A Comparison between the Past and Future Expected Wind Conditions in the European Coastal Environment of the Mediterranean Sea

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Abstract

In the last years, exploitation of the wind power has been constantly increasing together with the size of the turbines. Furthermore, by 2030 wind energy is expected to supply around 30% of EU's power demand. Offshore wind represents a significant future opportunity, since resources are abundant and more stable. In the North and Baltic seas more experience is gained on bottom fixed turbines, but also many initiatives emerge to accelerate the development of floating devices, such as the projects in the Mediterranean and Atlantic. From this perspective, the objective of this work is to analyze the expected dynamics of the of the wind conditions in the European coastal environment of the Mediterranean Sea. The study is focused on estimating the average and extreme wind speeds for the 30-year time interval 2021-2050. In parallel, an analysis of the historical wind data for the 30-year period 1976-2005 is also performed. The climatic wind fields provided by the Global Change Assessment Model are considered in the analysis under the Representative Concentration Pathway scenario 4.5. This is the most probable scenario and assumes that the CO2 emissions will increase until 2040 and then decline.

Keywords: Mediterranean Sea, wind power, 2050, RCP4.5, historical data

1. Introduction

In the last decades the climate changes significantly influenced the dynamics of the environmental matrix (Makris et al, 2016). Furthermore, in the coastal environment this influence is even more visible (see for example Ganea et al, 2019 or Onea and Rusu, 2018). From this perspective, analysis of the wind dynamics in enclosed and semi enclosed sea basins, such as the Mediterranean Sea (Ganea et al, 2017) or the Black and the Caspian seas (Onea et al, 2015) represents an issue of increasing interest. Thus, the objective of the present work is to analyze the most probable future scenario for the expected wind conditions in the European coastal environment of the Mediterranean Sea. This corresponds to the 30-year time interval 2021-2050 and assumes the Representative Concentration Pathway RCP4.5. Furthermore, in order to have a basis of comparison an analysis of the historical wind data for the 30-year period 1976-2005 is also carried out.

2. Materials and Methods

The wind fields provided in the public domain by SMHI (the Swedish Meteorological and Hydrologic Institute) resulted from the Rossby Centre regional climate model – RCA4 model (Samuelsson et al, 2011), forced with initial and lateral boundary conditions given by EC-EARTH Global Climate Model (GCM), are used in this study. The first dataset considered relates the historical wind fields that cover a 30-year period, from 1976 to 2005. The second dataset covers the 30-year interval from 2021 to 2050 and provides projections of the future wind fields simulated by the RCA4 model under RCP4.5 scenario. This scenario describes an intermediate concentration with radiative forcing stabilized at around 4.5 W/m^2 at the end of the 21st century. This is the most probable scenario, in relationship with RCP2.6 that assumes a stabilization of the emissions around 2020 or RCP8.5 according to which the emissions are supposed to increase along the entire 21st century (Moss et al, 2010).
10 reference locations along the coastal environment of the European countries were chosen in the Mediterranean Sea. The geographical positions of these 10 reference points are illustrated in Figure 1. Considering these reference points, an analysis of the near future wind data (period 2021-2050) has been performed in parallel with a similar 30-year period of historical data (1976-2005).

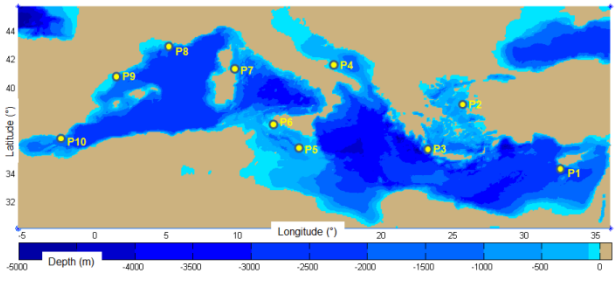

Figure 1. Map of the Mediterranean Sea and the reference sites marked with yellow circles

3. Results

The comparison between the results corresponding to the historical data against the near future period is presented next. Thus, Figure 2 presents the mean and maximum values of the wind speeds in the 10 reference points corresponding to the two 30-year time intervals considered. The corresponding statistical results are provided in Table 1. These include the standard deviation, skewness, 50th and 95th percentile computed according to their standard definitions.

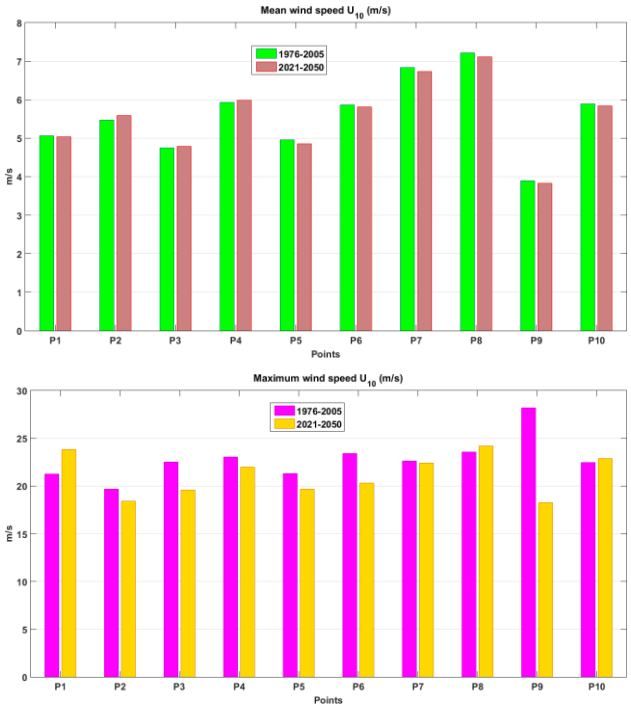

Figure 2. Mean and maximum values of the wind speeds for the 10 reference points

Table 1. Wind speed statistics in the 10 reference points considered (h-historical, nf-near future RCP4.5)

Points	Std (W/m^2)		50th (W/m^2)		95th (W/m^2)		Skew	
	hist	nf	hist	nf	hist	nf	hist	nf
P1	2.44	2.43	4.80	4.75	9.49	9.50	0.81	0.80
P2	2.68	2.70	5.25	5.38	10.17	10.21	0.48	0.42
P3	2.62	2.64	4.40	4.45	9.58	9.61	0.71	0.66
P4	3.08	3.10	5.58	5.63	11.52	11.55	0.62	0.57
P5	2.98	2.96	4.37	4.24	10.60	10.49	0.81	0.78
P6	3.05	3.02	5.54	5.47	11.54	11.44	0.68	0.66
P7	3.59	3.59	6.66	6.50	12.96	12.92	0.33	0.38
P8	3.74	3.82	6.98	6.84	13.69	13.71	0.36	0.41
P9	2.35	2.38	3.40	3.31	8.52	8.52	1.08	1.19
P10	3.17	3.22	5.39	5.29	11.68	11.77	0.64	0.72

Figure 3 illustrates the average monthly mean wind speeds in the same 10 reference points for both periods.

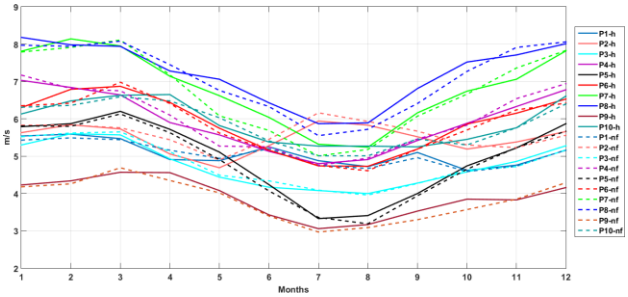

Figure 3. Average monthly mean wind speeds for the 10 reference points (h-historical, nf-near future RCP4.5)

4. Conclusions

The most probable scenario (RCP4.5) concerning the evolution of the wind speed in the next 30-year period (2021-2050) was considered. The expected wind fields were analyzed in the European coastal environment of the Mediterranean Sea. The results show that in terms of average wind speeds there are not expected significant variations in the near future in comparison with the recent past. However, in terms of maximum wind speeds a decrease is expected. This would be more significant in the western side of the sea. An exception is represented by the eastern corner of the sea, especially the area close to Cyprus, where an enhancement of the maximum wind speed is estimated in the near future.

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