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We acknowledge Aboriginal and Torres Strait Islander peoples as the First Australians and Traditional Custodians of the lands where we live, learn, and work.

Thank you for visiting nature . You are using a browser version with limited support for CSS. To obtain the best experience, we recommend you use a more up to date browser (or turn off compatibility mode in Internet Explorer). In the meantime, to ensure continued support, we are displaying the site without styles and JavaScript.

Solar ramps have been studied for different parts of the world5,6,7,8 using PV power output2,9 or GHI5,10 observations. These studies have quantified the ramp events at a PV plant scale and have highlighted their impact on the grid. Variability in power generated is affected by the sky conditions5,11,12 influenced by the local weather events2,10,13. Few studies have identified the localized weather events responsible for the occurrence of ramps2,9,13 and also studied their seasonal and annual variability9. The future changes in the cloud cover conditions and weather patterns due to climate change will influence the occurrence of ramps in different parts of the world.

Ramp magnitude across Australia. Panel (a) represents the mean ramp magnitude during the historical period (1976-2005). Panel (b) and (c) represent the future changes in mean ramp magnitude for the far future (2070-2099) period under RCP4.5 and RCP8.5. Panel (d) represents the ramp magnitude at the 90th percentile during the historical period (1976-2005). Panel (e) and (f) represent the future changes in ramp magnitude at the 90th percentile for the far future (2070-2099) under RCP4.5 and RCP8.5. Stippling indicates a significant change (according to methods: significance test).

Ramp frequency across Australia. Panel (a) represents the mean ramp frequency during the historical period (1976-2005). Panel (b) and (c) represent the future changes in mean ramp frequency per year for the far future (2070-2099) period under RCP4.5 and RCP8.5. Panel (d) represents the frequency of ramps with ramp magnitude at the 90th percentile during the historical period (1976-2005). Panel (e) and (f) represent the future changes in the frequency of ramps with ramp magnitude at the 90th percentile for the far future (2070-2099) period under RCP4.5 and RCP8.5. Stippling indicates a significant change (according to methods: significance test).

Ramping periods across Australia. Panel (a) represents the mean ramp periods during the historical period (1976-2005). Panel (b) and (c) represent the future changes in mean ramp periods per year for the far future (2070-2099) period under RCP4.5 and RCP8.5. Panel (d) represents the ramp periods with ramp magnitude at the 90th percentile during the historical period (1976-2005). Panel (e) and (f) represent the future changes in ramp periods with ramp magnitude at the 90th percentile for the far future (2070-2099) under RCP4.5 and RCP8.5. Stippling indicates a significant change (according to methods: significance test).

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Time series of annual power generation, ramp magnitude per unit capacity, ramp frequency and maximum annual mean ramping period duration per year for Sun Cable"s Powell Creek solar farm located in the Northern Territory, Australia. The black line represents the ensemble mean for the historical period. The blue and red lines represent the ensemble mean for the future periods under RCP4.5 and RCP8.5, respectively. The shading in the grey, blue and red represents the interquartile range of the ensemble members for the historical and future.

We estimate normalized power generation using the mono-Si module specifications in Table 1s and scale it as per the proposed generation capacity (20GW) for Powell Creek to understand the future changes in the power generation at the plant. It can be noted that there is a decline in the annual generation capacity of the farm (up to 1GWh/GW) in the future under both scenarios (Fig.4a). Our results indicate ~ 5% decrease in energy generation from the plant due to climate change. This estimation does not consider any future solar farm production capacity expansion.

In this study, we use meteorological observational data (temperature, GHI, wind speed, relative humidity, plane of array (POA) irradiance) and PV power data from Desert Knowledge Australia Solar Centre (DKASC), Alice Springs solar farm for the period 2010- 2016 recorded at 5-minute intervals. The DKASC has several solar technologies (Mono-Si, Mc-Si, CdTe cells) with fixed, single and dual-axis tracking systems. Supplementary Table 1s includes the PV technologies and their configurations for simulating power in PVLIB.

CORDEX-Australasia ensembles have been evaluated for the historical period and are found to reproduce many aspects of the climate of the region like minimum temperature, maximum temperature and precipitation23,28. The CORDEX-Australasia shortwave radiation has been evaluated using the reanalysis datasets and is found to capture the spatial pattern and magnitude with reasonable fidelity (supplementary Fig.1s). Further, the future changes in the land-use type and enlargement of arid areas were also studied using CORDEX projections29. In this study, we have used 1-hourly shortwave downward radiation, temperature, wind speed, relative humidity and pressure to obtain the power projections for different PV technologies.

Ramps correspond to sudden localized changes in a power time series. The ramps have been obtained for successive points in the time series using the method proposed in the recent report by the Australian Energy Market Operator37: