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A new algorithm for the downscaling of 3-dimensional cloud fields

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Cloud fields from dynamical models often have resolutions that are insufficient for exact 3-dimensional radiative transfer calculations. To solve this problem, we have developed a downscaling algorithm that produces higher resolution fields, while preserving the original coarse resolution fields of the mean liquid water content and cloud fraction. In our current algorithm, the power spectrum of the coarse field is extrapolated to small scales by fitting a power law, but the algorithm is able to handle any extrapolation function. The algorithm is similar to the Iterative Amplitude Adjusted Fourier Transform (IAAFT) algorithm used to generate surrogate fields and iteratively adjusts the spectrum and the coarse fields consecutively. In this way, the method takes the spatial correlations on small scales into account, which is paramount for radiative transfer applications, and does more than just adding noise to the coarse field.

We test the algorithm by starting with two sets of high-resolution clouds from large eddy simulations (LES): one set with sparse cumulus and one with stratocumulus clouds. From these clouds we calculate coarse fields with the mean LWC and cloud fractions, which are then used as input for the downscaling algorithm. In this way, we could compare the radiative properties of the downscaled surrogates with their original high-resolution clouds. The results show that the radiative properties of the surrogates are very similar to those of the original 3D clouds and that most of the bias error of the coarse clouds is removed. Both the downscaling algorithm itself, as well as the extrapolation of the power spectrum, contribute to the error.

A statistical analysis of the errors and further calculations for a new set of broken stratocumulus is ongoing.