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DESIGN REQUIREMENTS FOR THE ELECTRICAL HYDRO-PNEUMATIC STATIONS POWERED BY WAVES IN WEST AREA OF THE BLACK SEA USING SWAN MODEL

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ABSTRACT
Wave energy production is one of the most environmentally benign ways to generate electricity. For building of the power stations, that using sea wave motion to generate hydro-pneumatic pressure, which is then transformed into electricity, is necessary to know the characteristics of the sea waves in the interest area.
To obtain realistic estimated wind-generated waves for the bottom topography, wind field, water level and current field in the west area of the Black Sea, was used the numerical wave SWAN model.
In the paper are presented the method and numerical results obtained using SWAN model for predictions the characteristics of sea waves in west area of the Black Sea.

1. INTRODUCTION

SWAN model was initially conceived only for offshore applications, a fact that doesn’t involve much space flexibility. In the recent versions of software are tried the extension of the software capabilities so the software could be used in all geographical domain. Probably at oceanic level is not so efficient like wave generation models (WAM or WAVEWATCH III) but for sub oceanic levels (small or medium seas, like Black Sea) it can be successfully used. Moreover, it has the advantage of the fact that it used a single model to generate and to transform the waves, which is a great advantage. For generation of the wind fields in the Black Sea it was used the NCEP (National Centers for Environmental Prediction) global model, which, after that, generate the input dates for regional atmospheric model REMO. In this simulations spatial resolution of the wind is 0,25º and time resolutin is one hour.

2. MESH OF THE GEOGRAPHICAL SPACE, DESIGN OF PHYSICAL PHENOMENON AND CALCULATION STRATEGY ADOPTED

For utilization of the SWAN model in the Black Sea (also Azov Sea included) was take into consideration an aria between the following coordinates: from 41º N to 47º N and from 27,5º E to 41,5º E, figure 1. In interior of the designated area it was introduced an other domain of medium resolution which include all the Romanian Black Sea Coast between the following coordinates: from 43,5º N to 45.5º N and from 28,5º E to 30,5º E, figure 2. The grid calculation is identical with bathymetric grid. In table 1 are presented calculation parametrical value of SWAN model for low resolution area (entire surface of Black Sea) and the medium resolution area (Romanian Black Sea Coast), where ($\Delta x \times \Delta y$) represented the spatial resolution of grid calculation, Δt represented time integration pass and *np* represented the number of nodes of the grid. For simulation process was used SWAN 40.41 version, a quicker version comparative with the prevision versions because it used a new implementation method for DIA (Discrete Interaction Approximation) approximation in calculation of quadruples.

Table 1 – Calculations numerical parameters of SWAN model

Grids	Δx × Δy (º)	Δt (s)	nf	nθ	ngx × ngy = np	Δx × Δy (º)
Low resolution	0,08º × 0,08º	1200	30	24	176 × 76 = 13376	0,08º × 0,08º
Medium resolution	0,02º × 0,02º	1200	35	36	101 × 101 = 10201	0,02º × 0,02º

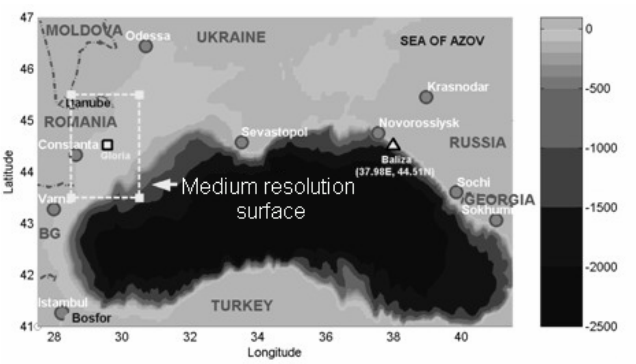


Figure 1. Bathymetric chart of Black Sea, the calibration point position and medium resolution surface position

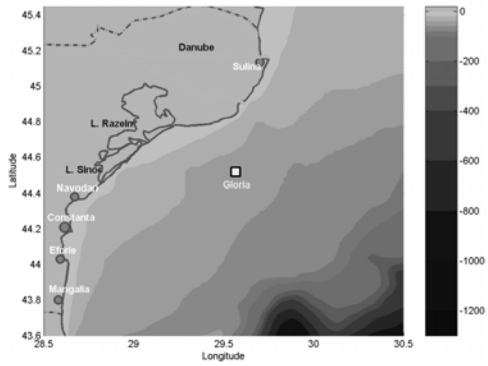


Figure 2. Bathymetric chart of medium resolution surface

3. 'IN SITU' COMPARISONS AND STATISTIC ANALYZE OF RESULTS

At the end of January 1977 (1997.01.29h03) was recorded one of the biggest energetic peaks of the analyzed period. In figure 3 are presented the significant wave height fields, wave vectors and wind vectors for that case, and in figure 4 peak periods and group speed vectors for the same event.

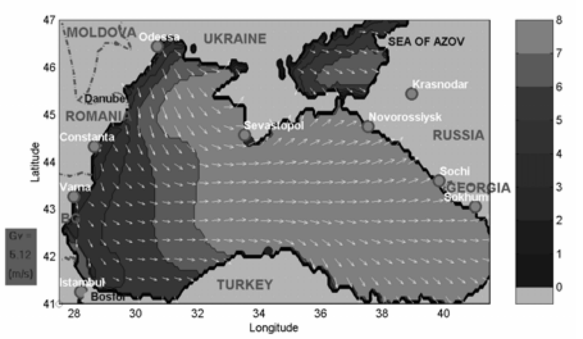


Figure 3. Field of Hs waves vectors (black arrows) and wind's vectors (white arrows) for local energetic peak 01.29h03

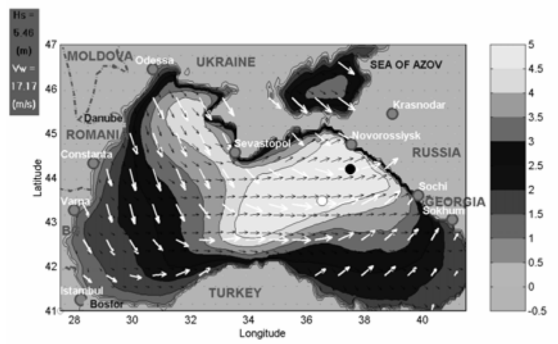
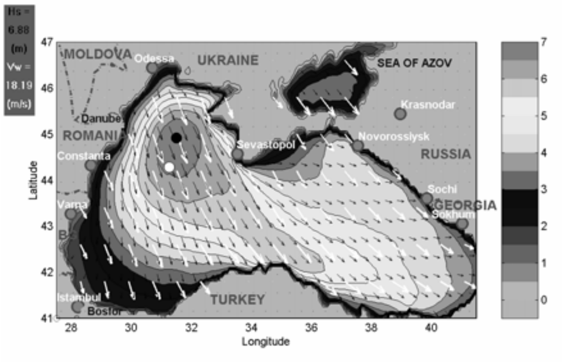


Figure 4. Field of Tp, group speed vectors (white arrows) for local energetic peak 01.29h03



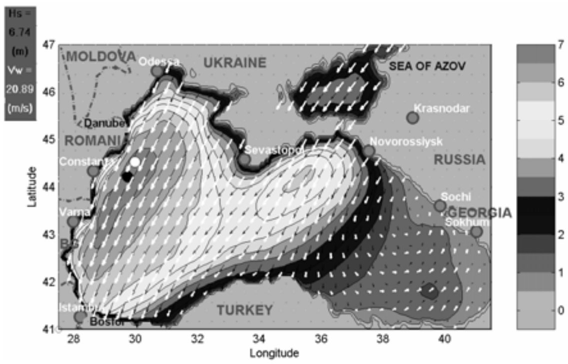


Figure 5. Field of Hs waves vectors (black arrows) and wind's vectors (white arrows) for global energetic peak 01.29h03

Figure 6. Field of Hs waves vectors (black arrows) and wind's vectors (white arrows) for global energetic peak at Gloria platform 12.27h00

In figure 5 are presented the significant wave height fields, wave vectors and wind vectors for global energetic peak for that case of the storm, which take place in approximate to 16 hours later than the local peak illustrated in figure 3 and 4.

4. THE VALIDATION OF THE RESULTS

Direct comparison between the buoy recordings (for indicated period) concerning the significant wave height, the peak period and medium direction are represented in the following figures. Therefore, in figure 7 are represented the results for Komen method and buoys recordings, in figure 8 and 9 are represented the results for Janssen method and Cumulative Steepness Method and finally compared with the same buoys recordings.

For all methods, direct comparison indicated good results regarding the significant wave height and peak period. However, there are same differences regarding medium direction of the waves whereas medium tendency was correct describe by model. There are no significant differences between the four tested methods, regarding the calculation period.

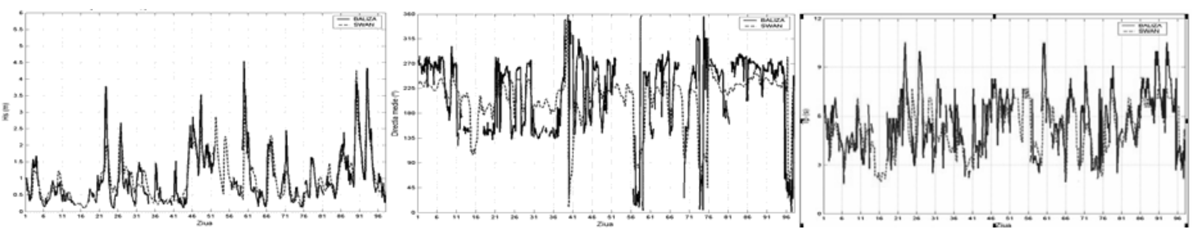


Figure 7. Comparison buoy -SWAN model (Komen method),
Hs, Tp and Medium Direction (1996.11.01h00-1997.02.06h00)

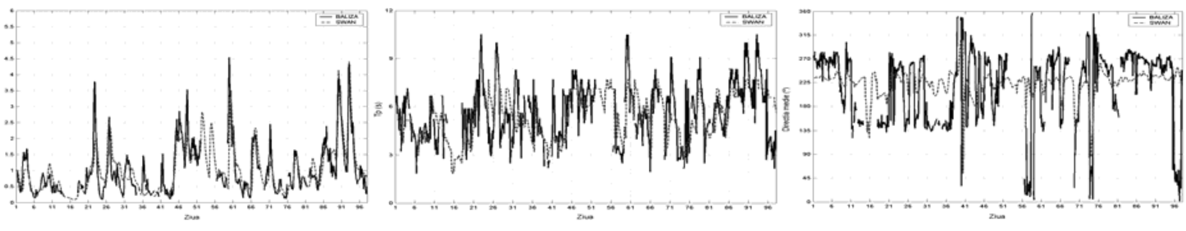


Figure 8. Comparison buoy -SWAN model (Janssen method),
Hs, Tp and Medium Direction (1996.11.01h00-1997.02.06h00)

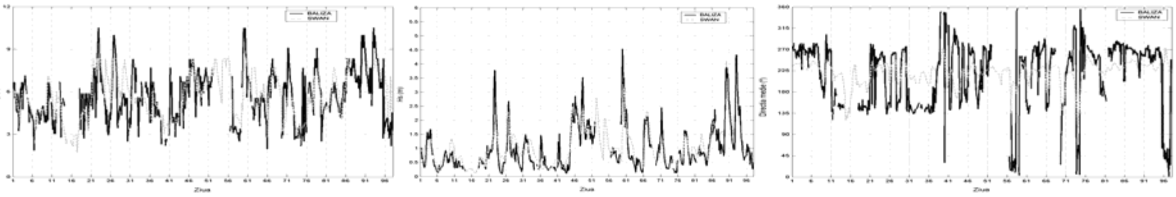


Figure 9. Comparison buoy -SWAN model (Cumulative Steepness Method), Hs, Tp and Medium Direction (1996.11.01h00-1997.02.06h00)

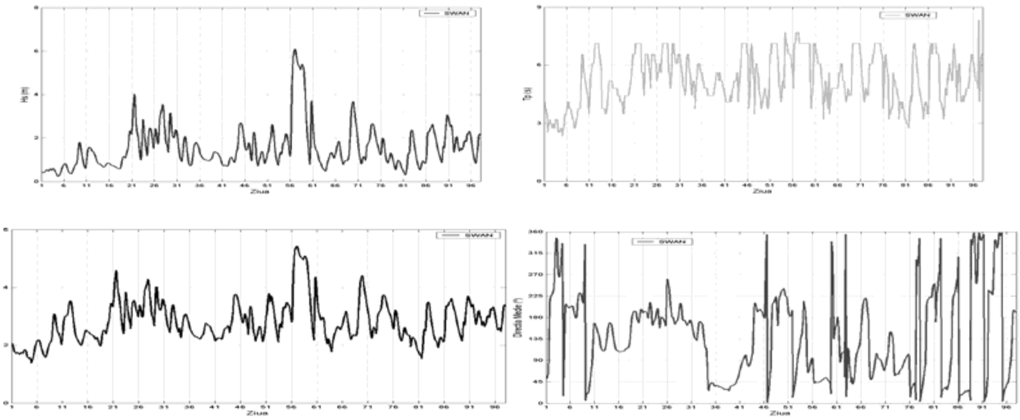


Figure 10. Simulation at Gloria platform in period: 1.11.1996 – 06.02.1997, Hs, Tp, Tm and Medium Direction

In figure 10 are presented the results of simulation for that period (1996.11.01h00-1997.02.06h00), represented in position of Gloria platform. There are analyzed significant wave height fields, peak spectral period, medium period and medium direction.

4. CONCLUSIONS

SWAN numerical model, developed by Delft University of Technology, Nederland, is based on equilibrium equation of spectral action, establish by Hasselmann in JONSWAP (Joint on North Sea WAve Project). Using the software it can obtain estimations near reality of wave's transformation and dissipation, influenced by bottom of the sea topography, wind direction and size and the presents of coast currents.

Expensive methods of real measurement of waves, using ships or oceanic field of buoys, are now successfully replaced by SWAN technology which can realized analyzes of wave's transformation in real time.

Implementation of SWAN model in the Black Sea was made on a medium resolution domain, which include all the Romanian Black Sea Coast, using a calculation grid identical with bathymetric grid.

Direct comparisons of results calculated with SWAN method and the values recorded by buoys, for significant storm periods (with the bigger energetic peaks), taking in account significant high, period of spectral peak and medium direction, gives us good results.

5. REFERENCES

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