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Designing more efficient and accurate parameterisation schemes utilising spatial and temporal correlations - two example radiative transfer parameterisations for limited area models

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The results of two adaptive radiative transfer parameterisations for the numerical weather prediction (NWP) Model, Lokal-Modell (LM), will be presented. We introduce the term "adaptive parameterisation scheme", for a scheme, which uses spatial and temporal correlations in geophysical fields to make the parameterisations computationally more efficient and thus to be able to include more physics in the parameterisations. The current LM radiation scheme is computationally expensive and thus only called once an hour. This leads to inaccuracies and physical inconsistencies. In an adaptive parameterisation scheme, the computation is split into a more complex, intrinsic calculation and a simple, adaptive generalisation algorithm. We propose to make an intrinsic calculation at a fraction of the time steps or only in a part of the grid boxes or columns to reduce the total computational cost. To generalise the results to the full domain, an adaptive generalisation method is used that utilises the results of nearby (in time and space) intrinsic calculations. As intrinsic calculation for our two adaptive schemes, we use a δ-two-stream radiative transfer parameterisation. The first adaptive scheme comprises an adaptive selection mechanism and a so-called perturbation method. These two components are based on a simple radiation scheme realised by a multivariate linear regression algorithm adapted to the δ-two-stream radiation scheme. For grid points where the regression algorithm predicts large changes, an intrinsic calculation is performed. For the other grid points an increment computed with the regression algorithm is added to the radiation fluxes, in order to account for small changes in the atmospheric column. When compared to radiation fluxes resulting from the hourly update, the hourly mean of root mean square errors (RMSE) generated by the adaptive scheme is reduced by more than 30% in the shortwave regime and by 20% to 55% in the longwave regime (frequent radiation calculations were performed as reference). Largest improvements are achieved for convective summer days, when the persistence assumption of the operational parameterisation performs worst. For one exemplary stratiform winter day still a significant reduction of hourly mean RMSE is achieved. The second scheme uses the spatial and temporal correlations in the field. The adaptive generalisation utilises the result of a similar nearby column. The similarity is based on the cloud cover, liquid water path, albedo, and the elapsed time since the intrinsic calculation was called. A version of the scheme that is equally computationally expensive as the operational scheme has a shortwave RMSE in a convective case study of only 31 Wm^{-2}, compared to 77 Wm^{-2} for the operational scheme. Another version which requires 3 times less δ-two-stream calculations, has a shortwave RMSE of 34 Wm^{-2}. We hope that similar efficient adaptive schemes are possible for parameterisation of other processes.