

**WORLD METEOROLOGICAL
ORGANIZATION**



**SOUTH-EAST EUROPEAN MULTI-HAZARD
EARLY WARNING ADVISORY SYSTEM
(SEE-MHEWS-A)**

IMPLEMENTATION PLAN

5 January 2018



**World
Meteorological
Organization**

Weather · Climate · Water

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Appendix 1: Regional Requirements for Observational Data and Products

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1. Executive Summary

In 2016, the World Meteorological Organization (WMO) initiated the development of a South-East European Multi-Hazard Early Warning Advisory System (SEE-MHEWS-A) with initial support from the U.S. Agency for International Development (USAID), Office of U.S. Foreign Disaster Assistance. The necessity and urgency for such a system is unquestionable in South-East Europe. Fully developed SEE-MHEWS-A system will support the National Meteorological and Hydrological Services (NMHSs) in fulfilling their core function: providing timely and accurate warnings of hazardous weather events in order to reduce loss of lives and other impacts on people, infrastructure and industry.

South-East Europe has experienced a significant number of severe meteorological and hydrological events in recent years. Heavy precipitation has caused floods and landslides. Droughts have increased the incidence of forest fires. People have also suffered under prolonged heat waves and episodes of cold spells. There have been severe thunderstorms and hailstorms. These natural hazards have had significant impacts: human lives have been lost, property and infrastructure damaged, and the functioning of key sectors impaired. In just one year, such hazards caused economic losses of several billion euros. The frequency of hydrometeorological events is expected to increase in the future. Because of this, there is greater demand for improved early warning for communities at risk as well as a need for better community level preparedness in order to improve resilience.

SEE-MHEWS-A will provide operational forecasters with effective tools for forecasting hazardous weather and hydrological events and their possible impacts. This will improve the accuracy of early warnings and ensure early actions to support hazard-related decision-making by national authorities and others. The system will function as a cooperative platform where forecasters from different countries will work together on the identification of potential hazards and their impacts, especially when impending weather hazards may have potential impacts in several countries, including their cross-border areas.

During the inception phase of the SEE-MHEWS-A project in 2016-2017, which was supported by USAID, a detailed Implementation Plan was developed that provides guidelines for development of the technical part of the system and for all activities necessary to establish advisory system operations by mid-2023. In addition, the Plan considers the governance structure and other management aspects of the project implementation. The establishment of the system will rely on the availability of resources during the implementation phase, including expert support and engagement by the NMHSs of the region and project collaborators (such as NMHSs from Europe, US and others, and research and development institutions). Engagement of development partners in the development and implementation is critical for success of the project. The estimated direct cost of the establishment of the operational system is approximately CHF 21 million. The financial support for the second phase of the SEE-MHEWS-A project was approved by the World Bank at the time of writing this executive summary.

This Implementation Plan was developed as a joint effort between WMO, NMHSs of the region, and numerous collaborators, including WMO Regional Specialized Meteorological Centers, research institutions, numerical weather prediction consortia, and European and US meteorological and/or hydrological services.

2. Purpose of this document

This document describes the implementation of the South-East European Multi-Hazard Early Warning Advisory System (SEE-MHEWS-A). SEE-MHEWS-A provides a new framework for enhanced service delivery through improvements in meteorological, hydrological and marine forecasting, which is made possible by strengthened modelling capabilities, nowcasting, ICT infrastructure and data provision.

It is important to recognize that SEE-MHEWS-A is not replacing the existing national or regional early warning systems (EWS), but is rather an overarching framework for the evolution of these systems, which will continue to be owned and operated by a diverse array of organizations and programmes. SEE-MHEWS-A will provide information to the meteorological, hydrological and marine forecasters to allow them to better respond to the weather-related natural hazards within their national EWSs. To address the limited resources within the SEE region, SEE-MHEWS-A will focus on improved sub-regional collaboration and joint operations of some of the functions within the advisory system.

This implementation plan (IP) addresses the necessary activities to establish an operational SEE-MHEWS-A by mid-2023. However, SEE-MHEWS-A is expected to evolve and improve beyond 2023 through the governance and management mechanisms established during execution of this plan.

The plan also addresses variety activities that would substantially improve the operational capabilities of SEE-MHEWS-A beyond the 2023 implementation; however, completion of all of these activities depends on the resources that will be identified for the project implementation. Budget constraints may cause that some activities may not be completed. However, SEE-MHEWS-A can still be considered operational, but the resulting system will be less effective, or delayed in achieving its goals and benefits to members.

This plan is laid out in several chapters that identify and describe the various activity areas to be addressed through the implementation of this project. Key activities are introduced in Chapter 3, while specific implementation activities, including deliverables, milestones, responsibilities and cost are given in Chapter 4. Based on the existing capabilities of project participants (PPs), the Chapter 5 lists the capacity development and implementation requirements by the project participants needed to fully benefit from the advisory system.

This IP was considered by the SEE-MHEWS-A project participants in Ljubljana, Slovenia on 14-15 June 2017, however, its implementation in full scope can only start once resources will become available. The amount of resources and time when they will become available for the project are not fully known at the time of writing this IP, which introduces uncertainties into this plan and constitutes one of the highest threats. Further scenarios/options should be considered by the SEE-MHEWS-A Project Steering Committee (PSC) in case the demand for resources will be considered implausible. From this perspective, the plan should be regularly updated by the PSC during the 5-year implementation period as new challenges, funding and opportunities arrive, as appropriate.

3. Introduction

South-East Europe (SEE) is highly diverse in terms of its government structures, economies, culture, and geography. During the past decade, the countries in SEE have undergone substantial transformations. The extent of progress made in economic development, social reforms, regional cooperation, and integration into global economic and financial markets are remarkable. However, this progress is vulnerable due to the exposure of SEE nations to a range of disasters caused by the impacts of the weather- and water-related natural hazards.

To assist the SEE in a provision of multi-hazard early warning services, the WMO with the support of USAID initiated in 2016 the implementation of the Phase I (development phase) of the SEE-MHEWS-A project. This project builds on the outcomes of several related projects

implemented in the SEE in recent years funded by the EU, UN Agencies, World Bank or other international and national organizations.

3.1 Rationale for SEE-MHEWS-A

In recent years, South-East Europe has experienced a significant number of severe meteorological and hydrological events that have brought heavy precipitation causing floods and landslides, droughts and forest fires, prolonged cold spells, heat waves, severe thunderstorms, and hailstorms. These hazards have had significant impacts in the region, including loss of human lives, damages to properties and infrastructure, and impaired the functioning of key sectors. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) suggests that there will be a marked increase in frequency of occurrence of weather and climate extremes in the future, in particular of heat waves, droughts, and heavy precipitation events, which brings the necessity for improved early warning for communities under threat in order to build their resilience.

One of the most important conclusions of the previous activities, (e.g., EU funded project 'Building Resilience to Disasters in Western Balkans and Turkey') in the region was the need to strengthen regional cooperation and address gaps in forecasting and warning provision related to hydrological and meteorological hazards at the national and regional level, particularly for transboundary areas. To achieve this, the development of a regional multi-hazard early warning advisory system consisting of information and tools for forecasters at the hydrometeorological services, contributing to harmonization of sub-regional early warning advisory systems is essential. The development of the SEE-MHEWS-A will support the NMHSs in the region in fulfilling their mandate for provision of timely and accurate warnings to limit impacts associated with hazardous weather, climate and hydrological events and to protect the lives and livelihoods of the people.

3.2 Objectives

The main objective of the SEE-MHEWS-A is to strengthen regional and sub-regional cooperation and national and regional capacities in a provision of meteorological, hydrological and marine forecasts, advisories and warnings through the establishment of a new regional framework for improved multi-hazard transboundary early warning advisory services, as well as transboundary communication and collaboration among NMHSs, by leveraging existing regional capabilities and resources where possible.

Through utilizing to the extent possible systems currently available in the region, the specific objectives are to:

- a) Identify and where possible mitigate gaps in observing networks of SEE region and foster an open exchange of meteorological, hydrological and marine observational data with improved space and temporal resolution (up to sub-hourly), as well as required topographic data (digital elevation models, soil types, land use, reservoirs and dam locations, etc.) for the purpose of the project;
- b) Development of a Centralized Observational Database (CODB) for the real-time access to additional observations from the SEE region for the purpose of their assimilation into numerical models, model verification, post-processing and nowcasting;
- c) Implementation of a suite of coupled meteorological, hydrological and marine models to be operated in a "cloud" (or virtual centre) environment with a view of their products to be made available to project participants;
- d) Implementation of a post-processing, visualisation and interactive tools for the access to commonly developed SEE-MHEWS-A information and products;
- e) Implementation of the nowcasting tools, to support a provision of meteorological,

- hydrological and marine forecasts, advisories and warnings;
- f) Implementation of a performance monitoring and verification tools;
 - g) Development of the “cloud-based” (or virtual centre-based) Common Information (and Communication) Platform (CIP) for an interactive access to models’ output, nowcasting, warning advisories, observational data and products, verification, exchange of warnings and communication among forecasters, including cross-boundary standard operational protocol, in order to strengthen decision making process related to weather-related hazards by the national authorities;
 - h) By utilizing CIP, promote further post-processing of data and products on national levels for a provision of more specific early warning services to users; this would also allow national entities to introduce impact-based forecasts and improve their risk-based warning capacities;
 - i) By utilizing CIP, introduce exchange of warnings within SEE thus allowing their harmonization in transboundary areas;
 - j) Promote capacity development, exchange of know-how, technology-transfer and scientific developments for building SEE-MHEWS-A.

3.3 Major Hazards

Meteorological, hydrological and marine forecasters of the SEE region agreed on the major hazards for which advisory would be needed under the scope of the SEE-MHEWS-A. Information and products elaborated under this project should assist forecasters in addressing the following major hazards: (a) rain inducing floods; (b) severe convection (lightning, hail, strong winds, squalls and flash floods); (c) heat/cold waves; (d) droughts; (e) wintry precipitations (snow, blizzards, freezing rain, blowing/drifted snow); (f) severe winds (wind storms, Bora, etc.); (g) forest fires; (h) sand and dust storms; (i) fog, including visibility at sea; (j) landslides, mudslides, air quality (and possibly earthquakes for future consideration); (k) sea waves; (l) sea currents; and (m) sea level (see: Final Report of the Forecasters’ Workshop, Skopje, the former Yugoslav Republic of Macedonia, 7-9 February 2017).

3.4 Project Management Overview

3.4.1 Project Steering Committee

Project Steering Committee (PSC) will be established to oversee the project implementation and to make decisions necessitated by the project implementation, especially related to the overseeing, monitoring, reviewing, guiding and supporting the project implementation and subsequent changes to it. Agreements/memoranda that stem from the project implementation will be considered by PSC. PSC will also conduct financial monitoring and reporting to project participants and the President of RA VI and will address and mitigate major challenges and risks confronted.

PSC will be composed of the Directors of meteorological, hydrological and hydrometeorological services of South-East Europe (project participants), which will meet annually either in person or via video link.

Until the end of 2017 (the resource mobilization phase), the provisional PSC will be established to oversee activities related to the initial management of the project activities that should start in the second half of 2017. The WMO President of Regional Association VI (RA VI, Europe) will be invited to chair the provisional PSC, which will be responsible for building the project management structure that would come in place once resources for implementation are available.

PSC will establish ad-hoc technical teams (TT) to address issues related to the project

implementation, such as TT on observations (TT-Obs), TT on modelling (TT-Mod), TT on post-processing and nowcasting (TT-PP), TT on information communication technology (TT-ICT), TT on scientific issues (TT-Sci) and TT on capacity development and training (TT-CD), and others as appropriate. TTs will be composed of experts from the project participants, contributing stakeholders, as well as other international experts, and will be responsible for implementation of tasks described in Chapter 4.

3.4.2 Project Advisory Group

Project Advisory Group (PAG) will be established to advise PSC in overseeing and monitoring the project implementation. PAG will address coordination and cooperation issues at national and regional levels. PAG will review project deliverables, feasibility and technical studies, technical specifications, proposals for new agreements or Memorandum of Understandings (MoU), including progress reports submitted by TTs.

PAG shall be composed of experts nominated by the project participants and contributing stakeholders. PAG expertise shall cover regional meteorological, hydrological, marine (oceanographic) observations, modelling and forecasting, and information communication technology. PAG shall communicate preferably via electronic means, such as e-mails and teleconferences with annual meetings organized if considered necessary.

3.4.3 Project Office

Project Office (PO) supports all SEE-MHEWS-A project implementation activities, including coordination with PAG, project participants and contributing stakeholders. It will prepare bi-annual project progress reports and financial reports with input from TTs, for consideration by the PAG and approval by PSC. PO will be also responsible for the organization of meetings and advising PAG and PSC when the project implementation requires urgent attention. PO will liaise with WMO and co-sponsored programmes. In its major role in the implementation of the SEE-MHEWS-A, the Project Office will be established under the WMO Regional Office for Europe (ROE).

PO was established in September 2017 in Croatia, in the premises of Meteorological and Hydrological Service of Croatia. Three project officers should be engaged for the period of the implementation of the project through an official WMO vacancy procedure, namely (a) Project Manager (P.4), (b) Project Officer (P.2), and (c) Project Secretary (G.4). The office professional staff should have managerial background, and should also include broad areas of professional expertise such as environmental monitoring (observing networks), forecasting, modelling, ICT, as well as financial management and administrative support.

PO will coordinate project implementation with the respective WMO Programmes and Secretariat entities, and for this purpose the WMO Secretariat internal coordination and oversight mechanism shall be established. Secretariat internal coordination and oversight mechanism, under the responsibility of the Assistant Secretary-General, shall include especially the Development & Regional Activities Department, Research Department, Climate and Water Department, Weather and Disaster Risk Reduction Services Department, and Observing and Information Systems Department.

3.4.4 Project Participants

Meteorological, hydrological, and hydrometeorological services of the SEE region are the core project stakeholders (hereinafter Project Participants, PPs) that will benefit from the SEE-MHEWS-A advisory system. The project participants during the phase I of the SEE-MHEWS-A project were from Albania, Bosnia and Herzegovina (two hydrometeorological services from Banja Luka and Sarajevo), Bulgaria, Croatia, Cyprus, Greece, Hungary, Israel, Jordan, Kosovo (as defined by UNSCR 1244/99), Lebanon, the former Yugoslav Republic of Macedonia, Moldova, Montenegro, Romania, Serbia, Slovenia, Turkey and Ukraine.

PPs will agree, through a Memorandum of Understanding (MoU) on their commitments to collectively implement the project as stipulated in this implementation plan and will jointly

operate the future advisory system. In signing the MoU, the project participants will contribute actively through their experts in a design, implementation and operation of the SEE-MHEWS-A and will share their knowledge and expertise with other project participants, as appropriate.

3.4.5 Contributing Stakeholders

Several stakeholders will contribute to the development of the framework for the improved multi-hazard early warning advisory system in SEE and/or to its subsequent operation. At the initial stage of the project implementation, the following major contributing stakeholders from intergovernmental/international organizations and institutes within the Region VI are envisaged: ECMWF, EUMETNET, EUMETSAT, COPERNICUS, Joint Research Centre (JRC), European Severe Storm Laboratory (ESSL), International Sava River Basin Commission (ISRBC), and International Commission for the Protection of Danube River (ICPDR).

Contributing stakeholders also include NMHSs from outside the SEE region. Potentially, those could be: Austrian Institute for Meteorology and Geodynamics (ZAMG), Czech Hydrometeorological Institute (CHMI), Deutscher Wetterdienst (DWD), including its Hans-Ertel Centrum, Finnish Meteorological Institute (FMI), National Oceanic and Atmospheric Administration (NOAA), Slovak Hydrometeorological Institute (SHMI), Météo France, Royal Netherlands Meteorological Institute (KNMI), Swedish Meteorological and Hydrological Institute (SMHI), UK Met Office, Spanish Meteorological Service (AEMET) and others. They will be supported by the Regional Specialized Centres, such as the WMO Regional Specialised Meteorological Centre with geographical specialization Offenbach (RSMCs) operated by Germany, WMO Global Precipitation Climatology Centre (GPCC) operated by Germany, WMO Drought Management Centre for South-Eastern Europe (DMCSEE), Regional Instrument Centre (RIC) operated by Slovenia, South East European Virtual Climate Change Centre (SEEVCCC) operated by Serbia, Adriatic Marine Meteorological Centre (AMMC) operated by Croatia, SDS-WAS Regional Centre for Northern Africa, Middle East and Europe (AEMET-BSC) operated by Spain, Hellenic Centre for Marine Research operated by Greece, and Regional Meteorological Training Centres (RTC), such as RTC Turkey, RTC Israel, RTC Italy, and the future RTC Spain (being established).

National water management/dam authorities in SEE region will also be included.

To become a contributing stakeholder, the interested entity shall declare, through a MoU, its willingness and a scope of its contribution to the SEE-MHEWS-A. The initial lists the potential contributing stakeholders and a scope of their possible contributions is in Appendix 3. Interested services or entities not identified in this document can apply to become contributing stakeholder.

3.4.6 Collaboration with WMO and Co-sponsored Programmes

WMO is the specialized agency of the United Nations responsible for (1) coordination of climate and weather research, (2) development of standards and technical developments, (3) operational cooperation and coordination among its Member States for observing, analysis, data exchange, and forecasting of weather, climate, water and related environmental conditions, and (4) capacity development at national and regional levels for the provision of meteorological, hydrological and climate services to support decision-making for safety of lives, livelihoods and property. This is achieved through (i) WMO's ten sponsored and four co-sponsored scientific and technical international programmes, (ii) eight technical commissions, composed of a network of over 1,500 leading research and operational experts designated by WMO Member States to establish methodologies, procedures and standards, (iii) a globally and regionally coordinated operational network, and (iv) a network of 30 Regional Training Centres.

WMO has 191 Member States and Territories, who are represented in the Organization through their Permanent Representative, usually the Director of the National Meteorological

and Hydrological Service (NMHS). WMO's institutional structure is comprised of (i) World Meteorological Congress, (ii) Executive Council, (iii) six Regional Associations, and (iv) WMO Secretariat, headed by the WMO Secretary-General with headquarters in Geneva, Switzerland, where the offices of all the WMO sponsored and co-sponsored programmes are located.

Building on more than sixty years of international and regional cooperation, WMO works through scientific and technical programmes. SEE-MHEWS-A project is building on several WMO Programmes, especially the Disaster Risk Reduction Programme (DRR), Education and Training Programme (ETRP), Hydrology and Water Resources Programme (HWRP), Marine Meteorology and Oceanography Programme (MMOP), Public Weather Services Programme (PWS), Regional Programme (RP), World Weather Research Programme (WWRP) and World Weather Watch Programme (WWW) with its three major components of Global Observing System (GOS), Global Telecommunication System (GTS), and Global Data-processing and Forecasting System (GDPFS), WMO Integrated Global Observing System (WIGOS) and WMO Information System (WIS).

SEE-MHEWS-A project will collaborate with the WMO Global Multi-Hazard Alert System (GMAS) and WMO Co-sponsored Programmes, such as the Associated Programmes on Flood Management and Integrated Drought Management Programme (IDMP).

3.4.7 Project Monitoring and Reporting

- a) PSC will monitor, review, guide and support the overall implementation of SEE-MHEWS-A. PSG will also be responsible for the financial monitoring of the project;
- b) PAG will report to subsequent sessions of PSC of the progress in implementation of SEE-MHEWS-A;
- c) PO, under the institutional guidance of the WMO Secretariat and its Regional Office for Europe (ROE), will be responsible for (a) the implementation of the project, (b) reporting to the project management entities (PSC and its TTs, PAG, ROE, WMO Secretariat internal coordination oversight body), (c) reporting to the project participants and contributing stakeholders; (d) reporting to RA VI Management Group and the RA VI President. Project office shall document the progress of the SEE-MHEWS-A implementation and make sure impediments are timely addressed.

3.4.8 Project Evaluation

Evaluation methodology will be designed against SEE-MHEWS-A key implementation activities (see Chapter 4), i.e. with respect to the activities, deliverables, timeline, responsibility and resources available. This will include a schedule of monitoring and evaluation activities and related responsibilities. Mid-term evaluation, interim progress reports and post-implementation reviews are planned as a means of providing early feedback on progress towards success, and as a means of meeting accountability and transparency requirements for the whole implementation phase.

3.5 Description of Implementation

3.5.1 Development Phase (mid-2016 to mid-2017)

Development phase included an extensive consultation with the potential project participants and contributing stakeholders through the project workshops dedicated to observations, forecasters' requirements, NWP modelling and information and communication technologies. It also included interaction with project participants and partners contributing to the rationale, concept, principles and characteristics of SEE-MHEWS-A.

The development phase, which focused on the development of the IP, started with the project kick-off meeting (Zagreb, Croatia, 5 October 2016) and ended by the consideration of

this IP at the meeting of SEE-MHEWS-A project participants (Ljubljana, 14-15 June 2017) and their commitment to collectively implement the project as stipulated in this implementation plan and to jointly operate the future advisory system.

3.5.2 Resource Mobilization Phase (mid-2017- end 2017)

Potential development partners for the project would consider their level of support according to the agreed SEE-MHEWS-A implementation plan. Therefore, the second half of 2017 will be devoted to resource mobilization; however, resource mobilization will be a continued activity throughout the project life.

In parallel to resource mobilization, initial implementation activities will start in mid-2017, especially those related to the project management.

3.5.3 Implementation Phase (2018 - 2022)

Five year implementation phase will start in 2018 or thereafter, as soon as the required resources would be made available. This phase will be led by PAG, supported by TTs, under the responsibility of PSC and in coordination with PPs, contributing stakeholders and the WMO and co-sponsored Programmes. It will focus on implementing a Centralized Observational Database (CODB), a suite of coupled meteorological, hydrological and marine/oceanographic prediction models, and a Common Information (and Communication) Platform (CIP), including several tools, such as for the post-processing, nowcasting, visualisation and cross-border communication among forecasters. It will also focus on preparing a framework for sustained operations and maintenance of the implemented advisory system that will contribute to the WMO GMAS concept.

Initial timelines and deliverables are given in Chapter 4.1 "Activities, Deliverables, Milestones, Cost and Risks". This section will be regularly reviewed and updated, as appropriate.

3.5.4 Testing Phase (January - June 2023)

During the testing phase, the system will run in a pre-operational mode to test all components of the system and to identify and fix the problems encountered. All TTs will participate in this pre-operational test.

Test protocol that shall be prepared beforehand by the Project Office shall describe how the pre-operational test will be conducted, including responsibilities of the project management team during the test. The test protocol shall demonstrate whether all components and the system as a whole respond to the defined technical specifications and whether all defined deliverables were achieved. PAG will submit the test protocol to PSC for approval.

3.5.5 Operational Phase (mid-2023 onwards)

Once the testing phase of the pre-operational mode of the system is declared successful, SEE-MHEWS-A shall enter into the operational phase. Nevertheless, SEE-MHEWS-A will continue to evolve to improve its performance in support of the early warning decision-making process, thus responding optimally to the needs of users and evolving technological opportunities at participating stakeholders' side.

The implementation of SEE-MHEWS-A will establish an improved scientific basis for national and regional efforts towards sustainable early warning systems, though project participants shall continue collaborating in the scientific undertakings relevant to improved operation of the SEE-MHEWS-A system. TT-Sci will be responsible for drafting the research and development plan that will be considered once the SEE-MHEWS-A is operational.

SEE-MHEWS-A will include capacity development requirements to assist project participants in the development and maintenance of their own infrastructures, human resources, and the knowledge needed to support the provision of early warning services.

While the development and implementation of the SEE-MHEWS-A shall be done under the

umbrella of the project, its operation and maintenance shall be a responsibility of the project participants and committed contributing stakeholders. For this an agreement between project participants and contributing stakeholders should be developed for the operation, maintenance, and further enhancement of the system through scientific advancement before the end of the project.

4. Key Activities for SEE-MHEWS-A Implementation

Key activities of the project implementation described in this section follow the vision for the SEE-MHEWS-A advisory system depicted in Figure 4.1 and Figure 4.2.

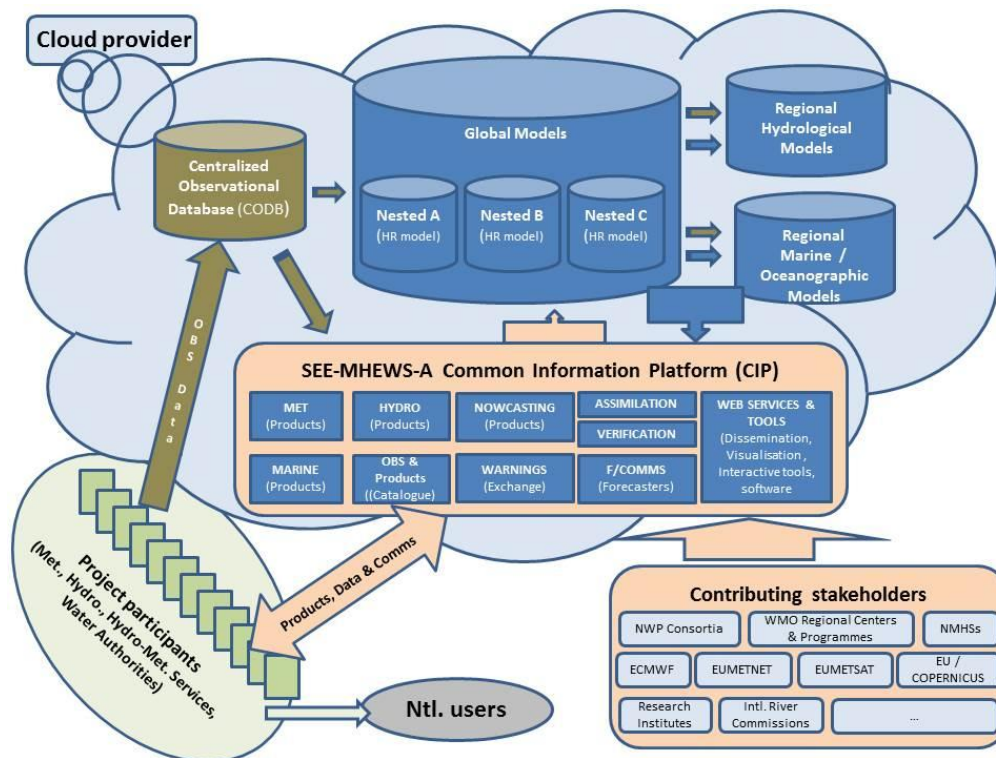


Figure 4.1: Depiction of the suite of coupled meteorological, hydrological and marine/oceanographic prediction models supported by the Centralized Observational Database together with Common Information (and Communication) Platform and contributing stakeholders.

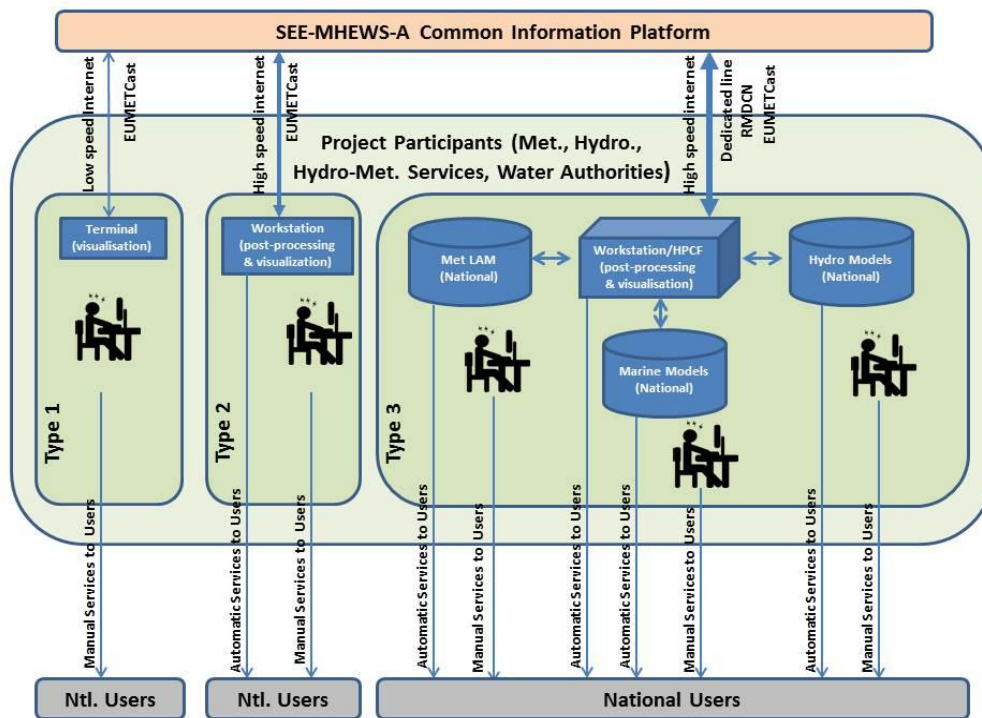


Figure 4.2: Depiction of three different types of the project participating entities depending on their information and communication technologies.

The vision is seen as a status of the system when all implementation activities and related deliverables are completed (see Table 4.1), and major gaps (see Table 5.1) addressed through the capacity development and training. The required resources, both financial and human, might not be available early enough to complete the project in its full scope within the implementation phase (2018 to 2022) and before SEE-MHEWS-A is operational (mid-2023). From this perspective, Figure 4.1 and Figure 4.2 may represent a vision beyond 2023.

At the beginning of the project three types of PPs are envisaged as depicted in Figure 4.2:

- Type 1 PPs use low speed communication means (may also have other limitations that need to be addressed), which would allow the project participant to provide limited set of observational data into CODB and also receive/download limited (lower resolution) products from CIP. One way EUMETCast system should provide full scope of data and products available at CIP that could be visualised on site.
- Type 2 PPs use high speed communication means allowing the project participant to provide all required observational data into CODB and receive/download most of the products available at CIP. In addition, one way EUMETCast system could provide full scope of data and products available at CIP that can visualised on site. This type of participants can make further post-processing at “home” and to develop additional (tailored) products for their national multi hazard early warning system.
- Type 3 PPs use high speed communication means (e.g., high speed internet, RMDCN) thus allowing the project participant to receive, download and visualise all data and products available at CIP in an interactive way and use them also for further post-processing and for their national “local” meteorological and/or hydrological and/or marine/oceanographic modelling activities. EUMETCast system could provide a back-up reception of data and products available at CIP.

Note, however, that through the project's capacity development activities, which will address basic systems (observations, data processing and communication), as well as necessary training and lack of know-how, all entities could eventually transit to type 3.

4.1 Management of SEE-MHEWS-A Implementation

Project management structure, including responsibility for the project implementation is described in section 2.4. It consists of (a) Project Steering Committee (PSC), (b) Technical Teams (TT), (c) Project Advisory Group (PAG), (d) Project Office (PO), and (e) Contributing Stakeholders (CSs). The project management will be supported by the WMO Secretariat, especially the Regional Office for Europe (ROE), as well as the WMO and co-sponsored Programmes.

Building of the project management structure will be a process that started at the meeting of the SEE-MHEWS-A project participants (14-15 June 2017) and should be in place when the implementation phase should start (January 2018). Nevertheless, the management structure can be updated as appropriate. SEE-MHEWS-A project participants will establish PSC (composed of Directors of meteorological, hydrological, and hydrometeorological services of PPs), its membership and the chairperson. The rest of the management structure, including membership of the Project Advisory Group and Technical Teams, will be a responsibility of PSC. A membership of TTs may vary in time according to expertise required.

4.2 Sub-Regional and RA VI Collaboration

Lessons learned from the catastrophic floods in Balkan Peninsula (May 2014) revealed the lack of regional/sub-regional cooperation in forecasting of floods but also other potential hazards of a transboundary nature. Such hazards have significant impact in the SEE region, including losses of human lives, damage to properties and infrastructure, and impaired functioning of key sectors.

The regional/sub-regional approach is essential in addressing these hydrometeorological hazards and their potential impacts in the region. Improvements in all early warning systems in SEE are envisaged through a collaborative effort of project participants and contributing stakeholders under the SEE-MHEWS-A project and capacity development activities that will allow all PPs to progress towards the type 3 creating a stronger partnership where all members contribute towards a common goal and workload is shared. The following are the main areas of expected improvements:

- a) **Observations** - Identification and filling the major observational gaps in the SEE region; and support to pilot projects in enhancing observation capacities (radiation balance meters, ceilometers, etc.). The development, implementation and operation of a Centralized Observational Database (CODB) that would facilitate data assimilation, model(s) verification, post-processing and nowcasting. Improved observational networks would allow gradually the project participants to provide to CODB in real-time observations with increased temporal (hourly, sub-hourly) and spatial resolutions;
- b) **Modelling** - Development and implementation of a suite of the coupled meteorological, hydrological and marine/oceanographic prediction models and operated in a "cloud" environment;
- c) **Communication** - Development, implementation and operation of a "cloud-based" Common Information (and communication) Platform (CIP) to facilitate access to-, and dissemination of model outputs, post-processing tools and post-processed products, such as nowcasting, dissemination of warnings, such as via MeteoAlarm, and communication among forecasters to coordinate advisories and warnings especially in transboundary areas;

- d) **Capacity Development** - Capacity development activities, which include resources and training, by addressing gaps in (i) observing and monitoring, (ii) modelling and post-processing, (iii) information and communication and (iv) know-how, will lead to a stronger partnership among project participants with shared responsibility and synergic use of resources in order to fully benefit from the SEE-MHEWS-A.

The sub-regional collaboration among PPs, within the scope of the adopted IP, will be based on the appropriate agreements or MoUs, which will be considered by the PSC. These may include the following:

- e) Agreement between all the project participants on data policy addressing differences between the existing official WMO data policies, namely, Resolution 40 (Cg-XII), Resolution 25 (Cg-XIII) and Resolution 60 (Cg-17) and the additional data that would be required for the operation of SEE-MHEWS-A;
- f) Agreement(s) on responsibilities of PPs and contributing stakeholders for the development, implementation, operation and maintenance of the system and its components;
- g) Agreement between PPs on the capacity development and training addressing existing gaps vis-à-vis the envisaged system, through i.e. training and transfer of knowledge and technology. This agreement will stipulate priority areas of capacity development that should be funded through the SEE-MHEWS-A project.

4.3 Collaboration with other relevant WMO projects and activities

The system shall build upon, as far as possible, on existing regional and sub-regional projects such as the WMO Severe Weather Forecasting Demonstration Project, the WMO Flash Flood Guidance System Project and relevant projects under the WMO Disaster Risk Reduction Programme.

4.3.1 WMO Severe Weather Forecasting Demonstration Project

WMO Severe Weather Forecasting Demonstration Project (SWFDP) is led by WMO's Data Processing and Forecasting Systems (DPFS) Programme under the auspices of the Commission for Basic Systems and in close collaboration with several related WMO Programmes.

The goals of SWFDP are to: (a) improve the ability of National Meteorological Centres (NMCs) to forecast severe weather events more accurately; (b) improve the lead time of alerting to these events; (c) improve interaction of NMCs with Disaster Management and Civil Protection Authorities before and during events; (d) identify gaps and areas for improvements; and (e) improve the skill of products from Global DPFS Centres through feedback from NMCs.

South-East Europe was identified as a new SWFDP regional subproject (SWFDP-SEE). A draft concept note for this subproject (January 2016) defines project outline as addressing gaps in severe weather forecasting, warning services and development across the region through (a) development of a regional information platform; (b) development of a regional collaboration and coordination mechanism; (c) capacity development of the NMHSs in severe weather forecasting and service delivery through implementation of SWFDP-SEE; and (d) development of feedback mechanisms.

In a broad sense SWFDP-SEE and SEE-MHEWS-A have complementary objectives. SEE-MHEWS-A goes further as it aims in providing advisory also for hydrology and marine hazards. For this to happen, SEE-MHEWS-A will design a suite of coupled meteorological, hydrological and marine (oceanographic) prediction models supported by the centralized database of observations for assimilation purposes, model verification and post-processing, such as nowcasting and early warnings. SEE-MHEWS-A will also provide inputs for higher

resolution national met/hydro/marine prediction models and/or further national post-processing, as appropriate. SEE-MHEWS-A will provide to the project participants, as a minimum, products that are defined in Annex A of the SWFDP Guidebook on planning regional subprojects towards implementation of a mechanism to strengthen operational centres.

With the above in mind, the DPFS Programme will implement some the envisaged activities within the scope of the SEE-MHEWS-A project thus building synergy in advancing both SWFDP-SEE and SEE-MHEWS-A.

4.3.2 WMO Flash Flood Guidance System Project

Recognizing that flash floods have a particularly disastrous impact on lives and properties of the affected populations, the Fifteenth WMO Congress had approved the implementation of a Flash Flood Guidance System (FFGS) project with global coverage that had been developed by the WMO Commission for Hydrology (CHy) jointly with the WMO Commission for Basic Systems (CBS) and in collaboration with the US National Weather Service, the US Hydrologic Research Centre (HRC) and USAID.

FFGS is an important tool for providing the operational forecasters and disaster management agencies with real-time informational guidance products pertaining to the threat of flash flooding. FFGS is a robust system designed to provide the necessary products to support the development of warnings for flash floods from rainfall and/or snow melt events using remote sensing observations of precipitation (e.g., radar and satellite-based rainfall estimates), temperature, snow cover extent and hydrological models. To assess the threat of a local flash flooding, the FFGS is designed to allow product adjustments based on forecaster experience with local conditions, incorporation of other information (e.g., NWP output), real time meteorological data and any last minute local observations (e.g., non-traditional rain gauge data) or local observer reports.

Within the scope of global FFGS implementation, the South-East Europe FFG (SEEFFG) regional project has been implemented and is operational at its Regional Centre hosted by the Turkish State Meteorological Service. The SEEFFG system could specifically benefit from SEE-MHEWS-A by using high resolution quantitative precipitation estimates (QPE) and forecasts (QPF) that will be provided by the SEE-MHEWS-A system for the small river catchments in the SEE region. Effort would be needed to expand the area of coverage of the FFGS over South East Europe to allow coverage of participating Members in the SEE-MHEWS-A. SEEFFGS expansion is needed to cover Cyprus, Greece, Hungary and Ukraine. Given the surface area of the latter country, a stand-alone FFGS would be needed. The first three countries could be incorporated into the SEEFFG.

Efforts would also be needed to take advantage of radar coverage in inclusion of radar precipitation data in the FFGS merged areal basin precipitation product. This would include working closely with NMHSs to develop a plan for effectively using the radars to improve regional forecasting efforts pertaining to the SEEFFG system, working with the US Hydrological Research Centre (HRC) and NMHSs to QA/QC and calibrate the radar data from identified radars that would be suitable for hydrological applications, develop a regional grid and ingest into the SEEFFGS gridded radar data and associated climatological bias factors. Dynamic bias adjustment for radar data will also be developed. A three-week workshop at HRC for a limited number of radar specialists/forecasters from each country will be conducted. Regional training workshops will also be conducted on radar hydrology and quality control of radar data and their use in operational forecasting as part of the SEEFFGS.

The functionality of the SEEFFGS will be expanded to include the latest modules and training on landslide susceptibility, application of urban flash flood forecasting sub-system over 4 large metropolitan areas to be selected by the Project Steering Committee, and the application of one riverine routing component for the Ukraine stand-alone FFGS.

An increase in the number of real-time hydrometeorological observing stations is needed to

improve forecast skill of the system. Improved observations would be required in several target countries within the SEEFFGS, namely Albania, Bosnia and Herzegovina, Republic of Moldova, Montenegro, and the former Yugoslav Republic of Macedonia among others. A similar strengthening of the observational network is needed in Ukraine to support its stand-alone system development.

WMO FFGS will be included in the suite of coupled meteorological, hydrological and marine/oceanographic prediction models of the SEE-MHEWS-A. Linkage between the SEEFFGS, its stand-alone Ukraine FFGS, and SEE-MHEWS-A will be established to secure best functionality of both systems. Synergy between these two projects will multiply the benefit expected from both projects.

A project officer (hydrologist) who has experience in implementing and operating the FFGS would be needed for two years to ensure effective implementation of the project.

4.3.3 Projects related to the WMO Disaster Risk Reduction Programme

The main long-term objective of the WMO Disaster Risk Reduction Programme (DRR) is to contribute to the strengthening of institutional capacities with respect to the provision of meteorological, hydrological and climate services, and cooperation in supporting disaster risk management for the protection of lives and property and contributing to sustainable development of Members.

The purpose of the WMO DRR Programme is to assist the Members to provide and deliver services that are directed towards the protection of lives, livelihoods and property, in a cost-effective, systematic and sustainable manner. This includes:

- a) Development and improvement of a sustainable early warning systems in particular related to scientific and technical infrastructures, systems and capabilities for research, observing, detecting, forecasting and warnings of weather-, water- and climate-related hazards;
- b) Development and improvement of a standardized and sustainable hazard databases, metadata, systems, methods, tools and applications of modern technologies such as geographical information systems for recording, analysing and providing hazard information for risk assessment, sectoral planning, risk transfer and other informed decision-making;
- c) Development and delivery of warnings, specialized forecasts and other products and services that are timely, understandable to those at risk and driven by requirements of disaster risk reduction decision processes and operations engaging socio-economic sectors;
- d) Stimulate a culture of resilience and prevention through strengthening of capacities for better integration of meteorological, hydrological and climate' products and services in disaster risk reduction across all socio-economic sectors, such as land use planning and infrastructure design and continued public education and outreach campaigns;
- e) Strengthening cooperation and partnerships of WMO and NMHSs in national, regional and international user forums, mechanisms and structures for implementation of disaster risk reduction.

DRR Programme will be actively reviewing and contributing to the implementation of the project to ensure that the development process is in alignment with and considers the end user requirements (e.g. MHEWS stakeholders such as disaster management). More specifically, the Programme will conduct workshops in cooperation with the WMO Public Weather Services Programme and DPFS at the start of each of the major activities of the project (i.e. observing, forecasting and modelling, and information and communication).

4.4 Leverage the Common Alerting Protocol Standard

During the development of the advisory system, leveraging the Common Alerting Protocol (CAP) standard will be considered. CAP, designated as International Telecommunication Union (ITU) Recommendation X.1303, is broadly recognized internationally as the key standard to achieve the goal of all hazards, all-media public alerting. WMO Executive Council has endorsed the CAP standard, and the WMO Commission on Basic Systems has strongly encouraged WMO Members to adopt it. To facilitate this, the WMO Service Delivery Division provides training to NMHSs to develop their capacity to publish warnings in the CAP standard format.

CAP Jump-Start Training Session was held 6-7 October 2016 in Zagreb, Croatia, as part of the Regional Conference on Multi-Hazard Early Warning Systems in South-East Europe. Leveraging the CAP standard in the SEE-MHEWS-A will be considered during the development of the Common Information (and Communication) Platform, especially for access to and exchange of warning advisories and communication among forecasters, including cross-boundary standard operational protocol. This follows various other international initiatives already leveraging or seeking to leverage CAP including the Universal App Program of the International Federation of Red Cross and Red Crescent Societies (IFRC), the International Network for Multi-Hazard Early Warning Systems (IN-MHEWS), the Flash Flood Guidance System (FFGS), and the WMO Alert Hub prototype, which is also associated with the proposed WMO Global Multi-Hazard Alert System (GMAS).

4.5 Observations

Higher temporal and spatial resolution observations are needed for the SEE-MHEWS-A system across the region. Gaps exist in some parts of the region and inventory would be needed to address those gaps. However, considerable amount of data already exists but are not exchanged as this goes beyond existing WMO data policies. An agreement between PPs would be needed on exchange of data for the purpose of the SEE-MHEWS-A, defining the scope of data that would be provided by the project participants into the system. A centralized observational database will be established for this purpose. Practical solution depends on the scope and volume of data and the technical capabilities of the potential host(s) of the database. The other modules of the SEE-MHEWS-A will receive data from this CODB.

4.5.1 Regional Requirements for Observational Data and Products

Regional requirements for observations were defined by the three project scoping workshops: (a) Forecasters' Workshop (Skopje, the former Yugoslav Republic of Macedonia, 7-9 February 2017), (b) Numerical Modelling Workshop (Budapest, Hungary, 8-9 March 2017), and (c) Workshop on ICT Technologies and Requirements for Observations (Athens, Greece, 4-6 April 2017). Summary is presented in Appendix 1.

Major conclusions comprise:

- a) Project participants should commit to free and open exchange of observational datasets via a Centralized Observational Database (CODB). This includes existing meteorological, hydrological, oceanographic and meteo-marine observational data, as well as historical data for model calibrations and topographic data. From ICT perspective the most demanding would be 3-D volume weather radar data;
- b) In designing CODB, TT-ICT should look what already exists rather developing new solution;
- c) Robust observing system providing good spatial and temporal coverage for all variables with low data latency will be critical to success of SEE-MHEWS-A. Further strengthening of observing networks is needed;

- d) Higher temporal and spatial resolutions of met/hydro/marine data are needed, many data already exist but are not exchanged;
- e) Minimum requirements in terms of spatial and temporal resolution should be adopted for observational data and products exchange that all project participants should comply with; the requirements should be based on the existing requirements for nowcasting and short-range numerical weather prediction captured and documented in the WMO Rolling Review of Requirements;
- f) Inventory of the capabilities of the SEE observing systems is needed so that gaps may be identified and filled. This should be done under the auspices of the WMO Integrated Global Observing System (WIGOS), using the OSCAR/Surface online WIGOS station catalogue/meta-database;
- g) Capacity development activities directed towards improving the observing networks and participants infrastructures should be defined, in order to allow participants to eventually fully benefit from the project. Further pilot projects could be needed to implement new equipment (ceilometers, visibility meters, radiation balance meters) for the purposes of early warning system enhancement;
- h) Access to both raw data and data that has been quality controlled or corrected using in-situ observations will be required for calibration of both existing and new hydrological models;
- i) Post-processed weather radar data, especially the Quantitative Precipitation Estimates (QPE) have an paramount importance for hydrological forecasting and nowcasting; with a preference to regional rather than national products, as for example OPERA;
- j) Integrated Nowcasting through Comprehensive Analysis (INCA), developed by ZAMG, is an excellent nowcasting tool and has potential for application in SEE-MHEWS-A project;
- k) In areas where weather radar data are unavailable either due to lack of technical expertise or financial resources, the potential use of precipitation mapping techniques based on mobile telecommunications tower-to-tower signal attenuation should be investigated.

EUMETNET Observations Programme (E-AMDAR, E-ASAP, E-GVAP, E-SURFMAR, E-PROFILE and OPERA) can provide necessary data and post-processed products for the assimilation, model verification and post-processing, such as nowcasting for the SEE-MHEWS-A. For example, use of OPERA data and products for nowcasting and as input to hydrological models is essential. Existing OPERA radar network covers only some of the weather radars of the SEE region; therefore, there is a need to establish the second regional radar centre that would encompass and process weather radars' data from the rest of the region. Turkish State Meteorological Service (TSMS) already operates the WMO weather radar database as a good practice example of internationally cooperated and participated project. By considering the existing experience, well designed infrastructure and the proven ability of TSMS, in case of agreed by parties, it can be a good candidate to establish and host the second SEE regional radar centre. It is proposed that products from these two centres (such as, QPE, VIL, and areal precipitation over river catchments, etc.) should then be available for input into regional and national hydrological models, Flash Flood Guidance System and nowcasting systems.

Similarly, EUMETSAT products, including those generated by the EUMETSAT Satellite Application Facilities (SAFs), should be made available for the data assimilation, verification and post-processing. For example, especially products generated by the H-SAF could substitute missing weather radar data in some parts of the SEE region.

For optimal results, hydrological models should be calibrated. For this, gridded historical

precipitation and temperature observations over 10 to 30 years are required from some parts of the SEE region. This activity can build on the techniques already used in the region, such as the CARPATCLIM project.

4.5.2 Centralized Observational Database

Centralized Observational Database (CODB) will be an indispensable tool to support the envisaged suite of the coupled meteorological, hydrological and marine/oceanographic models, their verification, calibration of hydrological models and further post-processing, such as nowcasting.

CODB could be operated in a “cloud” or in a virtual centre(s) hosted by a project participant(s) or a collaborating stakeholder(s). CODB can be split into two or more (virtual) centres based on the nature of observational data and their purpose of use within the project, e.g. one centre (CODB1) for meteorological data, while the other centre (CODB2) for hydrological data. However, the preferred option is to operate a single CODB, if possible, within the ECMWF environment thus using its infrastructure, software and tools to access, archive and visualize data and data products. It should be, however, verified that existing ECMWF systems can accommodate also hydrological data. Otherwise, split CODB would be an option.

ECMWF Member States (MS) have direct access to the ECMWF’s High Performance Computing Facility (HPCF) resources. Currently there are five MS from among the SEE NMHSs, namely: Croatia, Greece, Serbia, Slovenia and Turkey. They together have an aggregated HPCF allocation of ~55 million Cores*Hours for 2017 and if those five MS agree to use part of their allocations for the project, the SEE-MHEWS-A operational activities, such as CODB, the suite of coupled met/hydro/marine models and CIP, can be run at ECMWF using that allocation. MS from SEE currently utilize very little of their HPCF allocations. However, their plans for future must be verified.

TT-Obs and TT-ICT under the auspices of PAG will be responsible for the development of technical specification for CODB, and identification of the potential host(s) of CODB. TT-ICT will identify, acquire and implement needed ICT infrastructure and software, and will prepare an agreement with the host(s) for the operation and maintenance of CODB. If needed, additional computing power may be purchased under this project to supplement that of the host of CODB.

The scope of data, including the space and time resolution, formats and the respective volumes that shall be provided by project participants into a CODB will be defined by TT-Obs. PPs shall provide data into CODB according to an agreement developed by TT-Obs, approved by PAG and signed by all PPs (see also section 3.2).

4.6 Forecasting and Modelling

Meteorological, hydrological and marine/oceanographic models will be the core of the SEE-MHEWS-A. At least three high-resolution limited area models (HR LAM) should be nested in at least three global NWP models to provide so called “poor men” ensemble forecasts. HR LAM models will provide inputs to the hydrological and marine/oceanographic models. Practical solution depends on readiness to host so called suite of coupled meteorological, hydrological and marine/oceanographic models and whether the suite would be operated by one or more hosts and on their capabilities to accommodate the suite in their HPCF environment. The selection of models would depend on agreements with the respective consortia.

4.6.1 Regional Forecasters’ Requirements for Model Outputs and Post-processed Products

Regional requirements for model outputs were defined by the three scoping workshops: (a) Forecasters’ Workshop (Skopje, the former Yugoslav Republic of Macedonia, 7-9 February

2017), (b) Numerical Modelling Workshop (Budapest, Hungary, 8-9 March 2017), and (c) Workshop on ICT Technologies and Requirements for Observations (Athens, Greece, 4-6 April 2017). Summary of forecasters' requirements for model outputs is presented in Appendix 2.

The major conclusions comprise:

- a) SEE-MHEWS-A should build on existing systems;
- b) SEE-MHEWS-A should provide access to seamless, multiple NWP models at global (hydrostatic and non-hydrostatic), nested regional (non-hydrostatic) and local (convective scale non-hydrostatic) scales, adapted to the cascading process, accessible from, and visualized in a Common Information (and Communication) Platform (CIP), while applying agreed WMO standard practices;
- c) SEE-MHEWS-A should provide access to regional and local scales, calibrated and validated hydrological models coupled with NWP models and visualized in CIP, while applying agreed WMO standard practices;
- d) SEE-MHEWS-A should provide access to outputs of the regional and local scales, validated oceanographic models coupled with hydrological and NWP models and accessible from, and visualized in CIP, while applying agreed WMO standard practices;
- e) SEE-MHEWS-A should provide access to the COPERNICUS products, including Marine Environment Monitoring Service (CMEMS) oceanographic products;
- f) NMHSs should be in position to exchange the limited area weather prediction model results with the other project participants in a closed password protected network through the CIP. NWP models that are operated by SEE NMHSs already cover most of their neighbours;
- g) SEE-MHEWS-A should provide access to nowcasting tool(s) for forecasts up to 6 (-12) hours;
- h) SEE-MHEWS-A should provide password protected access to data and information, which would be made available at the CIP, to the meteorological, hydrological and marine forecasters;
- i) SEE-MHEWS-A should include the Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) for the Middle-East part of the region.

4.6.2 Suite of Coupled Meteorological, Hydrological and Marine (Oceanographic) Prediction Models

Major features of a design of the suite of coupled meteorological, hydrological and marine (oceanographic) prediction models are based on an outcome of the Numerical Modelling Workshop (Budapest, Hungary, 8-9 March 2017) and on proposals from the potential contributing stakeholders towards the SEE-MHEWS-A (see Appendix 3). These are as follows:

- a) Hydrostatic and non-hydrostatic global models that could be used are: ECMWF, JMA, GFS, NMM-B and ICON;
- b) High resolution non-hydrostatic models that could be used are: ALADIN/ALARO, COSMO-EU/ICON-EU, NMM-B, and potentially UK Met Office high resolution model;
- c) Nested HR non-hydrostatic models could be operated in ECMWF environment and run at least twice daily to provide deterministic and (poor men) probabilistic forecasts (at the beginning) up to 48 hours;

Domains of nested models should cover the whole SEE region, however, depending on a

demand for the computing power, the region may be divided into several smaller (partially overlapping) domains, as appropriate;

- d) National non-hydrostatic models that are currently used are: ALADIN/ALARO, COSMO-EU/ICON-EU, NMM-B and NMM-E. They will be operated by national entities, as appropriate;
- e) Cascading process will be adopted for the horizontal resolution of the global, regional and national models;
- f) Regional hydrological models that could be operationally used are, among others, EFAS and E-HYPE. HYPROM could be considered as regional hydrological model as well. They could be operated in centres of selected models' providers or in the ECMWF environment, as appropriate, and will be fed by nested NWP models and nowcasting;
- g) FFGS could potentially be operated with enhanced functionality by the regional centre for the Black Sea and Middle East FFG (BSMEFFG) and/or the regional centre for SEE (SEEFFG) situated in the Turkish State Meteorological Service (TSMS) for nine countries. Solutions to cover the rest of SEE will be explored;
- h) Local hydrological models that could be used include: MIKE-type, HYPROM, HYPE-Type, HBV, HEC suite, and ISRBC hydrological and hydraulic model. They will be operated by the national entities and fed by HR LAM models and nowcasting;
- i) Regional oceanographic and wave models (whole Mediterranean and Black Sea) that could be used are: WW3, WAM, CMES Mediterranean and Black Sea models. They will be operated in centres of selected models' providers and coupled with the ECMWF and other HR LAM models and with specific hydrological models;
- j) Local oceanographic and wave models that could be used are: WW3, SWAN, WAM, CMCC coastal models. They will be operated by the national entities and fed by the HR LAM, hydrological models and nowcasting;
- k) Sand and Dust Storm products for the Warning Advisory and Assessment could be provided by COPERNICUS (CAMs), AEMET (Barcelona supercomputing centre), Republic Hydrometeorological Service of Serbia (RHMS), as well as others.

RHMS and Meteorological Office of the Environmental Agency of the Republic of Slovenia made several tests to find out HPC requirements for the SEE-MHEWS-A project design. This took into account discussions made at both Forecasters and NWP Modelling workshops held in Skopje and Budapest, respectively. The scenario tested by Slovenian experts was based on: (a) single LAM model (ALADIN/ALARO/AROME), (b) less than 1 hr integrated time, (c) Ensemble Data Assimilation (10 members' ensemble), (d) One large domain covering the whole SEE area, (e) 2 km horizontal resolution, (f) ALADIN/SI as reference (432x432x87): 35min on 256 cores. The test shows that this scenario (one LAM only) would take 3 % of the existing ECMWF HPCF, which, however would equal only to 0.2 % of total ECMWF CPU at the time of the project operation in 2022.

Therefore, ECMWF HPCF would not be a limiting factor because ECMWF could allow taking up as much as 20 % to 25 % of prime time of HPCF for SEE-MHEWS-A. Even more, there are still possible optimizations that could save further computing resources. It was estimated that this scenario would eventually needed 5,000 cores*hours per run, which is 30,000 per day and 10 million cores*hours per year. Croatia, Greece, Serbia, Slovenia and Turkey have together allocation of about 55 million Cores*Hours for 2017 (that would increase in 2020 after the significant upgrade of ECMWF HPCF). Theoretically, provided agreement with the five ECMWF full member states from SEE is in place, even all three nested HR LAM models

could be operated in ECMWF HPCF.

PSC will, based on the proposal from TT-Mod, develop (a) an agreement with the respective NWP consortia for a provision of LBC to nested HR LAM models, (b) an agreement with the respective consortia to implement HR LAMs, hydrological and marine/oceanographic models in the identified HPCF environments, based on the feasibility study by TT-Mod, and (c) an agreement with the potential hosts that would operate HR LAMs, hydrological and marine/oceanographic models.

Eventually, PSC, supported by TT-Mod and TT-ICT, will oversee the implementation of the suite of models; based on the technical specification to be developed by TT-Mod together with TT-ICT.

HR nested models component

Three possible options of operating the suite of coupled meteorological, hydrological and marine/oceanographic prediction models (HR nested models component) would be possible:

Option 1:

- Operating all three nested HR LAMs (with a specification as tested by Slovenia above) in the ECMWF HPCF, using portion of the allocations of the five ECMWF MS from SEE (there would still be a possibility to split one SEE domain into smaller domains to save computing resources).

Option 2:

- Operate one HR LAM (e.g., ALADIN that is currently mostly used by the potential project participants) in the ECMWF HPCF; NMM-B then could be operated in HPCF of the Republic Hydrometeorological Service of Serbia.
- COSMO-EU/ICON-EU could be operated in HPCF of the Hellenic National Meteorological Service.

Option 3:

- Operate ALADIN in HPCF of one of the SEE potential participants currently operating their versions of ALADIN (namely, Bulgaria, Croatia, Hungary, Romania, Slovenia, and Turkey).
- Operate COSMO-EU/ICON-EU in HPCF of one of the SEE potential participants currently operating their versions of COSMO (namely, Greece, Romania, and Israel).
- Operate NMM-B in HPCF of one of the SEE potential participants currently operating their versions of NMM-B (currently NMM-B is operated by the Republic of Serbia for SEECOP members: Albania, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, and Montenegro).

Each option has its own advantages and disadvantages; however, ECMWF is the preferred option as declared by the participants of the three project workshops held in Skopje, Budapest and Athens. The major reasons being: (a) sustainable solution; (b) five ECMWF member states and six cooperating states are coming from the SEE region; additionally, new potential (cooperative) members may arise in the near future; they have established working relations with ECMWF, including use of ECMWF resources and communication infrastructure is in place; and (d) a solution acceptable to all. If required, additional HPC modules could be purchased under this project to supplement the HPCF of ECMWF, pending the Council approval, or the HPCF of another potential host(s), as appropriate.

Any of the above options will need a feasibility study and eventually agreements for the implementation, operation and maintenance of the defined HR LAM models. As a minimum, agreements will have to be established with: (a) ECMWF and/or other potential providers of HPCFs, (b) the five ECMWF MS from SEE, and (c) the respective NWP Consortia (ALADIN, COSMO, and SEECOP).

As for receiving lateral boundary conditions from global models, an agreement will be needed from the respective consortia operating ECMWF, JMA, GFS, NMM-B and ICON global models.

Regional hydrological models component

Two possible options of operating the suite of coupled meteorological, hydrological and marine (oceanographic) prediction models (regional hydrological models component) would be possible:

Option 1:

- Operate EFAS, E-HYPE, HYPROM and other potential candidate hydrological models in the ECMWF HPCF.
- Operate FFGS jointly by the existing regional centre for the Black Sea and Middle East FFG (BSMEFFG) and regional centre for SEE (SEEFFG).

Option 2:

- Operate EFAS in the ECMWF HPCF (this is currently the case).
- Operate E-HYPE, HYPROM and other potential candidate hydrological models in the computer facilities of one of the potential project participants.
- Operate FFGS jointly by the existing regional centre for the Black Sea and Middle East FFG (BSMEFFG) and regional centre for SEE (SEEFFG).

Each option has its own advantages and disadvantages; however, the preferred is the option 1 as declared by the participants of the three project workshops held in Skopje, Budapest and Athens). The major reasons being: (a) EFAS is currently being operated in ECMWF HPCF, (b) a sustainable solution; and (c) a solution acceptable to all.

Operating hydrological models in the computer facilities of one of the potential project participants will need a feasibility study. Agreements for the implementation, operation and maintenance of the hydrological models will have to be concluded with model providers and hosts of the computer facilities. As a minimum, agreements will have to be established with: (a) ECMWF and/or other potential providers of HPCFs, and (b) the EFAS Consortium. Relation to existing WMO FFGS centres should also be established.

Regional marine/oceanographic models component

Good option for operating the suite of coupled meteorological, hydrological and marine (oceanographic) prediction models (regional marine/oceanographic models component) is the one offered by the Euro-Mediterranean Centre on Climate Changes (CMCC) in Bologna and Lecce, Italy to provide the SEE-MHEWS-A with outputs of the prediction models currently operated by CMCC and the Copernicus Marine Environment Monitoring Service (CMEMS). This option covers requirements presented by the Project Workshops in Skopje and Budapest. Agreements with CMCC and COPERNICUS will have to be established through a simple registration process.

4.7 Information and Communication

Common Information (and Communication) Platform would be a heart of the SEE-MHEWS-A. All data and products would be accessible in an interactive way from CIP and/or will be disseminated to the project participants for further use and/or post processing. CIP should also provide accesses to products that are not produced by SEE-MHEWS-A but are required by forecasters, such as products from ESSL, etc. CIP should provide various tools and post processed products, such as nowcasting that would be essential for advisories in the first 6 to 12 hours. Practical solution depends on scenarios adopted for CODB and suite of models as well as telecommunication capabilities of project participants and contributing stakeholders that would be responsible for providing of some post processed products and other information, such as nowcasting and verification.

Project's essential Information and Communication Technology (ICT) covers all technology that is central for the operation and maintenance of the project essential modules, namely: (a) CODB, (b) suite of coupled meteorological, hydrological and marine (oceanographic) prediction models, (c) CIP, including its individual components (see section 3.6.2), and (d) communication means between the above three essential modules. These essential ICT will be established through the project agreements with PPs and contributing stakeholders and according to the availability of the project funding.

4.7.1 *Regional ICT Requirements*

Regional ICT requirements were defined by the three scoping workshops: (a) Forecasters' Workshop (Skopje, the former Yugoslav Republic of Macedonia, 7-9 February 2017), (b) Numerical Modelling Workshop (Budapest, Hungary, 8-9 March 2017), and (c) Workshop on ICT Technologies and Requirements for Observations (Athens, Greece, 4-6 April 2017). The major conclusions comprise:

- a) CIP should be preferably located in a single location with the preference to the ECMWF environment. TT-ICT should define services, standards and protocols for CIP Services;
- b) Visualisation, preferably using open source and/or commercially available solutions, would be an important module on CIP, especially for visualisation of model outputs and post-processed data and products. TT-ICT should look what already exists in NMHSs or what is commercially available, rather developing a new solution;
- c) For message and file switching, WIS standards should be applied. There are systems existing and widely used by NMHSs, such as the one developed by DWD based on the open source or other systems developed by commercial companies;
- d) For the communication between CIP and PPs, mixture of communication means may be used (e.g., GTS/ RMDCN, internet, EUMETCast), with preference to internet as a basic communication means, using high availability and secure network tunnelling conforming to the guidance provided by attachments to the Manual on WIS, such as Internet Protocol Security (IPSec) and Open Source VPN (OpenVPN). It is often possible for national institutes to achieve redundancy in telecommunications links by connection to more than one internet service providers;
- e) Exchange of data and products should be limited to project participants, for example using password protection; however, it would be up to each PP and their national data policy to decide whether they will share data in a protected or free and unrestricted manner. Transmission of information, and associated authentication, should use encrypted exchange protocols supported by the WIS;
- f) Lessons should be learned from Hydrological Information System of the Sava River Basin, which is a good example of cooperation and data exchange among NMHSs' of Bosnia and Herzegovina, Croatia, Serbia and Slovenia.

4.7.2 *Common Information (and Communication) Platform*

The major features of a design of CIP are based on an outcome of the Numerical Modelling Workshop (Budapest, Hungary, 8-9 March 2017 and on proposals from the potential contributing stakeholders towards implementing SEE-MHEWS-A (see Appendix 3):

- a) Observational data and products (including from radars and satellites SAFs) should be available through CIP (linked to CODB) and could be possibly managed by ECMWF data handling system (MARS, WEB services, FTP) or other existing commercially available low cost solutions;
- b) Model outputs of the suite of coupled met/hydro/marine(oceanographic) models

- should be available on CIP and could be visualised by ECMWF Metview, ecCharts, OMSZ HAWK, SmartMet or other commercially available products;
- c) Dissemination of the models' outputs, data and other post-processed products could be made available via a web browser applications, such as the one provided by ECMWF Web Services or available open source applications or commercially available solutions; one way satellite communication, such as EUMETCast may be considered, especially for PPs with inadequate telecommunication capabilities;
 - d) Post-processing and nowcasting products should be available on CIP and could be provided by e.g., ZAMG INCA, ESSL or other solution should be looked for;
 - e) Visualisation and other tools and software packages should be available on CIP and could be provided by ECMWF (e.g., Metview, Magics, ecCodes, ecFlow) and/or ESSL and/or commercially available solutions;
 - f) Verification of different LAM models, including interpretation of model outputs, post-processing and nowcasting products should be available on CIP and could be provided by the respective modelling consortia and/or contributing stakeholders in collaboration with TT-Mod;
 - g) Trans-boundary communication and collaboration among forecasters (especially between neighbouring countries) should be available through CIP and could be provided by ZAMG (MeteoAlarm-F). Agreement with EUMETNET and ZAMG will be needed. Finnish Meteorological Institute (FMI) could also contribute the free code for the trans-boundary communication;
 - h) Information on issued warnings should be available through CIP and could be provided by ZAMG (MeteoAlarm-P). In such a case, an agreement with EUMETNET and ZAMG will be needed;
 - i) Design of CIP should be done by SEE experts. CIP could be preferably operated within the ECMWF environment and linked to contributing stakeholders/providers who could operate some of its modules (e.g. MeteoAlarm and Nowcasting by ZAMG, nowcasting by ESSL, SAF by EUMETSAT, OPERA by EUMETNET, etc.).
 - j) Products and information needed for forecasting of major hazards (see section 2.3), which are not provided directly by the SEE-MHEWS-A suite of models and post-processing, should be also available on CIP, such as for forest fires, landslides, mudslides and air quality.

Based on the outcomes of the project workshops, the major modules of CIP could comprise:

- a) **ASSIMILATION:** Pre-processing of data for assimilation;
- b) **DATA & PRODUCTS:** Catalogue of data and data products from CODB and products from other sources than SEE-MHEWS-A;
- c) **F/COMMS:** Trans-boundary communication between forecasters;
- d) **HYDRO:** Catalogue of model outputs from at least two regional hydrological models;
- e) **MARINE:** Catalogue of model outputs from regional marine/oceanographic models provided by CMCC;
- f) **MET:** Catalogue of model outputs from, at least, three nested HR LAM models;
- g) **NOWCASTING:** Catalogue of nowcasting products;
- h) **VERIFICATION:** Results of the models' verification provided by the respective consortia;
- i) **WARNINGS:** Exchange of warnings and awareness reports within the SEE;
- j) **WEB SERVICES & TOOLS:** Various tools needed for advisory system's operations, such as dissemination, data handling, (post-) processing and visualisation;

k) Other modules that could be proposed through an analysis to be done jointly by TT-Obs, TT-Mod and TT-ICT.

a) ASSIMILATION:

- Assimilation is seen as the major contributor to the quality and accuracy of the NWP products. It should be preferred to improving horizontal resolutions of the models. Different data assimilation sub-teams should work on data assimilation on their respective LAMs. In this respect, one of the sub-teams could work with the Hans Ertel Centre of DWD that offered possible development of the seamless data assimilation for coupled atmospheric-ocean system for SEE-MHEWS-A, in case of available funding. An agreement with the Hans Ertel Centre of DWD would be needed.
- This module should provide assimilation files ready for the nested LAMs as well as for the nationally operated LAMs.
- Existing systems should be looked at, such as Scalable Acquisition and Pre-Processing system for observations (SAPP) of ECMWF and Data pre-processing for data assimilation and verification (OPLACE) of RC-LACE. RC-LACE would be willing to contribute to the SEE-MHEWS-A data pre-processing and data assimilation. Agreements with ECMWF and/or RC-LACE will be needed, as appropriate.

b) DATA & PRODUCTS:

- Based on the agreement between participating meteorological, hydrological, and hydrometeorological services, project participants shall provide defined set of observational data and products (in real-time, near-real time and historical data for calibration purposes) to CODB. PPs could also download data and data products needed for their own post processing, especially data from neighbouring countries. This module should contain a catalogue, as well as discovery mode and retrieve functionalities. Data should also be accessed programmatically, via e.g., Web API (see also WEB Services below).
- ECMWF provisionally proposed that MARS catalogue could be used; this would require an agreement.
- This module should also provide products and information needed for forecasting of major hazards, such as forest fires, landslides, mudslides and air quality, which could not be, at a time, provided directly from the SEE-MHEWS-A System. This should be done via links to external providers, such as COPERNICUS.

c) F/COMMS:

- To address cross border/boundary communication between services, a communication tool was requested allowing forecasters to communicate with each other, especially across borders, to harmonize their forecasts of extreme weather-related events, as appropriate. This should be a closed system for forecasters only that would also enable possibility of briefings and consultations when appropriate.
- Existing MeteoAlarm (Communication Tool) was identified during the three project workshops as a system that could be used by SEE-MHEWS-A. MeteoAlarm is a joint initiative of the Members of EUMETNET managed by ZAMG on behalf of the contributing NMHSs called the MeteoAlarm partners. Ten NHMSs of SEE are already MeteoAlarm partners. An agreement with EUMETNET and ZAMG will be needed.

d) HYDRO:

- This module will provide outputs from at least two regional hydrological models, such as EFAS and E-HYPE, and potentially HYPROM.
- The scope of products will be defined by TT-Mod.
- To access products from this catalogue, see WEB Services below.

e) MARINE:

- This module will provide outputs from the regional marine/oceanographic models

provided by CMCC.

- The scope of products will be defined by TT-Mod.
- To access products from this catalogue, see WEB Services below.

f) MET:

- This module will provide outputs from the nested HR LAM models, such as ALADIN, COSMO-EU/ICON-EU, NMM-B, and potentially UK Met Office high resolution model.
- The scope of products will be defined by TT-Mod.
- Inputs to the regional hydrological and marine/oceanographic models will be defined by TT-Mod.
- Initial fields and boundary conditions for LAM models operated at national level will be also available.
- To access products from this catalogue, see WEB Services below.

g) NOWCASTING:

- Early warning advisory for the first 6 (up to 12) hours will heavily rely on the nowcasting products. Therefore, participants of the three project workshops requested to implement the nowcasting capability in the SEE-MHEWS-A system. One such a system proposed is the Integrated Nowcasting through Comprehensive Analysis (INCA), developed by ZAMG. ZAMG is willing to provide support on implementing INCA system; however, an agreement with ZAMG shall be needed. In case, it would not be possible to build on INCA other solutions should be explored.
- Slovak Hydrometeorological Institute (SHMI) adapted INCA for use in the Central European region and could potentially adapt INCA also to the SEE region, this again would require an agreement with SHMI.
- INCA system may be implemented in the CIP itself or could be operated by one of the PPs or contributing stakeholders; ZAMG and SHMI could be in a position to operate INCA also for SEE-MHEWS-A. In such a case, operational and maintenance cost should be negotiated.
- In addition, several nowcasting products were offered by ESSL at the Forecasters Workshop in Skopje and those could be made available. Agreement with ESSL will be needed.
- To access products from this catalogue, see WEB Services below.

h) VERIFICATION:

- Model verification and validation are essential parts of the model development process so that models' outputs can be accepted and used to support early warning decision making within SEE-MHEWS-A.
- Results of the models' verification shall be provided by the respective NWP consortia in collaboration with TT-Mod.
- Procedures for models' verification will be defined by TT-Mod.
- Agreements with the NWP consortia will be needed.

i) WARNINGS:

- This module serves harmonization of warnings and awareness reports within the SEE region, especially across the borders.
- Existing MeteoAlarm (Public Awareness Tool) was identified during the project workshops as a tool that should be used to exchange warnings and avoiding discontinuities in issuing warnings across borders.
- MeteoAlarm is a joint initiative of the Members of EUMETNET managed by ZAMG on behalf of the MeteoAlarm partners. Ten NHMSs of SEE are already MeteoAlarm partners. An agreement with EUMETNET and ZAMG will be needed.

j) WEB SERVICES & TOOLS:

- Web services will support all above CIP modules, through various tools, such as for

dissemination, data handling, processing and visualisation. These should be based on Open Geospatial Consortium (OGC) standards using the recommendations of its MetOcean Domain Working Group (MetOcean DWG) and the project should provide feedback to the MetOcean DWG on the usefulness of their recommendations.

- This module should provide static, on-demand, interactive graphical products, as well as dynamic graphical products and visualisation to integrate and display observations, remote sensing data, post-processed data and products, and models' outputs.
- ECMWF offered several ECMWF Web services and other tools for use by SEE-MHEWS-A, such as MARS, ecCharts, ecFlow, ecCodes, Magics, and Metview; again, an agreement will be needed with ECMWF.
- Hungarian Meteorological Service offered its workstation HAWK for the visualisation purposes, based on the agreement. Project workshops' participants also requested to look at widely used products from commercial providers.
- SEE-MHEWS-A products should be stored in, and accessible from CIP through an archival and retrieval system such as MARS using a single interface. Products should be registered in the WIS catalogue, and accessible through interactive Web and machine-to-machine interfaces, for both routine dissemination and ad-hoc requests. Technologies such as Web catalogue and ecCharts, as well as commercially available systems using secure communication means such as, secure Internet & FTP, EUMETCast (satellite and terrestrial), GTS/WIS/RMDCN (Interoute) and also cloud services could be explored (note that WIS 2.0 is likely to provide cloud services).
- Potential PPs currently use a mixture of communication means, see Appendix 4. This will determine the scope and type of data and products generated by the advisory system that could be accessible by PPs and way how they can interact with the CIP. For example, visualisation at CIP will not be possible for low speed connections. For low speed connection, e.g. 1 Mbit/s, it might take about 12 hours to download 5 GB of data and products, while for high speed connections, e.g. 200 Mbit/s, it might take about 5 minutes. Visualisation on PP site would also not be possible for low speed connection. Therefore, capacity development activities should be looked at from the beginning to support PPs with the low speed connections.
- TT-ICT will define the optimal communication infrastructure and architecture for the project essential modules, as well as connection configuration with the PPs. TT-ICT should take into account various aspects of the communication systems, such as (i) reliability, (ii) performance, (iii) interactivity, (iv) scalability, and (v) cost effectiveness.
- EUMETCast would be a cost-effective means of disseminating model outputs as well as all data and post-processed products not only to those PPs that do not have sufficient telecommunication capabilities. Several PPs have already EUMETCast receiving system in place that would need an upgrade and some more could be purchased under this project. The new receiving station, including 1.8 m antenna and basic visualisation software may cost some 20 kEuro. As EUMETCast is a one-way system, it cannot allow interactive access to products available at CIP. Therefore, the receiving systems should be equipped with the visualisation software. For data generated by SEE-MHEWS-A System of about 10 Gb/day and the delivery time 6 hours, the yearly cost would be 24 kEuro/year, for 1 hour delivery it would cost 150 kEuro/year. In case of a need to distribute higher amount of data and products, a dissemination strategy may lower the yearly cost, e.g., different reception time by individual NMHSs or selection of products to be distributed via several communication means, e.g., via EUMETCast, RMDCN and internet;
- Based on the proposal of TT-ICT, several agreements will be needed, such as with ECMWF, EUMETSAT, and Internet providers (e.g., Interoute, CloudSigma, etc.).
- Several tools and software packages for post-processing on national levels should be provided through CIP.

Optimally CIP should be operated within the ECMWF environment and linked to contributing stakeholders/providers who could operate some of its modules (e.g. MeteoAlarm and

nowcasting by ZAMG, nowcasting by ESSL, SAF by EUMETSAT, OPERA by EUMETNET, etc.). Agreements should be made with the potential hosts of CIP and hosts of its individual modules.

As requested during the project workshops, design of CIP should be done by the project technical teams led by the TT-ICT, followed by a technical specification to be approved by PAG. Based on the design of CIP its technical specification, appropriate CIP host should be identified and agreement signed by PSC. TT-ICT will be responsible for technical specifications of tools to be used for visualisation, dissemination, archival, retrieval and other important functionalities of the system, including software needed for operation of the essential ICT modules, their acquisition and implementing on CIP. Finally, TT-ICT should define communication infrastructure of the system, prepare technical specification, acquire and implement it.

5. Implementation

5.1 Activities, Deliverables, Milestones, Cost and Risks

Goal of SEE-MHEWS-A is to become operational by mid-2023. Table 4.1 presents the key implementation activities that are required for SEE-MHEWS-A implementation within the timeframe 2018 – 2022. The table is arranged to correspond to the activity areas presented in Section 3. In the table, each implementation activity is presented along with its associated deliverables, timelines, responsibilities, costs and associated risk. This table is the core of the implementation plan and will be regularly reviewed and updated.

For each activity in Table 4.1, a detailed activity plan will be developed by the responsible entity or entities, with support of the SEE-MHEWS-A project office and guidance from PSC and PAG. The project office has responsibility for tracking execution of these activities and this plan itself.

Breakdown of the estimated costs is presented in Table 4.2, using five major expenditure groups: (a) meetings, (b) missions costs, (c) consultants and staff costs, (d) contracts with external providers, (e) capital investment/software/licences, and (f) capacity development. For meetings and missions, the cost was calculated using a daily subsistence allowance (DSA) of 250 CHF. For consultants, a monthly premium of 7 kCHF was used, while for external contracts 12 kCHF was used. Cost of the capital investment, software and licences uses loose estimation, while for capacity development, at this stage, information from PPs is used.

6. Capacity Development and Implementation Requirements by Project Participants needed to fully benefit from the Advisory System

There exist considerable differences in basic systems (observations, data processing and communication) and knowledge within the SEE region that will be addressed through this project. Some advanced services, especially those that are members of NWP Consortia, have access to global NWP model outputs, operates their versions of meteorological and/or hydrological and/or marine/oceanographic models on site, while some others have only limited information via their low speed internet connections and some countries are even not covered by the HR models operated in the region.

There will be a provision in the project to support major capacity development and training activities that will be found indispensable for some project participants to benefit from the advisory system. An agreement on the capacity development and training addressing major gaps and required training will be concluded and adopted by PSC. The most critical activities should be funded through this project, while for the rest an effort will be made to identify potential donors.

Potential project participants were requested to identify their capacity development and

implementation requirements that would be needed to fully benefit from the SEE-MHEWS-A system, which are included in Table 5.1. Project technical team on capacity development (TT-CD) will assess capacity development needs of the project participants and will prepare a capacity development and training programme.

An agreement on the capacity development and training programme addressing existing gaps vis-à-vis the envisaged advisory system should be concluded based on which, the required funding and twinnings will be sought out to assist the PPs.

7. Resources

US Agency for International Development (USAID) funded the Phase I SEE-MHEWS-A project. The implementation plan that is the major deliverable of the Phase I of the project will be submitted to funding agencies, such as EU, World Bank, Green Fund, UN Agencies, as well as other international donors for project implementation and initial operation over a couple of years. Intensive resource mobilisation will be done in the second half of 2017, however this would be a continuing activity throughout the life of the project.

To speed-up the implementation of SEE-MHEWS-A project, the World Bank is currently considering to initially support some critical project activities serving as testing ground of the project.

In parallel, the European Commission Directorate-General for International Cooperation and Development (DG DEVCO, Europe Aid) is supporting the project PRO NEWS: Programme for Improving National Early Warning System and flood prevention in Albania (Grant Contract: EuropeAid/151-248/DD/ACT/AL, Contract number: 2016/382-775, total eligible cost: 2.28 mil EUR).

The operation and maintenance of the advisory system during the project implementation will be done through the project funding. However, starting from the beginning of the project operational phase, the operation the system and maintenance of the project infrastructure shall be done according to an agreement to be made by project participants.

Starting from the implementation of the advisory system, the project participants shall be responsible for their own communication means connecting them to the project core ICT infrastructure in a compatible way. The optimal communication means will be suggested by TT-ICT so that project participants can fully benefit from the project at a reasonable cost.

It is estimated that the cost of development and implementation of the system could be of approximately 21 million CHF.

8. Risks and Mitigation

Project management will follow the WMO Risk Management Policy that focuses on strategic, operational, financial, governance and compliance risks, which are reviewed regularly to update the risk registers. Risk management at WMO is implemented as an integral part of systems of internal control and Results-based Management (RBM). The implementation of the Policy is facilitated through: (i) an Audit Committee; (ii) a Secretariat Risk Management Committee; (iii) WMO internal audit division; and (iv) external audits performed annually by independent third party who makes recommendations for measures required to mitigate identified risks. These are in turn addressed by the Audit Committee and the WMO Secretary-General to ensure compliance to the Policy. WMO is governed by United Nations financial practices and procedures and is audited annually by external auditors.

Risk management is an ongoing process that must be pursued consistently, systematically and on an ongoing basis. Project Manager and Project Steering Committee are responsible to monitor and address all risks associated with the project throughout its lifecycle.

Table 4.1 is the core of the implementation plan and will serve for continuous monitoring and

evaluation of the project performance, mainly: the activities, deliverables, timeline, responsibility and resources available for implementation. In this table, potential risks take into account dependencies between individual implementation activities. For example, if activity “B” depends on activity “A” and activity A is not implemented in time, this presents a risk that must be addressed. The target date for implementation would then be marked “red” as overdue, thus serving also as a risk log. In table 4.1, column named “potential risks/dependencies, the major dependent activities are included. This table is a living document, as well as the whole IP, and will be updated and revised annually, or as appropriate, following Project Steering Committee meetings.

Overall, the anticipated risks can be categorized into three major categories, (a) development risks, (b) financial risks, and (c) operational risks. Among the risks, two areas may be highlighted, including:

- Regional commitments and institutional risks:

Regional cooperation projects in the SEE region are more challenging due to the political and economic situation. There is also a risk that stakeholders’ commitment may be weaker than initially claimed. For example, there is a risk that a PP or a contributing stakeholder could unilaterally decide to limit or stop participation in the project or will stop information sharing. However, steps will be taken to reduce this risk. Along with ongoing efforts leading up to the design of the project, several agreements and MoU will be formed among the PPs and collaborating stakeholders to support development, implementation and operation of the SEE-MHEWS-A.

- Performance and project management risks:

Among contributing risks are potentially unclear roles and responsibilities of different stakeholders at different levels. Certain aspects of the project, such as those pertaining to achieving regional agreements for data sharing could depend on interests and political issues in the SEE region. In this respect, the project has been designed to facilitate this discussion towards reaching these agreements through systematic consultations with all stakeholders. Throughout the project, through the PSC, PO will work very closely with the donor agencies and ensure that project activities, progress, successes and lessons learned are communicated regularly to the various project management structures, PPs and contributing stakeholders.

Table 4.1: SEE-MHEWS-A Implementation Activities

- Activities in bold are considered the most critical for SEE-MHEWS-A to be implemented by mid-2023.
- Depending on the implementation scale, planned activities are specified as follows: **R** = Regional activity and **N** = National activity.
- FTE: Full-Time Equivalent (FTE) Employee. These resources will be provided by Project Participants (PPs) and consultants. PPs' work cost is not included in the project estimated costs.
- Breakdown of the estimated cost is in Table 4.2
- RR: required Resources, AR: Available resources, δ : Shortfall.
- Evaluation of Progress: **Completed**; **On-Track**; **Overdue** indicated in the column for "Target Date for Completion".

No.	Activity	Deliverables	Target Date / Period for implement.	Responsibility	FTE per month	Estimated Costs (k CHF)			Potential Risks and Dependencies
						RR	AR	δ	
3.1. Management of SEE-MHEWS-A Implementation									
3.1.1 R	Establish the provisional Project Steering Committee (PSC)	Provisional PSC established	12/2017	SEE-MHEWS-A project participants	-	0			Importance of the project to potential PPs
3.1.2 R	Confirm the SEE-MHEWS-A Implementation Plan (IP) and express the intention to collaborate on the project	SEE-MHEWS-A confirmed	06/2017	PSC	-	0			Regional collaboration, availability of resources
3.1.3 R	PSC to agree to implement SEE-MHEWS-A according to the agreed IP	MoU (or Agreement) adopted	12/2017	PSC	-	0			3.1.1, 3.1.2
3.1.4 R	Establish Project Advisory Group (PAG)	PAG established	02/2018	PSC, (ROE)	-	0			3.1.1, 3.1.2, 3.1.3
3.1.5 R	Establish WMO Secretariat Internal Coordination and Oversight Mechanism	Secretariat Internal Coordination and Oversight Team established	12/2017	ASG (ROE)	-	0			3.1.1, 3.1.2, 3.1.3
3.1.6 R	Establish Technical Teams (TTs), as appropriate	TTs established	12/2017 - 02/2018	PSC	-	0			3.1.1, 3.1.2, 3.1.3
3.1.7 R	Identify contributing stakeholders to support implementation of SEE-MHEWS-A according to IP	MoU (or Agreement) signed by contributing stakeholders	12/2017 - 02/2018	PSC, ROE	-	0			3.1.1, 3.1.2, 3.1.3
3.1.8	Identify resources for the project	Resources available for	08/2017 -	PO, ROE	-	0			3.1.1, 3.1.2,

R	implementation	project implementation	12/2017 (will continue till the end of project)						3.1.3, positive response from donors
3.1.9 R	Establishment and operation of WMO Project Office (PO)	PO established and operational	08/2017 - 01/2018 (operational until end of the project)	ROE	-	2,050			3.1.1, 3.1.2, 3.1.3, 3.1.8
3.1.10 R	Oversee the project implementation and regularly update IP, as appropriate	IP updated at PSC meetings	Yearly, or as appropriate	PSC (PAG, PO)	-	0			3.1.1, 3.1.2, 3.1.3, 3.1.6, 3.1.8
3.1.11 R	Develop testing procedures, including a test protocol for the pre-operational test of the System	Test protocol developed	02/2022 - 11/2022	PAG, (all TTs, PO)	3	39			3.1.6, 3.1.8
3.1.12 R	Perform the pre-operational test of the system and adopt a protocol to declare implementation was successfully completed	Test successfully completed, Protocol adopted and system put into operation	01/2023 - 06/2023	PSC & PO, (all TTs, PPs, PAG)	6	77			3.1.11
3.2. Sub-Regional and RA VI Collaboration									
3.2.1 R	Develop and agree on data policy defining responsibility of the project participants regarding data to be provided by them to CODB and conditions on use of data and products available to them via CIP	Agreement developed, adopted and dissemination of data initiated	10/2017 - 06/2018	PSC, PO, ROE (PAG, PPs)	1	19			3.4.2
3.2.2 R	Propose inclusion of SEE-MHEWS-A into RA VI Operational Plan	Inclusion of SEE-MHEWS-A in the RA VI Operational Plan	02/2018	ROE	0.2	0			3.1.3, Outcome of RA VI Session
3.2.3 R	Develop an agreement with contributing stakeholders regarding responsibilities for the development and implementation of the advisory system and its components	Agreement developed and adopted	04/2018 - 11/2018	PSC, PO, ROE (PAG, all TTs)	2	56			3.1.3, 3.2.2, 3.1.6
3.2.4 R	Develop an agreement with contributing stakeholders regarding	Agreement developed and adopted	11/2019 - 07/2020	PSC, PO, ROE (PAG, all TTs)	2	56			3.1.3, 3.1.6, 3.2.2, 3.2.3

	responsibilities for the operation and maintenance of the advisory system and its components								
3.2.5 R	Prepare capacity development and training programme addressing existing gaps vis-à-vis the envisaged advisory system. Develop agreements to implement the capacity building activities	Agreements, including the detailed programme, adopted and defined capacity development activities implemented	05/2018 - 11/2019 (capacity building throughout the project)	PSC & PO (PAG, all TTs, contributing stakeholders)	3	1,037			3.1.3, 3.4.1, 3.5.9, 3.6.1, proposals from PPs
3.2.6 R	Draft a research and development plan for continuing collaboration in the scientific undertakings relevant to improving operation of the SEE-MHEWS-A system	Research and development plan developed and adopted	06/2019 - 01/2022	PSC based on proposal from TT-Sci	10	56			
3.3. Collaboration with other relevant projects									
3.3.1 R	Seek approval from RA VI for implementation of SWFDP tailored for SEE	Implementation approved by RA VI	02/2018	DPFS, ROE	0.2	0			Outcome of RA VI Session
3.3.2 R	Identify resources for implementation of SWFDP tailored for SEE	Resources identified and made available for SWFDP-SEE implementation	12/2017 – 03/2018	DPFS, PO, ROE	0.2	0			3.1.3; 3.1.8, 3.2.2
3.3.3 R	Implementation of tailored SWFDP-SEE priority tasks (to be defined)	Synergy between SWFDP-SEE and SEE-MHEWS-A	06/2018 – 07/2020	DPFS	12	350			3.3.1, 3.3.2
3.3.4	Expansion of the current FFG system to include Cyprus, Greece and Hungary	Establishment of backup Regional Centre, establishment of a FFGS based on existing LAM in Cyprus, Greece and Hungary, urban FFGS for four cities, landslide susceptibility mapping for all participating countries, inclusion of radar precipitation,	06/2018 - 07/2020	HWR	24	3,242			3.1.3, 3.1.8, 3.4.1, 3.4.10, 3.4.11

		enhancement of hydrometeorological network, catchment relationship, and training							
3.3.5	Establishment a stand-alone FFGS for Ukraine	Stand-alone Ukraine FFGS, including riverine routing, enhancement of hydrometeorological network, catchment relations, and training	06/2018 - 07/2020	HWR		990			3.1.3, 3.1.8, 3.4.1, 3.4.10, 3.4.11
3.3.6	Conduct workshops, in coordination with DPFS and PWS, on the roles of (a) observations, (b) forecasting and modelling, and (c) information and communication to DRR	Workshops conducted	08/2018 - 10/2020	DRR, ROE	8	74			3.2.4
3.4 Observations									
3.4.1 R, N	Compile an inventory, using the OSCAR/surface tool, of the capabilities of the SEE observing systems. Provide recommendations to fill identified gaps and for further strengthening of the observing systems including pilot projects	Inventory compiled, gaps identified, actions to fill them and further strengthening recommended	2/2018 - 12/2018	TT-Obs & WIGOS, (PO)	R: 3 N: 2	37			Availability of national and WIGOS resources
3.4.2 R	Define the scope of data, including the temporal and spatial resolutions, data formats and data volumes, that shall be provided by PPs into a CODB	Scope of data to be exchanged, including their formats developed and agreed upon by PSG	02/2018 - 07/2018	PSG & TT-Obs, with help from working structure supporting RRR	2	37			3.2.1, 3.4.1, 3.4.7, 3.4.8, 3.4.10, 3.4.11
3.4.3 R	Analyse the required ECMWF HPCF resources that would be needed to operate CODB in ECMWF. Develop a technical specification for CODB	Analysis showing required HPCF resources to operate CODB in ECMWF and developed technical specification for CODB	05/2018 - 07/2018	TT-ICT, (TT-Obs, PAG, ECMWF)	1	40			3.4.2, ECMWF agreement
3.4.4 R	Verify whether five full-member states of ECMWF from SEE would	Agreement signed with the five full-member	07/2018	TT-ICT, (PAG, ROE,	0.5	0			Readiness of the five full-

	agree to use part of their HPCF allocations for the purpose of the advisory system and define how much HPCF resources they could offer for the project	states of ECMWF MS from SEE on use of their HPCF allocation for the advisory system		five full-member states of ECMWF from SEE)					member states of ECMWF from SEE to offer part of their HPCF allocations for the project
3.4.5 R	Identify a host(s) of CODB and prepare an agreement with the host(s) for CODB operations and maintenance	Agreement on CODB operations and maintenance signed with CODB host(s)	02/2018 - 12/2018	TT-ICT, ROE, PSC (TT-Obs, PAG)	1	37			Readiness of ECMWF or other potential host(s) to operate CODB
3.4.6 R	In cooperation with the host(s) of CODB identify and acquire ICT infrastructure, software and licenses	Infrastructure and software required by host(s) of the CODB identified and acquired	04/2019 - 10/2019	TT-ICT, (TT-Obs, PAG, host of CODB)	4	387			3.5.5, 3.5.6, 3.5.7, 3.6.1, 3.6.2
3.4.7 R	Define data and products of EUMETNET Observations Programme needed for the project purposes and make an agreement with EUMETNET to use them for the project	Agreement with EUMETNET signed including definition of data and products	05/2019 - 10/2019	PSC, EUMETNET, (TT-Obs, PAG)	1	19			Readiness of EUMETNET to support the Project
3.4.8 R	Define observational products of EUMETSAT needed for the project purposes and make an agreement with EUMETSAT to use them for the project	Agreement with EUMETSAT signed including definition of data and products	06/2019 - 11/2019	PSC & EUMETSAT, (TT-Obs, PAG)	1	19			Readiness of EUMETSAT to support the project
3.4.9 R	In cooperation with the host(s) of CODB implement acquired infrastructure and software	Infrastructure and software implemented, CODB pre-operational	09/2019 - 08/2020	TT-ICT & host of CODB, (PAG)	1	59			3.4.6
3.4.10 R, N	Identify host and establish the second weather radar centre for SEE countries and their radars not covered by OPERA. Define data and products that would be needed for nowcasting purposes, including for hydrological models	Weather radar centre established as proposed by PSC, processed data ready for CODB, hydrological models and nowcasting purposes	09/2019 - 11/2020	TT-Obs & WIGOS-PO & host of the Centre, PSC (TT-ICT, PAG)	R: 3 N: 12	187			Readiness to host the centre and availability of national resources; 3.4.10

3.4.11 N	Produce, where not existing, and collect available gridded historical precipitation and temperature observations over 10 to 30 years for calibration of hydrological models (projects similar to CARPATCLIM)	Gridded data provided to CODB and available for calibration of the regional hydrological models for selected river catchments	10/2018 - 01/2020	PPs, (TT-Mod)	10	51121			3.2.1, 3.5.3; inadequate national data policies
3.5 Forecasting and Modelling									
3.5.1 R	Identify global NWP models for the purposes of the advisory system and make an agreement with the respective consortia on their use for the project	Global NWP for SEE-MHEWS-A identified. Agreement signed with the respective NWP consortia to provide lateral boundary conditions to nested LAM models	01/2018 - 04/2018	PSC & Consortia, (TT-Mod, PO, PAG)	0.5	16			Policy of the identified NWP Consortia
3.5.2 R	Identify high resolution NWP LAM models for the purposes of the advisory system and make an agreement with the respective consortia on their use for the project, agree on licences	NWP LAM models for SEE-MHEWS-A identified. Agreement signed with the respective NWP consortia to implement high resolution LAMs in the identified HPCF	02/2018 - 07/2018	PSC & Consortia, (TT-Mod, PO, PAG)	1	97			Policy of the identified NWP Consortia
3.5.3 R	Identify regional hydrological models for the purposes of the advisory system and make an agreement with the respective consortia/owners on use of their models for SEE-MHEWS-A, agree on licences	Regional hydrological models for SEE-MHEWS-A identified. Agreement signed with the respective consortia/owners to implement defined models in the identified computing facility	03/2018 - 07/2018	PSC & Consortia / owners, (TT-Mod, PO, PAG)	0.5	59			Policy of the identified Consortia/owner
3.5.4 R	Identify regional marine/oceanographic models for the purposes of the advisory system and make an agreement	Marine/oceanographic models for SEE-MHEWS-A identified. Agreement signed with	03/2018 - 07/2018	PSC & Consortia, (TT-Mod, PO, PAG)	0.5	49			Policy of the identified NWP Consortia/owner

	with the respective consortia/owners on use of their models for SEE-MHEWS-A, agree on licences	the respective consortia/owners to implement defined models in the identified computing facility							
3.5.5 R	Identify sand and dust forecasting model(s) for the purposes of the advisory system and make an agreement with the respective consortia/owners on use of their models for SEE-MHEWS-A, agree on licences	Sand and dust forecasting model(s) for SEE-MHEWS-A identified. Agreement signed with the respective consortia/owners to implement defined models in the identified computing facility	03/2018 - 07/2018	PSC & Consortia, (TT-Mod, PO, PAG)	0.5	49			Policy of the identified NWP Consortia/owner
3.5.6 R	Develop a feasibility study and identify host(s) that could provide their computing facility to operate high-resolution LAM models for the purposes of the advisory system, including requirements for additional HPC resources	Feasibility study developed. Based on the feasibility study the host(s) is(are) identified and agreement(s) signed with the host(s) for operation of LAMs	07/2018 - 04/2019	PSC & host, (TT-Mod, TT-ICT, PO, PAG)	5	72			3.1.6, 3.5.2
3.5.7 R	Develop a feasibility study and identify host(s) that could provide their computing facility to operate regional hydrological models for the purposes of the advisory system, including requirements for additional HPC resources	Feasibility study developed. Based on the feasibility study the host(s) is(are) identified and agreement(s) signed to host operation of the hydro model(s)	08/2018 - 05/2019	PSC & host, (TT-Mod, TT-ICT, PO, PAG)	3	40			3.1.6, 3.5.3,
3.5.8 R	Develop a feasibility study and identify host(s) that could provide their computing facility to operate regional marine (oceanographic) models for the purposes of the advisory system	Feasibility study developed. Based on the feasibility study the host(s) is(are) identified and agreement(s) signed to host operation of the marine model(s)	09/2018 - 06/2019	PSC & host, (TT-Mod, TT-ICT, PO, PAG)	1	40			3.1.6, 3.5.4
3.5.9 R	Identify met/hydro/marine (oceanographic) models that could	Met/hydro/marine (oceanographic) models	01/2019 - 10/2019	PAG, (TT-Mod,	2	19			Knowledge on models' use and

	be used by project participants on national levels within the advisory system	identified by the project participants		TT-ICT)					implementation, resources
3.5.10 N	Develop technical specifications of the suite of coupled met/hydro/marine prediction models	Technical specification developed and agreed by PAG	04/2019 - 05/2020	TT-Mod & TT-ICT, (PAG)	6	98			3.5.1, 3.5.2, 3.5.3, 3.5.4, 3.5.5, 3.5.6, 3.5.7, 3.5.8
3.5.11 N	Implement the sand and dust operational forecasting for selected sub-domains in SEE (e.g. Middle East)	Operational sand and dust forecasting for selected sub-domains in SEE implemented	08/2019 - 08/2020	TT-Mod, TT-ICT & host of the operational activities, (PO, PAG)	18	639			3.1.6, 3.5.5
3.5.12 N	Acquire identified met/hydro/marine (oceanographic) models for national purposes and implement them at the national computing facility of PPs	Met/hydro/marine (oceanographic) models acquired and implemented locally by the Project Participants	07/2019 - 02/2021	PPs, (TT-Mod, TT-ICT)	20	70			Local knowledge, legislations, & funding
3.5.13 R	Implement the suite of coupled met/hydro/marine prediction models in the computing facilities of the identified host(s): (a) nested high-resolution LAM models; including purchase of additional HPC resources if required by the host	High-resolution LAM prediction models implemented, including purchase of additional HPC resources, as appropriate	08/2020 - 05/2022	TT-Mod, TT-ICT & host of the operational activities, (PO, PAG)	18	2,831			3.1.6, 3.5.6, 3.5.10
3.5.14 R	Implement the suite of coupled met/hydro/marine prediction models in the computing facilities of the identified host(s): (b) regional hydrological models; including purchase of additional HPC resources if required by the host	Regional hydrological models implemented	08/2020 - 05/2022	TT-Mod, TT-ICT & host of the operational activities, (PO, PAG)	18	1,139			3.1.6, 3.5.7, 3.5.10
3.5.15 R	Implement the suite of coupled met/hydro/marine prediction models in the computing facilities of the identified host(s): (c) regional marine/oceanographic models	Regional marine/oceanographic models implemented	08/2020 - 05/2022	TT-Mod, TT-ICT & host of the operational activities, (PO, PAG)	18	639			3.1.6, 3.5.8, 3.5.10

3.6 Information and Communication									
3.6.1 R	Develop a design of CIP, including technical specifications	Design of CIP developed and technical specification recommended by PAG	01/2018 - 05/2019	TT-ICT in collaboration with all TTs	6	98			all 3.4.x, all 3.5.x
3.6.2 R	Define the scope of advisory system's products (data, models' output, post-processing products, etc.), including their formats and respective volumes, that shall be made available to project participants via CIP (link to CODB)	The scope of products developed and agreed by PAG	09/2018 - 05/2019	TT-Mod & TT-PP, (TT-ICT, PAG)	3	37		0	3.2.1, 3.4.2
3.6.3 R	Prepare analysis for assimilation to be used for high-resolution nested LAM models, coordinate with identified partners for data assimilation (e.g. Hans Ertel Centre (DWD))	Analysis ready, including a roadmap for implementation	04/2018 - 10/2019	TT-Mod, (PAG)	3	40			3.5.2
3.6.4 R	Identify host of CIP, including required infrastructure, and make an agreement for operation and maintenance	Host of CIP and infrastructure identified and agreement signed	08/2019 - 03/2020	PSC, (TT-ICT, PAG)	2	40			3.6.1, Readiness to host CIP
3.6.5 R	Coordinate with EUMETNET (ZAMG) the use of MeteoAlarm for cross-border communication between forecasters and for exchange of warnings and implement it or explore other solution with FMI	Agreement signed with EUMETNET (ZAMG), MeteoAlarm ready for use by SEE-MHEWS-A or other solution proposed	08/2019 - 03/2020	PSC & ZAMG, (TT-PP, PAG)	1	27			3.6.1, 3.6.4, Readiness of EUMETNET (ZAMG) to offer MeteoAlarm to SEE
3.6.6 R	Coordinate with ZAMG and SHMI the use of INCA as nowcasting tool for SEE-MHEWS-A, and/or prepare analysis for an alternative solution	Agreement signed with ZAMG and SHMI, and/or alternative solution is identified	08/2019 - 03/2020	PSC & ZAMG, (TT-PP, PAG)	1	27			3.6.1, 3.6.4, Readiness of ZAMG/SHMI to offer INCA to the project
3.6.7 R	Identify tool(s) to be used for visualisation of data and products on CIP and prepare technical	Tools identified and technical specifications developed	08/2019 - 03/2021	TT-ICT & TT-Mod, (PAG)	1	19			3.6.1, 3.6.4

	specifications								
3.6.8 N	Identify tool(s) to be used for visualisation of data and products on PPs' site and prepare technical specifications	Tools identified and technical specifications developed	08/2019 - 03/2020	PPs, (TT-ICT)	1	19			3.6.1, 3.6.4
3.6.9 R	Identify tools to support dissemination, archival and retrieval functionality of the system and prepare technical specifications	Tools identified and technical specifications developed	08/2019 - 03/2020	TT-ICT, (PAG, host of operational activities)	1	19			3.6.1, 3.6.4
3.6.10 R	Coordinate with ECMWF (use of SAPP) and/or RC-LACE (use of OPLACE) pre-processing of data for assimilation, or prepare analysis for an alternative solution	Agreement with ECMWF or RC-LACE for the pre-processing of data for assimilation signed, or other solution identified	12/2019 - 08/2020	PSC & ECMWF or RC-LACE, (TT-Mod, TT-PP, PAG)	2	112			3.5.2, 3.5.5
3.6.11 R	Coordinate with ZAMG and SHMI the application/adaptation of INCA for SEE region	Agreement signed with ZAMG and SHMI, INCA adapted to SEE	03/2020 – 03/2021	PSC & ZAMG and SHMI, (TT-PP, PAG)	3	91			3.6.1, 3.6.6, Readiness of ZAMG/SHMI to adapt INCA to SEE
3.6.12 R	Collaborate with identified contributing stakeholders in data assimilation (e.g. Hans Ertel Centre (DWD), RC-LACE) in the development of seamless data assimilation for coupled atmospheric-ocean system	Agreement signed with identified contributing stakeholder(s), data assimilation scheme developed and ready for implementation	12/2019 – 10/2021	PSC & DWD, (TT-Mod, PAG)	2	144			3.5.2, 3.6.3,
3.6.13 R	Coordinate with NWP Consortia development of high-resolution models' verification tool(s)	Agreement signed and verification tool(s) developed	03/2020 - 12/2021	PSC & Consortia, (TT-Mod, PAG)	6	82			3.5.2, 3.5.5
3.6.14 R	Identify host of INCA, negotiate respective implementation, operational and maintenance costs, and implement INCA for SEE	Host identified, contract signed and INCA implemented	01/2021 - 03/2022	PSC & host of INCA, (TT-PP, PAG)	6	290			3.6.1, 3.6.4, 3.6.6, Readiness to host INCA
3.6.15 R	Acquire identified tool(s) for visualisation of data and products	Tool(s) implemented	10/2020 - 01/2022	TT-ICT & TT-Mod,	6	412			Cost depends on 3.6.7 and

	and implement it			(PAG)					could be lower or higher
3.6.16 N	Acquire identified tool(s) for visualisation of data and products for national purposes and implement it on national levels	Tool(s) implemented	11/2020 - 02/2022	PPs, (TT-ICT)	6	571			3.6.1, 3.6.7, availability of funding on PPs level
3.6.17 R	Acquire identified tools to support dissemination, archival and retrieval functionality of the system and implement them	Tools implemented	10/2020 - 04/2022	TT-ICT, (PAG)	6	412			Cost depends on 3.6.1, 3.6.4 and could be lower or higher
3.6.18 R, N	Define communication infrastructure (architecture) of the whole system, including technical specifications, acquire and implement it (this should include choosing which of the available interface standards will be used)	Communication infrastructure defined and implemented according to technical specification	10/2020 - 06/2022	TT-ICT, (TT-Mod, PAG)	6	3,071			3.4.5, 3.4.9, 3.6.1, 3.6.4, 3.6.5, 3.6.6, 3.6.14,
3.6.19 R	Define necessary software for operations of the essential project ICT modules (CODB, Suite of models and CIP), acquire and implement it	Software defined, acquired and implemented	01/2021 - 07/2022	TT-ICT, (TT-Mod, TT-PP, PAG)	5	218			3.4.6, 3.5.9, 3.6.1,
3.6.20 R	Implement CIP	CIP pre-operational by end-2022	01/2021 - 08/2022	TT-ICT, (all TTs, PAG)	12	238			3.6.1, 3.6.4
3.6.21 R	Implement data assimilation for high-resolution nested LAM models	Data assimilation implemented	01/2022 - 09/2022	TT-PP, (TT-ICT, PAG)	24	166			3.6.1, 3.6.3, 3.6.10
3.6.22 R	Verify the functionality of the advisory system components	SEE-MHEWS ready for testing	07/2020 - 11/2022	All TTs, PPs, PO, PAG	5	71			All above
	Operational costs until mid-2023					300			

Table 4.2: Breakdown of the Project Estimated Costs

No.	Implementation activity	A	B	C	D	E	F	G
		Mtgs	Mission s	Consult. & staff	Contract s	Invest. /SW /licenses	Cap. Dev.	Total (kCHF)
3.1. Management of SEE-MHEWS-A Implementation								
3.1.1	Establish the provisional Project Steering Committee (PSC)							0
3.1.2	Confirm the SEE-MHEWS-A Implementation Plan (IP) and express the intention to collaborate on the project							0
3.1.3	PSC to agree to implement SEE-MHEWS-A according to the agreed IP							0
3.1.4	Establish Project Advisory Group (PAG)							0
3.1.5	Establish WMO Secretariat Internal Coordination and Oversight Mechanism							0
3.1.6	Establish Technical Teams (TTs), as appropriate							0
3.1.7	Identify contributing stakeholders to support implementation of SEE-MHEWS-A according to IP							0
3.1.8	Identify resources for the project implementation							0
3.1.9	Establishment and operation of WMO Project Office (PO)			2,050				2,050
3.1.10	Oversee the project implementation and regularly update IP, as appropriate							0
3.1.11	Develop testing procedures, including a test protocol for the pre-operational test of the system	39						39
3.1.12	Perform the pre-operational test of the system and adopt a protocol to declare implementation was successfully completed	56		21				77
3.2. Sub-Regional and RA VI Collaboration								
3.2.1	Develop and agree on data policy defining responsibility of the project participants regarding data to be provided by them to CODB and conditions on use of data and products available to them via CIP	19						19
3.2.2	Propose inclusion of SEE-MHEWS-A into RA VI Operational Plan							0
3.2.3	Develop an agreement with contributing stakeholders regarding responsibilities for the development and implementation of the advisory system and its components	56						56

3.2.4	Develop an agreement with contributing stakeholders regarding responsibilities for the operation and maintenance of the advisory system and its components	56						56
3.2.5	Prepare capacity development and training programme addressing existing gaps vis-à-vis the envisaged advisory system. Develop agreements to implement the capacity building activities	37					1,000	1,037
3.2.6	Draft a research and development plan for continuing collaboration in the scientific undertakings relevant to improving operation of the SEE-MHEWS-A system	56						56
3.3. Collaboration with other relevant projects								
3.3.1	Seek approval from RA VI for implementation of SWFDP tailored for SEE							0
3.3.2	Identify resources for implementation of SWFDP tailored for SEE							0
3.3.3	Implementation of tailored SWFDP-SEE priority tasks (to be defined)							350
3.3.4	Expansion of the current FFG system to include Cyprus, Greece and Hungary	305		372	1,225	110	1,230	3,242
3.3.5	Establishment a stand-alone FFGS for Ukraine	160			605	30	195	990
3.3.6	Conduct workshops, in coordination with DPFS and PWS, on the roles of (a) observations, (b) forecasting and modelling, and (c) information and communication to DRR	74						74
3.4 Observations								
3.4.1	Compile an inventory, using the OSCAR/surface tool, of the capabilities of the SEE observing systems. Provide recommendations to fill identified gaps and for further strengthening of the observing systems including pilot projects	37						37
3.4.2	Define the scope of data, including the temporal and spatial resolutions, data formats and data volumes, that shall be provided by PPs into a CODB	37						37
3.4.3	Analyse the required ECMWF HPCF resources that would be needed to operate CODB in ECMWF. Develop a technical specification for CODB	19		21				40
3.4.4	Verify whether five full-member states of ECMWF from SEE would agree to use part of their HPCF allocations for the purpose of the advisory system and define how much HPCF resources they could offer for the project							0
3.4.5	Identify a host(s) of CODB and prepare an agreement with the host(s) for CODB operations and maintenance	37						37
3.4.6	In cooperation with the host(s) of CODB identify and acquire ICT infrastructure, software and licences	37				350		387

3.4.7	Define data and products of EUMETNET Observations Programme needed for the project purposes and make an agreement with EUMETNET to use them for the project	19						19
3.4.8	Define observational products of EUMETSAT needed for the project purposes and make an agreement with EUMETSAT to use them for the project	19						19
3.4.9	In cooperation with the host(s) of CODB implement acquired infrastructure and software		11		48			59
3.4.10	Identify host and establish the second weather radar centre for SEE countries and their radars not covered by OPERA. Define data and products that would be needed for nowcasting purposes, including for hydrological models	19			48	120		187
3.4.11	Produce, where not existing, and collect available gridded historical precipitation and temperature observations over 10 to 30 years for calibration of hydrological models (projects similar to CARPATCLIM)	16		105				121
3.5 Forecasting and Modelling								
3.5.1	Identify global NWP models for the purposes of the advisory system and make an agreement with the respective consortia on their use for the project	16						16
3.5.2	Identify high resolution NWP LAM models for the purposes of the advisory system and make an agreement with the respective consortia on their use for the project, agree on licences	37				60		97
3.5.3	Identify regional hydrological models for the purposes of the advisory system and make an agreement with the respective consortia/owners on use of their models for SEE-MHEWS-A, agree on licenses	19				40		59
3.5.4	Identify regional marine/oceanographic models for the purposes of the Advisory System and make an agreement with the respective consortia/owners on use of their models for SEE-MHEWS-A, agree on licenses	19				30		49
3.5.5	Identify sand and dust forecasting model(s) for the purposes of the advisory system and make an agreement with the respective consortia/owners on use of their models for SEE-MHEWS-A, agree on licences	19				30		49
3.5.6	Develop a feasibility study and identify host(s) that could provide their computing facility to operate high-resolution LAM models for the purposes of the advisory system, including requirements for additional HPC resources	37		35				72

3.5.7	Develop a feasibility study and identify host(s) that could provide their computing facility to operate regional hydrological models for the purposes of the advisory system, including requirements for additional HPC resources	19		21				40
3.5.8	Develop a feasibility study and identify host(s) that could provide their computing facility to operate regional marine (oceanographic) models for the purposes of the advisory system	19		21				40
3.5.9	Identify met/hydro/marine (oceanographic) models that could be used by project participants on national levels within the advisory system	19						19
3.5.10	Develop technical specifications of the suite of coupled met/hydro/marine prediction models	56		42				98
3.5.11	Implement the sand and dust operational forecasting for selected sub-domains in SEE (e.g. Middle East)		31	84	24	500		639
3.5.12	Acquire identified met/hydro/marine (oceanographic) models for national purposes and implement them at the national computing facility of PPs			70				70
3.5.13	Implement the suite of coupled met/hydro/marine prediction models in the computing facilities of the identified host(s): (a) nested high-resolution LAM models; including purchase of additional HPC resources if required by the host		70	189	72	2,500		2,831
3.5.14	Implement the suite of coupled met/hydro/marine prediction models in the computing facilities of the identified host(s): (b) regional hydrological models; including purchase of additional HPC resources if required by the host		31	84	24	1000		1,139
3.5.15	Implement the suite of coupled met/hydro/marine prediction models in the computing facilities of the identified host(s): (c) regional marine/oceanographic models		31	84	24	500		639
3.6 Information and Communication								
3.6.1	Develop a design of CIP, including technical specifications	56		42				98
3.6.2	Define the scope of advisory system's products (data, models' output, post-processing products, etc.), including their formats and respective volumes, that shall be made available to project participants via CIP (link to CODB)	37						37
3.6.3	Prepare analysis for assimilation to be used for HR nested LAM models, coordinate with identified partners for data assimilation (e.g. Hans Ertel Centre (DWD))	19		21				40

3.6.4	Identify host of CIP, including required infrastructure, and make an agreement for operation and maintenance	37	2					40
3.6.5	Coordinate with EUMETNET (ZAMG) the use of MeteoAlarm for cross-border communication between forecasters and for exchange of warnings and implement it or explore other solution with FMI		3		24			27
3.6.6	Coordinate with ZAMG and SHMI the use of INCA as nowcasting tool for SEE-MHEWS-A, and/or prepare analysis for an alternative solution		6	21				27
3.6.7	Identify tool(s) to be used for visualisation of data and products on CIP and prepare technical specifications	19						19
3.6.8	Identify tool(s) to be used for visualisation of data and products on PPs' site and prepare technical specifications	19						19
3.6.9	Identify tools to support dissemination, archival and retrieval functionality of the system and prepare technical specifications	19						19
3.6.10	Coordinate with ECMWF (use of SAPP) and/or RC-LACE (use of OPLACE) pre-processing of data for assimilation, or prepare analysis for an alternative solution	19		21	72			112
3.6.11	Coordinate with ZAMG and SHMI the application/adaptation of INCA for SEE region	19			72			91
3.6.12	Collaborate with identified contributing stakeholders in data assimilation (e.g. Hans Ertel Centre (DWD), RC-LACE) in the development of seamless data assimilation for coupled atmospheric-ocean system				144			144
3.6.13	Coordinate with NWP Consortia development of high-resolution models' verification tool(s)	19		63				82
3.6.14	Identify host of INCA, negotiate respective implementation, operational and maintenance costs, and implement INCA for SEE		2		288			290
3.6.15	Acquire identified tool(s) for visualisation of data and products and implement it	56	6				350	412
3.6.16	Acquire identified tool(s) for visualisation of data and products for national purposes and implement it on national levels	56	16				500	571
3.6.17	Acquire identified tools to support dissemination, archival and retrieval functionality of the system and implement them	56	6				350	412
3.6.18	Define communication infrastructure (architecture) of the whole system, including technical specifications, acquire and implement it (this should include choosing which of the available interface standards will be used)	56	16				3,000	3,071
3.6.19	Define necessary software for operations of the essential project ICT modules (CODB, suite of models and CIP), acquire and implement it	56	12				150	218

3.6.20	Implement CIP		31	63	144		238
3.6.21	Implement data assimilation for high-resolution nested LAM models		31	63	72		166
3.6.22	Verify the functionality of the advisory system components	37	12	21			71
	Operational costs until mid-2023						300
TOTAL COST							21,345

Legend
A: meetings: Cost of a meeting = (((DSA*No of days)+travel cost)*No of participants)
B: missions: Cost of a mission = (((DSA*No of days)+travel cost)
C: Consultants and staff cost: Cost of consultancy = No of months*7 kCHF
D: Contracts: Cost of a contract = No of months * 12 kCHF
E: capital investment, software, licenses: Rough estimate in k CHF
F: capacity development: CD = No. of countries*provision for a country; Note details will be defined based on Table 5.1

Table 5.1: Capacity development and implementation requirements by project participants needed to fully benefit from the advisory system

Project participants	Identified gaps and follow-up capacity development activities					
	Observing and Monitoring		Modelling and Post-processing		Information and Communication	
	Description of activities to fill the gaps in observing and monitoring	Cost (kCHF)	Description of activities to fill the gaps in modelling and post-proc.	Cost (kCHF)	Description of activities to fill the gaps in ICT	Cost (kCHF)
Albania	Traditional station network replacement and calibration	60	Access to European meteorological infrastructure Numerical modelling EUMETNET membership ECMWF membership	50 consortium fee,	Update of the IGEWE Web Site Additional observational data like satellite, radar and lightning images shall be included. Existing data services and climate services would become more user-friendly.	70
	Maintenance Currently, no funds are available for the major investments or the maintenance of the automatic station network. The costs for maintenance, repair works and calibration of the existing and planned hydro-meteorological network (manual and automatic, including the existing radar) are estimated between USD 300.000 now and USD 400.000 per year in future. Observation data around the country must be sufficient for forecasting and nowcasting.	280	Satellite data are required in high spatial resolution and brought to the state of the art nowcasting System (CAPEX and OPEX)	180	Telecommunication for the automatic stations	20
	Infrastructure for upgrading new station to automatic and	300	Implementation of a meteorological visualisation	250	Strengthen and update the capacity of the server room	100

	protection measures for vandalism. Additional budget is required for the further automatization and adaptation of the network.		platform		IGewe	
			Product harmonization			
			Data exchange			
			Calibration of rating curves			
			Data quality control			
			Data services			
			Digitalization of the archive of hydrometeorological information	100		
Bosnia and Herzegovina (FBiH)	Provision of one C-band Doppler Radar	2000	ECMWF membership Severe weather workshops (e.g. ESSL)		Server for AWS	3
	Provision of one upper air station	500	Assimilation of weather data into LAM	Project	Server for AHS	4
	Improvement of existing surface AWS network (15 AWS)	200			ICT equipment – Desktop workstations	5
	Maintenance and support for our real-time observation meteorological and hydrological network	50/year			Developing of technical capacities for data management and QC system	25
Bosnia and Herzegovina (RS)						
Bulgaria						
Croatia						
Cyprus	Provision of radar data from DoM	1600	Assimilation of weather data into Limited Area Models	Project	Message switching system either autonomous or as part of Modelling	Project
	New observations from DoM	5 each	Interface to provide access to model data, observations,	Project	CAP /MeteoAlarm integration	Project

			warnings and climatology			
	Buoys needed over eastern Mediterranean	5 each	Model verification for each run to build confidence among users	Project	Infrastructure for large uploading / downloading data volumes	Project
	Provision of gridded datasets of observations	Project	Long-term model verification	Project		
	Availability of satellite images with appropriate products	Project				
Greece	Maintenance and support for our in-situ observation network	150/year	Activities proposed for SEE-MHEWS-A depending on final design of the System	Will be defined later	Activities proposed for SEE-MHEWS-A depending on final design of the System	Will be defined later
	Implementation of twenty new AWS	50 per station				
	New/upgrade the management and collection of observation network system	100				
	Consumables for three upper stations	210/year				
	One new dual polarization C-band weather radar	2,000				
Hungary	Improvement of early warning monitoring system – pilot project in Hungary: Installation of 20 ceilometers 20 visibility meters	640+360	Offer of ALADIN/AROME model runs (depending on the approval of the ALADIN GA and LACE Council) at the Common Platform: manpower (1 FTE for 1 year) is needed for the configuration and testing of the model runs at the Common Platform	17	Selling of HAWK to the MHEWS Common Platform	43
	Improvement of verification of radar and satellite data required in early warning monitoring – pilot project in Hungary: installation of 20 radiation balance meters	700	Meteorological modelling support of the South-East Europe Flash Flood Guidance System (SEFFGS) expansion over Hungary: development and implementation of an hourly updated AROME model suite at 1 km (or preferably 500 m) horizontal resolution	85 (manpower)* + 520 (HPC)	Management of maintenance of HAWK system installed at the Common Platform (2 FTE for 5 years + yearly configuration for 5 years)	170+25

			Requirements: 1 FTE for 5 years* and additional HPC purchase at OMSZ			
	Calibration of different radiometers, such as pyrhemometers, pyranometers, pyrgeometers and certain spectral radiometers mainly in the visible and near IR spectra from the MHEWS project region (2 campaigns)	18			ICT equipment at OMSZ for central HAWK maintenance backup system: the Central Data Storage System enlargement (20 TB SSD storage)/Central Process Management and Database System enlargement (Cisco UCS blade server)	80+13
	Consultancy for MHEWS region concerning development of surface monitoring network and weather radar network (expert manpower costs per year)	17			3 training events in Budapest for HAWK application in forecasting (workshop catering + trainers preparation costs)	26
					ICT developments related to the South-East Europe Flash Flood Guidance System (SEFFGS) expansion over Hungary: Central Processes Management Server enlargement (10 Gb/s SAN/LAN)/Central Data Storage System enlargement (gross 30 TB SAS disk & 20TB SSD storage)/Central Process Management and Database System enlargement (Cisco UCS blade server)	17+29 + 80+13
Israel						
Jordan	Calibration and maintenance laboratory	200	High resolution LAM model	Project	Implementing of CAP	15
	Low level wind shear system	800	Training in modelling	Project	Connecting of AWS to GTS	10
			Training in effectively use of NWP products	30	Developing of technical capacities for data management and QC system	20

Kosovo (as defined by UNSCR 1244/99)	Upgrading the current network of meteorological and hydrological stations. Coverage of the whole territory with automatic meteorological and hydrological stations: - For 9 MS - Changing old equipment with automatic instruments - 12 new automatic meteorological stations - Weather radar with all acquisitions as software and hardware (server), installation and training. - Equipment of 20 hydrological stations with "data loggers systems" for online data transmission. - 20 automated hydrological online stations for surface water measurement Supply with spare parts. For all stations, necessary structures should be included.	15			3 computers with good performances.	3
		150				
		50				
		100				
		30% from the total amount				
			Digitalization of the archive of meteorological and hydrological data and information	20	Server for AWS	5
			Training in forecasting and modelling		Server for AHS	5
			Training of personnel for operation of NWP model, applications and model product visualisation		Maintenance of the web site and existing server	3
Lebanon						
the former Yugoslav Republic of	Upgrading and enhancement of national AWS observation network and hydrological		Establishment of integrated IT system/workstation in NMHS for proposed NWP model in context	10	Two servers for monitoring of meteorological and hydrological measurements and data	20

Macedonia	network. - 12 meteorological AWS - +30% spare parts - 50 automated hydrological online stations for surface water measurement - +30% spare parts	250 200 40	of Regional SEE MHEWS-A		management (data collection and dissemination)	
	Professional calibration kit for AWS for: - air temperature, and - atmospheric pressure	10	Training of personnel for operation of NWP model, applications and model product visualisation		Workstations for meteorological and hydrological data visualisation	
			Improvement of technical capacity (good performance) related to operations of NWP and hydrological flood assessment			
Moldova						
Montenegro	Weather radar C band (Vrsuta, Adriatic See)	1600	Hydrologic model implementation and training for staff		2 (two) x Servers (Rack or Tower) new Gen (7,8,9) with 2 CPU Intel Xeon E5-2667v4 (3.2GHz/8-core/25MB/135W)	20
			WAM III implementation and training for staff		Server for AWS	5
	Automatic weather station LAMBRECHT minimum 3 (three)	36	Training for visualisation and verification tools for models' data, Metview, ODB		Server for AHS	5
	Automatic mareograph with construction minimum (3 three)	50	Support for data transfer via GSM/GPRS		Workstation two 2	2
	Automatic hydrological station with construction minimum 3 (three)	50	Hydrological database WISKI Upgrade and training	50	Server for hydro database	5
	GNSS-GPS	22				
	Spare parts for automatic weather station LAMBRECHT	20				
Romania						

Serbia						
Slovenia						
	South East Europe Flash Flood Guidance System is available for flash flood issues including Croatia, Slovenia, Bosnia and Herzegovina, Albania, Moldova, Montenegro, Romania, Serbia and the former Yugoslav Republic of Macedonia, Turkey is also regional centre of the system.	-	Model building process is completed only development stages may continue in future.	-	Meetings are held in participant countries for capacity development and cooperation among members.	-
Turkey	Enhancing the observing network by installation of automatic weather stations, in particular at upper catchment areas	3,000				
	Design and establishment of X-Band radar network to fill the gaps of existing C-Band radar network (It is estimated that 10 X-Band radar will be needed in the first phase of the project)	8,000				
	Enhancing the marine observing network by installing new moored buoys equipped with automatic weather stations (It is estimated that 6 buoys will be needed in the first phase of the project)	1,500				
	Development and upgrade of the software for real time monitoring and management of the observing network					
Ukraine	Purchase of modern radars (4 units)	11942.4	Development of regional numerical model with the resolution of 3-5 km & local	4976.0	Formation of database and modern infrastructure of internal and external relations for	137.34

			models for big cities and high density regions of the country with the resolution of 1-3 km for forecasting main meteorological parameters, weather hazards.		receiving, technological processing, data storage, telecommunication processes monitoring and access to informational resources.	
	Purchase of automated meteorological stations (35 units)	2089.85	Development of weather forecasting in probabilistic form, creation of ensemble weather forecasts.	2239.2	Creation of automated system for users servicing and enhancement of the access to hydrometeorological data and products.	54.00
	Purchase of automated hydrological posts	302.48	Getting access to the results of weather modelling of the enhanced resolution capacity.	5.4		
	Purchase of automated marine hydrological posts (18 units)	1074.78	Creation of permanent integrated system for receiving and processing contact data on expected status of weather, inland water reservoirs and sea, crops development.	54.74		
	Purchase of air pollution observations automated posts (16 units)	1194.24	Creation of automated working places for forecasters (meteorologist, hydrologist, aviation forecaster, agrometeorologist, specialist for air pollution) at 25 hydrometeorological organizations	49.50		
	Purchase of automated systems for water flow measurements (8 units)	475.20				
	Purchase of on-ground air complexes (4 units)	238.84				

REGIONAL REQUIREMENTS FOR OBSERVATIONAL DATA AND PRODUCTS

(Excerpt from the Final Report of the Forecasters' Workshop, Skopje, the former Yugoslav Republic of Macedonia, 7-9 February 2017)

Reference is made to the need for free and open exchange of existing datasets via a **centralized database**.

Basic requirements for observations are defined in the Manual on the WMO Integrated Global Observing System, WMO-No.1160.

Further requirements:

1. Surface synoptic observations are required with up to sub-hourly resolution
2. Satellite data
 - a. 5 minute
 - b. 1km resolution
 - c. RGBs
 - d. Scatterometer data
 - e. Soil, snow and precipitation products
 - f. Soundings
 - g. SSTs, sea level
 - h. Satellite Application Facilities (SAFs), such as Support to nowcasting and VSRF, and Support to Operational Hydrology and Water Management.
3. Weather radar data
 - a. Up to 300 m resolution
 - b. Dual-polarization Doppler radar
 - c. Post-processed (e.g. QPE, VIL) data
 - d. 3D volume data
 - e. Improved QPE products
 - i. High resolution (1km)
 - ii. Regional rather than national radar (as in OPERA, INCA) - calibration
 - iii. Precipitation accumulations for last 1; 3; 6; 12; 24 hours
 - f. Quality controlled and assured data
 - g. Data shall be shared at regional level
4. Lightning (positive, negative and frequency) data
5. Upper-air sounding data
6. Aircraft (e.g., AMDAR) data

7. LIDAR data
8. Webcams images
9. Archived observational data
10. Aerosol observational data
11. Data from buoys
12. Voluntary and 3rd party observational data
13. Impact observations, including vulnerability and exposure datasets
14. Access to gridded historical precipitation and temperature observations (10-30 years) for model calibration
15. Streamflow observations (transboundary and including non-SEE countries)
16. Soil moisture in-situ observational data
17. In-situ snow observational data
18. In-situ bathymetry data
19. Coastal zone coverage with HF radar data
20. Topographic data:
 - a. Digital Elevation Models (DEMs)
 - b. Soil types
 - c. Land use
 - d. Reservoirs and dam locations
21. Reservoir operation rules and outflows
22. Tidal observational data
23. Ship observational data

REGIONAL FORECASTERS' REQUIREMENTS FOR MODEL OUTPUTS

(Excerpt from the Final Report of the Forecasters' Workshop, Skopje, the former Yugoslav Republic of Macedonia, 7-9 February 2017)

Reference is made to the access to seamless, multiple models at global, regional and local scales and visualized in a standard platform and according to agreed WMO standard practices.

Outputs parameters are defined according to two categories:

- i. **Basic:** Parameters that should be made available are described in WMO SWFDP Guidebook (version: 22 April 2010), Annex A (Sample list of products to be exchanged in a regional subproject for forecasting severe weather), see: http://www.wmo.int/pages/prog/www/DPFS/Meetings/RAII-SeA-SWFDP-RSMT_Hanoi2011/documents/SWFDP_Guidebook_Updated_22-04-2010.pdf, and European Severe Storm Laboratory (ESSL) parameters, as a minimum.
- ii. **Advanced:** To make available all parameters as defined by ECMWF Data Catalogue (Set I, II, III, IV, VI: see <http://www.ecmwf.int/en/forecasts/datasets/catalogue-ecmwf-real-time-products>) and in addition to other parameters required to derive further diagnostics.

COMMON REQUIREMENTS TO MET/HYDRO/ MARINE FORECASTING:

1. Hydrostatic and Non-hydrostatic global model (**at best/optimum resolution possible** e.g. 5-10km)
 - a. Ensembles
 - b. Hourly outputs for initial period and 3-6 hours for extended range
 - c. Extended range (10-30 days)
2. Convective scale non-hydrostatic model (**at best/optimum resolution possible** e.g. 1km)
 - a. Ensembles
 - b. Nested into a multi member ensemble suite
 - c. Hourly runs
 - d. 15 minute outputs
 - e. Up to 3-5 days
3. Nowcasting products (based on both observations and NWP), to include:
 - a. 5 minute
 - b. 300 m resolution
 - c. Up to 6 hour
4. Re-forecast datasets for each NWP model with minimum 10 year, preferably 30-year length

SPECIFIC HYDROLOGICAL REQUIREMENTS:

1. Regional scale, calibrated and validated hydrological models
 - a. Improvement of existing operational models (e.g. EFAS, E-HYPE, FFGS)
 - b. Application in small catchments (100 km²)
2. Integration of Sub-regional and National models – e.g. MIKE, HYPROM, HBV, etc., within the same system
3. Catchment integrated rainfall accumulations (mean areal precipitation products)
4. Drought forecasts and indices

SPECIFIC MARINE REQUIREMENTS:

1. Hydrodynamic model (fully 3D baroclinic models) integrated with tidal potential
2. Wave model (both large scale, e.g. WW3, and coastal-nearshore scale, e.g. SWAN)
3. Coupling between hydro and wave models
4. Scales:
 - a. Regional scale **at best/optimum resolution possible, e.g.** 4-6 km and 9 days
 - b. (Sub-regional 2-3 km)
 - c. Coastal up to 100 m (possibility to use unstructured grid approach) and 5 days
 - d. Harbour up to 10-5 m

SUMMARY OF PROPOSAL BY POTENTIAL CONTRIBUTING STAKEHOLDERS

(Preliminary list with potential contributions)

1. ALADIN

The main motivation for ALADIN support to SEE-MHEWS-A would be saving properties and lives envisaged through this Project. However, possible collaboration depends on a decision of the ALADIN General Assembly. Existing MoU allows cooperation with entities outside the Consortium by a mutual Agreement, therefore, WMO is expected to submit soonest possible a request to the General Assembly so that this collaboration could be assessed by the Advisory Committee due to meet in the beginning of April.

2. Centro EuroMediterraneo sui Cambiamenti Climatici

SEE-MHEWS-A requires “coastal inundation and storm surge forecasting” EWS to be designed and implemented in the SEE region.

CMCC (Centro EuroMediterraneo sui Cambiamenti Climatici, Lecce, Italy) is coordinating the Copernicus Marine Environment Monitoring Service (CMEMS) Monitoring and Forecasting Centre for the Mediterranean Sea that produces every day, a 10-day forecast of sea level, currents, waves and temperature, salinity in all marine areas of SEE. In addition, it operates the oceanographic forecasting system for the Black Sea Monitoring and Forecasting Centre of CMEMS.

Additionally, it develops:

- Unstructured grid operational ocean models for the southern Adriatic coastal areas up to the resolution of 500 meters along the coastlines; and
- Meteo-hydrological models coupled to the oceanographic modelling in order to arrive to coastal erosion forecasting in the next few years.

CMCC offers to make available, for free, on the SEE-MHEWS-A Common Information (and Communication) Platform all the operational forecasting products, both at the Med Sea and coastal level in the appropriate format and with harmonized protocols.

Furthermore, it suggests developing a SEE-MHEWS-A “coastal storm surge and inundation” forecasting test case based upon CMEMS products with coupled meteo-hydrological modelling in the Adriatic Sea area, together with other interested NMSs and NMHSs in the region.

3. COPERNICUS SERVICES

The European Commission Copernicus programme runs a number of forecasting systems that can contribute to MHEWS. Unless highlighted the data are publicly available under open licenses. In many case ECMWF acts to provide the forecasts and could arrange to deliver them directly to the SEE-MHEWS-A. Copernicus Services (<http://www.copernicus.eu/main/services>) includes:

- European and Global Drought Observatory (EDO) – regional and global drought monitoring and forecasting.
- European Forest Fire Information System (EFFIS) – forecasting and monitoring of fire risk.
- European Flood Awareness System (EFAS) – nowcasting to seasonal flood forecasting, including rapid risk assessment and monitoring information. This requires the agreement

of an adapted Copernicus license to maintain the 'single voice' warning principle, however, majority of the SEE-MHEWS-A states are already partners in EFAS.

- Atmospheric Monitoring Service (CAM5) – forecasting the future atmospheric pollution including medium range forecasts of the movement of dust (sand) in the atmosphere.
- Marine Environment Monitoring Service (CMEMS) – analysis, reanalysis and 10-day forecasts of waves, sea level, temperature, salinity, currents, pelagic biochemistry for the global ocean and the European regional Seas.
- Climate Change Services (C3S) – providing seasonal to decadal forecasts that are pertinent for drought risk management.

4. DWD

Development of seamless data assimilation for coupled atmospheric-ocean system could be offered by Hans Ertel Centre in case of available funding, with a justification and phases as follows:

Phase 1: Even if we consider the atmospheric application only, the models developed for global and regional scales differ significantly. In global models, the convection is parameterized and the flow is in approximate balance (geostrophic, hydrostatic). The analyses are calculated every 3 to 6 hours and more stationary covariances are used. On the other hand, the regional models have now reached a horizontal resolution of 1.3 to 2.8 km. They are non-hydrostatic, convection permitting, and nonlinear processes dominate. For the convection permitting models, due to the fast-changing processes that are resolved, it is important to have the time evolving error covariance as represented through an ensemble. Furthermore, we often have observations of severe weather (e.g., from radar data) that we would like to use to update the initial conditions in less than hourly updates. Simple downscaling from the lower resolution model to obtain initial conditions instead of running convective scale data assimilation, results in much worse precipitation forecasts.

Since precipitation forecast up to 24 hours could be improved by data assimilation we suggest modified EnKF to be developed for the seamless atmospheric data assimilation system that is consistent with the NMM-B model. Maintaining physical conservation laws numerically has long been recognized as being important in the development of numerical weather prediction models independent of their resolution and this is one of the main principles followed in the design of NMM-B model. In recent years, we have been working on the development of ensemble-based data assimilation algorithm that replicates properties of nonlinear dynamical systems such as conservation of mass, angular momentum, energy and enstrophy. In simple experiments conservation laws in data assimilation are helpful in reduction of noise as well as quality of the prediction.

Phase 2: Using data assimilation for estimation of parameters that couple atmospheric to ocean or hydrology models.

Phase 3: Seamless data assimilation for coupled atmospheric ocean system.

5. ECMWF

The level of ECMWF involvement in SEE-MHEWS-A is dictated by the agreement of the ECMWF member states (MS). With the agreement of the MS involved within the project it should be possible for ECMWF to:

- Assist in running of models (NWP or otherwise) on ECMWF computer systems using the (possibly pooled) MS permitted computer usage.
- Disseminate ECMWF forecasts directly to SEE-MHEWS-A (within the bounds of the current license).
- Other activities that may require fuller agreement amongst all MS include:
 - Use of the ECMWF MARS and associated systems for the archiving and dissemination of forecasts (could be considered a development of the TIGGE-

LAM project);

- Use of the ECMWF web architecture (ecCharts) for the provision of OGC compliant web services for forecast visualisation; and
- Provision of further computing resources to the SEE-MHEWS-A.

There are also several public software packages for scheduling computational tasks (ecFlow), manipulating data (ecCodes), plotting (Magics) and forecast visualisation (Metview) which could be used with SEE-MHEWS-A to provide a common infrastructure and improve the interoperability between SEE-MHEWS-A contributors.

ECMWF can also provide the fire risk forecasts under an open license for inclusion into the SEE-MHEWS-A.

6. ESSL

European Severe Storms Laboratory (ESSL) as an organization provides forecaster trainings focusing on severe weather. It also has experience in the evaluation of nowcasting and forecasting tools in quasi-operational practice at the ESSL Testbed. These tools include NWP (e.g. COSMO), radar and satellite (e.g., NWC-SAF) products. To SEE-MHEWS, ESSL offers these contributions:

1. Training courses on severe weather at a basic, intermediate and advanced level. These courses include on-site and remote trainings. They combine the acquisition of theoretical knowledge of storm systems and the use of data from radar, satellite, NWP and other nowcast systems in operational practice. Such courses always include practical forecasting exercises using real-time or past severe weather events.
2. Daily on-the-job remote training in teleconferencing sessions in synergy with the European Storm Forecast Support initiative of EUMETNET or ESTOFEX. Experts discuss the weather situation on a given day with forecaster participants in daily sessions using a prepared weather briefing that encourage international interaction at the forecaster level and enhance the spread of practical forecasting expertise.
3. Hosting of on-site training courses on related topics, such as hydrology, NWP, radar and satellite applications, to be carried out jointly with partner organizations.
4. Probabilistic NWP-based forecasting and nowcasting products developed by ESSL in previous research projects.
5. Consulting on the visualization and presentation of forecast and nowcast products and fields included in the MHEWS system.

7. OMSZ

Hungarian Meteorological Service (OMSZ) offered its meteorological workstation HAWK-3 as the possible visualisation tool for the project.

There are three possible ways for HAWK implementation in the SEE-MHEWS-A project, each having its advantages and its limitations: (a) one installation on a common application server, on which the software can be run directly in interactive or non-interactive mode; (b) one installation on a common application server, which generates predefined products (images or pdf files) in non-interactive mode. The result can be made available through a web page or directly downloadable by project participants; (c) Installation at the participating institutions.

User's guide and technical documentation will be included in the software. Due to resources the OMSZ can only provide a helpdesk to assist forecasters and IT administrators. It cannot provide direct maintenance of the system.

8. NCEP

NOAA National Centres for Environmental Prediction (NCEP) have already delivered their contribution by providing the Non-hydrostatic Multi-scale Model (NMMB) forecasting system and basic training and support. So, the NMMB is up and running on all scales in the South-eastern Europe and can productively support the SEE-MHEWS-A.

Deterministic models certainly can be further improved, but perhaps even more improvement can be achieved by improving data assimilation techniques, and by assimilating more data types and more data. For example, Panasonic claims that they got better forecast results than ECMWF using the NCEP GFS model, and data assimilation with more aircraft data.

9. SHMI

Swedish Hydrological and Meteorological Institute could offer the High-resolution pan-European water (HYPE) model. It is open source model designed for application at large scale and operational forecasting (ensemble forcing data, updating with observations, data assimilation). Existing model set-up is “ready to use” for SEE region, at least as first development iteration. SHMI can share the experience in national scale hydrological forecasting and could offer experts and user training. It can also provide operational infrastructure, such as forecasting server and forecasting web-services.

10. ZAMG

For the SEE-MHWES project, the Zentralanstalt für Meteorologie und Geodynamik (ZAMG) could provide the support on nowcasting system INCA (Integrated Nowcasting through Comprehensive Analysis) for implementation in the SEE-MHEWS-A.

Furthermore, ZAMG could also support the SEE-NHMSs to set up a seamless probabilistic forecast system in the next few years.

The RC-LACE Consortium could contribute to the SEE-MHEWS-A data pre-processing, data assimilation and verification through the RC-LACE operational OPLACE tool.

It is also possible for LACE to provide the regional ensemble forecast LAEF for all SEE countries.

11. WMO FFGS

“Filling gaps creates new gaps or these could be viewed as opportunities.” As advances and improvements are brought into the operational arena, they can, in turn, increase the capability of associated applications. For example, if radar data were to be corrected to allow more accurate estimates of precipitation and if these data were made available for use in the FFGS, these data could improve its accuracy and granularity of Flash Flood Guidance. Improved granularity, spatially and temporally, is needed in particular for urban flash flood forecasting and would also improve basin scale Flash Flood Guidance.

Specific areas of priority include:

- Enhanced QPE – Radar used in Mean Areal Precipitation (precipitation averaged over the small flash flood basin)
- Build nowcasting capability and ingestion of this new functionality into the FFGS
- Enhanced NWP high resolution (multi-modal ingestion) forecast coverage
- Not all countries in SEE-MHEWS-A are covered by high resolution NWP (e.g., 2 km or 4 km resolution)
- Expanding the existing FFGS projects’ spatial coverage to include all countries included in SEE-MHEWS-A (e.g., Cyprus, Greece, Israel, Hungary and Ukraine)
- Introduce new FFGS functionality into SEE-MHEWS-A where most needed
- Urban flash flood forecasting for major urban areas most vulnerable to flash flooding
- Riverine modelling for major damage centres
- Landslide susceptibility

12. WMO SWFDP

The WMO Severe Weather Forecasting Demonstration Project (SWFDP) is a project that uses the cascading forecasting process to enhance the capability of LDCs and SIDs to provide timely and more accurate weather warnings amongst other meteorological services. It is a true example of WMO Members assisting each other. The cascading forecasting process consists of passing high value information from Global Centre to Regional then to National Centres where local forecasts and warnings are issued. The project was initiated in Southern Africa in 2006 with only five countries (currently 16 countries) and expanded to Bay of Bengal, South-eastern Asia, Central Asia, Eastern Africa and Southwest Pacific. Overall 48 countries are members of the SWFDP in all WMO Region except for RA-IV and RA-V. Plan is underway to initiate the project in West Africa and in Lesser Antilles. It is a well proven concept that can benefit the SEE-MHEWS-A Project.

The SWFDP involves the contribution of several Global and Regional centres, offering predicted weather data that can be exploited by SEE-MHEWS-A participating countries in providing services getting boundary conditions to run their Limited Area Models (LAMs). The implementation of SWFDP in SEE is felt to be one of the key components for the SEE-MHEWS-A.

13. Drought Management Centre for South-eastern Europe (DMCSEE)

DMCSEE has contributed to Disaster Risk Reduction project in the region with organization of workshops and training of staff. It has participated also in Integrated Drought Management Programme (IDMP) regional project led by the WMO and the GWP. Slovenian Environment Agency, as a hosting institution of the DMCSEE, will continue to support the SEE-MHEWS-A project. Currently the Agency is leading a project Drought Risk in Danube region (DriDanube) co-financed by EU's regional transnational programme. One of DriDanube project activities is development of Drought User Service – a user interface to relevant databases (including remote sensing data and drought impact assessment models), which may fit well into SEE-MHEWS-A project. Drought User Service will be developed and tested in 2018.

14. Finnish Meteorological Institute FMI

Several FMI Open Source Software are available for the SEE-MHEWS-A implementation, for example:

- SmartMet Server (open)

High-capacity and high-availability data and product server for MetOcean data.

Backend for all FMI product generation incl. FMI Open Data Portal & INSPIRE data Service, FMI Client Data Portal, Mobile Applications, WEB Services, ECMWF Copernicus Climate Data Store.

- SmartMet Workstation (to be opened in 2018)

Tool for visualizing and editing meteorological (also marine, hydro, environmental etc.) data. Support for all kind of meteorological data (NWP, Satellites, Weather Radars, Observations, Lightning Detection, Soundings etc.)

SmartMet (Server and Workstation has been implemented by FMI and is in operational use at the moment in 27 countries.

- SmartMet Alert (to be opened in 2019)

Tool for creating and disseminating warnings. A user interface for the forecasters to input warning information. Produces automatic warning texts. Includes several possible (automatic) dissemination channels. Supports also CAP.

SmartMetAlert has been installed by FMI and is in operational use at the moment in 11 countries.

- HIMAN (open)

Post-processing suite for meteorological data

- PyTroll (open – in collaboration with SMHI, DMI and others)

Set of tools for the reading, interpretation, and writing of weather satellite data.

- SILAM (open)

Operational Emergency and Air Quality Modelling System

- Other software:

Radar Composite and Analysing; Observation network software and quality control; Data format conversion tools; Product generation tools; etc.

FMI is also available to support the operational implementation of the software and delivering the related training and user support (separate agreement needed). FMI is also willing to discuss on the potential provision of Technical Assistance and training to support the overall implementation of SEE-MHEWS-A.

15. International Sava River Basin Commission ISRBC

International Sava River Basin Commission (Sava Commission) in cooperation with relevant national institutions from the Sava River Basin, cooperating under the Framework Agreement for the Sava River Basin, in 2015 has established a joint platform *Hydrological Information System for the Sava River Basin* (Sava HIS), for the exchange and use of the hydrological and meteorological information and data. Sava HIS is established taking into account *Policy on the Exchange of Hydrological and Meteorological Data and Information in the Sava River Basin*, prepared by the Sava Commission in close cooperation with WMO. The Policy was signed by national hydrometeorological services and two water agencies in 2014. Sava HIS, as a component of *Geographical Information System for the Sava River Basin* (Sava GIS), represents a tool for collecting, storing, analyzing and reporting a sufficiently high quality hydrological and meteorological data. The overall objective of Sava HIS is supporting the Sava countries in sharing and disseminating of hydrologic and meteorological data, information and knowledge about the water resources in the Sava River Basin. Those data and information are in use for decision-making system in all aspects of water resources management, in the wide range of operational applications as well as in research. Since the *Water ML 2.0* format is implemented in Sava HIS, as the WMO exchange standard via web service, the system enables storage of water observations data and spatial information, sharing by countries, in a standard format as well as supports data sharing and publication via web services for further use.

Currently, the Sava countries are in the process of establishment of *Flood Forecasting and Warning System in the Sava River Basin* (Sava FFWS) which will be finalized by the end of August 2018. Sava FFWS will be implemented as an open shell platform for managing the data handling and forecasting process, allowing a wide range of external data and models to be integrated. This concept is particularly important for the five cooperating Sava countries, where different forecasting systems and models are in use. Sava FFWS will integrate Sava HIS, as a data hub for the collection of real-time hydrological and meteorological data, as well as various Numerical Weather Prediction models, available weather radar and satellite imagery, outputs of the existing national forecasting systems, different meteorological, hydrological and hydraulic models which all will be easily 'plugged' into a common platform. The resulting system will enable the five countries involved to take the right management decisions and implement operational measures to prevent and mitigate severe flood and drought situations on the basis of reliable forecasts of water levels and discharges with a

long lead time within area of an entire river basin.

With these systems, developed through the cooperation of countries within the scope of work of the Sava Commission, we hope that the Sava countries will be better prepared for emergency situations like the one that occurred in May 2014, when disastrous floods in the Sava basin resulted in 79 casualties and substantial economic damage. Sava HIS and Sava FFWS are a very special regional concept taking into account that the Sava river basin (97,700 km²) is shared by five countries: Slovenia, Croatia, Bosnia and Herzegovina, Montenegro and Serbia and each country has its own models, monitoring systems, forecasting systems, water authorities and interests. This regional, basin wide concept, will bridge such differences and support collaboration in the field of water management keeping the countries' own autonomy in monitoring, modelling and forecasting and remain open to developing its own models and supplementary forecasting initiatives. The system is assessed as added value to existing or developing systems, expecting that a common forecasting platform with well trained staff should provide better preparedness and optimized mitigation measures to significantly help reduce consequences of floods and droughts.

During the first phase of the SEE-MHEWS-A project both mentioned systems were presented and introduced to the project beneficiaries at the project workshops in Skopje and Budapest, showing the system capabilities as well as the Sava Commission's readiness of sharing a valuable experience achieved in entire process of the system development. Therefore, it is very important to emphasize that the Sava Commission still supports the SEE-MHEWS-A initiative and is open to transfer experiences gained through the development of Sava HIS and Sava FFWS to other SEE-MHEWS-A project beneficiaries, harmonizing the systems as much as possible in order to avoid duplication of work of the national data providers from the Sava River Basin, noting that the mode and extent of use of the systems within the SEE-MHEWS-A should be decided by the Sava countries.

16. **UK Met Office** (Contributed to the workshops, further engagement TBD)
17. **EUMETNET** (Contributed to the workshops, further engagement TBD)
18. **EUMETSAT** (TBD)
19. **EU Joint Research Center JRC** (TBD)
20. **Czech Hydrometeorological Institute CHMI** (Contributed to the workshops, further engagement TBD)
21. **Roshydromet** (Contributed to the workshops, further engagement TBD)
22. **China Meteorological Administration CMA** (Contributed to the workshops, further engagement TBD)
23. **Japan Meteorological Agency** (Contributed to the workshops, further engagement TBD)
24. **Slovak Hydrometeorological Institute SHMI** (Contributed to the workshops, further engagement TBD)
25. **Meteo France** (TBD)
26. **Royal Netherlands Meteorological Institute KNMI** (Contributed to the workshops, further engagement TBD)
27. **Spanish Meteorological Service AEMET** (Contributed to the workshops, further engagement TBD)
28. **Copernicus** (Contributed to the workshops, further engagement TBD)
29. **International Commission for the Protection of Danube River ICPDR** (TBD)
30. **South East European Virtual Climate Change Center SEEVCCC** (Contributed

to the workshops, further engagement TBD)

31. **Regional Instrument Center RIC**, operated by the Environmental Agency of the Republic of Slovenia (Contributed to the workshops, further engagement TBD)
32. **COSMO NWP Consortium** (TBD)
33. **SEECOP NWP Consortium** (Contributed to the workshops, further engagement TBD)
34. **HIRLAM NWP Consortium** (TBD)
35. **Marine Meteorological Centre for Adriatic Sea Area AMMC** (TBD)
36. **Eastern Mediterranean Climate Centre EMCC, Turkey** (TBD)
37. **WMO RTC (Regional Training Centers) in RA VI** (TBD)
38. **South East European Network for education and training SEEMET** (TBD)

TELECOMMUNICATION CAPABILITIES
(information from different sources, including WIS survey and ECMWF)

Participant countries	GTS (Mbps)		Internet (Mbps)	Communication means
		RMDCN		
Albania	0.55		25	GTS / SMT, Internet, RANET, Data via GSM or Cell Phone, SMS, Satellite Data Collection Systems (DCS) - e.g. Eumetsat/NOAA/CMA/JMA
Bosnia and Herzegovina			20	Internet, Satellite Data Collection Systems (DCS) - e.g. Eumetsat/NOAA/CMA/JMA
Bulgaria		10	100	GTS / SMT, Internet
Croatia		4	100	GTS / SMT, Internet
Cyprus			3	Internet
Greece		4	1000/100	GTS / SMT, Internet with redundancy, Data via GSM, Satellite Data Collection Systems (DCS) such as Eumetcast KU Band and Burum, SADIS
Hungary		8	400	GTS / SMT, Internet
Israel		15		
Jordan		1	1	GTS / SMT, Satellite Data Collection Systems (DCS) - e.g. Eumetsat/NOAA/CMA/JMA
Kosovo (UNSCR1244/99)			5	Internet, Data via GSM or Cell Phone
Lebanon		1 ^(*)		
Montenegro	10		10	GTS / SMT, Internet, Data via GSM or Cell Phone
Republic of Moldova	5		100	GTS / SMT, Internet
Romania		15	600	GTS / SMT, Internet
Serbia		8	280	GTS / SMT, Internet
Slovenia		8		
the former Yugoslav Republic of Macedonia		2		GTS / SMT, Internet, Data via GSM or Cell Phone
Turkey		34	500	GTS / SMT, Internet, Data via GSM or Cell Phone / Satellite Data Collection Systems (DCS) - e.g. Eumetsat/NOAA/CMA/JMA
Ukraine			300	Internet, Satellite Data Collection Systems (DCS)

^(*) Currently in planning

LIST OF ACRONYMS

AEMET	Agencia Estatal de Meteorología (Spanish State Meteorological Agency)
AEMET-BSC	Regional Centre for Northern Africa, Middle East and Europe
ALADIN	Aire Limitée Adaptation dynamique Développement InterNational (High Resolution Numerical Weather Prediction Project)
AMMC	Adriatic Marine Meteorological Centre
BSMEFFG	Black Sea and Middle East Flash Flood Guidance System
CAP	Common Alerting Protocol
C3S	(COPERNICUS) Climate Change Services
CAMS	(COPERNICUS) Atmospheric Monitoring Service
CBS	WMO Commission for Basic Systems
CHMI	Czech Hydrometeorological Institute
CHy	WMO Commission for Hydrology
CIP	Common Information (and Communication) Platform
CMCC	Euro-Mediterranean Centre on Climate Changes
CMEMS	Marine Environment Monitoring Service
CMES	Copernicus Marine Environment Monitoring Service
CODB	Centralized Observational Database
COPERNICUS	European Union Programme aimed at developing European information services based on satellite Earth Observation and in situ data
COSMO	Consortium for Small-scale Modelling
DMCSEE	Drought Management Centre for South-eastern Europe
DPFS	Data Processing and Forecasting Systems (DPFS)
DriDanube	Drought Risk in Danube region project
DRR	Disaster Risk Reduction
DWD	Deutscher Wetterdienst
ECMWF	European Centre for Medium-Range Weather Forecasts
ECMWF MS	ECMWF Member States
EDO	(COPERNICUS) European and Global Drought Observatory
EFAS	European Flood Awareness System
EFFIS	(COPERNICUS) European Forest Fire Information System
E-HYPE	High resolution pan-European water model
ESSL	European Severe Storm Laboratory
ETRP	Education and Training Programme
EUMETNET	Network of European Meteorological Service
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
EWS	Early Warning System
FFGS	Flash Flood Guidance System
FMI	Finnish Meteorological Institute
FTE	Full-Time Equivalent Employee
GDPFS	Global Data-processing and Forecasting System
GFS	Global Forecast System
GMAS	WMO Global Multi-Hazard Alert System
GOS	Global Observing System
GPCC	WMO Global Precipitation Climatology Centre
GTS	Global Telecommunication System
HAWK	Hungarian Meteorological Service Workstation
HBV	State of the art hydrological model (SMHI)
HEC	Hydrologic Modelling System (U.S. Army Corps of Engineers)
HPCF	High Performance Computing Facility
HR	High Resolution (LAM model)
HRC	US Hydrologic Research Centre
H-SAF	Satellite Application Facility on Support to Operational Hydrology and Water

	Management
HWRP	Hydrology and Water Resources Programme
HYPROM	Hydrology surface-runoff prognostic model
ICON	Icosahedral non-hydrostatic general circulation model
ICPDR	International Commission for the Protection of Danube River
ICT	Information and Communication Technology
IDMP	Integrated Drought Management Programme
IFRC	International Federation of Red Cross and Red Crescent Societies
INCA	Integrated Nowcasting through Comprehensive Analysis
IP	SEE-MHEWS-A Implementation Plan
ISRBC	International Sava River Basin Commission
ITU	International Telecommunication Union
JMA	Japan Meteorological Agency
JRC	Joint Research Centre
KNMI	Royal Netherlands Meteorological Institute
LBC	Lateral Boundary Conditions
Met Ocean DWG	Meteorology and Oceanography Domain Working Group of OGC
MIKE	Hydrological Models (DHI Technologies)
MoU	Memorandum of Understanding
MS	ECMWF Member States
NMC	National Meteorological Centre
NHS	National Hydrological Service
NMHS	National Meteorological and Hydrological Service
NMS	National Meteorological Service
NMM	Non-hydrostatic Multi-scale Model
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
OGC	Open Geospatial Consortium
OMSZ	Hungarian Meteorological Service
OPLACE	Data pre-processing for data assimilation and verification of RC-LACE
PAG	Project Advisory Group
PO	Project Office
PP	Project Participants
PSC	SEE-MHEWS-A Project Steering Committee
PWS	Public Weather Services Programme
QPF	Quantitative Precipitation Forecasts
QPE	Quantitative Precipitation Estimates
RA	Regional Association
RBM	Results-based Management
RC-LACE	Regional Cooperation for Limited Area Modelling in Central Europe
RHMSS	Republic Hydrometeorological Service of Serbia
RIC	Regional Instrument Centre
RMDCN	Regional Meteorological Data Communication Network
ROE	WMO Regional Office for Europe
RP	Regional Programme
RSMC	WMO Regional Specialised Meteorological Centre
RTC	Regional Meteorological Training Centre
SAF	Satellite Application Facilities
SAPP	Scalable Acquisition and Pre-Processing system for observations of ECMWF
SDS-WAS	Sand and Dust Storm Warning Advisory and Assessment System
SEE	South East Europe (for the purposes of this project it covers the region encircling all project participants' countries)
SEE-FFGS	South East Europe FFGS regional project
SEE-MHEWS-A	South East European Multi-Hazard Early Warning Advisory System
SEECOP	South-East European Consortium for Operational weather Prediction
SEEVCCC	South East European Virtual Climate Change Centre
SHMI	Slovak Hydrometeorological Institute
SmartMet	Software tool for visualisation and editing meteorological data (from FMI)
SMHI	Swedish Meteorological and Hydrological Institute

SWAN	Simulating Waves Nearshore (hydrological model from DELFT University)
SWFDP	WMO Severe Weather Forecasting Demonstration Project
SWFDP-SEE	SWFDP Regional Subproject for SEE
TSMS	Turkish State Meteorological Service
TT	SEE-MHEWS-A Project Technical Team
TT-CD	TT on capacity development and training
TT-ICT	TT on information & communication technology
TT-Mod	TT on modelling
TT-Obs	TT on observations
TT-PP	TT on Post-processing and nowcasting
TT-Sci	TT on scientific issues
USAID	US Agency for International Development
VIL	Vertically Integrated Liquid
WAM	Mediterranean Wave Forecast Model
WIGOS	WMO Integrated Global Observing System
WIS	WMO Information System
WMO	World Meteorological Organization
WWRP	World Weather Research Programme
WWW	World Weather Watch Programme
WW3	Wave Watch model from NCEP
ZAMG	Austrian Institute for Meteorology and Geodynamics