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# Large effects of the model timestep on simulated explicit convection – the impact, cause and solution

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In this presentation we show that there is a large and important sensitivity to the model timestep for convection-permitting simulations. This sensitivity likely affects the skill and predictability of convective events. We have identified that the cause is the numerical and practical implementation of the dynamics and physics in our model – which is typical of NWP models - and in particular affects the cloud microphysics parameterization. We have found a solution that removes almost all of the sensitivity to the timestep and requires only simple changes to the model code. The impact of this problem will be shown, the physical and numerical cause will be explained, and a solution will be presented.

Impact - The sensitivity to the timestep affects how much precipitation is produced, and where it falls. It can also affect the vertical distribution of hydrometeors and the sensitivity of the cloud system to perturbations (e.g. by aerosol). The problems are larger when the timestep is longer – therefore convective-scale NWP is most affected.

Cause – The sensitivity arises because of the numerical implementation of processes in the model, specifically the so-called “splitting” of the dynamics (e.g. advection and diffusion) and the parameterized physics (e.g. microphysics scheme). Using Operator Splitting - where the dynamics is calculated first, after which the prognostic variables are updated, and then the microphysics is calculated using the updated variables – has a significant timestep dependence.

Solution - Using Additive Splitting – where the dynamics and microphysics tendencies are both calculated using the same input, the tendencies added together, and then the prognostic variables updated – removes almost all of the timestep dependence.

The potential issues with Operator Splitting are easily demonstrated in a very simple model, where the convergence value depends on the chosen model timestep. The advantages of using Additive Splitting are seen in this model, and the benefits of using it in an NWP model are also shown.

The findings of this study suggest that most models could be affected by similar timestep dependencies, which could be affecting everything from process studies of clouds and precipitation at LES scales to operational numerical weather prediction and even climate simulations. An urgent assessment of the scale of this problem in all models is required.