Flood Pilot
Final Report
(April 2014 – November 2017)

Summary: The Flood Pilot of the CEOS Working Group on Disasters was created to improve the use of satellite data for predicting and responding to floods, particularly in countries with limited financial resources. Part of this effort has involved creating Web-based "dashboards" that provide one-stop access to flood-related products from satellite data in a format that can be easily understood, with a particular focus on the Caribbean, Southern Africa, and Southeast Asia. Another part has been to make some satellite data that normally cost money freely available to Pilot partners to demonstrate their value. A third focus has been to leverage ongoing efforts to train users in individual countries to access and use these data. During this time, the Flood Pilot has provided valuable data products in response to a number of flood disasters in many places including Sri Lanka and Haiti, and has installed software for easily obtaining and displaying these data in Costa Rica and Kenya.

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User Implementation Lead:
- Global: NASA Goddard Space Flight Center (GSFC)
- Caribbean: Caribbean Institute for Meteorology and Hydrology (CIMH)
- Southern Africa: Namibia Dept. of Water Affairs and Forestry
- Southeast Asia: Mekong - Mekong River Commission (MRC Technical Support Division), Asia Disaster Preparedness Center (ADPC), Java - Indonesian Ministry of Public Works

Collaborating organizations:
CEOS agencies: NASA, NOAA, Agenzia Spaziale Italiana (ASI), Canadian Space Agency (CSA), European Space Agency (ESA), Centre National d'Etudes Spatiales (CNES), South African National Space Agency (SANSA), United States Geological Survey (USGS), JAXA.

Other partners: CIMA, Hydrologic Research Center (HRC), Lippmann Institute, Deltares, Service Régional de Traitement d'Image at de Télédétection (SERTIT), University of Colorado, University of Maryland, Joint Research Centre (JRC), Central America Regional Climate Change Program (RCCP), ACRI, Global Facility for Disaster Reduction and Recovery (GFDRR), MRCTechnical Support Division, Government of Namibia, Kavango/Okavango River Commission, Government of Indonesia (Research Center for Water Resources – (RCWC), UNESCO, Jet Propulsion Laboratory (JPL).

Initial Objectives:
The Flood Pilot had three main objectives:

1. Create a Global Flood Dashboard to serve as a "one-stop shop" for information from a number of existing systems for monitoring and predicting floods in real-time. This Dashboard uses relatively coarse-resolution data for the entire globe to enable disaster managers and other users (especially those with multi-national responsibilities) to quickly identify "hot spots" where they need to focus their attention.
2. Create three regional Flood Pilots that are focused on delivering satellite products with a greater amount of spatial detail for smaller areas. When a flood occurs in one of these regional Pilot regions, users of the data will be able to transition from the big-picture focus of the Global Dashboard to much more detailed information for the area of interest. The three regions are:
   - The Caribbean/Central America, with a particular focus on Haiti;

- Southern Africa, including Namibia, South Africa, Zambia, Zimbabwe, Kenya, Mozambique and Malawi;
- Southeast Asia, with a particular focus on the lower Mekong River Basin and West Java, Indonesia.

3. Encourage each participating country to develop at least a basic capacity to access these data, understand them, and make them a part of their decision-making process. The Flood Pilot is leveraging a number of ongoing projects to accomplish this, including RASOR in Haiti and TIGER in Africa, and SERVIR in Asia.

Achievements:

- All three objectives are being met in part via a modified approach of developing an Open GeoSocial API Flood Monitoring software suite that permits easy access to and display of flood information in the form of map overlays; this is a much more flexible solution than the initially envisioned dashboards and also enables the users to readily share their own flood-related content. This has been implemented regionally in Costa Rica (Regional Climate Change Program) and at the Regional Center for Mapping of Resources for Development (RCMRD) in Kenya and a version is being considered for global implementation; it has also been demonstrated to other potential users such as the Sri Lanka head disaster manager and the Pacific Disaster Center.
- As part of Objectives 1 and 2, data from participating CEOS agencies have been provided to regional and local partners for a number of flood events, not only in the Pilot regions but throughout the world as data access permitted. Among the most significant of these events were Cyclone Roanu in Sri Lanka and Hurricane Matthew in Haiti.

Data accessed (the Flood Pilot used all available EO data; the following data sets were provided specifically for the Pilot:)

- Approximately a dozen images from CNES Pleiades (50-cm and 2-m optical imagery)
- 63 images from JAXA ALOS-2 PALSAR-2 (flood mapping through clouds)
- 144 images from CSA Radarsat-2 SAR-C (flood mapping through clouds)
- 144 images from ASI Cosmo Sky-Med SAR-2000 (flood mapping through clouds)

Products: The products delivered to end users are too numerous to list, so selected highlights are shown below. These products show flood inundation combining data from multiple satellites.
1.Dartmouth Flood Observatory products for Hurricane Matthew over Haiti
http://floodobservatory.colorado.edu/Events/2016USA4402/2016USA4402.html
User = Haiti Civil Protection
2.Mekong Flood Inundation System: http://projectmekongnasa.appspot.com
User = Mekong River Commission

Dissemination:
Aside from the dissemination efforts of some of the individual Pilot members, the most widespread dissemination efforts were undertaken via the Dashboards and the Open GeoSocial API software that was installed at RCCP and RCMRD. The Open GeoSocial API instances are operating under control of the regional host authority and enables local data producers to easily post their own products and reports in addition to ones from the Flood Pilot team then distribute those products to their own end users. Examples:

- Caribbean / Central American Flood Dashboard: http://centroclima.org/powered-by-nasa/
- Southern Africa Flood Dashboard: http://matsu-namibiaflood.opensciencedatacloud.org/
- iMERG / GFMS Product Server: https://pmm.nasa.gov/precip-apps

Evaluation Against Predefined Criteria

1. Quantitative evaluation of the effectiveness of modeling and observational products for warning and response for the three pilot areas is demonstrated by the use of flood pilot products to pre-position emergency assets in several regions and the front page news garnered by several of our team members for products used by end users to assist in pre flood warnings and post

flood damage assessment reporting.

2. Increased use of global flood monitoring and modeling tools/websites. End users in the Namibian Department of Hydrology use flood model and monitoring products developed by the flood pilot team that are posted on the RCMRD Open GeoSocial API instance running under control of RCMRD with feedback being provided by the Namibian hydrologists. The global products offered by the RCMRD node include the GFMS, G-WADI, and GDACS. In Central America, the Regional Climate Change Program is also integrating outputs from the flood pilot in their regular work. In Asia, SERVIR is integrating flood monitoring products on an operational basis in its flood monitoring system.
3. Successful integration of archived and near-real time satellite EO into operational flood monitoring systems in the three pilot areas as demonstrated in all three regional flood pilot areas described above.

Lessons Learned

- Data distribution is extremely challenging because there are no agreed-upon standards for data access and data formats for satellite flood data; much more labor was required to obtain data from the CEOS participating providers than initially anticipated.
- Better approaches to request access for retrospective cases in addition to the real-time cases is needed
  - Normal (non-flood) scenes at the same scale are essential to provide a robust means of accurately discriminating flooded from non-flooded regions;
  - Scenes from previous floods are also critical for
    - Validation of past events;
    - Comparison of current events to past events (e.g., return period)
- The ESA Sentinel system is a great example of this: one can download the latest scene and also easily identify and download exact repeat scenes from previous months and years to compare. Even for providers who charge for images, such collections may be of interest to those with the resources to purchase larger collections (e.g., the Development Banks)
- Coordination with the International Charter is critical; for much of the Pilot period images from Charter activations were not available to the Pilot because of licensing issues. However, Charter data was provided from early 2016 onwards and has been put to good use by the team to assist in flood extent mapping for purposes of maintaining flood records for future comparison

Sustainability

There were many successful aspects of the Flood Pilot including capacity building of numerous end user organizations to not only process their own monitoring products but to implement predictive modeling capabilities. In addition, development and implementation of standard interfaces for processing and distribution products in compact vector map layer format via the Open GeoSocial API provided end user groups the ability to maintain and enhance these modeling and monitoring tools. The API instances installed and operating in two of the three regions has superseded the initial vision for centralized “dashboards” by providing a much more flexible framework that allows local data providers to operate national or regional nodes, publish their own products, and provide a combined flood product stream to their end users. The use of GIS-ready vector map techniques greatly reduces the bandwidth required by the system while reducing the storage capacity required for each node in the network. These interfaces still provide the originally envisioned “one-stop shop” for not only obtaining flood-related products but also for intercomparing them for validation and product improvement. As noted above, these interfaces have already been implemented at RCCP in Costa Rica and at RCMRD thus creating the start of an expanded user base for satellite data.

Access to previously unavailable data from CEOS agencies (e.g., ASI's COSMO-SkyMed, CSA's Radarsat-2, JAXA's ALOS-2) and the corresponding monitoring products that can be produced from them has improved the flood disaster response cycle in all three regions as evidenced by the user feedback section below. Most of these users have developed local capacity to generate products from these sources and to enhance the products received from other providers; e.g., RCRMD in Nairobi, Kenya; RCCP in Costa Rica; CIMH in Barbados, the World Food Programme and the Inter-American Development Bank in Central America.

Recommendations and Next Steps

1. CEOS agencies should endeavor to make their satellite data available at no cost for disaster management, emergency response, and humanitarian assistance purposes. The International Disaster Charter mechanism is part of this answer, but access to raw data not provided through the charter is needed for value added processors to achieve the level of accuracy and complexity that is not possible when starting processed or composited products available through the Charter. While most agencies provide free and open access to weather and precipitation satellite data necessary for flood modeling, so far only the USA and ESA have done this with data that are required for flood monitoring such as the Earth Observing Systems and Landsat satellites in the U.S. and with the Sentinel satellites from ESA. Even with data freely available, most end users want a flood monitoring product that is GIS-ready rather than the raw data. Within the flood pilot regions, a few end user agencies have managed to develop the capability to process their own flood monitoring products from pointable assets such as Radarsat, CSK, and ALOS-2, but the global market for disaster data procurement remains small because of the cost to setup the processing capacity and the long lead time after successful demonstration for budget cycles to provide a steady stream of data procurement funding. Sustained ready access to these SAR data sources is needed to build the user community demand and establish a long-term market for those data. The capabilities implemented for processing flood monitoring products will exist for a while after the end of the flood pilot and data procurement budgets may appear, so the CEOS agencies need to stay aware of these activities to gauge for themselves whether continuing the data stream beyond the end of the existing flood pilot will be fruitful in the long run. But without new acquisitions with which to develop new end user products, the utility of those systems will diminish over time and eventually justification to maintain them will be impossible to argue.
2. Progress needs to be made toward common licensing and / or open access for humanitarian applications to reduce the difficulty in distributing the data when they are made available.
3. Progress also needs to be made toward standardized and open interfaces, data formats, and data distribution methods (data distribution remains very labor-intensive which greatly interferes with timely product delivery; data format issues also restrict usability).
4. An analysis needs to be made of the outputs of the Concept Phase for GEO-DARMA (planned for early November 2017) and the achievements of the flood pilot, to see where success in the pilot can serve as a starting point for new GEO-DARMA projects. To begin with, an engagement needs to take place with the user base established in the flood pilot to determine the extent to which the modeling and monitoring capabilities established under the flood pilot can be incorporated into GEO-DARMA work plans.
5. A sub-group is being established to consider both the opportunities for flood pilot results integration in GEO-DARMA, and also to analyze elements where the flood pilot success can be built upon for new work, including geographic extension of flood pilot components to other areas, easier scalability of user access to flood information from the global to the national and local levels, and extension of food pilot work from hazard analysis to risk analysis, with emphasis on exposure and vulnerability work and multi-hazard cascading risk. This sub-group will report back to the WG Disasters and SIT in spring 2018.

User Feedback/Endorsements

1. "The imagery [for flooding in Texas in May/June 2015] offered a detailed view of inundation impacting agriculture in rural areas, which is information that can be difficult to obtain from other sources. The imagery also helps to fill in the coverage gaps between stream gages that are monitored for current and forecast conditions…the greatest impacts do not necessarily coincide with the locations of the highest measured flood crests, but occur at sites that contain vulnerable features." (Theresa Howard and Gordon Wells, University of Texas at Austin
2. "These files [of flooding in Sri Lanka in May 2016] are perfect for me and our needs […]. This turned out to be super helpful. Your outreach and forward thinking about open data really does save lives." – Blake Giradot, Humanitarian Open Street Map Team
3. "This [GFMS flood products for Louisiana in May 2016 converted to GIS layers and submitted via an ojo-streamer client] is absolutely the direction we want to head [API based]." (C. Vaughan, Federal Emergency Management Agency (FEMA))
4. "We (the Namibia Department of Water Affairs, Hydrology Division) see our success as the openings we made with all the assistance offered and given by our CEOS partners. Some components are:
   - The use of optical and radar images for flood mapping including access to the International Disaster Charter data
   - The tremendous access to satellite images and the actual use of these images by our staff
   - The customized rainfall estimates and flood forecast from models
   - The remote sensing flood extent estimates (Dartmouth Flood Observatory/European Commission Joint Research Centre)
   - How this all augments the conventional hydrological approach which is based on time series in points
   - And last but not least the capacity building and access to new techniques for our young professionals."