DEVELOPING ENLARGED ACTIONS FOR SATELLITE EO & FLOODS: ANNEXES: 8th May 2014, CEOS Floods Thematic Team.

This document complements the CEOS DRM Proposal Draft concerning Floods. The proposal outlines several concepts which seek to aid the accelerated use of Satellite EO for Floods.

The proposal annexes provide details on projects listed as relevant to the proposal. In some cases the projects are building blocks for the CEOS work; in other cases, the projects provide a complementary service. There are 14 projects listed in flood proposal annex.

- Annex 1: NASA SensorWeb
- Annex 2: GEO Caribbean Satellite Disaster Pilot
- Annex 3: GEO Southern African Flood and Health Pilot
- Annex 4: Lower Mekong River Basin Project (NASA, USGS)
- Annex 5: ESA TIGER Initiative
- Annex 6: RASOR (CIMA, SERTIT, CIMH, Deltares, Indonesian Govt., AG)
- Annex 7: KAL-Haiti (CNES)
- Annex 8: Dartmouth Flood Observatory (Univ. Of Colorado)
- Annex 9: NASA NRT Global MODIS Flood Mapping
- Annex 10: Global Flood Monitoring System (U. of Maryland; TRMM and GPM)
- Annex 11: Global Flash Flood Guidance (HRC)
- Annex 12: International Charter Space and Major Disasters
- Annex 13: SERVIR
- Annex 14: Deltares Global Flood Observatory

These annexes are open; each of them can be edited.

Annex 1: NASA Sensorweb

SensorWeb is a group of NASA applied science and technology research projects that deliver advanced disaster risk management capabilities under a common architecture for asset tasking, data processing, and product discovery/distribution. Sensorweb links predictive models, detection triggers from other sensors, and community of practice inputs for situational awareness in rapid response mode. In particular, SensorWeb will deliver automated flood maps and reference water maps that are crowd-sourcing-ready for distribution to local experts at high resolution. SensorWeb is also the mechanism providing access to EO-1 for the DRM Flood pilot.

Annex 2: GEO Caribbean Satellite Disaster Pilot

The Caribbean Satellite Disaster Pilot is a regional and cross-cutting end-to-end project organized under CEOS Action DI-01-C3_1 focusing on Floods/Flashfloods, Hurricanes, Tsunamis, Earthquakes, Volcanoes, and Landslides. Its purposes are to demonstrate utility of satellite data and to develop risk-based decision support tools and applications supporting the full cycle of multi-hazard disaster management in the Caribbean and Central America (24 nations). It supports the implementation of the Sensor Web applications first in regional centers of excellence, before extending to national agencies and international organizations. It provides a forum for capacity building activities at national, regional, and international levels to improve the uptake of satellite data and products for disaster risk management. Recent accomplishments include:

Jun-Oct 2012: Worked with CIMH, CDEMA, UWI, and CATHALAC to provide satellite coverage for hurricanes Ernesto, Isaac, and Sandy for Haiti, Jamaica, Barbados, St Lucia, British Virgin Islands and for flooding in Panama, an earthquake in Guatemala, an algal bloom in El Salvador, wildfires in Belize, and landslides in Trinidad with a total of 34 Radarsat-2 and 19 EO-1 images plus MODIS daily coverage.

Sep-Dec 2012: Worked with CSA and MacDonald-Dettwiler Associates (MDA) to begin the development of a REST-ful tasking interface between the Campaign Manager (geobpms.geobliki.com) and the Radarsat-2 Acquisition Planning System.

Nov-Dec 2012: Implemented Precipitation Accumulation Calculator (PAC) for TRMM data on a cloud-computing platform (http://matsu.opencloudconsortium.org/trmmpac).

Nov-Dec 2012: Implemented crowd sourcing for correcting reference water and flood extent maps using Open Street Map tools and techniques before it was demonstrated in the GEOSS Architecture Implementation Pilot-5.

January-November 2013: Continued to coordinate capacity building activities with regional and national agencies, developing proposals to donors for support.

Jun-Nov 2013: Conducted pre and post event observations for Caribbean and Central America 2013 disasters, also working with CSA, MDA, and CCRS to upgrade the catalog web interface to enable API searches.

Jul-Dec 2013: Continued work expanding involvement of other CEOS agencies within the modeling, observation processing and capacity building, based on the coordination between CEOS WGISS (Disaster Architecture work), WGCapD, Societal Benefit Area Disasters Team (working with GEO), Ad Hoc Disaster Risk Management Team and GEOSS AIP-6 demonstrations.

Main areas of activity for CSDP: Floods/Flashfloods, Hurricanes, Tsunamis, Earthquakes, Volcanoes, and Landslides.

Annex 3: GEO Southern African Flood and Health Pilot
http://matsu.opencloudconsortium.org/namibia

The Southern African Flood and Health Pilot is a regional and cross-cutting, end-to-end project organized under CEOS Action DI-01-C3_2. Its purpose is to demonstrate the utility of satellite data, in order to develop risk-based decision support tools and applications supporting the full cycle of disaster management in Southern Africa. Likewise, the pilot seeks to support the implementation of the Sensor Web applications first in Namibia, before extending to surrounding countries. Furthermore, the pilot provides a forum for capacity building activities at national, regional, and international levels to improve the uptake of satellite data and products for disaster risk management. Recent accomplishments include:

Apr-Sep 2012: Improvements were made to the Namibia Flood Dashboard client (URL above) to allow autonomous user posting of water gauge readouts, histograms, and flood bulletins.

Jul-Nov 2012: Improved product publication, subscription, notification functionality and revised disaster use case descriptions to update operations concept for improved pub/sub activities.

Sep-Nov 2012: Exercised OpenID/OAuth web services security API under GEOSS AIP.

Oct-Dec 2012: Customized autonomous processing of disaster maps in CEOS-GEO disaster pilot regions.

Nov-Dec 2012: Obtained a new agreement with the CSA to expand tasking and data delivery for disaster pilots through March 2014 for additional radar modes, countries, and personnel data access.

Nov-Dec 2012: Developed full-resolution tiled KML overlays of disaster maps.

Nov-Dec 2012: Introduced Open Street Map (OSM) field validation approach for correcting data product mis-classifications with tiled OSM layers and tiled flood masks as OSM-ready polygons.

Jan-Feb 2013: Conducted a field campaign for the validation of satellite products in Northern Namibia using OSM tools.

Mar-May 2013: Covered 2013 flooding events with optical and radar observations.

Jul-Oct 2013: Upgraded CREST flood model for Northern Namibia to speed-up calibration runs, included new observations, and implemented higher resolution cell sizes.

Jul-Oct 2013: Updated OSM crowd sourcing capabilities to include fused satellite and ground data sets e.g., school facilities survey for use during emergencies.

Nov 2013: Plans made to conduct flood modeling and crowd sourcing workshop in Windhoek with the participation of Namibian Authorities, Kavango River Commission representatives, SERVIR, UNESCO, as well as other regional and national stakeholders.

Annex 4: Lower Mekong River Basin Project (NASA, USGS)

In August 2012, Project Mekong, a NASA Disasters project was selected by the NASA Applied Sciences Program for a 1 year feasibility pilot study. Upon completion of the pilot study, the team will re-compete for another three years of funding from the Program. The project was proposed through a collaborative effort between representatives from MRCS IKMP, NASA, USGS and Texas A&M. To this end, Project Mekong is highly aligned with the ongoing SWAT model development activities by the MRCS as part of the Decision Support Framework, under the WUP Program to support MRCS Basin Development Planning. Currently, several of the SWAT model databases and maps are outdated. Updated Soil databases, Land Use and Land Cover maps are expected to contribute significantly to the SWAT model development, by reducing the uncertainly of the SWAT-provided outputs for flood, drought, management studies, climate change and adaptation activities. As a result, this agreement will facilitate in the improved access to and application of satellite-based Earth observations and model integration, which are envisaged to be highly relevant towards the MRCS capacity building efforts in the region.

The primary goal of the project work is to apply NASA products, tools, and information for improved flood and water management in the Lower Mekong. By optimally integrating the necessary Earth observational measurements provided by various instrument types and modeling systems, this agreement will provide to Mekong River Commission (MRC) access to and development of some of the most state-of-the art data and tools for improving floodplain management, hydrological model improvement. Specifically, Project Mekong will provide and help transfer to the MRC an enhanced Soil and Water Assessment Tool (SWAT) using remotely-sensed precipitation, surface water, ground water, and root zone soil moisture variables, along with improved soils and land use and land cover maps. The soils and land cover maps are being developed and designed specifically for the MRCS SWAT. In addition, a Graphic Visualization Tool (GVT) is being developed to work in concert with the output of the SWAT model parameterized for the Mekong Basin as an adjunct tool of the MRC Decision Support Framework. This study strongly compliments our team's capabilities to strategically provide critically needed data and products, the development of which has centralized around the data gaps identified by the representatives from Texas A&M and MRCS.

Tasks and Deliverables:

NASA Data and Products

NASA agrees to produce and deliver* to MRCS IKMP the following products for Area 6, 7, and 8 based on their specified needs. Specifically, NASA will provide the following to MRC:

- MODIS and Landsat - based Land Use and Land Cover (LULC) Maps from for 2002-2012 reclassified and compatible with MRCS SWAT database,
- Updated Available Water Capacity (AWC) maps compatible with MRC SWAT database,

- Recalibrated version of SWAT with the updated LULC and AWC maps,
- A Graphic Visualization Tool (GVT) compatible with SWAT outputs and MRCS Toolbox,
- Feedback on the MRCS SWAT and suggested flood, drought, climate change information products and services that could be used to improve MRCS capacity for floodplain monitoring and management.

**NASA will provide MRCS open access to all data used/developed in this project.*

MRCS will have full access to all data and tools developed from this agreement through a data server hosted at NASA (ftp://gs6143shinano.gsfc.nasa.gov/pub/Mekong/).

MRCS Data and Products:

MRCS member contributions to this study include technical guidance of the ArcSWAT database calibration, access to the SWAT database, historical and validation data. These datasets are critical for the successful development, calibration and validation of the updated MRCS SWAT. To best facilitate a plan for future cooperation between NASA and MRCS, MRCS will provide the following to the Project Mekong team:

- Access to MRC SWAT databases for Area 6, 7, 8 including Digital Elevation Models, (DEM), vegetation, soils, and atmospheric forcing data,
- Access to relevant MRC spatial and time-series data, gauge data, vegetation and crop calendars where available,
- Gather, report/feedback and provide a performance assessment on the updated LULC and AWC maps, in light of a performance assessment of the re-calibrated version of SWAT, and GVT tool,
- Suggest integration of other NASA hydrological data and tools for possible application to MRC flood, drought, climate change, and capacity building efforts,
- Help define future service and integration directives related to CCAI and FMMP.

Through this agreement, we envision a successful collaboration that will lead to the enhancement of the MRCS floodplain model development and related capacity building efforts. We look forward to a rewarding partnership with the MRCS and MRCS partners.

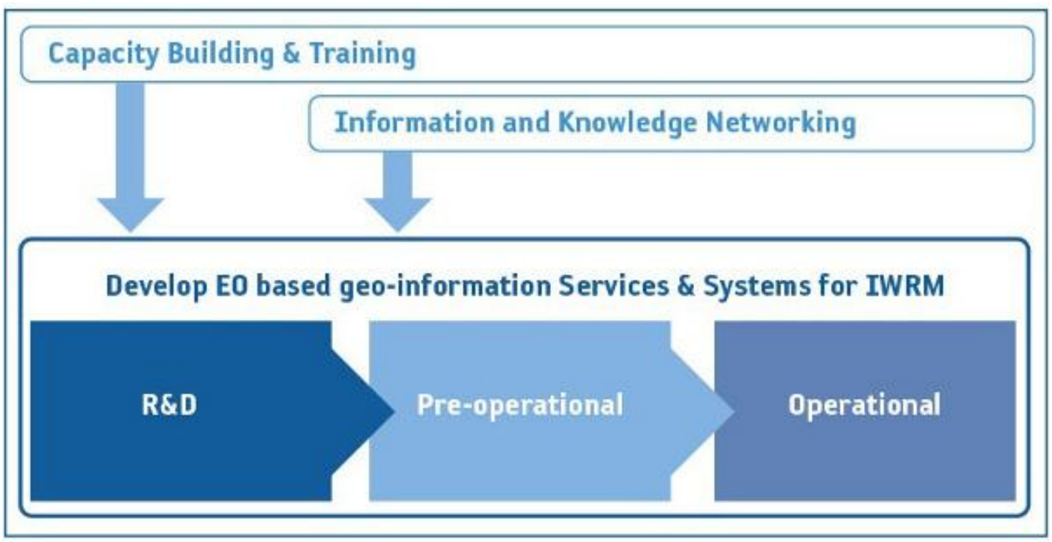
Annex 5: Overview of ESA's TIGER Initiative

http://www.tiger.esa.int

In 2002, in response to the urgent need for action in Africa, as stressed by the Johannesburg World Summit on Sustainable Development (WSSD), the European Space Agency (ESA) launched the TIGER initiative to promote the use of Earth Observation (EO) for the improvement of Integrated Water Resources Management (IWRM) in Africa.

The overall objective of TIGER is to assist African countries in overcoming the problems faced in the collection, analysis and use of water related geo-information by exploiting the advantages of EO technology. The aim is to fill existing information gaps relevant for effective and sustainable water resources management at the national to regional scale, thus helping to mitigate the widespread water scarcity in Africa.

Besides facilitating EO data access to African countries and carrying cross-cutting activities of coordination and outreach, TIGER focuses on several major action lines:



TIGER has been endorsed by AMCOW (African Ministerial Council on Water) and official recommendations concerning its continuation have been received by African stakeholders during the First African Week in 2008 and via the El Jadida declaration, released by the community attending the AARSE conference in 2012. The TIGER initiative is being guided by an international Steering Committee.

African Union Commissioning	African Water Facility	AMCOW	CSA	ESA
Ramsar	South Africa Department Water affairs	UNESCO	United Nations Economic Commission for Africa	

For over a decade the existence of TIGER has established and supported capacity building activities and development projects involving 42 African countries, with a total budget of more than 11 Mio euro reaching more than 150 African water authorities and research institutes. TIGER is an international collaboration founded within the context of the Committee of Earth Observation Satellites (CEOS) with an increasing number of strategic Partners involved.

Annex 6: Overview of RASOR (FP7 – CIMA Foundation)

EC FP7, Call SPACE

Project selected for funding, is to start in November 2013.

The RASOR project aims to develop tools for fast and reliable multi-hazard risk assessment, applicable to several natural hazards worldwide and fit for usage in all phases of the disaster management cycle.

The services offered by RASOR tools will be able to produce detailed and accurate risk information within minutes of the computing time and without the need to acquire costly and time consuming local ground-sourced data. This is achieved by using the latest generation of satellite data and related technology such as Digital Terrain Models (DTMs), Digital Elevation Models (DEMs) and land use information.

The RASOR tools support all phases of the disaster management cycle:

- **Prevention phase**: Risk prevention and mitigation are traditionally based on risk analyses. Since RASOR can be applied worldwide, it will offer a benchmark for all local risk assessments. RASOR can be further utilized to supply the first step of a two-stage risk assessment, identifying areas, locations and scenarios that will require attention within the second, more detailed step. In data-poor regions, such as developing countries, RASOR may be the only reliable source of risk information available.
- **Preparedness phase**: Similar to its applications in the prevention phase, the rapid risk assessment tools offered by RASOR can help to establish contingency plans and prepare response actions. In data-rich regions, RASOR can act as a first step in a course-to-fine approach. In data-poor regions, RASOR may be the only available source of information to prepare for natural disasters.
- **Response phase**: During the response phase, detailed and reliable risk information is extremely valuable, for example when selecting emergency measures that should minimize the damage following a disaster and supply NGO's with the essential geographical information needed prioritise aid distribution to people. A risk assessment can direct the provision of special precautions during unexpected and sudden events which take place as a disaster evolves. A rapid response is all the more important in such situations.
- **Recovery phase**: Immediately after the disaster has taken place, the RASOR tools can provide a first damage estimate and outline the affected areas. This type of information can be used by insurers and governments for financial negotiations and the planning of restoration work.

All these applications require that the risk information is readily available, reliable and accurate. The RASOR tools will offer this service within its capacity to combine a number of global data sources.

In order to maximise the usefulness of RASOR disaster support tools, it is essential that they are developed using a multi-hazard approach. This is critical because it is likely that the same civil protection authorities consider floods, fires, landslides and earthquakes over a given geographical area. The availability of a single tool that can serve as a platform to address multiple hazards is a significant advantage. Furthermore, it is important that the tool is standardised by nature in order to be able to consider different areas, without the need for specific tailoring. This allows international organisations such as the World Bank, the UN or the European Commission to provide support to countries unable to address risk due to capacity or development challenges.

A single tool using a standard input data functioning accurately at a global scale would provide the international disaster management community with an insight into the extent of risk exposure in developing nations where populations are most vulnerable. This form of risk quantification is currently unavailable but could be used to support development decisions for project funding, optimize emergency response and help minimize the damage of imminent disasters. Access to such a tool will enhance the understanding of risk, with evidence gathered from the prospective user community found to support such a concept. It may also serve as the basis for commercial services that will generate benefits for European industry and NGO's at both the SME and larger levels.

RASOR Objectives

RASOR will create an on-line platform to manage risk in real time using space and in-situ datasets.

The RASOR decision support tool will enable:

- Rapid spatialisation of assets and critical infrastructure without pre-existing or proprietary local data sets;
- Analysis of hazard exposure and extent;
- Support to analysis of risk elements for a broad range of hazards including flooding, storm surge, earthquakes, landslides and volcanoes, and ability to rapidly overlay data from other sources on other hazards such as drought, wildfires or windstorms;
- Mapping of vulnerabilities in near-real time;
- Estimation of likelihood of occurrence for certain key disaster types (e.g. flooding, geohazards);
- Ability to import other hazard data as overlays when available (e.g. fire, tsunami);
- Identification of specific areas at risk;
- Management support using the multi-hazard approach;
- Support to the full cycle of disaster management for civil authorities – mitigation, warning, response and recovery, with specific emphasis on vulnerability and risk assessment for prevention, preparedness, emergency response and recovery.

RASOR partnership

CIMA Research Foundation (CIMA)	Italy
Athena Global Europe (AG)	France
Acrotec (ACR)	Italy
SERTIT (UNISTRA)	France
Deltares (DLT)	Netherlands
EUCentre (EUC)	Italy
German Aerospace Centre (DLR)	Germany
INGV	Italy
National Observatory of Athens (NOA)	Greece
Altamira Information	Spain

RASOR Users

Caribbean Institute for Meteorology & Hydrology (CIMH)	CARICOM
Indonesia Ministry of Public Works – Research Centre for Water Resources (RCWC)	Indonesia
Munich Reinsurance	Germany
Italy National Civil Protection Department (DPC)	Italy
UNITAR'S Operational Satellite Applications Programme (UNOSAT)	International Organisation
World Bank (WB)	International Organisation
UN International Strategy for Disaster Reduction (UNISDR)	International Organisation

Annex 7: Overview of KAL-Haiti (CNES)

http://kal-haiti.kalimsat.fr/spip.php?article42

The earthquake that struck Haiti on January 12, 2010, is considered amongst one of the most destructive disasters of recent years, leading to more than 200 000 lives lost, tens of thousands injured and close to 2 million people homeless. Aside from the humanitarian suffering following the aftermath of the earthquake, the country was left financially devastated and the infrastructure network in a state of chaos.

Faced with this phenomenon, the response of the international community has been unprecedented, but beyond the justified compassion demonstrated in the wake of the earthquake, the time has come to focus on rebuilding the country. In addition, scientific studies should be carried out beyond the strict scope of Haïti to better understand disasters of this magnitude and draw together information about seismic hazards in general.

During the crisis phase, a multitude of **satellite images, optical and radar**, were collected by satellite operators - national space agencies or private companies, enhanced by aerial photography and *insitu* measurements. After photo-interpretation, these images were used by the Civil Protection Units to directly supervise the activities of the teams.
Limited to the crisis phase, Earth observation and *insitu* data should be used in order to benefit the coverage of the **whole disaster management cycle**, from prevention to rebuilding. This implies that the whole satellite and ancillary data (*insitu* measurements, maps, models, reports, and statistical information) should be made **available to users** - decision makers responsible for rebuilding, researchers – and in a directly exploitable form, which is easily accessible.

In reply to this requirement, the KalHaïti project aims at developing and maintaining a **remote sensing and ancillary data base** related to the January 2010 earthquake and coordinating the corresponding **user network**. This actual reference infrastructure will be used as support for research developing analysis methods, suitable for the units involved in disaster management, from anticipation to return to normal situations, but also for the rebuilding process started in Haïti.

This project is in-line with the activities carried out by the different partners, especially Earth observation data supply by CNES for scientific purpose (**Kalideos programme**), preparation for the launch of Pleiades satellite (**ORFEO preparatory programme**), support to research and applications (**ISIS programme**) and CNES and SERTIT involvement in the **International Charter "Space and Major Disasters"**.

Finally, the KalHaïti project has received the support of the French **National Research Agency**.

Annex 8: Overview of Dartmouth Flood Observatory

Dartmouth Flood Observatory (now located at the University of Colorado) – ***For Research, Humanitarian, and Water Management Applications***

The mission of the Flood Observatory is to:

1. *1) Acquire and preserve for public access a digital map record of the Earth's changing surface water, including changes related to floods and droughts.* The Flood Observatory provides the only comprehensive global archive of surface water change information which is freely available to the public.
2. *2) Conduct remote sensing-based water measurement and mapping, when appropriate, in "near real time".* The Flood Observatory uses automated water mapping algorithms and together with its NASA-GSFC partner, it is commonly the first to map major flooding events in terms of entire extent. Other organizations may provide more detailed coverage, through the use of higher resolution sensors targeted to the task. The Flood Observatory makes available in near-real-time, (NRT), the GIS files which support the maps, so to enable relief organizations to incorporate the information into their own decision-support systems.
3. *3) Support and encourage operational uses of remote sensing-based surface water information.* Routine surveillance of surface water via orbital remote sensing is relatively new (since early yr 2000): and it is being made possible by frequent-repeat, wide-area coverage sensors, such as MODIS and VIIRS. Whilst the global record accumulates, it is increasingly possible to assess today's surface water extent in relation to its observed long-term means and extremes. Hydrological quantities such as river discharge and lake water storage can also be measured by remote sensing, likewise the Observatory is conducting research and development activities to determine the viability of such a capability.

4) Conduct scientific research making use of these data products.

In this regard, an active area of research currently being undertaken is associated with the use of microwave sensors to monitor river discharge changes (*1-6*). The observatory recently used MODIS water extent information to address future flood risk reduction following the catastrophic flooding in Pakistan (August 2013) (*7*), and the damaging storm surges along critical delta shorelines (*8*).

Flood duration is a factor which affects the terrestrial portion of the global carbon cycle (*9-11*). Remote sensing can provide important numerical constraints.

The record of flooding provides invaluable information for continuing efforts to improve future flood risk assessment (*12*), and it can be used in tandem with hydrological modelling to facilitate flow and inundation prediction (*13*).

Climate variability has been proven to directly affect flood and drought frequency as well as severity (*14-16*). Future changes in the Earth's water cycle cannot be accurately predicted without adequate knowledge concerning the present status of the cycle and subsequent rates of change. The Flood Observatory helps meet this observational need by using orbital sensors to gather basic information concerning surface water variability, which it has done since early 2000 and continue to do so in the future.

DFO partners work with operational water organizations towards the further development of technical capabilities, and to participate in meeting operational needs. The Flood Observatory also actively collaborates with relief agencies, emergency managers, the insurance industry, and the media during and after major flood events, world-wide, to provide support to the response effort. http://floodobservatory.colorado.edu/index.html .

Annex 9: Overview of NASA NRT Global MODIS Flood Mapping

http://oas.gsfc.nasa.gov/floodmap/home.html

NASA Goddard's Office of Applied Science is working to operationalize NRT global flood mapping using available satellite data resources, currently this involves the twice daily overpass of the MODIS instrument, onboard the Terra and Aqua satellites. Likewise, NASA Goddard is working to include additional data sources, such as radar, to improve coverage and accuracy.

This work builds on the long-time expertise and efforts of the Dartmouth Flood Observatory (DFO) to map floodwater extent in detail for active floods. The DFO website provides additional detail, products and archives of historical flood maps. This OAS website provides links and information about the automated daily flood and surface water products produced at NASA Goddard.

In general, the DFO website may offer more accurate products, because experts at DFO will have been involved in building the flood extent maps using available data, and thus have the ability to edit any arising errors. Furthermore, the OAS website will have more timely products, as they are generated automatically within several hours of a satellite overpass and are posted directly on the website; however it should be considered that will not have been manually examined or edited for errors.

Although fairly robust, the current system is still in active development. If you would like to be kept informed of updates and developments, please sign up for the floodmap mailing list. We welcome and encourage any feedback on the products so we can improve their accuracy and usability.

Annex 10: Overview of Global Flood Monitoring System (U. of Maryland; TRMM and GPM)

Global Flood Monitoring System (GFMS), University of Maryland – a quasi-global flood detection and forecasting system using satellite rainfall and a global hydrological model.

The GFMS is a NASA-funded experimental system using real-time TRMM Multi-satellite Precipitation Analysis (TMPA), which uses precipitation information as an input to a quasi-global (50°N - 50°S) hydrological runoff and routing model running on a 1/8th degree latitude/longitude grid. Flood detection/intensity estimates are based on 13 years of retrospective model runs with the TMPA input and with flood thresholds derived for each grid location using routed runoff statistics (95th percentile plus parameters related to basin hydrologic characteristics). The intensity value is the calculated water depth above the flood threshold; likewise calculations of streamflow are shown as streamflow values above a flood threshold determined from retrospective model runs. In addition, the latest maps of instantaneous precipitation and totals from the last day, three days and seven days are displayed on the website: http://flood.umd.edu, furthermore all calculations are updated every three hours. Users can "zoom in" to regional areas, time sequence the maps over the last few days or months and plot time sequences of data at a point.

Annex 11: Overview of Global Flash Flood Guidance (HRC)

FLASH FLOOD GUIDANCE SYSTEM WITH GLOBAL APPLICABILITY

Hydrologic Research Center, San Diego, CA 92130, USA

Contact: Dr. Konstantine P. Georgakakos, Director (KGeorgakakos@hrc-lab.org)

PURPOSE OF THE FLASH FLOOD GUIDANCE SYSTEM: The primary purpose of the FFG system is to provide real-time informational guidance products pertaining to the threat of potential small-scale flash flooding over large regions, using high resolution data. The system is designed to reduce the loss of life and suffering caused by the devastation associated with flash floods. The FFG system provides the necessary products to support the development of warnings for flash floods following intense rainfall events through the use of gauge-quality-controlled satellite-based rainfall estimates and (when available) radar-rainfall estimates.

The short-term operational prediction of flash floods is different from that of large river floods in several aspects. Notably, short lead times for forecast, warning and response make operational flash flood prediction challenging, while in the meantime they also pose a hydrometeorological problem (rather than a purely hydrological prediction problem). Furthermore, the potential occurrence of flash floods at any time (day or night) necessitates 24x7 operations for forecasting and warning.

SYSTEM DESIGN: The FFG system outputs are made available to users as diagnostic information to enable the analysis of weather-related events that can initiate flash floods (such as; heavy rainfall, moderate rainfall on saturated soils), which can contribute to the rapid evaluation of the potential for a flash flood to occur at a particular location. The system aims to empower users with readily accessible, observed data and products, as well as other information to produce flash flood warnings over small flash flood prone basins. Likewise, the system is designed to allow the use of the forecaster's experience associated with local conditions, incorporate various other data and information (e.g., Numerical Weather Prediction output), any last minute local observations (e.g., non-traditional gauge data), perform local adjustments to system products, and to assess the threat of a local flash flood.

Evaluations of the threat of flash flooding are performed over hourly to six-hourly timescales for basins from 50 -200 km^2 in area. Radar precipitation estimates are used together with available local in-situ gauge data to obtain bias-corrected estimates of the rainfall volume over the region. Satellite-based rainfall estimates (both based on infrared with short latency and microwave channels) are used as a backup to support the radar estimates for locations/times when representative radar data are not available. Satellite estimates are also quality controlled using available in-situ observations. This precipitation data is also used to update soil moisture estimates, through a soil moisture model integrated within the system. Global and regional geographic information system (GIS) data and refinements are produced in collaboration with local country agencies and are used to develop model parameters for each small basin represented in the system. The system then provides information on rainfall and hydrologic response, the two important factors in determining the potential for a flash flood.

To reduce the loss of life in the last decade, modern flash flooding operations for countries around the world have evolved to include the following framework of operations: Regional centers established with powerful networks and computer capability, with hydrometeorological expertise run meteorological and hydrological models in real time serving several country areas with high resolution data (order of 100 km^2). The model diagnostic indices and predictions are fed (in real time and in appropriate formats that allow real time modification) to country forecasting agencies through secure internet dissemination servers. These in-country forecasting agencies use the products and other local information to adjust initial products and to produce warnings for small regions. These warnings are disseminated to the public and response agencies through appropriate in-country channels. The response agencies act on warnings produced to mitigate flash flood impacts to people and property.

Decisions are made at the in-country forecast agency level to issue warnings, watches or alerts on the basis of the adjusted model data and other local information. At the response agency level, under a given forecast agency a statement issued to determine the timing and location of the response action and deployment of mitigation resources. These are the "end-user" organizations concerned with flash flood guidance systems together with the regional center staff that operate the computational components of the regional flash flooding operations. Mandates for the in-country organizations have been established by individual countries and the mandate for the regional centers has been established by the WMO and by the agreement of the participating countries.

The development of such regional flash flood warning-response systems is largely the result of the ratification of (a) an agreement between a design and implementing organization (Hydrologic Research Center-HRC), a global facilitating agency (World Meteorological Organization -WMO), an operational forecast agency with global data repositories (National Oceanic and Atmospheric Administration National Weather Service – NOAA/NWS) and a donor agency (US Agency for International Development Office of Foreign Disaster Assistance – USAID/OFDA); and (b) agreements between the aforementioned agencies and countries around the world.

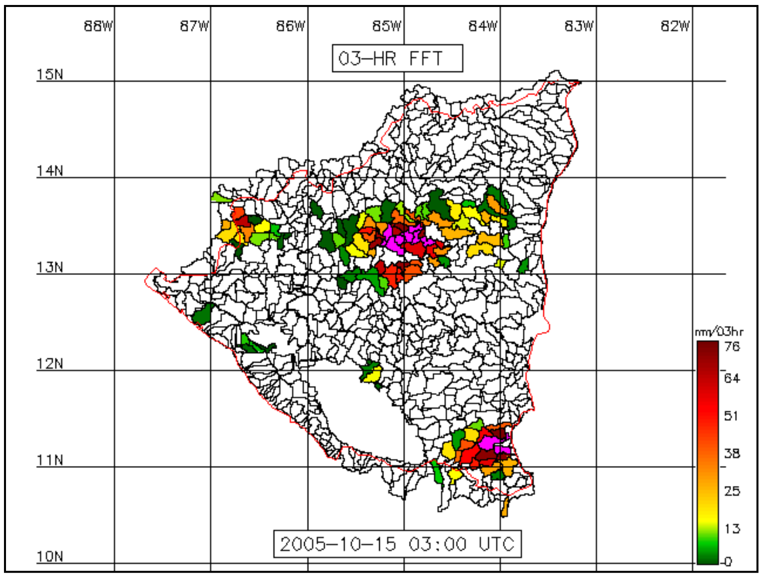
At the present time operational and in-development systems serve more than 50 countries worldwide with a total population in excess of 2 billion people. Currently, a significant program for training using on-line materials and courses is in development to support the participating country forecasters and disaster managers.

PRODUCTS: The modeling-products of the Flash Flood Guidance (FFG) system are based on the concepts of **Flash Flood Guidance** and **Flash Flood Threat (FFT)**. Both indices provide the user with the information needed to evaluate the potential for a flash flood, including assessing the uncertainty associated with the data.

NOTE A: Flash Flood Guidance (FFG) is the amount of rainfall of a given duration over a small basin needed to initiate minor flooding (e.g., bankfull) at the outlet of the basin. For flash flood occurrence estimation, durations up to 6 hours are evaluated and the basin areas are of such a size to allow reasonably accurate precipitation estimates from remotely-sensed and on-site data. FFG then is an index that quantifies how much rainfall is needed to cause minimal flooding in a basin.

NOTE B: Flash Flood Threat (FFT) is the nowcast amount of rainfall of a given duration in excess of the corresponding FFG value. THE FFT is then an index that provides an indication of areas where flooding is imminent or about to occur and where immediate action is needed.

FLASH FLOOD THREAT EXAMPLE:



FFG and FFT depend on the catchment and drainage network characteristics, and the soil water deficit determined by antecedent rainfall, evapotranspiration and groundwater loss. Soil water saturation fraction for the upper soil (down to depth of up to ~20cm) are also provided as guidance to the forecasters for assessing the propensity of a given small catchment to generate flash flooding within a region.

Information on the technical basis of the FFG system modeling is provided in the references listed below. More general pertinent information for the FFG systems is at the HRC web site: http://www.hrc-lab.org

REFERENCES:

Carpenter, et al. 1999:
http://www.sciencedirect.com/science/article/pii/S0022169499001158
Georgakakos 2004:
http://www.hrc-lab.org/publications/Paper-KGeorgakakos_proceedingsAustralia04.pdf
Georgakakos 2005:
http://www.hrc-lab.org/publications/FFG_KPG-HRC_Tromso_Oct2005.pdf
Georgakakos 2006:

http://www.sciencedirect.com/science/article/pii/S0022169405002623
Shamir et al. 2013:
http://link.springer.com/article/10.1007/s11069-013-0573-6

Annex 12: Overview of International Charter Space and Major Disasters

The Charter website provides a summary overview of how the Charter works: http://www.disasterscharter.org/home.

The International Charter aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through Authorized Users, (AU). Each member agency has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on life and property.

The International Charter provides a mechanism to obtain satellite EO data and value-added products for two weeks following a major disaster if the Charter is activated by an Authorised User.

Annex 13: Overview of SERVIR
https://www.servirglobal.net/Global.aspx

SERVIR is a collaborative venture among the NASA Earth Science Division Applied Sciences Program, the U.S. Agency for International Development (USAID), and worldwide partner institutions. SERVIR improves environmental management and climate change response by helping governments and other stakeholders integrate Earth observation and geospatial technologies into decision-making.

SERVIR—the Regional Visualization and Monitoring System—helps government officials, managers, scientists, researchers, students, and the general public make decisions by providing Earth observations and predictive models based on data from orbiting satellites.

The SERVIR system helps nations in Mesoamerica, Africa, and the Himalayan regions cope with eight areas of societal benefit identified by the Group on Earth Observations (GEO): disasters, ecosystems, biodiversity, weather, water, climate, health, and agriculture.

Decision makers use SERVIR to improve their ability to monitor air quality, extreme weather, biodiversity, and changes in land cover, the system has been used over 35 times since its initiation in 2004 to respond to environmental threats such as wildfires, floods, landslides and harmful algal blooms. In addition, SERVIR analyses, provides information about, and offers adaptation strategies for nations affected by climate change. In a very real sense, SERVIR provides the basic information for living on planet Earth.

Background:

SERVIR began operations in 2004 as a joint venture by the National Aeronautics and Space Administration (NASA), the U.S. Agency for International Development (USAID), the World Bank, and the Central American Commission for Environment and Development (CCAD).

In 2005, the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) in Panama became the first regional SERVIR facility, serving Central America and the Dominican Republic through 2011. CATHALAC served as the Central America hub from 2005 to 2011.

In late 2008, a SERVIR facility at the Regional Center for Mapping of Resources for Development (RCMRD) in Nairobi, Kenya, was dedicated to serve Africa.

A SERVIR facility was inaugurated in October 2010 in cooperation with International Centre for Integrated Mountain Development (ICIMOD) in Kathmandu, Nepal for the Hindu-Kush Himalaya region in Asia.

USAID and NASA are the primary supporters of SERVIR, with the long-term goal of transferring the SERVIR capability to the host countries.

SERVIR Structure:

SERVIR consists of a Coordination Office and Student Research Lab at the NASA Marshall Space Flight Center in Huntsville, Alabama, USA, with the current two Regional Operational Facilities, or "Hubs": SERVIR-Africa and SERVIR-Himalaya.

The SERVIR Coordination Office manages the overall program in cooperation with resource providers (host organizations, national governments, USAID, and other international cooperation agencies). The Prototyping Lab develops applied prototypes for the SERVIR website and integrates new or relevant technologies from NASA and other scientific research partner organizations into the overall system architecture to meet the needs of the host countries.

SERVIR's primary technical work occurs at the hubs in Panama, Kenya and Nepal, which are staffed by in-country and in-region experts. The SERVIR regional facilities also are responsible for interfacing and coordinating with other international and national organizations in their respective regions regarding climate change, environmental monitoring, disasters, weather, civil protection, and mapping, amongst others.

Annex 14: Overview of Deltares Global Flood Observatory

Deltares Global Flood Observatory : Reliable and timely information is essential for appropriate flood management. Currently, an operational service is being developed as part of the Dutch research programme Flood Control 2015, to provide a systematic and fully automated global flood mapping system in NRT. This service is called the Global Flood Observatory. The procedures for compiling the flood maps have been developed using the Remote Sensing Synthetic Aperture Radar (SAR) data from the Envisat satellite. The service is preparing to use the high resolution data from the Sentinel missions, a new satellite collective. Sentinel -1 (C-SAR sensor), was successfully launched on the 3rd April 2014.

By using SAR imagery it is possible to observe floods both during the day and night, even through clouds, (a limitation of Optical data). The SAR backscatter over a flooded region is very low and it is this characteristic that can be mapped effectively when looking at flood inundation. The mapping results are currently available in a pre-operational system, using Google Earth as a viewer. http://www.floodcontrol2015.com