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Addressing radiation and cloud uncertainties with the new radiation scheme ecRad in ICON

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Radiation in the atmosphere provides the energy that drives atmospheric dynamics and physics on all scales, so determining radiative balance correctly is crucial for understanding processes ranging from cloud particle growth to climate. Radiation schemes in global weather and climate models make assumptions to simplify the complex interaction of radiation with the Earth system, such as treating radiative transfer in only the vertical dimension. Capturing cloud-radiation interactions is particularly challenging since clouds vary strongly on small spatial and temporal scales not resolved in the models, and also interact strongly with radiation. In models, sub-grid atmospheric variables are simplified, describing three-dimensional cloud geometry, cloud particle size and shape and complex scattering functions with a few parameters. Uncertainties in these assumptions contribute to the large lingering uncertainty in the climatic role of clouds.

The new modular radiation scheme ecRad provides the opportunity to vary these parametrisations and assumptions individually to determine their impact. Several options are available for the radiation solver, cloud vertical overlap and horizontal inhomogeneity treatment and cloud ice and water optical property parametrisations. The solver SPARTACUS is the only radiation solver in a global model that can treat 3D radiative effects.

We use ecRad as the new operational radiation scheme in the DWD global model ICON to investigate the sensitivity of radiation results to radiation model assumptions and input variables such as cloud particle size and cloud geometry, as well as the varying role of cloud-radiation interactions in regional cloud regimes. We find that ecRad with an up-to date solar spectrum agrees much better with exact line-by-line radiation calculations than previous radiation models. In ICON, ecRad improves the global radiation balance, model physics and forecast performance.