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# GPM Rainfall-based Streamflow Analyses for East Africa

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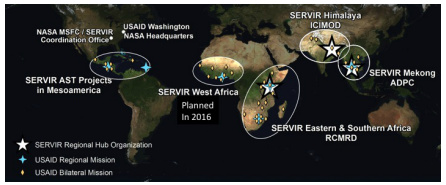
## SERVIR

- Joint project of NASA and US Agency for International Development (USAID)
- Local partners at several hubs around the world.
  - Mesoamerica ( Panama City, Panama)
  - Hindu Kush-Himlaya (Kathmandu, Nepal)
  - Eastern and Southern Africa (Nairobi, Kenya)
  - Mekong (Bangkok, Thailand).
- Mission is to use satellite data and geospatial technology to help developing countries manage resources, land use, and climate risks.
- Empowers local decision makers with tools, products, and services.
- means "to serve" in Spanish.
- Focus areas
  - Agriculture
  - Water
  - Disasters
  - Ecosystems
  - Land Use




*SERVIR network including regional hubs. SERVIR is improving awareness, increasing access to information, and supporting analysis to help people in Africa, Hindu Kush-Himalaya, Lower Mekong, and Mesoamerica manage challenges in the areas of food security, water resources, land use change, and natural disasters. With activities in more than 30 countries and counting, SERVIR has already developed over 40 custom tools, collaborated with over 200 institutions, and trained more than 1800 individuals, improving the capacity to develop local solutions.*

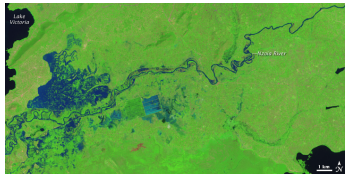
## SERVIR Eastern and Southern Africa

- Eastern and southern Africa are regions with great developmental challenges. Already intense floods and droughts are likely to worsen with global climate change. In combination with rising temperatures and sea level rise,climate stresses threaten health, agriculture, and biodiversity. In addition, these regions suffer from high levels of poverty and environmental degradation, especially deforestation and desertification.To help secure Africa's future, these regions must improve natural resources management and development decision-making to safeguard their environment and economies. SERVIR works in partnership with the Regional Centre for Mapping of Resources for Development (RCMRD) in Nairobi, an intergovernmental association with 20 member states, to help achieve these goals.

*RCMRD member states.*

## Floods

- Floods are one of the most catastrophic natural disasters in eastern Africa. Affecting human lives as well as infrastructure, floods can wipe out entire communities along with many of the resources needed to rebuild. To mitigate this problem, SERVIR-Eastern and Southern Africa (E&SA) has provided the CREST (Coupled Routing and Excess Storage) Hydrologic Modeling Tool (Wang et al. 2011) to several eastern African countries. CREST integrates real-time satellite rainfall information with land shape, elevation, soil characteristics, and other fixed variables to model evaporation, transpiration, soil moisture, and streamflow - factors that influence likelihood of flooding. The tool is also available in short-term forecast mode based on predicted rainfall. SERVIR also developed a CREST Viewer and Flood Simulator tailored to specific basins in Eastern Africa. These tools enable end-users to visualize the modeled information in the form of graphs and high-resolution inundation maps. Using the tools, end-users such as water managers can readily assess imminent and near-term likelihood of flooding at selected locations.

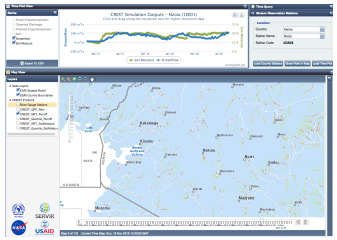



*False color image of Kenya's Nzoia River during flooding on November 13, 2008, as observed by the Advanced Land Imager (ALI) on NASA's Earth Observing-1 satellite. At least 5,000 people were marooned or evacuated from the banks of the swollen river, according to the United Nations Office for the Coordination of Humanitarian Affairs.*

## CREST Streamflow Viewer

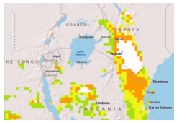
- Streamflow analyses are produced by the Coupled Routing Evolution and STorage (CREST) model (Wang et al. 2015), a distributed hydrological model which simulates the spatial and temporal variation of soil moisture, runoff, and streamflow. The model is forced with precipitation and potential evapotranspiration (PET). Satellite precipitation estimates are especially useful over areas such as East Africa where radar, rain gauge, and other ground-based networks are sparse. To take advantage of the most recent satellite data, CREST has been upgraded to use IMERG estimates of precipitation from the GPM constellation (ref). IMERG is a global dataset available at 30-minute time resolution and 0.1-degree spatial resolution, combining high-quality but limited-coverage microwave precipitation estimates from a constellation of low-earth orbiting satellites with frequent updates from geostationary infrared measurments. Currently, PET is prescribed from a monthly climatology produced by the Famine Early Warning Systems Network (FEWS NET; http:fews.net).

- SERVIR has developed the CREST Streamflow Viewer, a web interface that can be used to plot time series of modeled soil moisture and streamflow from CREST at selected stations. It can also plot maps of rainfall, runoff (streamflow), soil moisture, and quantiles of runoff and soil moisture. SERVIR-E&SA has calibrated the CREST model for several basins in Kenya, Rwanda, Uganda, Namibia, and Malawi and customized the CREST tools for use there. "The beauty of these tools is that they enable non-technical end-users to gain insights into actual and potential flooding in specific basins," says Faith Mitheu, of SERVIR-E&SA. "Water managers and other decision-makers and disaster response organizations can evaluate an evolving situation and make informed decisions to save lives, crops, and property."



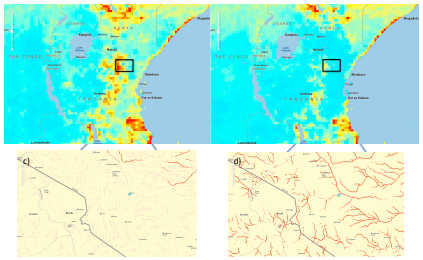
*CREST Streamflow Viewer web interface, showing time series plots and map of streamflow values..*

## Example Case: Dec. 2015 Rainfall



*Precipitation at 21:00 UTC 13 Dec. 2015*


*Time series of Soil Moisture and Streamflow at Tsavo for Dec. 2015.*




*a) Dec. 12, 2015 soil moisture; b) Dec. 16 soil moisture; c) Dec. 12 streamflow; d) Dec. 16 streamflow. For soil moisture, red is dry and blue is wet. For streamflow, pink is above average for that location and red is well above average. The effect of rainfall along the Kenya-Tanzania border region is seen in the higher soil moisture and increased streamflow.*

## CREST Flood Simulator

To generate a flood map showing potential inundation extent for a specified time period (as well as a graph showing streamflow discharges and water level stage versus time), the end-user can choose a country, then a particular basin in that country, and then 'CREST' as the simulation source. The Flood Simulator can generate a flood map for any streamflow discharge value from CREST above a set threshold. Also, by specifying a known water level value for a given river gauging station, an end-user can even use the Flood Simulator to generate a flood map for a basin that is not supported by the CREST model. Once a flood extent map is generated via either method, it can be downloaded in Geo-tiff, a format any GIS software can read.

Faith Mitheu of RCMRD explaining CREST in a training session.

## Links

SERVIR
- www.servirglobal.net

CREST Hydrologic Modeling tool (Description)
- catalogue.servirglobal.net/Product?product_id=4

CREST Viewer
- gis1.servirglobal.net/crestviewer/

Flood Simulator
- cloud.rcmrd.org/floodsimulator/

CREST Mobile Web Page
- www.servirglobal.net/mapresources/crestmobile/index.html

## References

Huffman, G. J., et al. "NASA Global Precipitation Measurement (GPM) Integrated Multi-satellitE Retrievals for GPM (IMERG)." Algorithm theoretical basis document, version 4.1. NASA, 2013.

Wang, J., and Coauthors, 2011: The coupled routing and excess storage (CREST) distributed hydrological model. Hydrol. Sci. J., 56, 84–98, doi:10.1080/02626667.2010.543087.