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Comparison of ground-based and satellite-based irradiance data for photovoltaic yield estimation

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Abstract

High accuracy of yield prediction is of utmost importance for commercial scale photovoltaic systems. One key parameter crucial to the prediction accuracy is the choice and availability of reliable solar radiation data. In this work we investigate the impact of two fundamentally different irradiance data sources on the calculation of the yearly yield and performance ratio for five locations in different climatic regions of Australia. We find an overestimation of the yield calculation of up to 9.3% for satellite-based climate irradiance data compared against one-minute ground-based irradiance data. The yield overestimation shows a general correlation with the number of cloudy days. We propose a linear correction of the yield calculation which allows to improve the prediction accuracy based on more broadly available satellite-based irradiance data.

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Keywords: Photovoltaic module; yield; performance ratio; irradiance data

1. Introduction

Yield calculations for photovoltaic (PV) modules can be effected by the detail of the available irradiance and temperature data. The choice of input data, e.g. with a low time-resolution as for typical satellite-based irradiance data, can be critical to the accuracy energy yield predictions [1]. Most abundant available data is based on satellite observations. It has been shown that satellite data can yield an overestimation of the available solar resource [1, 2].

In this work we compare two sources of irradiance data and three temperature datasets with different time resolution. Table 1 lists the datasets used in this work. The satellite-based Australian Solar Energy Information

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Table 1. Irradiance and temperature datasets.

Provider	Data type	Time resolution	Source
	Irradiance datasets		
ASEIS	Satellite-based, climate irradiance data	Monthly average hourly	[3]
BoM	Ground-based, weather irradiance data	One minute	[4]
	Temperature datasets		
BoM	Climate temperature data	Monthly minimum/maximum	[5]
BoM	Climate temperature data	Daily minimum/maximum	[6]
BoM	Weather temperature data	One minute	[4]

System (ASEIS) climate irradiance data [3] contains monthly average hourly irradiance values. The detailed reference irradiance data is one-minute irradiance data from the Australian Bureau of Meteorology (BoM) [4].

For the ambient temperature T_{amb} we use three data sources: BoM monthly minimum and maximum temperature data [5], BoM daily minimum and maximum temperature data [6] and BoM one-minute temperature data [4].

We study the impact of different available irradiance and ambient temperature datasets on the yearly yield and performance ratio by accounting for the temperature dependence of PV modules with three commercially available technologies. We compare five different climatic locations in Australia shown in Figure 1 (Adelaide: Mediterranean, Alice Springs: desert, Broome: semi-arid, Darwin: tropical savanna and Melbourne: oceanic) and perform energy yield and temperature corrected performance ratio calculations for four combinations of the irradiance and temperature datasets. The contours in Figure 1 show the average annual global horizontal irradiance for Australia based on 21 years of averaged satellite data.

2. Data preparation and methodology

2.1. Irradiance data

The calculations in this paper are based on two different sources of solar irradiance data. The ASEIS dataset is based on geostationary satellite data and contains monthly average hourly irradiance values. The BoM dataset contains ground-based measured one-minute solar irradiance data which are traceable to the World Radiometric Reference for solar components. Both datasets provide direct normal irradiance (DNI) $I_{dir,norm}$ and global horizontal irradiance (GHI) $I_{glob,hor}$ values. The BoM dataset additionally provides diffuse horizontal irradiance $I_{diff,hor}$ values.

In order to obtain the diffuse horizontal irradiance for the ASEIS dataset we subtract the direct horizontal irradiance $I_{dir,hor}$ from the global horizontal irradiance:

$$I_{diff,\,hor} = I_{glob,\,hor} - I_{dir,\,hor}\,. \tag{1}$$

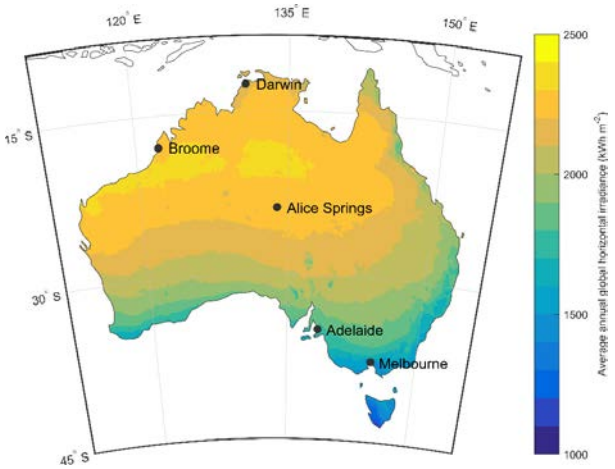

Fig. 1. Average yearly global horizontal irradiance over Australia for the period 1990 to 2011. Data reproduced from BoM [7]. The five locations investigated in this work are marked on the map.