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Accelerating climate- and weather-forecasts with faster multigrid solvers

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Successful operational weather forecasting with (semi-)implicit timestepping methods relies on obtaining an accurate solution to a very large system of equations in a timely manner. It is therefore crucial that the solver algorithm is fast and efficient, as this can account for up to a third of model runtime.

For models based on mixed finite element discretisations, the standard Schur-complement solver approach is not feasible since the Schur-complement system is dense and cannot be solved with iterative methods. To address this issue in its next-generation forecast model - codenamed LFRic - the Met Office is investigating a so called “hybridised” solver algorithm, which shows its full potential when combined with multigrid techniques.
We introduce both the hybridised discretisation and multigrid techniques on simplified problems, comparing and contrasting these with the current, non-hybridised multigrid solver algorithm used in the Met Office model. We will talk about how this is generalised to the full model and present results from this comparing several solver configurations.
Since our new hybridised multigrid solver reduces the number of global reduction operations, it is particularly promising when solving very large problems on a massively parallel computer. To explore this, we ran our code on large numbers of compute cores, and will present the results of those runs here.
The efficiency of our non-nested multigrid approach depends on the choice of the coarse level finite element space. To further improve the solver algorithm, we compare different coarse level spaces for a simplified setup in the Firedrake finite element code generation framework.