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## Establishment of a Flash Flood Guidance System for South America

Lima, Peru, 16 – 18 August 2016



**REPORT OF THE INITIAL PLANNING MEETING**

**August 2016**



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# **Establishment of a Flash Flood Guidance System for South America**

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## **1. Background**

In the continent of South America, flash floods account for a significant portion of the lives lost and property damages that result from flooding. Given that flash floods can occur at any time or place with disastrous results, there is an urgent need to prioritize efforts that aim to improve early warnings capabilities. Improvements help society cope with flash flood threats by enabling the mandated national authorities to undertake appropriate measures, thereby contributing to protecting the population at risk from the disastrous effects of flash floods.

As part of WMO's Flood Forecasting Initiative and on the basis of a 4-party Memorandum of Understanding signed by the World Meteorological Organization (WMO); US NOAA National Weather Service (US NWS), the Hydrologic Research Center (HRC), San Diego, USA, and U.S. Agency for International Development/Office of U.S. Foreign Disaster Assistance (USAID/OFDA), the signatories have established a cooperative initiative for the Flash Flood Guidance System with Global Coverage Project. To attain global coverage, specific projects are planned and carried out on a regional basis with countries that have committed in writing to participate actively in the implementation and operation of the forecast system.

## **2. Introduction**

The Regional Association III (South America) Working Group on Hydrology and Water Resources (RAIII WGHWR) at its last meeting in Asuncion, Paraguay, from 5 – 9 October 2015, had discussed progress to date on the application of the Flash Flood Guidance System (FFGS) to the Zarumilla river basin. The meeting had also been informed that funding had been secured from USAID/OFDA to allow a meeting to discuss lessons learned on the application of the FFGS to the Zarumilla river basin and to further explore the possible implementation of the System within South America. The RAIII WGHWR decided to hold the meeting in Peru, in the second half of 2016. Based on this decision, the WMO secretariat organized this Initial Planning Meeting on establishing a FFGS for South America, which was held at the kind invitation of the National Meteorological and Hydrological Service of Peru (SENAMHI) in Lima, Peru, from 16 – 18 August 2016. The Initial Planning Meeting were held at SENAMHI national office allowing participants the opportunity of visiting the meteorological and hydrological offices of SENAMHI to observe first-hand its forecast operations and interact with those responsible for the functioning of its forecasting facilities.

In opening the planning meeting, the representatives of SEAMHI, WMO and US NWS highlighted the importance of improving the timely delivery of flash flood information and guidance to the populations at risk and in the importance of fostering stronger partnerships among countries in the region to strengthen national capabilities. It was highlighted that the core aspects of the project focuses on the implementation of technology and scientific approaches

undertaken mainly by the countries National Meteorological and Hydrological Services (NMHSs), and that the ultimate indicator of success of FFGS implementation is the effective outreach to people thereby reducing their risk of being affected by flash floods in a disastrous way. It was also noted that this Initial Planning Meeting provided an opportunity for those present to reach consensus on whether there was a need, or not, for the implementation of the FFGS in South America. It was proposed that the results of these deliberations could be summarized in “conclusions and recommendations” that could, in turn, be shared with the Permanent Representatives of the NMHSs in South America. It was anticipated that these could then be further discussed and agreed upon at the Ibero-American meeting of Directors of NMHSs that is to take place 23 – 25 November 2016 in Antigua, Guatemala.

In her opening remarks, Eng. Amelia Ysabel Diaz Pabló, Executive President of SENAMHI and Permanent Representative of Peru with WMO, welcomed everyone to Peru and highlighted the value of working together through regional cooperation particularly to improve our early warning systems to help reduce the risks from hydrometeorological hazards, to promote sustainable development, and to attain and maintain economic prosperity. She indicated that this meeting was very important for setting out a clear path on how South American countries might bring this to fruition. Given the meeting’s importance, she wished it success and indicated that she looked forward to the meetings deliberations that she hoped would result in clear recommendations on concrete actions that are needed.

Mr Claudio Caponi (WMO) welcomed everyone to the meeting on behalf of the Secretary-General, Mr Petteri Taalas. He expressed pleasure at seeing the high degree of participation of experts from countries within South America to this important meeting, noting that only French Guyana (France) was not able to have experts present. He noted that there was an excellent mixture of expertise and very capable experts present that should help make the meeting a success. He recalled that in 2003, the WMO Flood Forecasting Initiative (FFI) was initiated based on the analysis of weaknesses of current forecasting systems and with a focus to enhance the ability of National Hydrological and Meteorological Services (NMHSs) to cooperate in an effective manner to provide improved flood forecasting services. As part of this effort, an international conference in 2006, which was held in Costa Rica, was instrumental in laying the ground work and path forward for this global project. The initiative to develop and implement flash flood early warning systems was endorsed by the Fifteenth Congress of WMO in 2007. This led to the Memorandum of Understanding (MoU) amongst WMO, US NWS, HRC, and USAID/OFDA and the commencement of a number of regional applications for the FFGS throughout the world. Consistent with these developments, he recalled that the RAIII WGHWR had agreed, at a meeting in Santiago, Chile, in 2011, to have the FFGS applied to one transboundary basin, namely the Zarumilla river basin, which he also noted was on the agenda of this meeting and would be discussed further. In closing, Mr Caponi stressed the importance of those present to ask questions so that there would be an excellent understanding by all of the forecast system, even if there might not be any interest in adopting the system, as this high level of understanding would help in forming recommendations from the meeting to be considered by the Permanent Representatives of RA III. He also took the opportunity to thank SENAMHI for hosting the meeting.

Ms Viviane Silva (US NWS) indicated that she was very excited about the meeting and its possible outcomes and that she looked forward to the interactions and deliberations that might possibly lead to a clear path forward through the meeting’s recommendations.

### 3. Organization and Reporting on the Initial Planning Meeting

The Initial Planning Meeting was attended by representatives of National Meteorological and Hydrological Services (NMHSs) from Argentina, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela (Bolivarian Republic of). Unfortunately, representatives from French Guyana (France) were unable to participate in the meeting. Other participants included representatives from WMO, US NWS and HRC. The list of participants is provided in Annex 1, while the annotated meeting agenda is given in Annex 2. The Project Brief and the Implementation Requirements document, which had been provided in advance of the meeting to participants, are attached as Annexes 3 and 4, respectively. Annex V provides a sample of the Terms of Reference for a Project Steering Committee, which is formed to help manage each regional FFGS project. Finally, Annex VI provides the draft Letter of Commitment (LoC) that each participating country in a (sub) regional project in South America would need to provide for inclusion in the specific initiative.

All presentations for the Initial Planning Meeting are available on the WMO website<sup>1</sup> and are linked on-line to the agenda of the meeting. It is recommended that these presentations be consulted for all pertinent information contained therein, which includes presentations by agenda items:

- Overview and purpose of the meeting
- Introduction to the FFGS and the Role of WMO
- Role of HRC
- Role of US NWS in the FFGS Initiative
- National presentations on flash flood issues
- Regional FFGS interface, components and product interpretation
- Zarumilla River Basin Flash Flood Guidance Pilot Project
- The Severe Weather Forecasting Demonstration Project (SWFDP) - Potential implementation in South America
- Roles and Responsibilities of NMHS in the FFGS application
- Roles and Responsibilities of the Regional Centre(s)
- Organizational and management aspects of project planning and implementation
- Conclusions and Recommendations of the Initial Planning Meeting

### 4. Proceedings of the Initial Planning Meeting

#### ***Country Presentations***

Experts from each country provided in-depth presentations on the current situation of their national services related to hydrometeorological forecasting capabilities, practices and development plans. As previously indicated, all country presentations are available on the WMO website. The presentations revealed the similarities and differences that exist among the countries regarding their capabilities to deliver weather and flood forecasting and early warnings, especially for those pertaining to flash floods. Countries do not presently have dedicated systems including the use of hydrological modelling to specifically address the provision of flash flood forecasts and warnings.

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<sup>1</sup> The link to the report of this Initial Planning Meeting and its presentations is <http://www.wmo.int/pages/prog/hwrf/flood/ffgs/saffq/saffq.php>.

### ***SWFDP and FFGS Linkages***

Mr. Abdoulaye Harou (WMO) informed the meeting participants about the Severe Weather Forecasting Demonstration Project (SWFDP) of WMO, its objectives and goals, progress of SWFDP Regional Subprojects in different areas of the world including the possible approach that could be taken for the development of one or more SWFDPs for South America. He also briefed participants on the potential expansion of SWFDP to cover many areas of the world within next 5 years for the benefit of the developing countries. He also highlighted efforts being undertaken to integrate the SWFDP-Southern Africa with Southern Africa Region Flash Flood Guidance (SARFFG) project and prospects of potential linkages and integration of SWFDP with FFGS projects in due course over time. The meeting noted the importance of obtaining high resolution quantitative precipitation forecasts from the cascading numerical weather prediction models of the SWFDP for use in the FFGS. Participants discussed the importance of having such high resolution numerical weather prediction model products (possibly of 2 km resolution) over areas where hazards of flash flooding exist and where populations and infrastructure are at risk.

### ***FFGS: Need for Local Data and Training***

The importance of using local data in the FFGS to calibrate model parameters was stressed, as was the need of making historical and real-time hydrometeorological data available to HRC, in particular precipitation data. It was mentioned that real-time precipitation data are used to bias-adjust satellite precipitation estimates, which greatly increases the accuracy of quantitative precipitation estimates. It was noted that there were various data types required for the FFGS to be developed and to allow it to perform well, such as precipitation, soil data, vegetation cover, evaporation, temperature, discharge, stream/river (locations) network, and quality controlled digital elevation data. Data requirements for the project are provided in Appendix B of Annex 4 of this document.

Training was also mentioned as being an integral part of the project, and extensive training would be provided to the forecasters of each participating country. The schematic diagram outlining the FFGS hydrometeorologist training programme is shown in Appendix A of Annex 4 of this report. When the training has been completed, forecasters would be confident and competent to use FFGS products for flash flood forecasting and the provision of early warnings.

### ***Overview of FFGS Products and Use***

FFGS products and their operational use were introduced and were preceded by a brief review of the definitions of terminology used within the FFGS. Satellite precipitation products presented included:

- Global Hydro Estimator (GHE) precipitation, which is produced by US National Oceanic and Atmospheric Administration (NOAA) using Infrared (IR) channel (10.5 micrometre) of geostationary meteorological satellites;
- Micro Wave adjusted Global Hydro Estimator (MWGHE) precipitation, which is estimated by correcting GHE precipitation with Micro Wave satellite precipitation;
- Gauge Mean Aerial Precipitation (Gauge MAP), which is estimated by using WMO synoptic reports obtained from the WMO GTS network;
- Merged Mean Aerial Precipitation (Merged MAP), which is estimated by merging GHE precipitation with MWGHE or Gauge MAP or Radar estimated precipitation.

The Merged MAP is the bias adjusted precipitation product to be ingested into FFGS models, that is the SNOW 17 and Sacramento Soil Moisture Accounting (SAC-SMA) models. The Forecasted Mean Aerial Precipitation (FMAP) would be obtained from the numerical weather prediction Limited Area Models (LAMs), possibly resulting from an application made by a participating NMHS or through an implemented SWFDP. Other FFGS products highlighted included:

- Average Soil Moisture (ASM), which indicates upper soil (20-30 cm) water content, including free and tension water;
- Flash Flood Guidance, which is an amount of actual rainfall that may cause bankfull flow conditions at the outlet of a sub-basin for a given duration (e.g., 1, 3, or 6 hours); and
- Three Flash Flood Threat products, which indicate the possibility of flash flood occurrences at the outlet of a particular sub-basin, including Imminent Flash Flood Threat (IFFT), Persistence Flash Flood Threat (PFFT), and Forecast Flash Flood Threat (FFFT).

Mention was also made of the snow products generated by the FFGS, namely Snow Water Equivalent (SWE), Snow Coverage, and contribution of snow melt (snow MELT).

Mr Shamir (HRC) demonstrated the operational capabilities of the FFGS and interpreted some of the derived products.

### ***Facilitated Discussions***

There was a lively discussion on several aspects pertaining to the development and implementation of the FFGS in South America. These covered different aspects including how many regions might there be within the continent of South America, which countries might be associated with each regional project, the potential interest of countries to be a Regional Centre for one or more regional projects, and the characteristics of the system that would be needed for each individual regional project. On this latter point, use of radar data for improving the resolution and accuracy of quantitate precipitation estimates was discussed, as was the importance of having the projects focus on where people lived, that is large urban centres. Riverine flooding and landslide susceptibility, captured by new FFGS functionality under development, were also cited as being of importance in regional application development.

The roles and responsibilities of NMHSs and the Regional Centre in a regional project were also reviewed. NMHSs had the following responsibilities: to provide historical data to the project developer, HRC; to provide in-situ data to the Regional Centre; to participate in flash flood hydrometeorological training programme; to issue flash flood warnings and disseminate them to the national Disaster Management Authority; and to cooperate with the Regional Centre on system issues. The roles and responsibilities of the Regional Centre were cited as being: to communicate effectively with WMO, HRC and NMHSs on regional system activities; to have computer hardware and software capabilities and good computer network connections; to monitor routinely the availability of the system's products; and to conduct flash flood validation studies. Detailed information about roles and responsibilities of NMHSs and RC are provided in Annex 4 and Appendix A in this document.

In response to questions on the human resource requirements for participating NMHSs and the Regional Centre(s), it was mentioned that FFGS was designed to provide country forecasters with the tools necessary for assessing the potential for and issuing flash flood warnings, so that additional staff was not required. However, forecaster time was needed to review the flash flood products prior to issuing warnings. As well, time would be needed to ensure data are flowing



from the field to the office and are continuously being made available in real time to the FFGS. In terms of Regional Centre requirements, it was indicated that two current regional centres had been contacted on this, and they had both indicated that about 3 person-months of effort per year was needed, mostly for convening regional meetings, including Project Steering Committee meetings, provision of training, and communicating with participating countries when stations are not reporting. Very little time, probably less than one week per year, was needed to manage the system as the software was very robust and stable. It was noted that HRC was available to assist remotely when such issues arose.

The meeting decided that the best way to capture the outcomes of the discussion was through the conclusions and recommendations section of this report, which is provided below in Section 5.

### ***Closing of the Initial Planning Meeting***

Closing remarks were made by representatives of SENAMHI and WMO. Thanks were also extended to all attendees for their active participation in the meeting and spirited involvement in the discussions, which contributed to the successful conclusion of the Initial Planning Meeting. Certificates were presented to all participants of the meeting.

## **5. Conclusions and Recommendations from the Initial Planning Meeting**

*[Note that the Conclusions and Recommendations were drafted and agreed upon in Spanish. The Spanish version, which is available on the WMO website, should be used as the definitive text.]*

Participants of the Initial Planning Meeting for the Establishment of a Flash Flood Guidance System (FFGS) for South America, which had representatives from 12 countries of RA III as experts in meteorological and hydrological forecasting, after having examined the technical characteristics of the system and discussed the various aspects of its application in the region, agreed to make the following recommendations to the Permanent Representatives of RA III:

- It is of interest to the region to implement the Flash Flood Guidance System (FFGS) in South America in order to reduce the loss of human life and economic damages. In addition, after being informed of the objectives of the Severe Weather Forecasting Demonstration Project (SWFDP), it is considered equally important to implement it concurrently with the FFGS, including the co-location of the regional centres, where possible. It also requested that WMO conduct an introductory workshop on the SWFDP in RA III as soon as possible.
- For FFGS, in view of the extent and diversity of meteorological and hydrological phenomena and geophysical characteristics of the region, it [South America] should be divided into four sub-regions. The sub-regions suggested cover a) the Northwest part, b) the three Guianas, and c) and d) two regions whose final composition would be determined later.
- Based on the technical, economic and human resources capacities, regional centres should be located in some of the following countries: Argentina, Brazil, Chile, Colombia, and Peru; the latter two having also expressed interest in hosting a Regional Centre. It should be noted that the sub-region b) should be supported by an external Regional Centre, as this has been successfully undertaken in regional projects in other parts of the world.
- The functionalities of each sub-regional system must be developed to reflect the needs of the

participating countries. In addition to providing tools for hydrological and meteorological forecasters to develop timely and site-specific alerts for flash floods, the system should include optional items to help forecasters in developing alerts for: areas that have available high resolution Radar information, urban areas of selected cities experiencing flash flooding, landslides and riverine floods.

- To consider starting implementation of the system in sub-region a).

In view of the above, to request WMO, through communication from the President of RA III to the Secretary-General, to take the necessary steps to mobilize the necessary resources to carry out the detailed actions herein described above.

**END**

## Establishing a Flash Flood Guidance System for South America

**INITIAL PLANNING MEETING**  
16 – 18 August 2016, Lima, Peru

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## Establishment of a Flash Flood Guidance System for South America

16 – 18 August 2016, Lima, PERU

### INITIAL PLANNING MEETING

#### DRAFT MEETING AGENDA

#### Tuesday 16 August

- 09:00–09:30 Registration of participants  
09:30–09:45 Opening remarks by Executive President of SENAMHI (Peru)  
09:45–09:50 Welcome speech by WMO  
09:50–09:55 Welcome speech by NWS  
09:55–10:00 Welcome speech by USAID  
10:00–10:15 Overview and purpose at the meeting (WMO)

#### **10:15 - 10:45 Coffee Break**

10:45–11:20 Introduction to the FFGS and the role of WMO (*WMO*)

- Flash flood definitions
- Global Flash Flood Guidance Initiative

11:20–11:55 Role of HRC (*HRC*)

- Flash Flood Guidance defined
- Forecaster Interface
- The Zarumilla Basin FFGS Example

11:55–12:05 Role of USAID/OFDA (*USAID/OFDA*)

12:05–12:15 Role of US NWS in the FFGS Initiative (*US NWS*)

#### **12:15–13:30 Lunch**

13:30–15:30 Presentations on flash flood issues – forecasting and warnings and their use in disaster management (*NMHSs*)

- The nature of the flash flood problem(s) and their impacts
- Roles of various agencies (in forecast development and dissemination of warnings)
- Role of disaster management agencies with respect to flash floods, including urban flash floods, and landslides
- Linkages of NMHS to disaster management agencies
- Capability of using current data and models to provide forecasts and warnings for flash floods (remotely sensed and in-situ data, including capabilities of Numerical Weather Prediction (NWP) modelling)
- Current/existing forecast operations for flash floods

**15:30-16:00 Coffee Break**

16:00-17:00 Facilitated discussions (*WMO*)

- Operational needs and constraints for warnings
  - Requirements for forecast lead times, location, accuracy of forecast, and impacts of forecast
  - Need for closer collaboration
  - Need for increased abilities of forecasting agencies.

**Wednesday 17 August**

09:00-09:30 Summary of Day 1

09:30-10:30 Demonstration of regional FFGS interface and components (*HRC*)

- Soil moisture model
- Satellite precipitation estimation including precipitation bias adjustment
- Flash flood guidance

**10:30-11:00 Coffee Break**

11:00-11:30 Demonstration of regional FFGS product interpretation (*HRC*)

- Product interpretation and real time adjustments
- From FFGS products to advisories and warnings
- Quantitative Precipitation Estimate and Forecast (QPE & QPF). Value of real-time data, their requirements and use

11:30-12:15 Demonstration of the Zarumilla River Basin Flash Flood Guidance Pilot Project in pseudo-real-time (*HRC*)

- Demonstration of the Zarumilla system interface
- Discussion of the process of the system development
- Presentation of a case study of a storm event from Zarumilla

### **12:15–13:15 Lunch**

- 13:15-14:00 *Continuation:* Demonstration of the Zarumilla River Basin Flash Flood Guidance Pilot Project in pseudo-real-time (*HRC*)
- 14:00-14:30 Discussion on QPF requirements for South America FFGS application (*HRC*)
- 14:30-15:00 Data requirements for FFGS application (*HRC*)
- 15:00-15:30 The Severe Weather Forecasting Demonstration Project (SWFDP) – Potential Implementation in South America (WMO)

### **15:30-16:00 Coffee Break**

- 16:00-16:30 Availability and access to data and information - Roles and Responsibilities of NMHSs in the Region - Discussion (*All*)
- Meteorology
  - Hydrology
- 16:30-17:00 Operations Concept of the project, including establishment of Regional Centre(s) and National Focal Centres, regional cooperation (*HRC*)

## **Thursday 18 August**

- 09:00-09:15 Summary of Day 2
- 09:15-10:30 Visit to the meteorological and hydrological forecasting centre(s) of SENAMHI

### **10:30-11:00 Coffee Break**

- 11:00-11:20 Organizational and management aspects of project planning and implementation (*WMO*)
- 11:20-11:50 Facilitated discussion on interest of countries to participate in the South America FFGS project (*All countries*)
- 11:50-12:15 Facilitated discussion on interest of countries to participate in the SWFDP - South America (*All countries*)

### **12:15 – 13:30 Lunch**

- 13:30-14:00 Facilitated discussion on developing a path forward, including Regional Centre(s) (*WMO*)
- 14:00 -14:45 National and regional professional and technical capacities needed for project operations – Discussion (*All*)
- 14:45-15:30 Next steps (*HRC*)

**15:30-16:00 Coffee Break**

16:00-16:30 Review and adoption of decisions and recommendations (*All*)

16:30-17:00 Final remarks and closing of the meeting

-----End of Meeting-----



**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.

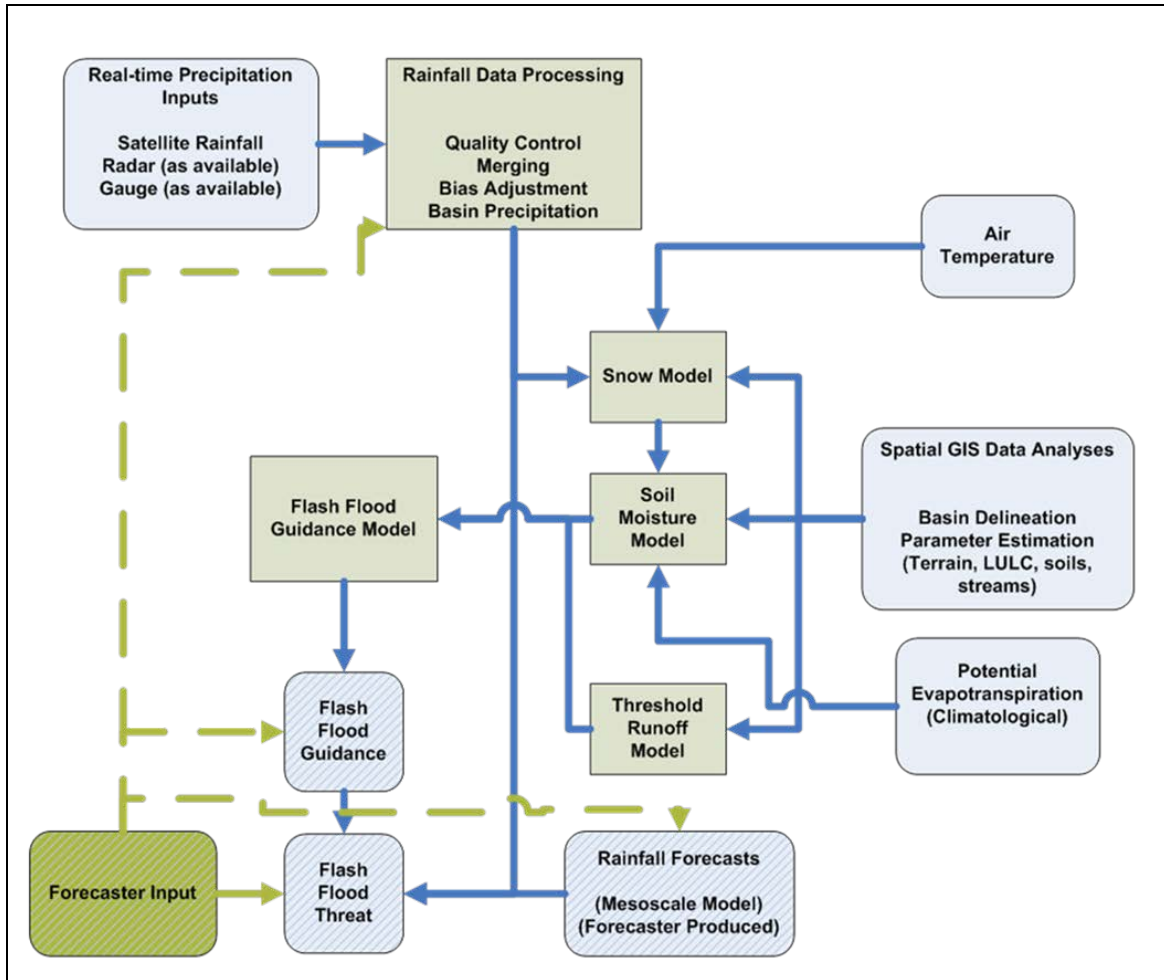
The work plan for disaster risk reduction will address activities such as joint training programs and public outreach and awareness programs. This effort will provide the opportunity for enhancement of regional collaboration of disaster risk management agencies and improvement of community awareness 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**

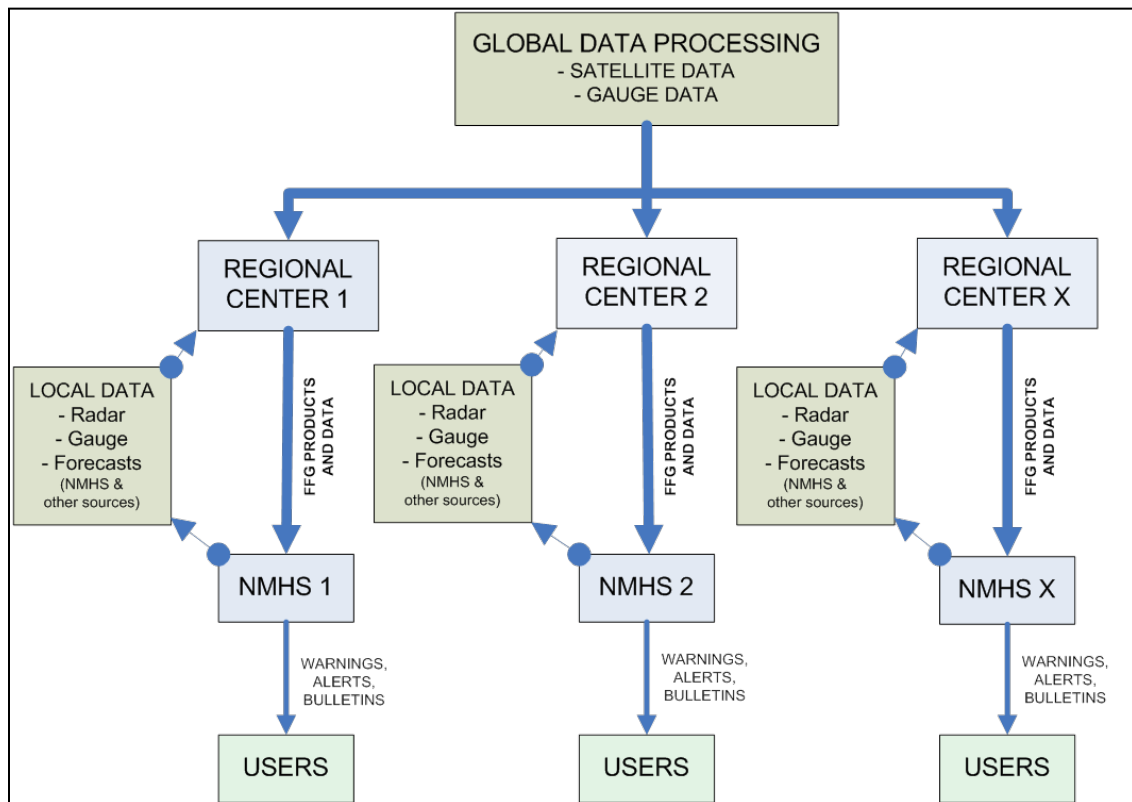
The system allows the NMHSs to use local nowcast/short-term-forecast methods they wish to use to issue the warnings, including (and strongly recommended) local forecaster adjustments. The system design allows this coupling with the existing or developing NMHS approaches on a national or even local scale.

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<sup>2</sup> in size.

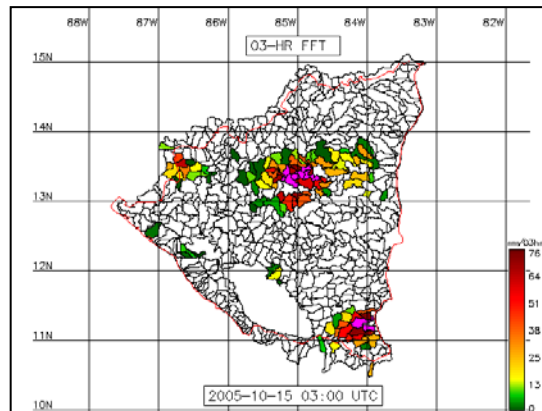
Important technical elements of the Flash Flood Guidance and Warning System are the development and use of a bias-corrected satellite precipitation estimate field, high-resolution numerical weather prediction model outputs (where available), and physically-based hydrological modelling to determine **Flash 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<sup>2</sup>.

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.

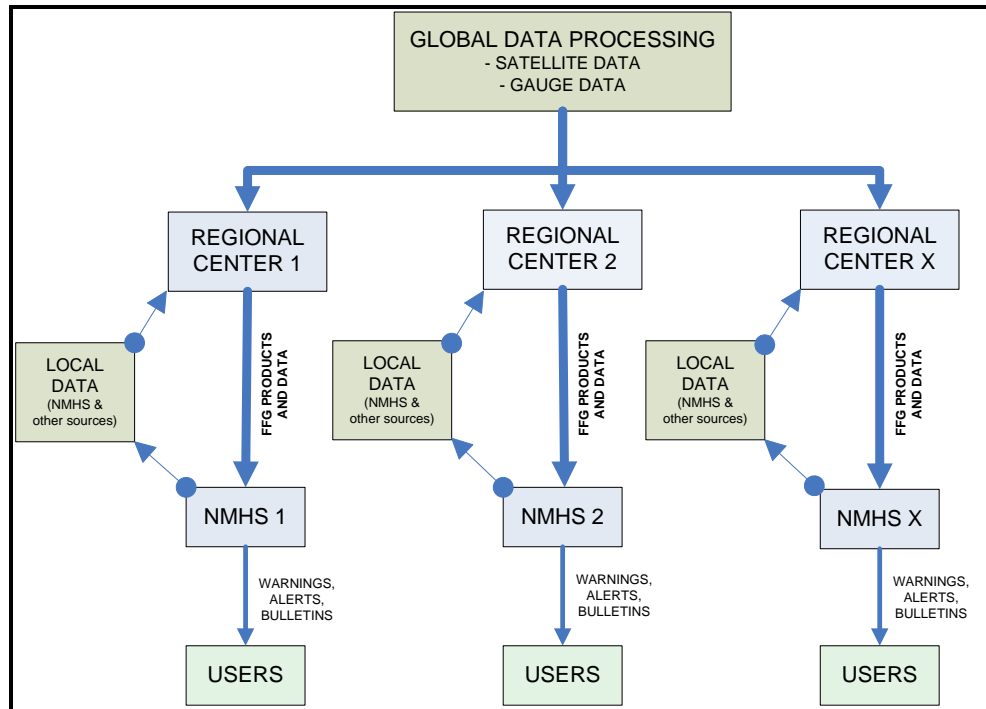
The interface with global information is the link to real-time global satellite precipitation estimates and to global in situ observations through the regional centre.

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.

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<sup>2</sup>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"



**Figure 1. GFFG System Schematic – Global Implementation**

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

- 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*

<b>Area of Expertise</b>	<b>Regional Centres</b>	<b>Country NMHS</b>
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

Area of Expertise	Regional Centres	Country NMHS
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

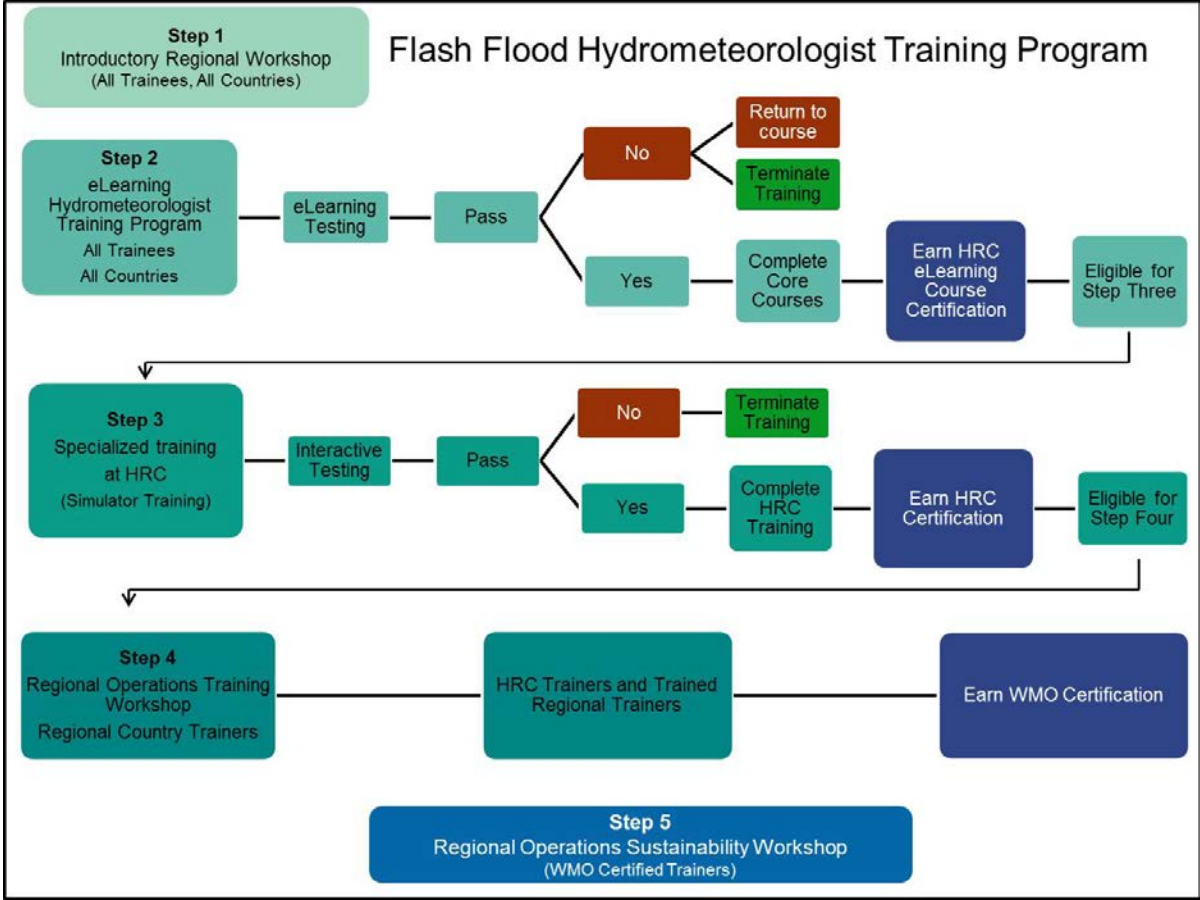


Figure 2. Illustrating five steps of the Flash Flood Hydrometeorologist Training Program

## **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 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.

<b>Area of Expertise</b>	<b>Regional Centre</b>
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<sup>2</sup>, 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<sup>2</sup> (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?

## Project Steering Committee (PSC)

**Preamble:** The Project Steering Committee (PSC) provides overall governance of the (sub) regional project and its related activities throughout the duration of the project. Its membership and the terms of reference would be confirmed and amended as deemed necessary during the first constituting session of the PSC.

### 1. Standing Core Members of the PSC

PSC consists of the following NMHSs focal points or their alternates for the (sub) regional Flash Flood Guidance System (FFGS) project within South America and partner organizations.

Organization	No of Representatives
Regional Centre	1
Each participating country	1
Development Partner (HRC)	1
Donor (USAID/OFDA)	1
US NWS	1
WMO	1

Additional experts/representatives may be invited by the PSC as needed on an ad-hoc basis, and observers may also be invited by the PSC to participate in meetings.

### 2. Terms of Reference

The principal Terms of Reference of the PSC are as follows:

- i. Ensure smooth and timely implementation of project activities and achievement of the project purpose and its expected outcomes based on regular summary reports from national centres and the regional centre,
- ii. Provide technical and administrative guidance to the implementation of the project,
- iii. Establish an adequate *monitoring and evaluation* (M&E) process for the project and implement findings from it,
- iv. Review and update the *project implementation plan* (PIP),
- v. Promote benefits of the project on national and regional levels,
- vi. Facilitate links with other regional and national relevant projects, such as the Severe Weather Forecast Demonstration Project (SWFDP) and other regional or national efforts to advance hydrometeorological early warning capabilities,
- vii. Ensure cross-sector linkages with relevant national and international organizations,
- viii. Seek additional expertise and financial support to supplement project activities.

### 3. Communication

Meetings of the Project Steering Committee will be initially organized annually. In addition, teleconferences may be organized on a tri-semester basis or as needed to monitor project progress and solve upcoming issues. Other communication means of the PSC will include a dedicated e-mail list and/or a web-based e-forum. Operational communication will be established between the Regional Centre and country focal points (NMHSs) and the technical development partner (HRC).

#### **4. Guiding Principles for the (Sub) Regional Project Implementation**

The guiding principles listed below provide an overall framework for the implementation of the FFGS and may be specified in more detail in the first session of the Project Steering Committee (PSC).

- Data providers remain owners of data. Data provided to the Technical Development Partner (Hydrologic Research Centre, HRC), will be used solely for the purpose of building up the regional FFG components and such data will not be re-distributed other than to the national centres that provided the data and the dedicated Regional Centre that will provide regional services.
- Equal, non-hierarchical access to data and information generated by the project for project partners and beyond are consistent with Resolution 40 (WMO CG-XII) WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities ([https://www.wmo.int/pages/about/Resolution40\\_en.html](https://www.wmo.int/pages/about/Resolution40_en.html)) and Resolution 25 (WMO CG-XIII) Exchange of hydrological data and products ([https://www.wmo.int/pages/about/Resolution25\\_en.html](https://www.wmo.int/pages/about/Resolution25_en.html)).
- Services provided by the technical development partner (HRC) and the Regional Centre are of an advisory nature.
- Full responsibility for provision of national flash flood guidance and warnings remains with the participating NMHS.

## Letter of Commitment

(SAMPLE – DRAFT)

*To be addressed to the Secretary-General of WMO*

**Subject: Letter of Commitment regarding the Establishment of a Flash Flood Guidance System for South America**

Dear Mr Taalas,

Reference is made to the Initial Planning Meeting on the establishment of a FFGS for South America held in Lima, Peru from 16 to 18 August 2016, which was organized by the World Meteorological Organization (WMO) in cooperation with the Hydrologic Research Center (HRC) and the US National Weather Service (NWS) and co-organized and hosted by the National Meteorological and Hydrological Service of Peru (SENAMHI), with funding from USAID/OFDA.

I am pleased to learn about the successful outcomes of this meeting and its conclusions and recommendations which constitute a milestone in the development of this initiative.

In this regard I would like to reconfirm the commitment of (country) participation in all project activities aiming towards the achievement of the project objectives to the benefit of (country) and the region as a whole.

I would also like to inform you that (name) has been designated as the focal point and (name) as alternate in all project related activities. The designated officer will represent the country in the Project Steering Committee. Their coordinates are given below.

Focal Point

Name:  
Function/Role  
Address  
Phone  
E-mail

Alternate

Name:  
Function/Role  
Address  
Phone  
E-mail

It is my pleasure to inform you that we have designated (institution) to act as a National Centre that will be responsible for the implementation of the project at the national level.

I would like to express our appreciation for the efforts so far undertaken by WMO, NOAA National Weather Service, and the HRC, as well as the generous financial support of USAID/OFDA.

Let me assure you of our full support and cooperation with the WMO Secretariat and the project partners in the successful implementation of this project.

Yours sincerely,  
Name of PR