

IMPACT OF CLIMATE CHANGE ON SOLAR RESOURCE: A REVIEW OF PROJECTIONS, UNCERTAINTIES AND PERSPECTIVES

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References

- [1] B. Bartók, M. Wild, D. Folini, D. Lüthi, S. Kotlarski, C. Schär, R. Vautard, S. Jerez, and Z. Imecs, “Projected changes in surface solar radiation in CMIP5 global climate models and in EURO-CORDEX regional climate models for Europe,” *Climate Dynamics*, vol. 49, no. 7, pp. 2665–2683, Oct. 2017. [Online]. Available: <https://doi.org/10.1007/s00382-016-3471-2>
- [2] A. Bichet, B. Hingray, G. Evin, A. Diedhiou, C. M. F. Kebe, and S. Anquetin, “Potential impact of climate change on solar resource in Africa for photovoltaic energy: analyses from CORDEX-AFRICA climate experiments,” *Environmental Research Letters*, vol. 14, no. 12, p. 124039, Dec. 2019, publisher: IOP Publishing. [Online]. Available: <https://dx.doi.org/10.1088/1748-9326/ab500a>
- [3] J. Boé, S. Somot, L. Corre, and P. Nabat, “Large discrepancies in summer climate change over Europe as projected by global and regional climate models: causes and consequences,” *Climate Dynamics*, vol. 54, no. 5, pp. 2981–3002, Mar. 2020. [Online]. Available: <https://doi.org/10.1007/s00382-020-05153-1>
- [4] L. Chen, “Uncertainties in solar radiation assessment in the United States using climate models,” *Climate Dynamics*, vol. 56, no. 1, pp. 665–678, Jan. 2021. [Online]. Available: <https://doi.org/10.1007/s00382-020-05498-7>

- [5] X. Costoya, M. deCastro, D. Carvalho, and M. Gómez-Gesteira, "Assessing the complementarity of future hybrid wind and solar photovoltaic energy resources for North America," *Renewable and Sustainable Energy Reviews*, vol. 173, p. 113101, Mar. 2023. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S1364032122009820>
- [6] D. K. Danso, S. Anquetin, A. Diedhiou, C. Lavaysse, B. Hingray, D. Raynaud, and A. T. Koba, "A CMIP6 assessment of the potential climate change impacts on solar photovoltaic energy and its atmospheric drivers in West Africa," *Environmental Research Letters*, vol. 17, no. 4, p. 044016, Mar. 2022, publisher: IOP Publishing. [Online]. Available: <https://dx.doi.org/10.1088/1748-9326/ac5a67>
- [7] P. de Jong, T. B. Barreto, C. A. S. Tanajura, D. Kouloukoui, K. P. Oliveira-Esquerre, A. Kiperstok, and E. A. Torres, "Estimating the impact of climate change on wind and solar energy in Brazil using a South American regional climate model," *Renewable Energy*, vol. 141, pp. 390–401, Oct. 2019. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S096014811930391X>
- [8] R. Dutta, K. Chanda, and R. Maity, "Future of solar energy potential in a changing climate across the world: A CMIP6 multi-model ensemble analysis," *Renewable Energy*, vol. 188, pp. 819–829, Apr. 2022. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0960148122001653>
- [9] S. Feron, R. R. Cordero, A. Damiani, and R. B. Jackson, "Climate change extremes and photovoltaic power output," *Nature Sustainability*, vol. 4, no. 3, pp. 270–276, Mar. 2021, number: 3 Publisher: Nature Publishing Group. [Online]. Available: <https://www.nature.com/articles/s41893-020-00643-w>
- [10] M. Gaetani, T. Huld, E. Vignati, F. Monforti-Ferrario, A. Dosio, and F. Raes, "The near future availability of photovoltaic energy in Europe and Africa in climate-aerosol modeling experiments," *Renewable and Sustainable Energy Reviews*, vol. 38, pp. 706–716, Oct. 2014. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S1364032114004936>
- [11] D. E. H. J. Gernaat, H. S. de Boer, V. Daioglou, S. G. Yalew, C. Müller, and D. P. van Vuuren, "Climate change impacts on renewable energy supply," *Nature Climate Change*, vol. 11, no. 2, pp. 119–125, Feb.

- 2021, number: 2 Publisher: Nature Publishing Group. [Online]. Available: <https://www.nature.com/articles/s41558-020-00949-9>
- [12] M. S. Ghanim and A. A. Farhan, “Projected patterns of climate change impact on photovoltaic energy potential: A case study of Iraq,” *Renewable Energy*, vol. 204, pp. 338–346, Mar. 2023. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0960148123000356>
 - [13] V. Gil, M. A. Gaertner, C. Gutierrez, and T. Losada, “Impact of climate change on solar irradiation and variability over the Iberian Peninsula using regional climate models,” *International Journal of Climatology*, vol. 39, no. 3, pp. 1733–1747, 2019, eprint: <https://onlinelibrary.wiley.com/doi/pdf/10.1002/joc.5916>. [Online]. Available: <https://onlinelibrary.wiley.com/doi/abs/10.1002/joc.5916>
 - [14] C. Gutiérrez, S. Somot, P. Nabat, M. Mallet, L. Corre, E. v. Meijgaard, O. Perpiñán, and M. Gaertner, “Future evolution of surface solar radiation and photovoltaic potential in Europe: investigating the role of aerosols,” *Environmental Research Letters*, vol. 15, no. 3, p. 034035, Mar. 2020, publisher: IOP Publishing. [Online]. Available: <https://dx.doi.org/10.1088/1748-9326/ab6666>
 - [15] Y. He, K. Yang, M. Wild, K. Wang, D. Tong, C. Shao, and T. Zhou, “Constrained future brightening of solar radiation and its implication for China’s solar power,” *National Science Review*, Nov. 2022.
 - [16] —, “Constrained future brightening of solar radiation and its implication for China’s solar power,” *National Science Review*, p. nwac242, Oct. 2022. [Online]. Available: <https://doi.org/10.1093/nsr/nwac242>
 - [17] X. Hou, M. Wild, D. Folini, S. Kazadzis, and J. Wohland, “Climate change impacts on solar power generation and its spatial variability in Europe based on CMIP6,” *Earth System Dynamics*, vol. 12, no. 4, pp. 1099–1113, Nov. 2021, publisher: Copernicus GmbH. [Online]. Available: <https://esd.copernicus.org/articles/12/1099/2021/>
 - [18] I. Huber, L. Bugliaro, M. Ponater, H. Garny, C. Emde, and B. Mayer, “Do climate models project changes in solar resources?” *Solar Energy*, vol. 129, pp. 65–84, May 2016. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0038092X15006891>
 - [19] S. Jerez, L. Palacios-Peña, C. Gutiérrez, P. Jiménez-Guerrero, J. M. López-Romero, and J. P. Montávez, “Gains and losses in surface solar

radiation with dynamicaerosols in regional climate simulations for Europe,” Climate and Earth system modeling,” preprint, Aug. 2020. [Online]. Available: <https://gmd.copernicus.org/preprints/gmd-2020-238/gmd-2020-238.pdf>

- [20] S. Jerez, I. Tobin, R. Vautard, J. P. Montáñez, J. M. López-Romero, F. Thais, B. Bartok, O. B. Christensen, A. Colette, M. Déqué, G. Nikulin, S. Kotlarski, E. van Meijgaard, C. Teichmann, and M. Wild, “The impact of climate change on photovoltaic power generation in Europe,” *Nature Communications*, vol. 6, no. 1, p. 10014, Dec. 2015, number: 1 Publisher: Nature Publishing Group. [Online]. Available: <https://www.nature.com/articles/ncomms10014>
- [21] X. Li, D. L. Mauzerall, and M. H. Bergin, “Global reduction of solar power generation efficiency due to aerosols and panel soiling,” *Nature Sustainability*, vol. 3, no. 9, pp. 720–727, Sept. 2020, number: 9 Publisher: Nature Publishing Group. [Online]. Available: <https://www.nature.com/articles/s41893-020-0553-2>
- [22] W. W. Ma, M. G. Rasul, G. Liu, M. Li, and X. H. Tan, “Climate change impacts on techno-economic performance of roof PV solar system in Australia,” *Renewable Energy*, vol. 88, pp. 430–438, Apr. 2016. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0960148115304699>
- [23] B. Müller, M. Wild, A. Driesse, and K. Behrens, “Rethinking solar resource assessments in the context of global dimming and brightening,” *Solar Energy*, vol. 99, pp. 272–282, Jan. 2014. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0038092X13004933>
- [24] G. Narvaez, L. F. Giraldo, M. Bressan, and A. Pantoja, “The impact of climate change on photovoltaic power potential in Southwestern Colombia,” *Heliyon*, vol. 8, no. 10, p. e11122, Oct. 2022. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S2405844022024100>
- [25] J. Niu, W. Qin, L. Wang, M. Zhang, J. Wu, and Y. Zhang, “Climate change impact on photovoltaic power potential in China based on CMIP6 models,” *Science of The Total Environment*, vol. 858, p. 159776, Feb. 2023. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0048969722068760>

- [26] O. S. Ohunakin, M. S. Adaramola, O. M. Oyewola, O. J. Matthew, and R. O. Fagbenle, "The effect of climate change on solar radiation in Nigeria," *Solar Energy*, vol. 116, pp. 272–286, June 2015. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0038092X1500153X>
- [27] S. Poddar, J. P. Evans, M. Kay, A. Prasad, and S. Bremner, "Estimation of future changes in photovoltaic potential in Australia due to climate change," *Environmental Research Letters*, vol. 16, no. 11, p. 114034, Nov. 2021, publisher: IOP Publishing. [Online]. Available: <https://dx.doi.org/10.1088/1748-9326/ac2a64>
- [28] J. C. Pérez, A. González, J. P. Díaz, F. J. Expósito, and J. Felipe, "Climate change impact on future photovoltaic resource potential in an orographically complex archipelago, the Canary Islands," *Renewable Energy*, vol. 133, pp. 749–759, Apr. 2019. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0960148118312618>
- [29] W. Sawadogo, M. S. Reboita, A. Faye, R. P. da Rocha, R. C. Odoulami, C. F. Olusegun, M. O. Adeniyi, B. J. Abiodun, M. B. Sylla, I. Diallo, E. Coppola, and F. Giorgi, "Current and future potential of solar and wind energy over Africa using the RegCM4 CORDEX-CORE ensemble," *Climate Dynamics*, vol. 57, no. 5, pp. 1647–1672, Sept. 2021. [Online]. Available: <https://doi.org/10.1007/s00382-020-05377-1>
- [30] P. M. M. Soares, M. C. Brito, and J. A. M. Careto, "Persistence of the high solar potential in Africa in a changing climate," *Environmental Research Letters*, vol. 14, no. 12, p. 124036, Dec. 2019, publisher: IOP Publishing. [Online]. Available: <https://dx.doi.org/10.1088/1748-9326/ab51a1>
- [31] K. Solaun and E. Cerdá, "Climate change impacts on renewable energy generation. A review of quantitative projections," *Renewable and Sustainable Energy Reviews*, vol. 116, p. 109415, Dec. 2019. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S1364032119306239>
- [32] F. Tahir, A. A. B. Baloch, and S. G. Al-Ghamdi, "Impact of climate change on solar monofacial and bifacial Photovoltaics (PV) potential in Qatar," *Energy Reports*, vol. 8, pp. 518–522, Aug. 2022. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S2352484722004449>

- [33] C. Tang, B. Morel, M. Wild, B. Pohl, B. Abiodun, and M. Bessafi, "Numerical simulation of surface solar radiation over Southern Africa. Part 1: Evaluation of regional and global climate models," *Climate Dynamics*, vol. 52, no. 1, pp. 457–477, Jan. 2019. [Online]. Available: <https://doi.org/10.1007/s00382-018-4143-1>
- [34] C. Tang, B. Morel, M. Wild, B. Pohl, B. Abiodun, C. Lennard, and M. Bessafi, "Numerical simulation of surface solar radiation over Southern Africa. Part 2: projections of regional and global climate models," *Climate Dynamics*, vol. 53, no. 3, pp. 2197–2227, Aug. 2019. [Online]. Available: <https://doi.org/10.1007/s00382-019-04817-x>
- [35] M. Wild, D. Folini, F. Henschel, N. Fischer, and B. Müller, "Projections of long-term changes in solar radiation based on CMIP5 climate models and their influence on energy yields of photovoltaic systems," *Solar Energy*, vol. 116, pp. 12–24, June 2015. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0038092X15001668>
- [36] J. Wu, Z. Han, Y. Yan, and X. Gao, "Future Projection of Solar Energy Over China Based on Multi-Regional Climate Model Simulations," *Earth and Space Science*, vol. 9, no. 5, p. e2021EA002207, 2022, eprint: <https://onlinelibrary.wiley.com/doi/pdf/10.1029/2021EA002207>. [Online]. Available: <https://onlinelibrary.wiley.com/doi/abs/10.1029/2021EA002207>
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- [37] L. Yang, J. Jiang, T. Liu, Y. Li, Y. Zhou, and X. Gao, "Projections of future changes in solar radiation in China based on CMIP5 climate models," *Global Energy Interconnection*, vol. 1, no. 4, pp. 452–459, Oct. 2018. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S2096511718300653>
- [38] F. Zhang, C. Wang, G. Xie, W. Kong, S. Jin, J. Hu, and X. Chen, "Projection of global wind and solar resources over land in the 21st century," *Global Energy Interconnection*, vol. 1, no. 4, pp. 443–451, Oct. 2018. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S2096511718300641>
- [39] J. Zhang, Q. You, and S. Ullah, "Changes in photovoltaic potential over China in a warmer future," *Environmental Research Letters*, vol. 17, no. 11, p. 114032, Nov. 2022, publisher: IOP Publishing. [Online]. Available: <https://dx.doi.org/10.1088/1748-9326/ac9e0b>

- [40] X. Zhao, G. Huang, C. Lu, X. Zhou, and Y. Li, “Impacts of climate change on photovoltaic energy potential: A case study of China,” *Applied Energy*, vol. 280, p. 115888, Dec. 2020. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0306261920313581>
- [41] L. Zou, L. Wang, J. Li, Y. Lu, W. Gong, and Y. Niu, “Global surface solar radiation and photovoltaic power from Coupled Model Intercomparison Project Phase 5 climate models,” *Journal of Cleaner Production*, vol. 224, pp. 304–324, July 2019. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0959652619309783>
- [42] C. F. Zuluaga, A. Avila-Diaz, F. B. Justino, F. R. Martins, and W. L. Ceron, “The climate change perspective of photovoltaic power potential in Brazil,” *Renewable Energy*, vol. 193, pp. 1019–1031, June 2022. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S096014812200670X>