



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

Ground System Architectures Workshop

"Harmonization: Challenges and Opportunities"

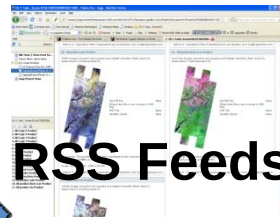
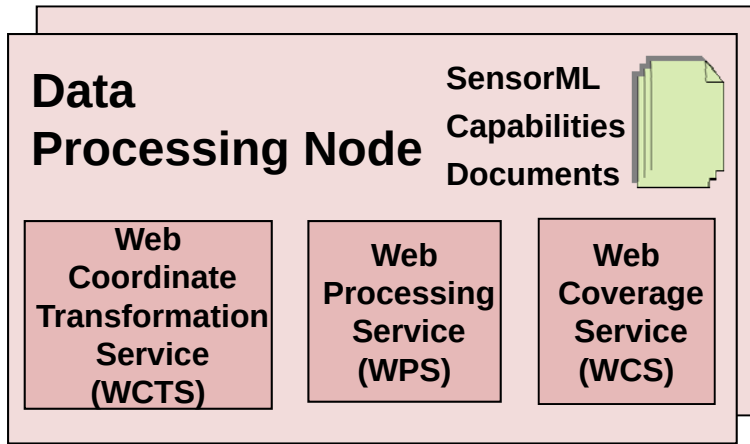
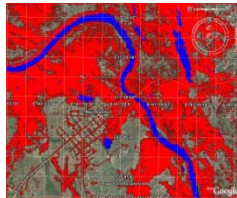
Sheraton Gateway Hotel, Los Angeles

February 28–March 3, 2011



SensorWeb High Level Architecture

floods, fires,
volcanoes etc

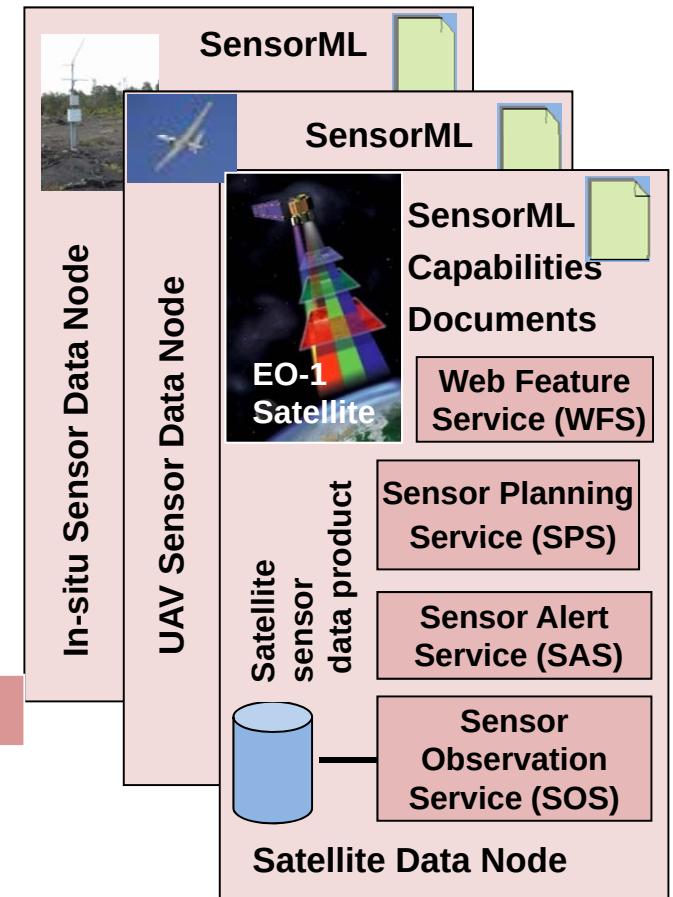
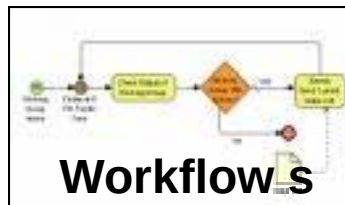


RSS Feeds

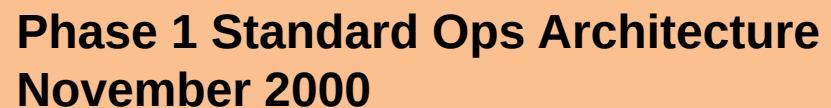
Sensor Data Products



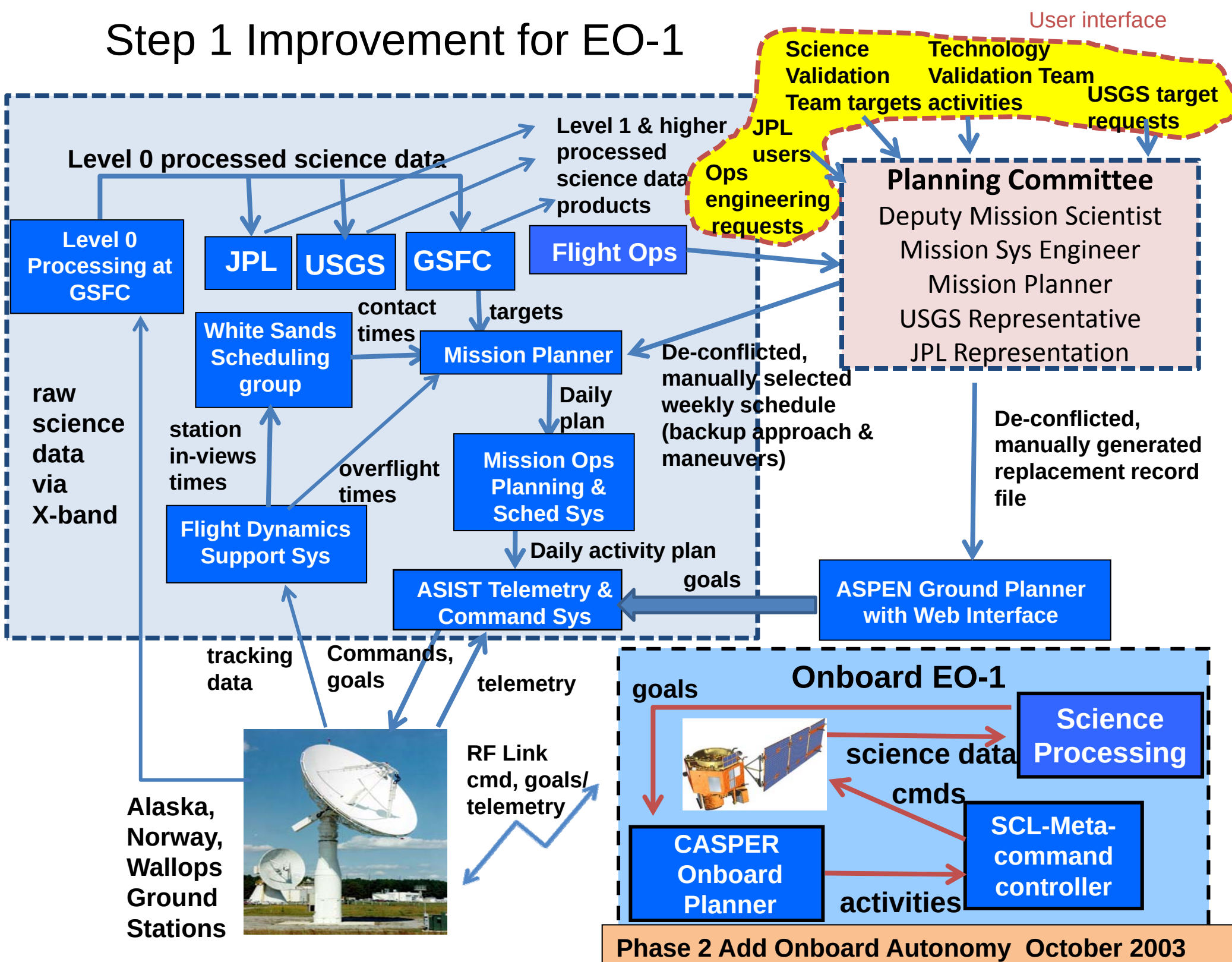
OpenID 2.0



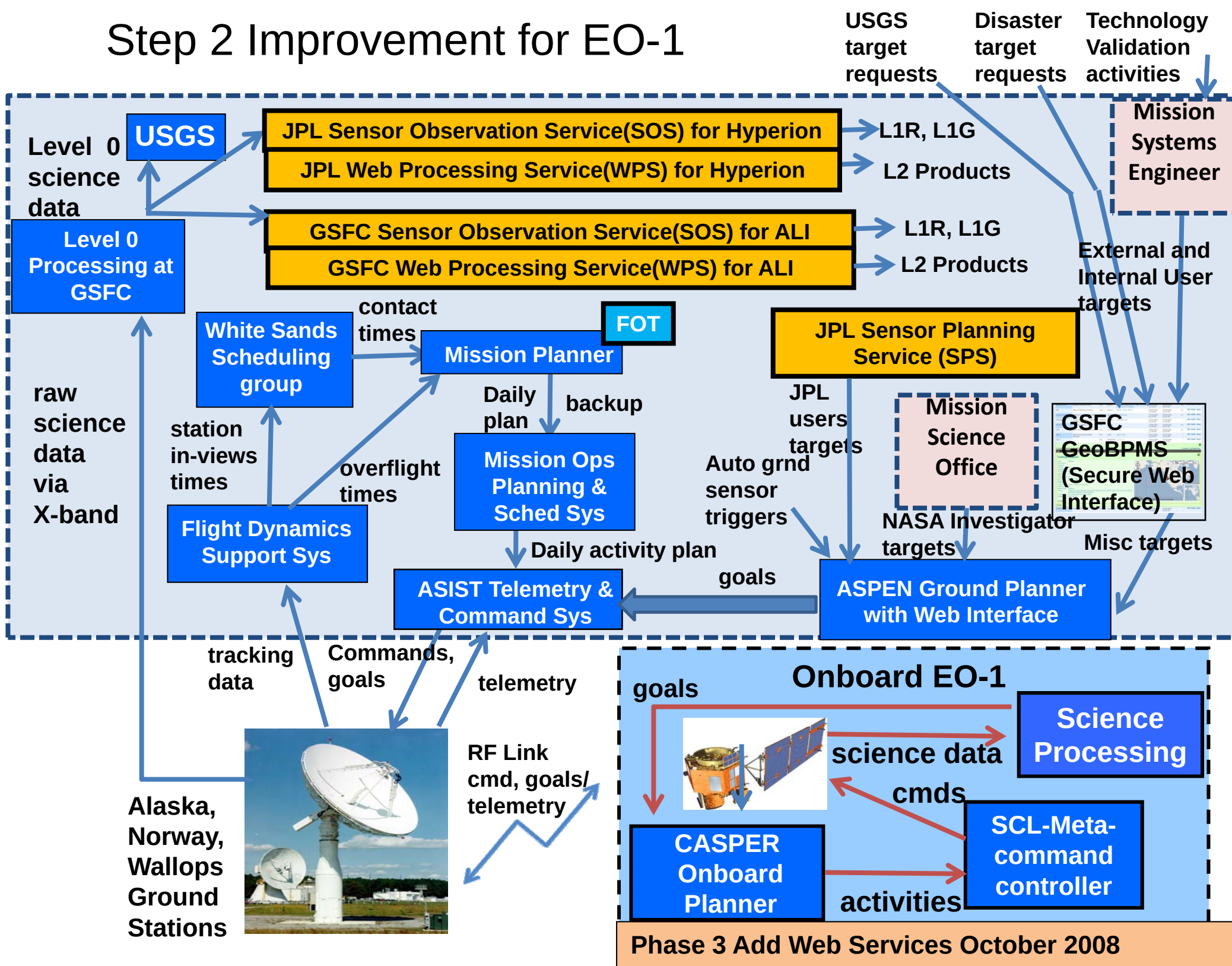
User interface



Step 1 Improvement for EO-1



Step 2 Improvement for EO-1



Step 3 Improvement for EO-1 - Overview

Hyperion and ALI
Level 0 Processed
data from GSFC,
building 3 server

External users,
especially international
(e.g. disaster workers)

NASA Investigators

Technologists

Starlight 100
Gigabit Ethernet
Exchange

Level 1R and Level 1G Processing for ALI & Hyperion

Atmospheric Correction for ALI & Hyperion

**Web Coverage Processing Service (WCPS) to enable
users to customize Level 2 products**

Amazon Elastic Cloud SW
300+ core processors
80 Tbytes of storage
80 Gbps connection to GSFC
At Univ of Illinois at Chicago
Supplied by Open Cloud Consortium
Virtual Machines (VM) & http server to VM's

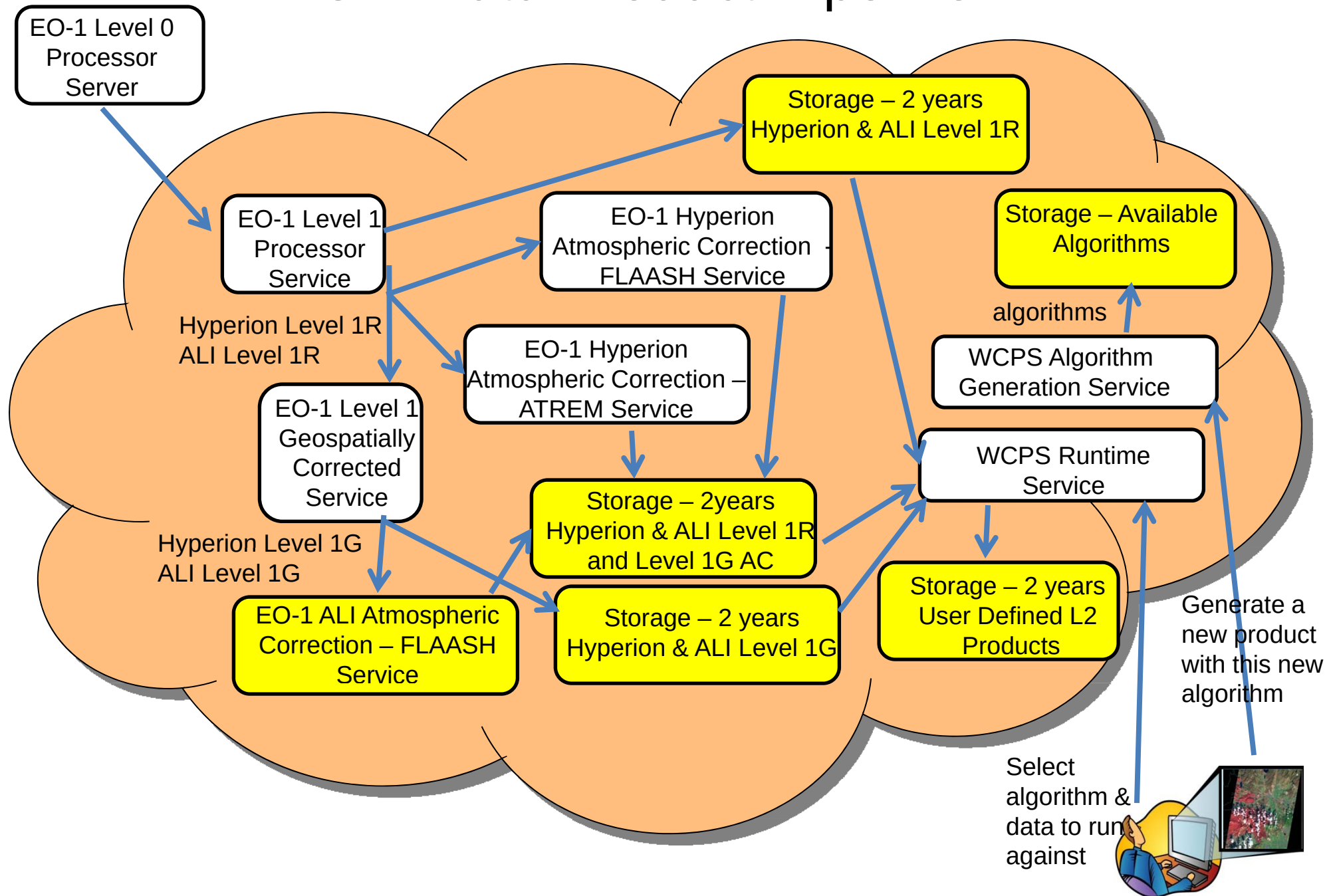
**Nambia Flood
Dashboard**

**2 year data product
archive**

80 Gbps

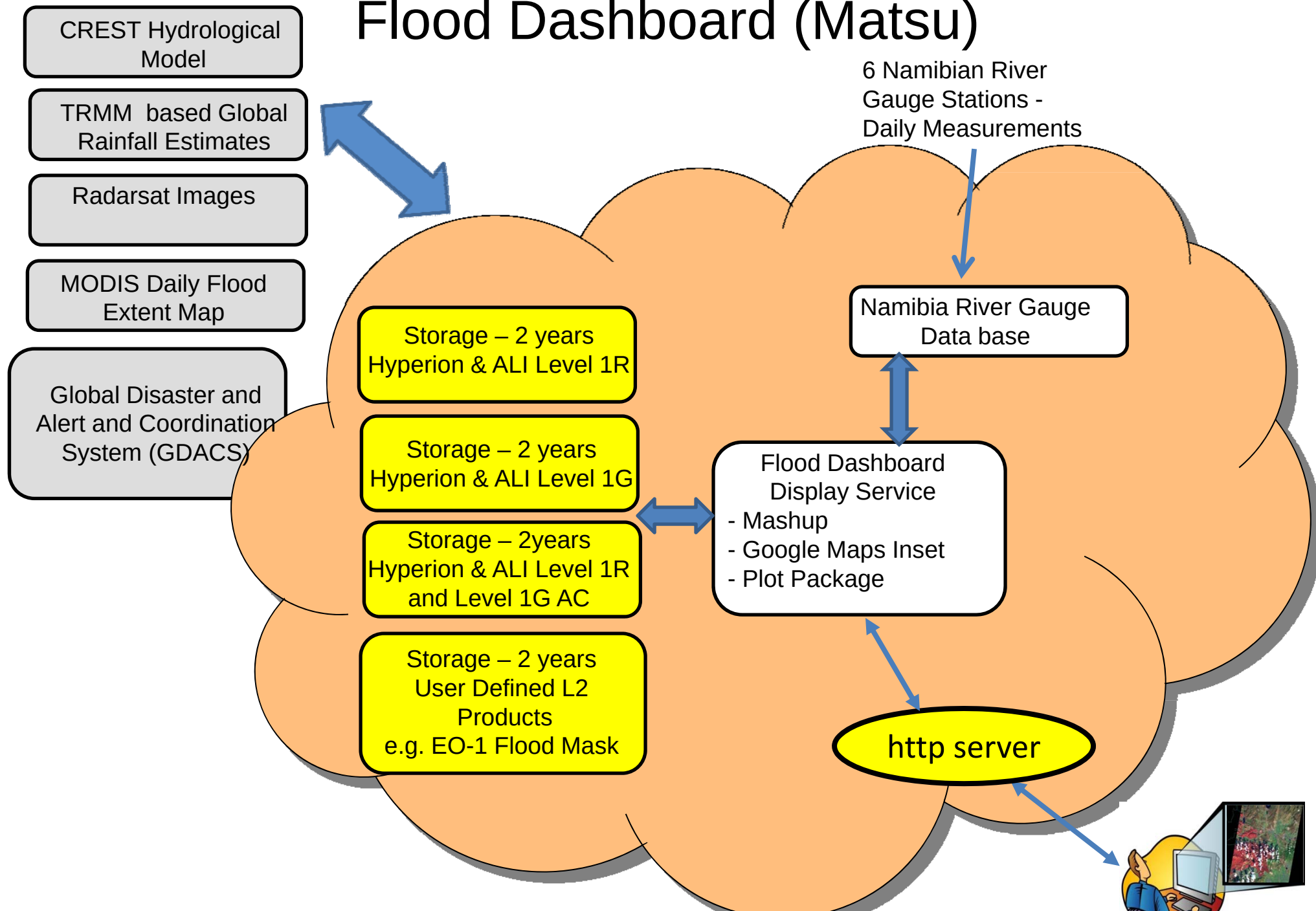
Transformation to On-Demand Product Cloud Part 1

EO-1 Data Product Pipeline



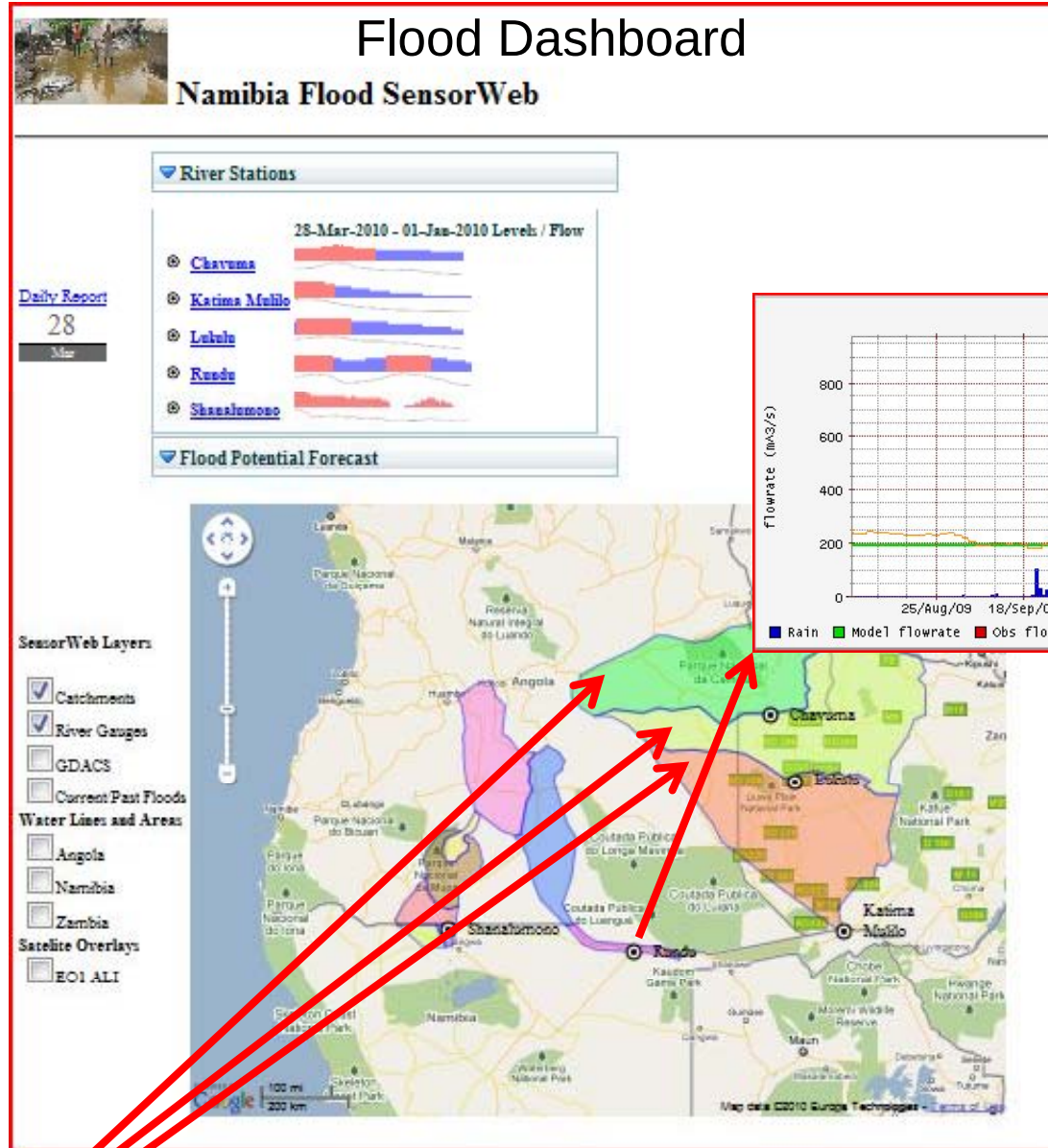
On-Demand Product Cloud Part 2

Flood Dashboard (Matsu)



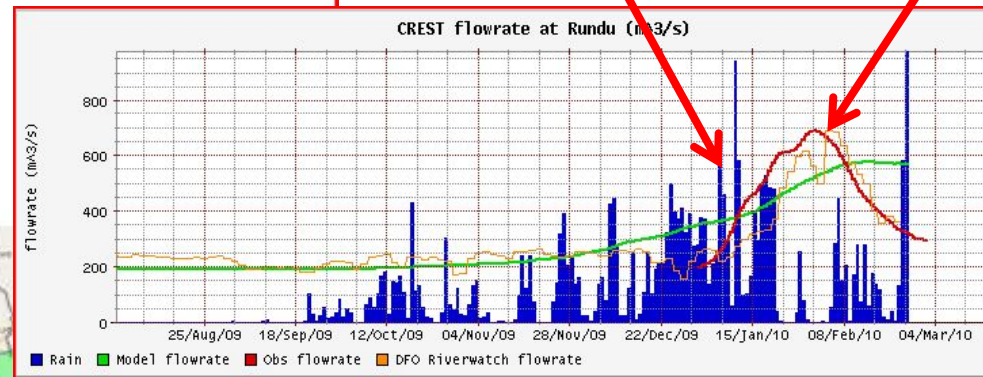
Phase 3 Add Elastic Cloud Ongoing Feb 2011

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

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



Flood Dashboard

Namibia Flood SensorWeb

[Daily Report](#)
25
Apr

River Stations

Flood Potential Forecast

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

Experimental TRMM-based Flood Forecast Products

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)

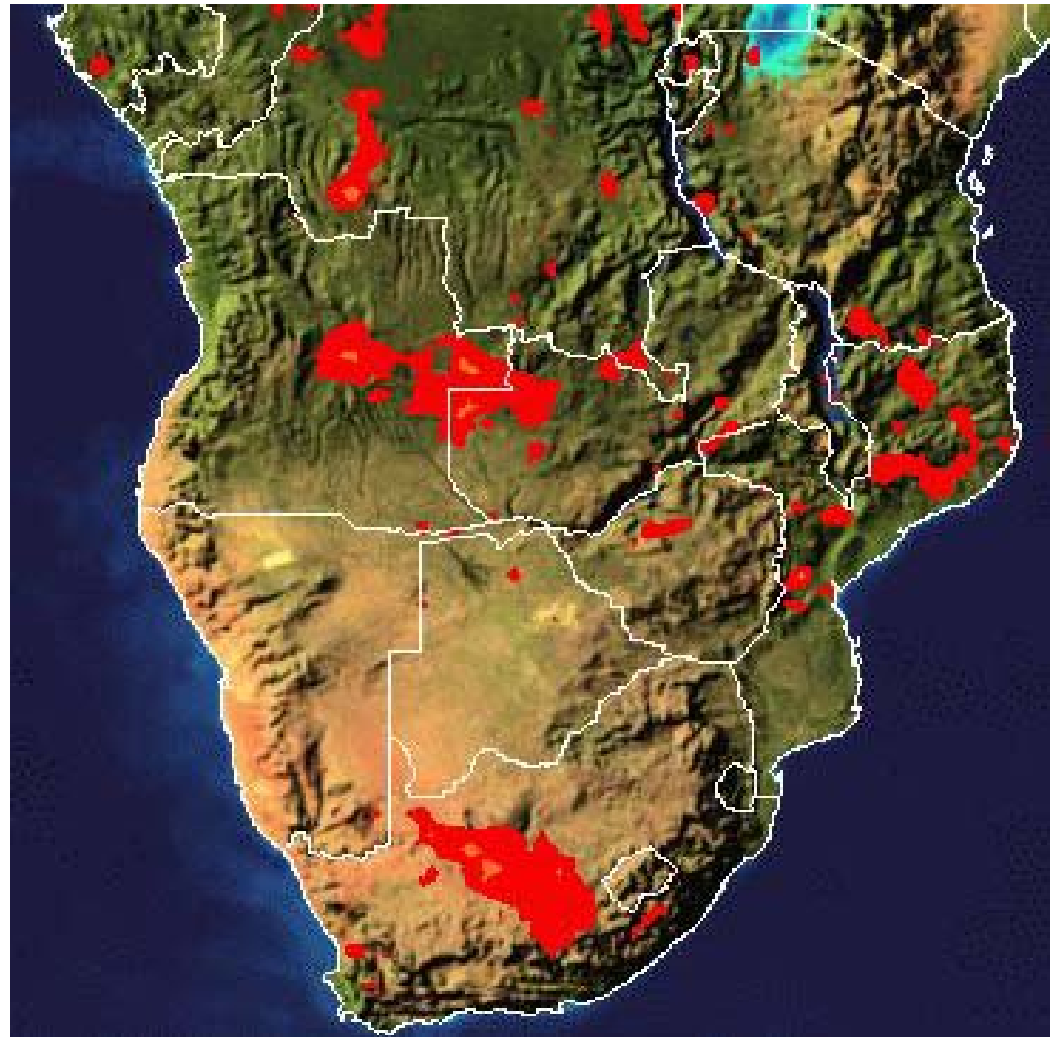
Map Satellite Terrain

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.

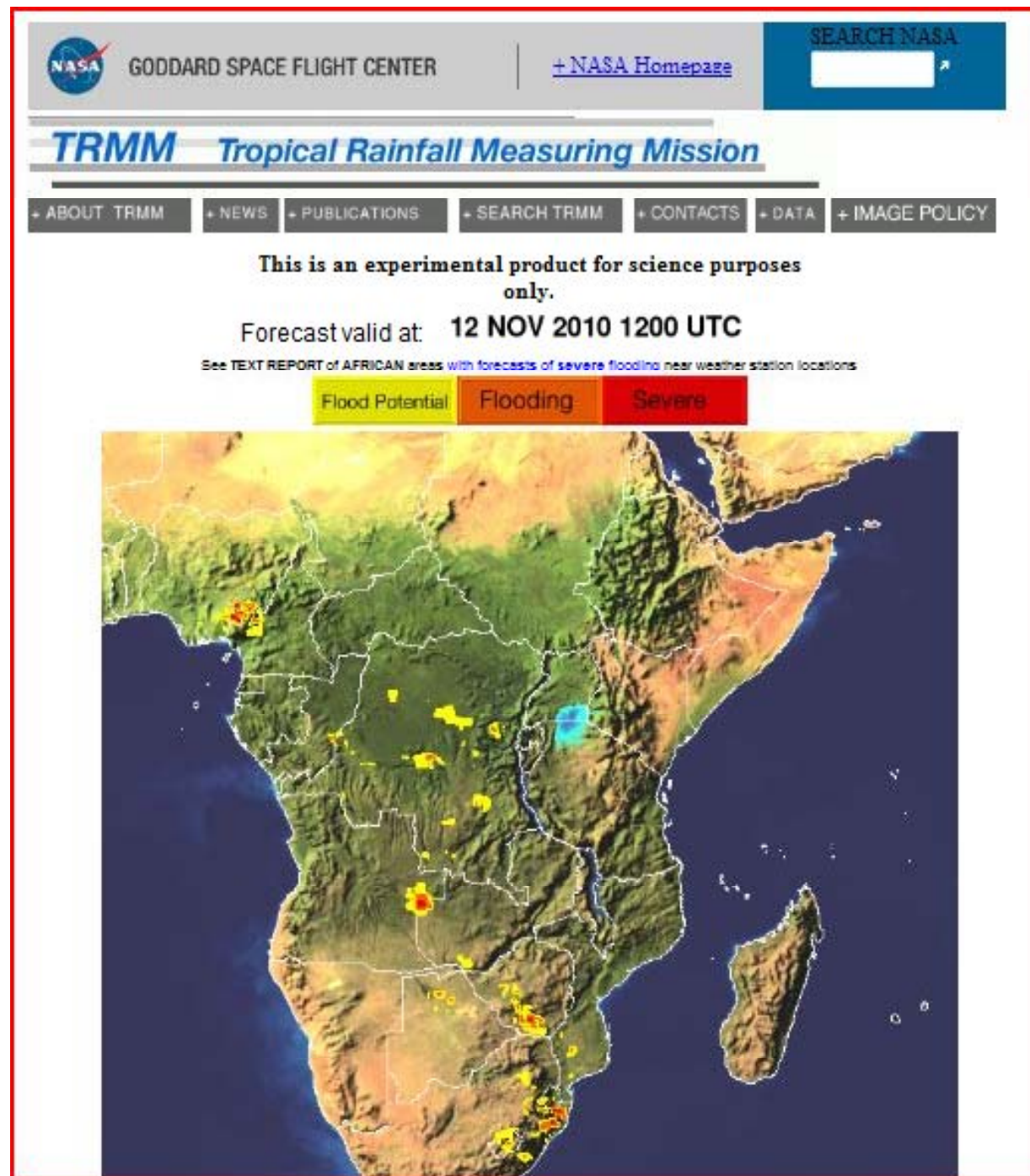
2010-03-28 (07:58 UTC)
[Download KML file](#)

Estimated Rainfall Webpage Based on TRMM Data

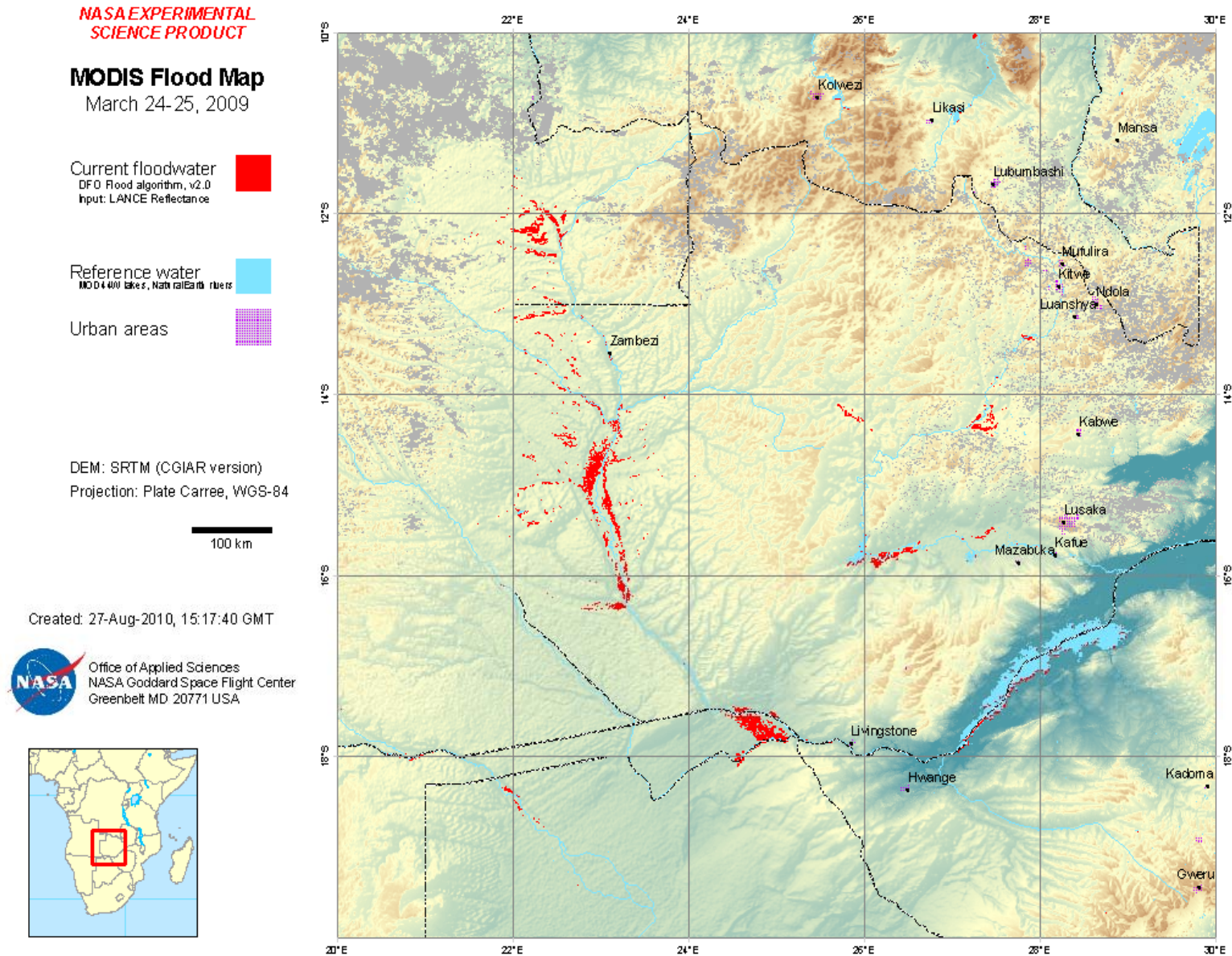
- Experimented with various hydrometeorological information for flood forecasting models
 - remote sensing
 - rainfall estimates
 - 24 February 2010
 - NASA Servir Africa
 - red is > 35 mm



Experimental Global TRMM Based Flood Forecast

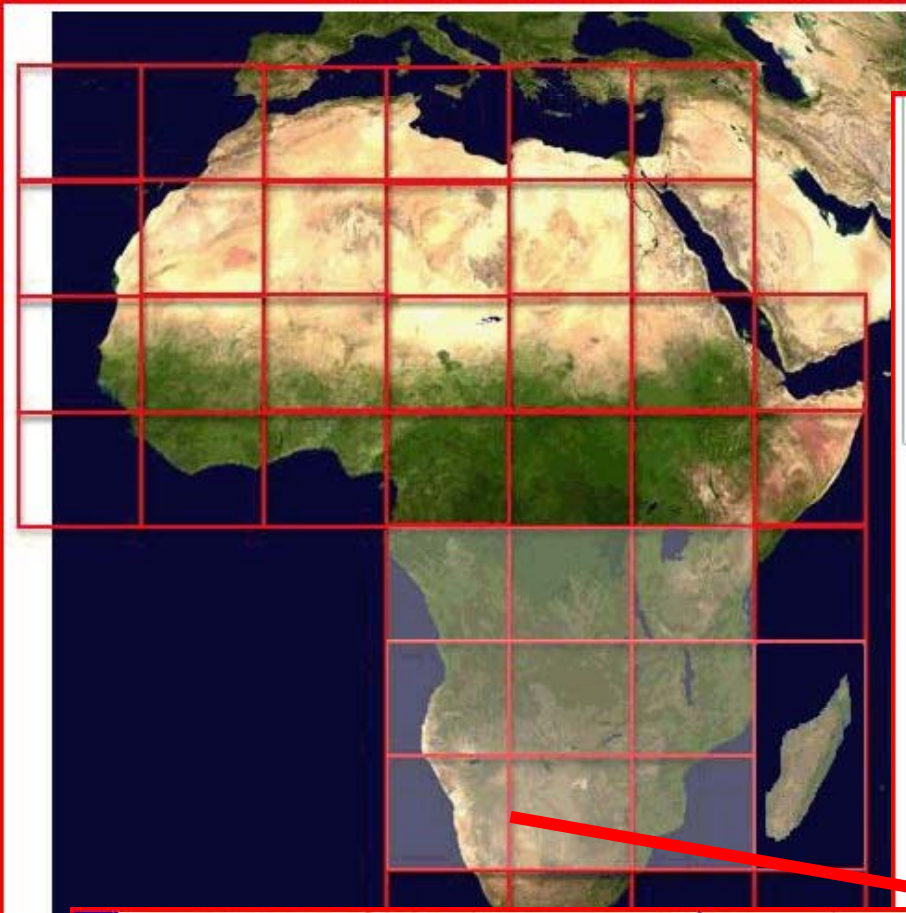


Experimental Flood Extent Data Product Derived from MODIS



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



Su	Mo	Tu	We	Th	Fr	Sa
						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

NASA EXPERIMENTAL
SCIENCE PRODUCT

MODIS Flood Map
28-30 Jan 2011
Tile 010E010S

Current floodwater
by 4:30 PM local time

Cloud
MODIS cloud

Reference water
MODIS water
by 4:30 PM local time

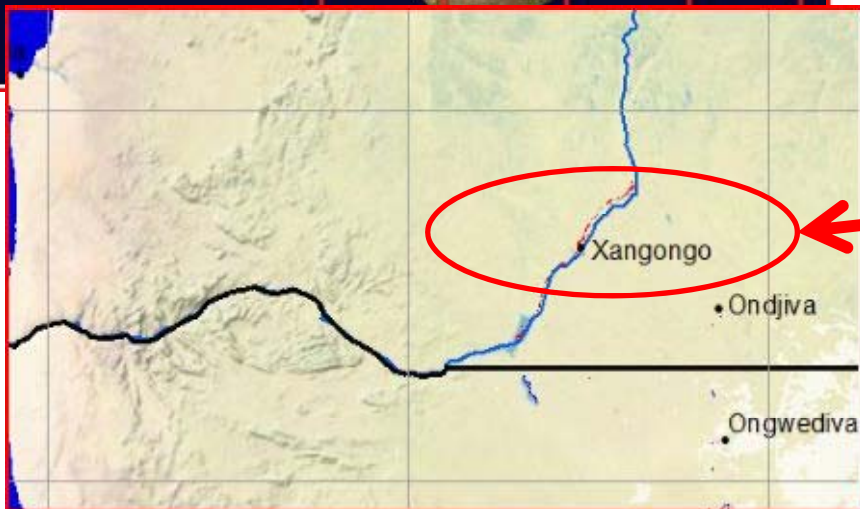
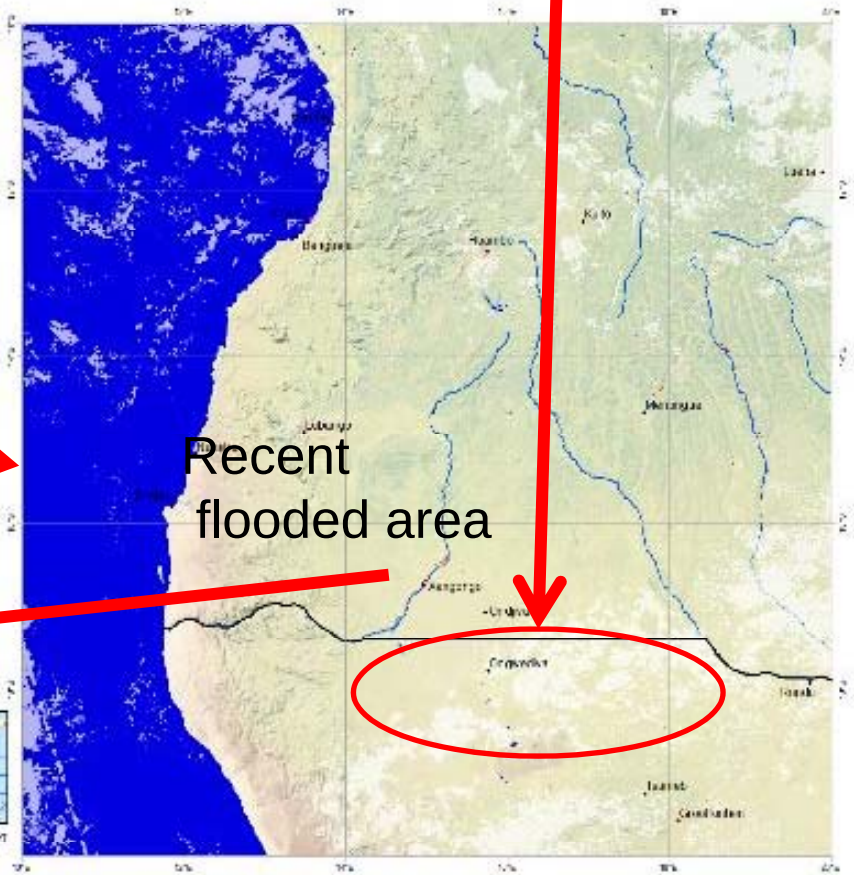
Urban areas
MODIS urban

Background
MODIS World Physical Map

100 km Projection: Pseudo-Cylindrical, WGS-84



Created: 20 Jan 2011 10:24:00 GMT



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

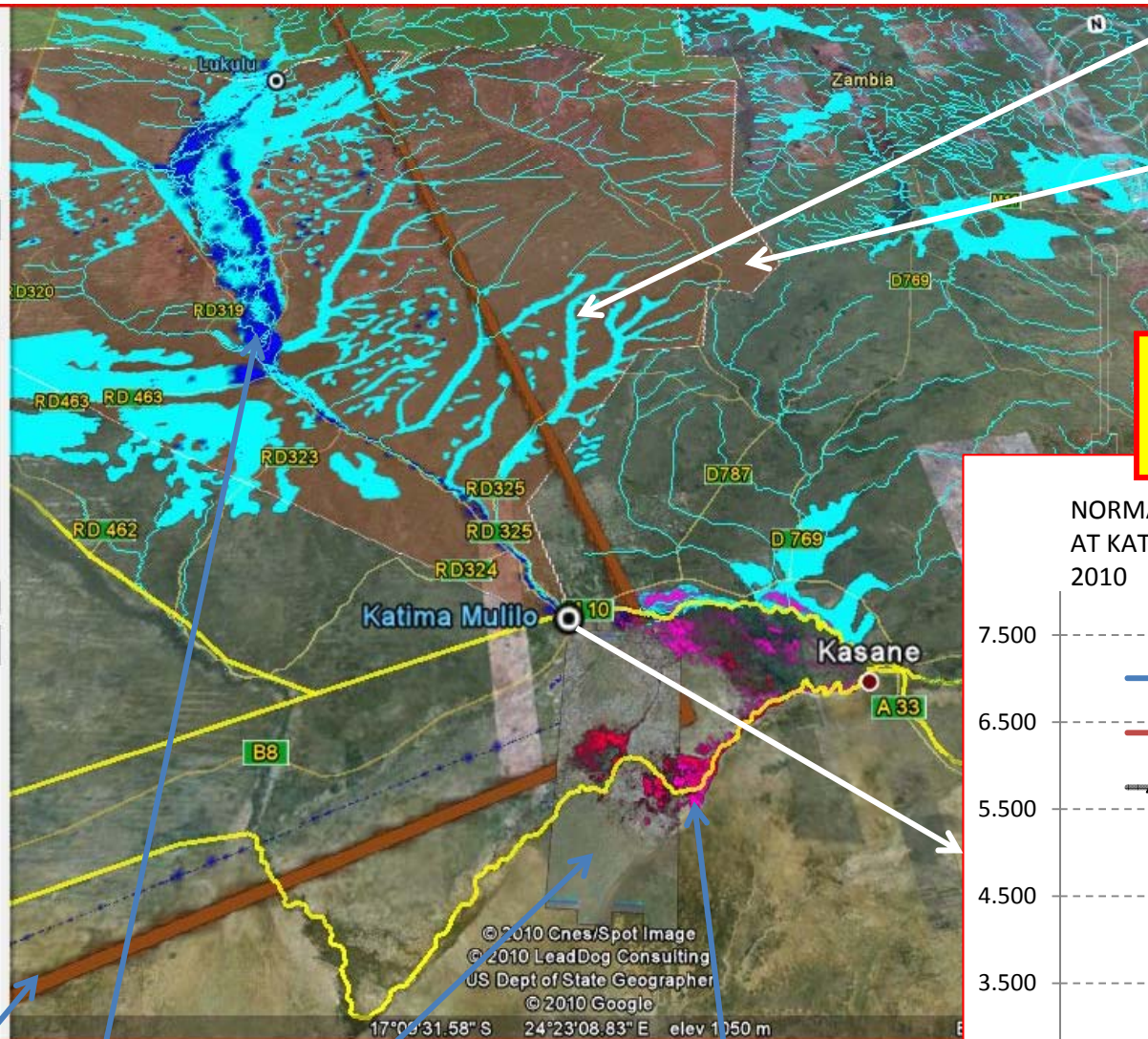
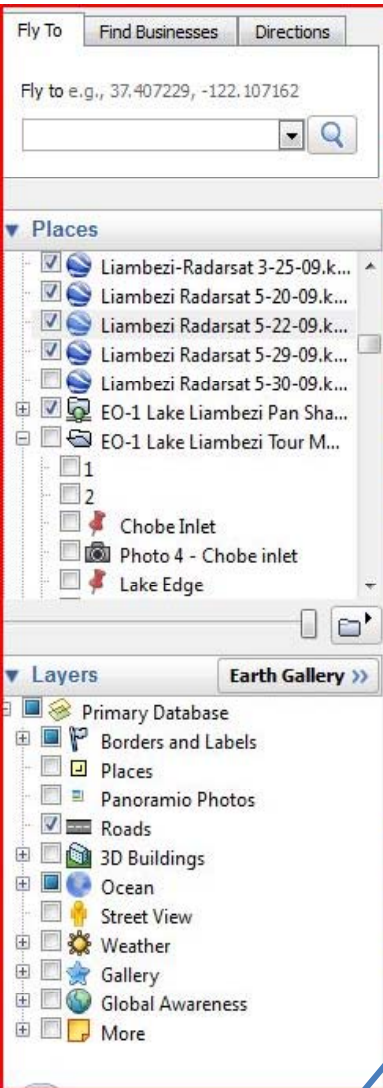
This false-color image combines infrared and visible light, which makes the extent of the flooding far more obvious. Water is dark blue, while plant-covered land is green, and bare earth is rosy tan.



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.

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



Zambia water lines
from old database

Lower Zambezi
catchment

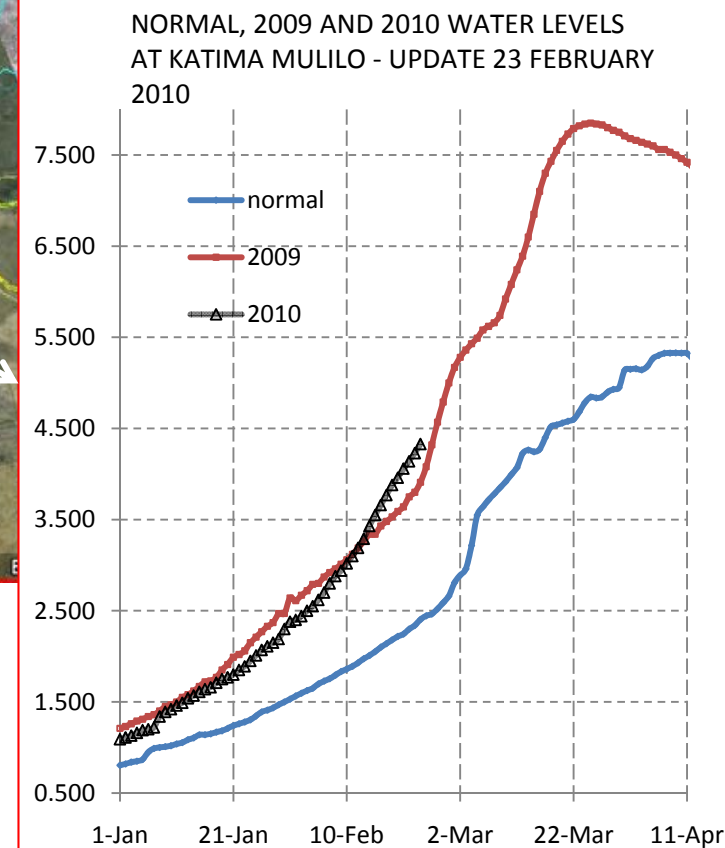
Multiyear river gauge
measurements

Envisat swath

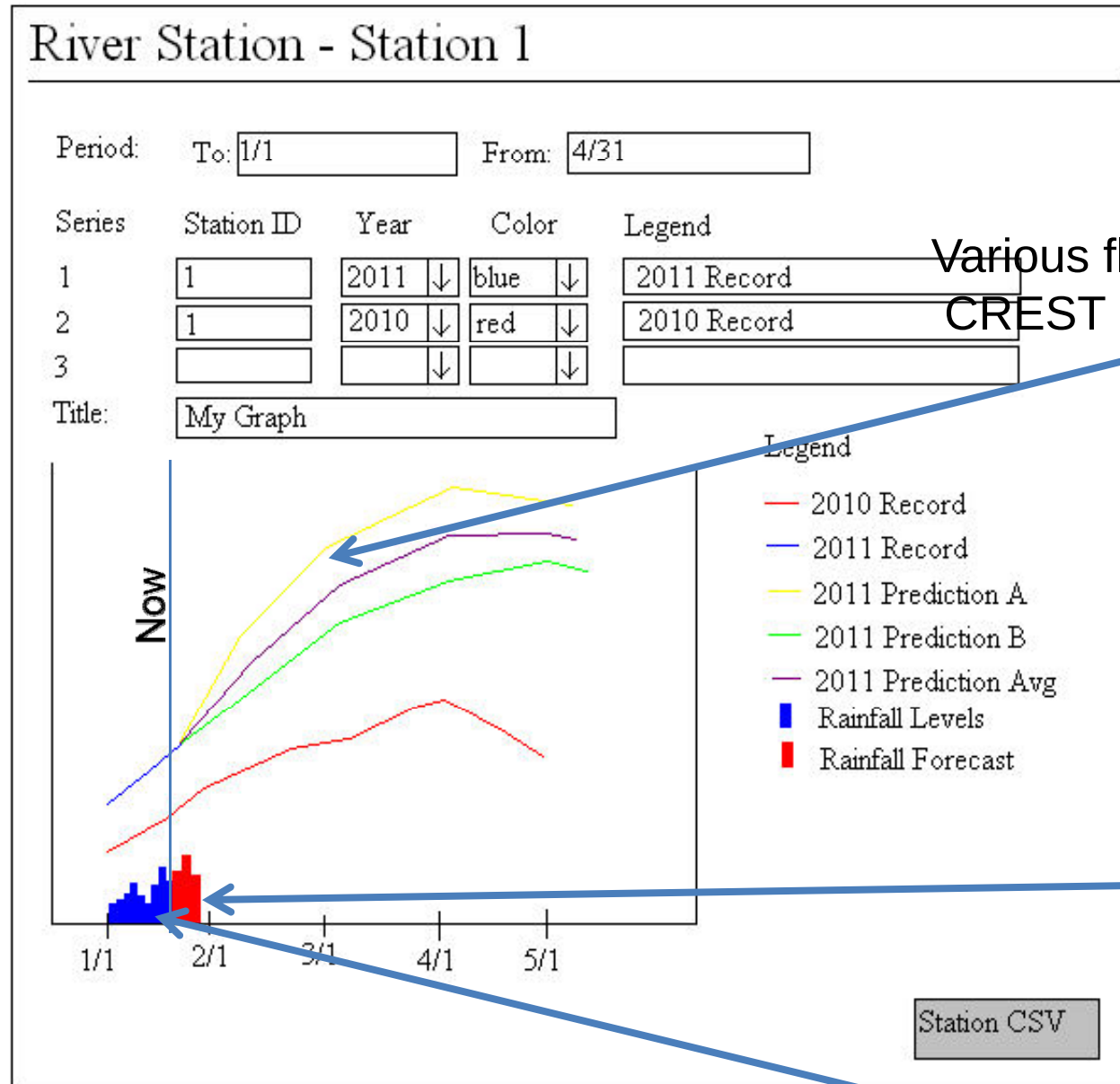
Envisat Data
March 2009

EO-1 Data
March 2009

Radersat Data
March 25, 2009



Mock up of Revised River Gauge Plot Page

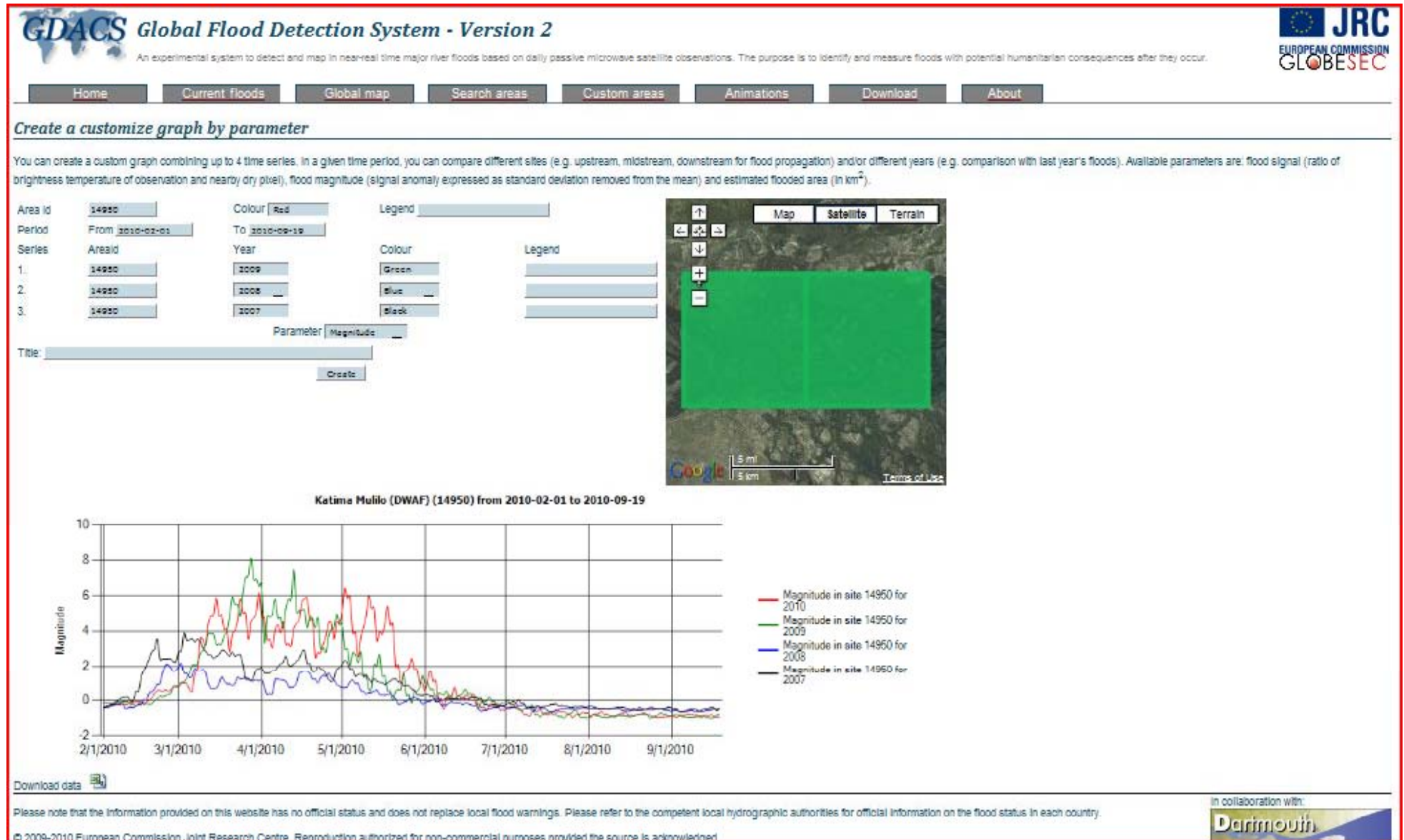


Various flood models such as
CREST model (Univ. of Oklahoma)

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:

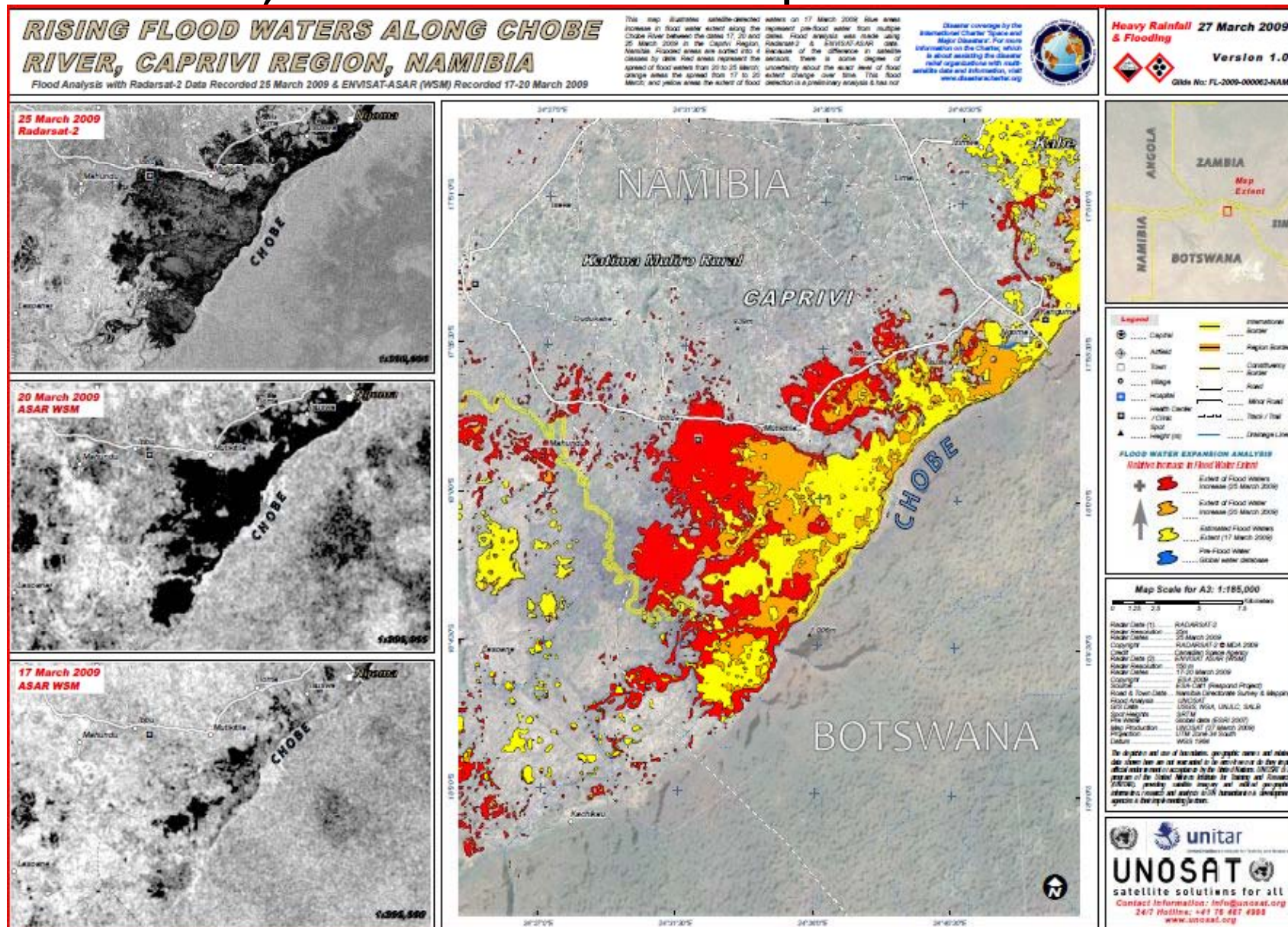
similar to 2007

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