**The cloud classification**

Chao TANG1 ✉, Béatrice MOREL1, Nathalie PHILIPPON2, Thierry PORTAFAIX3, Miloud BESSAFI1,

✉ Chao TANG

Email: [chao.tang@univ-reunion.fr](mailto:chao.tang@univ-reunion.fr)

1. Laboratoire d'Energétique, d'Electronique et Procédés, ENERGY-lab, Université de La Réunion, La Réunion, France

2 CRC, UMR6282 Biogéosciences CNRS-UBFC, bât. Sciences Gabriel, 6 blvd Gabriel, 21000 Dijon, France

3 LACy (Laboratoire de l'Atmosphère et des Cyclones), UMR8105, CNRS – Université de la Réunion – Météo-France, Saint Denis de la Réunion, France

# Microsoft word live editing link (login not required):

<https://1drv.ms/w/s!AhhWTWH2RB5fjetdI4NDwqHBFknlIA>

# Google Drive real time backup (without live editing):

<https://docs.google.com/document/d/1YAUEVlxqM1g7M8y9fNNj1f-l_JvcCOyy/edit?usp=sharing&ouid=115400583048984110222&rtpof=true&sd=true>

# Abstract

Keywords: South West Indian Ocean, cloud cover,

k

# Introduction

Increasing renewable energy use is an essential strategy for mitigating climate change towards a low carbon future. Solar energy is one of the most promising sources of renewable and clean energy.

The installation of Photovoltaic (PV) was continuously increasing last decade. In 2020, over 135 GW of new solar photovoltaic electricity generation capacity was installed increasing the total cumulative installed capacity to over 770 GW, and the 1 TW barrier will be broken during 2022 ([Jäger-Waldau 2021](#_heading=h.1v1yuxt)). At the same time in most markets, solar PV nowadays represents the cheapest available source of new electricity generation ([IEA 2021](#_heading=h.2grqrue)) benefiting from the price reductions of solar panels and the associated battery storage to stabilize the electricity output. While the unpredictable, intermittent nature of solar resources linked to Climate Variabilities (CV) still represents a key challenge to solar energy production ([Engeland et al. 2017](#_heading=h.ihv636)).

This study focuses on the variability of the solar energy resource, Surface Solar Radiation (SSR) related to climate variabilities. The understanding of climate related variability plays a key role for stabilizing the PV output, assessing the impacts of climate change on photovoltaics ([Yin et al. 2020](#_heading=h.28h4qwu)) and optimizing the electricity grid connected with multiple resources of renewable energy, such as solar-wind combination ([Liu et al. 2020](#_heading=h.4f1mdlm)).

This paper is organized as follows: Section 2 presents the data used in this study and the methods to identify the SSR variability over Reunion and to analysis the impact of climate variabilities. The results are shown in section 3 with the response of SSR to the CVs. Then conclusions are made in section 4 followed by a brief discussion.

# Data and Methods

## SSR Clustering of CM\_SAF SARAH-E data

# SARAH-E has missing values

# Found missing day = 154, between 1999-01-01 and 2016-12-31. total size = 6421

## ERA5 reanalysis and OLR regimes classification

Atmospheric fields used in this study are taken from the ERA5 ensemble reanalysis ([Hersbach et al. 2020](#_heading=h.41mghml)). ERA5 is the fifth generation of atmospheric reanalysis released by the European Centre for Medium-Range Weather Forecasts, providing either a deterministic member at a 0.25° × 0.25° global resolution, or a 10-member ensemble available at a 0.5° × 0.5° resolution. It currently covers the period 1979 onward (with a preliminary extension to 1950 onward). Available variables consist in hourly gridded outputs of surface and atmospheric fields at the global scale, and from 1979 to the present. In this study, we use the following variables: 1) the Top net thermal radiation (J.m-2, converted onto W.m-2), corresponding to the net longwave radiation at the top of the atmosphere, is used to approximate large-scale atmospheric convection, an equivalent to the satellite-based outgoing longwave radiation (OLR) used in previous studies (e.g., [Fauchereau et al. 2009](#_heading=h.32hioqz), F09 hereafter; [Macron et al. 2014](#_heading=h.2u6wntf); [Pohl et al. 2018](#_heading=h.19c6y18); [Vigaud et al. 2012](#_heading=h.3tbugp1)). For convenience, this reanalysis-based field is referred to as OLR in the remainder of this study. 2) the surface circulation, i.e., the u and v components of surface wind.

## Clear sky index and clear sky SSR

To quantify the impact of climate variabilities in terms of cloudiness, the clear sky index and the SSR under assumed clear sky conditions are calculated by the Python module “pvlib python” (<https://pvlib-python.readthedocs.io/en/stable/index.html>) where the clear sky SSR is calculated based on monthly climatological turbidity ([Ineichen 2008](#_heading=h.vx1227); [Ineichen 2016](#_heading=h.3fwokq0)).

# Influence of climate variability

## SSR classification

Coming soon…

### SSR climatology over Reunion

# Discussion and Conclusion

Summary:

climate change impacts:

Perspective:

This study focusses on the SSR variability due to climate variabilities, where the analysis is at regional scale, over Reunion area. However, more detailed variation at local scale is still missing. Uniformly distributed anomalous SSR (see the classification of SSR anomaly in section 3.1) implies an investigating at smaller scales, such as the cloud process and topography lifting, etc, which is a perspective of this study.

# Acknowledgments

The study is supported by the Europe Union and the Region of Reunion Island through the scientific project SWIO-Energy (Solar and Wind energy in the Indian Ocean) of University of Reunion. Thanks to CCuB to provide the computational resource for the OLR regimes classification, and CCuR for the classification of SARAH-E SSR anomaly.

Thank you to xxx for his thorough rereading of the manuscript.

# Appendix

# References

Engeland K, Borga M, Creutin J-D, François B, Ramos M-H, Vidal J-P (2017) Space-time variability of climate variables and intermittent renewable electricity production – A review Renewable and Sustainable Energy Reviews 79:600-617 doi:<https://doi.org/10.1016/j.rser.2017.05.046>

Fauchereau N, Pohl B, Reason C, Rouault M, Richard Y (2009) Recurrent daily OLR patterns in the Southern Africa/Southwest Indian Ocean region, implications for South African rainfall and teleconnections Climate Dynamics 32:575-591

Hersbach H et al. (2020) The ERA5 global reanalysis Quarterly Journal of the Royal Meteorological Society 146:1999-2049 doi:<https://doi.org/10.1002/qj.3803>

IEA (2021) World Energy Outlook 2021

Ineichen P (2008) A broadband simplified version of the Solis clear sky model Solar Energy 82:758-762 doi:<https://doi.org/10.1016/j.solener.2008.02.009>

Ineichen P (2016) Validation of models that estimate the clear sky global and beam solar irradiance Solar Energy 132:332-344 doi:<https://doi.org/10.1016/j.solener.2016.03.017>

Jäger-Waldau A (2021) Overview of the Global PV Industry☆. In: Reference Module in Earth Systems and Environmental Sciences. Elsevier. doi:<https://doi.org/10.1016/B978-0-12-819727-1.00054-6>

Liu L et al. (2020) Optimizing wind/solar combinations at finer scales to mitigate renewable energy variability in China Renewable and Sustainable Energy Reviews 132:110151 doi:<https://doi.org/10.1016/j.rser.2020.110151>

Macron C, Pohl B, Richard Y, Bessafi M (2014) How do Tropical Temperate Troughs Form and Develop over Southern Africa? Journal of Climate 27:1633-1647 doi:10.1175/jcli-d-13-00175.1

Pohl B, Dieppois B, Crétat J, Lawler D, Rouault M (2018) From synoptic to interdecadal variability in Southern African rainfall: toward a unified view across time scales Journal of Climate 31:5845-5872

Vigaud N, Pohl B, Crétat J (2012) Tropical-temperate interactions over Southern Africa simulated by a regional climate model Climate Dynamics 39:2895-2916 doi:10.1007/s00382-012-1314-3

Yin J, Molini A, Porporato A (2020) Impacts of solar intermittency on future photovoltaic reliability Nature Communications 11:4781 doi:10.1038/s41467-020-18602-6