Characteristics and Corrections of Thermal Offset for Secondary Standard Pyranometers

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Abstract

Accurate measurement of solar radiation arriving at the Earth's surface is an important information not only to the climate researches but also to the solar power systems. A pyranometer is a major instrument used for measuring solar radiation on a plane surface. To ensure the measuring accuracy, regular calibration of pyranometers and identification of the main errors are necessary. For pyranometers, the thermal offset error is one of the main errors which is due to the temperature difference between the detector and the domes, and it usually results in the overestimation of the measurements. In order to investigate the characteristic of thermal offset for different pyranometers and the performance of different correction methods, we collected 20 pyranometers and carried out an inter-comparison experiment at NCU in cooperation with NOAA and pyranometer manufactures from December 2017 to March 2018.

All the participating pyranometers were calibrated with indoor and outdoor ISO calibration procedures to ensure the sensitivities are traceable to reference values. The sensitivities from outdoor calibration were chosen because their lower expanded uncertainty (1.28%) and lower percentage change in sensitivity (-0.34%) compared to the values of 2.33% and 0.75% for indoor calibration. Two thermal offset correction methods (i.e., detector only and full correction method) were applied to daytime irradiance during the experimental period, and the values after correction were compared to the reference units provided by NOAA.

Our results show that the three modern pyranometer models (MS-80, SR25-T2, and SR30-D1), which had been designed for improving the thermal offset error, have the magnitudes of nighttime thermal offset (0.01Wm-2) much lower than that of the other pyranometers (-2.08-0.44 Wm-2). For the pyranometers which were designed without considering the thermal offset error, the correction for the error is necessary. According to the assessment, the full correction method is suitable for more than half the pyranometers such as CMP11, CMP21, CMP22, MS-80, and ventilated SR-75, SPP, and PSP (average correction improvement: 0.17-1.66 Wm-2); however, the better method for unventilated SR20-D2 and PSP, and ventilated SR30-D1 is the detector only correction (average correction improvement: 0.10-1.04 Wm-2). Furthermore, although the thermal offset correction was applied, the daytime data still show overestimation for most of the pyranometers at small solar zenith angle. We suggest that the dome and ambient temperatures may play an important role in this measurement error of pyranometers. In contrast, at large solar zenith angle, the high percent deviation from the reference is due to the cosine response of the pyranometer sensor.

Finally, except for the pyranometer model SR-75 and SR20, other models show that the mean values of the magnitudes of thermal offset are smaller when the ventilators were installed, which indicates the importance of ventilation to pyranometers. The results of the experiment show that the pyranometer measurements are affected by the choice of pyranometers, the on/off of the ventilation, and the usage of the thermal offset correction method.

Key word: pyranometer, thermal offset