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Improvement of radiation modelling during cloudy sky days using in-situ and satellite measurements.

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Solar radiation modelling is important for the evaluation and deployment of solar renewable energy systems. The amount of solar radiation reaching the ground is influenced by geographical parameters (seasons, latitude and local characteristics of the site) and meteorological and atmospheric parameters (like humidity, clouds or particles). Those parameters have important spatio-temporal variations that make solar radiation hard to model.

Various radiation models exist in literature. Among them, the 1D radiation model part of the computational fluid dynamics software "Code_Saturne" estimates the global and direct solar irradiances at the ground. It takes into account the impact of meteorology, atmospheric gas, particles and clouds whose influence is represented using the two-stream approximation.

The model showed satisfactory results during clear-sky days but not during cloudy-sky days. It is a common problem in solar radiation modelling, because of the complexity to accurately represent clouds, which are extremely variable in space and time and have a strong influence on the depletion of solar irradiance.

In the current study, the estimation of radiation during cloudy-sky days is improved by coupling the 1D radiation model of Code_Saturne with on-site and satellite measurements of the cloud optical properties. Meteorological data are obtained from the Weather Research and Forecasting (WRF) model, aerosol's concentrations from the air-quality modelling platform Polyphemus, and on-site measurements from the SIRTA observational site (close to Paris). Two periods are simulated: 'august 2009' and 'year 2014'. It is shown that the introduction of the measured cloud properties in the computation of the surface radiation fluxes leads to a strong reduction of the simulated errors, compared to the case where these properties are derived from the WRF model.

A sensitivity analysis on the parameters representing clouds in the model is conducted. It enabled us to identify the most influencing parameters - cloud optical thickness (COD) and cloud fraction - and instruments that are sufficient and mandatory for a good description of solar radiation during cloudy-sky days. A fitted model is developed to deduce the COD from liquid water path measurements. Satellite and radiometric measurements could both be used, although satellite measurements are not always available. For the estimation of cloud fraction, the best results are obtained from shortwave radiometric measurements or from a sky imager. Moreover, large error cases in hourly values of solar fluxes are examined to understand their origin. For a large part of these error cases, there is a high variation within the hour of satellite or in situ measurements, or the presence of low clouds (in more than 50% of these cases in august 2009).