NASA Support for GEOSS and Disaster Risk Management under the Committee on Earth Observation Satellites – Caribbean Example

Presented at the GEOSS Session of Latin American Remote Sensing week in Santiago Chile

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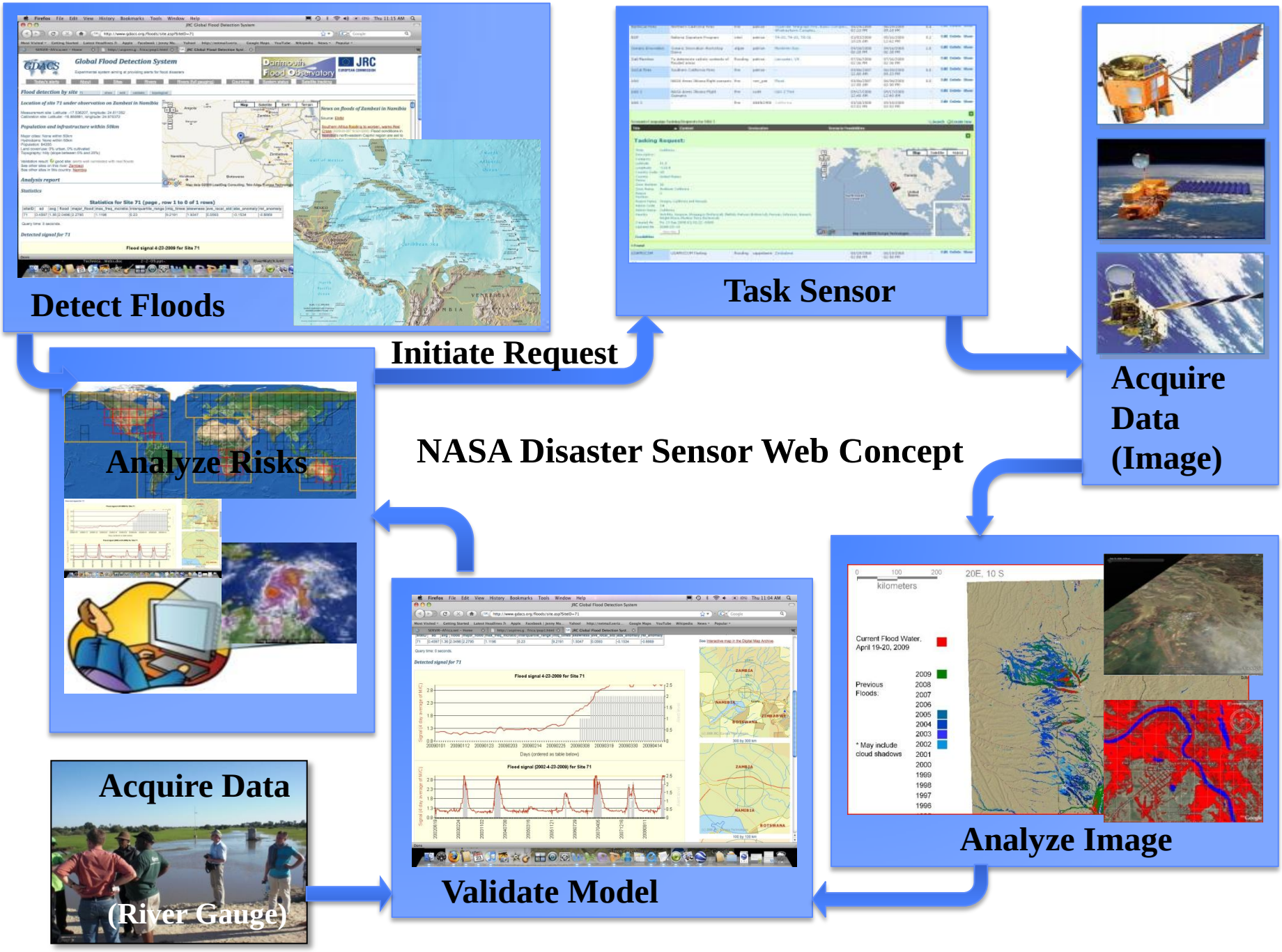
Overview

- National Aeronautics and Space Administration (NASA) satellite tasking, data processing, and distribution for disasters – Sensor Web technology and science research for full-cycle disaster management
- NASA collaboration with Canadian Space Agency (CSA) for disaster management
- Committee on Earth Observation Satellites (CEOS) Flood Pilot and Group on Earth Observations (GEO) End-To-End Disaster Systems projects
- Ground validation, crowd sourcing, and hand-held clients

Acknowledgment is to be given to Dan Mandl, Pat Cappelaere, Karen Moe, and Fritz Policelli for contributions to this presentation

NASA Disaster Sensor Web Concept



NASA Web Service URLs

- OpenID Provider-Server https://op.geobliki.com/ controls the security (this is where you setup your account)
- Campaign Manager http://geobpms.geobliki.com/home allows tasking requests to be submitted (i.e., targets)
- EO-1 Server http://eo1.geobliki.com/ this is where EO-1 data can be found along with the status of future and past taskings
- Radarsat Server http://radarsat.geobliki.com/radarsat where we provide access to Radar raw data, browse images, metadata, and processed flood products
- MODIS Flood Server http://oas.gsfc.nasa.gov/floodmap/ is where you can point your browser to manually check on daily MODIS flood maps (browser GUI-based only)
- MODIS Flood Server http://modis.geobliki.com/modis is the server that provides and API for accessing the daily MODIS maps

NASA URLs Concluded

- Flood Dashboard Client http://matsu.opencloudconsortium.org/namibiaflood this is an example of a client implementation that runs on a cloud computing platform provided through a collaboration with the University of Illinois/Chicago
- Web Coverage Processing Service (WCPS) http://matsu.opencloudconsortium.org/wcps/session/login is where you go to generate and run algorithms against satellite data
- Pub/Sub Server http://opsb.geobliki.com/session/new is where you setup a subscription for requesting notifications about new data in your area or from a particular instrument or with a particular feature or….The notifications come via Email, SMS, or twitter and contain RSS or Atom feeds for you to follow to find the processed or raw data. Clients can be automated to monitor the feeds and pull the data they are programmed to look for

NASA-CSA Collaboration Objectives

- To demonstrate the effectiveness of satellite imagery to strengthen regional, national and community level capacity for mitigation, management and coordinated response to natural and man-made hazards
- To identify specific satellite-based products that can be used for disaster mitigation and response on a regional level
- To identify capacity building activities that will increase the ability of the region to integrate satellite-based information into disaster management initiatives

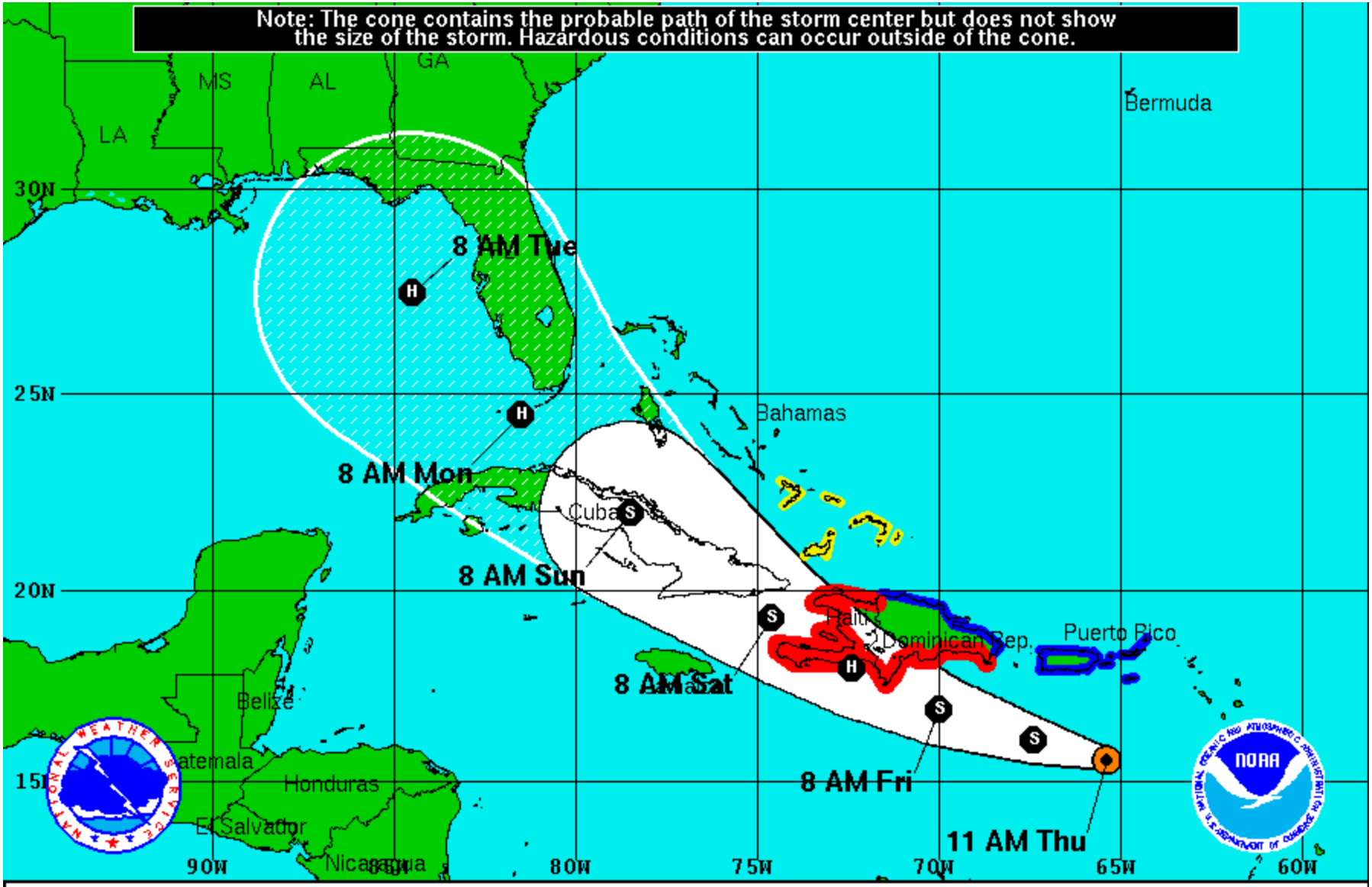
Collaboration Approach

- Focus on areas where Earth Observations from satellites can have most impact (flooding, landslides, volcanoes, wildfires, etc.) and on large-scale disasters
- Select a small number of regional and national partners to validate usefulness of Earth Observations
- National agencies solicited in 3 regions – Caribbean/Central America, Southern Africa, and Southeast Asia (lower Mekong/Indonesia/Java) and partners selected based on:
  - Commitment to make relevant data sets available
  - Agreement to provide direct support (in-kind)
  - Assurance of close collaboration between key national, regional, and international players
  - Representative cross-section of GIS capability development
- Regional Teams created in all three areas with broad participation from concerned Departments
- Global Component setup for low-spatial-resolution, high-temporal-resolution assets

Accomplishments in Caribbean

- EO-1, Worldview-2 and Radarsat-2 targeted coverage for hurricanes, earthquakes, algal blooms, wildfires, volcanoes, and landslides
- Daily coverage with MODIS (flood maps) and TRMM (Global Flood Monitoring System)
  - Real-time Calculations at 1 km
  - Streamflow and Water Storage (Routed Runoff + Bank Overflow)
- REST-ful tasking interface between the Campaign Manager (geobpms.geobliki.com) and satellites to integrate target requests (from models, other detections, and user inputs) and allocate image orders on a systematic basis
- Field validation of satellite maps using crowd sourcing
- Improvement of flood models and model interfaces

NHC's Potential Track Area for TS Isaac

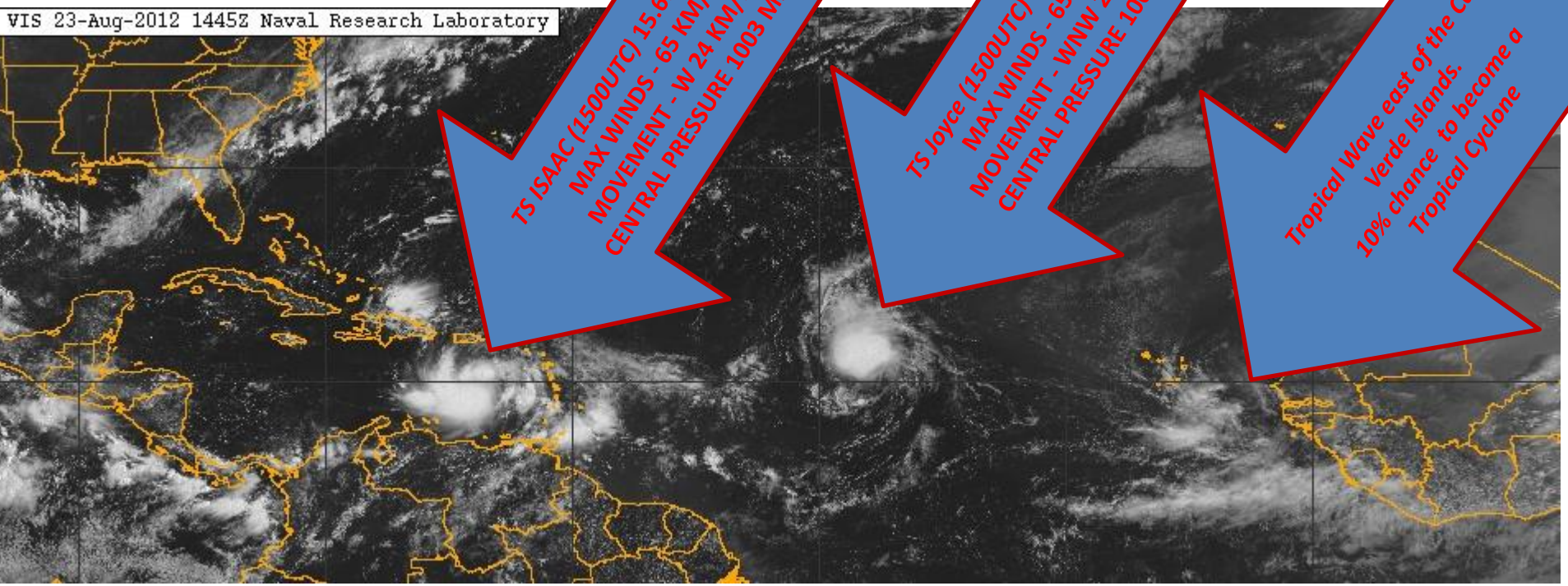


Tropical Storm Isaac
Thursday August 23, 2012
11 AM EDT Advisory 10
NWS National Hurricane Center

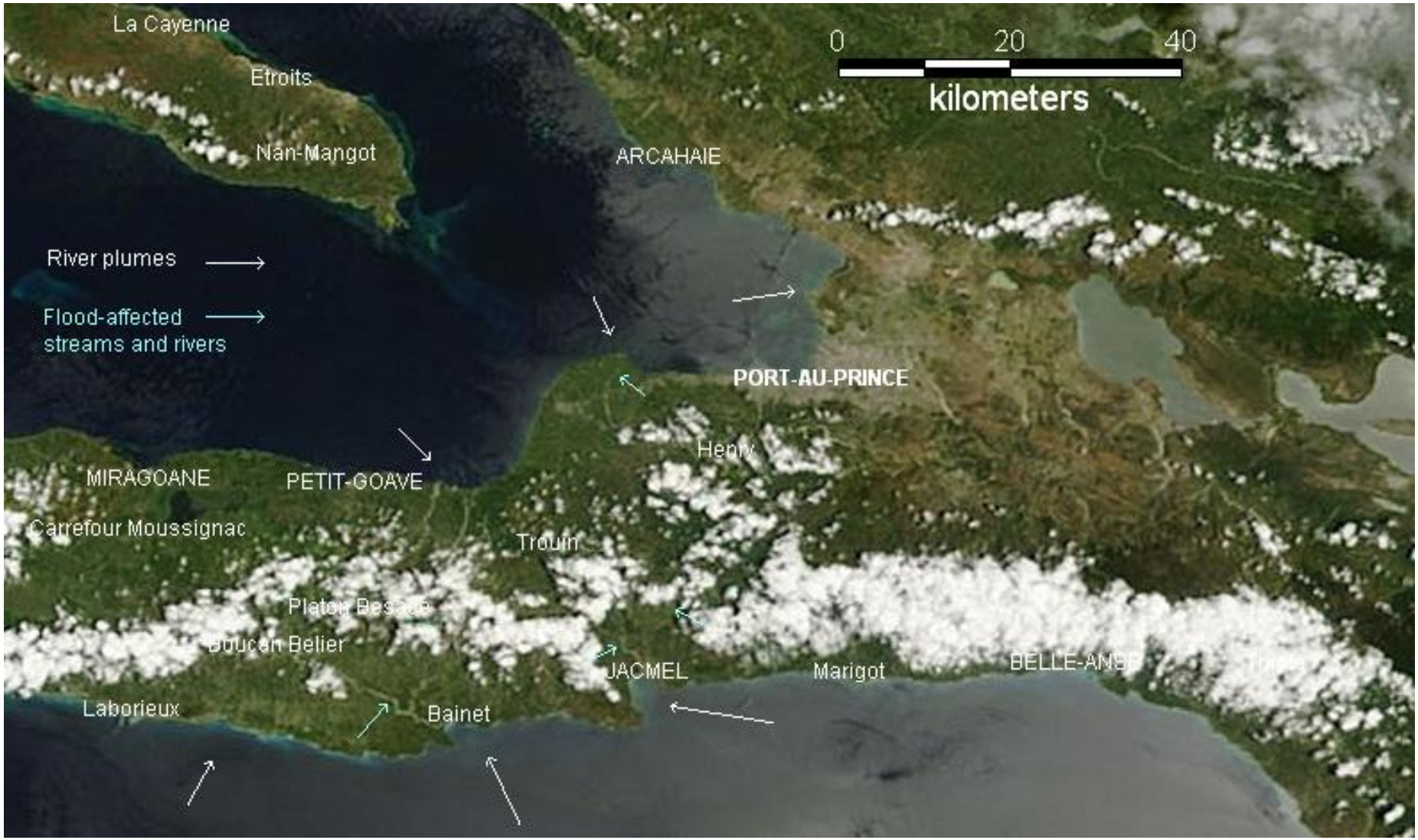
Current Information:
Center Location 15.6 N 65.4 W
Max Sustained Wind 40 mph
Movement W at 15 mph

Forecast Positions:
Tropical Cyclone Post-Tropical
Sustained Winds: D < 39 mph
S 39-73 mph H 74-110 mph M > 110mph

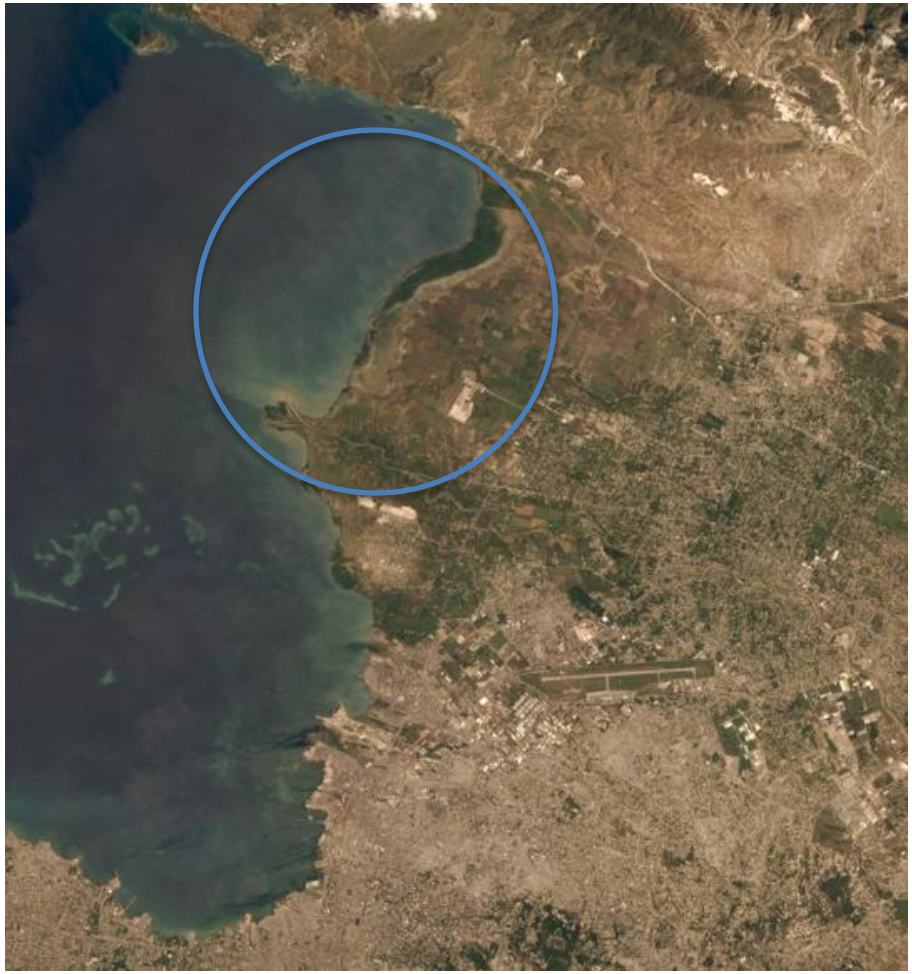
1445 UTC VIS


VIS 23-Aug-2012 1445Z Naval Research Laboratory
TS ISAAC (1500UTC) 15.6N 65.4W
MAX WINDS - 65 KM/H
MOVEMENT - W 24 KM/H
CENTRAL PRESSURE 1003 MB
TS Joyce (1500UTC) 15.2N 42.2W
MAX WINDS - 65 KM/H
MOVEMENT - WNW 28 KM/H
CENTRAL PRESSURE 1006 MB
Tropical Wave east of the Cape Verde Islands.
10% chance to become a Tropical Cyclone

MODIS – ISAAC aftermath



EO-1 Port of Prince, Haiti
Before and After TS Isaac



Haiti, Port of Prince area: August 18, 2012
Pre- TS Isaac
EO-1 ALI scene ID: EO1A0090472012231110P0
Pan-sharpened product

Haiti, Port of Prince area: August 31, 2012
Post- TS Isaac
EO-1 ALI scene ID: EO1A0090472012244110KF
Pan-sharpened product

EO-1 North of Port of Prince, Haiti
Before and After TS Isaac

Haiti, Port of Prince area: August 18, 2012
Pre- TS Isaac
EO-1 ALI scene ID: EO1A0090472012231110P0
Pan-sharpened product

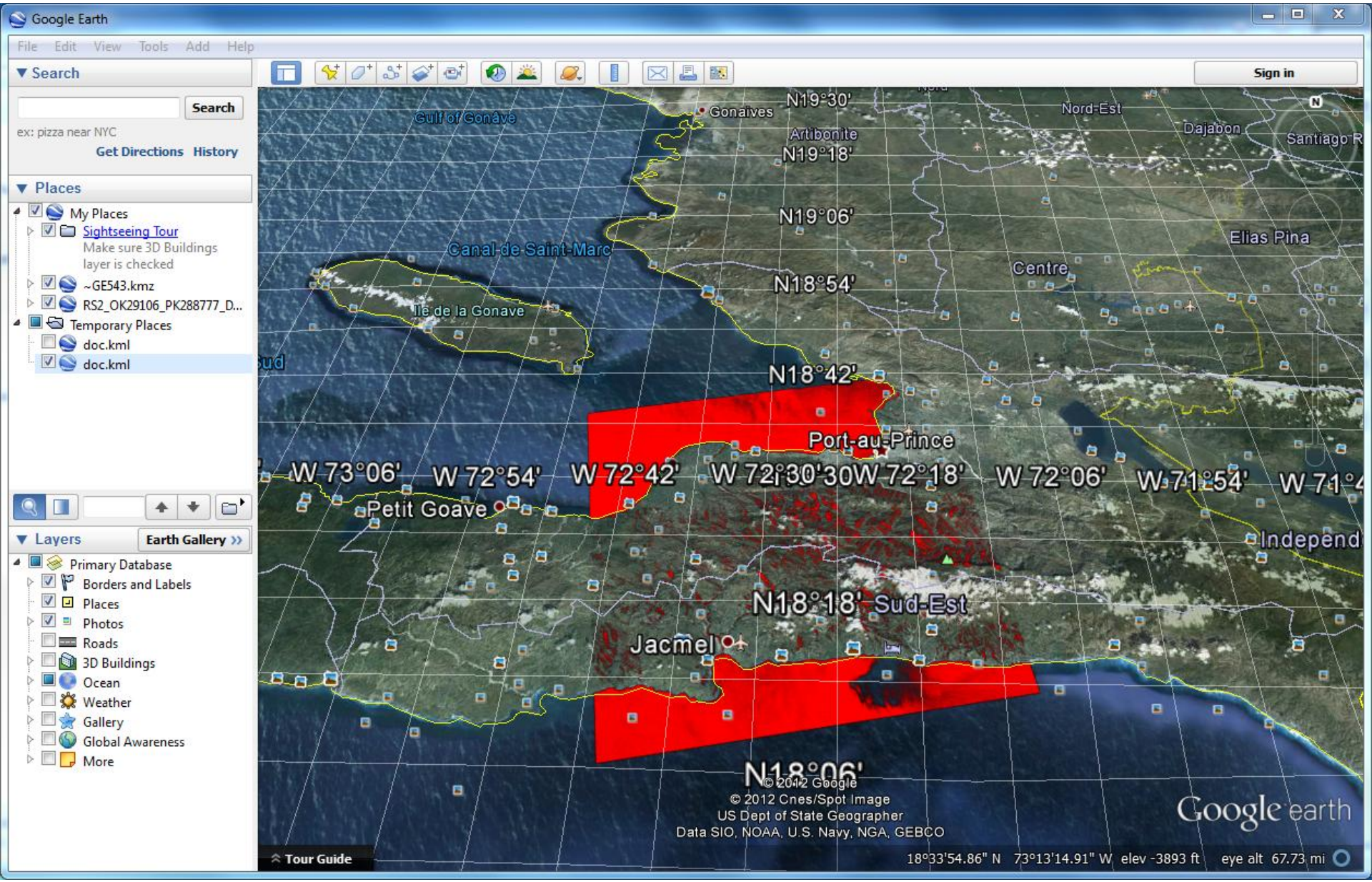
Haiti, Port of Prince area: August 31, 2012
Post- TS Isaac
EO-1 ALI scene ID: EO1A0090472012244110KF
Pan-sharpened product

Radarsat-2 ISAAC aftermath

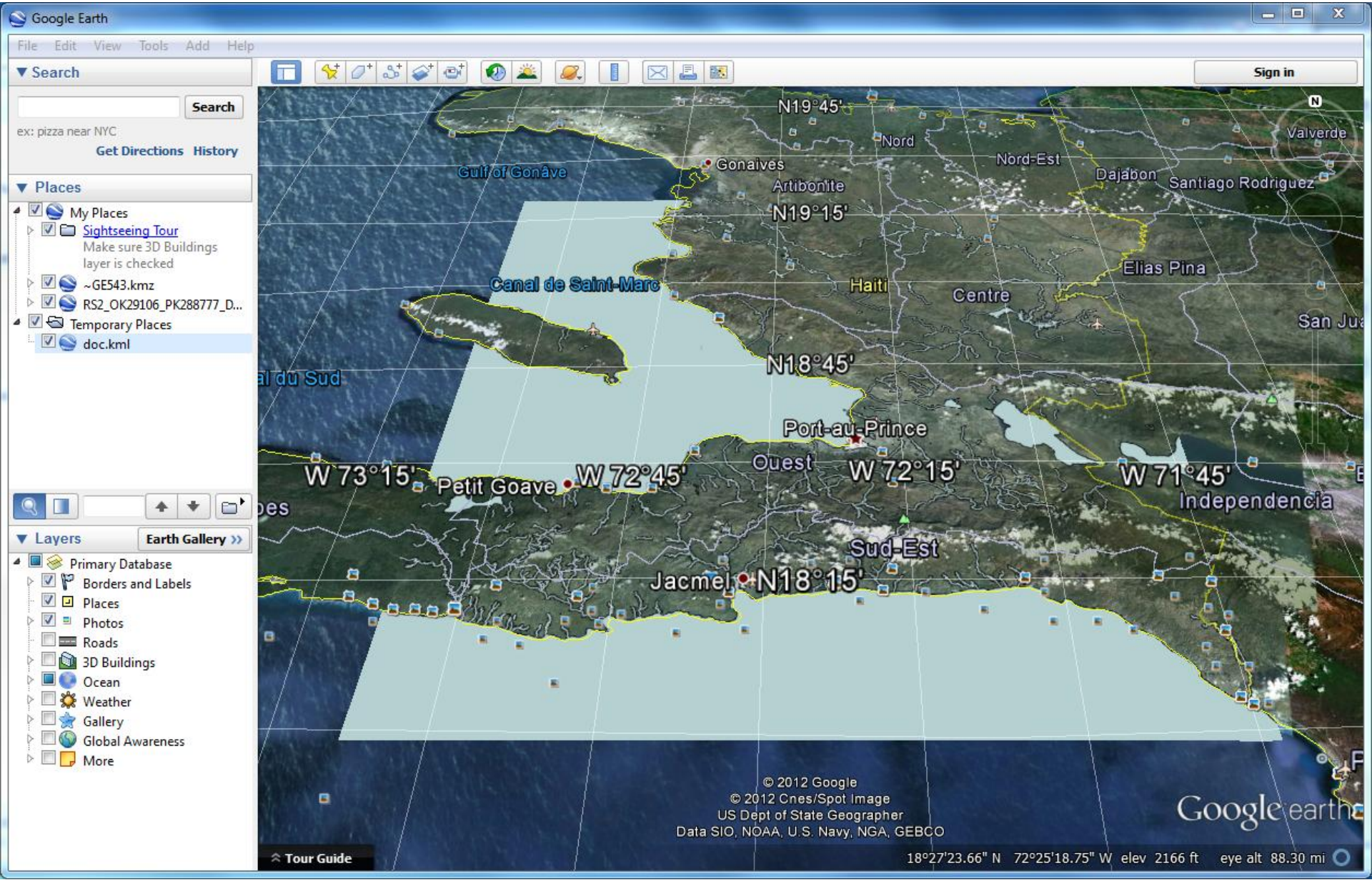
- Developed processing on radarsat.geobliki.com to show water as red layer in Google Earth (next page)
- Extracted Open Street Map baseline water level as light blue layer (second page)
- Served both as tiled doc.kml layers and as Open Street Map polygons (see third page for kml combined overlay)

NASA Web Service URLs and server descriptions available at
http://eo1.gsfc.nasa.gov/new/sensorWebExp/SensorWebReadMore.html

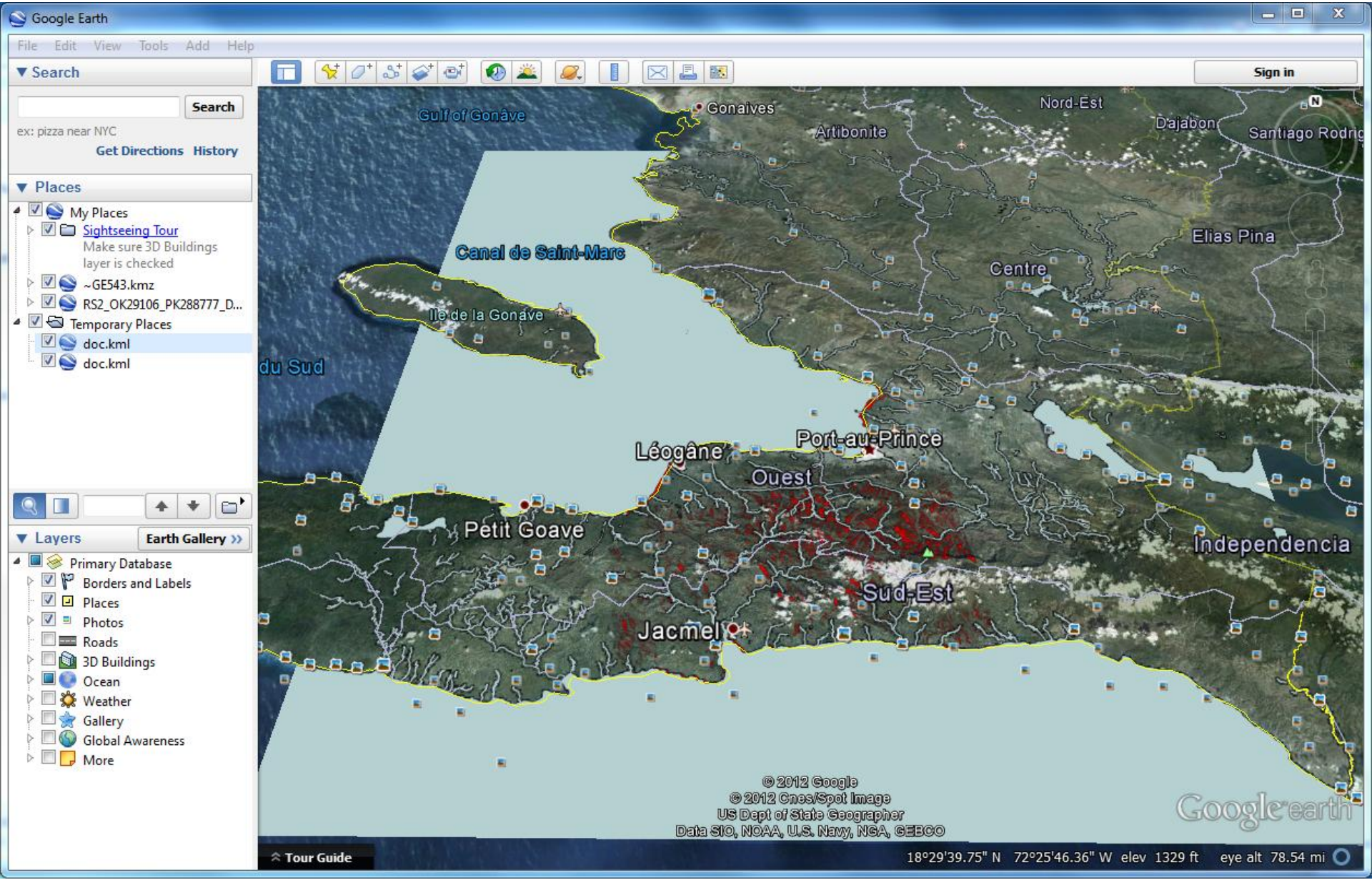
Radarsat-2 flood map (red layer)



OSM Normal Water (blue layer)



Combined Overlays (blue on red)

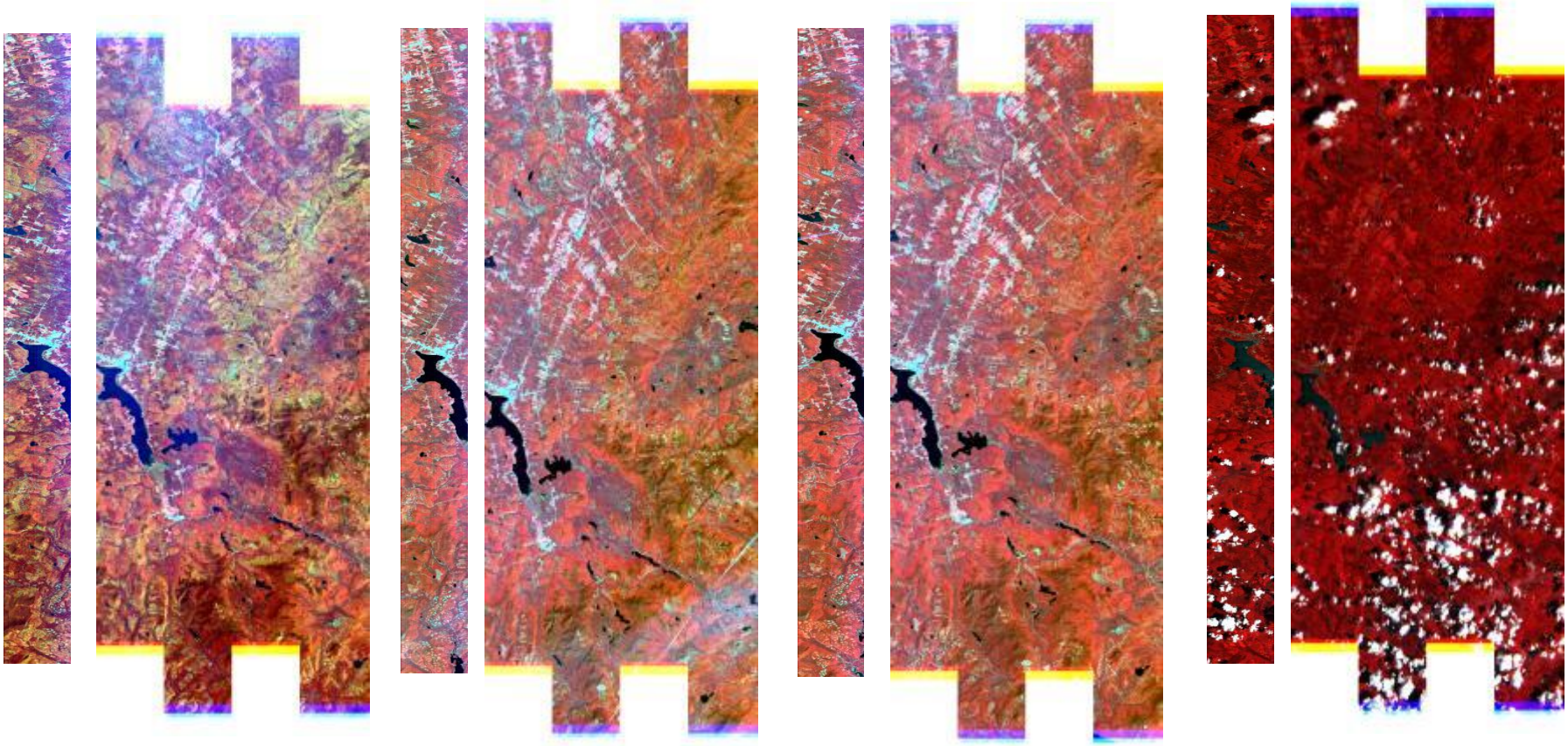


EO-1 Observations of Canada Lac Megantic Train Wreck and Oil Spill

Presented as an Example of Time Series Disaster Coverage

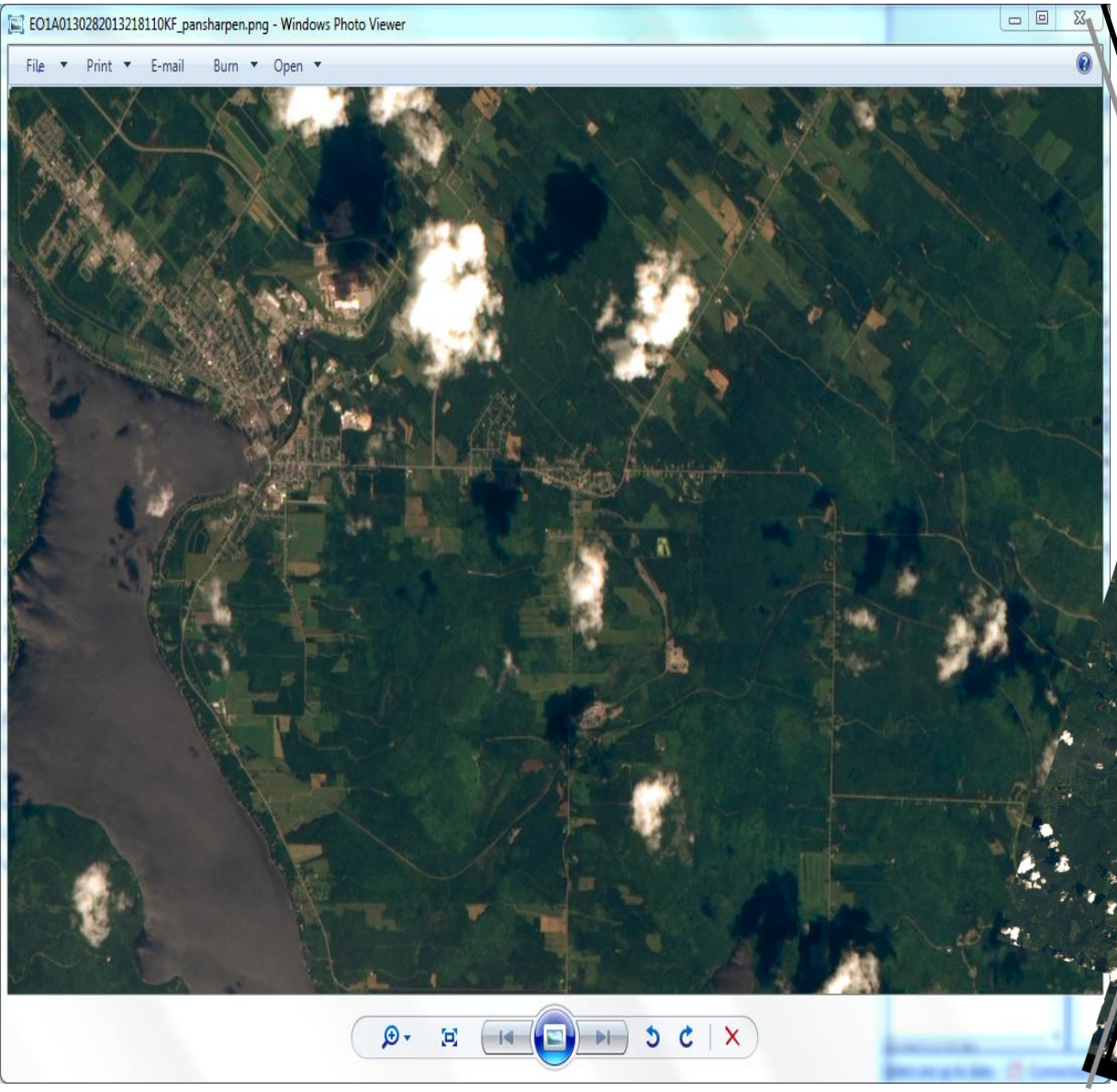
- Images acquired on July 10, 21, 31, August 6, 24, and September 1, 17
  - UTC days 191, 202, 212, 218, 236,249, and 260
- Both ALI (9-30m spectral bands and a 10m panchromatic band) and Hyperion (190-30m spectral bands in 400-2400 nm range)
- Level 1R (radiometrically corrected) and Level 1G (terrain corrected) delivered plus pan-sharpened products for all ALI scenes

EO-1 Level 1R Browse Images of 2013 Lac Megantic Acquisitions - Hyperion on left, ALI on right



17 Sep **6 Sep** **24 Aug** **6 Aug**

ALI Level 1G with Pan-enhancement



Full ALI Scene
37X85km

Acquired on 6 August 2013

Landsat 8 example in Haiti for construction of reference water mask

LC80090472013117LGN01 vis_composite (5-4-3) (EPSG 4326) TIF Compressed 76.4MB

Using WCPS

Original Data Set 8 OLI Bands TIF 108.7MB each (7461x7281 pixels 30m resolution)

Surface Water Detection Product

Using WCPS

5.9MB TIF LZW Compressed

Note: Particular Algorithm is Not Relevant In this Example

Analysis

- **TIF Surface Water Product (5.9MB)**
  - **Preserves coordinates/projection**
  - **RGBA (4 bands for a bit mask water/no-water) for visualization**
- **PNG Product (753KB)**
  - **But no map coordinates/projection information**
- **After ZIP Compression**
  - **TIF: 2.2 MB**
  - **PNG: 638KB (but not useable for cartography)**

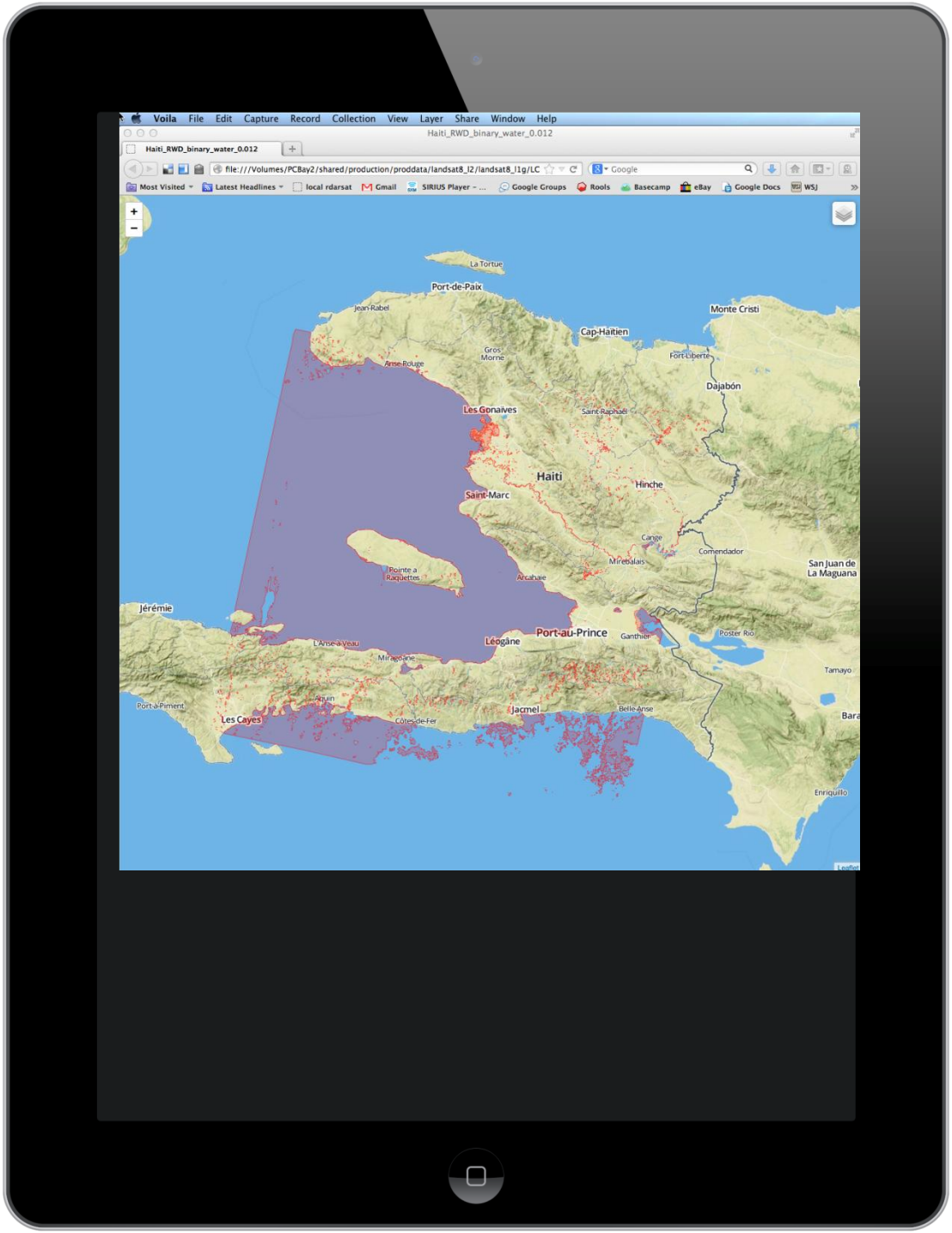
Vectorization to reduce size and preserve map alignment for overlay

- **Autotrace (potrace) and Convert to geojson**
  - **>10.6MB**
- **Convert to topojson**
  - **>3.5MB**
- **Simplify Lines 0.50 (Visvalingam Algorithm)**
  - **>2MB**
- **Compress**
  - **>350KB**

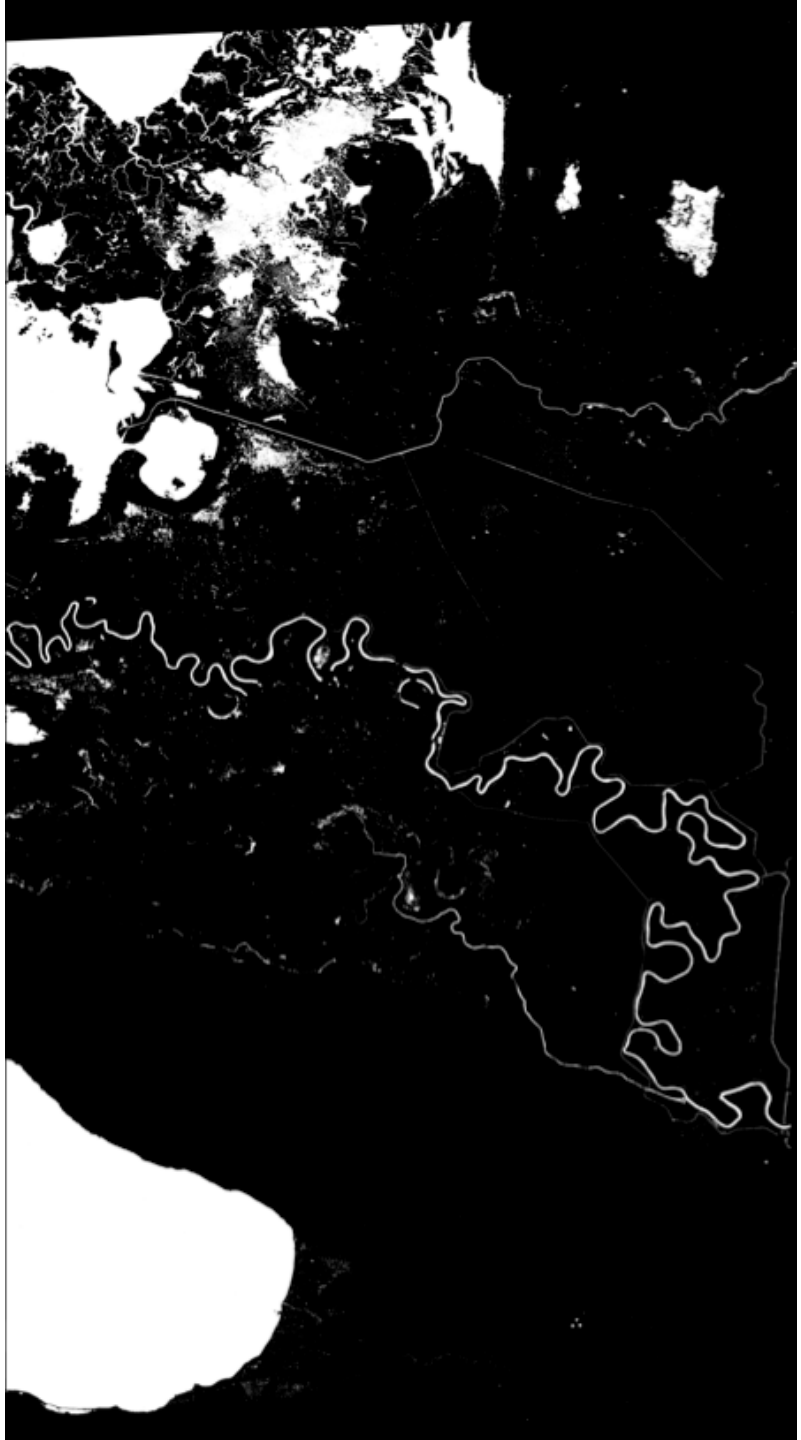
Resulting Product On Mobile Browser

Mapbox.js, MapBox Terrain Layer…

Other Layers Can be Added From OpenStreetMap such as Reference Water…
Or Population Density…



Final Achievement:
Product Compressed Size From:
2.2MB to 350KB



Worldview-2 Processed Data (Binary TIF File)

Surface Water in White

Files: Haiti_RWD_binary_water_0.012.tif
Size is 9419, 17304
Coordinate System is:
GEOGCS["WGS 84",
DATUM["WGS_1984",
SPHEROID["WGS 84",6378137,298.257223563,
AUTHORITY["EPSG","7030"]],
AUTHORITY["EPSG","6326"]],
PRIMEM["Greenwich",0],
UNIT["degree",0.0174532925199433],
AUTHORITY["EPSG","4326"]]
Origin = (-72.761256,19.38983)
Pixel Size = (0.000018,-0.000018)

~2m/pixel resolution

Image Structure Metadata:
INTERLEAVE=BAND
Corner Coordinates:
Upper Left (-72.7612560, 19.3898340)
Lower Left (-72.7612560, 19.0783620)
Upper Right (-72.5917140, 19.3898340)
Lower Right (-72.5917140, 19.0783620)
Center (-72.6764850, 19.2340980)
Band 1 Block=9419x1 Type=Byte, ColorInterp=Gray

OpenStreetMap Zoom levels

• Deutsch • **English** • español • français • Nederlands • polski

Level	Degree	Area	m / pixel	~Scale
0	360	whole world	156,412	1:500 Mio
1	180		78,206	1:250 Mio
2	90		39,103	1:150 Mio
3	45		19,551	1:70 Mio
4	22.5		9,776	1:35 Mio
5	11.25		4,888	1:15 Mio
6	5.625		2,444	1:10 Mio
7	2.813		1,222	1:4 Mio
8	1.406		610.984	1:2 Mio
9	0.703	wide area	305.492	1:1 Mio
10	0.352		152.746	1:500,000
11	0.176	area	76.373	1:250,000
12	0.088		38.187	1:150,000
13	0.044	village or town	19.093	1:70,000
14	0.022	largest editable area on the applet	9.547	1:35,000
15	0.011		4.773	1:15,000
16	0.005	small road	2.387	1:8,000
17	0.003		1.193	1:4,000
18	0.001		0.596	1:2,000
19	0.0005		0.298	1:1,000

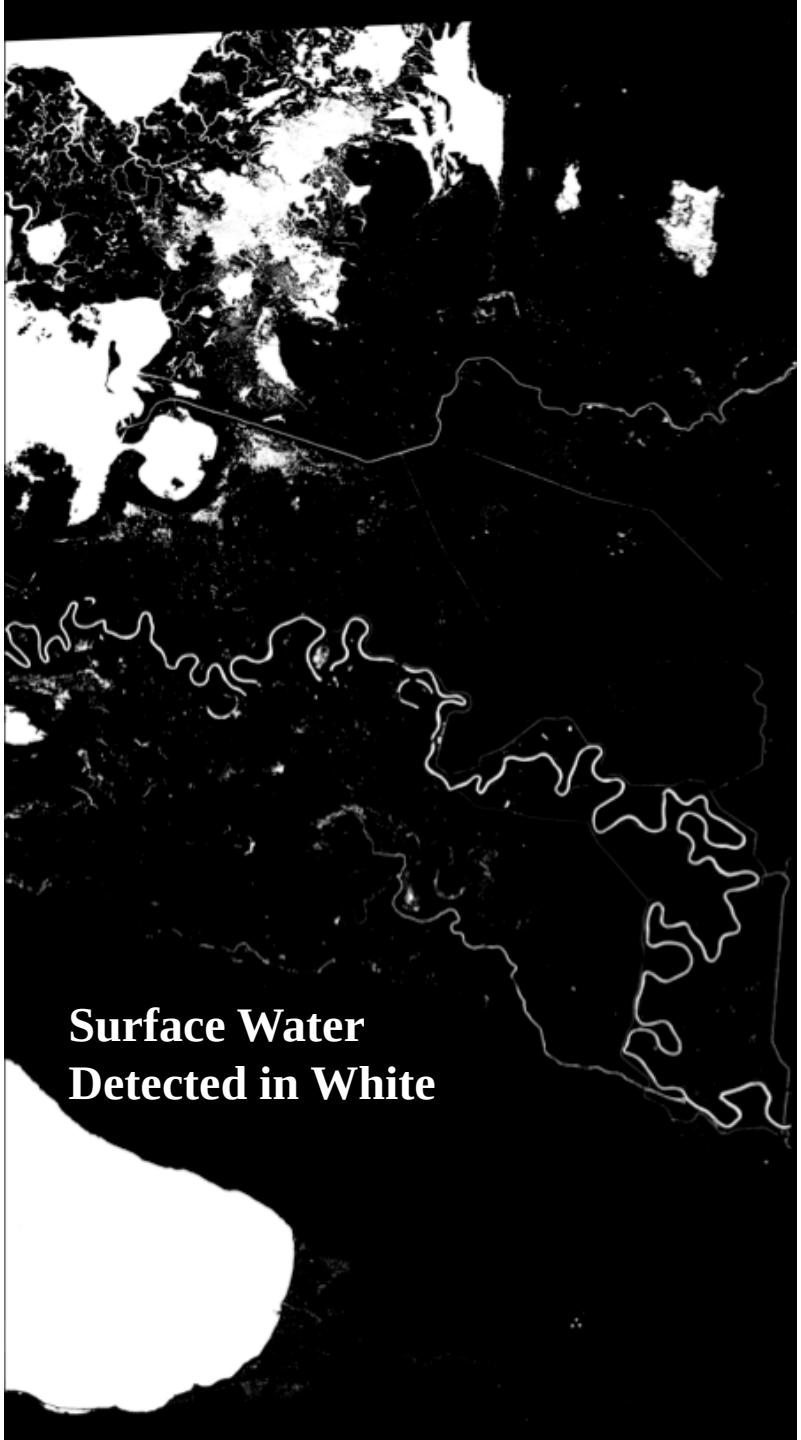
Disaster User Zoom Range 9-18

Image Resolution

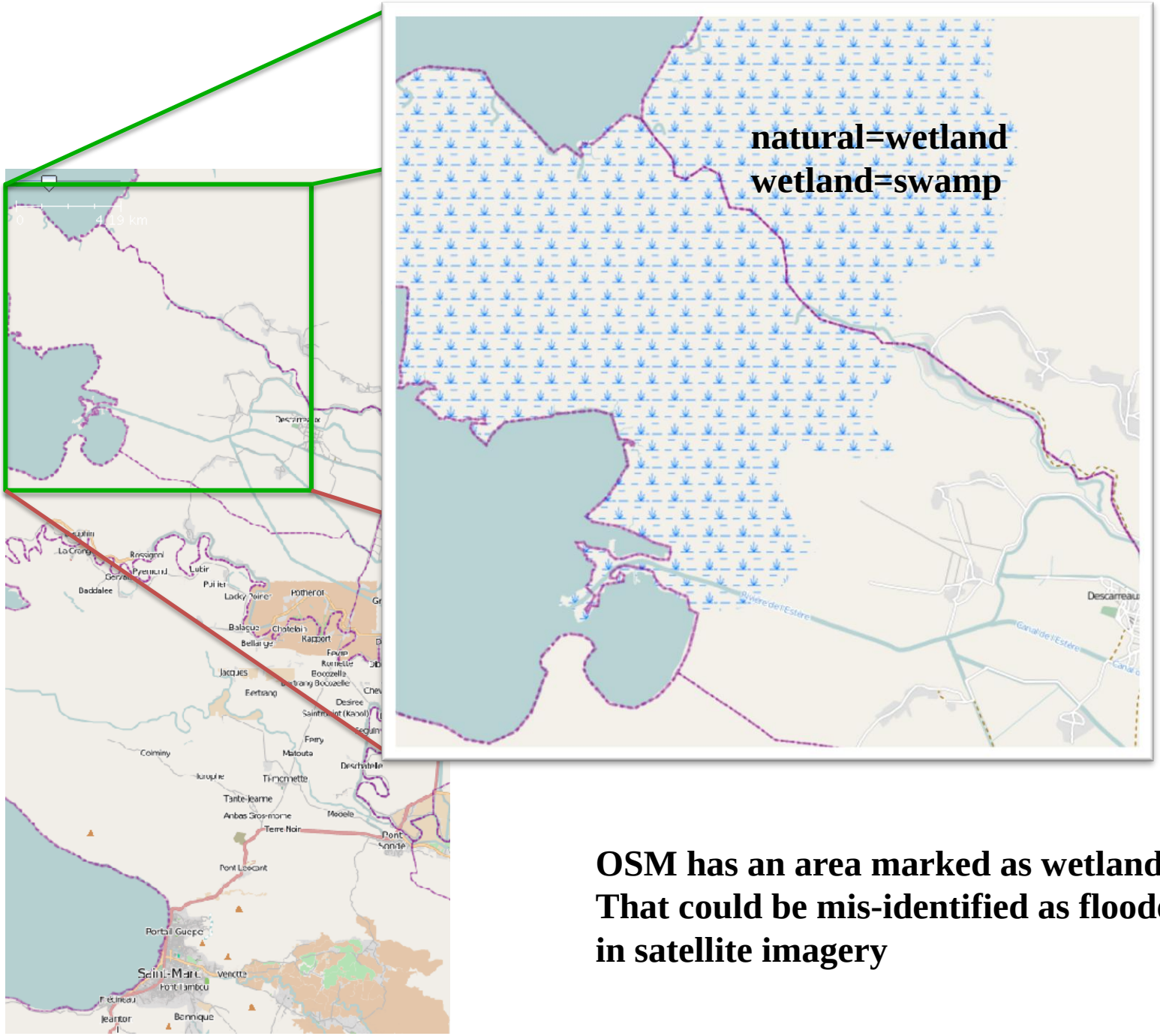
Process for Vectorization of Water Detection Layer

- **Generate a binary mask for water detection**
- **Convert to PNG (Black & White) and then to PNM**
- **AutoTrace and convert to GeoJSON**
- **Convert to TopoJSON**
- **Simplify Lines**
- **Remove false detections identified in Height Above Nearest Drainage (HAND) calculations**
- **Compress Files for Potential Distribution**
- **Map viewer in Plain Firefox Browser Using Open Source Libraries**

In addition, produce reference water layer for same footprint and deliver concurrently with water detection layer


Surface Water
Detected in White

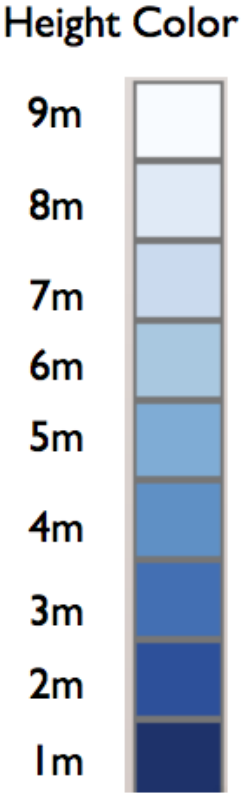
OpenStreetMap
0
4.19 km
RN 1
L'Estère
Dauphin
La Grange
Rossignol
Pyemond
Gervais
Lubin
Puilier
Daddalee
Lacky Poiner
Pothenot
Gravé
Balague
Chatelain
Rapport
Bellange
Fevre
Rornette
Dibuisson
Jacques
Bocozelle
Bertrang Bocozelle
Bertrang
Desiree
Saintrouint (Kabol)
Duclas
Seguin
Cadeu
Ferry
Matoute
Fougère
Colminy
Deschatelle
Tirmonette
Tante-Jeanne
Anbas Gros-morne
Modele
Terre Noir
Pont Sonde
Pont Lescant
Portail Guepe
Saint-Marc
Venette
Pont Tambou
Jeanton
Bannique



OSM has an area marked as wetland/swamp
That could be mis-identified as flooded area
in satellite imagery

Height Above Nearest Drainage: In Black, Areas to be masked based on Digital Elevation Model

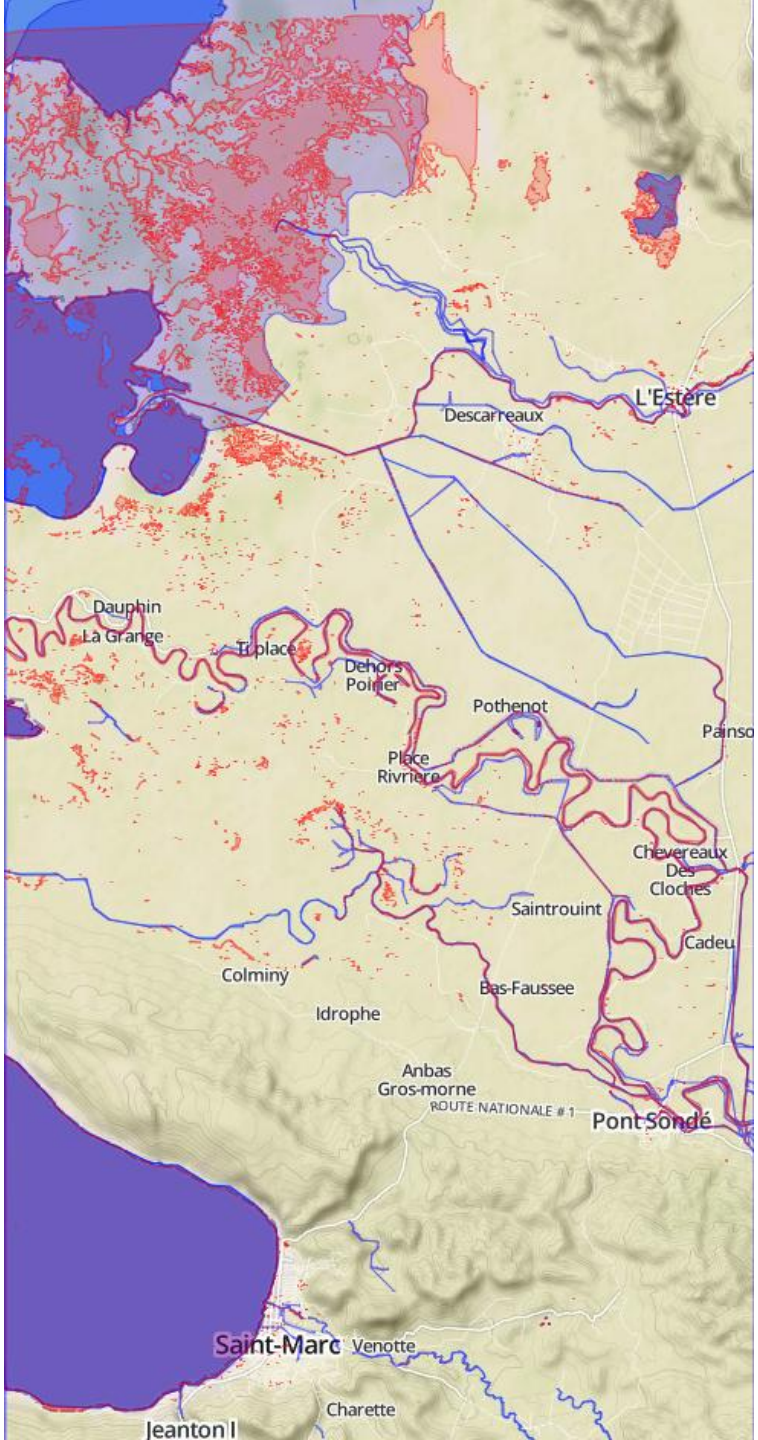
Removed:
46,297 out of 23,659,581

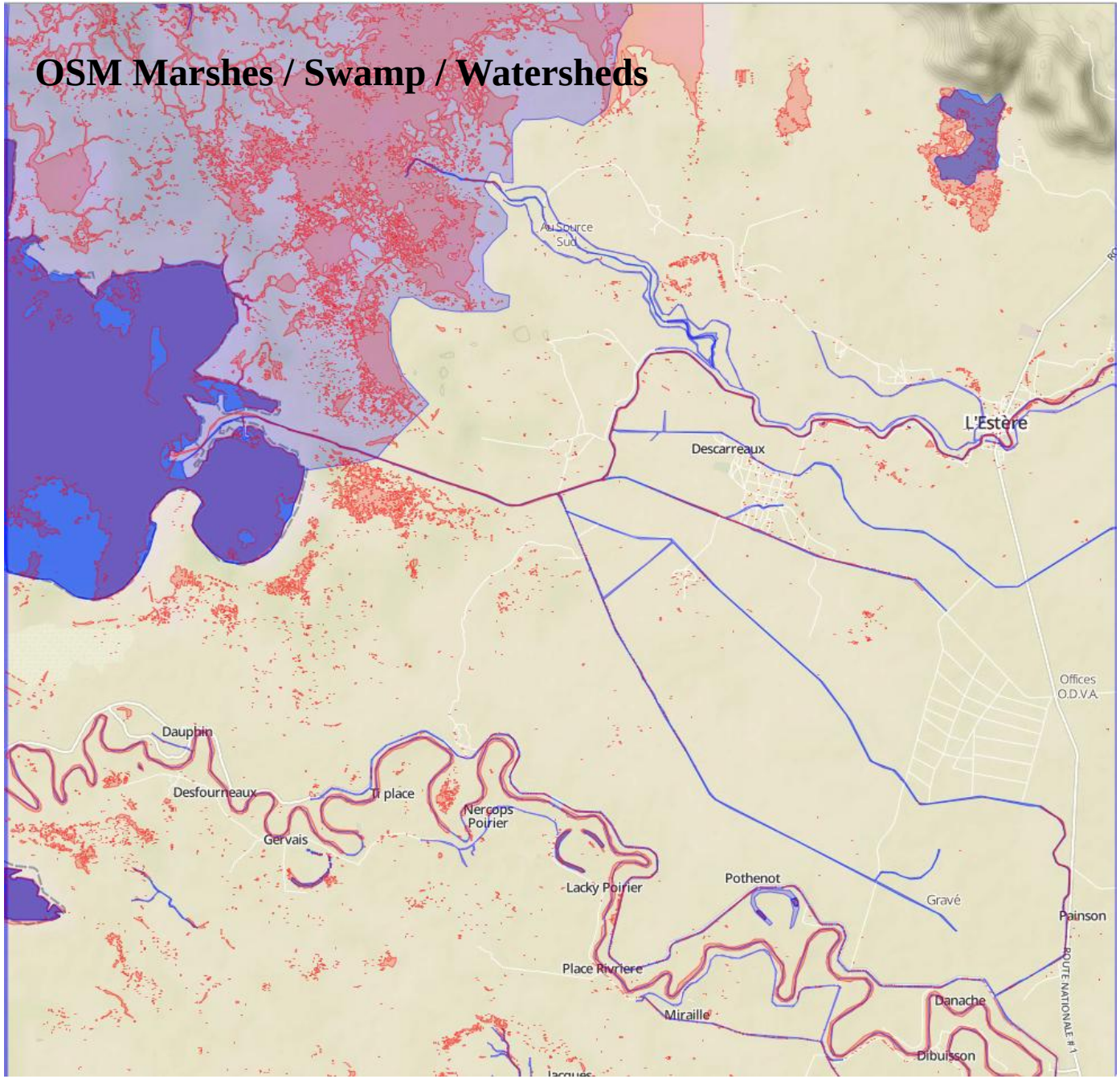


https://maps.google.com
Terrain Map

Resulting Zoomable Flood Map In Browser

Red: Surface Water (after HAND masking)
Blue: OSM Reference Water
Background: Terrain Map From Mapbox





OSM Marshes/Watershed Tags Are Important

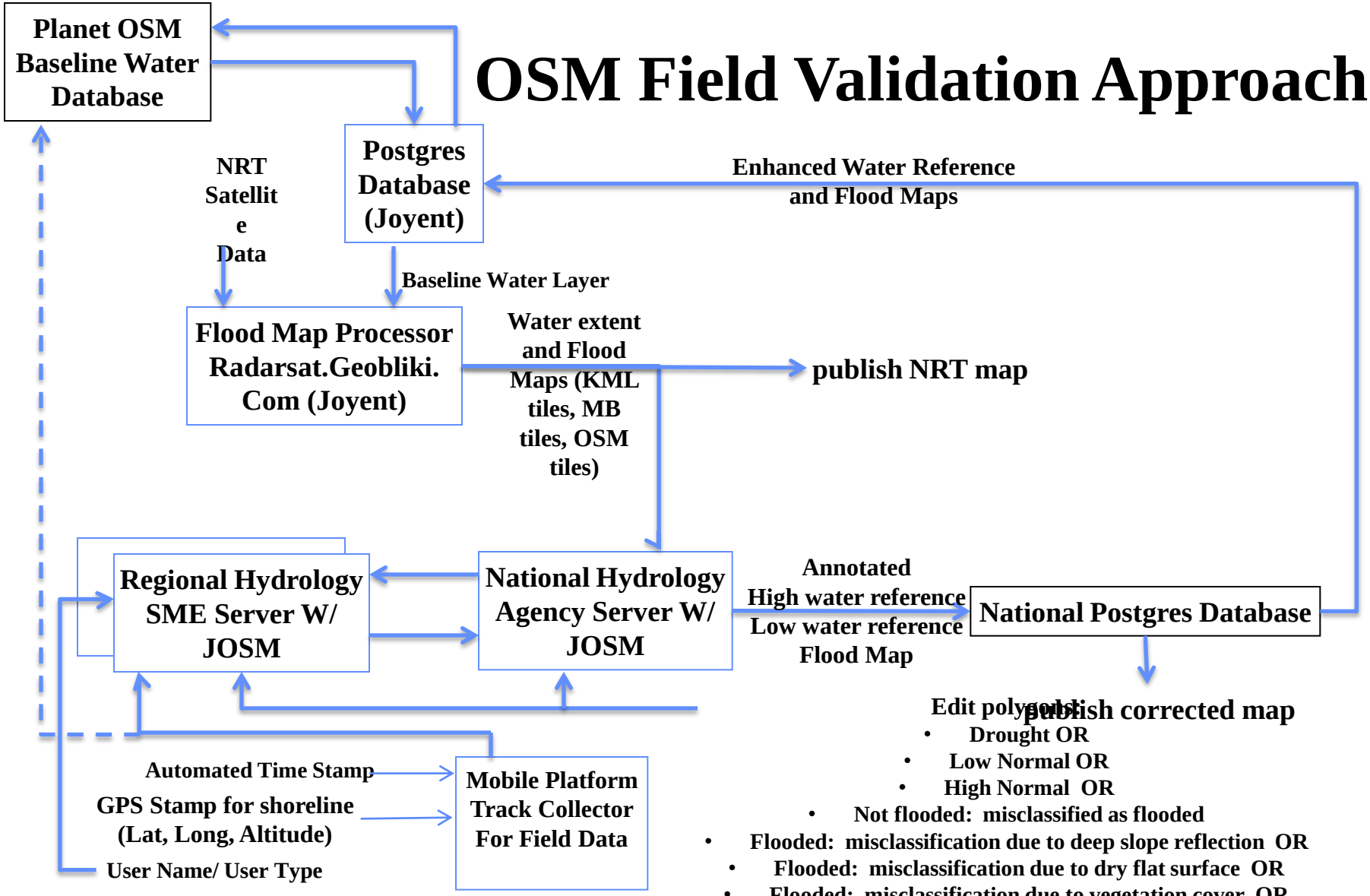
File Statistics

- **Processed Binary File (tif) 163.1MB**
- **GeoJSON 40MB**
- **GeoJSON.zip 7.2MB**
- **TopoJSON 6.4MB**
- **TopoJSON.zip 689KB**
- **Simplified TopoJSON < 1MB**
- **Simplified Compressed 210KB**

Issues

- **HAND processing needs validation**
- **Map Rendering (Browser)**
  - **A little slow to manage all the vectors (but does work)**
- **Next steps: Vector Tiling (Vector rendering at multiple scales) to speed map rendering for high res imagery [Already implemented in OSM]**

OSM Field Validation Approach



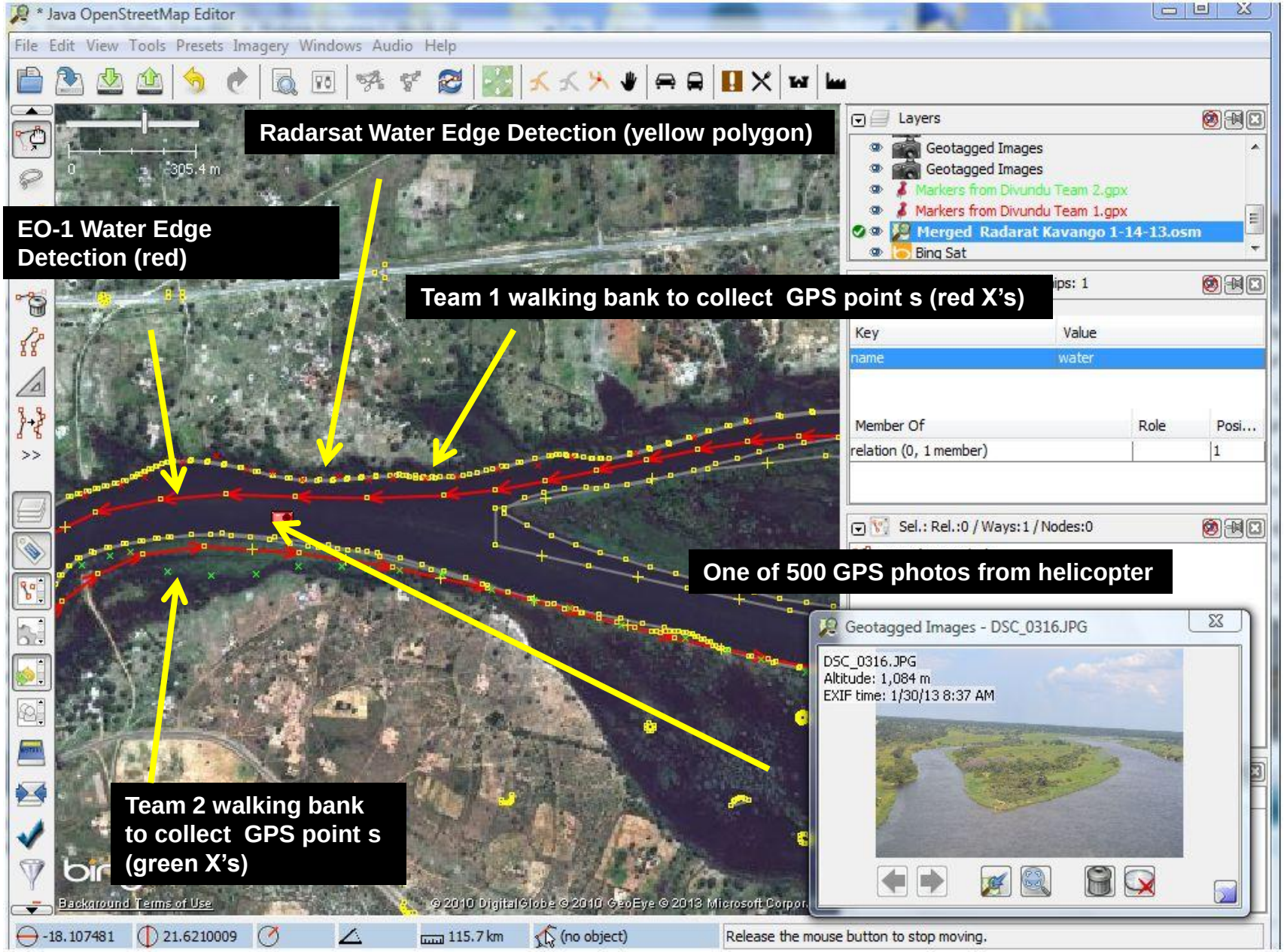
Edit polygons:

- Drought OR
- Low Normal OR
- High Normal OR
- Not flooded: misclassified as flooded
- Flooded: misclassification due to deep slope reflection OR
- Flooded: misclassification due to dry flat surface OR
- Flooded: misclassification due to vegetation cover OR
- Flooded: misclassification due to other

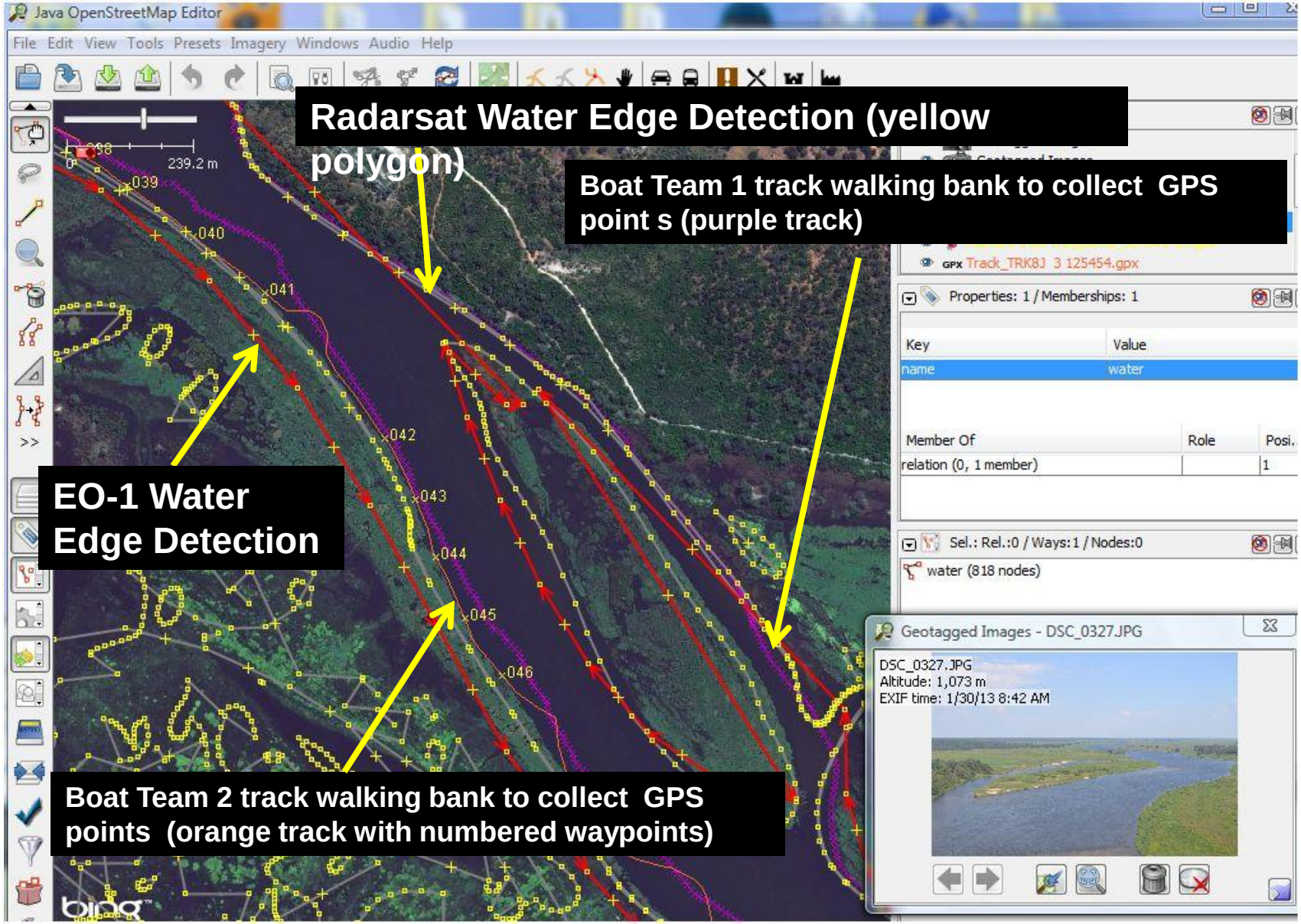
Enter Notes

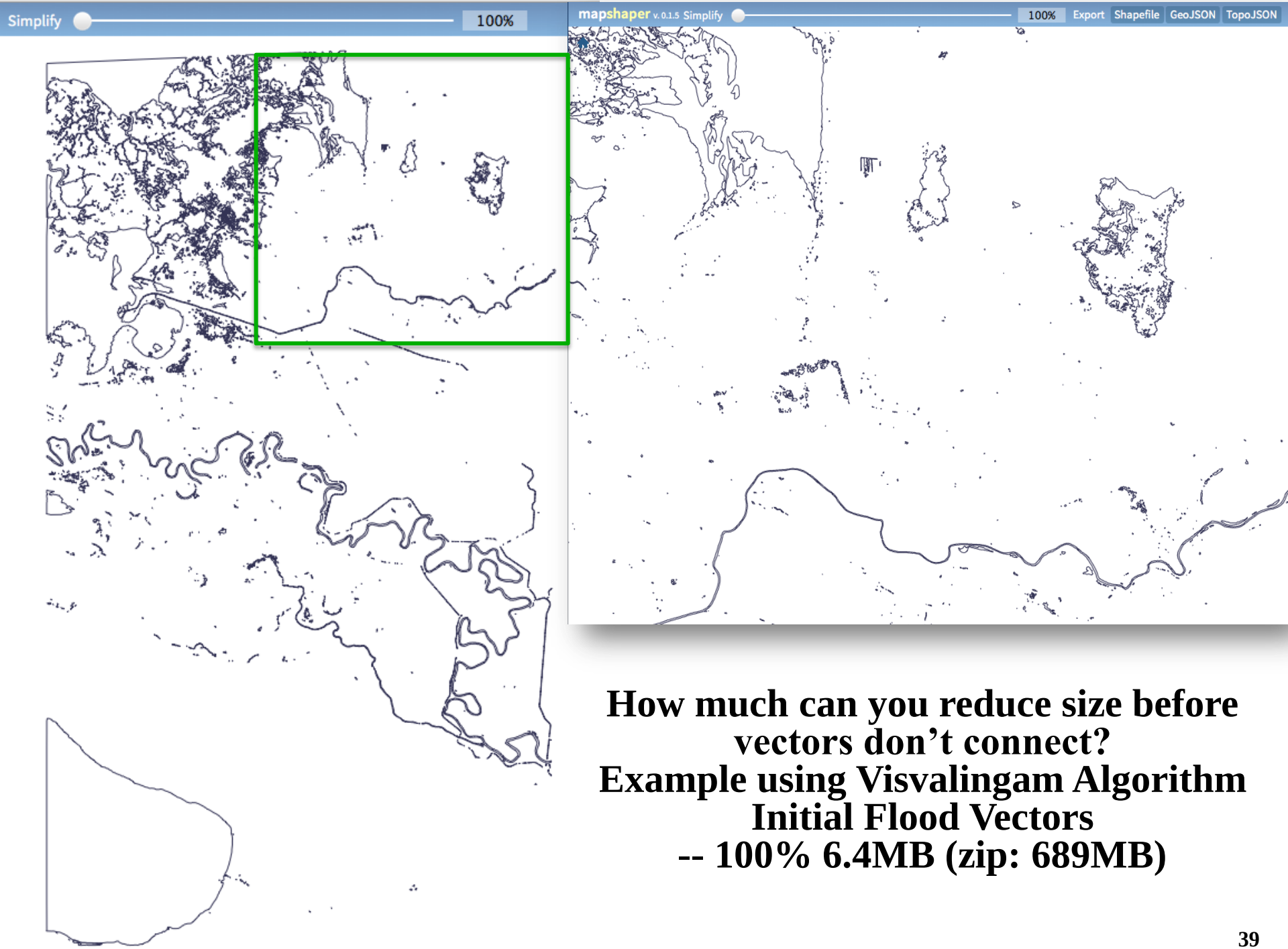
- Input data source (field measurement/ other: describe)
- Land Cover Type
- text

Ground Cal/Val Exercise with Radarsat, EO-1, Ground Team, Helicopter team, OpenStreetMap, Crowd Sourcing on Kavango river in Namibia 1-30-13

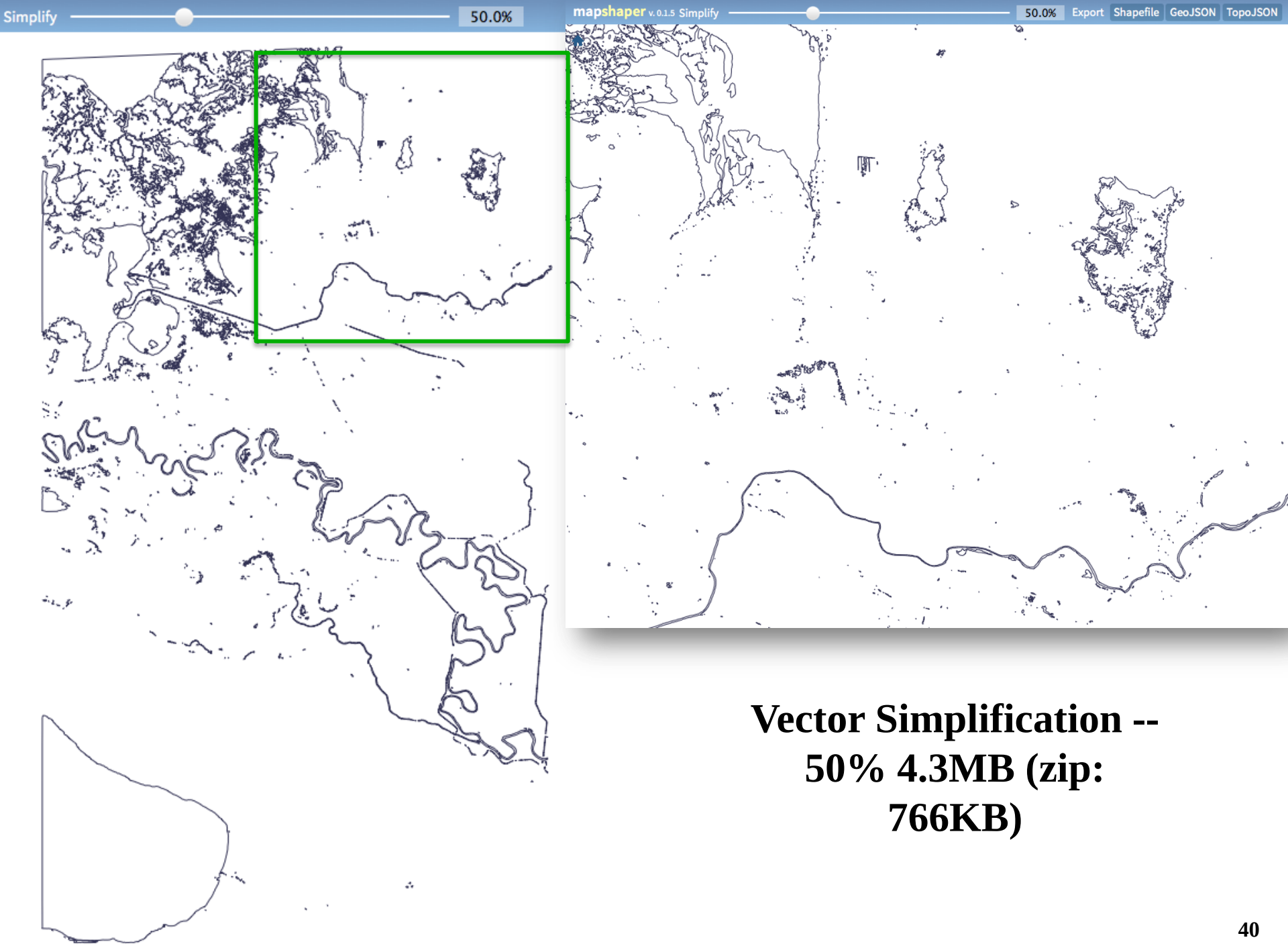


Integrated Water Edge Detection Display with Boat GPS Measurements, GPS located photos, Radarsat/EO-1 water edge detections





How much can you reduce size before vectors don't connect?
Example using Visvalingam Algorithm
Initial Flood Vectors
-- 100% 6.4MB (zip: 689MB)



Vector Simplification -- 50% 4.3MB (zip: 766KB)