Estimation of long-term solar power fluctuations across Australia using high-resolution regional climate projections

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Abstract: Weather-induced sudden fluctuations in the photovoltaic (PV) power output over short duration of time contribute to intermittency in the PV power generated during the day. These sudden fluctuations in PV power output, termed as “ramp events”, lead to inaccuracies in the solar power forecast and introduce grid stability issues at higher penetration levels. The installed capacity of grid-connected solar power systems is rapidly increasing in Australia and sensitivity of PV to weather-induced variability imposes limitations on its reliability. Therefore, understanding the solar power ramps is essential for estimating storage facilities, technological advancements in ramp control devices and optimal system design for integration of solar energy into the electricity grid. This research aims to understand solar power ramps across Australia for the historical period (1976–2005) and two future periods (near future 2030–2059 and far future 2070–2099) under an intermediate-emission scenario (representative concentration pathway; RCP 4.5) and a high-emission scenario (RCP8.5). We use high-resolution regional climate model projections from the Coordinated Regional Downscaling Experiment (CORDEX) for Australasia to identify the ramp events in Australia. We analyze ramp features such as ramp magnitude, frequency and ramping periods for the historical and future periods to assess weather-induced future intermittency across Australia. Results indicate an abundance of solar power in Australia, especially in the northern part of the country. It is expected that there shall be a decline in the solar power almost throughout the continent with small increments near the east in the future. Results indicate mean ramp magnitude is highest in the east and predict a uniform decline in the magnitude for both the future periods under both the scenarios. Further, the mean ramp frequency is expected to increase in some parts of north and east during the far future with highest decline near the west under both the scenarios. The mean ramping period is predicted to increase in the east with decline in the west under both the scenarios in the future. This indicates that intermittency is expected to increase near the east and would require additional storage to mitigate the weather-induced intermittency. This long-term future ramp variability analysis will be helpful in quantifying the battery storage requirements to meet the supply-demand ratio at all times of the day. Furthermore, this analysis will help in critical decision-making processes like optimal site selection for future PV plants and technological advancements of ramp control devices to manage voltage flicker and grid stability issues at higher penetration levels.

Keywords: *Solar energy, photovoltaic cells, electricity grid, energy fluctuations, solar power ramps*