

# Namibian Flood Early Warning SensorWeb Pilot

Dan Mandl

NASA/Goddard Space Flight Center



**Session Title:** IN34A. Sensor Networks:  
From Sensors to the Web II

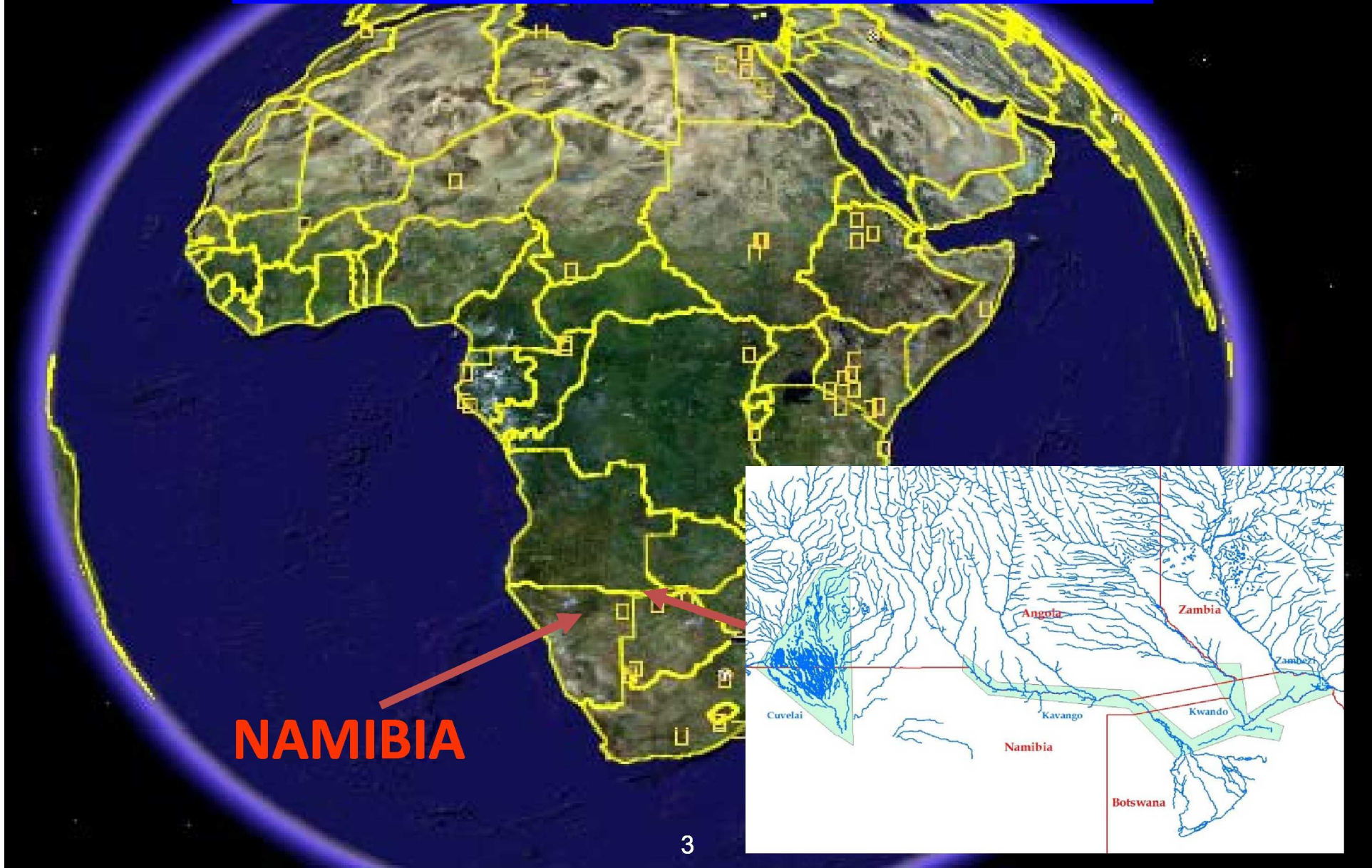
**Location:** 302 (Moscone South)

**Start time:** Wed, Dec 15 - 4:00 PM

# Team Members

- Guido Van Langenhove and Staff/Namibia Department of Hydrology
- Joerg Szarzynski, Lorant Czarán and staff/ United Nations Platform for Space-based Information for Disaster Management and Disaster Response (UN-SPIDER)
- Natalia Kussul, Serhiy Skakun/ Ukrainian Space Research Institute
- Carl Keuck, Jan Peter Mund, Herald Mehl/DLR
- Tom DeGroeve/Joint Research Centre
- Tom Rientjes/Geo-Information Science and Earth Observation (ITC) of the University of Twente
- Daniel Irwin and SERVIR team/SERVIR
- Lenny Roytman/City College NY
- Felix Kogan/NOAA
- Martha Maiden , Karen Moe & team/Committee on Earth Observing Satellites (CEOS)/Working Group on Information Systems and Services (WGISS)
- Dan Mandl, Stu Frye, Pat Cappelaere, Fritz Policelli and NASA SensorWeb Team- NASA/GSFC

# Country of Namibia and Flood Risk Areas in North



# 2009 Flood Disaster

- *In February and March 2009, torrential rains increased water levels in Zambezi, Okavango, Cunene and Chobe Rivers*
- *This led to a 40-year flood in Caprivi, Kavango and Cuvelai basins, affecting some 750,000 people (37.5% of population of Namibia)*
- *Whole villages were cut off and had to be relocated into camps. Some 50,000 people were displaced*
- *Livestock were stranded and died of hunger*
- *102 people died*



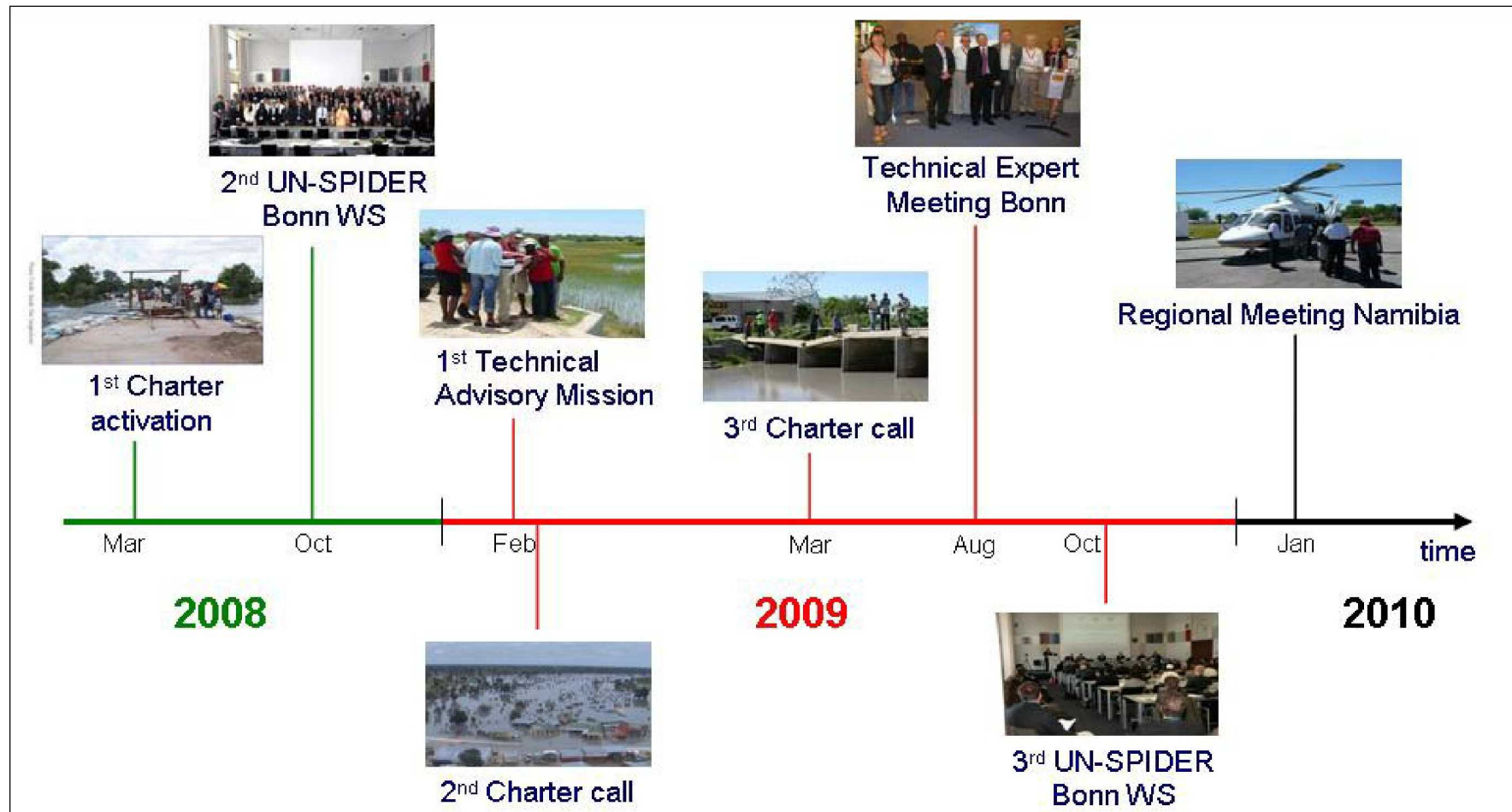
# Rescue Operations



# Formation of Flood-Disease Early Warning Project

- Against this background, major goal of the Namibia SensorWeb Pilot Project is a scientifically sound, operational trans-boundary flood management decision support system for Southern African region to provide useful flood and waterborne disease forecasting tools for local decision makers.
- Pilot Project established under the auspices of:
  - Namibian Ministry of Agriculture Water and Forestry (MAWF), Department of Water Affairs
  - Committee on Earth Observing Satellites (CEOS) , Working Group on Information Systems and Services (WGISS)
  - And moderated by the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER).
- Effort consists of identifying and prototyping technology which enables the rapid gathering and dissemination of both space-based and ground sensor data and data products for the purpose of flood disaster management and water-borne disease management.

# Timeline of Activities Related to Namibia Early Warning Flood Project



# Flood SensorWeb Workshop Held in Winhoek, Namibia in January 2010



**Front Row: left to right, Gail D. Mathieu, U.S. Ambassador to Namibia, John Mutorwa, Minister of Ministry of Agriculture, Watery and Forestry (MAWF) and Kari Egge, UN Resident Coordinator in Namibia**

The following agencies contributed to establish an international expert team and sent representatives to this field mission: European Commission, Joint Research Center (JRC), Italy; German Aerospace Center (DLR), Germany; German Technical Cooperation (GTZ), Windhoek, Namibia; International Institute for Geo-Information Science and Earth Observation (ITC), University of Tuent, The Netherlands; National Aeronautics and Space Administration (NASA), US; NOAA / National Environmental Satellite Data and Information Service (NESDIS), US; Ukraine Space Research Institute (USRI), Ukraine; UNESCO; United Nations Resident Coordinator, Namibia; United Nations Office for Outer Space Affairs (UNOOSA), Austria/Germany; and World Meteorological Organisation (WMO).



# Namibian Flood Early Warning Prototype



- Namibian Dept of Hydrology installing various telemetered flood gauges and other ground measurement devices

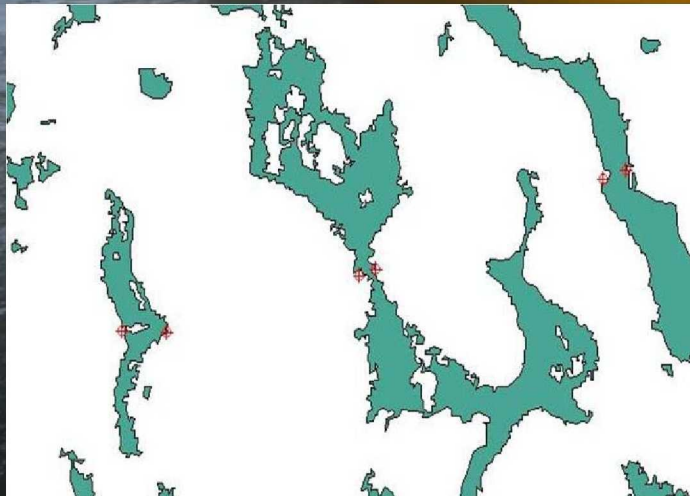
# Surveying Flood Damage



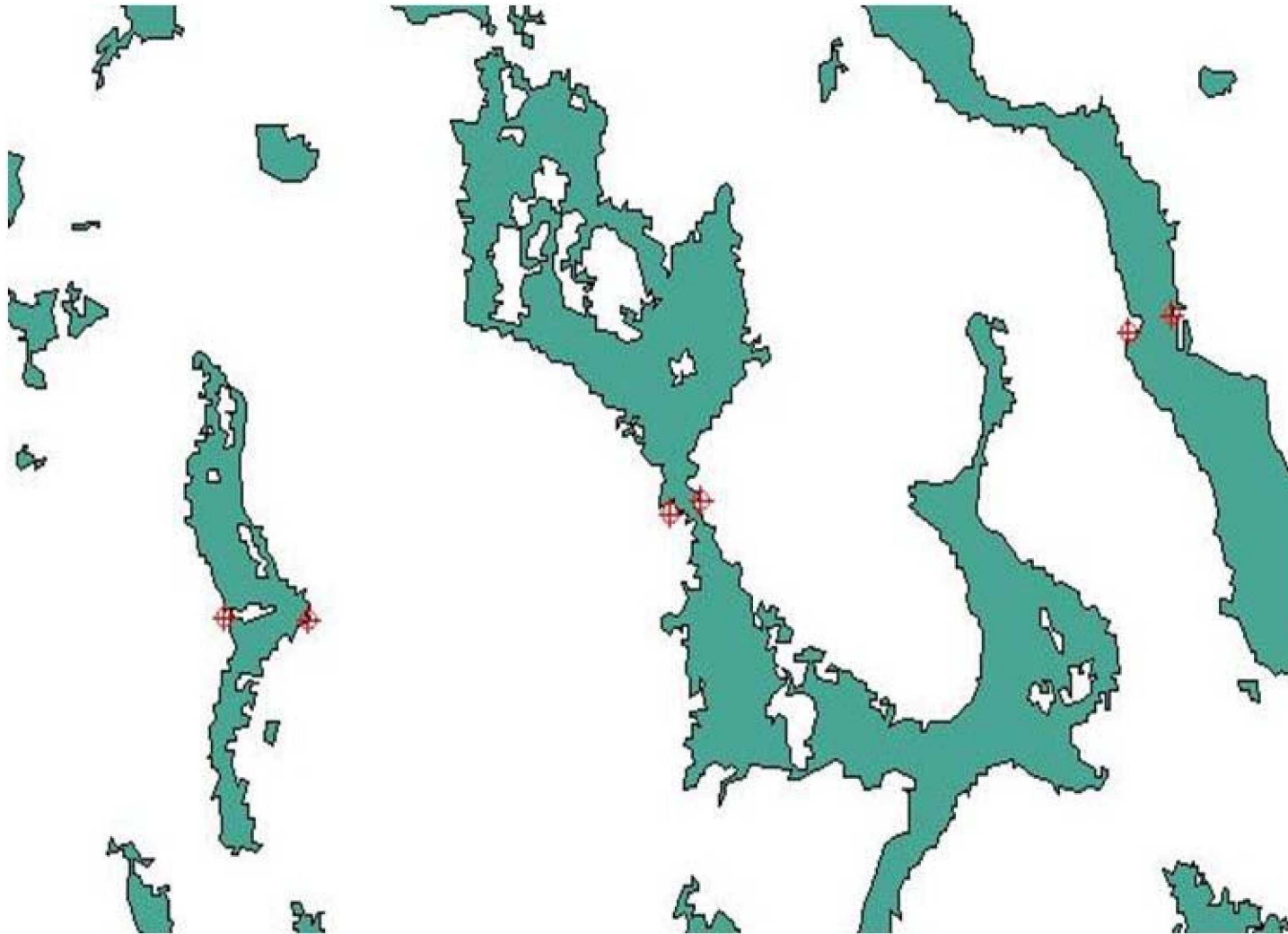
# Surveying Flood Damage and Validating Water Locations

Guido Van Langenhove  
Head, Department of Hydrology, Namibia

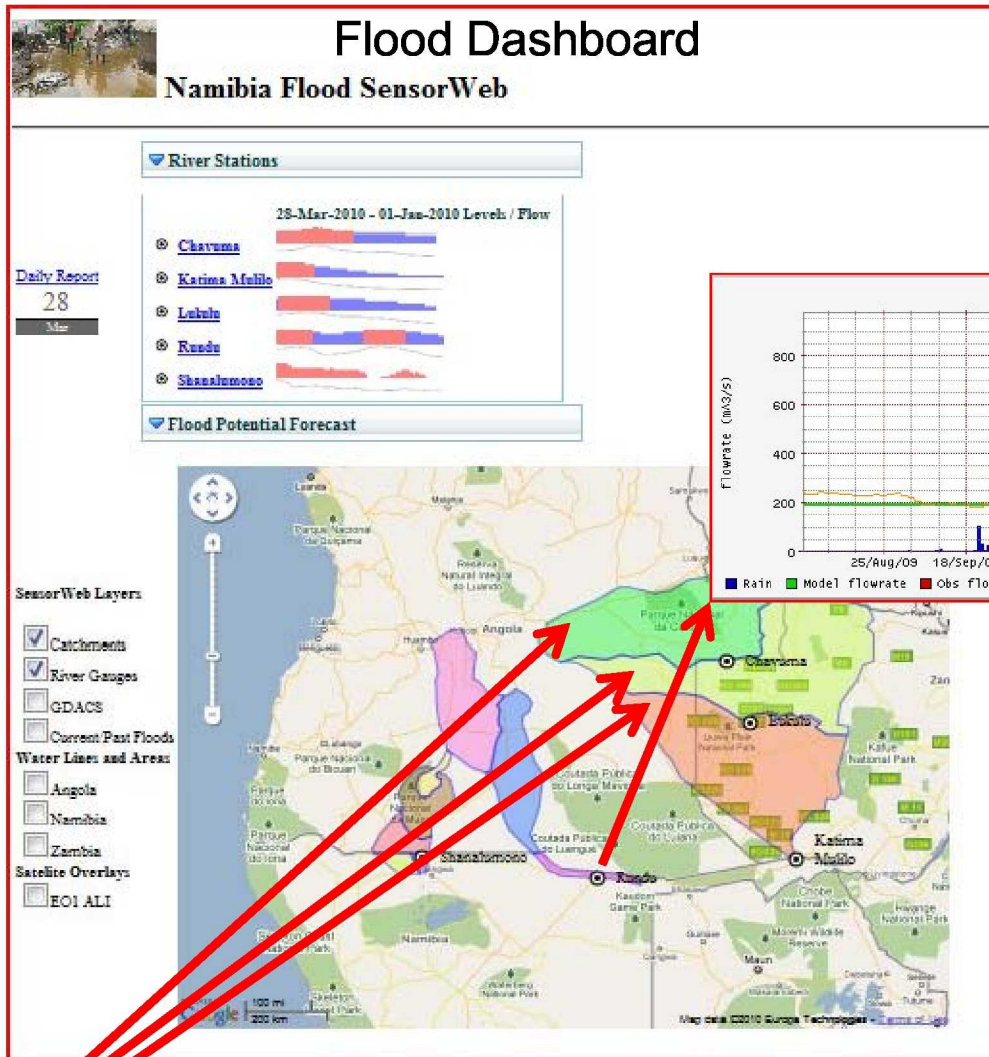
Hango Leonard  
Hydrologist & Basin support Officer  
Department of Water Affairs and Forestry  
Cuvelai-Etoshia Basin, Oshakati



# Validating Satellite Data via Ground Observations

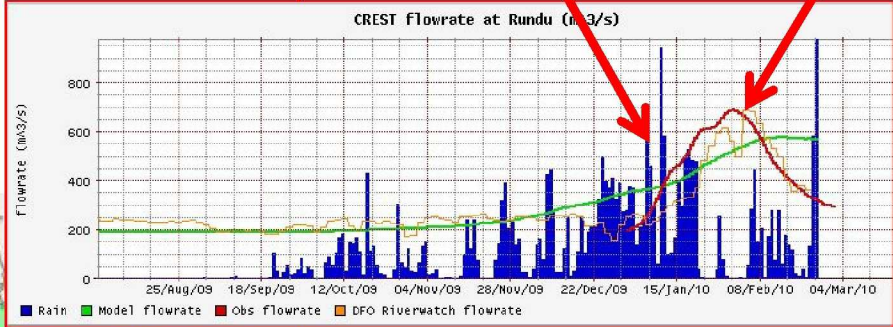


# Experimental Namibian Flood SensorWeb Webpage



Note blue bars indicating a surge of rainfall upstream

Then a flood wave appears downstream at Rundu river gauge days later



## Namibia Short Term Pilot for 2010

- Colored areas represent catchments where rainfall collects and drains to river basins
- River gauges displayed as small circles
- Detailed measurements are available on the display by clicking on the river gauge stations.
- This display can be viewed and manipulated at:

<http://geobpms.geobliki.com/namibia>  
and  
<http://geobpms.geobliki.com/namibia2>

Zambezi basin consisting of upper, middle and lower catchments

# Experimental Namibian Flood SensorWeb Webpage

## View of Available Envisat & EO-1 Overlay Images

### Flood Dashboard

#### Namibia Flood SensorWeb

Experimental TRMM-based Flood Forecast Products

**River Stations**

**Flood Potential Forecast**

[1-Day Flood Potential Forecast](#)  
[5-Day Flood Potential Forecast](#)  
[Severe Flood Report](#)

[Daily Report](#)  
25  
Apr

Envisat SAR and EO-1 Optical Image Overlays

**SensorWeb Layers**

- Catchments
- River Gauges
- GDACS
- Current/Past Floods

**Water Lines and Areas**

- Angola
- Namibia
- Zambia

**Dwelling Density**

- Northern Namibia

**Satellite Overlays**

- EO1 ALI
- SAR (SRI/Ukraine)

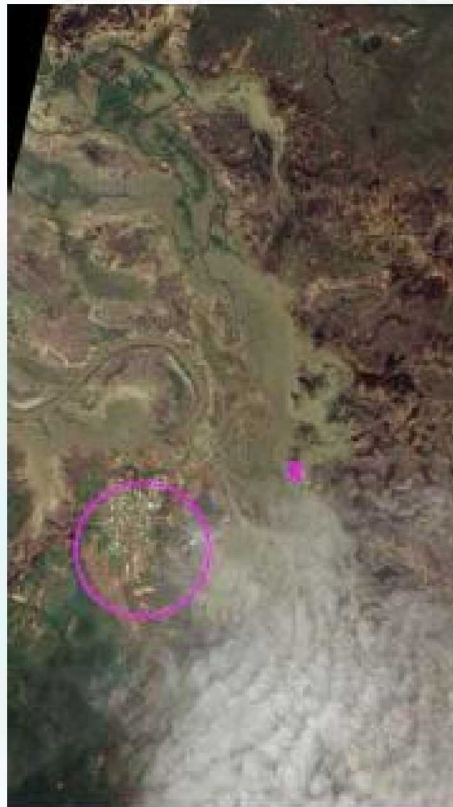
**2010-01-30 Flood Water Area**  
Flood/water mask derived from SAR imagery  
Image credit: Copyright ESA 2009, 2010  
Image processing, map created by:  
Space Research Institute,  
National Academy of Sciences of Ukraine,  
National Space Agency of Ukraine.

2010-03-28 (07:58 UTC)  
[Download KML file](#)

# Sample of Planned Addition of Flood Product Overlay

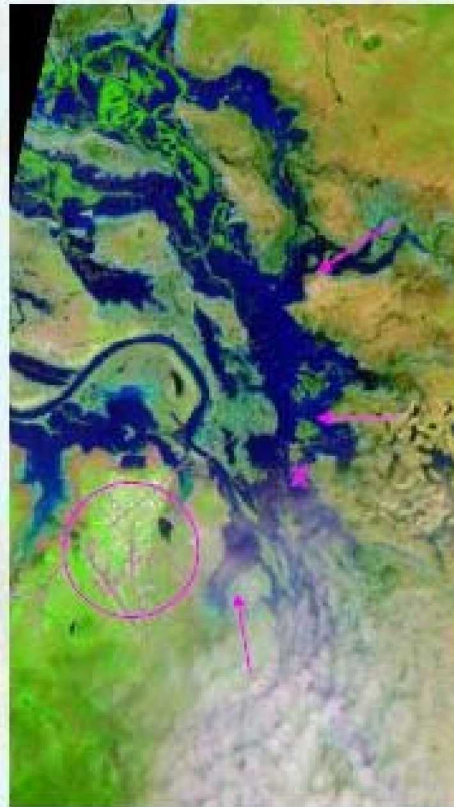
## EO-1 Land Cover Land Use Change

ALI Imagery of Australian Flood (Mar. 2009)



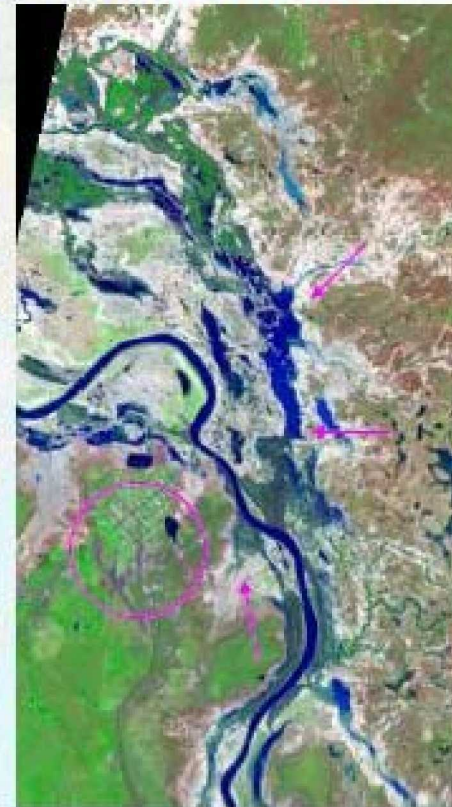
March 12, 2009  
True-Color Image  
EO-1 ALI Image

In this true-color image, note how the water color is so muddy that it makes discerning the extent of the flooding difficult



March 12, 2009  
False-Color Image  
EO-1 ALI Flood Product

This false-color image combines infrared and visible light, which makes the extent of the flooding far more obvious. Water is dark blue, while plant-covered land is green, and bare earth is rosy tan.



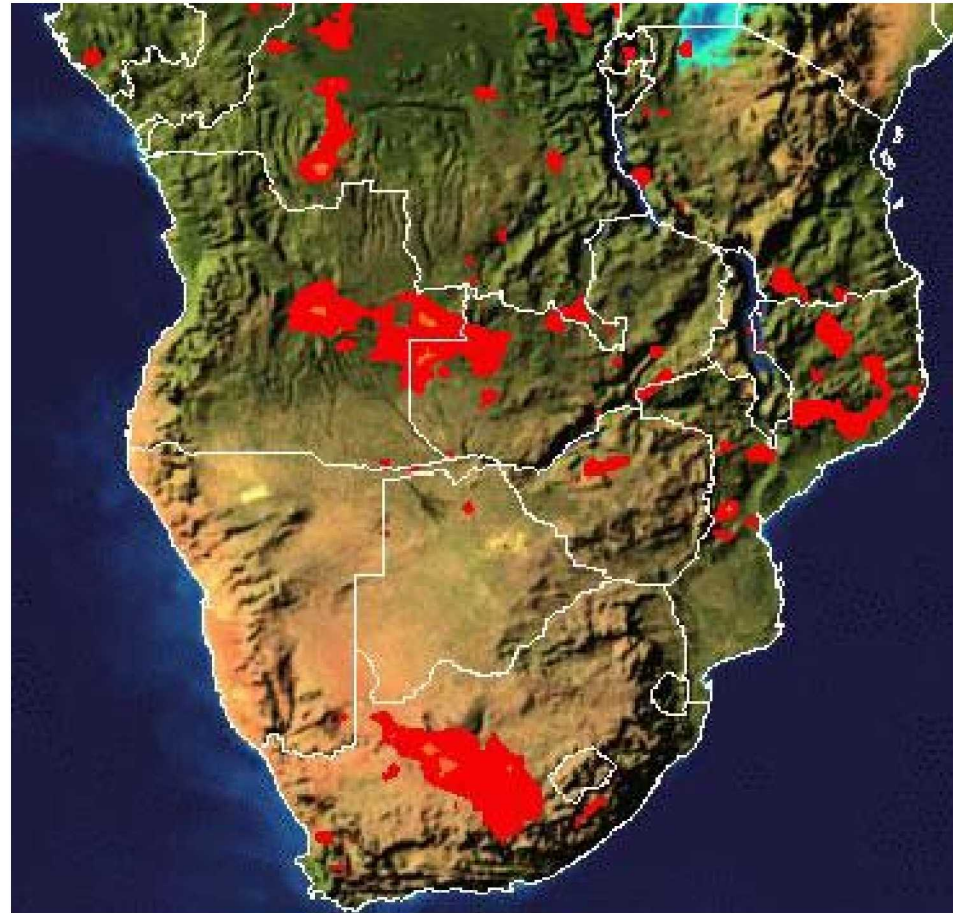
March 25, 2009  
False-Color Image  
EO-1 ALI Flood Product

Two weeks later, the flood waters have receded even more, which the EO-1 Flood Product makes evident.

Images are from NASA's Earth Observatory  
web site (<http://earthobservatory.nasa.gov/>)

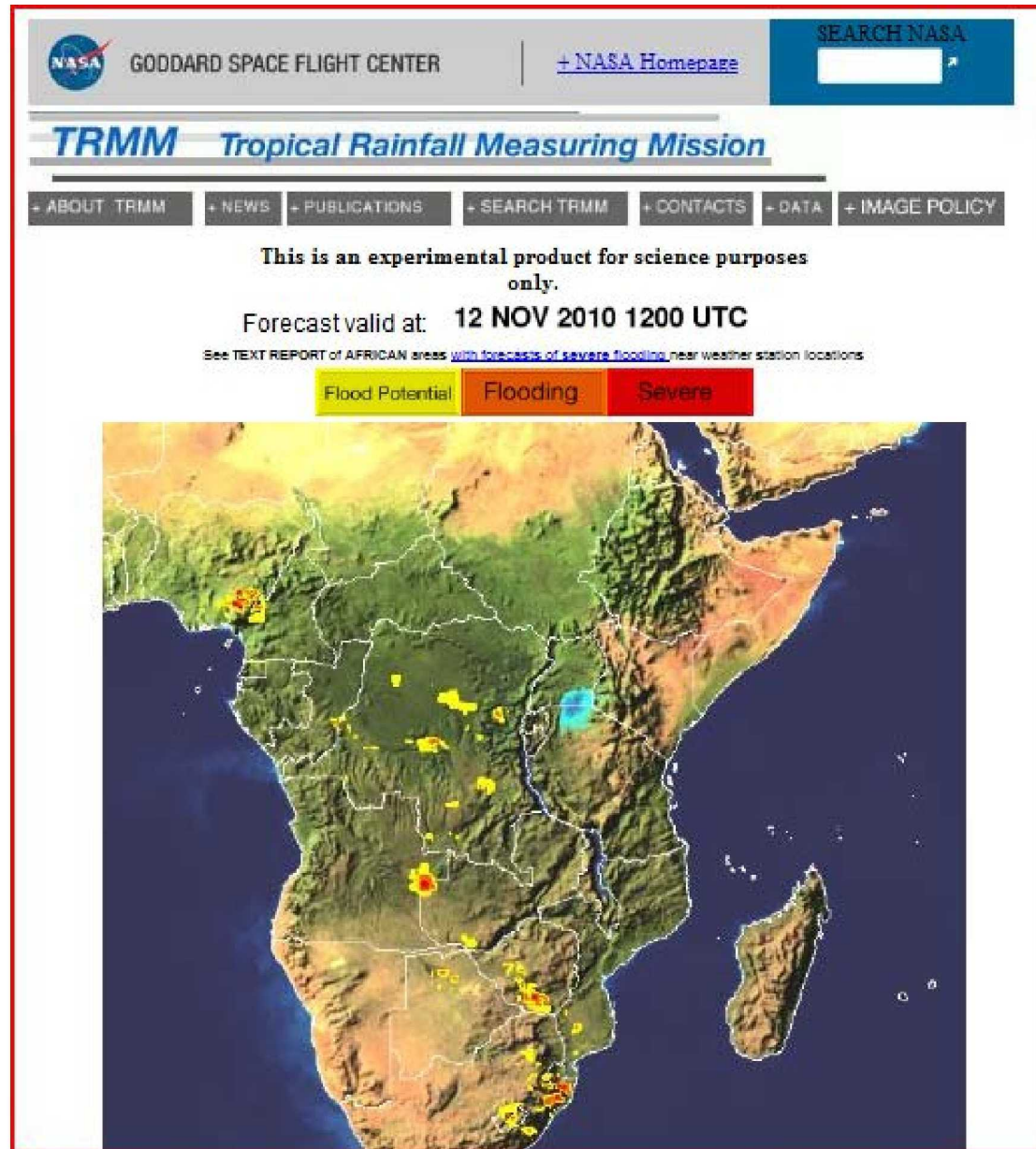
# Estimated Rainfall Webpage Based on TRMM Data

- Experimented with various hydrometeorological information for flood forecasting models
  - remote sensing
  - rainfall estimates
  - 24 February 2010
  - NASA Servir Africa
  - red is > 35 mm

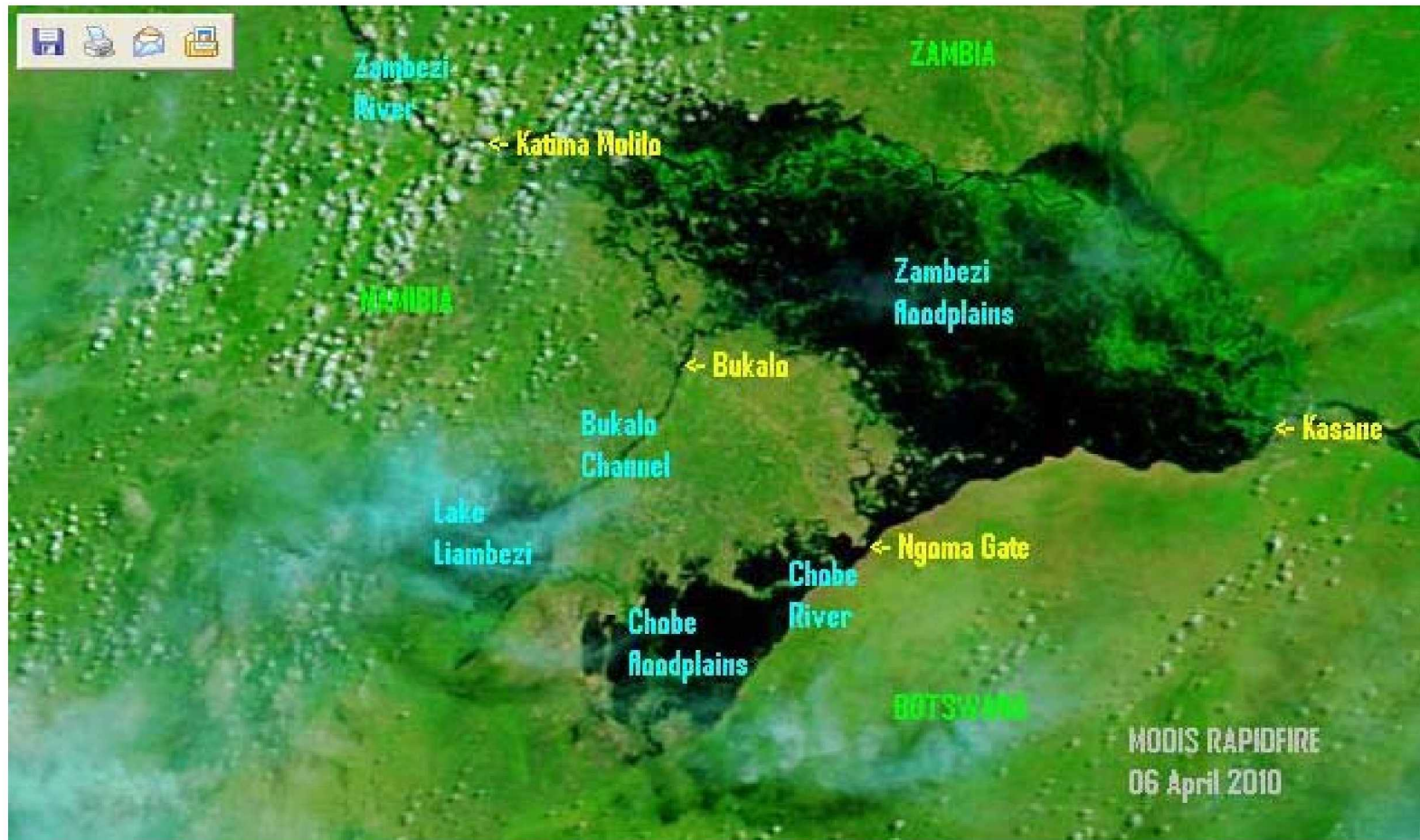




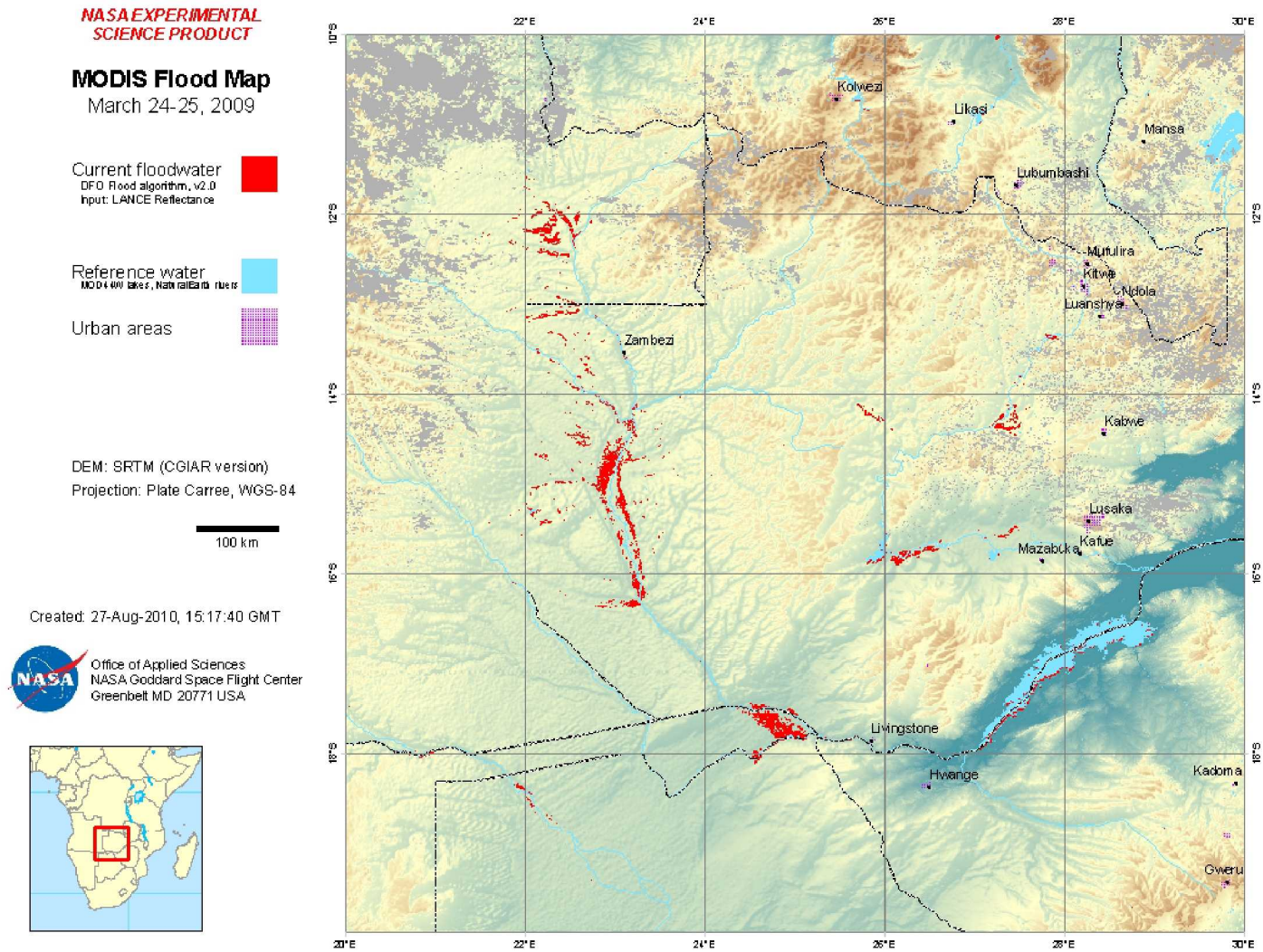
# Experimental TRMM Based Flood Forecast



# MODIS Image of Flood

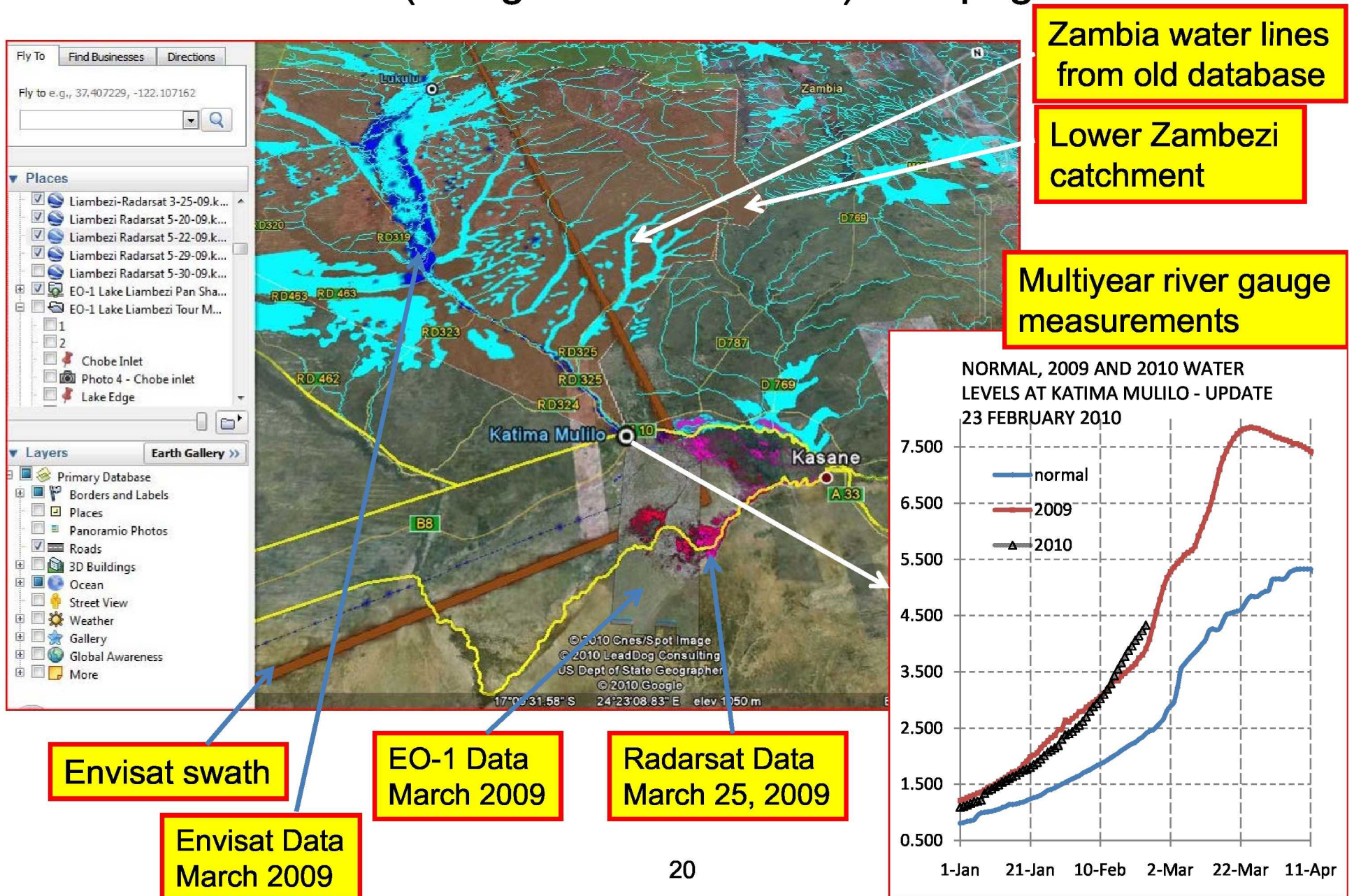


# Experimental Flood Extent Data Product Derived from MODIS



First product out of automated MODIS flood extent map pipeline prototype. Used data from March 2009 to test.

# Mashup of Satellite Data and River Gauge Data Using Namibia2 (Google Earth Version) Webpage Tool



# Sample Display of Multi-year Satellite Measurements (in month of March) of Katima Mulilo Linked to JRC Via Namibia Flood Mashup Based on AMSR-E Microwave Instrument

**GDACS Global Flood Detection System - Version 2**

An experimental system to detect and map in near-real time major river floods based on daily passive microwave satellite observations. The purpose is to identify and measure floods with potential humanitarian consequences after they occur.

EUROPEAN COMMISSION  
GLOBESEC

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Current floods
Global map
Search areas
Custom areas
Animations
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About

**Create a customize graph by parameter**

You can create a custom graph combining up to 4 time series. In a given time period, you can compare different sites (e.g. upstream, midstream, downstream for flood propagation) and/or different years (e.g. comparison with last year's floods). Available parameters are: flood signal (ratio of brightness temperature of observation and nearby dry pixel), flood magnitude (signal anomaly expressed as standard deviation removed from the mean) and estimated flooded area (in km<sup>2</sup>).

Area Id	<input type="text" value="14950"/>	Colour	<input type="text" value="Red"/>	Legend	<input type="text"/>
Period	From <input type="text" value="2010-02-01"/> To <input type="text" value="2010-09-19"/>				
Series	Area Id	Year	Colour	Legend	
1.	<input type="text" value="14950"/>	<input type="text" value="2009"/>	<input type="text" value="Green"/>	<input type="text"/>	
2.	<input type="text" value="14950"/>	<input type="text" value="2008"/>	<input type="text" value="Blue"/>	<input type="text"/>	
3.	<input type="text" value="14950"/>	<input type="text" value="2007"/>	<input type="text" value="Black"/>	<input type="text"/>	
		Parameter	<input type="text" value="Magnitude"/>		
Title: <input type="text"/>					
<input type="button" value="Create"/>					

**Katima Mulilo (DWAF) (14950) from 2010-02-01 to 2010-09-19**

- Magnitude in site 14950 for 2010
- Magnitude in site 14950 for 2009
- Magnitude in site 14950 for 2008
- Magnitude in site 14950 for 2007

[Download data](#)

Please note that the information provided on this website has no official status and does not replace local flood warnings. Please refer to the competent local hydrographic authorities for official information on the flood status in each country.

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In collaboration with:

# Sample Alert During Pilot

## Namibia daily flood bulletin 03 March 2010:

There have again been heavy rains in parts of the Zambezi catchment. See attached NASA map. The waterlevels at Chavuma started rising again. See attached graph. Our forecast remains that the Katima Mulilo waterlevels are heading for 7 m by mid-March 2010. For perspective, the flood would be:

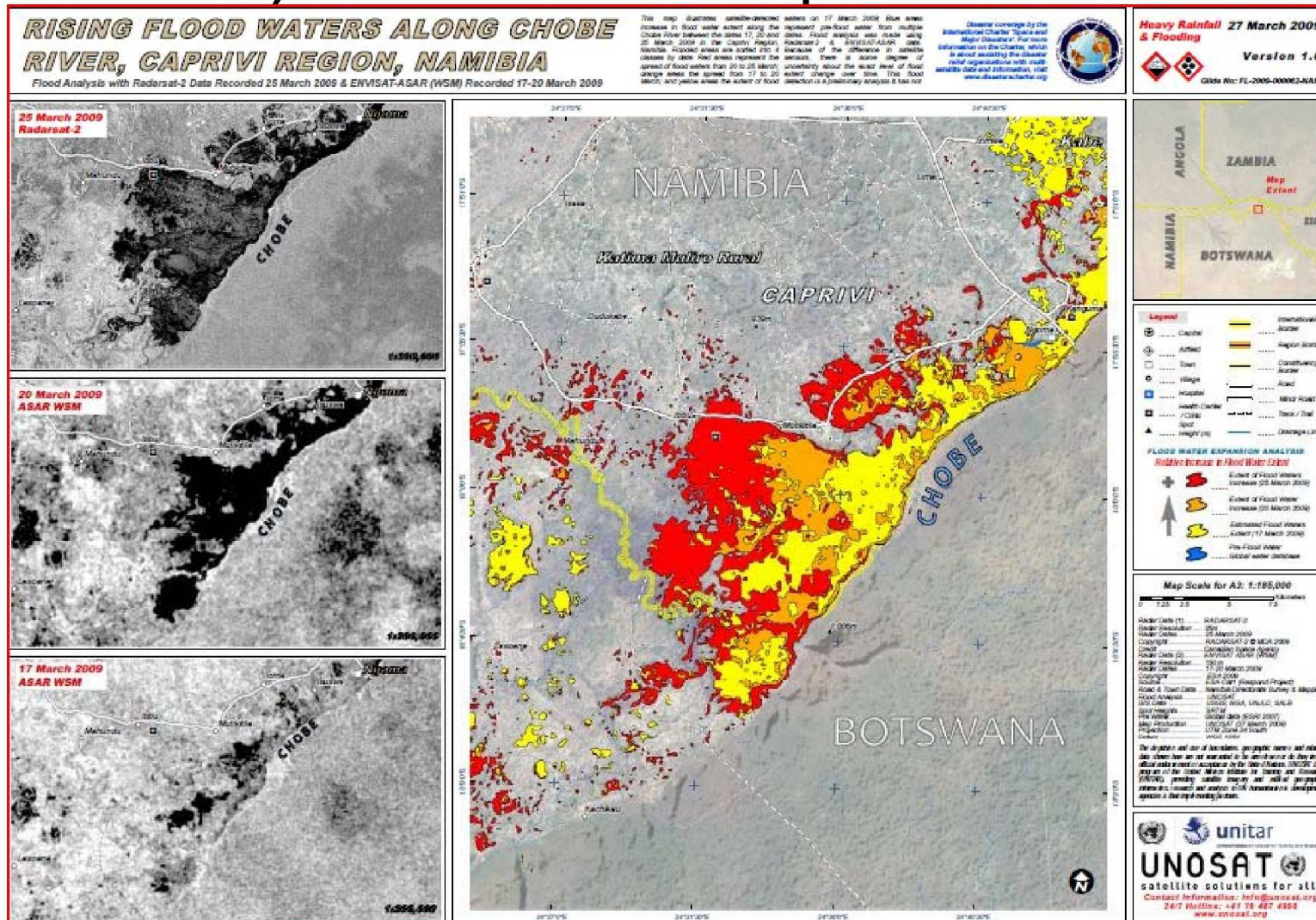
**similar to 2007**

**higher than 2008**

**lower than 2009**

But much will depend on the rains and the catchment response in the coming weeks.

# Sample Time Sequence Flood Map Generated by Unosat, Derived from Multiple Satellite Data Sets



Vision is to generate similar product automatically when floods predicted and pair them with river gauge measurements

# Capabilities Chart

Capability	Comment
Global low resolution flood predictive model	TRMM based pilot done
High resolution, basin specific hydrological models	NASA completed experimental high resolution model of Lake Victoria basin, would like to do Okavango basin next
Flood gauge data made available on line	Pilot done (Namibia Dept of Hydrology
Auto-generation of MODIS Flood Maps	Almost Done
Auto-generation of EO-1 flood Map	Near future
Auto-generation of Radarsat flood map	Future
Auto-generation of Envisat flood map	Ukraine Space Research Institute
Validation of satellite data and flood location	Namibian Dept of Hydrology, ongoing
Auto-Integration and auto-generation of multiple satellite images info flood differential map	Future
High resolution soil moisture satellite measurements	Future, needed to improve hydrological models



# Capabilities Chart

Capability	Comment
Building structure location database	Done, government of Namibia
Auto-generation of flood risk map upon prediction of future floods, auto-notification of people in high risk (red) zones	Future
Correlation of past floods to river gauge measurements to build rudimentary case-based flood forecast model for selected areas	Ongoing
Auto-generation of flood extent maps from TerraSAR	Desirable
High resolution airplane LIDAR generated Digit Elevation Models (DEM)	Desirable to improve hydrological models
Joint Research Centre (JRC) Riverwatch measurements based on Advanced Microwave Scanning Radiometer - Terra (AMSR-E)	Done

# Validating Rudimentary Forecast Model and Satellite Imagery for Flood Assessment

- Department of Hydrology validating various flood forecast tools and satellite imagery for flood extent
- Ran flood sensorweb system in spring of 2010 to see how good forecast model performs
- Successfully able to project flood wave downstream up to 10 days in advance
- Experimenting with dwelling unit database to overlay on risk map for future flood
  - Alerts can be sent to warn people to prepare or evacuate

# Planned Flood Pilot Effort for Spring 2011

- Use Global Flood Detection System (created and managed by Joint Research Center of European Commission in Italy, Tom De Groeve) to detect flooding levels in the upper regions of the Cuvelai and Zambezi basins
- Using known flood wave delays, trigger automated imaging of the downstream locations to produce flood extent maps as a time series using the EO-1 satellite and other satellites as available
- Make use of Flood Dashboard to store links to satellite related data products and in-situ rain and river gauge data
- Provide a text box alert area to inform viewers the status of flooding in key areas
- Show river water levels as comparative overlays to average and previous years
- Create a case-based history of flooding in relationship to rainfall levels, river levels and other pertinent data
- Create a rudimentary forecast capability via script and show areas at risk by taking a subset of Dwelling Unit database and showing specific dwelling locations at risk in a specified time frame base on flood forecast

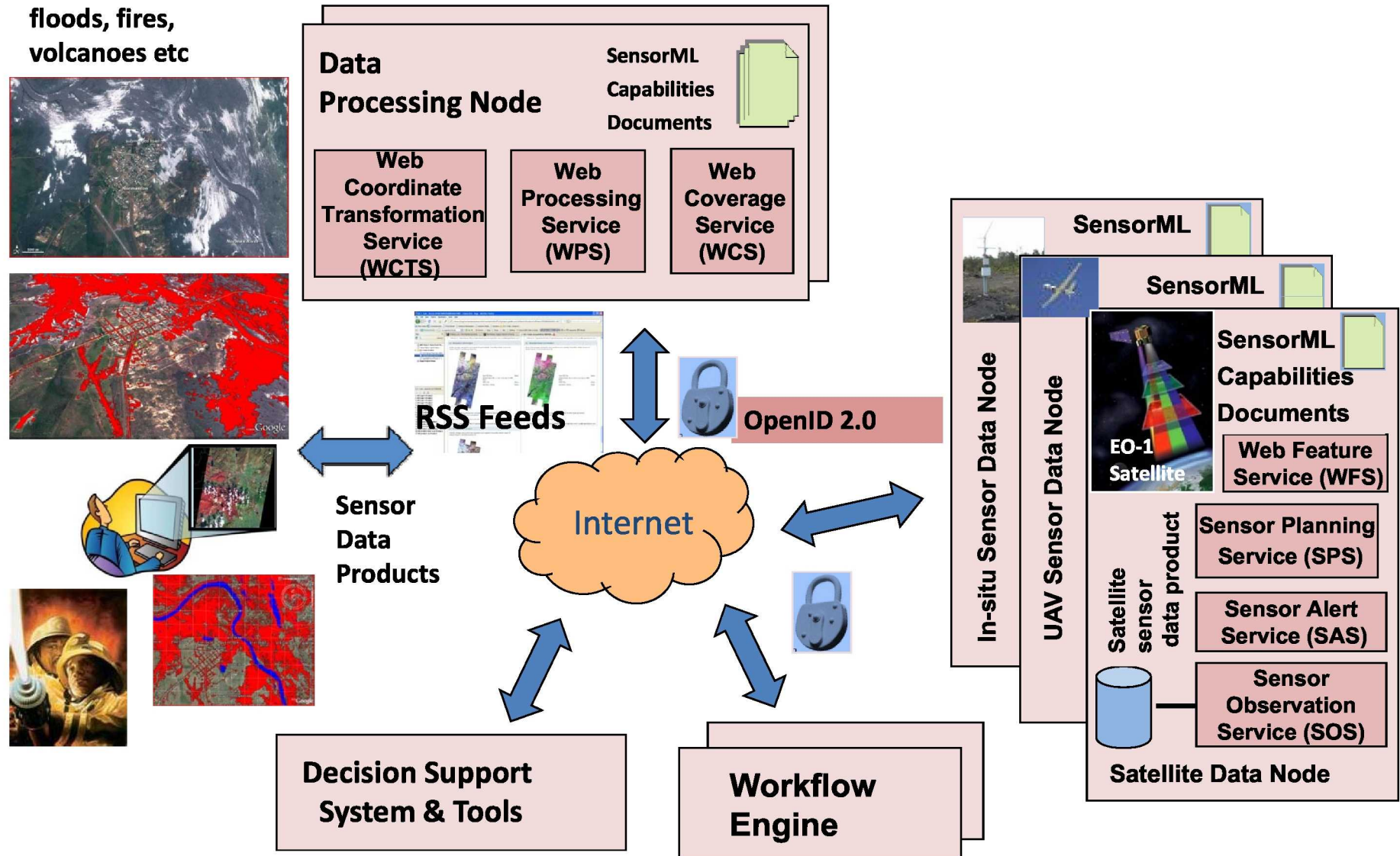
# Success of Prototyping Effort as Viewed by Namibian, Department of Hydrology

We (Dept of Hydrology, Namibia) see our success as the openings we made with all the assistance offered and given. Some components:

- The use of radar images for flood mapping
- The access to the space charter
- The tremendous access to satellite images
- The actual use of these images
- The customized rainfall estimates
- The RS estimates (Dartmouth Flood Observatory/European Commission Joint Research Centre)
- How this all augments the conventional hydrological approach which is based on time series in points.
- And last but not least the capacity building and access to new techniques for our young professionals.

# Backup

# Basic Components Used in Flood-Disease SensorWeb



# Campaign Manager Tasking Request Page

## Visualize request using Google Map

### Tasking Request:

Title: Lake Liambezi test1  
Description: Namibia flood campaign requested by Guido Van Langenhove  
Category:  
Latitude: -17.9108028411865  
Longitude: 24.21120262146  
Day/Night: day time  
Country Code:  
Country Name:  
Zone Number: 576  
Zone Name: Zambia  
Region Number: 37  
Region Name: Africa  
Admin Code:  
Admin Name:  
Nearby:  
Created At: Thu, 23 Apr 2009 02:37:14 -0000  
Updated At: 2009-04-23

[Show Map](#)

### Feasibilities

Potential Feasibility Asset: EO-1, Date: 2009-04-24T08:09:00Z  
Potential Feasibility Asset: ALOS, Date: 2009-04-24T23:24:50Z  
Potential Feasibility Asset: FORMOSAT-2, Date: 2009-04-25T00:45:28Z  
Potential Feasibility Asset: QB-2, Date: 2009-04-25T08:00:21Z  
Potential Feasibility Asset: SPOT-5, Date: 2009-04-25T21:15:14Z  
Potential Feasibility Asset: EO-1, Date: 2009-04-27T08:25:00Z  
Potential Feasibility Asset: FORMOSAT-2, Date: 2009-04-27T12:24:02Z  
Potential Feasibility Asset: SPOT-5, Date: 2009-04-28T06:24:02Z  
Potential Feasibility Asset: QB-2, Date: 2009-04-28T19:10:07Z  
Potential Feasibility Asset: ALOS, Date: 2009-04-29T00:35:33Z  
Potential Feasibility Asset: EO-1, Date: 2009-04-29T08:04:00Z  
Potential Feasibility Asset: ALOS, Date: 2009-04-29T20:38:33Z  
Potential Feasibility Asset: FORMOSAT-2, Date: 2009-04-29T23:19:50Z  
Potential Feasibility Asset: QB-2, Date: 2009-04-30T02:52:57Z  
Potential Feasibility Asset: SPOT-5, Date: 2009-04-30T11:02:33Z  
Potential Feasibility Asset: EO-1, Date: 2009-05-02T08:21:00Z  
Potential Feasibility Asset: ALOS, Date: 2009-05-02T14:09:28Z  
Potential Feasibility Asset: QB-2, Date: 2009-05-02T14:38:16Z  
Potential Feasibility Asset: SPOT-5, Date: 2009-05-03T01:43:33Z  
Potential Feasibility Asset: FORMOSAT-2, Date: 2009-05-03T09:47:24Z



# Deliver Level 2 Products via News Feeds to Users Along with Links to GeoTiff, KML and information about Image

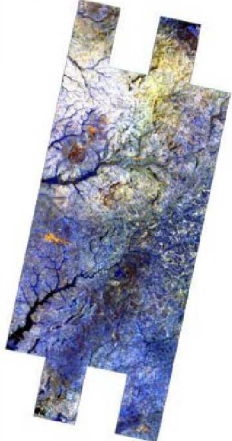
EO-1 Task, Scene:EO1A1700592008326110KF, Theme:fire - Sage - Mozilla Firefox

chrome://sage/content/feeds/summary.html?uri=http%3A%2F%2Fgeoboms.geobliki.com%2Fdata%2Fproducts%2Ffeeds%2F83080-B829-11DC

Patrice G. Cappelaere <http://cappelaere.pip.verisignlabs.com/> pat@cappelaere.com

**15. Ali product swir Product**

SWIR Image using EO1 ALI Level1G and Vigtel Classifier (Red: band 10, Green:band 9 and Blue:band 8).



GeoTiff File [here](#)  
 [Note:Data file is also include in KMZ file]  
 KMZ File [here](#)  
 GeoBliki Article [here](#)

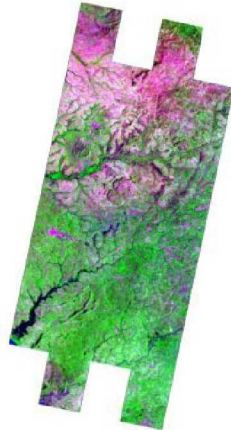
[Disclaimer: This product has not been validated by the Science team]  
 Provided by GeoBliki and GeoBPMS

Friday, November 21, 2008 2:04 PM

Patrice G. Cappelaere <http://cappelaere.pip.verisignlabs.com/> pat@cappelaere.com

**16. Ali product burn scar Product**

Burn Scar Image using EO1 ALI Level1G and Vigtel Classifier (Red: band 10, Green:band 7 and Blue:band 5).



GeoTiff File [here](#)  
 [Note:Data file is also include in KMZ file]  
 KMZ File [here](#)  
 GeoBliki Article [here](#)


[Disclaimer: This product has not been validated by the Science team]  
 Provided by GeoBliki and GeoBPMS

Friday, November 21, 2008 2:04 PM

Patrice G. Cappelaere <http://cappelaere.pip.verisignlabs.com/> pat@cappelaere.com

**17. Ali product vis Product**

Visible Image using EO1 ALI Level1G and Vigtel Classifier (Red: band 5, Green:band 4 and Blue:band 3).

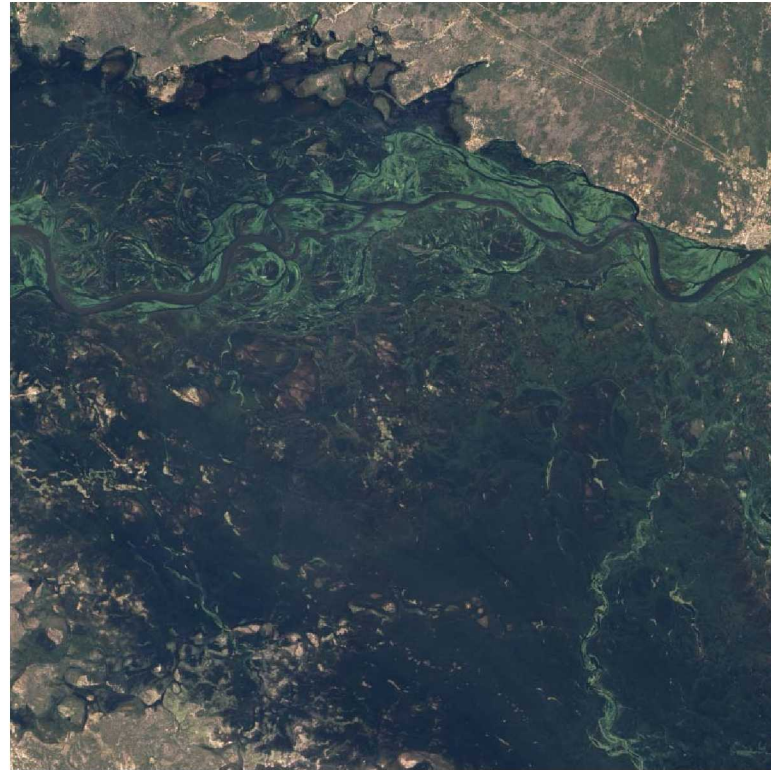




# Lake Liambezi Flood in Namibia

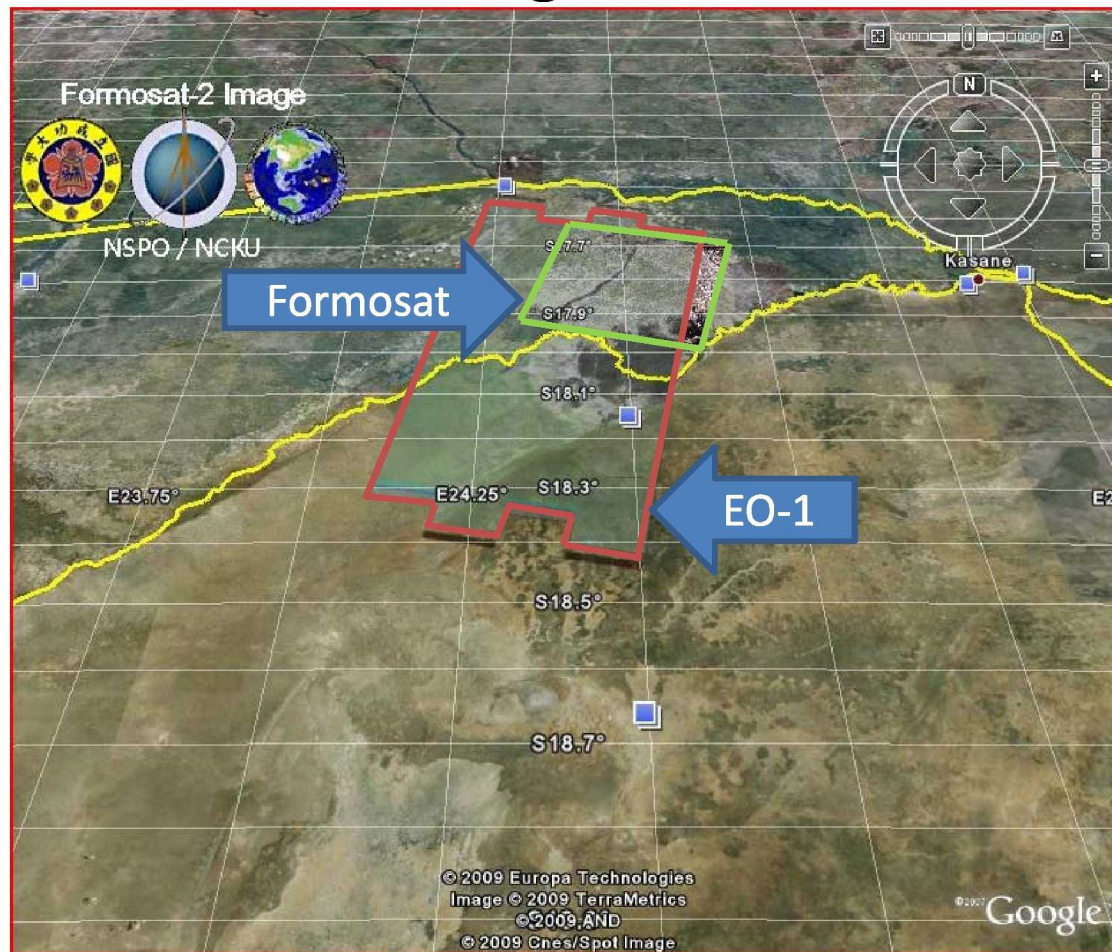


Landsat Image Oct 18, 2002



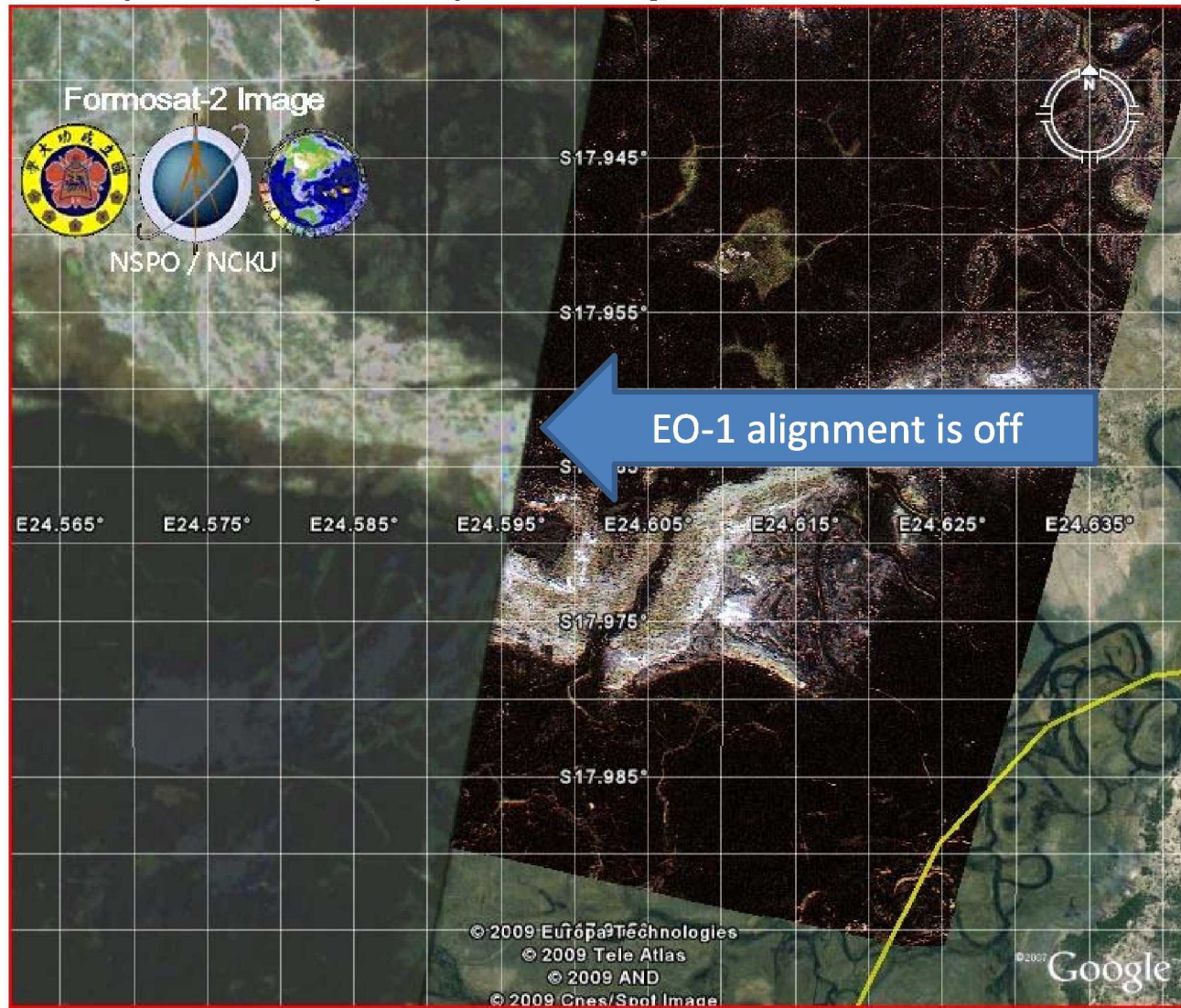
EO-1 Image March 27, 2009

Lake Liambezi: EO-1 ALI Image 4-9-09 ( 30 m resolution) Overlaid on Formosat Image 4-5-09 (2 m resolution) on Google Earth  
Both images Geo-tiled

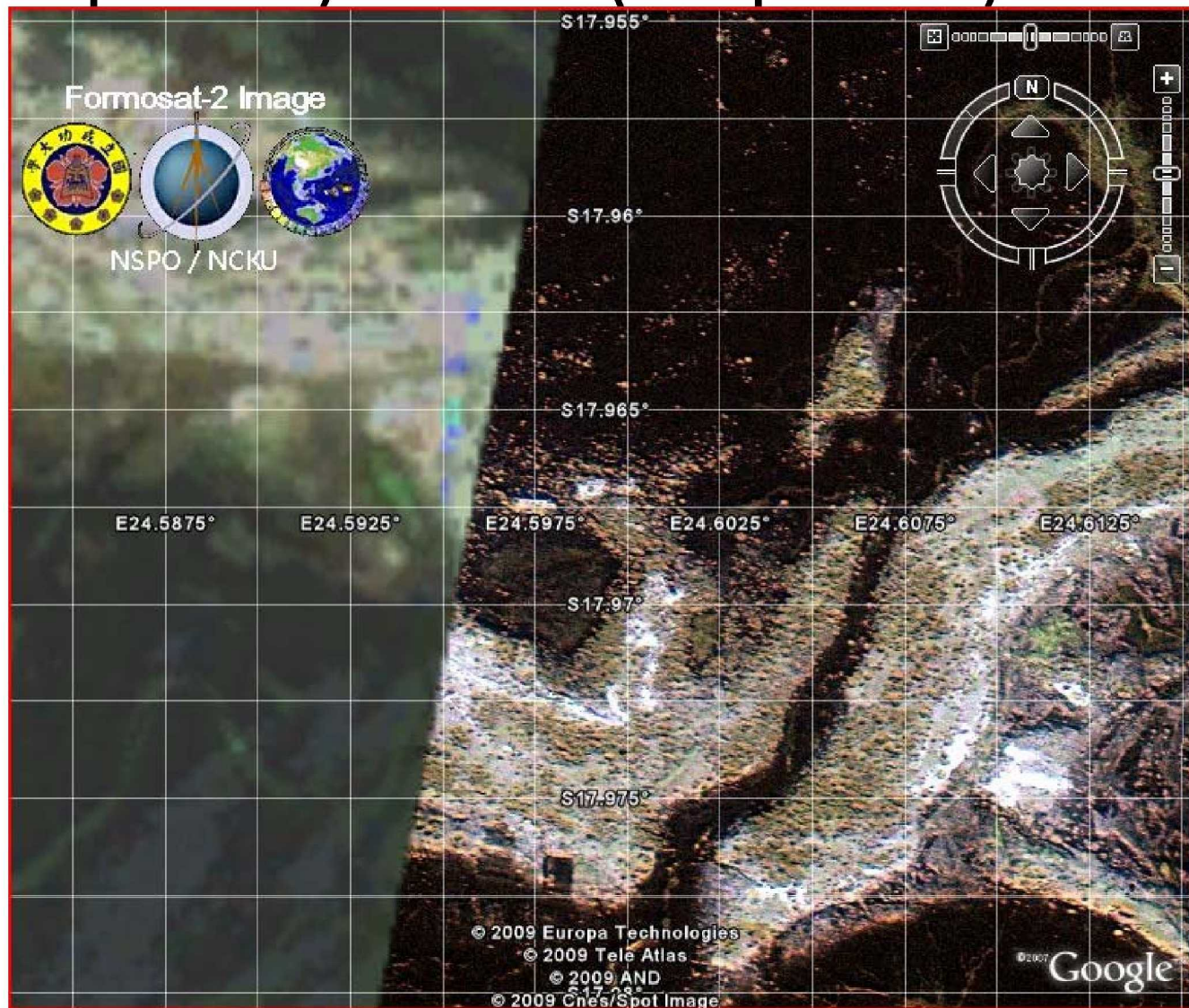


# Zoom 1 – Note Misalignment Problem

Example of Capability Needing Fix to Get to TRL 7



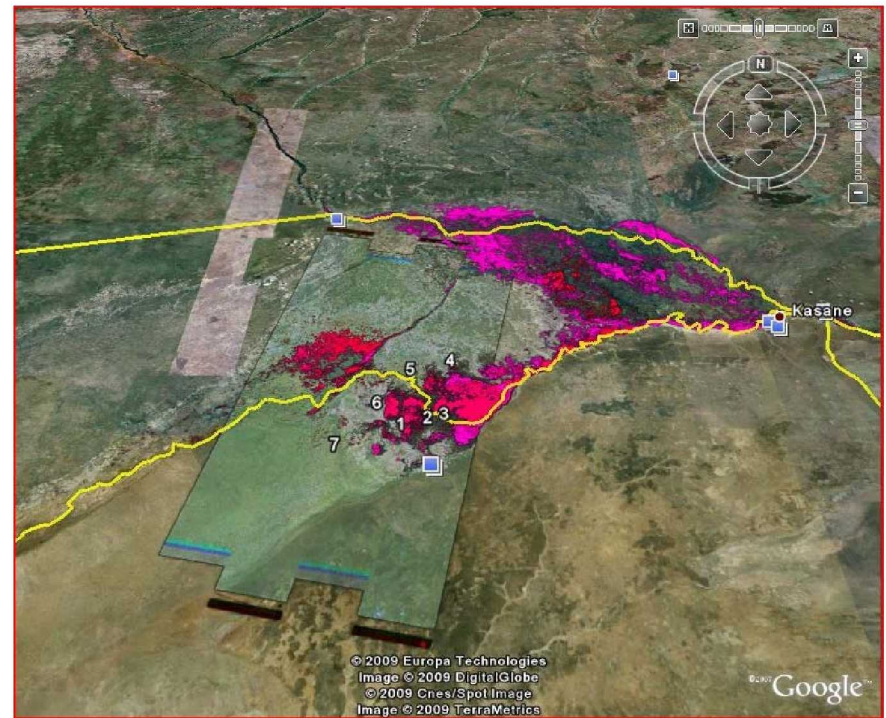
# Zoom – Note increased detail of Formosat(right portion) vs EO-1 (left portion)



# EO-1 & Radarsat 2 Flood Image



EO-1 Image 5-11-09 on Google Earth



EO-1 Image 5-11-09 overlaid with Radarsat 2 data from 3/25/09, 5/20/09, 5/22/09 and 5/29/09 on Google Earth

# SERVIR Experimental/Standard Flood Products Page – Policelli/GSFC (password protected)

File Edit View History Bookmarks Tools Help

http://aspires.gsfc.nasa.gov/SERVIR\_Africa/test.html

FreeRecorder Go Record Stop Pause Play Settings Amazing MP3 Song Recorder

Directory  
Collaborators  
Site Map  
Reference Material  
SERVIR Internal  
Contact Us

NASA  
USAID  
CATHALAC

NATURAL HAZARDS  
[Earthquakes](#)  
[Volcanoes](#)  
[Fires](#)

**Low Level Flood Potential**  
(25mm-75mm)

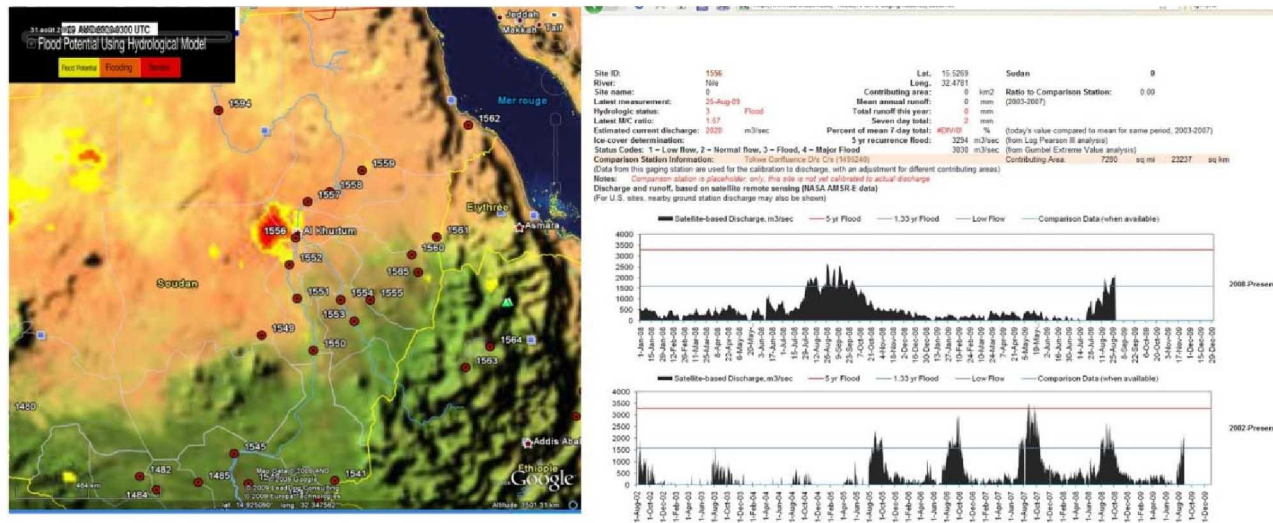
**Moderate Flood Potential**  
(75mm-125mm)

**Severe Flood Potential**  
(125mm+)

Imagery ©2009 TerraMetrics, NASA - Terms of Use

<b>Clouds/Rain</b> Meteosat Clouds Rain Accumulation Forecast Precip	<b>Current Flood Potential</b> Flood Potential 7Day Animation Severe Flood Report River Discharge	<b>Forecast Flood Potential</b> Flood Forecast 5Day Animation Severe Flood Report	<b>Field Reports/Flood Maps</b> Field Reports Quick Look Flood Maps
-------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------	---------------------------------------------------------------------------

# Red Cross Used Flood Potential Model and Relevant Info to Launch Appeal



**From:** Frederic Zanetta [mailto:Frederic.Zanetta@ifrc.org]  
**Sent:** Monday, August 31, 2009 11:05 AM  
**To:** Policelli, Frederick S. (GSFC-6104)  
**Subject:** Use of NASA product

Hi Fritz,

How are you ?

I just want to let you know that we have been using today the TRMM product (see attached) to confirm information from the field about floods near Kartoum and we will probably be launching an Emergency Appeal.

Have a nice day

Frederic

---

**Frédéric Zanetta**

Operations Support Department

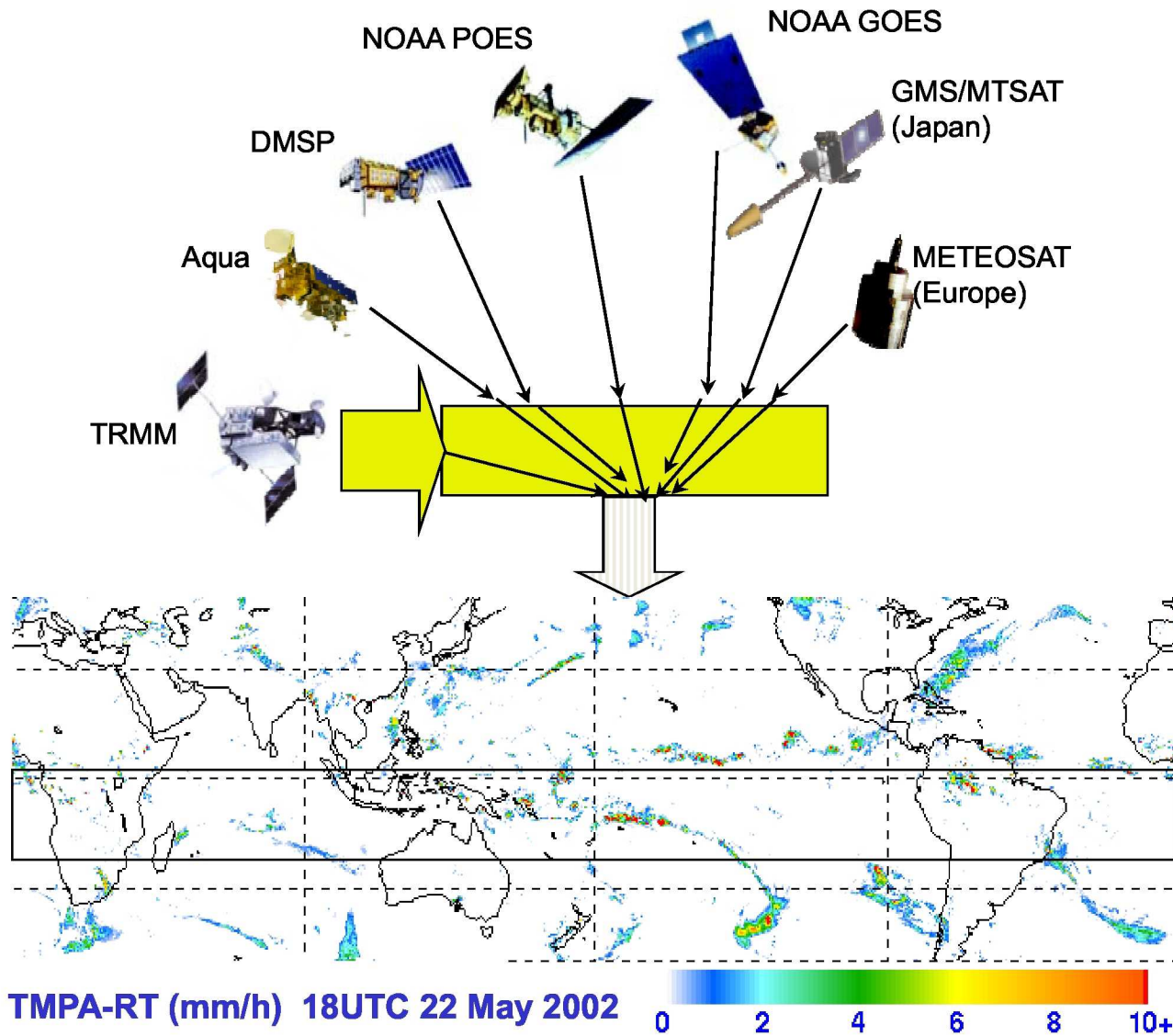
Disaster information senior officer

Chemin des Crêts 17 | Petit-Saconnex | P.O. Box 372 | 1211 Geneva 19 | Switzerland

Phone: +41 22 730 4291 | Fax: +41 22 730 4480

E-mail: [frederic.zanetta@ifrc.org](mailto:frederic.zanetta@ifrc.org) | Skype: fzanetta

## Near Real Time Rainfall Measurements



1. TRMM used to calibrated all other satellites
2. 25-km grid precipitation, every 3 hours, 1998-present;
3. <http://trmm.gsfc.nasa.gov>

From: Hong, Adler