A method for simultaneous broadband solar radiation calibration and aerosol optical depth retrieval

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Abstract

A new method is presented to calibrate pyrheliometer and pyranometer data using in-site measurements of Direct Solar Radiation (DSR) and Global Solar Radiation (GSR). A key point in the method is directly using World Radiation Reference (WRR, 1367.07w/m^2) as calibration standard, and it can be used to estimate and correct historical radiation records. Another key technique is simultaneous pyranometer calibration and aerosol optical depth (AOD) retrieval, based on the weak sensitivity of total atmospheric-surface transmittance to AOD, aerosol refractive index, and surface albedo in the case of the smaller AOD and larger solar zenith angle cosine (μ_0). There are three steps in this technique. The first step is to retrieve 750nm AOD from a ratio of horizontal-direct solar radiation to GSR by using Broadband Extinction Method (BEM) developed by Qiu (1998; 2001; 2003). Then, using the AOD retrieval, the total atmospheric-surface transmittance is calculated, and a ratio of ground-based pyranometer measurement with the transmittance is regarded as instrument coefficient. The GSR calibration is completed through a transforming value of equaling WRR divided by the coefficient. An iterative algorithm is demanded in these two steps. The third step is to calibrate the DSR measurement using the above AOD retrieval. It is emphasized that only these GSR/DSR data, made in cloudless and clear (as possible as smaller AOD) days, are available in calibrations. This method is validated through numerical simulations, comparisons between the present AOD retrievals and SIMEL sunphotometer AOD measurements, and some applications.

There are such two sets of numerical simulations as: (1) pyranometer calibration simulation; (2) simultaneous pyranometer calibration and AOD retrieval. As shown in the first simulations, the GSR calibration uncertainty is better than 4% under the condition of AOD<0.2, $\mu_0 \geq 0.5$, ±10%、±0.005 and ±0.02 uncertainties in column water vapor, imaginary part of aerosol refractive index and AOD, If AOD<0.1 and $\mu_0 \geq 0.8$, much better calibration

accuracy can be obtained. The second simulations will be presented.

The AOD uncertainty by BEM mainly depends on pyrheliometer data accuracy. If there is a 1% error in pyrheliometer measurement or calibration, there is about 0.01 uncertainty in AOD retrieval if $\mu_0 \approx 1.0$. Based on this point, AOD comparisons are carried out for validations. The BEM AOD retrievals from pyrheliometer data at Beijing's meteorological observatory during 2001-2007 are compared with AERONET AOD products at Beijing site. There are total 5199 sets of hourly-mean 670nm AOD comparisons. The mean CIMEL sunphotometer AOD equals 0.3314. The mean BEM AOD, retrieved from the original (no corrected) pyrheliometer data, is 0.3607, being 0.0293 larger than the CIMEL AOD. If the present calibration method is used in correcting pyrheliometer data, the mean BEM AOD is 0.323, having only a 0.0084 difference with the CIMEL AOD.

Furthermore, some applications are presented. The present method is used in estimating accuracies of GSR and DSR data at some meteorological observatories in China. It is estimated that more 90% GSR data made in Beijing, Wulumqi and Geermu during 1960-2004 are within ±10% uncertainty. The further estimation study of GSR and DSR data will be made and presented. Another application is to correct DSR data and then retrieve AOD from them, yielding trendily smaller (compared with no corrected case) AOD retrievals at three sites of Beijing, Geermu and Urumqi in China during 1960-2004.

References

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