

Next-generation weather forecasts with advanced mathematical models

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Abstract

Accurate and timely operational weather forecasts, especially of extreme events such as storms, floods and heatwaves, require high spatial resolutions, large computing resources and a sharp focus on impacts, data accessibility, and users. The field is currently experiencing fast-paced progress, as legacy numerical weather prediction models are developed and tested to run efficiently across high-performance computing architectures, and machine learning models broaden the range of available investigation directions and active users.

The talk will begin with an overview of the current frontiers in scientific weather prediction, including the fast-growing role of data-driven models, focusing then on limited-area modelling and describing on-demand forecasting of extreme weather and end-to-end workflows encompassing impact models.

Next, we will turn the attention to numerical approaches and experiments with PMAP (Portable Model for Atmospheric Prediction), a numerical weather prediction modelling framework currently trialed at the Danish Meteorological Institute and partner weather services within the ACCORD consortium for convective-scale modelling and the European Commission's Destination Earth initiative. Using a domain-specific language based implementation ensuring performance and portability across hardware architectures, PMAP's semi-implicit finite volume approach has attractive stability and conservation properties, as highlighted by promising high-resolution model output on real weather case studies.

Finally and time permitting, the talk will showcase recent research results on idealized test cases with a high-order discontinuous finite element solver for atmospheric dynamics with adaptive mesh refinement capabilities, recently extended to simulate large-scale rotating flows.

Keywords: digital twins, numerical weather prediction, high-order methods