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Introducing convection into the 4D-Var linear model

O. Stiller and Sue Ballard

Met Office (JCMM), University of Reading, Reading, UK, Olaf.Stiller@metoffice.gov.uk, Tel:+44 118 378 6524

At the centre of an incremental 4D-Var system is a linear atmospheric model whose match with the full nonlinear NWP model is essential for the quality of the forecast. While the linearisation of a dry adiabatic model is to some extent straightforward, moist processes are usually strongly nonlinear. Particularly convection parametrisations are notorious for their unsteady behaviour which in combination with their nonlocal nature makes their direct linearisation very problematic and prone to large errors and even instabilities.

A newly developed linear convection parametrisation is presented which shows a clear benefit for temperature and moisture as well as the dynamical fields of the linear model. Using several fields from the full nonlinear convection parametrisation as an input, the breakthrough in this work came through a statistical (time averaged) treatment which largely smooths the unsteady nature of these nonlinear input fields. The convective mass flux as the key input field is preprocessed by splitting it first into different components (related to different physical mechanisms) and then time-averaging each component separately. The information contained in the resulting mass flux components is then used to estimate the nonlinear scheme's response when perturbed by the data assimilation increments.

So far the linear parametrisation considers only two of the leading terms from the nonlinear scheme. The first, which describes the impact of the linearisation state mass flux on the assimilation increments, has a positive impact on the moisture field only (this is basically the term which was considered in the first parametrisation that was operational at ECMWF until last summer). The benefit for the dynamical fields is entirely due to the second term which is related to perturbations of the CAPE closure.