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ScienceDirect

Solar Energy 122 (2015) 1158–1169

SOLAR ENERGY

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Irradiance forecasts based on an irradiance monitoring network, cloud motion, and spatial averaging

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Received 2 July 2015; received in revised form 29 September 2015; accepted 10 October 2015

Communicated by: Associate Editor Jan Kleissl

Abstract

We describe and evaluate forecasts of solar irradiance using real-time measurements from a network of irradiance sensors. A forecast method using cloud motion vectors obtained from a numerical weather model shows significant skill over a standard persistence model for forecast horizons from 1 min to over 2 h, although the skill metric may be misleading. To explain this finding, we define and compare several different persistence methods, including persistence methods informed by an instantaneous spatial average of irradiance sensor output and persistence forecasts informed by a time-average of recent irradiance measurements. We show that spatial- or temporal-averaging reduces the forecast RMS errors primarily because these forecasts are smoother (have smaller variance). We use a Taylor diagram, which shows correlation, RMSE, and variance, to more accurately compare several different types of forecasts. Using this diagram, we show that forecasts using the network of sensors have meaningful skill up to 30 min time horizons after which the skill is primarily due to smoothing.

Keywords: Solar forecasting; Solar irradiance; Sensor network

1. Introduction

The intermittency of solar power causes a cost to utilities and, ultimately, rate payers (Joskow, 2011). Solar power forecasts (Kleissl, 2013; Inman et al., 2013) may reduce these costs by enabling utilities to manage the variability of solar power in a number of ways. For example, forecasts can be used in conjunction with battery storage systems to control ramp-rates or provide frequency support (Hill et al., 2012; Cormode, 2015). Additionally, forecasts will provide utility grid operators with a prediction of the expected photovoltaic (PV) output so they can more efficiently schedule backup generators.

A number of different techniques are used to forecast global horizontal irradiance (GHI). For forecast horizons in the intra-minute to a few minute range, techniques with input data from several ground sensors are often used (Achleitner et al., 2014; Elsinga and van Sark, 2014; Yang et al., 2015; Lipperheide et al., 2015).

For longer (intra-hour) forecast horizons, methods based on irradiance sensor networks (Lonij et al., 2013), machine learning techniques (Chu et al., 2015b), and sky imagers (Yang et al., 2014; Chu et al., 2015a) are being actively studied. Satellite image based forecasts are useful for 1-h to many hours in advance (Perez et al., 2010;

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http://dx.doi.org/10.1016/j.solener.2015.10.038
0038-092X/