CEOS WGDisasters Flood Pilot Implementation Plan

17 AUGUST 2020

<table>
<tr>
<td>Flood Pilot
2020-2022
Theme Area: Flood Risk</td>
<td rowspan="2">Co-Leads:
Mitch Goldberg, NOAA
Andrew Molthan, NASA
Guy Schumann, RSS
Dave Borges, NASA

Contributing Projects:
NOAA COAST
CEOS Earth Analytics Interoperability Lab Proposal
CEOS WGISS
CEOS SEO
CEOS COAST
CEOS GEO/LEO activities in development of flood mapping from GOES-R and JPSS Series
International Disasters Charter</td>
</tr>
<tr>
<td>Geographic Areas of Focus:

A. Canada
B. United States
C. Argentina
D. India
E. China
F. Greece
G. Myanmar/Laos</td>
</tr>
<tr>
<td>Partners:

CEOS Members:
NASA, NOAA, CSA, ESA, JAXA, USGS, ASI, DLR, UKSA, CSIRO, ISRO, CONAE, CAS

Other Partners:
Natural Resources Canada (NRCan)
University of Athens
Luxembourg Institute of Science and Technology (LIST)
GEO GFRM Community Activity
GEO DRR WG</td>
<td>Pilot objectives:
The Pilot aims to explore and demonstrate best practices for combining information from a growing constellation of optical and SAR ang GEO satellite methodologies for flood mapping and response at regional and local scales by:

A. Use 5-6 regional case studies representing large-scale, long-lasting flood events* where repeated mapping by multi-frequency SAR and multi-platform optical remote sensing can demonstrate the unique value of SAR in complementing LEO/GEO efforts to map water extent. Through these case studies, demonstrate how multi-frequency SAR can contribute additional mapping of water extent, and develop, document, and share potential best practices for merging their analyses in time and space.
B. Demonstrate methodologies within the community for deriving supplemental water depth estimation, using local and regional case studies as an opportunity for calibration and validation. Develop, document, and share potential best practices for communicating uncertainties and additional layer of depth estimation in combination with extent mapping.</td>
</tr>
</table>

	C. Engage with product developers, data services, and end users to characterize their needs for flood mapping and water depth products, feedback on value and utility of combined optical and SAR approaches and develop "best practice" standards for data products, their mapping, and sharing.

CEOS Objectives:

Improve access to and use of existing imagery, data access and processing technologies, and community expertise for the mapping of flood water extent from optical and SAR approaches. Document typical procedures and practices within the community to increase their visibility and use in support of disaster management activities;

Improve coordination and sharing of higher resolution optical imagery and multi-frequency SAR. Highest resolution, limited volume and coverage imagery will be used to demonstrate calibration and validation approaches for moderate resolution applications, and to explore higher degree of detail provided by new operational SAR wavelengths and fine-scale optical imaging;

Capture lessons learned in the use of multi-frequency SAR in combination with multi-platform optical imaging as well as opportunities for future work and improvements;

Explore the use of CARD4L-compliant optical data sets (e.g. USGS/Landsat Analysis Ready Data) and forthcoming CARD4L-compliant SAR to provide feedback to the developer community on ease of use and applicability.

Explore the use of the CEOS Earth Analytics Interoperability Lab Proposal, to help understand gaps and technical requirements that will ease data fusion in terms of flood disaster risk reduction.

Description:

Floods occur annually throughout the world, contributing to widespread property damage, loss of agricultural productivity, losses paid out by private sector and national insurance providers, and the displacement of populations affected by the flood's immediate impacts and longer-term socioeconomic consequences. Meteorological models inform hydrological models which in turn provide crucial forecasts of flooding and related human impacts. As the real event unfolds, remote sensing is valuable to help calibrate and validate model performance, and near real-time or reduced latency mapping of water extent and estimates of depth can best inform impact mapping, response, and recovery.

Earth observations (EO) via satellite remote sensing are frequently leveraged to map the extent of flood. A growing constellation of low-earth orbit (LEO) and geostationary (GEO) platforms and sensors provides both continuity and new capabilities for flood mapping. Large coverage, international missions are complemented by localized imaging at higher spatial resolution to understand fine-scale details of coarser resolution observations. Often, these targeted and higher resolution acquisitions are made through international partnerships and commercial enterprise, made available in greater frequency via the International Charter.

While these optical systems have demonstrated capabilities for mapping water extent in clear skies and where vegetation canopies, clouds, terrain, and their shadows do not obstruct their view, synthetic aperture radar (SAR) complements optical approaches by mapping water extent through cloud cover and active rainfall regardless of day or night conditions. Increased diversity of operational and experimental SAR wavelengths in the public and private sector offer specific advantages in mapping water extent through clouds, rain, and deep vegetation canopies that may go undetected by optical sensors. The combination of optical and SAR approaches provides an opportunity to combine the best of various approaches, if algorithm outputs can be combined in a thoughtful manner appropriate for use by an equally diverse end user community. Diverse methods for mapping flood water include measurement of a water fraction, mapping of full water extent, tracking of flood as a difference against typical water extent, and a variety of methodologies for communicating results in various legends, maps, services, and approaches. End users have discretion to create their own maps of interest which may include use of maps from individual sensors, their aggregation into daily mapping, or combination into an event-wide maximum extent.

Translating a flood extent to more detailed impacts requires a reasonable estimate of water depth. Flood extent maps are being combined with digital elevation models (DEMs) and a growing suite of approaches to translate two-dimensional flood maps to estimates of flood depth. This additional detail is believed to assist the emergency management community towards improved estimates of damage and impacts.

CEOS Contribution to Pilot:
CEOS will act as a coordinating body to facilitate participation by member agencies collaborating to execute the project. Main contributions of CEOS agencies include: (a) sharing of information on the current state of the art for flood mapping via optical and SAR approaches, (b) coordination on support for archival optical and SAR imagery for past, regional and major flood events and a limited number of future events where newly available SAR and optical data demonstrate future capabilities, (c) providing access to and feedback on CARD4L efforts relevant to chosen events, and (d) partnering agencies providing project support to oversee the implementation and execution of proposed work.

Key Pilot Outputs/Deliverables:

- Develop LEO/GEO optical and SAR flood mapping for past major hurricanes with known, large volume of data (e.g., Harvey/Florence) and other events chosen in collaboration with CEOS partners.
- Develop means and suggested methodologies of combining optical and SAR mapping capabilities while accounting for different observation times of day and modes (e.g., single image snapshots for LEO optical and SAR, full-day maximum extent potential from GEO) that provide flexibility to end users for their analysis.
- Discuss and document preferences for how flood water and extent should be defined (e.g. water fraction, probability of water class for a pixel, deterministic classification of a pixel as water) and communicated in mapping approaches.
- Document and compare methodologies for translating water extent mapping to flood water depth as a growing capability within the remote sensing community.

CEOS Outputs/Deliverables:

- Coordination of satellite EO data acquisitions to support the integration of both SAR and optical imaging in support of improved, collaborative flood mapping across data providers, methodologies, and end user communities.
- Coordination to support data acquisitions for new SAR and optical constellation data for recently launched and multi-frequency platforms, complementing past International Charter collections and other free and open data sources.
- Facilitate ongoing and future discussions to improve routine access to higher resolution optical and multi-frequency commercial or international SAR data holdings.
- Presentation of feedback to other CEOS teams regarding applicability of CARD4L formatted data sets for land surface remote sensing in optical and SAR approaches.

Key User Communities:

Users: Research and operational remote sensing communities developing techniques for application of SAR and optical to water/flood extent mapping;
Practitioners: Operational weather analysis, forecasting, and emergency response communities interested in the application of remote sensing to the mapping of water extent;
Institutions: Research institutions who are supporting development of water/flood extent and depth mapping to support emergency management and risk assessment;
General Public: Through collaboration with research and operational entities, community advancements on improved techniques to support response to flood events.

Key Outcomes:

- Demonstrate value added by SAR complementing optical remote sensing approaches currently used in research and operations to address water and flood extent mapping
- Develop suggestions and best practices for combining diverse water and flood extent maps from optical and SAR sensors, disparate times of observations, and latency
- Demonstration of flood extent and depth estimation for past, well-observed region events including major flood events for hurricanes Harvey, Florence, and events of research interest to unfold in areas of interest for collaborative partners
- Feedback to CARD4L collaborators in CEOS on the applicability of ARD data sets developed supporting land surface reflectance and SAR measurements

Milestones and Schedule:

2020-2021: Begin studies for each regional test case. Begin collection of data over the different study sites and development of derived products. Establish ties with users and work with them to define procedures for delivering products.
2021-2022: Provide derived products to appropriate users and agencies working on flood hazard and risk, response and resilience. Collect feedback from users about the data and derived products, and use the feedback to refine monitoring strategies. Provide initial evaluation of pilot results to the global flood community through GFP and international conferences.
2022: Produce reports from users on derived products and adjust as needed. Evaluate results from different study sites. Develop broader space-based EO strategy using insights from pilot in a formal report.

EO Data Requirements:

As the pilot effort evolves, the team will develop detailed requirements for EO needs. Case studies envisioned for Hurricane Harvey and Hurricane Florence have past, known contributions from partners that were offered to the International Charter in response to those

events along with operational LEO/GEO assets and L-band flights from the NASA/JPL UAVSAR. For additional events of interest, the team would desire contributions of high spatial resolution optical imagery (e.g., Pleiades, SPOT, similar) and multi-frequency and other new and evolving SAR capabilities (e.g., NovaSAR, Radarsat Constellation Mission, others) along with any available in situ or hydrological modeling data that can inform the true/potential extent of flooding (e.g., known damage assessments, predicted water extent, others).

Main Contributions by Partner

- NASA: Project activity leadership, contributions of data including UAVSAR, collaborative efforts with funded research partners developing flood mapping in Disasters Program response scenarios or through continued research funding
- NOAA: Flood mapping developed for LEO/GEO effort including GOES-E/W, Himawari, Suomi-NPP/JPSS
- ISRO: Lead subgroup focused on flood efforts in Orissa, India study area. Contributions include flood extent mapping through integration of SAR and optical datasets, hazard and risk mapping using historical data, depth estimates at different flood extents using DEM and modeling techniques and creation of best practices documentation for DRR.
- CONAE: Lead subgroup focused on flood efforts in transboundary Pilcomayo and Bermejo basins. Share relevant SAOCOM data and expertise with Flood Pilot Team.
- USGS: CARD4L data sets developed in collaboration with CEOS (e.g. Landsat), high water marks for flood extent of domestic U.S. events
- JAXA: ALOS-1 and/or -2 contributions of SAR imagery for flood mapping of past events and pre-event scenes to provide analyses and context
- CSA: Past event collections of RADARSAT-1/2 imagery for case studies of interest; RADARSAT Constellation Mission contributions for upcoming events of interest
- ESA/Copernicus: Continued free and open access to Sentinel-1 imagery; contributions of Sentinel-1 in CARD4L: SAR efforts, access to Sentinel-2 and -3 imagery for flood mapping of case study and future events.
- CNES: Contributions of Pleiades and SPOT-5/6/7 imagery of high spatial resolution for understanding optical flood detections in the context of coarser LEO/GEO and SAR observations
- ASI: COSMO-SkyMed contributions of imagery provided to NASA/JPL and other academic partners used for mapping past events; access to COSMO-SkyMed imagery for past events and future events of interest
- DLR: TerraSAR-X contributions previously made to the International Charter continued available to team members for their analysis and exploration; access to TerraSAR-X observations for future events
- UK and CSIRO: Access to S-band SAR observations for future flood events as an opportunity to understand how S-band observations compare to C- and L-band collections.

Capacity Building:

The CEOS pilot will work to integrate efforts with CEOS WGCapD, and with designated developing/developed-world flood "observatories" to identify EO-based methodologies that complement existing monitoring efforts and provide a more robust monitoring capacity. Where possible, EO-based methodologies and practices will be transferred with training to

ensure sustainability. The Global Flood Partnership (GFP) will be an important venue for this work.

Outreach Activities:
Training in the use and interpretation of EO data will be provided to the global flood community in the both the developed and developing world through research consortia and research collaborations. Results will be highlighted at research conferences (e.g., AGU, EGU) and workshops (especially those organized by CEOS agencies).

Suggested Evaluation Criteria:
- Identification of innovation in SAR/LEO/GEO for flood hazard, risk and impact monitoring
- Uptake by user community and monitoring agencies of EO-based methodologies for monitoring floods
- Utilization of EO data for operational monitoring by flood response agencies; emergency responders and water resource managers
- Interest expressed by global flood community to broaden approaches adopted in pilot (especially global SAR monitoring and new methodologies for EO-based monitoring of floods) through representative organizations

CEOS Flood Pilot Team:
David Green, NASA; David Borges, NASA; Andrew Moltan, NASA; Mitch Goldberg. NOAA; Guy Schumann, RSS; Ian Olthof, NRCan; Yves Crevier, CSA; Vincent Decker, NRCan; Marcelo Uriburu Quirno, CONAE; A Soldano, CONAE; A Medico, CONAE; Lucas Bruno, CONAE; L Frulla, CONAE; K H V Durga Rao, ISRO; Praveen Thakur, IIRS; G S Rao, ISRO; Shantanu Bhatawdekar, ISRO; P V N Rao, ISRO; R P Singh, ISRO; Raj Kumar Sharma, ISRO; Weiyuan Yao, CAS; C R Li, CAS; Z Y Li, CAS; L L Tang, CAS; Athanasios-Emm (Thanos) Mourampetzis, University of Athens; Patrick Matgen, LIST; Marco Chini, LIST.