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Is the MLB parameterization accurate enough to describe change in solar radiation with solar zenith angle?

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A new direct method, Heliosat-4, is currently being developed by the MINES ParisTech and the German Aerospace Center (DLR), aiming at estimating surface downwelling solar irradiance (SSI). This method is composed of two parts: a clear-sky module and a cloud-ground module (Oumbe et al. 2009). The clear-sky model is based on the radiative transfer model (RTM) libRadtran fed with advanced products on atmosphere optical parameters derived from recent Earth Observation missions. However, running a RTM in an operational mode is computer resources and time consuming. Therefore, it will be very beneficial to use parameterization to reduce the number of runs of RTM.

Several parameterizations have been proposed in recent years, for example, the parameterization with water vapour density (Muller et al. 2009), with altitude (Gueymard, Thevenard 2009; Oumbe et al. 2009) and with sun zenith angle by using Modified Lambert-Beer function (MLB) (Muller et al. 2004, 2009). Qu et al. (2010) studied the MLB parameterization for beam and global irradiance. They proposed a 4-interval piecewise MLB which demonstrates better performances than the initial version based on a single interval of solar zenith angle. This piecewise MLB outperforms the current linear interpolation techniques. However, it is interesting to know whether the accuracy of this 4-piecewise MLB applied to global irradiance complies with standard performances expected for high quality pyranometers or for RTM. In order to assess it, we focused on two quality criteria: the systematic error (bias) and the percentile P95 of the absolute error. According to WMO standard for the measurement of radiation (WMO, 2008), the P95 should be less than 10 W/m2 (high quality). Myers et al. (2002) and Geuder et al. (2003) have compared different pyranometers. They wrote that as a whole a bias of 15 W/m2 is acceptable. Gueymard (2007) have compared results between different RTMs and estimated that a bias of 3 W/m2 is a proof of very high consistency between them. Therefore, we evaluated the performance of the 4-piecewise MLB by using two criteria: bias < 3 W/m2 and P95 < 10 W/m2.

We observed that the 4-piecewise MLB does not satisfy the criteria of P95 when the ground albedo is greater than 0.1. Therefore, we propose a 5-piecewise MLB in adding another fitting angle at 40. We observe that this 5-piecewise MLB demonstrates satisfactory performance and could be used accurately in the Heliosat-4 method to reduce the number of runs of the RTM.

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