Scientific Report

concerning the implementation of the project

Assessment of the Climate Change effects on the WAve conditions in the Black Sea - ACCWA

in the period January - December 2018

In the second stage of the project implementation carried out in the period above mentioned, the specific objectives of the project were pursued:

1. Simulations with the wave climate system for the 'near future' period (2021-2050), RCP4.5 şi RCP8.5 scenatios (simulations for 60 years)
2. Simulations with the wave climate system for the 'future' period (2071-2100), RCP4.5 şi RCP8.5 scenarios (mulations for 30 years)
3. Dissemination of the results

1. Simulations with the wave climate system for the 'near future' (2021-2050), RCP4.5 şi RCP8.5 scenatios (simulations for 60 years)

The next step was to perform projections concerning the sea state conditions in the Black Sea basin corresponding to the near future time interval (2021-2050). The same wave modelling system based on SWAN (Simulating WAves Nearshore, Booij et al., 1999) model, as in the case of the historical simulations (1976-2005), was considered, but this time the input wind fields produced by the RCA4 (the same RCM – Regional Climate Model as in the case of the historical simulations) were those simulated under Representative Concentration Pathways (RCPs) scenarios.

It was found that the climate feedback significantly depends on the global warming and also probably on the history of the forcing. The global warming considers as a climatologically base the year 1850 and goes up to 2080–2100. The four RCP scenarios are RCP2.6, RCP4.5, RCP6, and RCP8.5 (Moss et al., 2010; Van Vuuren et al., 2011). They are named after the possible range of radiative forcing values in the year 2100 relative to the pre-industrial values. Thus, RCP 2.6 assumes that the global annual greenhouse gas emissions (measured in CO_2-equivalents) will have a peak in the interval 2010-2020, with emissions declining substantially thereafter. In such case, at the end of the century a temperature increase of about 1.5°C is expected, while the radiative forcing value will be about 2.6W/m^2. In RCP 8.5, it is assumed that emissions continue to rise throughout the 21st century and an increase of about 4.4°C is expected until 2100 with a radiative forcing value that will exceed 8.5W/m^2. Actually, the most studied greenhouse gas concentration scenarios are RCP4.5 and RCP8.5, and for this reason they will be further considered. Thus, RCP4.5 describes an intermediate concentration scenario with radiative forcing stabilized at around 4.5 W/m^2.

1.1 Wind speed analysis for 'near future' (2021-2050)

Various studies show that the wave conditions in the Black Sea are very sensitive to the climate changes, especially as regards the changes of the wind fields. Thus, the changes expected in the configuration of the environmental matrix concerning the wind speed may also induce new and completely different patterns in the future wave climate. For this reason, first comparisons of the data from the recent past with the near future projections of the wind speed can provide a perspective of the possible changes that can occur in the near future wave climate from the Black Sea. Furthermore, as a function of the greenhouse gas emissions/concentrations (reflected in a different way in RCP4.5 and RCP8.5) these changes can be more or less accentuated. Some comparisons between the wind fields simulated under RCP4.5 and RCP8.5 scenarios were performed in order to identify the differences induced by these two different scenarios. On the other hand, the comparisons between the recent past wind fields and those obtained under various scenarios are indicating the possible further evolution of the wind conditions.

An estimation of the expected wind climate in the near future (2021-2050) under two different RCP scenarios (RCP4.5 and RCP8.5) was made by Ganea et al. (2018), toghether with an evaluation of the climate change impacts on the wind speed and wind energy potential by performing comparisons between the past predictions and the future projections. Taking into account some previous studies that showed the existence of various areas in the Black Sea presenting different wind conditions, the target area was divided into five geographical zones with similar characteristics/patterns, labeled from A to E. In each area various reference points located in deep and shallow water were defined.

The EURO-CORDEX wind fields used in this study contain information about the wind speed components at 10 m height. They have a spatial resolution of 0.11° and 6 hours temporal resolution. The wind fields are simulated by the Rossby Centre regional climate model – RCA4 model at SMHI (Swedish Meteorological and Hydrologic Institute) under future climate projections, considering two RCPs (Representative Concentration Pathways) emission scenarios, RCP4.5 and RCP8.5. More detailed information regarding the CORDEX scenarios for the European areas, as provided by the Rossby Centre regional climate model RCA4, are given in Strandberg et al. (2015) and Kjellström et al. (2016). These two scenarios were simulated by RCA4 model with boundary conditions from a Global Climate Model (GCM), namely EC-EARTH.

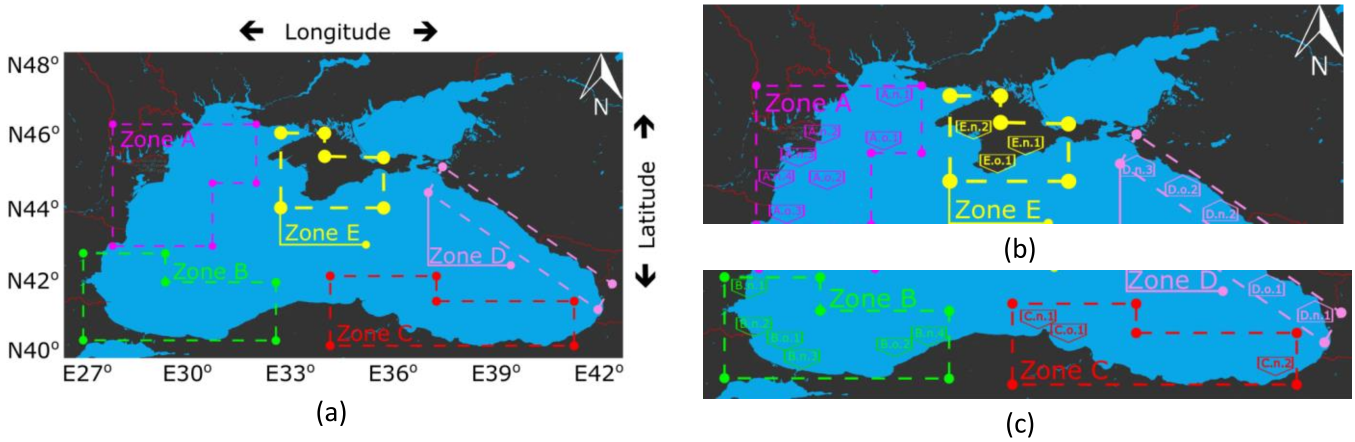

Figure 1. The geographical locations of the reference points corresponding to the 5 zones considered: zone A (shallow water points: A.n.1 to A.n.4 and deep water points: A.o.1 to A.o.3), zone B (shallow water points: B.n.1 to B.n.4 and deep water points: B.o.1 and B.o.2), zone C (shallow water points C.n.1 and C.n.2 and deep water point C.o.1), zone D (shallow water points: D.n.1 to D.n.3, deep water points: D.o.1 and D.o.2) and zone E (shallow water points: E.n.1 and E.n.2, deep water point: E.o.1); (a) Overview of the target zones; (b). The location of the points corresponding to zones A, E and a section of zone D; (c) The location of the points corresponding to zones B, C and a section of zone D.

The comparative analysis between the wind speeds projected by two of the future scenarios available in the framework of the EURO-CORDEX project, RCP4.5 and RCP8.5, is presented in Figure 2. By analyzing Figure 2 it can be noticed that between both data no significant differences appear in terms of average values, 5th and 95th percentiles. On the other hand, major differences in the evaluation of the maximum wind speed values in the shallow water areas of Bulgaria and Romania are observed.

According to the near future data, both scenarios present approximately the same values in terms of annual averages (see Figure 3), but with a lag of several years between the peaks. In the case of zone A (deep water locations), the data for RCP4.5 scenario are on average with 1% higher, while for zone B with almost 1% smaller than the RCP8.5 data. By conducting a comparative analysis of the shallow water and deep water locations for both zones A and B it can be concluded that there is no notable difference in terms of wind intensity. The near future projections near to the Turkish coast (see Figure 3d) present similar average values of the wind speeds as those computed from the EURO-CORDEX Evaluation data for the present climate. The near future annual wind speed analysis does not highlight any trend. Moreover, the differences between the annual averages are lower than the previous cases.

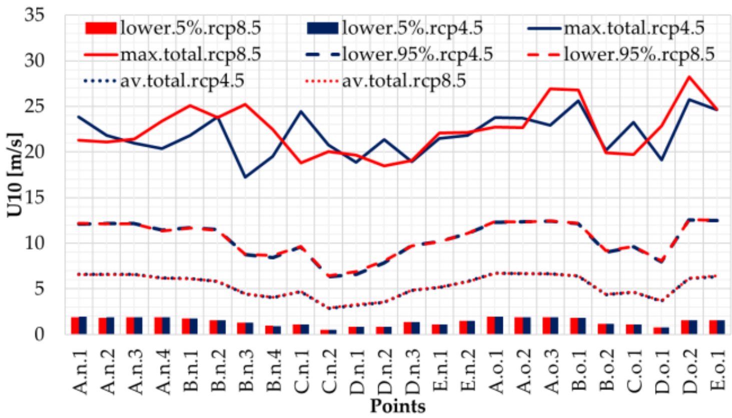

Figure 2. Analysis of the wind speed at 10 m (*U10*) height in terms of maximum values (max.total), average values (av.total), 5th percentile (lower.5%) and 95th percentile (lower.95%) values, corresponding to the reference points. Comparison between EURO-CORDEX wind speeds corresponding to RCP4.5 and RCP8.5 scenarios for a 30-year period (2021 - 2050).

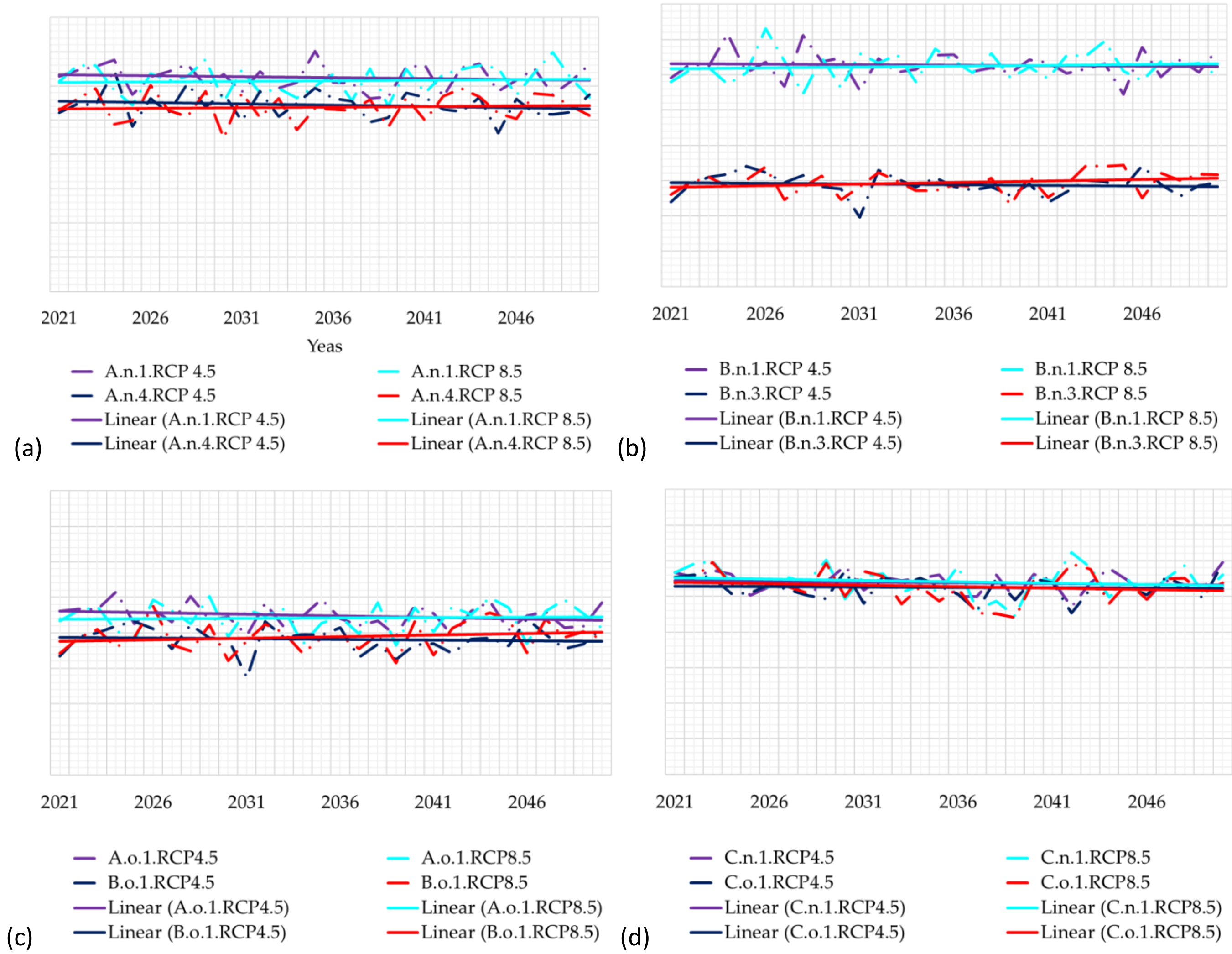

Figure 3. Annual averages of the wind speed at 10 m height, RCP4.5 and RCP8.5 data, time interval 2021-2050, for the most representative points located in: (a) the Romanian nearshore; (b) the Bulgarian nearshore; (c) deep water Bulgaria (B.o.1) and Romania (A.o.1); (d) shallow water (C.n.1) and in deep water (C.o.1) of Turkey.

Although the data for the interval 1981-2010 show an increase of the wind speed near to the Russian coastline (not shown here), both estimates an approximate constant pattern for the 30-year interval of the near future. Both RCP4.5 and RCP8.5 scenarios predict for the Crimea Peninsula region an increase of the wind at 10-meter height.

The seasonal distributions of the wind intensity (total, winter, spring, summer, and autumn) are presented in Figure 4. By looking at these data, it can be noticed that during the winter the magnitude of the wind speed average is higher. In almost 90% of the cases presented, the wind speeds during the summer interval have the lowest values. For example, the points C.n.1 and C.o.1, which are located north of Turkey, have during summer wind speed averages almost as high as in the winter interval. However, it can be noticed that in these regions the difference between the seasonal averages is small. As the results show, in most of the cases there are no relevant differences in the average wind speeds (smaller than 0.4 m/s) simulated under both scenarios. This is probably due to the fact that until the mid-century the differences between the two RCPs considered are not very high.

Regarding the linear tendency, for the 2021-2050 time period, the RCP4.5 scenario shows that the wind speed will have a low decrease while the RCP8.5 a small increase. The values of the linear trends computed for near future data are presented in Table 1. The linear tendency for the period 2021-2050, the RCP4.5 scenario shows that the wind speed will have a low decrease in 92% of the points (values ranging from -0.044 to -0.009 m/s per decade) while the RCP8.5 a small increase in 83% of the cases (values ranging from 0.008 to 0.044 m/s per decade).

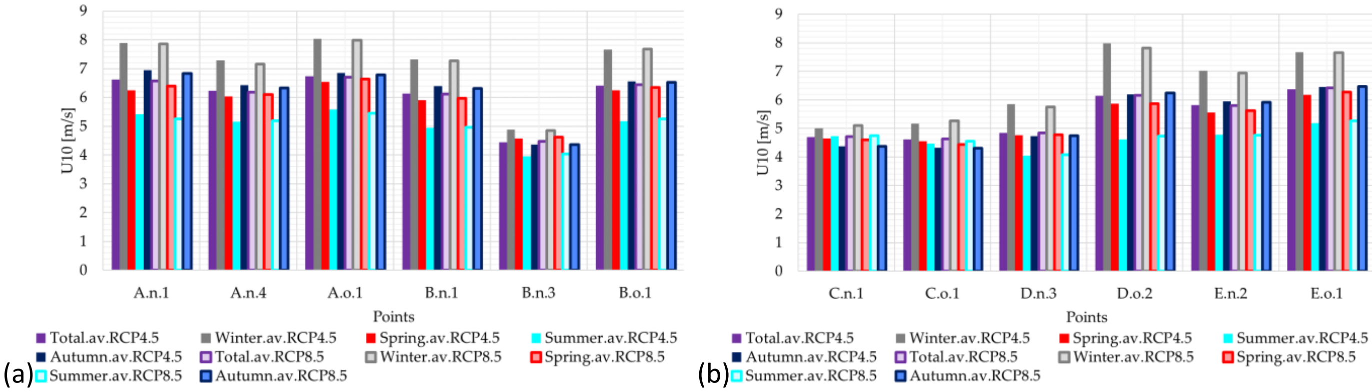

Figure 4. Seasonal wind speed averages at 10 m height compared with the total time averages, RCP4.5 and RCP8.5 data (time interval 2021-2050), for some representative points located in: (a) shallow water and deep water of Bulgaria and Romania coasts; (b) in shallow water and deep water of Crimea Peninsula, Russia and Turkey coasts

Table 1 – Linear trend (m/s per decade) values computed for all 24 points for near future data.

Point	**A.n.1**	**A.n.2**	**A.n.3**	**A.n.4**	**B.n.1**	**B.n.2**	**B.n.3**	**B.n.4**	**C.n.1**	**C.n.2**	**D.n.1**	**D.n.2**
RCP4.5	-0.026	-0.026	-0.040	-0.039	-0.013	-0.016	-0.022	-0.028	-0.021	-0.013	-0.013	-0.011
RCP8.5	0.016	0.023	0.016	0.015	0.025	0.018	0.044	0.016	-0.037	-0.027	0.008	0.010
Point	**D.n.3**	**E.n.1**	**E.n.2**	**A.o.1**	**A.o.2**	**A.o.3**	**B.o.1**	**B.o.2**	**C.o.1**	**D.o.1**	**D.o.2**	**E.o.1**
RCP4.5	-0.009	0.006	-0.023	-0.044	-0.042	-0.040	-0.018	-0.042	-0.012	-0.018	-0.011	0.002
RCP8.5	0.034	0.044	0.031	0.009	0.011	0.023	0.044	0.022	-0.041	-0.013	0.023	0.024

As regards the wind direction, the datasets analyzed contain information about the zonal (*u* component) and meridional (*v* component) velocities needed for analyzing the wind main directions from which the winds are blowing. From the wind roses presented in Figure 5, it can be observed the dominant direction and also the predominant wind speed range for all five zones studied. At a first sight, the data show that over the Black Sea there are two main wind patterns. The first pattern is more spread and it is observed in the northwest and west of the Black Sea basin. The main directions for these zones are north, northeast and southwest. However, it can be noticed that the EURO-CORDEX data show also that the wind blows quite often from the west. Moreover, the most frequent values of the wind speeds are in the interval 0 to 12 m/s. The second dominant wind pattern is narrower and occurs in the north, east, south, and southwest.

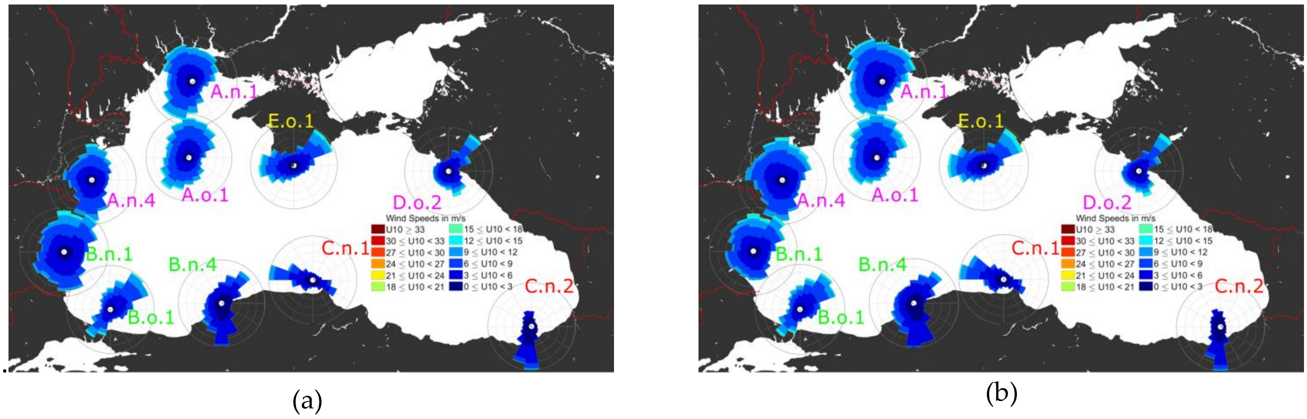

Figure 5. Wind roses corresponding to 30-year of data (2021-2050) coming from EURO-CORDEX: (a) RCP4.5 scenario; (b) RCP8.5 scenario.

The near future projections of the wind power potential of the Black Sea for the time interval 2021-2050 were also computed and compared with those corresponding to the time interval 1981-2010. Nowadays, the typical hub heights for the offshore wind turbines are ranging from 80 m to 100 m (Letcher, 2017), and for this reason, the wind data at 10 m height need to be recompiled. In order to adjust the wind speed to a level of 100 m for assessing the wind energy potential and output energy generated by a certain turbine, a logarithmic method is used. This method assumes neutral stability conditions (Kubik et al., 2011). Some results regarding the wind power projections and comparisons are presented in Figure 6.

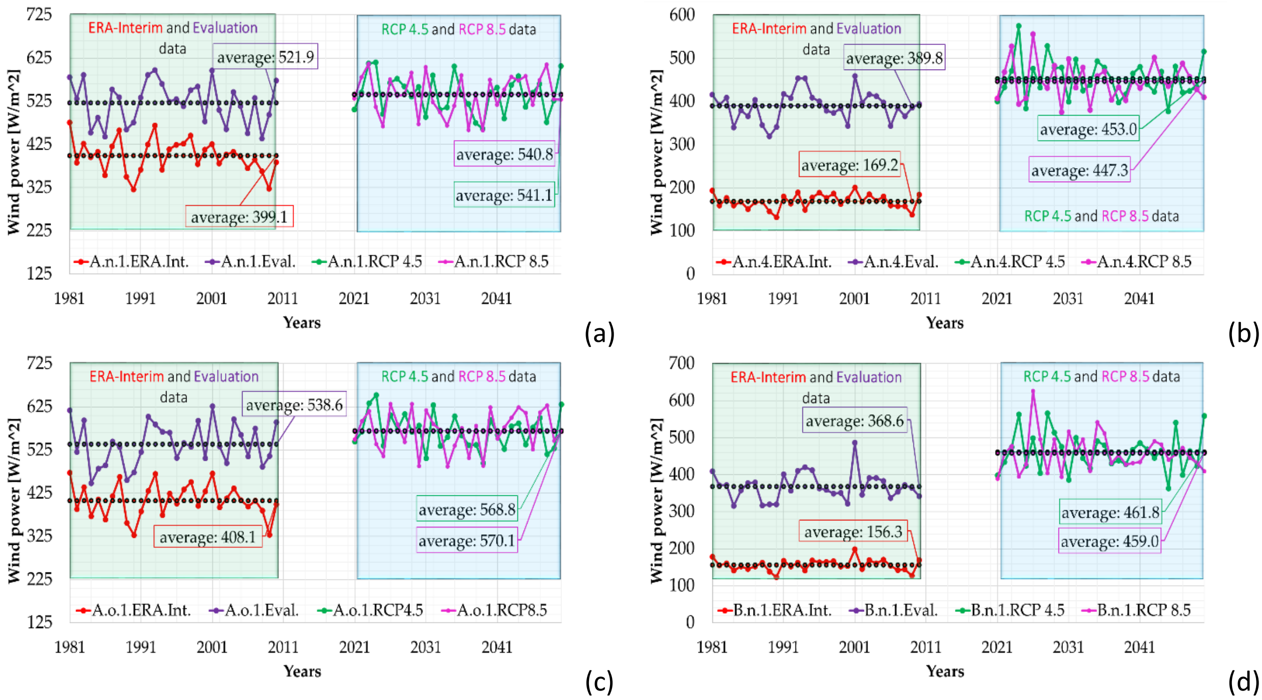

Figure 6. Annual wind power averages at 100 m height for 6 representative points for RCP4.5 and RCP8.5 scenarios, time interval 2021-2050. For each dataset, the average of the wind power corresponding to the entire time interval is indicated in the box.

According to the wind power averages computed for the near future, it results that the most energetic zones of the Black Sea seem to be located in the northwest (points A.n.1 and A.o.1), southwest (point B.o.1), east (point D.o.2) and the Crimea Peninsula (point E.o.1). More precisely, in these points, the averages computed for the 30-year period are higher than 500 W/m^2. Regarding zone A, the higher increase of the average wind power in the near future is observed in point A.n.4 (Figure 6b), where this will pass the level of 400 W/m^2, while in the present it is below this threshold. The fact that it was noticed an increase of the mean values of the wind resources in 95.6% of the reference points considered in the Black Sea, either under the RCP4.5 or RCP8.5 scenarios, can be considered beneficial from the perspective of the wind projects and this can give momentum to the installation of the wind farms in the areas already identified as having a good potential, as for example the western side of the basin.

The seasonal distribution of the average wind power is presented in Figures 7 and 8 for both scenarios (Rusu, 2018a). It can be noticed that the enhancement in terms of wind power is greater for the winter conditions.

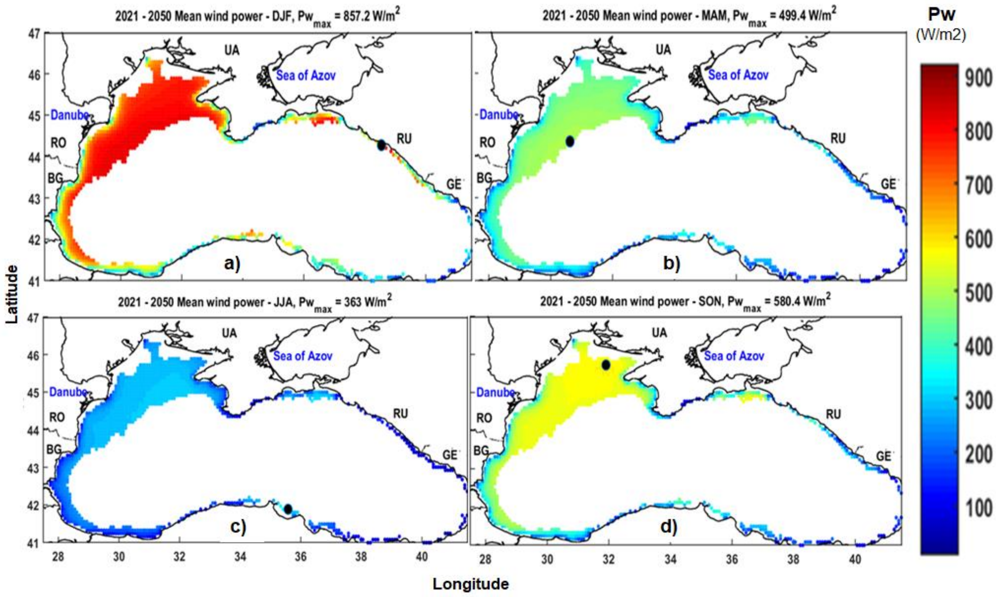

Figure 7. Average seasonal values of the wind power at 80m height (P_w) corresponding to the 30-year period 2021-2050, RCP4.5 scenario; a) winter (DJF); b) spring (MAM); c) summer (JJA); d) autumn (SON).

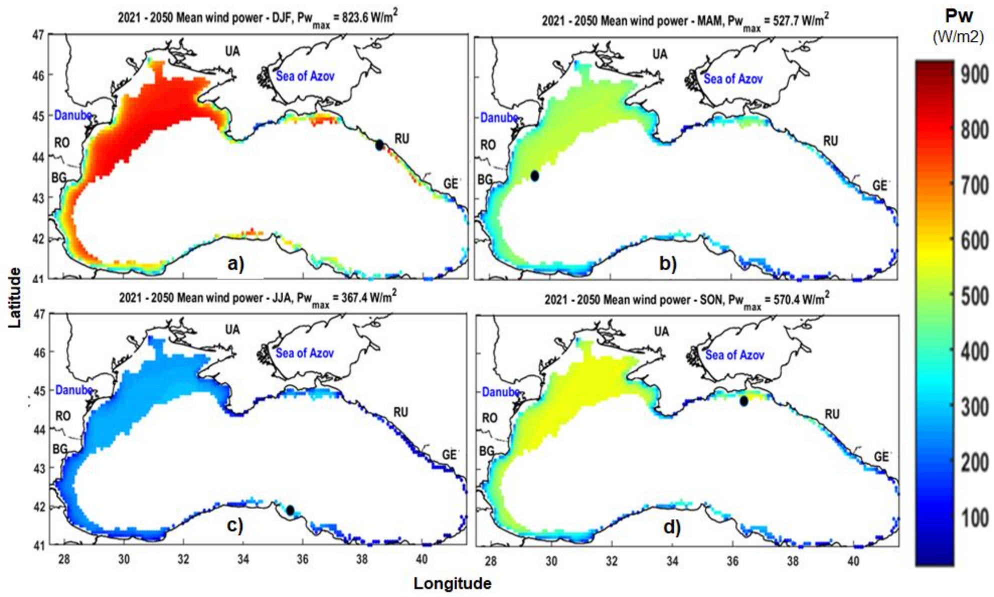

Figure 8. Average seasonal values of the wind power at 80m height (P_w) corresponding to the 30-year period 2021-2050, RCP8.5 scenario; a) winter (DJF); b) spring (MAM); c) summer (JJA); d) autumn (SON).

The results show that, for both scenarios, moderate enhancements of the average wind power are expected. The most energetic coastal environment is the north-western part of the basin and it seems that exactly in this area the enhancement of the wind power will be the highest. Furthermore, the RCP4.5 scenario indicates higher differences between summer and winter, with the months January and February being more energetic, much more than in the case of the RCP8.5 scenario. On the other hand, for the case of the RCP8.5 scenario, although the maximum average value is slightly higher than in the case of RCP4.5 scenario 543.7W/m^2 against 540.7W/m^2, this enhancement is more homogenous distributed.

1.2 Simulations with the wave climate system for the 'near future' period (2021-2050), RCP4.5 şi RCP8.5 scenatios (simulations for 60 years)

The projections of the sea state conditions in the Black Sea were performed under RCP4.5 and RCP8.5 scenarios. Each simulation covers a 30-year time interval (2021-2050). The wind fields used to force the SWAN model are those simulated by RCA4 under the scenarios above mentioned. As in the case of the historical simulations carried out in the fisrt stage of the project, in all the grid points the values of the following wave parameters have been generated: significant wave height (*Hs*), mean period (*Tm*), peak period (T_p), mean wave direction (*Dir*), wave energy (*Etr*) and direction of the wave energy transport (*Dtr*). Based on these data the climate analysis has been performed by evaluating the average values for total time, seasons and months, respectively corresponding to the entire basin of the Black Sea. All these data have a spatial resolution of 0.08° in both latitude and longitude and a time step of 3h.

Figure 9 presents the spatial distributions of the average *Hs* values resulted from the SWAN simulations forced with the RCA4 wind fields corresponding to RCP4.5 (a) and RCP8.5 (b). Both *Hs* fields present a similar pattern, a more extended area is covered by *Hs* values higher than 1m in the case of the RCP8.5 scenario.

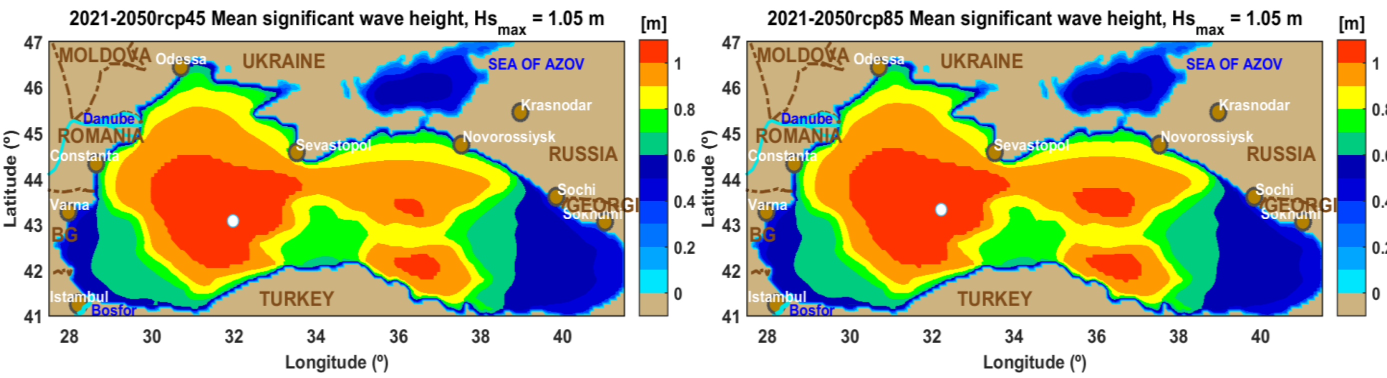

Figure 9. Average *Hs* fields resulted from the SWAN simulations forced with the RCA4 wind fields, corresponding to RCP4.5 (a) and RCP8.5 (b) scenarios for a 30-year time interval (2021-2050).

An analysis of the storm dynamics was made by Rusu (2018b), based on the projections concerning the expected storm conditions in the Black Sea basin corresponding to the near future time interval (2021-2050). Thus, it was found that the climate feedback significantly depends on the global warming and also probably on the history of the forcing. Thus, Figure 10 illustrates the *Hs* annual maximum series expected for the 30-year time interval 2021-2050. The maximum values of the wind speed are also indicated. From Figure 10, it can be noticed that the maximum *Hs* value it is expected in 2040/10/28. This maximum significant wave height it would be around 11.5 meters. The corresponding maximum wind speed for the respective time frame in the Black Sea basin it is expected to be about 30.75 m/s. Furher on, Figure 11 illustrates the *Hs* monthly maximums expected in the same 30-year time interval. The exact values of the significant wave height and of the wind speed at 10 meters height above the sea level (*U10*) as well as the locations of the maximum monthly significant wave height are also given in Table 2.

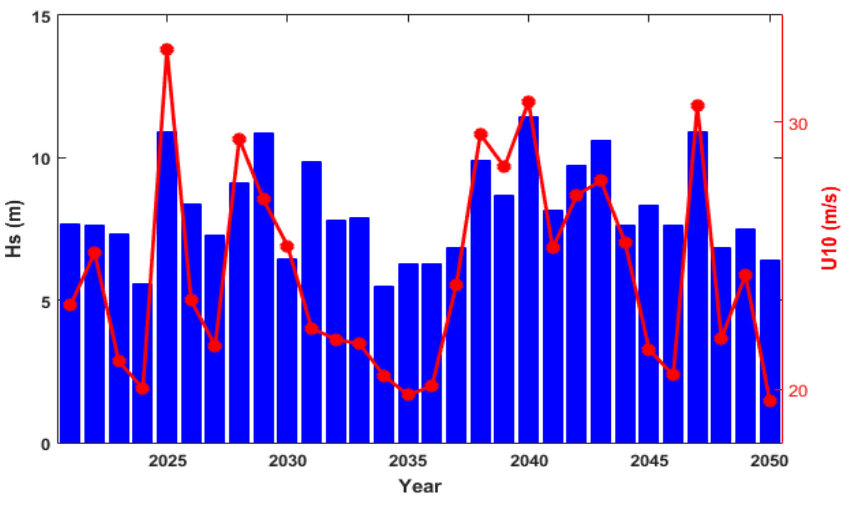

Figure 10. *Hs* and *U10* annual maximum series expected in the 30-year time interval 2021-2050.

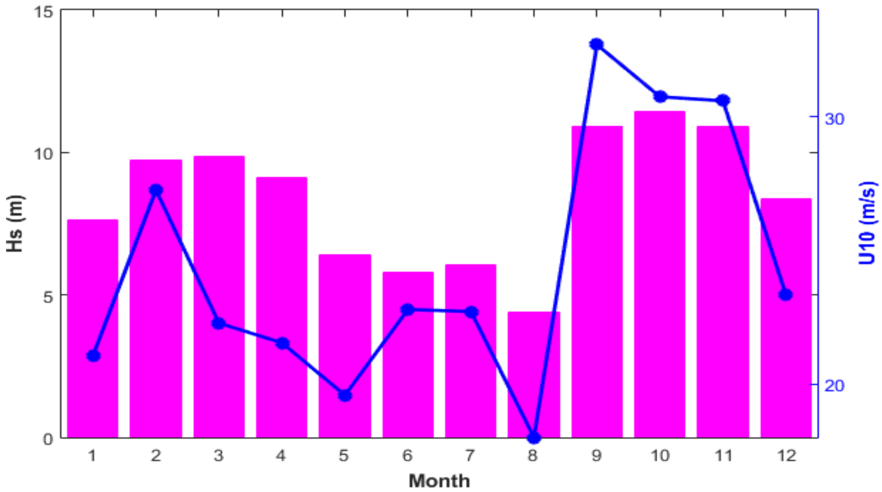

Figure 11. *Hs* and *U10* monthly maximums expected in the 30-year time interval 2021-2050.

Table 2. Values and locations of the maximum monthly *Hs* expected in 30-year time interval 2021-2050.

Month	Date	Long (°)	Lat (°)	Hs (m)	U10 (m/s)
January	2022/01/24	36.22	44.60	7.62	21.05
February	2042/02/06	37.90	44.36	9.74	27.26
March	2031/03/31	33.10	44.04	9.84	22.28
April	2031/4/01	34.38	43.88	9.12	21.54
May	2050/05/13	30.46	43.16	6.40	19.58
June	2038/06/25	38.30	44.04	5.80	22.79
July	2038/07/03	37.10	44.20	6.04	22.71
August	2033/08/23	32.62	43.08	4.38	18.00
September	2025/09/27	29.50	44.12	10.93	32.70
October	2040/10/28	38.38	44.04	11.45	30.75
November	2047/11/11	37.74	44.44	10.89	30.60
December	2026/12/11	29.34	43.64	8.36	23.33

At a first look, this result seems contradictory because a clear increase of the wind speed intensity is followed by a clear decrease of the significant wave height in the near future period 2021-2050. Interesting conclusions result also from the analysis of Figure 12 which illustrates the geographical location of *Hs* annual maximums registered in the 30-year time interval 1987-2016 (based on first stage data), represented by yellow circles against the *Hs* annual maximums expected in the 30-year time interval 2021-2050, represented by magenta circles.

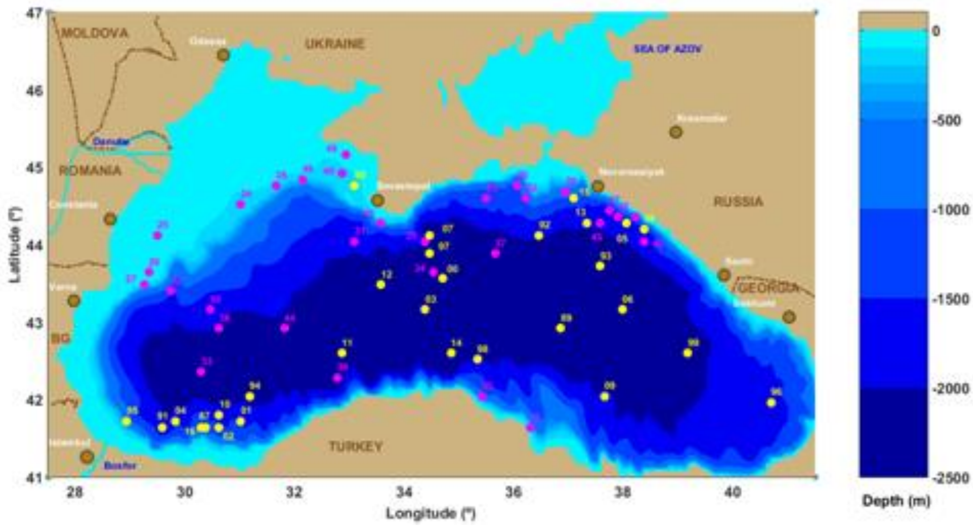

Figure 12. Geographical location of *Hs* annual maximums registered in the period 1987-2016 (yellow circles) against the *Hs* annual maximums expected in the period 2021-2050 (magenta circles).

From the analysis of the locations of the annual maximums as registered in the recent past against those expected in the near future, we can notice a tendency of migration of the storms from the south and the centre of the sea to the west and to the north.

As regards the expected annual storms in the near future period, the time frames considered are 2040/10/28 (*Hs*=11.45m, U10=30.75m/s), 2025/09/27 (*Hs*=10.93m, U10=32.70m/s) and 2047/11/11 (*Hs*=10.89m, U10=30.6m/s). The significant wave height scalar fields and the wave vectors for these expected top three storms of the 30-year time interval 2021-2050 are illustrated in Figure 11 (a, c and e).

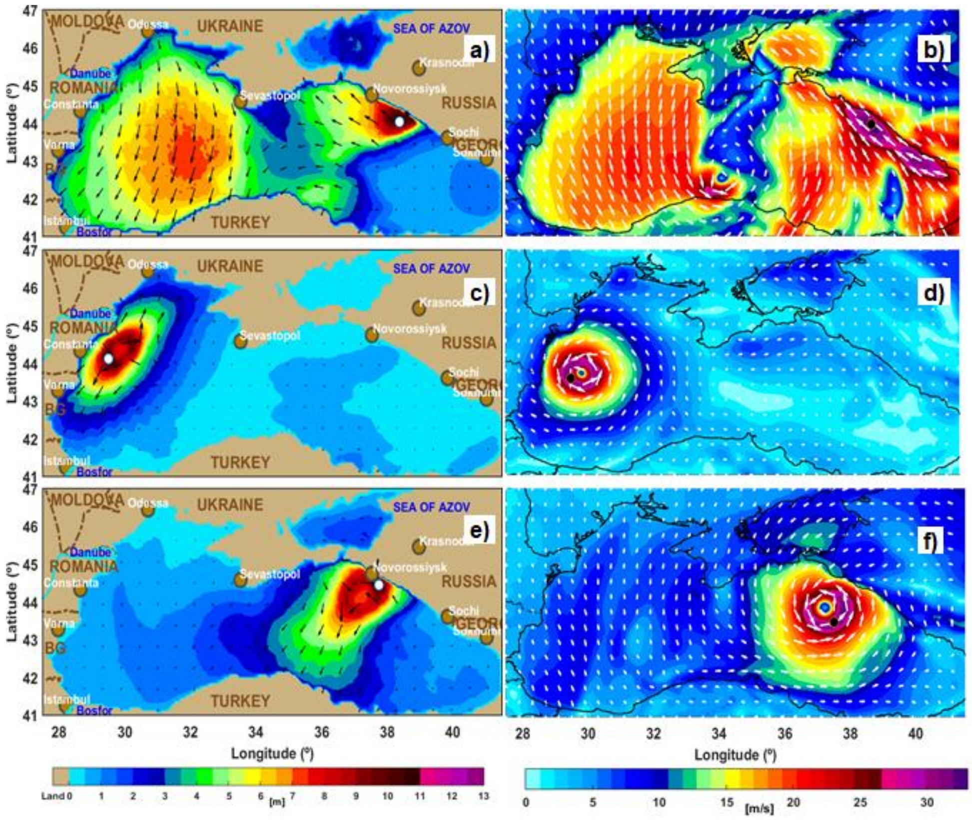

Figure 13. Significant wave height fields (Hs) and wave vectors for the expected top three storms of the 30-year time interval 2021-2050. The time frames considered are: a) 2040/10/28-h06; c) 2025/09/27-h18; e) 2047/11/11-h12. The corresponding scalar wind fields and wind velocity vectors (U10) for the top three storms b) 2040/10/28-h06; d) 2025/09/27-h18; f) 2047/11/11-h12.

The locations of the storm peaks are also indicated in these subplots with white circles. Looking at these figures, we can notice that for the storms presented in Figures 13a and 13e, the peaks are located in the northern side of the sea, very close to the coast. Moreover, both peaks are located not far from each other, close to the Russian city Novorossiysk. On the other hand, the storm peak illustrated in Figure 13c appears to be on the western side of the sea very close to the Romanian nearshore. Very interesting results come from the analysis of the wind fields presented in Figures 13b, 13d and 13f. In all these cases, the maximum value of the wind speed is higher than 30 m/s. Moreover, in all three cases we can see a cyclonic behaviour in the spatial distribution of the wind field.

However, while in the case illustrated in Figure 13b the storm covers the entire sea basin and the cyclone is located in the southern side of the sea, far away from the peak of the storm, in the other two cases (illustrated in Figures 13d and 13f), the storm peak is located practically inside the cyclone. Moreover, in these last two cases the storms, although very strong, are quite local and the rest of the sea appears to be almost calm. The effect of this high variability in the wind directions, which can be noticed in all the three cases presented in Figure 13, is that although the wind speeds are very high, the resulting maximum values of the significant wave height are lower than in the extreme cases corresponding to the recent past. This is because the wind field configurations expected for the extreme storms from the near future indicate a high variability of the wind direction, which reduces the fetch and does not allow the development of the very high waves as those characteristic to the recent past.

The spatial distributions of the wave power corresponding to the near future (2021-2050) are also computed based on the energy transport output of the SWAN model, forced with wind fields simulated under the climate projections made by RCP4.5 and RCP8.5 scenarios. The mean wave power fields for RCP4.5 and RCP8.5 scenarios are represented in Figure 14 and both show a maximum value of 3.8 kW/m, whose geographic position is indicated by a white circle. The mean direction of the energy transport, computed by averaging separately its components in the geographical space, is also represented with white arrows scaled with the wave power background field. No significant differences between the two mean wave power fields are observed (see Rusu, 2018c).

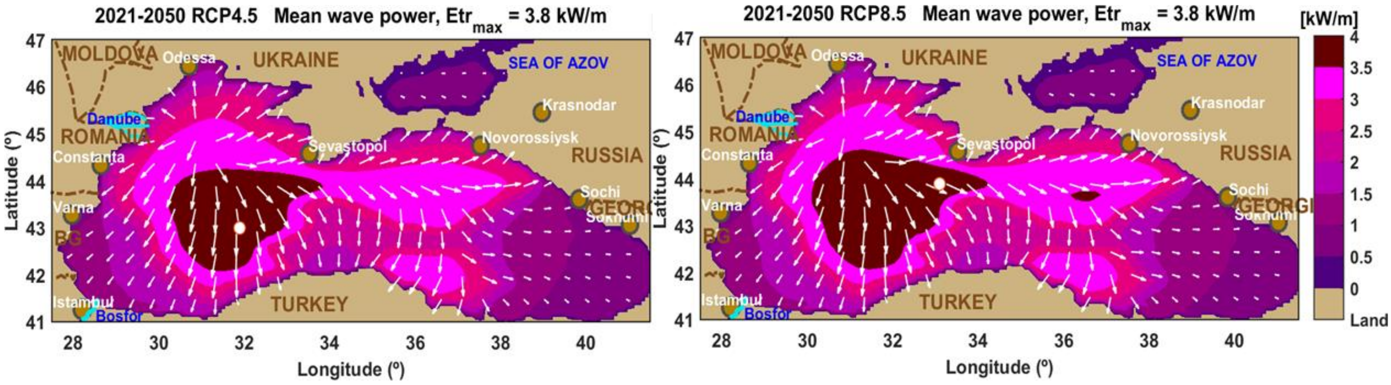

Figure 14. The spatial distribution of the mean wave power fields and the mean direction of the energy transport corresponding to the near future (2021-2050) for two emission scenarios: RCP4.5 (left) and RCP8.5 (right).

2. Simulations with the wave climate system for the 'future' period (2071-2100), RCP4.5 scenatio (simulations for 30 years)

The simulations with the wave climate system concerning the projections of the future sea state conditions in the Black Sea under the RCP4.5 scenario for the entire 30-year period (2071 - 2100) are completed, following processing of the data to be included in the databases of the project. In the next stage of the project these results will be analized.

3. Dissemination of the results

3.1 Preparation of the scientific articles and oral presentations to disseminate the results

- Publications in international journals WoS indexed (3)

1. Rusu, L., Raileanu, A.B., Onea, F., 2018. "*A comparative analysis of the wind and wave climate in the Black Sea along the shipping routes*", Water 10(7), 924. http://www.mdpi.com/2073-4441/10/7/924 **(WoS, IF=2.069)**

2. Rata, V., Gasparotti, C., Rusu, L., 2018. "*Ballast Water Management in the Black Sea's Ports*", Journal of Marine Science and Engineering 6(2), 69. http://www.mdpi.com/2077-1312/6/2/69 **(WoS indexed)**

3 Ganea, D., Mereuta, E., Rusu, L., 2018. "*Estimation of the Near Future Wind Power Potential in the Black Sea*", Energies 11(11). https://www.mdpi.com/journal/energies/special_issues/offshore **(WoS, IF=2.676)**

- Publications in national journals indexed in international databases (2)

1. Rusu, E., 2018. *"An analysis of the storm dynamics in the Black Sea"*, Romanian Journal of Technical Sciences - Applied Mechanics, 63(2), 127−142. http://www.academiaromana.ro/RJTS-AM.htm

2. Banescu, A. Georgescu, L.P., Iticescu, C., Rusu, E., 2018. *"Analysis of river level and of the volume flow on the Danube close to the city of Tulcea, based on in situ measurements",* Journal of Marine Technology and Environment 1, 7-13.

https://www.researchgate.net/publication/324149440_ANALYSIS_OF_RIVER_LEVEL_AND_OF_THE_VOLUME_FLOW_ON_THE_DANUBE_CLOSE_TO_THE_CITY_OF_TULCEA_BASED_ON_IN_SITU_MEASUREMENTS

- Publications in the proceedings of international conferences (12)

1. Rusu, L., 2018. *"The influence of climate change on the near future wave energy resources in the Black Sea Basin"*, presented at 13th Conference on Sustainable Development of Energy, Water and Environment Systems (SDEWES2018), 30 September – 4 October, Palermo, Italia. http://www.palermo2018.sdewes.org/

2. Rusu, E., 2018. *"A 30-year projection of the future wind energy resources in the coastal environment of the Black Sea"*, presented at 13th Conference on Sustainable Development of Energy, Water and Environment Systems (SDEWES2018), 30 September – 4 October, Palermo, Italia. http://www.palermo2018.sdewes.org/

3. Rata, V., Rusu, L., 2018. *"Assessing the traffic risk along the main Black Sea maritime routes"*, Proceeding of the Fourth International Conference on Traffic and Transport Engineering (ICTTE Belgrade 2018), 27 - 28 September, Belgrade, Serbia. (indexe **WoS**) http://ijtte.com/article/102/ICTTE_Belgrade_2018.html

4. Rusu, L., 2018. "*Assessment of the wave climate in the Black Sea based on 30-year of wave hindcast*", Presented at Coordinated Ocean Wave Climate Project (COWCLIP) meeting - UNESCO, 21 - 23 May, Paris, France. http://www.ioc-unesco.org/index.php?option=com_oe&task=viewEventAgenda&eventID=2242

5. Banescu, A. Georgescu, L.P., , Rusu, E., Iticescu, C. 2018. Use of GIS technology to support the navigation on the Danube River. Proceeding of the Fourth International Conference on Traffic and Transport Engineering (ICTTE Belgrade 2018), 27 - 28 September, Belgrade, Serbia. (indexe **WoS**), pp 160-168. http://ijtte.com/article/102/ICTTE_Belgrade_2018.html

6. Rusu, L., Bernardino, M., Guedes Soares, C., 2018. *"Analysis of extreme storms in the Black Sea"*, Presented at the 4th International Conference on Maritime Technology and Engineering - MARTECH 2018, 7-9 May, Lisbon, Portugal, published in Progress in Maritime Engineering and Technology , Guedes Soares & Santos (Eds.), Taylor & Francis Group, London, 699-704. http://www.centec.tecnico.ulisboa.pt/martech2018/

7. Ganea, D., Mereuta, E., Rusu, L., 2018. "*Analysis of the present and near future wind conditions in the western side of the Black Sea*". Proceeding of the 18th International Multidisciplinary Scientific GeoConference SGEM 2018 – Renewable Energy Sources and Clean Technologies, 30 June – 9 July, Albena, pp. 127-134. (indexed **WoS**) https://www.sgem.org/ https://doi.org/10.5593/sgem2018/4.1

8. Ganea, D., Rusu, L., Mereuta, E., 2018. "*Study of the winter extreme wind in the Black Sea in the context of the climate changes*". Proceeding of the 18th International Multidisciplinary Scientific GeoConference SGEM 2018 – Renewable Energy Sources and Clean Technologies, 30 June – 9 July, Albena, pp. 659-665. (indexed **WoS**) https://www.sgem.org/

9. Rață, V., Rusu, L., Gasparotti, C., 2018. "*Analysis of the extreme events reported in the proximity of the Romanian harbour areas*". Proceeding of the 18th International Multidisciplinary Scientific GeoConference SGEM 2018 – Marine and Ocean Ecosystems, 30 June – 9 July, Albena, pp. 1071-1077. (indexed **WoS**) https://www.sgem.org/

10. Raileanu, A., Onea, F., Rusu, L., 2018. *"Coastal Protection of the Romanian Nearshore throughout Hybrid Wave and Offshore Wind Farms"*, Paper presented at *Int. Conference on Advances on Clean Energy Research* (ICACER2016), 6-8 April, Barcelona, Spain. (indexed **WoS**) http://www.icacer.com/ https://doi.org/10.1051/e3sconf/20185101006

11. Mateescu, R., Vlasceanu, E., Rusu, L., 2018. "*Analysis-based results on the delineation of prearrangement areas for marine renewable energy installations in the western Black Sea basin*", Paper presented at *Int. Conference on Advances on Clean Energy Research* (ICACER2016), 6-8 April, Barcelona, Spain. (indexed **WoS**) http://www.icacer.com/ https://doi.org/10.1051/e3sconf/20185101009

12. Rață, V., Rusu, L., 2018. *"Evaluating Pleasure Navigation and Fishery Boats in the Black Sea Coastal Area of Romania"*, Conference: CSSD2018 - Scientific Conference of the Doctoral Schools - Perspectives and Challanges in Doctoral Research, June 2018, Galati, Romania, http://www.cssd-udjg.ugal.ro/index.php/abstracts-2018

3.2 Updating of the project ACCWA site

The web page for the dissemination of the ACCWA project results http://193.231.148.42/accwa/index_en.php. was updated with the activities and the publications corresponding to this second stage of the project and it will be periodically updated also from now on.

4. Concluding remarks

We can conclude that we succeeded to achieve all the objectives proposed for the second stage of the ACCWA project. All the activities included in the plan of achievement were accomplished.

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