Solar energy research and development brazil

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The share of solar power in Brazil"s electrical grid has rapidly increased, relieving GHG emissions and diversifying energy sources for greater energy security. Besides that, solar resource is susceptible to climate change, adding uncertainty to electrical grid resilience. This study uses satellite and reanalysis data to evaluate the performance of CMIP6 models in replicating and predicting surface solar irradiance (SSR) in Brazil. The results from the most reliable models indicate an increase in SSR by 2% to 8% in most regions, with a decrease of around 3% in the South. These findings highlight the potential for increased photovoltaic (PV) yield if backed by supportive public policies while underlining the importance of uncertainty assessment of climate models.

Since 2018, Brazil has been witnessing a significant surge in its installed PV capacity, which has now surpassed 30.7 GW in the second quarter of 202313,14,15. As PV power generation is set to play a more substantial role in Brazil"s future energy mix, it becomes imperative to delve into the impact of climate change on the spatial and temporal variability of solar energy.

The previous results revealed a high level of uncertainty in climate change impact assessments, partly due to the different methodologies and datasets adopted. A more rigorous selection of the climate models to be used in an ensemble analysis, focusing on selecting those with the best performance and ability to represent current climate patterns, is essential in improving the analysis of future climate scenarios. Bias-correction methods and statistical indicators to evaluate the model"s skill in reproducing spatial and seasonal patterns observed in historical reference datasets, like satellite-based or meteorological reanalysis, are fundamental to achieving more confidence in the climate change impact assessment.

Figure 1 provides a comprehensive view of the performance of CMIP6 models in reproducing (SSR) spatial patterns, providing visual information on the alternation between positive and negative bias for Brazilian territory. Uncertainty in model estimates is noticeable due to the large spread of deviations. The 40-models" ensemble ((ENS)) reproduces the (SSR)"s spatial pattern over Brazilian Northeast and Central regions with reduced bias. Nevertheless, the (ENS) overestimates (around (50 W/m^2)) the climatological (SSR) in the Amazon region. These results agree with findings showing a negative bias for precipitation outputs of CMIP6 models for the north of the Amazon22,23,24.

The panel presents the mapping of the BIAS deviation (in W/m2)shown by the (SSR) estimates provided by the ensemble (upper left corner) and by each of the forty climate models from CMIP6 used in the study. The model names are positioned above the corresponding map. The authors prepared maps using the available Python libraries.

Model M25 (HadGEM3-C31) is the top-performing model in terms of (TSS), with the highest time correlation and lowest (uRMSD). The (ENS) has the second lowest ((SD)) but performs poorly in other statistical indexes compared to the ten best-performing models.

The (SSR) changes for future scenarios obtained from (SME) are presented in three timeslices: near-future (2015-2040), mid-term future (2041-2070), and end-of-century (2071-2100). Complete plots and maps for the three timeslices and both climate scenarios (SSP2.45 and SSP5.85) are available at https://doi /10.6084/m9 gshare.25396612 for public access.

Figure 4c shows an opposite seasonal pattern in the South of Brazil (area A2). The (CCF) shows negative values most of the year except for January and February, ranging from (0.5) to (1.5%) in both scenarios and timeslices. The decrease in (SSR) is more severe during the Wet-Dry transition months when the predicted (CCF) is around(-2.0%) ((-4.5%)) in SSP2-4.5 (SSP5-8.5) at the end-of-century.

The seasonal mean CCF predicted by the SME for the SSP2-4.5 in 2015-2040 (a), 2041-2070 (b), and 2071-2100 (c) timeslices; and for SSP5-8.5 in 2015-2040 (d), 2041-2070 (e) and 2071-2100 (f) timeslices. The columns are from left to right: summer, autumn, winter, spring, and annual. The gray dots over the maps represent the grid locations with statistical significance (p-value <0.05). The authors prepared maps using the available Python libraries.

Solar PV technologies have rapidly grown in Brazilian metropolitan regions (MR) due to a sharp cost reduction and recent regulations encouraging distributed generation13. The SSR"s spatial distribution and future trends highlight the challenges in optimizing solar power benefits for Brazil"s energy mix while reducing risks and GHG emissions to fulfill international commitments. Based on recent works using data from PV power systems operating in Brazil27, we used the performance ratio (PR) around 0.8 to evaluate the impact of climate change on solar PV yield.

Figure 6 shows the annual PV yield from 1980 to 2100 assessed using the SSR outcomes of the SME for SSP2-4.5 and SSP5-8.5 pathways in seven MRs and two remote areas, covering different climate regimes. We assumed that technological advancements in PV technology will offset the losses in solar energy conversion due to the rise in ambient temperature. Table 1 lists the trend slope and p-value of the linear regression fitted for the nine locations and climate pathways. The statistically significant trends are highlighted in bold blue numbers.

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