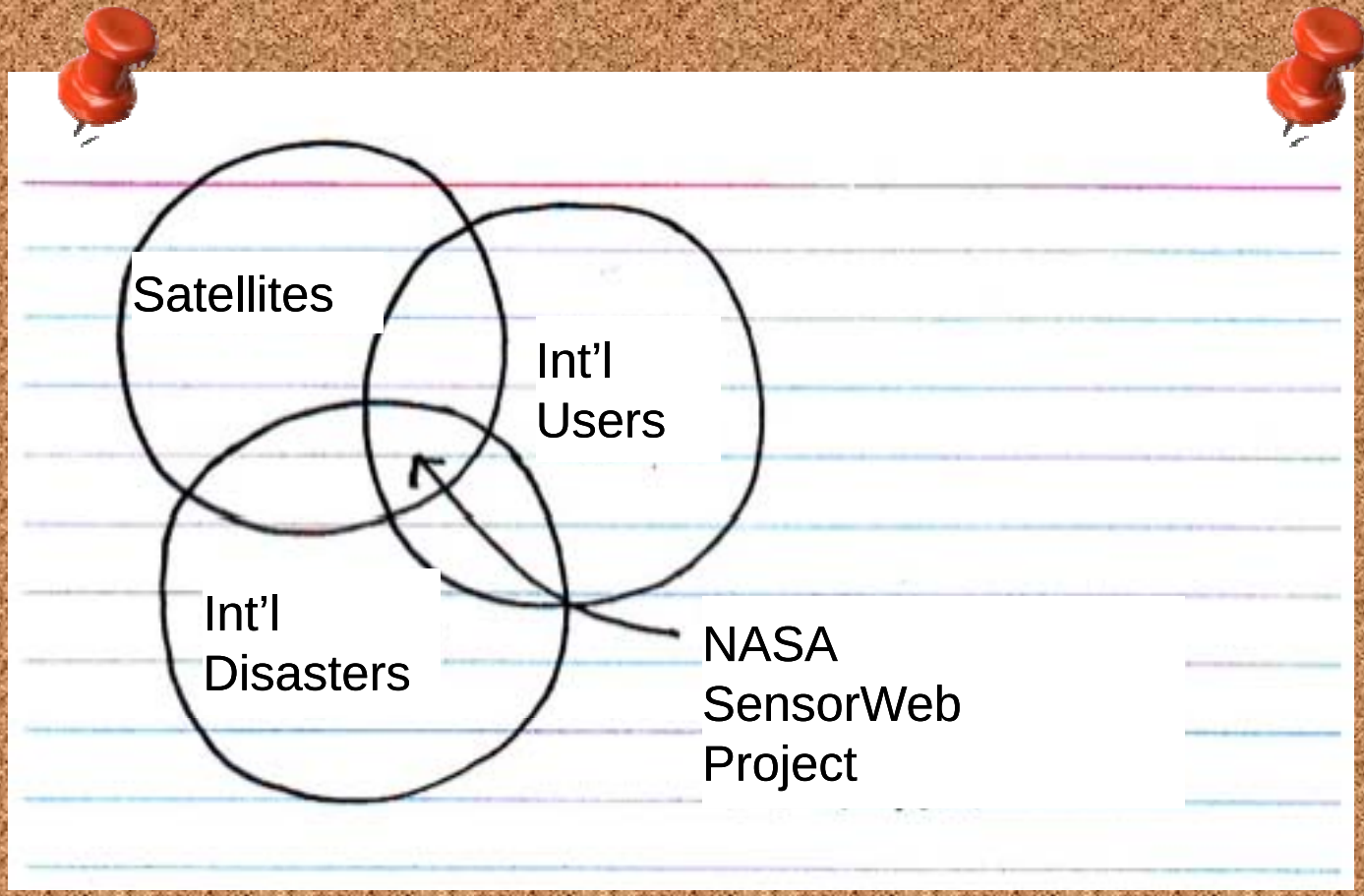
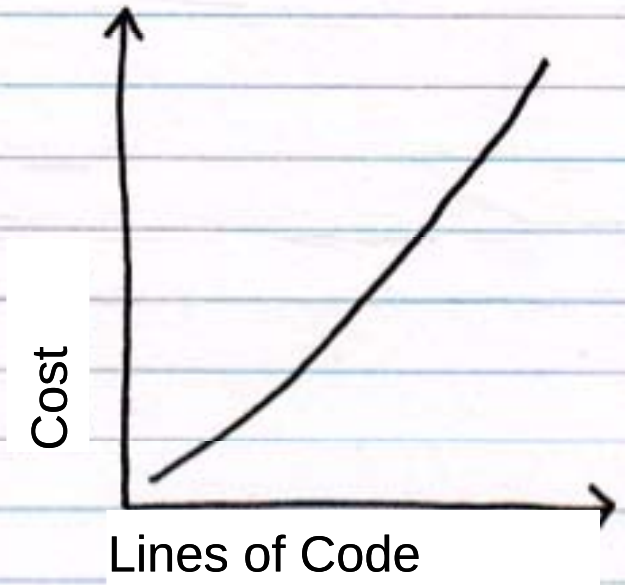
NASA SensorWeb and OGC Standards for Disaster Management

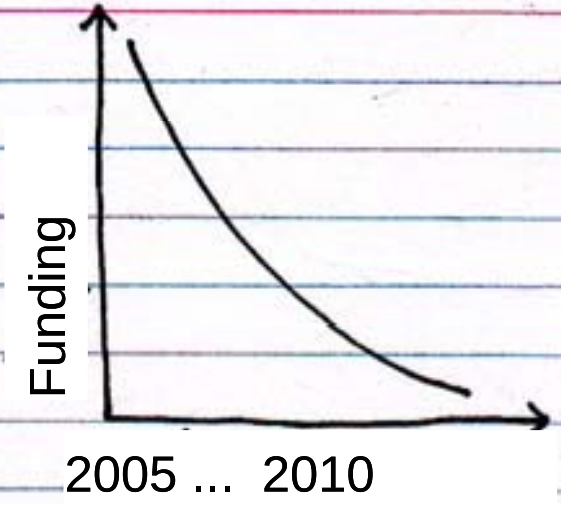
Dan Mandl 6/18/10
NASA/GSFC


Satellites
Int'l Users
Int'l Disasters
NASA SensorWeb Project

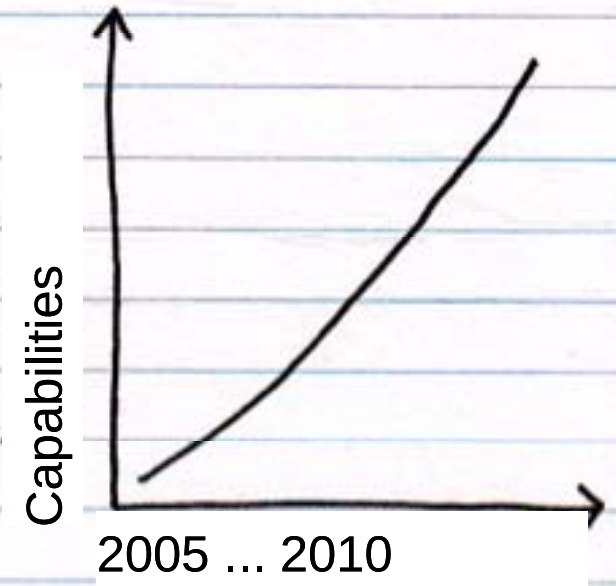
For big software projects, cost is a function of amount of code



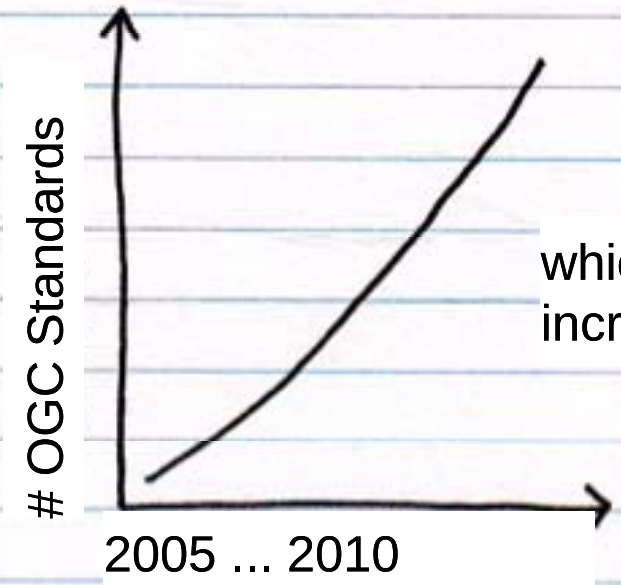
Our Reality...



But we have made some good progress...

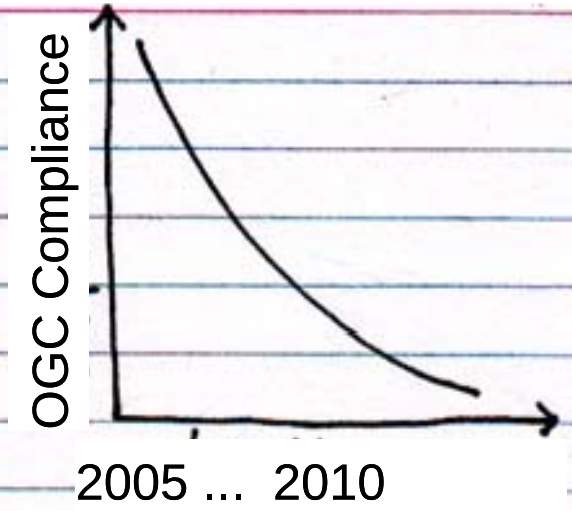


Number of OGC Standards Has Increased Significantly



which would
increase our cost!

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

floods, fires, volcanoes etc

Sensor Data Products

Data Processing Node

- Web Coordinate Transformation Service (WCTS)
- Web Processing Service (WPS)
- Web Coverage Service (WCS)

Internet

SWE Node

SWE Node

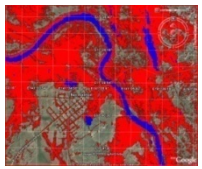
SWE Node

In-situ Sensor Data Node

UAV Sensor Data Node

- Web Map Service (WMS)
- Web Feature Service (WFS)
- Sensor Planning Service (SPS)
- OGC Pub/Sub (OPSB)
- Satellite sensor data product
- Sensor Observation Service (SOS)
- GeoTorrent Distribution Service
- RSS Feeds

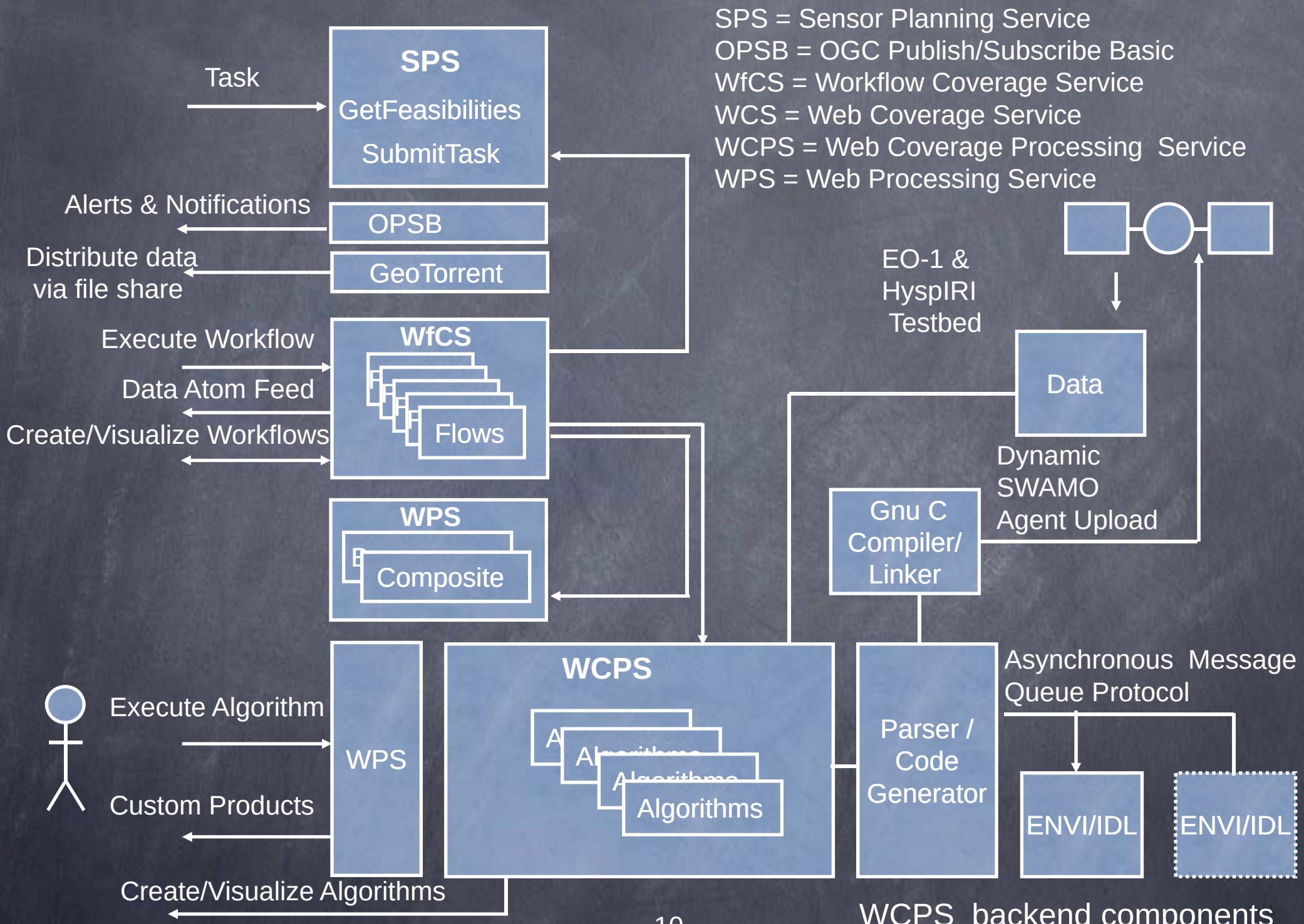
Campaign Manager API



Identity Management Service (OpenID 2.0)

Components outlined in red are part of NASA generic SensorWeb toolbox

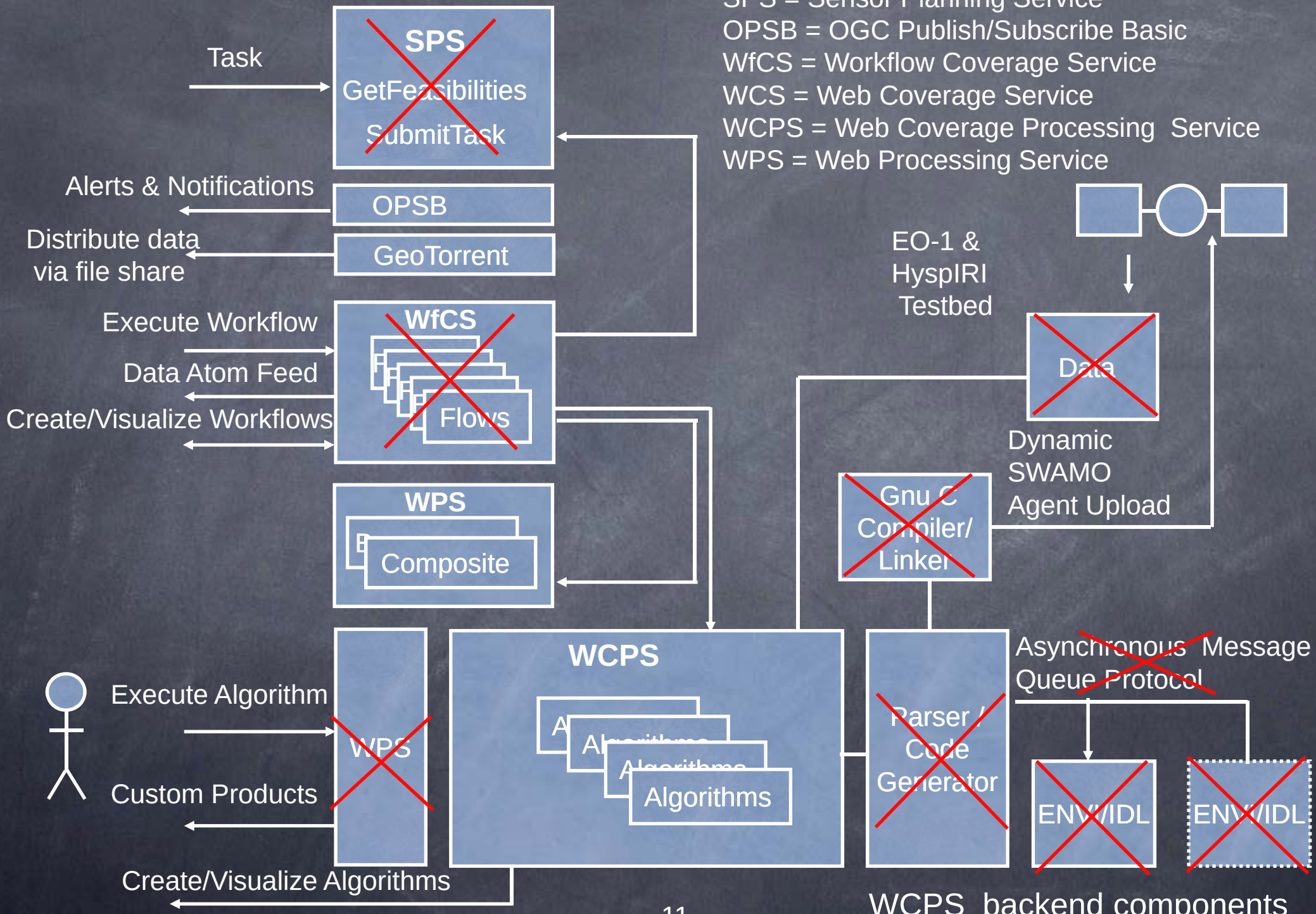
Present NASA SensorWeb 2.0



WCPS backend components

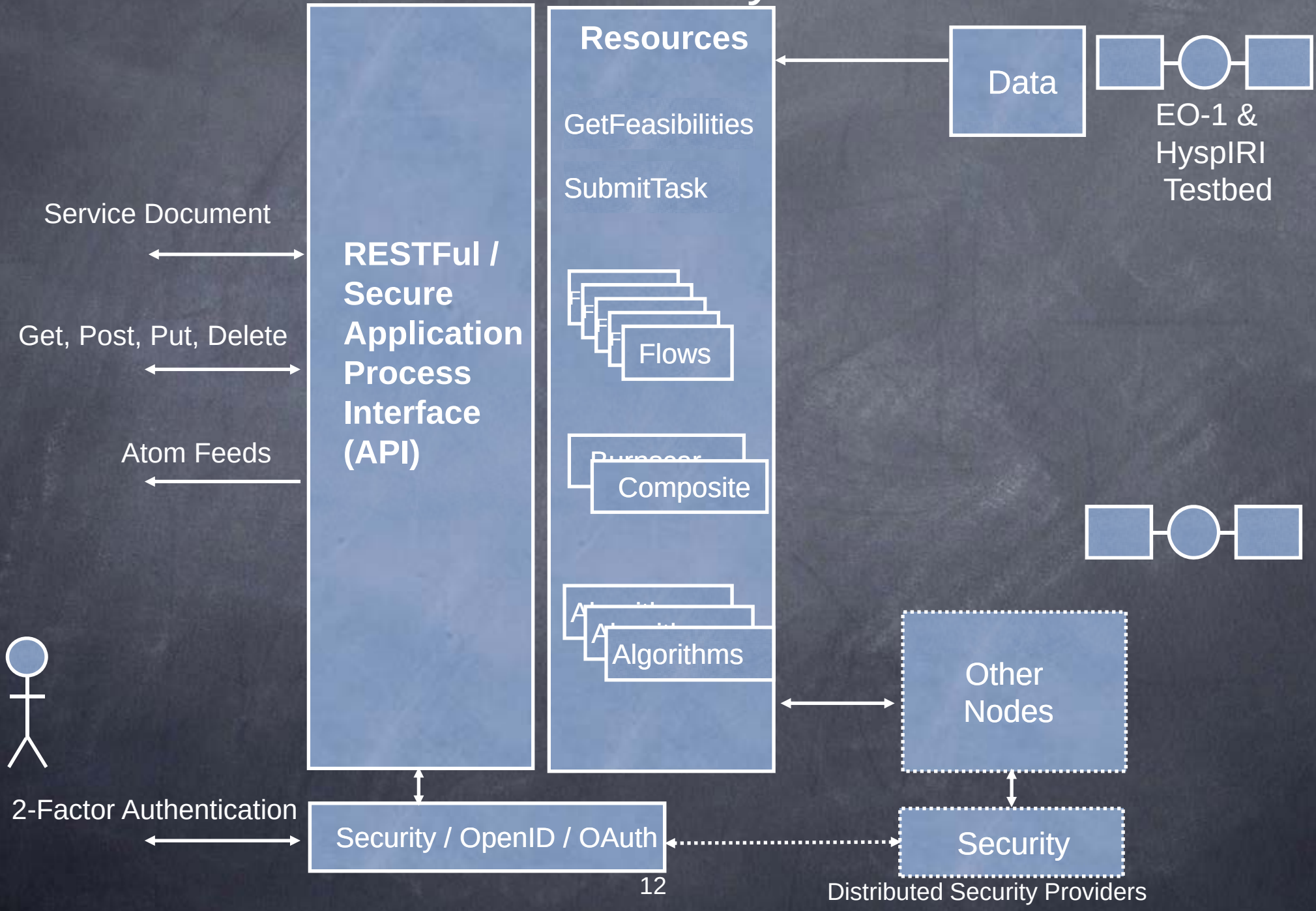
NASA SensorWeb 3.0 Approach

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



WCPS backend components

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

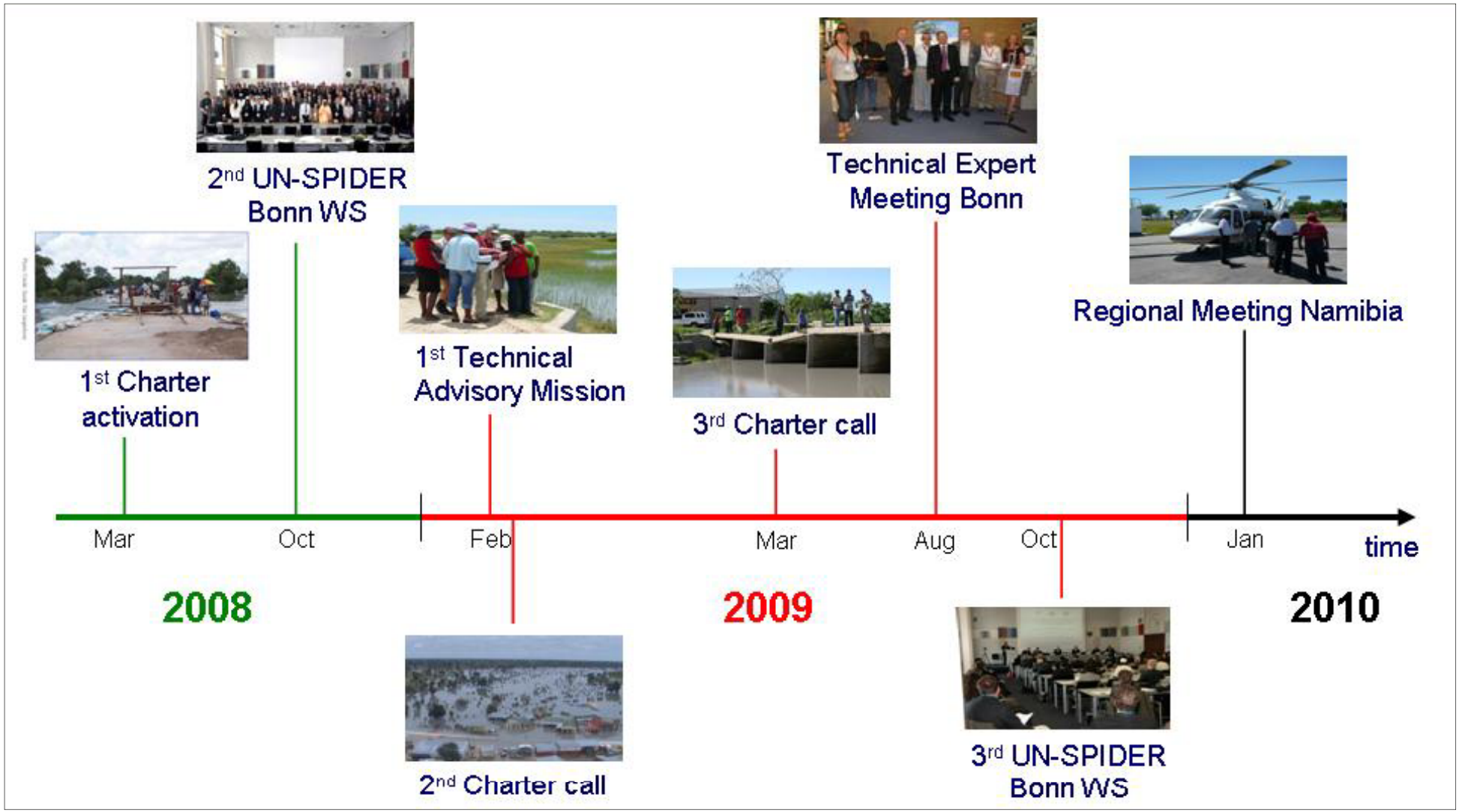
- *In February and March 2009, torrential rains increased water levels in the Zambezi, Okavango, Cunene and Chobe Rivers.*
- *This led to a 40-year flood in the Caprivi, Kavango and Cuvelai basins, affecting some 750,000 people (37.5% of the population of Namibia)*
- *Whole villages were cut off and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

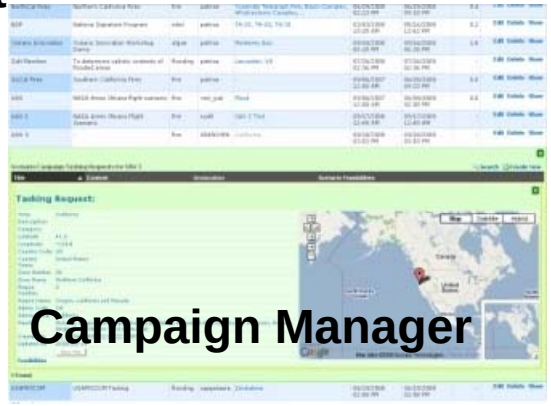
The following agencies contributed to establish an international expert team and sent representatives to this field mission:
European Commission, Joint Research Center (JRC), Italy; German Aerospace Center (DLR), Germany; German Technical Cooperation (GTZ), Windhoek, Namibia; International Institute for Geo-Information Science and Earth Observation (ITC), University of Tuente, 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

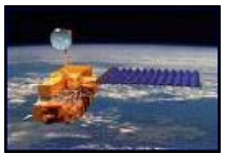
Request for satellite imagery in area of interest



Customized plan of needed satellite images

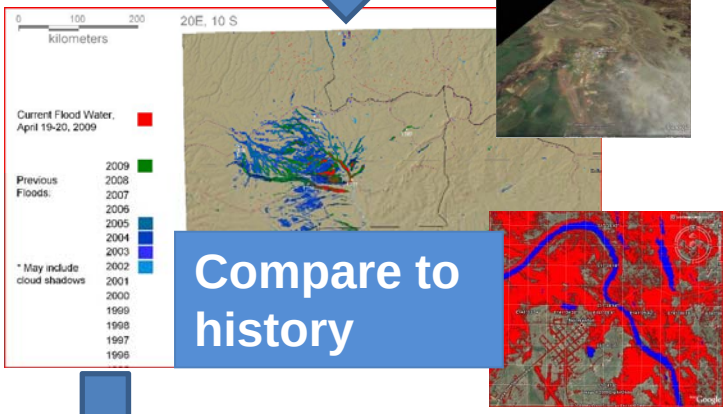
SPS

SPS



SPS

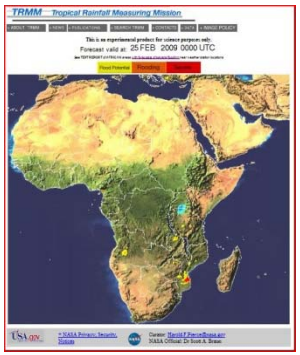
Flood conditions

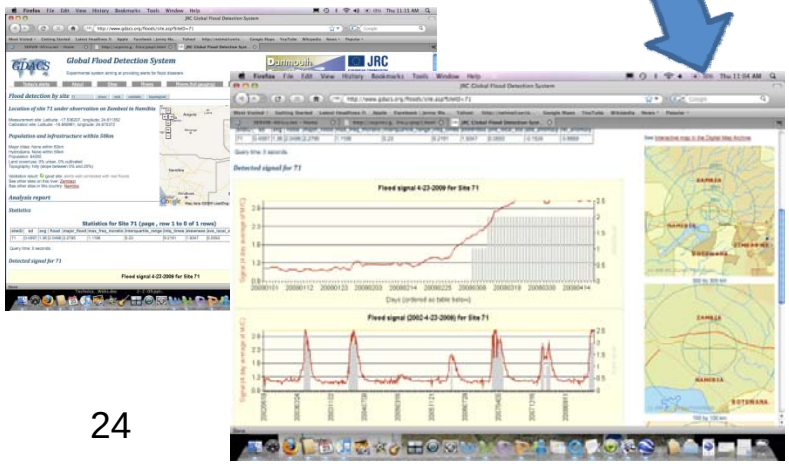


Flood alerts to automated tasking

Flood alerts to user

ground flood measurements To validate model

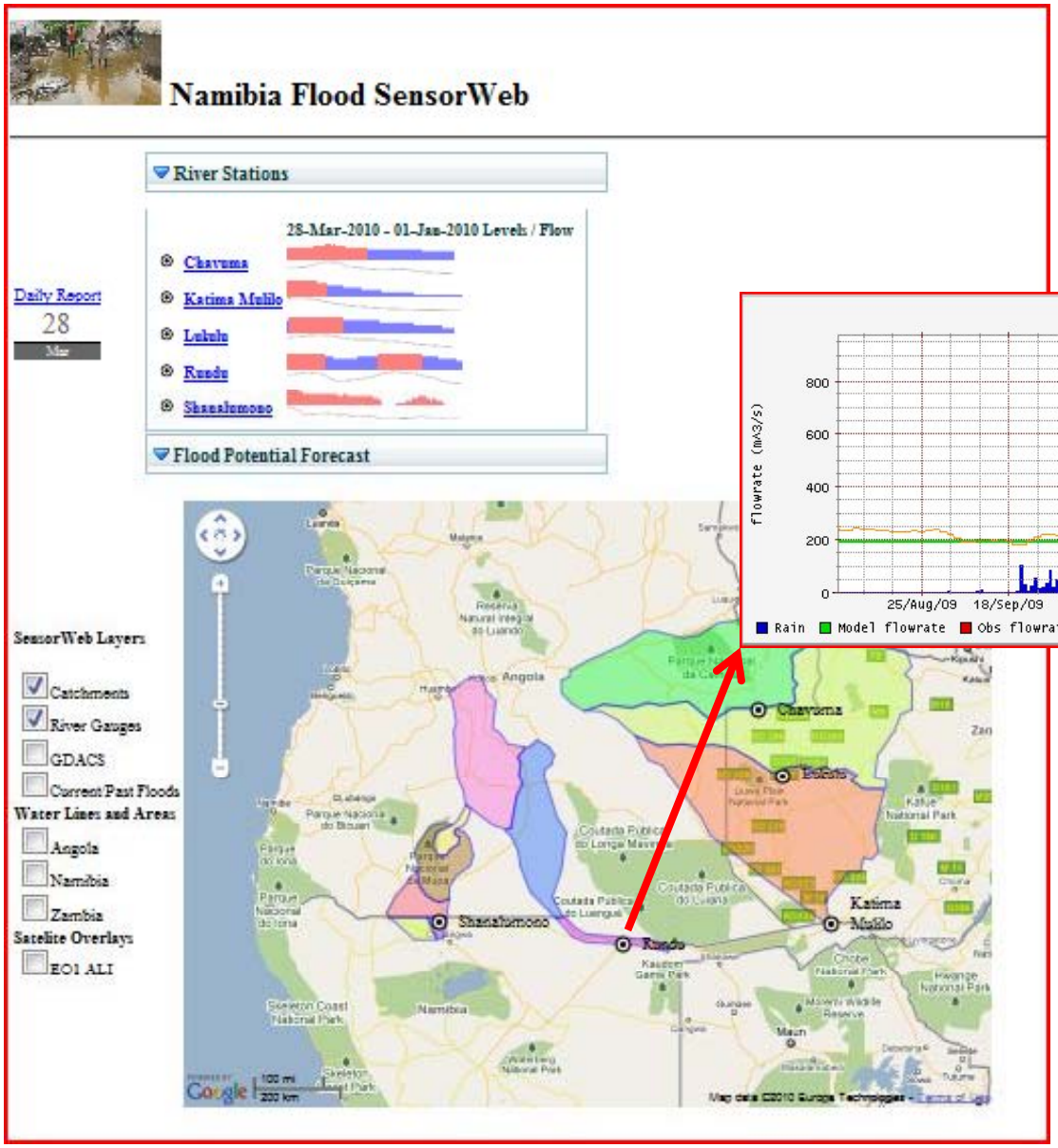


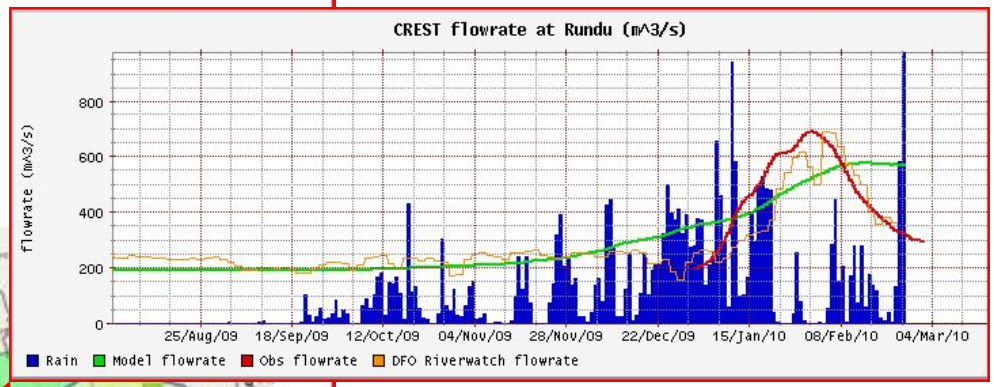


Improved Flood Prediction Model

***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:

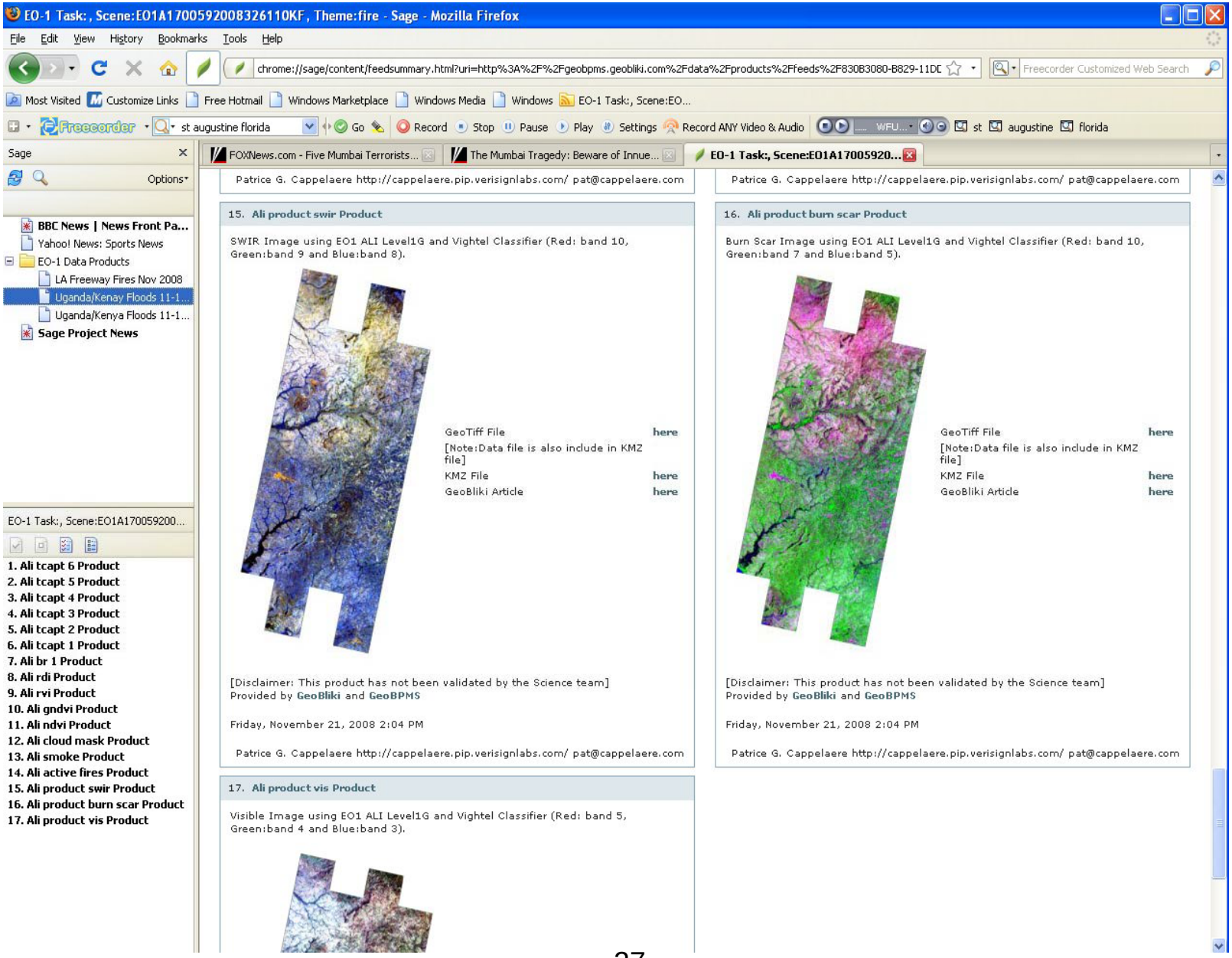
Title:	Lake Liambezi test1
Description:	Namibia flood campaign requested by Guido Van Langenhove
Category:	
Latitude:	-17.9108028411865
Longitude:	24.21120262146
Day/Night:	day time
Country Code:	
Country Name:	
Zone Number:	576
Zone Name:	Zambia
Region Number:	37
Region Name:	Africa
Admin Code:	
Admin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

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

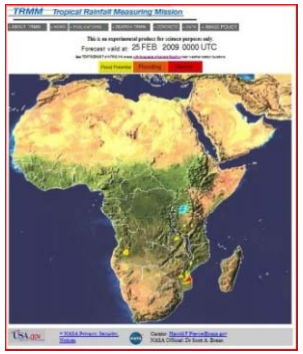
Deliver Level 2 Products via News Feeds to Users Along with Links to GeoTiff, KML and information about Image



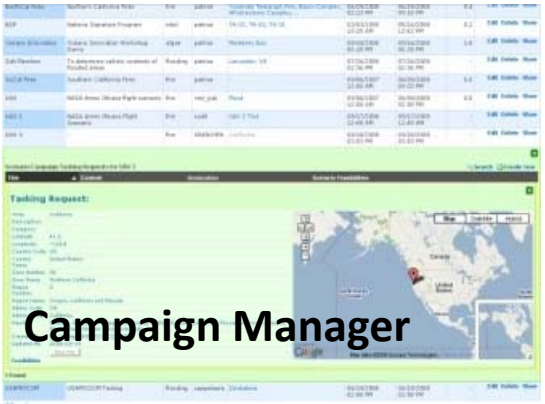
Another Sample Application: Disease SensorWeb

Top Level Malaria Early Warning SensorWeb Functional Flow

Flood Predictions



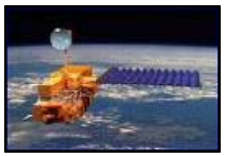
Flood alerts



Customized plan of needed satellite images

SPS

SPS



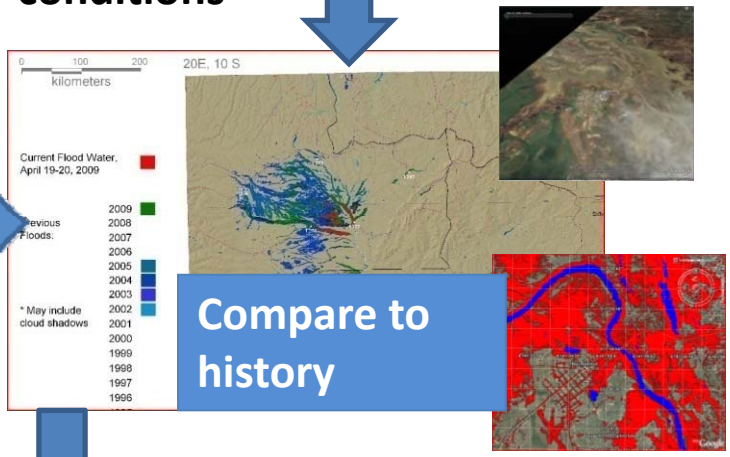
SPS

Flood alerts

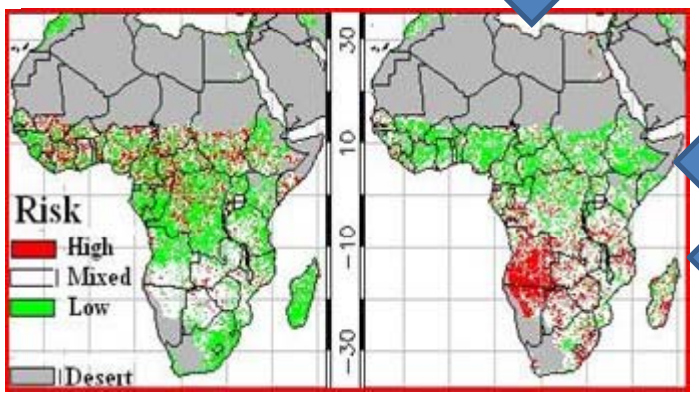
Request for satellite imagery in area of interest

Climate & vegetation conditions

Flood conditions



EFTB



Statistical disease risk alerts

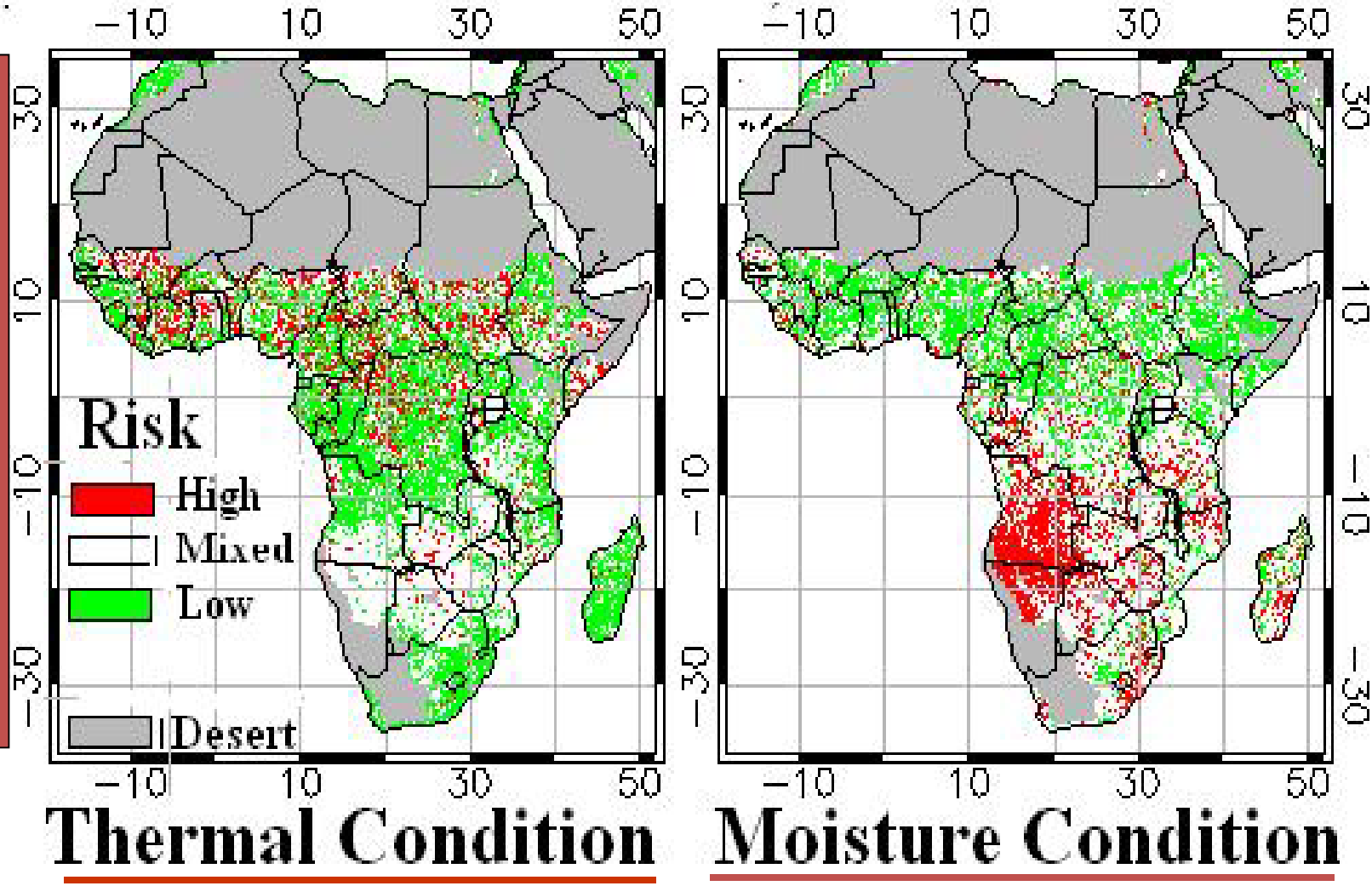
Historical epidemiological data

***SPS – Sensor Planning Service**

Strategy: WEATHER PROXY

AUGUST 26, 2008

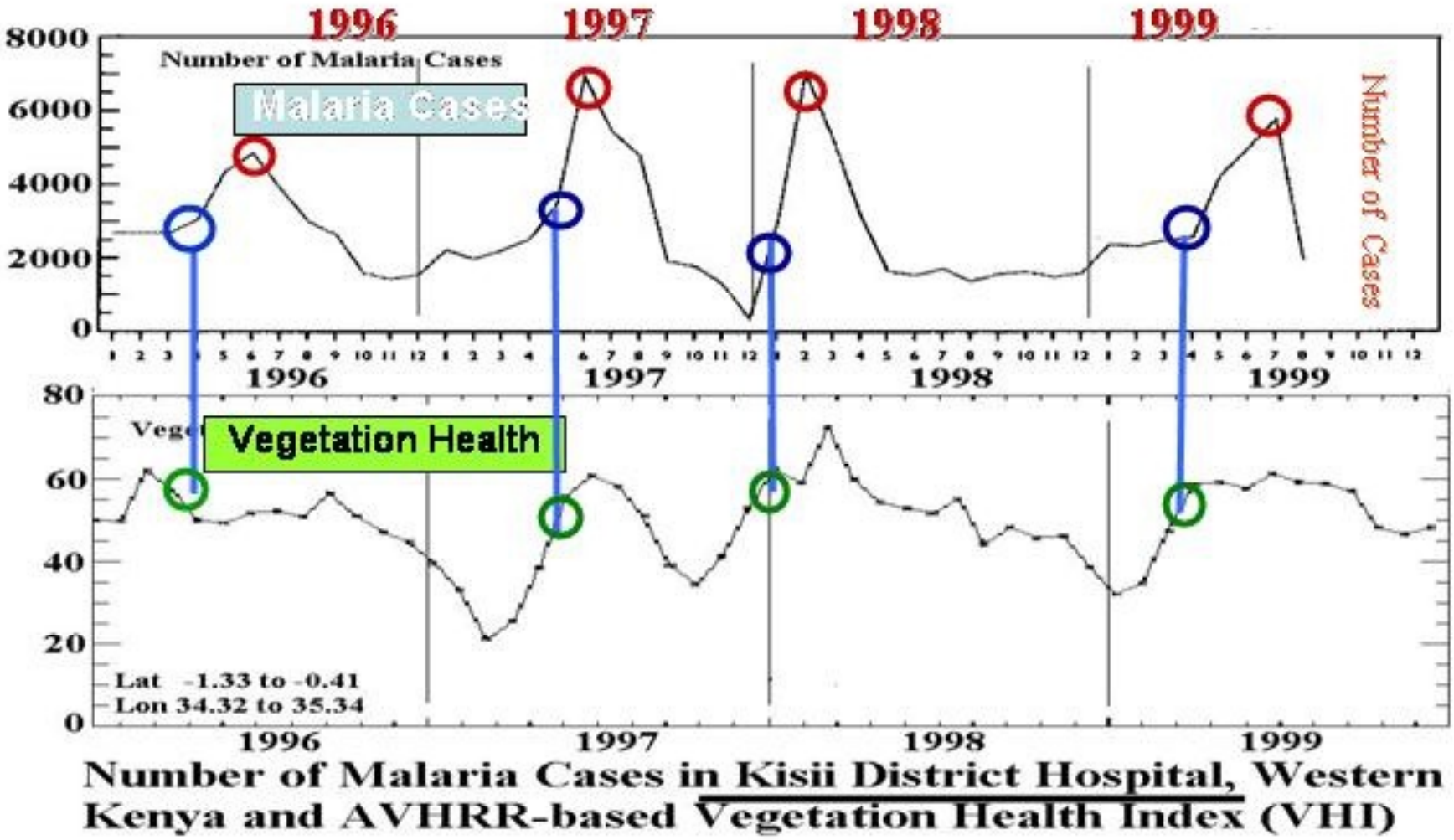
Malaria risk map identifies priority areas and additional resources needed to fight epidemics effectively



INTENSIVE MALARIA

Felix Kogan/NOAA/NESDIS

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

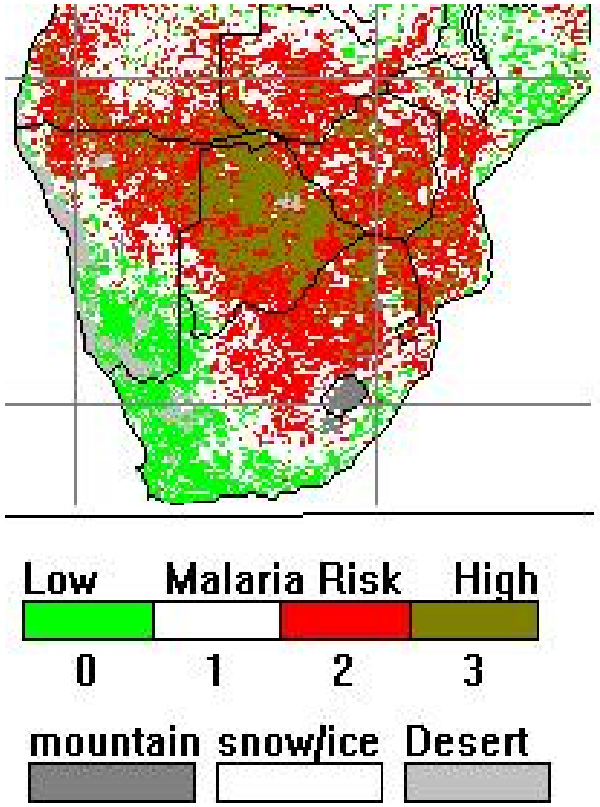
Felix Kogan/NOAA/NESDIS

NOAA Malaria Risk Indicators Area, southern Africa

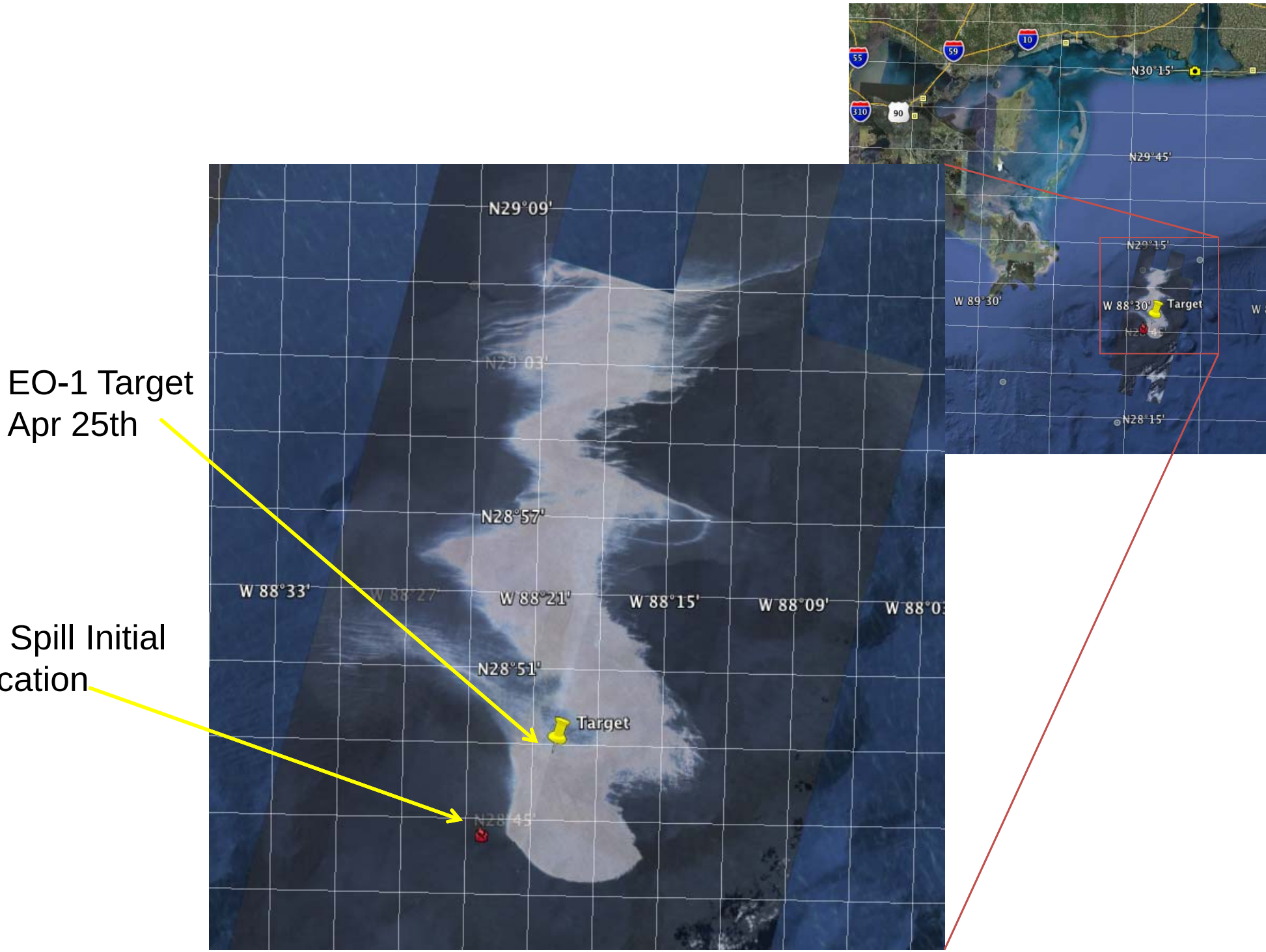
Based on Vegetation Health Index system assessment conditions are very favorable (risk level 3 and 4) for malaria epidemic in

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

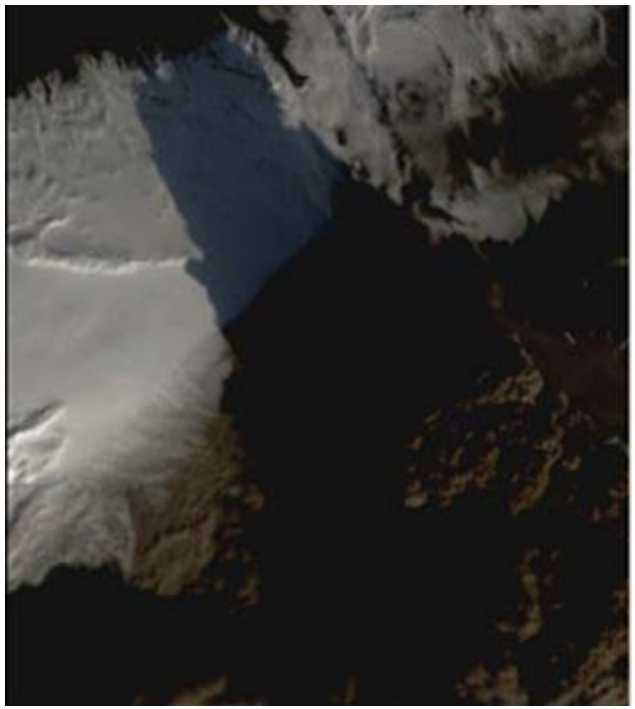
Malaria Risk 5/6/10



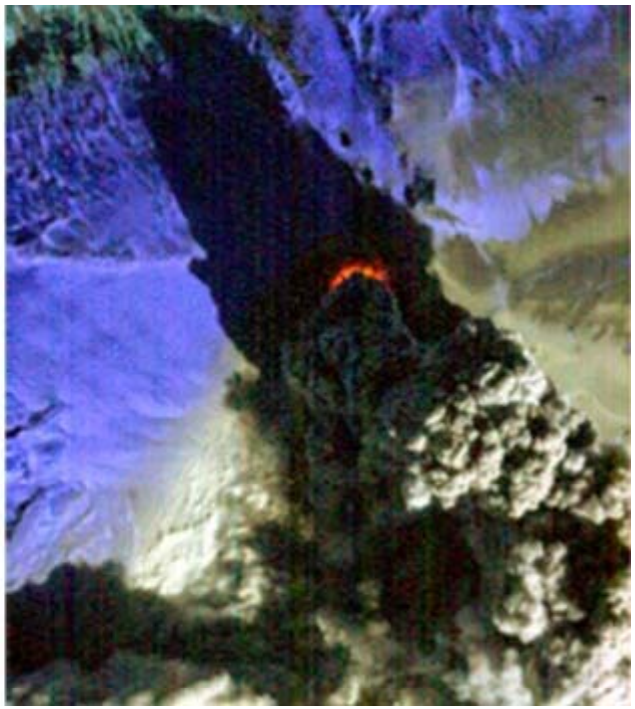
Recent SensorWeb Acquisitions: Oil Slick in Gulf of Mexico and Volcano in Iceland


EO-1 Target
Apr 25th
Oil Spill Initial
Location
N29°09'
N29°03'
N28°57'
N28°51'
N28°45'
W 88°33'
W 88°27'
W 88°21'
W 88°15'
W 88°09'
Target
55
59
10
310
90
N30°15'
N29°45'
N29°15'
W 89°30'
W 88°30'
Target
N28°15'

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.

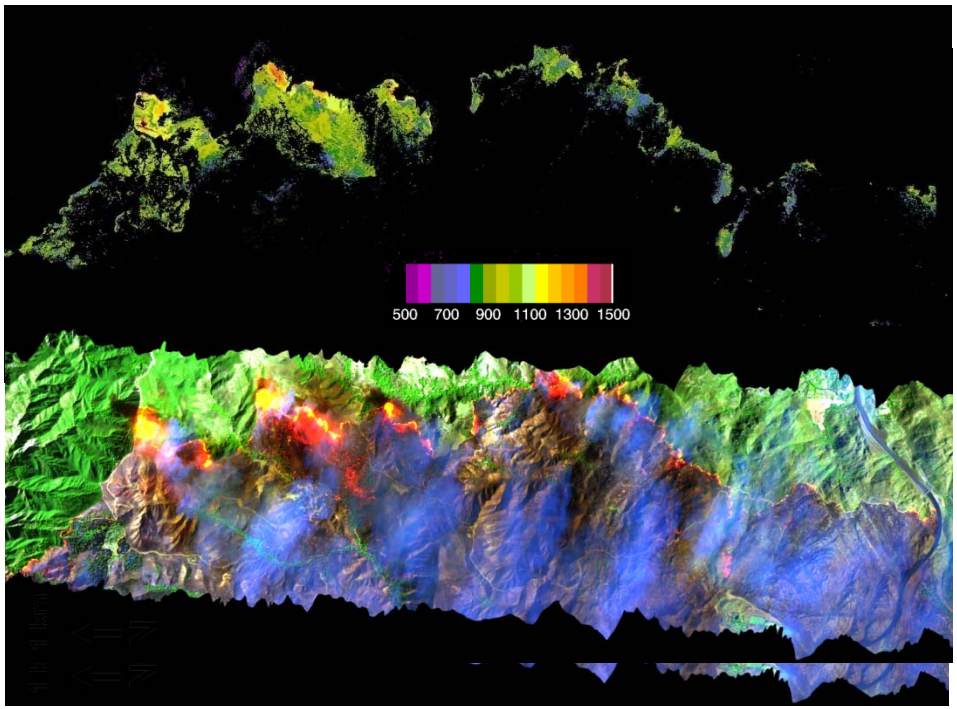
Extending SensorWeb Onboard Satellites: Detecting Materials Onboard a Satellite

HyspIRI Intelligent Payload Module (IPM)

4 run onboard automatically

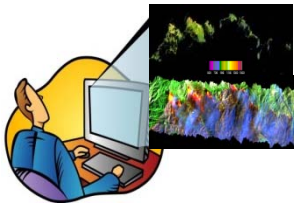
3 upload mobile agent

2 transform algorithm into mobile agent

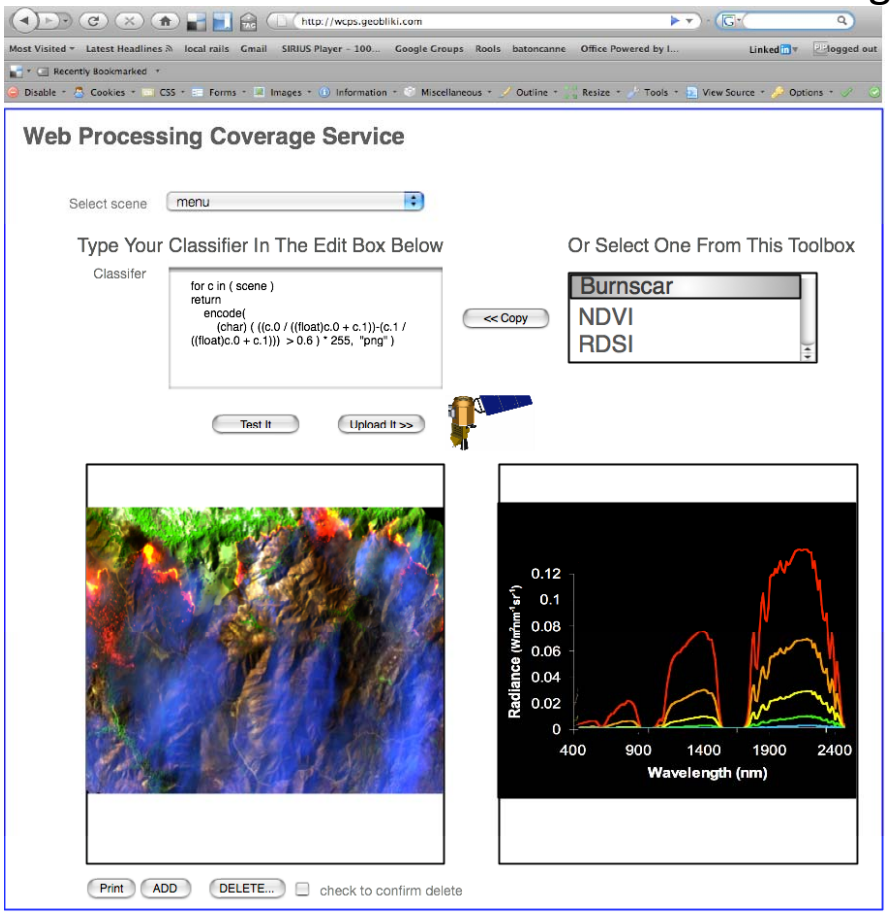


5 download customized low-latency onboard generated data products

Ground Station



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



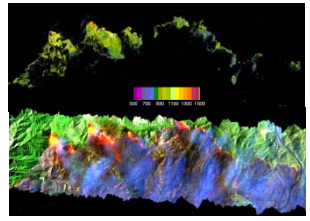


Image data products- Phil Dennison 2008

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.

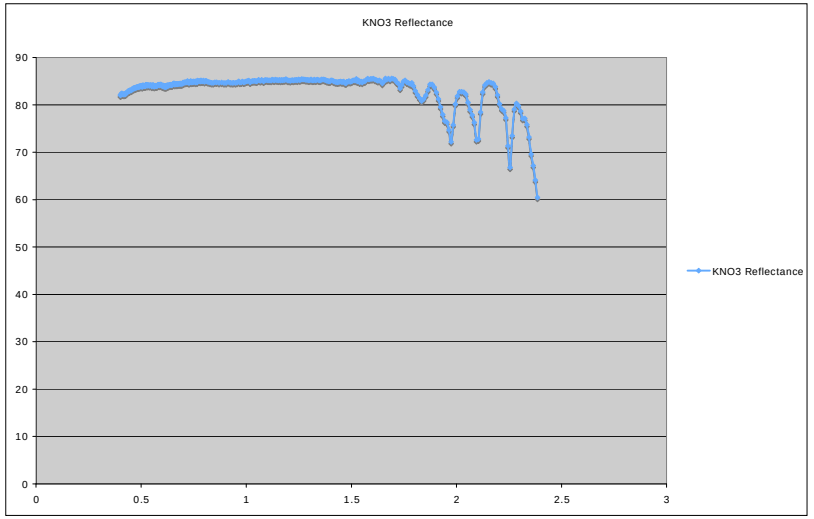
Acting on a tip, international forces and Afghan police discovered 1,000 100-pound bags of ammonium nitrate fertilizer and 5,000 parts for roadside bombs in a warehouse, the military said. After the initial find Sunday, an additional 4,000 100-bags of fertilizer were found in a nearby compound. The joint 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 KNO3 Detection - Atacama Desert, Chile

- User uploads signature of interest to spacecraft
  - Example: Potassium Nitrate (KNO3, Niter, saltpeter) (USGS Spectral Library) used in Fertilizer and Explosives. Major Source Can be Found in Atacama Desert, Chile.

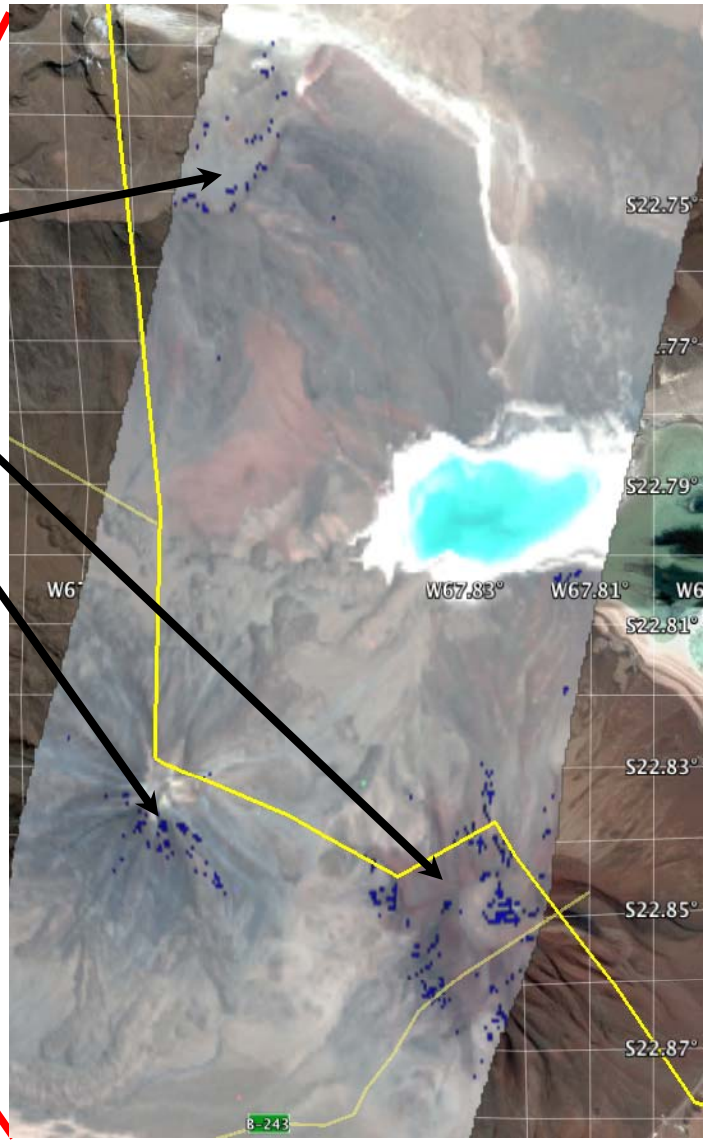


Experiment with KNO3 Detection - Atacama Desert, Chile conducted with Earth Observing 1

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

Potential KNO3

Detected Pixels (blue) as Overlay on Google Earth



In Less than 1 hour with a slow onboard CPU

Conclusion

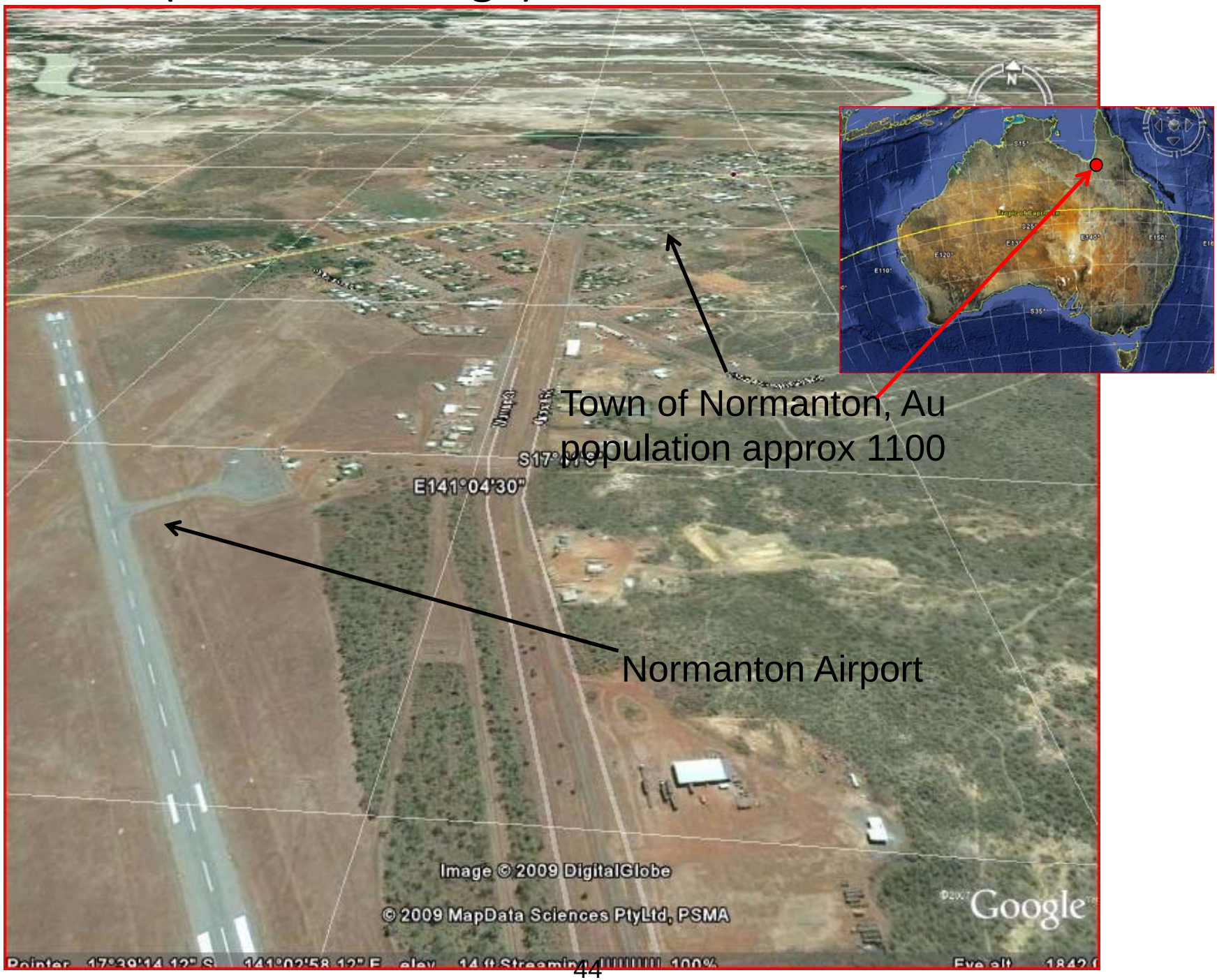
- Decrease barrier to entry in SensorWeb domain by using simpler interfaces
- Easy development and usage will enable many societal benefits at lower budgets
- Disaster management is the perfect arena to test out these concepts because there is a large demand and need internationally

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

Normanton, Queensland, Australian Floods February 2009 Data Simulation

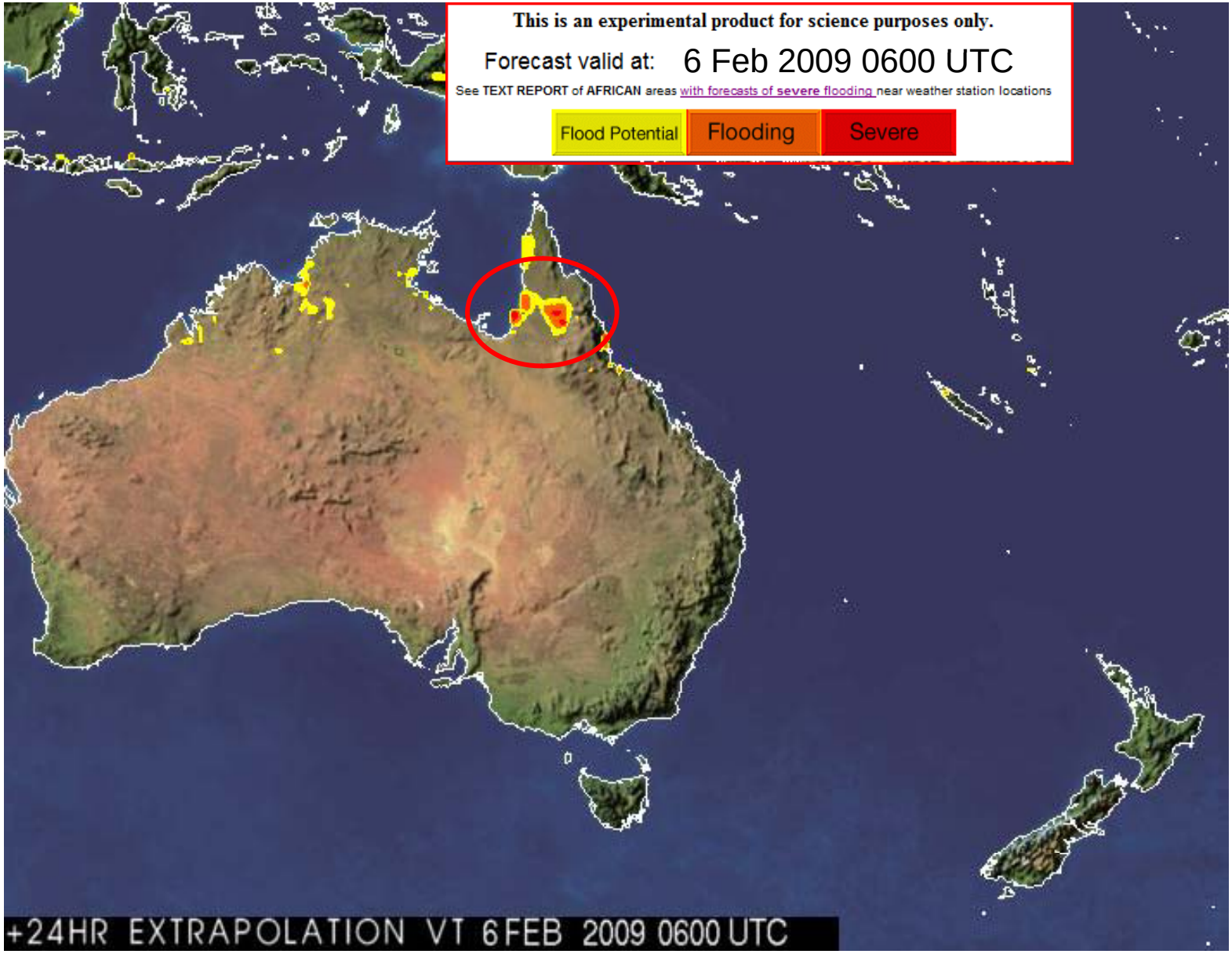
- **Prediction:** TRMM-based Predictive Flood Potential Model
  - Robert Adler/University of Maryland –NASA/GSFC
- **Survey:** MODIS Flood Map
  -Robert Brakenridge/ Dartmouth Flood Observatory
- **Details:**
  - Earth Observing 1 Advanced Land Imager and Hyperion
    -NASA/GSFC – Image acquisition, 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)



TRMM-based flood potential forecast for February 6, 2009

Prediction



Specific Water Level and Lat/Long Projected for Normanton Area

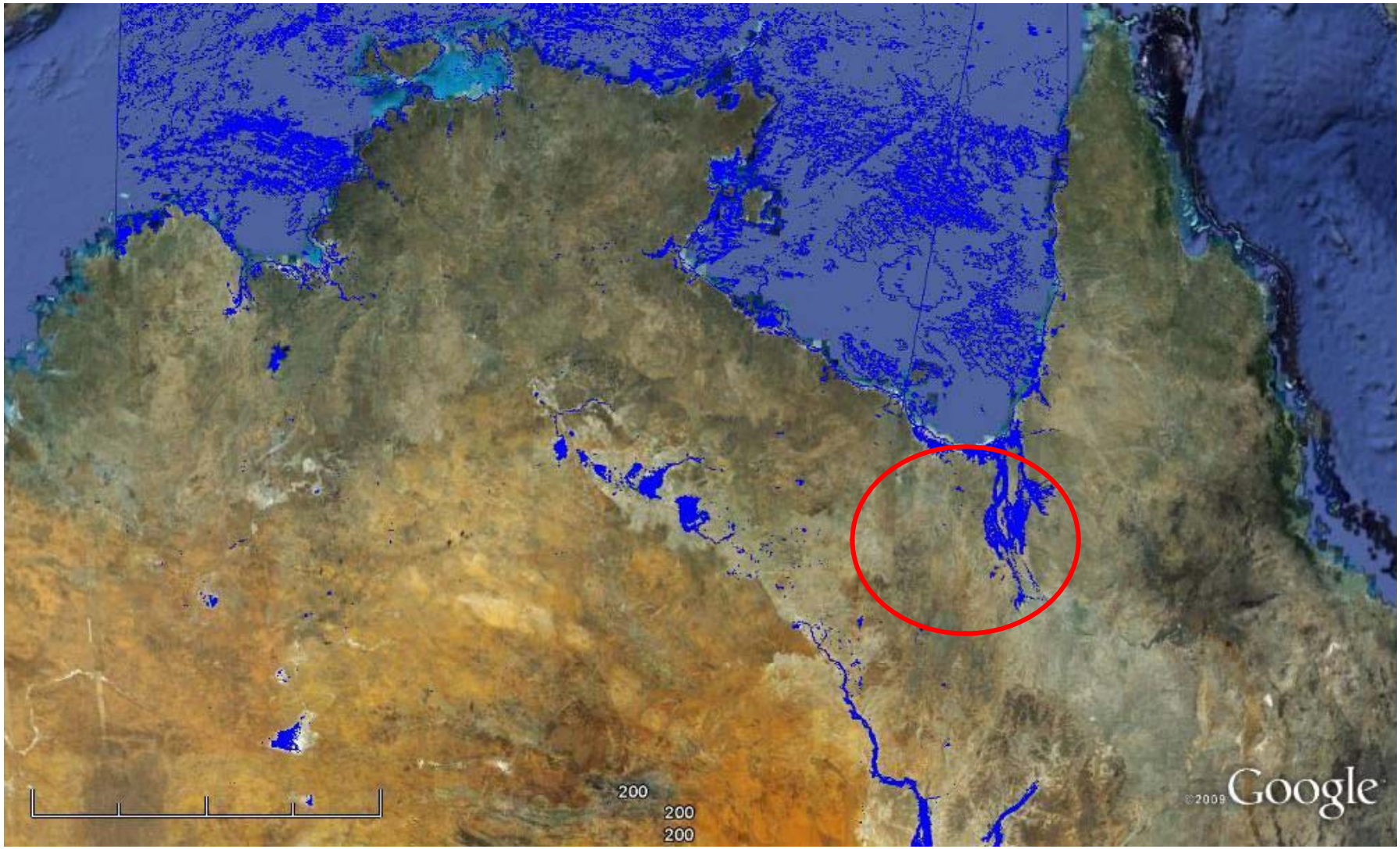
Use this lat/long to trigger other assets

FORECASTED Flood Potential at 02/06/2009 0600Z

Forecast generated at 02/05/2009 0600Z

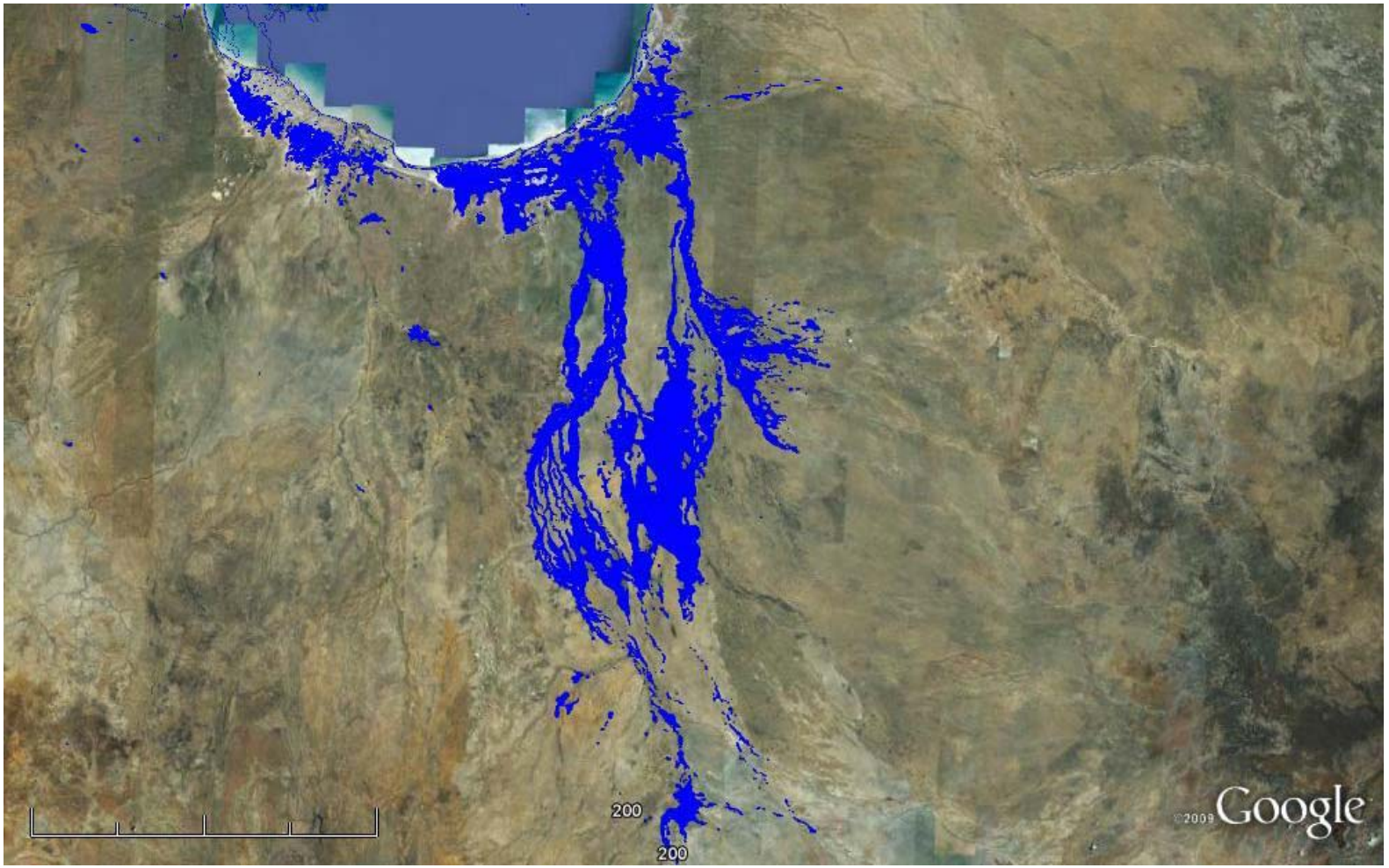
COUNTRY	WATER LEVEL & Latitude/Longitude	NEARBY LOCATION
Argentina	134mm -32.63 -60.88	~ 33.96km from ROSARIO AIRPORT -32.92 -60.78
Argentina	151mm -32.88 -61.13	~ 32.39km from ROSARIO AIRPORT -32.92 -60.78
Argentina	163mm -33.13 -60.88	~ 23.41km from ROSARIO AIRPORT -32.92 -60.78
COUNTRY	**WATER LEVEL & 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.

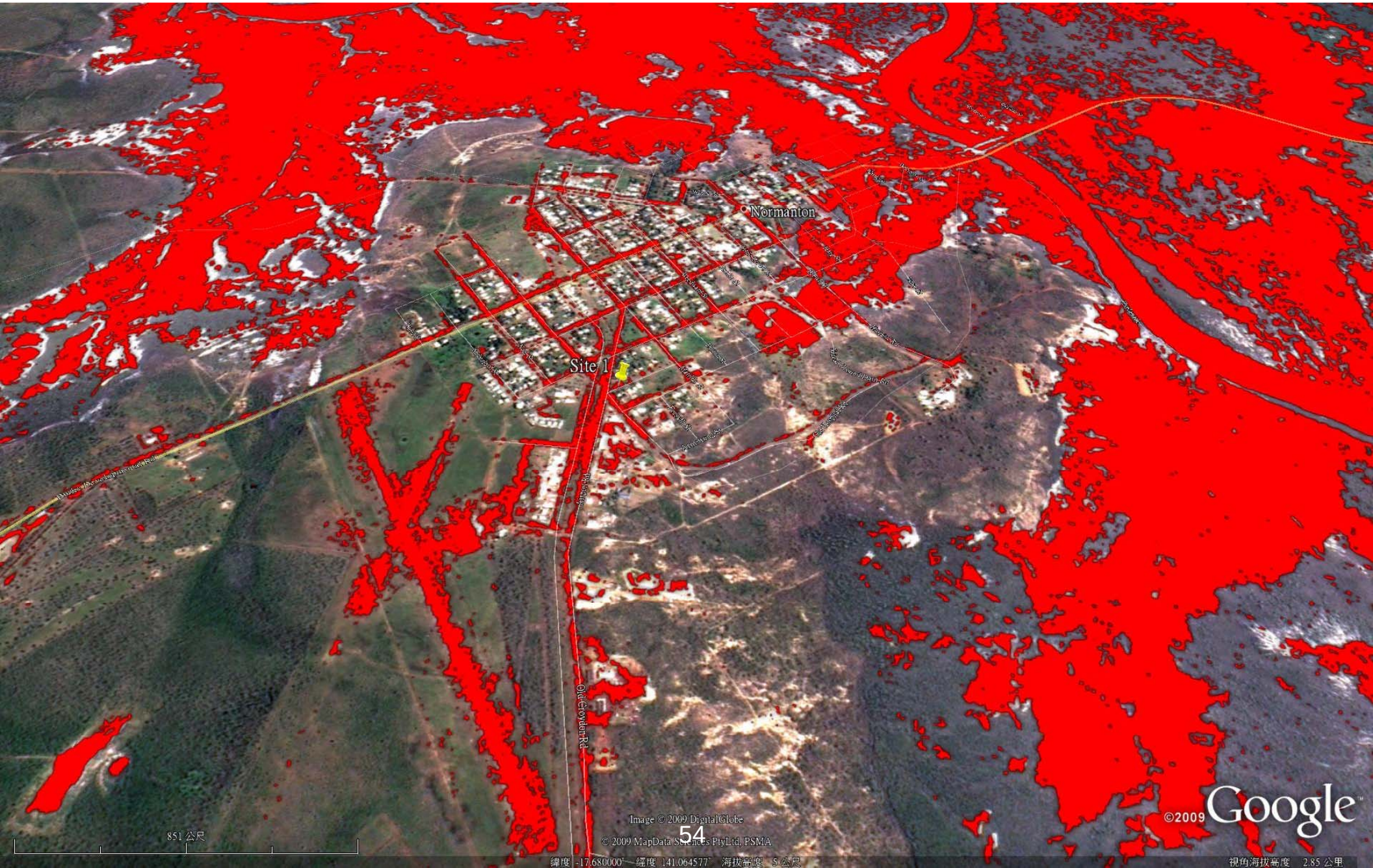
Normanton Airport Ground View 2-15-09

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

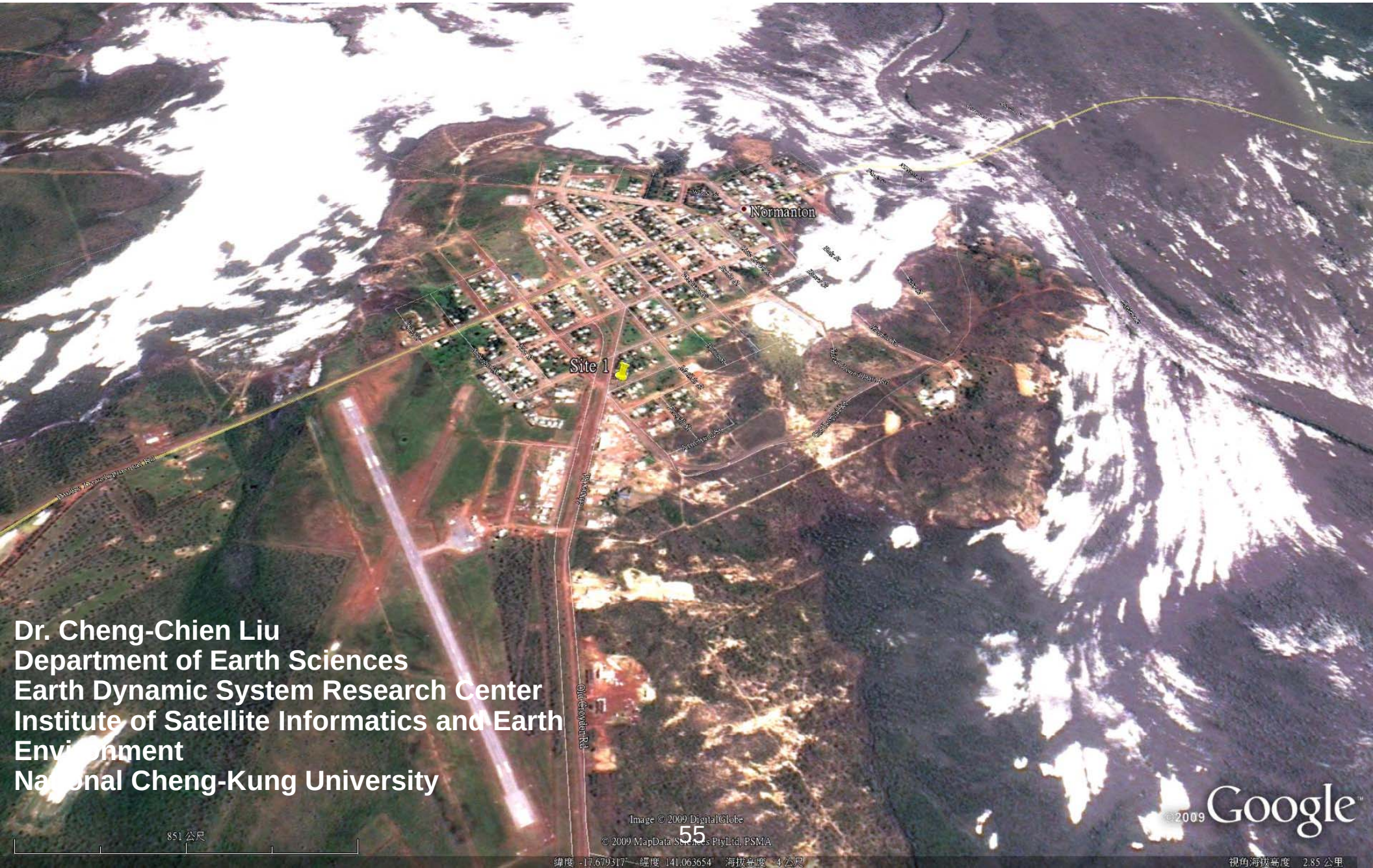
Normanton Airport View 2 2-15-09

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

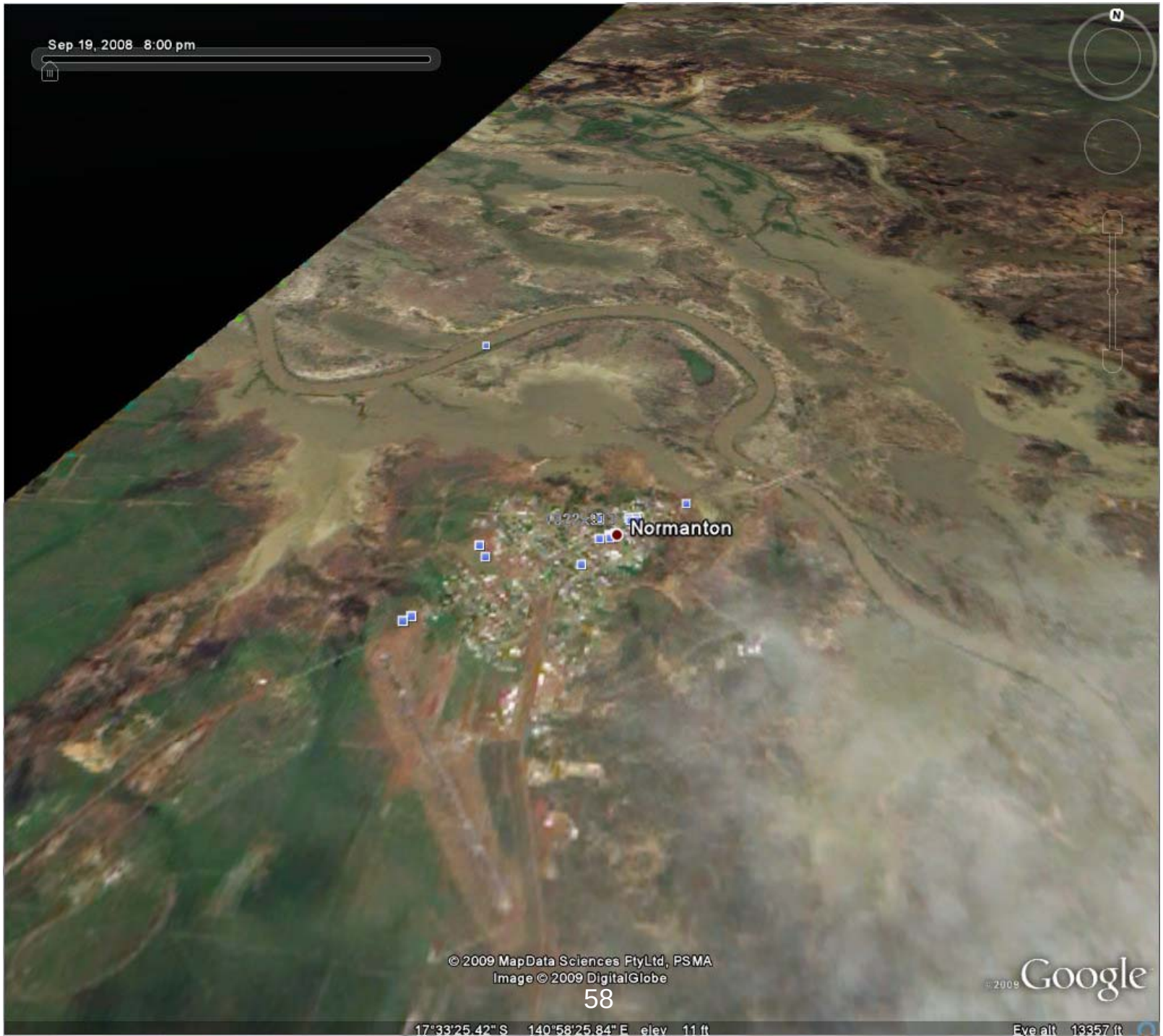


Dr. Cheng-Chien Liu
Department of Earth Sciences
Earth Dynamic System Research Center
Institute of Satellite Informatics and Earth Environment
National Cheng-Kung University

Normanton Floods - February 18, 2009 Zoom 1

Normanton Floods - February 18, 2009 Zoom 2

EO-1 Image March 11, 2009

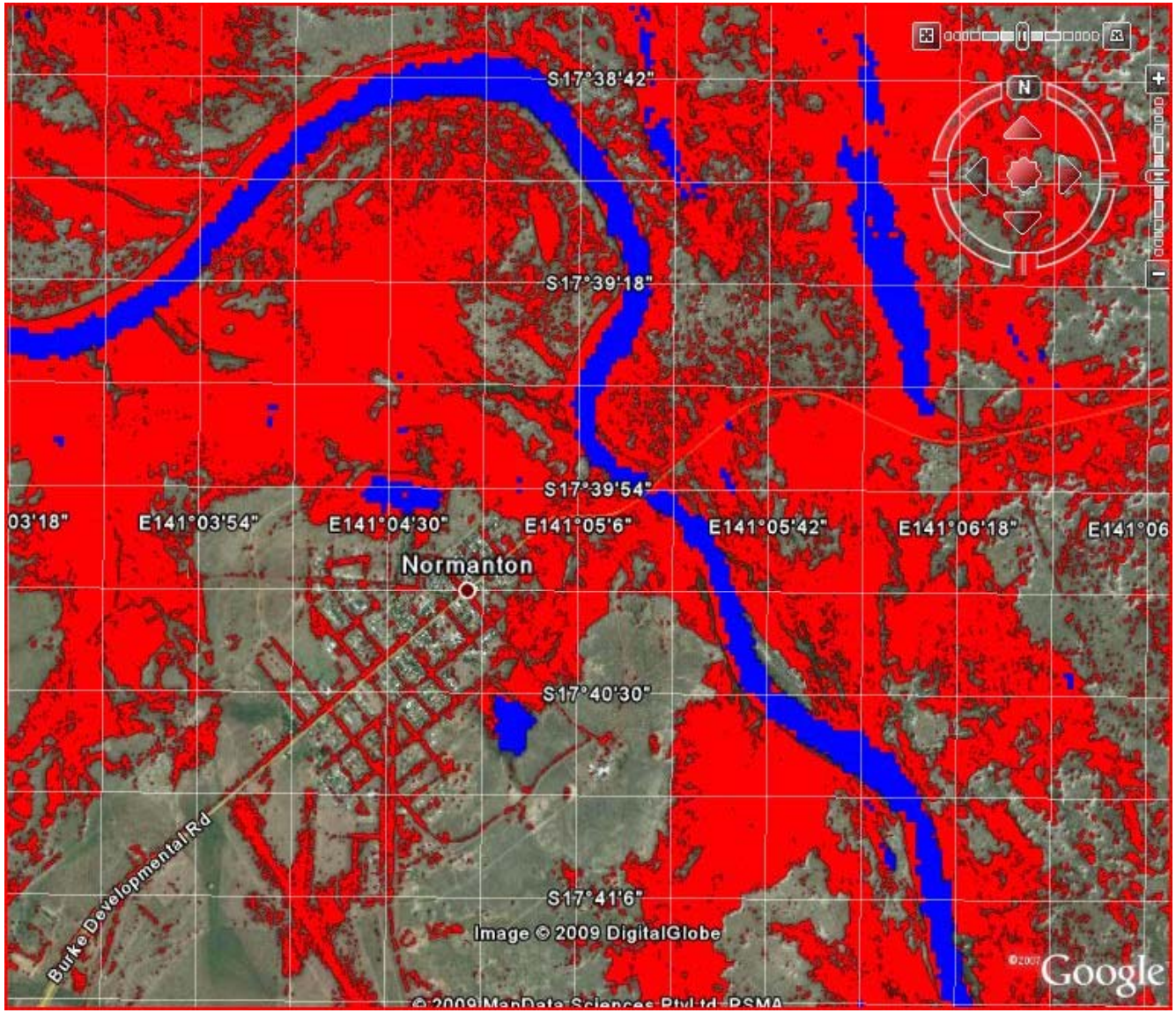


Radarsat/Landsat Flood Map

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

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

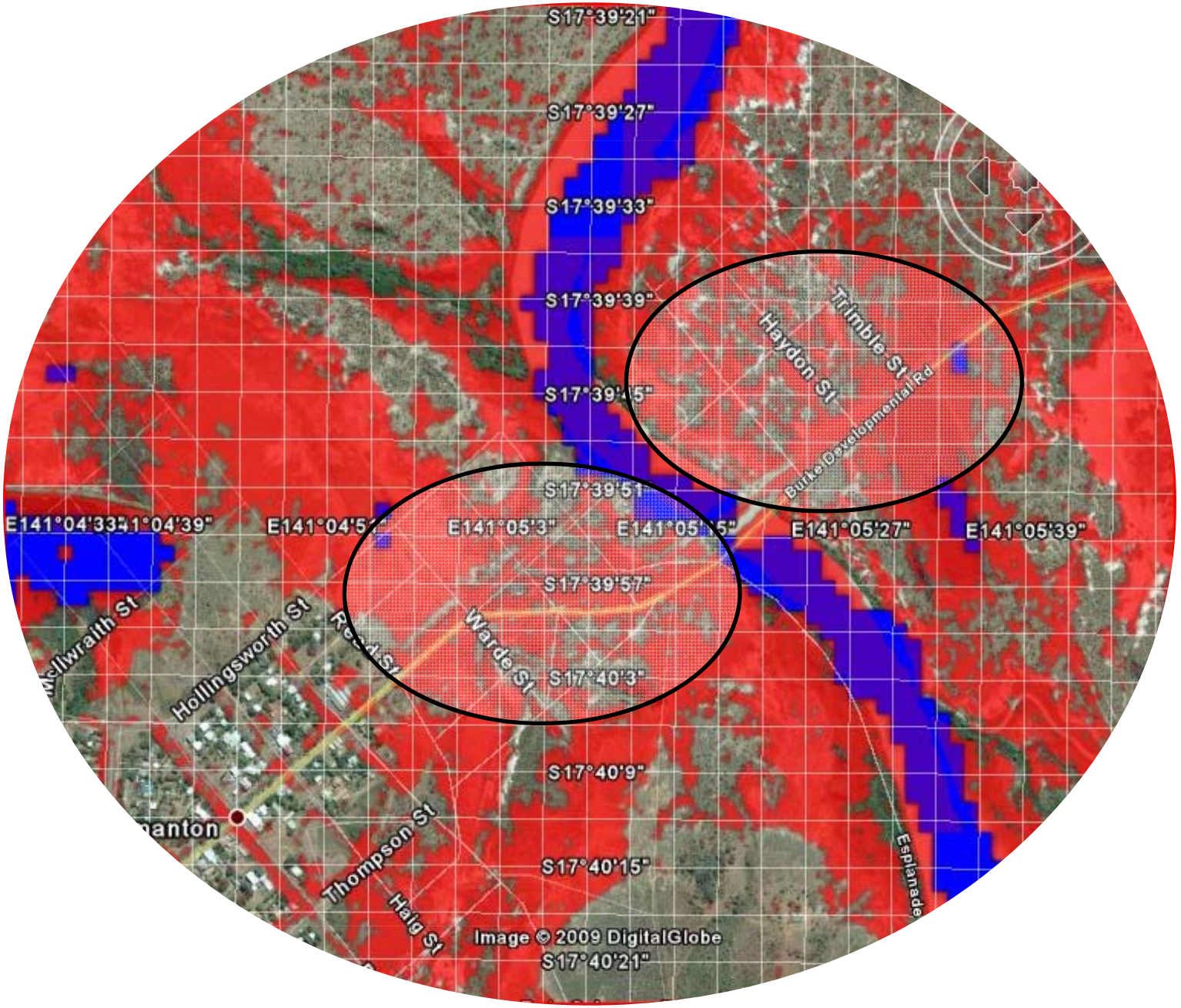
Flood maps produced by the Space Research Institute NASU-NSAU, Ukraine



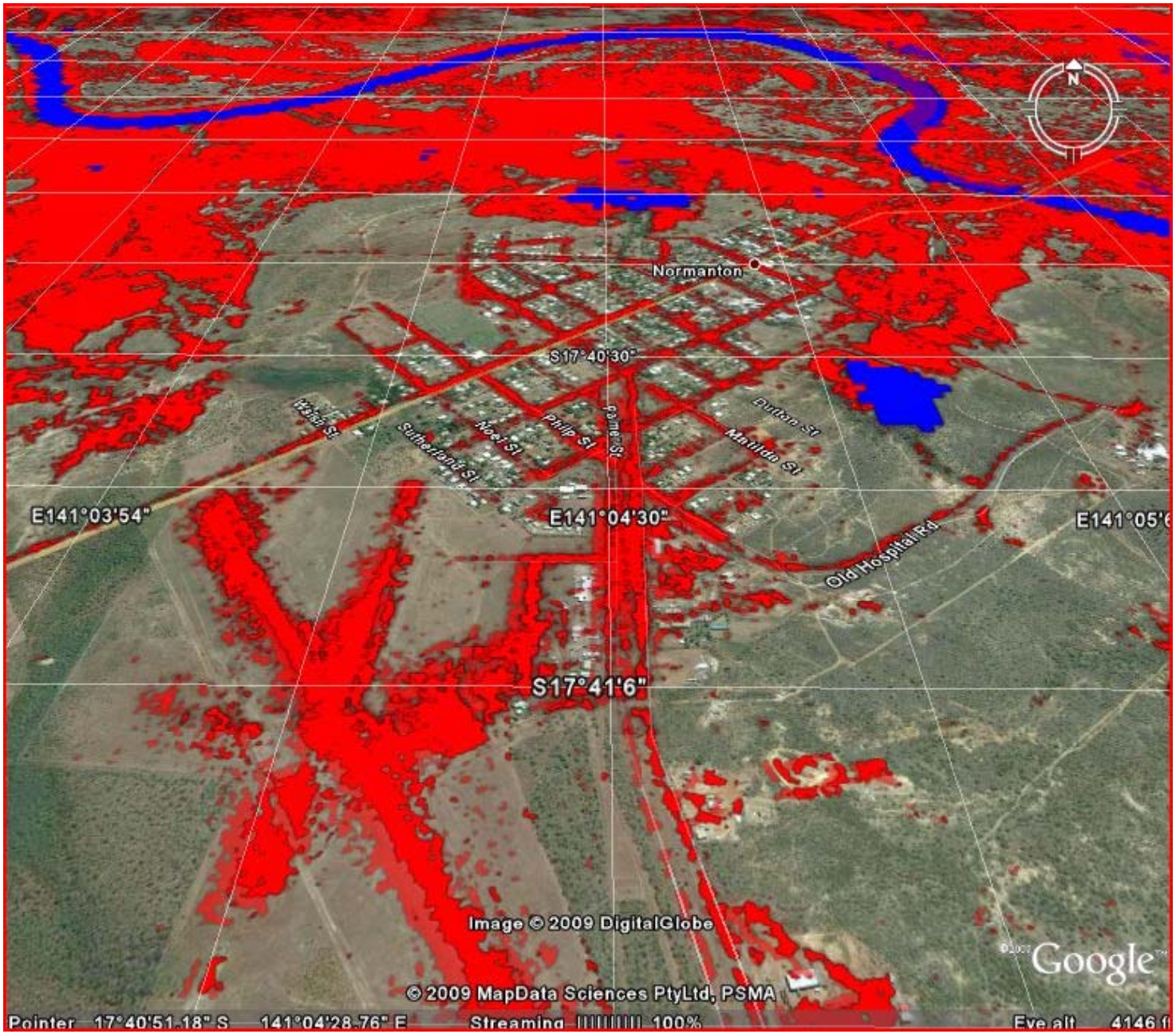
Red – flood waters

Blue – Existing waters

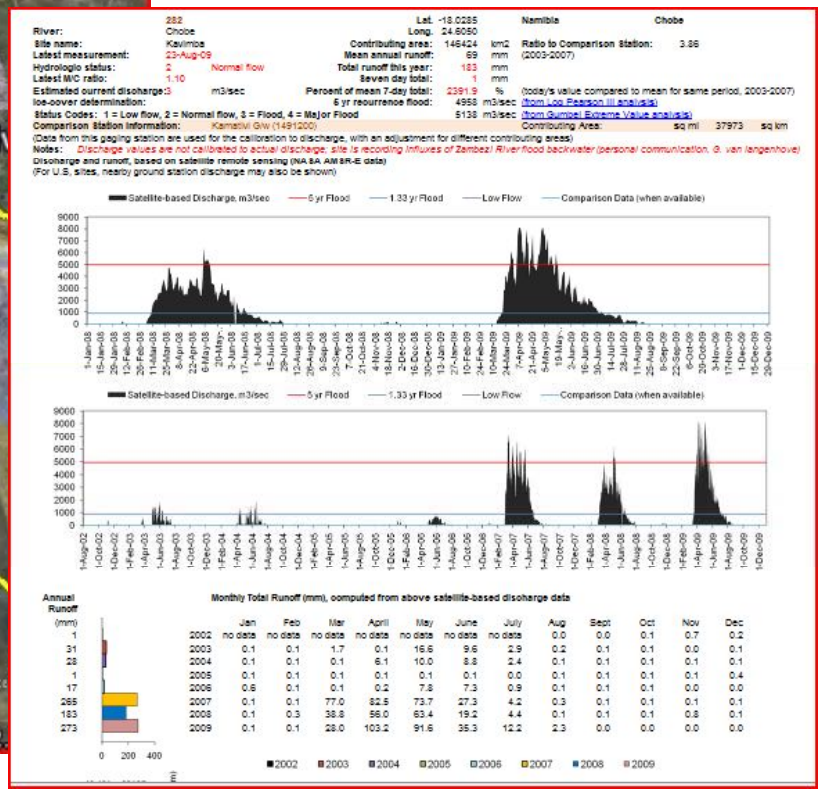
Find Flooded Streets



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