

Co-benefits of carbon neutrality in enhancing and stabilizing solar and wind energy

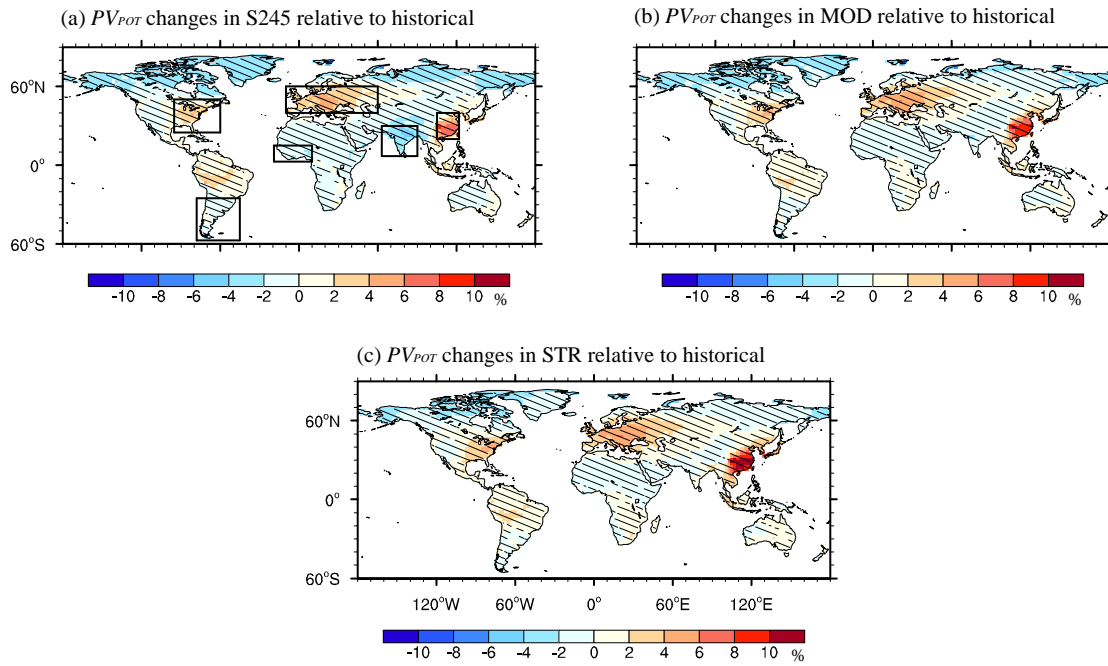
In the format provided by the authors and unedited

Supplementary Table 1 | Summary of Earth system models (ESMs) used in this study.

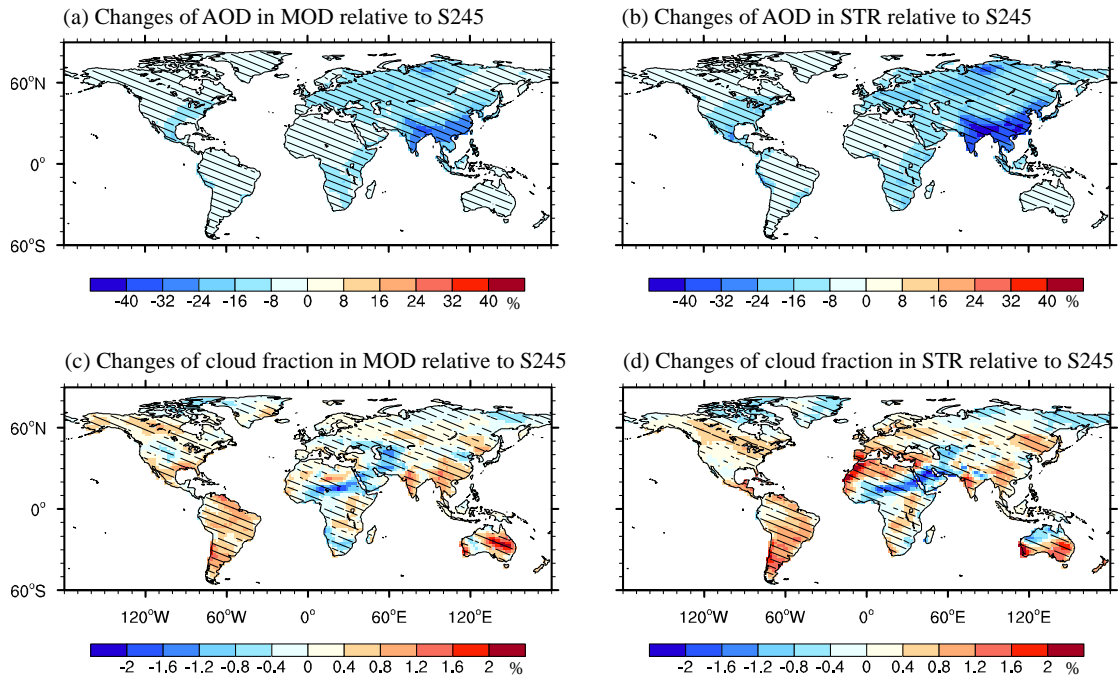
Model	Institute, Country	Resolution (Lat × Lon)	Member
ACCESS-ESM1-5	Commonwealth Scientific and Industrial Research Organization, Australia	1.2°×1.9°	30
MIROC-ES2L	University of Tokyo and the Japan Agency for Marine-Earth Science and Technology, Japan	2.8°×2.8°	30
MPI-ESM1-2-LR	Max Planck Institute for Meteorology, Germany	1.9°×1.9°	10
MRI-ESM2-0	Meteorological Research Institute, Japan	1.1°×1.1°	10

Supplementary Table 2 | Summary of six sub-regions defined in this study.

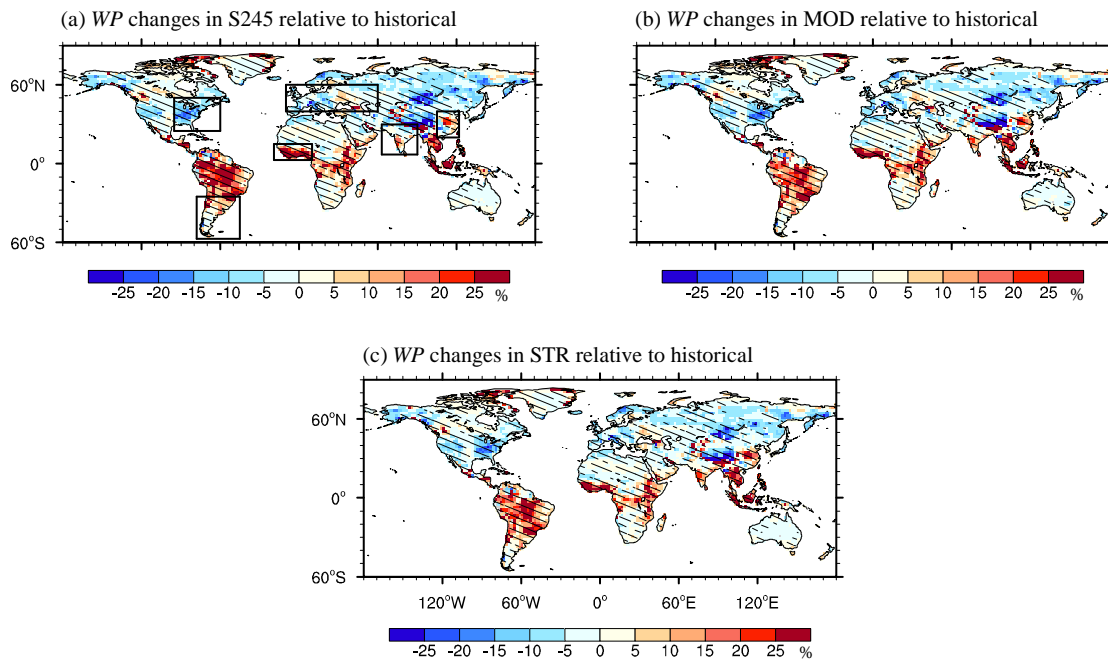
Name	Latitude	Longitude
Eastern United States (EUS)	25°N-50°N	95°W-60°W
Southern South America (SSA)	57°S-25°S	78°W-45°W
Western Europe (WEU)	40°N-60°N	10°W-60°E
Western Africa (WAF)	3°N-15°N	19°W-10°E
India (IND)	7°N-30°N	63°E-90°E
Eastern China (ECH)	20°N-40°N	105°E-122°W



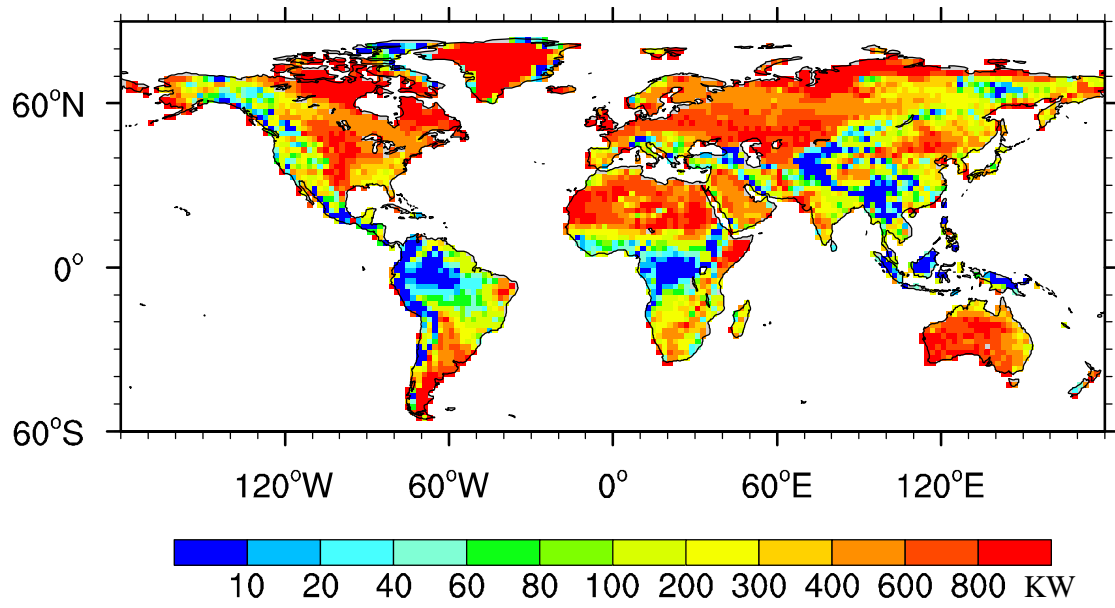
Supplementary Fig.1 | Changes of solar photovoltaic potential (PV_{POT}) under different climate change scenarios. Same as Fig.1, but (b) and (c) represent the changes under the moderate (MOD) and strong (STR) mitigation scenarios relative to the historical period.



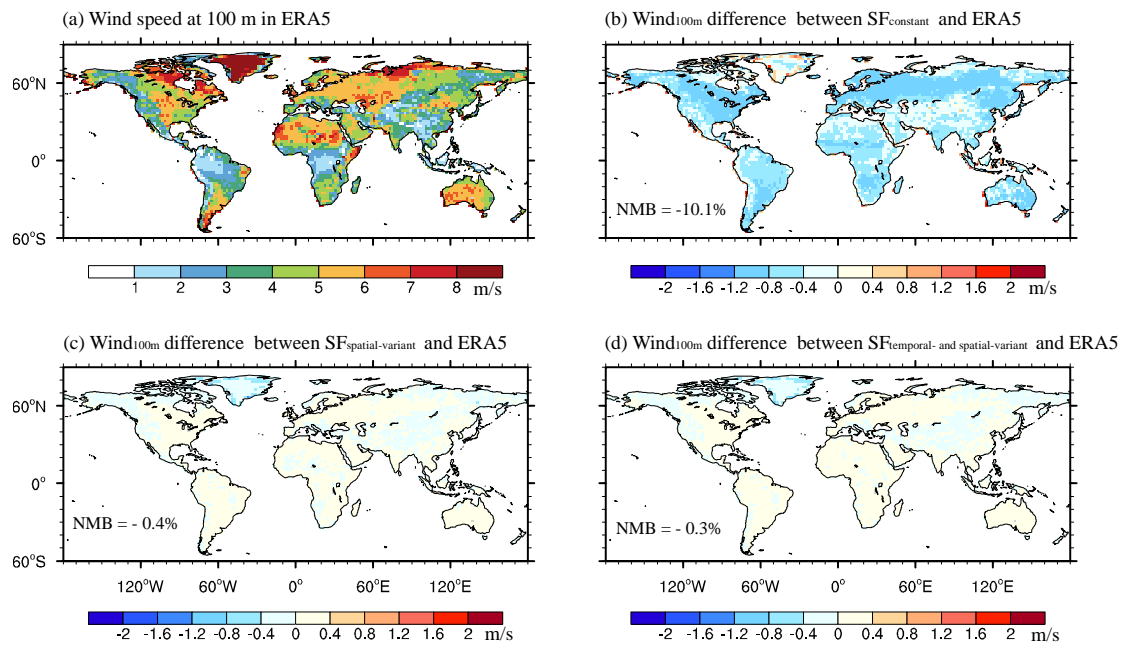
Supplementary Fig.2 | Relative changes of aerosol optical depth (AOD) and cloud fraction. (a-b), The relative changes of annual mean AOD during 2040-2049 under the moderate (MOD) and strong (STR) carbon-neutral scenarios relative to the SSP2-4.5 scenario (S245). **(c-d)**, The relative changes of annual mean cloud fraction during 2040-2049 under the moderate (MOD) and strong (STR) carbon-neutral scenarios relative to S245. Hatched regions represent a change with high inter-model agreement defined as at least three of the four CovidMIP models agreeing on the direction of change.



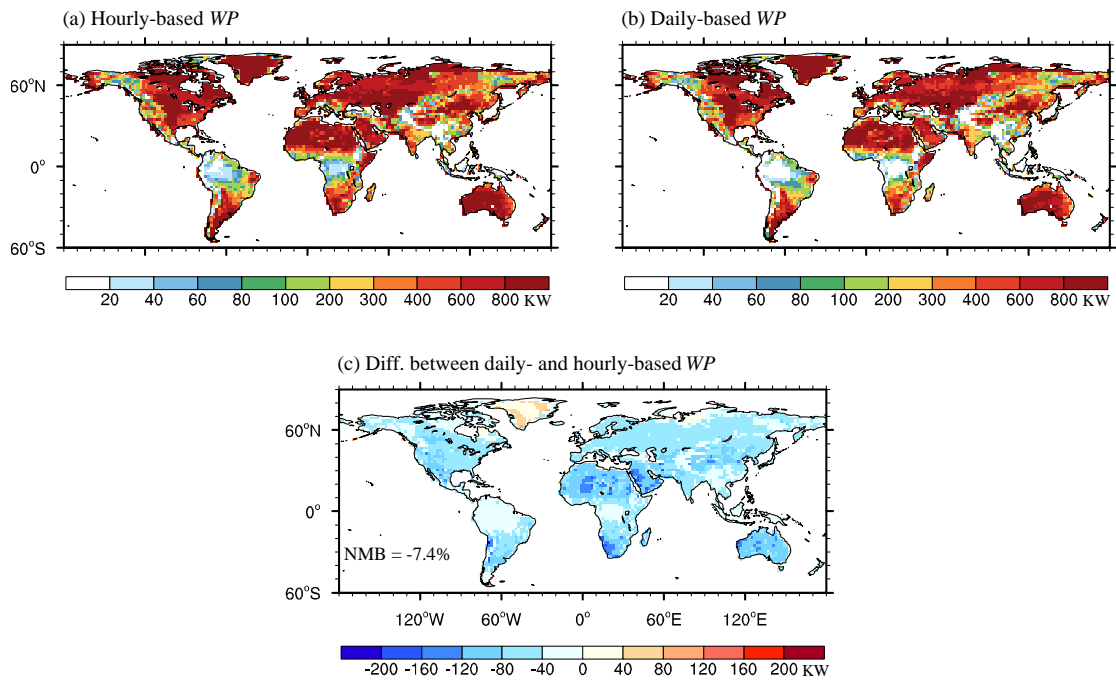
Supplementary Fig.3 | Changes of wind power (WP) under different climate change scenarios. Same as **Fig.3**, but **(b)** and **(c)** represent the changes under the moderate (MOD) and strong (STR) mitigation scenarios relative to the historical period.



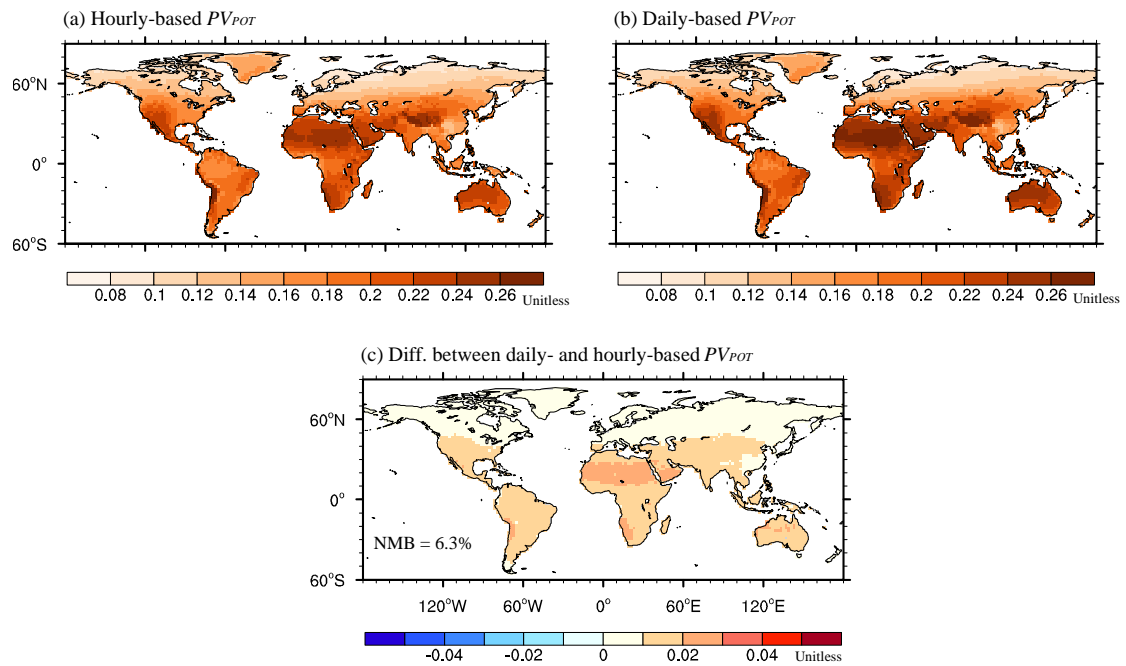
Supplementary Fig.4 | Annual mean wind power (KW) during 1995-2014 under historical simulations with bias correction.



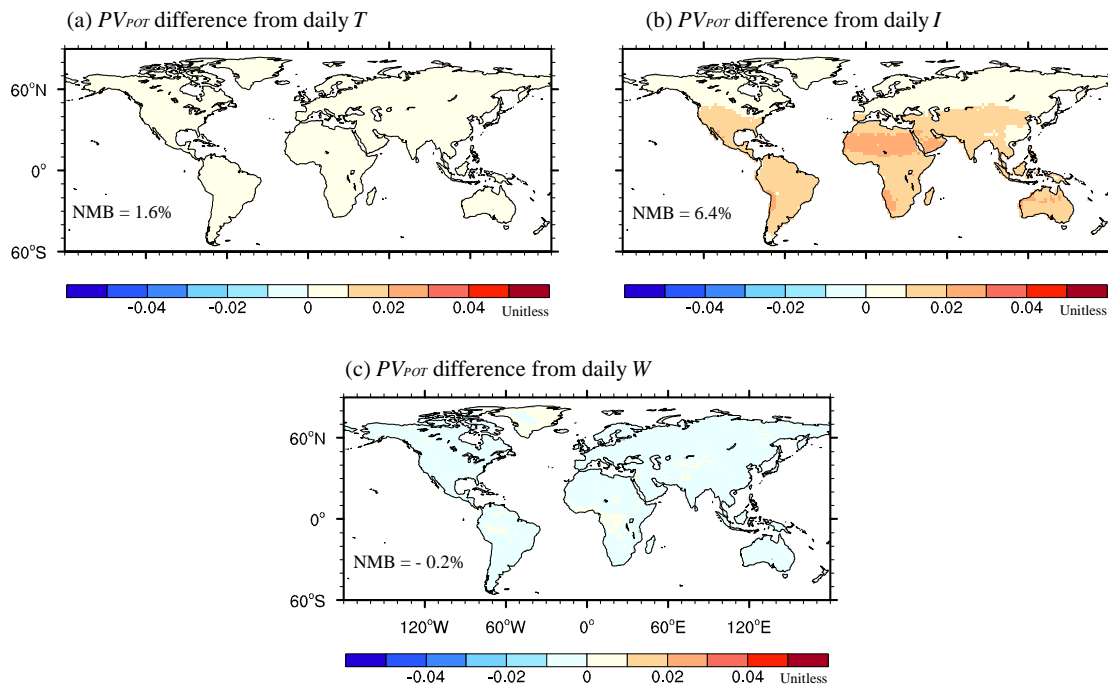
Supplementary Fig.5 | Comparisons of 100 m wind speed calculated using different scaling factors. (a), Wind speed at 100 m in the ERA5 reanalysis. **(b), (c), and (d),** The bias of 100 m wind speed calculated from 10 m wind speed using a constant of 0.143, spatially-variant (as in **Extended Data Fig.7c**), and spatiotemporally-variant scaling factors, respectively. Note that the temporal variation of scaling factor in **(d)** only includes annual cycle (365 day in a year; monthly mean shown in **Supplementary Fig.10**) but excludes year-to-year variations during 1995-2014. The normalized mean bias (NMB) is shown in the bottom panel.



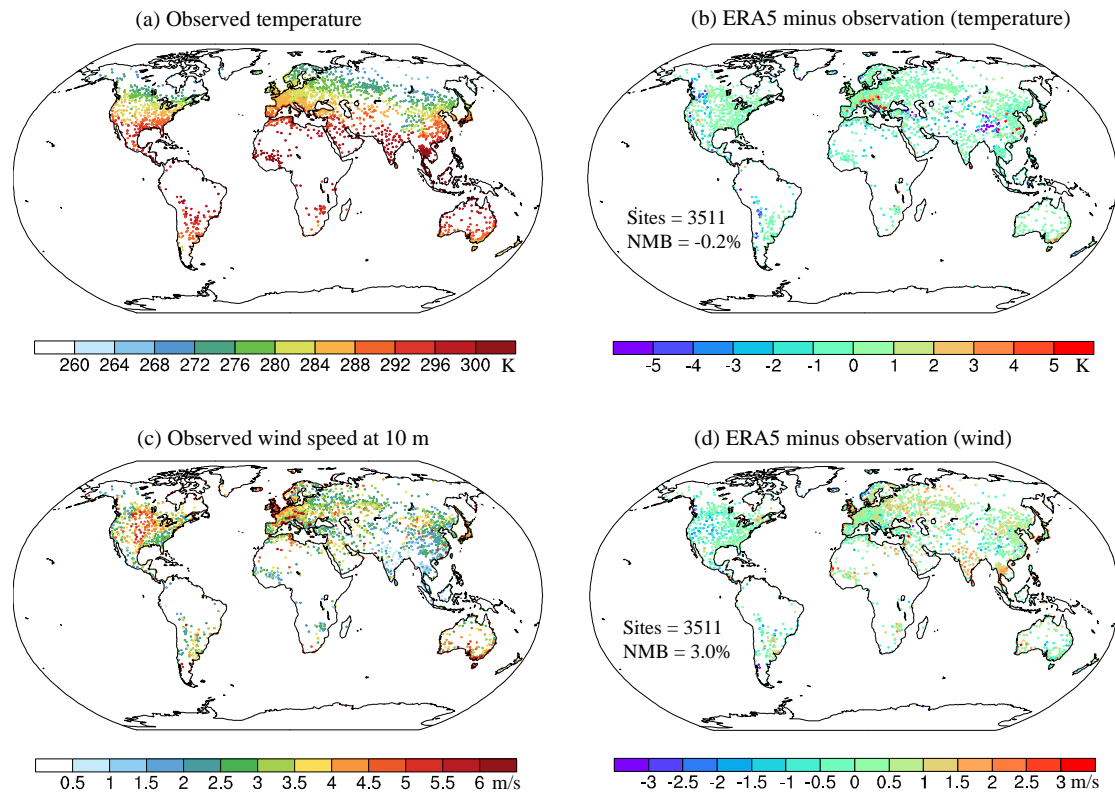
Supplementary Fig.6 | Comparison of wind power (WP). (a-b), The annual mean WP calculated based on hourly and daily ERA5 reanalysis during 1995-2014 (units: KW). (c), The difference between daily-based WP and hourly-based WP (units: KW). The normalized mean bias (NMB) is shown in the bottom panel.



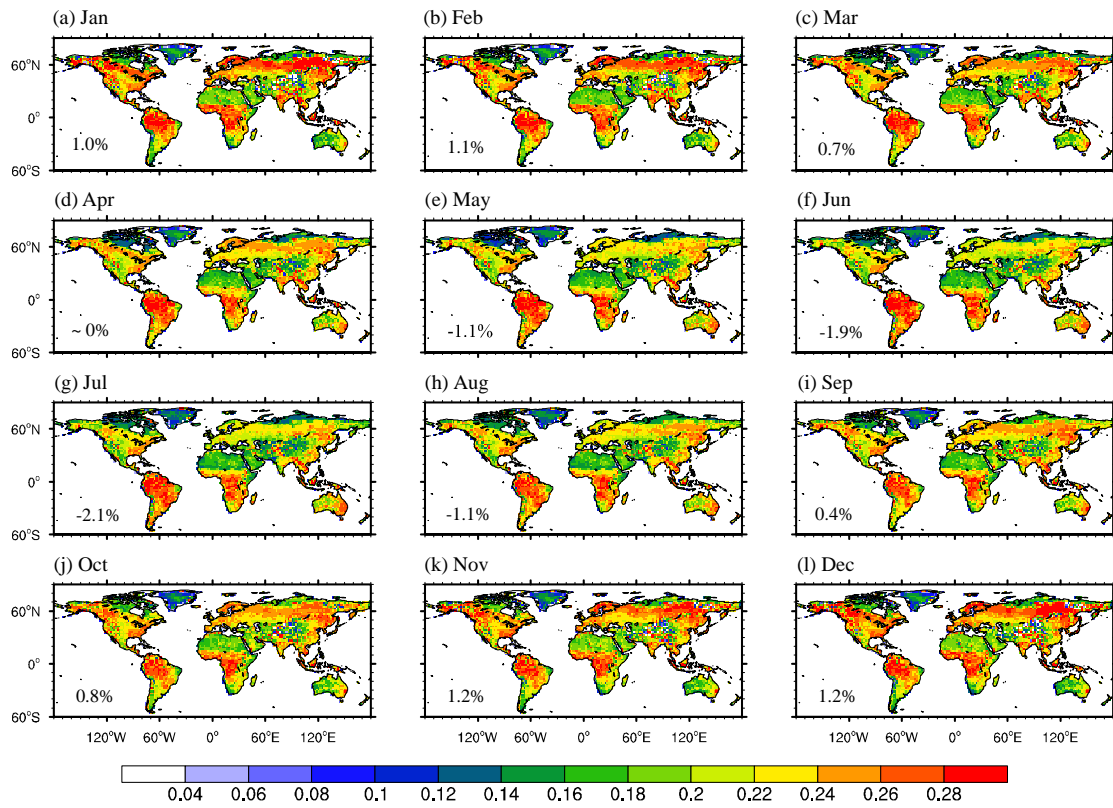
Supplementary Fig.7 | Comparison of solar photovoltaic potential (PV_{POT}). (a-b), The annual mean solar PV_{POT} calculated based on hourly and daily ERA5 reanalysis during 1995-2014 (unitless). (c), The difference between daily-based solar PV_{POT} and hourly-based solar PV_{POT} (unitless). The normalized mean bias (NMB) is shown in the bottom panel.



Supplementary Fig.8 | Attribution of solar photovoltaic potential (PV_{POT}) bias in Supplementary Fig.7c. (a), (b), and (c), The changes of solar PV_{POT} calculated using only daily temperature (T), surface downwelling shortwave radiation (I), and wind speed (W) relative to hourly-based solar PV_{POT} . The normalized mean bias (NMB) is shown in the bottom panel.



Supplementary Fig.9 | Evaluation of the ERA5 reanalysis during 1995-2014. (a) and (c), Observed temperature (units: K) and 10 m wind speed (units: m/s) at 3511 weather stations from the Met Office Hadley Centre observations datasets, HadISD (<https://www.metoffice.gov.uk/hadobs/hadisd/index.html>). **(b) and (d),** The bias of temperature and 10 m wind speed from the ERA5 reanalysis relative to observations. The site number and normalized mean bias (NMB) are shown in the bottom panel.



Supplementary Fig.10 | Month-to-month changes of scaling factor converting 10 m to 100 m wind speed during 1995-2014. The relative bias of monthly scaling factor relative to annual scaling factor is shown in the bottom panel.