FIRST STEERING COMMITTEE MEETING (SCM 1)
BLACK SEA AND MIDDLE EAST FLASH FLOOD GUIDANCE (BSMEFFG) SYSTEM
(Step-4 Training)

Tbilisi, Georgia

28–30 June 2016

Final Report

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First Steering Committee Meeting (SCM 1) of

The Black Sea and Middle East Flash Flood Guidance (BSMEFFG) System

Tbilisi, Georgia, 28-30 June 2016

1. Executive Summary

In the Black Sea and Middle East 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 Association National Weather Service (US NWS); the Hydrologic Research Center (HRC); 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 Black Sea and Middle East Flash Flood Guidance (BSMEFFG) System Initial Planning Meeting was held in Istanbul, Turkey on 29-31 March 2010. Six Black Sea and Middle East countries, namely Armenia, Azerbaijan, Georgia, Iraq, Lebanon, and Turkey, were represented in the meeting. Participants expressed their interest in participating in the BSMEFFG system, indicating that flash floods cause considerable loss of life and property damage in the Black Sea and Middle East region. At this meeting, the National Meteorological and Hydrological Service (NMHS) of Turkey graciously offered to host the Regional Centre of the BSMEFFG system, which was accepted by all participating countries. Bulgaria, Jordan, and Lebanon participated in the BSMEFFG project at a later stage. Armenia, Azerbaijan, Bulgaria, Georgia, Jordan, Lebanon, Syria, and Turkey have thus far sent Letters of Commitment (LoC) to WMO. The inclusion of Israel in the BSMEFFG was underway at the time of this meeting.

Based on the BSMEFFG system implementation plan adapted at the Initial Planning Meeting in Istanbul, Turkey, the following major project activities have been completed: 1) Operational training took place from 8 April to 3 May 2013 at HRC facilities in San Diego, USA. Three hydrometeorologists from Turkey, one hydrologist from Bulgaria, and one forecaster from Georgia attended the training. 2) Regional operations training took place on 17-19 December 2013 at the WMO RTC in Antalya, Turkey in which two forecasters from Armenia, one forecaster from Azerbaijan, one hydrologist from Bulgaria, one forecaster from Georgia, and nine forecasters from Turkey attended. 3) Following the regional operations training, upon requests from the NMHSs of Armenia and Georgia, Mr Sayin has separately given one-week forecasters training to the forecasters of both countries.

As per the implementation plan, the first Steering Committee Meeting (SCM 1) and Step-4 training were jointly held in Tbilisi, Georgia from 28 to 30 June 2016. 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 BSMEFFG products, their development methodology, and the interpretation and validation approaches to provide feedback for their further development; operational use of the BSMEFFG products through hands-on exercises; allow a better understanding of the needs of high resolution modelling, including its domains; review and evaluate the BSMEFFG 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

In opening the first Steering Committee Meeting, the representatives of Georgia, WMO and HRC, highlighted the importance of improving the timely delivery of flash flood information and guidance to the populations at risk and fostering stronger partnerships among countries in the region to strengthen national capabilities to forecast flash floods. In his opening remarks, Ms. Tamar Bagratia, Head of National Environmental Agency, NEA and Mr Ramaz Chitanava, Permanent Representative of Georgia with WMO and Director General of Hydrometeorological Department, 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 Georgia in last year, explaining that flash floods are very dangerous natural phenomenon in the region. He assured participants that Georgia will use the BSMEFFG products in the preparation of daily flash flood forecasts and warnings. He expressed his pleasure in being able to host the SCM 1 in Tbilisi. He welcomed all the participants to Georgia, 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 to benefit from the discussions. He also thanked the Georgian Department of Hydrometeorology for all its efforts including hosting the meeting, thereby helping to make a positive atmosphere that would undoubtedly contribute favourably to the success of the meeting. Mr Eylon Shamir, HRC, welcomed everyone to the meeting and was pleased to see that representatives from the four Black Sea and Middle Eastern countries were attending the meeting. He emphasized the importance of enhancing the capacities of NMHSs of the Black Sea and Middle Eastern counties for timely and accurate early warnings of flash floods. He also expressed his appreciation to the Georgian Hydrometeorological Department for hosting the meeting.

The national press also covered the meeting, with several newspaper reporters being present at the opening of the meeting. Ms Tamar Bagratia and Mr Ramaz Chitanava informed the press about the objectives and possible outcomes of the meeting and positive impacts of the project on the citizens of Georgia and other participating countries. Mr Ayhan Sayin also informed reporters about the WMO support provided for the BSMEFFG system.

3. Organization of the First Steering Committee Meeting (SCM 1)

SCM 1, which was held Tbilisi, Georgia from 28-30 June 2016, was attended by the representatives of NMHSs from Armenia, Azerbaijan, Bulgaria, Georgia, Jordan, Lebanon, and Turkey. Other participants included representatives from WMO and HRC. The list of participants is provided in Annex I, while the annotated workshop agenda is given in Annex II.

4. Proceedings of the First Steering Committee Meeting (SCM 1)

Mr Sayin provided a brief overview and purposes of the workshop. He stated 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 Black Sea and Middle East region, including dissemination procedures and coordination between 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 Disaster Management Authority; and to cooperate with the Regional Centre on the BSMEFFG 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 BSMEFFG system activities; to have computer hardware and software capabilities and good computer network connections; to routinely monitor the availability of the BSMEFFGS 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; Armenia, Azerbaijan, Bulgaria, Georgia, Syria, and Turkey sent LoCs to WMO. On the other hand, Jordan and Lebanon participated in the project in 2015. He stated that the inclusion of Israel into the BSMEFFG is underway. He also stated that TSMS and HRC will commence technical works such as real-time data transmission, basin delineations, and bias adjustments, once Letter of Commitment from Israel is sent to WMO. It was mentioned that the major project activities that have been completed were: 1) Development and implementation of the BSMEFFG System; 2) Operational Training at HRC, San Diego, USA; 3) Regional training workshop; and 4) Country-level training at the NMHSs of Armenia and Azerbaijan.

He stated that this meeting is one of the major project activities as Step-4 training aimed at: reviewing the BSMEFFG products to allow forecasters to become familiar with the BSMEFFGS products; promoting operational use of the BSMEFFG products through hands-on exercises; reviewing and evaluating the BSMEFFG 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.

He concluded his presentation by stating that at the end of this meeting, forecasters should have the following competencies: 1) analyse and monitor the evolving meteorological and hydrological situation; 2) analyse and monitor the BSMEFFGS products; 3) prepare flash flood advisories, watches, warnings and alerts; and 4) communicate flash flood warning information to internal and external users, including Emergency Management Agencies.

4.1. Country Presentations

4.1.1 Georgia

Ms Kordzakhia stated that the steam network of Georgia consists of more than 26,060 rivers with a total length of 60,000 km. It was mentioned that there are 25,075 small tributaries with less than 25 km length and total length of 54,768 km. She stated that Georgia has 786 glaciers; 856 lakes with total area of 170 km^2; and 44 reservoirs. She also mentioned that there are swamps, covering with total surface area of 225,000 hectares in western Georgia.

She provided an overview of history of the hydrometeorological observation network in Georgia, emphasising that the first meteorological station was installed in 1844. It was mentioned that number of meteorological stations significantly decreased from 200 before World War II, to 33 in 2012. She cited current operational components of the hydrometeorological network are: 22 Automated Weather Observing System (AWOS) stations, 11 manual surface weather stations, 24 gauges, and 20 stream gauges. She stressed the importance of making measurements of parameters such as snow in the remote regions such as in high mountains. She shared the plan to install 5 meteorological stations, 20 meteorological gauges, and 10 hydrological stations within the scope of Adaptation Fund Project. She continued her presentation saying that most of hydrometeorological data until 2006 are processed, quality controlled, and stored in the spatial database. She mentioned that the Czech Hydrological Institute provided hydrometric data monitoring software (WinZPV) to National Environmental Agency (NEA) in 2012 for recording river water parameter measurements.

She provided a brief overview of the flood forecasting and early warning system in Rioni River basin which is one of the most flood-prone areas in Georgia with 200,000 inhabitants in six municipalities. The Project was developed and implemented in collaboration between the Ministry of Environment and Natural Resources Protection of Georgia and United Nations Development Programme (UNDP) with financing from the Adaptation Fund. The aim of the project is to implement climate resilient economic practices and adaptation measures in the Rioni River basin that are the most vulnerable to floods and extreme climate events in the country. It was mentioned that within the scope of the project, structural and non-structural measures will be applied in managing floods such as development of new national policies, flood zoning, flood resilient building codes. Then, she described Rioni River citing that total length of river is 327 km; average inclination 7.2 percent; catchment area 13,400 km^2; and average height is 1084 m. It was mentioned that Rioni river basin has 112 glaciers with 75.10 km^2 of total area and the swamps with about 350-400 km^2. It was mentioned that Delft FEWS was also installed with its real-time data reception and processing capabilities such as hydrometeorological data, TRMM/GPM satellite data, and prediction from the WRF model and that it was planned to use COSMO model QPF and EUMETSA's Multi-sensor Precipitation Estimates (MPA) data. She concluded her presentation saying hydrological models provide discharge and water level predictions at critical points along the river.

4.1.2 Armenia

Mr Azizyan provided an overview of operational meteorological and hydrological stations and showed their geographical locations. He stated that there are 47 meteorological stations and 95 hydrological stations. It was stated that water level, discharge, temperature, and type of ice have been measured. He stated that the Armenian MHS makes approximately 25 to 30 streamflow measurements each year. He stressed that Armenia is very prone to floods and flash floods due to heavy precipitation over steep mountains. He emphasized flash floods and floods occur during the spring period because of heavy rain and snow melt. He stated that the statistic regression method is being used for flood forecasting in Armenia. For each individual river, multifactorial correlation between flood predicted value and flood developing parameters are developed. He stated that BSMEFFG system has been implemented in the Armenian Hydrometeorological Service since 2014 and that it increased the flash flood forecast accuracy. He stated that BSMEFFG forecasters training took place in Armenia in May 2014. During the three-day training, BSMEFFG products were briefly described and case studies were provided. He stated that training was very successful and useful for forecasters to help to better understand the BSMEFFG system and it use in real-time. Immediately after the training, forecasters started to collect historical information about flash flood cases to improve the BSMEEFFG system and for future case studies. He concluded by saying that flood forecasting methods and their accuracy need to be improved, and stressed the importance of the BSMEFFG system in flash flood forecasting process.

4.1.3 Azerbaijan

Mr Verdiyev provided an overview of the hydrometeorological observation network in Azerbaijan. He stated that it consists of 83 meteorological stations, 1 radio sounding station, 4 meteorological radars (MRL-5), 12 agrometeorological stations, 9 marine stations, and 109 hydrological stations. He also stated that the current automated observation network includes 55 AWOS stations, 8 automatic rain gauges, and 2 Acoustic Doppler Current Profilers (SonTec). He showed their geographical location on maps and stressed the importance of the stations located at high altitudes. He showed photos of automatic meteorological stations Shahdag (2,712 m), Shahduzu (3,700 m), Tufandag (4,172 m) and continued providing information on snow measurements, which include 15 snow stations and 28 snow-measurements routes (16 over the Big Caucasus and 12 over the Lesser Caucasus). He showed an example of flood mapping and graph indicating an increasing trend of flood events during the last decade. He emphasized the value of post flood field survey, estimation of maximum peak discharge, and time of peak. He stated that regional and international exchange of data and cooperation are essential to reduce the loss of lives and damage. He concluded his presentation by showing BSMEFFGS products and pictures of recent flood and flash flood events that occurred in Bumchay (22 July 2015), Girdimanchay (9 May 2016), Goychay (12 June 2016), and Zayamchay (16 June 2016) rivers.

4.1.4 Bulgaria

Ms Balabanova provided a brief overview of the status of operational flash flood forecasting and early warning capabilities at the National Institute of Meteorology and Hydrology (NIMH). She stated that main activities of the NIMH are: hydrological and meteorological observations, data processing, data storage, data updating, and meteorological and hydrological forecasting. She explained the administrative structure of NIMH that consists of headquarter in Sofia and 4 Regional Centres. She mentioned that NIMH is a member of number of international institutions such as WMO, EUMETSAT, European Centre for Medium Range Weather Forecast (ECMWF), and European Flood Awareness System (EFAS).

After reiterating the flash flood definition, she briefly described the process of flash flood forecasting and warning dissemination. She stated that this process can be divided in three stages. First stage composes of BSMEFFG system, EFAS, regional and hydrodynamic ALADIN-Bulgaria with high resolution. She explained that thresholds for intensive precipitation are made available to forecasters to analyse hydrological and meteorological conditions that can initiate flash floods. She explained the thresholds for intense precipitation and showed an example of 3-hr Forecast Mean Areal Precipitation (FMAP) generated from ALADIN-Bulgaria on 25 May 2016 at 19 UTC. She stated that in the second stage, the forecaster is using and testing the rational method to assess the maximum discharge at the catchment outlet. She proceeded to explain the third stage, which includes the application of physically-based, distributed hydrological TOPographic Kinematic APproximation and

Integration (TOPKAPI) model. She concluded her presentation by showing pictures of past flash flood events in Bulgaria.

4.1.5. Jordan

Mr Elryalat provided an overview of the climatological characteristics of Jordan. He explained that the climate is influenced by Jordan's particular location between the subtropical aridity of the Arabian desert areas, and the subtropical humidity of the eastern Mediterranean area. He stated that the weather systems that have an effect on Jordan’s climate are: frontal depressions (from December to February), Siberian Anticyclones (February), Khamsin (during spring), Red Sea trough (during summer), and monsoons (late summer and autumn). He stated that most of rainfall occurs between November and March, while the period from June to August is often rainless. Precipitation is often concentrated in heavy storms, causing erosion and local flash flooding, especially during the winter. He showed a map of high spatial rainfall variability over Jordan and stressed significant declining in precipitation amounts over west and south Jordan.

He cited operational meteorological stations and showed their geographical locations. He stated that there are 16 Automatic Weather Observing Stations (AWOS) and 26 manual stations including synoptic, agrometeorological and climatological stations. He said that Jordan does not have weather Radar. He also stated that WMO is helping Jordan Meteorological Department (JMD) to obtain a weather Radar, funded by a donor.

He emphasized flash floods are the deadliest hydrometeorological phenomena in Jordan, which take place in the areas below high mountains. He explained that flash floods are mostly triggered by frontal depressions and instability. He stated that during the night of 11 March 1966, torrential rain caused flash floods in the Maan region, and resulted in 85 deaths, 7 missed, and 86 injured.

He mentioned that 10 Automatic Weather Stations (AWS) were installed in 2012. He said that UNDP, through a partnership with JMD in 2014, launched the “Early Warning System (EWS) for Flash Floods” in Petra and Wadi Mousa. It includes 8 tipping bucket rain gauges, 2 flow meters, and a siren system. He stated that the main components of the EWS are: Central Control Unit (CCU) or REACT 4000, Remote Terminal Unit (RTU), and software.

He continued by describing the Jordan Crisis Management Centre (JMC) that was established in 2001 and noted it was a member of National Disaster Committee. He explained that JMD’s forecasters disseminate warnings through daily weather forecast bulletins. Each warning level also includes recommended actions to be taken. He concluded his presentation by showing pictures of past flash flood events.

4.1.6 Lebanon

Mr Doumit provided an overview of the Litani River Authority in Lebanon. He stated its roles and responsibilities as follows: water monitoring in all Lebanese rivers; conducting irrigation studies; providing potable water for south of Lebanon; responsibility for irrigation schemes in southern Bekaa and south Lebanon; and supervision of dams.

He explained that Litani River is the longest river in Lebanon with a length of 170 km, 60 km of tributaries, and water capacity of 750 m^3 per year. The Litani’s River basin is the largest basin in Lebanon (2,175 km^2), covering 20 % of the country’s territory.

He stated that many projects and studies have been conducted on the Litani River, which has several power reservoirs and hydroelectric power stations. It also provides drinking and irrigation water. He described the Qaraoun dam in the Litani River, which is the largest artificial lake in Lebanon, located in the Western Bekaa valley, with surface area of 12 km^2, and storage capacity around 220 million m^3, and dimensions of 60 meters high, 1,090 meters long, and 162 meters wide.

He stated that hydrological stations are in general located in the river basins and that there are also 12 groundwater monitoring wells and several meteorological stations in the upper Litani basin. He showed photos of some hydrometeorological stations and an example of Acoustic Doppler Current Profiler (ADCP) measurement.

He described the Litani River Basin Management Support Program financed by USAID. He also described how and where floods occur in Lebanon and categorized them in three groups: 1) Litani River and its major tributaries (Ghzayel, Berdawni, Qabb Elias); 2) seasonal flooding at the minor channels, mostly due to lack of agricultural drainage, permeability of soils (mostly clayey), and poor maintenance and disappearance of many drainage ditches in farm lands; and 3) flooding in urban areas (Bar Elias, Marj) during winter precipitation due to lack of storm or sewage networks. He concluded his presentation by stating that water level depths were computed by HEC-RAS, using digital elevation model of 1 m accuracy.

4.1.7 Turkey

Mr Ulupinar presented an overview of the status of operational flash flood forecasting and early warnings capabilities in Turkey. First, he explained the organizational structure of the Ministry of Forestry and Water Affairs, which is divided into the central units and affiliates where Turkish State Meteorological Department (TSMS) belongs. He stated that TSMS was founded in 1937 and it is the only legal organization which provides all meteorological information in Turkey. He proceeded to explain the meteorological observation network of TSMS, which consists of 1387 Automatic Weather Observation Stations, (1237 AWOS stations, 72 Airport AWOS, and 78 Marine AWOS), 18 radars (15 C-band radars, 1 mobile X-band radar and 2 marine radars), 35 lightning detection systems and 10 upper air observation stations.

He then continued by showing a map of the location frequencies of flash flood events that occurred from 2012 to 2015. He explained that spatial distribution reveals that majority of the flash floods occurred along the coastal regions, by cause of cyclonic depressions, orographic rainfall in the northeast coastal parts, and convective rainfall in the central Anatolia. He stated that big cities, such as Istanbul, Izmir, and Ankara, are also prone to urban flash floods.

He emphasized the importance of the use of remote sensing data and explained that TSMS's forecasters are able to access the weather satellite images produced from EUMETSAT MSG with spatial resolution of 3 km, and with temporal resolution of 5 minutes. He stated that forecasters are also able to access to satellite data from National Oceanic and Atmospheric Administration (NOAA) (polar orbit) with spatial resolution of 1 km and with temporal resolution of 6 hours. For operational forecasting, he said that TSMS is using several Numerical Weather Prediction (NWP) models such as ECMWF, MM5, ALADIN, WRF, METU3 (Marine), SWAN (Marine), DREAM-8 Dust Transport, MEUS (Forest Fire), AGROMETSHELL, and RegCM4.3.4. He continued to provide information on the provision of forecasts and early warnings, stating that weather forecasts are provided with lead times of 3-6, 24, 48, 72, and 168 hours (7 days). He said that flash flood warnings are disseminated to the Prime Ministry of Disaster and Emergency Management Authority, Regional Meteorological Directorates, local authorities, and the public via press and TSMS's web page. He stated that prepared warnings are disseminated through TSMS web page by Weather Forecast Department. He explained that warnings mostly include date, time, and severity degree of the event. He said that degree of detail in a warning can vary depending on its time span and the extent of the area to be warned. In greater detail, an effective flash flood warning can include current intensity of precipitation, the location of the flash flood's most likely impact(s) areas, validity period, and protective action statements. He also provided an overview of verification results for the BSMEFFG system for 2013 and 2014. He stated that Probability of Detection (PoD) was 70% in 2013, while it was 55% in 2014. He explained that PoD was lower in 2014 because the frequency of the convective storms was high and that satellite estimation and numerical weather forecasts of precipitations intensity and amount were relatively poor in comparison with synoptic and mesoscale systems. He also stated that in 2015, the hit rate was very low compared to previous yearsThis is because of convective precipitation, which occurs generally during the summer or spring months. He said that, according to TSMS FEVK observations, there were more than 80 flash flood events in June 2015, and concluded that NWP models are not sufficient for prediction of mesoscale events.

4.2. Overview of the BSMEFFG System Forecaster User Interface

Mr Shamir provided an overview of the BSMEFFGS 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 BSMEFFGS 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 BSMEFFGS 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 display full list of the BSMEFFGS and products in image formats; and 3) data download buttons in text, CSV, and CSVT formats. He 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 (10.5 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 (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,** ALADIN, ECMWF IFS, and WRF QPF products are ingested to allow forecasters to compare different FFGS products resulted 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;

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

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

- **Snow MELT.**

Mr Shamir 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 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 the 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.

4.3. BSMEFFG System Development and Theoretical Background

Mr Shamir explained the development and theoretical background of the BSMEFFG 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^2. 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*[1]. 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

[1] 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.

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, she showed comparisons of modelled SWE and observed snow depth. 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 18-26 hours latency 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.

4.4. BSMEFFG System Operational Concept

Mr Ulupinar 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 of 40 human losses and hundreds of millions of dollars property damages annually. He described the concept of FFGS operation at the Turkish State Meteorological Service. He said that hydrometeorological 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 first 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 Manual, brochures, and other material on Flash Flood Guidance System; and
- Cooperate with universities for the hydro-meteorological capacity development

4.5. 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 first, 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 the current weather outlook and weather conditions are favourable for the occurrences of flash floods; second, 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 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 continued to present a case study on a flash flood event that took place in Georgia on 12-14 June 2015 in which more than 20 people were killed and millions of dollars' worth of economic damage were inflicted, according to the UNDP report. He stated that the flash flood was caused by the occurrence of severe convective storms during the night. He said that there were two important lessons learned from this case study: first, convective rainfall may not be detected neither by FFG system nor NWP models. If this is the case, weather satellite and/or weather RADAR nowcasting products, depending on their availability, are very useful tools for flash flood forecasting. Second, 24/7 working hours are extremely important because flash flood may happen at any time, which was the case in this event. He also emphasized the WMO Common Alert Protocol (CAP) and recommended its implementation to disseminate warnings.

4.5.1 Georgia Flash Flood Event

Ms Kordzakhia gave her presentation on the disastrous flash flood event caused by Vere River on 13-14 June 2015. First, she showed the relief map and explained thebasin and hydrological characteristics of the Vera River. She stated that Vere River has the length of 38 km and basin area of 194 km^2; with the average height of basin at 1060 m, while average inclination is 0.034 ‰. She said that Vere River has 41 tributaries with 95 km total length, average stream density of 0.72 km/km^2; and is fed by snow melt, rain, and underground waters. She emphasized periodic occurrence of floods in the Vere River, during which the observed maximum discharges were 259 m^3/s (4 July 1960), 153 m^3/s (7 June 1972), and 155.3 m^3/s (4 June 2015). She stressed that the National Environment Agency (NEA) computed 468 m^3/s maximum discharge of the Vere River on 13 June 2015, which was nearly twice as big as the highest recorded discharge in 1960.

She stated that recorded maximum rainfall intensity at the Tbilisi meteorological station was 40 mm/4-hr from 13-14 June 2015, during which catastrophic flash floods as well as mud and debris flows occurred. She said that the landslide was triggered on the steep right bank slopes of the Vere River as a result of the intense precipitation falling on already saturated soil. She concluded her presentation by showing photos of the flash flood event in Tbilisi and stated that this flash flood caused loss of life, widespread property damage and considerable economical losses.

4.5.2 Armenia Flash Flood Event

Mr Azizyan from Armenia presented a case study for the flash flood event that took place on 2-3 June 2014 in Armenia. He stated that maximum rainfall intensity during the flash flood event was 47 mm/hr at 18 UTC. Because of heavy rainfall, many basements, fields, and gardens of Tashir town in Lori Marz were inundated, and fish farms were damaged. He stated that during the period from 30 May to 1 June, discharge values at Saratovka hydrological station located on Tashir River were between 4 and 6 m^3/s. He said that according to the weather forecast at 2nd June, intense precipitation was predicted.

Subsequently, discharge values increased from 5.93 m^3/s to 17.4 m^3/s on 2 June at Saratovka station. Then, he provided an overview of the BSMEFFG products from 1 June at 06 UTC to 3 June at 06 UTC. He stated that satellite precipitation products (GHE and MWGHE) and Merged MAP showed that 24-hr precipitation accumulation had maximum a value of 20 mm over the country on 1 June at 10 UTC. ASM on 1 June at 06 UTC had maximum values of 0.65 on several catchments in the north and central Armenia. FFG values were quite low ranging from 5 to 10 mm/1hr. This indicated that if rainfall intensity continued at the same rate or more, bankfull condition would be met resulting in flooding at the outlets of the catchments. 6-hr ALADIN Quantitative Precipitation Forecast (QPF) on 1 June at 10 UTC showed maximum precipitation accumulation in the northern Armenia. He continued his BSMEFFGS products analysis by showing satellite and Merged MAP products on 2 June at 23 UTC. He stated that rainfall continued causing soil saturation. The 24-hr FMAP on 2 June at 9 UTC had values between 20 and 60 mm, while FMAP at 18 UTC had maximum values of 80 mm/24-hr over the northern Armenia. He showed 6-hr FFG on 3 June at 00 UTC and stressed significant decrease of FFG values which reached their minimums (0.01-15 mm/6-hr) over the almost all Armenia. Considering FFG, ASM, Merged MAP, and FMAP products, and forecaster's local experience, he concluded that occurrences of the flash floods in Armenia were very likely. There were several sub-basins with Forecast Flash Flood Threat (FFFT) values over northern and central Armenia on 3 June at 00 UTC, with a maximum value of 5 mm. Finally, he showed maximum discharge values from 30 May to 10 June 2014, emphasizing two distinctive peaks with 17.5 m^3/s on 2 June, and 27.5 m^3/s on 3 June 2014 occurred. He concluded his presentation emphasizing that FFGS products are very valuable and useful for the issuance of flash flood forecasts and warnings.

4.5.3 Bulgaria Flash Flood Event

Ms Balabanova presented a case study on the flash flood event that occurred on 25-26 May 2016 in the City of Kazalnak. First, she provided an overview of the weather analysis from 24 to 27 May 2016, explaining that a well-developed cyclone passed over Bulgaria. A cold front associated with the cyclone, passed through the country. She said that 850 hPa temperature decreased from 10-12^{o}C on May 24 at 00 UTC to 4-5 ^{o}C on May 25 at 00 UTC. It was mentioned that the highest precipitation amount was 64 mm/48-hr which was measured at Kazalnak synoptic station, while precipitation amounts at Shipka meteorological station on 25 May 2016 were 28.6 mm for 3-hr period (16 to 19 EEST) and 61.9 mm for 9-hr period (16-00 EEST). She showed a map with spatial distribution of precipitation amounts from 07:30 EEST on 25 May 2016 to 07:30 EEST on 26 May 2016. Then, she showed ALADIN Quantitative Precipitation Forecast (QPF), indicating that model predicted rainfall of 60-90 mm/24-hr over Bulgaria on 25 May 2016 at 06 UTC. She gave an overview of the BSMEFFG products on 25 May 2016 at 12 UTC. She stated that ASM values over Bulgaria were up to 0.5 and stressed that forecasters must pay attention to spatial and temporal distribution of ASM. She stated 6-hr FFG values in the region varied from 21 mm to 44 mm, while 3-hr FFG values were between 19 and 40 mm. Forecast Mean Areal Precipitation (FMAP) showed that 6-hr precipitation accumulations were up to 60 mm. She stated that 6-hr FFFT and 3-hr FFFT existed over the central Bulgaria having maximum values of 14 mm indicating possibility of flash flood occurrence. After an overview of the BSMEFFGS products, she stated that Bulgarian Hydrometeorological Service is running hydrodynamic version of ALADIN model with spatial resolution of 7 km twice per day at 06 UTC and 18 UTC. She concluded her presentation by showing the flash flood warning and hydrometeorological bulletin issued on 26 May 2015 and emphasized that the BSMEFFG system is a very valuable supplementary tool for forecasting flash flood events.

4.5.4 Jordan Flash Flood Event

Mr Elryalat presented a case study on the flash flood event that took place on 26-28 March 2016 in the city of Azraq in the southern Jordan. He showed synoptic analysis of surface chart and 500 hPa geopotential height on 26 March 2016 at 06 UTC. He stated that a high pressure centre with 1016 hPa value was located over the northern and eastern parts of Jordan, while surface low pressure centre with 1012 hPa was located over the southern Jordan. It was stated that surface pressure tendencies had negative values in the north and east parts of the surface trough, indicating that the surface low pressure centre will propagate towards this region. He explained 500 hPa analysis in detail, stating that a deep upper low depression with 536 hPa value was located over Ukraine and associated trough expended southward to the eastern Mediterranean and Jordan. He stated that the surface low pressure centre associated with upper low formed instable conditions in the middle troposphere. Then, he showed Skew-T Log-P diagrams of Bet Dagan and Mafraq sounding stations on 26 March 2016 at 00UTC and stated that instability indices showed weak or no instability in the middle troposphere. He also depicted IR images of METEOSAT geostationary weather satellite showing a cloud band with associated medium and high cloudiness over the eastern Mediterranean and that convective clouds developed over Egypt, Saudi Arabia, and southern Jordan on 26th of March at 10:15 UTC.

He indicated that Radar images, provided by the Israel Meteorological Service (IMS), showed moderate to heavy rainfall over the southern, central and eastern Jordan, resulted in flash flooding, particularly in the urban areas. He provided an overview of the BSMEFFG products from 26 March to 27 March 2016. He stated that 6-hr Merged MAP had a maximum value of 45 mm over the central and northern Jordan on 26 March at 18 UTC and 27 March at 00 UTC. ASM values over the same parts were 0.85 or 1.00, indicating saturation of the top soil in the region. The 6-hr FFG values were 0-15 mm. 6-hr Imminent Flash Flood Threat (IFFT) on 27 March at 00 UTC existed over northern Jordan with the values up to 40 mm, indicating high probability of occurrence of flash flooding in the region. He concluded his presentation by showing a video of a flash flood event that occurred in the city of Azraq on 26 March 2016.

4.5.5 Lebanon Flash Flood Event

Mr Obeid presented a case study for a flash flood event that took a place in Lebanon on 25 October 2015. First, he described the geographical position of Lebanon, located on the eastern shore of the Mediterranean Sea. He showed a map of high spatial rainfall variability over the country and stressed significant declining in precipitation amount over northern Lebanon. He stated that mean annual rainfall amounts varied from less than 300 mm in the north to more than 1,200 in the south Lebanon. He showed a distinctive peak with 28.7 mm/hr rainfall intensity at 8 UTC. It was stated that intense rain started at 8 UTC and continued until 11 UTC. He stated that in a period of less than 3 hours, 49 mm, 67 mm, 75 mm, and 48 mm precipitation was recorded in Beirut, Tripoli, Abdeh, and Quartaba cities, respectively.

He provided an overview of the BSMEFFG products from 24 October at 18 UTC to 26 October 2015 at 00 UTC. He showed 6-hr Forecast Mean Areal Precipitation (FMAP) generated by ALADIN on 25 October at 00, 06, 12, and 18 UTC; and on 26 October at 00 and 06 UTC. He explained that the precipitation band was located over the coastal and central part of Lebanon, and then extended across the country. He emphasized that the precipitation core was located over the Lebanon Mountains and Anti-Lebanon Mountain Range with a maximum precipitation value of 25 mm on 25 October at 00 UTC. FMAP on 26 October at 00 and 06 UTC revealed that precipitation slowly diminished over time, while precipitation core did not propagate. 24-hr FMAP indicated that precipitation intensified on 25 October having a maximum value of 50 mm at 00 UTC. He stated that forecasters during the BSMEFFG system analysis should answer the following questions: 1) how much rainfall has already fallen?; 2) what is the level of soil moisture?; 3) how much rainfall is needed to cause bankfull at the outlet of the draining stream?; 4) how much rainfall is expected?; and 5) are there regions to be concerned for flash flooding?. He also stated that the forecaster should determine specific locations where flash flood occurrences are possible, taking into consideration the forecast uncertainties. He proceeded to show BSMEFFG products on 25 October at 00, 06, 12, and 18 UTC. He explained that Merged MAP 6-hr precipitation accumulation had a maximum value of 15 mm at 12 UTC. The ASM values ranged from 0.85 to 1.00, indicating that upper parts of soil were almost or completely saturated, especially over the mountains. He also showed how FFG values changed over time and what their magnitudes were. The 6-hr FFG values were very low with 0-15 mm/6-hr over the most of sub-basins indicating very high possibility of flash flood occurrence. After reiterating that Persistence Flash Flood Threat (PFFT) assumes that past precipitation will persist for the next 1,3 and 6 hours, he showed that PFFT existed over the mountains with maximum value of 10 mm at 12 UTC. On the other hand, 6-hr Forecast Flash Flood Threat (FFFT) existed over the same area reaching value of 10.06 mm/6-hr. He mentioned that Lebanese Meteorological Service issued flash flood warning on 25 October at 12 UTC for the northern mountainous areas (Qartaba and Qoubayat), and the central part of Lebanon (Baysour). He concluded his presentation by showing flash flood images and emphasized that BSMEFFG system was very precise and useful.

4.5.6 Turkey Flash Flood Event

Mr Ulupinar presented a case study on the City of Hopa flash flood event that took place on 24 August 2015. First, he explained the importance of the flash flood case studies that may allow forecasters to understand the behaviour 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 explain the top-down approach for the preparation of a case study, given in the following order: 1) analysis of the diagnostic and prognostic synoptic and mesoscale products (surface charts, 850, 700, 500 hPa charts, and jet streaks); 2) Quantitative Precipitation Forecast (QPF) of different NWP models such as ECMWF, ALADIN and WRF; 3) instability analysis including instability indices; 4) satellite and radar images; 5) monitoring of in-situ observations, particularly precipitation intensity and precipitation accumulations; and 6) detailed analysis of the BSMEFFG products.

Secondly, he explained meteorological conditions that resulted in producing heavy precipitation, which started at 06:00 UTC on 24 September and lasted until 11:00 UTC with an accumulation of 185 mm. He stated that a surface low pressure centre with 1000 hPa value was located in the eastern Turkey, while 850 and 500 hPa low centres were located in the eastern Black Sea with geopotential height values of 147 hPa and 573 hPa at 00 UTC. He showed the instability analysis of the region explaining that atmosphere was quite unstable. His analysis included such instability indices as K index, TT index and Sweat index that had values of 45, 62 and 425, respectively. Satellite images showed dense cloud cover, while weather Radar indicated heavy rainfall at 09:30 UTC.

Thirdly, he provided an overview of the BSMEFFG products from 23 August to 24 August 2015. He stated that ASM values at the Hopa region were 0.85 or 0.90, indicating saturation of the top soil in the region. The 6-hr FFG values at 06:00 UTC varied from 15 to 40 mm over the same areas. The 24-hr FMAP had values between 100 and 200 mm at 18:00 UTC on 23 August 2015. The 6-hr Forecast Flash Flood Threat (FFFT) on 24 August at 06 UTC, existed over the City of Hopa with the values up to 60 mm, indicating high probability of accordance of flash flood in the region.

Finally, he explained the consequences of flash flood events, which resulted in 8 deaths and 27 injuries, 6 destroyed buildings, and 28 significantly damaged buildings. He concluded saying that BSMEFFGS products are very useful for the prediction of flash floods.

4.6. Technical Background on the Flash Flood Verification

Mr Shamir provided a presentation on technical background on the flash flood verification. At the beginning, he stressed the different aspects of the BSMEFFG system which can be validated, including: diagnostic products (observed MAP, soil moisture), forecast products (mesoscale model, FMAP), and validation of flash flood warnings issued by forecasters. He stated that if persistent biases are found in certain regions, they can be corrected by post-processing the system results before estimating FFFT and deciding whether to issue a warning. To identify strengths and challenges in the end-to-end process of warning-response, flash flood events should be collected and archived in database. He showed evaluation of the Probability of Detection (POD) and False Alarm Rate (FAR) sample frequencies for 20 years for discharge at the catchment outlet exceeding a given threshold (mm/hr). He explained that POD reached 83 % for the flow of a 2-year return period with a corresponding FAR frequency of 7 %. He continued to explain that the system can perform well under good quality of data. Reduction of POD and increase of FAR may happen because of system-input data quality degradation in different regions and locations (e.g. satellite or radar data quality, and rainfall nowcast or forecast quality). He continued by explaining initial validation of FFG system products, which were made for the Central America FFG (CAFFG) system implemented in 2004. He stated that for 3 months training, system operators from Costa Rica and El Salvador were in daily communication with Country Agencies to receive community information regarding local flooding. The evaluation considered the success of the system-produced FFT and the forecaster-adjusted FFT during the period from September to November 2004. The ground truth data used to evaluate FFT were local reports of flash flood occurrence (or non-occurrence). The metrics used in this case were number of hits, false alarms, and number of misses. He showed the results of operational evaluation of CAFFG FFT explaining that when system is used as intended by the forecaster and forecaster adjustments are made, significant skill is added in both predicting events that occurred and minimizing the warnings for the events that did not occurred. Mr Shamir also showed an example of contingency table for the flash flood bulletins developed by Turkish State Meteorological service (TSMS) for the period from 21 May 2012 to 17 June 2013. He concluded stressing the importance of BSMEFFG system validation and advising participating countries to develop a database of observed flash flood events, and statistical measurements for assessing performance of warning generation process.

4.7. BSMEFFG System Verification Results and Challenges

Mr Ulupinar presented BSMEFFG system verification results and challenges. At the beginning, he stressed the definition of the verification process given by WMO, citing that the main goal of verification process is to constantly improve the quality (skill and accuracy) of the services including: Establishment of a skill and accuracy reference against which subsequent changes in forecast procedures or introduction of new technology can be measured; Identification of the specific strengths and weaknesses in a forecaster's skill and the need for forecaster training and similar identification of a model's particular skill and the need for model improvement; and Information to the management about a forecast program past and current level of skill to plan future improvements; information can be used in making decisions concerning the organizational structure, modernization and restructuring the National NMHSs. After describing the verification process, he showed an example of TSMS Extreme Event Observation (FEVK) Records. He explained that flash flood records include data such as: latitude and longitude of the event, start/finish date and time of event, precipitation amount, remarks, location of event, images if available, and whether flash flood bulletin was issued or not. He stated that all records are saved in Excel sheet. He stressed that verification process in Turkey is very challenging, because Turkey has more than 11,800 sub-basins, with an average drainage area of 64 km^2. He showed and compared maps of location frequencies of flash flood events in 2014 reported by TSMS, State Hydraulic Affairs (DSI) and press. He also showed a map with combined reports by these three resources. He continued by showing and explaining the contingency table of flash flood warnings for 2014. He stated that Probability of Detection (PoD) was 55 %, False Alarm Ratio was 15 % and Critical Success Index 0.4 %. After presenting flash flood warnings in 2014, he also showed and compared maps of location frequencies of flash flood events in 2015 reported by TSMS, DSI, and press. In 2015, TSMS reported 276, DSI 94, and press 82 flash flood events in different locations across Turkey, respectively. Spatial distribution reveals that majority of the flash floods occurred along the coastal regions. He showed a graph presenting monthly distribution of TSMS extreme event observation and flash floods hits in 2014. He stressed June as a month with the most extreme event observations (47) in 2014, and stated that 15 of them were flash floods. He also showed a monthly distribution of flash flood events in 2015, which also revealed that most of flash floods occurred in June (80), and emphasized the seasonality of flash flood occurrence in Turkey. At the end, he stressed the importance of flash flood verification process, which is necessary to evaluate the performance of the FFG system.

4.8. Hands-on Exercises

As hands-on exercises, two flash flood events were studied by the participants collectively. First one was led by the forecasters from Georgia who explained weather and BSMEFFGS products analysis on 30 June 2016. After the weather briefing, facilitated discussion took place amongst participants who expressed their views on the interpretation of the BSMEFFGS products and possible occurrences of flash floods in Georgia. Second hands-on exercise was led by the forecasters from Turkey who explained in detailed weather conditions and BSMEFFGS products resulting in flash floods in the northwestern Turkey on 30 June 2016.

4.9. Post-processing of BSMEFFG products with QGIS and preparation of Operational Flash Flood Bulletins and Warnings: Hands-on Exercises

Mr Akbaş presented post-processing of BSMEFFG products with QGIS, as a part of hands-on exercise. He emphasized the goal of his presentation, which is to show forecasters how to prepare maps for post processing of BSMEFFG system products using QGIS. He stressed the importance of the forecaster’s evaluation of current situation using BSMEFFG products showing some examples from Georgia. He stated that for the preparation of a Flash Flood Early Warning Bulletin, forecaster can use Forecasted Flash Flood Threat (FFFT) products. He 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, he recalled that the colour scale of the 1-hr, 3-hr, and 6-hr products is approximately a measure of flash flood possibility. The web page for QGIS software download and installation instructions were provided. He said that all BSMEFFG participating countries have sub-basin boundaries in the shapefile format under the “Static Resources” tab of BSMEFFG user interface. These files can be opened by GIS programmes after unzipping them. Because flash flood often occurs in small areas, forecasters would like to see not only the BSMEFFG products, but also additional layers that can be displayed with the products so that precise location can be determined. He showed where and 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. During the hands-on exercise, each participant downloaded country shapefiles and tab-delimited hourly BSMEFFGS output data from the Product console, and created its own map for the Flash Flood Guidance Bulletin. Finally, he showed an example of such bulletins created and disseminated by Turkish State Meteorological and Hydrological Service.

4.10. BSMEFFG Hydrometeorological Training

As a part of the facilitated discussions, Mr Sayin stated that training was an integral part of the project, and extensive training would be provided to the participant countries' forecasters. He showed the schematic diagram outlining the FFGS hydrometeorological training programme, which is contained in ANNEX III of this report. 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 further articulated that once the training was completed, forecasters should be confident and competent to use FFGS products for flash flood forecasting and the provision of early warnings. Forecasters recommended that WMO should facilitate more regional operational sustainability trainings (Step-4) for the forecasters.

4.11 Evaluation of the trainees

This workshop corresponds to the step-4 training of the flash flood hydrometeorologist training programme. One of the main goals of this workshop is to evaluate the forecasters who participated in BSMEFFGS step-2 and 3 training, and successfully qualified for the MWO certified FFG trainer. That is why, Mr Yusuf Ulupinar from Turkey, Mr Dafi Elryalat from Jordan, Mr Abbas Obeid and Mr Fadi Doumnit from Lebanon presented flash flood case studies and took written exam. The results will be evaluated by the WMO and HRC representatives.

5. Conclusions and Outcomes of the First Steering Committee Meeting (SCM 1)

1. There was agreement among participants that the BSMEFFG System is a useful tool for enabling 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 agreed that more regional operational training or country-level training (step-5) should be facilitated by the project partners.

3. Participants became familiar with the BSMEFFGS operational concept.

4. Participants developed competencies to be able to access the BSMEFFGS servers to use its products in issuancing flash flood forecasts and warnings.

5. Participants reviewed the key technical and scientific backgrounds of the BSMEFFGS developments, including bias adjustments with historical and dynamic precipitation data, soil moisture modelling, threshold runoff modelling, snow modelling and flash flood guidance modelling.

6. Participants noted the necessity of real-time data reception through the GTS and FTP 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. Georgia expressed its wish to provide more AWOS data to the BSMEFFGS server through FTP.

7. Participants became familiar with the BSMEFFGS 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, FFG, Flash Flood Threats (FFT), Forecast Mean Areal Precipitation (FMAP), Snow Water Equivalent (SWE), Snow MELT, Mean Areal Temperature (MAT), and satellite snow coverage.

8. Participants developed basic competencies to be able to make synoptic, mesoscale, and nowcasting analysis and interpret the BSMEFFGS products to prepare flash flood warnings.

9. Participants developed competencies for the post-processing of the BSMEFFGS products with QGIS, and to prepare clear and understandable flash flood warning messages.

10. Forecasters who successfully completed step-2 and step-3 training are evaluated to qualify as a WMO certified FFG trainer.

6. Closing of the First Steering Committee Meeting (SCM 1)

Closing remarks were made by WMO, HRC, National hydrometeorological service of Georgia 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

FIRST STEERING COMMITTEE MEETING (SCM 1)

BLACK SEA AND MIDDLE EAST FLASH FLOOD GUIDANCE (BSMEFFG) SYSTEM

Tbilisi, Georgia

28–30 June 2016

List of Participants

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ANNEX II

First Steering Committee Meeting (SCM 1) Black Sea and Middle East Flash Flood Guidance (BSMEFFG) System

Tbilisi, Georgia, 28-30 June 2016

Workshop Agenda

The objectives of the workshop are to explore the best use of the BSMEFFG products in issuance of flash flood warnings and evaluation of the in-country trainees for eligibility to receive WMO certification. Training modules consist of a brief discussion on the technical background and system development, operational use of system products through case studies and hands-on exercises reviewing past flash flood events in the region. The workshop will also introduce the forecasters to verification methodologies of flash flood events, preparations of the flash flood bulletins, and post-processing using QGIS.

Day 1

09:00-09:15 Registration of participants
09:15-09:45 Opening of the workshop (Department of Hydrometeorology, 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)

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 BSMEFFG System Forecaster User Interface (HRC)

- Forecaster Console
- Dashboard

14:30-15:00 Review of the BSMEFFG 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 BSMEFFG System Design/Theoretical Background 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 BSMEFFG 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 BSMEFFG System Design/Theoretical Background
Snow Products (HRC)
- Snow Water Equivalent (SWE)
- MELT

16:00-17:30 BSMEFFG System Operational Concept (RC)
- Computational Server
- Dissemination Server
- Status of RC Operations

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

<u>Day 2</u>

09:00-09:30 Review of Day 1

09:30-10:30 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 BSMEFFG Products

10:30-11:00 Tea Break
Country-presentations to be provided by those who attended Operational Training at HRC

11:00-11:30 A Flash Flood Case Study and Discussions (Bulgaria)

11:30-12:00 A Flash Flood Case Study and Discussions (Georgia)

12:00-12:30 A Flash Flood Case Study and Discussions (Jordan)

12:30-14:00 Lunch Break

14:00-14:30 A Flash Flood Case Study and Discussions (Lebanon)

14:30-15:00 A Flash Flood Case Study and Discussions (Turkey)

Country-presentations to be provided by those who attended BSMEFFG regional operational training in Turkey

15:00-15:30 A Flash Flood Case Study and Discussions (Armenia)

15:30-16:00 Tea Break

16:00-16:30 A Flash Flood Case Study and Discussions (Azerbaijan)

16:30-17:00 Technical Background on the Flash Flood Verifications (HRC)

17:00-17:30 BSMEFFG System Verification Results and Challenges (RC-TSMS)

19:00 *Welcome Dinner hosted by Department of Hydrometeorology of National Environmental Agency (TBC)*

Day 3

09:00-09:30 Review of Day 2

O9:30-11:00 Hands-on Exercise for Past Events in the region (Guided by WMO, All) (example "daily operations")

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

11:00-11:30 Tea Break

11:30-13:00 Hands-on Exercise for Past Events in the region (Guided by WMO, All) (example "daily operations")

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

12:30-14:00 Lunch Break

14:00-15:00 Post-processing of BSMEFFG products with QGIS: Hands-on Exercises (guided by RC-TSMS, All)

15:00-15:30 Preparations of Operational Flash Flood Bulletins and Warnings (RC-TSMS)

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 BSMEFFG products (All)

17:00-17:30 Sustainability of the BSMEFFG System: Cooperation with the RC and NMHSs, Feedbacks, and Step-5 Training (WMO)

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

-End of Workshop-

Flash Flood Hydrometeorological Training Programme

An ongoing regional training program involving the Centres will be developed to maintain proficiency with system operations, ensure continued system validation, and ensure continued system use and ownership. This will involve continual engagement with the community of users. Tools will be developed to build capacity to improve the system and handle more complex contingency scenarios (e.g. key data missing, failure in "normal" operations, communications, or other such events).