Development and Implementation of the Northwest South America Flash Flood Guidance System (NWSAFFGS)

Bogotá, Colombia, 20-22, February 2018

Initial Planning Meeting
Final Report

March 2018

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1. Background

In Northwest 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, 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 undertaken 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 and Opening of the Meeting

The meeting on Establishing Flash Flood Guidance Systems (FFGSs) for South America, held 16-18 August 2018 in Lima, Peru, concluded and recommended that it was of interest to the region to implement the Flash Flood Guidance System (FFGS) for South America. The meeting also recommended that due to the extent and diversity of meteorological and hydrological phenomena and geophysical characteristics of the region that South America should be divided into 4 sub-regions for the application of the FFGS. It also recommended that consideration be given to starting the FFGS implementation in the northwestern part of South America, one of the four identified sub-regions. The Thirteenth Meeting of the Conference of Directors of Ibero-American Meteorological and Hydrological Services, which was held 23 to 25 November 2016 in Antigua, Guatemala, endorsed all conclusions and recommendations of the Lima meeting.

At the kind invitation of Colombia, the Initial Planning Meeting on the development and implementation of the Northwest South America Flash Flood Guidance System (NWSAFFGS) was held in Bogotá, Colombia, 20-22 February 2018, and was organized by the WMO Secretariat. The meeting was hosted by the Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM) of the Ministerio del Medio Ambiente, Colombia. Having the meeting in Bogotá also allowed the participants an opportunity of visiting the premises of the IDEAM to see operational weather analysis and forecasting capacities, to be given presentations on activities undertaken in hydrology and water resources, and to tour their offices including IT infrastructure. All participants expressed their deep appreciation to IDEAM for its hosting of the Initial Planning Meeting and for providing a valuable visit of its facilities.

In opening the Initial Planning Meeting, the representatives of IDEAM, WMO, and USAID/OFDA 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 to forecast and warn populations at risk from flash flooding and other hydrometeorological hazards. Although the core aspects of the project focus on the implementation of technology and scientific approaches undertaken mainly by the countries' National Meteorological and Hydrological Services (NMHSs), it was highlighted that the guiding indicator for the ultimate success of the project is the effectiveness of the outreach to citizens and reducing their risk of being affected by flash floods in a disastrous way.

In his opening remarks, Dr Omar FRANCO TORRES, Director-General of IDEAM and the Permanent Representative of Colombia with WMO, indicated that Colombia was not immune from hydrological hazards and lost over 1 billion Colombian Pesos annually from their occurrence in addition to countless lives lost due to such phenomena. He noted the gravity of the losses by citing that over 300 people died last year in the south from one event. He provided a clear message that Colombia would benefit from the implementation of the Flash Food Guidance System (FFGS), and the government of Colombia is investing in the physical and technical infrastructure of IDEAM to allow it to strengthen its observing and forecasting systems. He cited examples of the investments that were underway. For example, a new C-band weather radar was nearing completion and would be joined by three additional ones. The number of radiosonde stations was moving from 4 to 7, and hundreds of new hydrometeorological monitoring stations were being deployed.

Dr Omar FRANCO TORRES stressed the government wishes to strengthen the meteorological agency and to expand on the products and services that it provides. He indicated that IDEAM is working diligently to improve its capabilities and wanted support from WMO to help IDEAM in these efforts. He indicated that he would prefer a strategic alliance for technology implementation to extend beyond the implementation of projects. He also noted that IDEAM is working within the framework of climate services for water, health, agriculture, and energy. IDEAM issues a 30-day "Weather Agriculture Bulletin", and it works closely with the sectors of mining, health, energy and transportation on some important rivers. He noted that reliable river forecasts are needed for the operation of dams for hydroelectric energy production and to facilitate riverine transportation on, for example, the Magdalena River.

Mr. Paul PILON, on behalf of the Secretary-General of WMO Mr. Petteri TAALAS, welcomed everyone to the Initial Planning Meeting for the implementation and development of the Flash Flood Guidance System (FFGS) for Northwest South America. He recalled that the FFGS was designed to improve the timely delivery of flash flood information and guidance to the populations at risk by strengthening national capabilities to forecast and warn populations at risk from flash flooding and other hydrometeorological hazards.

Mr Konstantine GEORGAKAKOS (HRC) said that he was pleased to attend this meeting and to work closely with country experts to develop a system that will be able to meet forecaster needs in providing early warnings of flash flooding. Mr Paul PILON (WMO) recalled the objectives of the meeting and its expected results and welcomed the participants to provide their active inputs into shaping this important regional Flash Flood Guidance System project. He also thanked IDEAM for all its efforts including hosting the meeting, thereby helping to make a positive atmosphere for the meeting.

3. Organization of the Initial Planning Meeting

The meeting was attended by representatives of National Meteorological and Hydrological Services (NMHSs) from Colombia, Ecuador and Peru. Representatives from WMO and HRC were also in attendance. The list of participants is provided in Annex 1, while the final agenda of the meeting is given in Annex 2. In general, in-depth information was provided by WMO and HRC to participants of the Initial Planning Meeting on the objectives and deliverables of the Flash Flood Guidance System (FFGS), its conceptual and operational set-up, and products that would be available from the FFGS. The Project Brief and the Implementation Requirements documents are attached as Annexes 3 and 4, respectively.

Information was provided by WMO on the purposes of the meeting. These included: to present and discuss the needs for flash flood forecasting and early warnings in the Northwest South America region; to discuss dissemination procedures and protocols for warning populations at risk including the interaction with and role of Disaster Management Agencies; to reach agreement with countries on their intent to participate in the project; and to develop a common understanding of the roles and responsibilities of participating NMHSs, the WMO and HRC in the project; and the determination of a Regional Centre for the project.

The meeting also allowed a platform for participating countries to provide an overview of their flash flood forecasting and warning infrastructure. It also provided participating countries an understanding of the concepts behind the Flash Flood Guidance System, its implementation and data requirements. A brief overview was also provided on the Zarumilla River basin FFGS demonstration project. Presentations were also given on the roles and responsibilities of participating NMHSs and the Reginal Centre in the NWSAFFGS and on the organization and management aspects of the project's planning and implementation. As well, there were facilitated discussions that led to specific conclusions being made by the meeting.

All presentations are available on the WMO website (www.wmo.int)[1].

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. The presentations are available on the WMO website (www.wmo.int). 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.

[1] The cited material for the Northwest South America Flash Flood Guidance System can be located by referring to the activities of the Flash Flood Guidance System within Floods/Flood Forecasting heading under the Hydrology and Water Resources Programme: http://www.wmo.int/pages/prog/hwrp/flood/ffgs/index_en.php and clicking on the location of the project on the map of the world.

Mr Jorge Fernando GARCIA CORDERO and Mr Juan Pablo LLERENA LASTRA (Ecuardor) provided an overview of the new organizational structure of the Instituto Nacional de Meteorología e Hidrología (INAMHI) and the collaborative work being undertaken with various ministries within their country. It was noted that hours of operation of the NMHS was 16/7. It was indicated that various model products are used for weather forecasting, such as those form GFS, WRF and ECMWF. It was noted that different models are used with more confidence in different geographical areas. As well, there are approximately 75 stations operating providing precipitation data with about 42 providing real-time water level data. Data are available digitally on a monthly and daily basis. Sediment and water quality data are also available. Flood alerts are also provided 365 days of the year and are shared with emergency management. A colour coding is applied for flood alerts, with yellow being warning, red being imminent alert. Alert thresholds are based on observations.

They noted that there are 3 small X-band having a 30 km radius in the capital city of Quito. There is a German funded group working with one province that is using radar, unfortunately the data are not calibrated. Mention was also made of a C-band radar in Cuenca with data not being shared with the INAMHI. There are no current plans to install or develop radars within INAMHI.

Mr Waldo Sven LAVADO CASIMIRO and Mr Nelson QUISPE GUTIERREZ (Peru) provided an overview of the organizational structure of Servicio Nacional de Meteorología e Hidrología (SENAMHI). They showed some maps illustrating observing station locations. They indicated satellite data were used to monitor the evolution of systems causing rainfall, as currently there were no operational radars in Peru. They noted that there is one experimental radar, and there is no funding available to expand use of radar in Peru.

They noted that merging of in situ rainfall data with satellite data would be useful for flood forecasting. Rainfall forecasts are also monitored for areas that have risk of flash flooding, and they provided a cast study of an area that experiences flash flooding, which illustrated the need for an early warning system for flood forecasting. They indicated that use is made of the ETA (48 km) model, another model at 30 km resolution, and a 4 km resolution model in the north (west) once a day. They also indicated that it would be beneficial to have access to the ECMWF model results. As well, there are 215 precipitation stations reporting in real-time, 45 hydrological stations (water level and discharge, of which 60% are transmitted in real time. The hydrological stations have been in operation since 2015. They also commented that there were several landslides last year in Peru and that the national institute of civil defense maintains data on these.

Mr Christian EUSCATEGUI COLLAZOS (Colombia) provided an overview of the structure of the Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM) of Colombia. He indicated that IDEAM has access to ECMWF products and uses its quantitative precipitation forecasts at 9 km resolution. It is also experimenting with a WRF model at 3 km resolution using boundary conditions of the ECMWF model. IDEAM also has a 1.6 km resolution model running for Bogotá and has two models running for the Caribbean and Pacific coasts at 9 and 3 km resolution. The vision is to have the entire country modelled at a higher resolution than is currently available. For example, it would be advantageous to have a 3 km resolution model of the Andean region, and it is anticipated that this might be available in April 2018. It was also mentioned that IDEAM was working with GOES 16 satellite data, radar data and on merging these with in situ station data to have improved estimates of rainfall spatially over Colombia.

It was indicated that there are approximately 500 automatic real-time stations, with an approximate split of 300 being meteorological and 200 being hydrological (water level and discharge), while overall there are approximately 2,700 observing stations across the country. Since 2014, IDEAM has been using the Deltares FFEWS to assist it in flood forecasting for provision of early warnings; and in doing so, it has configured hydrological-hydraulic models for some major rivers and small basins. Models used include, but are not limited to, HBV, HEC-RAS, HEC-HMS, SOBEK, and MIKE 11.

Brief Overview of Zarumilla River FFGS Demonstration Project

Mr Konstantine GEORGAKAKOS provided a brief overview of the Zarumilla River FFGS demonstration project. He reminded participants that it was the Regional Association III Working Group on Hydrology that suggested this basin as a pilot to demonstrate the utility of the FFGS within South America. As well, the results of the application were shared and discussed at the workshop held in Lima Peru 16-18 August 2016 on Establishing Flash Flood Guidance Systems (FFGSs) for South America, where the meeting recommended the further implementation of the FFGS in South America.

He provided a step-by-step description of the process that was followed for the development of the FFGS for the Zarumilla basin, as it was illustrative of the process that will be followed for NWSAFFGS. He indicated that firstly, software is applied that has been developed over the last 25 years for delineating small basins. HRC does the first pass on delineations, with these being provided in the form of shape files to the countries. Countries review these and provide HRC with comments on where adjustments are needed. HRC then uses software to fine tune the delineations. These delineations then form the basis for our modelling of the area. It was stressed that it is very important that countries provide corrections to the delineations, as otherwise best local knowledge is not being used to advantage in correctly locating watershed divides within the modelling system.

He noted that the size of the basins are not randomly selected as the system is established, but rather that scale is dependent on what is available on soils, land-use and land-cover data, what type of rainfall input (e.g., satellite or radar) is available and its resolution. This process resulted in basins ranging from about 30 to 50 km^2. He indicated that the demonstration was for a specific period of time and was intended as a real-time application. Products from the application were available on-line for participants to access, and some features were presented.

He then indicated the second step is Quality Control (QC) of data from each station, both historical and real-time. Groups of stations are reviewed at different scales. Analysis is undertaken on the distribution of rainfall (cumulative distribution analysis). Comparisons are made with satellite data and some derivative products. This analysis identifies the bias adjustment factors to be applied to the remotely sensed data before their use in the hydrological models. He stressed that this was a very important step. This process also identifies key stations as well as some that should be dropped from further analysis due to bad quality data. Results show that the gridded satellite data need to be adjusted using in situ ground-based station data both by climatological adjustments dependent on season and region but also for the occasional large deviations from the same-scale gauge precipitation data averages. The second adjustments happen in real time through the use of adaptive filtering of large errors.

MR GEORGAKAKOS indicated that for flood forecasting satellite infrared-based products are available to the system as hourly accumulations, at 4 x 4 resolution, and are used to feed the hydrological component and produce the first line of flash flood guidance products. These products ae available quickly but are inferior to the satellite microwave-based products (also ingested by the system), which are available with considerable latency. Due to their latency, the microwave-based products are primarily used for soil water adjustments, as it is critical for the system land surface products to have good soil water estimates in real time.

He also indicated the need to have cross sections from natural river channels that span the range of basins within the FFGS system upon which regression analyses are performed. This allows parameters of the geomorphological unit hydrograph to be estimated based on locally available data. As well, he pointed out the need for local reference evapotranspiration (ET) data or climatologies. Using temperature data from individual stations in conjunction with climatological estimates of reference ET and land-use and land-cover digital data, HRC produces spatially varying estimates of evapotranspiration demand, necessary to run the land surface models. When validation data are available, model results are validated with river data and alert levels for minor flooding, that is over-bank flow levels. This was done for time periods of 1, 3, and 6 hours. He then illustrated and discussed various products from the FFGS such as merged mean areal precipitation, the depth-integrated soil water fraction for the basin (Average Soil Moisture (ASM)), the Flash Flood Guidance (FFG), and various forecast products.

He emphasized that the FFGS should be viewed as being forecaster centric and is not intended to be an automatic system to generate forecasts and warnings. Reliability is improved by having the forecaster making adjustments from what the system shows. HRC is building systems that are intended to support forecasters. He also indicated all data generated by the system are available for further use, so you can generate your own products. He indicated that, for example, vulnerability maps could be generated. He e-mailed participants a link to the FFGS for the Zarumilla River basin and reminded participants that this effort was a demonstration for a specific time period.

Benefits of the FFGS Implementation in the Region

A brief discussion focused on possible benefits of the application of the FFGS to Northwest South America. The discussion points are summarized as being:

- Forecaster-usable data and forecasted products are integrated from global, regional and local sources (including QPE and QPF) and the ability to use these externally
- Forecaster-usable products to permit real-time forecasting of flash flood occurrence
- Availability of extensive training in applied and operational hydrometeorology
- Products for soil moisture that are potentially useful for agriculture
- Enhancements of the current FFGS implementations that are being tested currently for selected regions and basins worldwide, are available for tailoring to the NWSA region and are relevant to water management (riverine forecasting and sub-seasonal to seasonal forecasting), landslide susceptibility assessments, and urban flash flooding

Possible Linkages between SWFDP and NWSAFFGS

Mr PILON, on behalf of colleagues in the WMO Weather and Disaster Risk Reduction Services (WDS) Department, informed the participants about the Severe Weather Forecasting Demonstration Project (SWFDP) of WMO, its objectives and goals, and efforts that have been made to progress on the potential application of the SWFDP Regional Subprojects in South America.

The SWFDP Vision is to enable NMHSs in developing countries to implement and maintain reliable and effective routine forecasting and severe weather warning programmes through enhanced use of Numerical Weather Prediction (NWP) products and delivery of timely and authoritative forecasts and early warnings ..." consistent with decisions of Cg-15 (2007) and Cg-16 (2011). The SWFDP uses a cascading forecasting process whereby global scale information is made available to the Regional Specialized Meteorological Centers (RSMCs) or network of centers that integrate and synthesize information to provide daily guidance to the NMHSs to generate warnings for their areas of responsibilities. An integral part of SWFDPs is regular training in NWP and Ensemble Prediction Systems (EPSs) as well as in Public Weather Services and verification processes. As well, the SWFDP is consistent with the WMO Strategy for Service Delivery (Cg-17, 2015) and is promoting the use the move to impact-based forecasts and risk-based warnings.

A Technical Planning Workshop on exploring the potential for a SWFDP for South America was held in Ascension from 2-3 October, 2017, following the meeting of the Regional Association (RA) III Working Group on Infrastructure. It was organized in response to the request of RA III to WMO, based on the recommendation of the Initial Planning Meeting for the Establishment of a Flash Floods Guidance System (FFGS) for South America, which was held in 2016 in Lima, Peru. The Workshop participants: reviewed current operating environment of NMSs in RA III; agreed on a number of recommendations to be made to the Permanent Representatives of RA III; and called for a plan for the development of a SWFDP for RA III.

The Workshop participants recommended that the implementation of the Project should be planned at the regional level and implemented through sub-regional components that would be will be defined by an expert Work Team. Participants felt this Team should comprise experts based on the participants of the Technical Planning Workshop, to develop the Project in coordination with the RA III Working Groups on Hydrology and Infrastructure. A short presentation is planned to be given to CIMHET in Curaçao (7 to 9 March 2018) on the outcomes of the Technical Planning Workshop and seek the immediate formalization of the expert Task Team with a Terms of Reference to prepare the draft Implementation Plan for consideration of RA III in its17th Session to be held in November 2018.

Overview of FFGS for Northwest South America

Mr GEORGAKAKOS (HRC) explained the role of HRC and presented scientific and technical aspects of the Flash Flood Guidance System (FFGS). These were given at the introductory level and included an overview of the general concept of the FFGS, building on the Zarumilla demonstration presentation, and included causes of flash flood events, flash flood guidance definitions, soil moisture model parameterization, snow model, satellite precipitation estimation and bias adjustment, threshold runoff, and data requirements for NWSAFFGS. He also briefly introduced the FFGS Hydrometeorologist Training Programme.

He first explained some key definitions and characteristics. He explained the following satellite precipitation products:

- 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 microwave satellite precipitation;
- Gauge Mean Areal Precipitation (Gauge MAP), which is estimated by using WMO synoptic reports obtained from the WMO GTS network and spatial interpolation; and
- Merged Mean Areal Precipitation (Merged MAP), which is derived from the best available mean areal precipitation estimates from GHE precipitation or MWGHE precipitation or Gauge MAP or Radar estimated precipitation.

He indicated that the Merged MAP is the bias adjusted precipitation product to be ingested into FFGS models; namely the SNOW 17, Sacramento Soil Moisture Accounting (SAC-SMA) and Flash Flood Threat models. The Forecast Mean Areal Precipitation (FMAP) is often generated using applications of numerical weather prediction Limited Area Models (LAMs), such as ALADIN and WRF. He continued by explaining other FFGS products:

- Average Soil Moisture (ASM), which indicates upper soil (20-30 cm) water content, including free (to move under the influence of gravity) and tension (bound to soil particles with molecular forces) 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).

He also presented on some recent efforts to advance FFGS functionalities, such as Urban Flash Flood Warning, use of satellite inundation mapping to correct soil moisture, landslide susceptibility mapping, channel routing (riverine forecasting), sub-seasonal to seasonal forecasting, and the new Map Server interface.

Mr GEORGAKAKOS explained the importance of using local data in the FFGS to calibrate model parameters. He also emphasized the importance of participating countries in providing their available historical hydrometeorological data to HRC and in making real-time precipitation data accessible; otherwise, only global data with coarse resolution would be used. The importance of the use of real-time precipitation data to bias-adjust satellite precipitation estimates was also stressed. He reviewed the various data types required for the FFGS, 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. He also pointed out that there was a need to share historical and real-time radar CAPPI hourly precipitation accumulations as available or alternative radar products useful for hydrological modelling.

Mr GEORGAKAKOS stated that training was an integral part of all FFGS projects, and extensive training would be provided to the participant countries' forecasters. He showed the schematic diagram outlining the FFGS hydrometeorologist training programme, which is contained in Appendix A of Annex 4 of this report. He explained that it consisted of five steps:

- Step 1 introductory regional workshop;
- Step 2 eLearning hydrometeorologist training;
- Step 3 specialized training at HRC;

- Step 4 regional operations training workshop; and
- Step 5 regional operational sustainability workshop.

He further articulated that when the training was completed, forecasters should be confident and competent to use FFGS products for flash flood forecasting and the provision of early warnings.

Facilitated Discussions

Colombian experts indicated that IDEAM used .5 degree radar data rather than CAPPIs to avoid ground clutter. They were curious to know if using different degrees for different radars might pose a problem to HRC for use in the FFGS. Mr GEORGAKAKOS indicated the preference was to use CAPPIs as they provide more stable estimates of rainfall. When using CAPPI data, he indicated that HRC analyses them and then removes ground clutter. He noted that in order to clear certain obstructions, there might be the need to estimate CAPPIs from volume scans from different elevations. He indicated that should IDEAM not have volume scans, HRC would use the angle available and do computations for each radar for bias for range and sector. It is feasible to do this, but more adjustments are needed.

Participants from Ecuador indicated that INAMHI was willing to share its precipitation and temperature data given there is a confidentially agreement and that this is a WMO project. Concern was expressed on the possible lack of QA/QC programmes, which might need to be strengthened. As well, the participants indicated that they would check to see if data could be made available from the 3 X-Band radars in the area of the city of Quito.

Mr GEORGAKAKOS indicated that part of the FFGS includes QA/QC checking. The QA/QC includes automated checking gradients and magnitude bounds. While the system is at HRC, staff run QA/QC on all historical data (temporal, spatial, etc.) and lets the participating countries know what has been detected. He indicated that the automated procedures run for one gauge at a time. He also commented on arrival of “late” data that might be one or two days old. Regarding receipt of delayed data, the systems runs from two days prior to the present forecast preparation time and repeats several times during the six hour period of data update in order to update system states to ensure it captures and reflects the latest available data.

Participants from Peru indicated that SENAMHI has no restrictions on sharing its data, particularly given this is a WMO project. They also indicated that this policy was consistent with the national law on freedom of information. They indicated that one key point of concern was on QA/QC of observed data. As well, they indicated that on occasion there might be communication issues in getting data from the field to the office.

Participants from Colombia indicated that IDEAM has an open data policy for hydrological data (precipitation, temperature, water level and discharge data). IDEAM participants also expressed concern regarding the QA/QC of precipitation daily for both daily and hourly values. Regarding historical data, participants indicated that IDEAM had about 750 stations.

Common Alerting Protocol

Mr Eliot CHRISTIAN (United States of America) provided a detailed overview of the Common Alerting Protocol, also know broadly as “CAP”. He indicated that he was willing to share his material electronically including pdf lecture notes. He was pleased to have these made available on the WMO website for the meeting.

Participants discussed potential use of CAP and had several questions for Mr CHRISTIAN concerning details of how they can more fully leverage CAP as they complete their initial implementations. Participants were pleased with his offer to assist them in facilitating the use of CAP within their nations. IDEAM in Colombia has had an operational CAP system for years, as IDEAM asserted when the meeting participants visited their office. INAMHI in Ecuador started its CAP implementation as "Alert-EC" with support from INMET in Brazil, which offers an operational CAP system (Alert-AS) free for use by all countries in South America. As of this writing, SENAMHI in Peru has its CAP system in testing.

Roles and Responsibilities of NMHSs and the Regional Centre

Mr PILON outlined the roles and responsibilities of NMHSs and Regional Centre for the NWSAFFGS. NMHSs have the following responsibilities: to provide historical data to the project developer, HRC; to provide in-situ data to the Regional Centre; to participate actively in the flash flood hydrometeorological training programme; to issue flash flood warnings and disseminate them to their national Disaster Management Authority; and to cooperate with the Regional Centre on the NWSAFGS issues. He then presented on the roles and responsibilities of the Regional Centre. They include: to communicate effectively with WMO, HRC and NMHSs on NWSAFFGS activities; to have good computer network connectivity including to the Internet for receiving data and sharing products; to monitor routinely the availability of NWSAFFGS products; and to conduct flash flood validation studies. Detailed information about roles and responsibilities of NMHSs and the Regional Centre are provided in Annex 4 (Appendix A) of this document.

Mr PILON provided a brief overview of the organizational and managerial aspects of the project, reiterating the roles and responsibilities of the NMHSs and the Regional Centre. He then introduced the concept of a Project Steering Committee (PSC) and its composition, indicating that each participating country would be represented on it, as well as HRC, USAID/OFDA, US National Weather Service, and the Regional Centre. Details of the PSC are found in Annex 5, while the Implementation Requirements are provided in Annex 4 of this document. Mr PILON also described the process by which countries would possibly let the WMO Secretariat know of their formal desire to participate in the project. This is through a Letter of Commitment to be sent to the Secretary-General of WMO from the Permanent Representative of the country that wishes to participate. A sample Letter of Commitment is provided in Annex 6.

There was mention made that it was a challenge to improve quantitative forecasts and that it would be beneficial if the Regional Centre ran a high resolution model for the region covered by the NWSAFFGS. It was also mentioned that it would be beneficial for the Regional Centre to “homogenize” NWP outputs for use by the system. Mr GEORGAKAKOS indicated that the FFGS can ingest up to 5 different model streams and provide products for each stream, so theoretically it could have one from Ecuador and Peru, as well as the Regional Centre.

Interest of the Participating Countries

During the facilitated discussions, participants asked a number of questions about the FFGS products and system operations. After clarifications were made by HRC and WMO, all participants of the three countries (Colombia, Ecuador and Peru) indicated agreement that implementation of the FFGS would be very useful for their countries particularly given the importance and value of issuing flash flood warnings. As well, such implementation was seen as being an important contribution to enhancing their national capabilities and would also help foster closer regional cooperation on disaster risk reduction. Participants indicated that although they expressed the desire to participate in the project, they will need to seek the approval of their respective governments. Participants indicated that consideration would be given to providing a Letter of Commitment, consistent with the sample letter found in Annex 6. Participants were kindly asked to send their Letter of Commitment to WMO by the end of March to start the implementation of the project.

Offer of the Regional Centre

Participants from IDEAM, expressed the willingness of the Colombian NMHS to host the Regional Centre for the NWSAFFGS, saying, as well, that Colombia may need assistance from WMO and HRC for the implementation and operation of the system and that IDEAM would need to more formally consider this prior to arriving at a final decision. Participants from Ecuador and Peru were pleased with the kind offer of Colombia to host the Regional Centre. Representatives of WMO and HRC ensured him of their organizations support for the successful implementation of the NWSAFFGS.

Project Implementation Plan

Mr GEOGAKAKOS and Mr PILON described the project implementation plan, showing the major tasks, milestones, and schedule. The draft implementation plan was discussed, indicating that dates are usually somewhat flexible but are best estimates of when items will be delivered or completed. The draft implementation plan is given in Annex 7. Delegates agreed on the project implementation plan, saying that they would do their utmost to comply with the plan.

Closing of the Planning Workshop

The Initial Planning Meeting agreed on a number of conclusions. These appear in Section 5 of this report.

Closing remarks were made by Mr Nelson Omar VARGAS (IDEAM) and Mr PILON (WMO). Thanks were also extended to all attendees for their active participation in the meeting and their spirited involvement in the discussions, which contributed to the successful conclusion of the meeting. Participants expressed that they were much looking forward to working towards the successful implementation of the system

5. Conclusions from the Initial Planning Meeting

1. There was agreement among participants that the development and implementation of the NWSAFFG system will significantly improve the capabilities of the NMHSs of Colombia, Ecuador, and Peru to produce timely and accurate warnings of flash flood induced hazards, thereby contributing to disaster risk reduction by saving lives and reducing property damages.

Participants discussed the concept and expected results of the NWSAFFG project and agreed that it was consistent with the global aspect of the Flash Flood Guidance System and its regional implementation projects. The objective of the Northwest South America Flash Flood Guidance project is to contribute towards reducing the vulnerability of the region to hydrometeorological hazards, specifically flash floods, by developing and implementing a Flash Flood Guidance System to strengthen regional capacity to develop timely and accurate flash flood warnings.

2. Participants agreed that the official name of this initiative will be Northwest South America Flash Flood Guidance (NWSAFFG) project. This name will be used in all documents and communications.

3. Workshop participants noted that the FFGS has a global aspect and that it is being implemented as a component of the WMO Flood Forecasting Initiative (WMO-FFI). The intent is that the implemented FFGS will be fully integrated into the day-to-day operational activities of the National Meteorological and Hydrological Services responsible for the provision of flash flood early warnings.

4. Participants agreed in principle on the following core elements of this regional project:

- General concept and technical approach chosen to provide Flash Flood Guidance;
- Roles and responsibilities of the dedicated Regional Centre and the National Meteorological and Hydrological Services for project implementation;
- Project governance including the roles of all partners;
- Guiding principles for the implementation of the NWSAFFG system; and
- Concept of Operations.

All items listed above are provided in the Project Brief (Concept Note) document, which is Annex 3, and in the Implementation Requirements document, which is Annex 4. These are also supplemented through the discussions and conclusions arising from the Initial Planning Meeting held in Bogotá, Colombia, on 20-22 February 2018.

5. With regard to the governance of the project, participants agreed on the structure and interim terms of reference of a Project Steering Committee (PSC) as attached as Annex 5 to this report.

6. To enable the effective functioning of the PSC, the participants agreed that participating countries should designate, through their Permanent Representative with WMO and after consultation with their hydrological advisor, focal points and alternates in serving on the PSC, with the expectation that these designates would serve throughout the duration of the project.

7. The participants agreed that once government approvals to participate in the NWSAFFG project had been obtained, Letters of Commitment (LoC) of the participating countries should be signed by the Permanent Representatives with WMO and sent to the secretary-General of WMO. It is proposed that wherever feasible, the letters should reach WMO not later than May 2018 (see draft Letter of Commitment in Annex 6).

8. Participants noted with appreciation the offer of the NMHS of Colombia to provide services as the Regional Centre for the project within the terms of reference as described in the "Implementation Requirements" document. The offer was discussed in detail and was accepted

unanimously by all country representatives. Additional correspondence from the NMHS of the Colombia will be required to confirm its offer of hosting the Regional Centre.

9. WMO and HRC will work with the NMHS of Colombia to assist it in establishing the functionality of the Regional Centre, to facilitate data transfer for project implementation, and to provide forecast products to participating countries.

10. WMO requested HRC, the Regional Centre, and the participating countries to develop, at the earliest, direct communication links to facilitate project implementation.

11. Participants recognized that the incorporation of local data and information are necessary to enhance system reliability, accuracy and effectiveness in the provision of flash flood early warnings.

12. With a view to a timely implementation of the project, the participants agreed to comply as much as possible with data requirements specified in Appendix B of Annex 4 such that the following data will be transferred to HRC through the Regional Centre, which is responsible for data exchange between the NWSAFFG developer (HRC) and NMHSs:

- Historical hydrometeorological data since May 2012 to present;
- Soil data, vegetation cover and stream network;
- Metadata of hydrometeorological stations; and
- Quality controlled Digital Elevation Model (DEM) data.

13. Participants noted the data and information requirements of the project at the global, regional and local levels. The required data, metadata and related information were discussed at the Initial Planning Meeting and are specified and documented in the Implementation Requirements document that is contained in Annex 4. HRC will contact focal points and their alternates regarding data and information questionnaires. The feed-back information from focal points (and alternates) should reach the Hydrologic Research Center (HRC) and the Regional Centre according to the Implementation Plan (Annex 7), which had been agreed upon at the Initial Planning Meeting.

14. Participants agreed that the establishment of the system is a collaborative endeavour, based on the continuous feedback between development and testing, and between the Regional Centre and the three participating countries. Participants recognized also that a successful design and reliable operation of the NWSAFFG requires high quality data provided in a timely manner to the Regional Centre. The real time data of selected hydrometerological stations needs to be transferred to the Regional Centre as per the Implementation Plan through the WMO GTS and/or ftp services and/or other means.

15. To facilitate system implementation, it was agreed that data, metadata and related information needs to be transferred to the Regional Centre as soon as they become available within the timelines to be specified in the Implementation Plan. The Regional Centre will establish promptly a dedicated and secured FTP server to ensure safe data transfer.

16. Subject to the fulfilment of commitments by the NMHSs, WMO in collaboration with HRC and the Regional Centre will strive to deliver beta-versions of first regional products by May 2019.

17. Participants agreed on the proposed milestones for the Implementation Plan that are included as Annex 7 to this report.

18. Participants noted that WMO, within the limitations of available resources, will provide overall project coordination and necessary support to activities that lead to the successful implementation of the project. This includes, inter alia, the development and provision of training programmes that will be undertaken by the Regional Centre, HRC, and WMO.

19. Participants noted that there is a great benefit for the concurrent implementation of the Severe Weather Forecasting Demonstration Project for South America and NWSAFFGS in the region such that these two projects can be linked to exchange data and products such as Quantitative Precipitation Forecasts (QPFs) of the high resolution numerical weather prediction model and nowcasting to enhance flash flood early warning capabilities.

ANNEX 1

Development and Implementation of
the Northwest South America Flash Flood Guidance System (NWSAFFGS)

Initial Planning Meeting
(Bogotá, Colombia, 20 – 22 February 2018)

List of participants

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ANNEX 2

Development and Implementation of the Northwest South America Flash Flood Guidance System (NWSAFFGS)

INITIAL PLANNING MEETING

Bogotá, Colombia, 20-22 February 2018

Final Agenda

<u>Day 1</u>

Opening Session

09:00–09:30	Registration
09:30–10:00	Opening of the Meeting (IDEAM, WMO, USAID/OFDA, HRC)
10:00–10:15	Purposes of the meeting (WMO)
10:15–10:30	Photo session

10:30 - 11:00 Tea Break

11:00-11:15	Review of Draft Agenda and Introduction of participants (All)
11:15-11:30	Overview of the global FFGS (WMO)
11:30-11:45	Role of WMO (WMO)
11:45-12:00	Role of HRC and NOAA (HRC)
12:00–12:15	Role of USAID/OFDA (USAID/OFDA)
12:15-13:00	Overview of existing flash flood forecasting and warning infrastructures of NMHSs of Northwest South America (Country presentations[2])

- National capacity for the provision of flash flood early warnings;
- National capacity for weather forecasting and nowcasting (high resolution Limited Area Models, meteorological data processing and visualization software);
- Current hydrometeorological networks (number and types of meteorological and hydrometric stations, Radar network, data dissemination methods, GTS reporting, databases);
- Availability of systematically observed hydrometeorological data (availability of the data, data types, digital or paper, periods of coverage) since May 2012;
- Any archives they have on past flash flood events that show the time and place (coordinates) of occurrence.
- Organizational structure and human resources (7/24 working, number of trained forecasters, forecasting department); and

[2] Each presentation will have maximum 10 slides and will be limited to 15 minutes.

- Collaboration with emergency management agencies other governmental and non-governmental (private sector, TV, Radio etc.) organizations;
    - o Brief overview of products and services provided, and the form with which they are provided.

13:00-14:00 Lunch

14:00-15:00 Facilitated discussion on *current* flash flood forecasting approaches in the region (All)
15:00-15:30 Brief overview of Zarumilla River Basin FFGS demonstration project (HRC)

15:30-16:00 Tea Break

16:00-16:30 Benefits of the Flash Flood guidance System Implementation in the Region (HRC)
16:30-17:00 Possible linkage between SWFDP and NWSAFFGS (WMO)

18:00-20:00 Networking event

<u>Day 2</u>

09:00-09:30 Summary of Day 1 (Chair)
09:30-10:30 Overview of the Flash Flood Guidance System (FFG) for the Northwest South America Region

- Introduction to the NWSAFFG system
- Background and key components
- Delineations
- Radar data ingestion
- High Resolution Mesoscale QPF ingestion
- Nowcasting

10:30 - 11:00 Tea Break

11:00-12:30 Overview of the Flash Flood Guidance System (FFGS) for the Northwest South America Region – Continued (HRC)

- FFGS products
- Product use
- Map Server Interface
- Enhancements
- Training Program

12:30–14:00 Lunch

14:00-14:15 Data requirements for the NWSAFFGS (HRC)
14:15-15:00 Facilitated discussions on the availability and access to historical and real-time data and information (All)
15:00-15:30 Data priorities (HRC)

15:30-16:00 Tea Break

16:00- Visit to IDEAM (TBC)

Day 3

09:00-10:30: Presentation of CAP (Common Alerting Protocol) Program (NOAA/WMO), followed by Q/A

10:30-11:00 Tea Break

11:00-11:30 Roles and responsibilities of the participating NMHSs and the Regional Centre in NWSAFFGS (WMO)

11:30-12:00 Facilitated discussions on the national professional and technical capacities needed for national project operations (All)

12:00-12:30 Organizational and management aspects of project planning and implementation (WMO)

12:30 – 14:00 Lunch

14:00 -15:00 Facilitated discussion on interest of countries to participate in the project, including establishment of the Regional Centre (All)

15:00-15:30 Next steps and work plan (HRC)

15:30-16:00 Tea 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------

Northwest South America Flash Flood Guidance System (NWSAFFGS)

Concept Note

As part of the Flash Flood Guidance System (FFGS) project with global coverage, which was developed by the World Meteorological Organization (WMO), the U.S. Agency for International Development Office of Foreign Disaster Assistance (USAID/OFDA), the U.S. National Oceanic and Atmospheric Administration (NOAA) and the Hydrologic Research Center (HRC), this Concept Note addresses the development and implementation, with associated training, of a regional FFGS that encompasses the countries of Colombia, Ecuador, and Peru in South America.

FFGS systems have been or are being implemented for multi-country regions around the world as shown in the following map (Figure 1). The general implementation approach is designed to support capacity building in the regions and aims at the reduction of flash flood hazard impacts to life. The approach is summarized in the Appendix A that accompanies this project note.

Following formal WMO requirements for the establishment of a regional centre in an FFGS region, the participant countries identify the country that will host such a centre. The regional system is then implemented in that regional centre, and the participating countries have access to diagnostic and prognostic images and data through secure internet links.

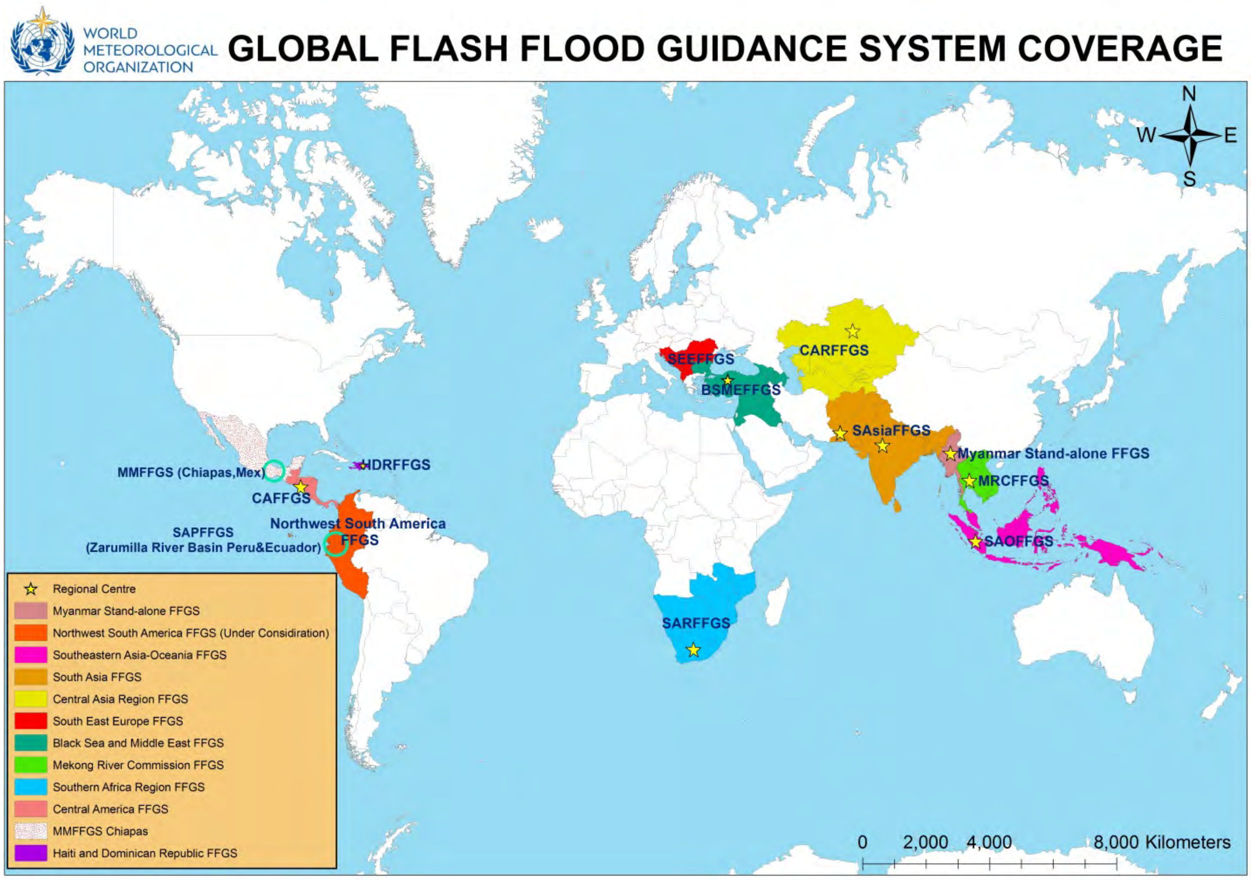

Figure 1. Map of FFGS Region coverage around the world as of the date of this writing[3].

For the region of interest in South America, there has been a demonstration and there is regional consensus of NMHSs that support a full implementation of the FFGS. An initial meeting in 2011 in Santiago, Chile with participants from the Working Group of Hydrology and Water Resources endorsed the development of a demonstration project in the Zarumilla River basin which falls within Ecuador and Peru.

HRC developed a demonstration FFGS for that basin using data and information provided by the two countries for a historical period (Figures 2 and 3). A planning workshop held in Lima, Peru 16-18 August 2016 endorsed the implementation of a full scale FFGS for several regions in South America, beginning with the region of Colombia, Ecuador and Peru. For the purposes of this document we will call the new system by NWSAFFGS using the initials of the three countries.

[3] Adopted from: http://www.wmo.int/pages/prog/hwrp/flood/ffgs/index_en.php.

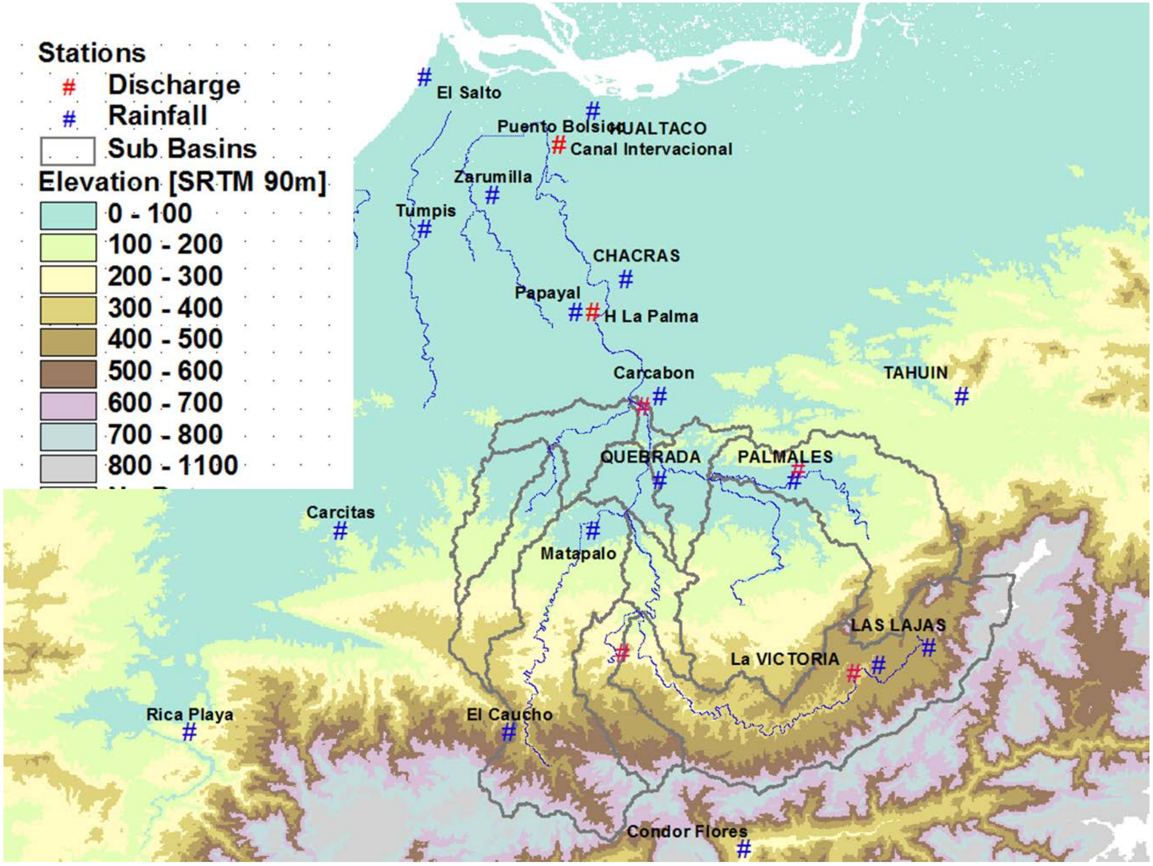

Figure 2. A topographic map of the Zarumilla River basin. Meteorological and hydrological stations are indicated in blue (precipitation) and red (discharge), respectively.

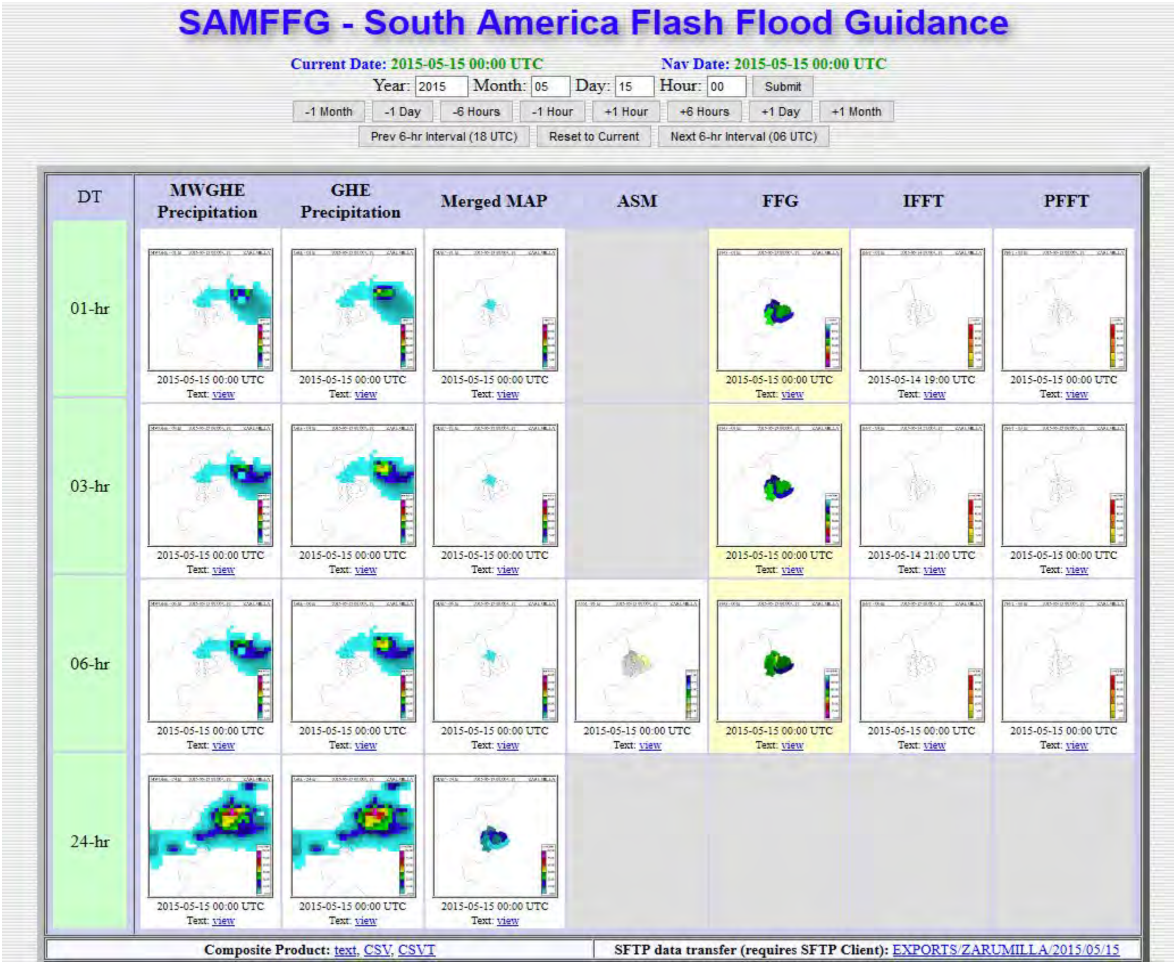

Figure 3. Forecaster interface panels for the Zarumilla River basin demonstration FFGS.

Figure 3 provides panels of:

- MWGHE – Microwave-adjusted global Hydroestimator precipitation (gridded);
- GHE – Global Hydroestimator precipitation (gridded); Merged MAP – Mean Areal Precipitation produced by bias adjusting satellite products with on-site raingauge data;
- ASM – Average Soil Moisture for upper soil layer of each basin;
- FFG – Flash Flood Guidance;
- IFFT – Imminent Flash Flood Threat; and
- PFFT – Persistence Flash Flood Threat.

Development and Implementation of Standard NWSAFFG System

Development and implementation of the complete NWSAFFG system will cover three countries in the region, namely Colombia, Ecuador and Peru (Figure 4). It will be implemented in two phases. Phase one will include standard flash flood guidance system with landslide module and weather Radar data ingestion. Phase two will include FFG advanced modules - Riverine Routing and Urban Flash Flood Early Warning System for selected River Basins and cities in the participating countries. The system under phase one will be implemented initially at HRC and then, when it has been completed and tested, it will be transferred to the Regional Centre with appropriate IT training and documentation. Phase one major activities are specified below.

Figure 4. NWSAFFGS Coverage

Standardized System Implementation

- Delineation of the basins in the NWSAFFGS domain, including quality control (QC). Delineation of 100-150 km^2 sub-basins in land domain of more than 2.5 million square kilometres and QC of delineations with local feedback. Higher resolution delineations will be undertaken for those areas covered by operational weather Radars;

- Adaptation and implementation of FFGS backbone to the NWSAFFGS with multi-model ensemble feature;

- Real-time data ingestion into NWSAFFGS-Radar and real-time gauge data ingest into the NWSAFFGS through the Regional Centre;

- Bias adjustment and calibration of the satellite precipitation data with local historical data;

- Calibration of soil, snow and channel models, and relevant system software adjustments; estimation of model parameters, including threshold runoff; and estimation of snow cover extent in southern hemisphere from satellite data;

- Implementation and calibration of landslide module for the NWSAFFGS domain. Landslide module calibration and implementation; and

- Radar rainfall calibration and ingest into the NWSAFFG system, including development of clutter masks and bias adjustment factors using historical weather Radar data; and generation of gridded Radar precipitation data for processing and display.

Training Workshops and Meetings

Training is an integral part of the NWSAFFGS project, and extensive training would be provided to the forecasters from the participating NMHSs. The flash flood hydrometeorlogist training programme consists of the following steps:

Step 1 introductory regional workshop;

Step 2 eLearning hydrometeorological training;

Step 3 specialized training at HRC;

Step 4 regional operations training workshop; and

Step 5 regional operational sustainability workshops

Installation of the Servers and IT training

Servers will be purchased and installed at the Regional Centre to exchange hydrometeorological data, run FFGS models and display the NWSAFFGS products. Forecasters from the participating countries will access the servers to display the NWSAFFGS products to assess the need for issuing flash flood warnings and forecasts. After the installation of the servers, IT training will be provided to the IT staff of the Regional Centre, and a maintenance guide will also be provided.

Implementation of Advanced FFGS Modules

Riverine Routing and Urban Flash Flood Early Warning System (Urban FFEWS) are advanced functionality of the Flash Flood Guidance System. They are implemented on top of standard FFG system, using its existing products such as precipitation, soil moisture and run off. It is efficient to implement such modules after the completion of the standard FFG system. Within the scope of this project, it is envisaged to implement riverine routing and Urban Flash Flood Early Warning Systems in selected Rivers Basins and cities.

Appendix A

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

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

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.

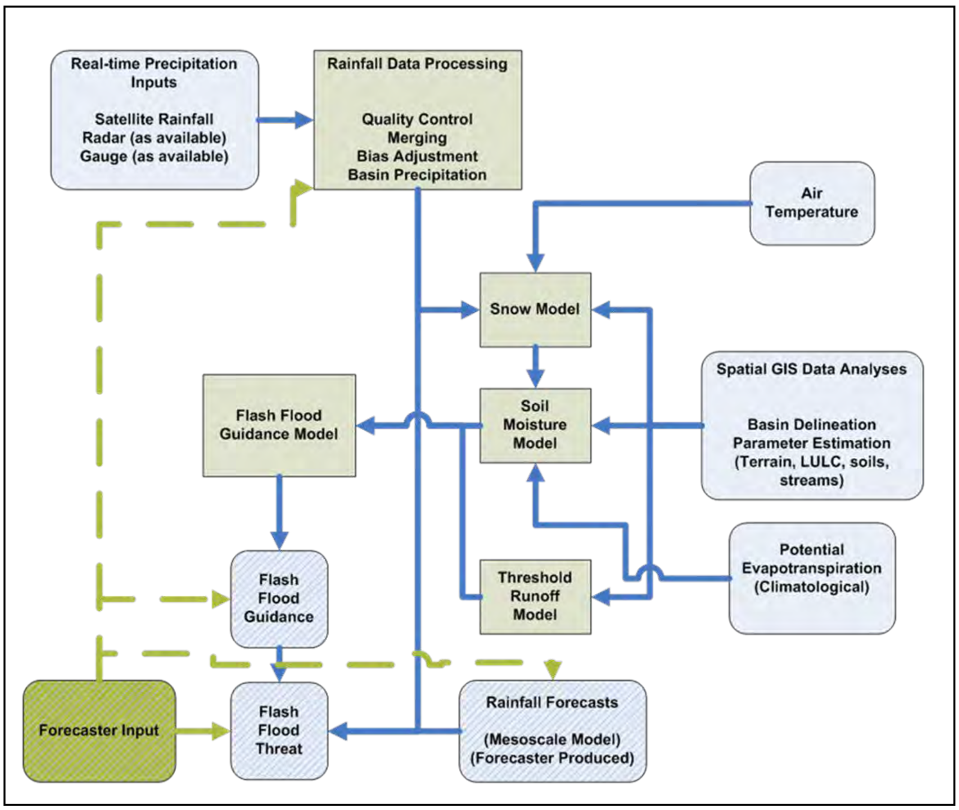

Figure 1. Schematic Flow Chart of the Flash Flood Guidance System.

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.

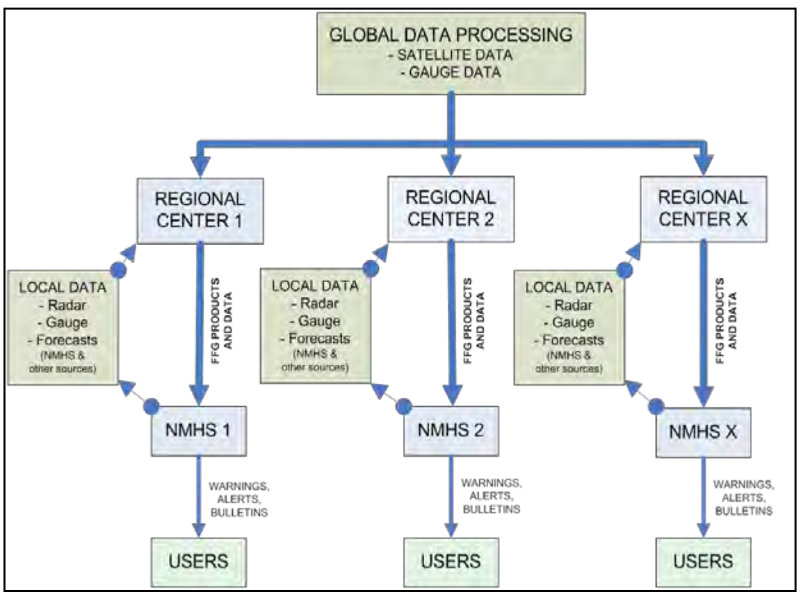

Figure 2. Flash Flood Guidance and Warning System as a distributed system of computer hardware, data and information to support NMHSs. worldwide.

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 FFGS 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 FFGS;
- 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 FFGS 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.

ANNEX 4

GLOBAL FLASH FLOOD GUIDANCE SYSTEM

Implementation Requirements

Regional Implementation Requirements for the Northwest South America Flash Flood Guidance System (NWSAFFGS)

February 2018

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)** with global coverage. In addition, the document provides information of the functions of the Regional Centre 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 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 products 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 sub-basins from 100 - 150 km^2 in size.

Important technical elements of the FFGS are the development and use of a precipitation gauge-based bias-corrected satellite precipitation estimate field and the use of hydrological modelling. The system then provides information on rainfall and hydrological 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 (FFT)** and flooding at or near the catchment outlet may be likely (Figure-1).

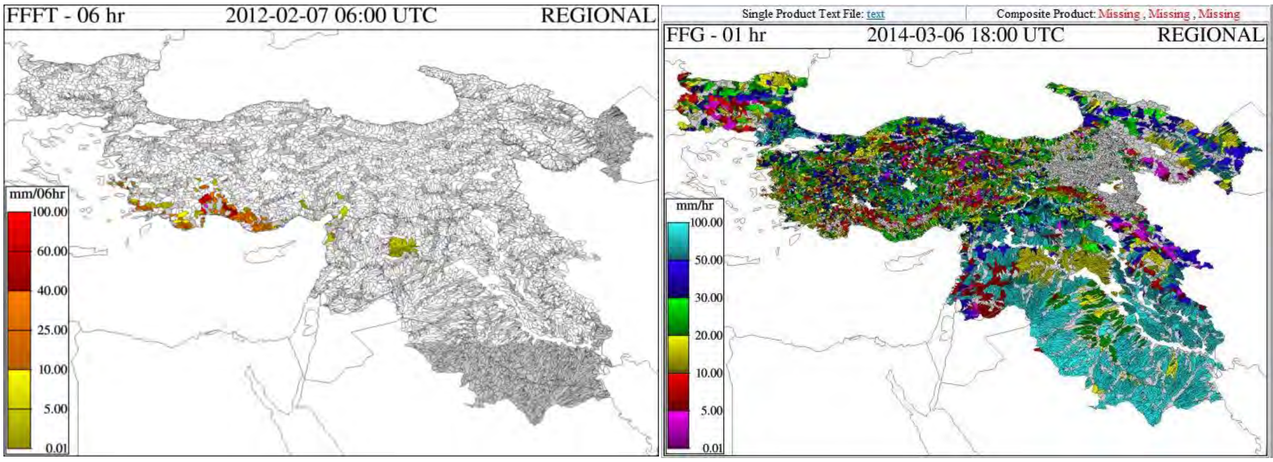

Figure-1: 6hr-Flash Flood Threat and 1-hr Flash Flood Guidance for Black Sea and Middle East FFG (BSMEFFG) System

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 programs in Central America, Southeast 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[4] through funding by the U.S. Agency for International Development/Office of U.S. Foreign Disaster Assistance (USAID/OFDA).

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-2.

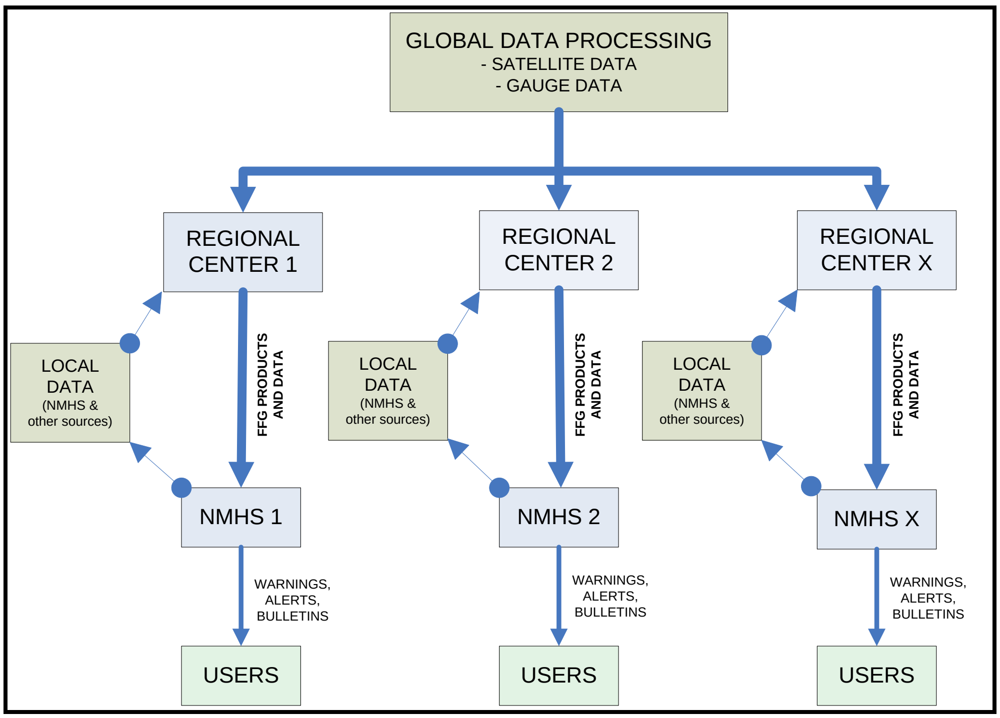

Figure-2: GFFG System Schematic – Global Implementation

Implementations of regional projects are achieved through the development of an interface with the global core and with the Regional Centres. The global data core link to real-time global satellite precipitation estimates will be through the U.S. National Oceanic and Atmospheric Administration/National Environmental Satellite, Data and Information Service (NOAA/NESDIS). If required, global in situ observations will be provided through one or more of the World Meteorological Organization (WMO) Global Centres (Washington, DC; Moscow; and

[4]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"

Melbourne) and Regional Telecommunication Hubs including Bangkok, Beijing, New Delhi and Tokyo. The primary functions of the global data ingest and processing core are to:

- Provide global data ingest and quality control;
- Access global meteorological information to supplement data collected at the regional level as needed;
- Maintain correspondence with the Regional Centres; and
- Implement computational system changes.

The Regional Centres will require ***appropriate communications*** and ***infrastructure facilities*** to support operations. The proposed responsibilities of the Regional Centres are outlined in Appendix A.

In summary, the Regional Centres responsibilities are to:

- Disseminate real-time detailed country graphical products and/or data for the NMHSs in the region;
- Provide routine regional hydrometeorological analysis;
- Provide communications for system analyses to NMHSs of region;
- Provide communications of regional system modifications necessary to developers;
- Provide regional flash flood hazard information;
- Provide regional *validation of products* and formulation of plans for improvements;
- Provide daily *guidance discussion* to NMHSs from a regional perspective;
- Collect available *real-time meteorological data* for the development of regional products;
- Provide *regional training* of NMHSs representatives;
- Provide, if necessary, a *computational platform* for country scale real-time computations and modifications of flash flood guidance products for those NMHSs that lack adequate computational capabilities;
- Provide routine *maintenance and IT support*; and
- Develop *a historical archive* of the system products.

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 (products) performance (availability and effectiveness), conduct country *verification studies* 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 expertizes are given in Table-1.

Table-1: Minimal personnel Equipment for Regional Centre and NMHSs

Area of Expertise	Regional Centres	NMHSs
Have a meteorological and/or hydrological technical background.	Both meteorological and hydrological forecast expertise.	Either meteorological and/or hydrological forecast expertise.
Have experience in operational weather and/or hydrological 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 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.

Computers and Communications

High performance servers with the LINUX operating system will be run at the Regional Centres through the project. The country NMHSs are required to have current-generation PCs and an internet connection with periphery devices in order to access products from the internet. On the other hand, the Regional Centre will need hi-speed internet service and, potentially, access to GTS/WIS.

Training Program

During the course of the FFGS 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 3). 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; and

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.

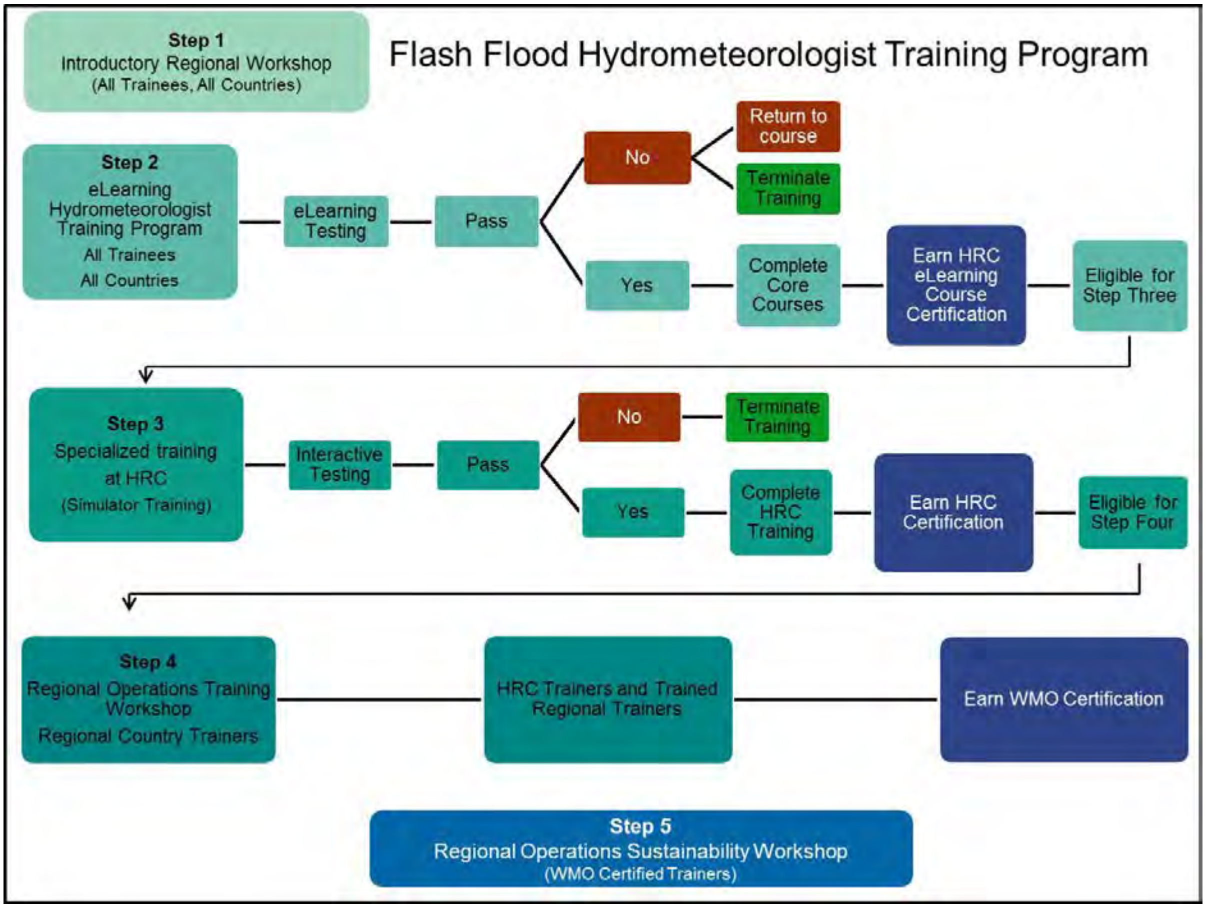

Figure 3. Illustrating five steps of the Flash Flood Hydrometeorologist Training Program

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; and
- 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; and

- 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; and

- 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

Area of Expertise	Regional Centre
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 Northwest South America 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 FFGS Program partners during FFGS implementation and operations;
- Provide regional and national validation of FFGS 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 FFGS,
- 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 FFGS 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; and
    - 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: and
- 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?

ANNEX 5

Project Steering Committee (PSC)

Preamble: The Project Steering Committee (PSC) provides overall governance of the 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 of the Northwest South America Flash Flood Guidance System (NWSAFFGS) project and partner organizations.

Table-1 Composition of Steering committee

Organization	No of Representatives
Regional Centre	1
Colombia	1
Ecuador	1
Peru	1
Partner (US NWS)	1
Development Partner (HRC)	1
Donor (USAID/OFDA)	1
WMO	1

Additional experts/representatives are to 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 (intermediate) principle terms of reference of the PSC are as follows:

- 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;
- Provide technical and administrative guidance to the implementation of the project;
- Establish an adequate *monitoring and evaluation* (M&E) system for the project and implement findings from the M&E process;
- Review and update the *project implementation plan* (PIP);
- Promote benefits of the project on national and regional levels;
- Facilitate links with other regional and national relevant projects, including Severe Weather Forecast Demonstration Project (SWFDP), regional World Bank hydrometeorological early warning projects;
- Ensure cross-sector linkages with relevant national and international organizations; and

- 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, tele-conferences 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 NWSAFFGS Implementation

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

- Data providers remain owners of data. Data provided to the Technical Development Partner (Hydrologic Research Center, HRC), will be used solely for the purpose of building 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) and Resolution 25 (WMO CG-XIII) Exchange of hydrological data and products (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; and
- Full responsibility for provision of national flash flood guidance and warnings remains with the participating NMHS.

ANNEX 6

Letter of Commitment

(SAMPLE – DRAFT)

To be addressed to the Secretary-General of WMO

Subject: **Letter of Commitment regarding Northwest South America Flash Flood Guidance System (NWSAFFGS) project**

Dear Mr Taalas,

Reference is made to the Initial Planning Meeting of the NWSAFFGS in Bogotá, Colombia, from 20 to 22 February 2018, which was organized by the World Meteorological Organization (WMO) in cooperation with the Hydrologic Research Center (HRC), the U.S. National Weather Service and the U.S. Agency for International Development/Office of the U.S. Foreign Disaster Assistance (USAID/OFDA) and co-organized and hosted by the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) of Colombia.

I am pleased to learn about the successful outcomes of this meeting and its conclusions, which constitute a milestone in the implementation of this important project.

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 Northwest South America 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 related technical activities of the project. The designated officer will represent the country on 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 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

ANNEX 7

Milestones for the Draft Implementation Plan

	2018				2019				2020			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task name												
Initial Planning Meeting	■											
Letters of Committment and points of contacts provided	■	■										
Obtain static and historical hydrometeorological data			■									
Basin delineation validation			■									
Obtain real-time data information, data availability access			■									
Regional Centre develop and provide real-time data format			■									
Training Workshop and data collection (Step 1)				■								
Regional Centre operational (to collect real-time data)				■	■	■	■	■	■	■	■	■
National Centres operational and provide real-time data access				■	■	■	■	■	■	■	■	■
National and Regional Centre complete online courses (Step 2)				■	■							
Complete standard FFGS development	■	■	■	■	■							
Operational training at HRC (Step 3)					■							
Purchase and shipping of two servers at Regional Centre (FFG and NWP model)					■	■						
Onsite system implementation and IT training at Regional Centre						■						
Steering Commmitte Meeting 1 and training (Step 4)							■					
Landslide component calibration and implementation							■	■				
Radar data calibration and ingest								■				
Landslide workshop									■			
Radar hydrology and radar QA/QC workshop									■			
Operations sustainability workshop and links to DMA, and SCM2 Meeting (Step 5)											■	