Project: 1555
Project title: C3sar - Cloud 3D Structure and Radiation
Principal investigator: Vera Schemann
Allocation period: 2026-01-01 to 2026-10-31

Report

High-frequency radiation fluctuations

Approximately 1,000 node-hours were used for the various simulations during the project period. 250 hours were spent on multiple iterations of the ICON simulation, which were necessary to adjust the parameterizations for better agreement with the observational data. 150 hours were used for the development of two related workflows: the conversion of ICON output into libRadtran cloud and atmospheric files, as well as the development of tools for automating and parallelizing radiation transfer with libRadtran based on SLURM and GNU Parallel. 600 hours were spent on radiation transfer calculations, primarily for 200x200 surface irradiance maps for 5 different observation days of the observational campaign, as well as 1-minute surface irradiance data for 45 station equivalent to the PYRNET observations for the same days.

The figure 1 shows a comparison between the observed and simulated power density spectra for 45 surface irradiance time series under broken clouds on the 17th of July 2026. Compared to the 1D simulation the 3D radiative transfer captures the variability for frequencies up $\frac{3}{1000}$ Hz. Smaller scale variability cannot be captured with a horizontal resolution of 250m. These simulations help assess which findings from model-based sensitivity studies can be applied to observations. The results are also used to link the occurrence of surface enhancement - surface irradiance above an equivalent clear-sky simulation - to macro- and microphysical cloud properties.

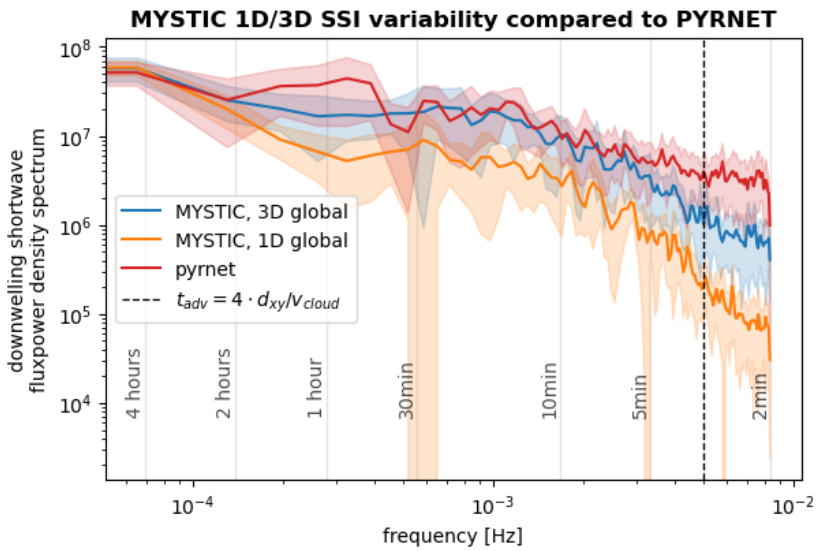


Figure 1: Power density spectra of observed surface irradiance for 45 station of the pyrnet instrument compared to equivalent simulations using ICON based clouds for 1D and 3D radiative transfer. The figures shows results for single layer low cumulus regime on 17th of July 2026.

Campaign simulations

To accompany the campaign, selected cases have been simulated to be compared with the campaign measurements. A special scientific focus of the simulations has been on the 3D reconstruction of clouds and to test this in the virtual model world. Many algorithms for 3D reconstruction use the assumption of frozen turbulence and forward column observations in space. In this project part, the ICON simulations have been used to test this for specific cases and situations in the virtual realization by a model. The results can be used to improve and evaluate the algorithms applied on observational datasets.

Furthermore, the simulations made within this compute proposals are at the moment used in many different parts of the whole research unit - e.g. as a baseline for further radiation calculations. A campaign paper is currently under preparation and will show more details about the use of the model simulations for the campaign.