SERVIR
Connecting Space to Village

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SERVIR Project Scientist, NASA

August 19, 2014

Workshop on Cyberinfrastructure and Water Resources
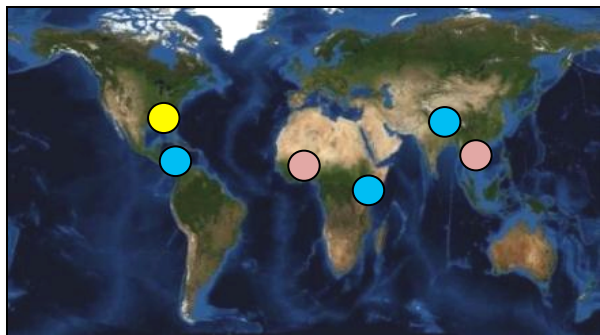
About SERVIR

A NASA-USAID partnership to improve environmental management and resilience to climate change by strengthening the capacity of governments and other key stakeholders to integrate earth observation information and geospatial technologies into development decision-making
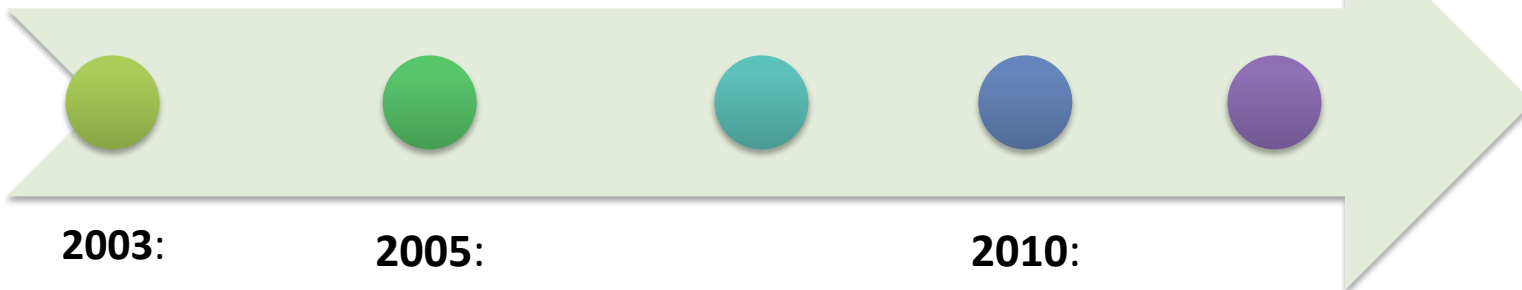
Background - Timeline

SERVIR Network

2008: SERVIR-Africa at RCMRD

2014: SERVIR-Lower Mekong

2003: SERVIR Concept

2005: SERVIR-Mesoamerica at CATHALAC

2010: SERVIR-Himalaya at ICIMOD

Background - Components

- NASA
  - NASA Headquarters Program Management
  - SERVIR Coordination Office
  - SERVIR Applied Sciences Team

- USAID
  - USAID Washington Team
  - Mission AORs
  - Demand Team

- SERVIR Hubs
  - Mesoamerica
  - Africa
  - Hindu Kush Himalaya
  - Soon: SERVIR Mekong


SERVIR Applied Sciences Team

SERVIR team members from Hubs, USAID, NASA

What We Do

- Identify needs in SERVIR regions
- Link science products from research institutions to meet those needs through improved access to data, models, online maps, and visualizations
- Build capacity of regional institutions, stakeholders, and young professionals
- Strengthen partnerships and foster collaboration across SERVIR network
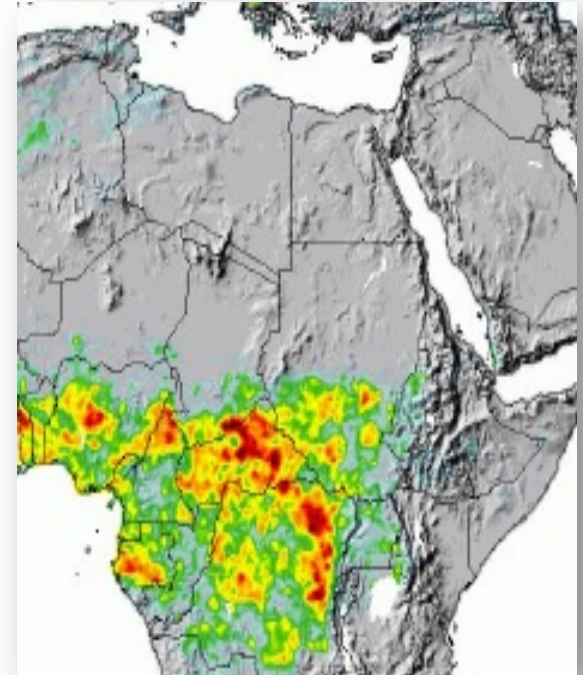
Science

End User Needs
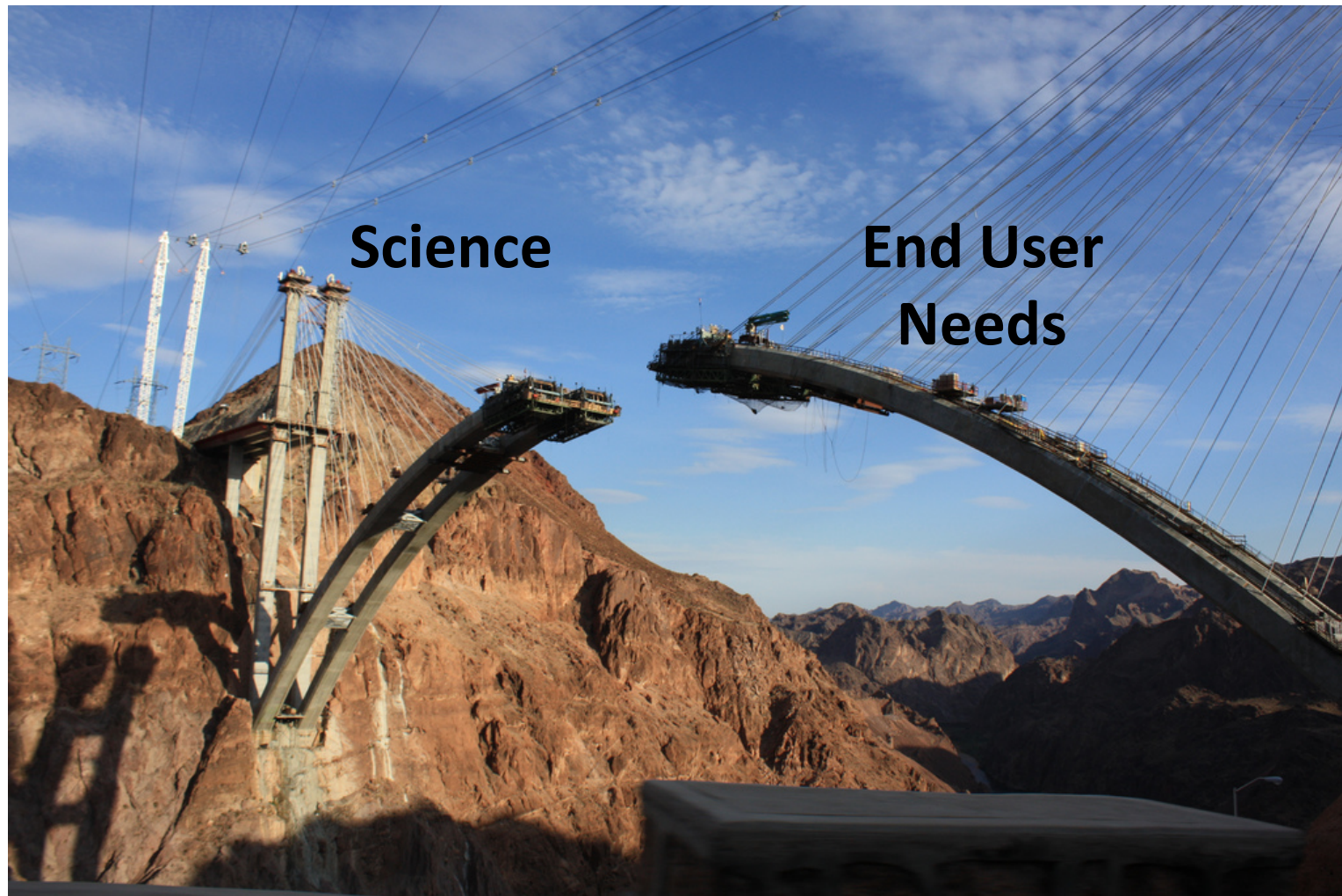
Courtesy: alifayre

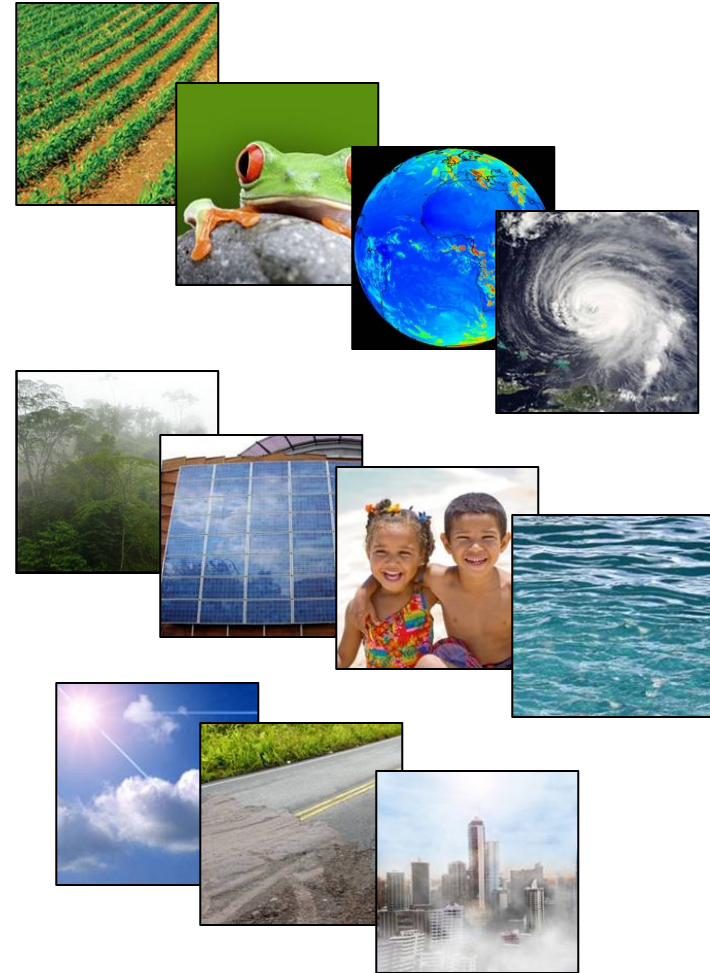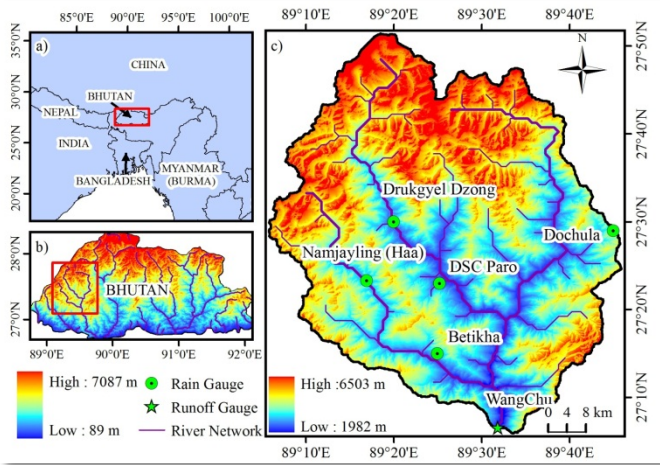# SERVIR Thematic Areas

- Agriculture
- Biodiversity
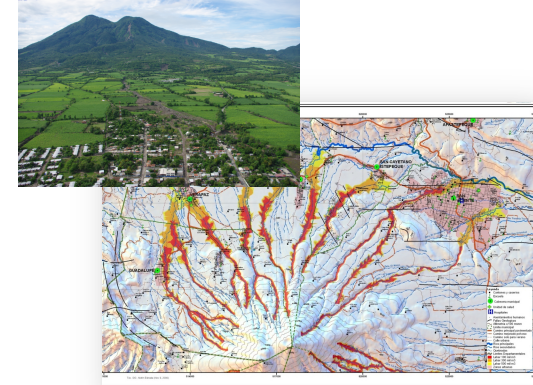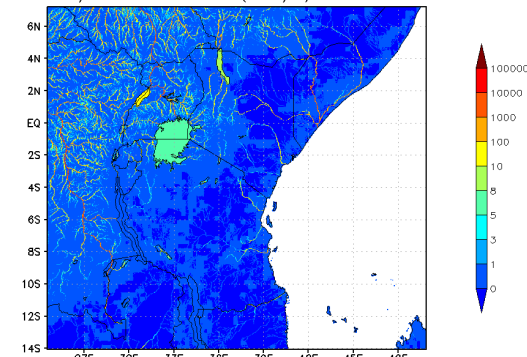- Climate
- Disasters
- Ecosystems
- Energy
- Health
- **Water**
- Weather

SERVIR Science Applications for Decision Making
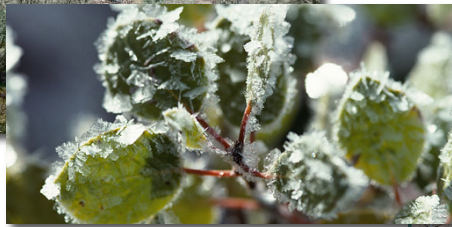

Bhutan Water Resource Assessment

Real Time Streamflow in East Africa

Landslide Prediction System in Mesoamerica

Frost Mapping in Africa

Near Real-time Forest Fire Monitoring in Nepal
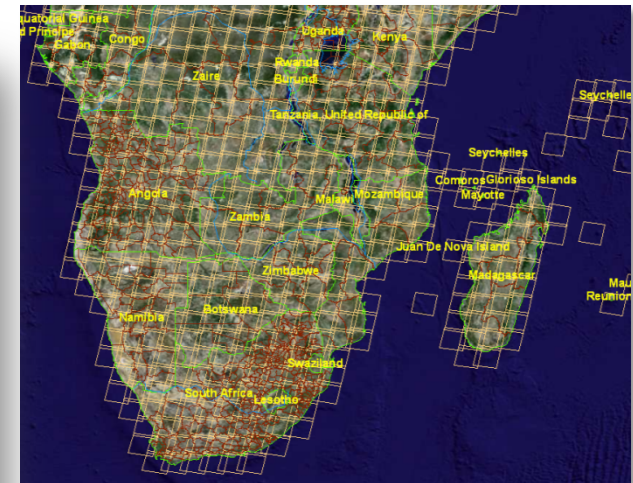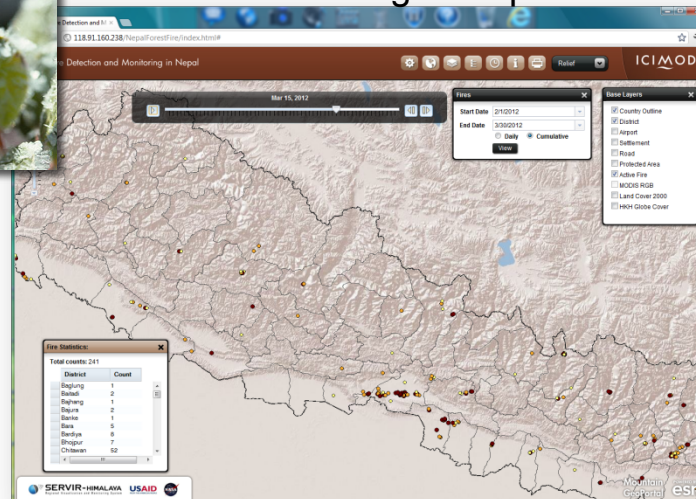
Greenhouse Gas Emissions Inventory in Africa

Flood Forecasting in East Africa

- Needs assessment in East Africa identified characterization and forecasting of droughts and floods as two most pressing needs.

- Ministry of Water in Kenya, Rwanda, Uganda, and Tanzania do not have real time assessments of hydrologic conditions
  - Very few real time stream gages, even fewer in working condition.
  - District managers need real time information to inform the local authorities of floods, ideally forecasts with several hours of lead time.

- Spatially distributed hydrologic model CREST, developed by GSFC for one Kenyan watershed

- Spatial resolution 1km, run every 3 hours in the Amazon cloud infrastructure

- Uses near real-time satellite-derived rainfall estimates and rainfall forecasts from Kenya Meteorological Service (KMS) to produce streamflow

- Streamflow estimates enable Kenya Department of Water Resources to issue early flood warning, especially in the flood prone watersheds in western Kenya
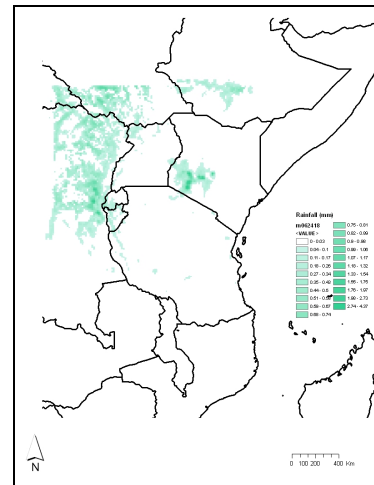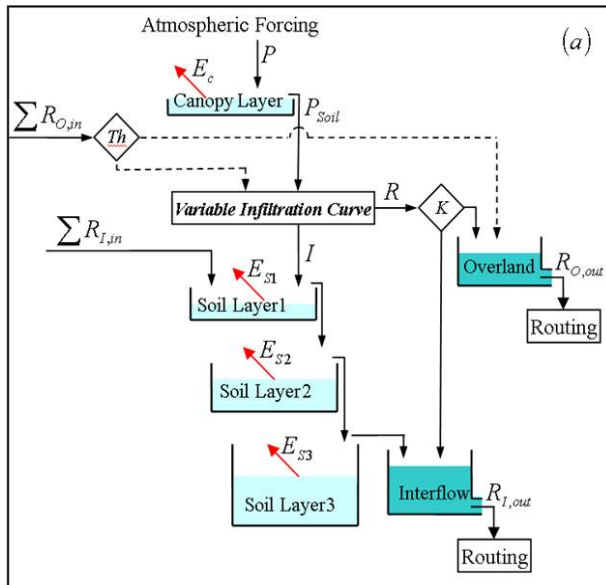
KMS QPF
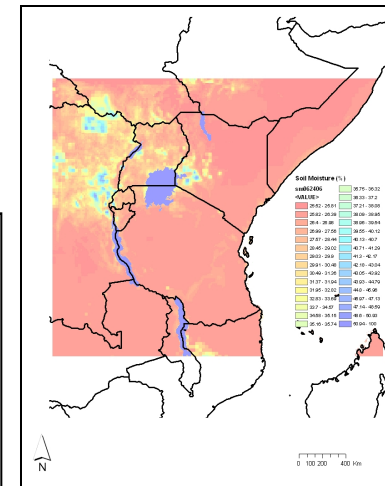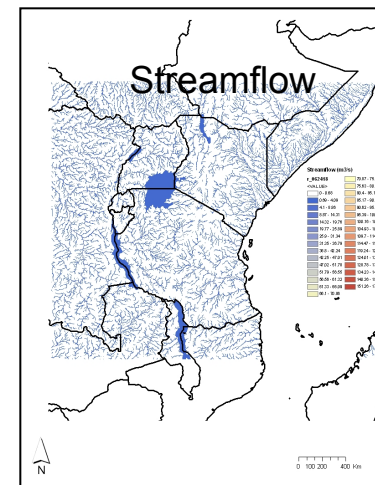
Streamflow

Soil Moisture

Historical Data Perspective

- SERVIR has used 10+year historical satellite rainfall data to drive the CREST model, which has resulted in historical daily streamflow at 1 km resolution.

- Those historical and near real time data are shared with Kenya Department of Water Resources (KDWR) for ~850 stream gage locations of their choice. SERVIR Africa makes the data available on our web portal and through automated emails to KDWR-identified field hydrologists.

- We have used the historical data to assess 5th, 20th, 80th and 95th percentiles for each 1 km pixel to put the real time streamflow in context.

Latest 24h/3h Stream Flow (m^3/s) 2013-09-19 15h

Streamflow at Nzoia

Comments from CREST End User
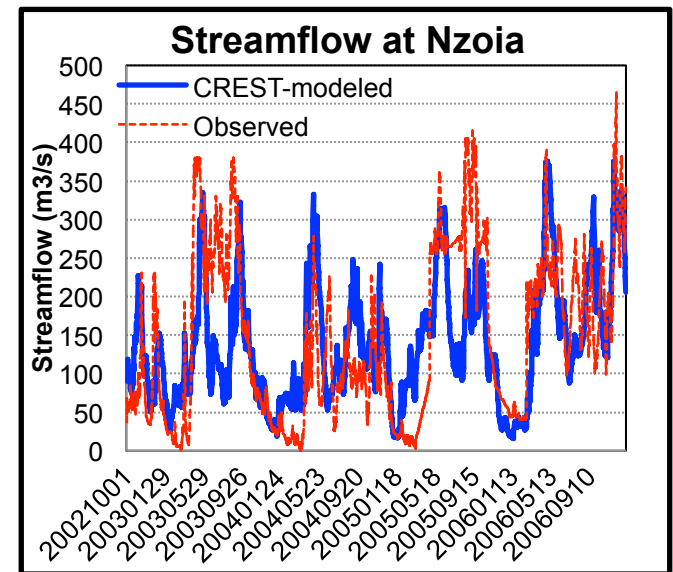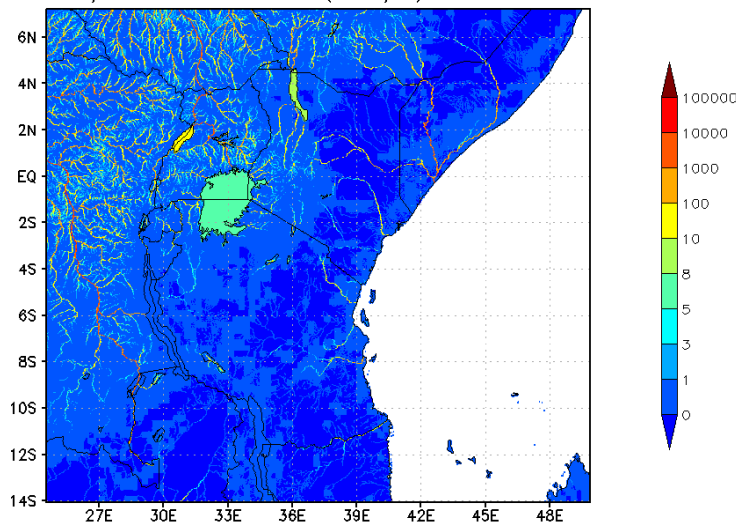
"The biggest problem we have is lack of data. When someone, like SERVIR Africa comes along to help us out it is very good because we have been missing floods."

-Simintei Kooke
Deputy Director of Water Resources,
Kenya Ministry of Water and Irrigation

Hydrologic Model CREST Developed for Single Watershed in Kenya
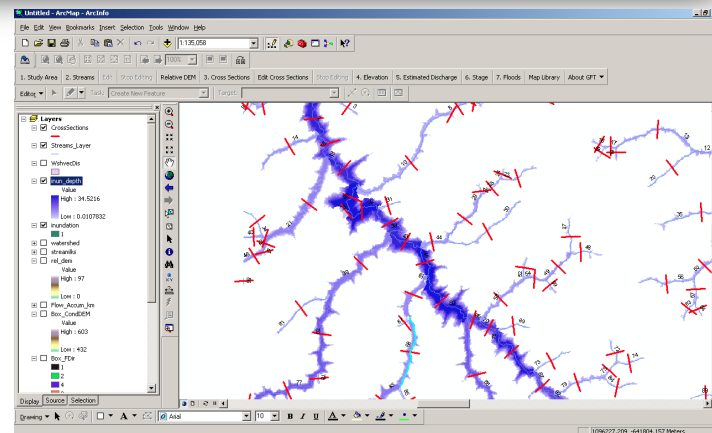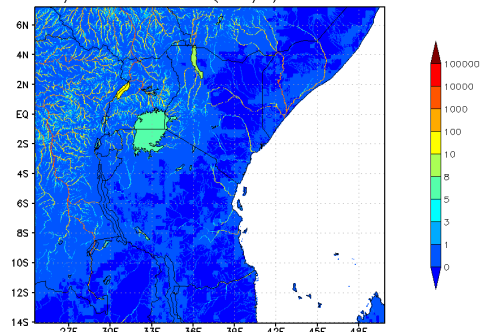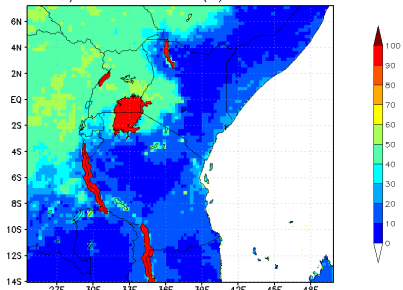
Real Time, Historic and Seasonal Streamflow

Soil Moisture

Near Real Time NASA TRMM Satellite Rainfall Data

Working on seasonal hydrologic forecasts at the request of Kenyan and Rwandan Ministries of Water Resources

Working in collaboration with FEWS NET, and at the request of KDWR, RCMRD developed stand alone Flood mapping tool. It translates the streamflow into a better visualization and decision making tool.

Training and Capacity Building

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SERVIR has adapted CREST model products to fit the mobile needs.
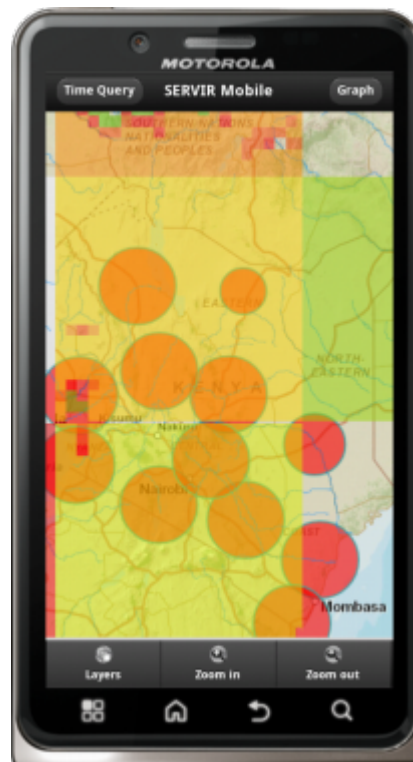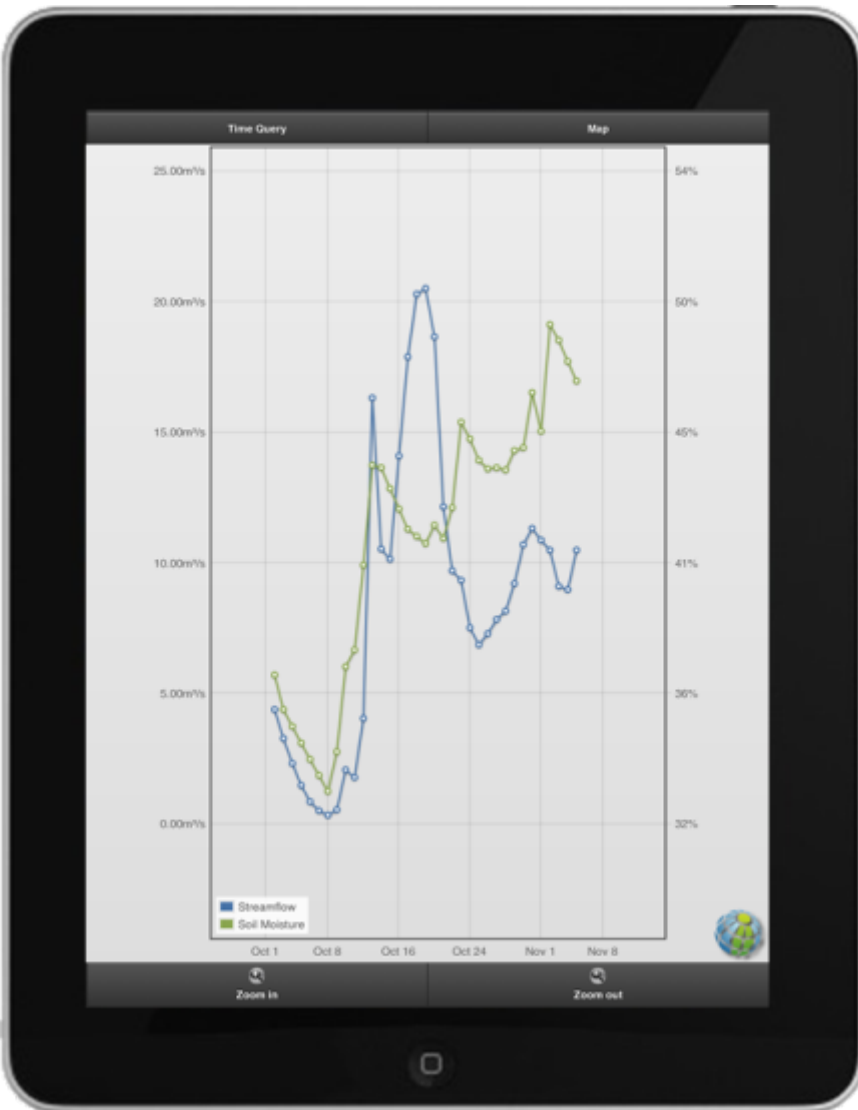
CREST app runs on iOS and Android devices.

Frost Monitoring and Early Detection

Estimated Frost Occurrences on 2013-06-14

Legend
- Boundary
- Frost Map
- Temperature in Kelvin
  - NoData
  - Very Severe Frost (0 - 250)
  - Severe Frost (250 -260)
  - Modarate Frost (260 - 270)
  - Minor/Frost Pockets (270 - 280)
  - No Frost (> 280)

This map represents the possible occurrence of frost for the above mentioned date. The map was derived from MODIS night time Land Surface Temperature (LST) by RCMRD/SERVIR-Africa (USAID - NASA supported) project geared towards use of Earth Observation (EO) to help governments in policy and decision making.

RCMRD

SERVIR

Disclaimer:-Data used to create this map is based on MODIS satellite night time temperature estimation, therefore should be used for information purposes only.

Map Reference no :- 164

- SERVIR is keen on getting satellite data and products to end users in the agricultural community to improve decision making.

- In Kenya, as with many other countries in Africa, frost damages are a significant threat to agriculture.

- Kenya Meteorological Department requested SERVIR to help with identifying the frost damaged areas, for public dissemination and damage assessment purposes.

- Using satellite and KMD datasets, SERVIR Africa has put together a system for early detection of frost and for damaged area assessment. Next phases will include near real time temperature observations and forecasts of frost areas.

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USAID FROM THE AMERICAN PEOPLE

NASA

- SERVIR, with the help of NASA Short-term Prediction Research and Transition Center (SPoRT), is producing real-time numerical weather forecasts for Mesoamerican region at the request from Meteorological Services in the region.
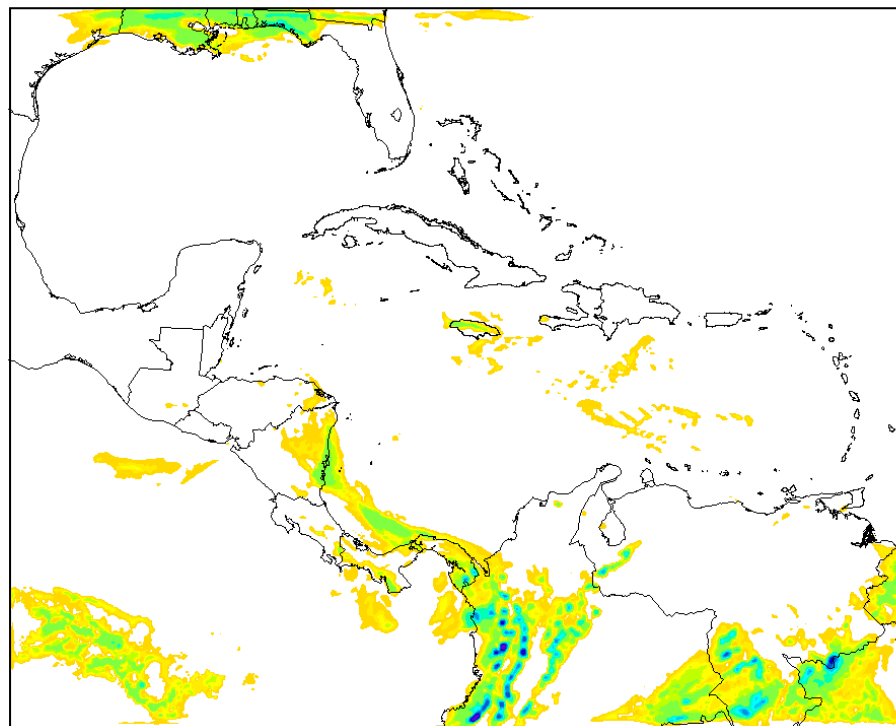
130213/0600V024 24-h Accumulated Precipitation (mm)

- Kenya Meteorological Service (KMS) has responsibilities analogous to US National Weather Service.

- KMS uses numerical weather forecasting model WRF, along with the observed data, to generate alerts on potential vulnerabilities in the region, such as floods and droughts, and to support the agriculture sector with accurate weather information.

- KMS alerts are well regarded and widely used in the region. However KMS does not use satellite datasets in generating their numerical weather forecasts. KMS recognize the potential of improving the forecasts using satellite data, especially the soil moisture products from SMAP.

- KMS approached SERVIR Africa to improve their WRF modeling system. Recently, we have integrated NASA LIS into their WRF forecasts. Remotely sensed soil moisture products is expected to enhance the WRF accuracy. Our preliminary assimilations have shown substantial improvement.

0-10 cm Volumetric Soil Moisture (m3/m3*100)
LIS 0-h Forecast Valid: 00Z 06 JAN 2014
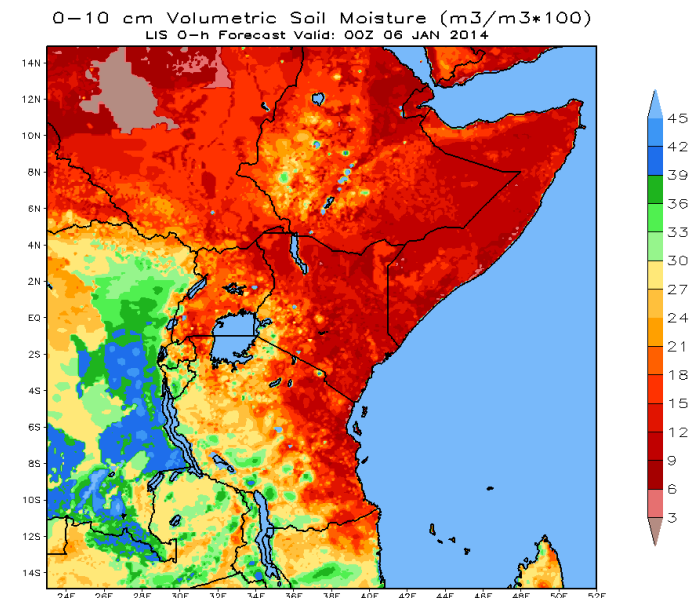
Fire Monitoring and Forecasting
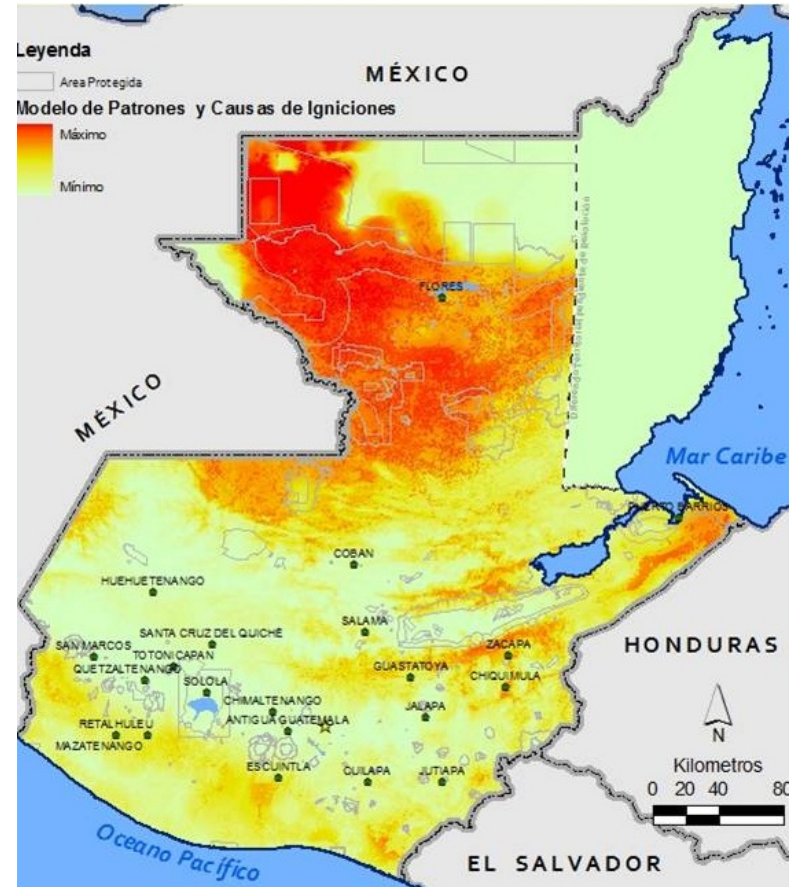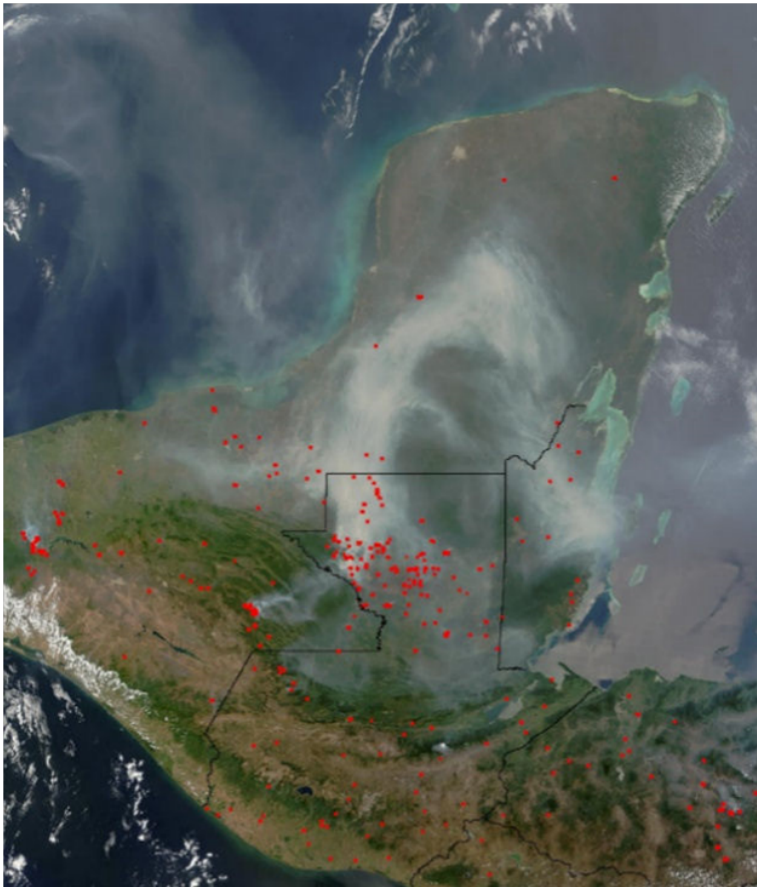
Land Use and Land Use Change for Greenhouse Gas Emissions Inventory

- SERVIR is working in collaboration with another USAID funded activity, the US EPA effort on greenhouse emissions inventory effort with UNFCCC. The GHG emissions inventory depends on high quality land use land use change maps.

- SERVIR is working on providing consistent, reliable, relevant land use land use change information by harmonizing data compilation at national and regional levels.

- Participating Countries: Botswana, Malawi, Namibia, Rwanda, Tanzania, and Zambia

- We are using 30m satellite data for assessing the land cover change maps in 2000 and 2010. The land cover change statistics are enabling the countries quantify the changes in greenhouse gas emissions inventory.
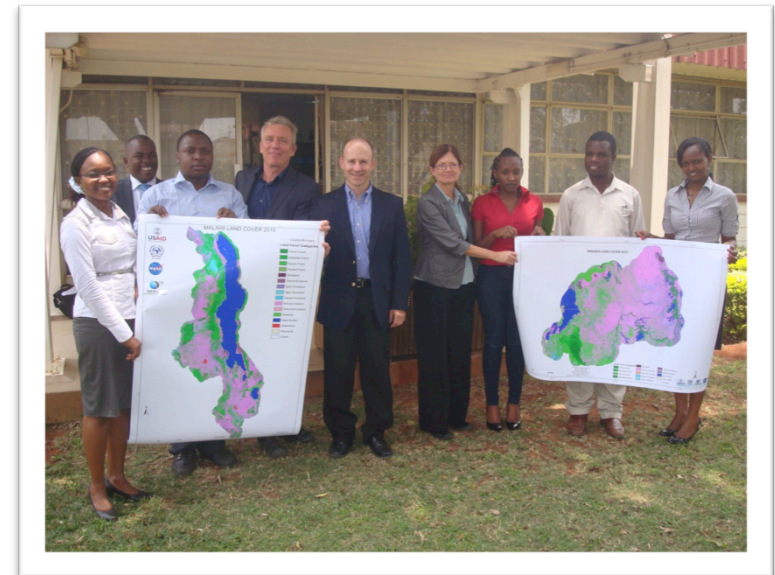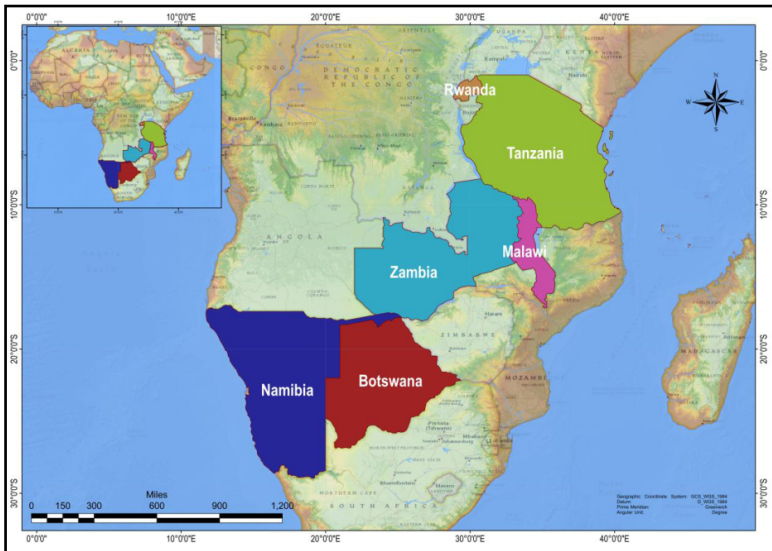
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Disaster Risk Reduction and Rapid Response System

National disaster response support systems; Community level DRR

Forest Fire Monitoring with SMS Alerts

WSN based Flash Flood early Warning System in Bangladesh

SERVIR Applied Science Team (AST)

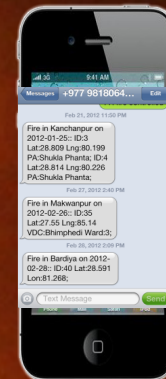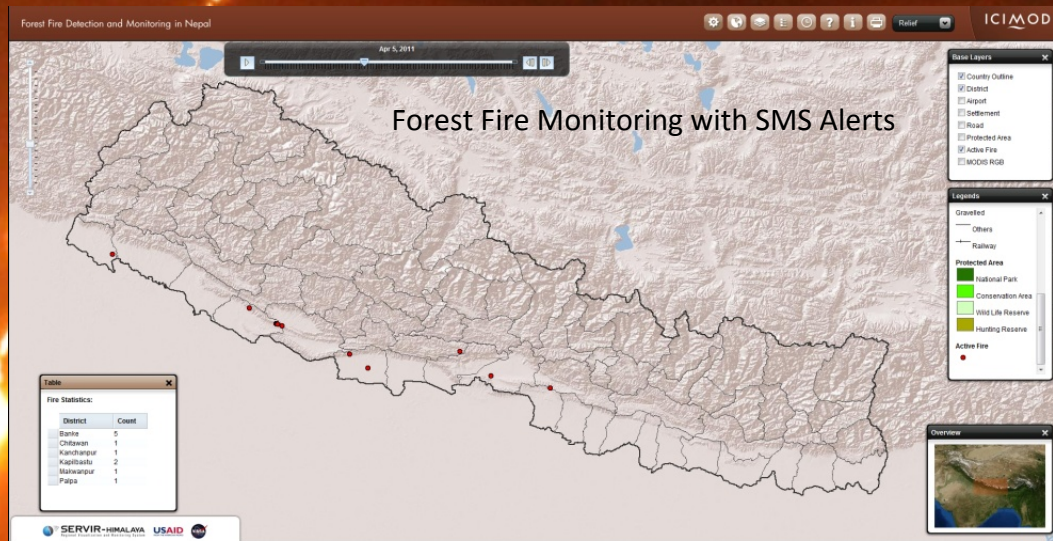| PI Last name	Title	Institution	Theme	Region
Laporte	Forest carbon assessment for REDD in the East Africa SERVIR region	The Woods Hole Research Center	Carbon	East Africa
Kargel	Interdisciplinary science applications to glacier and alpine hazards in relation to development and habitation in the Hindu Kush-Himalaya: SERVIR Science Team project	University of Arizona	Disasters	Hindu Kush-Himalaya
Hossain	A Satellite-based Early Warning, Mapping and Post-Disaster Visualization System for Water Resources of Low-lying Deltas of the Hindu Kush-Himalayan region	Tennessee Technological University	Water	Hindu Kush-Himalaya
Verdin	A Long Time-Series Indicator of Agricultural Drought for the Greater Horn of Africa	U.S. Geological Suvey	Agriculture	East Africa
Blackman	Using Earth Observation Data to Improve REDD+ Policy in Mesoamerica and the Dominican Republic	Resources for The Future, Inc.	Carbon	Mesoamerica
Huff	Applications of Satellite Products for Air Quality Monitoring, Analysis, Forecasting, and Visualization in the SERVIR Mesoamerica and Himalaya Regions	Battelle Memorial Institute	Air Quality	Mesoamerica, Hindu Kush-Himalaya
Robertson	Leveraging CMIP5 and NASA / GMAO Coupled Modeling Capacity for SERVIR East Africa Climate Projections	NASA / MSFC	Climate Scenarios	East Africa, Hindu Kush-Himalaya, Mesoamerica
Granger	East Africa Drought and Agricultural Productivity Assessment and Prediction System	Jet Propulsion Laboratory	Disasters, Agriculture	East Africa
Valdes	SERVIR Water Africa-Arizona Team (SWAAT)	The University of Arizona	Water	East Africa
Kirschbaum	Landslide Hazard Assessment and Forecasting System using near real-time remote sensing information over SERVIR-Mesoamerica	NASA Goddard Space Flight Center	Disasters	Mesoamerica
Ceccato	Development and Implementation of Flood Risk Mapping, Water Bodies Monitoring and Climate Information for Disaster Management and Human Health (integration within SERVIR)	Columbia University	Public Health	East Africa

Improved Flood Forecasting in Bangladesh

- **Problem:** Bangladesh's severe flooding affects millions of residents every year. The Flood Forecast Warning Center (FFWC) issues flood forecasts in Bangladesh just 3 days in advance – insufficient time for families and farmers to prepare.

- **What SERVIR did:** A SERVIR AST effort led by Dr. Faisal Hossain linked satellite altimetry data (JASON 2) to flood forecasts. SERVIR-HKH has trained FFWC scientists to generate flood forecasts 8 days in advance using this near real time satellite data.
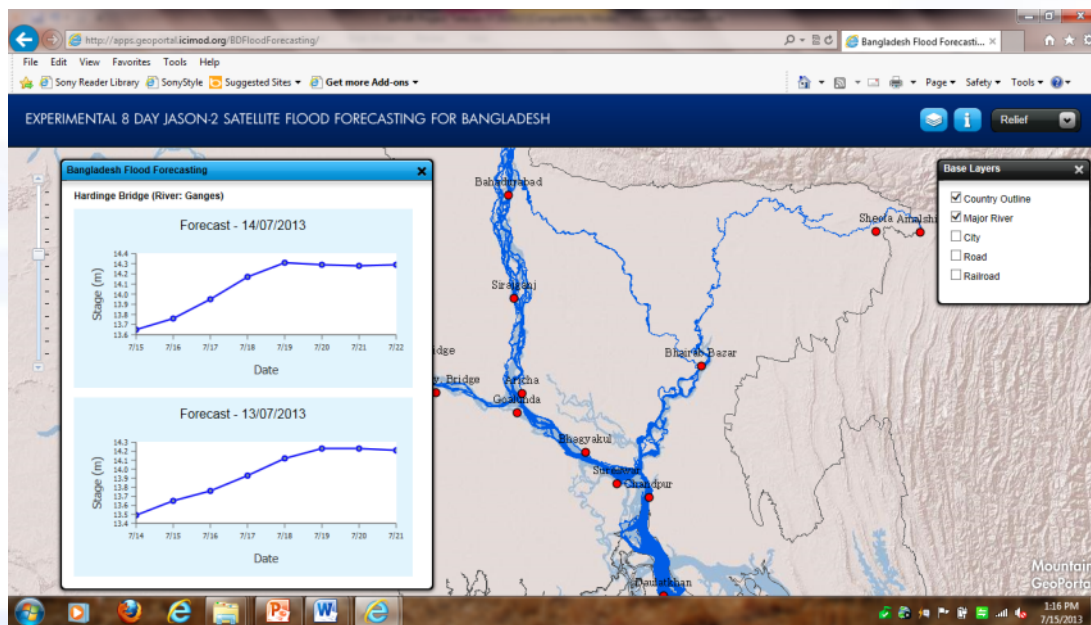
- **Results:** FFWC has begun generating experimental 8-day forecasts representing river levels for the 2014 monsoon season. The satellite-derived system is being run independently by FFWC, and is expected to be adopted as the official forecasting system for the 2015 monsoon season. The 8-day forecasts will provide 160 million impacted citizens with longer lead time for disaster preparedness.

East Africa Drought and Agricultural Productivity Assessment and Prediction System

The objective of this effort is to provide SERVIR with linked drought and crop productivity nowcasts and forecasts using the best available ground and satellite-based information.

The resulting hydrologic variables, drought and productivity products will be directly available for use by the agricultural communities of the SERVIR Africa node and may also be used by Climate Change, Agriculture and Food Security Initiative (CCAFS) research program. The resulting system, Regional Hydrological Extremes Assessment System (RHEAS) is expected to improve crop productivity, and drought contingency plans by providing quantitative and targeted risk-based information.

East Africa Seasonal Calendar and Critical Events overlaid with RHEAS outputs
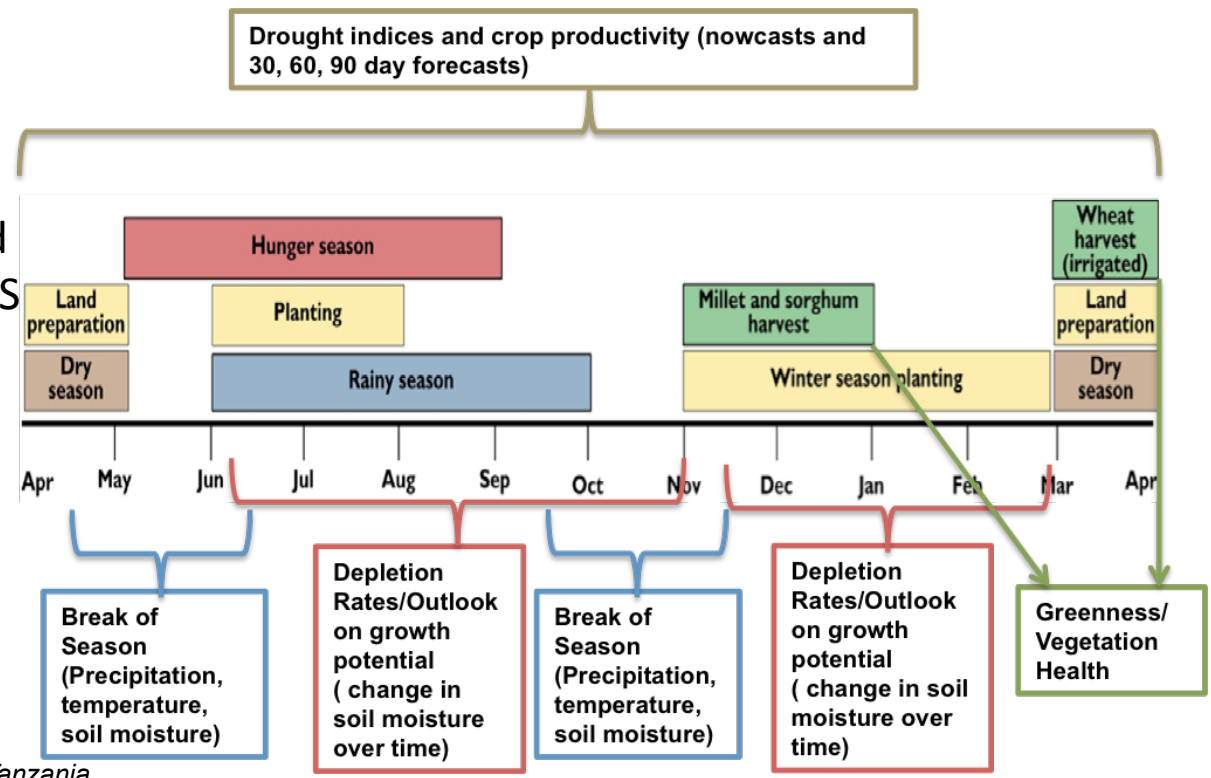
Societal Benefit Area(s): Water, Agriculture, Disasters
Geographic Focus: Eastern and Southern Africa
Targeted End-Users: Ministry of Ag in Kenya, Uganda, Tanzania, and Ethiopia

This effort seeks to leverage improved global climate modeling capabilities, various hydrometeorological data sets, and a new generation of reanalyses to narrow the uncertainties in projecting the exposure of the SERVIR end user community to climate variability and climate change. The **purpose** of this project is develop an array of hydrometeorological scenarios spanning seasonal to multi-decadal time horizons that will serve various SERVIR decision support system applications, including other SERVIR AST efforts.

The project has three main **objectives**:

1. Develop an array of multi temporal scale baseline scenarios

2. Scenario evaluation, refinement and downscaling

3. Disseminate the scenarios with SERVIR AST PIs
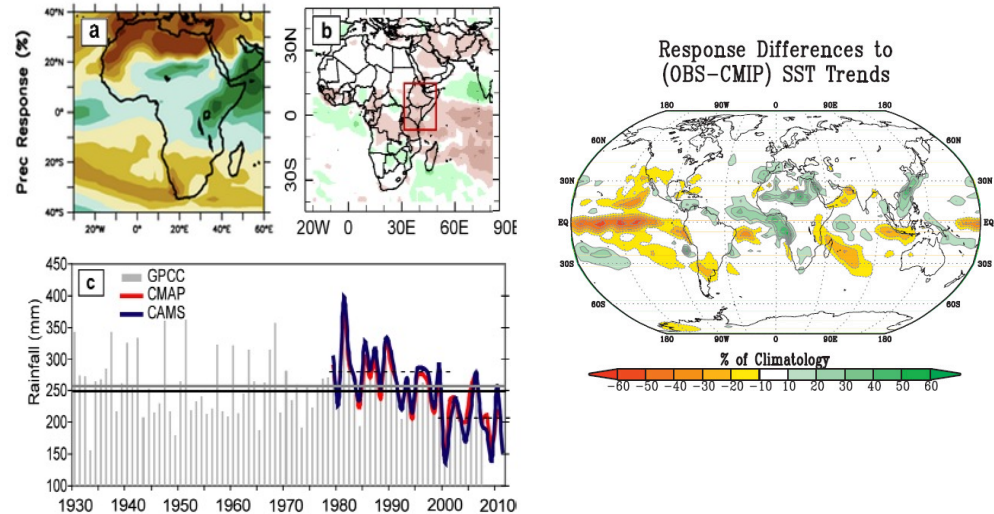
Figure: Annual mean fractional precipitation changes over Africa, averaged over 21 IPCC 4 models.; (b) Reanalysis rainfall Mar-May anomaly (1999-2010 average) and (c) Mar-May total rainfall averaged over (10S-12N, 30-53E) box. The IPCC model trends are different than observed for the East African region. This project will close this gap between IPCC rainfall projections and recently observed rainfall patterns.

Societal Benefit Area(s): Disasters, Agriculture
Geographic Focus: East Africa
Targeted End-Users: IGAD Climate Prediction Center, (ICPAC) Ministries of Agriculture in Ethiopia, Kenya, FAO Somalia Water and Land Information Management (SWALIM), Kenya Meteorological Department, USAID FEWS NET

Applications of Satellite Products for Air Quality Monitoring, Analysis, Forecasting, and Visualization in SERVIR-Mesoamerica

Purpose and Objective

The **purpose** of this project is to utilize NASA satellite EO data for vetting and inclusion in a national Air Quality modeling system for Mesoamerican and Himalayan countries

To Enhance NASA satellite products
•Develop daily near real-time MODIS true color imagery at 1 km resolution and aerosol optical depth at 3 km high resolution – useful for tracking pollution events
•Vet experimental satellite products with advisory group of regional stakeholders and transition to operational status on SERVIR website at end of project

To Develop national AQ modeling systems
•Based on U.S. EPA's Community Multi-scale Air Quality (CMAQ) model
•In conjunction with stakeholders, optimize modeling systems and verify output with pollutant monitor and satellite data

To Conduct training and capacity building
•Stakeholder meetings to review air quality satellite products and get feedback/improve
•Training sessions for stakeholders on use of the new air quality satellite products and on the national air quality modeling systems
Societal Benefit Area(s): Public Health & Air Quality
Geographic Focus: Central America, Himalaya
Targeted End-Users: Ministerio de Medio Ambiente y Recursos Naturales (MARN), Ministry of Environment and Telecommunications (MINAE), UNA Costa Rica (National University), Ministerio de Salud (Ministry of Health in El Salvador), Central American Commission for Environment and Development (CCAD), Univ. of Panama, CATHALAC
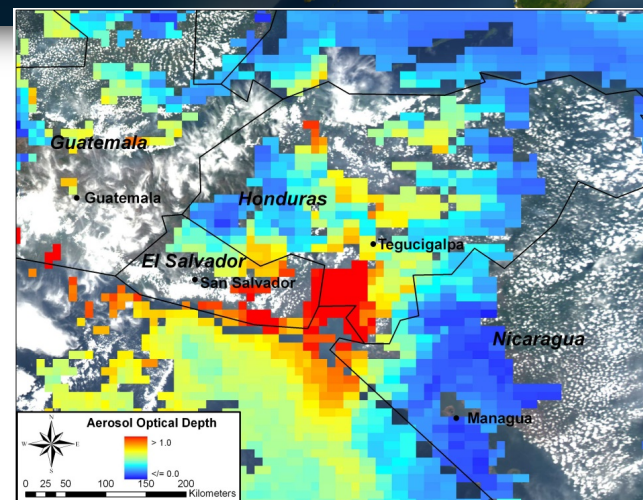
Figure: MODIS true color and Aerosol Optical Depth on April 27 2008 showing smoke in Honduras and El Salvador..

Approach & Risks

The Battelle group has conceptualized three major tasks to build on their initial accomplishments in Mesoamerica.

• Production of experimental daily near real-time MODIS AOD and true color products for the Mesoamerican and Himalayan region.
• Work closely with SERVIR-Mesoamerica staff and the informal air quality community of practice in the region to create suitable regional and national subsets of AOD and true color imagery.
• Implement an experimental version of the SERVIR-Mesoamerica air quality model and begin tracking model forecasts and disseminating them to the end users.
• Track Trans-Boundary Pollution in Himalayas using PM10/AOD relationships
• Conduct a regional scoping survey and inventory to understand key stakeholders' needs in the Himalayan region.

Co-I's: Jill Engel-Cox, Glynis Lough, Stephanie Weber, Erica Zell (Battelle Memorial Institute); Robert Levy (Science Systems And Applications, Inc.), Hai Zhang (Univ. of MD Baltimore County)

Latest update

➢ Higher resolution AOD data being evaluated for use in the Mesoamerican air quality modeling system

➢ Established close working collaboration with Costa Rican and El Salvadorian environmental ministries and universities.

➢ CMAQ modeling setup for Mesoamerican domain complete.

➢ Requirements for trans-boundary air quality in Hindu Kush Himalayan region are needed. ICIMOD is anticipated to provide connections with the end users in that region.

➢ Training and capacity building session at ICIMOD planned for early 2014, in collaboration with NASA Applied Science Program's ARSET program.

Bangladesh Flash Flood Early Warning System Pilot

- Requested by the Center for Environmental and Geographical Information Systems (CEGIS), Bangladesh, and led by SERVIR-HKH, a Wireless Sensor Network (WSN) based flash flood early warning system was recently installed in Sunamganj, (north-eastern) Bangladesh

- System consists of 4 river level sensors along the length of the Jhalukhali river

- Warnings are sent out to the public via sirens that are part of the WSN system, along with SMS-based alerts sent to emergency managers

- CEGIS is working with the local community to take responsibility for and maintain the network

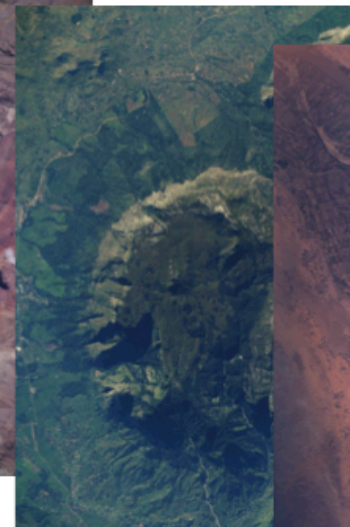# ISERV: The ISS / SERVIR Environmental Research and Visualization System

- Testbed SERVIR camera on the International Space Station
- Tasked by SERVIR Hubs
- 4m Spatial Resolution
- 14.5km x 10km field of view
- Visible Spectrum
- Operating since February 2013
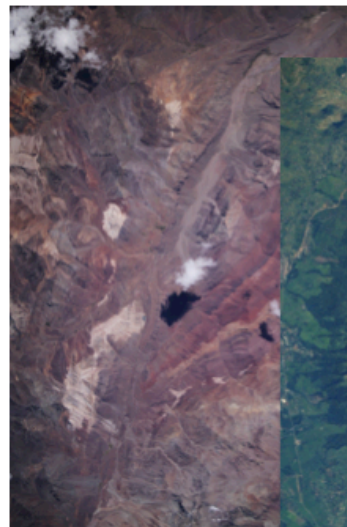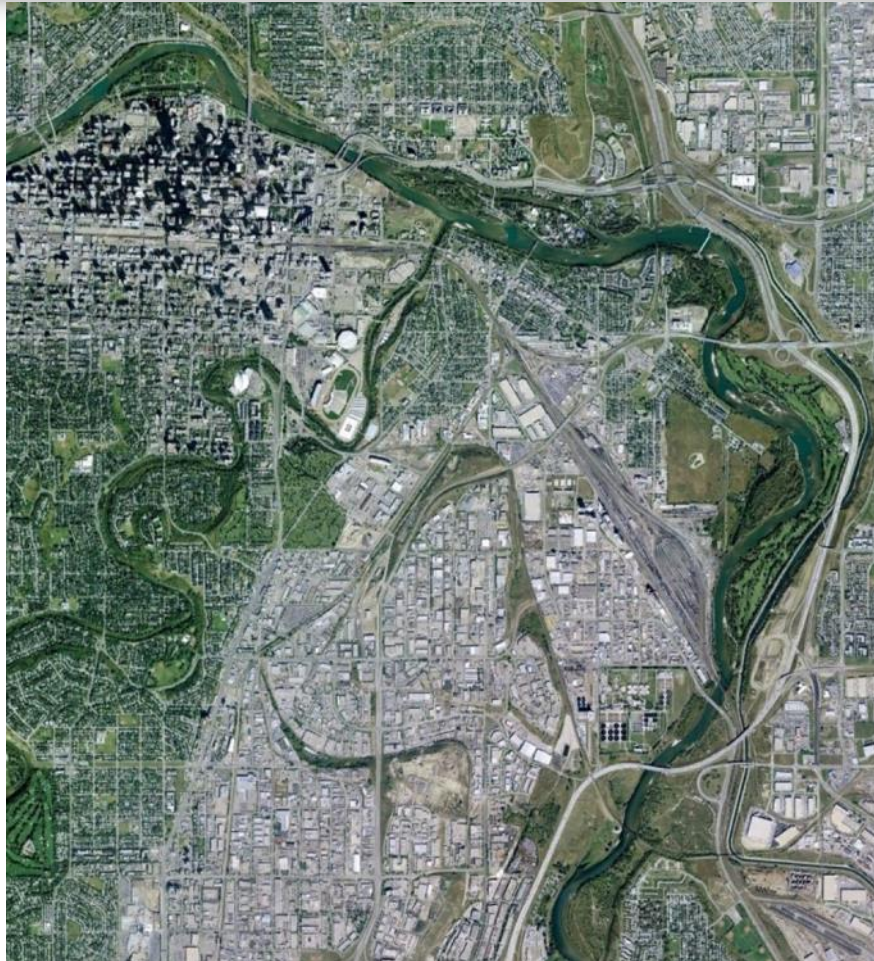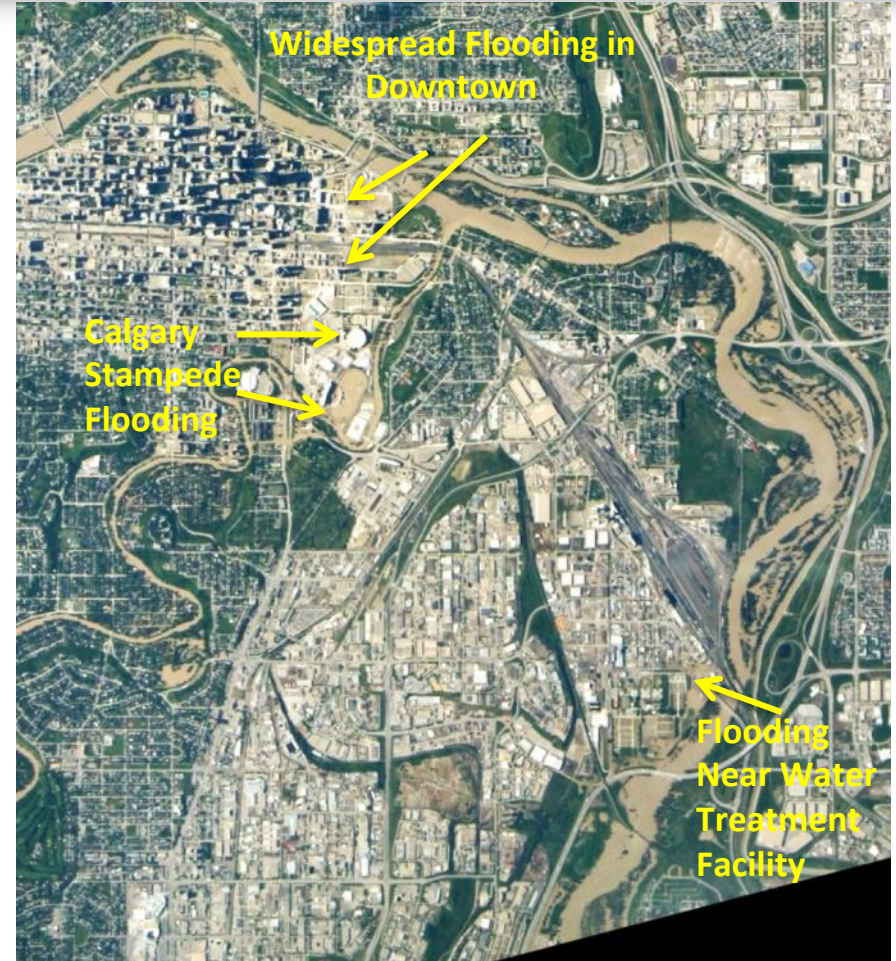

Chile

Malawi

Sudan

San Francisco, USA

Calgary Pre-Flood/Post-Flood Comparison

Widespread Flooding in Downtown

Calgary Stampede Flooding

Flooding Near Water Treatment Facility

Before flood: Google Earth Image
September 2008

After flood: NASA/ISERV Image
June 22, 2013

This image was taken by ISERV-- a new NASA-developed testbed camera onboard the International Space Station.

- SERVIR is a link between research institutions and end user decision making.

- SERVIR efforts are led by the needs of the region. Some examples include hydrological modeling, frost monitoring, fire alert system, and land cover change assessment.

- Presence of SERVIR Hub, a technical institution with regional governmental support, makes the linkage sustainable.
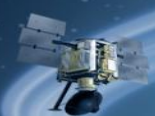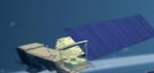
SERVIR GLOBAL
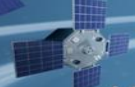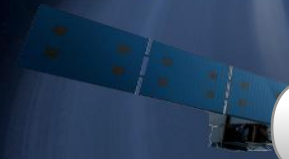
Connecting Space To Village

More information:

SERVIR Global: http://www.servirglobal.net

SERVIR Contacts:

Daniel Irwin – Project Director

Nancy Searby – NASA HQ Program Manager

Ashutosh Limaye – Project Scientist (Ashutosh.Limaye@nasa.gov)