the Shelter Location Layer and Village Location Layer are placed above each flood detection product used in previous project to assess the product’s flood signal through qualitative analyses. Satellite based products that produced flood maps during January 2015 in Malawi are used for this analysis, including; DFO, NRT-GFM, TerraSAR-X, RADARSAT, RADARSAT-2, GFMS-FD, and GFMS-I.

To isolate the maximum flood extent and georeference each product, different techniques were used. For TerraSAR-X shapefile, RADARSAT shapefile, RADARSAT-2 shapefile, DFO geotiff image and NRT-GFM shapefiles included maximum flood extent data and were received in a georeferenced format; therefore, no further data processing was needed using QGIS. For NRT-GFM data, each day of January 2015 were overlaid in chronological order to compile a maximum flood extent map. GFMS-FD and GFMS-I images were downloaded as .gif format. Due to additional map scale and exogenous white space, we cropped out the map portion of all the images and reprocessed each as a raster in.png format. Next, each of the GFMS-FD raster data files were georeferenced in QGIS, and subsequently polygonized (raster to vector) to isolate flood signal from the background noise. Afterwards, all eight GFMS-FD polygonized layers were stacked on top of each other in chronological order to generate a single maximum flood extent map. Similarly, the eight GFMS-I images in raster format were georeferenced in QGIS and stacked in chronological order to generate a single map of maximum flood extent.

The satellite products were then grouped into three categories based on characteristics of the primary flood-detecting sensor. Group 1 consisted of products using the Synthetic Aperture Radar sensor: TerraSAR-X, RADARSAT and RADARSAT-2. Group 2 included products using MODIS: DFO and NRT-GFM. Group 3 comprised of products produced by University of Maryland’s Global Flood Monitoring System using TRMM/Global Precipitation Monitoring (GPM) precipitation data coupled with a hydrologic model: GFMS-FD and GFMS-I.

These analyses will yield qualitative comparisons of each group to both the Shelter Location Layer and Village Location Layer.

Second, we will process soil moisture data from various sources to explore antecedent environmental conditions before the floods. Based on a disaggregation of flood types based on definitions established in the initial project, we will explore the potential to use changes in soil moisture as a predictor for change in risk for certain flood types.

Third, we will produce a prototype framework for flash flood disaster risk management, including components of risk identification, early warning and humanitarian response. This framework could be an important element in informing the development of a flood type specific early warning system in Malawi, with potential to be scaled up to other countries in the region.

# IV. Results & Discussion

[More details forthcoming]

Insert images, graphs, maps, charts, etc. here. Choose the most important results to highlight here. No word cap, but two to six pages is a good range.

Things to discuss:

* Analysis of Results: What can you tell from your graphs, images, etc? What does this mean for your project?
* Errors & Uncertainty: What factors could you not account for, what things didn’t work out like you expected they would, etc.
* Future Work: If this project was to be selected for another term, what would be the focus? What other areas would be of interest?

# V. Conclusions

[More details forthcoming]

Final conclusions. Word count: 200-600 (~a page).

# VI. Acknowledgments

[More details forthcoming]

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This material is based upon work supported by NASA through contract NNL11AA00B and cooperative agreement NNX14AB60A.

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# IV. Appendices

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