Matsu: An Elastic Cloud Connected to a SensorWeb for Disaster Response

Matt Handy - NASA/GSFC 4/13/11

SensorWeb High Level Architecture

floods, fires, volcanoes etc

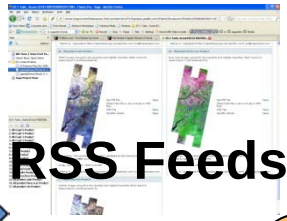
Data Processing Node

SensorML
Capabilities
Documents

Web Coordinate Transformation Service (WCTS)

Web Processing Service (WPS)

Web Coverage Service (WCS)



RSS Feeds

Sensor Data Products

Internet

OpenID 2.0

SensorML

SensorML

SensorML
Capabilities
Documents

Web Feature Service (WFS)

In-situ Sensor Data Node

UAV Sensor Data Node

Satellite sensor data product

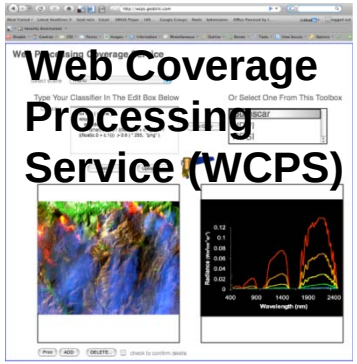
Sensor Planning Service (SPS)

Sensor Alert Service (SAS)

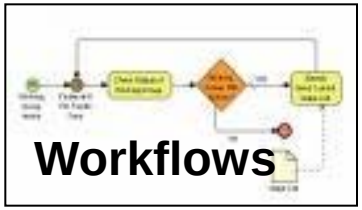
Sensor Observation Service (SOS)

Satellite Data Node

GeoBPMS

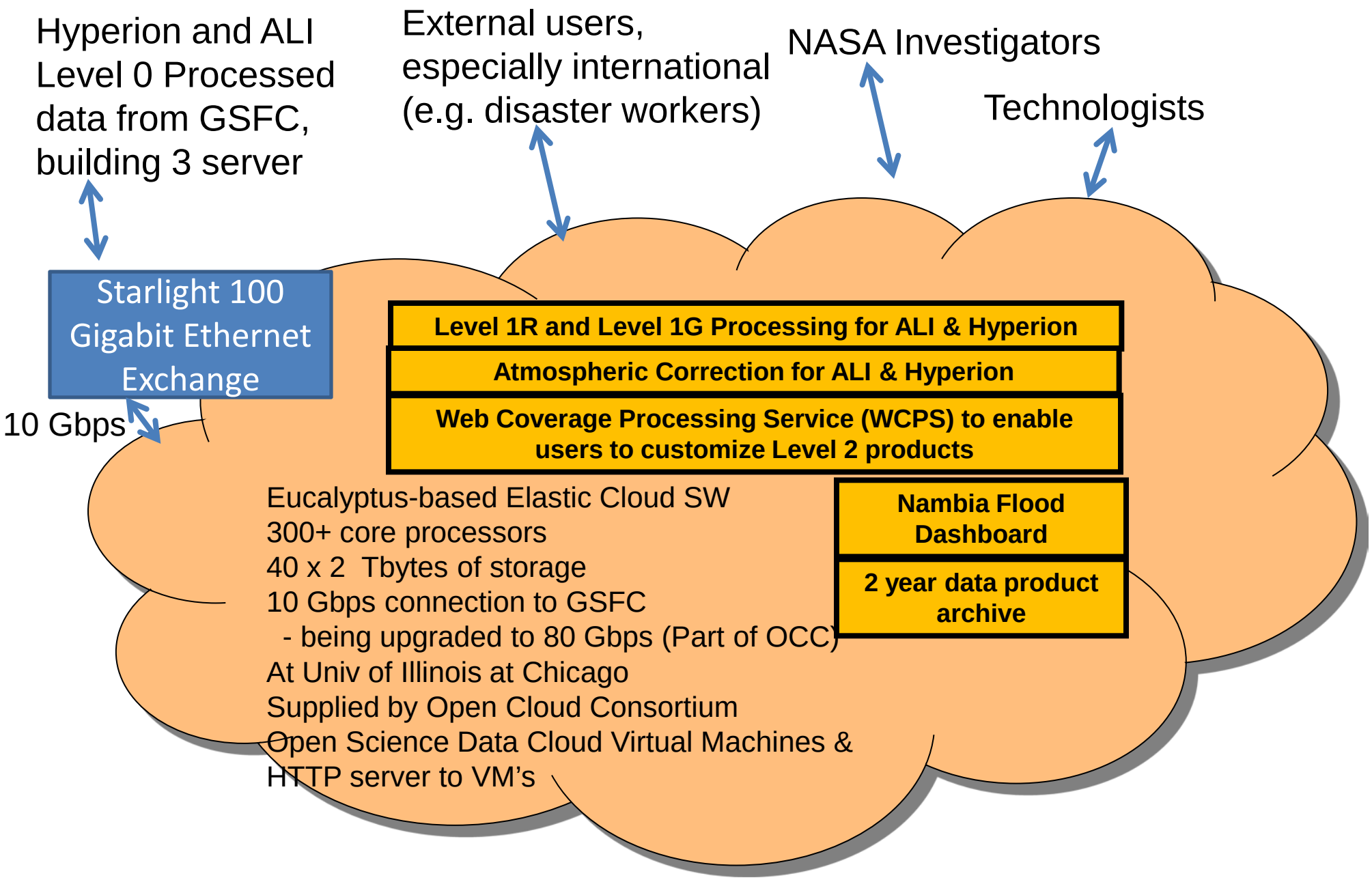


Web Coverage Processing Service (WCPS)



Workflows

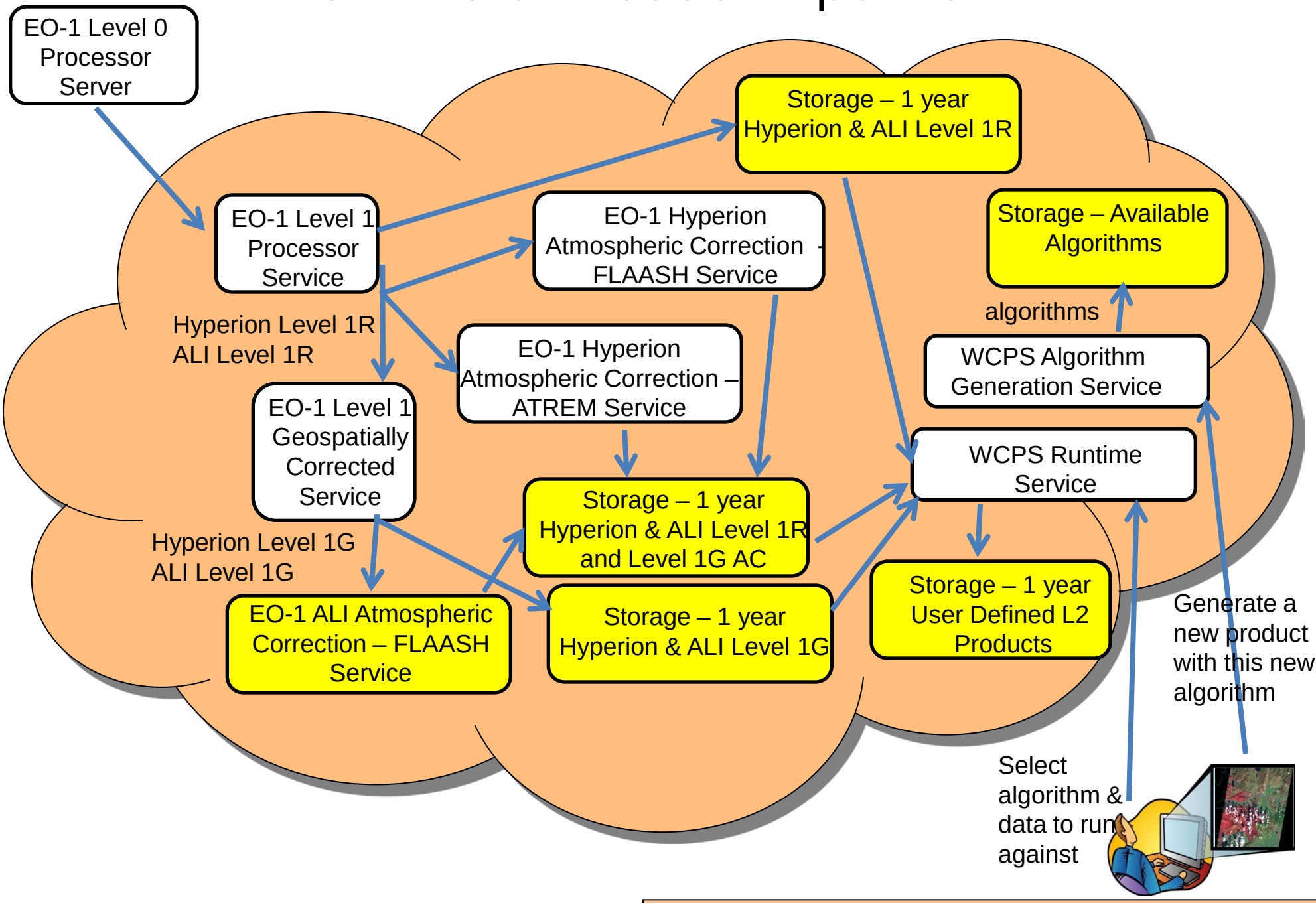
Cloud Integration for EO-1 - Overview



OCC = Open Cloud Consortium

Phase 3 Add Elastic Cloud Ongoing April 2011

Transformation to On-Demand Product Cloud Part 1
EO-1 Data Product Pipeline



Phase 3 Add Elastic Cloud Ongoing April 2011

On-Demand Product Cloud Part 2
Flood Dashboard (Matsu)

CREST Hydrological Model

TRMM based Global Rainfall Estimates

Radarsat Images

MODIS Daily Flood Extent Map

Global Disaster and Alert and Coordination System (GDACS)

5 Namibian River Gauge Stations - Daily Measurements

Namibia River Gauge Data base

Storage – 1 year Hyperion & ALI Level 1R

Storage – 1 year Hyperion & ALI Level 1G

Storage – 1 years Hyperion & ALI Level 1R and Level 1G AC

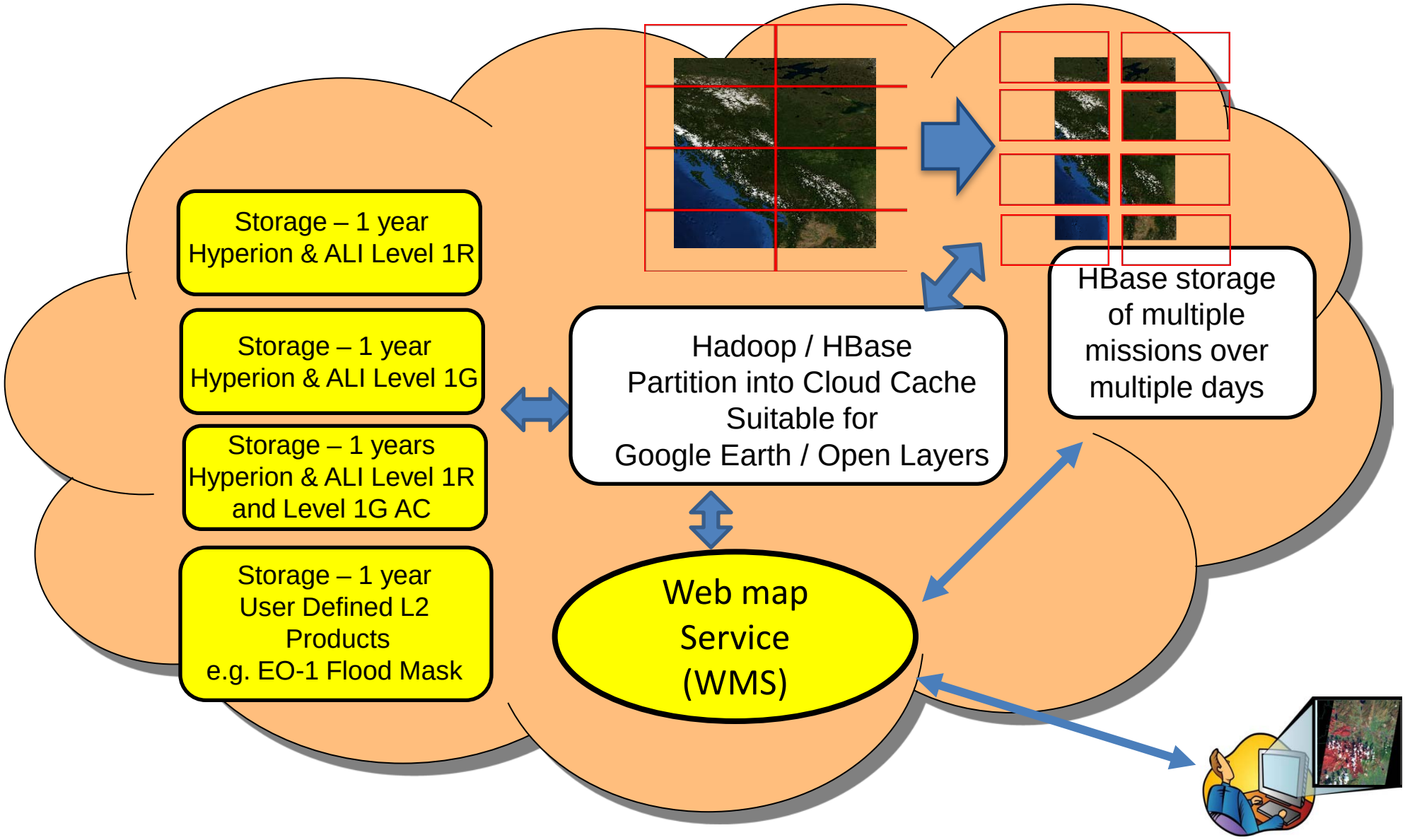
Storage – 1 year User Defined L2 Products e.g. EO-1 Flood Mask

Flood Dashboard Display Service
- Mashup
- Google Maps Inset
- Plot Package

http server

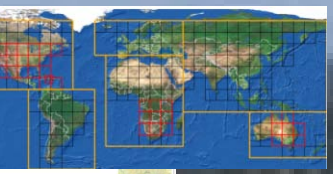
Phase 3 Add Elastic Cloud Ongoing April 2011

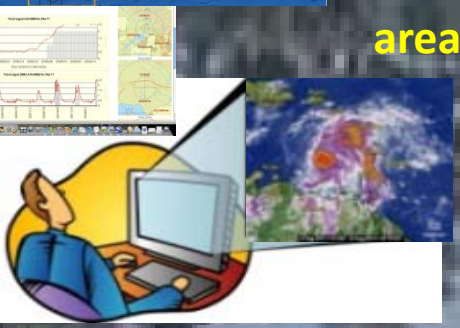
Detail of Processing Image Data in OCC Open Science Data Cloud



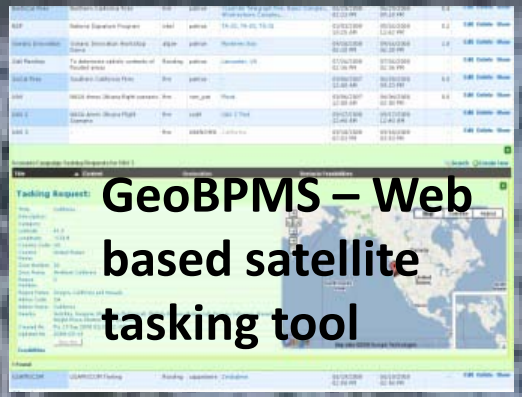
Phase 3 Add Elastic Cloud Ongoing April 2011

Top Level Flood SensorWeb Concept





Manual or automated triggered requests for satellite imagery in area of interest



Customized plan of needed satellite images

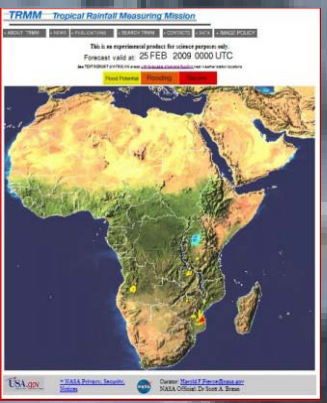
SPS

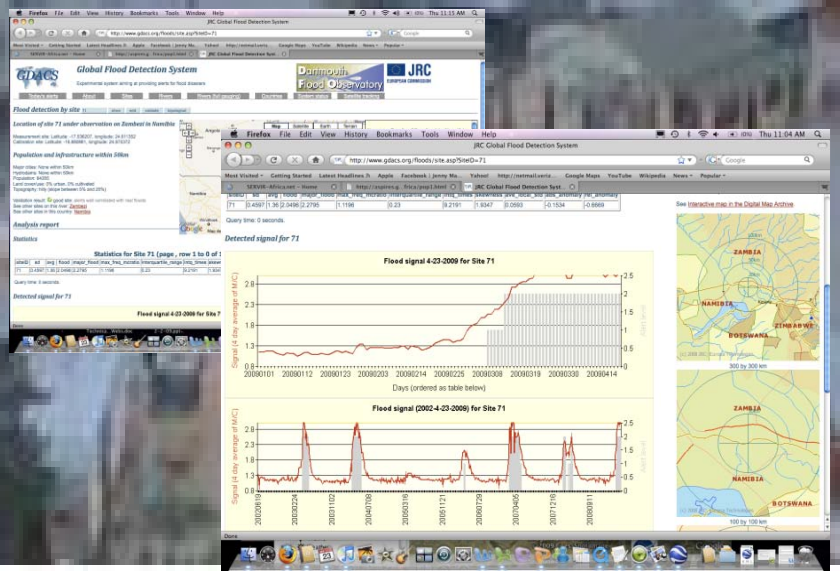
SPS

SPS

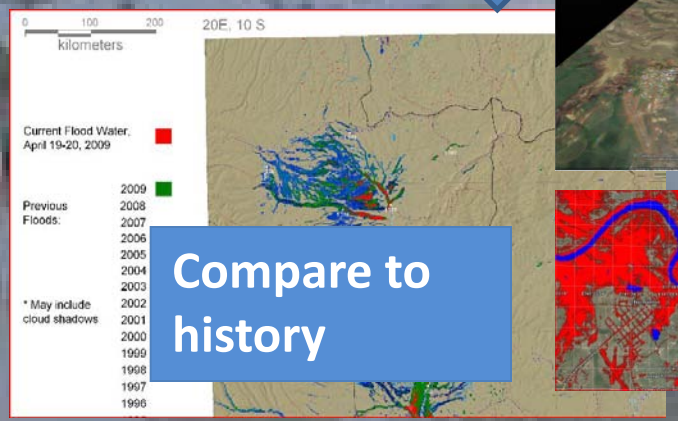
Flood alerts to users

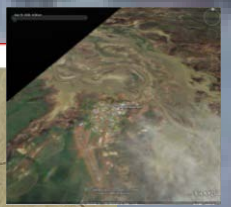
Ground flood measurements to validate model





Flood conditions



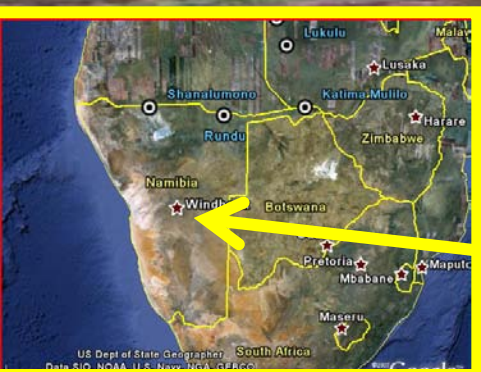


Compare to history

Improved flood prediction model

*SPS = Sensor Planning Service

Portion of 2011 Namibian Flood SensorWeb Early Warning Pilot



Angola

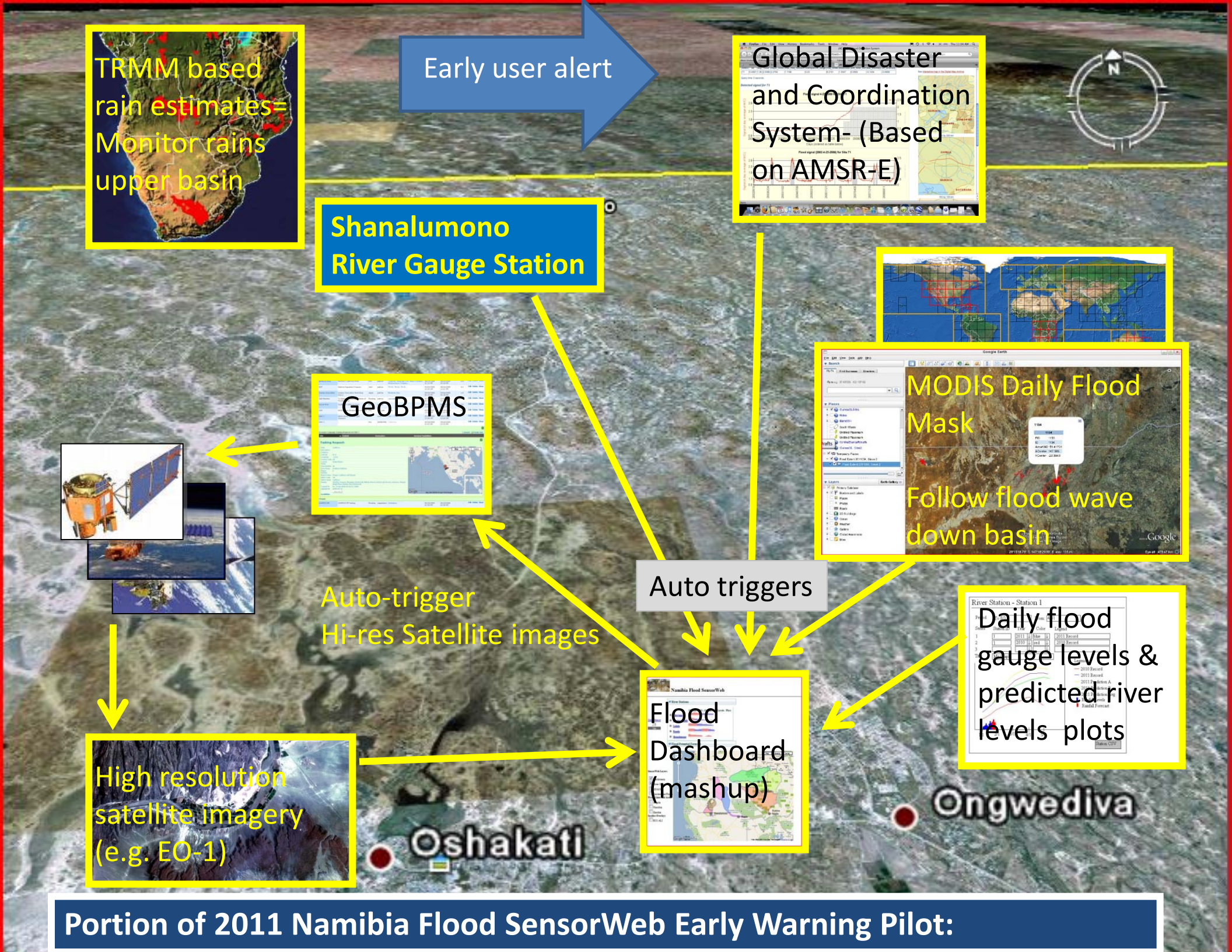
Namibia

Shanalumono River Gauge Station

Water flow from North through basin

Oshakati

Ongwediva

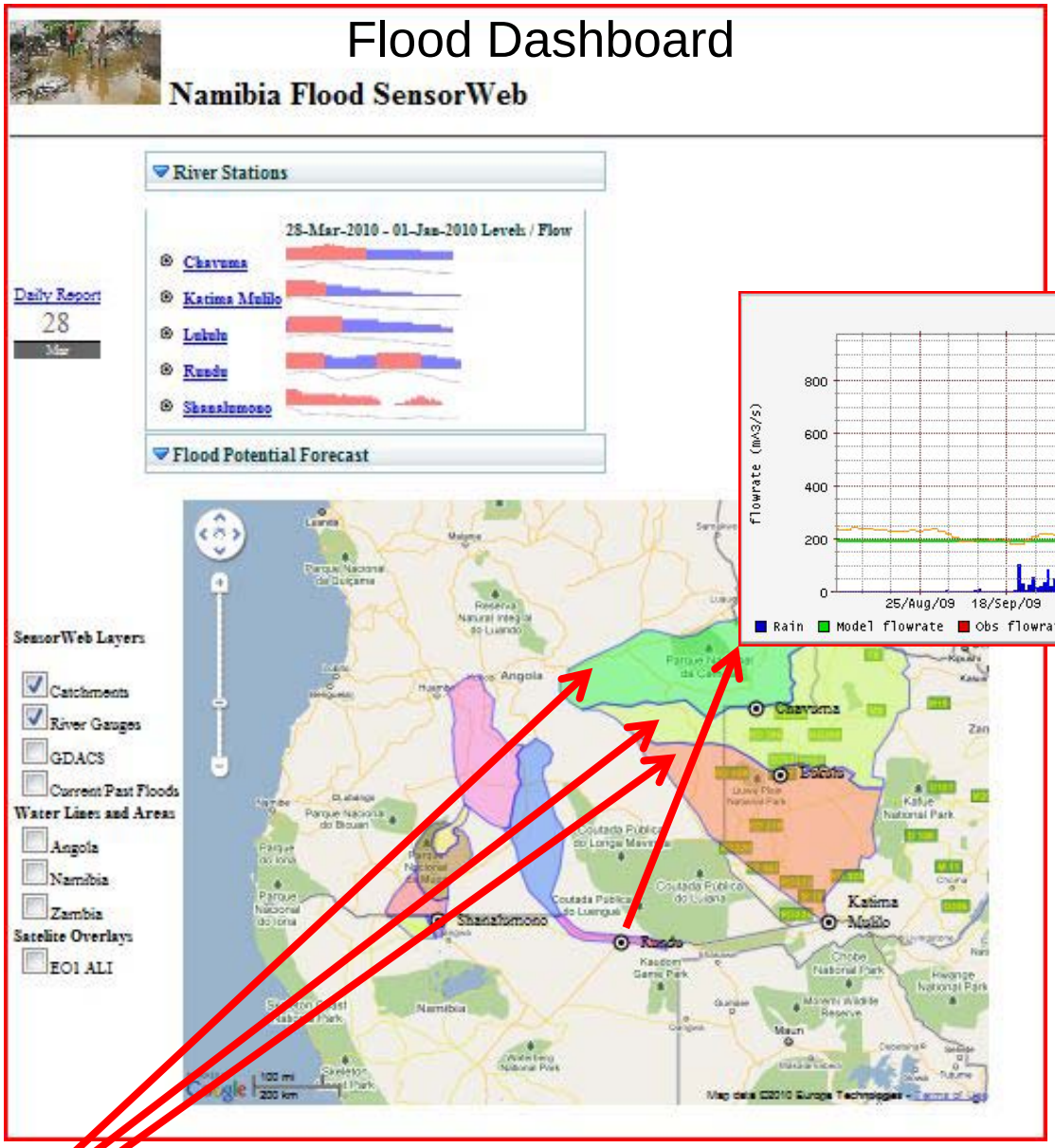


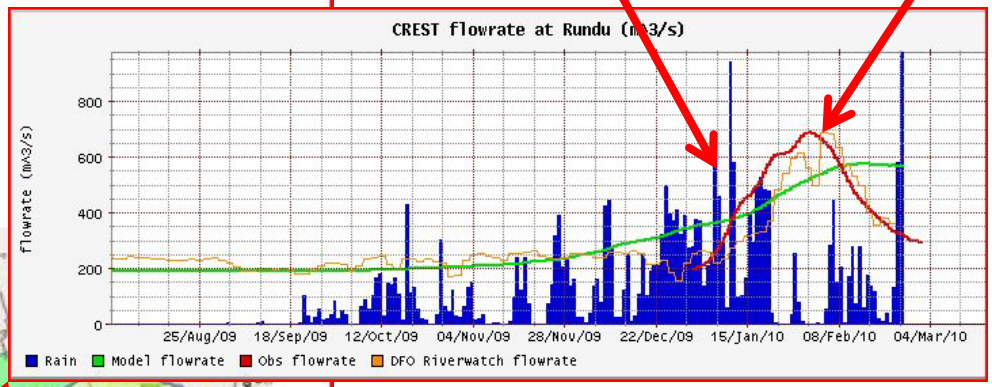
Portion of 2011 Namibia Flood SensorWeb Early Warning Pilot:

Experimental Namibian Flood SensorWeb

Note blue bars indicating a surge of rainfall upstream

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





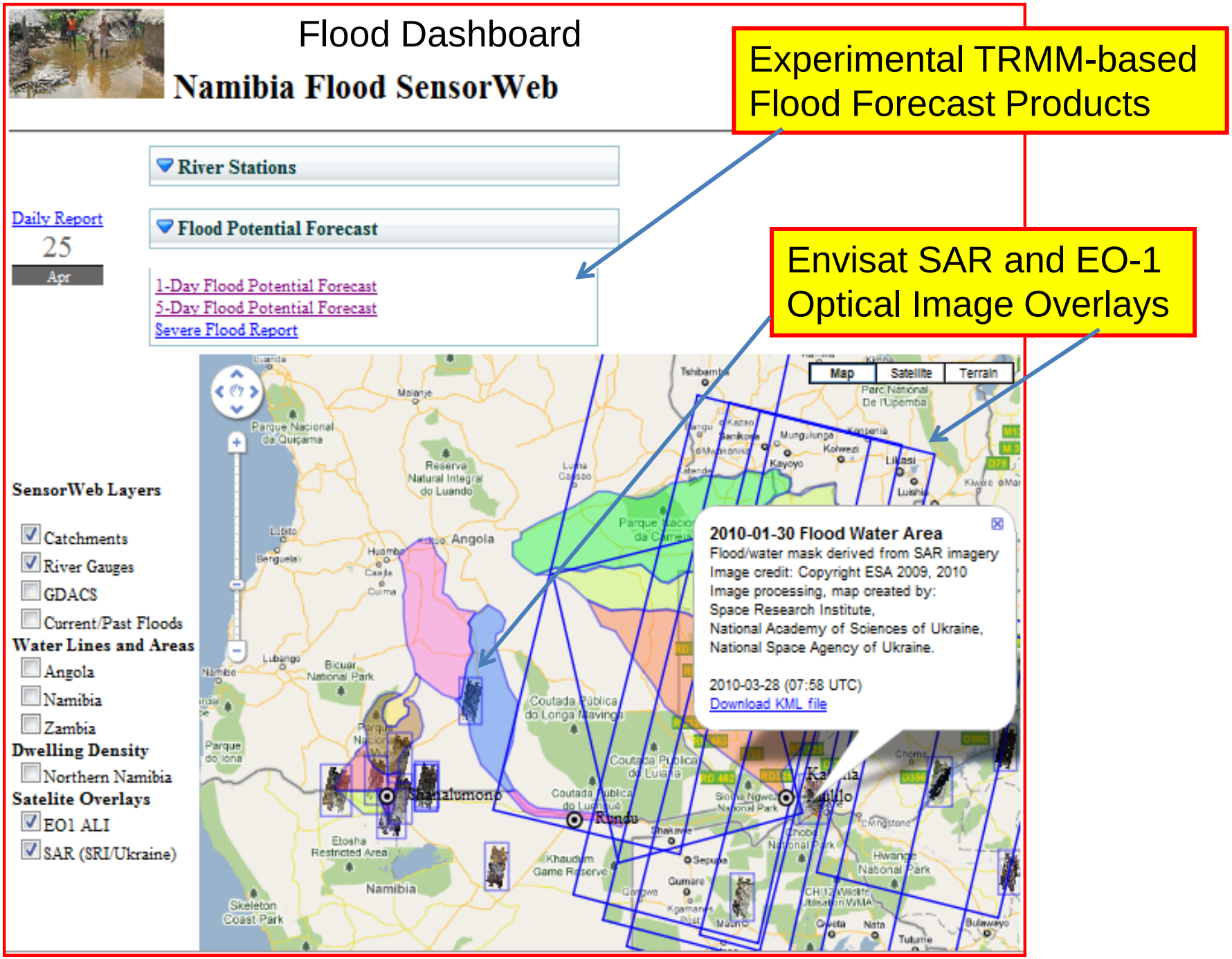
Namibia Short Term Pilot for 2010

- 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

Shanalumono River Gauge Station and Community Prone to Flooding

Experimental Namibian Flood SensorWeb
Test View of Envisat & EO-1 Overlay Images

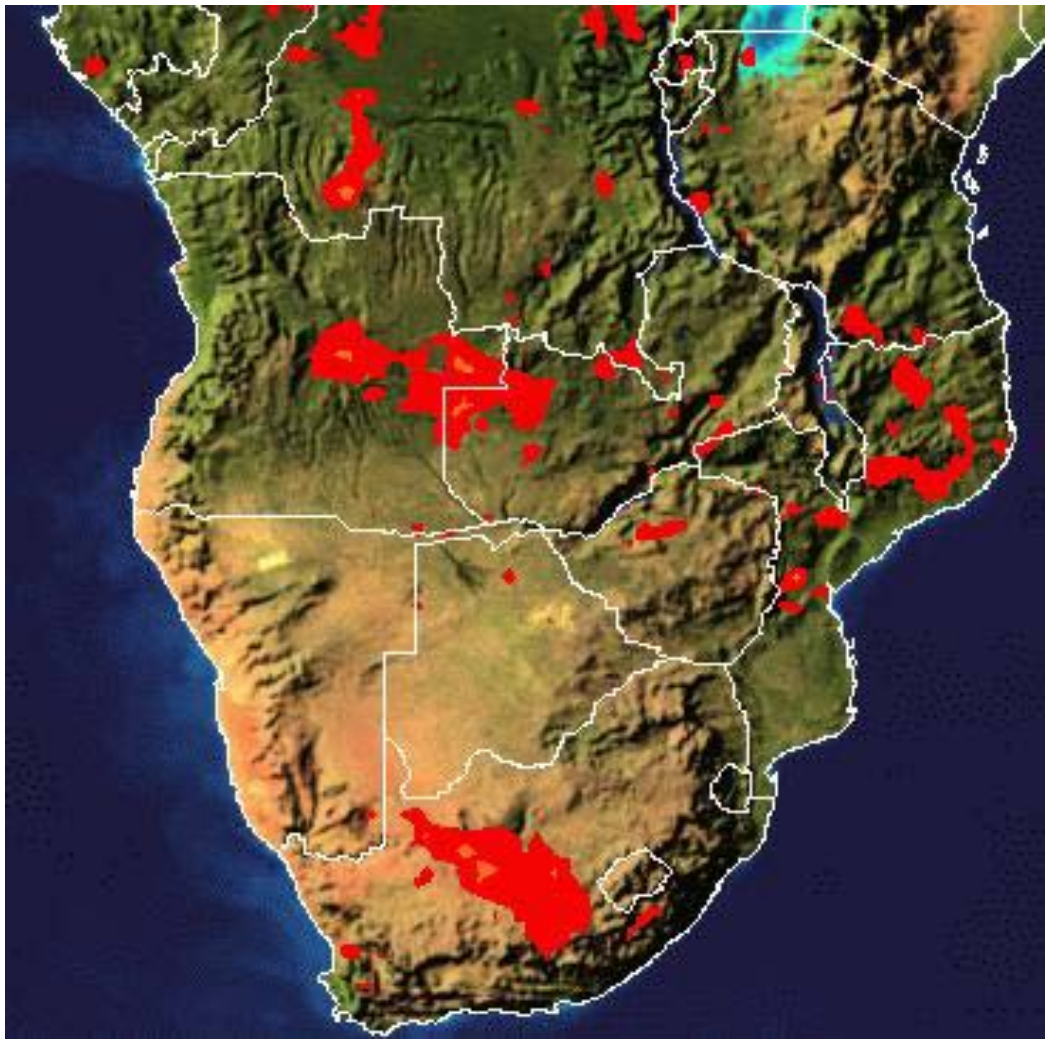


Status as of 3-24-11

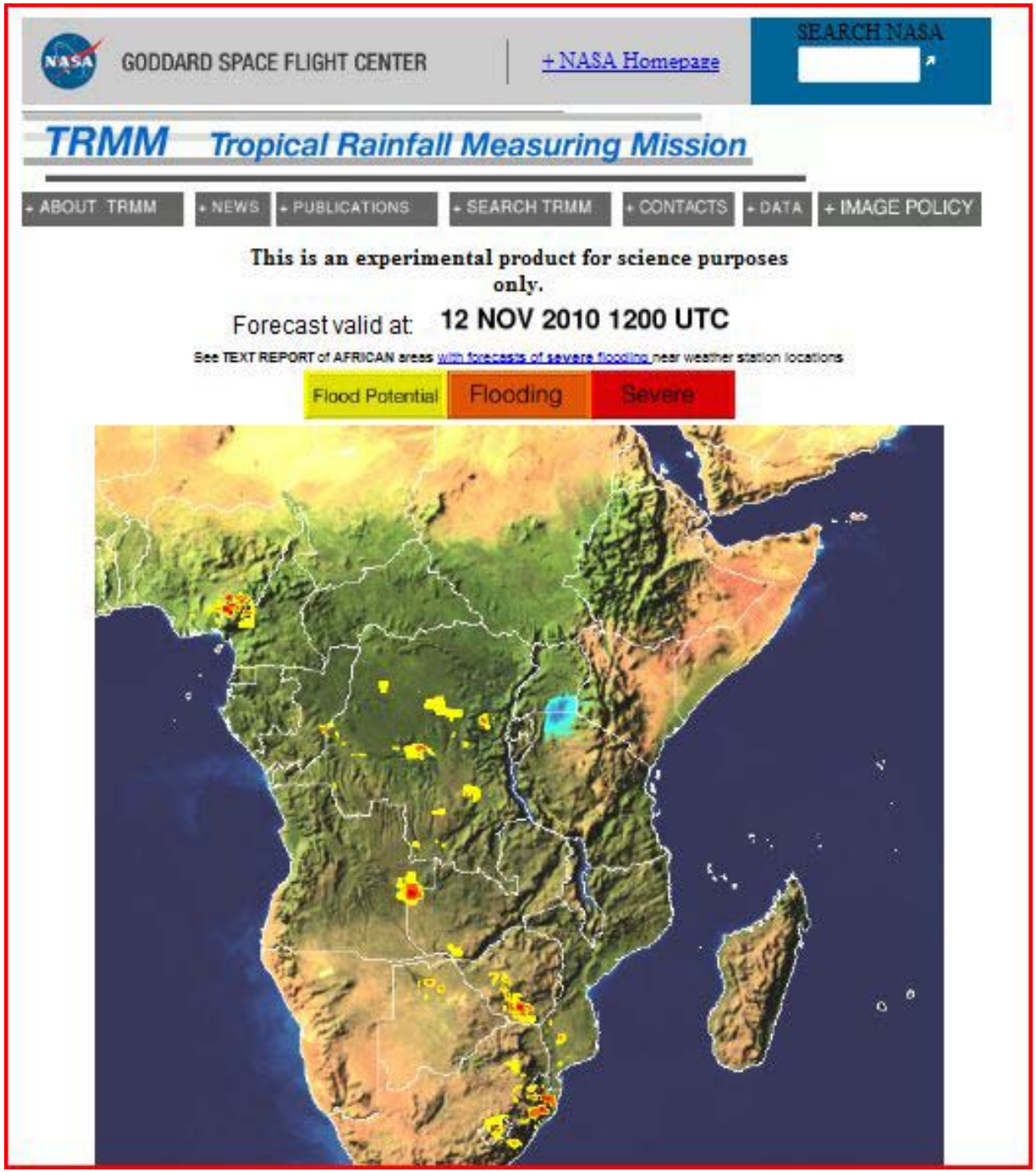
Item	Status
Port Flood Dashboard to Single Virtual Machine in Full Environment Upgrade	Complete
Integrate MODIS Daily Flood Extent Overlay	April 2011
Display Joint Research Center River Watch AMSR-E based 2 sigma River Flood Trigger (triggers will be used later to auto-trigger EO-1)	April 2011 (display portion
Integrate Radarsat Flood Extent Overlay	May 2011
Integrate TRMM based Rainfall Estimate Overlay	June 2011
Rework River Gauge Plot Widget	Sometimes between April-June 2011
Multi-Virtual Machine Load Balancing	Summer/Fall 2011
EO-1 Flood Extent Overlays	TBS

Estimated Rainfall Webpage Based on TRMM Data

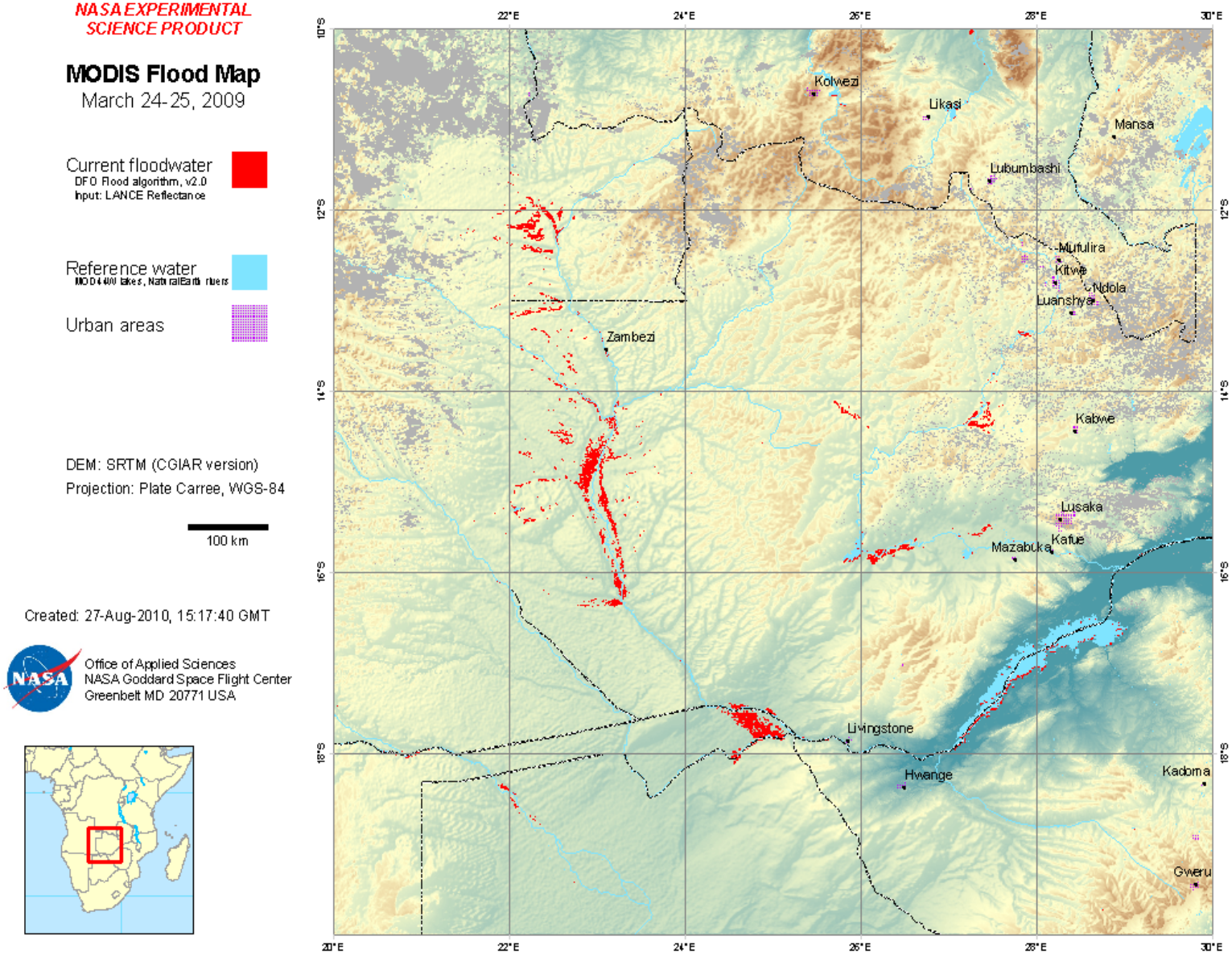
- Experimented with various hydrometeorolgical information for flood forecasting models
  - remote sensing
  - rainfall estimates
  - 24 February 2010
  - NASA Servir Africa
  - red is > 35 mm



Experimental Global TRMM Based Flood Forecast

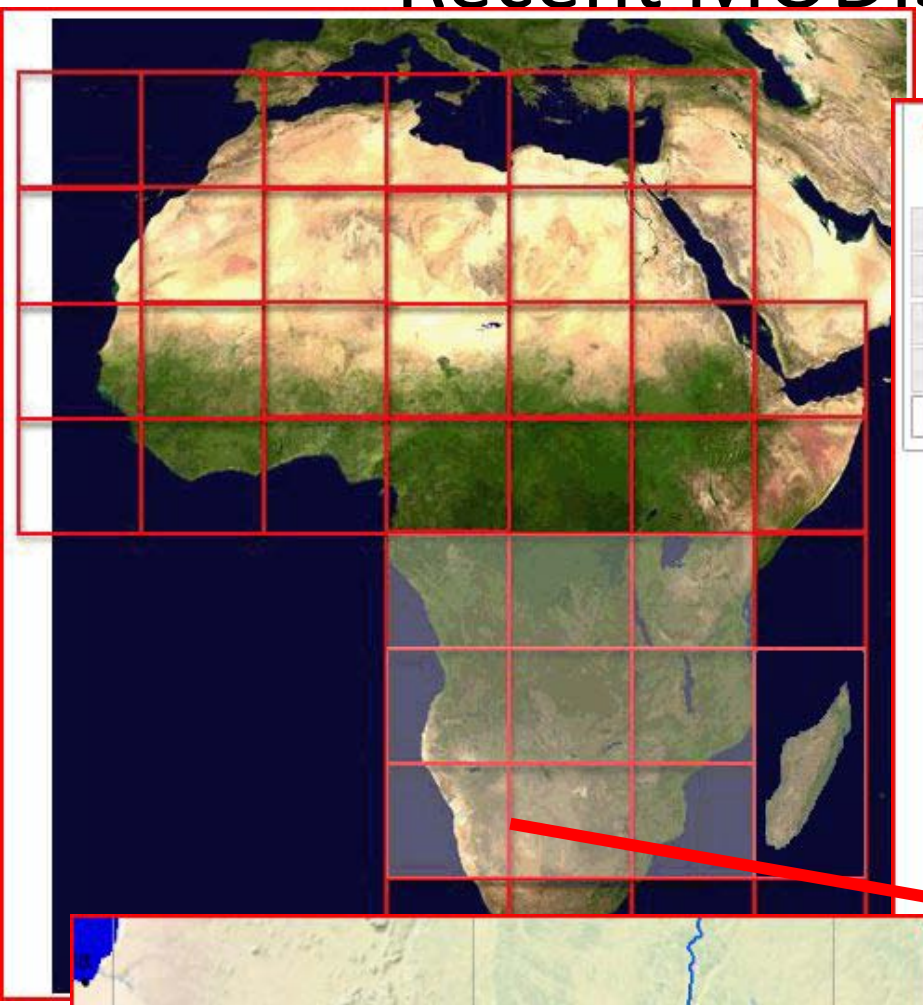


Experimental Flood Extent Data Product Derived from MODIS



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

Recent MODIS Daily Flood Extent



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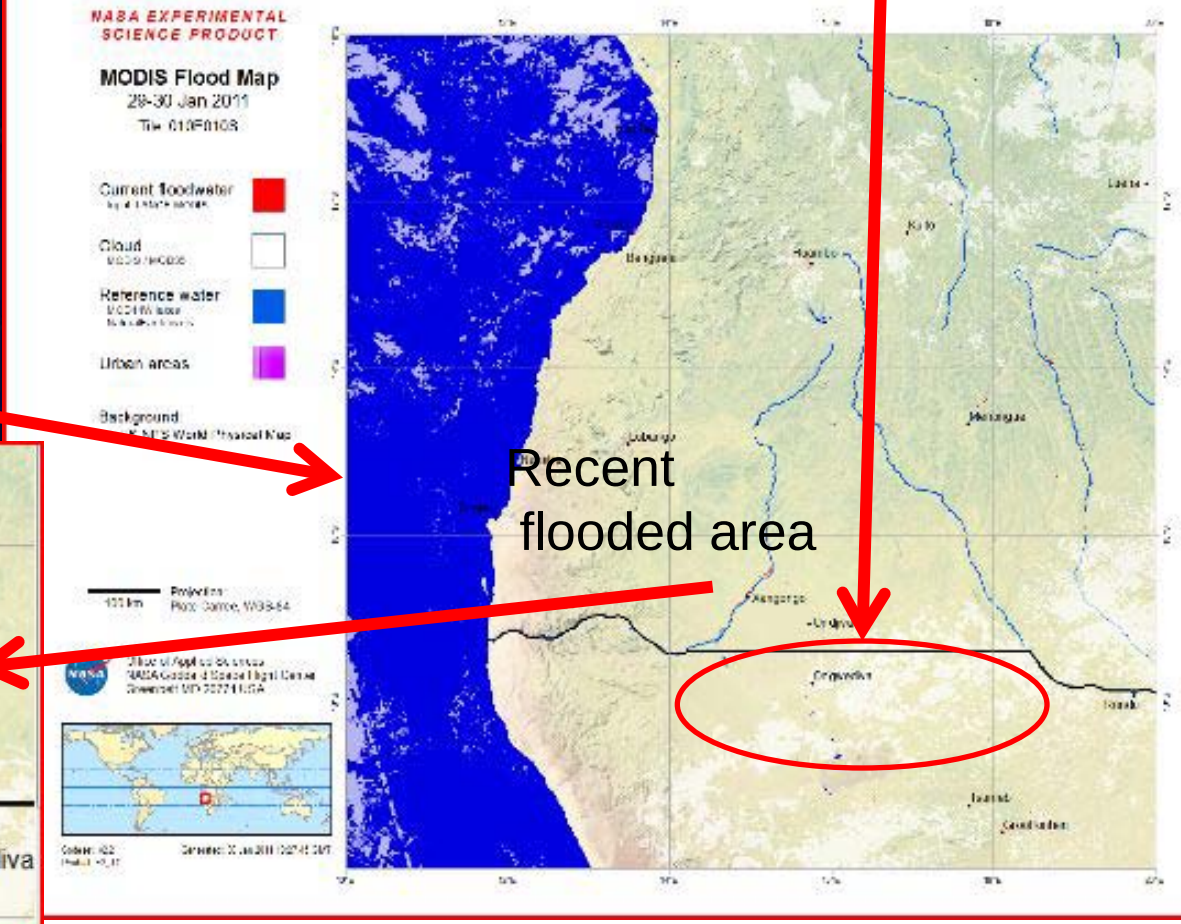
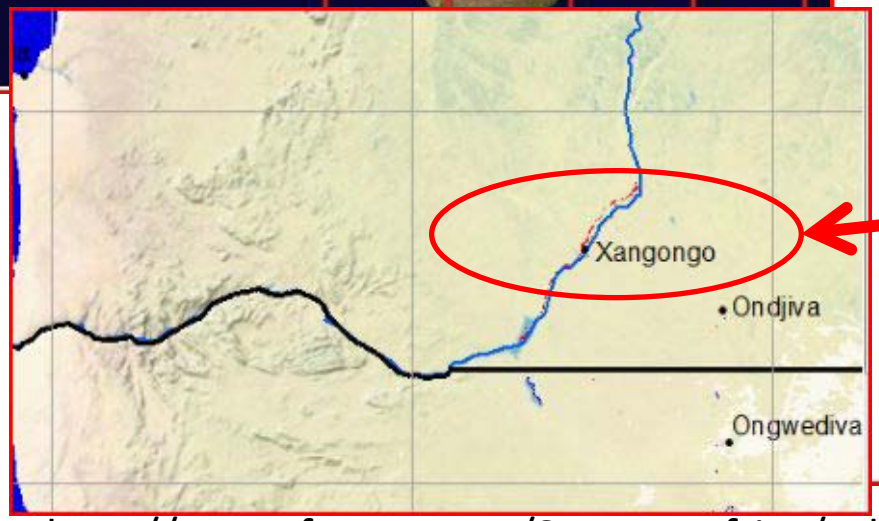
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Area toured on January 2011 trip



Recent flooded area

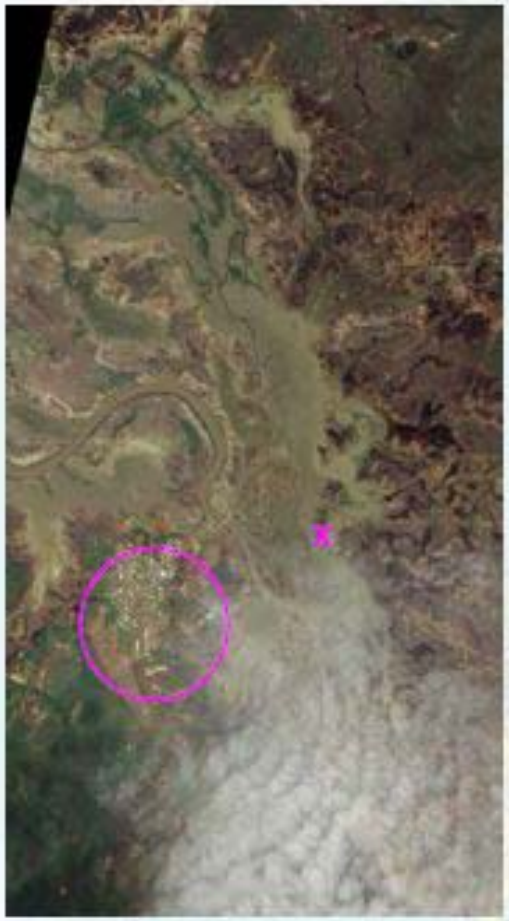


http://oas.gsfc.nasa.gov/SERVIR_Africa/calendar.html?latlong=010E010S

Sample of Planned Addition of Higher Resolution Flood Product Overlay Using EO-1

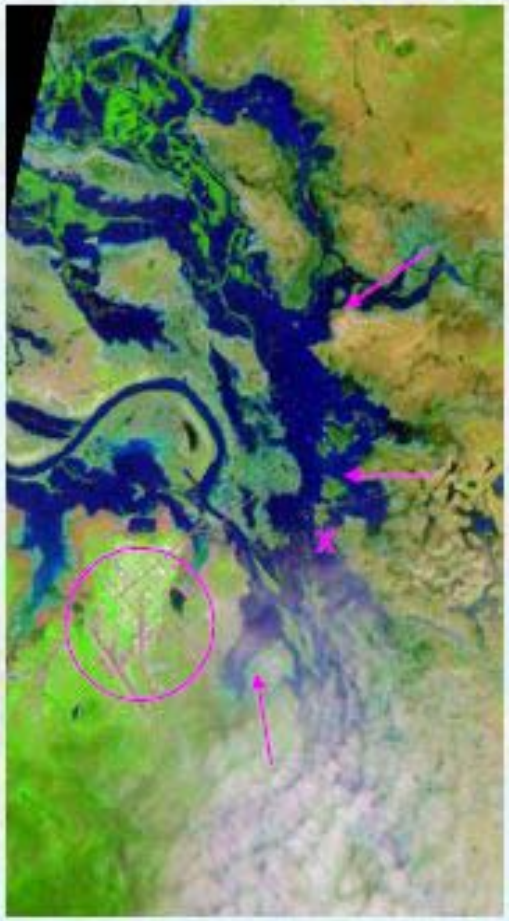
EO-1 Land Cover Land Use Change

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

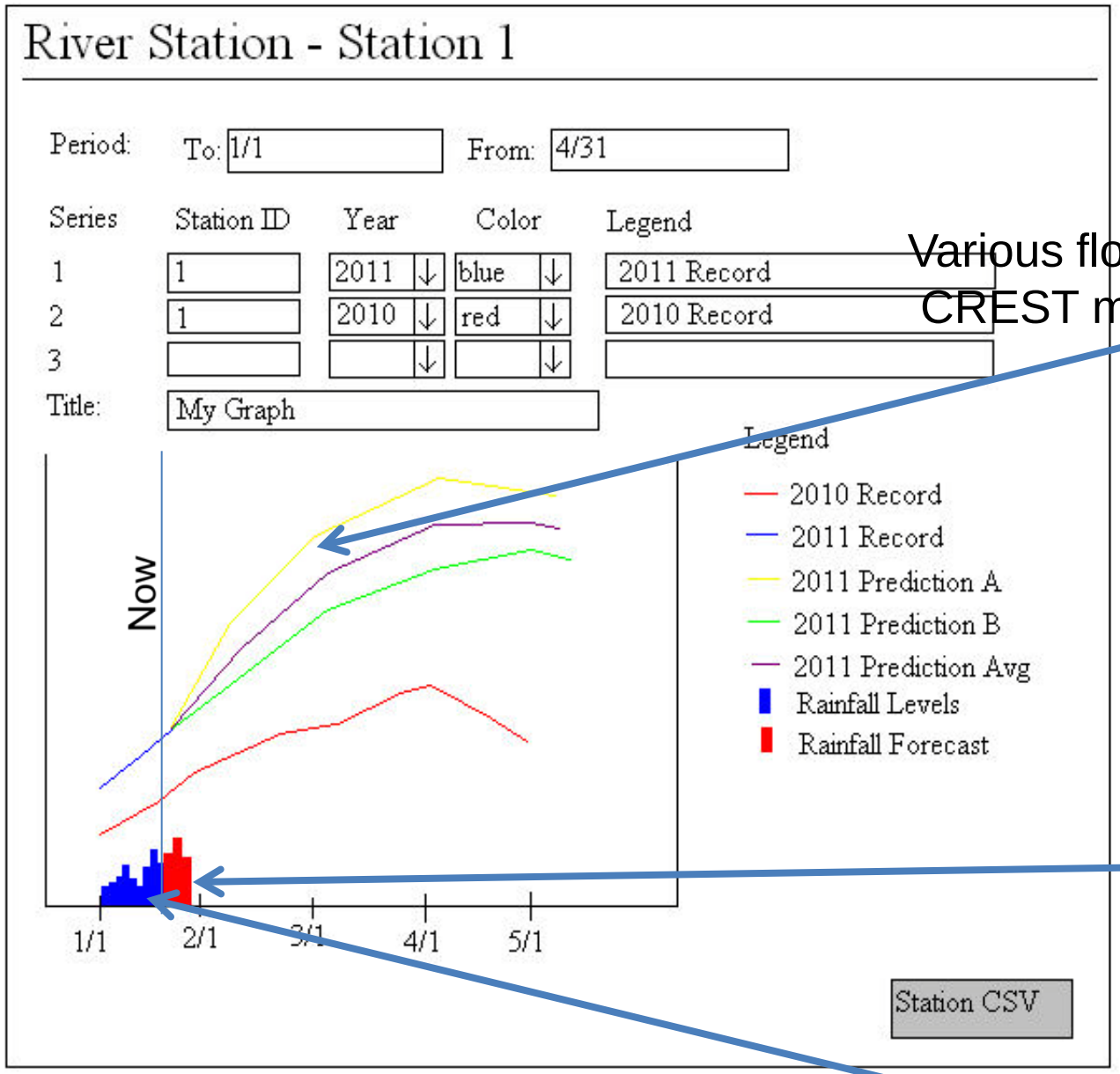
This false-color image combines infrared and visible light, which makes the extent of the flooding far more obvious. Water is dark blue, while plant-covered land is green, and bare earth is rosy tan.

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/)

Mock up of Revised River Gauge Plot Page

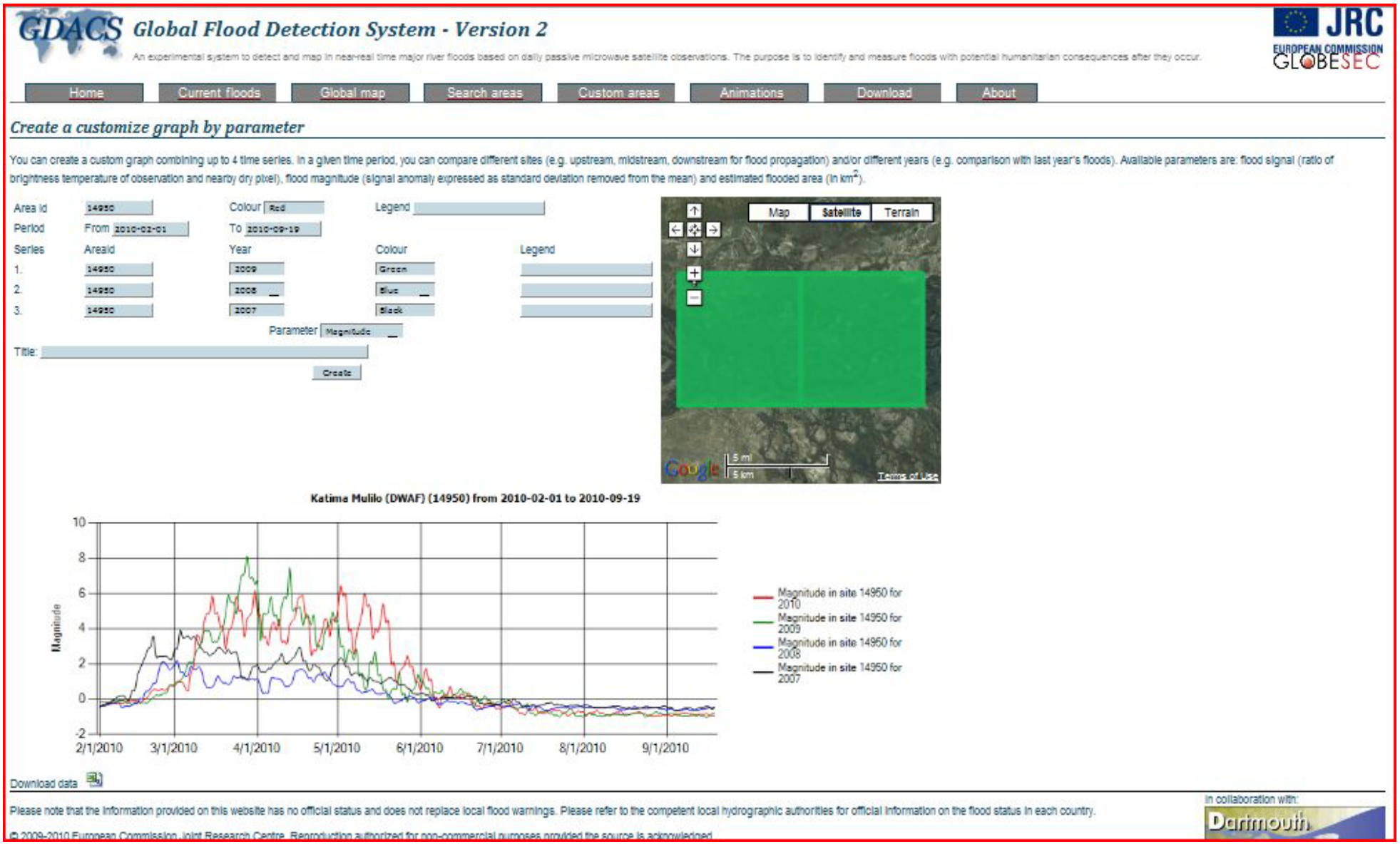


Various flood models such as CREST model (Univ. of Oklahoma)

Rainfall prediction From GEOS-5

TRMM based daily rainfall estimates

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



Sample Alert During Pilot

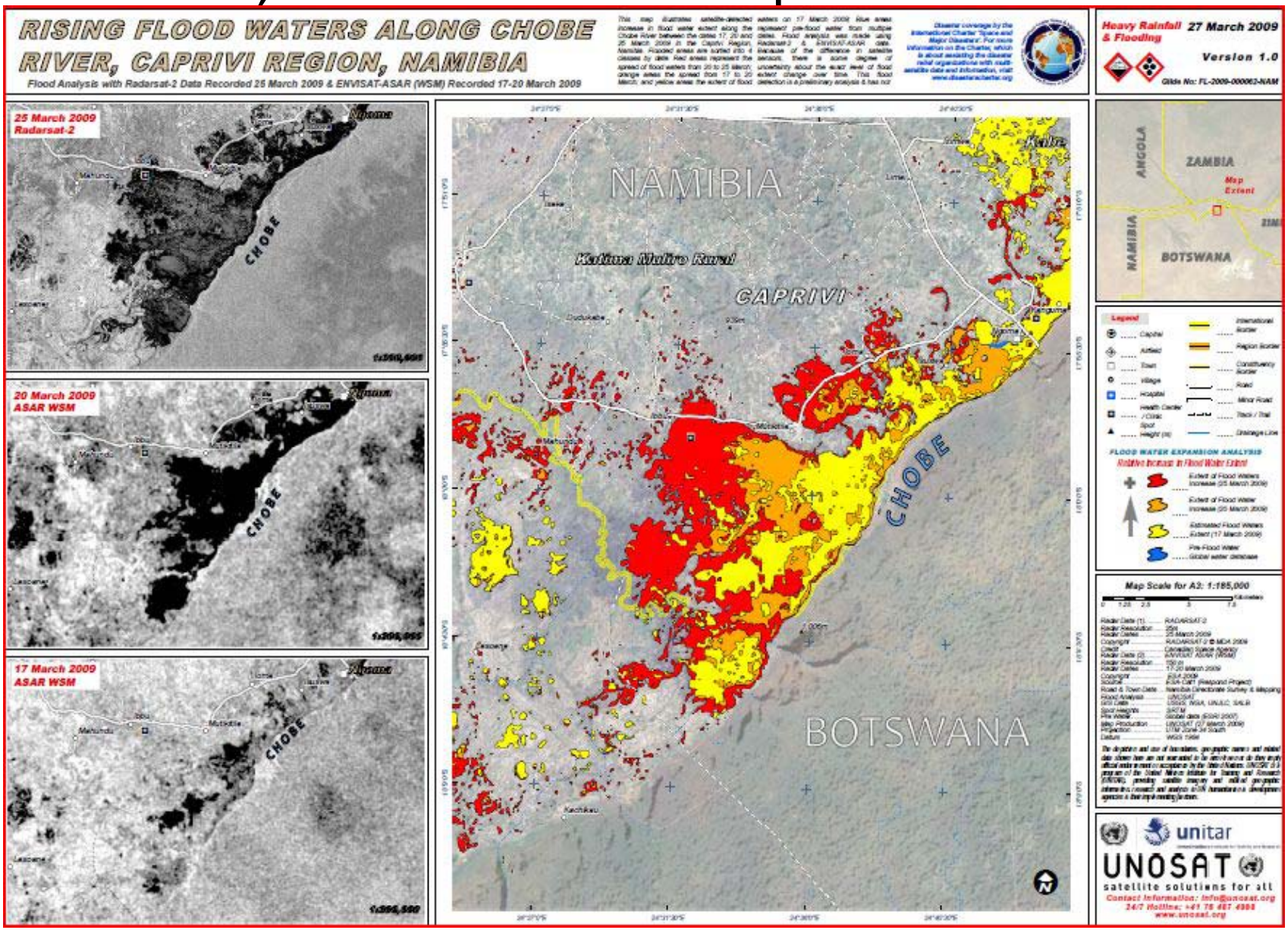
Namibia daily flood bulletin 03 March 2010:

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

Conclusion

- Combining SensorWebs with an elastic computation cloud enables surge capacity for disasters by enabling parallel processing of various algorithms and other processes within the cloud
- Elastic cloud provides work space for user to customize their experience instead of preset outputs
- Elastic cloud allows capacity to expand and contract server capacity to fit current user load