SOUTH EAST EUROPE FLASH FLOOD GUIDANCE (SEEFFG) SYSTEM

SECOND STEERING COMMITTEE MEETING (SCM2)

(Step-5 Training)

Podgorica, Montenegro

26–28 September 2017

DRAFT REPORT

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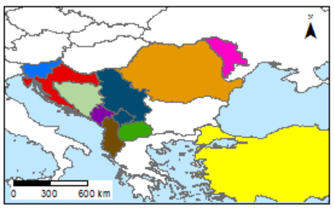
The South East Europe Flash Flood Guidance (SEEFFG) System
Podgorica, Montenegro, 26-28 September 2017

1. Executive Summary



In the South East European region, flash floods account for a significant portion of the lives lost and property damaged from flood. Flash floods can occur at any time or place leading to disastrous outcomes. This makes it necessary to prioritize efforts that aim at improving early warning capabilities which can in turn help the society to cope with flash flood threats by enabling the mandated national authorities to undertake appropriate measures, thereby, minimizing the losses.

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

The South East Europe Flash Flood Guidance (SEEFFG) System Kick-Off Meeting was held in Ankara, Turkey on 22-24 March 2013. The participants expressed their interest in participating in the SEEFFG system, highlighting the considerable losses caused to human life and property by the flash floods in the South East European region. At this meeting, the Turkish State Meteorological Service (TSMS) graciously offered to host the Regional Centre of the SEEFFG system, which was accepted by all participating countries.

Based on the SEEFFG system implementation plan adopted at the Kick-Off Meeting in Ankara, Turkey, the following project activities have been completed: 1) First Project Steering Committee Meeting took place from 31 March to 2 April 2015 in Skopje, The former Yugoslav Republic of Macedonia; 2) Operational training took place from 5 July to 2 August (12 July – 9 August) 2015 at HRC facilities in San Diego, USA. One forecaster from Albania, two hydrometeorologists from Bosnia and Herzegovina, two hydrometeorologists from Croatia, one forecaster from Moldova, one hydrologist from Serbia, two hydrologists from Slovenia, one hydrologist from The former Yugoslav Republic of Macedonia, and one forecaster from Turkey attended the training; 3) Follow-Up Operational Workshop and Step-4 training were held in Zagreb, Croatia from 9 to 13 May 2016.

As per the implementation plan, the second Steering Committee Meeting (SCM 2) and Step 5 training were held in Podgorica, Montenegro from 26 to 28 September 2017. The objectives of this meeting were to: review the development and implementation status of the SEEFFG system; use its products in preparation of daily flash flood forecasts and warnings through case study presentations; familiarize participants with the Flash Flood Guidance System Simulator; conduct hands-on exercises for past flash flood events; prepare flash flood bulletins for the issuance of flash flood warnings; perform validation studies; and obtain feedback from the participants for future development.

2. Opening of the Session

During the opening of the second Steering Committee Meeting, the representatives of Montenegro and WMO highlighted the importance of improving the timely delivery of flash flood information and guidance to the populations at risk and the need for fostering stronger partnerships among countries in the region to strengthen national capabilities to forecast and warn the people at risk from flash flooding and other hydrometeorological hazards. In his opening remarks, Mr Luka Mitrovic, Director General of the Institute of Hydrometeorology and Seismology of Montenegro (IHMS) and Permanent Representative of Montenegro with WMO, highlighted the value of regional cooperation, particularly, given the impacts of climate variability and change in 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 international exchange of data and information for improving the provision of forecasts and early warnings, stressing that severe weather events and their impacts do not confine themselves to national borders. He cited occurrences of flash flood events in Montenegro this year, explaining that flash floods are a very dangerous natural phenomenon in the region. He assured participants that forecasters from the IHMS will use the SEEFFG products in the preparation of daily flash flood forecasts and warnings. He expressed his pleasure in being able to host the SCM 2 in Podgorica. He welcomed all the participants to Montenegro, and he wished everyone a very successful meeting.

Mr. Ayhan Sayin, WMO, welcomed everyone on behalf of the WMO. He recalled the objectives of the meeting and its expected outcomes and also encouraged the participants to provide their inputs for shaping the FFG system. He also thanked the Institute of Hydrometeorology and Seismology of Montenegro for all its efforts and for hosting the meeting.

The meeting was also covered by the national press, with several newspaper reporters being present at the opening. Mr Luka Mitrovic, Director General of IHMS and Permanent Representative of Montenegro with WMO, informed the press about the objectives and possible outcomes of the meeting and positive impacts of the project on the citizens of Montenegro and other participating countries. Mr Ayhan Sayin also informed reporters about the WMO support provided for the SEEFFG system. Ms Petra Mutic informed the press about the flash flood warning verification results from Croatia, stating that SEEFFGS proved to be valuable for disseminating flash flood warnings in Croatia.

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

The SCM 2, which was held in Podgorica, Montenegro from 26-28 September 2017, was attended by representatives of the NMHSs from Albania, Bosnia and Herzegovina, Croatia, Moldova, Montenegro, Romania, Serbia, The former Yugoslav Republic of Macedonia, and Turkey. The list of participants is provided in Annex I, while the annotated meeting agenda is given in Annex II.

4. Proceedings of the Second Steering Committee Meeting (SCM 2)

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

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

Mr. Sayin explained the project implementation status, stressing upon major project milestones. It was stated that the following major project activities were completed: 1) Development and implementation of the SEEFFG System; 2) Operational Training at HRC, San Diego, USA [step-3 training]; and 3) Follow-up Operational Workshop [step-4 training].

He outlined that this meeting is one of the major project activities, as Step-5 training aimed at: reviewing the SEEFFG products to allow forecasters to become familiar with them ; promoting operational use of the SEEFFG products through hands-on exercises; reviewing and evaluating the SEEFFG products for selected past flash flood events through case studies.

He concluded his presentation by indicating that at the end of this meeting, forecasters should have the following competencies: 1) analyze and monitor the evolving meteorological and hydrological situation; 2) analyze and monitor the SEEFFGS Product; 3) forecast meteorological and hydrological phenomena and parameters such as flash floods; 4) prepare flash flood advisories, watches, warnings, and alerts; and 5) communicate flash flood warning information to internal and external users, including Emergency Management Agencies.

4.1. SEEFFG System Operational Concept

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.

Ms. Ünal described the concept of FFGS operation at the TSMS. She said that hydrometeorological division is the core element within the administration structure to maintain the BSMEFFG and SEEFFG systems 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 in 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

4.2. Overview of the SEEFFGS Products

Ms. Mutic provided an overview of the SEEFFGS dashboard and forecaster console. She stated that the FFGS user interfaces are secure web-based interfaces that provide an overview of the system processing status and current and historical products for IT and forecasting personnel. She explained that the functionalities of the dashboard are: 1) display of selected SEEFFGS 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 SEEFFGS forecaster console with the following main features: 1) navigation toolbars that allow users to display the products at certain date and time; 2) product table that displays full list of the SEEFFGS and products in image formats; and 3) data download buttons in text, CSV, and CSVT formats. She demonstrated the following products in detail:

- **Global Hydro Estimator (GHE) precipitation**, which is produced by the US National Oceanic and Atmospheric Administration (NOAA) using Infrared (IR) channel (10.7 micrometre) of geostationary meteorological satellites;

- **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);

- **NWP model ingestion,** Turkish and Croatian ALADIN models are merged and are ingested into the SEEFFGS;

- **Forecast Mean Areal Precipitation (FMAP),** which is estimated by using merged 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 MAT),** which is estimated using in-situ surface temperature observations from the WMO GTS and from the 0.5 degrees Global Forecast System (GFS) from NOAA;

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

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

- **Snow MELT.**

Ms. Mutic explained the Flash Flood Guidance System approach. She provided 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. She explained the need for the FFG system and compared large river flooding with flash floods. She emphasized that it is critical to distinguish them and that it is the fundamental concept for flash flood development and implementation. She indicated that the main components of the FFG system are: runoff modelling; bankfull flow; flash flood guidance; end-to-end process for flash flood warning processes; key components of the FFGS modelling such as precipitation sources and their quality control, snow model, soil moisture model, threshold runoff model, NWP QPF ingestion, and flash flood threat. She illustrated the diagnostic and prognostic FFG products while stressing that the forecasters' experiences are fundamental for the issuance of flash flood warnings. She concluded her presentation by emphasizing on the needs of local data for model calibration and bias adjustments.

4.3. Operational Concept of the SEEFFGS

Ms. Ünal from the Turkish State Meteorological Service presented the operational concept of the SEEFFG system. She commenced by giving an overview of the servers and the existing infrastructure for the BSMEFFGS and SEEFFGS. As the regional center for both the BSMEFFGS and the SEEFFGS is based in Turkey, she talked in detail about the computational server and the dissemination server. She emphasized that daily review of the system was carried out to confirm the availability of data, storage and processing resources.

4.4. Guidance for Preparation of Flash Flood Warnings

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 if 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 concerned authorities through various media such as email, SMS, and fax.

4.5. Case Studies

The second day of the Second Steering Committee Meeting (SCM 2) of the SEEFFGS began with a review of the activities done during day 1. This was followed by a host of case studies by the participating members as well as by the WMO.

4.5.1 Flash Flood Case Study by WMO

Mr. Sayin presented a case study on the South East Europe flash flood event that took place from 6-8 March 2016 causing loss of life and extensive economical losses in Montenegro and Serbia. First of all, he explained the importance of the flash flood case studies that can 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. 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 three 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 had developed over the central Mediterranean and propagated to South East Europe in 24 hours, resulting in flooding and flash floods in the region. He explained that a low pressure center located over Italy with a value of 1000 mb, while 850 HPa chart showed strong warm air advection ahead of the trough and cold air advection behind the trough indicating a transition zone between the cold air mass and warm air mass and frontal lifting. While the depression was moving towards the east, gradients of the 850 HPa isotherms increased over time between Italy and Turkey. It was stated that 500 HPa low center with a central value of 546 HPa was located over northern Europe and axis of the trough was expanding towards Morocco on 6 March at 00 UTC. The 500 HPa tough propagated eastwards until 6 March at 00 UTC. Strong divergence existed ahead of the trough over the Balkans indicating the presence of low level horizontal divergence and vertical motions in the middle troposphere. The -30 ^{o}C isotherm expanded from England to Spain indicating flow of the cold polar air mass into the Mediterranean. A well-defined boundary between cold air masses propagating from the north and warm air masses propagating from the south existed over the Balkans resulting in the development of steep cold and warm fronts in the region. The depression moved east overtime and skewed towards the east, increasing geopotential gradients over the Balkans. The lower and middle atmosphere were unstable ahead of the 500 HPa trough where strong vertical circulation was associated with the frontal lifting. It was stated that there are several prominent instability indices such as K-Index and Convective Available Potential Energy (CAPE) commonly used to measure the atmospheric stability. CAPE field had a maximum value of 2000 over Italy and along the Adriatic coast, indicating strong atmospheric instability that may create favorable conditions for the development of convective storms.

He compared the 6-hr ECMWF IFS and WRF Quantitative Precipitation Forecasts (QPF) accumulation from 6th March at 00 UTC to 7th March at 18 UTC. It was stated that there were big differences in the QPF fields of the two models at 06 UTC, 12 UTC, and 18 UTC such that the maximum values of the ECMWF IFS QPF were 46.4 mm, 44.1 mm, and 39.9 mm; while WRF values were 68.3 mm, 92.3 mm, and 90.6 mm. It was clearly shown that WRF QPF values were twice as high as ECMWF IFS QPF. That is 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 was one, indicating that the top soil was completely saturated due to the accumulation of rainfall over the last six hours. On the other hand, Flash Flood Guidance (FFG) values were quite low, ranging from 15 to 30 mm/6-hr. This 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. Therefore, 6-hr and 24-hr QPF values of the ALADIN mesoscale model were analyzed to find out spatial and temporal distribution of precipitation forecasts over next the 24 hours. The 24-hr ALADIN QPF was 75 mm over Croatia and the Adriatic Sea. Once the depression moved southeast to the Adriatic coast, maximum precipitation intensity reached 75 mm/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. The 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 the 6-hr FFG values decreased to 15 mm for the same period. Forecast Flash Flood Threat (FFFT) values which shows excess amount of rainfall, ranged from 15 mm to 25 mm/6-hr over Montenegro, indicating high possibility of occurrences of flash floods. The system propagated to the northeast from Montenegro to Bosnia and Herzegovina, and Serbia with 90 mm/6-hr rainfall intensity. FFFT expanded towards the northwest in Montenegro and had a maximum value of 60 mm/6-hr on 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 be submitted to the concerned authorities through various media such as email, SMS, and fax. He emphasized that central

Mediterranean depressions, which are associated with fronts and propagate along southeast Europe through Adriatic Sea, produce heavy rainfall causing flash floods.

4.5.2 Croatia Flash Flood Event

Ms. Martinkovic and Ms. Macek presented a case study of flash flood event that took place on 11 September 2017 in the cities of Zadar and Nin in Croatia. Ms Martinkovic explained the meteorological part 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 (surface charts, 850, 500, and 300 hPa charts); 2) Quantitative Precipitation Forecast (QPF) of different NWP models such as ECMWF and ALADIN; 3) instability analysis including instability indices; 4) satellite images; and 5) monitoring of in-situ observations, particularly precipitation intensity and precipitation accumulations. She explained that a well-developed mesoscale convective system (MCS) with horizontal dimension greater than 400 km caused extreme amounts of precipitation in the cities of Zadar and Nin in the middle Adriatic.

Ms. Macek provided an overview of the SEEFFGS products from 11 September at 00, 06, 12 and 18 UTC. It was stated that Merged Mean Areal Precipitation (Merged MAP) indicated that precipitation band had a maximum core value of 40 mm/6-hr and 120 mm/24-hr on 11 September at 00 and 06 UTC. Average soil moisture (ASM) chart showed that the top soil of all catchments in middle Dalmatia was saturated, while low 6-hr Flash Flood Guidance (FFG) values were estimated for the same catchments. 6-hr FFG values were as low as 15 mm. It was stated that saturated top soil coupled with low FFG values created favorable conditions for the possibility of flash floods depending on the forecast precipitation intensity for the next 6 hours which was up to 60 mm/6-hr. 6-hr Forecast Flash Flood Threat (FFFT) showed excess amount of rainfall up to 100 mm in coastal Croatia, indicating a very high possibility of flash flood occurrence. Taking into consideration, the Merged MAP, FFG, ASM, and FMAP products, she stated that flash floods were predicted and warnings were issued in advance. She concluded the presentation by showing photographs and video recordings of flash flood events that occurred in Zadar and Nin on 11 September 2017. Moreover, during the facilitated discussions, Ms Macek stated that the SEEFFG System is a very valuable supplementary tool for forecasting flash flood events.

4.5.3 Romania Flash Flood Event

Mr. Matreata presented a case study on the flash flood event that occurred in north-eastern (NE) Romania, in the upper part of the Tutova River Basin on 13 May 2017. He compared the SEEFFG System's results with the results generated by Romanian Flash Flood Guidance System (ROFFGS) and European Flood Awareness System (EFAS). He showed the configuration of the sub-basins within ROMFFGS and SEEFFGS, stressing upon the difference in catchment sizes. As the radars ingested into the ROFFGS provide precipitation estimates at a higher resolution than the satellite estimates, sub-basins were delineated at a higher resolution of approximately 30 km^2 on average. He provided an overview of the SEEFFGS products on 13 May 2017. He started by showing spatial and temporal distribution of various FFGS diagnostic products, such as ASM, mentioning that ASM values were very high indicating a saturation of the top soil, while 6-hr FFG values were around 50 mm. The 6-hr ALADIN QPF at 18 UTC was up to 60 mm over NE Romania and up to 25 mm over the Tutova River basin. The 6-hr FFFT at 18 UTC existed over NE Romania, including the Tutova River basin. He stressed on the importance of using weather radar in operational hydrological forecasting of floods and flash floods. The 6-hr ROFFGS RADAR product showed that maximum precipitation accumulation was up to 150 mm over the Tutova River basin. He emphasized on the collaboration between the hydrologist and meteorologists prior to the issuance of flood and flash flood warnings. He concluded his presentation by showing the photos of the flash flood event and by highlighting that it was critical for the forecasters of the national services to collaborate with the Disaster Management Agency (DMA) of Romania to prevent loss of life and minimize economic damages.

4.5.4 Turkey Flash Flood Event

Mr. Aydin presented a case study on the flash flood event that took place on 28-29 November 2016 in Ayvalık, Turkey. He began by explaining the meteorological conditions that resulted in producing heavy precipitation. He showed the synoptic analysis of surface chart on 28 November 2016 at 12 UTC and stated that a low pressure centre with 1007 hPa value was located over Aegean Sea. It was stated that 850 hPa indicated two warm fronts occurring over the Ayvalık region. He explained the 500 hPa analysis by showing the wide trough, divergence and convergence fields over the Middle Mediterranean which formed unstable conditions over the Ayvalık. He further illustrated the Skew-T Log-P diagrams of Izmir sounding station on 28 November 2016 at 12 UTC and stated that instability indices showed high instability in the middle troposphere. He also depicted radar and METEOSAT geostationary weather satellite images showing cloud band with associated medium and high clouds over the Ayvalık bay. Radar images showed moderate to heavy rainfall on 28 and 29 November 2016 which resulted in flash floods in Ayvalık.

He provided an overview of the BSMEFFGS products. The 24-hour Merged MAP estimates had a maximum value of up to 60 mm over the Ayvalık area. ASM values on 28 November were ranging from 0.65 at 12 UTC to 1.00 at 18 UTC, indicating that the upper part of the soil reached complete saturation, making that area vulnerable to the occurrence of flash floods. He showed the 24-hr FMAP products generated from ALADIN, WRF, and ECMWF IFS precipitation forecasts, emphasizing that 24-hr FMAP generated by ALADIN mesoscale model on 28 November at 18 UTC showed the highest value of up to 200 mm. All three 6-hr FFFT products (ALADIN, WRF, and ECMWF IFS) on 28 November at 18 UTC existed over Ayvalık with values up to 40 mm, indicating a high probability for the occurrence of flash floods in the region. He concluded his presentation by emphasizing that FFGS products are very valuable and useful for the issuance of flash flood forecasts and warnings.

4.6. Hands-on Exercises

Hands-on exercises of four flash flood events were collectively studied by the participants and were led by Ms. Babic, one of the regional WMO certified FFGS trainers. The first exercise was about the multiple flash flood events that occurred in October 2015 in southern Croatia. After the weather briefing, a facilitated discussion took place among the participants who expressed their views on the interpretation of the SEEFFGS products and possible occurrences of flash floods. Participants predicted flash floods on Peljesac where flash floods took place on 14 and 15 October 2015 due to heavy rainfall. Similarly, flash flood events that occurred on 8 November 2016 and on 19 September 2017 in Croatia were studied by the participants. Ms. Babic and Ms. Mutic led a case study as part of the hands-on exercise for the flash flood event that took place on 6 March 2017 in Croatia. Participants used the Flash Flood Guidance Simulator to interpret the SEEFFGS products for the issuance of flash flood warnings in combination with weather analysis, nowcasting, and local hydrometeorological data.

4.7. Verification of flash flood warnings

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

Ms. Ünal provided verification results of flash flood warnings in Turkey for 2015 and showed their spatial distribution.

4.8. Advances in the FFG System

Mr. Sayin presented the enhancements being developed for the FFGS to improve operations and to extend its functionality. He touched upon the following four items:

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

He articulated each topic saying that it was the forecasters' demand to include multiple mesoscale model inputs in the display of the FFGS forecaster console because each model behaves differently in different seasons even in different months. He demonstrated multiple NWP ingestion examples from the BSMEFFGS and Central Asia Region Flash Flood Guidance System (CARFFGS) and explained their impacts on the accuracy of the FFGS products. He also stated that there is a growing demand for an urban flash flood early warning system to be incorporated into FFG due to the increased occurrence of urban flash floods in recent times on account of climate change and climate variability. He further stated that a demonstration project for the urban flash flood early warning system has been conducted for the city of Pretoria, South Africa, and two of them are under implementation in Istanbul, Turkey and Jakarta, Indonesia. He showed a demonstration case study of landslide prediction using Central America Flash Flood Guidance System (CAFFGS) products conducted in El Salvador which includes landslide susceptibility mapping, real-time occurrence prediction based on FFGS rainfall and soil moisture data, and susceptibility class.

Ms. Ünal showed an application that was developed by the TSMS to display the BSMEFFGS snow products such as Snow Water Equivalent (SWE), snow MELT, and Snow Coverage Area (SCA) time series in graphical format, tables, and google Earth for each of the big river basins in Turkey. She stated that this application was developed upon request from the State Water Authority (DSI) for their reservoir management studies.

4.9. SEEFFGS Hydrometeorologist Training

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

- Step 1 introductory regional workshop;
- Step 2 eLearning hydrometeorological training;
- Step 3 specialized training at HRC;
- Step 4 regional operations training workshop; and
- Step 5 regional operational sustainability workshops.

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

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

During the facilitated discussions, participants expressed their appreciation with the quality of the training and its content, thanking WMO for facilitating and providing such valuable training. It was mentioned that two forecasters from Bosnia and Herzegovina, two forecasters from Croatia, and two forecasters from Slovenia had successfully completed Step-3 and Step-4 training and became certified WMO FFG trainers. Forecasters recommended that WMO should facilitate more regional operational sustainability training (Step-5) for the forecasters in collaboration with WMO FFGS certified trainers.

Ms. Mutic provided an overview of the SEEFFGS Forecaster Guide, a joint product of regional WMO FFGS certified trainers. It not only presents the FFGS products for the SEEFFGS and its models, but also discusses flash flood case studies, hydrological and meteorological ingredients for flash flooding, descriptions on how to prepare flash flood alerts and warnings, verification of flash flood warnings, and geographic information system (GIS) support for spatial decisions, with examples from numerous literature.

5. Conclusions and Outcomes of the Second Steering Committee Meeting (SCM 2)

1. There was agreement among participants that the SEEFFG 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 noted that in addition to the WMO GTS data, more AWOS data can be provided to the SEEFFG System through FTP.

3. Participants agreed that more regional operational sustainability training (Step-5) should be facilitated by the project partners.

4. Participants noted that additional training should be provided to the forecasters from Montenegro (Step-3) as they did not participate in the Operational training at HRC. It was recommended that such a training can be organized in the Regional Centre in Ankara, Turkey.

5. Participants from Moldova requested additional training for forecasters, because forecasters who participated in the previous trainings were no longer a part of the NMHS. It was recommended that one regional WMO Certified FFGS trainer provide on-the-job training in Moldova.

6. Participants became familiar with the SEEFFGS operational concept.

7. Participants developed competencies to be able to access the SEEFFGS servers to use its products in issuing flash flood forecasts and warnings.

8. Participants became familiar with the SEEFFGS forecaster console, dashboard, and its products such as Global Hydro Estimator (GHE), Microwave adjusted GHE (MWGHE), gauge Mean Areal Precipitation (GMAP), Merged MAP, Average Soil Moisture (ASM), Flash Flood Guidance (FFG), Flash Flood Threats (FFTs), Forecast Mean Areal Precipitation (FMAP), Snow Water Equivalent (SWE), Snow MELT, Mean Areal Temperature (MAT), and satellite snow coverage.

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

10. Participants developed basic competencies to prepare clear and understandable flash flood warning messages.

11. Participants developed basic competencies to be able to create contingency tables, calculate and interpret verification scores.

12. Participants agreed that country-level verification studies shall be conducted on the flash flood warnings and FFGS products to improve the performance of the SEEFFG System and that a verification guideline should be available to the participating countries.

13. Participants agreed that implementation of the advanced modules such as multi-NWP QPF and Radar ingestion is very beneficial to NMHSs.

14. Participants agreed that linkages between Multi-Hazard Early Warning Systems and SEEFFGS will be beneficial for participating countries.

15. Participants agreed that new advanced FFGS Forecaster console (Map Server Interface) should be implemented in SEE.

16. Participants recommended shorter update period for the ASM product (e.g. every one hour) because of high precipitation variability in space and time.

17. Participants recommended having a stand-alone tool to run SAC-SMA and SNOW-17 models to change, update and get a better understanding of the models' initial and state parameters, and to carry out what-if scenarios.

18. Participants recommended that regional WMO FFGS Certified trainers should work (e.g. once or twice per year) on future developments and improvements to the SEEFFGS.

19. Participants recommended re-analyzation of sub-catchments for which FFG is not computed. They suggested that FFG should be calculated for this sub-catchments too.

20. Participants recommended having threshold runoff values for their countries on how they could provide updates if needed.

21. Participants agreed that due to the system`s server replacements, historical SEEFFGS data should be available again on the SEEFFGS Forecaster Console.

22. Participants from Romania offered to provide on-the-job trainings in Romanian NMHS with WMO support.

23. Participants noted that the SEEFFGS Forecaster Guide is a valuable guideline to the forecasters.

24. Participants noted that the FFGS Simulator is a valuable tool for hands-on exercises.

25. Participants agreed that the Regional Centre needs to update gauge observations for Montenegro.

26. Participants agreed that the NW part of Moldova should be covered by NWP model and they welcomed the offer from Romania for ingestion of Romanian ALARO QPF.

6. Closing of the Second Steering Committee Meeting (SCM 2)

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

ANNEX I

Second Steering Committee Meeting (SCM 2) of the

South East Europe Flash Flood Guidance

(SEEFFG) System

Podgorica, Montenegro
26-28 September 2017

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ANNEX II

Second Steering Committee Meeting (SCM 2) of the South East Europe Flash Flood Guidance (SEEFFG) System (Step 5 Training)

Podgorica, Montenegro, 26-28 September 2017

Workshop Agenda

<u>Day 1</u>

09:00-09:15 Registration
09:15-09:45 Opening of the Meeting (IHMS, WMO)
09:45-10:15 Introduction of Participants *(All)*
10:15-10:30 Overview and Purpose of the Meeting (WMO)

10:30-11:00 Tea Break

11:00-11:30 Overview of the Global FFGS (WMO)

11:30-12:00 Status of the SEEFFGS Project (WMO)

12:00-12:30 Overview of the SEEFFGS Forecaster Console and Dashboard (WMO)

12:30-14:00 Lunch Break

14:00–15:00 Overview of the SEEFFGS Products: Precipitation (WMO)

- Satellite/Radar Precipitation Estimation
- Bias adjustments
- Merged Mean Areal Precipitation (Merged MAP)
- Multi model NWP Precipitation Ingestion
- Forecast Mean Areal Precipitation (FMAP)

15:00-15:30 Overview of the SEEFFGS Products (Continued) (WMO)

- Average Soil Moisture (ASM)
- Flash Flood Guidance (FFG)
- Flash Flood Threats (IFFFT, PFFT, FFFT)

15:30-16:00 Tea Break

16:00-16:30 Overview of the SEEFFGS Products (Continued): Snow Products (WMO)

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

16:30-17:00 Operational Concept of the SEEFFGS (RC-TSMS)

- Computational Server
- Dissemination Server
- Status of RC Operations

17:00-17:30 Guidance for Preparation of Flash Flood Warnings (WMO)

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

Day 2

09:00-09:30 Review of Day 1

09:30-10:00 A Case Study: A Flash Flood Event Induced by Frontal System (WMO)

10:00-10:30 A Case Study: A Flash Flood Event Induced by Convective System (WMO)

10:30-11:00 Tea Break

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

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

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

12:30-14:00 Lunch Break

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

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

15:00-15:30 Tea Break

15:30-16:15 Hands-on Exercise for Past Flash Flood Events in the region (Guided by WMO, All)
(example “daily operations”)

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

16:15-17:00 Hands-on Exercise for Past Flash Flood Events in the region (Guided by WMO, All)
(example “daily operations”)

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

Day 3

09:00-09:30 Review of Day 2

09:30-11:00 FFGS Simulator Hands-on Exercise for Past Flash Flood Events in the Region (Guided by WMO, All)

11:00-11:30 Tea Break

11:30-12:00 Preparations of Operational Flash Flood Bulletins and Warnings (RC-TSMS)

12:00-12:30 Verification of Flash Flood warnings (WMO, RC-TSMS)

12:30-14:00 Lunch Break

14:00-14:30 SEEFFGS User Guide (WMO)

14:30-15:00 Advances in FFGS (WMO, RC-TSMS)

15:00-15:30 An overview of SEEFFG system operations and recommendations for further applications (All)

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

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

-End of Workshop-