Physical parameterisations for a high resolution operational numerical weather prediction model

Luc Gerard, Institut Royam Météorologique de Belgique
luc.gerard++at++oma.be

Summary

In a first part, we provide an up-to-date description of the whole set of physical parameterisations used in the operational Aladin model (this part is also published separately as the documentation of Aladin Physics, available on the web site).

We focus then on the present parameterisation of deep convection. Our personal contribution to this concerned the entrainment of horizontal momentum into the convective cloud. We then discuss the main weak points and the hypotheses of the scheme that would need revisiting in order to reduce the mesh sizes, and propose paths to new developments.

We assess more deeply two proposals emerged from this discussion: using prognostic variables for convective activity, and introducing a distinction between the properties of the air at the immediate cloud vicinity (``environment", which is the air entrained into the cloud) and the value of the resolved model fields.

This leads to the development of a prognostic scheme for the up- and downdraught vertical velocities and active mesh fractions. Such a scheme should still be complemented by a prognostic parameterisation of the suspended condensate (still in development by others) and a few other enhancements that we propose.

The implementation of the prognostic scheme includes the advection by the resolved wind of the 4 new prognostic variables, performed in grid point only. Further tests confirmed that no coupling was necessary for such prognostic internal variables.

A first set of tunings of the scheme was performed in Single Column Model. This showed for instance that shortening the time step (similar to reducing the mesh size in a 3D model) induces a progressive extinction of the prognostic scheme, while the diagnostic scheme proceeds by abrupt cuts (following the feedback of the resolved precipitation) of its activity.

Validation and behaviour tests were performed in Local Area Model (ALADIN) at two different resolutions and in Global Circulation Model (ARPEGE) at four different truncations.

Behaviour tests yielded a spin-up time of about half an hour, consistent with observations of convective systems. The convergence of the prognostic scheme with the diagnostic scheme for very large time steps was tested by lengthening artificially the physical time step in the convection routine, for both schemes. We observed a good convergence when multiplying the time step by 30, which alerted us that the convergence of the results was not be expected with the present truncations used in the GCM. The tests in GCM at different truncations showed indeed always different behaviours with the diagnostic and the prognostic scheme.

The more progressive start of the prognostic scheme leads to a slower development of the convective activity than with the diagnostic scheme. To compensate this, it helped reducing the entrainment coefficients (which modulate the cloud activity), but we think a wider re-tuning would be welcome.

The impact of the new scheme on the global budgets has also been approached. Zonal diagnostics suggest a possible enhancement by the prognostic approach, of the temperature and water vapour mean tendencies; but more systematic tests should be done after a complete tuning.

The experiments brought new insights in the behaviour of the convective scheme and on the problem of merging contributions from the subgrid deep convection scheme and the resolved precipitation scheme. The use of meshes thinner than 5 km requires to leave the hydrostatic approximation in the large scale equations, and we envisage potential refinements of the parameterisation in this case.