Scientific Report

concerning the implementation of the project

Renewable Energy extraction in MARine environment and its Coastal impact

REMARC

in the period January – December 2018

In the second stage of the project implementation (E2) carried out in the period above mentioned, the specific objectives of the project were pursued, as follows:

2.1 Implementation and validation of multi level wave modelling systems, based on the SWAN spectral averaged model, which will be focused on the European areas with higher wave potential (Act. 2.1).
2.2 Long term analyses of the wave (and wind) conditions in the areas targeted (Act. 2.2).
2.3 Updating the webpage for the project dissemination.
2.4 Dissemination of the results.

2.1 Implementation and validation of multi-level wave modelling systems, based on the SWAN spectral averaged model, which will be focused on the European areas with higher wave potential

2.1.1 Numerical modeling of the wave energy propagation in the Iberian nearshore and wave modeling in the Mediterranean Sea

A wave modeling system, SWAN based, was implemented in the Iberian nearshore and downscaled towards the most significant coastal areas. In this way an updated picture of the wave energy propagation patterns in the western side of the Iberian nearshore was provided. Four different SWAN computational levels are considered. The first (D-domains) is related to the sub-oceanic scale and represents the link between the ocean models and the coastal domains. Six SWAN coastal domains (denoted as the C domains) are considered in the present approach. Furthermore, five SWAN high-resolution domains (denoted as the H domains) are considered and also four Cartesian SWAN domains (X-domains). The bathymetric maps of the corresponding computational domains are illustrated in Figures 1 and 2.

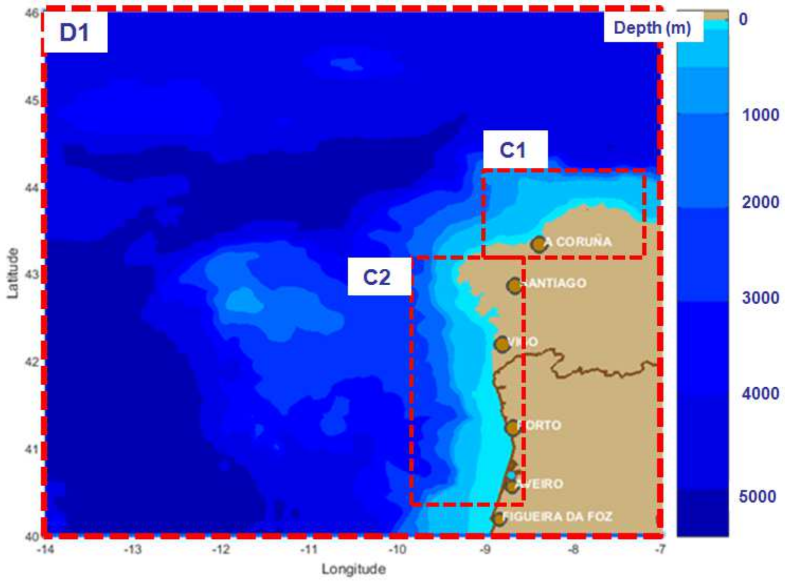


Figure 1. The northern wave driver and the subsequent coastal computational domains.

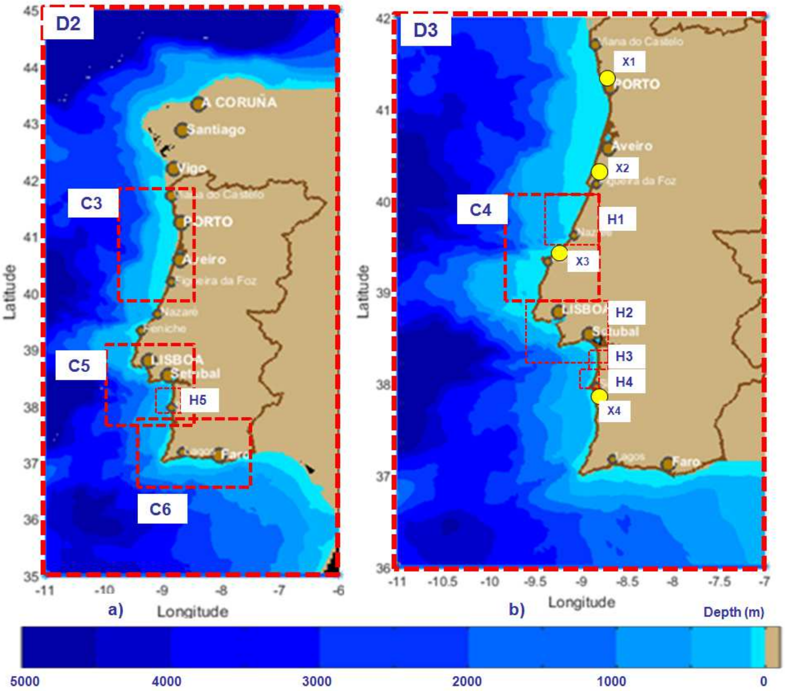


Figure 2. The Iberian (**a**) and the Portuguese (**b**) wave drivers and the subsequent computational domains corresponding to the computational levels: coastal, high resolution and Cartesian, respectively.

Some example of wave energy propagation patterns corresponding to the above mentioned computational domains are illustrated Figures 3-9.

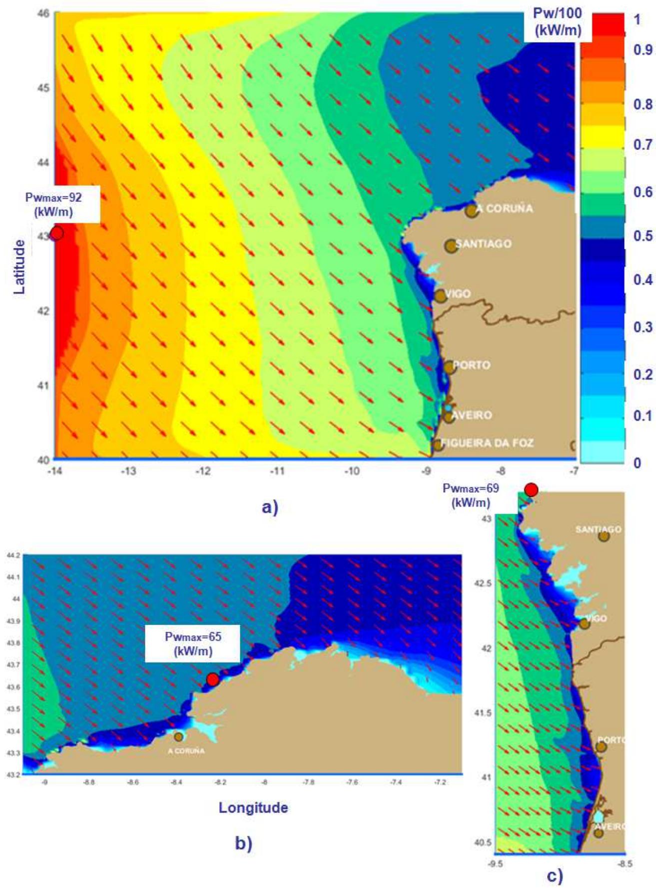


Figure 3. Normalized wave power and energy transport vectors illustrating an average winter time wave energy pattern in the north-western Iberian nearshore. (**a**) Northern wave driver (D1); (**b**) Coastal domain (C1); (**c**) Coastal domain (C2). Model results correspond to the time frame 22 October 2016.

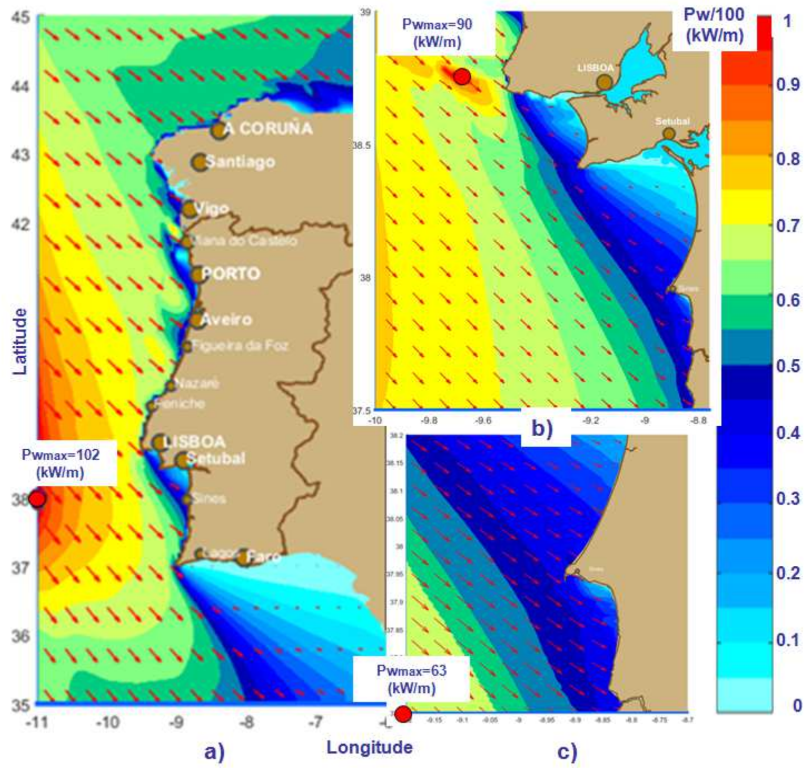


Figure 4. Wave energy propagation towards the Portuguese port of Sines. (**a**) Iberian wave driver (D2); (**b**) Coastal domain (C5); (**c**) High resolution area in the nearshore of Sines (H5). Model results correspond to the time frame 10 March 2017.

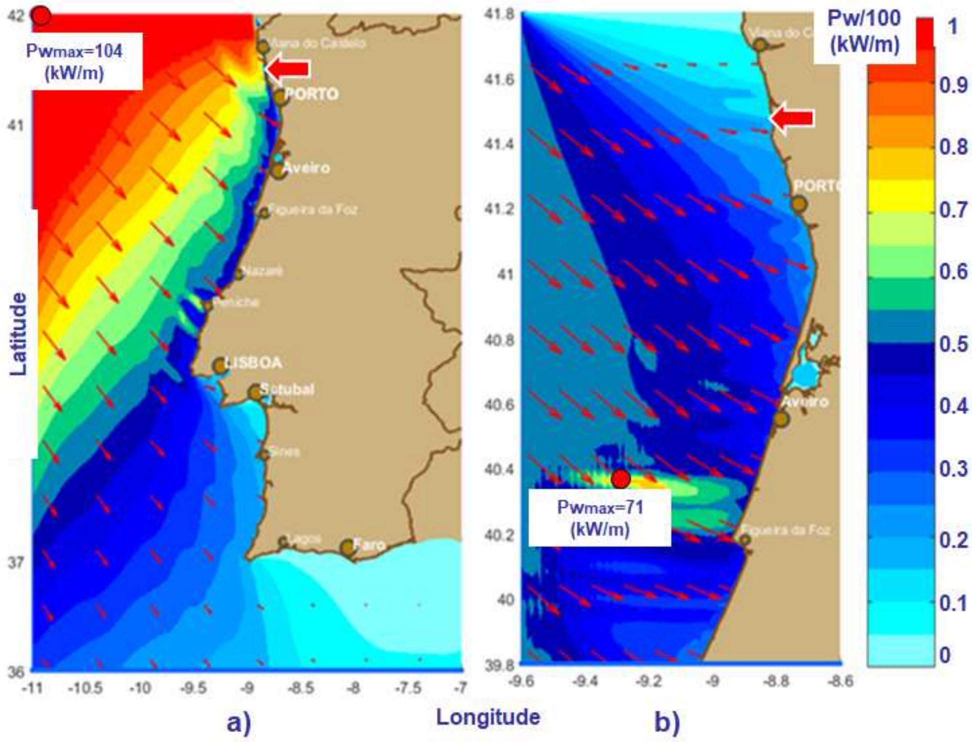


Figure 5. Wave energy propagation in the Portuguese nearshore. (**a**) Portuguese wave driver (D3), simulation corresponds to the time frame 18 November 2017; (**b**) Coastal domain (C3), simulation corresponds to the time frame 2 December 2017. The red arrow indicates one of the two Portuguese pilot areas.

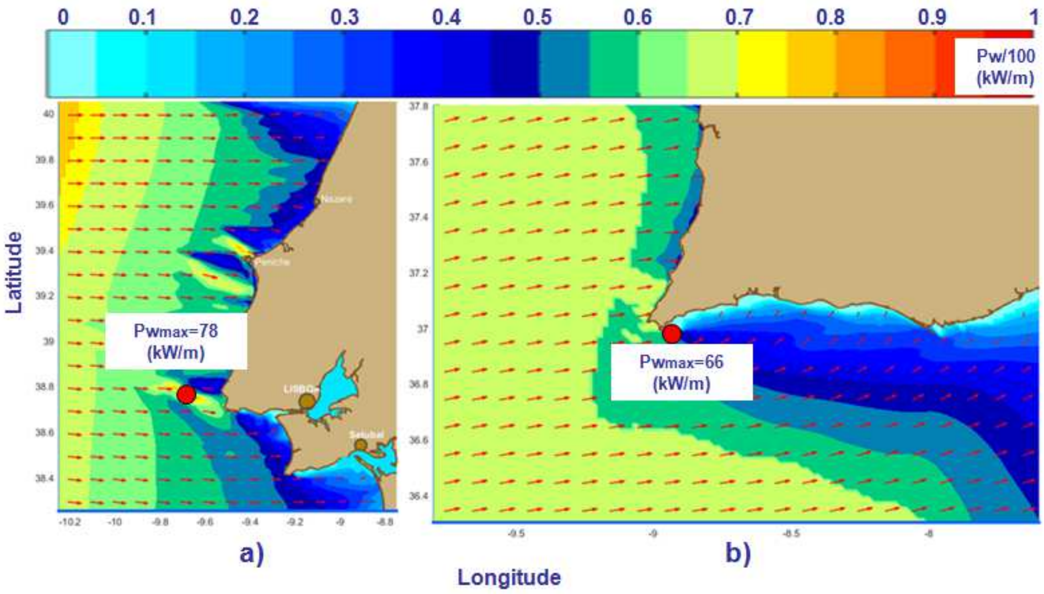


Figure 6. Wave energy propagation in the central and southern coastal domains, simulation corresponding to the time frame 14 October 2017. (**a**) Results for the central coastal domain (C4), (**b**) Results for the southern coastal domain (C6).

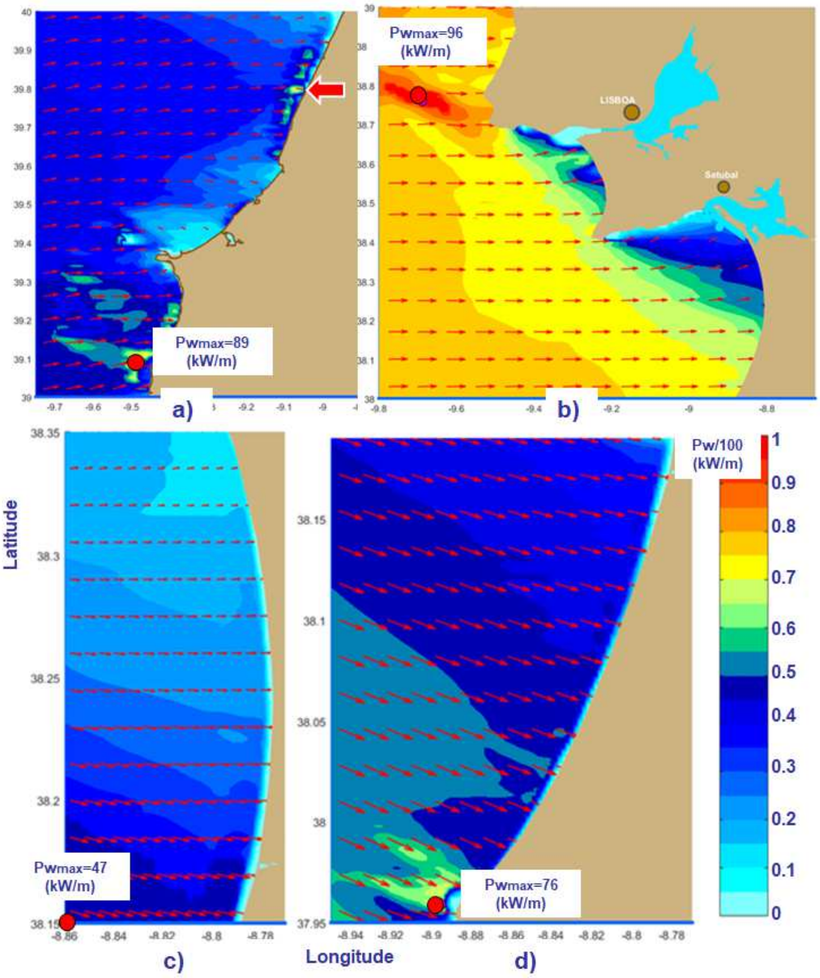


Figure 7. Wave energy propagation in the high resolution computational domains. (**a**) Peniche area (H1), simulation corresponding to the time frame 18 September 2017, the red arrow indicates one of the two Portuguese pilot areas; (**b**) Lisbon nearshore (H2), simulation corresponding to the time frame 17 December 2017; (**c**) Pinheiro da Cruz area (H3) and (**d**) North of Sines (H4), simulations corresponding to the time frame 19 November 2017.

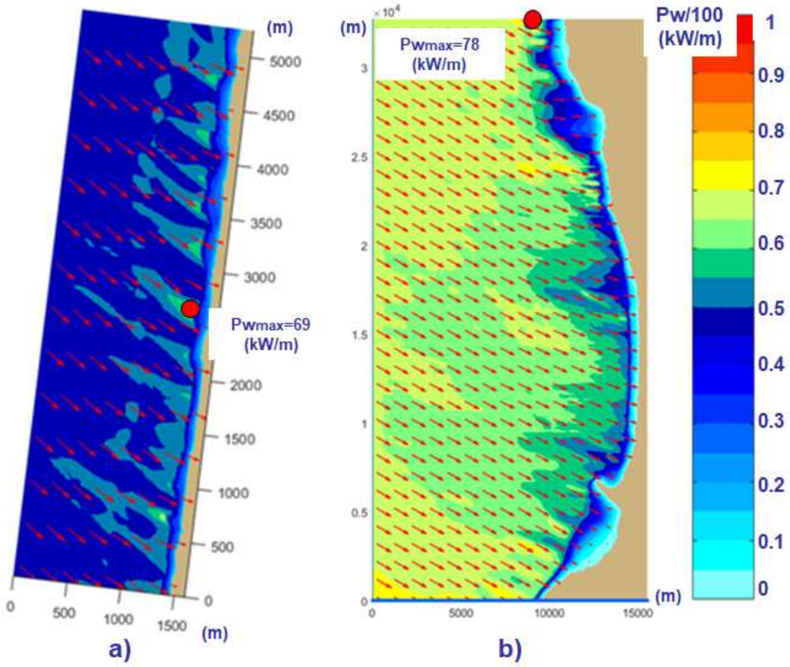


Figure 8. Wave energy propagation in the Cartesian computational domains. (**a**) Figueira da Foz (X2), simulation corresponding to the time frame 17 September 2017; (**b**) Obibos (X3), simulation corresponding to the time frame 17 November 2017.

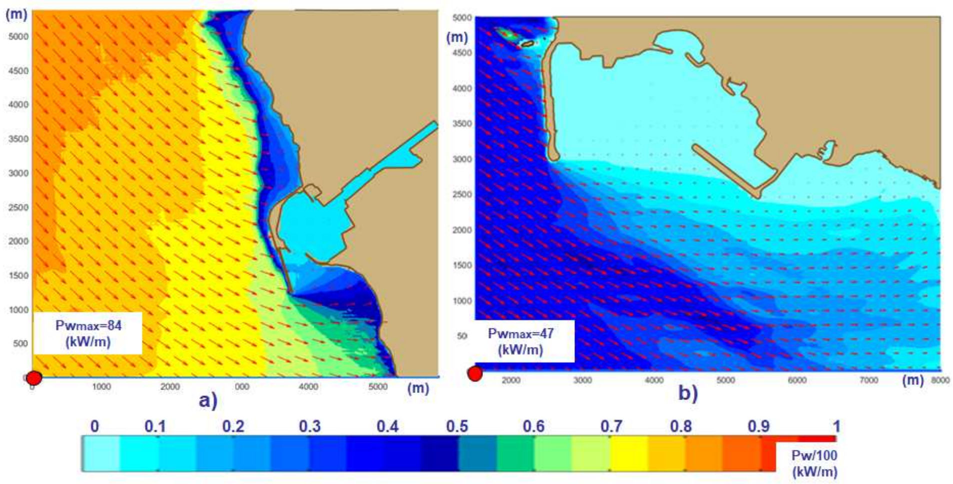


Figure 9. Wave energy propagation in the Cartesian computational domains defined close to the Portuguese harbours. (**a**) Leixoes (X1), simulation corresponding to the time frame 17 November 2017; (**b**) Sines (X4), simulation corresponding to the time frame 10 March 2017.

More details concerning the wave energy propagation patterns in the Iberian nearshore can be found in the paper [1] from the list of publications, work published in Energies journal.

The process of wave modelling was continued in the Mediterranean Sea. Thus Figure 10 illustrates the bathymetric map corresponding to the sea level and two target areas. One regional, corresponding to the Greek seas and another one local, Porto Ferro in Sardinia Island. From this perspective Figure 11 presents the wave conditions corresponding to a relevant pattern in the Mediterranean Sea. The process of wave modelling in the Mediterranean Sea is ongoing.

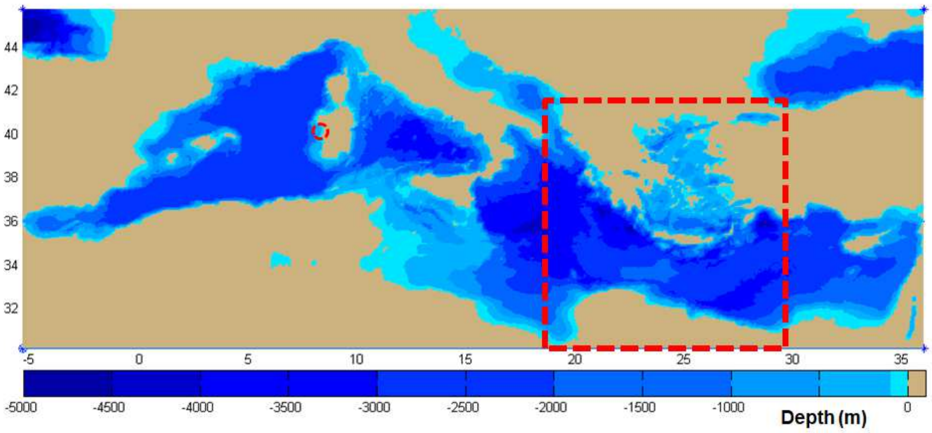


Figure 10. The Mediterranean wave driver and northern wave driver and the subsequent coastal computational domains.

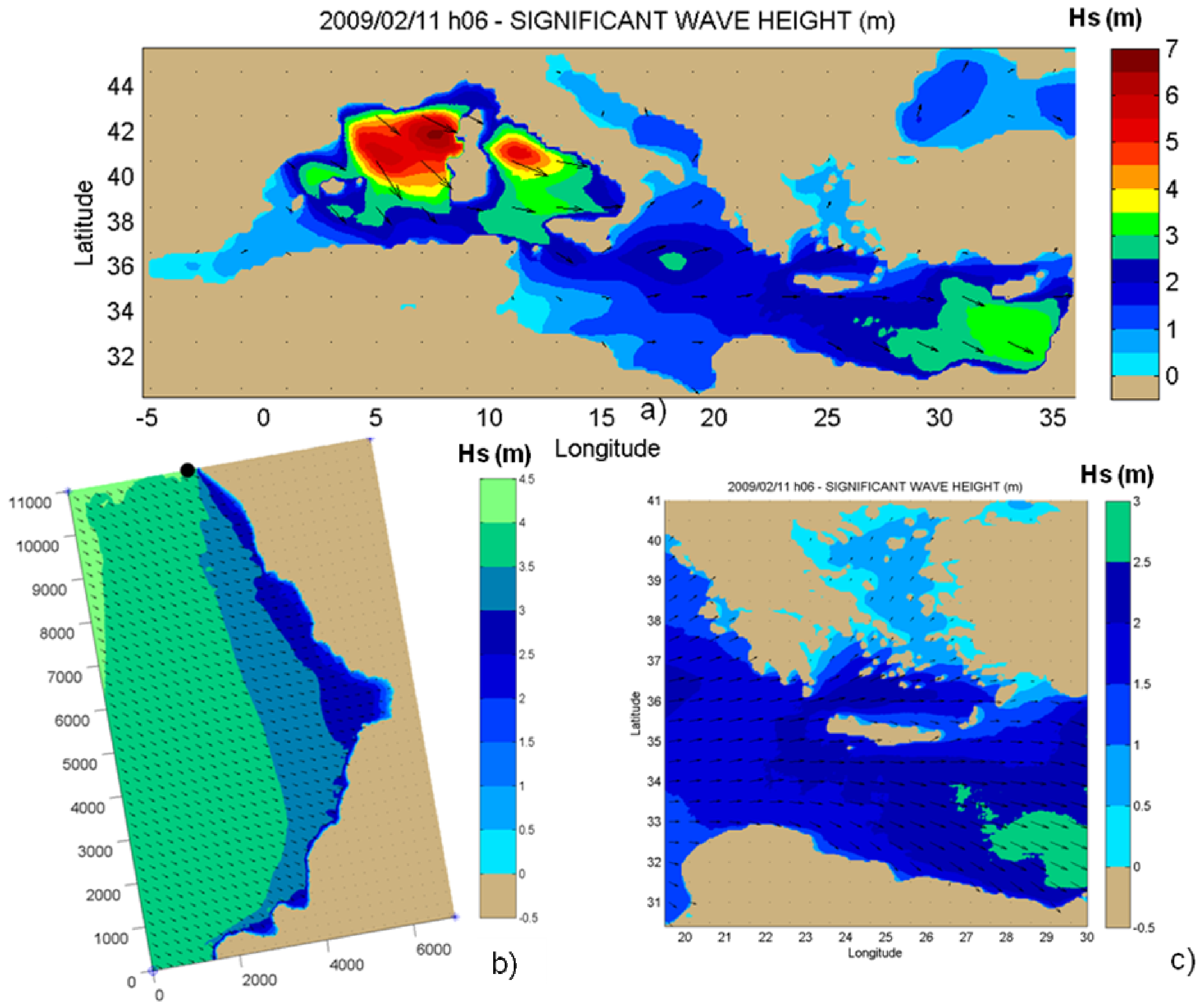


Figure 11. Wave propagation in the Mediterranean Sea a) Sea level; b) high resolution domain, Porto Ferro, Sardinia; c) Regional domain focused on Greece.

2.1.2 Wave energy propagation patterns in the Western Black Sea

The most relevant patterns of the wave energy propagation in the western side of the Black Sea were also assessed at this stage in the framework of the REMARC project. The emphasis was put on the western side because this is also the most energetic part of the Black Sea. The assessments performed relate some recent results provided by a numerical wave modelling system based on the spectrum concept. The SWAN model (acronym for Simulating Waves Nearshore) was considered. This was implemented over the entire sea basin and focused with increasing resolution in the geographical space towards the Romanian nearshore. Furthermore, some data assimilation techniques have been also implemented, such that the results provided are enough accurate and reliable. Four SWAN computational levels have been defined, performing model simulations in eight different areas. The first three levels correspond to the spherical coordinates while the last to Cartesians. The correspondent geographical spaces are illustrated in Figures 12 and 13, where the bathymetric maps are presented.

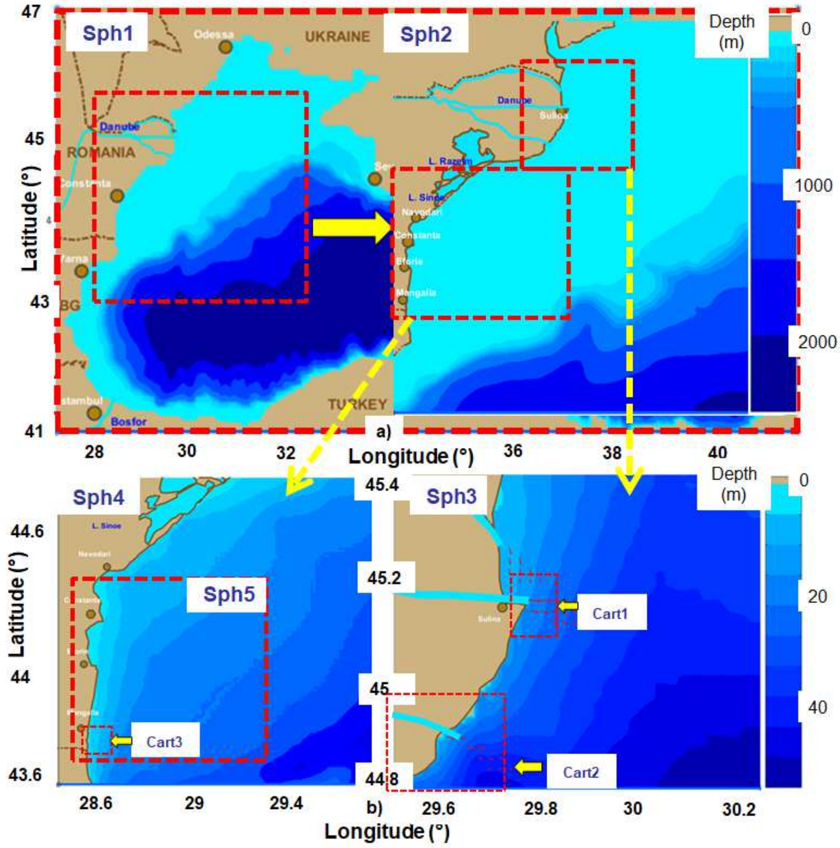


Figure 12. The computational domains defined in spherical coordinates: a) Sph1 –Black Sea basin and Sph2 (right side) – western coastal driver; b) Sph3 – nearshore area at the mouths of the Danube River (right side); Sph4 and Sph5 (left side) – Southern RO1 and RO2. The positions of the three Cartesian domains are also indicated.

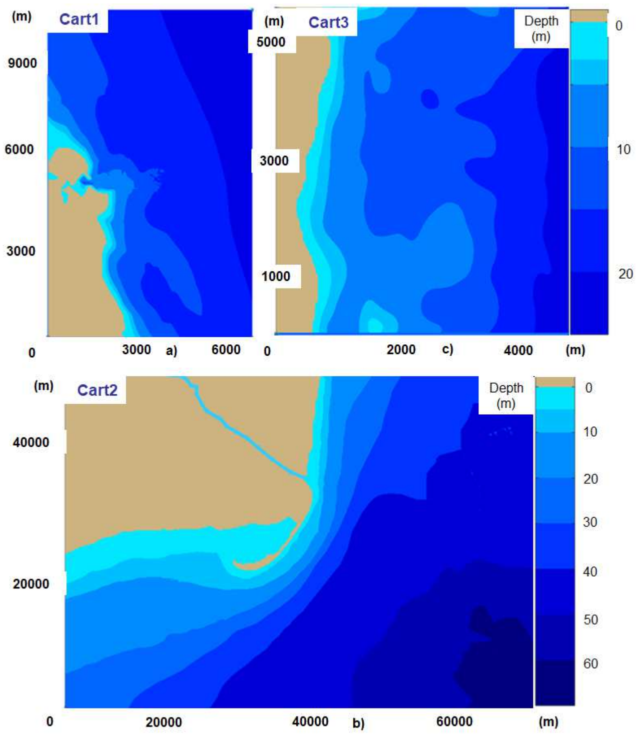


Figure13. The computational domains defined in Cartesian: a) Cart1 –the nearshore in front of Sulina arm of the Danube River; b) Cart2 – Sacalin Peninsula and the Saint George arm of the Danube River; c) coastal environment close to Mangalia city, the south of the Romanian nearshore.

From this perspective, the present report illustrates some of the most recent patterns of wave energy propagation in the western side of the Black Sea, considering eight different SWAN computational domains. According to most of the recent evaluations, the nearshore of the Black Sea is characterized by an average wave power lower than 6 kW/m. A special attention was paid to the high winter non storm wave energy conditions. This also takes into account the fact that, mainly due to the climate changes, the configuration of the environmental matrix in the Black Sea is currently subjected to significant changes. The results of the work carried out up to now show that there is a real tendency of the wave energy enhancement. This tendency, especially concerns the western side of the basin, where even in the non-storm conditions considered, values of the wave power about 10 times greater than the average have been noticed. From this perspective, Figures 14-19 illustrate some relevant wave and energy propagation patterns in the Black Sea and corresponding to the downscaling process towards the western side.

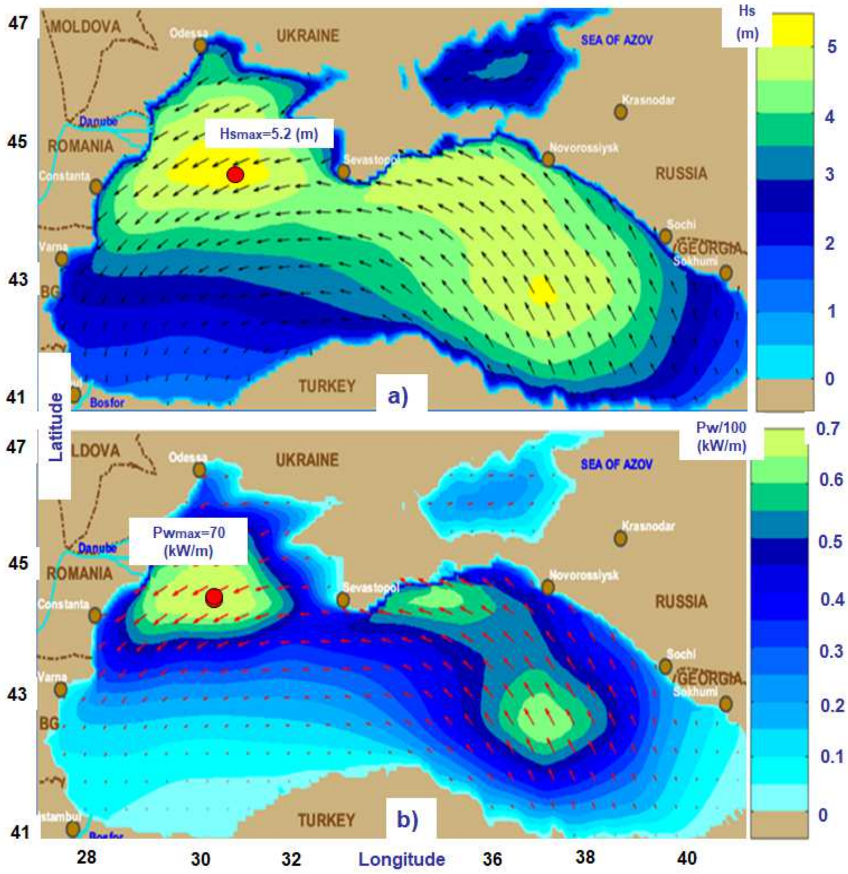


Figure 14. High non storm wave conditions in the Black Sea (computational domain Sph1), model results corresponding to the time frame 2017/01/08. a) Significant wave height scalar fields and wave vectors; b) Wave power scalar fields and energy transport vectors. The maximum values of the significant wave height and wave power are also indicated.

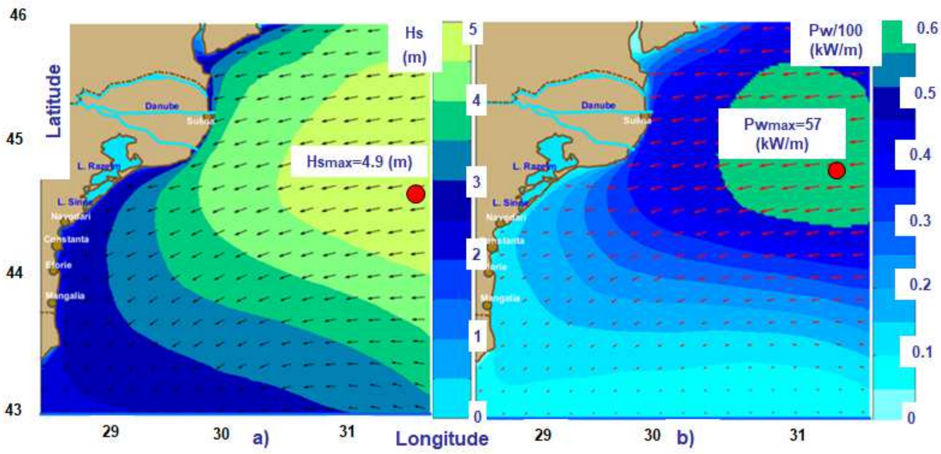


Figure 15. High non storm wave conditions in the western Black Sea (computational domain Sph2), model results corresponding to the time frame 2017/02/04. a) Significant wave height scalar fields and wave vectors; b) Wave power scalar fields and energy transport vectors.

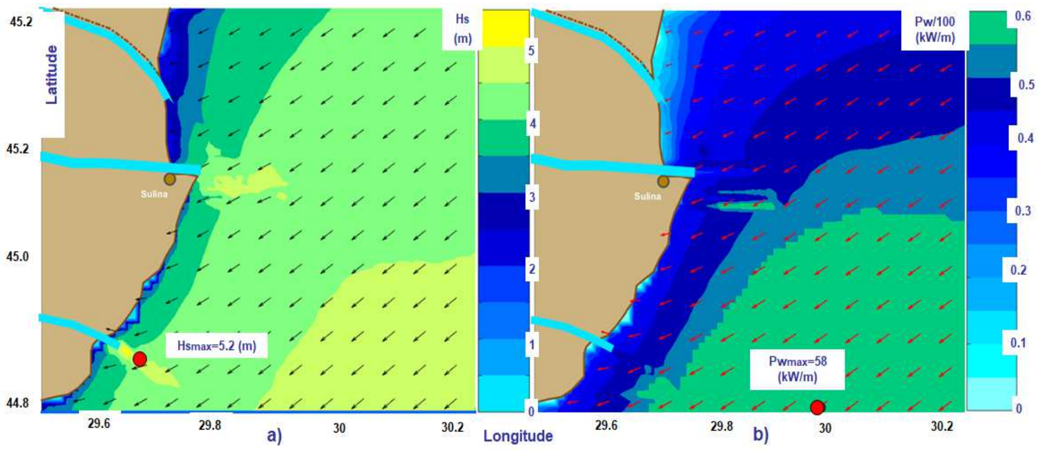


Figure 16. High non storm wave conditions at the mouths of the Danube River (computational domain Sph3), model results corresponding to the time frame 2017/03/22. a) Significant wave height scalar fields and wave vectors; b) Wave power scalar fields and energy transport vectors.

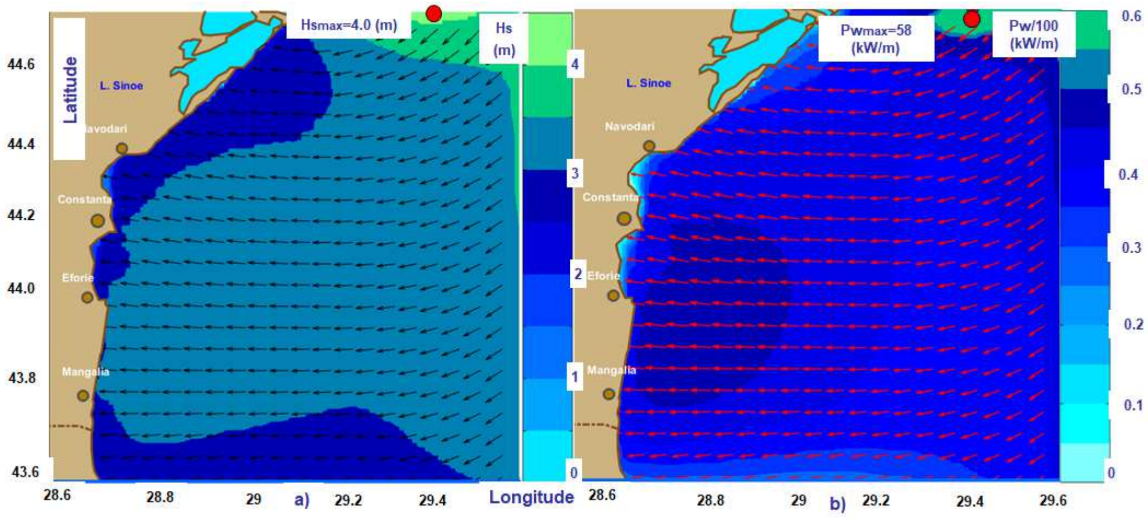


Figure 17. Average to high non storm wave conditions in the southern side of the Romanian nearshore (computational domain Sph4 – Southern RO1), model results corresponding to the time frame 2017/10/07. a) Significant wave height scalar fields and wave vectors; b) Wave power scalar fields and energy transport vectors.

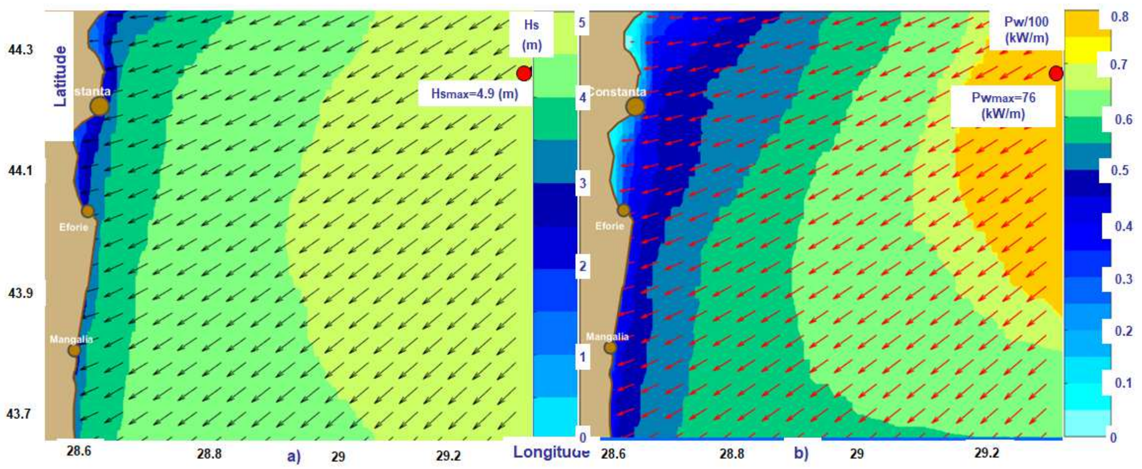


Figure 18. High non storm wave conditions in the southern side of the Romanian nearshore (computational domain Sph5– Southern RO2), model results corresponding to the time frame 2017/10/25. a) Significant wave height scalar fields and wave vectors; b) Wave power scalar fields and energy transport vectors.

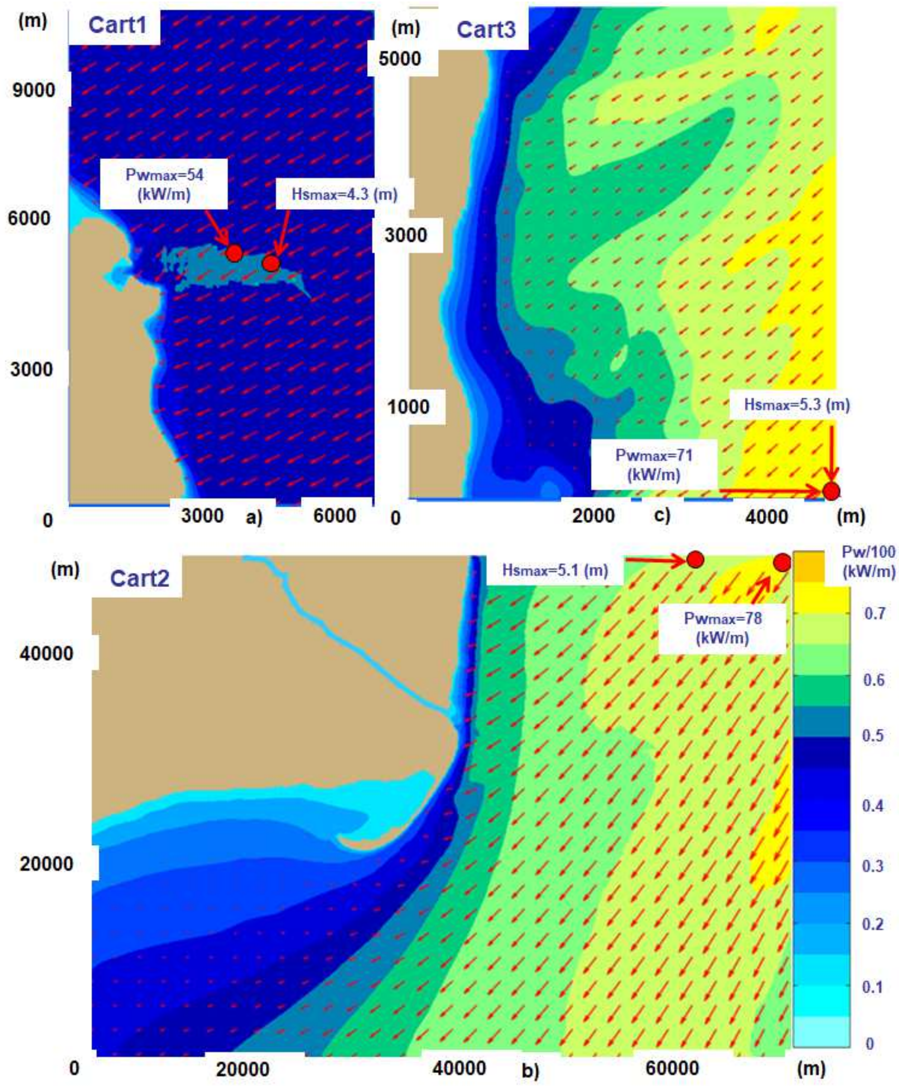


Figure 19. Wave power scalar fields and energy transport vectors in the high resolution Cartesian domains defined: a) Cart1 – Sulina bar, average to high wave energy situation corresponding to the time frame 2017/11/08; b) Cart2 – Sacalin Peninsula, high non storm wave conditions, time frame 2017/11/28. c) Cart3 – Mangalia nearshore, high non storm wave conditions, time frame 2017/12/18.

More details concerning the wave conditions and the energy propagation patterns in the western side of the Black Sea can be found in the paper [2] from the list of publications, published in the journal Applied Science.

2.1.3 Advanced numerical modeling in the nearshore areas

In the framework of the REMARC project, some alternative approaches were also explored. Thus, it was designed a prediction methodology for the significant wave height (an implicitly the wave power), based on the artificial neural networks. The proposed approach takes as input data the wind speed values recorded for different time periods. The prediction of the significant wave height is useful both for assessment of the wave energy as also for marine equipment design and navigation. The data used cover the time interval 1999 to 2007, and it was measured at the Gloria drilling unit, which operates in the Romanian nearshore of the Black Sea at about 50 meters water depth.

As the establishing of the network architecture represents the most important stage in the ANN model building, an optimization procedure was used: several networks were built and trained for a low number of cycles and the best was chosen. Taking into account that the wind has the main influence on wave height, as training datasets, the values for wind speed and significant wave height were used. In order to cover all the connections between the wind and waves, the datasets contain values at every day/month, for 1999-2007, with 6 hours time step. The date, time and wind speed stand as inputs and wave height as output. As results, eight ANNs were obtained, one for each year data-set, named further as M-1999....M-2007. In figure 20 it is presented, as an example, the ANN architecture for two different years.

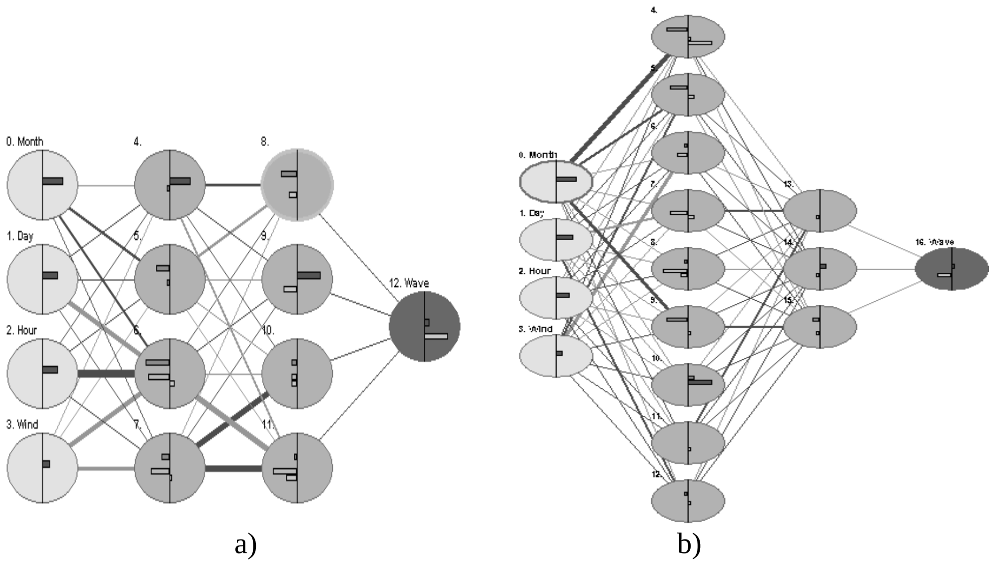


Figure 20. ANN architectures a) 1999 dataset; b) 2006 dataset

More details concerning the application of the neural networks to the estimation of the nearshore wave energy are provided in the paper number [10] from the list of publications. This work was presented to the conference ICACER 2018 - 3rd International Conference on Advances on Clean Energy Research, 4-6 April, 2018, Barcelona, SPAIN.

At the end of this section it has to be highlighted that an original numerical model was also designed for the estimation of the Wave Energy Converter (WEC) performance in variable bathymetry regions, taking into account the interaction of the floating units with the bottom topography. The proposed method is based on a coupled-mode model for the propagation of the water waves over the general bottom topography, in combination with a Boundary Element Method for the treatment of the diffraction/radiation problems and the evaluation of the flow details on the local scale of the energy absorbers. An important feature of the proposed method is that it is free of mild bottom slope assumptions and restrictions and it is able to resolve the 3D wave field all over the water column, in variable bathymetry regions including the interactions of floating bodies of general shape. Numerical results are presented concerning the wave field and the power output of a single device in inhomogeneous environment, focusing on the effect of the shape of the floater. We considered the hydrodynamic problem concerning the behavior of a number *N* of identical cylindrical-shaped WECs of characteristic radius *a* and draft *d*, operating in the nearshore environment, as shown in Figure 21. Extensions of the method to treat the WEC arrays in variable bathymetry regions are also presented and discussed.

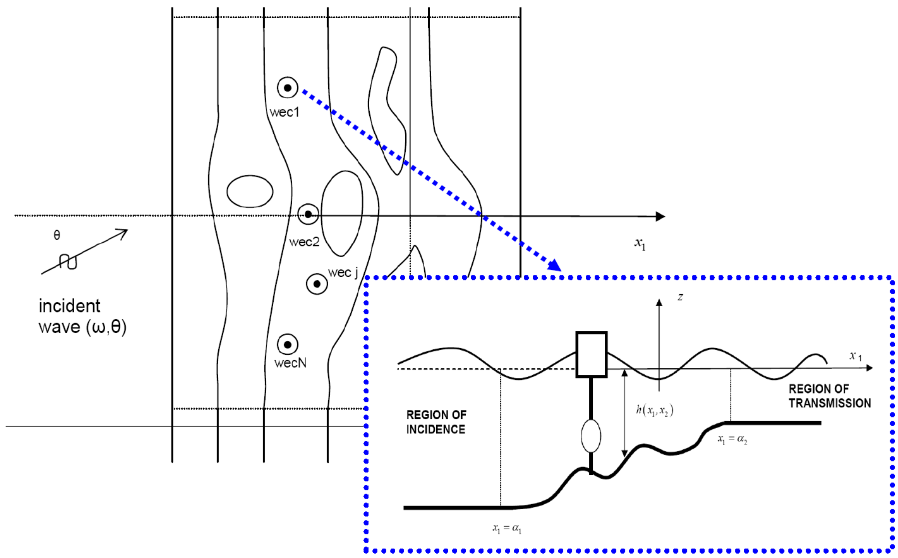


Figure 21. Array of WECs in variable bathymetry region.

More details concerning the wave energy propagation patterns in the nearshore areas with variable bathimetry can be found in the paper [3] from the list of publications, work published in Energies journal.

2.2 Long term analyses of the wave (and wind) conditions in the areas targeted

2.2.1 Comparisons of the wind and wave power between the European nearshore sites and other coastal environments

A first analysis has as main objective to perform a joint evaluation of the wave and wind power along the continental coasts of Latin America and Europe and also to assess the synergy between these two resources. 17 years of data (2000-2016), provided by the European Centre for Medium-Range Weather Forecasts through the ERA – Interim project, have been considered and several reference points have been defined along each coast for performing the analysis (Figure 22). Figure 23 presents the wind and wave power corresponding to the 17-year time interval considered, structured on total and winter time distribution, respectively.

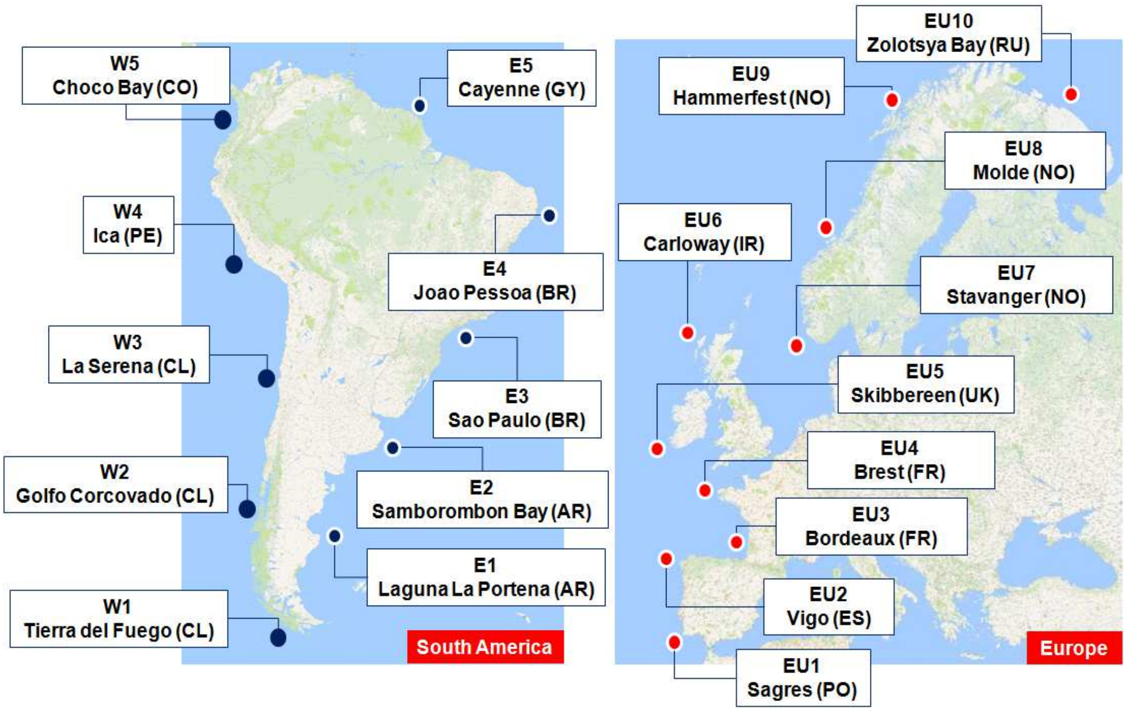


Figure 22. Map of South America and Europe including the positions and characteristics of the reference points considered.

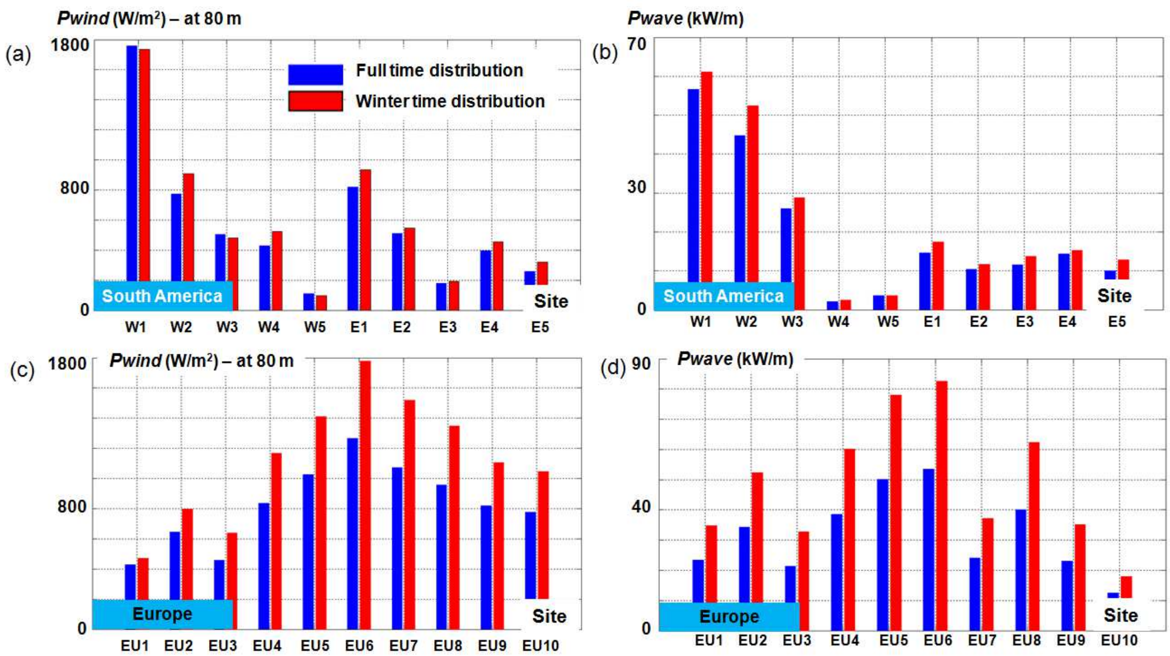


Figure 23. Wind and wave power corresponding to the 17-year time interval from January 2000 to December 2016, structured on total and winter time distribution, respectively. The results are reported in: a) South America – wind power; b) South America-wave power; c) Europe-wind power; d) Europe-wave power.

More details concerning the comparison concerning the wind and wave resources between the Latin American and the European coastal environments are provided in the paper number [7] from the list of publications. This work was presented to the 1st Latin American SDEWES conference, Rio de Janeiro, Brazil.

The global wind and wave resources in the vicinity of some developing countries, by evaluating this time 16-year of data (2001–2016), are illustrated in Figure 24 (presenting the wind roses) and in Figure 25 (presenting the monthly variations of the main wave parameters).

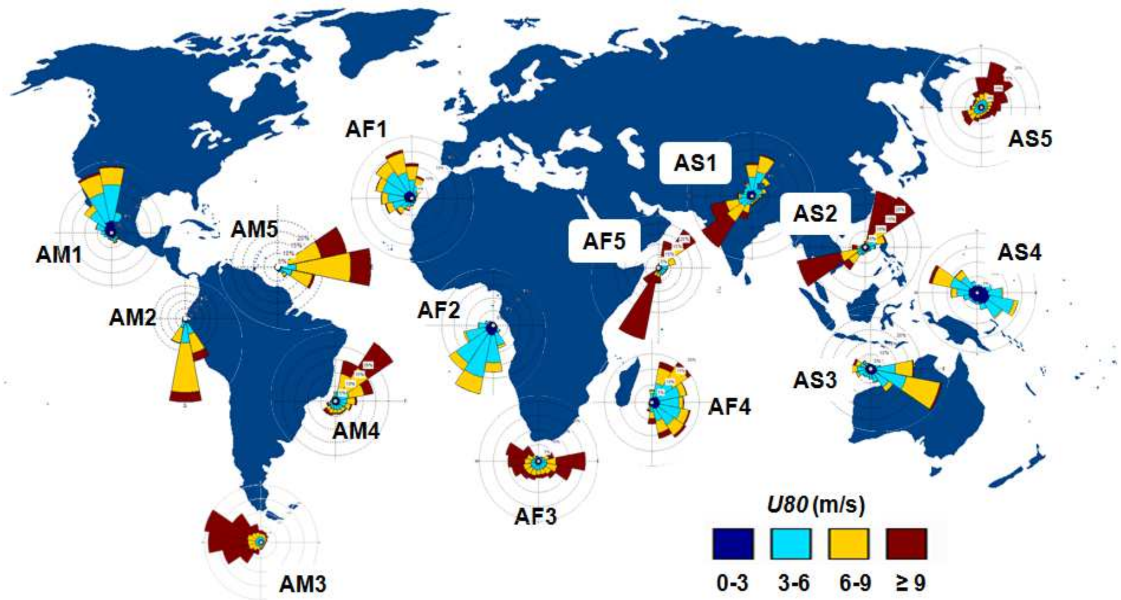


Figure 24. Wind roses corresponding to 16-year of ECMWF wind data (2001–2016).

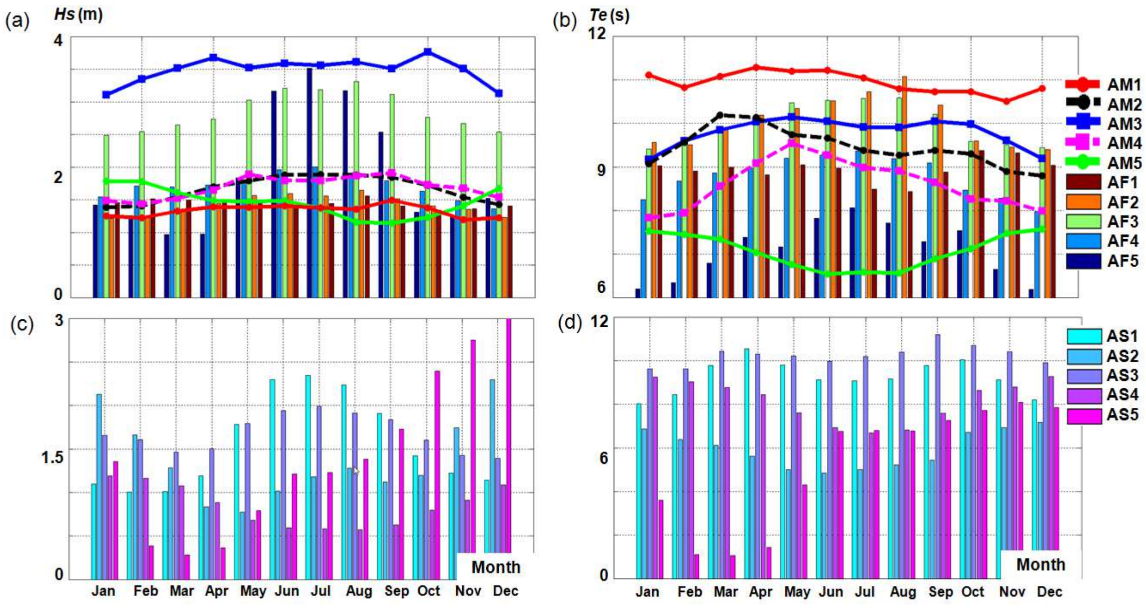


Figure 25. Monthly variations of the main wave parameters corresponding to the 16-year interval (2001–2016). The results (average values) are indicated in terms of the wave parameters: (**a**, **c**) *Hs* (m)—America/Africa and Asia; (**b**, **d**) *Te* (s)—America/Africa and Asia.

Further on the work developed in the framework of the REMARC project was focused on the French coastal environment. Thus, Figure 26 illustrates the target area where the 15 reference sites (denoted from P1 to P15) were defined along five reference lines. There are two groups of sites, the first is located in the Atlantic Ocean (P1-P9) while the second covers the Mediterranean Sea (P10-P15). Figure 27 presents the distribution of the average wave power and the evolution of the fluctuation of Wave Energy Development Index (WEDI), considering the total and winter time season (from October to March). The wave power (*Pwave*), is computed by using the expression corresponding to the deep water conditions, while the WEDI index represents the ratio between the average wave power and the maximum storm wave power (*Jwave*). A higher WEDI value is usually associated with a potential loss of utilization, and therefore the sites with such characteristics should be avoided

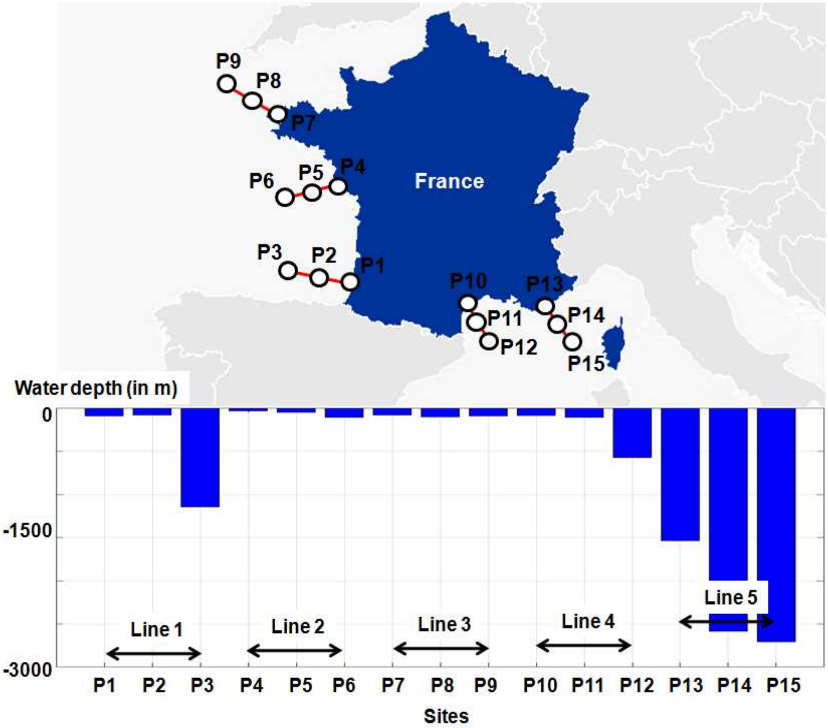


Figure 26. Map of the target area including the reference sites (and the water depth) considered for evaluation

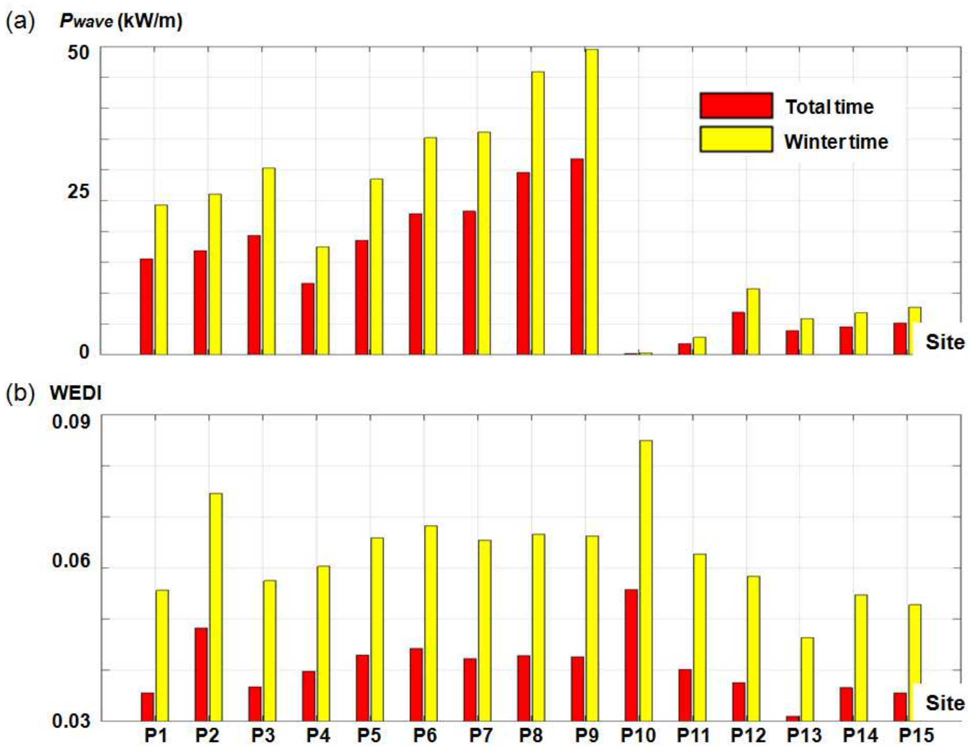


Figure 27. Wave conditions reported for the 10-year of ECMWF wave data (2008-2017). The results are computed for the total time and winter season, where: (a) *Pwave* index; (b) WEDI index.

More details concerning the evaluation of the wind and wave resources in the French coastal environment are provided in the paper number [14] from the list of publications. This work was presented to the : 2018 International Conference on Power and Energy Technology (ICPET 2018), July 2018, Lille, France.

2.2.2 Long term analyses of the wind and wave conditions in the Black Sea

A special attention concerning the long term analyses of the wind and wave conditions was payed to the basin of the Black Sea, for which 30 years of SWAN model simulations (1987-2016) have been performed and analysed. Thus, Figure 28 presents the mean significant wave height (left panel) and wind speed (right panel) fields averaged for 30-year period considered (1987-2016). Furthermore, Figure 29 illustrates the spatial distributions of the mean wave power fields (left panel) and the mean wind power density at 80 m (right panel) corresponding to the same 30-year period.

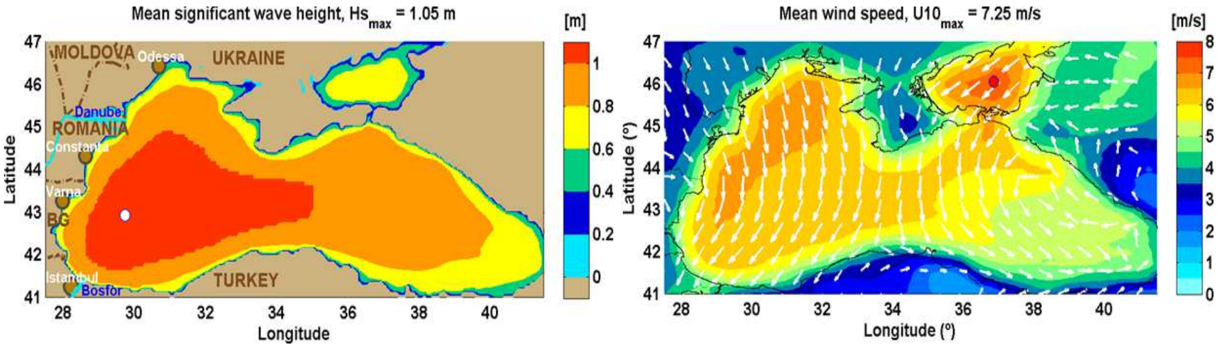


Figure 28. Mean significant wave height (left panel) and wind speed (right panel) fields averaged for 30 years (1987-2016).

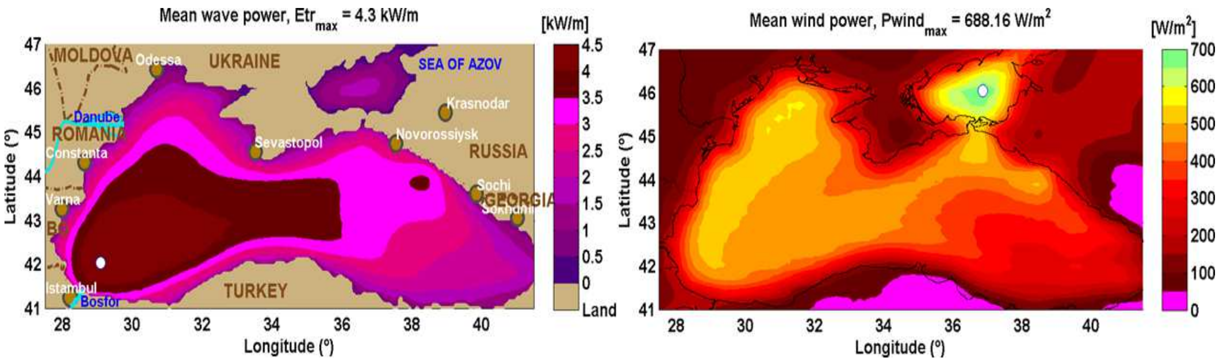


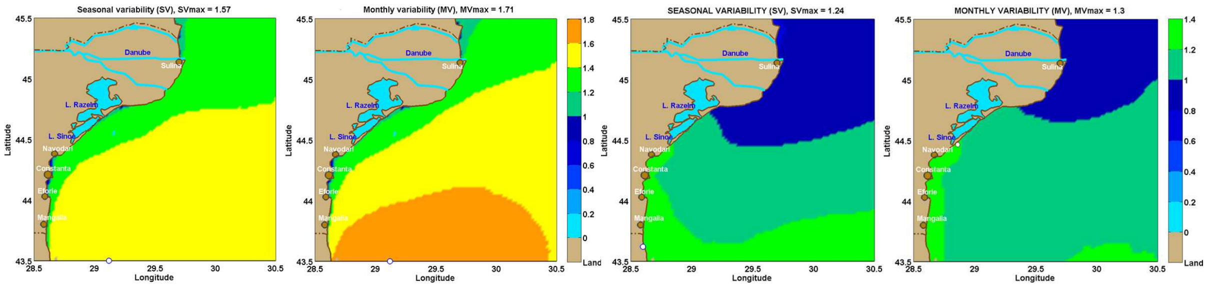
Figure 29. The spatial distributions of the mean wave power fields (left panel) and the mean wind power density at 80 m (right panel) corresponding to the 30-year period 1987–2016.

In order to have more detailed information about the variability of resources, the monthly and the seasonal variability indexes (MV and SV, respectively) were evaluated. These indexes are defined as the differences between the most energetic season/month and the least energetic season/month divided by the yearly average value evaluated over the whole dataset:

$$MV = \frac{P_{M\,\max} - P_{M\,\min}}{P_{year}} \quad (1)$$

$$SV = \frac{P_{S\,\max} - P_{S\,\min}}{P_{year}} \quad (2)$$

The SV and MV values computed for the wind and wave power are presented in Figure 30. The results show that for the same resources the seasonal and monthly variability indexes have similar behaviour. Both variability indexes computed for the wind power are lower (about 0.4) than those computed for the wave power.



a) b) c) d)

Figure 30. Seasonal variability of the mean wave (a) and wind (c) power; Monthly variability of the mean wave (b) and wind (d) power; for the 30-year period 1987-2016.

More details concerning the 30-year analysis of the wind and wave data in the Black Sea are provided in the paper number [8] from the list of publications. This work was presented to the 1st Latin American SDEWES conference, Rio de Janeiro, Brazil, where it received the distinction BEST PAPER AWARD in a conference with more than 300 participants.

3. Updating the web page (Ro-Eng) of the REMARC project

During the project unfolding the web page associated to the REMARC project http://193.231.148.42/remarc/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.
REMARC project was also included in the RESEARCHGATE platform and it was made a direct link between the web page and RESEARCHGATE. https://www.researchgate.net/project/REMARC-Renewable-Energy-extraction-in-MARine-environment-and-its-Coastal-impact

4. Dissemination of the results

4.1 Dissemination through scientific publications

Publications in international journals (6)

1. Rusu, E., 2018, *"Numerical Modeling of the Wave Energy Propagation in the Iberian Nearshore"*, Energies 11(4), 980, **(WoS, IF=2.676)**, https://doi.org/10.3390/en11040980
2. Rusu, E., 2018, *"Study of the Wave Energy Propagation Patterns in the Western Black Sea"*, Applied Sciences 8(6), 993, **(WoS, IF=1.689)**, https://doi.org/10.3390/app8060993
3. Belibassakis, K., Bonovas, M., Rusu, E., 2018, "A novel method for estimating wave energy converter performance in variable bathymetry regions and applications "Energies 11(8), 2092, **(WoS, IF=2.676)**, https://www.mdpi.com/1996-1073/11/8/2092
4. Onea, F., Rusu, E., 2018, *"Sustainability of the Reanalysis Databases in Predicting the Wind and Wave Power along the European Coasts"*, Sustainability 2018, 10(1), 193, **(WoS, IF=2.075)**, http://www.mdpi.com/2071-1050/10/1/193
5. Niculescu, D., Rusu, E., 2018, *"Evaluation of the new coastal protection scheme at Mamaia Bay in the nearshore of the Black Sea"*, Ocean Systems Engineering, Vol.8, No. 1 (2018), pp. 1-20, **(WoS)**, http://www.techno-press.org/?page=container&journal=ose&volume=8&num=1
6. Rusu, E., Onea, F., 2018, *"A review of the technologies for wave energy extraction"*, Clean Energy, 2018, 1–10, https://academic.oup.com/ce/advance-article/doi/10.1093/ce/zky003/4924611

Participation in international conferences and publication in conferences' proceedings (15)

7. Rusu, E., Onea, F., 2018, *The Synergy Between Wave and Wind Energy along the Latin American and the European Continental Coasts*, Conference: 1st Latin American SDEWES conference, Rio de Janeiro, Brazil, http://www.rio2018.sdewes.org/programme.php

8. Rusu, L., 2018, *The Wave and Wind Power Potential in the Western Black Sea*, Conference: 1st Latin American SDEWES conference, Rio de Janeiro, Brazil, **BEAST PAPER AWARD!**, http://www.rio2018.sdewes.org/programme.php
9. Rusu, E., Onea, F., 2018, *Evaluation of the shoreline effect of the marine energy farms in different coastal environments*, Conference: ICACER 2018 - 3rd International Conference on Advances on Clean Energy Research, 4-6 April, 2018, Barcelona, SPAIN, http://icacer.com/
10. Ciortan, S., Rusu, E., 2018, *Prediction of the wave power in the Black Sea based on wind speed using artificial neural networks*, Conference: ICACER 2018 - 3rd International Conference on Advances on Clean Energy Research, 4-6 April, 2018, Barcelona, SPAIN, http://icacer.com/
11. Niculescu, D., Rusu, E., 2018, *An overview of the wind power potential in the Romanian coastal environment-moving from onshore to offshore*, Conference: ICACER 2018 - 3rd International Conference on Advances on Clean Energy Research, 4-6 April, 2018, Barcelona, SPAIN, http://icacer.com/
12. Rusu, L., 2018, *Evaluation of the synergy between wind and wave power for combined exploitation in the Black Sea*, Conference: ICACER 2018 - 3rd International Conference on Advances on Clean Energy Research, 4-6 April, 2018, Barcelona, SPAIN, http://icacer.com/
13. Banescu, A., Georgescu, L., Iticescu, C., Rusu, E., 2018, *Analysis of the wind action on the turbines operating in the Dobrogea region from Romania*, Conference: 18th International Multidisciplinary Scientific GeoConference SGEM 2018, Albena, Bulgaria, https://www.sgem.org/
14. Onea, F., Rusu, E., 2018, *Sensitivity analysis of the wave energy converters operating in the French coastal waters*, Conference: 2018 International Conference on Power and Energy Technology (ICPET 2018), July 2018, Lille, France, http://www.icpet.org/
15. Anton, C., Gasparotti, C., Rusu, E., Anton, I., 2018, *Approach to the analysis and evaluation of strategic intervention options in the Romanian coastal zone taking into account economic, social and environmental factors*, Conference: 18th International Multidisciplinary Scientific GeoConference SGEM 2018, Albena, Bulgaria, https://www.sgem.org/
16. Anton, C., Gasparotti, C., Rusu, E., 2018, *Identification of the economic pressure on environmental factors in the Romanian coastal zone-case study Eforie*, Conference: 18th International Multidisciplinary Scientific GeoConference SGEM 2018, Albena, Bulgaria, https://www.sgem.org/
17. Picu, L, Rusu, E., Picu, M., 2018, *Evaluation of human exposure to whole-body vibration-verification method of stevens's power law*, Conference: 18th International Multidisciplinary Scientific GeoConference SGEM 2018, Albena, Bulgaria, **(WoS)**, https://www.sgem.org/
18. Caranfil, V., Rusu, E., Onea, F., 2018, *An analysis of the renewable energy resources in the Republic of Moldova*, Conference: 18th International Multidisciplinary Scientific GeoConference SGEM 2018, Albena, Bulgaria, https://www.sgem.org/
19. Stingheru, C., Rusu, E., and Gasparotti, C., 2018, The cause-effect method used in highlighting the main causes and implications of maritime accidents in the Black Sea, ICTTE Belgrade 2018. International Conference on Traffic and Transport Engineering, 27th – 28th September 2018, Belgrade (Serbia), pp 283-289, http://ijtte.com/uploads/news_files/ICTTE%20Belgrade%202018_Proceedings.pdf
20. Picu, L., Rusu, E., 2018, Quantifying the effect of the ship vibration on crew for the inland navigation-case study a cargo navigating in the lower Danube sector, ICTTE Belgrade 2018. International Conference on Traffic and Transport Engineering, 27th – 28th September 2018, Belgrade (Serbia), pp. 169-174, http://ijtte.com/uploads/news_files/ICTTE%20Belgrade%202018_Proceedings.pdf
21. Anton, C., Gasparotti, C. and Rusu, E., 2018, A challenge for the inland navigation-a connection between the Baltic and the Black Seas, , ICTTE Belgrade 2018. International Conference on Traffic and Transport Engineering, 27th – 28th September 2018, Belgrade (Serbia), pp. 175-186, http://ijtte.com/uploads/news_files/ICTTE%20Belgrade%202018_Proceedings.pdf

Publications in Romanian national journals indexed in international databases (4)

22. Novac, V., Rusu, E., 2018, *Black Sea littoral military operations - environment impact*, Scientific Bulletin of Naval Academy, Vol. XXI 2018, pp. 607-616. doi:10.21279/1454-864X-18-I1-091, https://www.anmb.ro/buletinstiintific/buletine/2018_Issue1/04_FAR/novac.pdf
23. Gasparotti, C. and Rusu, E., 2018, Assessment of the energy potential of the waves in the Black Sea, Mechanical Testing and Diagnosis, ISSN 2247 –9635, 2018 (VIII), Volume 3, pp. 5 -10, http://www.im.ugal.ro/mtd/download/2018-3/1_MTD_Volume%203_2018_Gaparotti%20xx.pdf

24. Stingheru, C., Gasparotti, C., Raileanu, A., Rusu, E., 2018, *A SWOT Analysis of the Marine Energy Sector at the European Level*, Acta Universitatis Danubius. Œconomica, Vol 14, No 3 (2018), pp. 213-237, http://www.journals.univ-danubius.ro/index.php/oeconomica/article/view/4551
25. Caranfil, V., Rusu, E., Onea, F., 2018, An evaluation of the solar and wind energy in the south - east of Romania Mechanical Testing and Diagnosis, ISSN 2247 –9635, 2018 (VIII), Volume 2, pp. 15 -20, http://www.im.ugal.ro/mtd/download/2018-2/3_MTD_Volume%202_2018_Caranfil%20xx.pdf

Presentations at national conferences (6)

26. Rusu, E., 2018, *An Assessment of the Wind Energy Potential in the Romanian Nearshore*, **INVITED LECTURE**, Conference: CSSD2018 -Scientific Conference of the Doctoral Schools - Perspectives and Challanges in Doctoral Research, June 2018, Galati, Romania, https://www.researchgate.net/publication/325662815_An_Assessment_of_the_Wind_Energy_Potential_in_the_Romanian_Nearshore
27. Anton, C., Gasparotti, C., Rusu, E., 2018, *Analysis of the Mamaia Bay Shoreline Retreat Using Hard and Soft Protection Works*, 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
28. Anton, C., Gasparotti, C., Rusu, E., 2018, *Introducing the Blue Economy Concept in the Romanian Nearshore*, 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
29. Picu, L., Rusu, E., 2018, *Multiple Physical Stress Exposures of Sailors on Several Ships. A Longitudinal Study*, 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
30. Caranfil, V., Rusu, E., Onea, F., 2018, *Partial Energy Consumption Supplied by Renewable Energy Sources for a Production Hall*, 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
31. Picu, L., Rusu, E., 2018, *Single Degree of Freedom Vibrating System and the Prediction of Human Discomfort Due to its Transient Vibrations*, 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
32. Rusu, E., 2018, Marine Environment – an Important part of our Future, INVITED CONFERENCE at the Iași Branch of the Romanian Academy, 1 November 2018. http://acadiasi.org/mediul-marin-o-parte-importanta-a-viitorului-nostru/

In addition to these, other 5 papers are currently under review for various international journals.

4.2 Dissemination through participation in international scientific committees

The international visibility of the team members is proved also through the participation as program chair or member in technical/organizing/scientific committee to relevant international meetings. Besides the prove of the international recognition of the project director and of the team members, this also represents a very good mean for disseminating the results of the REMARC project. Thus, there can be mentioned the followings:

Prof Eugen RUSU (project director): Program chair – 3rd International Conference on Advances on Clean Energy Research – ICACER2018 – Barcelona Spain, and 4th International Conference on Advances on Clean Energy Research – ICACER2019 – Coimbra, Portugal, http://icacer.com/com.html

Prof Eugen RUSU (project director): Program chair – 2nd International Conference on Energy Economics and Energy Policy, ICEEEP2018, 3rd International Conference on Energy Economics and Energy Policy, ICEEEP2019, http://www.iceeep.com/com.html

Prof Eugen RUSU (project director): scientific committee member - 2nd International Symposium on Natural Hazards and Disaster Management (ISHAD2018), http://ishad.info/Content/Pages/Committees.aspx

Prof Eugen RUSU (project director): organizing committee member, 2018 International Conference on Clean Energy and Smart Grid (CCESG2019), http://www.ccesg.org/

Prof Liliana RUSU (team member): organizing committee member, 2018 International Conference on Clean Energy and Smart Grid (CCESG2019), http://www.ccesg.org/

Prof Liliana RUSU (team member) scientific committee member, 1st Latin American Conference on Sustainable Development of Energy Water and Environment Systems, SDEWES2018, http://www.rio2018.sdewes.org/sab.php

Prof Liliana RUSU (team member) scientific advisory board member, 13th SDEWES Palermo, Italy http://www.palermo2018.sdewes.org/sab.php

At this point, it might be also relevant to mention, as international and romanian national recognition, the fact that the project director became in 2018 corresponding member of the Romanian Academy, which is the highest scientific and cultural forum in Romania, http://www.acad.ro/sectii/sectia08_tehnica/teh_membri.htm

4.3 Support for the young researchers

In the framework of the project, several papers have been published where young scientists (PhD and master students) were included. This can be checked in the list of publications above presented. Besides this, six master theses have been finalized in the framework of the REMARC project, as described bellow.

Master Degree Theses defended (6)

1. Pintilie Viorel (Master: Modeling and Simulations in Mechanical Engineering), topic: *"Installation of renewable energy extraction in rivers"*, supervisor Prof. Dr. Ing. Eugen RUSU
2. Migireanu Bogdan (Master: Naval Architecture - in English), topic: *"Studies on the main economic indicators (LCOE, CAPEX, OPEX) in extracting renewable energy from the marine environment"*, supervisor Conf. Dr. Habil. Ing. Carmen GASPAROTTI
3. Niță Lucian (Master: Naval Architecture - in English), topic: *"Floating devices for wave energy extraction"*, supervisor Conf. Dr. Habil. Ing. Carmen GASPAROTTI
4. Florea Viorica (Master: Advanced Material Engineering), tema: *"Fatigue behaviour of a wave energy converter"*, supervisor Conf. Dr. Ing. Sorin CIORTAN
5. Stăvarache Gheorghe (Master: Advanced Material Engineering), tema: *"Analysis of the energy potential in marine environment using neural networks"*, supervisor Conf. Dr. Ing. Sorin CIORTAN
6. Păun George Robert (Master Naval Architecture in English) *"Joint evaluation of the wind energy resources in the Black Sea nearshore and comparison with other European coastal environments",* supervisor Conf. Dr. Habil. Ing. Carmen GASPAROTTI

5. Conclusions

It can be finally appreciated, that the objectives corresponding to this second stage (through the two actions previewed Act 2.1 and Act 2.2) were fully accomplished. In fact, they were exceeded and more than 30 scientific papers have been published this year in the framework of the REMARC project. From this perspective it can be concluded that all the necessary premises exist for the REMARC project to continue and be finalized in very good conditions and to produce valuable results with a high international visibility.

Budget (2018) 255.559,00 lei (aprox 55 000 EUR)

Project Director

Prof. dr. ing. Eugen Rusu