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Two adaptive schemes for radiative transfer parameterisations in NWP models

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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. As an illustration of this general idea, we will present two adaptive radiative transfer parameterisation schemes for numerical weather prediction (NWP) models. In an adaptive parameterisation scheme, the computation is split into a more complex, physical calculation and a simple, adaptive algorithm.

We propose to make a physical calculation at a fraction of the time steps or only in a part of the grid boxes or columns. Due to the reduced number of calls to the physical calculation, its total computational cost goes down. As a consequence the physical calculation can be made more complex and physical. To generalise the results to the full domain, an adaptive generalisation method is used that utilises the results of nearby physical calculations.

As physical calculation for our two adaptive schemes, we use the 2-stream radiative transfer parameterisation used operationally in the Lokal-Modell (LM) of the German meteorological service (DWD). This computationally expensive scheme with a considerable number of spectral bands takes into account the profiles of liquid and ice water content, the cloud cover profile, gases and aerosols and surface albedo. Because of its complexity, this scheme is only run once an hour and most other weather services have chosen a simpler scheme that can be computed more often.

In the first adaptive parameterisation scheme the physical calculation is made for the full domain at the beginning. A computationally inexpensive regression algorithm is used to estimate the deviations of the radiative fluxes at the surface from the initial

calculation. If they are acceptably small, these fluxes are updated by adding these estimated deviations, otherwise physical calculations are performed. In essence, the complex 2-stream radiative transfer scheme is only utilized if necessary, e.g. due to large changes in cloud conditions.

The second scheme uses the spatial and temporal correlations in the field. The adaptive generalisation calculates an index value for every column based on its cloud cover, liquid water path and ice water path. It then "searches" in the database of previous physical calculations for a nearby column that has the most similar index value, and uses this column to predict the radiative fluxes.

In our first version of the latter algorithm, we reconstructed the solar flux at the surface at 15 LST, from the solar flux at 14 LST and the respective cloud fields. The generalisation was able to reconstruct the solar (infrared) flux at 15 LST with an RMS error of 51 (14) W m^{-2}, whereas the solar (infrared) flux at 14 LST was different by 163 (23) W m^{-2}. The error field of the generalisation is also much less correlated, and thus likely dynamically of minor disruptive influence.

Thus, we have achieved an error reduction of a factor 3 compared to the operational practice of assuming time constant fluxes for one hour. More importantly, from the view point of the users of other models with simpler radiative transfer schemes that are run more often, we now have a scheme that is more physical, but can be run almost as often.