Solar World Congress 2025

SPATIAL CHARACTERIZATION OF OVERIRRADIANCE EVENTS IN THE CITY OF NATAL

Summary

This study analyzes data from two solarimetric stations installed in the city of Natal-RN (Brazil) approximately 2,450 meters apart and evaluates whether extreme overirradiance events can occur simultaneously at this distance. The results showed that a significant sample of events occurred on the same day at both stations and that many of the cases were verified with a time lag between the event measured at the stations, suggesting that the EOIE may have a spatial action in an area greater than 2,450 meters.

Keywords: Solar Energy, EOIE, Solarimetric station,

1. Introdution

Overirradiance events (OIE) occur when the solar irradiance incident on the Earth's surface is intensified by atmospheric effects, especially by reflection at the edges of clouds (cloud enhancement) and by an increase in surface albedo. These mechanisms can cause irradiance values measured at the surface to be higher than the extraterrestrial irradiance. When this amplification exceeds the value of the solar constant, the phenomenon is classified as an extreme overirradiance event (EOIE) (Braga et al., 2020; Horner et al., 2023).

In Brazil, several studies present locations where the irradiance reaches extreme values, such as a record in the city of Florianópolis, in the state of Santa Catarina, where the irradiance reached the value of 1845.5 W/m² (Martins et al., 2022; Nascimento et al., 2019). However, few studies have analyzed the spatial scope of the phenomenon.

Thus, the objective of this study is to analyze data from two solarimetric stations installed in the city of Natal-RN (Brazil) approximately 2450 meters apart and evaluate whether EOIE can occur simultaneously at this distance.

2. Materials and Methods

Data from two solarimetric stations were used, the first (SE-ISI-ER) installed at the SENAI Institute for Innovation in Renewable Energy (ISI-ER) and the second (SE-UFRN) installed at the Federal University of Rio Grande do Norte (UFRN). The stations are approximately 2450 meters apart in the southeast direction (Figure 1a). Global horizontal irradiance (G) data from January 2015 to December 2019 were used. Measurements were taken every second and integrated per minute using a Kipp & Zone CMP22 pyranometer at SE-ISI-ER (Figure 1b) and a Kipp & Zonen CM11 (Figure 1c).

To identify EOIE, the measured G values that exceeded the extraterrestrial horizontal irradiance values (G_0) were analysed. The G_0 values were estimated using the following expression:

$$G_0 = G_{sc} \cdot \varepsilon_0 \cdot \cos(\Theta_z) \quad \text{(eq. 1)}$$

where I_{sc} is the solar constant, equal to 1367 W/m², ε_0 é is the eccentricity of the Earth's orbit and $\cos(\Theta_z)$ is the cosine of the zenith angle. G above 1000 W/m² were considered for the analyses of overirradiance events, as values much lower than the Standard Test Conditions (STC) irradiance (1000 W/m^2) do not present relevant or potential problems that affect the operational performance of photovoltaic plants.

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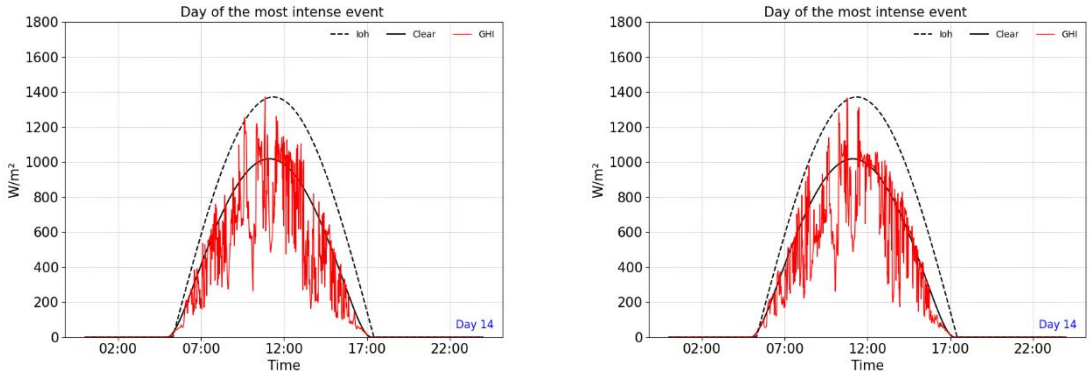
(a) **(b)** **(c)**

Fig. 1: (a) Position of the solarimetric stations used, (b) SE-UFRN and (c) SE-ISI-ER

3. Results and Discussion

The results showed that during the analyzed period, SE-ISI-ER recorded 363 OIR (1000W/m² < *G* < 1367 W/m²) and 55 EOIR (*G* > 1367 W/m²), while SE-UFRN recorded 163 OIE and 17 EOIE. Of this total, 57 OIE and 5 EOIE were identified that occurred at both stations on the same day. Although approximately 2450 meters apart, the stations presented very similar *G* variability (Figure 2). However, a time lag was observed (Figure 3) that resembles the time in which the cloud moves between stations. The results suggest that even if it does not occur at the same time, the same cloud can cause events over a much longer period of time and that this, as the cloud moves, could be measured initially at SE-UFRN and immediately afterwards at SE-ISI-ER. According to Järvelä et al. (2020), the spatialization of overirradiance events shows that these phenomena have localized distribution and significant variability in space. The authors observed that the most intense events presented irradiances up to 1.5 times higher than the clear sky irradiance and covered areas with diameters greater than 500 meters. It was found that in this study an EOIE event can cover an area greater than 2450 meters.

The quality of overirradiance event detection is directly related to the characteristics and limitations of the radiometric sensors used. Martins et al. (2020) demonstrated that factors such as response time, expanded uncertainty, temporal resolution, and field calibration significantly influence the ability of sensors to accurately record overirradiance (OIE) events. The difference in the sensor standard used at each station may be one of the factors that explain the difference in the number of events recorded between stations. Another important point is to ensure time synchronization in both dataloggers.



(a) **(b)**

Fig. 1: Variability of daily Global horizontal irradiance and EOIE (a) SE-UFRN (b) SE-ISI-ER.

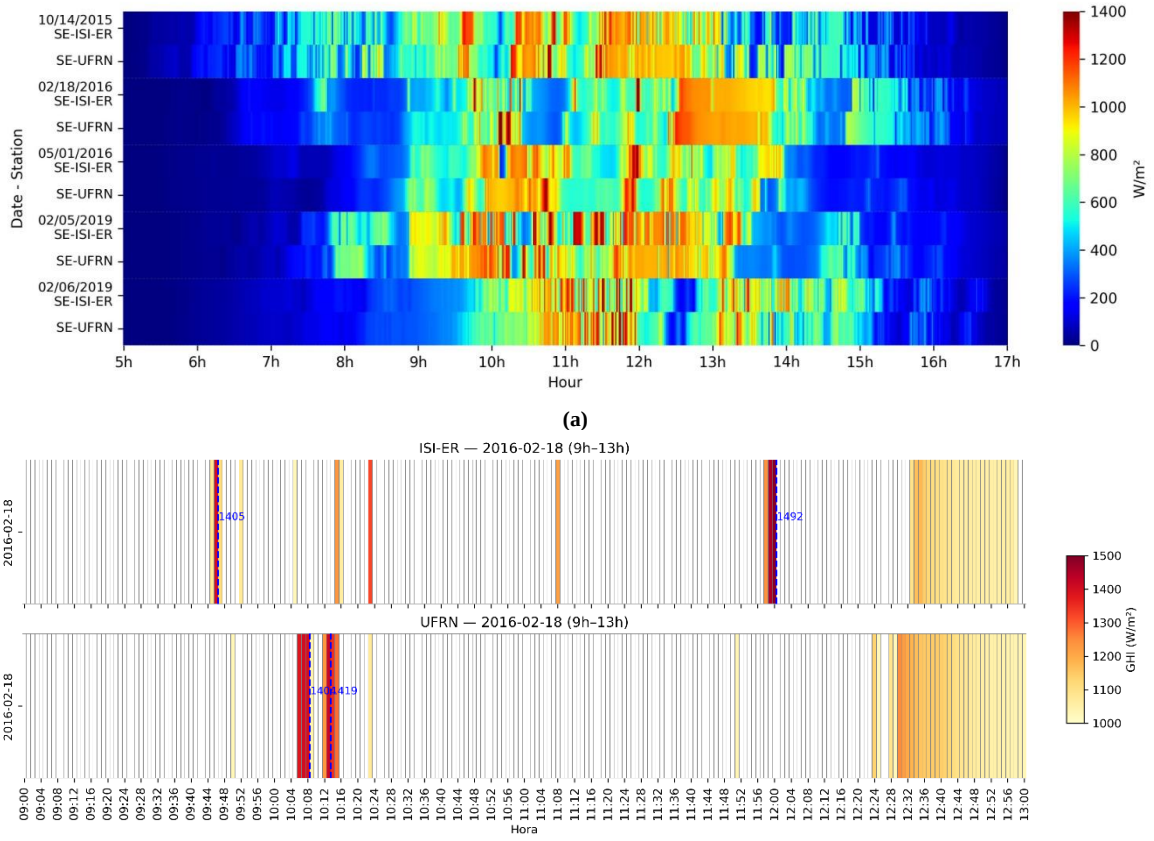


Fig. 2: Simultaneous EOIE between solarimetric station SE-ISI-ER and SE-UFRN (a) and details of the event that occurred on 02/18/2015.

4. Conclusions

The evaluation of overirradiance events at nearby stations allows us to understand the spatial and temporal dynamics of these extreme phenomena, which can significantly impact the performance and durability of photovoltaic systems. By identifying the simultaneous or delayed occurrence of these events, it is possible to assess the reliability of the data, validate sensors with different characteristics and improve solar forecast models. In addition, this analysis provides support for the appropriate dimensioning of inverters and overload protection strategies, especially in regions prone to high atmospheric variability.

5. References

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