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Ship and satellite observations over the ocean for verification of the shortwave cloud radiative effect in climate models

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In this study the accuracy of the radiative transfer scheme of the ECHAM-5 climate model for reproducing the shortwave cloud radiative effect (SWCRE) at the sea surface has been investigated. A characterization of both the observed state of the atmosphere and the surface radiation budget from ship and satellite is used for this purpose. The ship observations yield cloud fraction, liquid water path from a microwave radiometer, cloud bottom height as well as temperature and humidity profiles from radiosonde ascents. Level-2 products of the Satellite Application Facility on Climate Monitoring (CM-SAF) from the Spinning Enhanced Visible and InfraRed Imager (SEVIRI) have been used to characterize clouds. An initial sensitivity study has been performed to highlight and to quantify the uncertainties introduced by estimating the effective radius and the cloud fraction for the calculation of radiative fluxes. For the effective radius we have found a strong dependency on the assumed vertical cloud extent and cloud droplet number concentration. The cloud fraction determined from total sky imager data shows an increase with an increasing field of view in particular for broken cloud fields. Within a closure study we have defined six different experiments to find the optimal set of measurements to model downward shortwave radiation (DSR) and the SWCRE from the model under seven different synoptic situation. Four of these experiments are defined to investigate the advantage of using the satellite-based cloud droplet effective radius as additional cloud property. In comparison to the radiation measurements we find that estimates based on satellite data have a comparable accuracy to those based on ship data for modeling the SWCRE. For several cases, an improvement through introducing the satellite-based estimate of effective radius as additional information to the ship based data was found. Due to their different measuring characteristics, however, each dataset shows best results for different atmospheric conditions.