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Projected Changes of Wind Power Potential over a vulnerable eastern Mediterranean area using EURO-CORDEX RCMs according rcp4.5 and rcp8.5 scenarios

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INTRODUCTION & AIM

Climate change is a dominant challenge that affects the energy sector. The increased penetration of Renewables (RES) is an alternative that is aligned to European principles for the clean energy and green transition strategy.

Past studies have shown that Eastern Mediterranean presents notable short and long term wind speed variability due to climate change. In this context, this work investigates the mean changes in Wind Energy Potential (WEP) in a typical height of offshore turbines (80m) over the climatic sensitive area of Aegean Sea during early, middle and late periods of 21st century with reference to a basis period (from 1970 to 2005). Data, available from Regional Climate Models (RCMs; available from the EURO-CORDEX project) under the moderate and extreme future scenarios (rcp4.5 and rcp8.5) as well as the recent past (historical) period (from 1970 to 2005), are studied.

Model projections indicate an increase in the WEP over the Aegean area as compared to the basis period. In particular, the maximum increase of WEP is presented in extreme (rcp8.5) as compared to moderate (rcp4.5) scenario. The most significant changes are shown over the southeastern (the straights between Crete and Rhodes Island) and central-eastern Aegean area

This work aims to provide elements regarding the impact of climate change on energy sector and the RES as an alternation to restrain the energy crisis. The priorities of Smart Specialization Strategies (S3) that are aligned to climate neutrality, net-zero greenhouse gases (GHGs) emissions and de-carbonization strategies are taken under consideration.

METHOD

DATA:

- Monthly mean zonal and meridional wind speed components at 10m were retrieved form the EURO-CORDEX project over the eastern domain of Mediterranean region in order to calculate the wind speed and Wind Energy Potential (WEP).
- WEP Changes under moderate and extreme future scenarios (rcp4.5 and rcp8.5) with reference to the recent past (historical) period (from 1970 to 2005), are investigated.

➢ The differences between three different future periods (2010-2039; F1, 2040-2069; F2 and 2070-2099; F3) and the historical period that is considered as reference period (1970-2005; Ref.) are calculated.

Table 1. List of model simulations that are used in this study.

RCM	Driving GCM	Experiment	hist	rcp4.5	rcp8.5
ALADIN63.v2	CNRM.CNRM-CERFACS-CNRM-CM5	r1i1p1	×	×	×
RACMO22E.v2	CNRM.CNRM-CERFACS-CNRM-CM5	r1i1p1	×	×	×
RACMO22E.v2	KNMI.MOHC-HadGEM2-ES	r1i1p1	×	×	×
RCA4.v1	SMHI.MOHC-HadGEM2-ES	r1i1p1	×	×	×
RCA4.v1	SMHI.MPI-M-MPI-ESM-LR	r1i1p1	×	×	×
REMO2015.v1	GERICS. NCC-NorESM1-M	r1i1p1	×	×	×

The logarithmic law was used in order to extrapolate the wind speed from 10m to 80m (equation 1). WEP is calculated using the equation 2:

$$V_H = V_{10} * \frac{\ln\left(\frac{H}{z_0}\right)}{\ln\left(\frac{10}{z_0}\right)}, \quad (1) \qquad WEP = \frac{1}{2} * \rho * V_H^3, \quad (2)$$

RESULTS & DISCUSSION

- ❖ All model simulations show that the maximum WEP over the Aegean area is located over the southeastern Aegean (in the area southeastern of Agios Nikolaos in Crete; **Fig. 1**)
- ❖ Projections show that WEP is maximized mainly during the last period of 21st century.
- ❖ The maximum increase of future WEP is over the southeastern Aegean area from 10 to 100 W/m² (locally; **Fig. 2 & Table 2**).
- ❖ Model simulations show positive changes from (a) 10% to 26% for rcp4.6 and (b) from 13% to 40% for rcp8.5 scenarios.

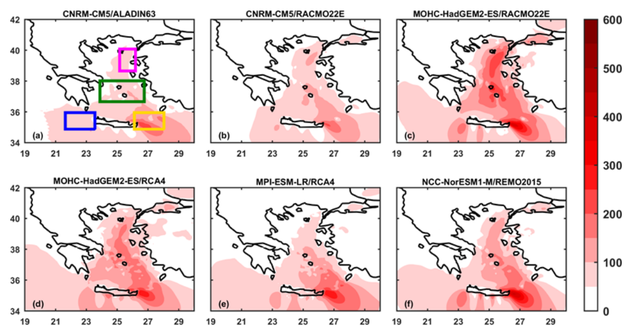

Figure 1. Composite mean of WEP (W/m2) during the historical period from 1970 to 2005. The blue/ green/ magenta and yellow boxes indicate the southwestern/ central/ northeastern and south-eastern Aegean areas.

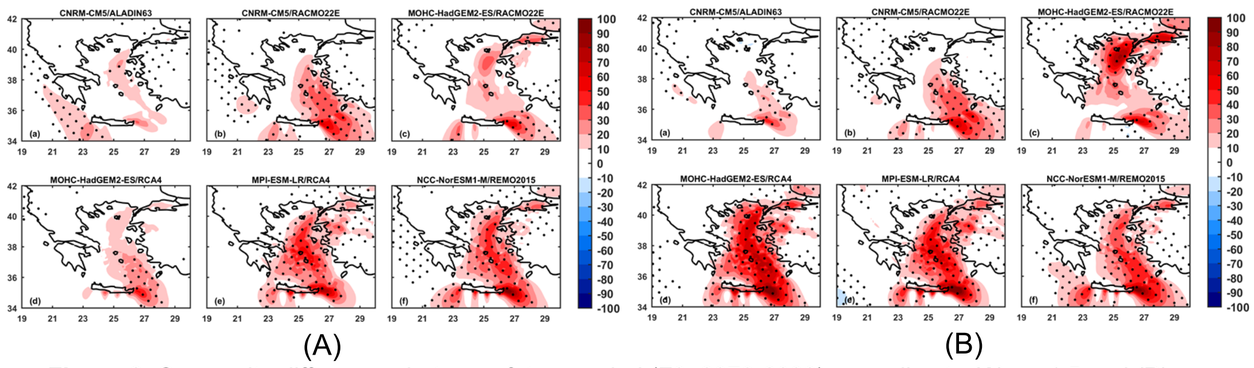

Figure 2. Composite differences between future period (F3: 2070-2099) according to **(A)** rcp4.5 and **(B)** rcp8.5 scenario and reference period (historical period: 1970-2005). The dots denote the statistically significant differences at the level of 95% (student t-test).

Table 2. Mean differences of WEP averaged over the southwest/ central/ northeast and southeast Aegean regions between F3 (according rcp8.5 scenario) and historical reference period. The star shows the statistically significant differences at the level of 95%

RCM	cAeg	NAeg	SEAeg	SWAeg
CNRM-CM5_ALADIN63	8.82	1.80	32.72*	8.63
CNRM-CM5_RACMO22E	23.56	0.74	55.07*	2.10
MOHC-HadGEM2-ES_RACMO22E	39.17	67.03*	30.56*	11.22
MOHC-HadGEM2-ES_RCA4	71.34*	58.57*	100.44*	17.84*
MPI-ESM-LR_RCA4	65.34*	35.89*	73.91*	11.57
NCC-NorESM1-M_REMO2015	38.75*	28.22*	69.34*	6.25

CONCLUSION

- All model simulations project increase in WEP over the Aegean basin during the future period both for moderate and extreme scenarios.
- The high WEP of Aegean in combination with low variability of wind speed is possibly beneficial for offshore wind energy generation.

❖ *This study emphasizes on wind energy potential over a Mediterranean climate "hot spot" area and highlights the need for further investigation of WEP using a combination of different datasets (observations, GCMs, RCMs etc.).*

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