



Projected Changes in Türkiye's Wind Energy Potential Using Next-Generation Climate Models and Scenarios

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ABSTRACT

Renewable energy is a cornerstone in reducing greenhouse gas emissions and, accordingly, mitigating changes in the global climate system. Wind energy is becoming more common among all renewable energy sources used for electricity generation in terms of generation capacity, rapid growth and technological maturity. The share of wind energy in Türkiye's total electricity production, whose installed capacity has been increasing in recent years, has nearly tripled in the last decade. However, given that wind energy potential varies with wind speed, even small changes in future wind patterns and characteristics can strongly affect future wind power generation dependent on projections. For this purpose, in this study, Türkiye's mid-future (2031-2060) wind energy potential is examined under optimistic (SSP2-4.5) and pessimistic (SSP3-7.0) scenarios. In the study, 0.25° x 0.25° spatial resolution CMIP6 models from the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6) dataset were used. The results point to regional differences in Türkiye's mid-future (2031-2060) wind energy potential.

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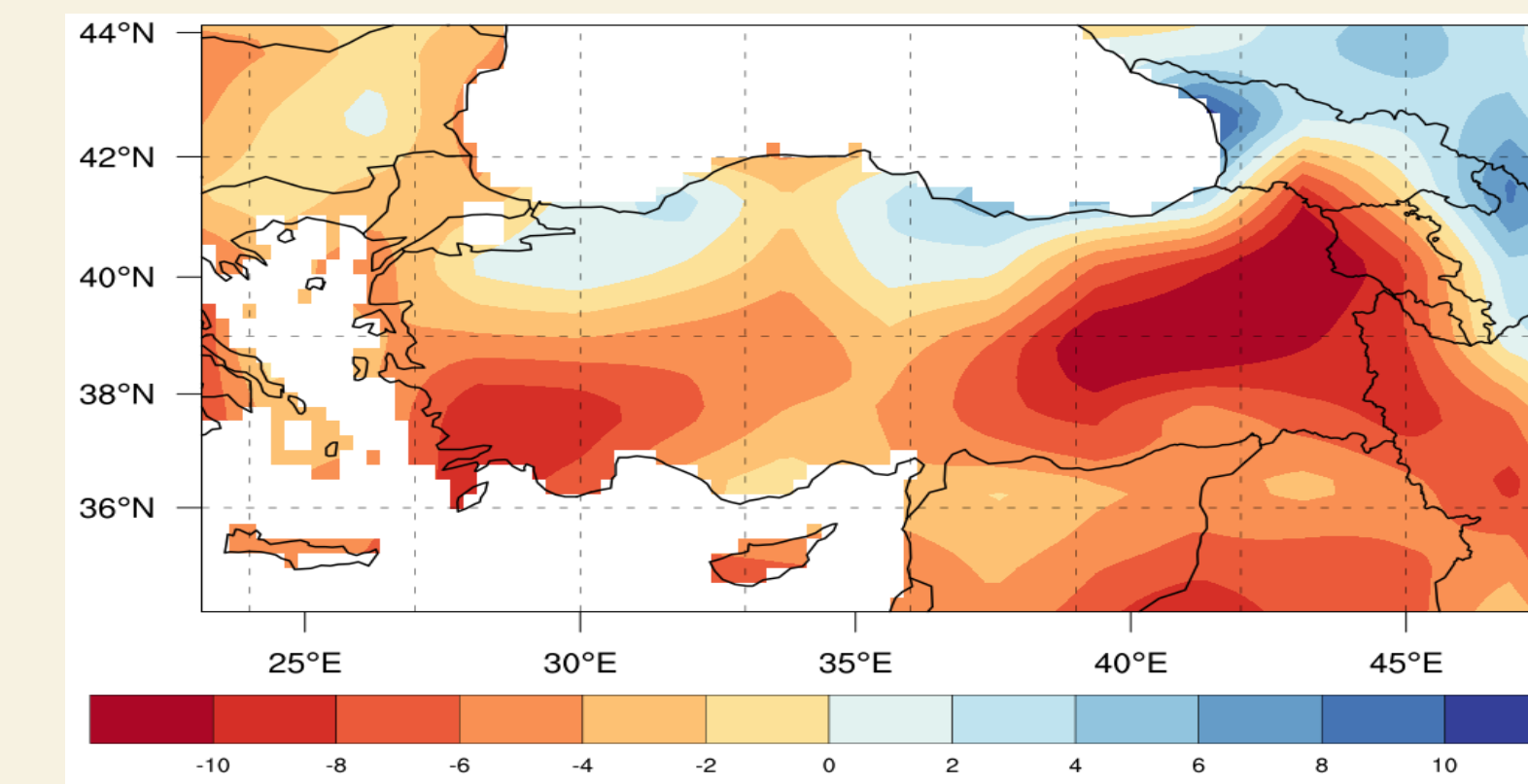


Figure 1. Projected change in wind power density in the future period of 2031-2060 for Türkiye compared to the 1971-2000 reference period for ACCESS-ESM1.5 model and SSP2-4.5 projection scenario.

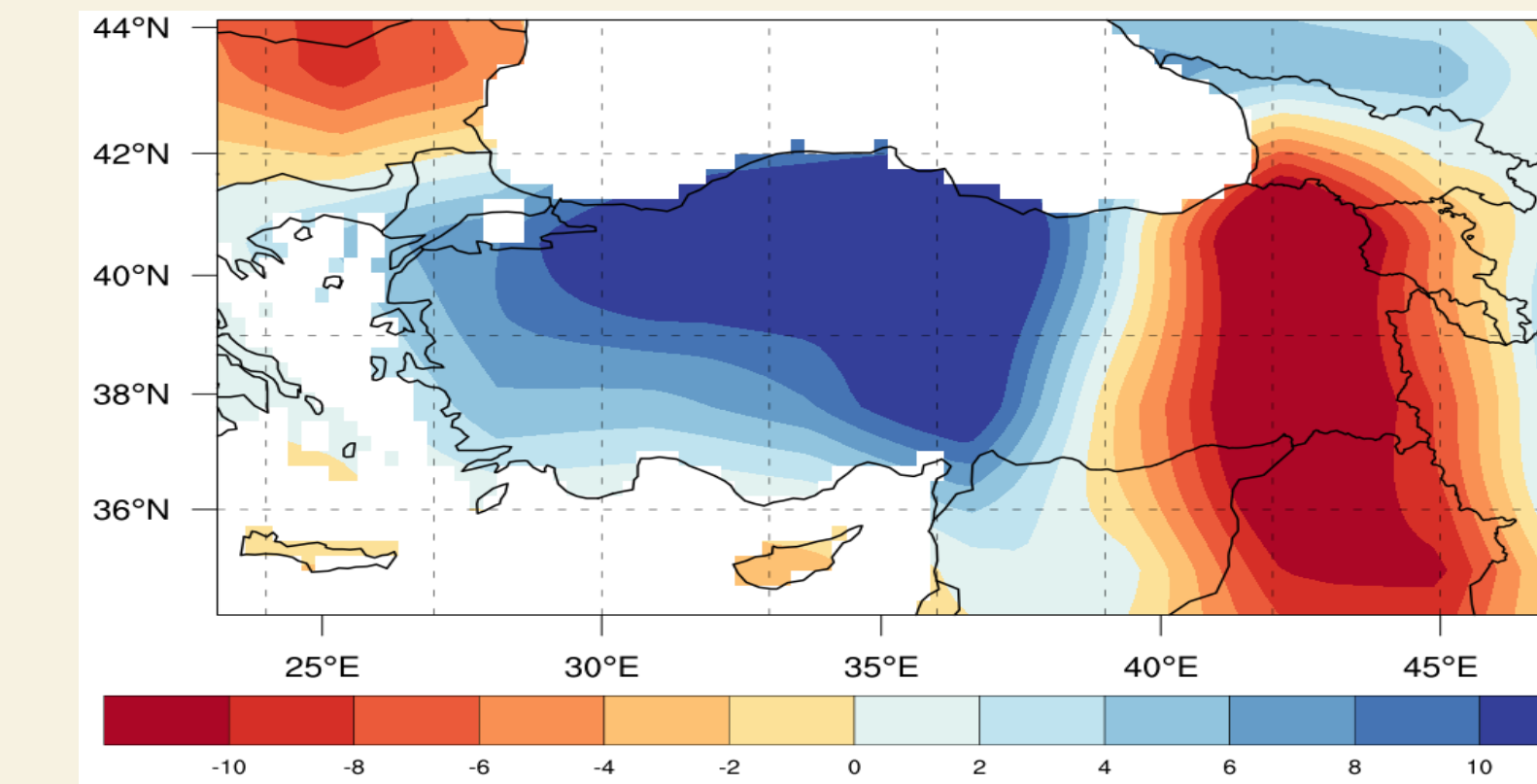


Figure 2. Projected change in wind power density in the future period of 2031-2060 for Türkiye compared to the 1971-2000 reference period for CanESM5 model and SSP2-4.5 projection scenario.

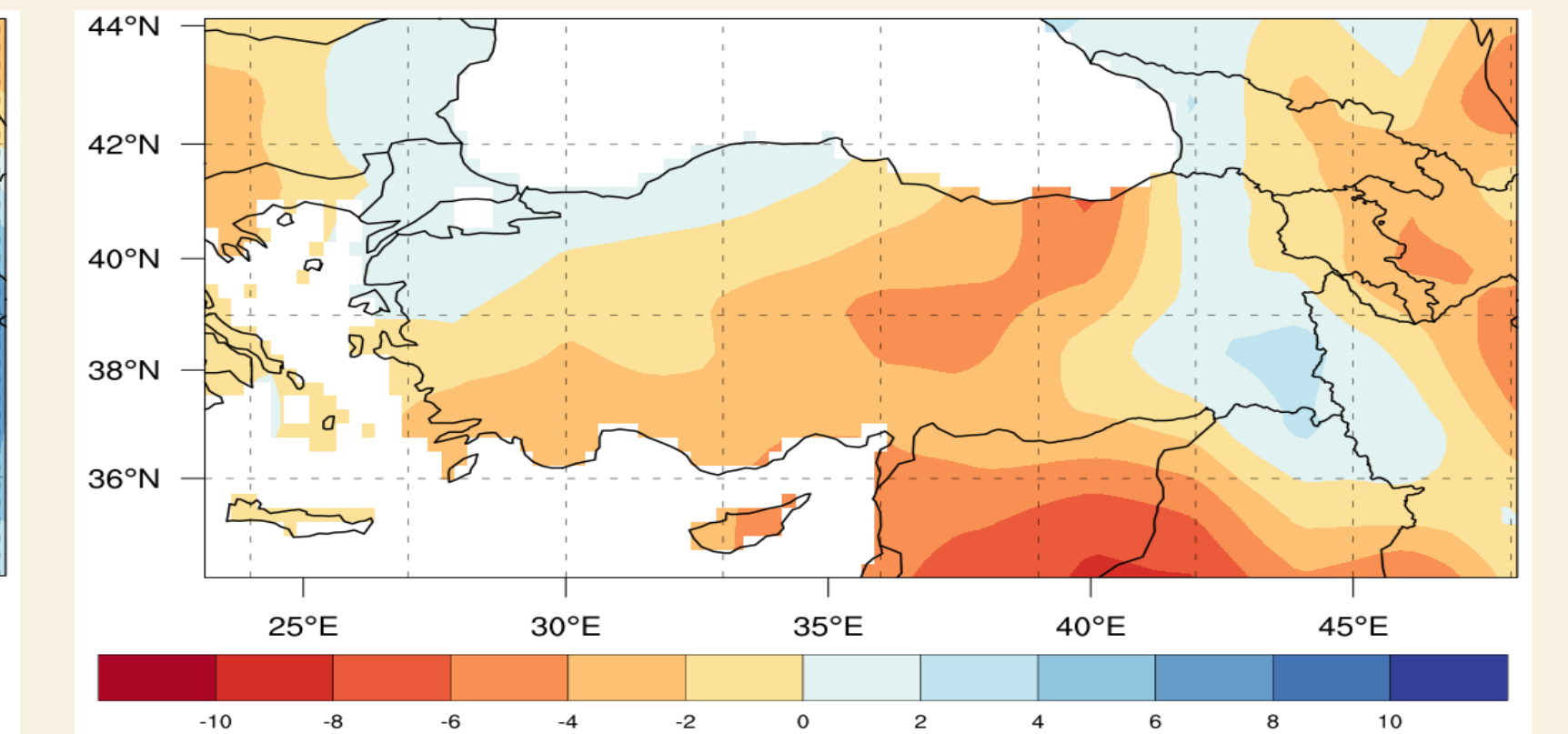


Figure 3. Projected change in wind power density in the future period of 2031-2060 for Türkiye compared to the 1971-2000 reference period for INM-CM4-8 model and SSP2-4.5 projection scenario.

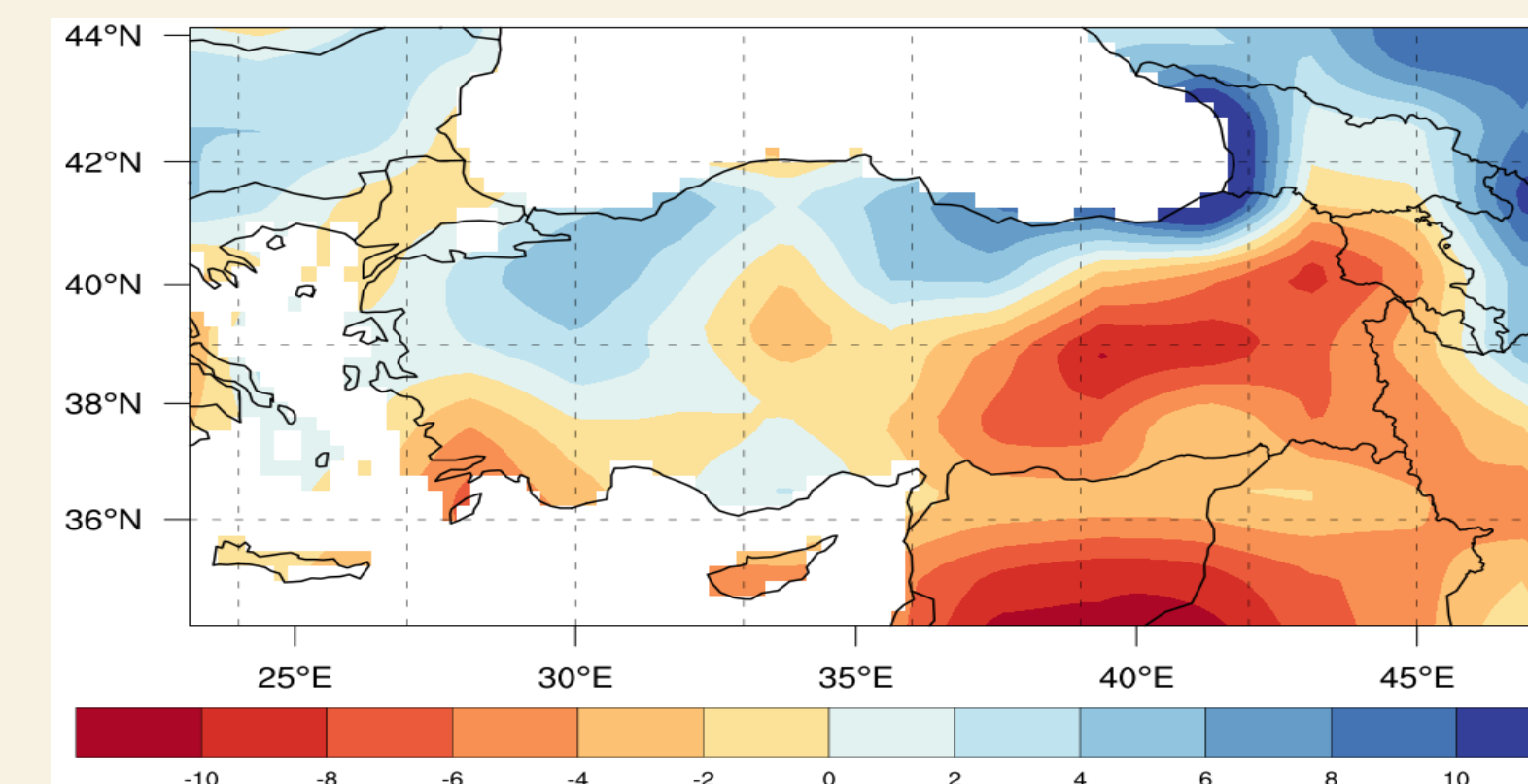


Figure 4. Projected change in wind power density in the future period of 2031-2060 for Türkiye compared to the 1971-2000 reference period for ACCESS-ESM1.5 model and SSP3-7.0 projection scenario.

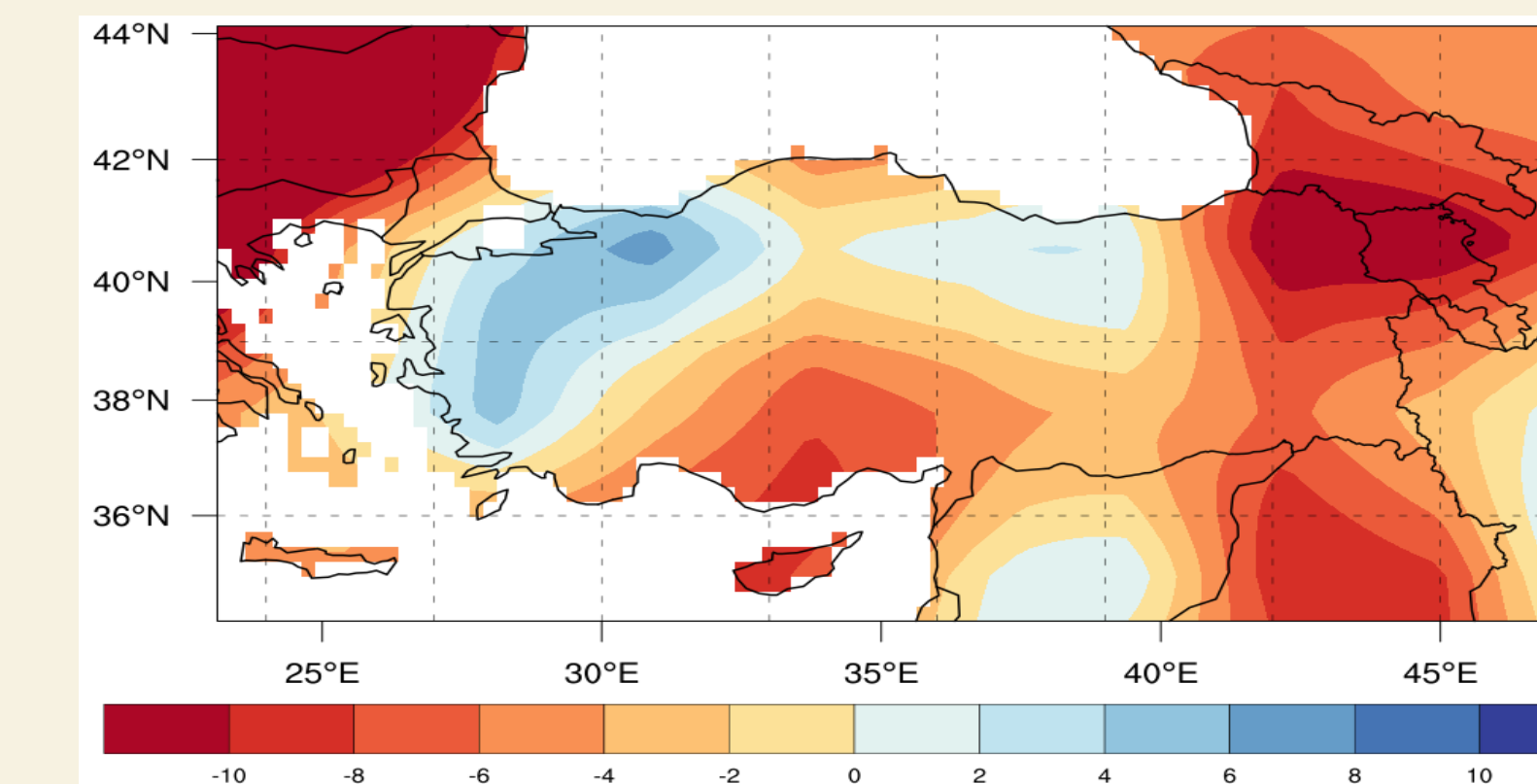


Figure 5. Projected change in wind power density in the future period of 2031-2060 for Türkiye compared to the 1971-2000 reference period for CanESM5 model and SSP3-7.0 projection scenario.

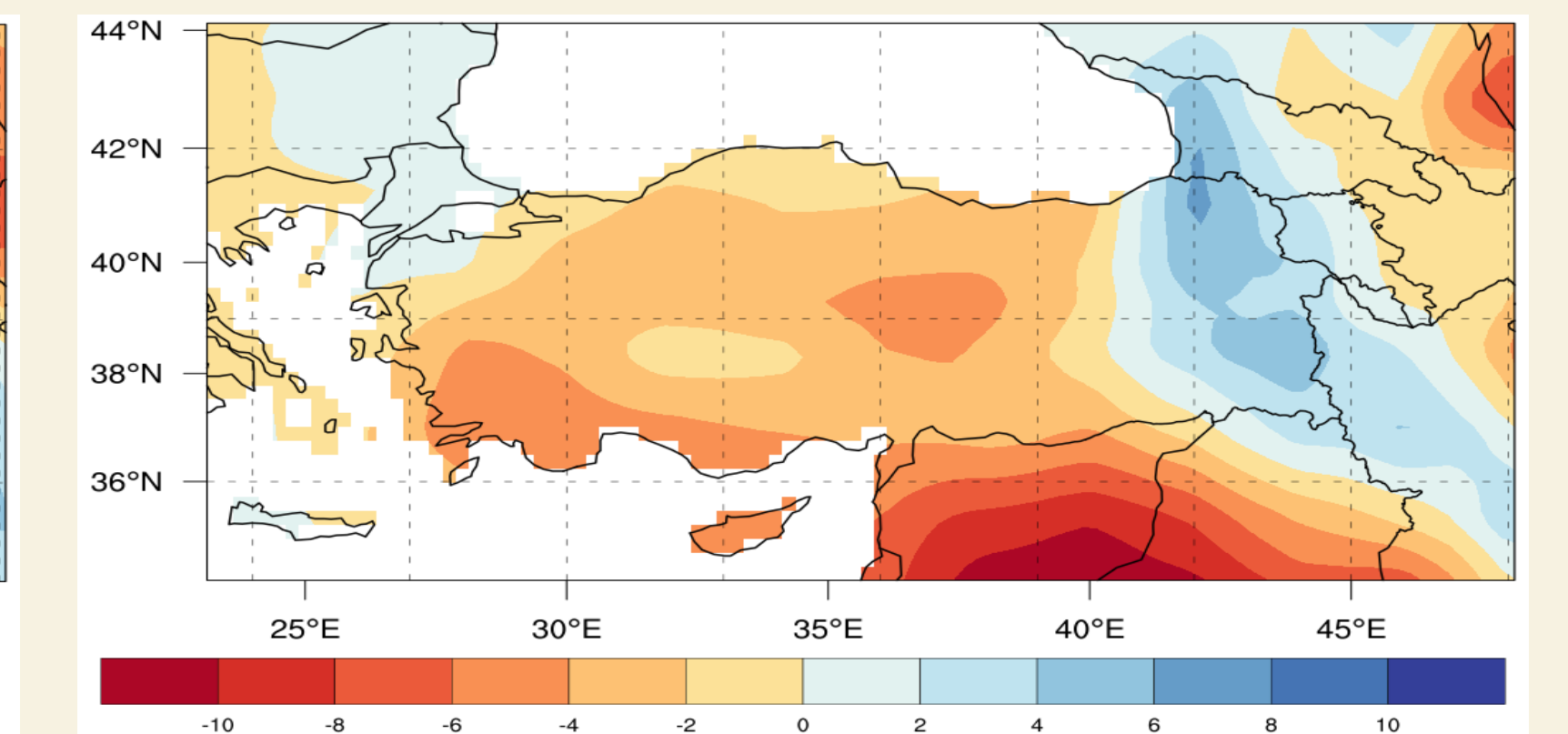


Figure 6. Projected change in wind power density in the future period of 2031-2060 for Türkiye compared to the 1971-2000 reference period for INM-CM4-8 model and SSP3-7.0 projection scenario.

CONCLUSION

This study examines the potential impacts of climate change on wind power density in Türkiye for the period of 2031-2060, under two different scenarios - SSP2-4.5 and SSP3-7.0 - in comparison to the baseline period of 1971-2000. Three climate models with varying Equilibrium Climate Sensitivity (ECS) were selected for the analysis: ACCESS-ESM1.5 (medium ECS), CanESM5 (highest ECS), and INM-CM4-8 (lowest ECS). The results indicate that the ACCESS-ESM1.5 model suggests an increase in wind power density in the southern and eastern regions of Türkiye due to changing climatic conditions. However, the CanESM5 model projects a decrease in wind power density in the western regions of Türkiye under the SSP2-4.5 scenario, while showing similar results to the ACCESS-ESM1.5 model under the SSP3-7.0 scenario. The lowest ECS model, INM-CM4-8, predicts smaller changes and an increase in wind power density across most of Türkiye, except for the far east and northwest regions.

FORCING DATA AND EXPERIMENT DESIGN

Domain	Türkiye
Domain Coordinates	Lon: 25.21E-45.28E & Lat: 35.81N-42.51N
Global Climate Model	The Australian Earth System Model (ACCESS-ESM1.5), The Canadian Earth System Model version 5 (CanESM5), Global Climate Model of Institute for Numerical Mathematics (INM-CM4-8)
Variable	Wind Power Density
Grid Resolution	0.25° x 0.25°
Reference Time Scale	1971 - 2000
Future Time Scales	2031 - 2060
Projection Scenarios	SSP2-4.5, SSP3-7.0

Table 1. Forcing Data and Experiment Design