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**FOLLOW-UP OPERATIONAL WORKSHOP  
CENTRAL ASIA REGION FLASH FLOOD GUIDANCE (CARFFG) SYSTEM**

*Astana, Kazakhstan*

*30 October-1 November 2017*



**DRAFT REPORT OF THE FOLLOW-UP OPERATIONAL  
WORKSHOP**

**July 2018**

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**Follow-up Operational Workshop of  
The Central Asia Region Flash Flood Guidance (CARFFG) Project  
Astana, Kazakhstan, 30 October – 1 November 2017**

**1. Executive Summary**

In the Central Asia region, flash floods account for a significant portion of the lives lost and property damaged 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 warning capabilities. Improvements help society to 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); United States National Oceanic and Atmospheric Administration (NOAA) National Weather Service (US NWS); the Hydrologic Research Center (HRC), San Diego, and United States Agency for International Development/Office of United States 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 conducted on a regional basis with countries that have committed in writing, to participate actively in the implementation and operation of the forecast system.

The Central Asia Region Flash Flood Guidance (CARFFG) System Initial Planning Meeting was held in Ankara, Turkey on 5-7 May 2015. Five Central Asian countries, namely Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, were represented in the meeting. Participants expressed their interest in participating in the CARFFG system, indicating that flash floods cause considerable human losses and property damage in the central Asia region. At this meeting, the National Meteorological and Hydrological Service (NMHS) of Kazakhstan, Kazhydromet, graciously offered to host the Regional Centre of the CARFFG system, which was accepted by all the participating countries. Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan have, thus far, sent Letters of Commitment (LoC) to WMO to participate in the project.

Based on the CARFFG system implementation plan adopted at the Initial Planning Meeting in Ankara, Turkey, the following major project activities have been completed: 1) First CARFFG system Steering Committee Meeting (SCM 1) took place from 12 to 14 September 2015 in Astana, Kazakhstan; 2) Operational training took place from 1 to 26 February 2016 at HRC facilities in San Diego 2016; 3) Second Steering Committee Meeting (SCM 2) was held in Astana, Kazakhstan from 4 to 6 October 2016.

As per implementation plan, the Follow-up Operational Training and Step-4 training were jointly held in Astana, Kazakhstan, from 30 October to 1 November 2017. The objectives of this meeting were to: review the theoretical basis of the Flash Flood Guidance System; explore in detail, through presentations and discussions, the CARFFG products, their development methodology, and the interpretation and validation approaches to provide feedback for their

future development; operational use of the CARFFG products through hands-on exercises; allow a better understanding of the needs of high resolution modelling, including its domains; review and evaluate the CARFFG products for the past flash flood events through case studies; and evaluate the performances of participants who successfully completed Flash Flood Guidance (FFG) Step-2 and Step-3 training to be qualified as WMO certified FFG Trainers.

## **2. Opening of the Session**

During the opening session of the Follow-up Operational Workshop, the representatives of Kazakhstan, WMO, and HRC highlighted the importance of improving the delivery time of flash flood information and guidance to the populations at risk and the need for 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' NMHSs, it was highlighted that the guiding indicator for the ultimate success of the project is effective outreach to people and reducing their risk of being affected by flash floods in a disastrous way.

In his opening remarks, Mr. Marat Kynatov, Director General of the Kazhydromet, highlighted the value of regional cooperation, particularly, given the impacts of climate variability and change on infrastructure and the need for early warning systems to help reduce the risks from hydrometeorological hazards, to promote sustainable development, and to attain and maintain economic prosperity. He also emphasized the need for the international exchange of data and information for improving the provision of forecasts and early warnings, stressing that severe weather events do not confine themselves to national borders. He cited occurrences of flash flood events in Kazakhstan this year, explaining that flash floods are a very dangerous natural phenomenon in the region. He assured participants that Kazakhstan will use the CARFFGS products in the preparation of daily flash flood forecasts and warnings. He expressed his pleasure in being able to host the Follow-up Operational Workshop in Astana. He welcomed all the participants to Kazakhstan, and he wished everyone a very successful meeting. Mr. Ayhan Sayin, WMO, recalled the objectives of the meeting and its expected results. He welcomed the participants, and encouraged them to provide their active inputs into shaping this important regional Flash Flood Guidance system project. He also thanked the Kazhydromet for all its efforts, including the hosting of this workshop, thereby, creating a positive atmosphere that would undoubtedly contribute to the success of the workshop. Mr. Eylon Shamir, HRC, welcomed everyone to the workshop and was pleased to see that representatives from four central Asian countries were attending the workshop. He emphasized the importance of enhancing the capacities of NMHSs of the Central Asian Countries for effective early warnings of flash floods. He also expressed his appreciation to the Kazhydromet for hosting the workshop.

The workshop was also covered by the national press and Mr. Ayhan Sayin informed the reporters about the support being provided by the WMO for the CARFFG system, objectives and possible outcomes of the workshop, positive impacts of the project on the citizens of Kazakhstan and other participating countries, and project's future enhancement.

## **3. Organization of the Follow-up Operational Workshop**

The Follow-up Operational Workshop, which was held in Astana, Kazakhstan from 30 October to 1 November 2017, was attended by representatives of the NMHSs from Kazakhstan, Tajikistan, Turkmenistan, and Uzbekistan. Other participants included representatives from

WMO and HRC. The list of participants is provided in Annex 1, while the annotated workshop agenda is given in Annex 2.

#### **4. Proceedings of the Follow-up Operational Workshop**

Mr. Sayin provided a brief overview on the purpose of the workshop. He stated that the goal of the Flash Flood Guidance System was to build capacities at the NMHSs to help society cope with hydrometeorological hazards particularly those of flash floods. The workshop would also be an opportunity to present and discuss the needs for flash flood forecasting in the central Asian region, including dissemination procedures and coordination between the NMHSs and the Disaster Management Agencies. He provided information about the WMO Flood Forecasting Initiative, stating that FFGS was in-line with the WMO Flood Forecasting Initiative objectives. He also outlined the global FFGS implementation strategy.

Mr. Sayin reiterated the roles and responsibilities of the participating NMHSs and the Regional Centre. Participating NMHSs have the following responsibilities, inter alia: to provide historical data to the project developer, HRC; to provide in-situ data to the Regional Centre; to participate in the flash flood hydrometeorological training programme; to issue flash flood warnings and disseminate them to their national DMA; and to cooperate with the Regional Centre on the CARFFG system issues. Then, he cited the roles and responsibilities of the Regional Centre as, inter alia: to communicate effectively with WMO, HRC and NMHSs on the CARFFG system activities; to have computer hardware and software capabilities and good computer network connections; to routinely monitor the availability of the CARFFGS products; and to conduct flash flood validation studies.

Mr. Sayin explained the project implementation status, stressing upon major project milestones. It was also stated that after the Initial Planning Meeting; Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan sent LoCs to WMO. It was mentioned that the major project activities that have been completed were: 1) Development and implementation of the CARFFG System; 2) First Steering Committee Meeting (SCM1); 2) Operational Training at HRC, San Diego, USA; and 3) Second Steering Committee Meeting (SCM2).

He stated that this meeting is one of the major project activities as Step-4 training aimed at: reviewing the CARFFG products to allow forecasters to become familiar with the CARFFGS products; promoting operational use of the CARFFG products through hands-on exercises; reviewing and evaluating the CARFFG products for the past flash flood events through case studies; evaluating the performance of participants who have successfully completed Step-2 and Step-3 training.

##### **4.1 Overview of the CARFFGS Products**

Mr. Sayin provided an overview of the CARFFGS dashboard and forecaster console. He stated that the FFGS user interfaces are secure web-based interfaces to provide overview of the system processing status and current and historical products for IT and forecasting personnel. He explained that the functionalities of the dashboard are: 1) display of selected CARFFGS products with animation tools; 2) real-time data and inventory status; 3) real-time data processing status; 4) computational server status; 5) dissemination server status. He continued to explain the CARFFGS forecaster console with the following main features: 1) navigation toolbars that allow users to display the products at certain date and time; 2) product table that displays full list of the CARFFGS and products in image formats; and 3) data download buttons in text, CSV, and CSVT formats. He further explained the following products in detail:

- **Global Hydro Estimator (GHE) precipitation**, which is produced by the US National Oceanic and Atmospheric Administration (NOAA) using Infrared (IR) channel (10.7 micrometre) of geostationary meteorological satellites;
- **MicroWave adjusted Global Hydro Estimator (MWGHE) precipitation**, which is estimated by correcting GHE precipitation with Micro Wave satellite precipitation;
- **Gauge Mean Areal Precipitation (Gauge MAP)**, which is estimated by using WMO synoptic reports obtained from the GTS network;
- **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.
- **Average Soil Moisture (ASM)**, which indicates upper soil (20-30 cm) water content, including free and tension water;
- **Flash Flood Guidance (FFG)**, 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);
- **Multi-NWP model ingestion**, WRF QPF products, provided in two domains with 13x13 km and 4x4 km spatial resolutions are ingested to allow forecasters to compare different FFGS products resulting from these models.
- **Forecast Mean Areal Precipitation (FMAP)**, which is estimated by using WRF QPF data;
- **Flash Flood Threat (FFT) 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).
- **Gauge Mean Areal Temperature (gauge MAP)**, which is estimated using in-situ surface temperature observations from the WMO GTS and Global Forecast System (GFS);
- **Snow Coverage Area (SCA)**, which is driven by satellite observations;
- **Snow Water Equivalent (SWE)**; and
- **Snow MELT.**

Mr. Sayin also explained the Flash Flood Guidance System approach. He stated definitions of flash floods by WMO and American Meteorological Society (AMS) and cited the natural cause of flash floods as intense rainfall from slow moving thunderstorms or tropical systems, orographic rainfall in steep terrain, soil saturation or impervious land surface, and hydraulic channel properties. He explained the need for the FFG system and compared large river flooding with flash floods. He emphasized that it is critical to distinguish them and that it is the fundamental concept for flash flood development and implementation. He continued to explain that the main components of the FFG system are: runoff modelling; bankfull flow; flash flood guidance; end-to-end process for flash flood warning processes; key components of the FFGS modelling such as precipitation sources and their quality control, snow model, soil moisture model, threshold runoff model, NWP QPF ingestion, and flash flood threat. He stressed that the forecaster's experiences are fundamental for the issuance of flash flood warnings while demonstrating the diagnostic and prognostic FFG products. He concluded his presentation by emphasizing on the needs of local data for model calibration and bias adjustments.

#### **4.2 CARFFG System Development and Theoretical Background**

Mr. Shamir explained the development and theoretical background of the CARFFG system in each of the following major categories: 1) Special analysis and threshold runoff; 2) Soil moisture,

snow and FFG modelling; and 3) Satellite precipitation and bias adjustment. He stated that flash flood basin delineations, which are estimated from quality controlled SRTM-90 m DEM data, are used for model parameterisation, model computations and product displays and have average drainage areas of 150 km<sup>2</sup>. He said that results of the delineation are used to compute the geometric properties of each watershed, which are used, in turn, for the computation of *Threshold Runoff*<sup>1</sup>. He indicated that this is a constant property of a watershed and that FFG is then estimated from the Threshold Runoff, soil moisture deficit, and evapotranspiration.

He gave an overview of soil moisture, snow and FFG modelling. He said that the ASM product provides an estimate of current soil water in the upper soil depth, expressed as a fraction of saturation. He stated that Sacramento Soil Moisture Accounting (SAC-SMA) model, in which rainfall and snow melt are ingested as input data, is used to estimate ASM. He explained that parameter estimation within the soil model is based on soil texture and soil depth data as provided by the UN Food and Agriculture Organization (FAO). He stated that the Snow Accumulation and Ablation Model (SNOW-17) of US NWS is employed to estimate Snow Water Equivalent (SWE) and snow melt products for the Central Asia Region. After providing an overview of the snow model, he showed comparisons of modelled SWE and observed snow depth, MELT and frozen ground concepts. He then continued to explain the FFG model, specifying that it integrates Threshold Runoff, soil water content, and current precipitation and that it is updated every six hours.

He continued by explaining that satellite precipitation estimates are derived from geostationary and polar orbiting satellites, providing valuable information for the region where ground-based hydrometeorological observations are sparse. He said that Global Hydro Estimator (GHE) precipitation with 4 km resolution is calculated using the Infra-Red (IR) channel, such that the rainfall rate is correlated with cloud top brightness temperature, while microwave precipitation estimate with 8 km resolution is based on backscattering measurements from raindrops in the microwave spectrum. He also mentioned that there is a latency of 18-26 hours in operation and that GHE is corrected using microwave precipitation data. He finally articulated that two kinds of bias adjustments were employed. The first one is the climatological bias adjustment to determine the long-term bias in satellite precipitation within a given region using historical precipitation observations, while the second one is the dynamic bias adjustment using in-situ observations disseminated through the GTS.

#### **4.2.1 Case Studies**

Mr. Sayin explained how to prepare flash flood warnings by using a top-down approach from synoptic analysis to interpretation of the FFGS products. He explained that, firstly, weather analysis and forecasting tools and models such as surface charts, 850 hPa and 500 hPa charts, and NWP QPF products should be analysed to see if the current weather outlook and weather conditions are favourable for the occurrence of flash floods; secondly, mesoscale and nowcasting analysis including RADAR and weather satellite images, if available, should follow to make smaller scale analysis such as instability and development of convective clouds; thirdly, FFGS products should be interpreted starting from diagnostic products and ending with prognostic products; and finally, the preparation of flash flood bulletins and warnings should be made, provided, conditions for the flash flood occurrences are suitable. At the end, he showed a

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<sup>1</sup> Threshold Runoff is defined as the amount of effective precipitation of a given duration which produces the volume of runoff required to cause bankfull flow at the watershed outlet of the draining stream.

template for the flash flood warning messages that may be used by the duty forecasters for submission to the concerned authorities through various media such as email, SMS, and fax.

He continued to present a case study on a flash flood event that took place in South East Europe from 6-8 March 2016. First of all, he explained the importance of the flash flood case studies that can help forecasters understand the response of the Flash Flood Guidance System (FFGS) under different atmospheric conditions such as storms associated with synoptic and mesoscale depressions and convection in different seasons. Then, he continued to provide an overview of the top-down approach for the preparation of a case study in the following order: 1) analysis of the diagnostic and prognostic synoptic and mesoscale products such as surface, 850, 700, 500 hPa weather charts, as well as jet streams that will allow forecasters to overview of atmospheric states; 2) Quantitative Precipitation Forecasts (QPF) of different NWP products such as global ECMWF IFS, and mesoscale ALADIN and WRF models; 3) atmospheric instability analysis including sounding that shows tendency of the air parcels to produce convection and associated cloudiness such as Cumulonimbus clouds; 4) interpretation of satellite and radar images to monitor synoptic and mesoscale scale atmospheric circulation as well as development of local convection; 5) monitoring of in-situ observations, particularly, precipitation intensity and accumulation over time and space; 6) analysis of the FFG products; 7) preparation of the FFG bulletins; and 8) issuance of the flash flood warnings and alerts.

He presented an overview of ECMWF IFS surface pressure, 850 hPa, and 500 hPa weather charts from 6 March 2017 at 00 UTC to 7 March 2017 at 12 UTC. He stated that a depression had developed over central Mediterranean and propagated to South East Europe in 24 hours, resulting in flooding and flash floods in the region. He explained that a low pressure center located over Italy with a value of 1000 mb, while the 850 hPa chart showed strong warm air advection ahead of the trough and cold air advection behind the trough, indicating transition zone between cold air mass and warm air mass and frontal lifting. While the depression was moving towards the east, gradients of the 850 hPa isotherms increased over time between Italy and Turkey. It was stated that 500 hPa low center with a central value of 546 hPa was located over northern Europe and axis of the trough was expanding towards Morocco on 6 March at 00 UTC. The 500 hPa trough propagated eastwards until 6 March at 00 UTC. Strong divergence existed ahead of the trough over Balkans indicating presence of the low level horizontal divergence and vertical motions in the middle troposphere. -30 °C isotherm expanded from England to Spain, indicating flow of the cold polar air mass into the Mediterranean. A well-defined boundary between cold air masses propagating from the north and warm air masses propagating from the south existed over Balkans resulting in the development of steep cold and warm fronts in the region. The depression moved to the east over time and skewed towards east, increasing geopotential gradients over the Balkans. The lower and middle atmosphere were unstable ahead of the 500 hPa trough, where strong vertical circulation was associated with the frontal lifting. It was stated that there are several prominent instability indices such as K-Index and Convective Available Potential Energy (CAPE) commonly used to measure the atmospheric stability. CAPE field had a maximum value of 2000 over Italy and along the Adriatic coast, indicating strong atmospheric instability that may create favorable conditions for the development of convective storms.

He compared the 6-hr ECMWF IFS and WRF Quantitative Precipitation Forecasts (QPF) accumulation from 6<sup>th</sup> March at 00 UTC to 7<sup>th</sup> March at 18 UTC. It was stated that there were big differences in the QPF fields of the two models at 06 UTC, 12 UTC, and 18 UTC such that the maximum values of the ECMWF IFS QPF were of 46.4 mm, 44.1 mm, and 39.9 mm; while WRF values were of 68.3 mm, 92.3 mm, and 90.6 mm. It was clearly shown that WRF QPF values were twice as high as ECMWF IFS QPF. That's why, multi-model NWP model QPF



ingestion was quite important to compare QPFs of different models and to monitor their performances during various seasons and months under different weather conditions.

He provided an overview of the SEFFG products from 5<sup>th</sup> March at 00 UTC to 6<sup>th</sup> March at 18 UTC. He stated that satellite precipitation products (GHE and MWGHE) showed that 6-hr precipitation accumulation had a maximum value of 60 mm over Serbia, Croatia, and western Romania on 5<sup>th</sup> at 00 UTC. Average Soil Moisture (ASM) values over the same region were one, indicating that top soil was completely saturated due to the accumulation of rainfall over the last six hours. On the other hand, Flash Flood Guidance (FFG) values were quite low ranging from 15 to 30 mm/6-hr. This indicates that if rainfall intensity continues at the same rate or more, bankfull condition will be met, resulting in flooding at the outlets of the catchments. Therefore, 6-hr and 24-hr QPF values of ALADIN mesoscale model were analyzed to find out spatial and temporal distribution of precipitation forecasts over the next 24 hours. 24-hr ALADIN QPF was 75 mm over Croatia and the Adriatic Sea. Once the depression moved southeast to the Adriatic Coast, maximum precipitation intensity reached 75mm/24-hr over Montenegro and Albania where precipitation intensified due to moisture influx from the sea and orographic lifting, attaining 120 mm/24-hr rainfall accumulation at 18 UTC. 6-hr ASM from 5<sup>th</sup> March 00 UTC to 6<sup>th</sup> March 00 UTC showed that top soil was saturated in Croatia, Bosnia and Herzegovina, and Montenegro, while 6-hr FFG values decreased to 15 mm for the same period. Forecast Flash Flood Threat (FFFT) values which shows excess amount of rainfall ranged from 15 mm to 25 mm/6-hr over Montenegro, indicating high possibility of occurrences of flash floods. The system propagated to the northeast from Montenegro to Bosnia and Herzegovina, and Serbia with 90 mm/6-hr rainfall intensity. Spatial coverage of FFFT expanded towards the northwest in Montenegro and had a maximum value of 60 mm/6-hr on 6<sup>th</sup> March at 06 UTC. It was stated that two people were killed and extensive property damages occurred due to flash floods from the 6<sup>th</sup> to the 7<sup>th</sup> of March in the region. He emphasized that central Mediterranean depressions, which are associated with fronts and propagate to southeast Europe through Adriatic Sea, produce heavy rainfall causing flash floods.

Ms. Gulmira Akisheva from Kazakhstan, Ms. Dzhamilya Baydulloeva from Tajikistan, Ms. Irina Dergacheva from Uzbekistan and Mr. Nazar Bayramov from Turkmenistan provided flash flood case studies in their countries. Participants who attended the Operational training in San Diego (Step 3 training) took the written exam to be qualified as a WMO certified FFGS Programme trainer.

#### **4.2.2 Hands-on Exercises**

Hands-on exercises of two flash flood events were collectively studied by the participants and were led by Ms. Mutic. Participants used the Flash Flood Guidance System Simulator to interpret the CARFFGS products for the issuance of flash flood warnings in combination with weather analysis, nowcasting, and local hydrometeorological data. The FFGS Simulator had the following features:

- Synoptic (ECMWF) Analysis: Geopotential height 500 hPa, Mean Sea Level Pressure (MSLP), Convective Available Potential Energy (CAPE), 3-hr and 24-hr Quantitative Precipitation; Forecast (QPF), Wind fields;
- Weather Satellite images: RGB air mass analysis, and severe storm RGB;
- FFGS Diagnostic products: Global Hydro Estimator (GHE) precipitation, Micro Wave adjusted Global Hydro Estimator (MWGHE), Gauge Mean Areal Precipitation (Gauge MAP), Merged Mean Areal Precipitation (Merged MAP), Average Soil Moisture (ASM), and Flash Flood Guidance (FFG);

- FFGS Forecast products: Forecasted Mean Areal Precipitation (FMAP) based on WRF NWP model;
- FFGS Warning products: Forecasted Flash Flood Threat (FFFT); and
- Other data: Elevation map of Kyrgyzstan.

Participants predicted flash floods in Kyrgyzstan where flash floods actually happened in Kyrgyzstan on 4<sup>th</sup> and 6<sup>th</sup> October 2017. Participants discussed the development and propagation of the low pressure centres, troughs, ridges, cold and warm air advections, divergence and convergence fields, and associated weather patterns. After the weather briefing, a facilitated discussion took place among participants who expressed their views on the interpretation of the CARFFGS products and occurrences of flash floods.

#### **4.2.3 Verification of flash flood warnings**

Ms. Mutic explained the importance of the flash flood warning verification studies. She stated that flash flood warning verification studies are used to understand the uncertainties and limitations of the FFG system. She briefly explained how to prepare contingency tables and compute the verification scores such as Probability of Detection (PoD), False Alarm Ratio (FAR), False Alarm Rate (RA), Threat Score (TS), and Critical Success Index (CSI). She showed verification results of the BSMEFFGS and SEEFFGS for the years of 2013 and 2014; and 2015 and 2016, respectively. She explained the spatial and temporal distribution flash flood warnings in Turkey and Croatia. She recommended that each participating county should collect flash flood events data and conduct verification study on its own or in collaboration with the Regional Centre and make the results available to the project partners. She concluded her presentation by stating that the verification of flash flood warnings is essential for evaluating and improving operational forecast products and holds great potential for advancing predictability of flash floods.

#### **4.2.4 Post-processing of CARFFGS products with QGIS**

Ms. Mutic presented post-processing of CARFFG products with QGIS, as a part of the hands-on exercise. She emphasized that the goal of her presentation is to show forecasters how to prepare maps for post processing of CARFFG system products using QGIS. The web page for downloading the QGIS software and its installation instructions were provided. She said that all CARFFG participating countries have sub-basin boundaries in the shapefile format under the “Static Resources” tab of CARFFG user interface. These files can be opened by GIS programmes after unzipping them. Since flash flood often occurs in small areas, forecasters would like to see the CARFFG products as well as the additional layers that can be displayed with the products so that precise location can be determined. The participants were shown how to download additional free vector GIS layers such as cities, roads, railways, rivers, lakes, administrative boundaries, land use, soil data, and raster layer such as digital elevation model. She stated that for the preparation of a Flash Flood Early Warning Bulletin, the forecaster can use FFFT and FMAP products. She reiterated that FFFT provides the forecaster with an idea of regions forecasted to be of concern for flash flooding based on the difference of FMAP and the corresponding FFG. Also, she recalled that the color scale of the 1-hr, 3-hr, and 6-hr products is an approximate measure of flash flood possibility.

#### **4.2.5 Advances in the FFG System**

Mr. Shamir presented current enhancements for the FFGS improved operations. He touched upon the following four major topics:

- Multi-model QPF use in the FFGS;
- Landslide Susceptibility Mapping;
- Seasonal ensemble forecasting of snow water equivalent
- Urban Flash Flood Warning; and
- Riverine Routing and Ensemble Discharge Prediction.

He articulated each topic, saying that it was the forecasters' demand to include multiple mesoscale model input display on the FFGS forecaster console because each model behaves differently in different seasons even in different months. Then, he showed multiple NWP ingestion examples from the BSMEFFGS and CARFFGS and explained their impacts on the accuracy of the FFGS products. Secondly, he stated that there is a growing demand for an urban flash flood early warning system to be incorporated into FFG due to the increased occurrence of urban flash floods in recent times on account of climate change and climate variability. He further stated that a demonstration project for the urban flash flood early warning system has been conducted for the city of Pretoria, South Africa and two of them were under implementation: in Istanbul, Turkey and Jakarta, Indonesia. He showed a demonstration case study of Landslide prediction using Central America Flash Flood Guidance System (CAFFGS) products conducted in El Salvador which includes landslide susceptibility mapping, real-time occurrence prediction based on FFGS rainfall and soil moisture data, and susceptibility class. Finally, he explained seasonal ensemble forecasting of snow water equivalent, and combined runoff from snowmelt and rainfall with 6-hourly resolution. This was done for Tajikistan using the data and models of the CARFFG system in collaboration with Tajikhydromet.

During the facilitated discussions, participants affirmed that mudflow/landslide is a very important hydrometeorological hazard in the Central Asia region, causing severe loss of human life and extensive damage to property, particularly in the mountainous regions. It was emphasized that water management is also a big concern in the region due to climate variability and change. They unanimously agreed that inclusion of mudflow/landslide and riverine routing modules into the CARFFG system would improve capabilities of the participating countries to mitigate adverse effects of such hydrometeorological hazards and improve the water management.

#### **4.2.6 CARFFGS Hydrometeorologist Training**

Mr. Sayin provided an overview of the FFGS Hydrometeorologist Training Programme. He stated that training was an integral part of the project, and extensive training would be provided to the forecasters from the participating NMHSs. He showed the schematic diagram outlining the FFGS hydrometeorological training programme. He explained that it consisted of five 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.

He said that online training (Step-2), which is a prerequisite for the specialized training (Step-3) at the HRC premises in San Diego, USA, comprises of five modules:

- Elements of Meteorology;
- Elements of Hydrology;

- Flash Flood Guidance Products;
- Geographical Information System (GIS); and
- Remote Sensing.

He stated that the first three modules are available in Russian, Spanish and French, while all modules are available in English. She said that two forecasters from each participating NMHSs of the CARFFGS except Turkmenistan attended the operational training at HRC (Step 3), San Diego, USA from 1 to 26 February 2016 and successfully completed it.

During the facilitated discussions, participants appreciated the quality of the training and its content, thanking the WMO and HRC for facilitating and providing such excellent training.

## **5. Conclusions from the Follow-up Operational Workshop**

1. There was agreement among participants that the CARFFG System is a useful tool to enable forecasters to issue timely and accurate flash flood warnings in combination with other available tools such as weather analysis and forecasts and nowcasts.
2. Participants understood the responsibilities of the Regional Centre and NMHSs, noting that cooperation and collaboration amongst the project partners is the key to success of the project.
3. Participants agreed that country-level verification studies shall be conducted on the flash flood warnings and FFGS products to improve the performance of the CARFFG System and that a verification guideline should be available to the participating countries.
4. Participants agreed that implementation of advanced modules such as multi-NWP QPF ingestion is very beneficial to the NMHSs. They noted the possibility of implementing Riverine Routing in Kazakhstan and recommended that it should be implemented in other participating countries.
5. Participants noted the necessity of real-time data reception through the GTS to allow real-time bias precipitation adjustment and use of other surface data in model calculations such as surface temperature data ingestion into snow accumulation and ablation model.
6. Participants expressed their appreciation with the availability of the snow products: SWE, MELT, and Snow Coverage Area (SCA) in the CARFFG system. They affirmed that snow accumulation and depletion cause major mountainous hazards such as flooding, and avalanches and that snow is a major water resource in the region.
7. Participants agreed that translation of the CARFFGS forecaster console, dashboard, and on-line available resources such as product descriptions into Russian would improve operational use of the system by the duty forecasters as it is the common working language of the participating countries.
8. Participants affirmed that flash floods, mudflow, landslide, glacier melting, and avalanche are the major mountainous hazards in the region, inflicting heavy economical losses and causing widespread property damages and loss of lives.

9. Participants became familiar with the CARFFGS operational concept.
10. Participants agreed to request the World Bank in writing, through the Regional Centre, to support Mudflow/Landslide and Riverine Routing modules in two transboundary river basins within the scope of the CARFFG system. They also agreed that each participating NMHS will send its interest letter signed by the Permanent Representative with WMO to the Regional Centre in implementation of these two modules.
11. Participants developed competencies to be able to access the CARFFGS servers to use its products.
12. Participants agreed that country-level verification studies shall be conducted on the flash flood warnings and FFGS products to improve the performance of the CARFFG System and that a verification guideline should be available to the participating countries.
13. Participants became familiar with the CARFFGS forecaster console, dashboard, and its products such as Global Hydro Estimator (GHE), Microwave adjusted GHE (MWGHE), Gauge Mean Areal Precipitation (GMAP), Merged MAP, Average Soil Moisture (ASM), Flash Flood Guidance (FFG), Flash Flood Threats (FFT), Forecast Mean Areal Precipitation (FMAP), Snow Water Equivalent (SWE), Snow MELT, Mean Areal Temperature (MAT), and satellite snow coverage.
14. Participants developed basic competencies to be able to make synoptic, mesoscale, and nowcasting analysis and interpret the CARFFGS products to prepare flash flood warnings.
15. There was agreement among participants that FFGS Simulator is a useful tool to train the forecasters.
16. Participants developed basic competencies to prepare clear and understandable flash flood warning messages.
17. Participants developed basic competencies to prepare contingency tables and compute verification scores.
18. Participants who successfully completed Step 2 and Step 3 training took a written exam on the FFGS technical and scientific background and gave a presentation of a flash flood event that took place in their respective countries for obtaining the qualification of WMO certified FFGS Programme trainer.

## **6. Closing of the Follow-up Operational Workshop**

Closing remarks were made by WMO, HRC, Kazhydromet, and participants. Thanks were also extended to all attendees for their active participation in the workshop and spirited involvement in the discussions, which contributed to the successful conclusion of the workshop.



**FOLLOW-UP OPERATIONAL WORKSHOP  
CENTRAL ASIA REGION FLASH FLOOD GUIDANCE (CARFFG) SYSTEM**

*Astana, Kazakhstan*

*30 October – 1 November 2017*

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## Follow-up Operational Workshop of the Central Asia Region Flash Flood Guidance (CARFFG) System (Step 4 Training)

Astana, Kazakhstan, 30 October - 1 November 2017

### Workshop Agenda

#### Day 1

- 09:00-09:15 Registration of participants  
 09:15-09:45 Opening of the workshop (Kazhydromet, WMO, HRC)  
 09:45-10:15 Introduction of participants (*All*)  
 10:15-10:30 Overview and Purpose of the Workshop (WMO)
- 10:30-11:00 Tea Break**
- 11:00-12:30 Status of Operational flash flood forecasting and early warnings capabilities at the NMHSs (Country presentations and Discussions<sup>2</sup>)
- 12:30-14:00 Lunch Break**
- Interactive session-participants to be engaged in discussions to demonstrate their comprehension of the system.*
- 14:00-14:30 Overview of CARFFG System Forecaster User Interface (WMO)
- Forecaster Console
  - Dashboard
- 14:30-15:00 Review of the CARFFG System Design/Theoretical Background  
 Precipitation Components (HRC)
- Satellite/Radar Precipitation Estimation and bias adjustment
  - Precipitation Observations
  - Merged Mean Areal Precipitation (merged MAP)
  - NWP Rainfall Forecasts
- 15:00-15:30 Review of the CARFFG System Design/Theoretical Background

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<sup>2</sup> 15 minutes for each presentation

#### System's Hydrological Model Components (HRC)

- Spatial GIS Analysis
- Threshold Runoff Estimation
- Soil Moisture
- Snow Model

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

*Interactive session-participants to be engaged in discussions to demonstrate their comprehension of the system*

#### 16:00-16:30 Review of the CARFFG System Design/Theoretical Background Flash Flood Guidance (HRC)

- Flash Flood Guidance (FFG)
- Flash Flood Threats (IFFT, PFFT, FFFT)

#### 16:30-17:00 Review of the CARFFG System Design/Theoretical Background Snow Products (HRC)

- Snow Water Equivalent (SWE)
- MELT
- Frozen ground

#### 17:00-17:30 CARFFG System Operational Concept (RC-Kazhydromet)

- Computational Server
- Dissemination Server
- Status of RC Operations

#### 17:30-18:00 Discussions on the CARFFG System Design/Theoretical Background (All)

### **Day 2**

#### 09:00-09:30 Review of Day 1

#### 09:30-10:00 How to prepare flash flood warnings: Methodology (WMO)

- Interpretation of weather analysis and forecasts
- Mesoscale and Nowcasting Analysis
- Weather RADAR and Satellite images
- Interpretation of CARFFG Products

*Country-presentations to be provided by those who attended Operational Training at HRC*

#### 10:00-10:30 A Flash Flood Case Study and Discussions (Kazakhstan<sup>3</sup>)

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

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<sup>3</sup> Those who successfully completed step 2 and 3 will make presentations to be evaluated by WMO and HRC to be qualified for the WMO certified FFG trainer.

- 11:00-11:30 A Flash Flood Case Study and Discussions (Kyrgyzstan<sup>2</sup>)
- 11:30-12:00 A Flash Flood Case Study and Discussions (Uzbekistan<sup>2</sup>)
- 12:00-12:30 A Flash Flood Case Study and Discussions (Tajikistan<sup>2</sup>)
- 12:30-14:00 Lunch Break**
- 14:00-14:30 A Flash Flood Case Study and Discussions (Turkmenistan)
- 14:30-15:00 Verification of Flash Flood Warnings-Croatian and Turkey Verification studies (WMO)

**15:00-15:30 Tea Break**

- 15:30-17:00** Hands-on Exercise for Past Flash Flood Events in the region (Guided by WMO, All) (example “daily operations”)
- Daily Weather Briefing
  - Hydrologic Output
  - CARFFG Product Analysis
  - Flash Flood Threats
  - Discussion

17:00-17:45 Written Exam<sup>4</sup>

19:00 *Welcome Dinner hosted by Kazhydromet*

**Day 3**

09:00-09:30 Review of Day 2

- 09:30-10:30 Hands-on Exercise for Past Flash Flood Events in the region (Guided by WMO, All)
- (example “daily operations”)
- Daily Weather Briefing
  - Hydrologic Output
  - CARFFG Product Analysis
  - Flash Flood Threats
  - Discussion

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

**11:00-12:00** FFGS Simulator Hands-on Exercise for Past Flash Flood Event (Guided by WMO, All)

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<sup>4</sup> Those who successfully completed step 2 and 3 will take written exam in English or Russian to be evaluated by WMO and HRC to be qualified for the WMO certified FFG trainer.

**12:00-13:30 Lunch Break**

13:30-14:30 Post-processing of CARFFG products with QGIS: Hands-on Exercises (guided by WMO, All)

14:30-15:00 Preparations of Operational Flash Flood Bulletins and Warnings (WMO)

15:00-15:30 Advances in FFGS (HRC)

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

16:00-16:30 Dissemination of flash flood Warnings and Emergency Management Agency (EMA) Needs and How to Improve Service Delivery of Flash Flood Warnings to EMA and Public (All)

16:30-17:00 Forecasters Expectations and Recommendations on the Best Use of CARFFG products (All)

17:00-17:30 Sustainability of the CARFFG System: Cooperation with the RC and NMHSs, Feedbacks, and next steps (All)

17:30-18:00 Final Discussions and Closure (All)

**-End of Workshop-**