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Cloudy-sky shortwave radiative closure study for the Cabauw BSRN site

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A radiative closure study is an important tool to evaluate the accuracy of atmospheric retrievals (e.g. cloud and aerosol properties) and measurement techniques. Radiative transfer models can also be validated through a closure study using well-defined cases and high quality measurements. Especially cloudy atmospheres are a challenge for measurements and modelling. Therefore, a shortwave radiative closure analysis for cloudy skies is presented for the Cabauw Baseline Surface Radiation Network (BSRN) site (51.97˚N, 4.93˚E). The cloudy cases are carefully selected to be overcast, single-layer, homogeneous, non-precipitating water clouds. We selected in total 639 cases on 9 days between May 2008 and May 2009 and on 30 January 2007. The Doubling-Adding KNMI (DAK) code is used to simulate global irradiances. The cloud optical thickness is derived from the cloud liquid water path from microwave radiometer (MWR) measurements and the MODIS L2 cloud effective radius product. The scattering phase matrix of the cloud particles is calculated using a Mie code with the two-parameter Gamma size distribution. MWR integrated water vapor column, and aerosol climatology are also used in the simulations. The cloudy cases cover a large range of liquid water path (30-400 g/m^2), water vapor column (0.7-3.1 cm) and solar zenith angle (41-75˚).

The mean difference between simulated global irradiances and BSRN measurements is 6 W/m^2 (5%), with a standard deviation of 14 W/m^2 (13%). This difference is within the uncertainties of the model input parameters and measurement errors. The correlation coefficient between the measured and simulated global irradiances is 0.95. The effects of clouds, aerosols, water vapor and surface albedo on the global irradiance have been analyzed carefully. In cloudy cases, the surface albedo has a larger effect on the global irradiances at the surface than in clear-sky cases. In-situ aerosol measurements or lidar measurements are of importance for the cloudy closure study because of missing aerosol retrievals from AERONET sun photometer. The cloudy closure could be further improved by using aerosol and surface albedo measurements instead of the climatologies.