Recent Developments in Numerical Methods for Atmosphere and Ocean Modelling

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Introduction

The 2013 Seminar on "Recent Developments in Numerical Methods for Atmosphere and Ocean Modelling" brought together mathematicians, fluid dynamics specialists, and atmospheric/oceanic scientists to review and highlight recent advances and future challenges in high-resolution numerical modelling of the atmosphere and ocean.

Driven by the rapidly increasing core counts, and the relative (energy) cost of communicating between processors on the computers procured for numerical weather prediction applications, a clear trend towards more scalable solution procedures, meshes and algorithms was presented. With recent advances, ECMWF demonstrated that the semi-Lagrangian, semi-implicit spectral transform technique remains competitive at current hydrostatic resolutions and with existing processor technologies. However, it seems clear from all the presentations that substantial investment in alternative solution procedures is required to face the future.

With pedagogical reviews the lectures highlighted the various aspects important for simulating oceans and atmospheres. Alternative choices for the horizontal discretisation, in contrast to the more customary latitude-longitude grid, included icosahedral grids, Voronoi (hexagonal) meshes, finite-elements, higher-order continuous or discontinuous Galerkin methods, and fully unstructured approaches. In the search for scalable alternatives, more local time-stepping methods were reviewed, as well as alternative equation sets and the multi-scale nature of their solutions. The interaction with physical parameterisations and the problems faced with partially resolved processes, most importantly the redistribution of energy in the vertical via explicitly resolved convection, was also discussed extensively. Finally, given the uncertainty of simulated processes in weather and climate prediction, the need for the same accuracy in all computations has been challenged and indeed may in itself provide an opportunity for scalability and (energy) cost reduction.

The lectures were given by world leading experts (including 7 ECMWF speakers), of which three hold the prestigious Advanced Grant for European Frontier Research funded by the European Research Council. The excellent programme attracted not only students but also other experts in the field for their education. This led to interesting questions and exchanges between the speakers and the audience.

ECMWF would like to thank all participants for an interesting seminar, and in particular the lecturers for their stimulating presentations and for the written contributions to these proceedings.