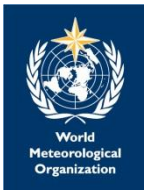

Development and Implementation of International and Regional Flash Flood Guidance (FFG) and Early Warning Systems

Draft

Project Brief

SOUTH AMERICA FLASH FLOOD GUIDANCE SYSTEM

SUMMARY

The purpose of this project is the development and implementation of flash flood guidance and early warning systems. The approach will entail development of technology, training, protocols and procedures to address the issues of mitigating the impacts of flash floods and the application of such a system allowing the provision of critical and timely information by the National Meteorological and Hydrological Services (NMHSs) of the participating countries.

To accomplish this, the World Meteorological Organization (WMO) will cooperate with the Hydrologic Research Centre (HRC), San Diego, USA to implement a flash flood guidance and early warning system designed along the lines of similar systems that have been made operational in different parts of the world. In coordination with one or more designated Regional Centres, normally located within one of the participating countries within a specified region, the project will be executed by the participating national hydrometeorological services with the HRC providing technical assistance in cooperation with NOAA/National Weather Service for the provision of appropriate global data; and WMO providing technical backstopping and supervisory services including monitoring and evaluation of the project.

Based on estimation of rainfall from satellite imagery and available gauges and/or radars, the system will provide the NMHS of each participating country with an estimate of the precipitation amount and an indication (guidance), based on physically-based hydrological modelling, as whether it would generate a bankfull discharge (e.g., minor flooding) at the outlets of small, flash flood prone basins throughout each country. The NMHSs will integrate local knowledge from other sources (their national networks, observers report, etc.) to validate the guidance and issue as required a warning through channels proper to each country

Technical assistance includes the development and implementation of the flash flood guidance and warning system as well as research and development into system enhancements, including inclusion of infrared and microwave technology for satellite rainfall estimates, as needed for the different implementations, and training and capacity building on system operations and applications to disaster risk reduction (i.e., an end-to-end system approach). The approach will provide a tool for each country to access the data and information needed to develop alerts and warnings for flash floods.

The main objective of this proposed project is, therefore, to contribute towards reducing the vulnerability to hydrometeorological disasters, specifically flash floods, by developing and implementing a flash flood guidance system to strengthen capacity to develop timely and accurate flash flood warnings.

1. Beneficiaries

In many areas of the world, flash floods are a regular phenomenon accounting for loss of human life and significant economic and social damages, adding up to hundreds of millions of Euros for a single event. Flash floods can affect not only mountainous and hilly rural areas with sparse settlements but also major urban areas. In addition, an increase in their frequency and magnitude is anticipated as a consequence of climate change. Implementation of a flash flood guidance system would provide benefits to all societal and economic stakeholders of each country.

A key benefit of the proposed system is that it is capable to provide early awareness of impending local flash flood threats for all potentially vulnerable communities. A true value of the system will be to provide rapid assessments of the potential of flash floods allowing improvement of the early warnings for the occurrence of a flash flood and therefore allowing for more rapid mobilization of response agencies.

The system implementation also provides capacity building and cooperation for effectively mitigating disasters from flash floods. Training and capacity building will be a strong component of

the implementation of this program. There will be opportunities in cross-training of hydrologists and meteorologists from countries within the region and with different backgrounds and skills in hydrometeorology, which forms the basis of flash flood detection and prediction.

The availability of the system guidance products will also help to improve the way flash flood events on trans-boundary rivers are addressed, encouraging international technical cooperation and regional cooperation in preparing public awareness campaigns and response strategies.

Primarily aiming to improve national service delivery capabilities to deal with flash flood threats, the implementation of the flash flood guidance system will also provide the opportunity for enhancement of regional collaboration of disaster mitigation and response agencies and improvement of community awareness of flash flood disaster threat and mitigation.

Training programs will be designed to include NMHSs to develop strong scientific and technical capabilities to use the FFG system and further to include disaster management agencies where the responsible agencies will be involved in system validation programs which will require determinations of where flooding did or did not occur. The issuing of warnings based on flash flood guidance and flash flood threat products will conform to establish national practices, if existing; alternatively the project could provide support to a national dialogue for their development. The establishment of such criteria requires understanding of the hydrometeorological processes and prediction uncertainties, as well as capabilities of the population to take effective action. Such a process will encourage the national agencies to interact with local communities both in establishing such criteria, and in regular reviews of their effectiveness. The responsible agencies will need to design awareness campaigns for both municipal agencies and the public at large concerning the interpretation of flash flood warnings and effective action strategies (i.e., what to do in when flash flood warnings are received). To be effective, this effort will require input from local community representatives (emergency response agencies and the public at large). Maintaining these public awareness campaigns and information distribution as ongoing efforts required to reduce flash flood casualties will be needed.

The flash flood guidance system functions at one level as a disaster mitigation tool by mitigating loss of life and livelihoods, and by rapidly targeting disaster response agencies to potential problem areas. On another level it can be used to provide maps of flash flood probabilities, threats and decision-aiding for imminent actions. These maps can be used to provide a risk assessment tool and guidance concerning the development of infrastructure – that is, as a guide to where special care should be taken in the design and locations of particular facilities as the population expands to live in flash-flood prone areas.

All these agencies will be involved in system validation programs which will require determinations of where flooding did or did not occur. To be effective, this effort will also require input from local community representatives (emergency response agencies and the public at large).

2. Sector-Level Coordination

Through the project partners representing the technical aspects of the system implementation and operation, NMHSs will be brought together with agencies in disaster risk reduction to develop a detailed work plan that will enable operational engagement of technical and disaster risk reduction agencies for implementation of the system.

The work plan for disaster risk reduction will address activities such as joint training programs and public outreach and awareness programs. This effort will provide the opportunity for enhancement of regional collaboration of disaster risk management agencies and improvement of community awareness of flash flood disaster threat and mitigation. Training programs will be designed to include NMHSs and the disaster management agencies.

3. Technical Design

Flash floods are a hydrometeorological phenomenon that requires (a) integration of meteorology and hydrology in real time and (b) ingestion of local information and expertise for reliable warnings. The system design aims to allow for both. This system will serve as a catalyst to develop protocols in line with regional and country norms pertaining to other event warnings. The system allows that even within a region different countries will develop their own manner of system configuration and use adapted to local requirements as a tool for developing flash flood warnings and watches together with other local timely information.

Important technical elements of the Flash Flood Guidance and Warning System are the development and use of a bias-corrected satellite precipitation estimate field, high-resolution numerical weather prediction model outputs (where available), and physically-based hydrological modelling to determine flash flood guidance and flash flood threat. These system elements can now be applied anywhere in the world. Real-time estimates of high resolution precipitation data from satellite are now routinely available globally (and can be further enhanced with locally available radar estimates of precipitation). Global digital terrain elevation databases and geographic information systems may be used to delineate small basins and their stream network topology anywhere in the world. In addition, there are global soil and land cover spatial databases available to support the development of physically-based soil moisture accounting models (see flow chart in Figure 1). The real-time satellite precipitation estimates needed to drive the regional systems on a global scale (using global data provided by NOAA and the WMO) will be developed first followed by the development of specialized products.

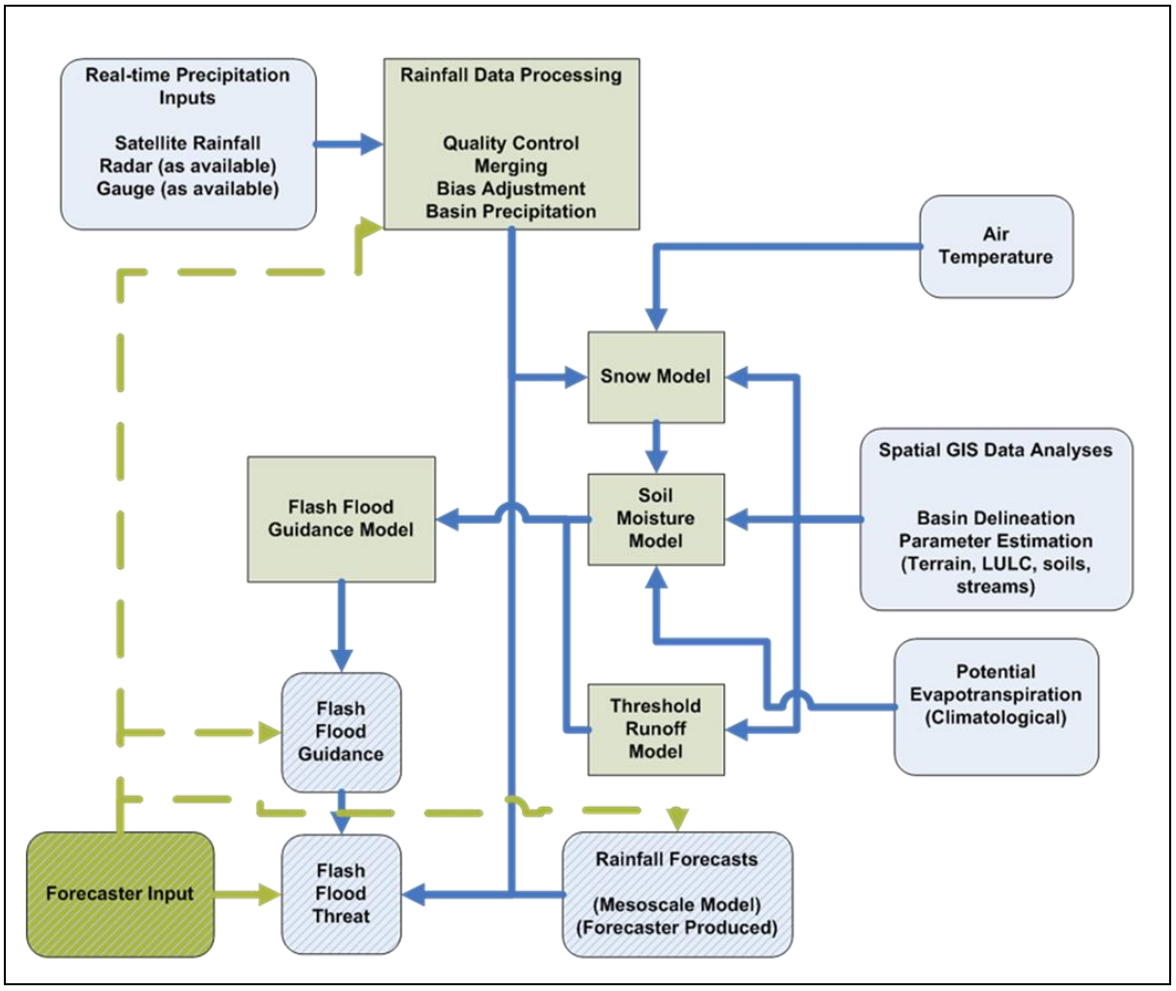

Figure 1: Schematic Flow Chart of the Flash Flood Guidance System

The system allows the NMHSs to use local nowcast/short-term-forecast methods they wish to use to issue the warnings, including (and strongly recommended) local forecaster adjustments. The system design allows this coupling with the existing or developing NMHS approaches on a national or even local scale.

System flexibility and system capability to engage local forecasters should help greatly towards the development of regional/local protocols for integration within existing warning dissemination systems.

The system will provide evaluations for the threat of flash flooding over time scales of hourly to six hours and for basins on the order of 150 sq. km. Given the computational burden and depending on available computational resources, it is very likely that the most valuable lead times for system use will be 3 - 6 hours. Efforts might also be undertaken through the application of numerical weather prediction model outputs to extend the range of threat prediction to 48 hours.

4. Implementation Approach

The system design is such that it allows for efficient global data ingest and it supports regional cooperation among NMHSs. The design is characterized by distributed operations and functions. Several centres of computation and product dissemination will support the operational functions of the NMHSs through the timely provision of data, software, hardware and training. The overall organizational structure is shown in Figure 2. Regional centres will be identified during project planning meetings.

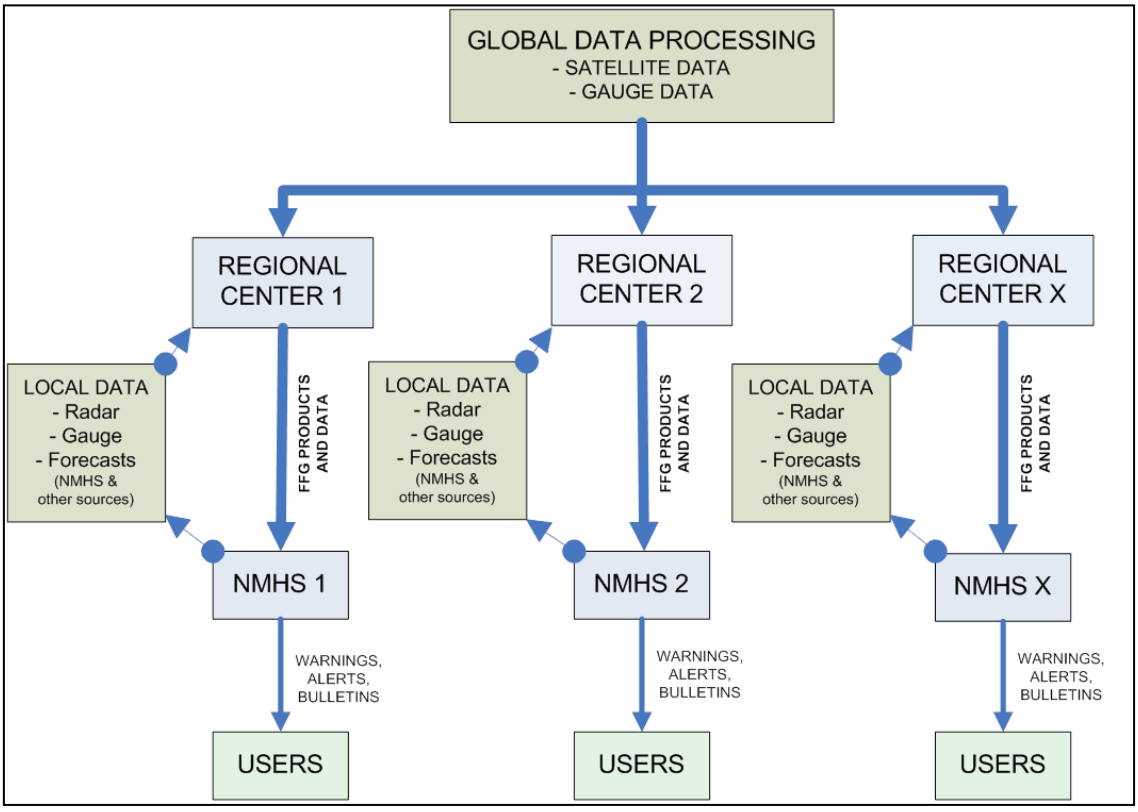

Figure 2: Flash Flood Guidance and Warning System as a distributed system of computer hardware, data and information to support NMHSs worldwide.

The interface with global information is the link to real-time global satellite precipitation estimates and to global in situ observations through the regional centre. All requisite real-time data (global, regional, and local) are ingested at servers located at the Regional Centres where the FFG

software is installed. Graphical and text products are then provided to the participating countries through a secure internet connection.

It is necessary to designate a focal institution (most probably an NMHS or an existing Regional Centre with proven scientific and technical capabilities) and with existing communications and infrastructure capabilities to support a Regional FFGS Centre. Key operational Regional Centre responsibilities are:

- Disseminate real-time country graphical products from the FFGS for the NMHSs in the region;

- Collect available real-time local meteorological data for ingest to the FFGS for the development of regional products;

- Support regional flash flood operations by:
  - Provide regional validation of products and formulation of plans for improvements, and
  - Provide communications for system analyses to NMHSs of the region.

- Provide communications of regional system modifications necessary to system developers;

- Develop a historical archive of the system products;

- Support WMO and developers with regional training of NMHS representatives; and,

- Provide routine maintenance and IT support for the FFGS server.

NMHSs functions pertaining to the use of the flash flood guidance and warning system will include: country hydrometeorological analysis using the system products and information and other local products and information; country modifications of the regional-centre flash flood guidance and precipitation nowcasts on the basis of within-country most-recent data and information; development of local flash flood watches and warnings; monitoring of system performance (availability and effectiveness) and feedback to the regional centre; and links to within-country disaster management agencies for effective disaster risk reduction. Resources of country NMHSs will determine the actual configuration and type of software used in each case, given the provision of within-country baseline software and links to regional centre facilities as discussed previously.

It is expected that the products available from the Regional Centre will be adequate to support a range of processing capabilities at the NMHSs, from those that can be performed on a PC with Excel software to those that support interactive graphical generation of products. This provision will allow the NMHSs of all the countries to develop real time flash flood forecasts and watches/warnings using the global-data information and their local data and information. There will also be a provision for countries that are willing to share local real-time data to produce graphical products and updated guidance information for their areas to complement the locally produced products with the baseline configuration mentioned.

One key to sustainability is confidence in a reliable, accurate system. To accomplish this, reliability evaluations will be included in the concept of operations.

5. Transition and Exit Strategy

Upon completion of the project, each country will have access to the flash flood guidance and early warning system data and products via the internet. The required data will be accessed and processed through the regional facilities. At the country level only a PC and internet connectivity will be required to access the data and products required to evaluate potential flash flood threat,

making the system very sustainable. The regional centres will be selected based on resource requirements to ensure appropriate access to the required data and maintenance capacity.

Much of the effort to ensure sustainability of the flash flood guidance and early warning system will be through training and cooperative development efforts. This approach is intended to ensure ownership and full operations responsibility. In addition, a concept for the operation of the system within the existing operations protocols of the countries will be outlined for each country during training. A User Guide will be developed for the Regional Centre for system operations and maintenance.

6. Project Implementation

Project implementation is based on the basis of a Project Implementation Plan (PIP) that will be discussed during the initial regional planning meeting. The Plan will provide information with regard to essential requirements and criteria that need to be met for the successful implementation of the project. These requirements include: Availability and accessibility of critical input data and information including geo-spatial information, historical and near real-time meteorological and hydrological data, basic institutional infrastructure and technical/professional expertise of participating meteorological and hydrological services.

The PIP including a work plan will be discussed during the initial planning meeting with principal stakeholders and beneficiaries of the project.

7. Institutional status

In February 2009, WMO signed a Memorandum of Understanding (MoU) with USAID, HRC, and NOAA on the implementation of the Flash Flood Guidance System with Global Coverage project. In June 2012, the MoU was renewed until the end of 2017.

As a result of the expression of interest of South American countries, an initial planning meeting, including an overview of a prototype FFG system developed for the Zarumilla River basin in Peru and Ecuador, has been arranged. This meeting will allow:

- Country experts to see first-hand the technical components of the FFG system;
- Country experts to assess the potential utility of adopting such a system within their operations;
- Understanding of the requirements of national and regional centres;
- Defining FFG sub-regions within South America for implementations;
- Understanding of national implementation requirements including professional staff;
- Understanding of the primary data collection required for the initiation of the project;
- Discussing potential funding sources; and,
- Countries to consider the overall project and whether each wishes to commit to undertaking and supporting an implementation of the project in South America.

Should countries wish to commit to the implementation of the project, countries would then decide on their national centres and the Regional Centres for each sub-region identified in South America.

WMO, in collaboration with financial, technical and regional partners now plans to organize the initial planning meeting where interested countries, represented by experts designated by the Permanent Representatives of WMO Members and their Hydrological Advisors, are expected to discuss all aspects of the proposed project and eventually express whether they commit to participate and cooperate in the project activities and provide technical information that is critical for the successful implementation of the project in the region.

Aside from the commitments made by participating national agencies, it will be essential to have full details available on issues such as in-kind contributions through infrastructure and personnel, areal information specifying the area(s) to be covered by project activities in the region, availability of supporting data and information including geospatial and historical hydrometeorological information. Likewise, the governance of the project and the roles and responsibilities of national participating centres and Regional Centres will be on the agenda of discussion with expected recommendations and decisions to be made during the meeting. This will be compiled through information received from countries and services on the basis of a Requirements Document to be developed.

The project will be phased over a period of several years that will be discussed during the initial planning meeting, with the bulk of the development and implementation activities occurring during the first two years. The remaining years of the project will focus on training, system operations/evaluation and validation of system outputs to ensure on-going sustainability.

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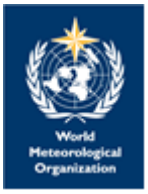


GLOBAL FLASH FLOOD GUIDANCE SYSTEM

South America

IMPLEMENTATION REQUIREMENTS

Global Flash Flood Guidance System
Implementation Requirements

June 2016

Document Purpose

This document provides guidance to project participants, in particular National Meteorological and Hydrological Services (NMHSs) on minimum requirements with respect to professional capabilities, availability of data and information as well as computational and communication infrastructure to implement a **Flash Flood Guidance System (FFGS)**. In addition, the document provides information of the functions of the Regional Centres and NMHSs leading to the delivery of flash flood guidance products on regional and national levels.

These requirements reflect a system that provides timely and useful data and information based on robust communication infrastructure in a form that is consistent with the operations in place in many of the National Meteorological and Hydrological Services (NMHSs) throughout the world. Of primary importance is to establish a system that becomes part of NMHS operations and is used as the primary tool by these services for providing flash flood alerts/warnings to the appropriate agencies and/or the public.

Overview of the FFGS

The primary purpose of the FFGS is to provide real-time informational guidance products pertaining to the threat of potential small-scale flash flooding. The system is designed to address the reduction in devastation caused by flash floods in terms of reductions in the loss of life, suffering and property damage. The system provides the necessary products to support the development of warnings for flash floods from rainfall events through the use of remote sensing-based rainfall estimates (primarily satellite).

The system outputs are made available to forecasters as a diagnostic tool to analyze weather-related events that can initiate flash floods (e.g., heavy rainfall, rainfall on saturated soils) and then to make a rapid evaluation of the potential for a flash flood at a location. The system empowers users with readily accessible observed data and products and other information to produce flash flood warnings over small flash flood prone basins. The system is designed to allow the addition of experience with local conditions, incorporate other data and information (e.g., Numerical Weather Prediction output) and any last minute local observations (e.g., non-traditional gauge data), to assess the threat of a local flash flood. Generally, evaluations of the threat of flash flooding are done over hourly to six-hourly time scales for basins from 100 - 150 km^2 in size.

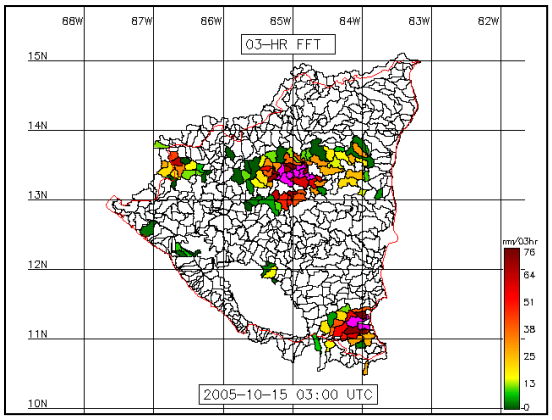
Important technical elements of the Flash Flood Guidance and Warning System are the development and use of a bias-corrected satellite precipitation estimate field, high-resolution numerical weather prediction model outputs (where available), and physically-based hydrological modelling to determine **Flash Flood Guidance** and **Flash Flood Threat**. These system elements can now be applied anywhere in the world. Real-time estimates of high resolution precipitation data from satellite are now routinely available globally (and can be further enhanced with locally available radar estimates of precipitation). Global digital terrain elevation databases and geographic information systems may be used to delineate small basins and their stream network topology anywhere in the world. In addition, there are global soil and land cover spatial databases available to support the development of physically-based soil moisture accounting models. The real-time satellite precipitation estimates needed to drive the regional systems on a global scale (using global data provided by NOAA and the WMO) will be developed first followed by the development of specialized products.

The system then provides information on rainfall and hydrologic response, the two important factors in determining the potential for a flash flood. The system is based on the concept of **Flash Flood Guidance** and **Flash Flood Threat.** 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.

The flash flood guidance approach to developing flash flood warnings rests on the comparison in real time of observed or forecast rainfall volume of a given duration and over a given catchment to

a characteristic volume of rainfall for that duration and catchment that generates bank full flow conditions at the catchment outlet. **Flash Flood Guidance** (FFG) is that characteristic rainfall volume for the given duration over the small catchment that generates bank full flow conditions at the catchment outlet. FFG is updated in time based on current soil water deficit (as determined by antecedent soil moisture conditions), rainfall, evaporation, and groundwater losses. If the observed or forecast rainfall volume exceeds the FFG of the same duration, this excess is termed the **Flash Flood Threat** and flooding at or near the catchment outlet may be likely.

Flash Flood Threat



Global Flash Flood Guidance System Program Background

The purpose of the Global FFGS (GFFGS) program is the development and implementation of regional flash flood guidance and early warning systems. The approach entails development of infrastructure on a global scale to then support the development and implementation of regional flash flood guidance projects comprising of technology, training, protocols and procedures components to address the issues of mitigating the impacts of flash floods.

Regional flash flood guidance and early warning systems are designed based on operational regional programs in Central America, Southeast Asia, Central Asia, South East Europe, South Asia, Black Sea Middle East and Southern Africa. The project approach is to provide a tool for each country within a specified region to access the data and information needed to develop alerts and warnings for flash floods. The main objective of this project is, therefore, to contribute towards reducing the vulnerability of people around the world to hydrometeorological hazards, specifically flash floods, by developing and implementing flash flood guidance systems to strengthen regional capacity to develop timely and accurate flash flood warnings.

The data and information part of the requirements also provides guidance with respect to the selection of areas/basins on national level that can be covered with a flash flood guidance system based on the availability of critical data and information.

Implementation of this program is in concert with the World Meteorological Organization's Flood Forecasting initiative guided by the Hydrology and Water Resources Branch of the Climate and Water Department of WMO. In the context of this initiative, the World Meteorological Congress has endorsed the implementation of a Flood Forecasting Initiative. A goal of this initiative is to develop and implement programs that encourage hydrologists and meteorologists to work together towards the improvement of operational flood forecasting services.

The GFFGS program is being accomplished under the Memorandum of Understanding (MoU) noted below[1].

The system design is such that it allows for efficient global data ingest and support of regional cooperation among NMHSs. The system design is characterized by distributed operations and functions on global, regional and national levels. Centres of computation and product dissemination will support the operational functions of the NMHSs through the timely provision of data, ancillary information, software, hardware and training. A schematic of the global-regional-national system is shown in Figure 1.

The interface with global information is the link to real-time global satellite precipitation estimates and to global in situ observations through the regional centre.

All requisite real-time data (global, regional, and local) are ingested at servers located at the Regional Centres where the FFG software is installed. Graphical and text products are then provided to the participating countries through a secure internet connection.

It is necessary to designate a focal institution (most probably an NMHS or an existing Regional Centre with proven scientific and technical capabilities) and with existing communications and infrastructure capabilities to support a Regional FFGS centre. Key proposed operational Regional Centre responsibilities are identified in Appendix A.

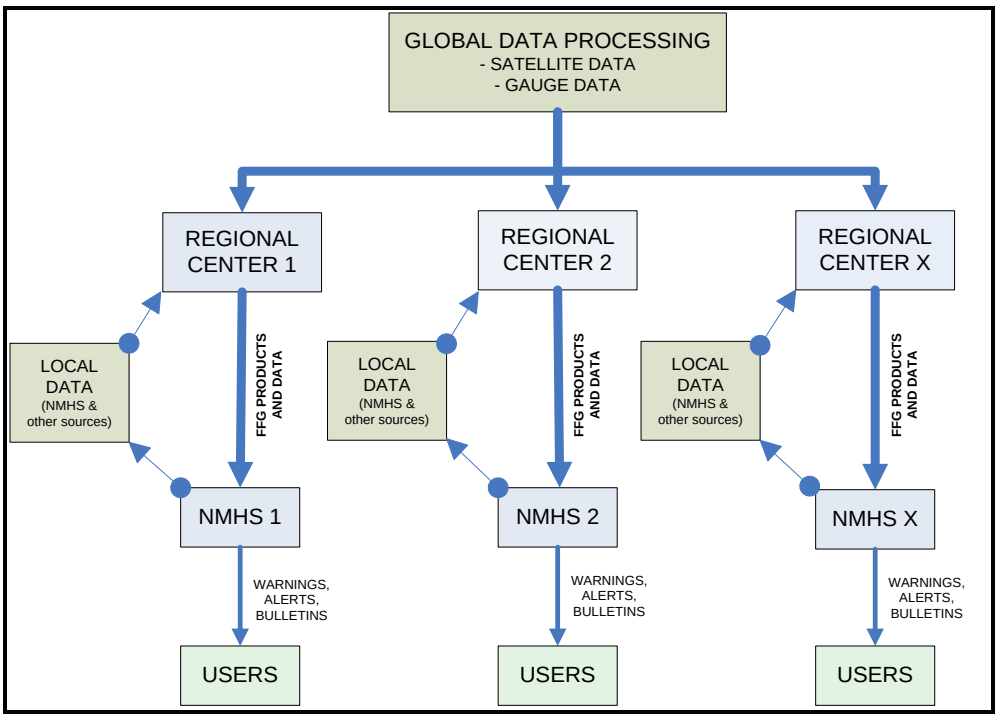


Figure 1. GFFG System Schematic – Global Implementation

NMHS functions pertaining to the use of the flash flood guidance and warning system include:

[1]MoU "Establishing a Cooperative Initiative among the World Meteorological Organization, Hydrologic Research Centres, U.S. National Oceanic and Atmospheric Administration/National Weather Service and the U.S. Agency for International Development/ Office of U.S. Foreign Disaster Assistance for the Flash Flood Guidance System with Global Coverage Project"

- Develop country hydrometeorological analysis using the system products and information and other local products and information;
- Develop country adaptations of the flash flood guidance and precipitation nowcasts on the basis of within-country most-recent data and information;
- Develop local flash flood watches and warnings as required;
- Provide data and information to the Regional Centres (based on regional agreements);
- Monitor system performance (availability and effectiveness) and feedback to the Regional Centres; and,
- Communicate with user agencies for effective disaster risk reduction.

Resources of country NMHSs will determine the actual configuration and type of software used in each case, given the provision of within-country basic software and communication links to Regional Centres facilities.

It is expected that the products available from the Regional Centres will be adequate to support a range of desk top computer-based processing capabilities at the NMHSs, from using simple spreadsheet software to those computational facilities that support interactive graphical generation of products (much like the capability of the Regional Centres). This provision will allow the NMHSs of participating countries to develop near real-time flash flood guidance and warnings.

Data and Information Requirements

To ensure that the FFGS provides the highest quality data and information to forecasters, various historical and real-time hydrometeorological data and other information are required in order to develop, implement and operate the flash flood guidance systems. Historical data and information are needed for the development of the system and calibration of the models. Real-time data are needed for system operations. Terrain and other spatial-database information are used to delineate the small catchments for which flash flood guidance will be computed, to calibrate the models and to operationalize the flash flood guidance information.

It cannot be emphasized enough that quality data and information are needed to provide the optimum system for use by forecasters for the development of flash flood warnings.

Data and information needs are detailed in Appendix B. Appendix C is a survey of automatic rain gauges and weather stations. This information is important to fully understand the current status of these systems.

Resource Requirements

Personnel

The system is designed to be used operationally and jointly by meteorologists and hydrologists. The following expertise is recommended at the Regional Centres and country levels for the primary users, mainly the system operators.

Recommended Minimal Available Expertise

Area of Expertise	Regional Centres	Country NMHS
Have a meteorological or hydrologic technical background	Both meteorological and hydrologic expertise	Either meteorological or hydrologic expertise
Have experience in operational quantitative weather or hydrologic forecasting specific to the region or country	Priority	Priority
Have experience in weather-related hazard emergency management operations	Priority	Priority
Have experience in or knowledge of quantitative analysis of satellite-based rainfall estimates	Priority	Preferred
IT capability for server system administration, network connectivity, and product availability	Priority	Preferred

Both the Regional Centres and the country NMHS should operate on a round-the-clock basis either continuously year-round or at the minimum during seasons with significant flash flood risk.

Computers and Communications

Servers using the LINUX operating system will be provided for the Regional Centres through the project. The country NMHS requires a current-generation PC and an internet connection with periphery devices in order to access products from the internet. The Regional Centres will need hi-speed internet service and, potentially, access to GTS/WIS.

Training Program

During the course of the FFG System implementation for the region, training will be provided to forecasters on the scientific basis and operations of the system. The training program is a five step blended learning model - known as the Flash Flood Hydrometeorologist Training (FFHT) Program (Figure 2). The five step program includes:

1. Introductory regional workshop.

2. eLearning program to support system operations, product interpretation, system validation, including the use, management, and interpretation of output from the system, and the development of protocols to alert response agencies and the public of an impending or existing threat. For each completed course learners earn an HRC Course Certification, once they have completed the core curriculum they are eligible for Step Three.

3. Advanced Operations and Interactive Simulator Training at the Hydrologic Research Center to assist with reviewing and assessing the operating versions of the system. Included is the Interactive Simulator training to provide the user with the skill to interpret and validate skill using real flash flood events. Upon successful completion of the Advanced Operations Training each learner earns an HRC Advanced Training Operations Certification; once they have completed this step they are eligible for Step Four.

4. Regional Operations Training Workshop – where HRC trainers in combination with Trained Regional Trainers present regional operations workshop. Upon successful

completion of this stage of training Regional Trainers earn a WMO Certification as FFG trainers.

5. Regional Operation Sustainability Workshop led by WMO certified trainers acts as refresher training in operations, overview of data requirements, system verification and user validation

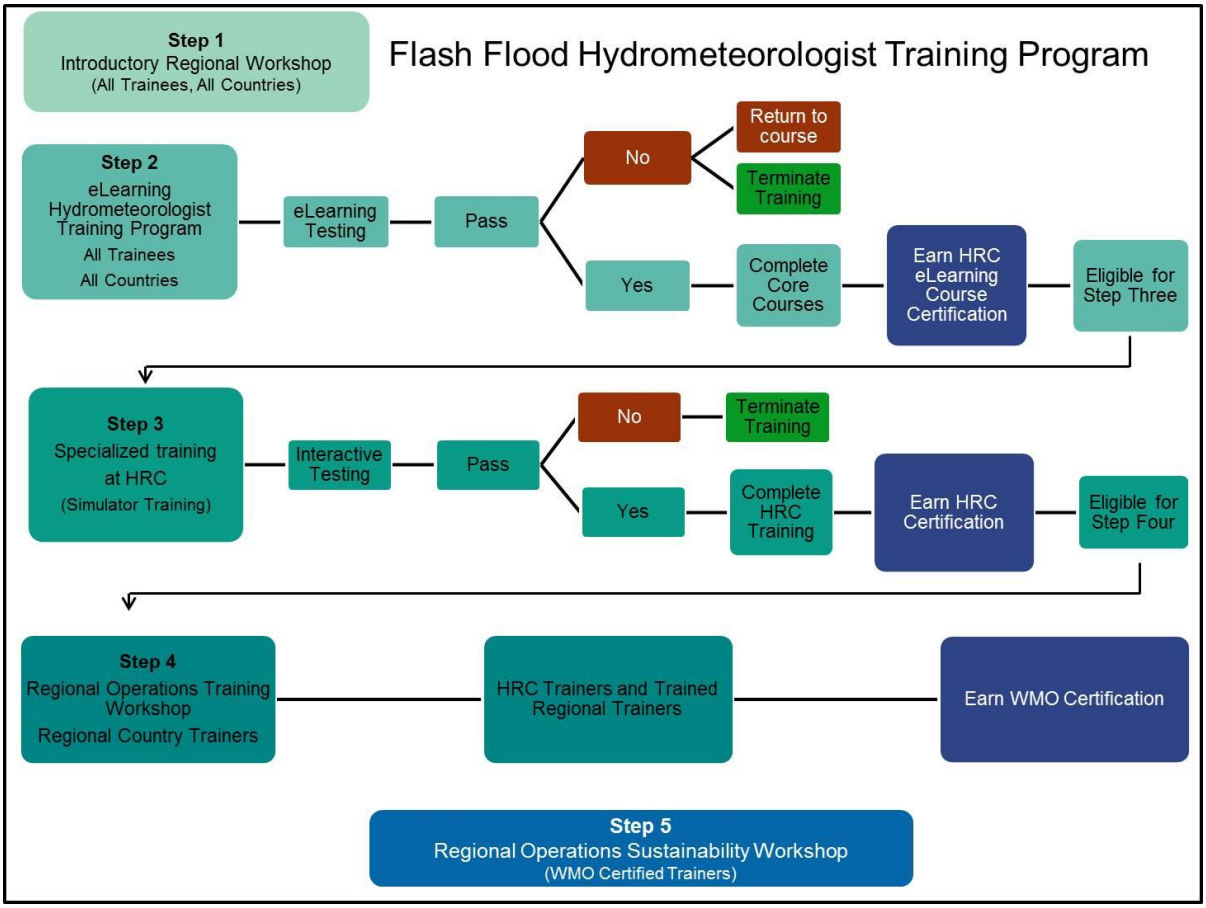


Figure 2. Illustrating five steps of the Flash Flood Hydrometeorologist Training Program

Appendix A

Regional Centre Roles and Responsibilities

System Development

The Centre has the responsibility to assist with tasks during the regional FFGS development and implementation. These responsibilities include:

- The Centre will be the focal point for the collection of the required spatial and historic hydrometeorological data needed for system development from the countries.

- The Centre will assist the FFGS developer in coordinating country-specific reviews of various products created and data sets used during system development.

System Operations Responsibilities

In meeting its responsibility to maintain the base node of the FFGS system, the Centre will have the following roles, responsibilities, and operations to the extent possible and reasonable:

- The Centre will develop and maintain a local database of contributed, real-time input products from participating NMHS agencies and make available those products to the automated acquisition processes of the FFGS Server. This will require that the Centre work with the countries to develop a set format of the data to be transferred to the Centre for use in developing this real-time database that feeds the FFGS.

- The Centre will provide access via the internet (as primary) to all FFGS products to all key participating agencies from the countries in the in the region in real-time.

- Centre forecasters will work directly with the country forecasters in evaluating and applying the FFGS products and will provide critical hydrometeorological expertise when required.

- When appropriate, the Centre will be available for the briefings and discussions needed to properly evaluate flash flood potential using the FFGS tool. The Centre forecasters will work with the country forecasters to ensure that they understand the weather forecasts and to provide consistency, including evaluating and interpreting the applicability of current and forecast precipitation events.

- The Centre will evaluate the FFGS products from a regional perspective and will communicate this perspective to the countries as appropriate. The Centre will ensure consistency of FFGS products throughout the region.

- The Centre will provide regional and national validation of system results and will advise the countries of the presence of noted biases in system outputs.
- Where appropriate, the Centre will coordinate the issuance of flash flood watches and warnings (as applicable) in a consistent format using the FFGS tool as well as incorporating other information and tools available.

- The Centre will support routine training/workshops on system operations, product interpretation and development, product verification, etc. to country forecasters.

- The Centre will coordinate with the FFGS global data processing Centre or its equivalent in matters of data flow and communications or for conveying information regarding potential improvements that will affect the region products.

Centre System Management/Maintenance Roles and Responsibilities

The Centre will maintain and operate the Regional Linux server which computes and disseminates regional and country FFGS products (text and/or images). A server using the LINUX operating system will be provided for the Regional Centre through the project.

Even though the FFGS servers are designed to be fully automated, there will always remain a critical need for ongoing observation and quality control of its processing tasks and data products. This requires expertise from two basic categories: systems administration and operational quality control of the data products. Skills in both areas of expertise are needed to properly monitor and confirm the overall performance of the system. This can be fully achieved only through the cooperative efforts of both IT Staff and Forecasters. In fulfilling its system maintenance responsibilities, the Centre needs to perform the following activities.

- Maintain Network Connectivity and Data Availability – This relates primarily to the systems administration efforts of IT staff. Of concern are potential problems related to internet and/or GTS service availability, adequate communications throughput to ensure timely data downloads and access by the NMHSs, network cabling, switches, or any one of numerous hardware and security issues related to the servers themselves. The assessment and correction of potential problems relating to any of these areas requires specific technical skill and an understanding of the systems and technologies involved.

- Product Quality Control – This relates to the function of the forecasters at the Centre. Their expertise in hydrology and meteorology is required to properly understand the relative quality of the FFGS input and output products at any given time. Accordingly, Centre forecasters must perform quality control procedures on the data and outputs and determine whether or not any perceived problems are the result of a parametric shortcoming, a failure in one of the FFGS models, or if it might relate to the quality or availability of the real-time input data that drives the system.

- Operational Process Monitoring – In order to successfully fulfill the specific responsibilities of IT staff and forecasters identified above, both groups must engage in a necessarily cooperative effort of routine and systematic review of system processing activity. This involves regular inspection of system image products, data products, status indicators and log files as a means to confirm the proper operation and health of the system while maintaining a keen familiarity with the status quo in order to immediately recognize any deviation from it.

Training Responsibilities

The Centre will be directly involved in the various training programs during implementation and operations. Training programs can involve both Centre staff and country staff. Regional representatives will be equipped to play a fundamental part in the training of country staff, especially during system operations. The primary purpose of training is for Centre representatives to familiarize themselves and develop a level of competency in the FFGS system basics (physical principle, components, operation, and validations), product interpretation and use, and collaboration for prediction and warning. Particular emphasis for the Centre will be placed on validation, operations, trouble shooting and maintenance, data management, communications, realistic scenarios, and preparedness for unusual circumstances or errors. The Centre may offer opportunities for NMHS personnel to serve at the Centre for hands-on training and to support the Centre operations.

Centre Personnel Recommendations

Staff that supports the operations of the Centre should possess the following qualifications to the extent possible.

Staff

The following expertise is recommended for the staff supporting the Centre.

Area of Expertise	Regional Centre
Have a meteorological or hydrologic technical background	Both meteorological and hydrologic expertise
Have experience in operational quantitative weather or hydrologic forecasting specific to the region or country	Priority
Have experience in weather-related hazard emergency management operations	Priority
Have experience in or knowledge of quantitative analysis of satellite-based rainfall estimates	Priority
IT capability for server system administration, network connectivity, and product availability	Priority

Focal Point

It is recommended that the Centre maintain a focal point for all operations and activities. This focal point should meet the following qualifications and responsibilities:

Qualifications

The qualifications for the Centre Focal Point are recommended to be as follows:

- Have good knowledge and background in operational meteorology and hydrology in the Central Asia region;
- Have appropriate experience in providing technical training in hydrometeorology; and,
- Have undergone advanced training in the theory and operations of the FFG system from the system developer and implementer.

Responsibilities

The responsibilities for the Centre Focal Point are recommended to be as follows:

- Assist the system developer in the collection of required regional spatial and hydrometeorological data needed for system development;
- Be directly involved in the various training programs provided by the Global FFG Program partners during FFG system implementation and operations;
- Provide regional and national validation of FFG System results (with and without forecaster adjustments) to the countries; and, on the basis of such regular feedback, coordinate with the Global Data Processing Centre for potential improvement and to review system products;

- Submit a detailed report annually based on:
    - Number of major events of flash flooding in the region
    - Deaths/property losses estimates for those events
    - Performance of the regional FFG
    - Operations information (percent of hours of system downtime and percent of hours with lack of remotely-sensed and in-situ rain gauge data); and,

- When needed, arrange and possibly visit a country's forecasting operations to provide training if the operations of the regional FFG is not at its optimum in that country (based on outputs from the annual report and country feedback).

Operation Schedule

Both the Regional Centre and the country NMHS should operate on a round-the-clock basis either continuously year-round or at the minimum during seasons with significant flash flood risk.

Summary

In summary, key Regional Centre responsibilities are:

- Disseminate real-time country graphical products from the FFGS for the NMHSs in the region;

- Collect available real-time meteorological data for ingest to the FFGS for the development of regional products;

- Support regional flash flood operations by:
    - Provide routine regional hydrometeorological analysis,
    - Provide daily guidance discussion to NMHSs from a regional perspective,
    - Provide regional flash flood hazard information,
    - Provide regional validation of products and formulation of plans for improvements, and
    - Provide communications for system analyses to NMHSs of the region.

- Provide communications of regional system modifications necessary to developers;

- Collect spatial and historical hydrometeorological data needed for system development;

- Develop a historical archive of the system products;

- Support regional training of NMHS representatives; and,

- Provide routine maintenance and IT support for the FFGS server.

Appendix B

Data and Information Requirements

For each area or basins where flash flood guidance will be provided, various historical, real-time and state variable data and information are needed for the development and operation of the flash flood guidance system. As much of the following data and information as possible should be collected and/or made available from each country within the region. Note that the following items represent the optimum data and information requirements; system development and operations designs will consider which data are available for use.

Logistical Data (Metadata)

- Longitude and latitude coordinates (in decimal degrees) and elevation (in meters) of all sensors providing real time data and historical data, type of data, units of measurement and sensor.

- Longitude and latitude coordinates (in decimal degrees) of dams and reservoirs

- Evaluation of basin delineation: initial delineations based on hydrologic processing of the SRTM (90-m) resolution digital elevation data and hydrographic information from the Digital Chart of the World

    - Evaluation of the delineation results with local knowledge and expertise is required for final quality assurance
    - Delineation maps may be provided in GIS format; shapefiles are preferred.

Spatial Digital Data or Maps (for areas of interest)

- Digitized stream network data

- Digitized country catchment boundaries data

- Land-use and land-cover data

- Soils data to include soil texture or FAO soil classification or soil properties data, and depth of upper soil and sub-soil

- Local stream cross-sectional survey data for natural streams draining 10-2000km^2, including any reports of regional relationships between channel cross-sectional characteristics and catchment characteristics

- GIS map of bedrock and alluvial channels

- Population distribution data

Reports

- Flood Frequency Analysis (regional and local)

- Flash Flood Occurrence (regional and local)

- Stream geometry studies for small streams

- Climatological precipitation and flood studies

Historical Data

- Precipitation data (hourly, daily, monthly, climatology)
- Air temperature data (hourly, daily, monthly, climatology)
- Pan evaporation data (daily, monthly, climatology)
- Soil moisture data for top 1 meter of soil (weekly, monthly, climatology)
- Streamflow discharge data for local streams with drainage areas less than 2000 km^2 (hourly, daily, monthly, climatology)
- Spring discharge data
- Stream stage data (hourly, daily, monthly, climatology) and associated stage-discharge curves (rating curves), also for local streams
- Radiation data for computation of potential evapotranspiration (daily, monthly, climatology)
- Wind, humidity data for computation of potential evapotranspiration (daily, monthly, climatology)
- Historical radar data, once radars become operational, and satellite data
- Groundwater recharge rates, channel transmission losses, and groundwater level data for surficial aquifer
- Snow water equivalent data

Real Time Data

- Surface precipitation and weather data (hourly or 6hourly) (**important**)
- River stage + rating curves, or discharge data (hourly, 6hourly or daily)
- Snow water equivalent or depth (daily or weekly data)

Appendix C

Real-Time Data Specifications and Information

Please provide the following information for each real-time rain gauge and automatic weather station:

- Location of the station as latitude and longitude in decimal degrees and elevation in meters.
- Deployment status – e.g., in place and operational, in place but not yet operational, planned for installation. If known, please specify the start date of operation.
- Current operational status (for all in-place stations) – e.g., fully operational, operating but intermittent, operating but erroneous or unreliable, offline for maintenance/repair, etc. Current status should be provided for each sensor of multi-sensor stations. Any additional information relating to problematic stations/sensors will be helpful.
- Method of data transmission – e.g. Internet, satellite, telephone landline, telephone cellular, telephone SMS, telephone fax, microwave radio, HF/VHF radio (voice or data), etc.
- Period of observation (data recording resolution, per sensor) – This is the duration of time over which data is accumulated or averaged, as provided, e.g., 15-minute, 1-hourly, 6-hourly, 12-hourly, daily. For any instantaneous measurements, such as temperature, please indicate the interval between recordings.
- Frequency of data transmission/collection (on what interval is the data received by the responsible agency?) – e.g. randomly, 5-minute, 15-minute, 1-hourly, 3-hourly, daily or manual data logger collection.
- Survey information:
    - What is the functionality and adequacy of the data-reception and storage systems in the country?
    - What preventive maintenance, calibration or repair needs to be performed on the gauges/stations? What is the typical schedule for routine, operational maintenance of gauges/stations?
    - What is the perceived level of institutional support for the agencies responsible for monitoring?
    - How can real-time data from the currently operating rain gauges and weather stations be accessed for use by the FFGS?

Establecimiento de un Sistema Guía de Crecidas Repentinas para América del Sur

Lima (Perú), 16 a 18 de agosto de 2016

Reunión inicial de planeación
ORDEN DEL DÍA PROVISIONAL

Lunes 16

09:00–09:30 Inscripción de los participantes
09:30–09:45 Apertura de la reunión por la Presidenta Ejecutiva del Servicio Nacional de Meteorología e Hidrología de Perú *(SENAMHI)*
09:45–09:50 Palabras de bienvenida a cargo de la Organización Meteorológica Mundial *(OMM)*
09:50–09:55 Palabras de bienvenida a cargo del Servicio Meteorológico Nacional *(SMN)* de Estados Unidos
09:55-10:00 Palabras de bienvenida a cargo de la Agencia de Estados Unidos para el Desarrollo Internacional *(USAID)*
10:00–10:15 Descripción y objetivos de la reunión *(OMM)*

10:15 - 10:45 Pausa

10:45-11:20 Introducción al Sistema Guía de Crecidas Repentinas y rol de la OMM *(OMM)*

- Definiciones relacionadas con las crecidas repentinas
- Iniciativa Mundial de Guía de Crecidas Repentinas

11:20-11:55 Rol del Centro de Investigación Hidrológica (CIH)*(CIH*)
- Definición de Guía de Crecida Repentina
- Interfaz para el pronosticador
- Ejemplo del Sistema Guía de Crecidas Repentinas en la cuenca del río Zarumilla

11:55–12:05 Rol de USAID/Oficina de Asistencia para Desastres en el Extranjero (OFDA) *(USAID/OFDA*)
12:05–12:15 Rol de la Administración Nacional del Océano y de la Atmósfera (NOAA) *(SMN de Estados Unidos)*

12:15-13:30 Almuerzo

13:30-15:30 Presentaciones sobre temas relacionados con las crecidas repentinas: pronósticos y alertas y su utilización en la gestión del riesgo de desastres (*Servicios Meteorológicos e Hidrológicos Nacionales (SMHN)*)

- Naturaleza de los problemas de crecidas repentinas y sus impactos

- Rol de las distintas agencias (en la elaboración de pronósticos y en la difusión de las alertas)
- Rol de las agencias encargadas de la gestión del riesgo de desastres con respecto a las crecidas repentinas, incluidas las crecidas repentinas urbanas y los deslizamientos de tierra
- Vínculos de los SMHN con las agencias encargadas de la gestión del riesgo de desastres
- Capacidad de utilizar datos y modelos para la elaboración de pronósticos y alertas de crecidas repentinas (datos de sensores remotos e *in situ*, incluida la capacidad de utilizar modelos basados en la predicción numérica del tiempo)
- Arreglos operativos existentes para crecidas repentinas

15:30-16:00 Pausa

16:00-17:00 Discusión facilitada (*OMM*)

- Necesidades operativas y limitaciones para las alertas
  - Requerimientos de tiempos de previsión, localización, precisión e impacto del pronóstico
  - Necesidad de una mejor colaboración
  - Necesidad de reforzar las capacidades de las agencias que emiten pronósticos

Martes 17

09:00-09:30 Resumen del primer día

09:30-10:30 Demonstración de la interfaz y componentes del Sistema Guía de Crecidas Repentinas regional (*CIH*)

- Modelo de humedad del suelo
- Estimación satelital de la precipitación, incluyendo ajustes del sesgo de la precipitación
- Guía de Crecidas Repentinas

10:30-11:00 Pausa

11:00-11:30 Demonstración de la interpretación de productos del Sistema Guía de Crecidas Repentinas regional *(CIH)*

- Interpretación de productos y ajustes en tiempo real
- De los productos del Sistema Guía de Crecidas Repentinas a los avisos y alertas
- Estimaciones y previsiones cuantitativas de precipitación (ECP y PCP). Valor de los datos en tiempo real, sus requerimientos y utilización

11:30-12:15 Demonstración del Proyecto piloto de Guía de Crecidas Repentinas para la cuenca del río Zarumilla en seudo-tiempo real *(CIH)*

- Demonstración de la interfaz del Sistema para el río Zarumilla
- Discusión del proceso de desarrollo del Sistema
- Presentación de un caso de estudio de un fenómeno de tormenta en la cuenca del río Zarumilla

12:15–13:15 Almuerzo

13:15-14:00 *Continuación:* Demonstración del Proyecto piloto de Guía de Crecidas Repentinas para la cuenca del río Zarumilla en seudo-tiempo real *(CIH)*

14:00-14:30 Discusión sobre los requerimientos de la PCP para la aplicación del Sistema Guía de Crecidas Repentinas en América del Sur *(CIH)*

14:30-15:00 Requerimientos de información para la aplicación del Sistema Guía de Crecidas Repentinas en América del Sur *(CIH)*

15:00-15:30 Proyecto de demostración de las predicciones de fenómenos meteorológicos extremos – Implementación potencial en América del Sur *(OMM)*

15:30-16:00 Pausa

16:00-16:30 Disponibilidad y acceso a datos e información - Rol y responsabilidades de los SMHN de la región - Discusión *(todos)*

- Meteorología
- Hidrología

16:30-17:00 Funcionamiento del Proyecto, con inclusión del establecimiento de Centros Regionales y Centros Nacionales, y la cooperación regional *(CIH)*

Miércoles 18

09:00-09:15 Resumen del segundo día

09:15-10:30 Visita a los centros de pronóstico meteorológico e hidrológico del SENAMHI

10:30-11:00 Pausa

11:00-11:20 Aspectos organizativos y de gestión relativos a la planeación e implementación del Proyecto *(OMM*)

11:20-11:50 Discusión facilitada sobre el interés de los países en participar en el proyecto de Sistema Guía de Crecidas Repentinas para Sudamérica (todos los países)

11:50-12:15 Discusión facilitada sobre el interés de los países en participar en el Proyecto de demostración de las predicciones de fenómenos meteorológicos extremos –para Sudamérica (todos los países)

12:15 – 13:30 Almuerzo

13:30-14:00 Discusión facilitada sobre las medidas que deberán adoptarse, incluidas las relativas a los Centros Regionales *(OMM)*

14:00 -14:45 Necesidad de capacidades profesionales y técnicas a nivel nacional y regional para el funcionamiento del Proyecto – Discusión (todos)

14:45-15:30 Próximos pasos (*CIH*)

15:30-16:00 Pausa

16:00-16:30 Examen y adopción de las decisiones y recomendaciones (*todos*)

16:30-17:00 Observaciones finales y clausura de la reunión