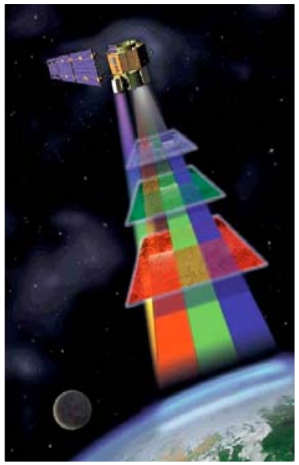
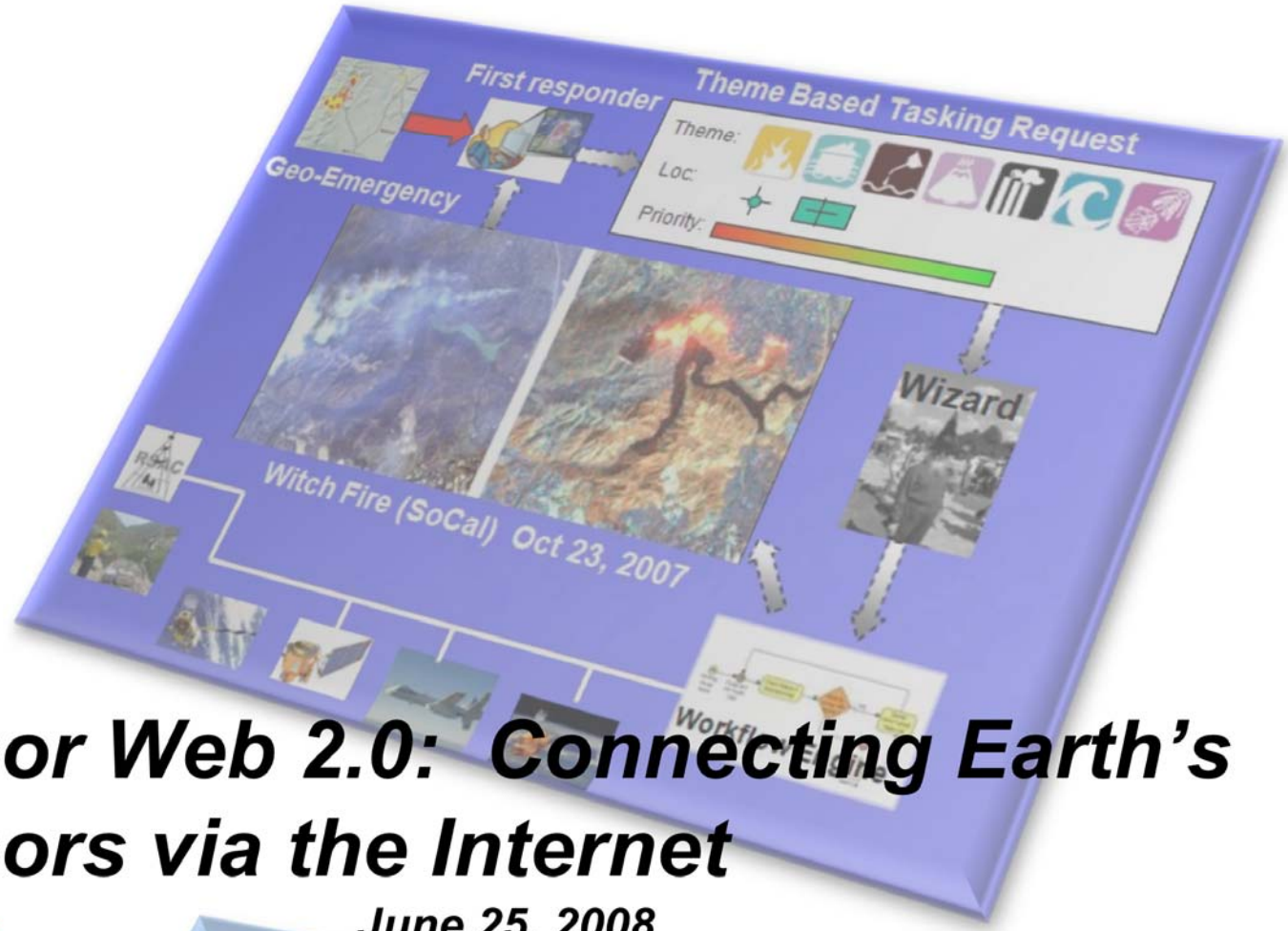




Sensor Web 2.0: Connecting Earth's Sensors via the Internet

June 25, 2008

Goddard Space Flight Center

JPL

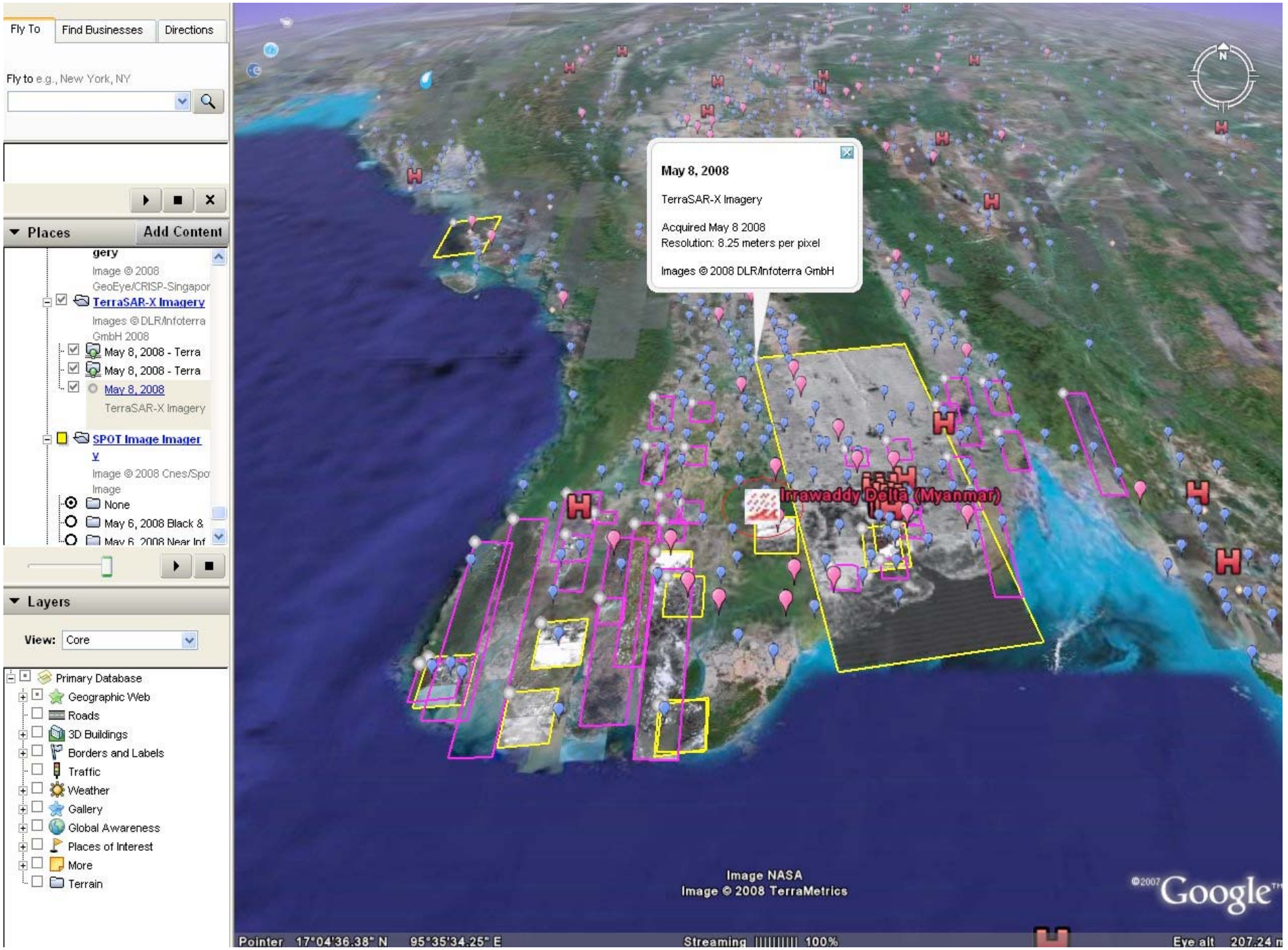
Ames Research Center

University of Maryland

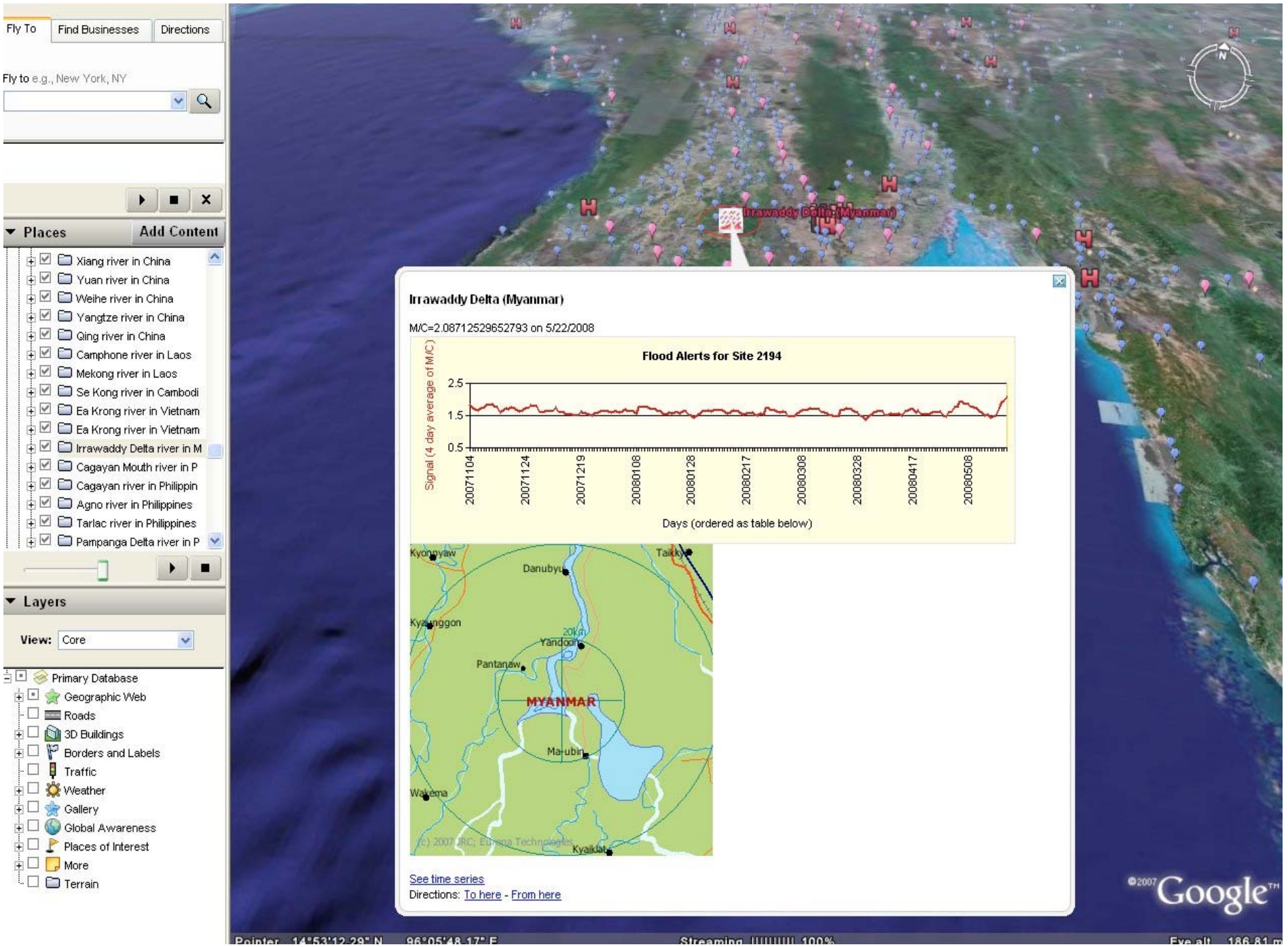
Draper Laboratory

Sensor Web 2.0

ESTC2008



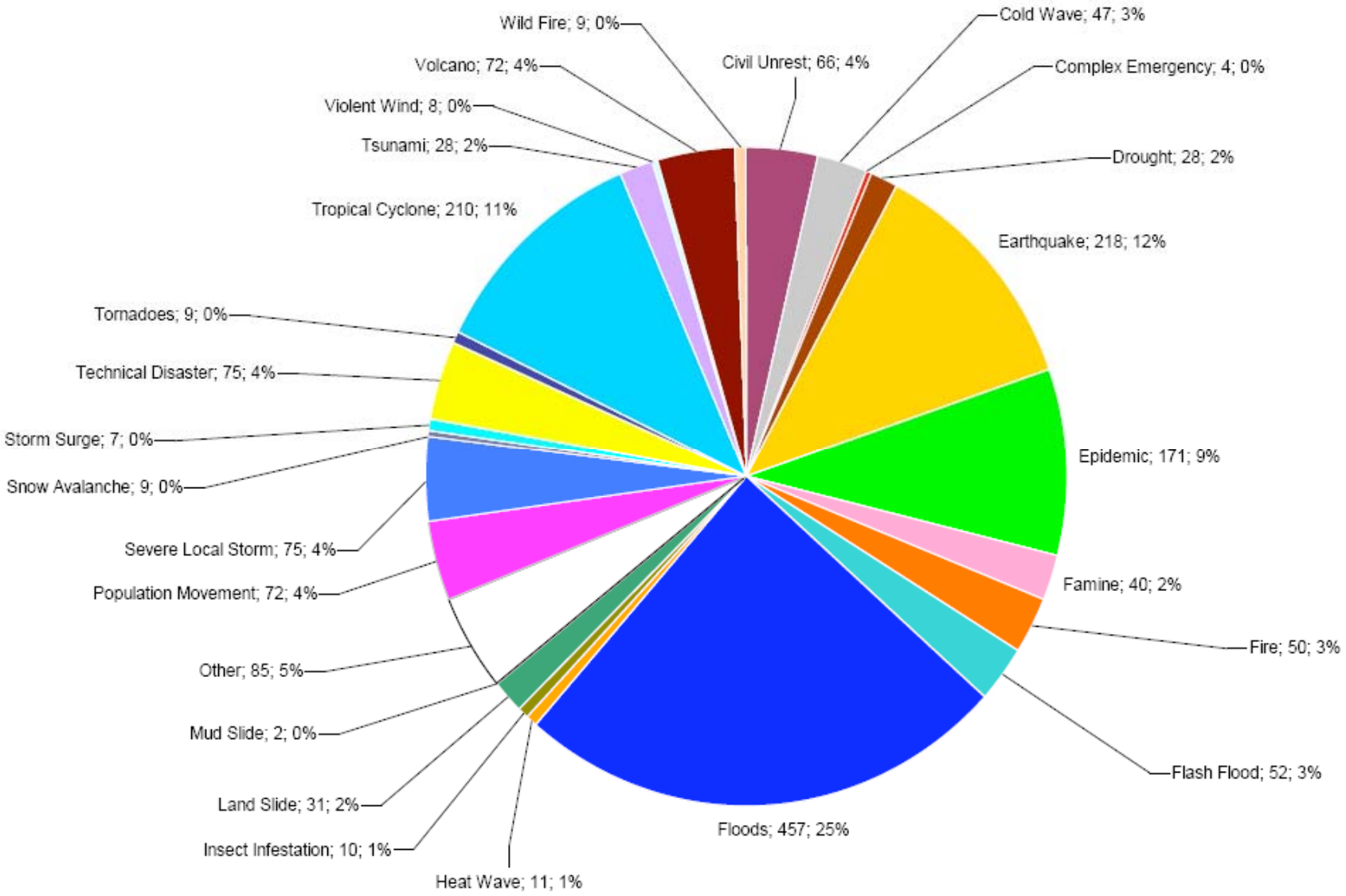
Sensors are everywhere! Space, air and


Fly To
Find Businesses
Directions
Fly to e.g., New York, NY
Places
Add Content
Xiang river in China
Yuan river in China
Weihe river in China
Yangtze river in China
Qing river in China
Camphone river in Laos
Mekong river in Laos
Se Kong river in Cambodi
Ea Krong river in Vietnam
Ea Krong river in Vietnam
Irrawaddy Delta river in M
Cagayan Mouth river in P
Cagayan river in Philippin
Agno river in Philippines
Tarlac river in Philippines
Pampanga Delta river in P
Layers
View: Core
Primary Database
Geographic Web
Roads
3D Buildings
Borders and Labels
Traffic
Weather
Gallery
Global Awareness
Places of Interest
More
Terrain
Irrawaddy Delta (Myanmar)
Irrawaddy Delta (Myanmar)
M/C=2.08712529652793 on 5/22/2008
Flood Alerts for Site 2194
Signal (4 day average of M/C)
2.5
1.5
0.5
20071104
20071124
20071219
20080108
20080128
20080217
20080308
20080328
20080417
20080508
Days (ordered as table below)
Kyonnyaw
Danubyu
Kyaiklat
Yandoon
Pantanaw
MYANMAR
Maubin
Wakema
20km
See time series
Directions: To here - From here
©2007 Google

ground!

Disasters occur everywhere also!

Types of disasters 2004-2008



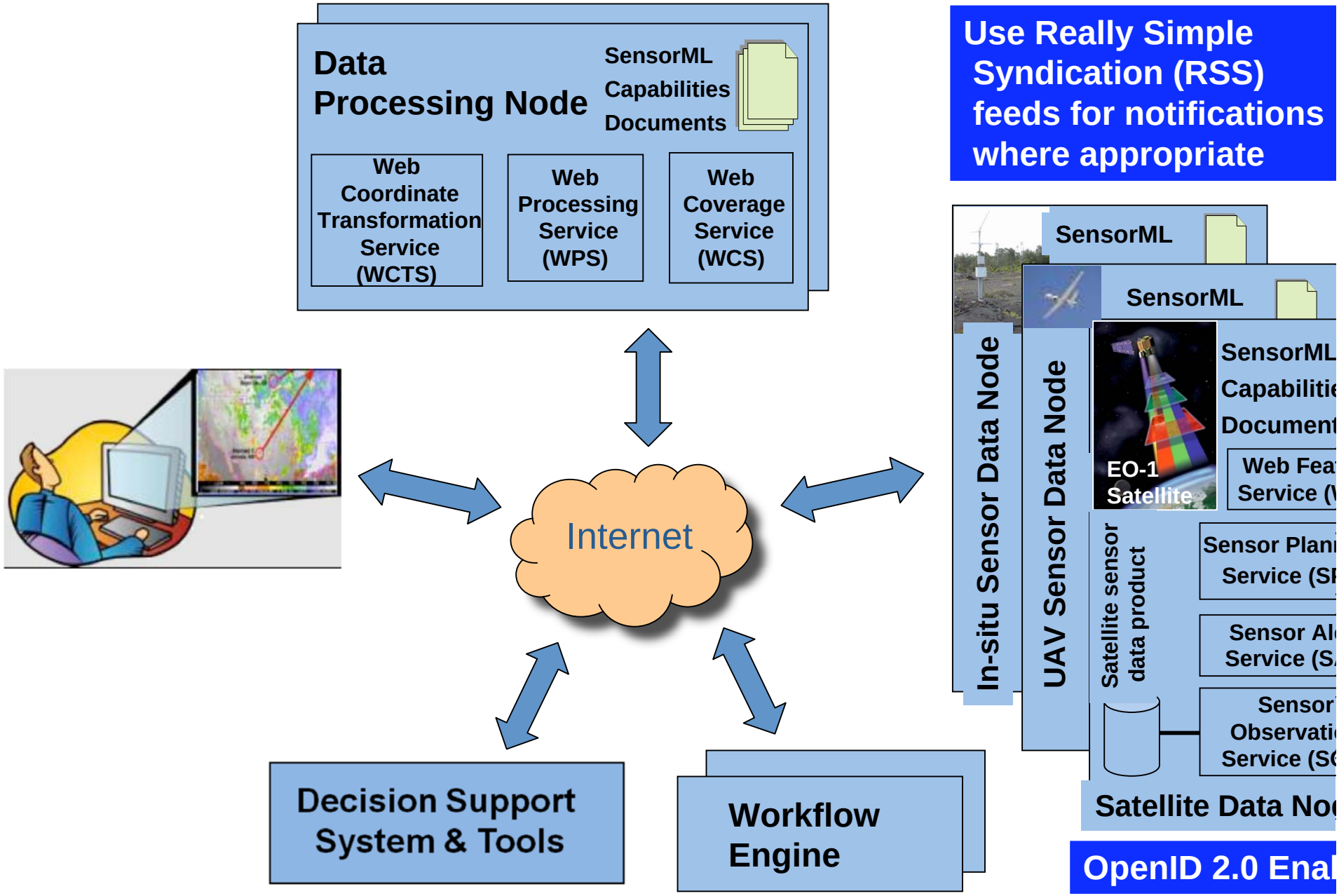
Enable Rapid Deployment of Existing Sensors - Desirable Features

- Theme-based tasking
- User customized data products
- Rapid electronic delivery of data products
- Discoverable workflows (recipes) to create these data products
- Workflows reusable
- Network of sensors is easily scalable
- Security
- Open standards
- Leverage Internet

Past and Ongoing Demonstrations/Collaborations

- OGC Interoperability Pilots
  - OWS-4
  - OWS-5
  - Empire Challenge with DIA
- GEOSS/CEOS
  - Architecture Implementation Pilot
  - Red Cross Flood Early Warning System
- SERVIR emergency response
  - Panama – Cathalac
  - Kenya - RCRMD
- Southern California Fire Sensor Web demos
  - Summer 2007
  - Summer 2008
- Collaborations with
  - Cloud screening - Kolitz
  - ASF – John Dolan
  - Lightning Early Warning – Prasana B.
  - UAVSAR – Y Lou
  - SWAMO – K. Witt

Sensor Web 2.0 Vision



Key Architecture Features

- OGC standards
  - Sensor Web Enablement standards
- Web 2.0
  - RSS
  - News Readers
  - Web Broswers
- Rest-ful approach versus SOAP/WSDL approach for SOA
  - Simpler
  - Supports mashups
  - Point and click access

Composite Sensor Web Demo

ICS209 National Fire Database

National Interagency Fire Center (NIFC)

Quayle/Remote Sensing Application Center (RSAC) - Forest Service

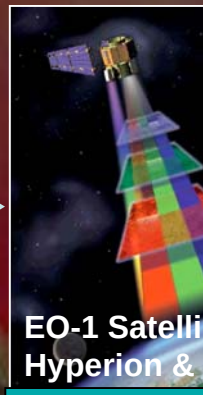
Kolitz, Abramson/Draper Cappelaere/Vightel

Decision Support System
- Cross correlate possible fire targets within flight path of UAS
- Get feasible assets
- Get feasible task allocations
- Allocate tasks to various assets

Ambrosia, Sullivan/

Get feasibilities & Task

Get feasibilities & Task



Mandl/GSF
Chien/JPL

Get feasibilities & Task

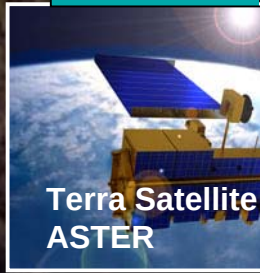
Get feasibilities & Task

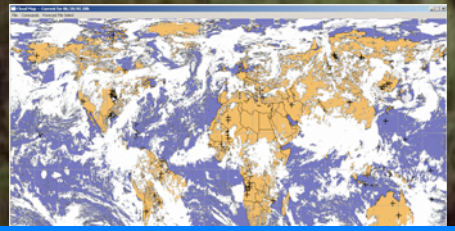
Get feasibilities & Task

Ambrosia, Sullivan/ARC

Internet

Remote Automated Weather Stations (RAWS)

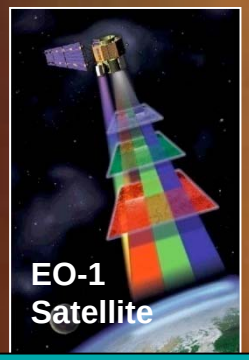




Air Force Weather Agency

EO-1 Fire Sensor Web Workflow

- Potential savings
  - Originally, USGS charged $2(task EO-1 and perform L0 an data processing for customer ($1250 now)
  - Potential cost reduced to und $100 since tasking EO-1, L0 L1G data processing automat



Sensor Planning Service (SPS)

Cappelaere/Vightel

Alexander/GSFC
Tran, Chien/JPL

Level 0 Science Process

Tran, Chien/JPL

Level 1G Process

Tran, Chien/JPL

Level 0.5 Process

Classify hot pixels

Pixels and heat values

1

2

Sensor Observation Service (SOS)

Cappelaere/Vightel

Level 1G or Level 0.5

Web Processing Service (WPS)

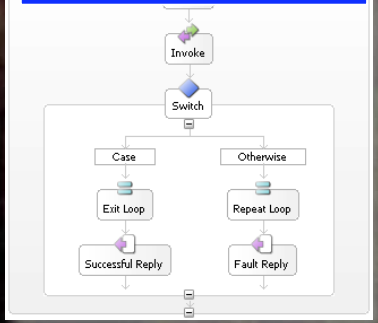
Tran, Chien/JPL

Web Coverage Servic –Transformation (WCS-T)

Zhao/GMU

JPEG

BPEL Workflow Engine



L. Di, Zhao/GMU

3

4

5

Publish composite JPEG map with data overlay (map with fire locations)

Community Map Builder client (on eo1.geobliki.com)

Web Map

UAS Fire Sensor Web Workflow

Kolitz, Abramson/Draper

Updated flight plan

Sensor Planning Service (SPS)

Ambrosia, Sullivan/AMES

Global cloud predicts

Air Force Weather Agency Global Cloud Predictions

Kolitz, Abramson/Draper

Sullivan/AMES

Web Coverage Service (WCS)

Web Map Service (WMS)

GoogleEarth Service

Event Notification Service

Tasking mess to EO1 SPS

OASIS CAP 1 Notifications over SMTP

Level 1G Terrain Corrected and Georectified GeoTiff 1-3 bands

KML Files

(PNG Graphic

GIS – Geographical Information System

Future Smoke Prediction Model with Auto Tasking for EO-1 and UAS

National Interagency Fire Center (NIFC)

ICS209 National Fire Database

Quayle/Remote Sensing Application Center (RSAC) - Forest Service

Fire ID and general fire location

Web Feature Service (WFS)

Refined fire location

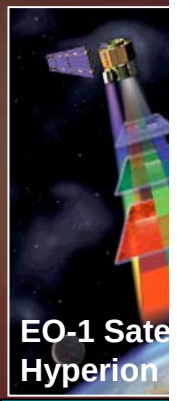
Web Processing Service (WPS)

S. Falke/NGC

2007 Table of Graphics Markup Language

Sensor Planning Service (SPS)

Ambrosia, Sullivan/AMES

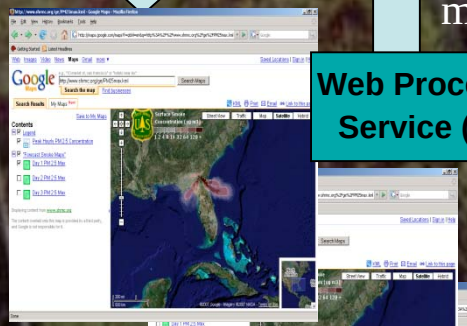


EO-1 Sate Hyperion

Sensor Pla Service (

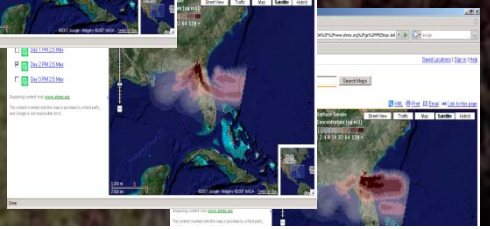
Mandl/GSF Chien/JPL

Automatic tasking requests based on model analysis



Web Processing Service (WPS)

2008 Smoke Mod

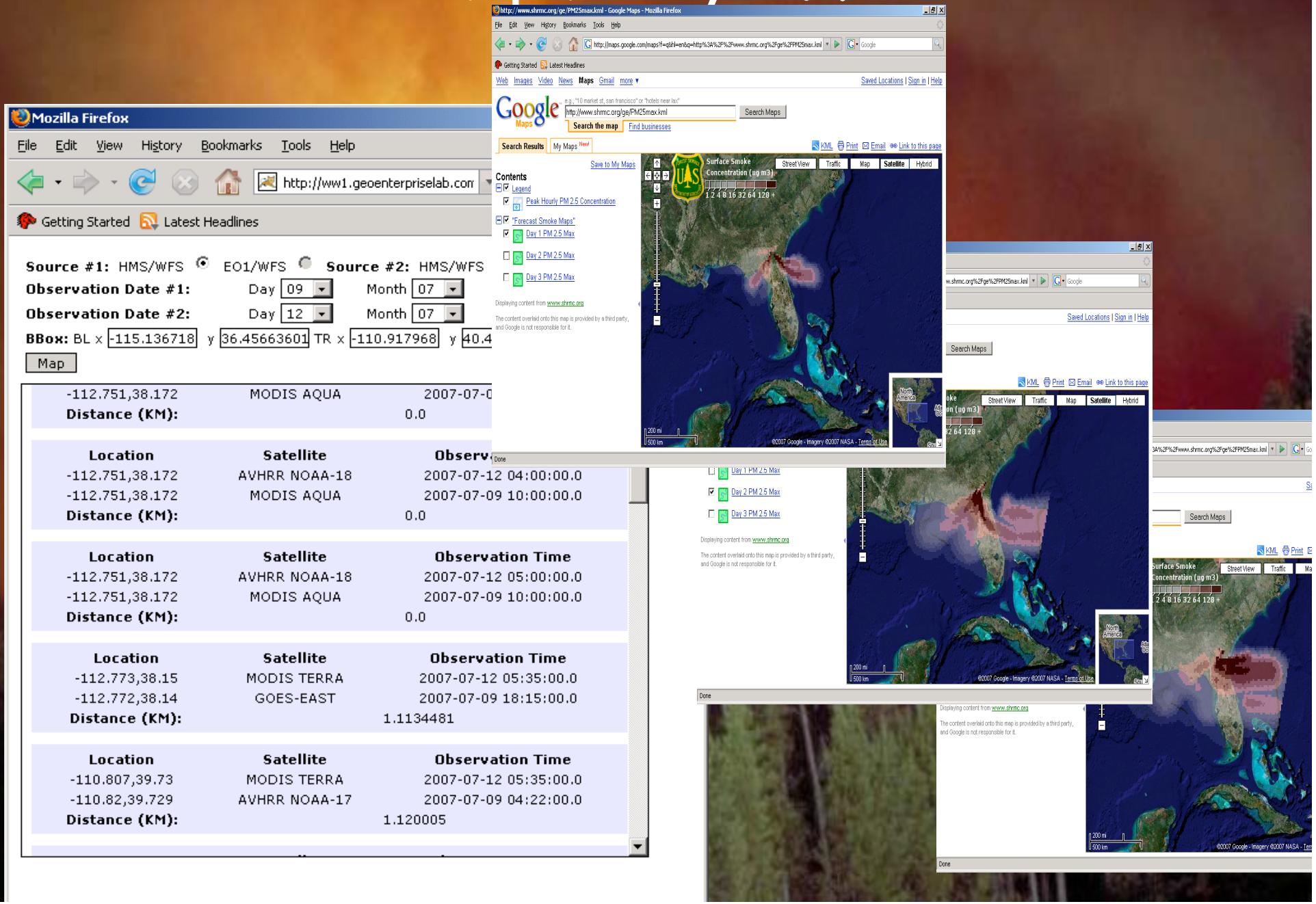


Web Feature Service (WFS)

Ambrosia, Sullivan/AMES

Refined fire location

Prototype Smoke Prediction Model Outputs by S. Falke



Accomplishment for Year 2 Thus Far (1 of 5)

Sensor Web Services Established

JPL SPS
EO-1 Hyperion
EO-1 ALI

JPL SOS
EO-1 Hyperion L0
EO-1 Hyperion
EO-1 Hyperion
EO-1 Hyperion
EO-1 ALI L0
EO-1 ALI L1R
EO-1 ALI L1G

Geobliki WfCS
WfXML workflow engine

JPL WPS
Thermal classifier
Burn Index
Composite Browse
Fluvial classifier
Cloud classifier
Sulfur classifier
SWIL classifier
Fire fuel load classifier (various, future)

Geobliki WPS
Vegetation Index (future)
Burn scar
Water classifier (future)
Rhodamine dye (future)
Snow & Ice (future)

Geobliki SPS
EO-1 Hyperion
EO-1 ALI

Geobliki SOS
EO-1 Hyperion L0
EO-1 Hyperion
EO-1 Hyperion
EO-1 Hyperion
EO-1 ALI L0
EO-1 ALI L1R
EO-1 ALI L1G

Geobliki WMS
Fire maps
KML transform for Google Earth

Accomplishment for Year 2 Thus Far (2 of 5)

Sensor Web Services Established

Draper WPS

AFWA Cloud Cover

Northrop Grumman

Smoke Model

WVHTF WfCS

Sensor Workflow Engine

AMES WCS

Ikhana UAS hot pixels

GMU WCS

Hot Pixels

ASTER SPS

ASTER

AMES SPS

Ikhana UAS Wildfire Instrument

GMU WCS-T

Transform Hot Pixels for Map production

ASTER SPS

ASTER

AMES WMS

Ikhana UAS Wildfire Images & Fire location maps

KML transform for Google Earth

GMU WfCS

BPEL engine to execute workflow

MODIS WFS

MODIS Hot Pixels

SPOT-5 SPS

SPOT-5

Earth Science Gateway CSW

NASA data

Global Change Management Directory CSW

Accomplishment for Year 2 Thus Far (3 of 5)

Sensor Web Services Established

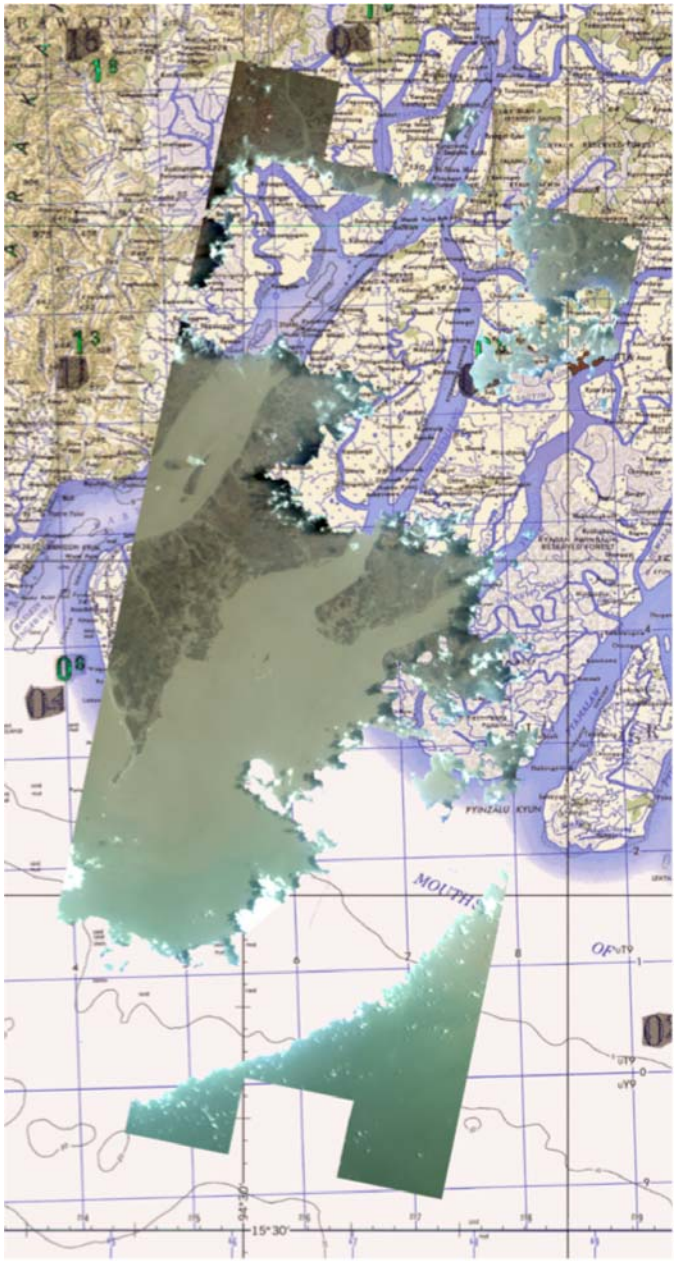
JPL SAS/WNS
MODVolc Alert
CVO Mt. St. Helens
MEVO Alerts

Geobliki SAS/WNS/OPS
EO-1 Hyperion/ALI products ready for pick up User subscribes to products they are interested and then receive SMS, IM or Twitter
EO-1 Hyperion/ALI tasking complete, notification via SMS, IM or Twitter

SAS – Sensor Alert Service (pub/sub)
WNS – Web Notification Service
OPS – OGC Publish/Subscribe

Accomplishment for Year 2 Thus Far (3 of 5)

Sensor Web Services Established



Prototype web service that
Georectified Advanced Lan
Imager onto
map with clouds removed.

WPS ALI Geo-
Automatic geo-rectification of ALI images

Accomplishment for Year 2 Thus Far (5 of 5)

Sensor Web Services Established

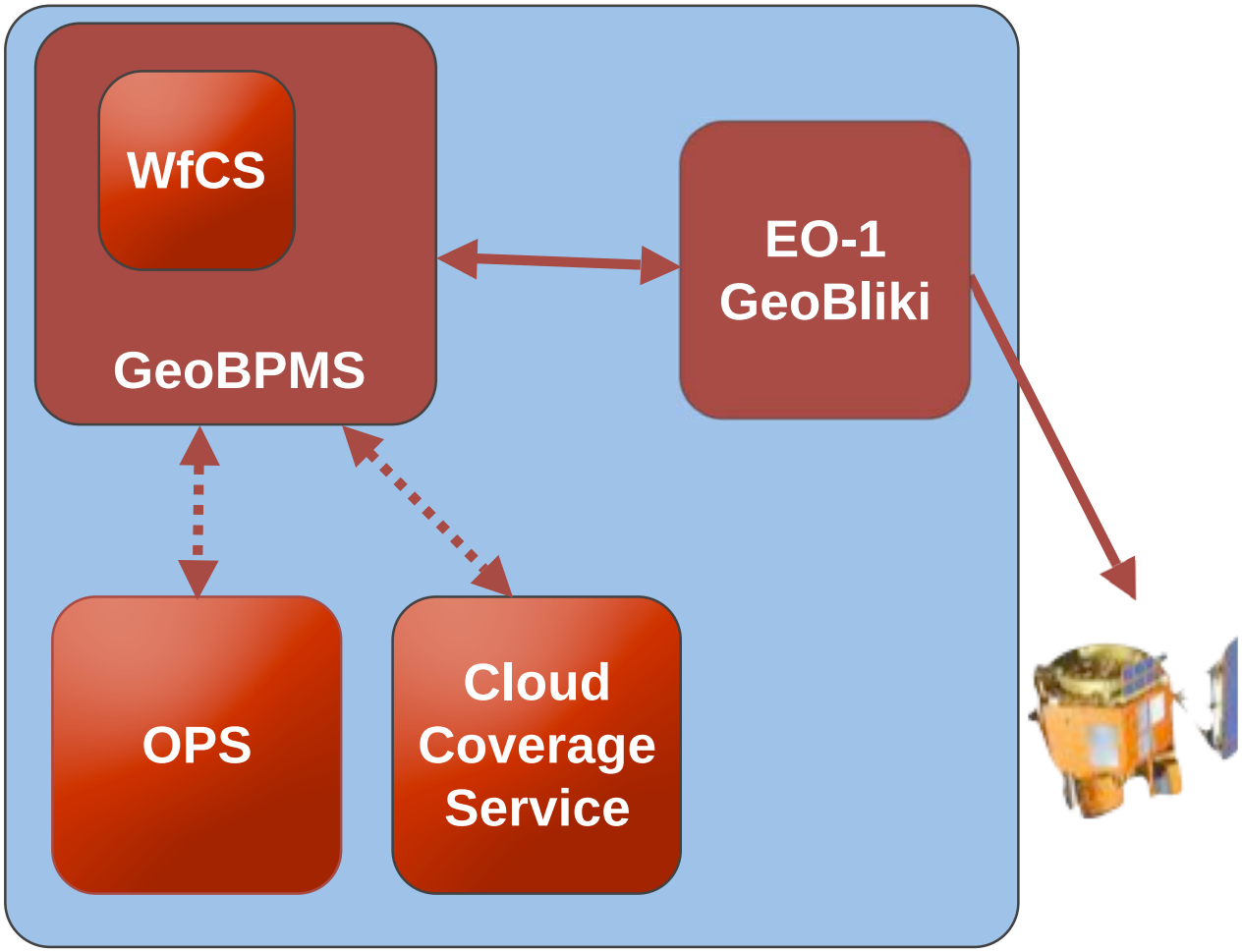
Prototype web service that performs atmospheric correction on each Hyperion image.

WPS Hyperion Atmospheric Correction
Decision support system discovers what other sensors are available to input into MODTRAN/FLAASH to get best atmospheric

LIR-AC

Workflow Chaining Service

Workflow Chaining Service
Wf-XML-R specification
developed with OGC and WFMC



GeoBPMS = Workflow Engine
(WfCS) + Multi-Criteria
Decision Support System

GeoBPMS – Geographical Business Processing Management Service
OPS - OGC Publish-Subscribe
WfMC – Workflow Management Coalition

Status:
WfCS: 90% Complete
DSS: 50%
OPS: 50%
Clouds: NOAA 95%
Draper 0%

Multi-Criteria Decision Support System

Short Term Campaigns, Emergencies...
1-2 scenes per day

Long Term Campaigns, Surveys...
20-25 scenes per day

Sensor Web

Priority
Replacement

Mission Science Office (MSO)

Event though sensor web requests are infrequent, we can not unilaterally bump all science requests. Some are more important than others.

How Multi-criteria Decision Support System will be used

Short Term Campaigns, Emergencies...
1-2 scenes per day

Long Term Campaigns, Sur
20-25 scenes per dc

Sensor Web

MSO

Priority
Replacement

New Campaign

Weight

Weight

New Campa

Request

Request

Joint Review Board

Criteria

Short Term Campaigns, Emergencies...
1-2 scenes per day

Long Term Campaigns, Surve
20-25 scenes per day

Sensor Web

MSO

Priority
Replacement

Priority

Campaign Weight

User Role

Weather Forecast

NOAA Global Forecast Model

Draper Forecast Model

Security for Open Web Services

Short Term Campaigns, Emergencies...
1-2 scenes per day

Long Term Campaigns, Surve
20-25 scenes per day

SensorWeb

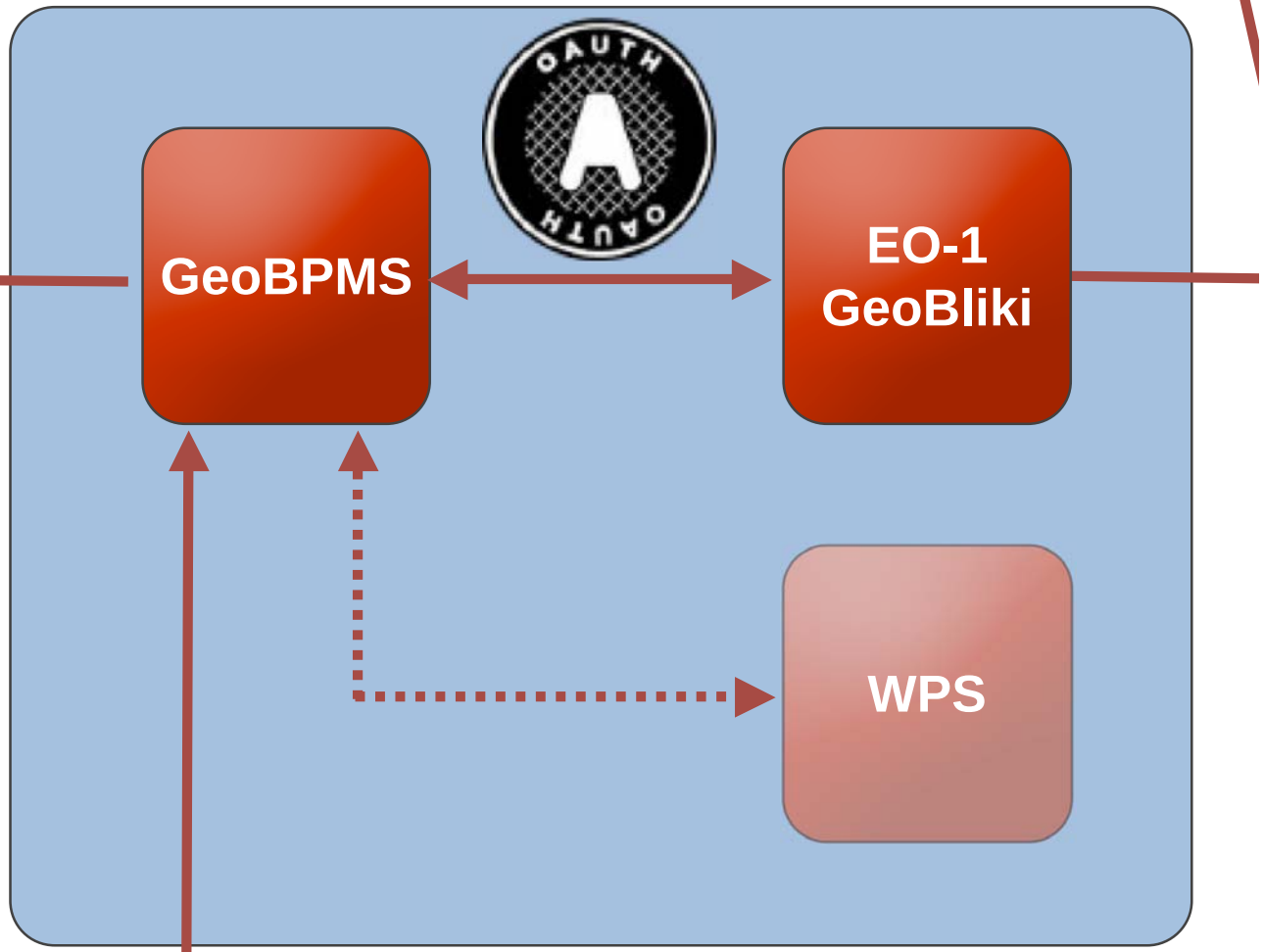
MSO

OpenID Provider

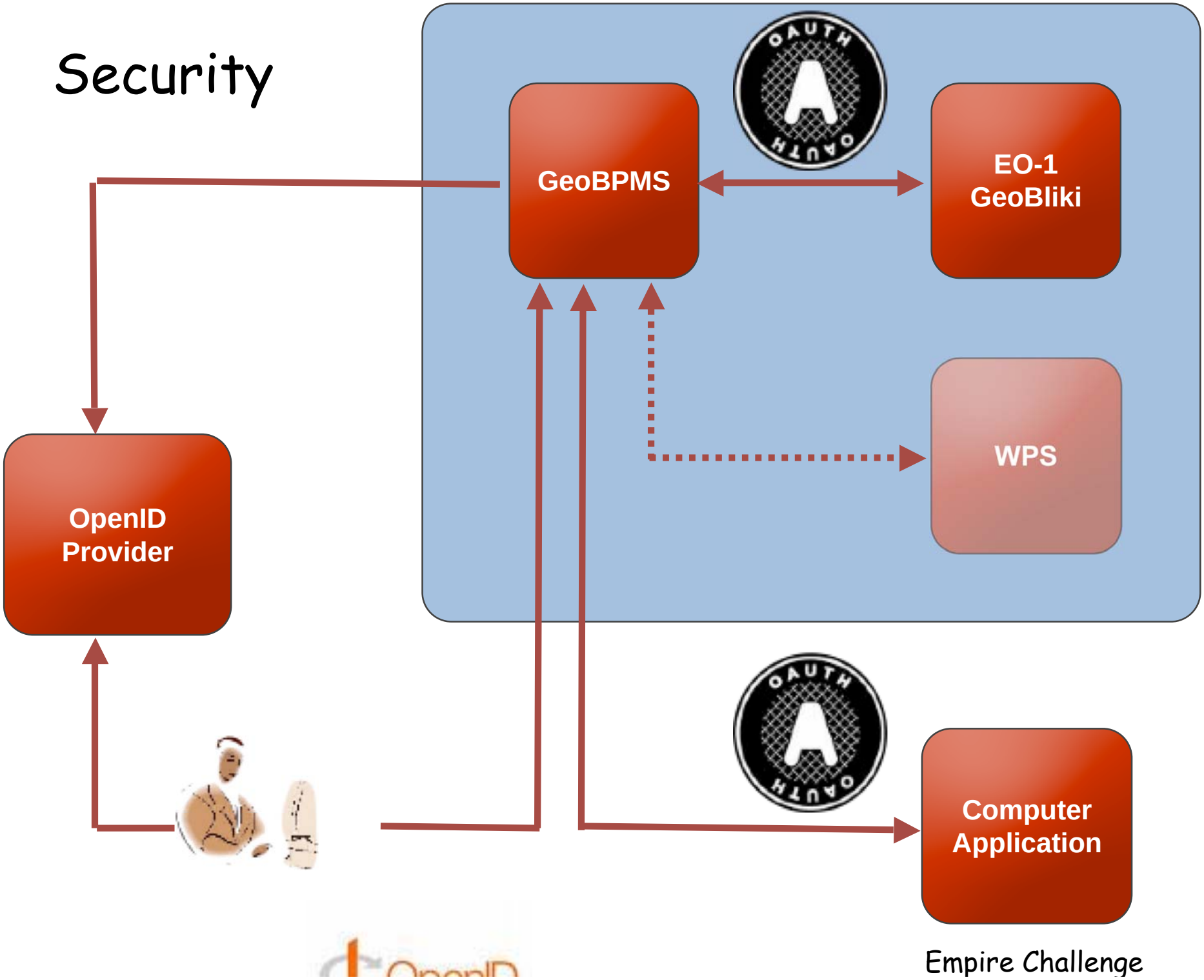
User Authentication
Profile Exchange
Roles

OpenID

Security



Security


GeoBPMS
EO-1
GeoBliki
WPS
OpenID
Provider
Computer
Application

Screenshots

main | campaigns | requests | tasking | c

Scenario/Campaign Entries

Search Creat

Title	Content	Theme	User	Scenario Requests	Created At	Updated At	Weight	
Chengdu Earthquake	China EarthQuake - May 2008	quake	veri_pat	Chengdu, Tongzhou - East Bejing	06/03/2008 02:32 AM	06/04/2008 01:59 PM	0.3	Edit Delete

Scenario/Campaign Tasking Requests for Chengdu Earthquake

Search Creat

Title	Content	Geolocation	Scenario Feasibilities

Tasking Request:

Title:	Chengdu
Description:	Epicentre
Category:	
Latitude:	31.0
Longitude:	103.4
Country Code:	CN
Country Name:	China
Zone Number:	307
Zone Name:	Sichuan, China
Region Number:	26
Region Name:	India - Xizand - Sichuan - Yunnan
Admin Code:	27
Admin Name:	CN.27
Nearby:	Xuankou, Sanjiangkou, Yingxiu
Created At:	Tue, 03 Jun 2008 02:35:53 -0000
Updated At:	2008-06-03

Show Map

Feasibilities

Potential Feasibility	2008-06-06T03:18:00Z
Potential Feasibility	2008-06-09T03:36:00Z
Potential Feasibility	2008-06-11T03:14:00Z

Tongzhou - East Bejing	Second Epicentre	39.8, 116.8	2008-06-08T02:54:00Z, 2008-06-10T02:33:00Z	Edit Delete

2 Found

Screenshots

Scenario/Campaign Tasking Opportunities

Search Update Forecast

Campaign	Theme	Request	User	Org	Asset	Date	Weather	Score	
Chengdu Earthquake	quake	Chengdu	veri_pat	Vightel	EO-1	2008-06-06T03:18:00Z	94	24	Edit Delete Show
EC'08	ships	China Lake	veri_pat	Vightel	EO-1	2008-06-06T18:04:00Z	0	37	Edit Delete Show
EC'08	ships	Pt Mugu	veri_pat	Vightel	EO-1	2008-06-06T18:04:00Z	0	37	Edit Delete Show
Myanmar	flood	Initial	patrice	Vightel	EO-1	2008-06-07T04:01:00Z	99	3	Edit Delete Show
NSP	intel	TA-03	patrice_OLD	Vightel	EO-1	2008-06-07T07:13:00Z	0	22	Edit Delete Show
NSP	intel	TA-02	patrice_OLD	Vightel	EO-1	2008-06-07T07:13:00Z	0	22	Edit Delete Show
GEOSS	fire	Kenya	veri_pat	Vightel	EO-1	2008-06-07T07:23:00Z	95	18	Edit Delete Show

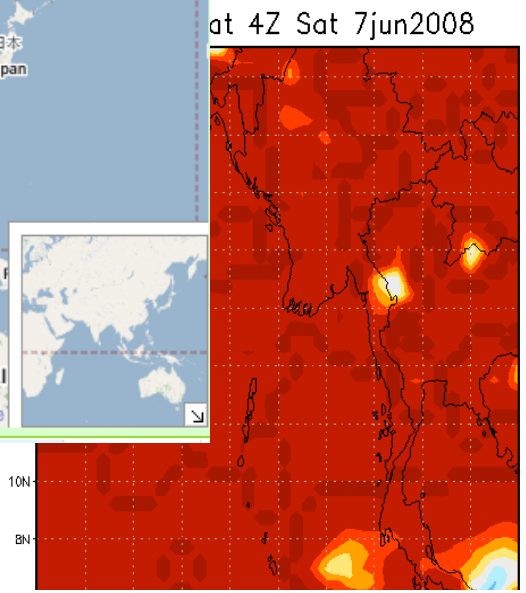
Scenario/Campaign Tasking Opportunities

Campaign	Theme	Request	User	Org	Asset	Date	Weather

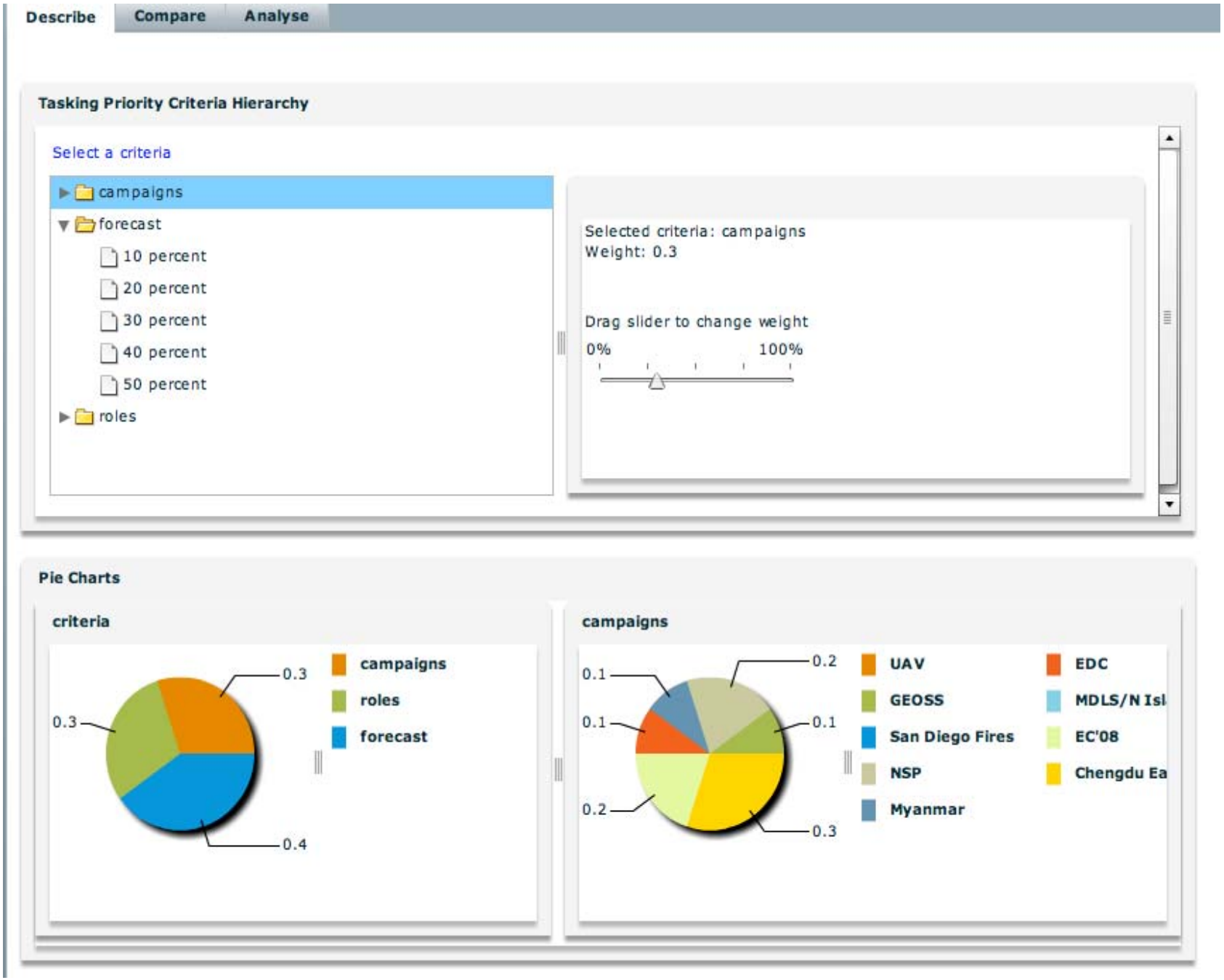
Tasking Opportunity:

Campaign: Myanmar
Theme: flood
Request: Initial
Latitude: 15.965
Longitude: 94.425
Date: Sat, 07 Jun 2008 04:01:00 -0000
Weather: 97
Score: 3

Show Map
Show Weather Forecast



Screenshots

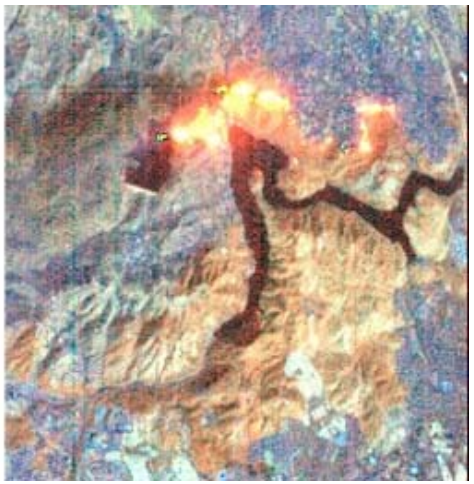


High Level Architecture for Fall 2007 Fire Sensor Web Demo

First responder

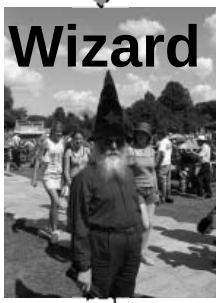
Theme Based Tasking Request

Geo-Emergency



Witch Fire (SoCal) Oct 23, 2007

EO-1 Fire Sensor Web Image
Published in CNN- Popular Science



- Emergency
- Discover availab sensor assets ov Internet
- Wizard assembl possible workflo
- Workflow engine controls creation multi-sensor products, proces and delivery to u desktop

Workflow Engine

Result: Efficient / timely use of a

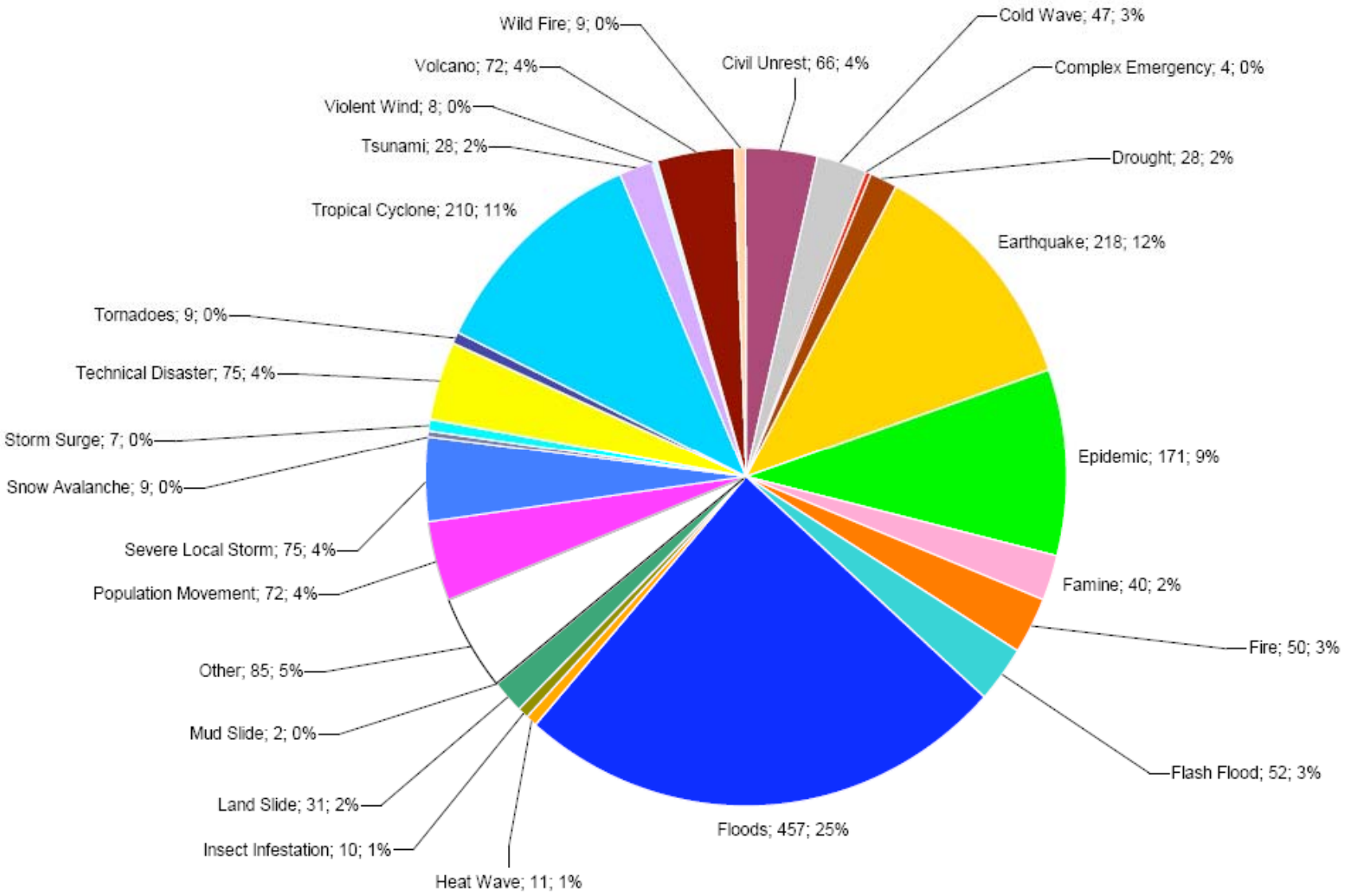
Sensor Web 2.0 Experiments

Connecting Earth's sensors with the Internet

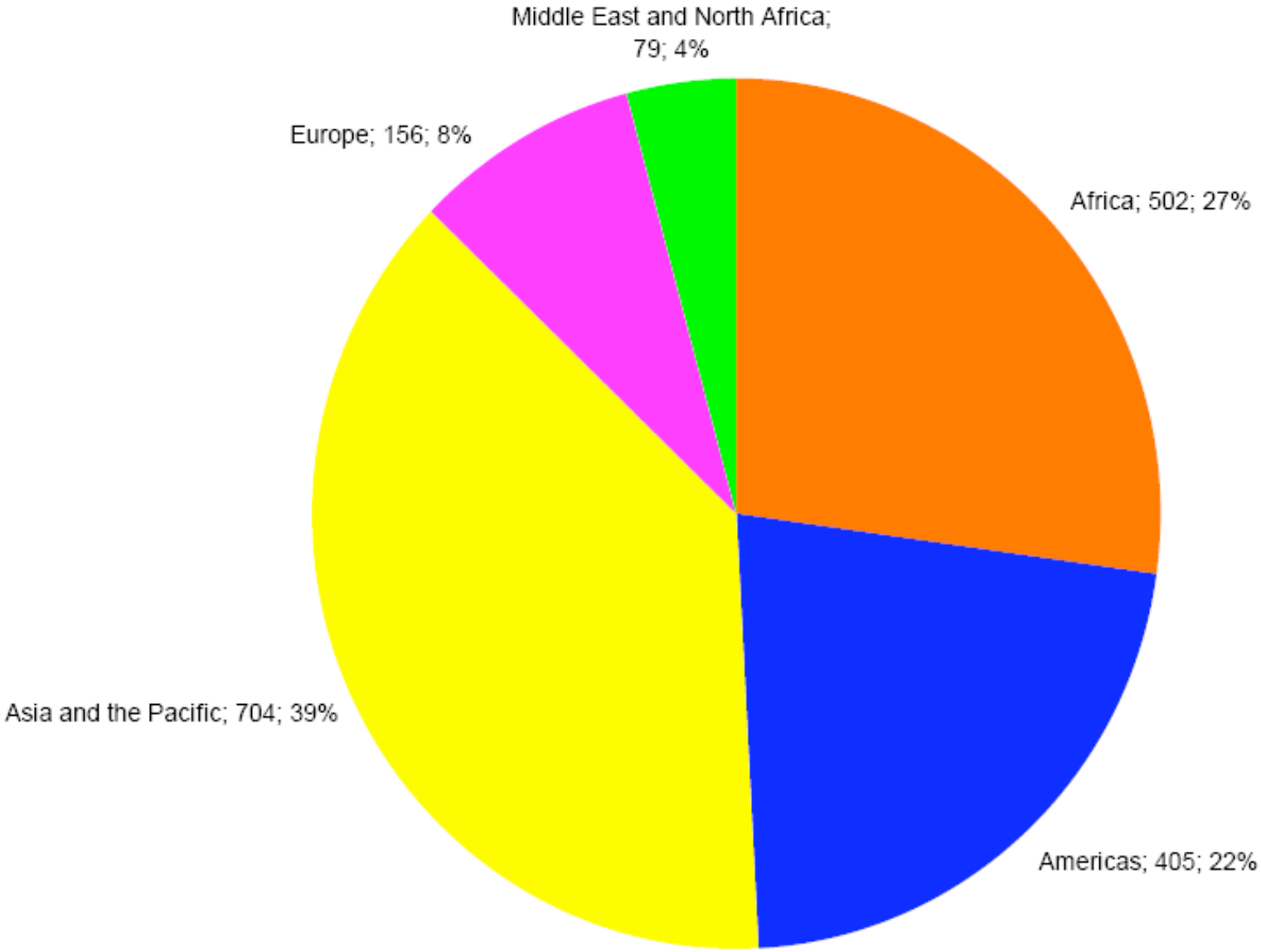
Established Collaboration with International Federation of Red Cross/Red Crescent Flood Early Warning System

- Developing prototype Flood Sensor Web Early Warning System
- Selected area of interest in Africa and Asia
  - Underserved
  - Population at greatest risk with least resources
  - Greatest potential to save lives
- Question- How to augment workflow to enable earlier decisions and save lives

Type of disasters 2004-2008



Disasters by region 2004-2008



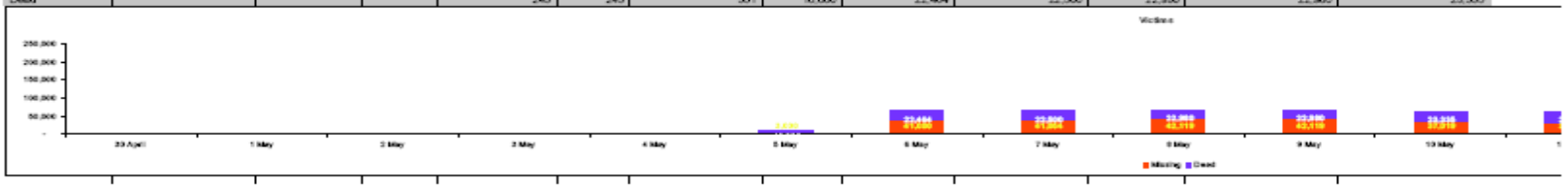
Established Collaboration with International Federation of Red Cross/Red Crescent

-Timeline of Myanmar Red Cross Effort

Cyclone NARGIS - Timeline

15/05/2008 21:26

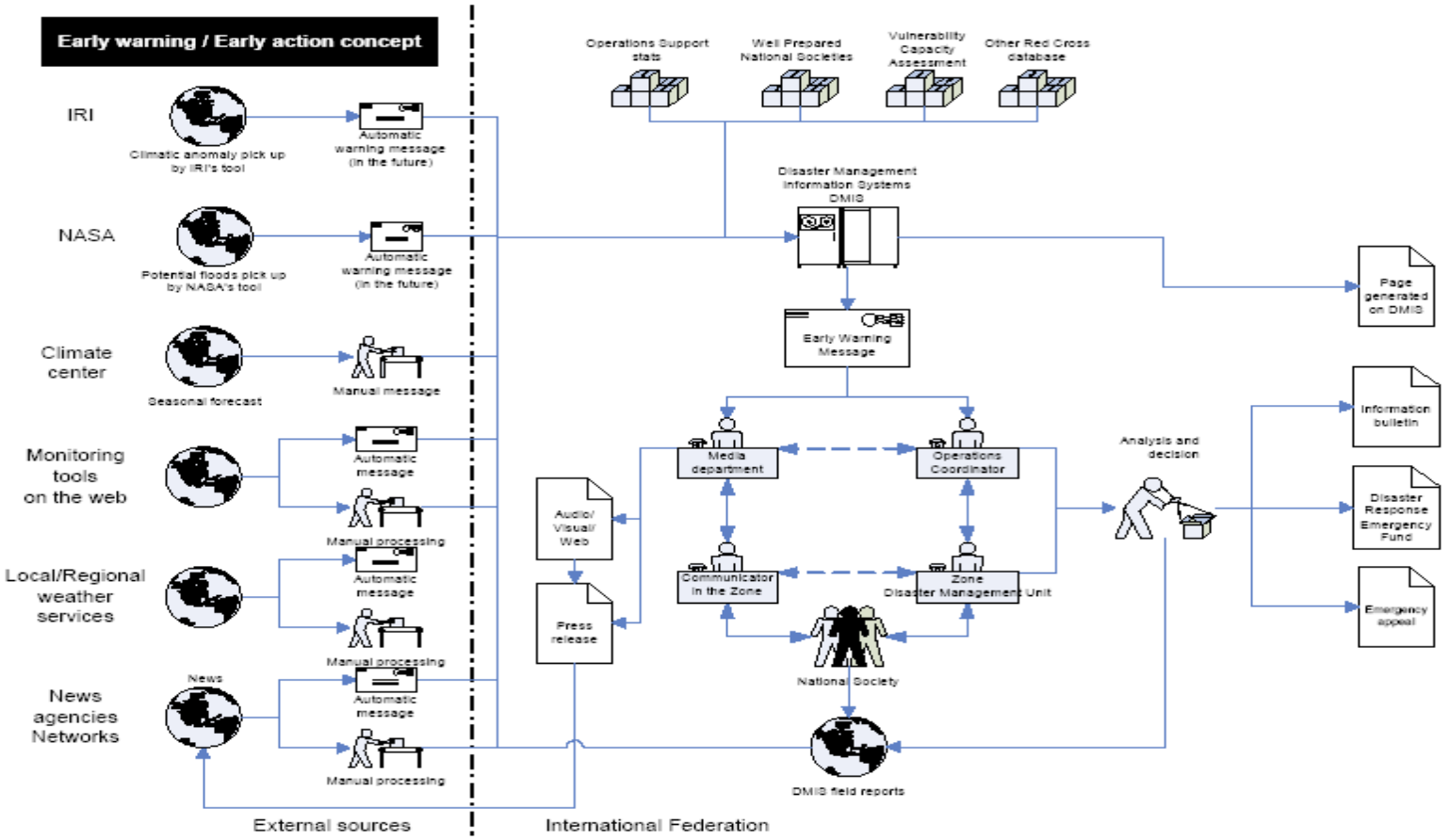
	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Date	29 April	30 April	1 May	2 May	3 May	4 May	5 May	6 May	7 May	8 May	9 May	10 May
Position	900 KM from land	750 KM from land	300 KM from land	LANDFALL	Pass over Yangon	Dissipated	Dissipated	Dissipated	Dissipated	Dissipated	Dissipated	Dissipated
Early warning	E-mail and briefing to OCT Nargis direction Bangladesh/Myanmar	e-mails OCT	e-mails OCT	e-mails OCT - The govt owned news station reported on "50% chance of heavy rain" (Source: Asia Times online)	e-mails OCT		Research to OCT (History)	Weather forecast and 5D rain forecast sent to OCT				
DMIS		ALERT		Update		Update	Special Focus created	SF updated	SF updated	SF updated	SF updated	SF updated
Information/GIS				IB		First UNOSAT map of the path of Nargis	First IFRC map and KMZ (Google Earth) created - First MODIS derived flood extend	Request for EO1 sat pics sent to NASA - Received SHP extend of floods (MODIS) from Bob Brakenridge (Dartmouth)		Sat imagery from JAXA - Univ. Of Maryland: Floods derived from MODIS	Earth Observatory beWell pic of Yangon - Not useful - difficult to make analysis	
FACT						INFORMATION	Update		ALERT at 08:50 - team selected and composition sent to the field at 15:51		4 members on the ground (Morning)	
ERU								Update	REQ LOG at 11:10 ALERT LOG at 11:40		REQ WATSAN at 06:00 ALERT WATSAN at 08:15 LOGS TO DEPLOY German/Austrian RC M15 greenlight to deploy at 14:57 French RC M40 greenlight to deploy at 15:04	French RC M40 equipment in Yangon, 1 FRC staff awaiting visa in Paris
RDRT						request for names - naming possibilities received from BKK	following up with request for names		Requesting status of RDRT's		2 persons in Rangon (15:04)	
UN							OCHA sitrep 1	OCHA sitrep 2	OCHA sitrep 3	OCHA sitrep 4 - Decision on lead agency Shelter	OCHA sitrep 5 - WHO worried about malaria outbreaks - Flash Appeal launched	OCHA sitrep 6
Appeal & DREF						DREF CHF 200'000		CHF 6,250,000	OU 1	OU 2	OU3	OU4
Missing							3,000	41,000	41,054	42,119	42,119	37,019
Homeless/Affected						100,000	100,000	1,000,000	1,000,000	1,000,000	1,000,000	1,500,000
Dead				243	243	351	10,000	22,464	22,500	22,950	22,980	23,395



Thank you for sending the updates to Frederic

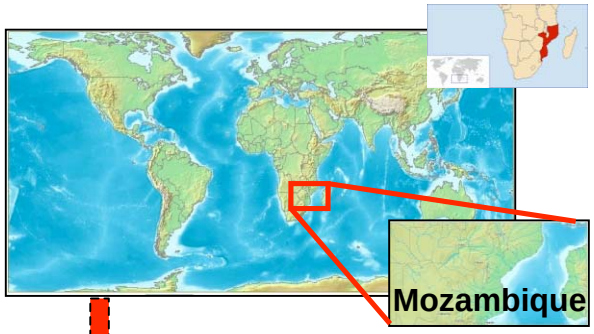
Established Collaboration with International Federation of Red Cross/Red Crescent

Trying to augment their workflow to enable earlier decisions

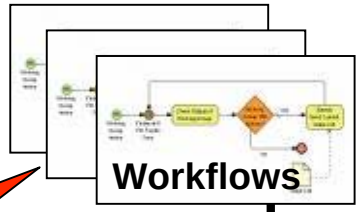


Vision -Theme-Based Flood Product Generation for IF

From portal select desired theme(s) and area of interest



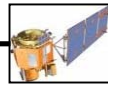
Selected workflow automatically activates needed assets and models



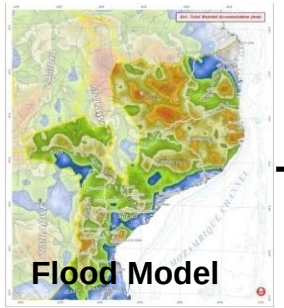
Disaster Management Information System (DMIS)

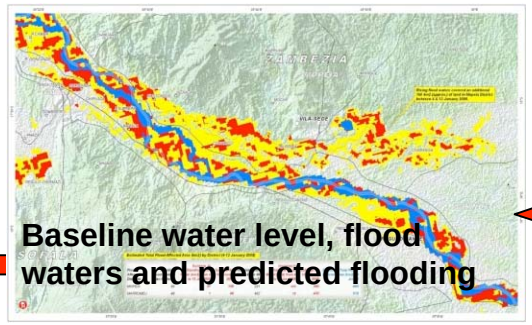
- Air Quality
- Coral Bleaching
- Droughts
- Earthquakes
- Excessive Heat
- Fire Weather
- Flooding
- Harmful Algal Blooms(HABs)
- Hurricanes/Tropical Weather
- Oil Spills
- Rip Currents
- Severe Weather
- Space Weather
- Tsunamis
- Volcanoes

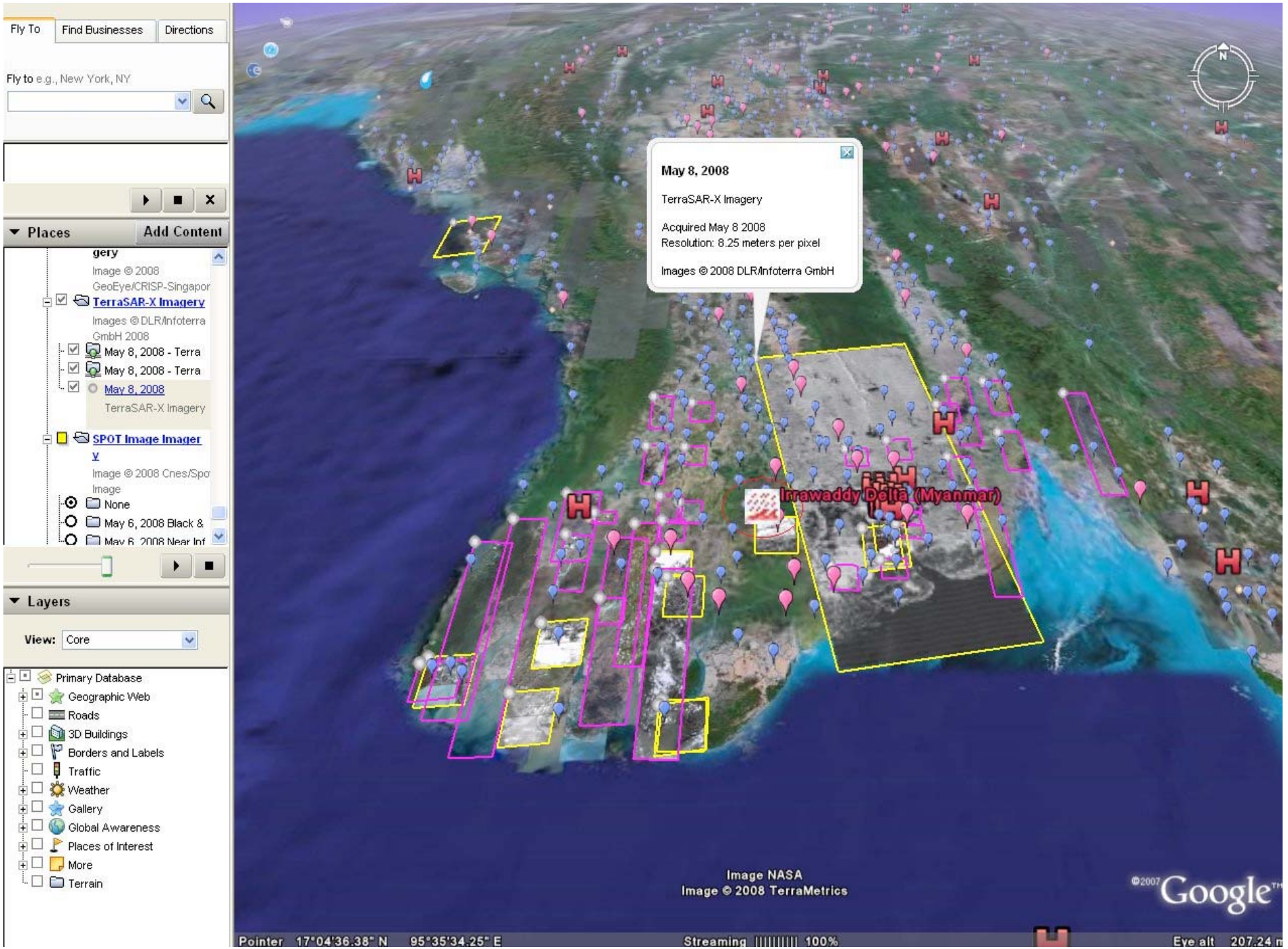
Wizard picks appropriate workflow for desired result



Estimated rainfall accumulation and flood prediction model






Fly To
Find Businesses
Directions
Fly to e.g., New York, NY
Places
Add Content
gery
Image © 2008 GeoEye/CRISP-Singapor
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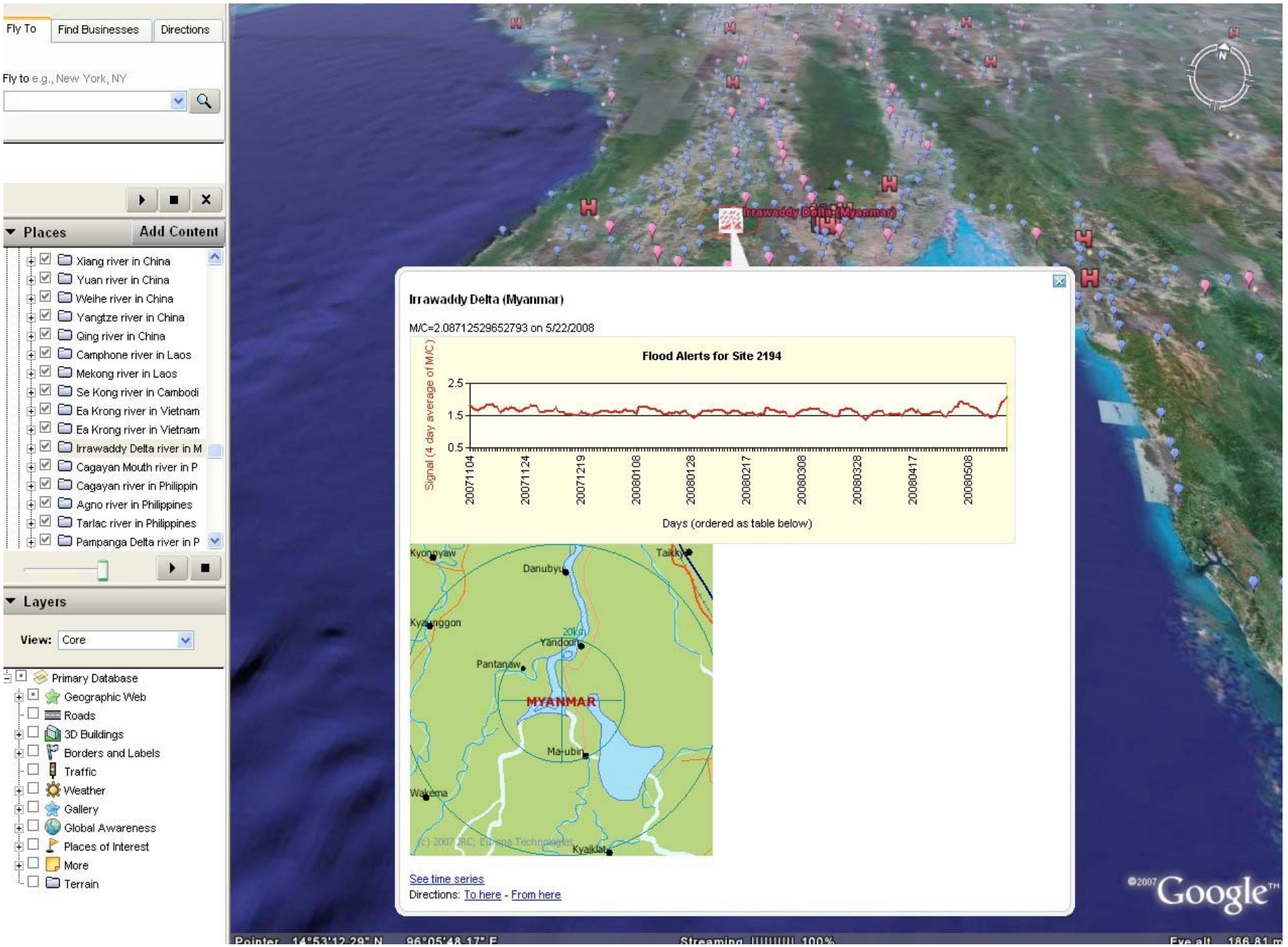
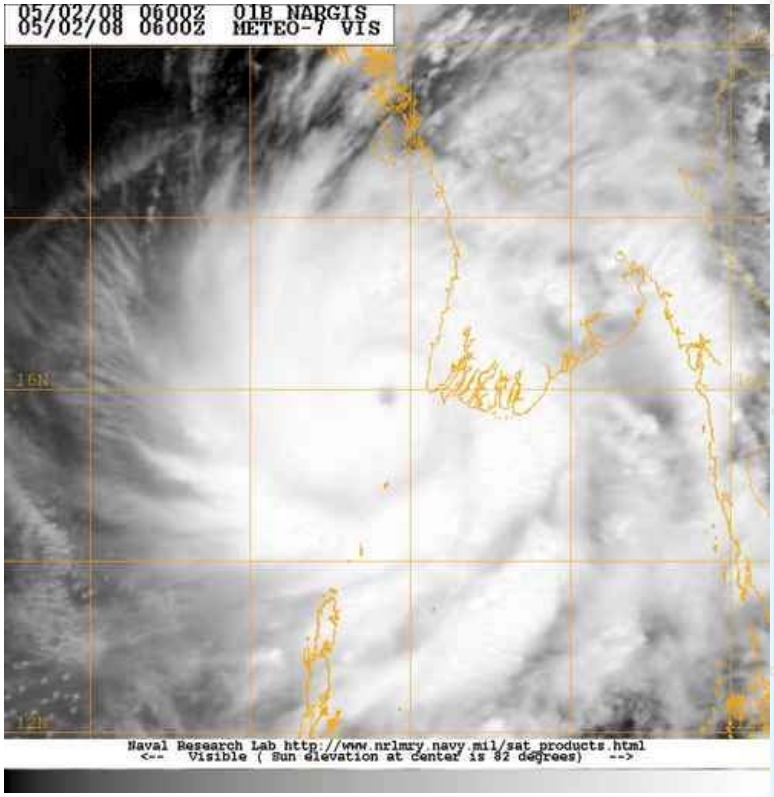
SPOT Image Imagery
Image © 2008 Cnes/Spot Image
None
May 6, 2008 Black &
Layers
View: Core
Primary Database
Geographic Web
Roads
3D Buildings
Borders and Labels
Traffic
Weather
Gallery
Global Awareness
Places of Interest
More
Terrain
May 8, 2008
TerraSAR-X Imagery
Acquired May 8 2008
Resolution: 8.25 meters per pixel
Images © 2008 DLR/Infoterra GmbH
Irrawaddy Delta (Myanmar)
Image NASA
Image © 2008 TerraMetrics
©2007 Google
Pointer 17°04'36.38" N 95°35'34.25" E
Streaming 100%
Eye alt 207.24 m

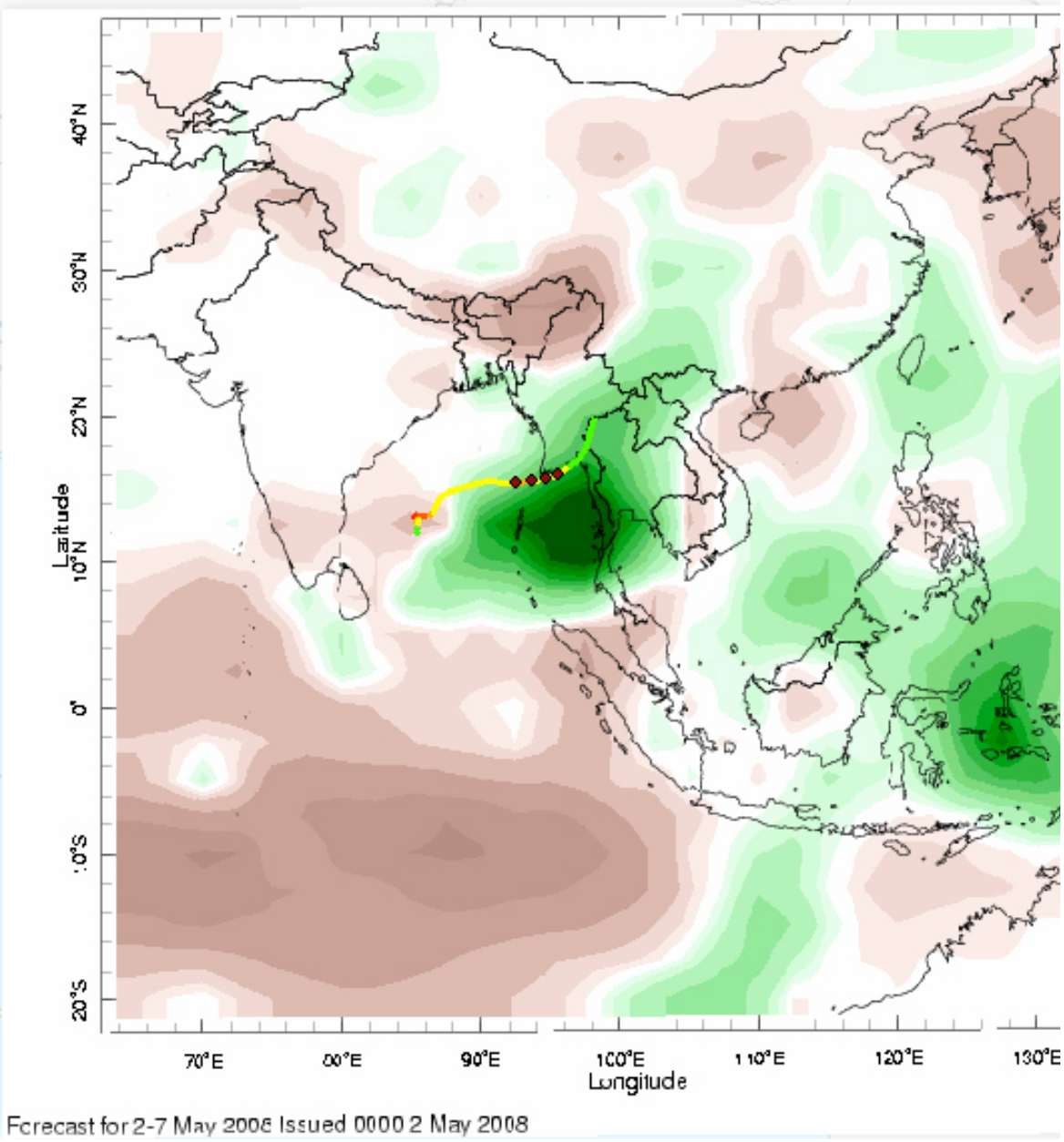


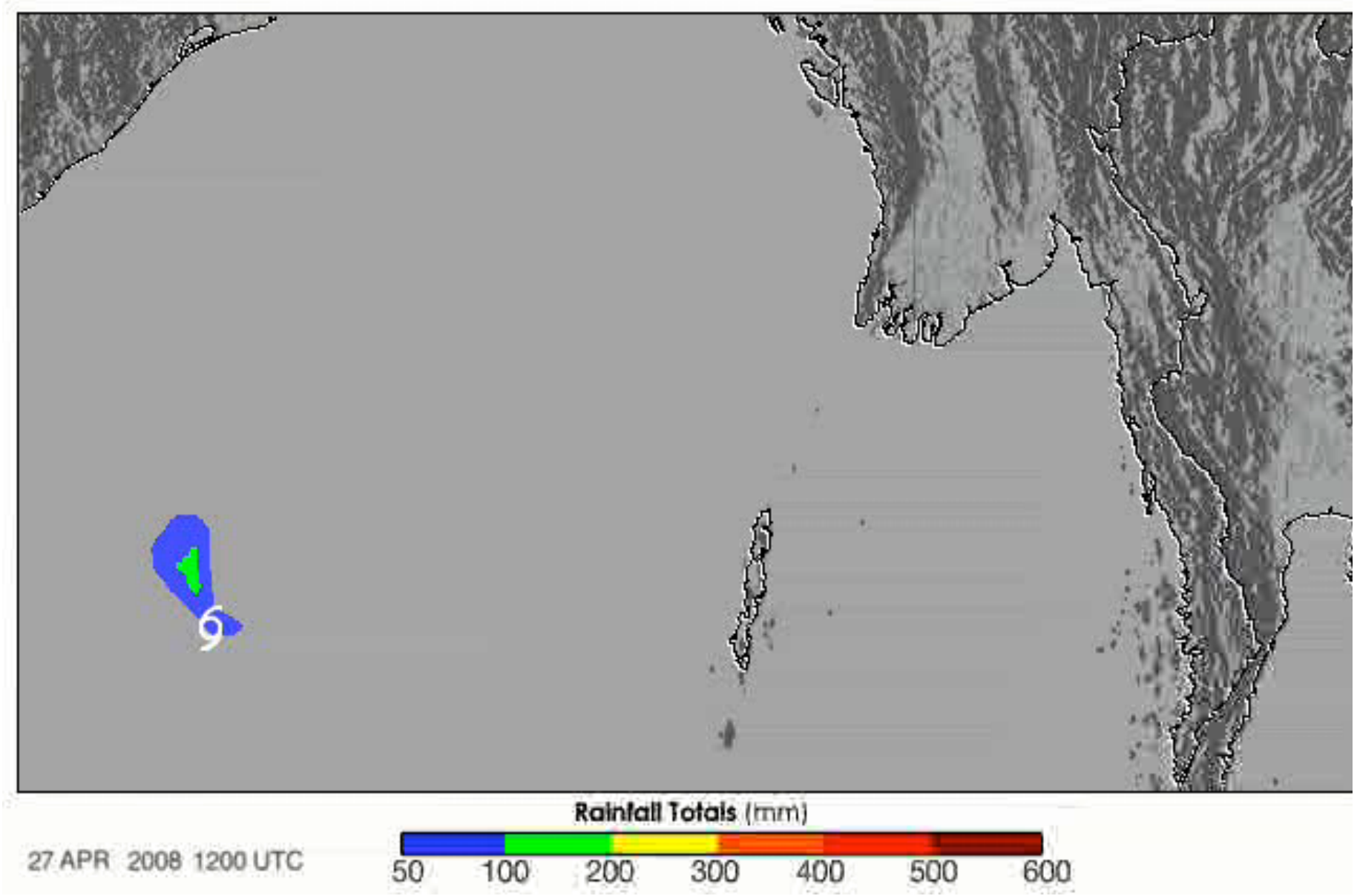
Select sensor and get details

Columbia Univ IRI
Average climatic rainfall
as compared to current
Predicted rainfall. Thus looking
for rainfall anomalies as
Possible early flood warning.

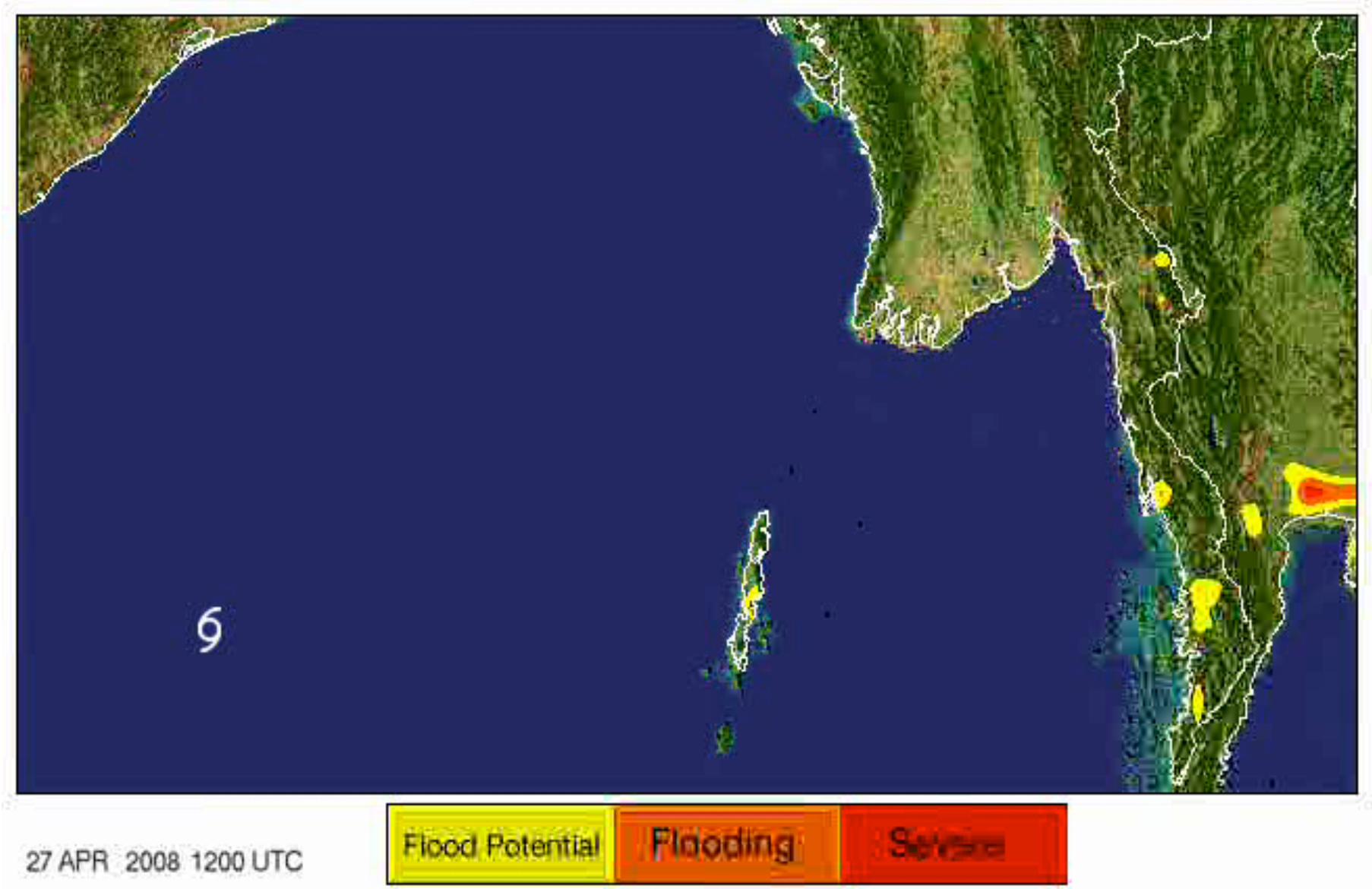
2 May





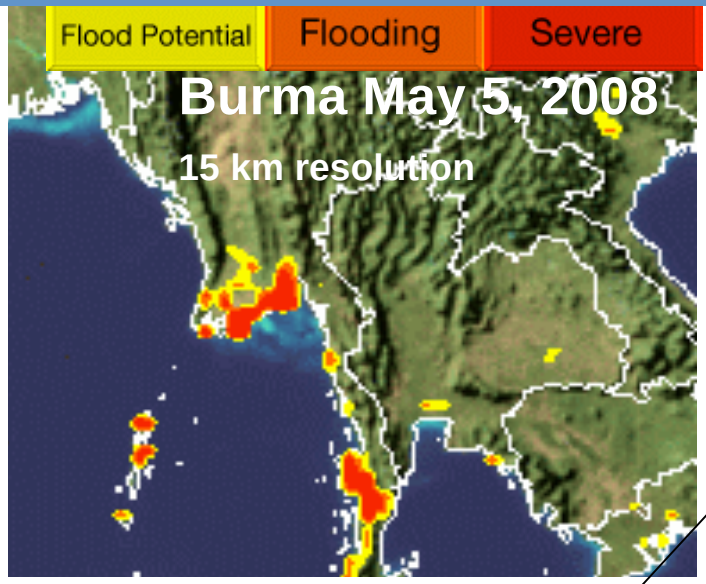


NARGIS TRMM Animation of Rainfall Progression

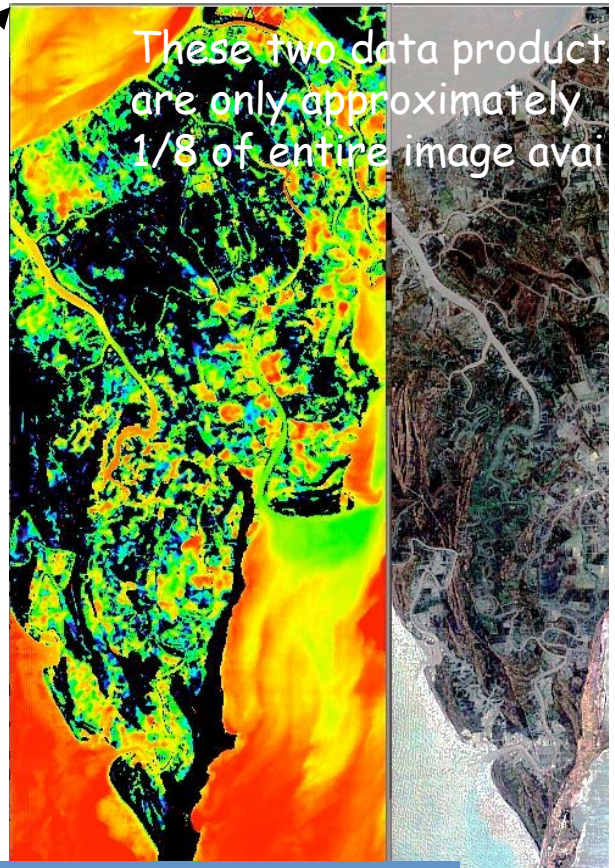


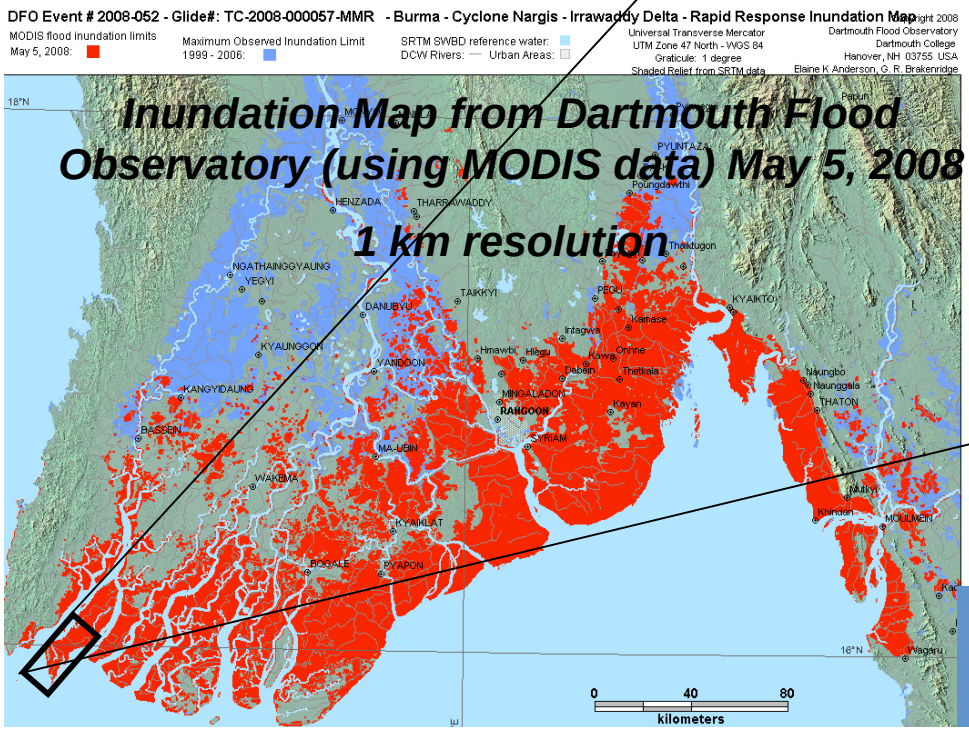
NARGIS TRMM Animation of Flash Flood Potential

1. Real-time flood estimate using global hydrological model and satellite rainfall estimate - Adler



4. Future experiment will be to substitute predicted rainfall versus real time rainfall estimate into Adler model to obtain predicted flood warning and automatically task EO-1 in area of interest and create MODIS and EO-1 data products





3. EO-1 Advanced Land Imager automatically triggered and pointed to get more water depth details in area of interest.

Water Depth Classifier True c
Advanced Land Imager 30r
May 5, 2008

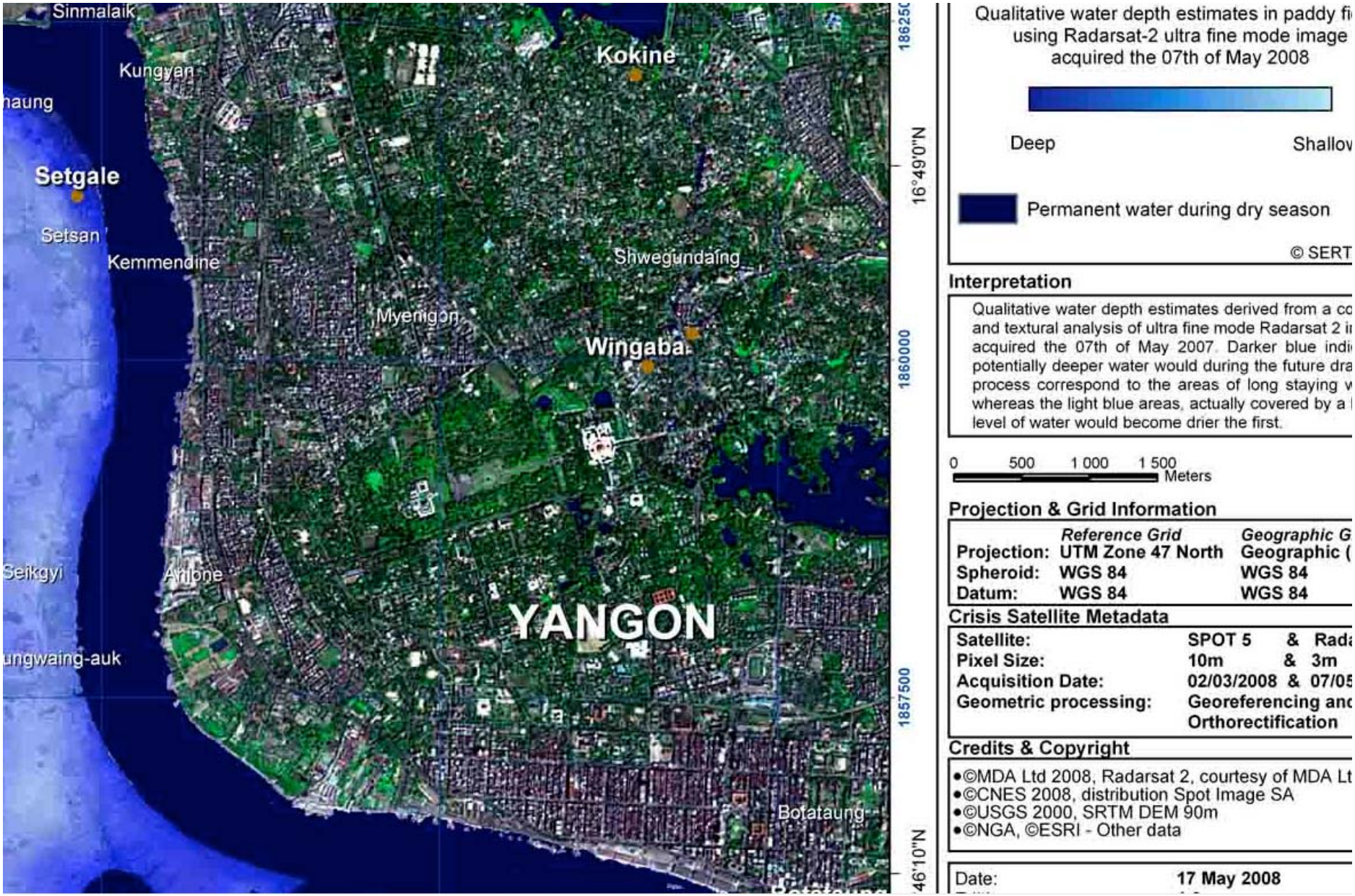
Red - deep
Yellow - me
Green - me
Blue - shall

2. MODIS used to validate flood locations with direct observation

International Charter for Disaster Management

- The International Charter aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-mad disasters through Authorized Users. Each member agency has committed resources to support the provisions of the Charter and thu is helping to mitigate the effects of disasters on human life and property.
- Members
  - ESA ERS, Envisat (Europe)
  - CNES SPOT, Formasat (France)
  - CSA Radarsat (Canada)
  - ISRO IRS (India)
  - NOAA POES, GOES (US)
  - CONAE SAC-C (Argentina)
  - JAXA ALOS (Japan)
  - USGS Landsat, Quickbird (2 ft res), GeoEye-1 (2 ft res) (US)
  - DMC ALSAT-1 (Algeria), NigeriaSat, Bilsat (Turkey), UK-DMC, Topsat
  - CNSA FY, SJ, ZY satellite series (China)

Radarsat (3 m) – May 7, 2008 Myanmar



Quickbird Image (2 ft res) – May 5, 2008 Myanmar

Future Work

- Correlate Red Cross workflow with available images, measurements and models
- Establish one workflow to demonstrate early decision/warniong due to flood sensor web
- Show decision save lives or property
- Leverage demonstration to get ministers of various nations to fund expansion.
- Sample decision
  - Detect whether flood water is fresh or salty water
  - If fresh water then send water purifiers valued at $500K to $1 million
  - If salty water then send water
  - Problem – have not identified how to classify water as fresh or salty
- Looking for other similar decision scenarios

NASA

SensorWeb

Linking Sensors, Products & People

For Science, Humanitarian Assistance and Disaster Relief Applications