ABSTRACTS

of the scientific publications submitted by Assoc. Prof. Dr. Eng. Snezhanka Stoyanova Balabanova for participation in the competition for academic position „Professor“ in scientific area 5. Technical sciences, professional field 5.7. Architecture, Civil engineering and Geodesy, in scientific field “Engineering Hydrology, Hydraulics and Water management” in section “Hydrological Forecasts” at the department of “Forecasts and Information Services”, announced in State Gazette No. 100/01.12.2023

	Type of publication, authors, title, publisher, doi /ISBN/ISSN, abstract
	Publications in group B (Bulgarian version “B”)
1	Wetterhall, F., Pappenberger, F., Alfieri, L., Cloke, H.L., Thielen-Del Pozo, J., **Balabanova, S.**, Daňhelka, J., Vogelbacher, A., Salamon, P., Carrasco, I., Cabrera-Tordera, A.J., Corzo-Toscano, M., Garcia-Padilla, M., Garcia-Sanchez, R.J., Ardilouze, C., HESS Opinions forecaster priorities for improving probabilistic flood forecasts, Hydrology and Earth System Sciences 2013, pp. 4389-4399, DOI 10.5194/hess-17-4389-2013 , Review, Scopus, WoS Hydrological ensemble prediction systems (HEPS) have in recent years been increasingly used for the operational forecasting of floods by European hydrometeorological agencies. The most obvious advantage of HEPS is that more of the uncertainty in the modelling system can be assessed. In addition, ensemble prediction systems generally have better skill than deterministic systems both in the terms of the mean forecast performance and the potential forecasting of extreme events. Research efforts have so far mostly been devoted to the improvement of the physical and technical aspects of the model systems, such as increased resolution in time and space and better description of physical processes. Developments like these are certainly needed; however, in this paper we argue that there are other areas of HEPS that need urgent attention. This was also the result from a group exercise and a survey conducted to operational forecasters within the European Flood Awareness System (EFAS) to identify the top priorities of improvement regarding their own system. They turned out to span a range of areas, the most popular being to include verification of an assessment of past forecast performance, a multi-model approach for hydrological modelling, to increase the forecast skill on the medium range (>3 days) and more focus on education and training on the interpretation of forecasts. In light of limited resources, we suggest a simple model to classify the identified priorities in terms of their cost and complexity to decide in which order to tackle them. This model is then used to create an action plan of short-, medium- and long-term research priorities with the ultimate goal of an optimal improvement of EFAS in particular and to spur the development of operational HEPS in general.
2	Puca, S., Porcu, F., Rinollo, A., Vulpiani, G., Baguis, P., **Balabanova, S.**, Campione, E., Ertürk, A., Gabellani, S., Iwanski, R., Jurašek, M., KaÅăk, J., Kerényi, J., Koshinchanov, G., Kozinarova, G., Krahe, P., Lapeta, B., Lábó, E., Milani, L., Okon, L', The validation service of the hydrological SAF geostationary and polar satellite precipitation products, Natural Hazards and Earth System Sciences, 2014, DOI 10.5194/nhess-14-871-2014, pp 871-889, Scopus, WoS The development phase (DP) of the EUMETSAT Satellite Application Facility for Support to Operational Hydrology and Water Management (H-SAF) led to the design and implementation of several precipitation products, after 5 yr (2005-2010) of activity. Presently, five precipitation estimation algorithms based on data from passive microwave and infrared sensors, on board geostationary and sun-synchronous platforms, function in operational mode at the H-SAF hosting institute to provide near real-time precipitation products at different spatial and temporal resolutions. In order to evaluate the precipitation product accuracy, a validation activity has been established since the beginning of the project. A Precipitation Product Validation Group (PPVG) works in parallel with the development of the estimation algorithms with two aims: to provide the algorithm developers with indications to refine algorithms and products, and to evaluate the error

	structure to be associated with the operational products. In this paper, the framework of the PPVG is presented: (a) the characteristics of the ground reference data available to H-SAF (i.e. radar and rain gauge networks), (b) the agreed upon validation strategy settled among the eight European countries participating in the PPVG, and (c) the steps of the validation procedures. The quality of the reference data is discussed, and the efforts for its improvement are outlined, with special emphasis on the definition of a ground radar quality map and on the implementation of a suitable rain gauge interpolation algorithm. The work done during the H-SAF development phase has led the PPVG to converge into a common validation procedure among the members, taking advantage of the experience acquired by each one of them in the validation of H-SAF products. The methodology is presented here, indicating the main steps of the validation procedure (ground data quality control, spatial interpolation, up-scaling of radar data vs. satellite grid, statistical score evaluation, case study analysis). Finally, an overview of the results is presented, focusing on the monthly statistical indicators, referred to the satellite product performances over different seasons and areas.
3	E., Vincendon, B., Kroumova, K., Nedkov, N., Tsarev, P., **Balabanova, S**., Koshinchanov, G., Flood forecasting and alert system for Arda River basin, Journal of Hydrology 2016, pp. 457-470, DOI 10.1016/j.jhydrol.2016.02.059, Scopus The paper presents the set-up and functioning of a flood alert system based on SURFEX–TOPODYN platform for the cross-border Arda River basin. The system was built within a Bulgarian-Greek project funded by the European Territorial Cooperation (ETC) Programme and is in operational use since April 2014. The basin is strongly influenced by Mediterranean cyclones during the autumn–winter period and experiences dangerous rapid floods, mainly after intensive rain, often combined with snow melt events. The steep mountainous terrain leads to floods with short concentration time and high river speed causing damage to settlements and infrastructure. The main challenge was to correctly simulate the riverflow in near-real time and to timely forecast peak floods for small drainage basins below 100 km2 but also for larger ones of about 1900 km2 using the same technology. To better account for that variability, a modification of the original hydrological model parameterisation is proposed. Here we present the first results of a new model variant which uses dynamically adjusted TOPODYN river velocity as function of the computed partial streamflow discharge. Based on historical flooding data, river sections along endangered settlements were included in the river flow forecasting. A continuous hydrological forecast for 5 days ahead was developed for 18 settlements in Bulgaria and for the border with Greece, thus giving enough reaction time in case of high floods. The paper discusses the practical implementation of models for the Arda basin, the method used to calibrate the models' parameters, the results of the calibration-validation procedure and the way the information system is organised. A real case of forecasted rapid floods that occurred after the system's finalisation is analysed. One of the important achievements of the project is the on-line presentation of the forecasts that takes into account their temporal variability and uncertainty. The web presentation includes a comparison of the forecasted river flow to three predefined alert levels.
4	Kazandjiev, Valentin; Georgieva, Veska; **Balabanova, Snezhana**; Malasheva, Petia; Determination of drought vulnerable regions in Bulgaria during contemporary period, Journal of balkan ecology, 2020,Volume:23, 1, Signature:Сп I 857, ID:LTU090055838 Dry spells and droughts are one of the major adverse factors for agriculture in the continental and temperate-continental climates, which are predominant in Bulgaria. In the years of contemporary climate, there is an increased frequency and intensity of local and global droughts. They cause very serious damage to agricultural production, resulting in the reduction of yield, the development of diseases and pests leading to completely compromise the harvest in individual years. The purpose of this study is to locate the areas of the country's agricultural territory, where dry spells and droughts occur most often on a multi-annual scale, Under conditions of increased frequency and intensity of drought as an adverse meteorological phenomenon, we identify the eligible land, according to the EU Parliament and Council Regulation 130512013 with a view to assisting farmers in areas with natural handicaps, in which

	the magnitude of drought is greatest. According to this Regulation, recommendations should be made to farmers.
5	Bezak, N., Petan, S., Kobold, M., Brilly, M., Bálint, Z., **Balabanova, S**., Cazac, V., Csík, A., Godina, R., Janál, P., Klemar, Ž., Kopáčiková, E., Liedl, P., Matreata, M., Korniienko, V., Vladiković, D., Šraj, M., A catalogue of the flood forecasting practices in the Danube River Basin, River Research and Applications 2021, pg 909-9018, DOI 10.1002/rra.3826, Review, Scopus, WoS Floods are one of the most devastating natural disasters that can cause large economic damage and endanger human lives. Flood forecasting is one of the flood risk mitigation measures serving to protect human lives and social estate. The Danube River Basin (DRB) is the world's most international river basin, flowing through the territory of 19 countries, covering more than 800,000 km2. The frequency of floods in the DRB increased in the last decades, urging the need for a more effective and harmonized regional and cross-border cooperation in the field of flood forecasting. Reliable and comprehensive hydrologic data are the basis of flood forecasting. This paper provides an overview of the national flood forecasting systems in the DRB. Detailed information about meteorological and hydrological measurements, flood modelling, forecasting, and flood warnings is provided for 12 countries that cover almost 95% of the total DRB area. Notably, significant differences exist among the countries in terms of the measuring network density, the models used as well as forecasting and warnings methodology. These differences can be attributed to the geographical and climatological setting, political situation, historical forecasting development, etc. It can be seen that there is still much room left for improvements of measurement networks (e.g., density, measured parameters) and models used that could be improved to enhance the flood forecasting in the DRB.
6	Yordanova, V., Koshinchanov, G., **Balabanova, S**., Analyses of simulations with ground and satellite data using fully distributed hydrological model, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM 2021, pg 9-16, DOI 10.5593/sgem2021/3.1/s12.02, Scopus During the last decades the extreme hydrometeorological events increased. Respectively the needs for more accurate estimation of the precipitation amounts have increased. One of the opportunities to get denser precipitation data in space and time is through the remote-sensing. Satellite-based products allow obtaining spatially distributed hydrologic variables and could be very useful in the modeling of the elements of the hydrological cycle. A big variety of hydrological models exist nowadays. In this study the fully-distributed, physically-based hydrological model TOPKAPI (TOPographic Kinematic APproximation and Integration) for simulating the rainfall-runoff processes is used. It is applied over a pilot watershed in Northwest Bulgaria (Ogosta river). Two types of precipitation data are used in this study: the precipitation from the H05b satellite product, produced in the framework of HSAF (Satellite Application Facility on Support to Operational Hydrology and Water Management) project, which is under the cap of EUMETSAT (European operational satellite agency for monitoring weather, climate and the environment); and the precipitation from the conventional monitoring stations of the National Institute of Meteorology and Hydrology in Bulgaria. There are presented analyses for two different from hydrological point of view years (2018 and 2019) - the first being wet year and the second - dry. Conclusions are on the simulations performed with the precipitation input data over the studied periods.
7	**Balabanova, S**., Koshinchanov, G., Stoyanova, V., Yordanova, V., Geodatabase for occurred floods to support preliminary flood risk assessment, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM 2021, r. 225-232, DOI 10.5593/sgem2019/3.1/S12.029, Scopus Floods are a phenomenon that over the centuries has a strong impact on societies around the world. An overview of historical information can help for better understanding the factors that lead to extreme events like floods. The description of past floods is an important part of the preliminary flood risk assessment. Such information is usually available in various documents, articles published in the media and etc. In order to assess the adverse effects of floods, it is

	necessary to analyze and combine different information. This paper presents the ability to use the Geographic Information Systems (GIS) applications for data processing. Data is presented as the information related to the recording of floods occurring on the territory of the Republic of Bulgaria. The Archive includes a GIS (.shp format) file presenting flood location with attribute data (e.g., type of flood, dates, duration, and fatalities). Hyperlinks are set up to connect affected area with excel file that is comprehensive set of synoptic, meteorological and hydrological information, based on data from National Institute of Meteorology and Hydrology (NIMH). Additionally layers with meteorological, hydrometric stations are presented. The data is organized in GeoDatabase.
8	**Snezhanka Balabanova**; Silviya Stoyanova; Vesela Stoyanova; Georgy Koshinchanov; Valeriya Yordanova, Hydrological forecasting and activities in Bulgaria in the framework of the DAREFFORT project, Proceedings of 22nd International Multidisciplinary Scientific GeoConference SGEM 2022, DOI 10.5593/sgem2022/3.1/s12.13, Scopus Floods are the most frequent and widespread natural disasters worldwide (WMO, 2013). In 2006 for instance, exceptionally high river levels caused loss of lives and considerable economic losses in Serbia, Bulgaria and Romania. Thus risk prevention strategies were reconsidered and the need for common solutions for the Danubian countries was outlined. Non-structural measures to mitigate flood risk as is the improvement of forecasting capabilities on a basin-wide scale are known to be highly effective. The DAREFFORT project is a horizontal initiative to implement a flood risk mitigation measure in a joint and sustainable way on catchment level. The main output was the Danube Region Enhanced Flood Forecasting Cooperation that was a step towards creating the basis of ICPDR Danube Hydrologic Information System (HIS). This was only reached through a standardized data format utilized by the responsible national organizations and improved data exchange between the participating countries as reliable and comprehensive hydrologic data is the basis of sound forecasting in any country. In this paper the Bulgarian experience and contribution to the DAREFFORT project is presented. This study is aimed at overviewing the present status of the national forecasting capabilities and main topics are the process of the hydrological forecasting, data flow, data processing and data exchange.
9	Valeriya Yordanova; Silviya Stoyanova; **Snezhanka Balabanova**; Georgy Koshinchanov; Vesela Stoyanova, Flash flood forecasting using flash flood guidance system products, Proceedings of 22nd International Multidisciplinary Scientific GeoConference SGEM 2022, DOI 10.5593/sgem2022/3.1/s12.11, Scopus Flash floods are defined as rapidly developing extreme events caused by heavy or excessive amounts of rainfall. Flash floods usually occur over a relatively small area within six hours or less of the extreme event with quite a rapid streamflow rise and fall. Increased occurrence of flash flood events is expected due to climate change and increase in extreme precipitation events [1]. Flash flood forecasting is still a challenge for hydrologists and water professionals due to the complex nature of the event itself. Besides having sufficient background in hydrological and meteorological forecasting as well as information about local conditions yet an adequate approach for flash flood forecasting is needed. The Flash Flood Guidance System (FFGS) is widely recognized for enhancing the capacity to issue timely and accurate flash flood warnings by providing hydrological and meteorological forecasters with real-time information and products. FFGS is based on global data as well as national hydrometeorological data and analyses. In this paper the use of the Black Sea Middle East Flash Flood Guidance System (BSMEFFGS) products for flash flood forecasting by the hydrologists at the Hydrological Forecasting department at the National Institute of Meteorology and Hydrology (NIMH) in Bulgaria is presented. An overview of the FFGS for Bulgaria with closer attention paid to the Flash Flood Guidance (FFG), Flash Flood Risk (FFR) and the Flash Flood Threat Products is introduced. Two case studies are also presented - a flash flood in the town of Shumen and another one in the area of the village of Popovitsa on September 28th 2015.
10	Vesela Stoyanova; **Snezhanka Balabanova**; Georgy Koshinchanov; Valeriya Yordanova; Silviya Stoyanova , Flood hazard mapping using two-dimensional hydraulic modeling results, Proceedings of 22nd International Multidisciplinary Scientific GeoConference SGEM 2022, DOI

	10.5593/sgem2022/3.1/s12.12, Scopus Floods are one of the deadliest natural disasters in the world. According to the World Meteorological Organization (WMO), this is a consequence of the increasing frequency of heavy precipitation, changes in upstream land use, and a continuously increasing concentration of population and assets in flood-prone areas [1]. For this reason, flood prevention, and protection are a growing priority these days. Flood hazard mapping is a state-of-the-art tool for decision-makers and stakeholders when it comes to flood protection and Flood Risk Management Plans. The visualization of the various parameters (range, depths, velocities, etc.) of a flood event gives a clear vision for implementing measures that help to protect and restore the natural functions of rivers and floodplains. This article presents the different types of flood hazard maps - with either a single parameter or a combination of several parameters (range, depths, velocities, and combination of flow velocity and flow depth. For this purpose, results obtained from 2D modeling with the software product HEC-RAS were used. The digital terrain model used was provided by Drone and has a resolution of 0.05 cm. Land cover information from CLC 2018 was used to determine the Manning coefficients. According to Art. 146e. of the Water Act (New, SG No. 61/2010) [2], several scenarios should be considered for Bulgaria: low-probability floods, medium-probability floods, and high-probability floods. As a result, a number of maps with different probabilities of flood occurrence and different flood parameters were obtained. These maps were used to analyze and assess potential damage in the different flood scenarios and parameters.
11	Vesela Stoyanova; **Snezhanka Balabanova**; Georgy Koshinchanov; Valeriya Yordanova; Silviya Stoyanova, A combined hydrological and hydraulic model for flood applied to the downstream Kamchia river, Proceedings of 22nd International Multidisciplinary Scientific GeoConference SGEM 2022, DOI 10.5593/sgem2022/3.1/s12.02, Scopus Future climate scenarios of the Global Circulation model (GCM) show an increased frequency of heavy rainfall events, which may lead to more severe floods. It is also expected that more and more areas will suffer due to flooding as a result of growing urbanization. Public attention has increased in many parts of the world in recent years and calls have been made to improve flood warnings, including the United States, the European Union and Australia (Hapuarachchi, H.A.P, and Q.J. Wang 2008). To respond and manage flood hazard there is a need to provide a high spatial resolution flood forecast and with sufficient lead time. This study presents an approach for creation of a forecast model based on the analysis of historical hydrometeorological data from conventional and automatic monitoring networks of the National Institute of Meteorology and Hydrology in Bulgaria. The study area is the downstream Kamchia river watershed. Real-time water level observations and calculated discharges based on temporary rating curves are used to dynamically adjust the runoff forecasting. In this paper an approach for combining a hydrological model (TOPKAPI) and a two-dimensional hydraulic model (HEC-RAS) for flood simulation is presented. Hydrological modelling is used for forecasting the outflow at a hydrometric station (43800) on Kamchia River near the village of Grozdyovo. The 2D hydraulic HEC-RAS model is used for simulating rainfall - runoff process in Kamchia watershed downstream of the village of Grozdyovo and the results from the hydrological modeling are used as an input data. In this paper the results of using operational hydrological data and forecast precipitation totals for flood simulation is presented.
12	**Balabanova, S.**, Stoyanova, V., Yordanova, V., Neural network-based models for Struma river flow forecasting, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, 2023, 23(3.1), pp. 107–113 Accurate river flow forecasting is an extremely important issue for proper management and optimal use of water resources as well as for warnings of extreme hydrometeorological events. Rainfall-runoff simulation is essential for short and longterm forecasting of the river discharge. Determining the relationship between rainfall and runoff is one of the most important tasks faced by hydrologists. This relationship is a nonlinear and extremely complex process influenced by many factors such as watershed topology, vegetation cover, soil types, river bed characteristics, groundwater aquifers, precipitation distribution, snowmelt, rural and urban activities. Artificial

	Neural Networks (ANNs) are known as powerful and flexible models and are widely used in hydrology and forecasting. This paper aims to demonstrate the research and operational application of ANN in hydrologic modeling to construct an effective operational forecasting system of stream flow and potential flood risks in the studied area. The studied area is the Struma river Basin. The availability of long historical records and a good physical understanding of the hydrologic process in the area are very important in selecting the input predictors and designing a more efficient network. Historical data from automatic stations for the period 2015 - 2022 is selected to create the networks. The six hourly precipitation, daily temperature and runoff data from eleven subwatersheds are collected and used in developing the ANN. Additional analyses of lags are performed using correlation analysis of runoff at hydrometric stations at the outlet of the watersheds and correlation analysis of runoff and accumulated precipitation data in watersheds. The statistical estimates are Nash Sutcliffe model 0.8 - 0.9, MSE - 0.04 - 0.149, MAE 0.13 -0.176 and R 0.8-0.98. Operational forecasting is based on data from the global weather model ECMWF.
	Publications in group G7 (Bulgarian version "Г7")
1	Ninov, P., **Balabanova, S.,** Evaluation of the flooded areas based on historical information in eastern aegean basin of bulgaria, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM 2021, p 83-89, DOI 10.5593/sgem2021/3.1/s12.12, Scopus Floods are natural phenomena which cannot be prevented. In order to avoid and reduce the adverse impacts of floods for human health, the environment, cultural heritage and economic activity it is important to provide flood risk management plans. Development of flood risk management plans under Directive 2007/60/EC are elements of integrated river basin management. For the implementation of Directive 2007/60 / EC, Member States need to carry out a preliminary flood risk assessment based on available or readily derivable information. Based on this flood risk assessment, areas are identified where a potential significant flood risk exist or might be considered likely to occur. As part of a preliminary flood risk assessment, it is necessary to describe floods which have occurred in the past and which had significant adverse impacts on the protected categories "Human Health", "Environment", "Cultural Heritage" and "Economic Activities" and where there is a likelihood of recurrence of similar future events. In order to obtain as much information as possible about past floods, different sources of information were used for data collection. The results of the following data collection methods are taken into account: survey of municipalities through a questionnaire on past floods, a list of information of specialized services and departments and evaluation of available materials from literature sources, websites, scientific articles and monographs. After processing, analysing and evaluating the information provided by the various sources, it was found that, for the Eastern Aegean Basin, the main reason for the floods is intense, prolonged rainfall. Another type of floods, common for the basin, is flash floods resulting from intensive (up to 6 hours) rainfall. A small part of the documented floods (three) are as result of sewage overflow. Criteria for the number of affected inhabitants and material damages in the settlements, infrastructure and agriculture are applied. As a result of the analysis and evaluation of the information, 23 sensitive areas have been identified in the region. When identifying potential flood risk areas based on the provided information, there is a risk of missing such areas for which insufficient or complete historical information has been collected. To approximate these areas, an approach with the introduction of a criterion for horizontal distance from the river bed was used. 1D hydraulic modeling and GIS were used to determine the flooded areas in the defined areas at risk in terms of future flood risk.
2	**Balabanova, S**., Stoyanova, V., Simulating flash floods in urban areas using two-dimensional hydraulic model, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM 2021, p 239-246, DOI 10.5593/sgem2021/3.1/s12.38, Scopus Urban floods, which are most often caused by intensive rainfall and the fast formation of surface runoff, cause great damage to the urban population and infrastructure. Due to the stochastic

	(random) nature of precipitation, it is not entirely possible to achieve reliable operation of sewer systems. We can only try to design and operate them in the most reliable way. Urbanization and changes in climatic conditions are one of the main factors for increasing the frequency of flash and rain floods in urban conditions. According to the World Meteorological Organization (WMO), flash floods are among the most dangerous natural phenomena with the highest mortality (deaths / affected people) and cause devastating property damage every year. Flash floods modeling are an important tool for forecasting the phenomena and for effective flood mitigation. Due to the physical characteristics of convective precipitation, the time to forecast flash and rain floods, in a contrast to river floods, is very short. This article presents an approach to modeling flash floods in an urban area. The method is performed using two-dimensional (2D) modeling with HEC-RAS software. The computational mesh for terrain representation is 0.05 m. Detailed terrain data for mesh generation in the 2D model was provided by Drone. Land cover information from CLC 2018 was used to determine the Manning coefficients. A simulation was conducted including main streets and buildings in the area in order to evaluate the influence of streets in the flooding. Two more values of the Manning coefficient were added manually, one for the riverbed and one for buildings and streets. Data from meteorological measurements were used to evaluate the 24 hourly maximum of the rain with probability 5%, 1% and 0.1%. Flood maps from the simulation of 20-, 100- and 1000-year-hyetograph are presented.
3	Spiridonov, V., **Balabanova, S.,** The impact of climate change on intensive precipitation and flood types in Bulgaria, Climate and Land Use Impacts on Natural and Artificial Systems: Mitigation and Adaptation, 2021, p. 153-169, DOI 10.1016/B978-0-12-822184-6.00001-6, Book Chapter, Scopus The ALADIN-Climate regional model was used to simulate climate change with a reference period 1961-90 and a future period 2021-50. The model operates with precipitation amounts for 6 hours. This imposes the use of one of the thresholds accepted in the practice of NIMH, as well as on the Meteoalarm website of 15 mm/6 hours, as a necessary condition for the occurrence of floods. The climate change signal shows an increase of cases with intensive rain in some areas, although the amount of precipitation may decrease overall. The least affected area of high rainfall intensity is Eastern Bulgaria, except Strandja Mountain. The areas with an increased number of intensive rainfall cases are Western and Northwestern Bulgaria. It was also investigated how climate change would affect the intense rainfall at NIMH climate stations. Rain measurements in the climate stations during the period 1961-90 are for 24 hours. Comparing the 24-hour amounts with the rainfall intensity measured by automatic stations installed in a later period, it was found that rainfall with intensity greater than 15 mm/6 hours can be observed if the 24-hour rainfall exceeds 35 mm/24 hours. This value was used to analyze climate change in 52 climate stations. It is known that intensive rainfall occurs mainly in warm seasons. Climate experiments show an increase in temperature in the future for all seasons. Observation records do not indicate whether precipitation is snow or rain, or whether it is stratiform or convective. To have comparability between the reference and future period, instead of the seasons, we used the condition that the minimum and maximum temperatures during the day should be above 10°C and 20°C, respectively, no matter what the season is. This gives a priority to the convective rainfall, which is the main type of precipitation causing flooding. The impact of climate change on the spatial and temporal variability of flood characteristics has been evaluated. Special attention was paid to flash and pluvial floods that are most affected by climate change.
4	Koshinchanov, G., Balabanova, S., Hydrological modelling using remote sensing techniques in Bulgaria, Proceedings of SPIE - The International Society for Optical Engineering 2019, DOI 10.1117/12.2533155, Scopus, WoS The availability of detailed well distributed in space information on precipitation is of essential importance for the hydrological modeling and forecasting. Conventional measurements of precipitation are in a limited number of points represented by synoptic, climatic and precipitation stations. This information is not sufficient for correct spatial distribution of precipitation. The distribution of the ground stations are quite irregular and thus distances between stations could be quite big, sometimes more than 35 km. On the other hand, precipitation has high variability in

	space. One of the possibilities to achieve high density gridded precipitation is remote sensing techniques such as products derived from satellites, radars etc. One of the aims HSAF project is to produce different products for precipitation, snow and soil moisture in order to facilitate the hydrological modelling. Bulgaria, in particular NIMH, is a partner in HSAF project since 2009 and the obligations are to validate and hydrovalidate these products. This paper will present simulations with MIKE11 and Artificial Neural Networks (ANN) over two different basins in Bulgaria using precipitation data from the HSAF's H05 product. Analyses will be made using data for the period June 2016-May 2017. Conclusions will be made on the behaviour of the precipitation product over the two basins and will be discussed the possibility to use this product.
5	Velizarova, Emiliya; **Balabanova, Snezana**; Marinov, Ivan, Assessment of current and future drinking water quality vulnerability under anticipated climate changes at the watershed level, Advances in Geoecology 45. CATENA soil sciences, 2018, ISBN 978-3-510-65418-5, US ISBN 1-59326-267-1, pp14-24, WoS Sustainable management of freshwater resources has gained increasing importance at regional, national and global scale. Climate and freshwater quantity and quality are interconnected in complex ways. Vulnerability of surface water quality for drinking water supply is mainly due to the change in using land, which is related to climate, hydrology and water resources management. Different catchments at one and the same region respond differently to such changes, depending largely on catchemnt’s physico-geographical and hydrogeological characteristics and on the amount of reservoir or groundwater storage in that catchment. The purpose of the present study is to assess the current and make predictions on future drinking water quality vulnerability ot the watershed level of the Ticha river lake (reservoir) under anticipated conditions of climate change. The applied methodological approach was based on assessing the main drivers that cause higher vulnerability of drinking water quality – land cover and land use practices. Pollution indices (PLIj) for each class of the CORINE land cover for 2006 within the Ticha watershed reservoir and water quality indexes were calculated taking into account export coefficients for nitrates and phosphorus. Maps for distinct scenarios of the future land use for the studied territory were developed according to the methodology, proposed in the Prospective Environmental analysis of Land-Use Development in Europe (PRELUDE) project. It was found that in terms of water quality vulnerability – only small watersheds used for agriculture purposes are moderately vulnerable. Over the forecast period – 2020-2050 the watershed area is anticipated to remain in the same vulnerability category.
6	Stoyanova, S., **Balabanova, S.**, Hydrological modelling with the soil and water assessment tool: Spatial data processing for identifying model parameters using geographic information system, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM 2019, p. 253- 258, DOI 10.5593/sgem2019/3.1/S12.033, Scopus River basin management is at present of great importance as a response of the increased frequency of extreme hydrological events in a changing climate. The emerging need for streamflow control awaits a capable hydrological outcome. Data collection and processing are the essence of a proper representation of the hydrological processes in a watershed. The main objective of this study is to introduce an approach for a watershed spatial variability processing hence determining the parameters for building up a hydrological model. The ArcSWAT geographic information system (GIS) interface for the Soil and Water Assessment Tool is used. Geographic Information System (GIS) is a very successful tool for analyzing spatial relationships between important hydrologic features such as rivers, diversions, drains and monitoring points. The ArcSWAT model is a geodatabases system storing the Soil and Water input information and results. The Soil and Water Assessment Tool (SWAT) is an open source watershed scale, semi-distributed hydrological model. Preprocessing of the initial inputs to the SWAT model via the ArcSWAT GIS interface is presented in this paper: digital elevation model set-up for a selected watershed, soil properties and landcover data processing, integration of the attributed data, determining the basic hydrologic parameters for which SWAT model calculations are performed. Statistical evaluation and analysis of the outputs are also presented together with outlines for their further use.

	Publications in group G8 (Bulgarian version “Г8”)
1	Dobri Dimitrov, Snezhanka Balabanova, Georgy Koshinchanov , Merged satellite information and ground measurements of the precipitation for hydrological modeling, EUMETSAT conferefence, September 2012 The availability of detailed well distributed in space information on precipitation is of essential importance for the hydrological modeling. Conventional measurements of precipitation are in a limited number of points represented by synoptic, climatic and precipitation stations. This information is not sufficient for correct spatial distribution of precipitation. The distribution of the ground stations are quite irregular and thus distances between stations could be quite big, sometimes more than 30 km. On the other hand, precipitation has high variability in space. The results of the spatial distribution depend on the density of the ground measurements. Precipitation estimated from satellite information includes spatial information that could be used to ameliorate precipitation field based only on ground stations. This paper presents the results of an application that merges satellite information with conventional ground measurements of the precipitation for hydrological modeling purpose. Hydrological simulation will be performed with 3 types of precipitation fields. Simulation using satellite information for precipitation, simulation with real measured precipitation and with merged information for precipitation. Geographic Information System (GIS) and ArcInfo techniques will be applied for spatial distribution and spatial analysis of the precipitation data. Relevant analyses and conclusions will be provided.
2	**Sn. Balabanova**, G. Koshinchanov, S. Stoyanova, V. Stoyanova, V. Yordanova, N. Filipov, A. Gardeva, I. Galabova, The floods and floods precondition in 2014, Bulgarian journal of Meteorology & Hydrology, vol.20, issue 5, pp. 73-104, 2015 Floods are without a doubt among the most devastating natural disasters, affecting many regions of the world every year. Flooding was a major problem for Bulgaria in 2014. During the year many urban, industrial and rural areas were flooded. The consequences of floods are loss of human life, property, crops and a very negative impact on human well-being. Floods are hydrometeorological phenomena and occur when specific meteorological and hydrological conditions are present at the same time. Except however for floods that occur as a result of the destruction of a protective or retention facility. In this paper the meteorological situations, which in combination with certain hydrological precondition led to floodings are described and analyzed. Situations leading to either flash or fluvial floods are presented. Flash floods are rapidly developing extreme events resulting from intense rainfall over relatively small watersheds. Fluvial floods occur due to heavy rainfall for an extended period of time thus resulting in rivers water level rising and overflowing.
3	G. Koshinchanov, E. Artinyan, **Sn. Balabanova,** Validation activities on some of the elements of hydrological cycle in the framework of HSAF project, INHGA - Scientific Conference, Romania, ISBN 978-973-0-18825-7, pp. 85-92 The availability of detailed well distributed in space information on precipitation is needed for the successful hydrological modelling and flood forecasting. Conventional measurements of precipitation are in a limited number of points represented by synoptic, climatic and precipitation stations. This information is not sufficient for correct spatial distribution of precipitation. The distribution of precipitation measuring stations in Bulgaria is quite irregular and thus distances between stations could be quite big, sometimes more than 30 km. On the other hand, precipitation has high variability in space. Precipitation estimate from satellite information has spatial information that could be very useful in the task to decrease precipitation grids. One of the projects which main task is to provide new satellite-derived products is H-SAF. H-SAF is project for developing products based on satellites for The "EUMETSAT Satellite Application Facility on Support to Operational Hydrology and Water Management” (http://hsaf.meteoam.it/). The main objectives of the project are to provide new products from existing and future satellites with sufficient space resolution to satisfy the needs of operational hydrology for the following products: precipitation, soil moisture, different types of snow parameters. NIMH - BAS became partner in the project in 2009. Its activities are to validate different type of

	products i.e. different type of precipitation, soil moisture and snow products and to take active participation in the preparation of validation methodologies for the different products. This work will focus on the results from the validation of precipitation for the period 1.07.2012-30.06.2013 over the pilot territory of Bulgaria. The validation methodology includes extracting of the precipitation estimates from satellites and comparing them with the existing ground data. Several categories are used depending on the precipitation intensity. Several statistical scores for each category will be discussed.
4	Georgy Koshinchanov, **Snezhanka Balabanova**, Michal Veverka, Hydraulic Modeling of High Wave With Different Return Period in The Section Between The Towns of Plovdiv and Parvomay Along Maritsa River Using MIKE11 Platform, BULAQUA 3/2015, pp. 82-89, ISSN 1312-3912 The number of extreme events that are observed over the Bulgarian territory has increased during the last decades, i.e. intensive rainfall, floods etc. They cause significant damages and sometimes even cause human losses. In this aspect the prevention is one of the compulsory measures that should be implemented in order to mitigate the negative effects of the extreme events. In this paper are shown the methodology for creation of flood hazard maps along Maritsa in the region between the towns of Plovdiv and Parvmay. The flood maps are created for different scenarios using hydraulic model MIKE11 and GIS software ArcGIS and are for the implementation of the Flood directive EC 60/2007.
5	Ilcheva, I., Niagolov I., **Balabanova Sn**., Yordanova A., Zaharieva V., Rainova V., Vatralova A., Georgieva D., Water resource balance for Vitosha natural park, including analysis under conditions of climate change and extreme phenomena, Iinternational Scientific Conference Proceedings, SUSTAINABLE MOUNTAIN REGIONS: MAKE THEM WORK, 14-16 May, 2015, Borovets, e-book, ISBN 978-954-411-220-2, pp. 246-253 This report presents some results of implementing the studies of the National Institute of Meteorology and Hydrology (NIMH) on the Development of water balance of the Vitosha Natural Park (NP) financed under the Operational Programme Environment 2007-2013. Water resources are under increasing pressure from climate change and land use. The results of the global and regional climate models confirm that these tendencies for the effect on water resources and water demand will continue. The results of NIMH researches show that mountainous areas are affected to a lesser extent by the effects of climate change and extreme events – floods and drought, but some negative tendencies are established. For the aims of the Vitosha NP management, water and water resource system (WRS) balances are developed for different scenarios. A new methodological approach to the assessment of the water and WRS balance has been elaborated with integrated analysis of all elements (precipitation, temperatures, evapotranspiration, soil and land cover, hydrogeology, water intake and water use, water transfer, WRS, etc.). A water use scheme, a methodological approach and a simulation model of WRS have been developed. Simulation modeling of the WRS balance of the Vitosha NP, including analysis in terms of climate change and extreme events (drought and flood), has been developed. A methodology for ecological flow determination is applied. Assessment and analysis of drought conditions, which include analysis of drought with hydrological series modeling and drought index analysis are made. Evaluation of high water is developed. Areas at risk, taking into account the natural and anthropogenic factors in GIS environment, are analyzed. According to the results of the analysis and appropriate long-term strategic and shortterm measures are developed. Recommendations and management measures are given. The developed water and WRS balances are the first ever comprehensive study for the Vitosha NP water resources and for the possibilities of their use.
6	Valery Spiridonov, **Snezhanka Balabanova,** Retrieval of 6-hour peak rainfall from 24-hour measurements Bulgarian Journal of meteorology and hydrology, volume 22, number 5, pp. 61-70, ISSN 0861-076, 2017 The article provides a methodology for retrieval of the 6 hour peak precipitation from the 24-hour measurements performed in the climatic and rainfall networks of NIMH. This is the maximum

	rainfall that can be measured for 6 hours within a 24 hour interval and is one of the indicators for issuing flash and rainy flood risk warnings. These are floods caused by torrential or excessive rainfall over a short period of time, usually within or less than 6 hours on a small area. The task of identifying areas with increased risk of such floods has not been enough reliably solved The methodology developed here allows the accumulated precipitation records in the mentioned stations to be used more fully to identify the risk areas mentioned. The methodology only concerns summer rainfall with a 24-hour amount over a certain threshold. An analysis of their structure was carried out in one-hour periods, based on four yearly records from the system of objective analysis using ground and satellite information. Thus, the relationship between rainfall in both periods is determined, as well as the area in which it is reliable.
7	Valery Spiridonov, **Snezhanka Balabanova,** Influence of climate change (by 2050) on the intensive rainfall on the territory of Bulgaria, Bulgarian Journal of meteorology and hydrology, volume 22, number 5, pp. 26-37, ISSN 0861-0762, 2017 The article provides a methodology for retrieval of the 6 hour peak precipitation from the 24-hour measurements performed in the climatic and rainfall networks of NIMH. This is the maximum rainfall that can be measured for 6 hours within a 24 hour interval and is one of the indicators for issuing flash and rainy flood risk warnings. These are floods caused by torrential or excessive rainfall over a short period of time, usually within or less than 6 hours on a small area. The task of identifying areas with increased risk of such floods has not been enough reliably solved The methodology developed here allows the accumulated precipitation records in the mentioned stations to be used more fully to identify the risk areas mentioned. The methodology only concerns summer rainfall with a 24-hour amount over a certain threshold. An analysis of their structure was carried out in one-hour periods, based on four yearly records from the system of objective analysis using ground and satellite information. Thus, the relationship between rainfall in both periods is determined, as well as the area in which it is reliable.
8	Valeriya Yordanova, **Snezhanka Balabanova**, Vesela Stoyanova, Application of the TOPKAPI model on the Ogosta river basin“, Electronic book with full papers from XXVII Conference of the Danubian Countries on Hydrological Forecasting and Hydrological Bases of Water Management, ISBN 978-954-90537-2-2, pp. 357-364, 2017 The flood forecasting and warning systems are essential in regional and national strategies to protect the population and the infrastructure from flooding. Recently they are widely used as a tool in flood forecasting and to assist the decision makers to manage extreme events. The hydrological processes are very complex and the hydrological and hydraulic models are the main components in the flood forecasting and warning systems. They identify the dominant hydrological processes which influence the water balance and result in conditions of extreme water events. There are variety of hydrological models. Nowadays with the development of the automatic stations networks, the ability of satellite information, numerical weather prediction models with high resolution and digital spatial information for elevation data, soils and land cover the fully distributed hydrological models are broadly used in flood forecasting. In this study the physically-based and fully distributed hydrological TOPKAPI (TOPographic Kinematic APproximation and Integration) model is applied on Ogosta river basin. The model utilities three non-linear reservoir differential equations for the drainage in the soil, the overland flow on saturated or impervious soil, and the channel flow along the drainage network. The advantage of the model is that it is physically based and the model parameters can be directly obtained from the existing spatial datasets. Meteorological information for 21 stations and hydrological information for 10 stations are used to set up the model. The model is calibrated for 2009-2012 and validated for 2014 year. The years are selected after analysis of the rainfall and flow data. The data set includes periods with high waves and with flow data below long-term averages. After sensitive analysis the most sensitive parameters controlling the runoff production are obtain and applied in a model in order to minimize root mean square error (RMSE) objective function comparing modelled and observed discharges at a daily time step.
9	Vesela Stoyanova, **Snezhanka Balabanova**, Valeriya Yordanova, Evaluation of the thresholds for flood forecasting and warning, Electronic book with full papers from XXVII Conference of

	the Danubian Countries on Hydrological Forecasting and Hydrological Bases of Water Management, ISBN 978-954-90537-2-2, pp. 435-443, 2017 One of the most important task for hydrological forecasters is to decide if the simulated discharges exceed critical discharges and decide on whether a flood warning should be issued or not. This leads to solving: 1) How to define critical thresholds along all the rivers under survey? 2) How to link locally defined thresholds to simulated discharges, which result from models with specific spatial and temporal resolutions? This study is focused on the assessment of critical thresholds and is a preliminary step for the development of flood forecasting and warning system. Hydrologically based thresholds rely on observed river conditions and forecasts. The process can involve various approaches, from the use of simple correlation techniques between upstream and downstream sites to complex hydrological or hydraulic model based warning levels. A study of scientific literature and good practice related to the problem has been made. After considering available hydrological information and local conditions, some of the methods have been applied to the rivers Cherna and Biala in the Arda river catchment. High waves along the rivers in 2005 and 2006 lead to floods in Smolyan town and causing loss of lives and property. Quantitative characterization of discharges are used to characterize the river discharge/level as low, medium and high. Duration curves for the monitoring stations are defined with historical data series using daily mean discharges/levels. The traditional flood warning approach is also applied. In this method warning thresholds levels are defined based on preliminary determined flood hazard prone area for different scenarios. HEC-RAS model is used for multiple profile analysis and flood threshold levels/ runoffs are identified along the river. This provides the basis for developing threshold-stage based flood early warning system in these rivers. For the studied region will be presented development of warnings based on impact and according WMO recommendation.
10	Valeriya Yordanova, **Snezhanka Balabanova,** Forecasting river flow using distributed hydrological model (TOPKAPI), Bulgarian Journal of Meteorology and Hydrology, Volume 23, Number 1, pp. 80-96, ISSN 0861-0762, 2019 Streamflow forecasts with sufficient accuracy and lead time are important to water managers and emergency protection services. To provide these forecasts hydrologists need to predict the behavior of complex coupled human–natural systems. Hydrological forecasting models are used extensively for simulation of river flows in both flood and drought events. The evolution of physically based hydrological models in recent years has significantly improved the ability to describe and represent the hydrological processes at a basin scale. In this thesis the TOPKAPI model (TOPographic Kinematic Approximation and Integration) was applied to the Ogosta river for simulating the rainfall-runoff processes for the watershed. TOPKAPI is a fully-distributed, physically-based hydrological model and is widely used for continuous streamflow modelling. The TOPKAPI model was set up for the period 2009-2014: calibration was performed using five years of data (2009 – 2013) and data for the year 2014 was used for model validation. The model was applied with a grid size of 250m/250m and a time step of 24 h. Due to TOPKAPI physical basis, model parameters were derived from digital elevation maps, soil maps and land cover maps.
11	Georgy Koshinchanov, **Snezhanka Balabanova,** Verification of hydrological forecasts, Bulgarian journal of Meteorology & Hydrology, vol.24, issue 1, pp. 40-54, ISSN 0861-0762printed version, ISSN 2535-0595 The possibility of simulating and forecasting of discharges and water levels is of great importance nowadays. It is also important to know how accurate a given forecast is. That is why a verification of the forecast should be an integral part of the forecasting. The process of continuous checking of the quality of the hydrological forecasts provides valuable information for both the forecasters and the forecast users (Welles, et al., 2007). The information can be used to evaluate forecasts, to improve them and how to use forecast products. This information is also important for specialists who develop different models (hydrological, hydraulic and empirical). Hydrological forecast verification can be applied to various hydrological phenomena, such as snowmelt runoff, high waves, low waters, also for floods and droughts. Due to the great

	importance of this process, the article will focus on this aspect of the forecasts, using the achievements of the PhD thesis for the catchment of the Rusenski Lom River (in particular for the catchment of the Cherni Lom River to the Shirokovo hydrometric station).
12	**Balabanova, Sn.,** Stoyanova, V, Comparison of one- and two-dimensional models for flood mapping in urban environments, XXIX Conference of the Danubian Countries, 2021, ISBN 978-80-7653-031-7, full papers, 61-66 Floods are natural phenomena as a result of a combination of natural, geological and anthropogenic factors. Every year, floods cause loss of life, economic losses, adverse effects on the environment and cultural heritage all over the world. Floods are complex processes that have to be properly analyzed in order to know the exact spatial and temporal changes during a flood as well as the causes of these changes. Hydraulic modeling is used to model river flows, delineate floodplains, analyze flood characteristics, to identify the causes of flood and flood consequences. The 'Floods Directive' 2007/60/CE by the European Parliament requires all Member States shall prepare flood hazard maps according to the three scenarios: (a) floods with a low probability; (b) floods with a medium probability; (c) floods with a high probability. For each scenario the flood extent, water depths or water level and the flow velocity should be shown. To assess this, complete analyses of the watershed hydraulics based on one, two or even three-dimensional modeling are needed. Traditionally, 1D models have been used to simulate river floods using Saint-Venant equations. The final results of the modeling are the average velocity and water depth in each cross-section. Generally, 2D models are used for local surveys in places with complicated hydraulic conditions, where it is important to have detailed information in flooded areas on the spatial distribution of the speed and water depth. In this study, a 2D hydraulic model using HEC-RAS software for river flow and floodplains modelling was applied on part of the town of Smolyan, where the Biala River flows into the Cherna River (Fig.1). According to Flood Directive 2007/60/EC this area in the phase of Preliminary Flood Risk Assessment was defined as an area with potentially significant flood risk. In the frame of development of flood warning system under ARDAFORECAST project between Bulgaria and Greece, 1D modeling was applied for the segment of the Arda river in the region of the town Smolian. This paper presents a comparative analysis of the performance of 1D and 2D modelling of floods in an urban area with respect to the generation of inundation for flood events with 20, 100 and 1000 – year return periods. The 1D analysis and 2D modelling are performed using the software HEC-RAS.
13	Georgy Koshinchanov, **Snezhanka Balabanova,** Improving the flood forecasting by reducing the time step, Bulgarian Journal of meteorology and hydrology, volume 25, number 1, pp. 29-44, ISSN 0861-0762printed version, ISSN 2535-0595 (online version), 2021 Floods are one of the most dangerous natural phenomena. They often have human casualties. In order to mitigate the adverse effects of floods, it is especially important to take preliminary preventive measures. In order to take adequate and timely measures, it is necessary to forecast the extreme event with sufficient lead-time and accuracy, both in time and space. The present study presents flood forecasting with optimization of the time step for the catchment of Fakiyska river. The reason for this study is that very often the interval between the time of precipitation and the flood occurrence is less than 24 hours. The Fakiyska river catchment was chosen because significant floods have occurred in the past and during the development of the preliminary flood risk assessment, the catchment has been identified as an area with a significant potential risk of future pluvial floods (https://bsbd.org).
14	Igor Niagolov, Krasimira Nikolova, Irena Ilcheva, **Snejana Balabanova**, An Assessment and Mapping of Water Resources Vulnerability in the Reservoir "Ticha" Watershed. BULAQUA, 2, 2015, 46 - 54, ISSN 1312-3912 Climate changes indicating temperature increase and precipitation decrease influence significantly water resources, land use, economic development and environment. Some extreme events such as floods and droughts become more frequent. The established significant trend of drought in the region of Southeast Europe (SEE) causes a water stress, vulnerability of water resources, beginning of shortages in water supply and threat for biodiversity. The international scientific project CC –WARE was aimed at the development of an integrated transnational

	strategy for water resources protection and mitigation of their vulnerability in relation to the climate change and land use in the countries of SEE taking into consideration the ecosystem services of forest for supplying pure drinking water. A corresponding methodology of vulnerability assessment was elaborated on two levels: transnational which gives a common assessment for the whole SEE and regional (on local test areas of each one of the participating countries), which considers the peculiarities and national legislation. In this article some results from the investigations carried out for the test area "watershed of reservoir Ticha" according to the working package 3 of the project are given. An assessment of the present and future surface water resources vulnerability concerning water quantity and the water supply risk has been made. A methodology is proposed in case of water resource system using two types of indices for vulnerability assessment: water exploitation index WEI and water shortage index WSHI with its system of probability indices –probability of exceedence (reliability) by volume, by years, by months and reliability index. Two time periods are investigated: basic 1961-1990 and future 2021-2050. The main climate factors such as temperature, precipitations and evapotranspiration are being analyzed for both periods. Based on both types of indices some conclusions are being made about the vulnerability of the separate rivers, because they are loaded with water consumption to a different extent. The reservoir "Ticha" catchment can be defined as "medium vulnerable" for the basic period. In the future the vulnerability increases due to the decrease of river runoff –assessment expressed in terms of high values of WEI and big shortages WSHI classifies some part as of the watershed as "highly vulnerable". Some vulnerability maps are made. The availability of water resources vulnerability even now in this region demonstrates that in case of draught the vulnerability will grow up and it is needed to mark out some measures for mitigating the consequences of draughts and adaptation to the foregoing climate changes.
15	V. Spiridonov, I. Ilcheva, **Sn. Balabanova**, I. Niagolov, Mitigating Vulnerability of Water Resources under Climate Change, 2014c, CC-WARE project, broshure prepared by Project Partner 08, Executive Forest Agency and associated organizations, Forest University, Forest research Institute, NIMH, 2014b Vulnerability of water resources in south-eastern Europe to climate change. Climate is a major driver of changes in water resources. The precipitation, temperature and evapotranspiration are most commonly used for water resource assessment and forecasting. For this purpose, the CC-WaterS project climate change data were used, which were obtained from 3 regional climate models: RCMs (RegCM3 – ITCP, Aladin – CNRM, Promes – UCLM) based on the A1B scenario. Periods: 1961-1990 (baseline climate interval), 1991-2020 (current state), 2021-2050 (future state). The main climate indicators were examined and analyzed: Precipitation (RR), Temperature (T), Potential and actual evapotranspiration (PET and AET). Additional climate indicators presented: UNEP Drought Index, De Martonne Drought Index. Results: Southeast Europe is not homogeneous in terms of climate change. Temperature: tendency to increase (especially in the summer season). Precipitation: decreasing trend (especially in southern parts). Evapotranspiration: strong increase across south-eastern Europe. Drying: relatively stable; serious increase in some areas (including Romania, Bulgaria and Greece). The sensitivity of water resources to climate has been studied. Changes. Available water was calculated as a simplified water balance: $Q = P - AET$, where Q is the total runoff (surface and underground). For all periods, it is evident that the total runoff in the Alps and the Carpathians is high, while in all other parts it is quite low, which means less available water. The differences in periods were very small, therefore the relative difference in absolute values of total runoff (ΔLTR) was calculated. A slight rise has been observed in the mountainous parts of the Alps and the Carpathians. The total outflow is likely to be slightly larger in the future period. On the other hand, in the western and eastern parts of Greece, northeastern Bulgaria and southeastern Romania, the scenarios show a decrease in total runoff.