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Cloud radiative budget and cloud radiative effect over the Atlantic from ship based observations

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The aim of this study is to determine cloud-type resolved cloud radiative budgets and cloud radiative effects from surface measurement of broadband radiative fluxes over the Atlantic Ocean. Furthermore, based on simultaneous observations of the state of the cloudy atmosphere a radiative closure study has been performed by means of the ECHAM5 single column model in order to identify the models ability to realistically reproduce the effects of clouds on the climate system.
An extensive data base of radiative and atmospheric measurements has been established along five meridional cruises of the German research icebreaker POLARSTERN. Besides pyranometer and pyrgeometer for downwelling broadband solar and thermal radiative fluxes a sky imager and a microwave radiometer has been utilized to determine cloud fraction and cloud type on the one hand and temperature and humidity profiles as well as liquid water path for warm non-precipitating clouds on the other hand.
Averaged over all cruise tracks we obtain a net (solar + thermal) surface budget of $144\,W/m^2$ that is dominated by the solar component. In general, the solar contribution is large for cirrus clouds and small for stratus clouds. No significant meridional dependencies were found for the surface radiation budgets and cloud effects. The strongest surface longwave cloud effects were shown in the presence of low level clouds. Clouds with a high optical density induce strong negative solar radiative effects under high solar altitudes. The mean surface net cloud radiative effect is $-34\,W/m^2$.
For the purpose of quickly estimating the mean surface longwave, shortwave and net cloud effects in moderate, subtropical and tropical climate regimes a new parameterization was created, considering the total cloud amount and the solar zenith angle.
The ECHAM5 single column model provides a surface net cloud effect that is more cooling by $16\,W/m^2$ compared to the radiation observations. This overestimation in solar cooling is mostly caused by the shortwave impact of convective clouds. The latter show a large overestimation in solar cooling of up to $112\,W/m^2$. Mean cloud radiative effects of cirrus and stratus clouds were simulated close to the observations.