ESCAPE 2: Energy-efficient SCalable Algorithms for weather and climate Prediction at Exascale

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In the simulation of complex multi-scale flow problems, such as those arising in weather and climate modelling, one of the biggest challenges is to satisfy operational requirements in terms of time-to-solution and available energy without compromising the accuracy and stability of the solution. These competing factors require extreme computational capabilities in conjunction with state-of-the-art algorithms that can optimally suit the targeted underlying hardware while improving the convergence to the desired solution.

The European Centre for Medium Range Weather Forecasts (ECMWF) is leading the ESCAPE project funded by Horizon 2020 under initiative Future and Emerging Technologies in High Performance Computing. The first ESCAPE project finished in September 2018 and the second ESCAPE project has now started. The ESCAPE projects include the development of new algorithms that are specifically designed for better energy efficiency and improved portability through domain specific languages. Both projects incorporate through ECMWF’s project partners the expertise of leading European regional forecasting consortia, university research, experienced high-performance centres and hardware vendors.

This talk gives an overview of results obtained in ESCAPE 1 and future plans for ESCAPE 2. The participating models IFS, ALARO, COSMO-EULAG, ICON and NEMO are broken down into smaller building blocks called dwarfs (Fig.1). These are then optimised for different hardware architectures and alternative algorithms are investigated. Algorithmic developments include the development of a multigrid preconditioner for the elliptic solver, a HEV-time integration scheme with significantly improved stability, a high-order finite difference shallow water model on the sphere and semi-Lagrangian discontinuous Galerkin methods. In terms of code optimisations it was shown in ESCAPE that GPU optimisation which takes full advantage of NVLink interconnect can provide a massive speedup (23x for spectral transform and 57x for MPDATA) if all computations are run on the GPU.

FIG. 1: Illustration of the main idea behind the ESCAPE project. The entire model is broken down into smaller building blocks called dwarfs. These are adapted to different hardware architectures. Based on the feedback from hardware vendors and high performance computing centres alternative numerical algorithms are explored. These improvements are eventually built into the operational model.