

## The CMIP6 efficiency to capture Wind Energy Potential over south Eastern Mediterranean and Future projections according SSP2-4.5 and SSP5-8.5

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### INTRODUCTION

Climate crisis is categorized as one of the dominant threat for ecosystems and socioeconomic environments. Energy is in the core of European Union (EU) priorities that promotes green, low-cost and innovative technologies to ensure and increase the future efficiency and resilience for the Energy sector. Renewables could provide an alternative solution to increase the energy efficiency towards to green and sustainable future.

This work focuses on Mediterranean climate “hot spot” studying the JJA (a) efficiency of CMIP6 model simulations to reproduce the **Wind Energy Potential (WEP) over central eastern Mediterranean (cEMed)** and (b) projected WEP changes during 21<sup>st</sup> century (under SSP2-4.5 and SSP5-8.5). Results show that CMIP6 models’ mean significantly underestimates the WEP (compared to ERA5 data) and simulations show high multi-model WEP variability over cEMed.

### DATA & METHODS

- **DATA:** Zonal and Meridional monthly mean wind component at 10m form:
  - Models Mean (18 CMIP6 model simulations; CMIP6 MM) for historical: 1970-2000 and future: 2015-2099 (SSP2-4.5 & SSP5-8.5) periods and
  - ERA 5 (period: 1970 -2000), are used.
- The analysis focuses on summer period (JJA) over a geographical window of central eastern Mediterranean (25°–30°E, 32.5°–37.5°N; cEMed; Fig. 1). ERA 5 is used as reference dataset.

- **Wind Energy potential (WEP)** is calculated using the logarithmic law (to extrapolate WS from 10m to 80m):

$$WEP = \frac{1}{2} * \rho * \left( WS_{10} * \frac{\ln\left(\frac{H}{z_0}\right)^3}{\ln\left(\frac{10}{z_0}\right)} \right)^3$$

where,  $WS_{10}$  is wind speed at 10 m and  $z_0$  is the roughness length ( $z_0=0.001m$  was used for open, calm seas).

- The efficiency of CMIP6 to capture the spatiotemporal WEP features over cEMed is studied by using Statistical indices (bias ratio, variability ratio, correlation and Kling–Gupta efficiency; KGE):

$$KGE = 1 - \sqrt{(r - 1)^2 + (\sigma_s/\sigma_0 - 1)^2 + (\mu_s/\mu_0 - 1)^2}$$

- Mean Composite Difference maps are constructed in order to study the future CMIP6 MM WEP changes

### RESULTS & DISCUSSION

- ❖ Max. WEP → over the central East Mediterranean (Fig. 1a)
- ❖ CMIP6 MM:
  - ❖ underestimates the cEMed WEP,
  - ❖ shows the maximum WEP southern in EMed, as compared to ERA5 (Fig. 1a&2a).

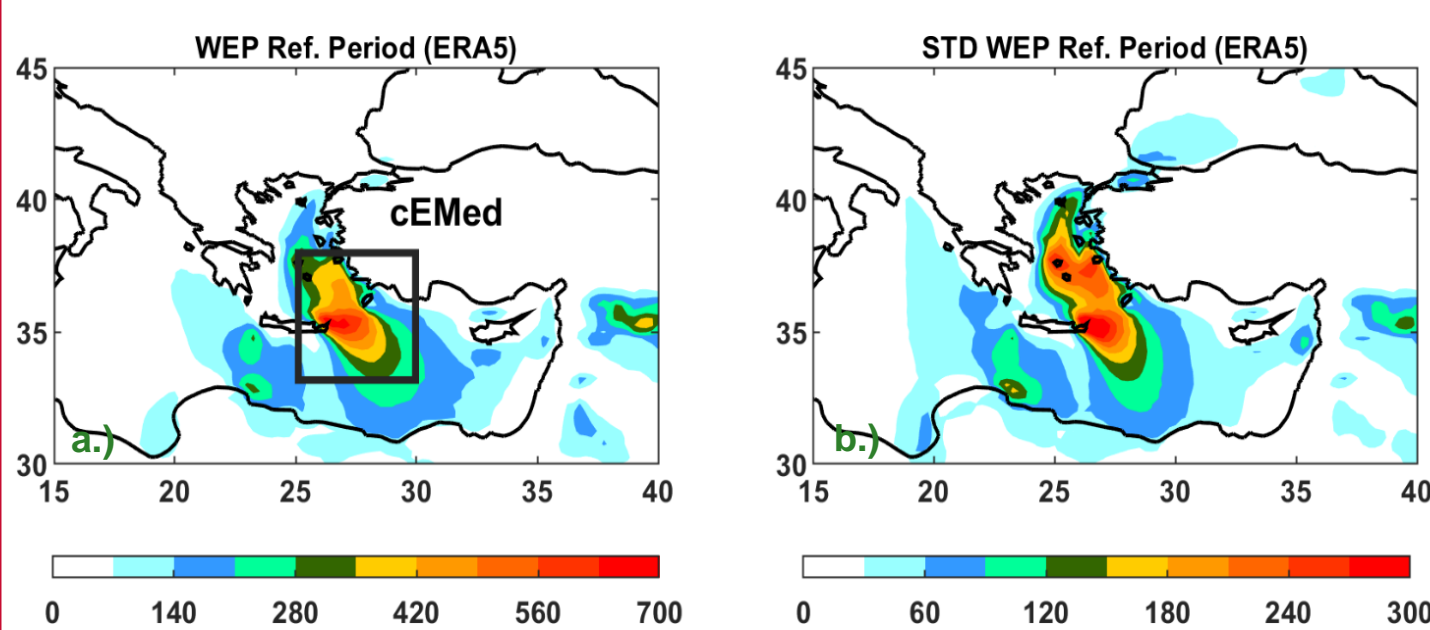


Figure 1. (a) Mean WEP (W/m2) and (b) standard deviation over EMed during period from 1970 to 2000 for ERA5.

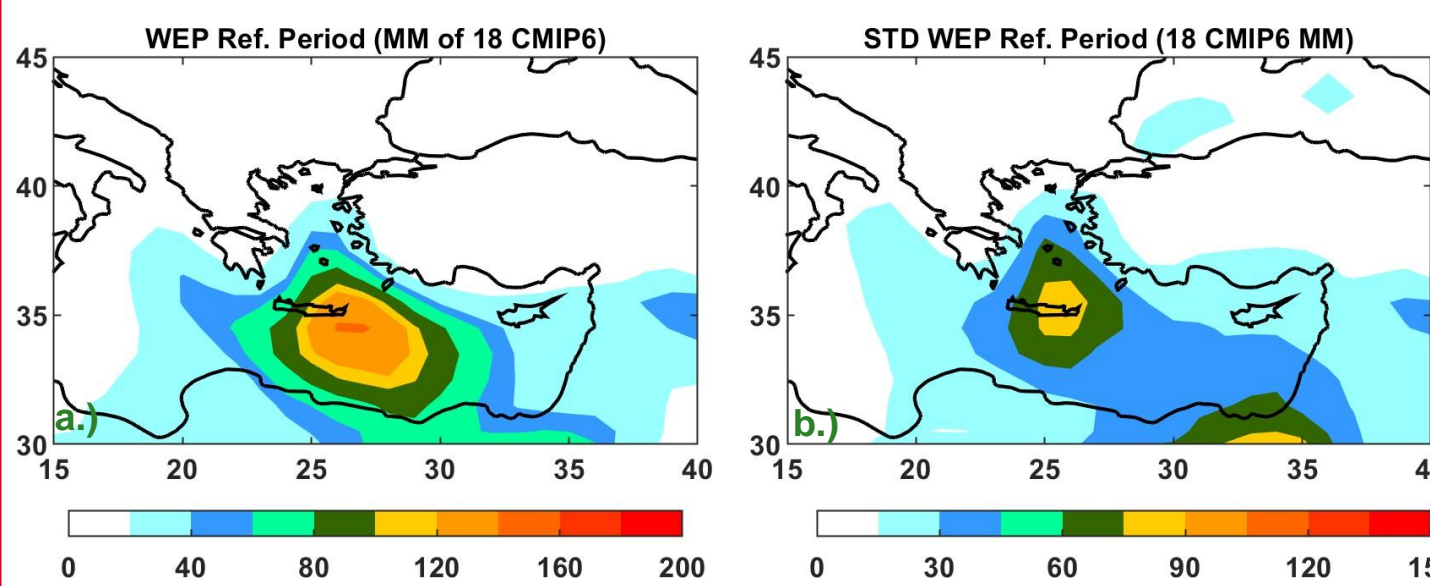


Figure 2. As Fig. 1 but for CMIP6 MM.

- ❖ CMIP6 simulations show high multi-model variability (to reproduce WEP over cEMed) (Fig. 3a),
- ❖ CMIP6 performance to capture and reproduce spatiotemporal features of WEP over EMed (wrt ERA5) is viewed as deficient (KGE = -0.22) (Fig. 3c),
- ❖ 4 out of 18 model simulations show positive KGE (KGE > 0.35) → indicating good model performance (Fig. 3c).

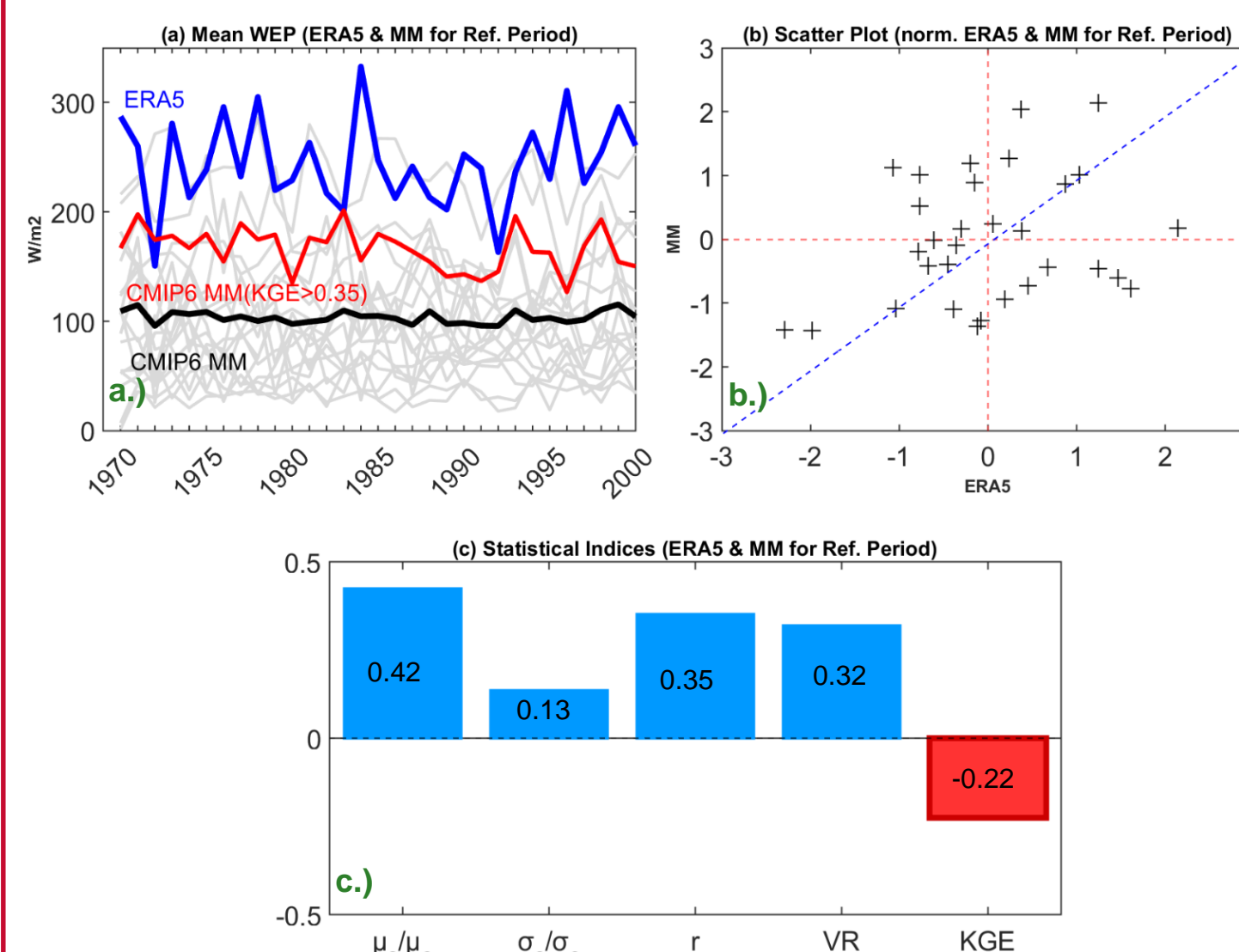


Figure 3. (a) Timeseries of WEP (cEMed) for ERA5 and CMIP6 (b) Scatter plot of JJA WEP wrt period mean anomalies over cEMed norm. with one standard deviation of each model (period: 1970 – 2000) and (c) Statistical indices of CMIP6 efficiency to reproduce the WEP spatiotemporal features over cEMed.

- ❖ 2070-2099 Period: CMIP6 MM shows an increase/ decrease over central/southeastern EMed, respectively (Fig. 4),
- ❖ CMIP6 model simulations with KGE >0.35 show a reduction of WEP over southeastern EMed and a slight increase over Aegean and south EMed (Fig. 5)

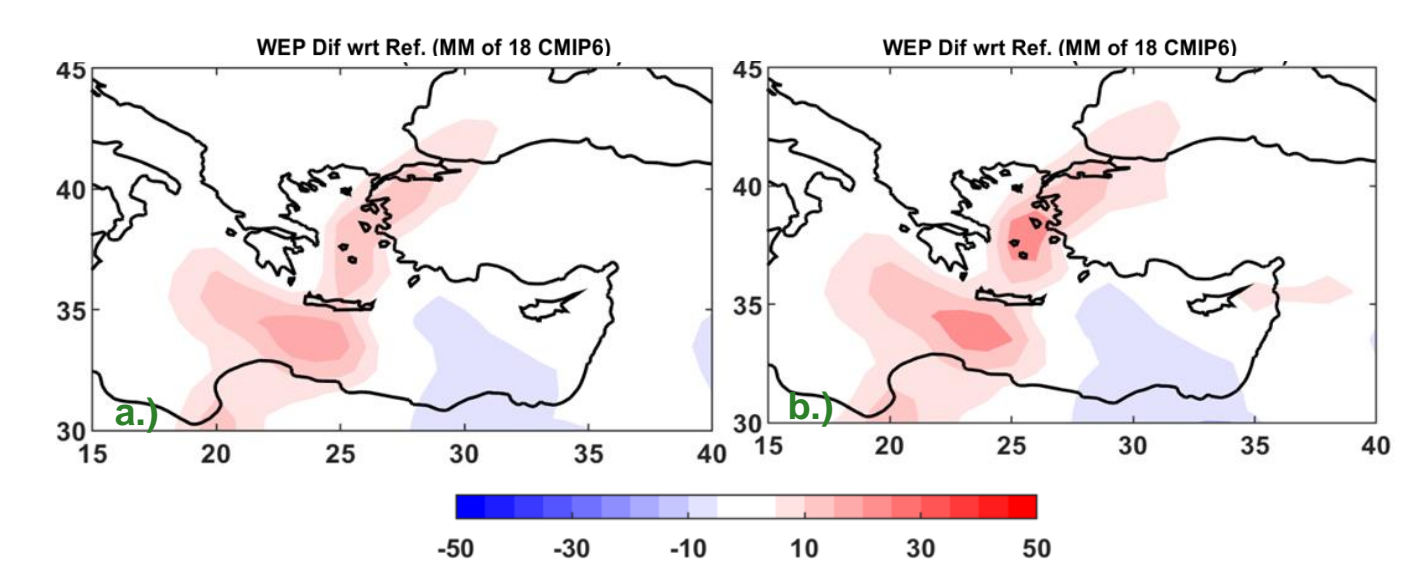


Figure 4. Composite mean of WEP between 2070 – 2099 and Ref. period periods (a) SSP2-4.5 and (b) SSP5-8.5 for CMIP6 MM.

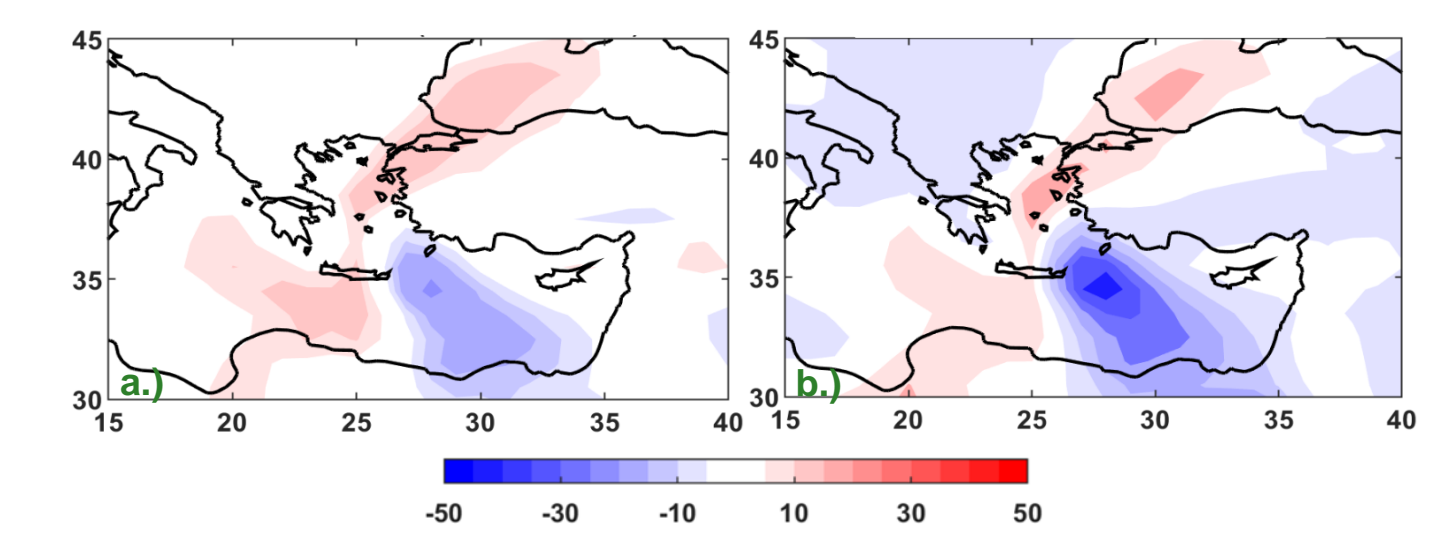


Figure 5. As Fig. 4 but for the models that show the best features to reproduce WEP (KGE>0.35) over cEMed (wrt ERA5).

### CONCLUSION

- CMIP6 MM:
  - underestimates the WEP and
  - shows negative KGE values → indicating limitations to reproduce JJA WEP over cEMed as compared to ERA5 (reference data set),
  - shows a increase/ decrease over central/southeastern EMed, respectively (model simulations high multi-model WEP variability),
- Focusing on 2070-2099, CMIP6 simulations that present better performance wrt ERA5 (KGE>0.35), show a reduction of WEP over south EMed (wrt to 1970-2000 period).

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