CEOS Disaster Risk Management for Societal Benefit

Presented at the HyspIRI Data Product Symposium
by Stu Frye (stuart.frye@nasa.gov)
4 June 2014
Context/Overview

- **Purpose** – to improve delivery of satellite data and products for societal benefit in local/regional setting, but on a global scale

- **Method** - develop and infuse Earth Observation (EO) monitoring and modeling technology for data acquisition, processing, and product distribution for disaster applications
  - Sensor Webs and applied science research

- **Experience** - based on Committee on Earth Observation Satellites (CEOS) and Group on Earth Observations (GEO) activities
  - CEOS Disaster Risk Management (DRM) Pilots address ground validation, crowd sourcing, and hand-held clients to validate disaster products and services
  - Capacity building to infuse standardized web servers and clients that provide open access to critical disaster management information, data, and maps via the internet using common, open desktop tools

- **Link to presentation for GeoSocial API**

- **Link to presentation for OJO GeoApp**
  - [https://cappelaere.wistia.com/medias/faz1hi8bpu](https://cappelaere.wistia.com/medias/faz1hi8bpu)
## CEOS DRM Pilots Overview

<table>
<thead>
<tr>
<th>Pilot</th>
<th>Team Co-Leads</th>
<th>Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Floods</strong></td>
<td>NASA, S. Frye</td>
<td>• Global Flood Dashboard (single access for multiple existing systems)</td>
</tr>
<tr>
<td></td>
<td>NOAA, B. Kuligowski</td>
<td>• Three regional pilots showcasing end user benefit of frequent high spatial resolution observations (Caribbean, Southern Africa, Mekong/Java)</td>
</tr>
<tr>
<td><strong>Seismic</strong></td>
<td>ESA, P. Bally</td>
<td>• Demonstrator for EO-based global strain map (main focus on Turkey, Himalayas and Andes)</td>
</tr>
<tr>
<td><strong>Risks</strong></td>
<td>DLR, J. Hoffmann</td>
<td>• Exploitation platform for large data set analysis (strain map, supersites)</td>
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<td></td>
<td>• Rapid scientific products for 4 to 6 earthquakes per year (&gt;M5.8)</td>
</tr>
<tr>
<td><strong>Volcanoes</strong></td>
<td>USGS, M. Poland</td>
<td>• Demonstrate feasibility of systematic global monitoring in regional arc (Latin America)</td>
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<td></td>
<td>ASI, S. Zoffoli</td>
<td>• Develop new EO-based monitoring products at supersites</td>
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<td></td>
<td></td>
<td>• Real-time in-depth monitoring of one ‘100-year’ category major eruption</td>
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</tbody>
</table>
Develop flood monitoring products for flood mitigation, warning, response and recovery in the Caribbean/Central America, Southern Africa and Southeast Asia. Use these regional pilots to validate/calibrate lower resolution global flood products and to develop capacity in region.

Mesoamerican countries eligible for no-cost Radarsat-2 acquisitions include Haiti, Virgin Islands, Barbados, Grenada, Jamaica, St Lucia, Dominican Republic, Anguilla, Belize, Guatemala, Guyana, Honduras, Nicaragua, Costa Rica, Dominica, and Panama, Caicos, St. Kitts, Antigua, Trinidad, Tobago, Cayman Island, Nevis, Montserrat, Guadeloupe, Martinique, Aruba, Curacao, St. Martin, St. Vincent, Grenadines, Yucatan Peninsula, Belize, Guatemala, Honduras, Costa Rica, Colombia, and Venezuela.
Target areas for Seismic Pilot EO data

Portions (in purple) of the global seismic belt including the Alpine-Himalayan Belt (incl. Turkey, Iran, Tibet, etc.), subduction zones in South America, with validation sites in Southern California, Western Turkey and Southern Japan. Gradually extend to red zones beyond current pilot.
Target Areas for Volcano Pilot EO data
CEOS Agency Response to Pilots: Strategic EO Data Acquisition Plan

• Detailed EO Requirements for each pilot approved at last Plenary
  • Pilot definition included types of data required, frequency of observations and polygons of interest, etc

• Pilot EO Requirements submitted to Data Coordination Team made up of representatives from CEOS agencies

• Assessment of EO Requirements between last Plenary and SIT-29 by each individual agency
  • Agencies’ responses analysed and consolidated by Data Coordination Team and pilot Leads. *(WGDisasters meeting # 1, Montreal 17-19 March)*
  • Analysis included trade-offs between pilots (e.g. *Pleiades data to be used in priority for volcanoes and seismic hazards*), synergies across pilots (*volcanoes and seismic hazards*) and possible overlaps with other major initiatives (*GEOGLAM, GFOI in S-E Asia, Supersites*)
Analysis from Space Agencies
# Data Contributions* from CEOS Agencies (1/3)

<table>
<thead>
<tr>
<th>CEOS Agency</th>
<th>Flood Pilot</th>
<th>Seismic Pilot</th>
<th>Volcano Pilot</th>
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<tr>
<td><strong>ASI</strong></td>
<td>Approximately 300 CSK images/year/pilot over three years, in addition to existing GSNL commitments. Priority given to archived imagery. NRT images for rapid science products under Flood Objective B, Seismic Objective C (1-2 events/year) and Volcanic Objective C (1 major eruption) to be evaluated on case by case basis.</td>
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<tr>
<td>Proposed contribution under review.</td>
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<tr>
<td><strong>CNES</strong></td>
<td>SPOT World Heritage Archive made available to pilots (1000s of SPOT-5 archived images) with five-year rolling buffer. Up to 50 Pleiades images/year/pilot over three years. Commitment to be finalized after discussions with industrial partner. Night-time SPOT-5 imagery during 2014. ANR KalHaiti data base over Haiti.</td>
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<tr>
<td>NRT imagery request being discussed with commercial partner</td>
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<tr>
<td><strong>CSA</strong></td>
<td>About 500 RSAT-2 products to support the Flood Pilot until November 2016 (end of the Pilot). More than 400 RSAT-2 products to support GSNL i.e. Hawaii (ongoing) and Iceland (in negotiation with MDA). Potential access to Volcano Watch Background Mission over Latin America (archived RADARSAT-2 products). Data for rapid science products for Seismic and Volcano Pilots evaluated on case-by-case basis: contribution of 40 RSAT-2 products for Event Supersite: Sinabung Volcano, Indonesia.</td>
<td></td>
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<tr>
<td>Review against commercial conflict required.</td>
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</tbody>
</table>

*contributions are in addition to existing GSNL contributions and International Charter data made available during or after activation
# Data Contributions* from CEOS Agencies (2/3)

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<tr>
<td><strong>ESA</strong> Sentinel-1 launch April 2014. Six months commissioning. Sentinel-2, SMOS.</td>
<td>Sentinel-1 gradually made available starting with pilot targets in 2014 when these converge with baseline observing strategy. +20000 scenes over Italy, Japan, California, Turkey &amp; Greece the first year overall for 3 pilots.</td>
<td>Sentinel-1 gradually made available starting with pilot targets in 2014 and with the goal to cover priority areas of Objective A for 2016 – 10s of 1000s of images</td>
<td>Sentinel-1 gradually made available starting with pilot targets in 2014 and with the goal to cover priority areas of Objective A for 2016, especially when these converge with seismic areas</td>
</tr>
<tr>
<td><strong>DLR</strong> Proposed contribution under review. Review against commercial conflict required.</td>
<td>200 TSX scenes over three years; access to TanDEM Elevation Model without data transfer (through viewer) being considered.</td>
<td>Assessment of validation areas and data volumes (Objective A) under way. Possible access to TanDEM Elevation Model without data transfer being considered.</td>
<td>400 TSX scenes over three years (under Obj. A); contribution to Obj. C to be evaluated after eruption; access to TanDEM Elevation Model for erupting volcano being considered.</td>
</tr>
<tr>
<td><strong>JAXA</strong> Proposed contribution under review. ALOS-2 launch May 2014.</td>
<td>100 ALOS-2 products/year/pilot made available for promotion/demonstration; additional data available at marginal cost of $100/scene; barter arrangements for further data requests under review. Acquisitions requested are covered by ALOS-2 Basic Observation Scenario</td>
<td></td>
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</tbody>
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### Data Contributions from CEOS Agencies (3/3)

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<th>Volcano Pilot</th>
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<tr>
<td>NASA EO-1 estimated end of life 2016</td>
<td>300 EO-1 images/year 2014-2015</td>
<td>JPL/ARIA to provide rapid processing for 2-4 events/year under Objective C</td>
<td>Hyperion data for lava temperature and structure information (approx. 100 images/year 2014-2015)</td>
</tr>
<tr>
<td>NOAA</td>
<td>Precipitation products; flash flood warning system in regional pilot areas</td>
<td>N/A</td>
<td>Atmospheric data products over Latin America</td>
</tr>
<tr>
<td>USGS Further tasking of Landsat-8 possible if required</td>
<td>Landsat-8 imagery</td>
<td>Landsat-8 imagery</td>
<td>Night-time tasking of Landsat-8 over 19 active volcanoes in Latin America</td>
</tr>
</tbody>
</table>

*Contributions are in addition to existing GSNL contributions and International Charter data made available during or after activation*
# How data will be exploited – flood pilot

<table>
<thead>
<tr>
<th>Geographic Area</th>
<th>Product</th>
<th>Value Added Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haiti</td>
<td>Flood extent maps, flood risk maps, landslide maps, flash flood guidance / threat maps, integrated risk assessment platform</td>
<td>SERTIT, CIMA, INGV, Altamira, CIMH, RASOR FP7, NOAA/HRC</td>
</tr>
<tr>
<td>Other Caribbean islands, Central America</td>
<td>Flood damage maps, change detection products, co-registered map overlays</td>
<td>CATHALAC, CIMH, NASA/GSFC</td>
</tr>
<tr>
<td>Namibia</td>
<td>Flood extent maps, flood warning products, co-registered map overlays</td>
<td>Namibia Hydrology Dept, Namibian Water Authority, NASA</td>
</tr>
<tr>
<td>Zambezi basin</td>
<td>Flood extent maps, flood forecast models, flood hazard maps, flood depth forecasts</td>
<td>Lippmann Institute (PAPARAZZI, HAZARD, WATCHFUL), DELTARES, NASA/JPL</td>
</tr>
<tr>
<td>Mekong</td>
<td>Flood extent maps, flood risk maps, flash flood guidance / threat maps</td>
<td>Mekong River Commission, NASA, NOAA/HRC, USGS, University of South Carolina, Texas A&amp;M</td>
</tr>
<tr>
<td>Java (Bandung, Jakarta, Cilacap)</td>
<td>Flood risk maps, subsidence maps tied to flood risk, tsunami risk maps (Cilacap only), flood extent maps</td>
<td>SERTIT, Deltares, CIMA, Altamira, INGV, RASOR FP7</td>
</tr>
</tbody>
</table>

Products used by: national end users, civil protection agencies, World Bank, Red Cross, River Commissions (Kavango, Zambezi, Mekong)
## How data will be exploited – seismic pilot

<table>
<thead>
<tr>
<th>Activity</th>
<th>Product</th>
<th>Value Added Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide extent monitoring for strain map generation</td>
<td>Interfermetric processing (conventional InSAR and PSinSAR) to derive strain rate estimates based on deformation measurements; Generation of fault mapping products; EO based urban footprint to support exposure mapping as supporting information for seismic risk analysis.</td>
<td>COMET+, ISTerre</td>
</tr>
<tr>
<td>Geohazard Supersites and Natural Laboratories</td>
<td>Interfermetric processing (conventional InSAR and PSinSAR) to derive interseismic, co-seismic and post-seismic deformation mapping products; Generation of surface fracture mapping products to support modelling of seismic sources and possibly map some large aftershock in the surroundings.</td>
<td>Various over each supersite and event supersite, on best efforts basis</td>
</tr>
<tr>
<td>Rapid generation of science products</td>
<td>Interfermetric processing (conventional InSAR and PSinSAR) to derive co-seismic and post-seismic deformation mapping products; Generation of surface fracture mapping products to support modelling of seismic sources and possibly map some large aftershock in the surroundings.</td>
<td>INGV, JPL/ARIA</td>
</tr>
</tbody>
</table>

Products used by: academia and researchers, civil protection agencies…
# How data will be exploited – volcano pilot

<table>
<thead>
<tr>
<th>Activity</th>
<th>Product</th>
<th>Value Added Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional volcanic monitoring in Latin America</td>
<td>Terrain deformation products over 300 volcanoes to identify unsuspected activity; weekly monitoring of 19 active volcanoes; thermal anomaly detection; atmospheric products during eruptions; ash dispersal and ash cover maps.</td>
<td>Bristol University, Cornell University, Open University, NOAA, Buenos Aires and Washington VAACS</td>
</tr>
<tr>
<td>Development of new methodologies and products for intensive monitoring over supersites</td>
<td>Using GSNL data collects over the volcano supersites, the CEOS pilot will develop and validate new monitoring protocols for active volcanoes and generate products that could be used for global monitoring of holocene volcanoes after the pilot period.</td>
<td>USGS, INGV, University of Iceland</td>
</tr>
<tr>
<td>Major volcano eruption 2014-2016</td>
<td>Pre-event deformation products if data available over volcano selected, to examine retroactively the benefit of deformation mapping in precursor phase Co- and Post-event deformation Co- and Post-event products for ground (ash cover, thermal monitoring etc.) Co- and Post-event atmospheric products (ash dispersal, SO2 monitoring etc.)</td>
<td>USGS/VDAP, Bristol, Cornell and others depending on eruption location</td>
</tr>
</tbody>
</table>

Products used by: national end users, civil protection agencies, volcanic observatories in Latin America, VAACS
Response to Pilots: CONCLUSIONS

• Majority of contributions (*open & free data*) confirmed by Agencies. Some options still being worked (e.g. alternatives addressing some data policies constraints.
  • Main issue: data contributions are for R&D activity; should some activities become operational after 2016, funding is required to ensure sustainability

• Consolidated response from space agencies very positive; volume of EO data & products confirmed is similar or greater to what was initially provided for Forest Carbon Tracking and for JECAM.

• Main objectives of each pilot can be reached with the firm contributions announced.

• On-going refinement for data; some specific imaging requirements being reconsidered given trade-offs between agencies: how to best exploit synergies?
User Challenges

• Users are split into three categories:
  a) Satellite operators and their value added providers,
  b) National agencies/ regional centers/ international organizations, and
  c) The general public (think weather app on your smart phone)

• Users b) and c):
  • Want products specific to their disaster event, not data they have to manipulate
  • Don’t want to program, they want to execute requests with point and click apps
  • Don’t want to purchase software tools, they want open source tools that are freely available and ubiquitous
User Challenges #2

• All users want products to be accessible using tools they usually have installed on their desktop or hand held devices
• Digital products are preferred over paper (important to disaster users we have in our regional pilots)
• PNG, PDF, and JPEG are nice for pictures in reports and presentations, BUT…
• Users want map based products such as
  • KML raster overlays and vectorized polygons
  • These can be combined with other data on a common map background for mashups/analysis/reporting
User Challenges #3

There are hidden services that the users will expect without necessarily knowing they need to ask for it.

• Situational awareness requires a stream of new data in addition to static overlays and archive data
  • New acquisitions need to be visible to all users so they can know what to request for tomorrow and the next day, available from the variety of feasibilities that are provided

• Automated mapping servers and map service organizations need to have new data availability published and the capability to subscribe for notification of URL/URI of those data sets

• Product processing should be automated for every available user option – either for every data set or on-demand for specific detection and classification algorithms
User Challenges #4

More hidden services that the users will expect without necessarily knowing they need to ask for it.

• Tiling and compression should be available for raster and vector-based products that can be ingested and visualized by desktop and hand-held devices without any programming knowledge

• Product publication and distribution can be via RSS or Atom-type feeds, but should evolve to become “product feeds”

• Product providers need to ensure that
  • Native resolution is maintained
  • Products are terrain corrected and co-registered to map control points
  • Products are delivered only within the user area of interest (i.e., down scaling global-regional-local)
  • Delivered products can be easily validated/corrected by non-experts
NASA Disaster Sensor Web Concept

Detect Floods

Analyze Risks

Validate Model

Acquire Data

(River Gauge)

Initiate Request

Task Sensor

Acquire Data (Image)

Analyze Image
## Satellites for Flood and Drought Monitoring

### Global Moderate Resolution
- Terra
- Aqua
- S-NPP
- TRMM
- GPM
- SMOS
- GCOM-W1
- SMAP
- GOES
- DMSP
- NOAA-19
- METOP
- METEOSAT

### Pointable High Resolution
- EO-1
- Terra ASTER
- Radarsat-2
- Cosmo-Skymed
- TerraSAR-X
- Pleaides-1
- ALOS-2
- Sentinel-1
- Spot-5
- Worldview-2
- Landsat-8
## Details for High Resolution Satellites

<table>
<thead>
<tr>
<th>Category</th>
<th>Mission</th>
<th>Instrument</th>
<th>Agency</th>
<th>Launch</th>
<th>Repeat or Revisit *</th>
<th>Swath</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optical - Coarse Resolution (&gt;100m)</strong></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Core</td>
<td>Terra</td>
<td>MODIS</td>
<td>NASA</td>
<td>Dec 1999</td>
<td>1 day</td>
<td>2330 km</td>
<td>250, 500, 1000m</td>
</tr>
<tr>
<td>Core</td>
<td>Aqua</td>
<td>MODIS</td>
<td>NASA</td>
<td>May 2002</td>
<td>1 day</td>
<td>2330 km</td>
<td>250, 500, 1000m</td>
</tr>
<tr>
<td>Core</td>
<td>NPP</td>
<td>VIIRS</td>
<td>NASA</td>
<td>Oct 2011</td>
<td>1 day</td>
<td>3000 km</td>
<td>375, 750m</td>
</tr>
<tr>
<td><strong>Optical - Moderate Resolution (10 to 100m)</strong></td>
<td></td>
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</tr>
<tr>
<td>Core</td>
<td>Landsat-8</td>
<td>OLI + TIRS</td>
<td>NASA/USGS</td>
<td>Feb 2013</td>
<td>16 days</td>
<td>183 km</td>
<td>15, 30, 100m</td>
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<tr>
<td>Core</td>
<td>Sentinel-2A</td>
<td>MSI</td>
<td>ESA</td>
<td>Feb 2015</td>
<td>10 days</td>
<td>290 km</td>
<td>10, 20m</td>
</tr>
<tr>
<td>Core</td>
<td>Sentinel-2B</td>
<td>MSI</td>
<td>ESA</td>
<td>May 2016</td>
<td>10 days</td>
<td>290 km</td>
<td>10, 20m</td>
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<tr>
<td>Core</td>
<td>EO-1</td>
<td>ALI</td>
<td>NASA</td>
<td>Nov 2000</td>
<td>2-4 days</td>
<td>185 km</td>
<td>10, 30m</td>
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<tr>
<td><strong>C-Band SAR</strong></td>
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<tr>
<td>Core</td>
<td>Sentinel-1A</td>
<td>SAR</td>
<td>ESA</td>
<td>Mar 2014</td>
<td>12 days</td>
<td>80, 250, 400 km</td>
<td>9, 20, 50 m</td>
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<tr>
<td>Core</td>
<td>Sentinel-1B</td>
<td>SAR</td>
<td>ESA</td>
<td>May 2016</td>
<td>12 days</td>
<td>80, 250, 400 km</td>
<td>9, 20, 50 m</td>
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<tr>
<td>Core</td>
<td>Radarsat-2</td>
<td>SAR-C</td>
<td>CSA</td>
<td>Dec 2007</td>
<td>1-6 days</td>
<td>8-500 km</td>
<td>0.8 - 100m</td>
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<td>Core</td>
<td>ALOS-2</td>
<td>PALSAR-2</td>
<td>JAXA</td>
<td>Dec 2013</td>
<td>14 days</td>
<td>25 to 490 km</td>
<td>10 to 100 m</td>
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<td><strong>X-Band SAR</strong></td>
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<tr>
<td>Contributing</td>
<td>TerraSAR-X</td>
<td>SAR</td>
<td>DLR</td>
<td>Jun 2007</td>
<td>11 days</td>
<td>5 to 100 km</td>
<td>1, 3, 16 m</td>
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<tr>
<td>Contributing</td>
<td>COSMO SkyMed</td>
<td>SAR-2000</td>
<td>ASI</td>
<td>Jun 2007</td>
<td>5 days *</td>
<td>10 to 200 km</td>
<td>1 to 100 m</td>
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## Details for Global Coverage Satellites

<table>
<thead>
<tr>
<th>Category</th>
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<tr>
<td>Optical - Coarse Resolution (&gt;100m)</td>
<td>Core Terra</td>
<td>MODIS</td>
<td>NASA</td>
<td>Dec 1999</td>
<td>1 day</td>
<td>2330 km</td>
<td>250, 500, 1000m</td>
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<tr>
<td></td>
<td>Core Aqua</td>
<td>MODIS</td>
<td>NASA</td>
<td>May 2002</td>
<td>1 day</td>
<td>2330 km</td>
<td>250, 500, 1000m</td>
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<tr>
<td></td>
<td>Core NPP</td>
<td>VIIRS</td>
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<td></td>
<td>Core JPSS-1</td>
<td>VIIRS</td>
<td>NOAA</td>
<td>Jan 2017</td>
<td>16</td>
<td>3000 km</td>
<td>375, 750m</td>
</tr>
<tr>
<td></td>
<td>Core Sentinel-2A</td>
<td>MSI</td>
<td>ESA</td>
<td>Feb 2015</td>
<td>10 days</td>
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<td>ESA</td>
<td>May 2016</td>
<td>10 days</td>
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<tr>
<td>SAR</td>
<td>Core Radarsat</td>
<td>Radar</td>
<td>CSA</td>
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<td>500km</td>
<td>250m</td>
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<td></td>
<td>Core Envisat</td>
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<td>ESA</td>
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<td>250m</td>
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<td></td>
<td>Core ALOS</td>
<td>PALSAR</td>
<td>JAXA</td>
<td></td>
<td>7 days</td>
<td>500km</td>
<td>250m</td>
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<tr>
<td>Soil Moisture and Precipitation</td>
<td>Core SMOS</td>
<td>MIRAS (L-Band MW)</td>
<td>ESA</td>
<td>Nov 2009</td>
<td>1-3 days *</td>
<td>1050 km</td>
<td>40 km</td>
</tr>
<tr>
<td></td>
<td>Core GCOM-W1</td>
<td>AMSR-2 (MW)</td>
<td>JAXA</td>
<td>May 2012</td>
<td>1-2 days *</td>
<td>1450 km</td>
<td>5 to 50 km</td>
</tr>
<tr>
<td></td>
<td>Core SMAP</td>
<td>SMAP (L-Band MW)</td>
<td>NASA</td>
<td>Oct 2014</td>
<td>1-3 days *</td>
<td>1000 km</td>
<td>10 to 40 km</td>
</tr>
<tr>
<td></td>
<td>Core GCOM-W2</td>
<td>AMSR-2 (MW)</td>
<td>JAXA</td>
<td>2016</td>
<td>1-2 days *</td>
<td>1450 km</td>
<td>5 to 50 km</td>
</tr>
<tr>
<td>Rainfall Rate</td>
<td>Core TRMM</td>
<td>TMI</td>
<td>NASA</td>
<td>Nov 1997</td>
<td>~12 hours</td>
<td>760 km</td>
<td>4.4 km</td>
</tr>
<tr>
<td></td>
<td>Core GPM</td>
<td>GMI</td>
<td>NASA</td>
<td>Feb 2014</td>
<td>~3 hours</td>
<td>885 km</td>
<td>4.4 km</td>
</tr>
<tr>
<td></td>
<td>Core DMSP F17</td>
<td>SSMIS</td>
<td>DoD</td>
<td>Nov 2006</td>
<td>12 hours</td>
<td>1707 km</td>
<td>14 km</td>
</tr>
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<td>Core DMSP F18</td>
<td>SSMIS</td>
<td>DoD</td>
<td>Oct 2009</td>
<td>12 hours</td>
<td>1707 km</td>
<td>14 km</td>
</tr>
<tr>
<td></td>
<td>Core DMSP F19</td>
<td>SSMIS</td>
<td>DoD</td>
<td>2014</td>
<td>12 hours</td>
<td>1707 km</td>
<td>14 km</td>
</tr>
<tr>
<td></td>
<td>Core NOAA-19</td>
<td>MHS</td>
<td>NOAA</td>
<td>Feb 2009</td>
<td>12 hours</td>
<td>2348 km</td>
<td>17 km (nadir)</td>
</tr>
<tr>
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<td>Core METOP-B</td>
<td>MHS</td>
<td>EUMETSAT</td>
<td>Sep 2012</td>
<td>12 hours</td>
<td>2348 km</td>
<td>17 km (nadir)</td>
</tr>
<tr>
<td></td>
<td>Core NPP</td>
<td>ATMS</td>
<td>NASA-NOAA</td>
<td>Oct 2011</td>
<td>12 hours</td>
<td>2300 km</td>
<td>15.8 km (nadir)</td>
</tr>
<tr>
<td></td>
<td>Core GOES-West (current series)</td>
<td>Imager</td>
<td>NOAA</td>
<td>1995</td>
<td>15-180 min</td>
<td>Sectors and FD*</td>
<td>4 km (nadir)</td>
</tr>
<tr>
<td></td>
<td>Core GOES-West (GOES-R series)</td>
<td>ABI</td>
<td>NOAA</td>
<td>Sep 2016</td>
<td>5-15 min</td>
<td>FD</td>
<td>2 km (nadir)</td>
</tr>
<tr>
<td></td>
<td>Core GOES-East (current series)</td>
<td>Imager</td>
<td>NOAA</td>
<td>1994</td>
<td>15-180 min</td>
<td>Sectors and FD</td>
<td>4 km (nadir)</td>
</tr>
<tr>
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<td>Core METEOSAT (Second Generation)</td>
<td>SEVIRI</td>
<td>EUMETSAT</td>
<td>2002</td>
<td>15 min</td>
<td>FD</td>
<td>3 km (nadir)</td>
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<tr>
<td></td>
<td>Core METEOSAT (Indian Ocean)</td>
<td>MVIRI</td>
<td>EUMETSAT</td>
<td>2006</td>
<td>30 min</td>
<td>FD</td>
<td>5 km (nadir)</td>
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<td></td>
<td>Core MTSAT-2</td>
<td>Imager</td>
<td>JAXA</td>
<td>2005</td>
<td>15-60 min</td>
<td>Hemispheric / FD</td>
<td>4 km (nadir)</td>
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<td></td>
<td>Core Himawari-8 (replaces MTSAT-2)</td>
<td>AHI</td>
<td>JAXA</td>
<td>2015</td>
<td>10 min</td>
<td>FD</td>
<td>2 km (nadir)</td>
</tr>
</tbody>
</table>

**Details for Global Coverage Satellites**
NASA Web Service URLs

- OpenID Provider-Server [https://op.geobliki.com/](https://op.geobliki.com/) controls the security (this is where you setup your account)
- Campaign Manager [http://geobpms.geobliki.com/home](http://geobpms.geobliki.com/home) allows tasking requests to be submitted (i.e., target requests)
- EO-1 Server [http://eo1.geobliki.com/](http://eo1.geobliki.com/) this is where EO-1 data can be found along with the status of future and past task requests
- Radarsat Server [http://radarsat.geobliki.com/radarsat](http://radarsat.geobliki.com/radarsat) where we provide access to Radarsat-2 browse images, metadata, and processed flood products in several formats
- MODIS Flood Server [http://oas.gsfc.nasa.gov/floodmap/](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 API [http://modis.geobliki.com/modis](http://modis.geobliki.com/modis) is the server that provides an Application Programmer Interface (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 and Open Cloud Consortium

• Web Coverage Processing Service (WCPS)
  http://matsu.opencloudconsortium.org/wcps/session/login is for generating and executing algorithms against satellite data

• Pub/Sub Server http://opsb.geobliki.com/session/new is for setting up subscriptions to be notified when new products of interest to you are published....The notifications come via Email, SMS, or twitter and contain RSS or Atom feeds for you to follow to find the product. Clients can be automated to monitor the feeds and pull the data they are programmed to look for

Radarsat-2 Water Detection Example (red)
Open Street Map Reference Water (blue)
Combined Overlays (blue on red) Indicates Flooded Areas
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

Note: Particular Algorithm is Not Relevant In this Example

5.9MB TIF LZW Compressed
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
Surface Water Detected in White
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

Height Color

9m
8m
7m
6m
5m
4m
3m
2m
1m

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 / Swamp / Watersheds

OSM Marshes/Watershed Tags Are Important
OSM Field Validation Approach

Planetary OSM Baseline Water Database

Postgres Database (Joyent)

Flood Map Processor Radarsat.Geobliki.Com (Joyent)

NRT Satellite Data

Baseline Water Layer

Water extent and Flood Maps (KML tiles, MB tiles, OSM tiles)

Enhanced Water Reference and Flood Maps

publish NRT map

publish corrected map

Regional Hydrology SME Server W/ JOSM

National Hydrology Agency Server W/ JOSM

Annotated
High water reference
Low water reference
Flood Map

National Postgres Database

Mobile Platform Track Collector For Field Data

Automated Time Stamp
GPS Stamp for shoreline (Lat, Long, Altitude)
User Name/ User Type

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

- 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

- Not flooded: misclassified as flooded

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

EO-1 Water Edge Detection (red)

Radarsat Water Edge Detection (yellow polygon)

Team 1 walking bank to collect GPS points (red X's)

Team 2 walking bank to collect GPS points (green X's)

One of 500 GPS photos from helicopter
Integrated Water Edge Detection Display with Boat GPS Measurements, GPS located photos, Radarsat/EO-1 water edge detections.

Radarsat Water Edge Detection (yellow polygon)

Boat Team 1 track walking bank to collect GPS points (purple track)

EO-1 Water Edge Detection

Boat Team 2 track walking bank to collect GPS points (orange track with numbered waypoints)