

An Investigation of Systematic Errors in Solar Radiation for Reanalysis Datasets

Eadaoin Doddy, Conor Sweeney

School of Mathematics and Statistics, University College Dublin
eadaoin.doddy@ucdconnect.ie



Introduction

Solar energy systems require knowledge of radiation climatology. The network of pyranometer measurements is sparse so reanalyses are used as a representation of climatology. Links between errors in radiation and cloud structures at different spatial scales are analysed by making use of satellite imagery and reanalysis cloud data. The aim is to establish the skill of reanalyses for solar radiation over Ireland.

Data and Methods

Reanalysis datasets, MERRA2 and ERA-Interim, are compared with 7 Irish pyranometer datasets (fig. 1) for time periods of up to 35 years (1980-2016).

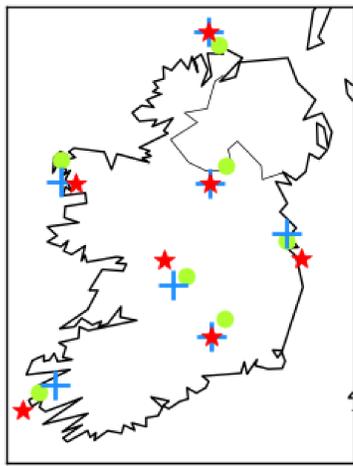


Figure 1: Stations (●) and ERA-Interim (★) and MERRA2 (+) grid points.

Standard skill scores and subjective analysis of satellite images are used to find the prevailing cloud structure associated with large error events.

Conclusion

1. ERA-Interim performs better than MERRA2 SW overall and at each individual station.
2. Both reanalyses overestimate the total daily SW compared to ground observations.
3. Convective clouds are a source of negative bias in MERRA2 SW, whereas frontal clouds are a source of positive bias.

The next step is to develop objective classification of cloud structures in numerical weather prediction models. This information will be used to help reduce errors in SW forecasts.

References

- [1] DP Dee, SM Uppala, AJ Simmons, P Berrisford, P Poli, S Kobayashi, U Andrae, MA Balmaseda, G Balsamo, P Bauer, et al. The era-interim reanalysis: Configuration and performance of the data assimilation system. *Quarterly Journal of the royal meteorological society*, 137(656):553–597, 2011.
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- [3] A Boilley and L Wald. Comparison between meteorological re-analyses from era-interim and merra and measurements of daily solar irradiation at surface. *Renewable Energy*, 75:135–143, 2015.

Acknowledgements

This publication has emanated from research conducted with the financial support of Science Foundation Ireland under the SFI Strategic Partnership Programme Grant Number SFI/15/SPP/E3125.

Results - Skill Scores

Average total daily shortwave radiation (SW) values are about $750Wm^{-2}$ in winter and about $4,500Wm^{-2}$ in summer. Skill score results (table 1) suggest ERA-Interim is a better overall representation of SW than MERRA2. Both reanalyses overestimate total daily SW compared to ground observations, as seen in previous works [1, 2]. Anomaly Correlation Coefficient (ACC) is a score relative to climate to compare the performance in different seasons. An ACC value of 0.6 corresponds to the range up to which there is skill for the largest scale weather patterns. The ACC values shows both reanalyses are skillful.

	MERRA2	ERA-Interim
Mean Error (Wm^{-2})	479.73	296.03
RMSE (Wm^{-2})	1061	872.28
Pearson's Correlation	0.907	0.927
Anomaly Correlation Coefficient (ACC)	0.6136	0.7186

Table 1: SW skill scores.

Results - Cloud Type

Cloud structures are classified from visible satellite imagery into 3 basic categories; frontal (fig. 2(left)), convective (fig. 2(right)) or neither.

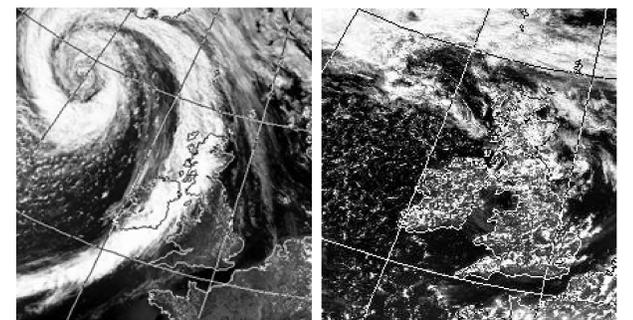


Figure 2: Visible satellite image - frontal cloud (left) and convective cloud (right).

- Reanalyses contain both large positive and negative errors (fig. 3).
- Reanalyses tend to simulate clear sky conditions when actual conditions are cloudy more so than the other way around [3]. All stations show a larger absolute value for positive error events compared to negative error events (fig. 4).

- By linking cloud structure and errors, initial analysis in fig. 4 suggest:

MERRA2 - convective clouds are linked to negative errors and frontal clouds are linked to positive errors.

ERA-Interim - no clear systematic cloud features are associated with errors.

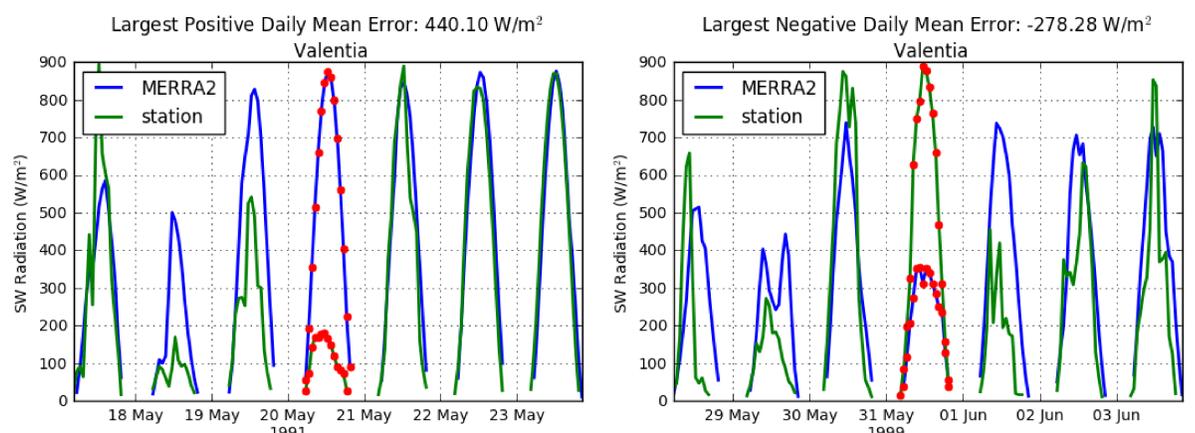


Figure 3: Time series of hourly MERRA2 and pyranometer SW during the largest positive (left) and negative (right) total daily SW errors at Valentia.

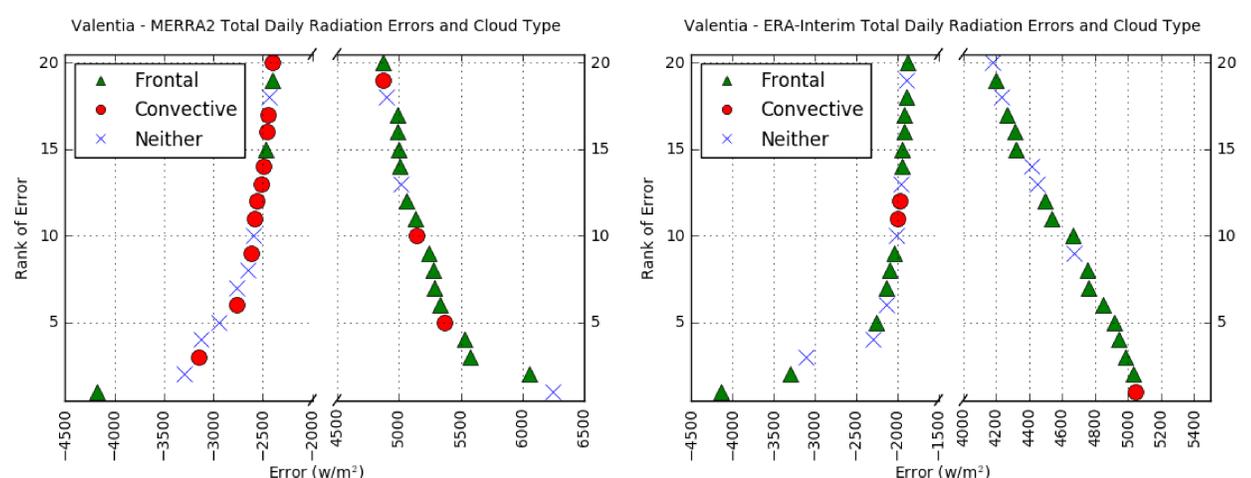


Figure 4: Subjective analysis of the 20 largest positive and negative total daily SW errors in MERRA2 (left) and ERA-Interim (right) at Valentia and the associated cloud type present on the day. Fronts (as in fig. 2(left)), convective (fig. 2(right)) and neither/unknown.