SHORT TIME AND SPACE VARIATIONS OF SOLAR IRRADIANCE UNDER CLOUDS

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Time fluctuation of solar irradiance or its space variation cause of reduction of the efficiency of photovoltaic (PV) systems. These instability or non-uniformity are mainly caused by cloud distribution and their moving. In the middle latitude area including Japanese islands, horizontal movement is the dominant in the atmosphere. Therefore clouds' travelling is important for solar irradiance fluctuation in time and space in Japan. The short period fluctuation of the irradiance is frequently discussed. However, discussions about space variation of the irradiance is poor. In this study, two dimensional solar irradiance distribution is observed in the field and discuss short time and space variations of the irradiance for some typical events caused by clouds' moving.

Twelve PV module sensors (PVMSs) introduced in our University for this study are shown in Fig. 1. Six PVMSs are located from West (No.1) to East (No.6), and the others are from South (No.1) to North (No.6). Distance between neighboring sensors is 1.145 m. The sampling speed of solar irradiance is 10 ms. The sky camera has the shadow-blade for avoiding the direct solar irradiance into the lens. The observation started from March 2016, and continues more than one year.

We pick up the event around 12:28:10 in April 12, 2016 and others. Solar irradiance time series observed by West-East PVMSs in daily and short period around the event is shown in Fig. 2. The corresponding clouds' images are shown in Fig. 3. In this figure, the sun locates behind the shadow-blade. Difference of the instantaneous irradiance observed by each PVMSs in Fig. 2 indicate the space distributions of the irradiance. Moreover, in Fig. 2, each sensors follow to the fluctuation of the irradiance of No.6 with the same pattern. It means that clouds traveled from upstream (East, No.6) to downstream (West, No.1), and the PVMSs measure the travelling shadows of the clouds running are them from East to West. Figure 4 shows the solar irradiance distributions in space in each time around the target time, 12:28:10 in April 12, 2016. The reference of the irradiance is PVMS No. 1 in the figure. From this figure, the maximum difference in the irradiance between the sensors No. 1 and 6 is about 130 W/m² and it corresponds to 1.8 %/m in non-uniformity of the irradiance.

Similar characteristics can be found in the time series solar irradiance observed by PVMSs in the South-North line. from these analysis the clouds was moving over the target point and their shadow running on the PVMSs with 12.1 m/s in speed toward to north-northwest.