**NASA DEVELOP National Program**



Wise County Clerk of Court’s Office

*Fall 2015*

East African Great Lakes Weather

Utilizing NASA Earth Observations to Identify Indicators to Help Predict Deadly Storms over African Great Lakes

 **Technical Report**

Rough Draft – October 8, 2015

William Wilson (Project Lead)

Annabel White

Grant Bloomer

Juan Antonio

Dr. Kenton Ross, NASA DEVELOP (Science Advisor)

Kristopher Bedka, NASA Applied Sciences Climate Science Branch (Science Advisor)

Dr. DeWayne Cecil, Global Science and Technology, Inc. (Science Advisor)

Professor Robert VanGundy, University of Virginia’s College at Wise (Science Advisor)

Melanie Salyer, Wise County Clerk of Court’s Office (Mentor – NASA DEVELOP WC)

# I. Abstract

**Keywords**

Earth Observations, Lake Victoria, weather, hazardous storms, natural disasters, MERRA, SEVIRI

# II. Introduction

The East African Great Lakes region spans eastern Africa’s tropical rift valleys, including parts of the sovereign states of Kenya, Tanzania, Uganda, Burundi, Rwanda, and the Democratic Republic of the Congo. The most significant of these is Lake Victoria, which is the second largest freshwater lake in the world in terms of surface area, and Lake Tanganyika, which holds the same distinction when ‘largest’ is figured by volume. Here, these large freshwater lakes influence regional climate conditions and play a vital role in the economic livelihood of millions of people; 30 million of whom live along the coasts of Lake Victoria alone. Almost 1/3 of this population’s food supply is drawn from the lake by more than 200,000 fishermen (Thiery, 2015). The provinces surrounding the lake constitute one of the most productive agricultural realms in East Africa.

While much is already known about how these large lakes regulate climate and contribute to the diurnal cycles of lake/land breezes and the thermal gradient surrounding the lake, less is understood about the provenance of hazardous weather events in the lakes’ immediate vicinity. Part of this is due to the area’s tropical conditions, where tumultuous storm events arise suddenly and are not always accompanied by larger, more comprehensive storm movements. Thunderstorms that arise over these lakes (esp. Lake Victoria) are severe; their convective activity commonly approaching depths of 6 km, producing gale-like conditions of high winds, and having some of the densest and most frequent lightning strikes in the world. It is estimated that around 5,000 fisherman die every year on the lake as a result of these storms (Barnett, 2013).

This project aims to better understand the meteorology of these storm events by analyzing atmospheric conditions that surrounded some of the most severe storms during the study period (2005 – 2013). Data compiled into a ‘Hazardous Storm Event Database’ over the African Great Lakes region were utilized for this research. This Hazardous Storm Event Database is a directory of pixels that have been classified as ‘overshooting tops’ (OT’s) by a detection algorithm developed by NASA’s Applied Sciences Program and the GOES-R Aviation Algorithm Working Group. This database has been maintained by Kristopher Bedka at the NASA Langley Research Center. The designation of OT refers to the convective phenomenon in which strong updraft currents punch through into the lower stratosphere, above the storm equilibrium level. Storm events that feature overshooting tops yield especially hazardous conditions at ground level. Employing infrared brightness temperatures from the SEVIRI sensor onboard EUMETSAT’s METEOSAT satellite, this algorithm analyzed 15 minute geostationary images during the aforementioned time period, and thus set the terms for the temporal study area by nature of what was included in the database.

The partners for this project are from the Kenya Meteorological Department (KMD), whose mission is, “To facilitate accessible meteorological information and services and infusion of scientific knowledge to spur socio-economic growth and development”. The KMD is a new partner to DEVELOP, but it has worked closely with NASA SERVIR in the past. NASA’s Short-term Prediction Research and Transition Center (SPoRT) worked with the KMD on inserting data from NASA LIS into KMD weather prediction models. SERVIR has previously had a presence at the department, helping to train KMD personnel on use of NASA imagery and to better integrate model changes.

This project will assist both the project partners and the researchers at NASA Climate Sciences Division by expanding on the knowledge associated with the detection of overshooting tops. Thus by nature of the scope of this initial term the project falls most directly into the Weather application area. However, the themes of ecological forecasting and disasters are arguably the inspiring source on which the project is grounded and subsequent terms might be better classified within these application areas.

# III. Methodology

Pixel directories which spanned from 2005 – 2013 were acquired from this Hazardous Storm Event Database. Each row in the data corresponded to a pixel that had been classified from the SEVIRI images as an OT by the detection algorithm mentioned in the introduction. The rows were set up with 7 columns with the following information:

* Column 1: YYYY-MM-DD-HHmm, Y=4 digit year, M=month of year, D=day of month, HHmm=time of satellite scan in UTC
* Column 2-3: Latitude/Longitude of pixel with storm detection
* Column 4: Satellite-observed infrared temperature of pixel
* Column 5: The temperature difference between the pixel with storm detection and the surrounding cirrus anvil cloud.
* Column 6: A quality control parameter
* Column 7: The “ID number” for the storm detection within the satellite image at a particular date and time.   There are multiple pixels within each storm and the ID number helps one to cluster them together.

MATLAB r2015a was used to compile the raw data from the Hazardous Storm Event Database. The initial data contained multiple OT detections for almost every day over the 9 year study period, totaling tens of millions of data points. This data was imported into MATLAB and summarized by day, reducing the amount of data points to fewer than 3,500.

After processing in MATLAB, the data was imported into Microsoft Excel for further consolidation. Using the Percentile function within Excel, days that recorded within the 99th percentile were extracted from the database’s temporal span. The same was done at the 50th percentile to use as a baseline for comparison. From these subsets, 10 days were randomly chosen amongst the group to use as study cases.

From the GES – DISC Mirador Data Holdings, 2 MERRA products were downloaded as zipped NetCDF files for each study case at the 99th and 50th percentile study cases.

This data product information is described below.

1. Product name: inst6\_3d\_anaNP

 Short name: *MAI6NPANA*

Long name: *MERRA DAS 3d analyzed state on pressure*

1. Product name: tavg1\_2D\_slv\_Nx

Short name: *MAT1NXSLV*

Long name: *MERRA IAU 2d atmospheric pressure single level diagnostics*

# IV. Results & Discussion

(To be added)

# V. Conclusions

(To be added)

# VI. Acknowledgments

Insert here. Keep to a concise paragraph or bullets of names. End with the following sentence.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration.

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

# VII. References

Barnett, E. (2013, January 17). Lethal weather on 'world's most dangerous lake' - CNN.com. Retrieved October 7, 2015, from <http://www.cnn.com/2013/01/17/world/africa/lake-victoria-weather-deaths/index.html>

Bedka, K. (2011). Overshooting cloud top detections using MSG SEVIRI Infrared brightness temperatures and their relationship to severe weather over Europe. Atmospheric Research, 175-189.

Bedka, K., Brunner, J., Dworak, R., Feltz, W., Otkin, J., & Greenwald, T. (2010). Objective Satellite-Based Detection of Overshooting Tops Using Infrared Window Channel Brightness Temperature Gradients. J. Appl. Meteor. Climatol. Journal of Applied Meteorology and Climatology, 181-202.

Burleyson, C., Yuter, S., & Rose, L. (2011). Athmospheric Observations Feasibility Study - Final Report.

Improving Kenya Meteorological Department Numerical Weather Prediction. (n.d.). Retrieved October 7, 2015.

Chamberlain, J., Bain, C., Boyd, D., Mccourt, K., Butcher, T., & Palmer, S. (2013). Forecasting storms over Lake Victoria using a high resolution model. Meteorological Applications, (21), 419-430. doi:10.1002/met.1403

Thiery, W., Davin, E., Panitz, H., Demuzere, M., Lhermitte, S., & Lipzig, N. (n.d.). The Impact of the African Great Lakes on the Regional Climate. Journal of Climate J. Climate, 4061-4085.

# VIII. Content Innovation

In preparation for DEVELOP’s coming microjournal, please select three content innovation features to support your paper. For each item, please list the name of the feature, and include the tool itself if possible (eg. glossary terms and definitions). If the tool does not work in Microsoft Word (eg. Interactive MATLAB Figure Viewer), please list the file name and upload the related file to the DEVELOP Exchange. If you choose to use Inline Supplementary Material, please also include where the material should appear in the text.

**Some options include:**

AudioSlides

Database Linking Tool

Data Profile

Executable Papers

Featured Author Videos

Featured Multimedia for this Article (video and podcast options)

Glossary Viewer

Inline Supplementary Material (figures, tables, computer code)

Interactive Map Viewer

Interactive MATLAB Figure Viewer

Interactive Plot Viewer

Nomenclature Viewer

# IV. Appendices

Insert here