ARM RACORO Data Produces New Radiometer Tilt Correction Method

Research Highlight

The downwelling shortwave irradiance typically consists of both a direct component of radiation from the sun and a diffuse component of scattered sunlight from the sky. Significant offsets can occur in downwelling shortwave irradiance measurements made from moving platforms due to the tilt of the instruments from horizontal, which changes the angular orientation of the direct component of sunlight to the instrument and causes an artificial variation in the measured signal.

To properly correct for this tilt, a priori knowledge of the partitioning between the direct and diffuse components of the total shortwave irradiance is needed to properly apply a correction for tilt. This partitioning information can be adequately provided using a newly available commercial radiometer named the SPN1 that produces reasonable measurements of the total and diffuse shortwave irradiance (and by subtraction the direct shortwave irradiance) with no moving parts and regardless of azimuthal orientation. Using data from the recent RACORO campaign, we have developed methodologies for determining the constant pitch and roll offsets of the radiometers for aircraft applications and for applying a tilt correction to the total shortwave irradiance data. Results suggest that the methodology is accurate for tilt up to +/-10°, with 90% of the data corrected to within 10 Wm-2 at least for clear-sky data (Fig. 1). Without a proper tilt correction, even data limited to 5° of tilt can still exhibit large errors, greater than 100 Wm-2 in some cases (Fig. 2). Given the low cost, low weight, and low power consumption of the SPN1 total and diffuse radiometer, opportunities previously excluded for moving platform measurements such as small unmanned aerial vehicles and solar-powered buoys now become feasible using our methodology.

For situations on moving platforms such as aircraft, buoys, and ships where an active stabilization platform is not feasible, a new method has been developed to correct downwelling shortwave measurements for tilt from horizontal. This method employs a newly available radiometer that is relatively lightweight and low-power. The method has been shown to be accurate to within 10 Wm-2 at least for the clear-sky case where the tilt effect is maximum. The increase in measurement accuracy is important, given current concerns over long-term climate variability and change, especially over the 70% of the Earth's surface covered by ocean where long-term records of these measurements are sorely needed and must be made on ships and buoys.

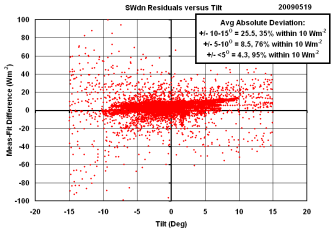

Figure 1: Residuals of tilt corrected minus clear-sky fit versus tilt for the May 19 RACORO flight showing the tilt correction works well for up to 10° of tilt.

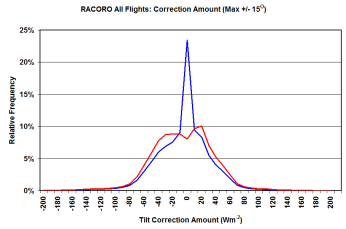

Figure 2: Frequency of occurrence of the tilt correction amount applied to the raw measured CM-22 data during the RACORO campaign including all data (blue) and times when at least 500 Wm-2 of direct normal SW was present (red).

Reference(s)

Long CN, A Bucholtz, H Jonsson, B Schmid, A Vogelmann, and J Wood. 2010. "A Method of Correcting for Tilt from Horizontal in Downwelling Shortwave Irradiance Measurements on Moving Platforms." The Open Atmospheric Science Journal, 4, 10.2174/1874282301004010078.

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Radiative Processes