SECOND STEERING COMMITTEE MEETING (SCM 2)

CENTRAL ASIA REGION FLASH FLOOD GUIDANCE (CARFFG) SYSTEM

Astana, Kazakhstan

4–6 October 2016

FINAL REPORT OF THE SECOND STEERING COMMITEE MEETING

May 2017

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Steering Committee Meeting 2 (SCM 2) of

The Central Asia Region Flash Flood Guidance (CARFFG) Project

Astana, Kazakhstan, 4-6 October 2016

1. Executive Summary

In the Central Asia region, flash floods account for a significant portion of the lives lost and property damages that result from heavy rainfall. 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 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); US NOAA National Weather Service (US NWS); the Hydrologic Research Center (HRC), San Diego, USA; and U.S. Agency for International Development/Office of U.S. Foreign Disaster Assistance (USAID/OFDA), the signatories have established a cooperative initiative for the Flash Flood Guidance System with Global Coverage Project. To attain global coverage, specific projects are planned and 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 interests to participate in the CARFFG system, indicating that flash floods cause considerable human losses and property damages 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 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 adapted at the Initial Planning Meeting in Ankara, Turkey, the first CARFFG system Steering Committee Meeting (SCM 1) was facilitated by WMO in Astana, Kazakhstan from 12 to 14 September 2015. As per the implementation plan, second Steering Committee Meeting (SCM 2) was held in Astana, Kazakhstan form 4 to 6 October 2016. Composition of the SCM are: the focal point of each participating NMHS or his/her alternate and representatives of the project partners, namely HRC, USAID/OFDA, US NWS, and WMO. Additional experts/representatives may also be invited to the Steering Committee (SC) meeting as needed on an ad-hoc basis, and observers may also be invited to participate. Therefore, WMO on behalf of the SC has sent invitation letters to attend the meeting to: the NMHS of Uzbekistan (Uzhydromet) and a hydrological expert from the NMHS of the Russian Federation (Roshydromet).

The objectives of this meeting were to: review the development and implementation status of the CARFFG system; use of its products in operation through case study presentation and hands-on exercises of the past flash flood events; prepare flash flood bulletins for the issuance of flash flood

warnings; perform validation studies; and obtain feedbacks from the participants for further developments. The SCM 2 also represents step one training of the flash flood hydrometeorologist training programme.

2. Opening of the Session

In opening the second Steering Committee Meeting, the representatives of Kazakhstan, WMO, and HRC 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 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 the flash flood events in Kazakhstan in this year, explaining that flash floods are very dangerous natural phenomenon in the region. He assured participants that Kazakhstan will provide the necessary support for the implementation and operation of the CARFFG project. He expressed his pleasure in being able to host the SCM 2 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, 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 hosting the meeting, thereby helping to make a positive atmosphere that would undoubtedly contribute favorably to the success of the meeting. Mr Konstantine Georgakakos, HRC, welcomed everyone to the meeting and was pleased to see that representatives from the five central Asian countries are attending the meeting. He emphasized its importance in enhancing the capacities of NMHSs of the Central Asian Counties for effective early warnings of flash floods. He also expressed his appreciation to the Kzhydromet for hosting the meeting.

The national press covered the meeting extensively. More than ten TV and Newspaper reporters were present. A news conference was held after the opening speeches. Mr Marat Kynatov, Director General of Kazhydromet and Permanent Representative of Kazakhstan with WMO, informed the press about the objectives and possible outcomes of the meeting and positive impacts of the project on the citizens of the participating countries. Mr Ayhan Sayin also informed reporters about the WMO support being provided for the CARFFG system.

3. Organization of the Second Steering Committee Meeting (SCM 2)

The SCM 2, which was held in Astana, Kazakhstan from 4th to 6th October 2016, was attended by representatives of the NMHSs from Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. Other participants included representatives from WMO, USAID/OFDA, 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 Second Steering Committee Meeting (SCM 2)

The proceedings were performed in two sessions: project management and training. Project management session comprised overviews of project development and implementation status, while training session focused on operational use of the CARFFGS products through case studies and hands-on exercises.

4.1 Project Management Session

Mr Sayin provided an overview of the purposes of the workshop indicating that the main objective of the Flash Flood Guidance System was to build capacity of the NMHSs to help society cope with hydrometeorological hazards particularly those of flash floods. The workshop would also allow an opportunity to present and discuss the needs for flash flood forecasting in the Central Asia region, including dissemination procedures and coordination between the National Meteorological and Hydrological Services 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, and he also outlined the global FFGS implementation strategy.

Mr Sayin outlined the roles and responsibilities of NMHSs and Regional Centre in the CARFFFG project. NMHSs had the following responsibilities: to provide historical data to the project developer, HRC; to provide in-situ data to the Regional Centre; to participate in 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 CARFFG system issues. Then, he cited the roles and responsibilities of the Regional Centre as being: 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 monitor routinely availability of the CARFFGS products; and to conduct flash flood validation studies.

Mr Sayin explained the project implementation status, stressing major project milestones. It was stated that after the initial planning meeting four countries, Kazakhstan, Kirgizstan, Tajikistan and Turkmenistan, have sent Letters of Commitment (LoC) to WMO to participate in the CARFFG project. However, even though Uzbekistan has not sent LoC, it has been invited to participate in the CARFFG project activities. It was mentioned that First Steering Committee Meeting (SCM1) was held in Astana, Kazakhstan 14-16 September 2015 to review the project status and provide Step1 training. After successfully completing on-line training (Step 2), two forecasters from each participating county attended advanced operational training (Step 3) at HRC, San Diego, USA from 1 to 26 January 2016. He concluded his presentation stating that development of the CARFFG system has been completed and it had been temporarily installed at Kazhydromet before the SCM2.

Mr Georgakakos outlined the development and implementation status of the Central Asia Region Flash Flood Guidance project. He stated that activities that have been completed are:1) real–time data ingestion through Kazhydromet; 2) prototype development of the CARFFG system; 3) calibration of models; 4) bias adjustments; 5) monitoring of the system for commissioning[1]; 6) training steps 1-3; and 7) installation of inauguration version of the system at Kazhydromet. He continued to explain in detail some of the project activates such as in-situ data transmission through GTS, satellite precipitation and snow products, provision of mesoscale WRF QPF in two domains-regional domain with 13x13km spatial resolution and inner domain with 4x4 km spatial resolution covering mountainous regions, precipitation bias adjustment with historical data, and soil model parameterisation.

Mr Sayin provided an overview of the World Bank's Strengthening Early Warning of Mountain Hazards in Central Asia Project. He said that the meeting took place in Almaty, Kazakhstan on 21 July 2016

[1] Commissioning refers to the system test period until it becomes operational at the Regional Centre.

with the participation of representatives of the five central Asian countries, WMO, and the World Bank. He stated that objective of the project was to provide targeted technical assistance to National Meteorological and Hydrological Services (NMHSs) for operational early warning and risk assessment of severe weather, avalanches, flash floods, debris flows and landslides in mountainous regions, as well as help set the foundation for translating technical forecasts into products that are informed, understood and utilized by the NMHSs users ("impact-based forecasting").

During the facilitated discussion, participants expressed their willingness to submit a request letter through the Regional Centre to the World Bank to seek its support for inclusion of the Mudflow/Landslide and Riverine Routing into the CARFFG system.

4.1.1 Project Maintenance and Sustainability

Participants expresses that sustainability of the CARFFG system is extremely important to provide services without any interruption to the users and to assists forecasters to enhance their knowledge on the CARFFG products. It was suggested that a Helpdesk should be established to provide supports to the regional centre and participating NMHSs for the maintenance of the CARFFG system, hardware and software, and for use of the CARFFG products in operation.

4.1.2 Revised Project Implementation Plan

Mr Georgakakos described the revised project implementation plan, showing the major tasks, milestones, and schedule. He stated that such major activities as development of the system, Step-3 training have been completed. He also stated that the system servers will be shipped to Kazhydromet by April and IT training will be given after the delivery of the servers. It was stated that follow-up operational training (Step-4 training) will be performed in July in one of the participating countries that is willing to host the training. It was also stated that Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan have sent Letters of Commitment (LoC) to WMO to participate in the project. Uzbekistan is encouraged to join the CARFFGS activities even though it has not yet sent its LoC to WMO. Participants agreed on the implementation of the remaining CARFFG activities, saying that they would do their utmost to comply with the plan. Revised CARFFGS implementation plan is provided in ANNEX IV of this document.

4.2 Training Session

4.2.1 Overview of the CARFFGS Products

Ms Modrick provided an overview of the CARFFS dashboard and forecaster console. She 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. She explained that 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. She continued to explain the CARFFGS forecaster console with the following main features: navigation toolbars that allow users to display the products at certain date and time; product table that display full list of the CARFFGS and products in image formats; and data download buttons in text, CSV, and CSVT formats. She explained the following products in detail:

- **Global Hydro Estimator (GHE) precipitation**, which is produced by US National Oceanic and Atmospheric Administration (NOAA) using Infrared (IR) channel (10.5 micrometre) of geostationary meteorological satellites;

- **Micro Wave adjusted Global Hydro Estimator (MWGHE) precipitation**, which is estimated by correcting GHE precipitation with Micro Wave satellite precipitation;

- **Gauge Mean 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**, 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);

- **WRF QPF products,** provided in two domains with 13x13 km and 4x4 km spatial resolutions.

- **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;

- **Snow Coverage Area (SCA),** which is driven from satellite observations**;**

- **Snow Water Equivalent (SWE)**; and

- **MELT.**

She stressed the importance of availability of the NWP QPF in the mountainous region and compared forecast MAP and Forecast Flash Flood Threat (FFFT) products of the regional domain with 13 x13 km and mountain domain with 4x4 km special resolutions. She emphasised that high resolution WRF QPF products in the mountain region considerable improve accuracy of the relevant products such as FFFT. It was noted that this was a major improvement in the CARFFG system. Regional domain and mountain domain of the WRF model are presented in ANNEX III.

4.2.2 Case Study

Mr Sayin presented a case study on the South East Europe flash flood event that took place on 6-8 March 2016. First of all, he explained the importance of the flash flood case studies that may help forecasters understand responses 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 there dimensional 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 convention; 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 was developed over the central Mediterranean and propagated to the 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 850 HPa chart showed strong warm air advection ahead of 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 toward east, gradients of the 850 HPa isotherms were 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 were expanding toward Morocco on 6 March at 00 UTC. The 500 HPa tough propagated eastward until 6 March at 00 UTC. Strong divergence existed ahead the trough over Balkans indicating presence of the low level horizontal divergence and vertical motions in the middle troposphere. -30 ^{o}C isotherm expanded from England to Spain indicating flow of the polar cold polar air mass into Mediterranean. A well-defined boundary between cold air masses propagating from the north and warm air masses propagating from the south existed over Balkans resulted in the development of steep cold and warm fronts in the region. The depression moved the east overtime and skewed toward east, increasing geopotential gradients over 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, indicated strong atmospheric instability that may create favorable conditions for the development of convective storms.

He compared 6-hr ECMWF IFS and WRF Quantitative Precipitation Forecasts (QPF) accumulation from 6th March at 00 UTC to 7th March at 18 UTC. It was stated that there were big differences in the QPF fields of two models at 06 UTC, 12 UTC, and 18 UTC such that 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 as twice 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 SEEFFG products from 5th March at 00 UTC to 6th 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 5th at 00 UTC. Average Soil Moisture (ASM) values over the same region were one, indicating that top soil was completely saturated due to accumulation of the rainfall over 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 next 24 hours. 24-hr ALADIN QPF was 75 mm over Croatia and the Adriatic Sea. Once the depression moved the 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 5th March 00 UTC to 6th 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 access 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 toward the northwest in Montenegro and had a maximum value of 60 mm/6-hr at 6th March at 06 UTC. It was stated that two people were killed and extensive property damages accrued due to flash floods from 6th to 7th of March in the region. He showed a template for the flash flood warning messages that may be used by the duty forecasters to submit them to the concern authorities through various media such as email, SMS, and fax. He emphasized that central Mediterranean depressions, which associated with fronts and propagate southeast Europe through Adriatic Sea, produce heavy rainfall causing flash floods.

4.2.3 Hands-on Exercises

Ms Modrick presented a case study as part of hands-on exercise for the flash flood event that took place on 9 May 2016 in Kirgizstan. Daily weather briefing was provided by the Kazhydromet service depicting surface, 850 hPa, 500 hPa, and precipitation analysis on 9th May at 00 UTC and their 72 hours forecasts. Development and propagation of the low pressure centres, troughs, ridges, cold and warm air advections, divergence and convergence fields and associated weather patterns were also explained in detailed. It was indicated that a depression located in the central Asia would propagate eastward over time and produce significant amount of precipitation such that more than 60 mm/6-hr precipitation intensity was forecasted by the WRF QPF model in Kirgizstan. Then, she commenced to provide an overview of the CAFFGS products. It was stated that merged Mean Areal Precipitation (MAP) indicated a precipitation band expanding from Tajikistan to the eastern Kazakhstan with a maximum core value of 40mm /6-hr on 9th May at 00 UTC, while Average Soil Moisture (ASM) chart indicated that top soil in several catchments were saturated. Spatial distribution of 6-hr Flash Flood Guidance (FFG) field showed that FFG values were in a range between 1 to 15 mm indicating that occurrence of the bankfull conditions was very likely over the next 6 to 24 hours if current precipitation intensity persists. 6-hr Forecast Flash Flood Threat (FFFT), which is the difference between 6-hr Forecast Mean Areal Precipitation (FMAP) and 6-hr FFG, existed over central Kirgizstan having a maximum value of 15 mm. For the same date and time, WRF QPF showed that 24-hr precipitation accumulation exceeded 75 mm over some catchments in Kirgizstan and Tajikistan. It was emphasised that forecasters had to be wary of these catchments with FFFT values and monitor propagation of depression and precipitation intensity over next six to twenty four hours for issuance flash flood warnings. Considering current states of the weather conditions, forecasts, and analysis of the CARFFGS products; participants suggested that flash flood watch could be issued for the central Kirgizstan. Snow Coverage Area (SCA) and MELT products were also explained stressing that for catchments with more than 40 percent of snow coverage, FFG values were not calculated.

She continued to explain the CARFFGS products from 9th May at 06 UTC to 18 UTC. 6-hr merged MAP showed that precipitation band propagated eastward and precipitation intensity increased over Kirgizstan reaching 60 mm at 06 UTC. ASM chart indicated that more catchments had saturated top soil, while as low as 15 mm/6-hr FFG values were attained over the southeast Central Asia. The system estimated 6-hr Imminent FFT (IFFT) in the northern Kirgizstan and Tajikistan at 06 UTC, indicating that that flash floods could be happening in the region. On the other hand, 6-hr Forecast FFTs were estimated in the northern and southern region of Kirgizstan such that some catchments attained a maximum value of 40 mm. Merged MAP at 18 UTC indicated that rainfall decreased during the last six hours. 6-hr ASM and 3-hr FFG charts at 18 UTC showed that top soil in the most of the catchments were saturated and FFG values considerable decreased across Kirgizstan, indicating suitable conditions for the occurrences of flash floods. Participants confirmed that flash floods and mudflows occurred on 9th of May and 10th of May in Kirgizstan and Tajikistan.

Similarly, second guided hands–on exercise was performed for the flash flood event took place on 2 October 2016 in Kirgizstan. First, Kazhydromet provided an overview of the weather analysis on 2nd

October at 00 UTC and forecasts up to 72 hours. Then, she gave an overview of the CARFFGS products at 00 UTC in the following order: Satellite precipitation GHE showed a narrow precipitation band expanding from Tajikistan to Kirgizstan. 6-hr merged MAP has similar pattern with a pick of 40 mm rainfall. ASM chart showed that top soil of some catchments was saturated in a narrow band from Tajikistan to Kirgizstan, while low 6-hr FFG values were estimated for the catchments along the band. 6-hr FFG values were as low as 15 mm. It was stated that saturated top soil coupled with low FFG values created favourable condition for the possible occurrence of flash floods depending on the forecast precipitation intensity for the next 6 hours. It was recalled that WRF model running at Kazhydromet had two domains: outer domain with 13x13 km spatial resolution covering whole central Asia region and inner domain with 4x4 km spatial resolution covering mountainous regions. 6-hr outer domain QPF had a maximum of 40 mm rainfall in Kirgizstan, while it was 60 mm for the 6-hr inner domain QPF. It was suggested that flash flood warnings could be issued for the region where FFFT2 were estimated. It was also suggested that forecasters could use their local experiences to decide on which colour scale would be appropriate- yellow with 10 upper scale or orange with 40 mm upper scale, for issuance flash flood warnings.

4.2.4 Demonstration of an Operational FFG System and Verification: Black Sea and Middle East FFG System

Mr Sayin provided an overview of operational capabilities of the Black Sea and Middle East Flash Flood Guidance (BSMEFFG) system and illustrated use of its derived products. He explained the spatial and temporal distribution of flash flood events in Turkey. It was stated that flash floods happen along the coast and in the central and northeastern regions of the county, causing on average forty human losses and hundreds of millions of dollars property damages annually. He described concept of operation FFGS operation at the Turkish State Meteorological Service. He said that hydrometorological division is the core element within the administration structure to maintain the BSMEFFG system and provide products and services to the agencies within the country and participating NMHSs. Its roles and responsibilities are as follows:

- Monitor BSMEFFG and SEEFFG Systems;
- Provide fist level IT maintenance and collaborate with HRC and TSMS IT department to ensure robust operation of the servers;
- Coordination with HRC, WMO, participating countries, national and international organizations;
- Participate in FFG training programme and provide training to the local forecasters;
- Prepare flash flood bulletins and distribute to the weather analysis and forecasting division and executive management;
- Conduct verification studies;
- Promote flash flood products to be used by other national agencies such as agriculture, water management;
- Organize and participate national and international workshops, conferences and meetings on flash floods and floods;
- Prepare user Manuel, brochures, and other material on Flash Flood Guidance System; and
- Cooperate with universities for the hydro-meteorological capacity development.

He also provided an overview of verification results for the BSMEFFG system for the years of 2013 and 2014. He stated that Probability of Detection (PoD) was 70% in 2013, while it was 55% in 2014. He concluded his presentation explaining that PoD was lower in 2014 because of the fact that frequency of the convective storms were high and that satellite estimation and numerical weather forecasts of precipitations intensity and amount are relatively poor in comparison with synoptic and mesoscale systems.

4.2.5 FFGS Approach

Mr Georgakakos gave a presentation on 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 needs for the FFG system and compared large river flooding with flash floods. He emphasized that it is critical to distinguish them and it is the fundamental concept of the flash flood development and implementation. He continued to explain 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 showed the diagnostic and prognostic FFG products in stressing that forecasters experiences are fundamental for the issuance of flash flood warnings. He concluded his presentation emphasizing the needs of local data for model calibration and bias adjustments.

4.2.6 Snow Accumulation and Depletion

Snow accumulation and depletion was a big concern for the mountainous regions of Central Asia such that five meter snow height is not unusual during winter. Hundreds of people are killed annually and enormous amount of economic losses are inflicted by the snow and ice-related hazards such as avalanches, floods due to sudden snow melting, and glacier. On average economic losses are almost one percent of GDP per annum.

Mr Georgakakos presented an overview of the CAFFGS snow products. He explained gauge Mean Areal Temperature (Gauge MAT), latest Interactive Multi-sensor Snow and Ice Mapping System (IMS), Snow Water Equivalent (SWE), and MELT products in detailed. He showed the schematic presentation of the snow model that receives surface Mean Areal Temperature (MAT) and merged Mean Areal Precipitation (MAP) to estimate SWE and MELT. It was stated that MAT is estimated using in-situ observations, Global Forecasts System (GFS), and climate data set. Snow depth and SWE observations are also ingested into the snow model if they are available. He said that the snow model is based on “Snow-17” snow accumulation and ablation model that was developed and operationally used by NOAA/NWS for the river forecast system. It has the following major components: 1) a conceptual areal lumped energy and mass balance; 2) air temperature is used as an index for pack energy and separation of precipitation as rain and snow; 3) takes into account of melting during no rain, melting during rain, and no melting; 4) model parameters are SWE, heat deficit, liquid content, and snow coverage area.

He showed a study conducted in Turkey to compare in-situ snow observations with satellite snow measurements. that on average ninety present of satellite observations matched with the ground observations. He explained that Glacier information obtained from Global Land Ice Measurements from Space (GLIMS) can be incorporated into the CARFFG system to monitor the Glaciers and then he showed fractional glacier coverage of the catchments for the Central Asia Region.

He continued to explain frozen grounds, Frost Index (FI), and reduction factor and then he concluded his presentation showing maps and graphs of climate and land cover of Kazakhstan; MODIS satellite surface temperature and snow coverage areas; and FI and MAT.

During the facilitated discussions, participants expressed that there are not sufficient snow measurements in their countries. It was stated that snow measurements are conducted one a month or once every two months. They also expressed their appreciations that the CARFFG system has extensive snow products that can be use in different sectors including water management.

4.2.7 Advances in the FFG System

Ms Modrick presented current enhancements for the FFGS improved operations. She touched upon the following four major topics:

- Multi-model QPF use in the FFGS;
- Landslide Susceptibility Mapping;
- Urban Flash Flood Warning; and
- Riverine Routing and Ensemble Discharge Prediction.

She articulated each topic saying that it was 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, she showed multiple NWP ingestion examples from the BSMEFFGS and CARFFGS and explained their impacts on the accuracy of the FFGS products. Secondly, she stated that there is a growing demand for a urban flash flood early warning system to be incorporated into FFG because occurrences of urban flash floods have recently increased due to climate change and climate variability. She 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 second one is underway to be implemented in Istanbul, Turkey. Finally, she showed a demonstration case study of Landslide prediction using Central America Flash Flood Guidance System (CAFFGS) products conducted in El Salvador includes landslide susceptibility mapping, real-time occurrence prediction based on FFGS rainfall and soil moisture data, and susceptibility class.

During the facilitated discussions, participants affirmed that mudflow/landslide is a very important hydrometeorlogical hazards in the Central Asia region, causing hundreds of human losses and extensive property damages 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.

4.2.8 CARFFGS Hydrometeorologist Training

Ms Modrick provided an overview of the FFGS Hydrometeorlogist Training Programme. She stated that training was an integral part of the project, and extensive training would be provided to the forecasters from the participating NMHSs. She 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.

She said that on-line 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.

She stated that first there modules are available in Russia, 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 expressed their appreciations with the quality of the training and its content, thanking to WMO and HRC for facilitating and providing such excellent training. It was mentioned that those forecasters who have successfully completed step-3 training will be requested to attend Step-4 training to give presentation and take written exam to be qualified for the certified WMO FFG trainer. It was recommended that written exam in Step-4 training should also be available in Russia and that forecasters who will participate in Step-5 training should take on-line (step-2) courses.

Representatives from Turkmenistan stated that Turkmenistan has not participated in the operational training took place at the HRC facilities in San Diego, USA because relocation of the Turkmenistan Meteorological Service coincided with the operational training. They indicated their willingness to participate in an operational training such as SAsiaFFG that may be conducted in the near future or on-the-job training at the Turkish State Meteorological Service.

4.2.9 Accessibility to the CARFFG System Console

Flash Flood Guidance System regional components are designed in a way that FFG servers are located in the Regional Centres and participating countries access to the FFG products through internet. That´s why, each participating NMHS shall have enough internet bandwidth to access to the FFG user interface console and dashboard. In this regard, representatives from Tajikistan and Turkmenistan expressed their concerns that their internet bandwidths are not sufficient to access to the CARFFG servers located at Kazhydromet in Astana, Kazakhstan.

5. Conclusions from the Steering Committee Meeting 2

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

2. Participants understood the responsibilities of the Regional Centre and NHMSs, noting that cooperation and collaboration amongst the project partners is the key to success for the project.

3. Participants became familiar the key technical and scientific backgrounds of the CARFFGS developments, including bias adjustments with historical and dynamic precipitation data, soil moisture modelling, threshold runoff modelling, soil accumulation and depletion modelling and flash flood guidance modelling.

4. Participants became familiar with the CARFFGS forecaster console, dashboard, and its products such as Global Hydro Estimator (GHE), Microwave adjusted GHE, gauge Mean Areal Precipitation (MAP), merged MAP, Average Soil Moisture, 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.

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 main water resource in the region. However, measurements of the snow parameters such as snow depth and SWE are not sufficiently performed.

7. Participants appreciated use of two nested WRF domains by the Kazhydromet: outer domain has a spatial resolution of 13 x13 km, while inner domain has 4x4 km spatial resolution covering mountainous regions. They noted the improved accuracy of the forecast flash flood threats in the mountainous regions. They urged improved linkages between the SWFDP-CA and CARFFGS such that high resolution (2x2 km) COSMO QPF products, covering the mountainous regions of the participating countries, could be used in the CARFFGS as multi model NWP ingestion.

8. Participants agreed that translation of the CARFFGS forecaster console, dashboard, and on-line available resources such as product descriptions into Russia would improve operational use of the system by the duty forecasters because Russia is the common working language of the participating countries.

9. 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.

10. Participants noted that the World Bank's Strengthening Early Warning of Mountain Hazards in Central Asia project, will provide targeted technical assistance to National Meteorological and Hydrological Services (NMHSs) for operational early warning and risk assessment of severe weather, avalanches, flash floods, debris flows and landslides in mountainous regions in coordination and support with the existing regional projects such as CAHMP, CAMP4ASB, CA-WaRM, SWFDP-CA and CARFFGS.

11. 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 Permeant Representative with WMO to the Regional Centre. in implementation of these two modules.

12. Participants appreciated that development of the CARFFG system has been completed and temporarily installed on a server at the Kazhydromet. They agreed on the revised implementation plan activities such as delivery of the servers to the Kazhydromet and provision of IT and Step-4 training.

13. Participants agreed that written exam that will be taken in Step-4 training for the qualification of certified WMO FFG trainer should be available in Russia and that forecasters who will participate in Step-5 training should take on-line courses (Step-2) before attending the training.

6. Closing of the Steering Committee Meeting 2

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.

ANNEX I

SECOND STEERING COMMITTEE MEETING (SCM 2)

CENTRAL ASIA REGION FLASH FLOOD GUIDANCE (CARFFG) SYSTEM

Astana, Kazakhstan

4-6 October 2016

List of Participants

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ANNEX II

SECOND STEERING COMMITTEE MEETING (SCM 2)
CENTRAL ASIA REGION FLASH FLOOD GUIDANCE (CARFFG) PROJECT

Astana, Kazakhstan

4–6 October 2016

Final Agenda

Day I

08:30-09:00 *Registration*

09:00-09:45 Opening Session

Welcome speeches by the Kazhydromet, WMO, and HRC

09:45 – 10:00 *Photo session*

10:00-10:30 Tea Break

10:30 – 10:45 Selection of the session chair, review of the agenda, and Participants self-introductions (All)

10:45 – 11:15 Objectives of the meeting and overview of the global FFG System (WMO)

11:15 – 11:30 Project implementation status (WMO)

11:30 – 12:00 Development and implementation status: model parameters, data, and operation (HRC)

12:00 – 12:30 CARFFG Forecaster Console and Dashboard (HRC)

12:30 – 14:00 Lunch Break

14:00 – 14:30 Roles and Responsibilities of the Regional Centre and NMHSs (WMO)

14:30 - 15:30 Overview of the CARFFG products: Diagnostic Products (HRC)

- Precipitation products (GHE, NWGHE, merged MAP)
- Soil Mositure (ASM)
- Flash Flood Guidance (FFG)
- Flash Flood Threat (IFFT, PFFT, and FFFT)

15:30-16:00 Tea Break

16:00 – 17:00 Overview of the CARFFG products: Prognostic and Snow Products (HRC)

- Mesoscale NWP
- Forecast MAP

- Snow Water Equivalent (SWE)
- Snow Coverage
- MELT

DAY II

09:00 – 09:30 Overview of day I presentations/discussions (All)

09:30 – 10:00 Demonstration of an Operational FFG System and Validation: Black Sea and Middle East Flash Flood Guidance (BSMEFFG) System (WMO*)*

10:00-11:00 Flash Flood Forecasting and Warnings: The Flash Flood Guidance System Approach (HRC)

11:00 – 11:30 Tea Break

11:30 – 12:00 How to prepare flash flood warnings: Methodology (WMO)

- Weather analysis and forecasting
- Mesoscale and Nowcasting Analysis
- Weather RADAR and Satellite images
- Interpretation of FFG Products

12:00 – 12:30 A Flash Flood Case Study (WMO)

12:30 – 14:00 Lunch Break

14:00 – 15:30 Hands-on Exercise for Past Events in the region (Guided by HRC, All)
(example “daily operations”)

- Daily Weather Briefing
- Hydrologic Output
- FFG Product Analysis
- Flash Flood Threats
- Discussion

15:30 – 16: 00 Tea Break

16:00 – 16:30 Overview of the World Bank hydrometeorological projects in the Central Asia Region and possible future projects collaborations (WMO)

16:30-17:00 Status of COSMO NWP modelling for the Central Asia Region (WMO-Yuri)

19:00 Welcome Dinner

Day III

09:00 – 09:30 Overview of previous day presentations/discussions (All)

Snow Accumulation and Depletion Session

09:30-10:30 Snow Analysis and Prediction Experiences in the CA Region-
Discussions/Contry Presentations (All)

10:30 – 11:00 Basis/data for snow modeling for CARFFG and examples of results (HRC)

11:00-11:30 Tea Break

11:30-12-00 Discussion of Analysis and Prediction Results for CARFFG (ALL)

12:00-12:30 Assessments, Potential Utility, and Data-Availability for snow cover, snow water equivalent and snow melt runoff for CARFFG (ALL)

12:30 – 14:00 Lunch Break

14:00 – 14:30 Advances in FFG System (HRC)

- Multi-Model QPF Ingestion in FFGS
- Landslides
- Urban flooding early warning system
- Riverine Routing

14:30-15:00 Flash Flood Hydrometeorlogist Training Programme: Step 4 and 5 (HRC)

15:00 – 15:30 Review of Work Plan (HRC)

- Adjustments and next steps

15:30-16:00 Tea Break

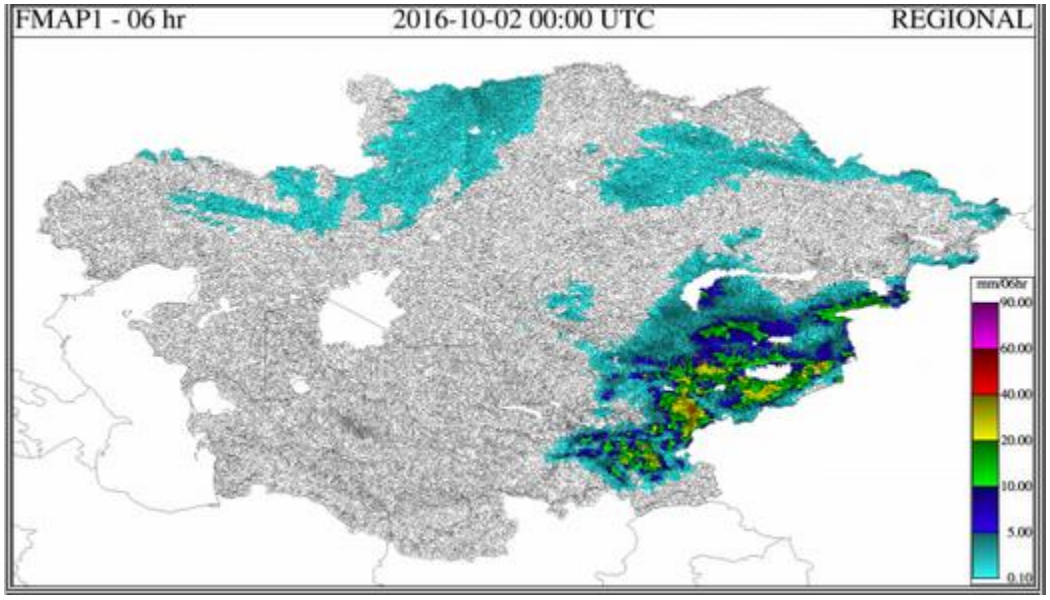
16:00 – 16:30 Final Discussions, conclusion and recommendation for further development (All)

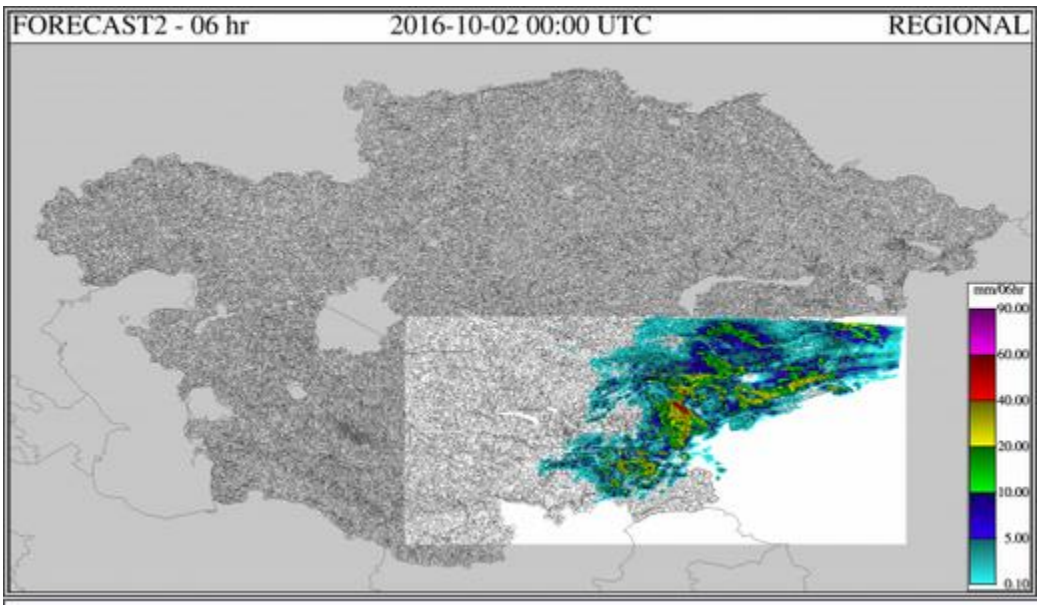
16:30- 17:00 Closing statements & closure of the meeting (All)

- End of Workshop -

ANNEX III

WRF Model Regional and Mountain Domains for the Central Asia Region





ANNEX IV

Revised Implementation Plan of the CARFFG System

Revised CARFFGS Implementation Plan

Activities	2015								2016										2017		
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Se.	Oct.	May	June	July
Initial Planning Meeting																					
Server Purchase - Regional Centers																					
Letters of commitment and points of contact provided-India																					
Obtain static and historical hydromet data																					
Obtain real-time data information - data availability/access																					
Training Workshop - Step 1 (Steering Committee Meeting #1)																					
National/Regional Centers complete online courses - Step 2																					
Complete system development																					
Regional Center develop and provide real-time data format																					
Regional Center operational (to collect real-time data)																					
National Centers operational and provide real-time data access																					
Complete operational training at HRC - Step 3																					
Steering Committee Meeting #2																					
Onsite system installation at Regional Center																					
Follow-up operational workshop [Step 4 training]																					
Steering Committee Meeting #3 [Step 5 training]																					