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

(Session 12F Working Group: **Cloud Computing for Spacecraft Operations)**

Daniel Mandl - NASA/GSFC 3/2/11

SensorWeb High Level Architecture

floods, fires, volcanoes etc

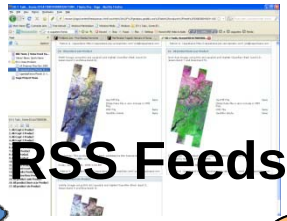
Data Processing Node

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

EO-1 Satellite

Web Feature Service (WFS)

In-situ Sensor Data Node

UAV Sensor Data Node

Satellite sensor data product

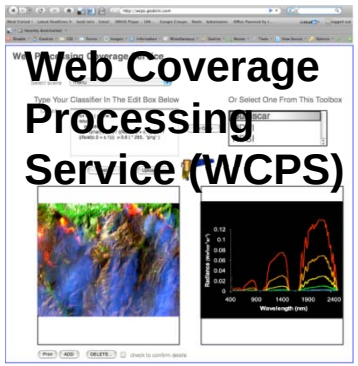
Sensor Planning Service (SPS)

Sensor Alert Service (SAS)

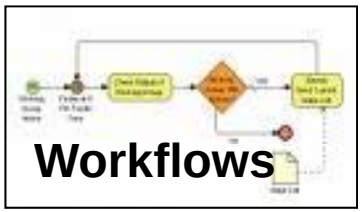
Sensor Observation Service (SOS)

Satellite Data Node

GeoBPMS

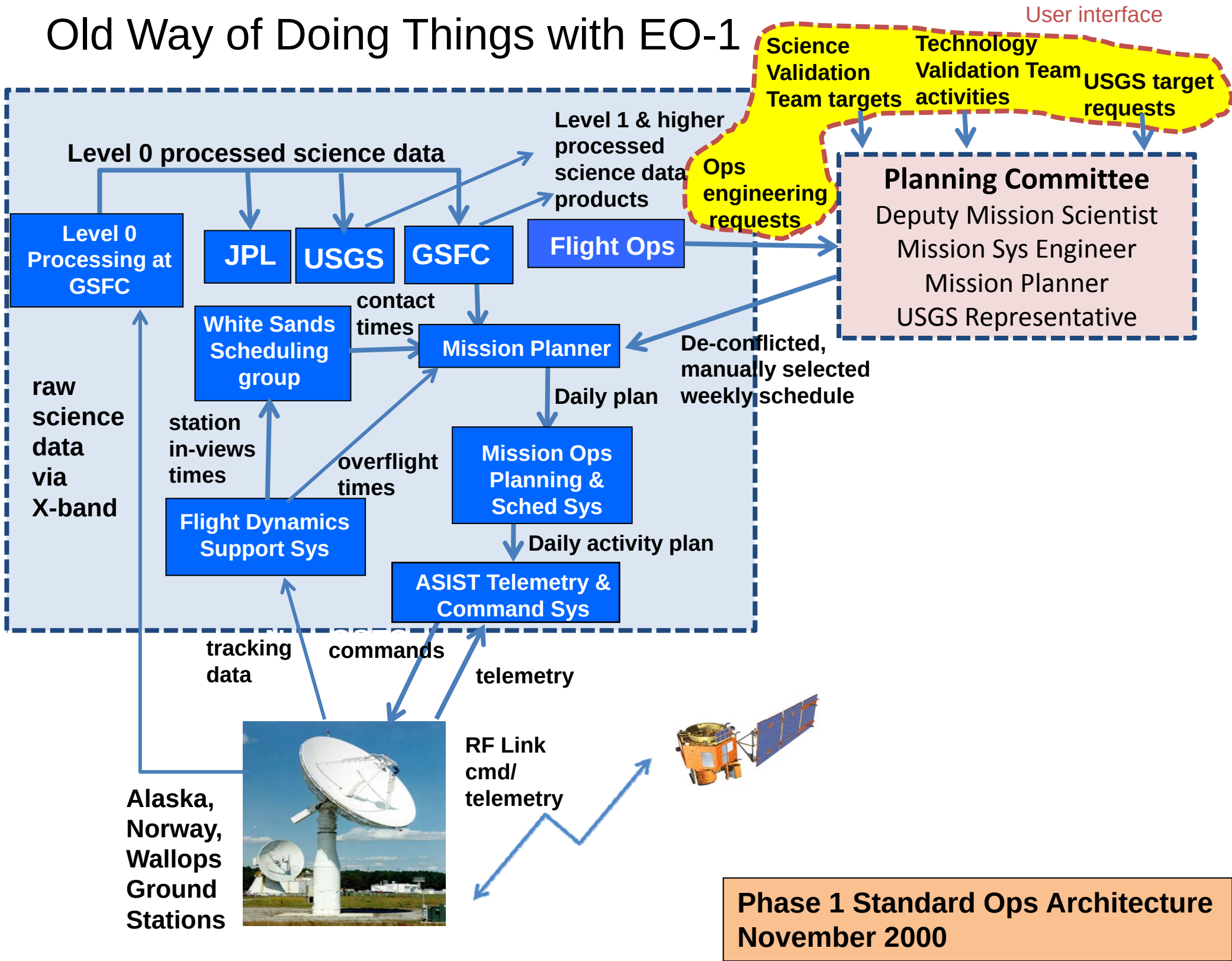


Web Coverage Processing Service (WCPS)



Workflows

Old Way of Doing Things with EO-1



Phase 1 Standard Ops Architecture
November 2000

Step 1 Improvement for EO-1

User interface

Science Validation Team targets
Technology Validation Team activities
USGS target requests
JPL users
Ops engineering requests

Planning Committee
Deputy Mission Scientist
Mission Sys Engineer
Mission Planner
USGS Representative
JPL Representation

Level 0 processed science data

Level 1 & higher processed science data products

Level 0 Processing at GSFC

JPL

USGS

GSFC

Flight Ops

contact times

targets

White Sands Scheduling group

Mission Planner

De-conflicted, manually selected weekly schedule (backup approach & maneuvers)

raw science data via X-band

station in-views times

overflight times

Daily plan

Mission Ops Planning & Sched Sys

Flight Dynamics Support Sys

Daily activity plan goals

ASIST Telemetry & Command Sys

ASPEN Ground Planner with Web Interface

De-conflicted, manually generated replacement record file

tracking data

Commands, goals

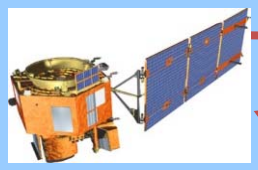
telemetry

RF Link cmd, goals/ telemetry

Alaska, Norway, Wallops Ground Stations

Onboard EO-1

goals



Science Processing

science data

cmds

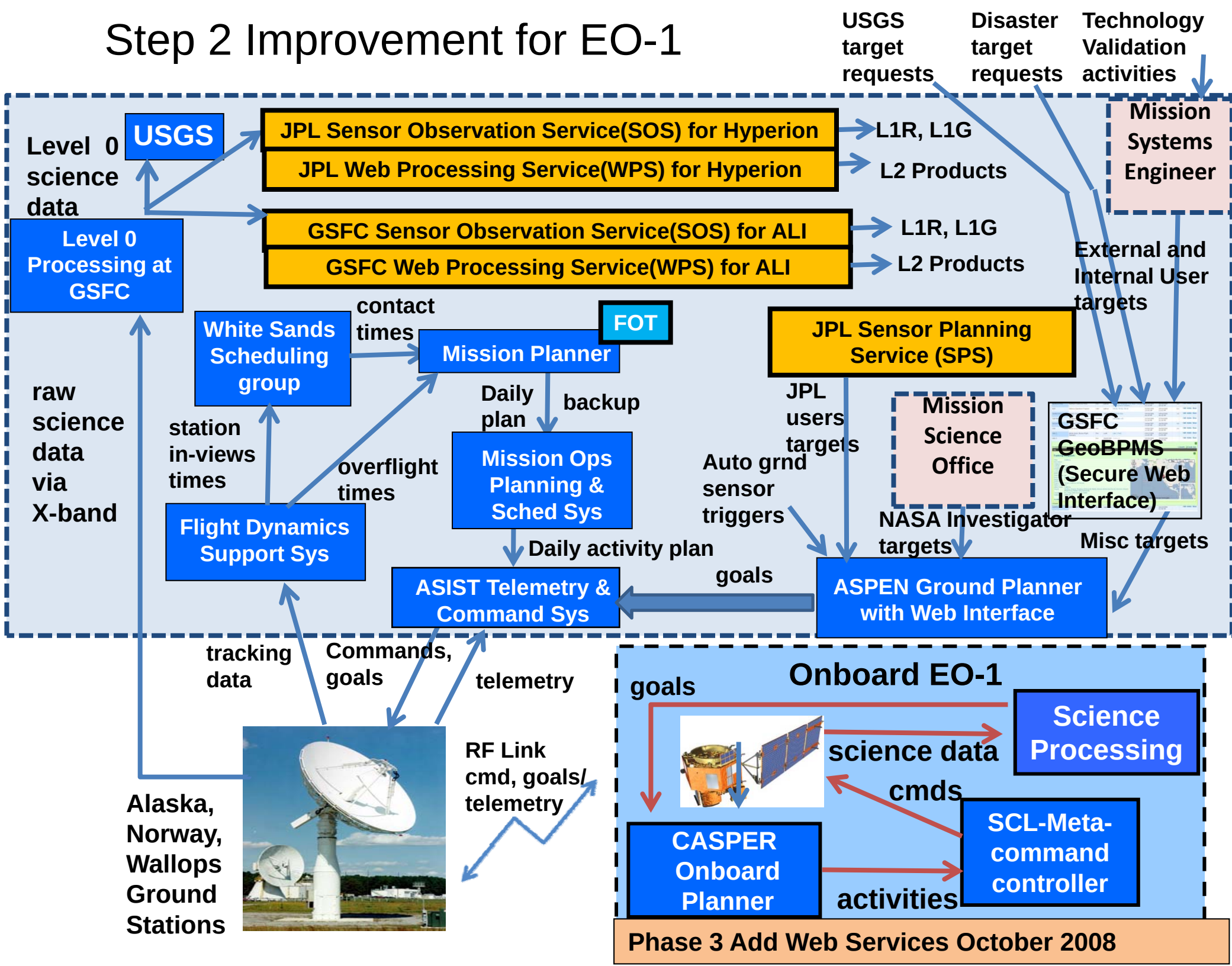
CASPER Onboard Planner

SCL-Meta-command controller

activities

Phase 2 Add Onboard Autonomy October 2003

Step 2 Improvement for EO-1



Open Science Data Cloud

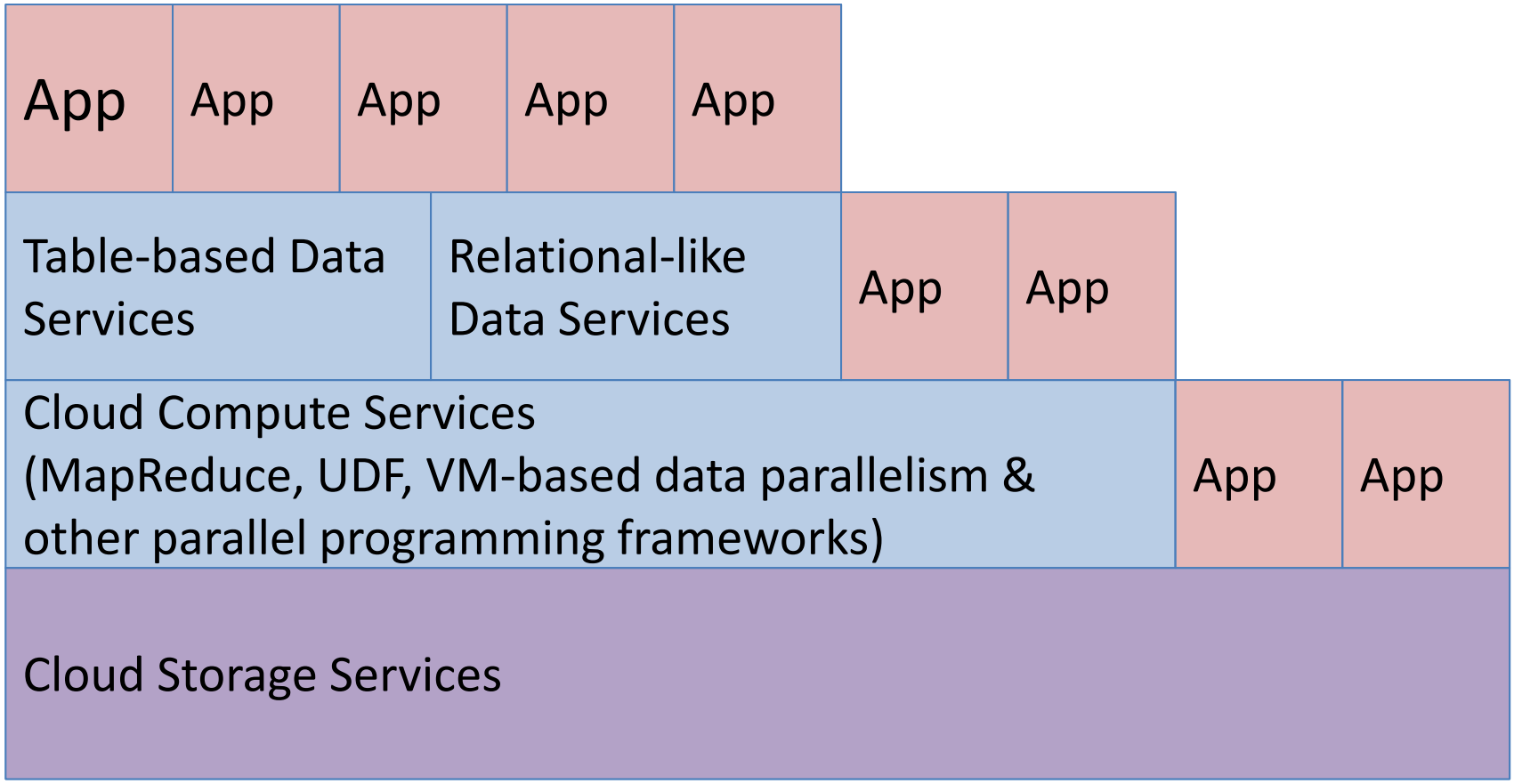
Biological data (Bionimbus)

Astronomical data

Earth science data (& disaster relief)

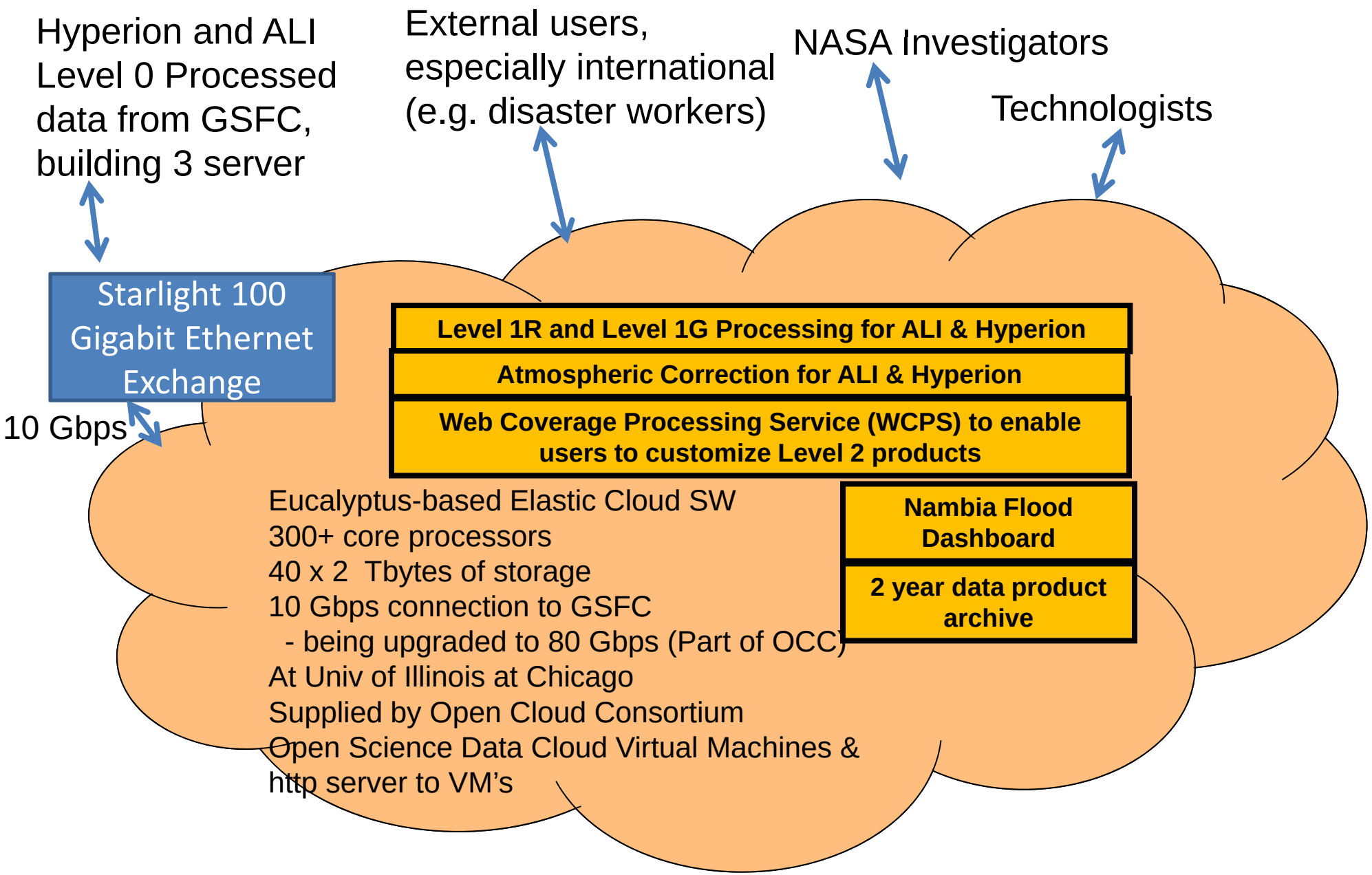
NSF-PIRE OSDC Data Challenge

Focus of OCC Large Data Cloud Working Group



- Developing APIs for this framework.

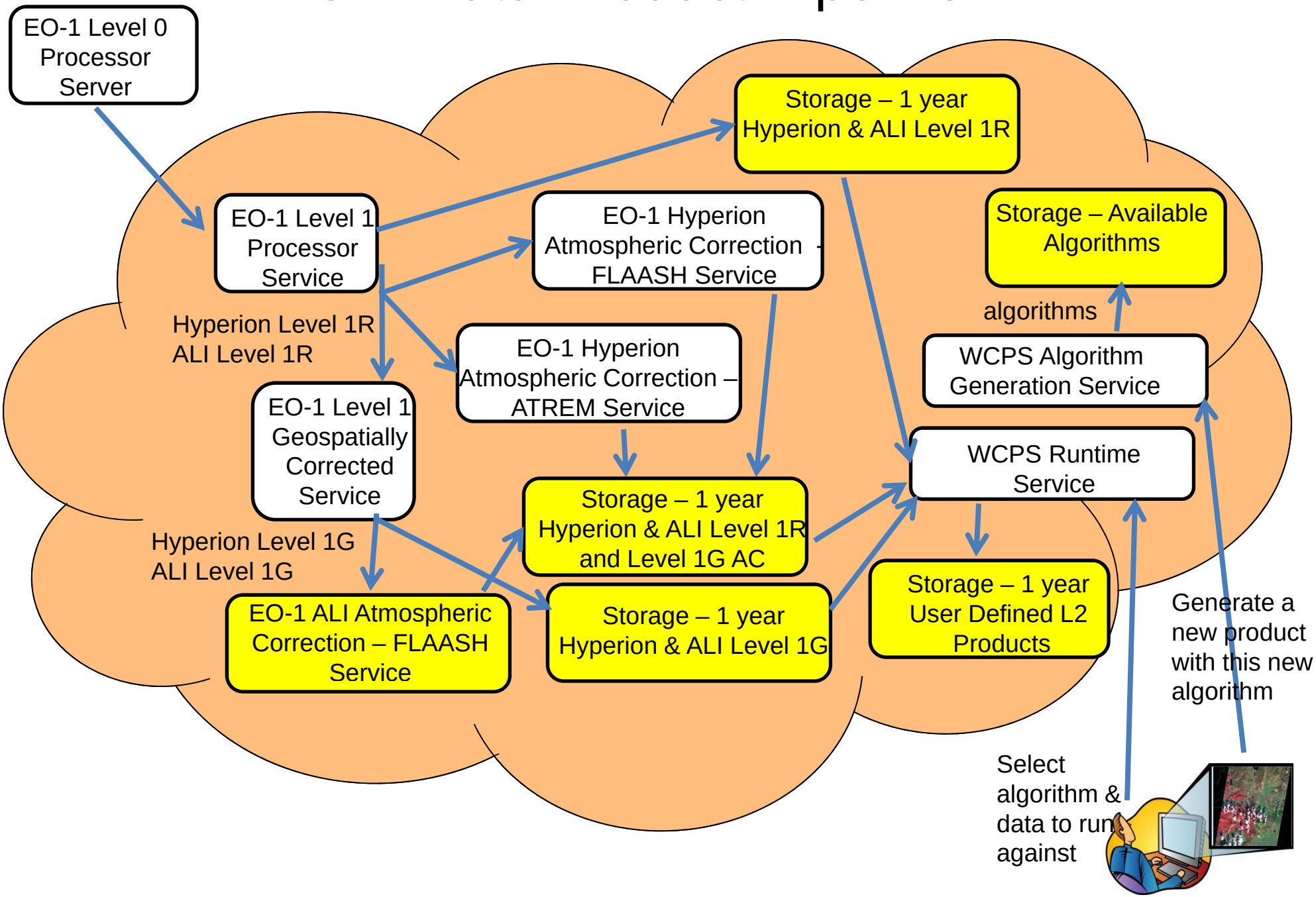
Step 3 Improvement for EO-1 - Overview



OCC = Open Cloud Consortium

Phase 3 Add Elastic Cloud Ongoing Feb 2011

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



Phase 3 Add Elastic Cloud Ongoing Feb 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)

6 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

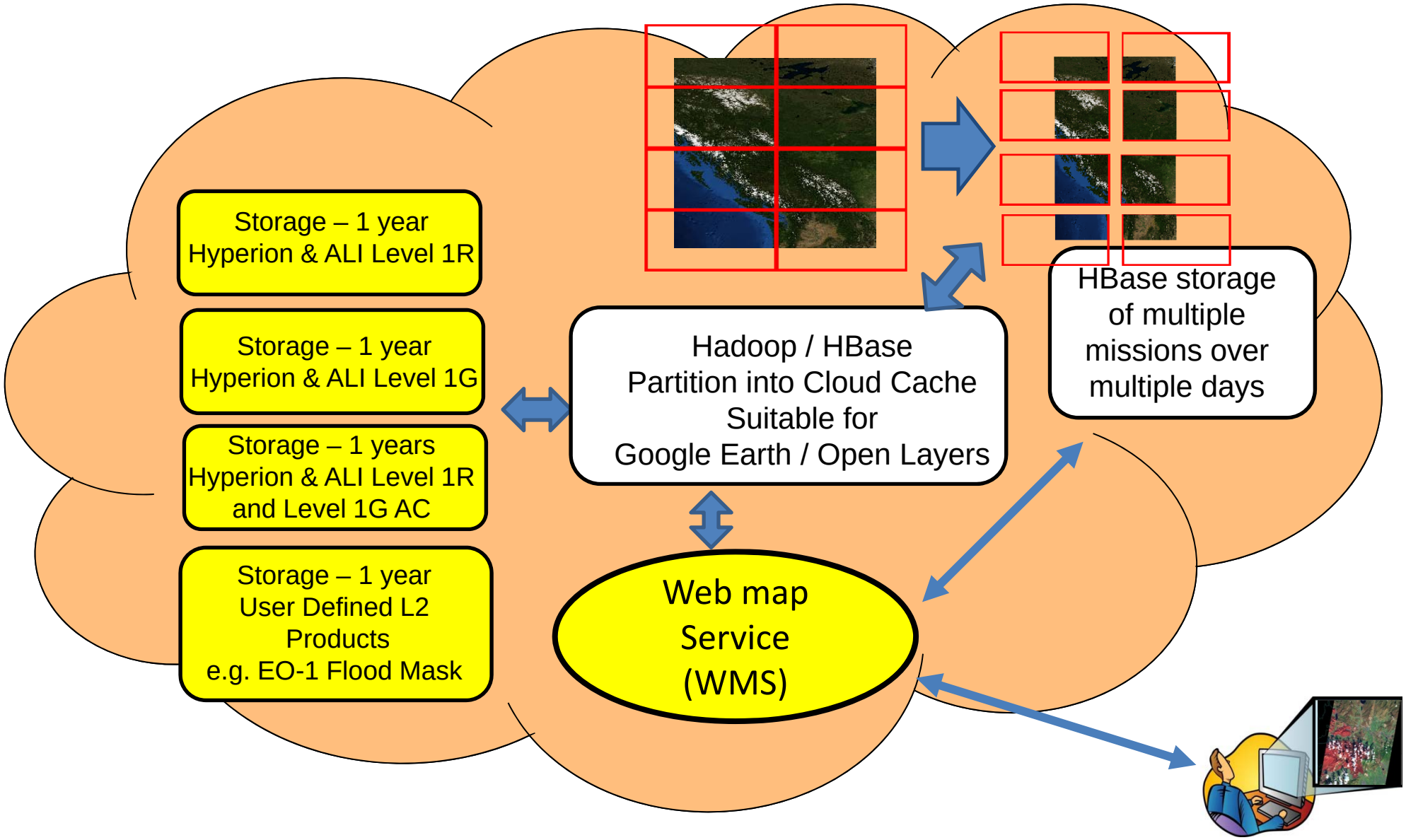
Storage – 1 year User Defined L2 Products e.g. EO-1 Flood Mask

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

http server

Phase 3 Add Elastic Cloud Ongoing Feb 2011

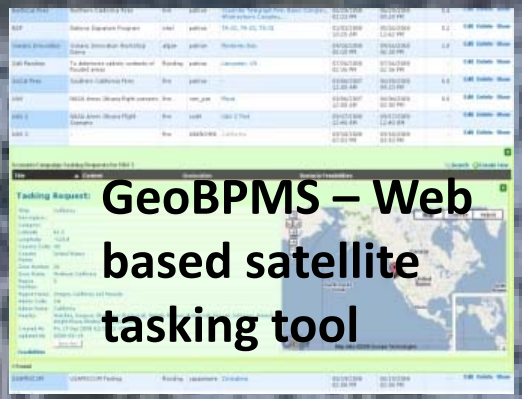
Detail of Processing Image Data in OCC Open Science Data Cloud



Phase 3 Add Elastic Cloud Ongoing Feb 2011

Top Level Flood SensorWeb Concept

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



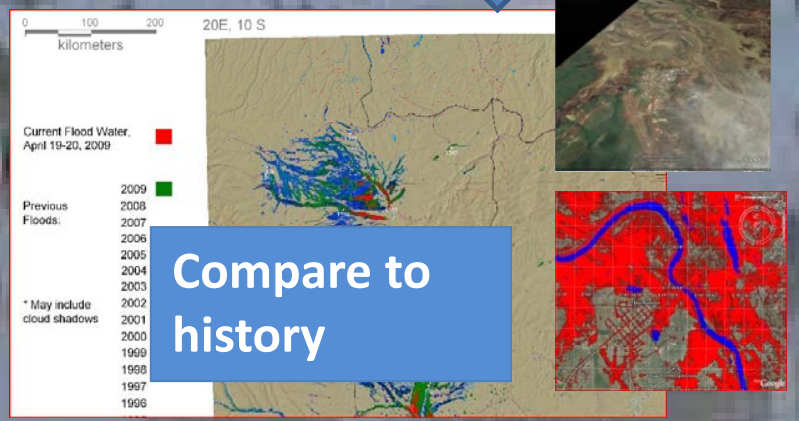
Customized plan of needed satellite images

SPS

SPS

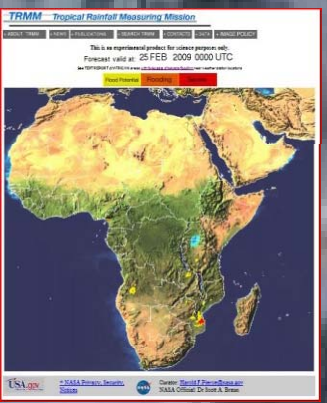
SPS

Flood conditions

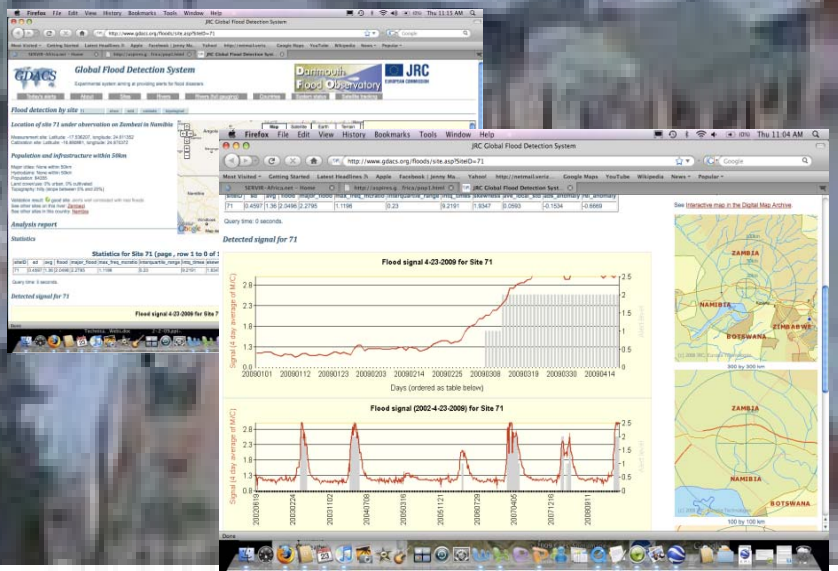


Compare to history

Flood alerts to users



Ground flood measurements to validate model



Improved flood prediction model

*SPS = Sensor Planning Service

Portion of 2011 Namibian Flood SensorWeb Early Warning Pilot

Angola

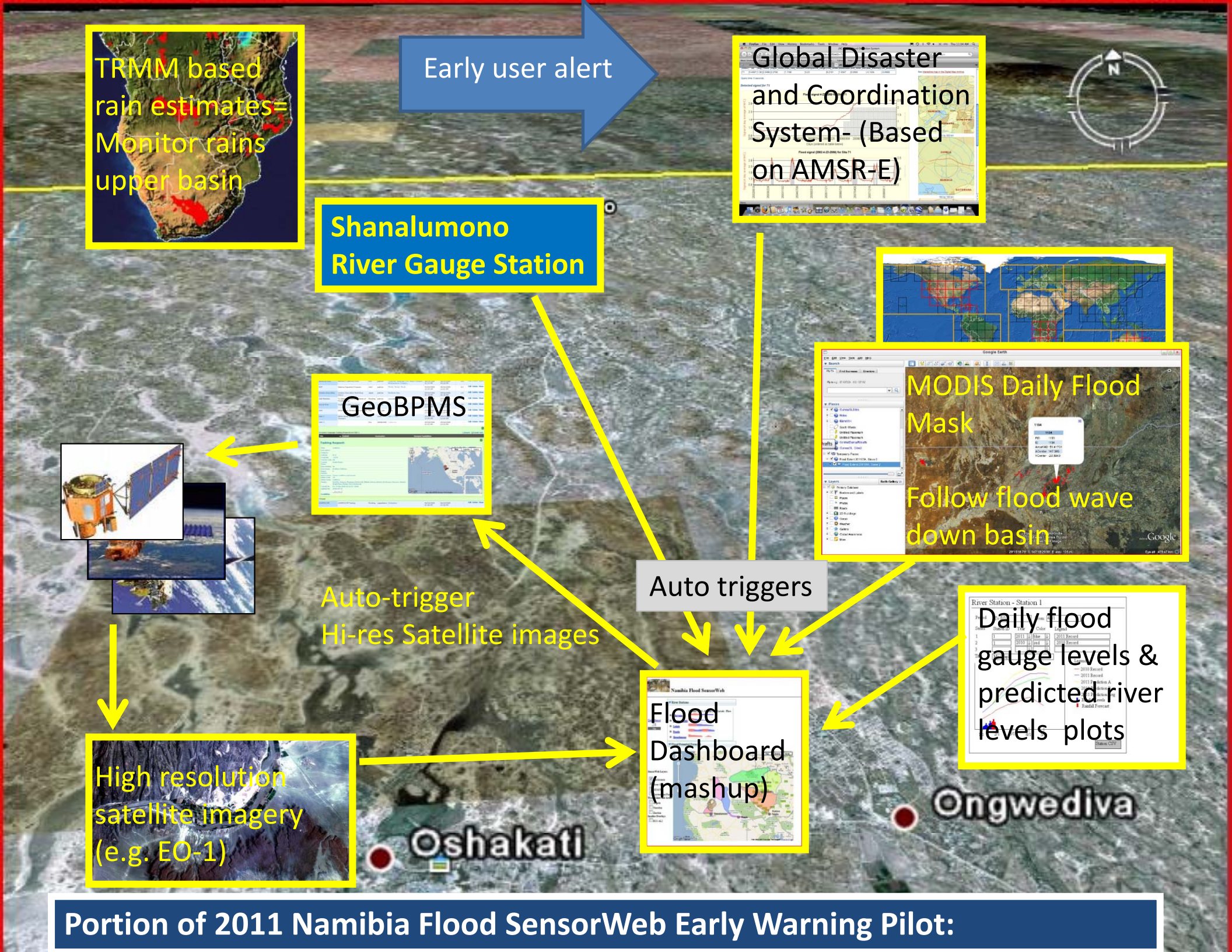
Namibia

Shanalumono River Gauge Station

Water flow from North through basin

Oshakati

Ongwediva

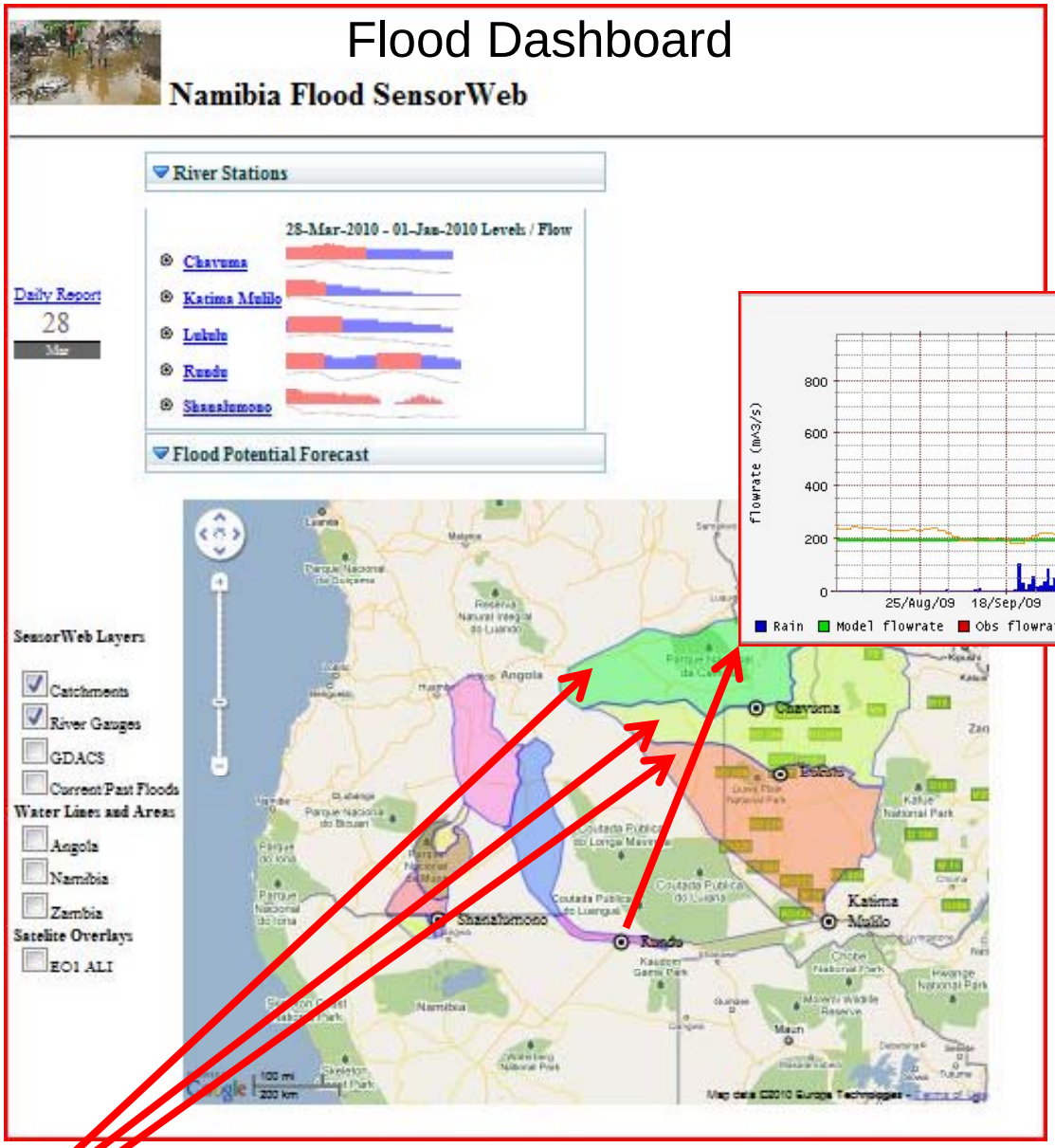


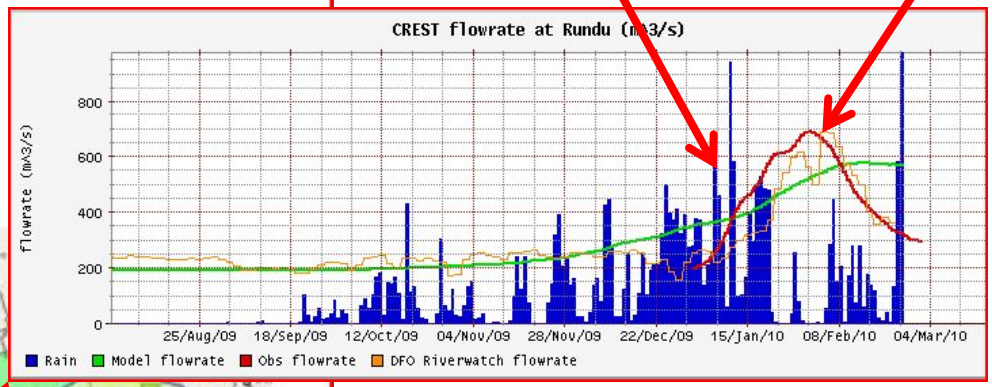
Portion of 2011 Namibia Flood SensorWeb Early Warning Pilot:

Experimental Namibian Flood SensorWeb Webpage

Note blue bars indicating a surge of rainfall upstream

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





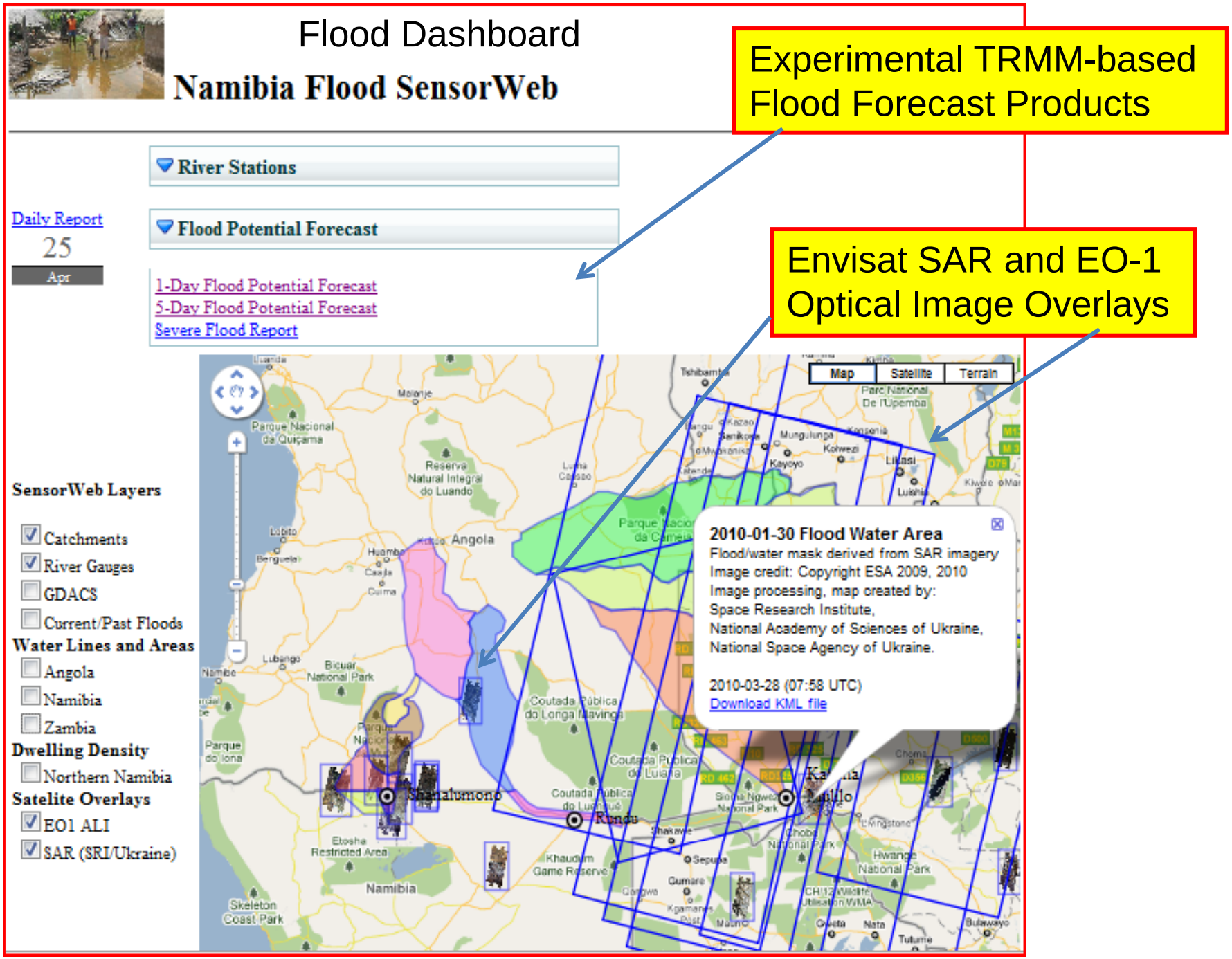
Zambezi basin consisting of upper, middle and lower catchments

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

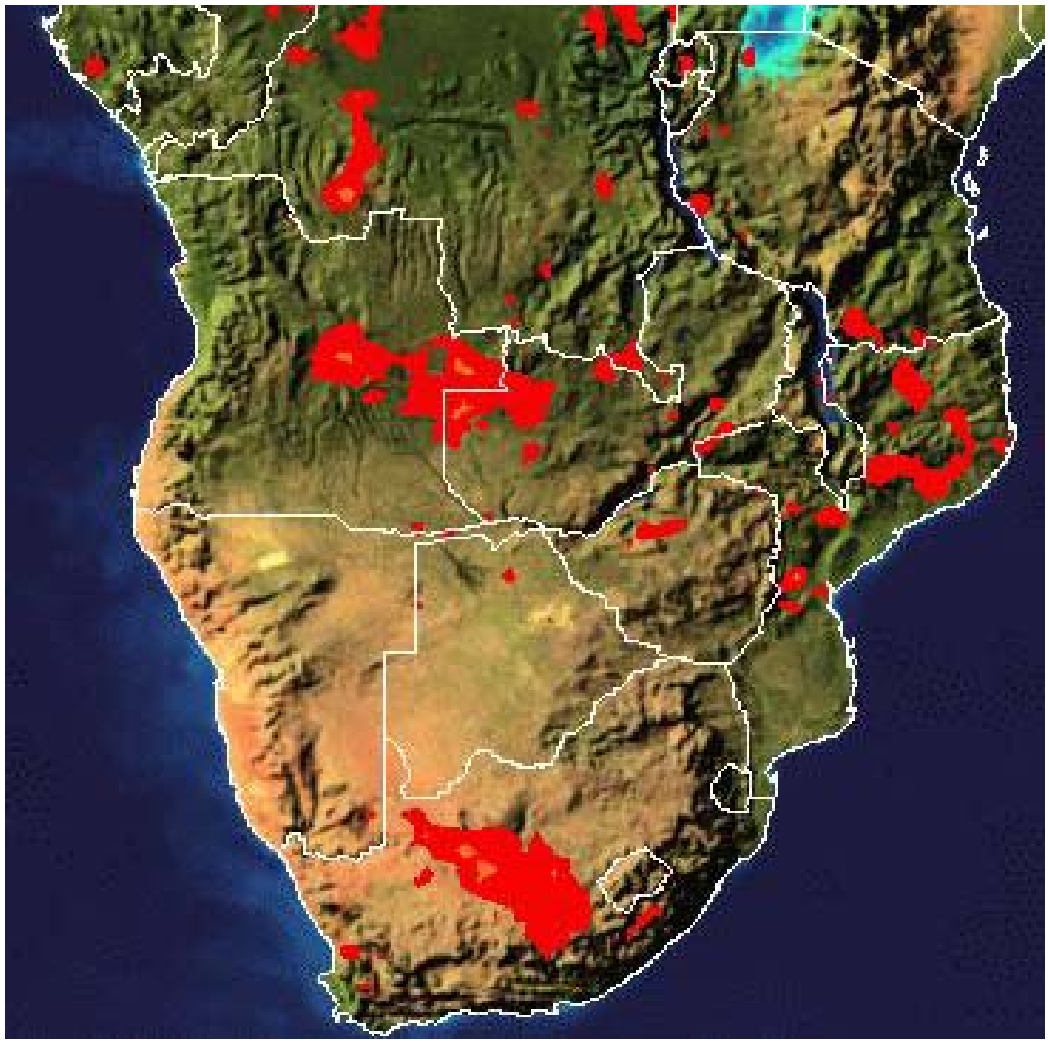
Shanalumono River Gauge Station and Part of Community Prone to Flooding Downstream

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

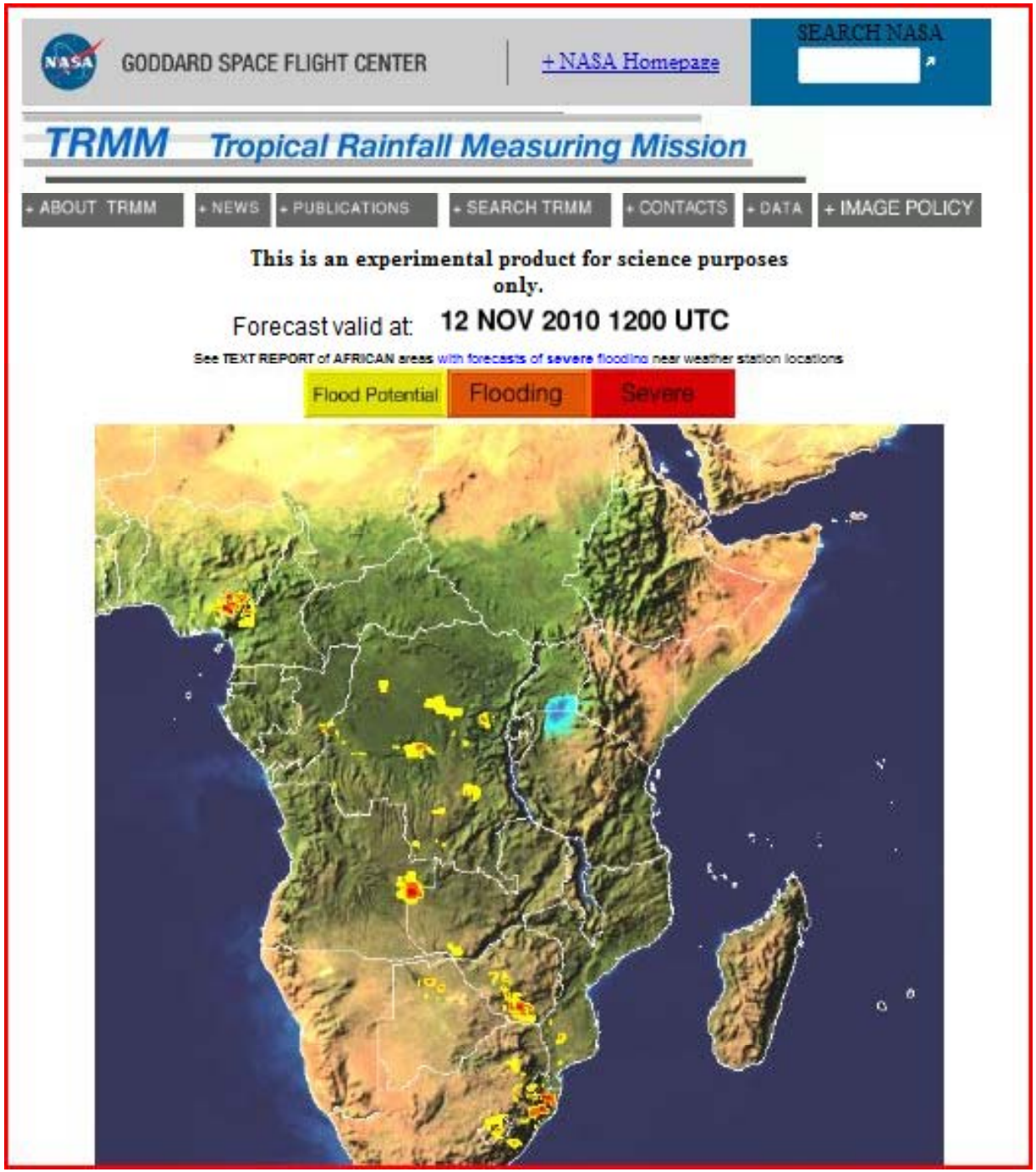


Estimated Rainfall Webpage Based on TRMM Data

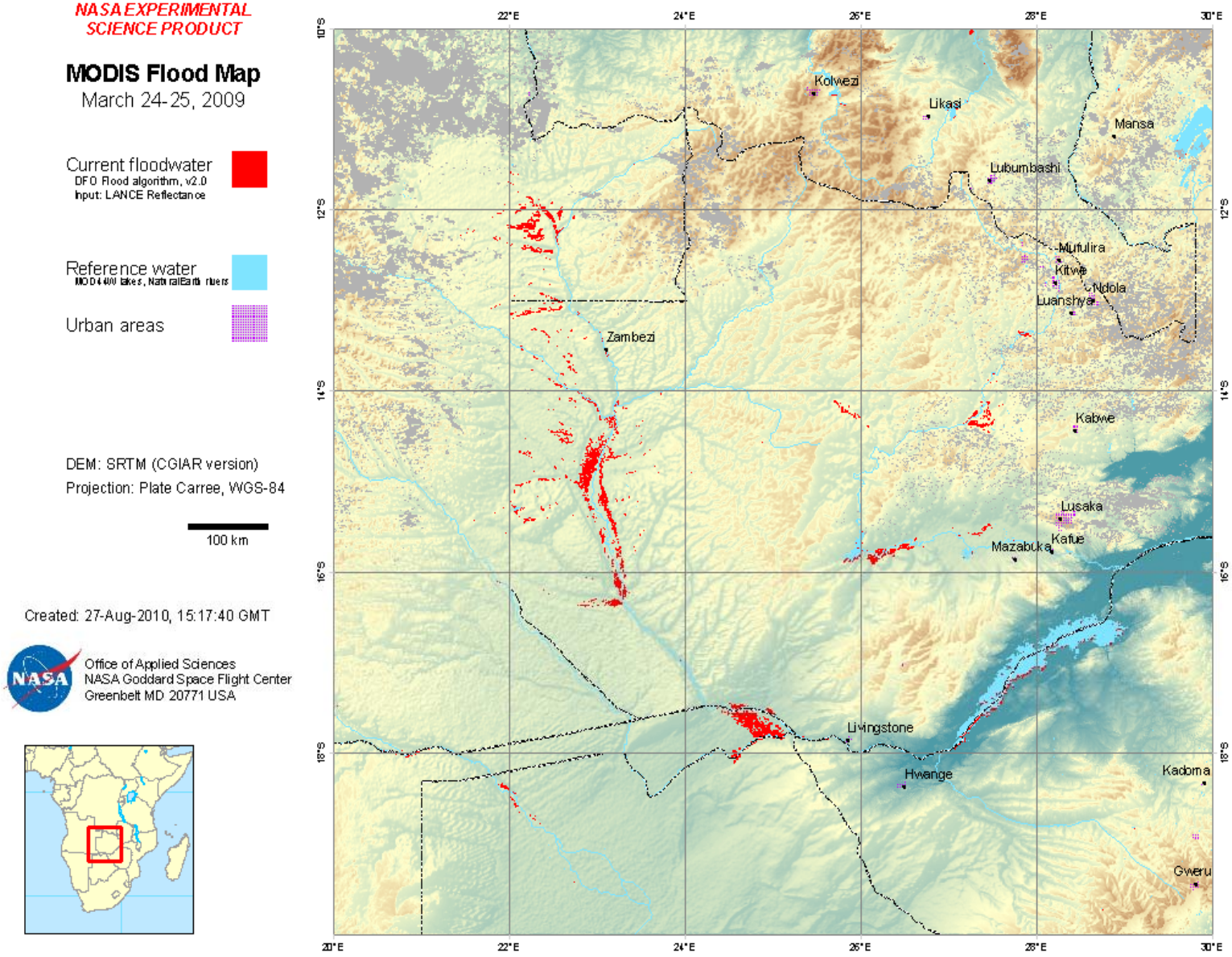
- Experimented with various hydrometeorolgical information for flood forecasting models
  - remote sensing
  - rainfall estimates
  - 24 February 2010
  - NASA Servir Africa
  - red is > 35 mm



Experimental Global TRMM Based Flood Forecast

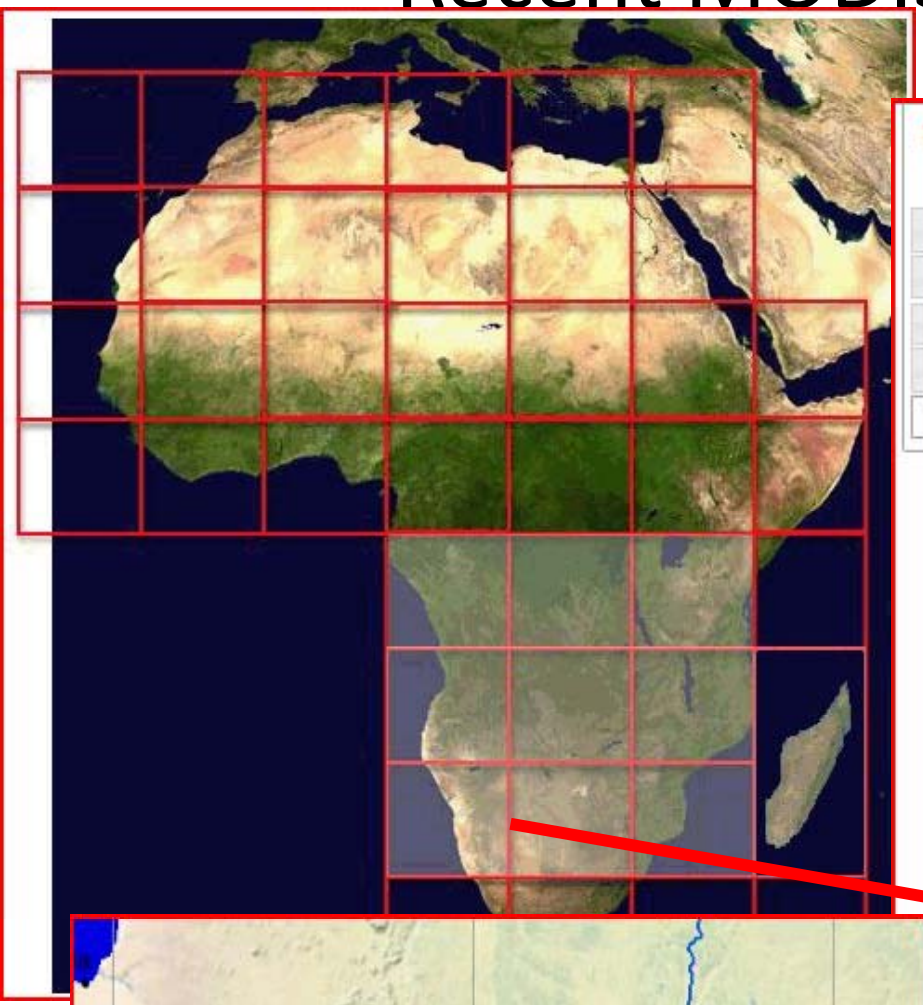


Experimental Flood Extent Data Product Derived from MODIS



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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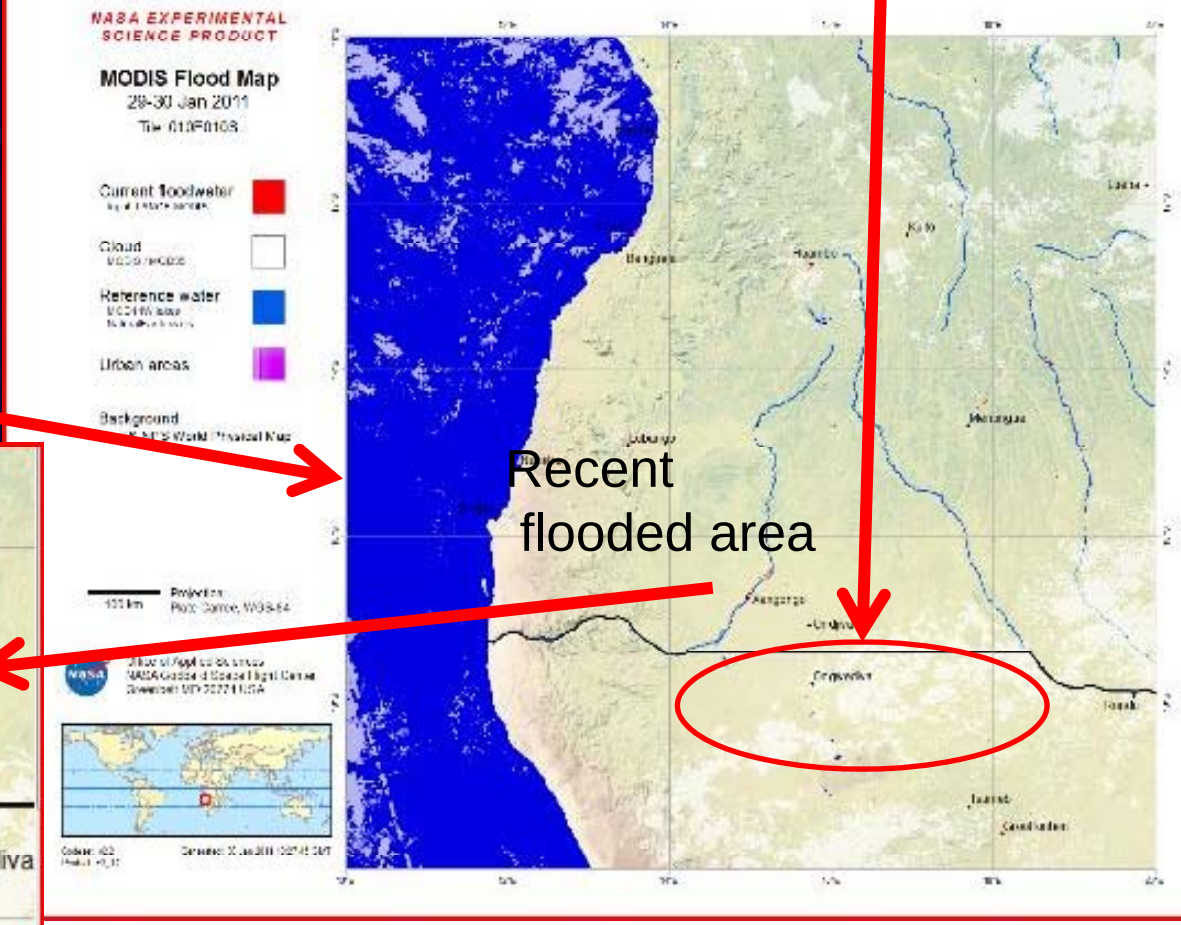
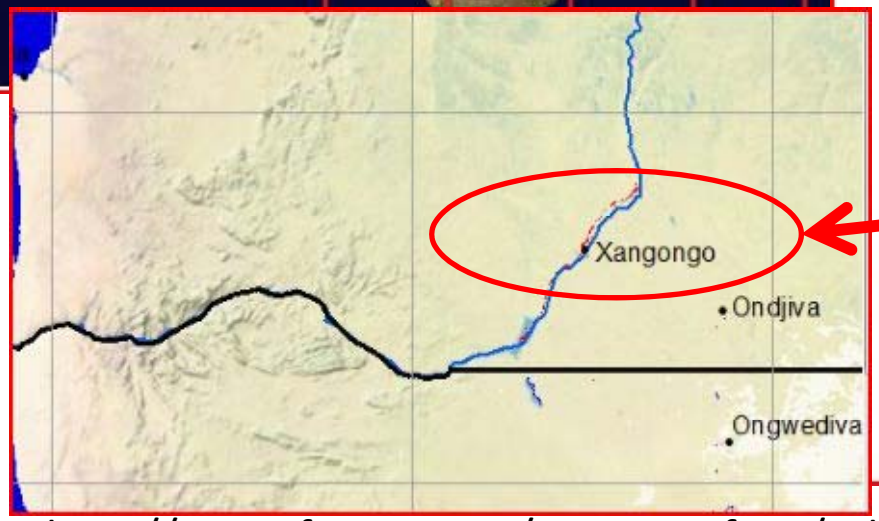
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

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

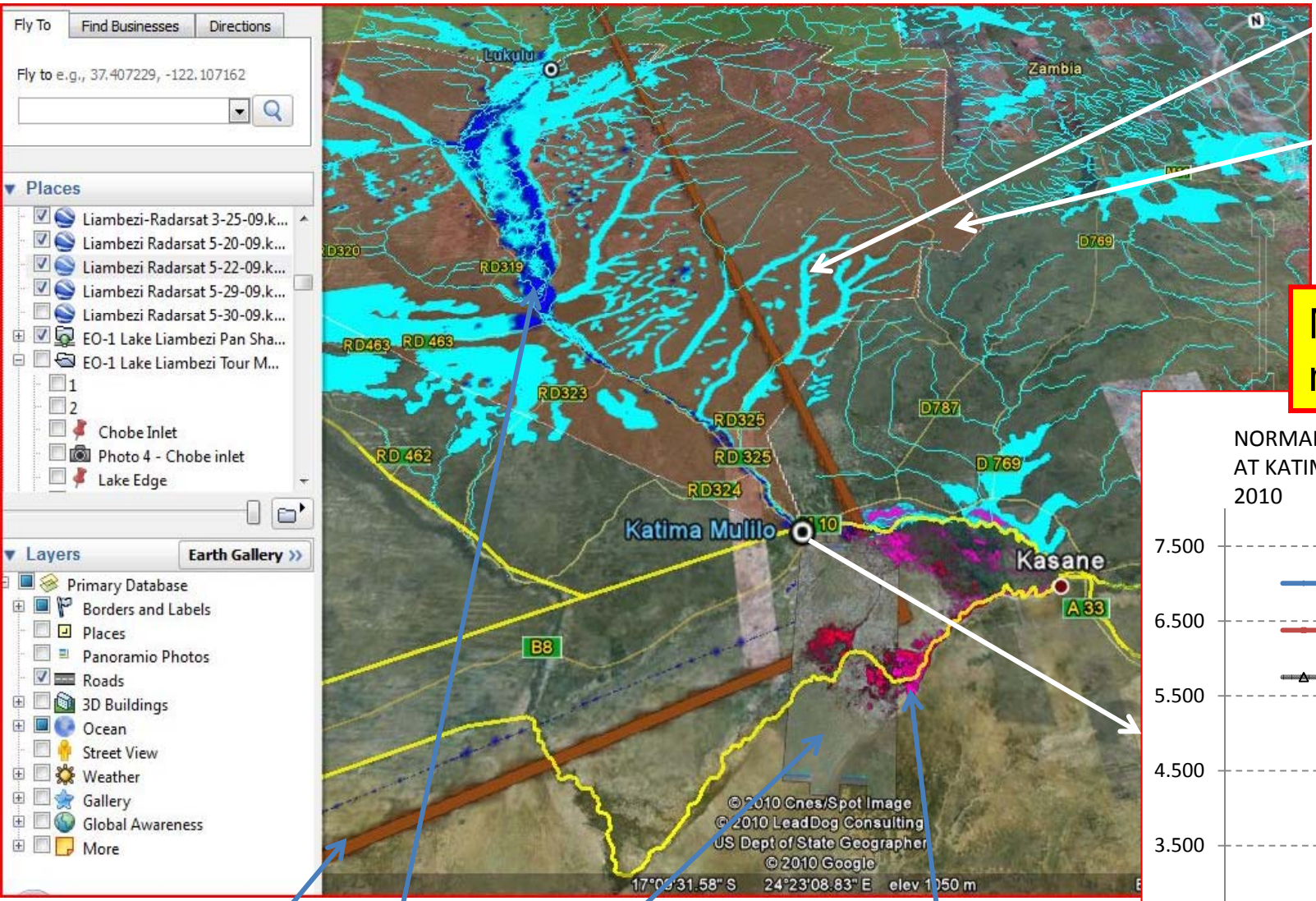
This false-color image combines infrared and visible light, which makes the extent of the flooding far more obvious. Water is dark blue, while plant-covered land is green, and bare earth is rosy tan.

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)

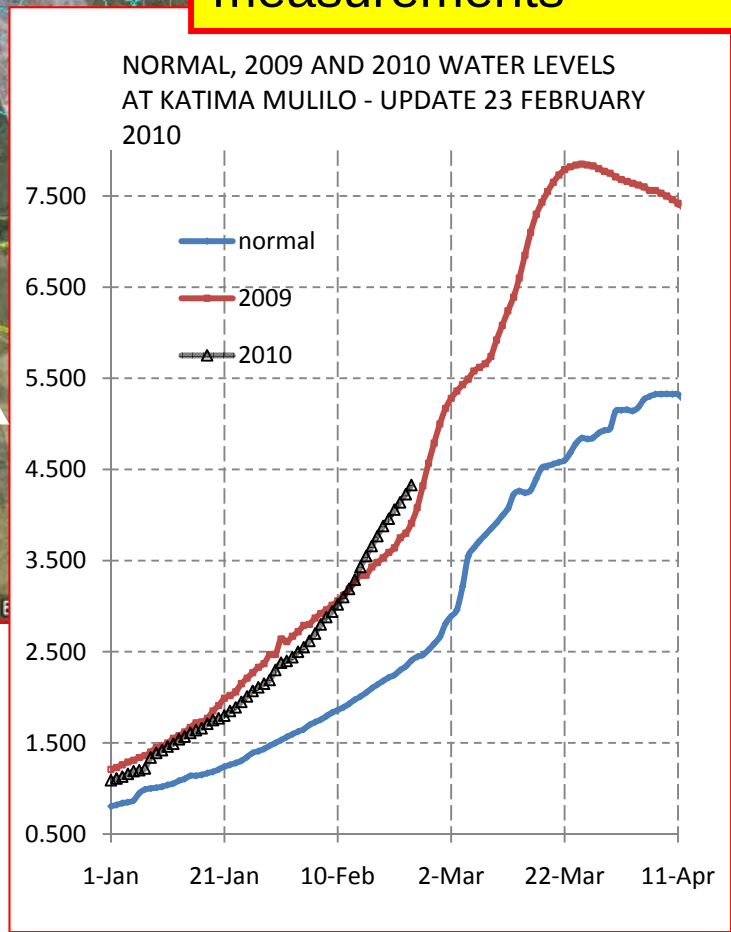
Mashup of Satellite Data and River Gauge Data Using Namibia2 (Google Earth Version) Webpage Tool



Zambia water lines from old database

Lower Zambezi catchment

Multiyear river gauge measurements



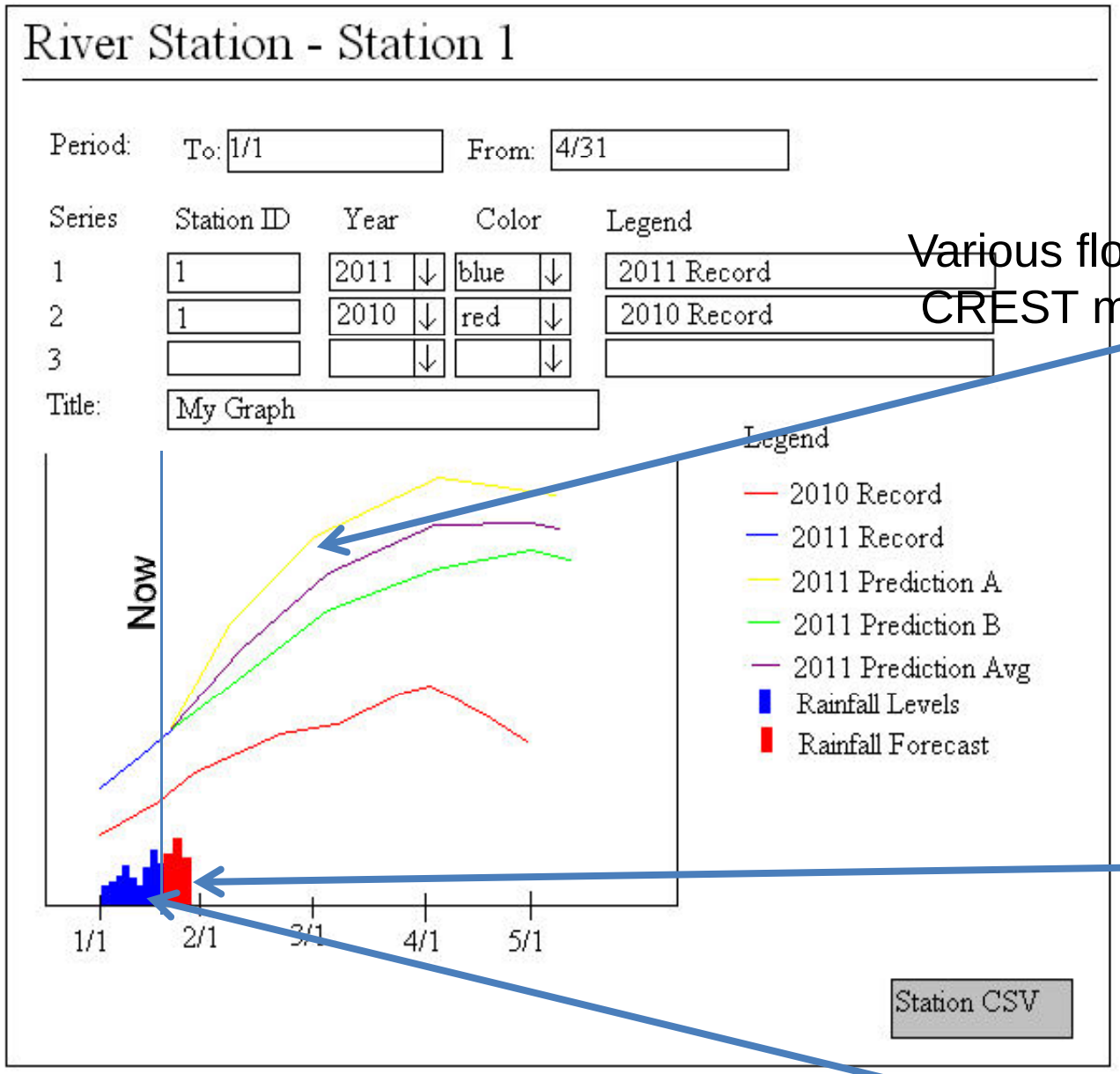
Envisat swath

Envisat Data March 2009

EO-1 Data March 2009

Radarsat Data March 25, 2009

Mock up of Revised River Gauge Plot Page

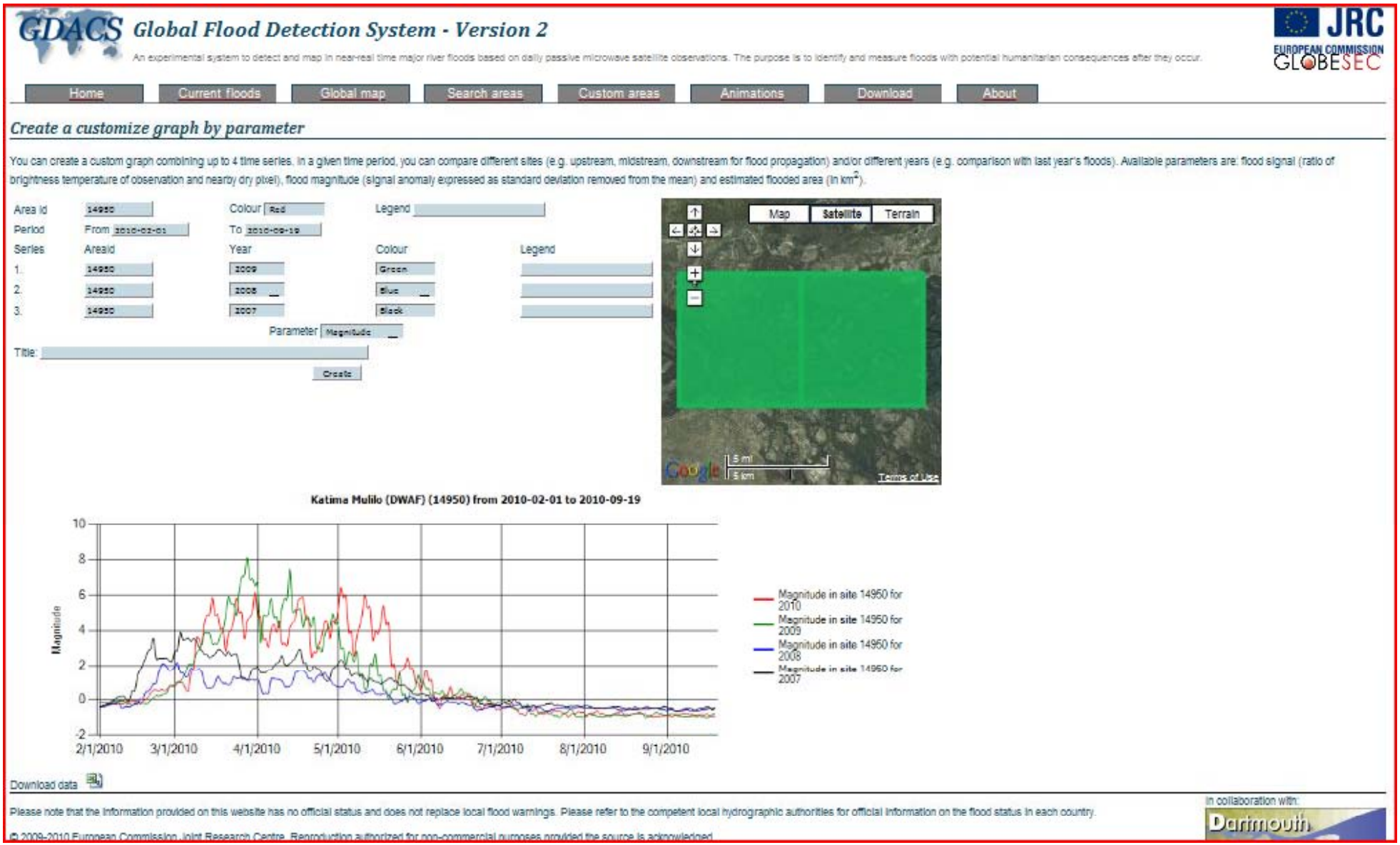


Various flood models such as CREST model (Univ. of Oklahoma)

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

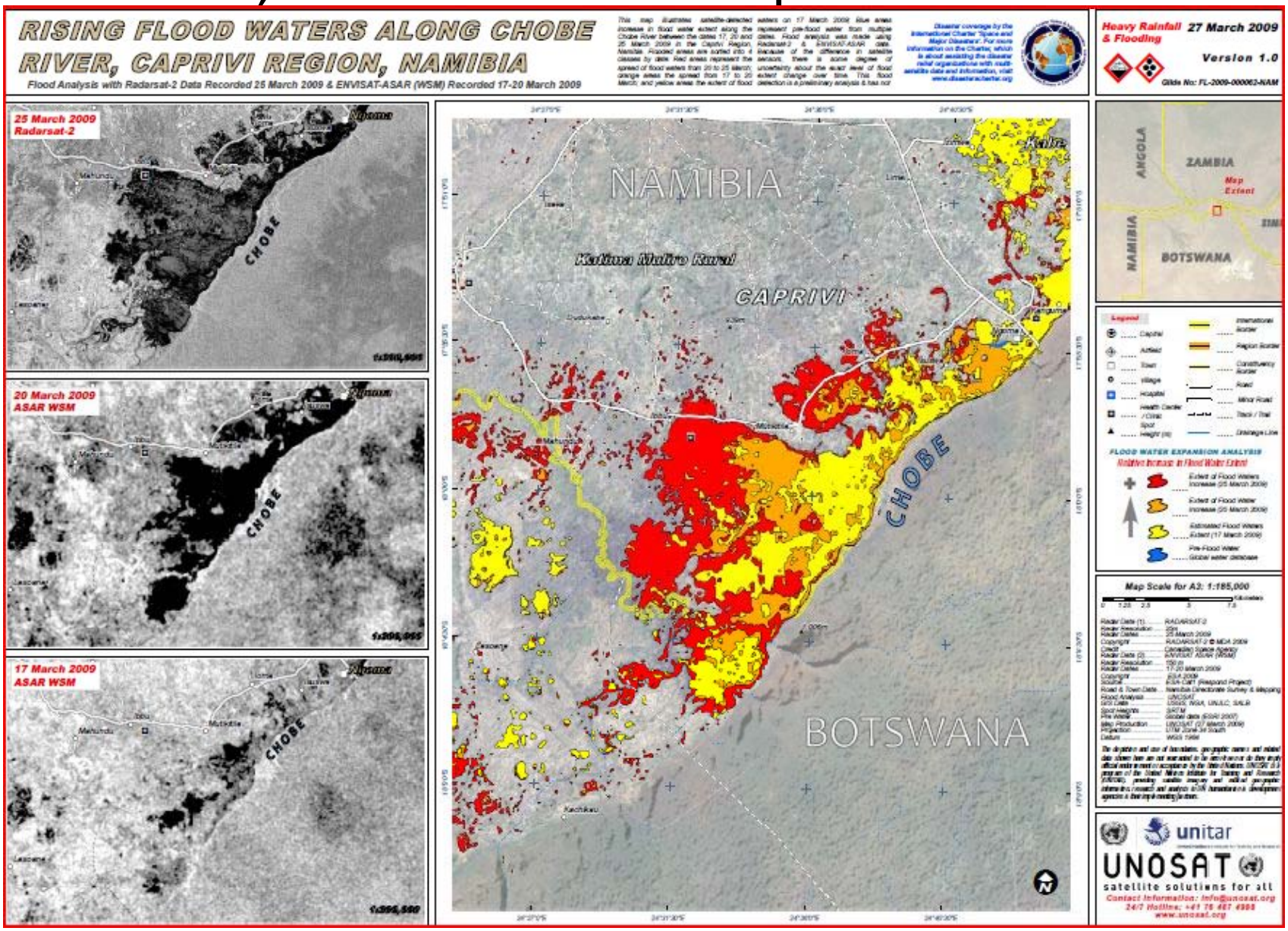
Namibia daily flood bulletin 03 March 2010:

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 a preset outputs