Spatially and temporally dense monitoring of global solar radiation using solar panels

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1. INTRODUCTION

In recent years, factors such as climate change and unplanned land use might have resulted in intense and frequent localized torrential rainfall in urban areas. Thus to understand about these urban phenomena, much attention has been paid on urban local climate. The magnitude of the solar radiation becomes an index of the thickness of the cloud aloft. However, there are many difficulties in measuring the amount of solar radiation with high spatial resolution due to the limitation of the number of the meteorological observatories. Large scale cloud information is available from satellite observations, but such data might be provided in a low resolution and may contain error. According to Long et al. 2006, it is difficult to determine the solar obstruction from the satellite sensor which is of utmost importance in radiation/cloud studies. Thus the use of solar panels as a solar radiometer can be a solution to such problems.
The use of solar panels has been increasing from houses, commercial building and schools, and thus, the main objective of this study is to propose a method to estimate the global solar radiation using the Photovoltaic (hereafter PV) system. The temporal variation pattern of the solar radiation and PV power of the solar panel is in high agreement with each other which indicates that the estimation of the global solar radiation using a PV system might be possible. The proposed method was further validated using dataset of the pyranometer observation.

2. METHODOLOGY

Solar panels (single crystal hybrid module VBHN233SJ01A manufactured by Panasonic cooperation) were installed on the rooftop of Engineering building, Ehime University, Matsuyama (132.771509 E, 33.850238 N). The solar panels were installed horizontally and at a tilt angle due south. A dataset of pyranometer was used to validate the proposed method for the estimation of the global solar radiation. In order to incorporate the effects of environmental factors, power ratio is corrected using a conversion factor for the estimation of the global solar radiation.
The PV power of solar panels installed at an inclination is considered to be proportional to the amount of solar radiation on the slope. Therefore, to estimate the global solar radiation, it is necessary to convert the solar radiation on a slope to the global solar radiation on a horizontal plane. Thus, for this conversion the separation of the solar radiation into the direct beam solar radiation and the diffuse solar radiation was conducted.

3. RESULTS AND REMARKS

In the case of horizontally equipped solar panel, once a calibration parameter was attained using one day in one season, solar radiation estimated from photovoltaic generation using the parameter highly agreed with measured data in other days. The good performance was not only fair weather days but also for other cloudy days. In the case of tilted solar panel, it was demonstrated that the conversion using direct/scatter separation improved the estimation. The validity of the method proposed for the estimation of global solar radiation using solar panels at a tilt angle of 20deg and 30deg was also confirmed with high correlation.
The spatial distribution of global solar radiation was obtained from the datasets of power generation of solar panels installed at 25 locations in the Matsuyama and compared to images of sky camera and the direct and scattering pyranometer. While the spatial variation of solar radiation

under clear-sky days or cloudy days (stratus covering) was small, that under partially fair weather days (cumulus existing) clouds was large. The place where the solar radiation is locally small corresponded to clouds observed by sky camera. The estimation provided in this study is promising for monitoring of spatial and temporal variation of short wave radiation.

Keywords: solar radiation, solar panel, local climate

