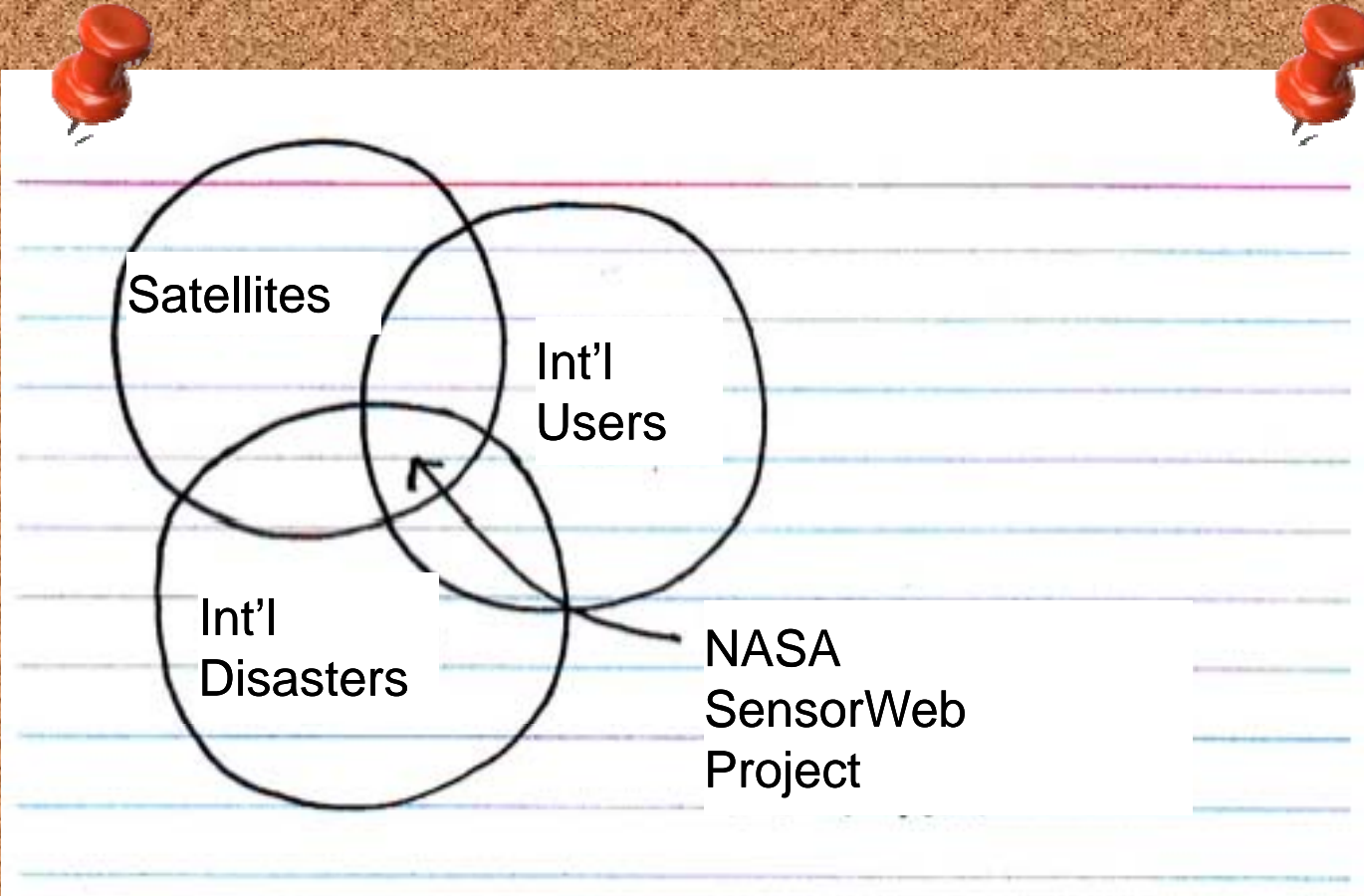




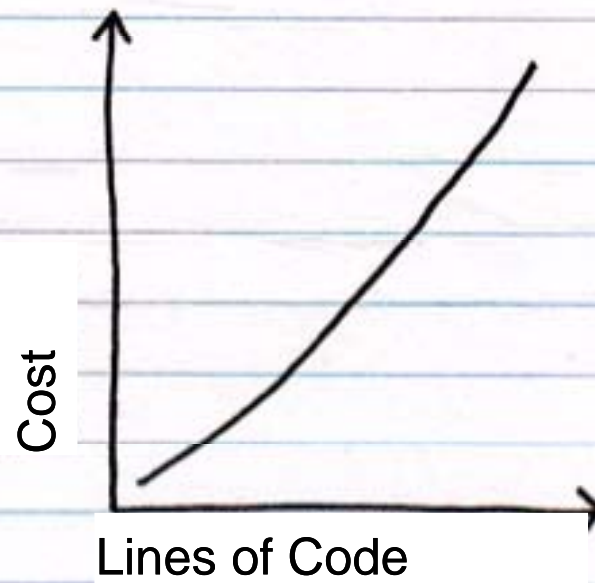
# NASA SensorWeb and OGC Standards for Disaster Management

Dan Mandl 6/18/10

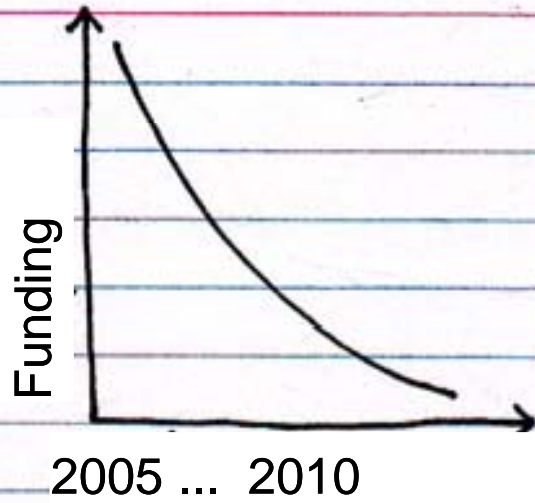
NASA/GSFC



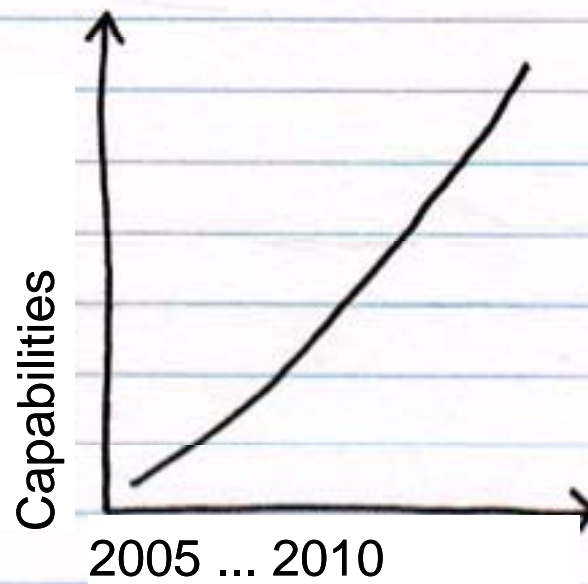
For big software projects, cost is a function of amount of code



Our Reality...

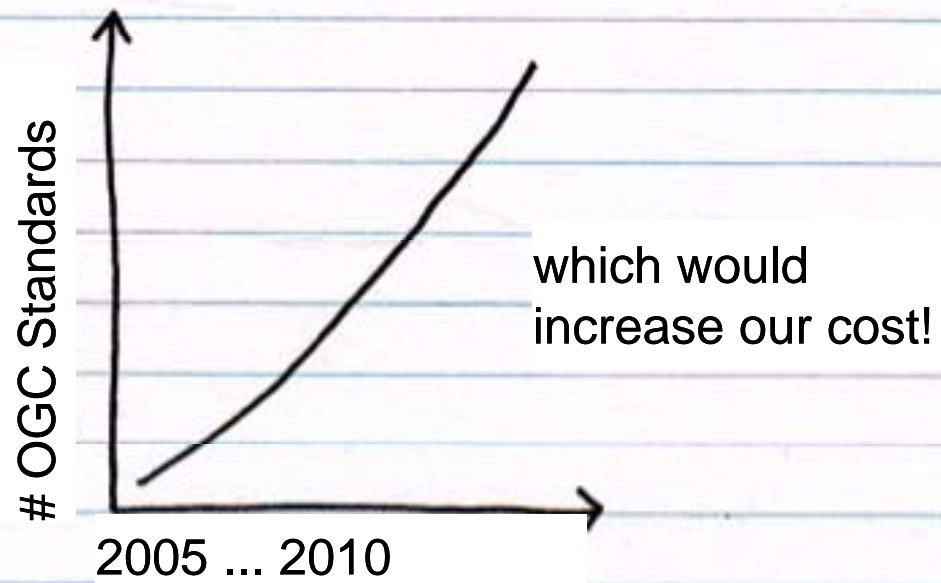


But we have made some good progress...

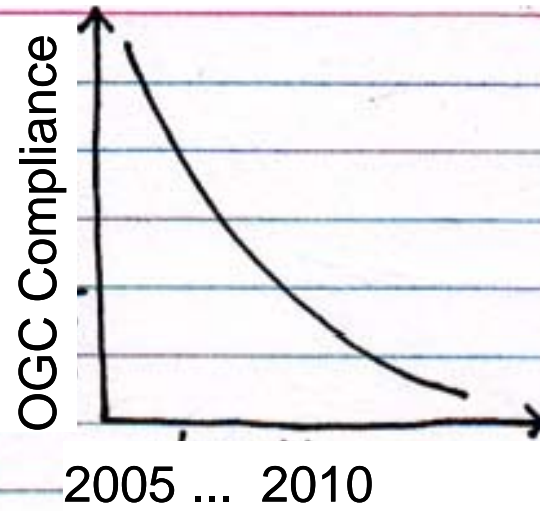




## Number of OGC Standards Has Increased Significantly



So Our OGC Compliance Has Decreased

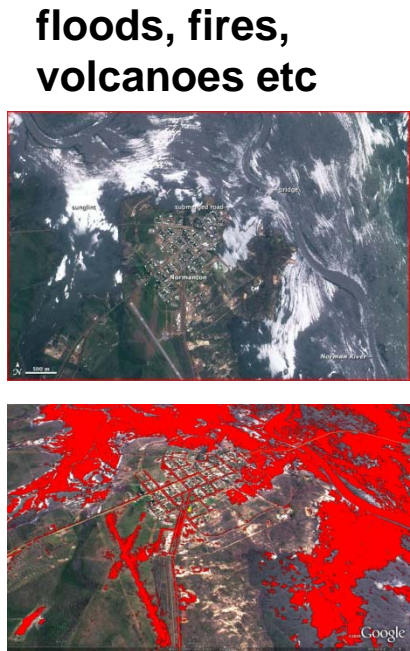


# General Approach

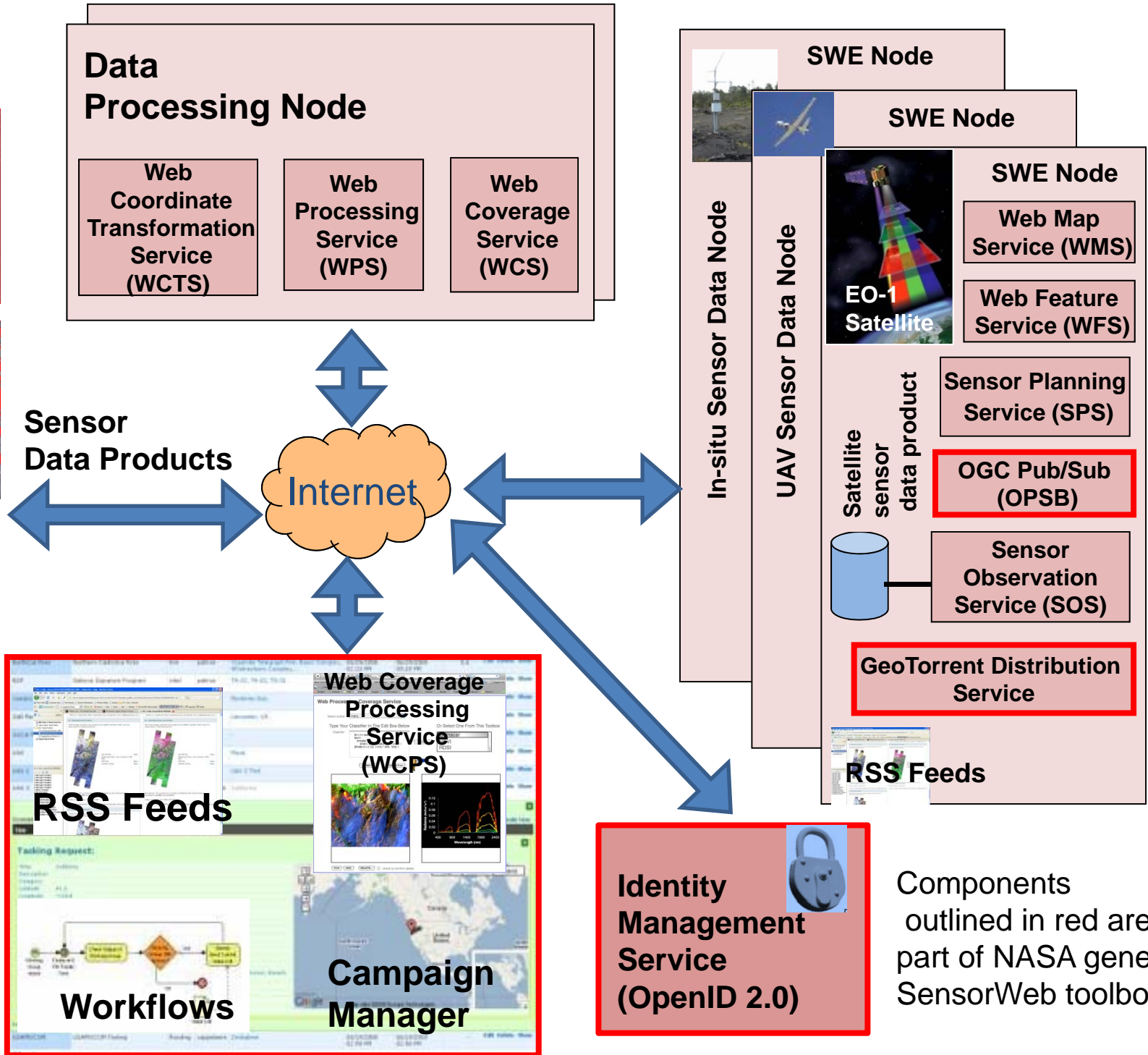
- Goal: Enable user to cost-effectively find and create customized data products to help manage disasters
  - On-demand
  - Low cost and non-specialized tools such as Google Earth and browsers
  - Access via open network but with sufficient security
- Use standards to interface various sensors and resultant data
  - Wrap sensors in Open Geospatial Consortium (OGC) standards
  - Wrap data processing algorithms and servers with OGC standards
  - Use standardized workflows to orchestrate and script the creation of these data products
- Target Web 2.0 mass market
  - Make it simple and easy to use
  - Leverage new capabilities and tools that are emerging
  - Improve speed and responsiveness



# SensorWeb High Level Architecture



**Campaign Manager API**

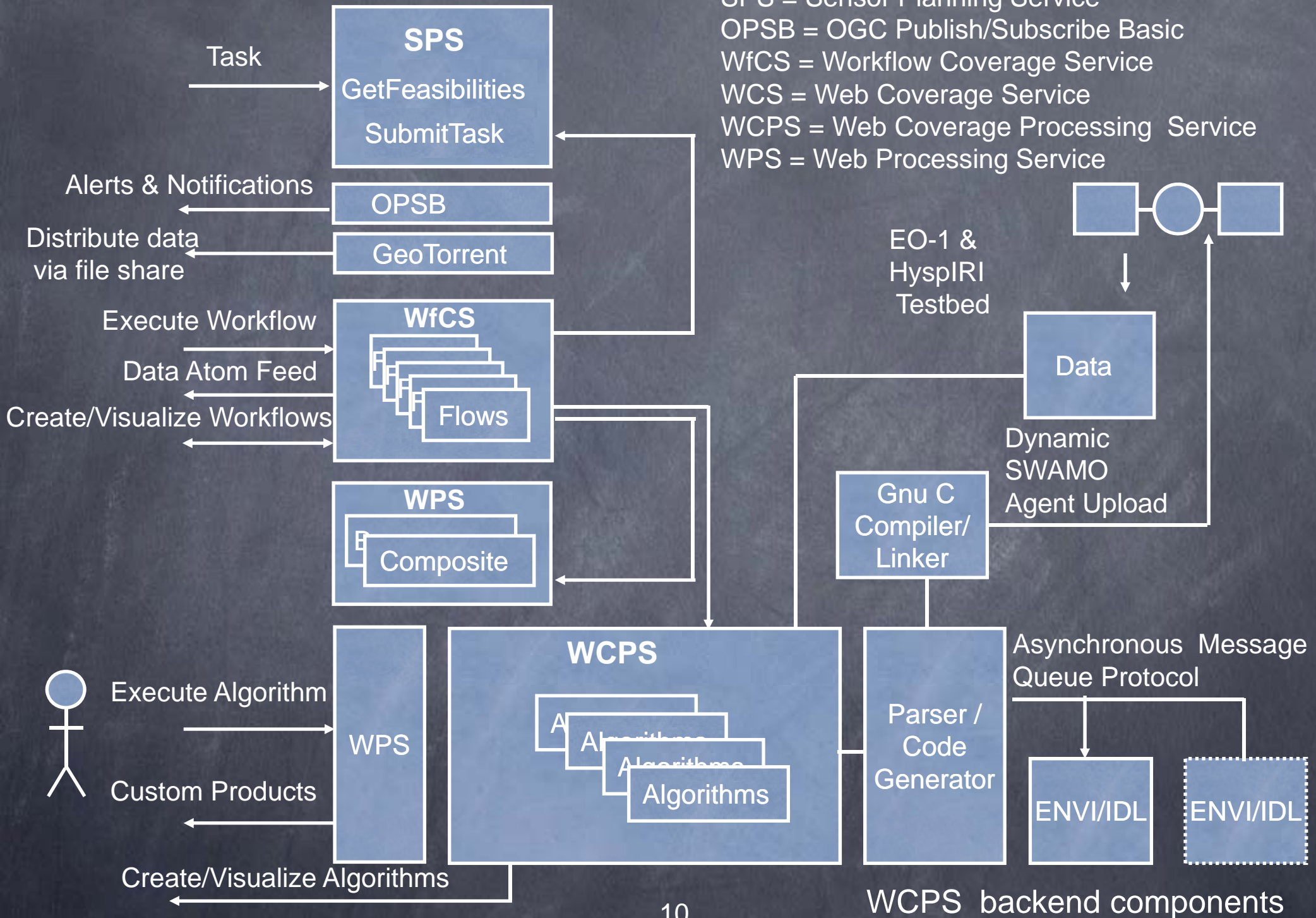


Components outlined in red are part of NASA generic SensorWeb toolbox



# Present NASA SensorWeb 2.0

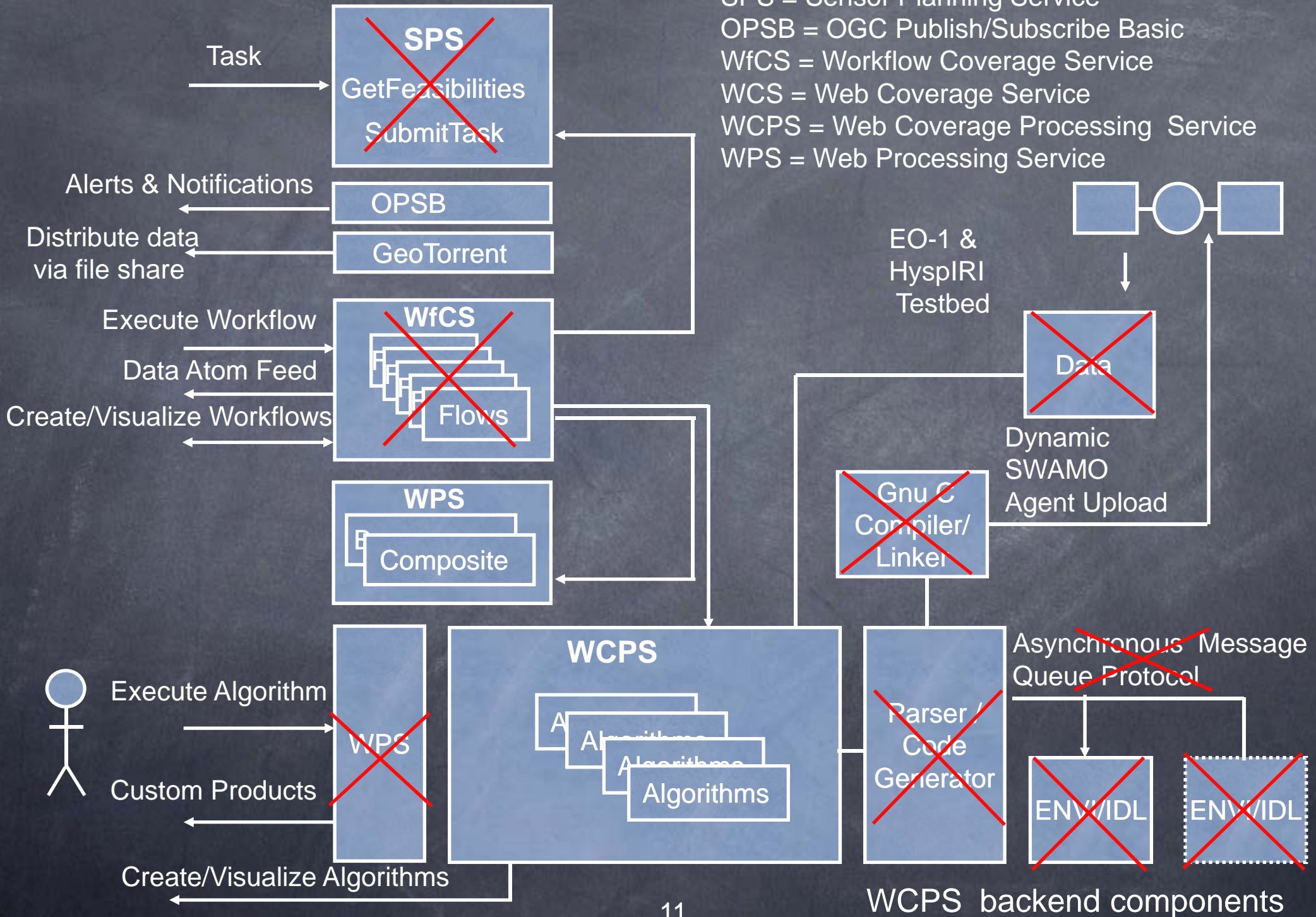
SPS = Sensor Planning Service  
 OPSB = OGC Publish/Subscribe Basic  
 WfCS = Workflow Coverage Service  
 WCS = Web Coverage Service  
 WCPS = Web Coverage Processing Service  
 WPS = Web Processing Service



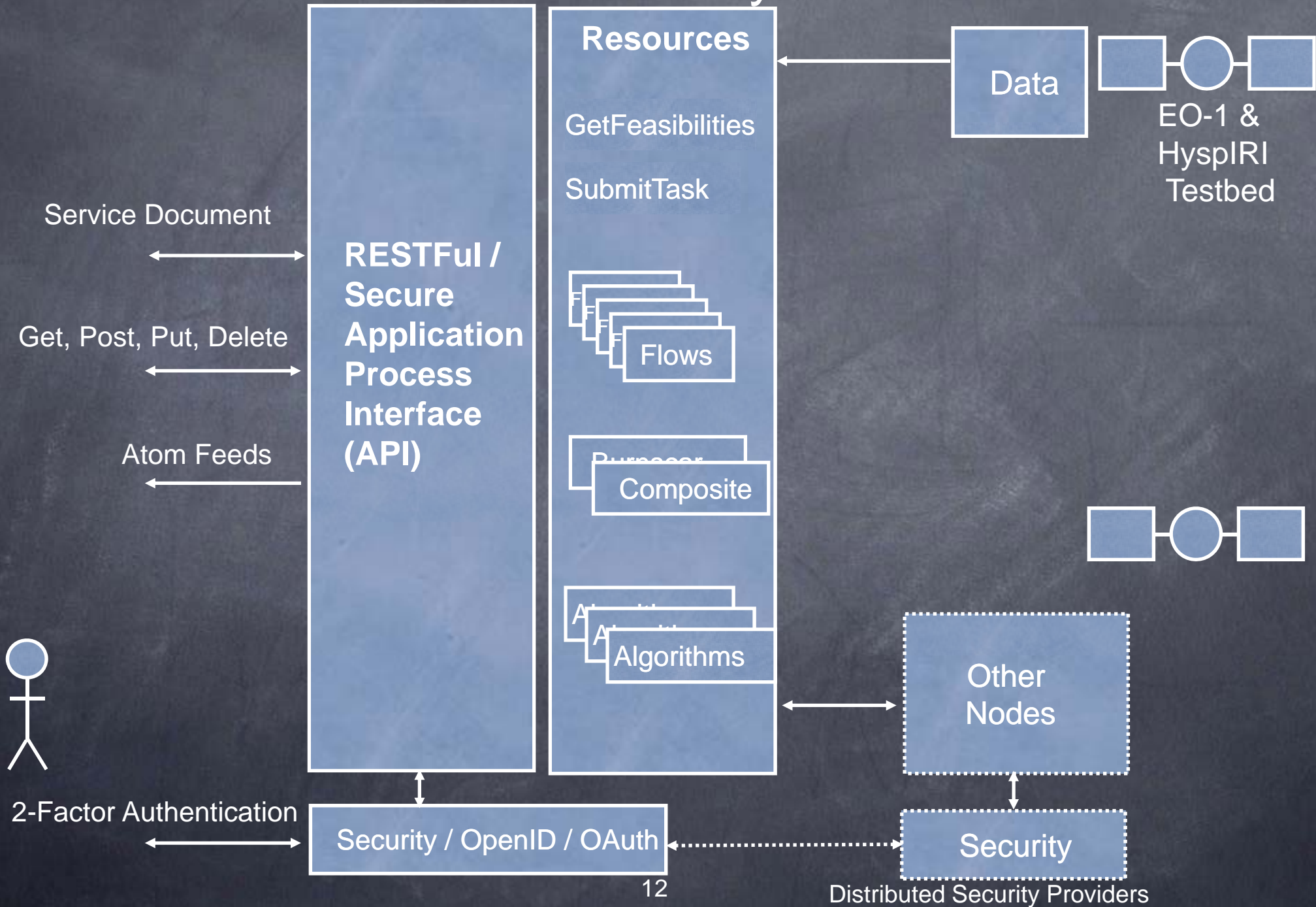


# NASA SensorWeb 3.0 Approach

SPS = Sensor Planning Service  
 OPSB = OGC Publish/Subscribe Basic  
 WfCS = Workflow Coverage Service  
 WCS = Web Coverage Service  
 WCPS = Web Coverage Processing Service  
 WPS = Web Processing Service



# NASA SensorWeb 3.0 Unified Restful Interface with Security



# One Example of Decreased Complexity to Develop Application Processing Interfaces (API's)

## REST RPC bindings specifications

| Interface s for SensorWeb 2.0 | Pages for specifications |
|-------------------------------|--------------------------|
| SPS 1.0                       | 186                      |
| WPS 1.0                       | 73                       |
| WCPS 1.0                      | 66                       |

## RESTful binds (aka AtomPub specifications)

| Interfaces for SensorWeb 3.0 | Pages for specification |
|------------------------------|-------------------------|
| Consolidated RESTful API     | 27                      |

Comparison does not include SOS, WNS/SAS, WFS, WfCS....

Increased complexity is a barrier to entry for development, sustaining engineering and usage.



# Examples of SensorWeb Usage for Disasters



**NAMIBIA**

# The 2009 Disaster

- *In February and March 2009, torrential rains increased water levels in the Zambezi, Okavango, Cunene and Chobe Rivers.*
- *This led to a 40-year flood in the Caprivi, Kavango and Cuvelai basins, affecting some 750,000 people (37.5% of the 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*











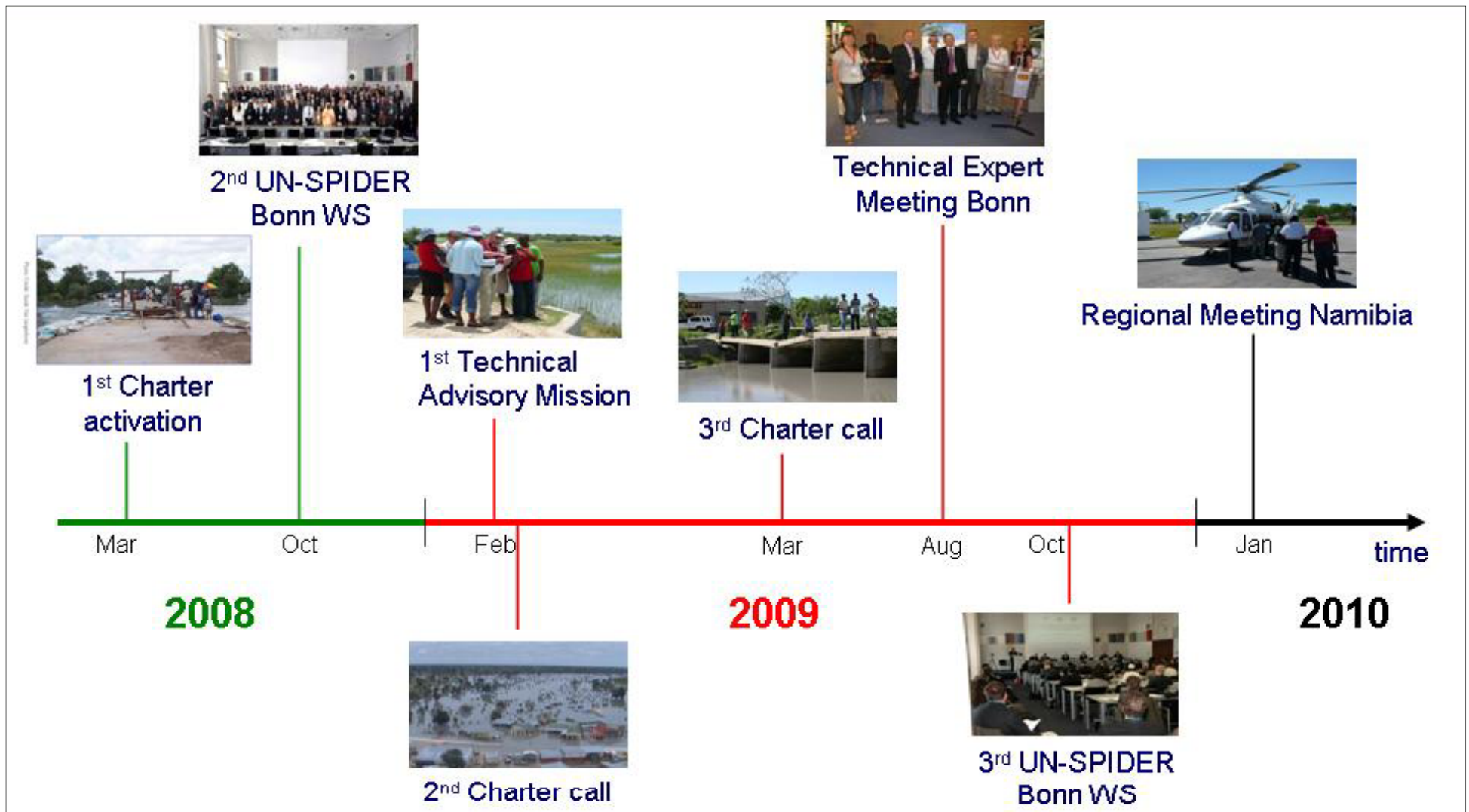


***Flooded village in Northern Namibia in viewed from helicopter by expert team during workshop in January 2010 (Photo: Dr. Joerg Szarzynski)***

# 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 Windhoek, 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 Tuate, 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

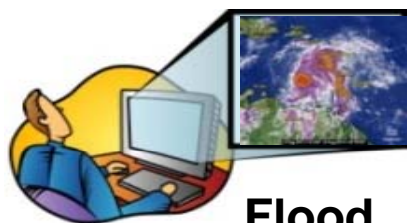


- Namibian Dept of Hydrology installing flood gauges and rain gauges
- Correlating ground measurements with satellite imagery to calibrate imagery and thus improve flood forecast models

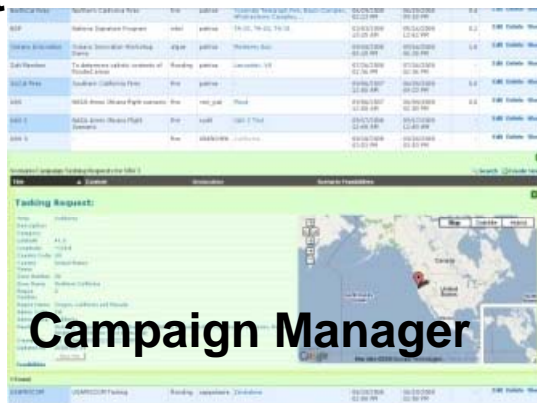


# Top Level Flood SensorWeb Functional Flow

Request for satellite imagery in area of interest



Flood alerts to automated tasking



Campaign Manager

Customized plan of needed satellite images

SPS



SPS



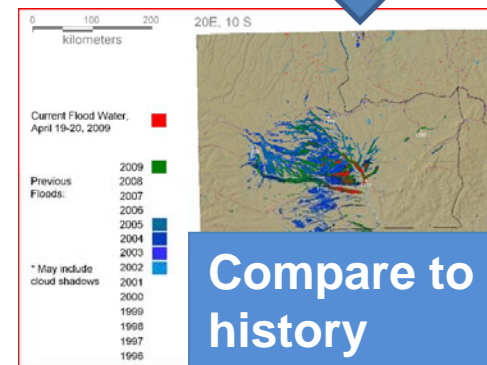
SPS



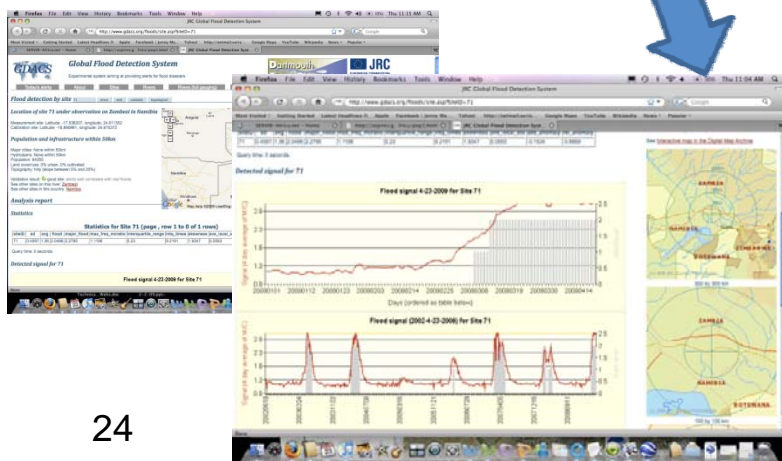
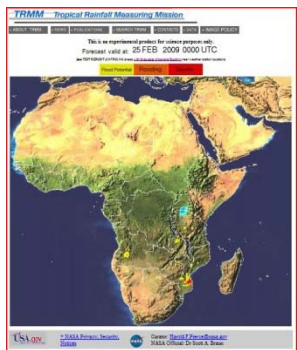
Flood conditions

Flood alerts to user

ground flood measurements To validate model



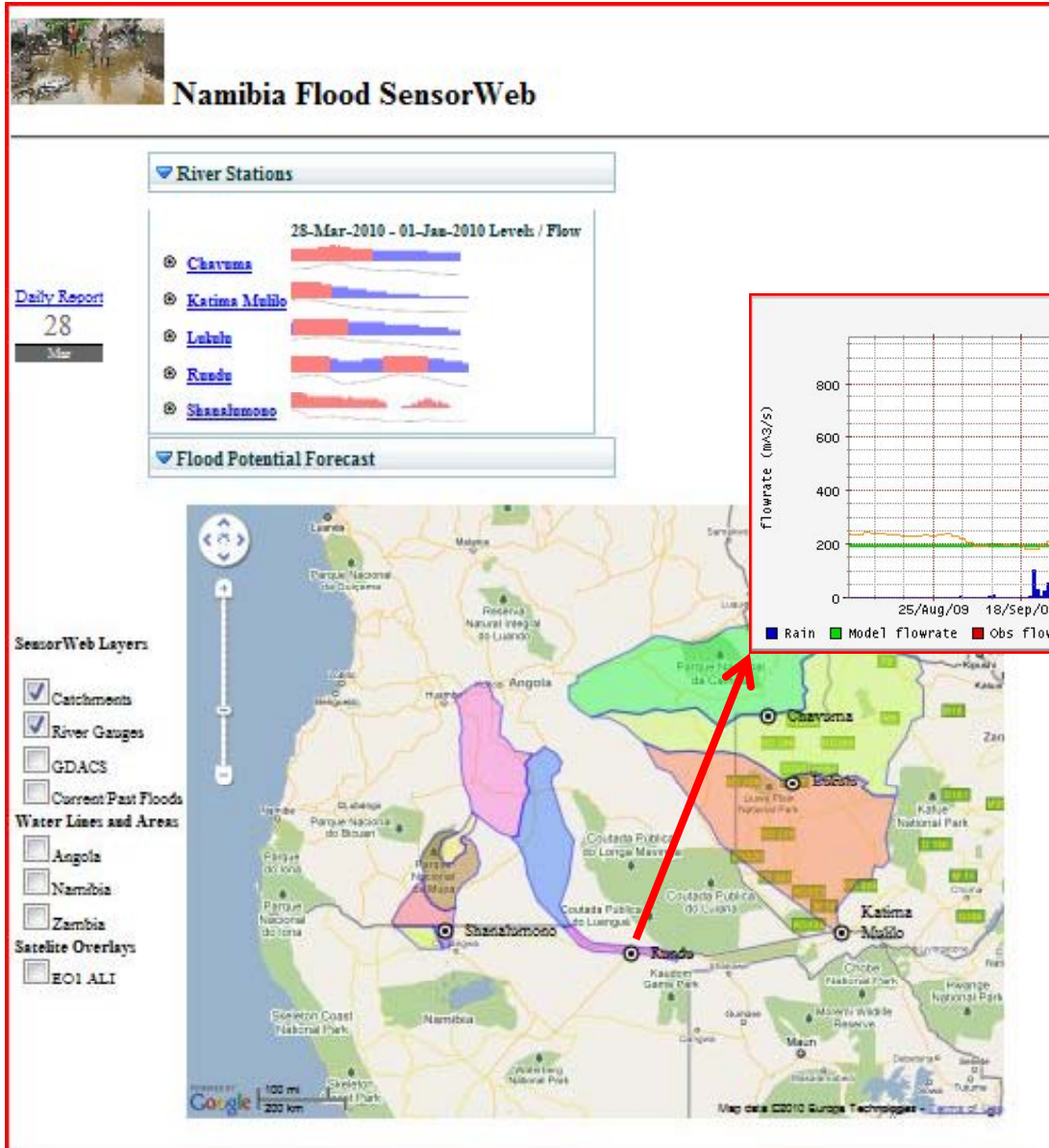
Compare to history



Improved Flood Prediction Model

\*SPS – Sensor Planning Service

# Namibian Flood Early Warning Prototype



## 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>



# 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

### 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/feedssummary.html?uri=http%3A%2F%2Fgeobpms.geobliki.com%2Fdata%2Fproducts%2Ffeeds%2F83080-B829-11DC

Freeorderer Customized Web Search

Freeorderer st augustine florida

Sage

Options\*

BBC News | News Front Pa...  
 Yahoo! News: Sports News  
 EO-1 Data Products  
 LA Freeway Fires Nov 2008  
 Uganda/Kenay Floods 11-1...  
 Uganda/Kenay Floods 11-1...  
 Sage Project News

EO-1 Task, Scene:EO1A170059200...

1. Ali tcapt 6 Product  
 2. Ali tcapt 5 Product  
 3. Ali tcapt 4 Product  
 4. Ali tcapt 3 Product  
 5. Ali tcapt 2 Product  
 6. Ali tcapt 1 Product  
 7. Ali br 1 Product  
 8. Ali rdi Product  
 9. Ali rvi Product  
 10. Ali gndvi Product  
 11. Ali ndvi Product  
 12. Ali cloud mask Product  
 13. Ali smoke Product  
 14. Ali active fires Product  
 15. Ali product swir Product  
 16. Ali product burn scar Product  
 17. Ali product vis Product

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

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

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

17. Ali product vis Product

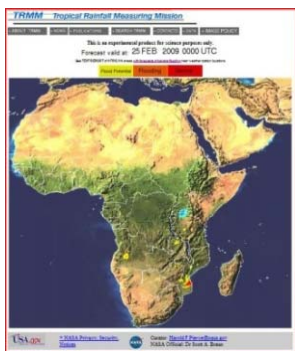
Visible Image using EO1 ALI Level1G and Vigtel Classifier (Red: band 5, Green:band 4 and Blue:band 3).

# Another Sample Application: Disease SensorWeb

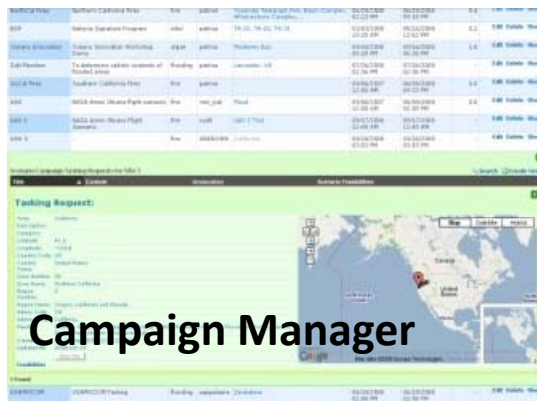


# Top Level Malaria Early Warning SensorWeb Functional Flow

Flood Predictions



Flood alerts



Campaign Manager

Customized plan of needed satellite images



SPS



SPS



SPS



Flood conditions



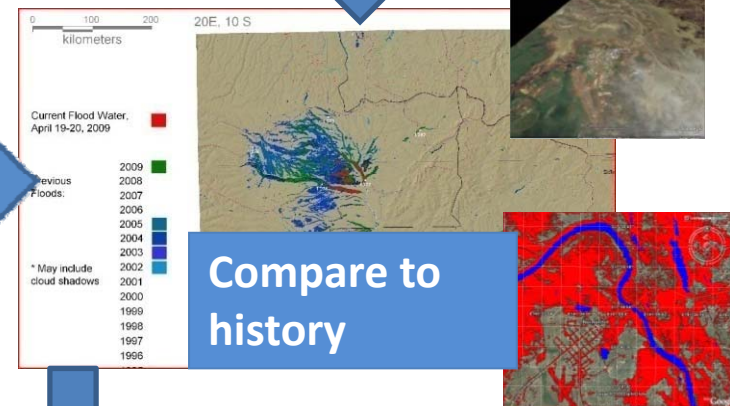
Flood alerts



Request for satellite imagery in area of interest

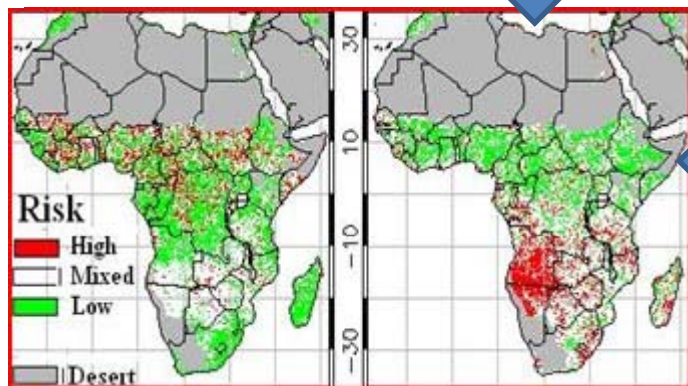


Climate & vegetation conditions



Compare to history

EFTB



Risk  
 High  
 Mixed  
 Low  
 Desert

Historical epidemiological data

Statistical disease risk alerts

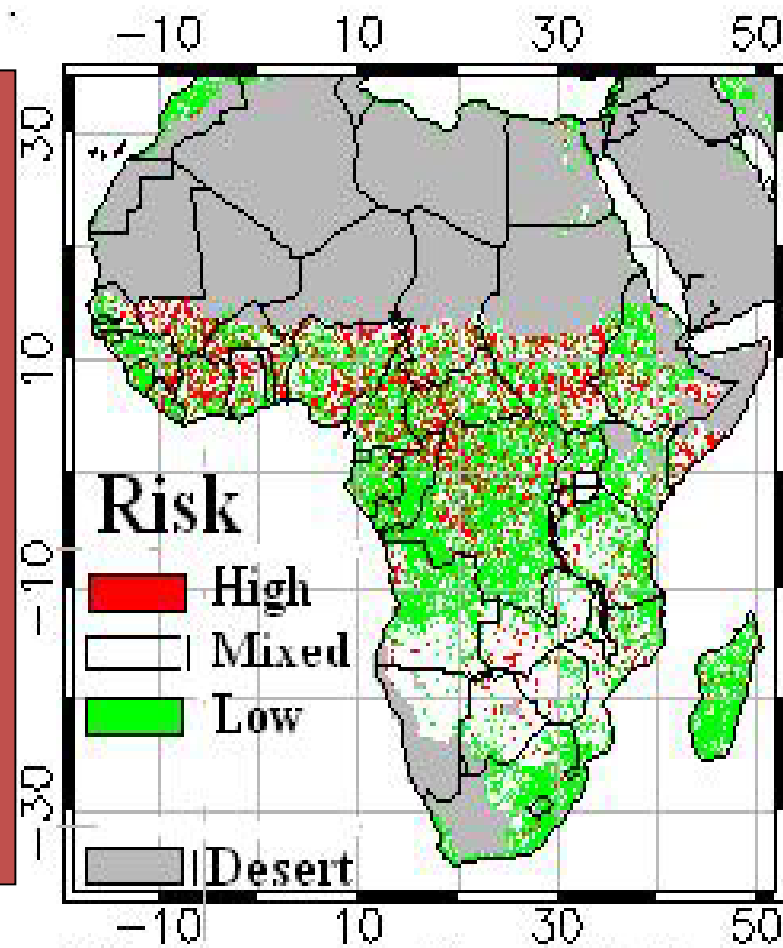


\*SPS – Sensor Planning Service

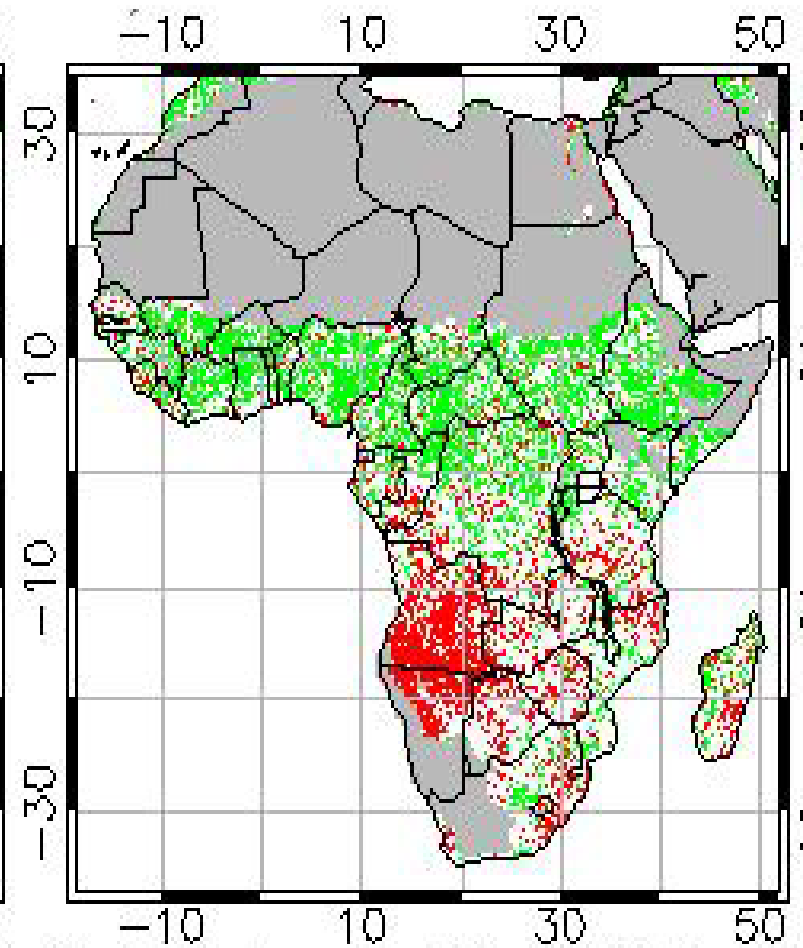
# Strategy: **WEATHER PROXY**

## **AUGUST 26, 2008**

Malaria risk map identifies priority areas and additional resources needed to fight epidemics effectively



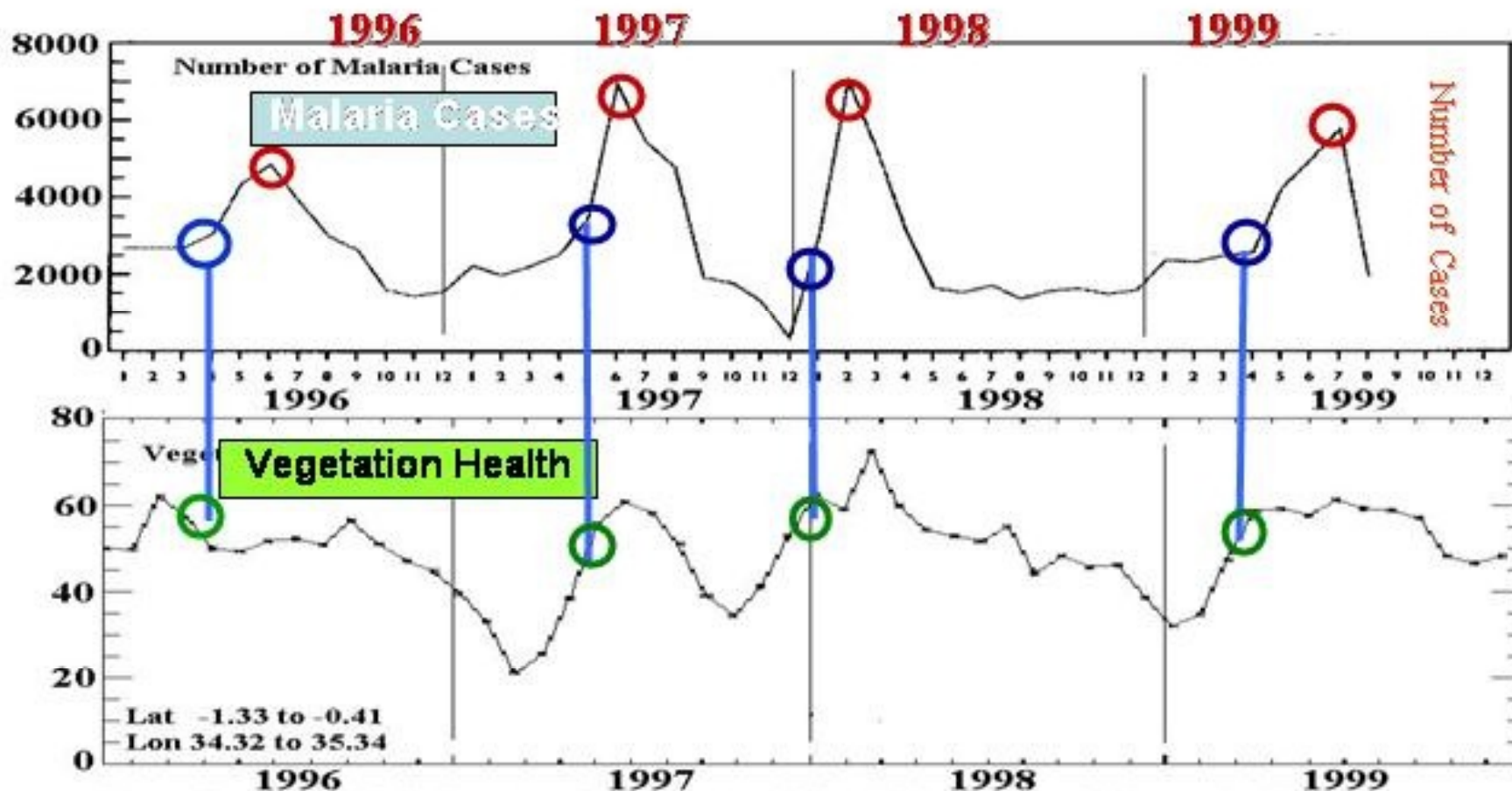
**Thermal Condition**



**Moisture Condition**

# **INTENSIVE MALARIA**

# Predicting Malaria in KENYA



Number of Malaria Cases in Kisii District Hospital, Western Kenya and AVHRR-based Vegetation Health Index (VHI)

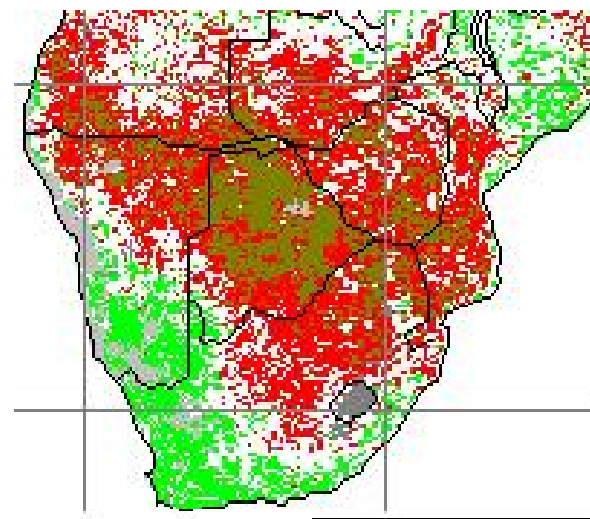
**VH provides up to 4 months advance malaria warning**

# NOAA Malaria Risk Indicators Area, southern Africa

Based on Vegetation Health Index system assessment conditions are very favorable (risk level 3 and 4) for malaria epidemic in

Northeast Namibia  
Most of Botswana (except south)  
Southern Angola  
Southeast Zambia  
Most of Zimbabwe  
Parts of Mozambique

Malaria Risk 5/6/10





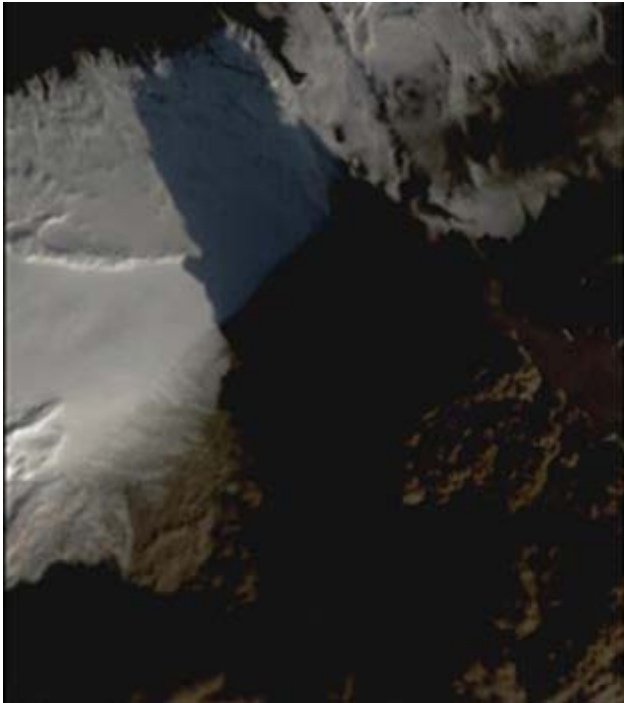
# Recent SensorWeb Acquisitions: Oil Slick in Gulf of Mexico and Volcano in Iceland



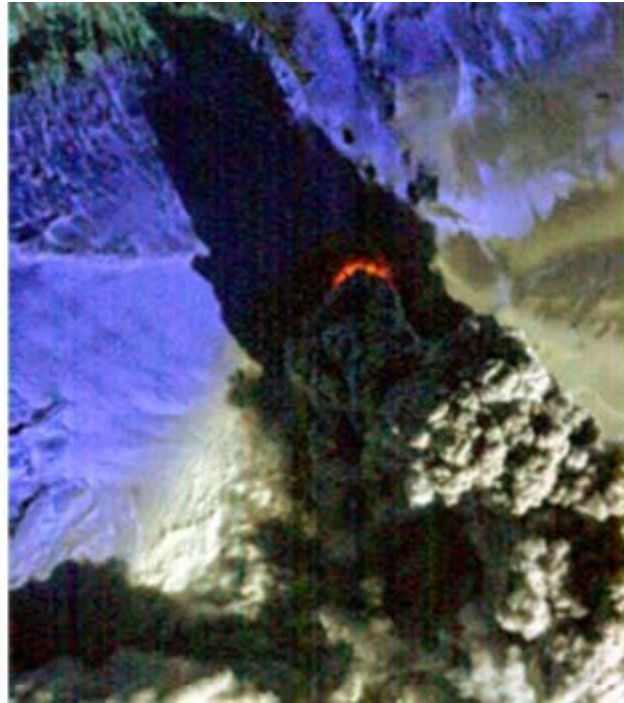
EO-1 Target  
Apr 25th

Oil Spill Initial  
Location

Iceland's Eyjafjallajökull volcano, acquired April 17, 2010, from the Hyperion instrument onboard NASA's Earth Observing-1 (EO-1) spacecraft.



Visible bands



Infrared bands

On Sat., April 17, 2010, the Hyperion instrument onboard NASA's Earth Observing-1 (EO-1) spacecraft obtained this pair of images of the continuing eruption of Iceland's Eyjafjallajökull volcano. In the left-hand image, created from visible wavelengths, new black ash deposits are visible on the ground, as well as nearby brilliant unsullied ice and snow and the volcano's brown, billowing plume. The plume's dark color reflects its large ash content. These fine particles of pulverized rock are carried high into the atmosphere, where they create a hazard for aviation and are carried long distances by the prevailing winds.

# Extending SensorWeb Onboard Satellites: Detecting Materials Onboard a Satellite



4 run onboard automatically

3 upload mobile agent

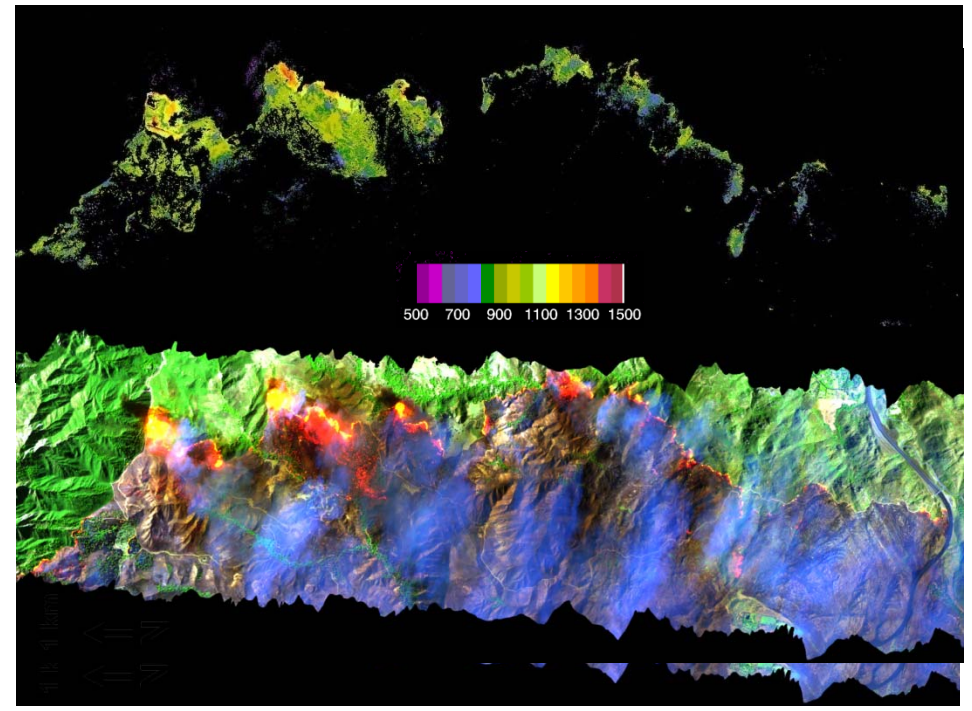
2 transform algorithm into mobile agent

5 download customized low-latency onboard generated data products

1 create, edit, test algorithms/classifiers for use onboard space-based sensors



HyspIRI Intelligent Payload Module (IPM)



Web Processing Coverage Service

Select scene: menu

Type Your Classifier In The Edit Box Below

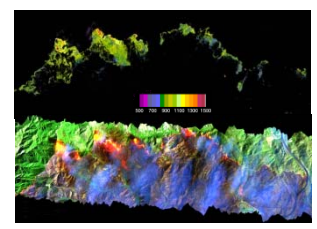
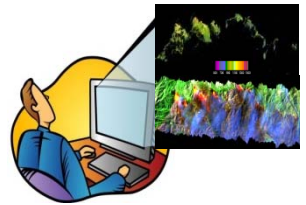
Classifier: 

```
for c in ( scene )
return
encode(
(char) ( ((c.0 / ((float)c.0 + c.1)) - (c.1 / ((float)c.0 + c.1))) > 0.6 ) * 255, "png" )
```

Or Select One From This Toolbox: Burnscar, NDVI, RDSI

Test It | Upload It >>

Print | ADD | DELETE... | check to confirm delete



# Extension of SensorWeb Onboard

# Use-Case

## NATO Seizes Tons of Bomb Material in Afghan Raid

Tuesday, November 10, 2009  
Associated Press

[Print](#) | [ShareThis](#)

**KABUL — International troops and Afghan police seized 250 tons of ammonium nitrate fertilizer — enough to make up to a couple hundred roadside bombs, the Taliban's most lethal weapon in what has been the deadliest year of the war, NATO announced Tuesday.**

Separately, video footage emerged of insurgents brandishing what appears to be limited stocks of U.S. ammunition in a remote area of eastern Afghanistan where eight Americans died in a battle last month.

NATO officials hoped Sunday's raid in the southern city of Kandahar would hurt Taliban militants, whose homemade bombs have become the biggest killer of U.S. and allied troops.

Acting on a tip, international forces and Afghan police discovered 1,000 100-pound bags of ammonium nitrate fertilizer and 5,000 parts for roadside bombs in a warehouse, the military said. After the initial find Sunday, an additional 4,000 100-bags of fertilizer were found in a nearby compound. The joint forces also made 15 arrests.

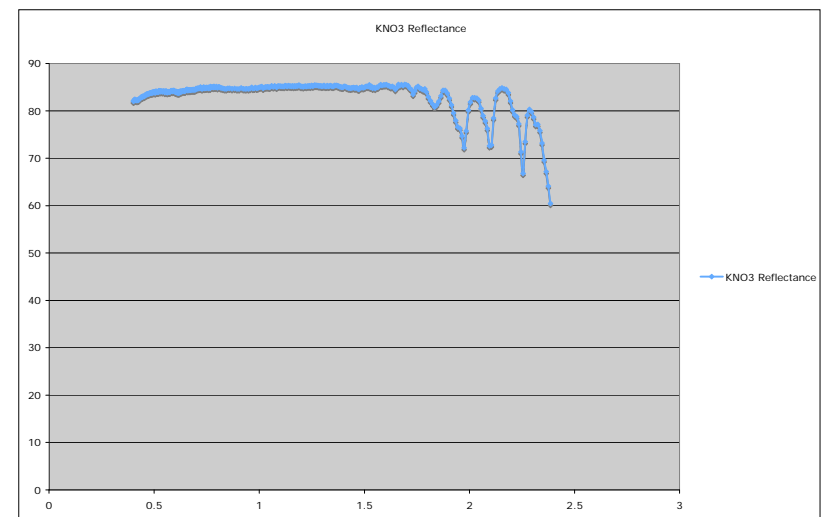
The seizure included enough fertilizer to make dozens to a couple of hundred roadside bombs, said John Pike, director of the military think tank Globalsecurity.org.

The insurgents have been successful manufacturing homemade bombs from materials such as fertilizer, which is easily available in agricultural areas of the south.



# Experiment with KNO<sub>3</sub> Detection - Atacama Desert, Chile

- User uploads signature of interest to spacecraft
  - Example: Potassium Nitrate (KNO<sub>3</sub>, Niter, saltpeter) (USGS Spectral Library) used in Fertilizer and Explosives. Major Source Can be Found in Atacama Desert, Chile.

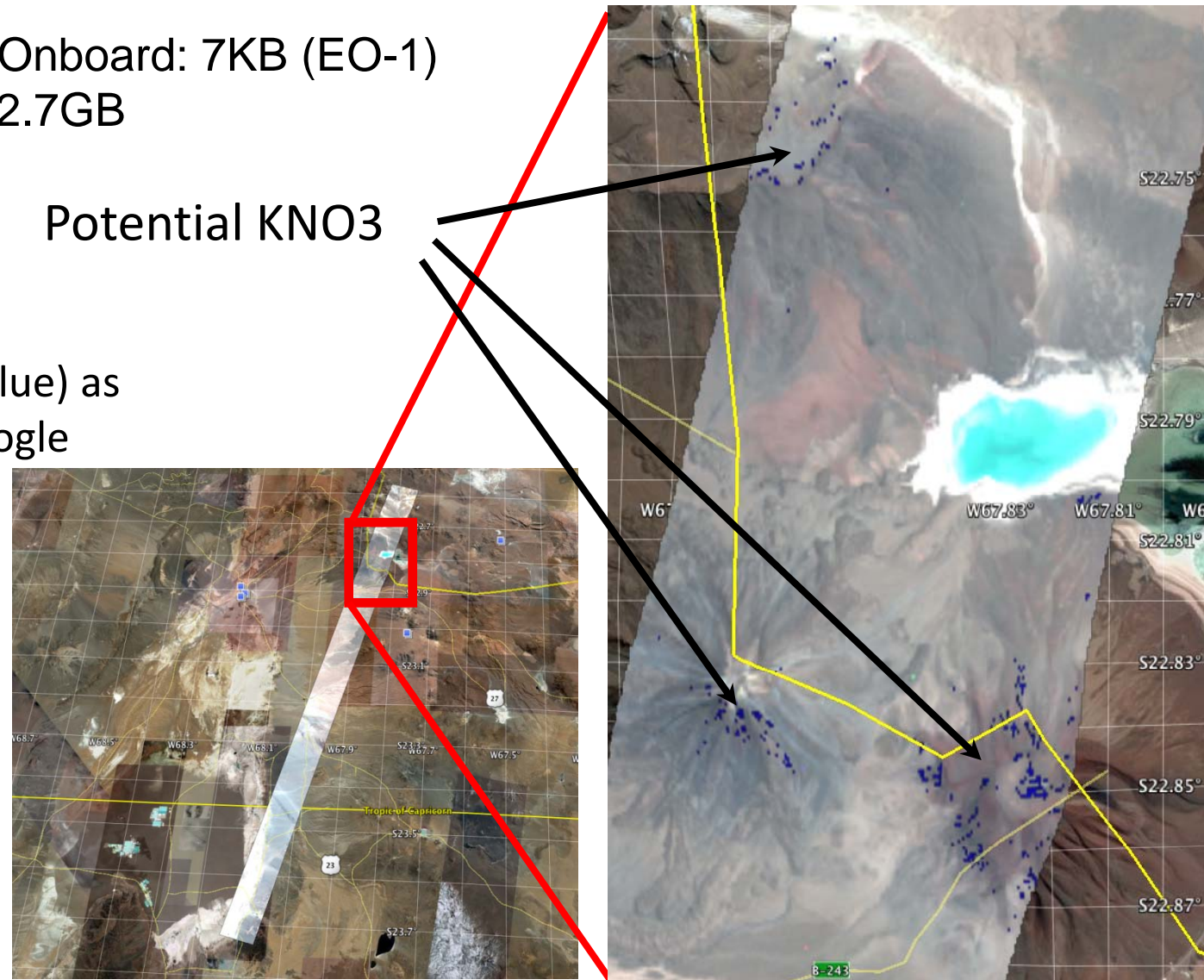




# Experiment with KNO<sub>3</sub> Detection - Atacama Desert, Chile conducted with Earth Observing 1

Product Generated Onboard: 7KB (EO-1)  
Original Raw Data: 2.7GB

Detected Pixels (blue) as  
Overlay on Google  
Earth



**In Less than 1 hour with  
a slow onboard CPU**



# Conclusion

- Decrease barrier to entry in SensorWeb domain by using simpler interfaces
- Easy development and usage will enable many societal benefits at lower budgets
- Disaster management is the perfect arena to test out these concepts because there is a large demand and need internationally

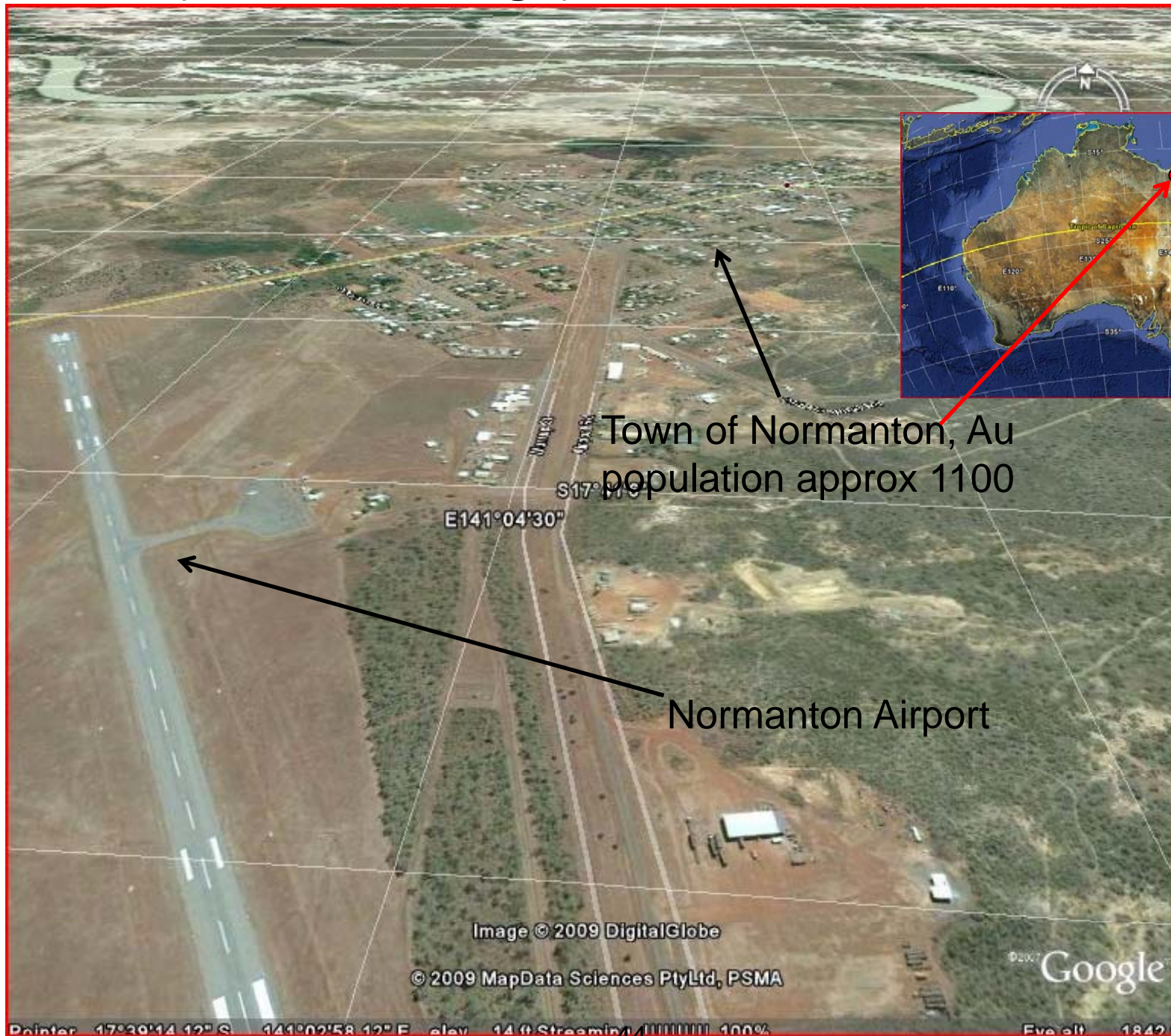
**Backup Charts**  
**Sample Application:**  
**Normanton, Australia,**  
**Flood SensorWeb**  
**February/March 2009**

# Normanton, Queensland, Australian Floods February 2009

## Data Simulation

- **Prediction:** TRMM-based Predictive Flood Potential Model
  - Robert Adler/University of Maryland –NASA/GSFC
- **Survey:** MODIS Flood Map
  - Robert Brakenridge/ Dartmouth Flood Observatory
- **Details:**
  - Earth Observing 1 Advanced Land Imager and Hyperion
    - NASA/GSFC – Image acquisition, flood map, automation
    - Mandl, Frye, Cappelaere
  - Radarsat Flood Image
    - MDA/Canadian Space Agency – Image acquisition
    - Space Research Institute NASU-NSAU, Ukraine – Flood Map Production
    - Serhiy Skakun and Natalia Kussul
  - Landsat Water Mask
    - Space Research Institute NASU-NSAU, Ukraine – Water Mask
    - Serhiy Skakun and Natalia Kussul
  - Formosat Flood Image
    - Taiwan National Program Science Office – Image acquisition
    - National Cheng-Kung University – Data processing
    - Cheng-Chien Liu

# Normanton Floods- Google Earth view from before floods (Quickbird image)



Town of Normanton, Au  
population approx 1100

Normanton Airport

E141°04'30"

S17°11'09"

Image © 2009 DigitalGlobe

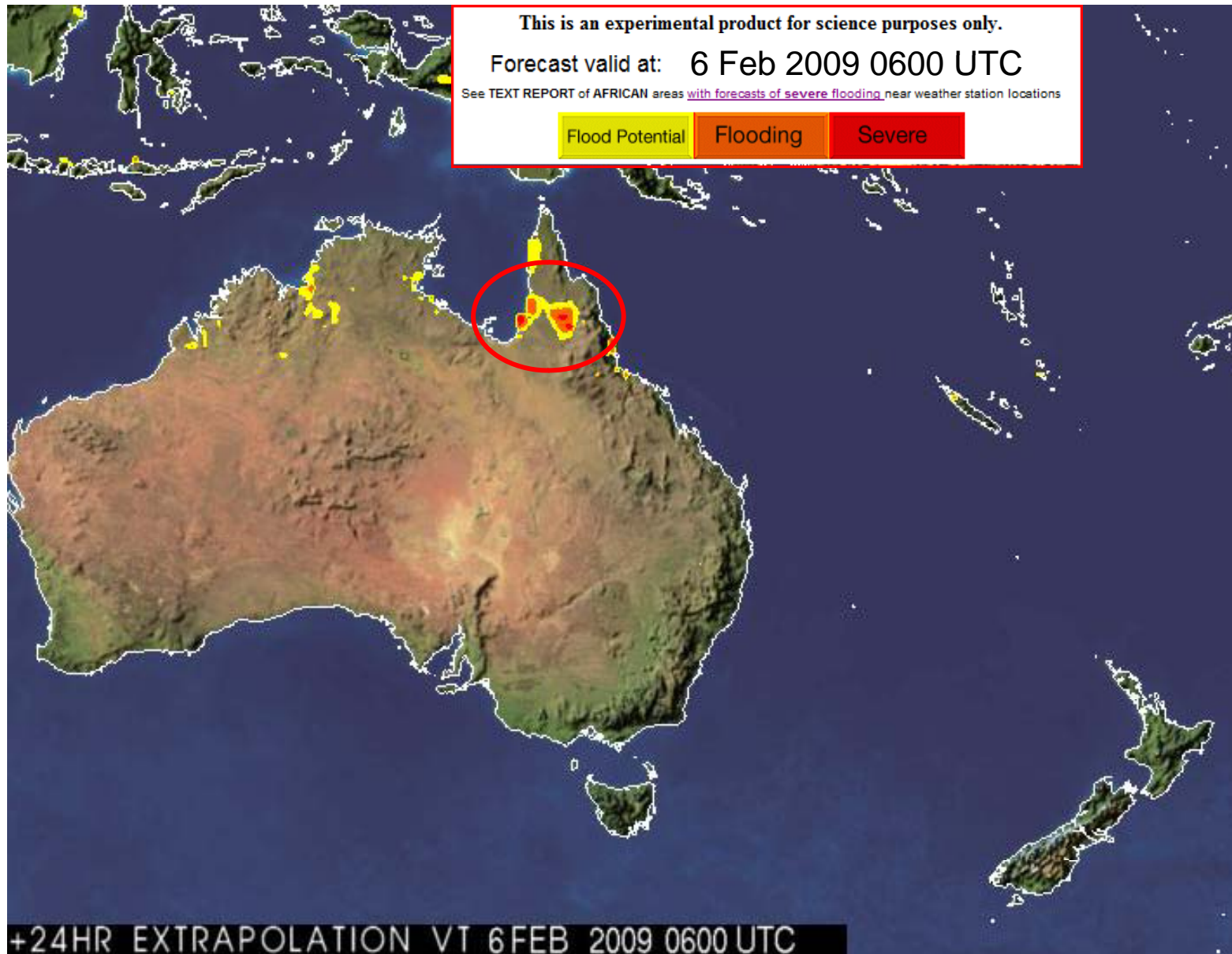
© 2009 MapData Sciences PtyLtd, PSMA

Google



# TRMM-based flood potential forecast for February 6, 2009

**\*\*Prediction\*\***



# Specific Water Level and Lat/Long Projected for Normanton Area

Use this lat/long to trigger other assets

**FORECASTED** Flood Potential at 02/06/2009 0600Z  
 Forecast generated at 02/05/2009 0600Z

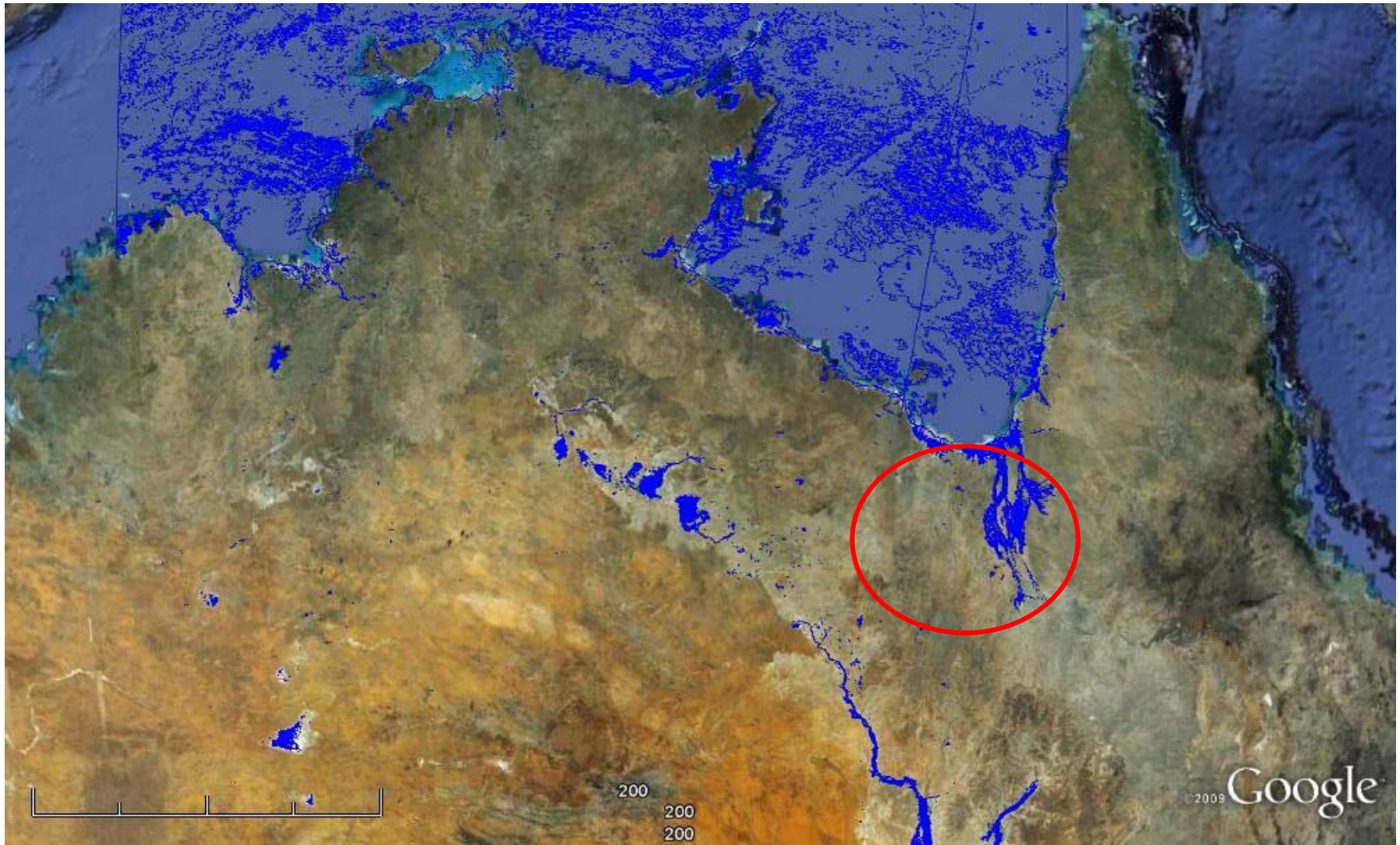
| COUNTRY    | WATER LEVEL & Latitude/Longitude | NEARBY LOCATION                                    |
|------------|----------------------------------|--|
| Argentina  | 134mm -32.63 -60.88              | ~ 33.96km from ROSARIO AIRPORT -32.92 -60.78       |
| Argentina  | 151mm -32.88 -61.13              | ~ 32.39km from ROSARIO AIRPORT -32.92 -60.78       |
| Argentina  | 163mm -33.13 -60.88              | ~ 23.41km from ROSARIO AIRPORT -32.92 -60.78       |
| COUNTRY    | WATER LEVEL & Latitude/Longitude | NEARBY LOCATION                                    |
| Australia  | 126mm -16.88 143.63              | ~ 107.79km from PALMERVILLE QU-16.00 144.07        |
| Australia  | 127mm -16.88 141.13              | ~ 89.09km from NORMANTON QU-17.67 141.08           |
| Australia  | 129mm -14.88 129.88              | ~ 84.91km from PORT KEATS AWS(AUT) NT-14.23 129.45 |
| Australia  | 129mm -16.38 143.13              | ~ 109.00km from PALMERVILLE QU-16.00 144.07        |
| Australia  | 131mm -15.63 141.63              | ~ 20.25km from KOWANYAMA QU-15.47 141.73           |
| Australia  | 137mm -16.38 141.38              | ~ 107.91km from KOWANYAMA QU-15.47 141.73          |
| Australia  | 138mm -16.38 143.38              | ~ 84.60km from PALMERVILLE QU-16.00 144.07         |
| Australia  | 139mm -16.38 143.63              | ~ 62.37km from PALMERVILLE QU-16.00 144.07         |
| Australia  | 148mm -18.13 146.13              | ~ 17.03km from CARDWELL QU-18.25 146.02            |
| Australia  | 181mm -16.63 141.13              | ~ 116.07km from NORMANTON QU-17.67 141.08          |
| Australia  | 187mm -16.88 143.88              | ~ 99.04km from PALMERVILLE QU-16.00 144.07         |
| Australia  | 201mm -16.38 141.13              | ~ 119.57km from KOWANYAMA QU-15.47 141.73          |
| Australia  | 216mm -17.63 146.13              | ~ 15.56km from INNISFAIL QU-17.52 146.02           |
| COUNTRY    | WATER LEVEL & Latitude/Longitude | NEARBY LOCATION                                    |
| Indonesia  | 170mm -8.13 120.38               | ~ 154.43km from ENDEH/IPI -8.80 121.60             |
| Indonesia  | 174mm -5.13 105.63               | ~ 51.55km from TELUKBETUNG/BRANTI -5.27 105.18     |
| Indonesia  | 179mm -5.38 105.63               | ~ 50.22km from TELUKBETUNG/BRANTI -5.27 105.18     |
| Indonesia  | 224mm -5.13 105.88               | ~ 78.64km from TELUKBETUNG/BRANTI -5.27 105.18     |
| COUNTRY    | WATER LEVEL & Latitude/Longitude | NEARBY LOCATION                                    |
| Mozambique | 169mm -25.88 32.63               | ~ 7.07km from MAPUTO/MAVALANE -25.92 32.57         |
| COUNTRY    | WATER LEVEL & Latitude/Longitude | NEARBY LOCATION                                    |



# MODIS Flood Extent on Google Earth as KML File

## February 18, 2009

**\*\*Survey\*\***



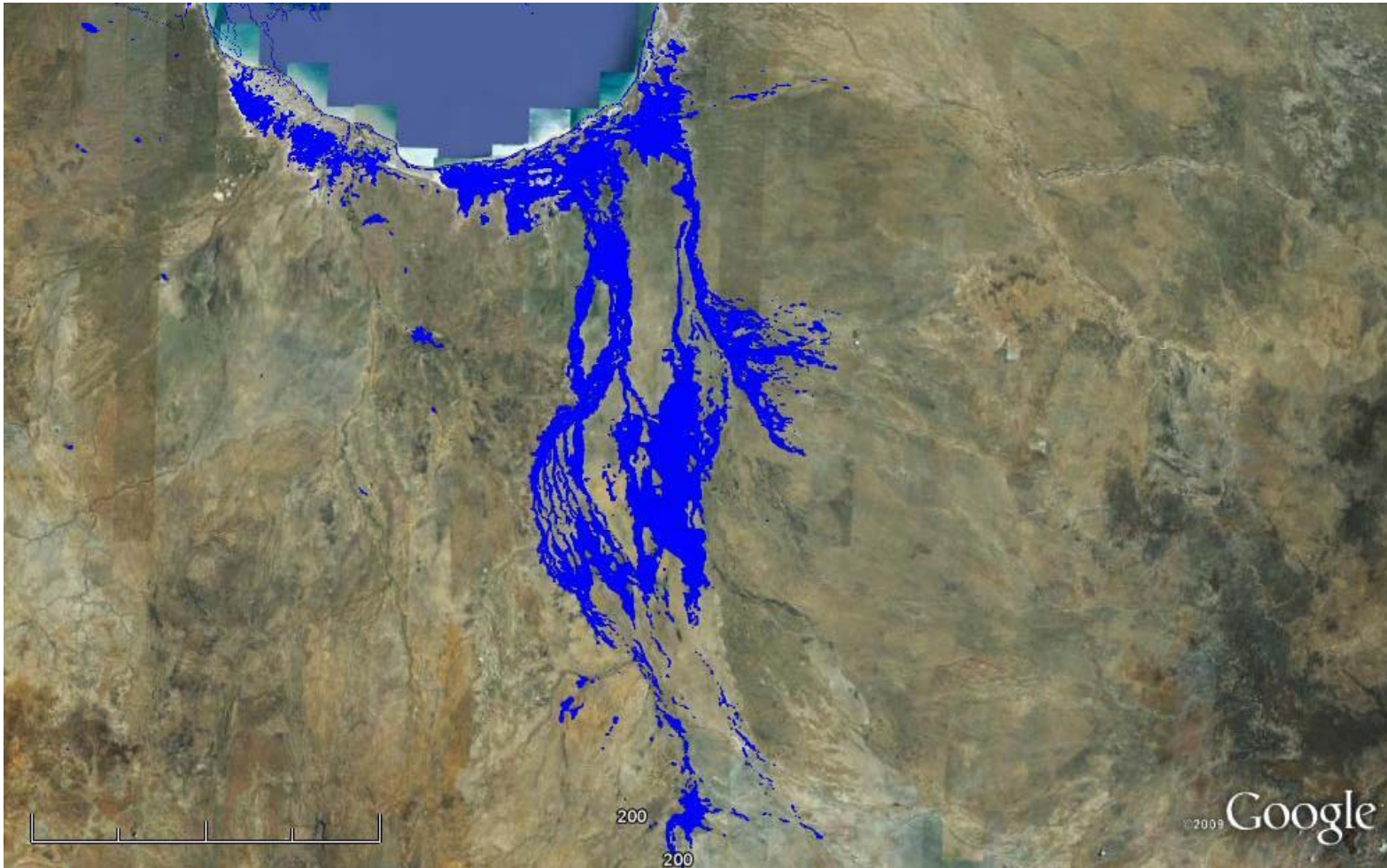
Robert Brakenridge – Dartmouth Flood Observatory



# MODIS Flood Extent on Google Earth as KML File

## February 18, 2009

**\*\*Survey- Zoom\*\***



Robert Brakenridge – Dartmouth Flood Observatory



# MODIS Flood Extent on Google Earth as KML

File February 18, 2009

**\*\*Survey- Closeup Normanton\*\***



Robert Brakenridge – Dartmouth Flood Observatory

# Article on Normanton Floods from the Northwest Star

## Minister faces hazards in Gulf

TROY ROWLING

2/4/2009 9:05:00 AM

OVERFLOWING **sewerage, crocodiles and mosquito-borne diseases** were among the possible hazards Queensland Emergency Services Minister Neil Roberts faced when he arrived in the Gulf yesterday. Mr Roberts visited Karumba and Normanton to gauge the impact the floodwaters were having on the region.

And according to a statement released by Carpentaria Shire Council yesterday, there were quite a few issues making an impact on the isolated communities.

A spokesperson for Carpentaria Shire Council said the council was anticipating possible sewage overflows in the towns due to the inundation of pump stations.

The spokesperson also said there had been increased sightings of large crocodiles in the floodwaters surrounding Normanton and that Queensland Health had recommended the public avoid wading and playing in floodwaters due to mosquito-borne diseases.

However, despite the possible dangers, the Minister pressed on with his trip undeterred. "I'm here to be shown around the district and to talk to locals about the impact of the flooding," Mr Roberts said. "I really need to take advice from local governments and emergency services personnel on the ground. So I'll be waiting for their advice about what other measures need to be taken."

The Carpentaria Shire Council spokesperson said another issue they planned to discuss with the minister was the upgrade of the Einasleigh and Gilbert crossings. They said this would enable road access for the essential re-supply of goods. The isolated communities were currently reliant on food drops via aircraft and a fortnightly barge service from Cairns to Karumba to supply food, fuel and essential items to residents in the area.

With the Norman River continuing to rise, the communities could be cut off for a further six weeks. Carpentaria Shire Council and Emergency Management Queensland met with local retailers and suppliers to discuss re-supply sustainability.

## Article on Normanton Floods from the Northwest Star (continued)

Retailers were encouraged to monitor stocks and liaise with the Council to ensure all residents had adequate food and other essential items.

A business advisor from the Department of Tourism, Regional Development and Industry was flown into Normanton at the weekend to help the businesses manage the effects of ongoing flooding on their bottom line.

His feet firmly on dry ground, Mr Roberts took time during his brief stopover in Mount Isa to thank local emergency services leaders for their hard work.

“I’ve received very good feedback from the Mayors in the local communities about the work and support the emergency service crews are doing,” he said.

# Normanton Airport Ground View 2-15-09



<http://blogs.abc.net.au/.shared/image.html?/photos/uncategorized/2009/02/15/normanton.jpg>



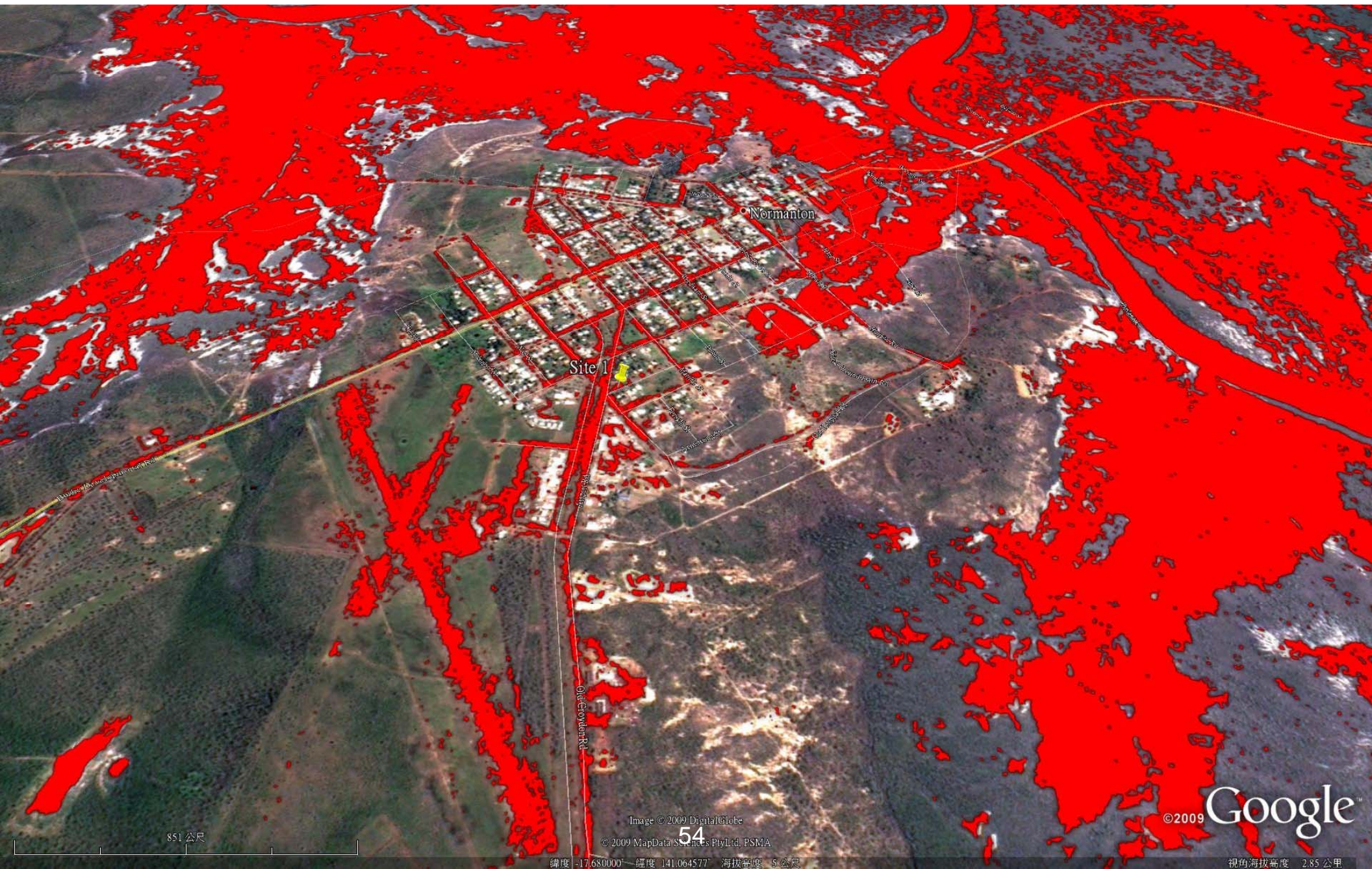
# Normanton Airport View 2 2-15-09



<http://blogs.abc.net.au/.shared/image.html?/photos/uncategorized/2009/02/15/normanton.jpg>

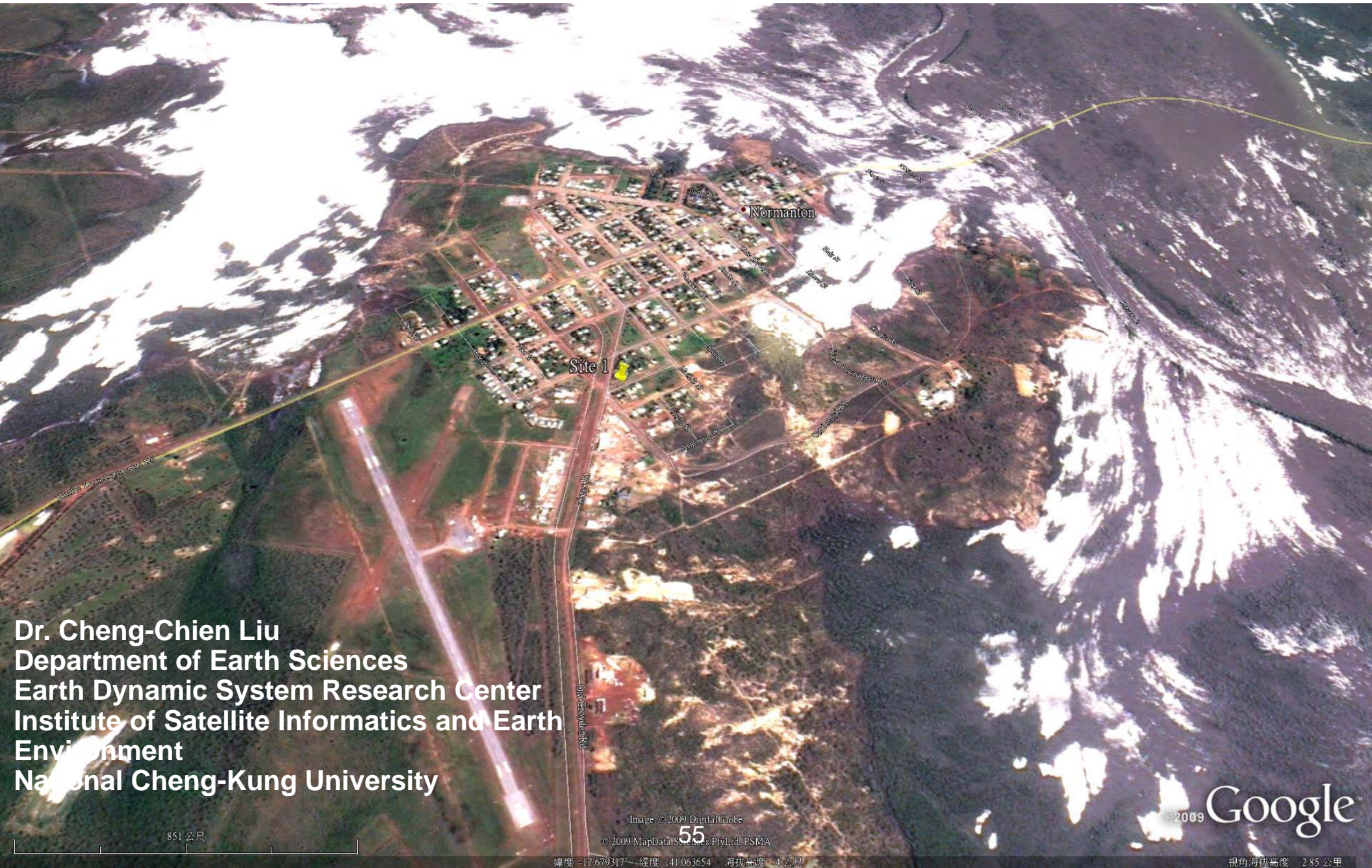


# Radarsat-2 Water regions 14 Feb 2009)





# Formosat-2 image 18 Feb 2009



Dr. Cheng-Chien Liu  
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Earth Dynamic System Research Center  
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Environment  
National Cheng-Kung University

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緯度 -17.679317 經度 141.063654 海拔高度 4公尺 視角海拔高度 2.85 公里



# Normanton Floods - February 18, 2009 Zoom 1



Main road to  
Hospital flooded

Hospital

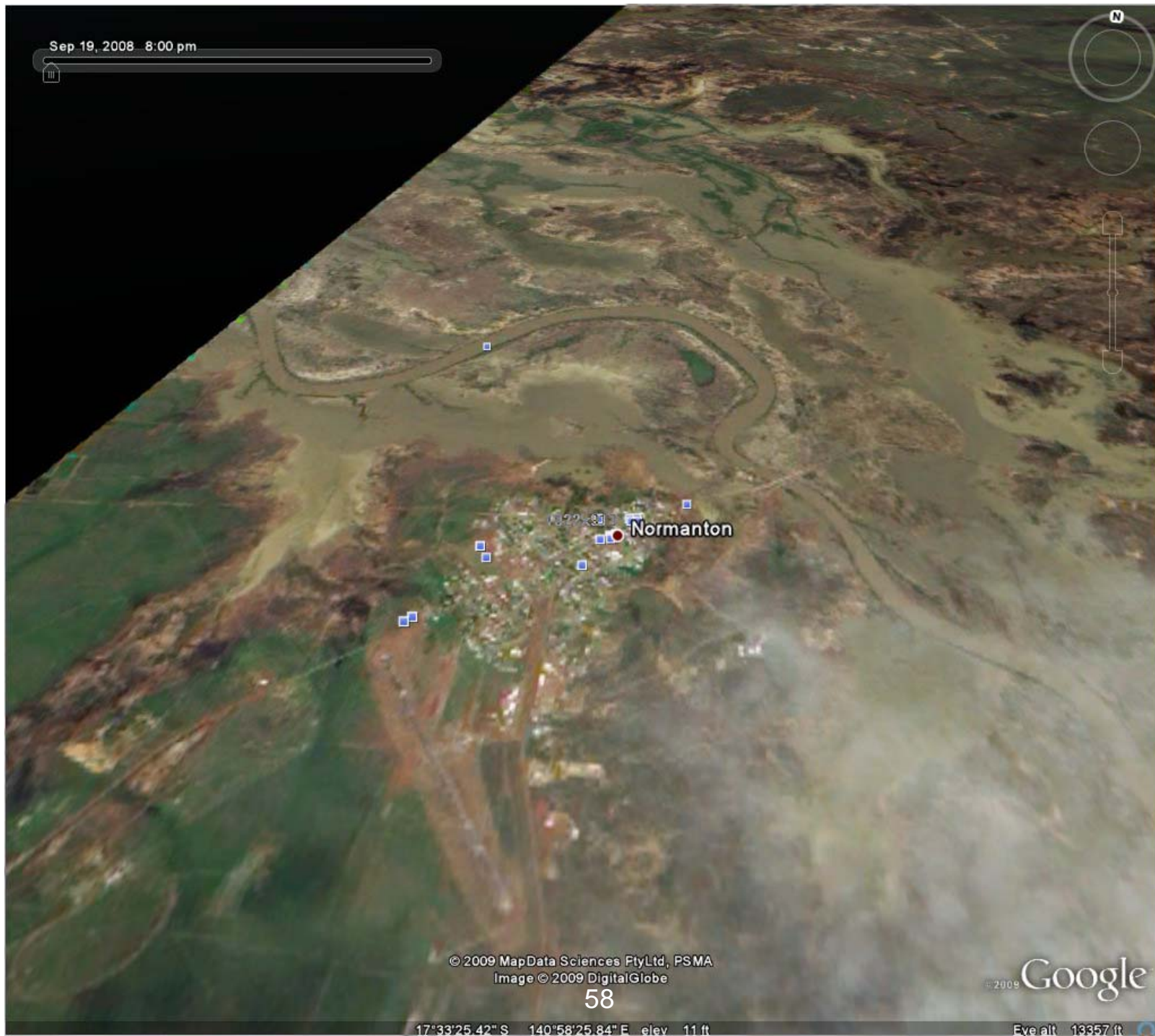


# Normanton Floods - February 18, 2009 Zoom 2





# EO-1 Image March 11, 2009



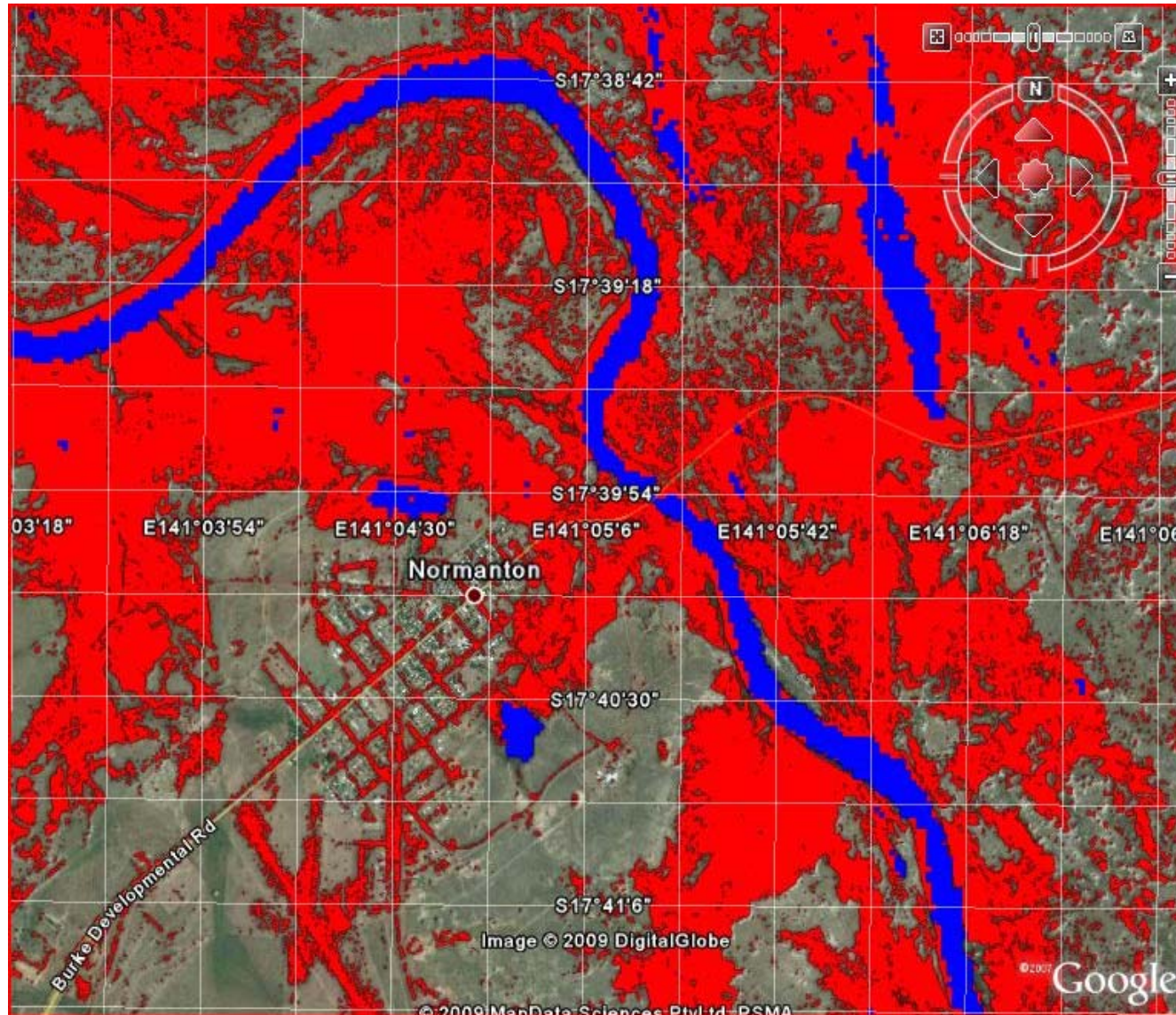


# Radarsat/Landsat Flood Map

Radarsat Image 2-14-09 (red), 3 meter resolution

Landsat Image pre-flood 5-6-02 (blue), 30 meter resolution

Flood maps produced by the Space Research Institute NASU-NSAU, Ukraine

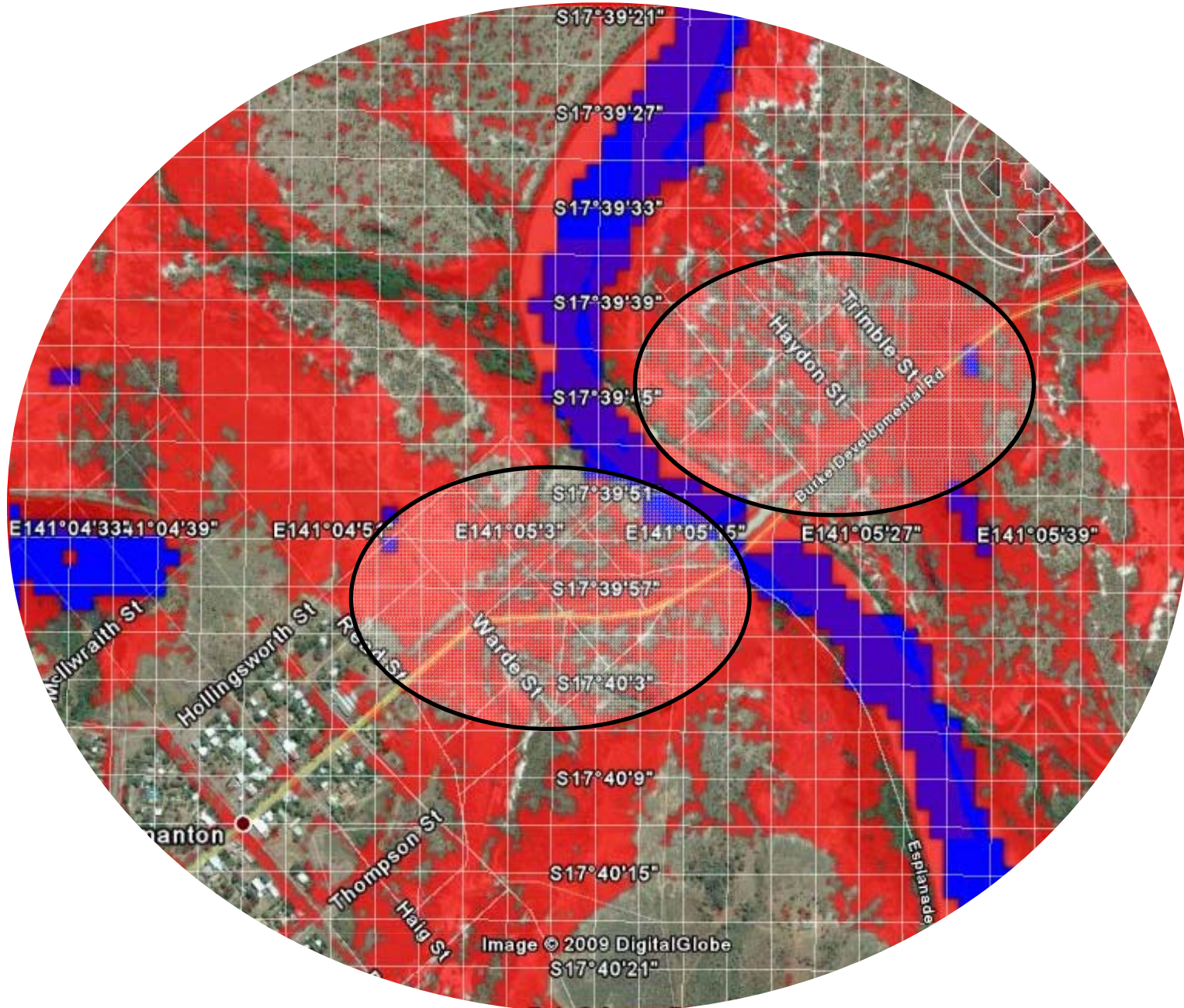


Red – flood waters  
Blue – Existing waters

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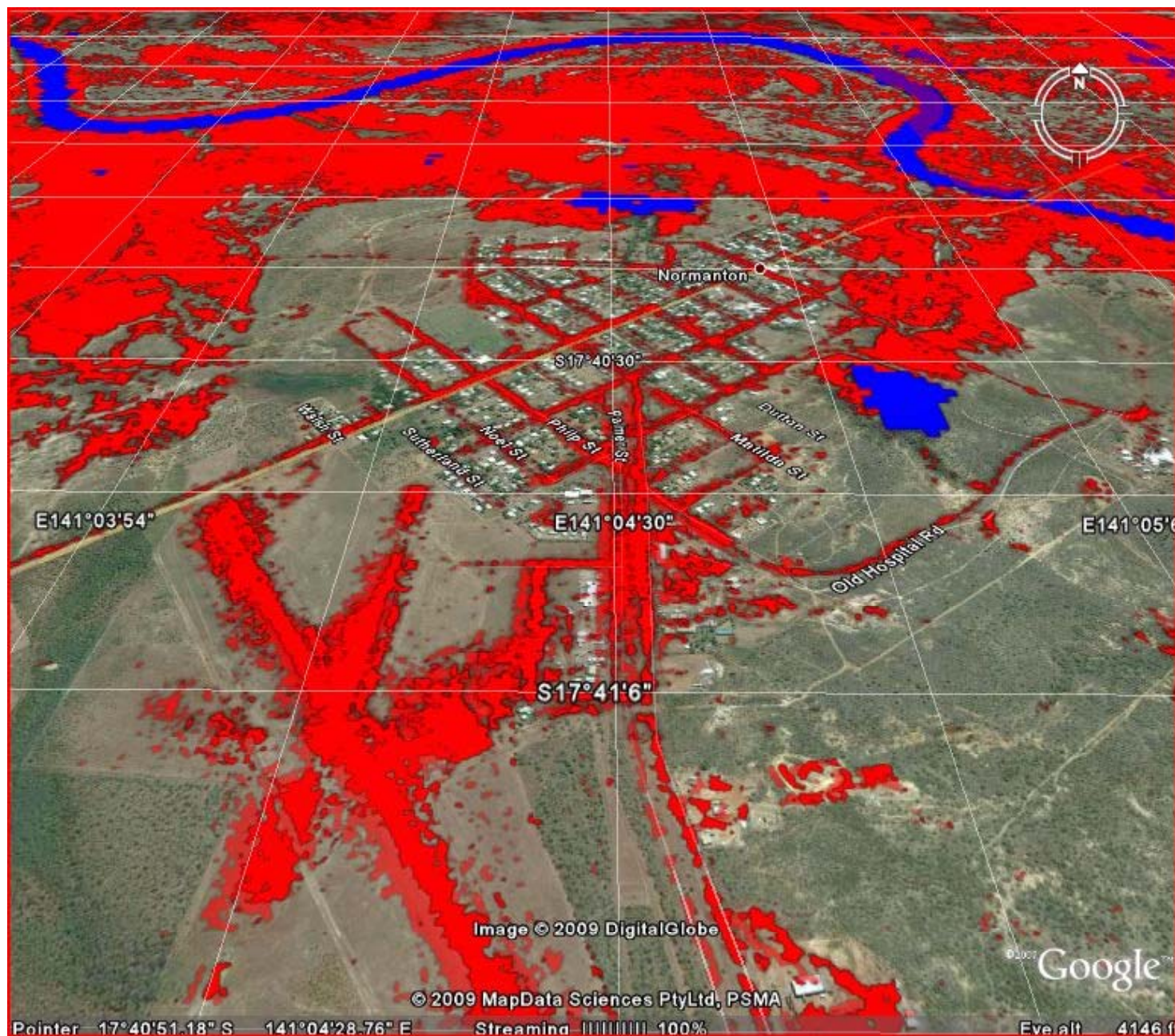


# Find Flooded Streets



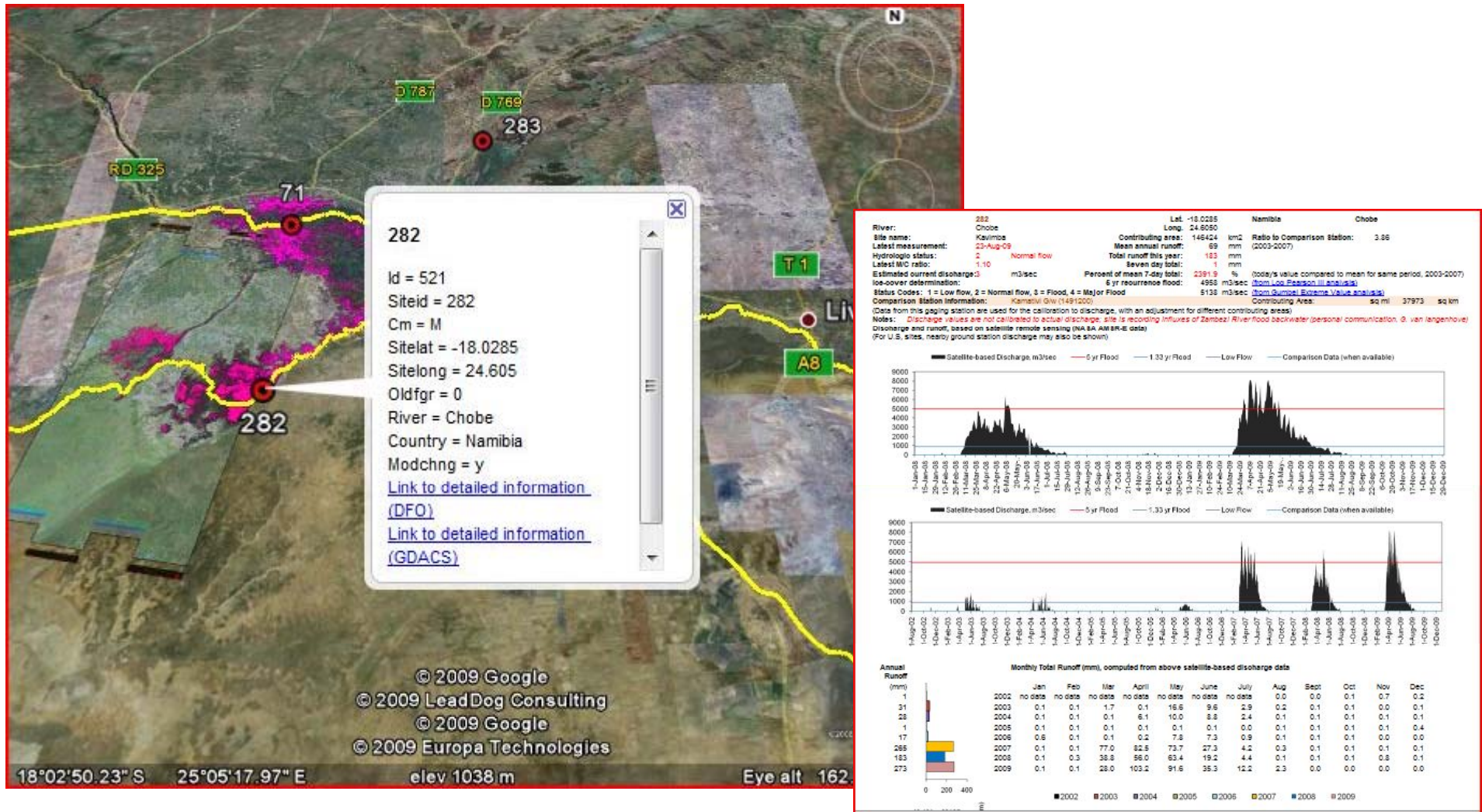


# Normanton with Landsat 7 5-7-02, Radarsat 2 Flood Extent Overlay February 14, 2009 and February 17, 2009 3m resolution





# EO-1, Radarsat, River Watch Example



Goal is to calibrate River Watch measurements which use AMSR-E to calculate river flows and thus provide early warning for flooding downstream