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Preface

Predicting weather, climate and extreme events

Keywords: Numerical weather prediction; History of NWP; Climate modelling; Climate simulation; Climate change; Regional climate model; El Nino-southern oscillation; Air quality forecasting; Biogeochemical cycles; Ozone pollution; Regional ocean prediction; Sea ice modelling; Wave forecasting; Prediction; Predictability; Uncertainty; Data assimilation; Kalman filter; Incompressible Navier–Stokes equations; Compressible flow; Physics-dynamics coupling; Turbulence; Atmospheric general circulation models; Cloud resolving model; Cloud clusters; Aqua-planet experiments; Numerical methods; Conservation; Finite-difference; Semi-implicit; Semi-Lagrangian; Split-explicit time stepping; Time-staggered; Icosahedral grids; Four-wave interactions; Garden-Sprinkler effect; Wind input

Day-to day weather, and the highly topical and crucial subject of our changing climate continue to engage us all. Furthermore, recent weather related natural disasters amplify our interest in how we predict weather and climate and also in how skilful are these predictions. Much of the public's appreciation of what is involved in forecasting natural phenomena comes from media dramatization and news reporting. This special issue of the Journal of Computational Physics aims at presenting to a broad scientific community the niche that meteorology occupies in modern interdisciplinary science, crossing boundaries between physics, mathematics and chemistry, and representing one of the largest users of scientific supercomputing. The idea underlying this special issue is to portray the integrated efforts of the entire meteorological community that serves the public on a daily basis all over the world with state-of-the-art prognoses of weather, climate and extreme events. In order to achieve this goal, we invited a series of technical papers with some spirit of review – the degree of which was left to the authors' judgment – which would expose our models, techniques and computational methods to the broad interdisciplinary readership of the Journal. The series should also reflect on the difficulties, controversies and unresolved problems, and provide a reference point for further technical reading.

The issue is organized such as to outline representative operational models, aspects of modelling the whole Earth-System, and to highlight some key elements essential for their success. Hence, following a historical review of the development and challenges of Numerical Weather Prediction (NWP), three papers describe current models used for numerical weather prediction and climate studies at very high spatial resolutions. These papers are followed by a contribution on Ensemble Prediction. Meteorology has pioneered the use of ensemble methods for quantifying uncertainty in its predictions, because the evolution of the Earths atmosphere has a fundamentally chaotic component. Initially ensembles were used for forecasts on the timescale of a week or so, but nowadays are increasingly used on all timescales from less than a day to a century or more. The following three papers then discuss the extension of the basic atmospheric modelling to include air quality, ocean surface waves and the ocean itself, all key components for describing and predicting the whole Earth system. Papers on two important application-oriented forecasting systems are those for seasonal to inter-annual and regional climate respectively. The former combining key aspects of weather and climate prediction, while the regional climate models provide the higher resolution, local climate-related data that applications demand. The volume concludes with three contributions on specific aspects (from an admittedly much longer list) of relevance to the overall aims of improving our predictive capabilities described in the issue's title.

As in many branches of science, meteorology keeps advancing on a daily basis, not least because of its operational status whereby its prognoses are challenged and verified continuously. It develops from the cumulative

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efforts of universities, research laboratories and operational centers, and it is impossible, in a single volume, to account for and acknowledge in any detail all broad research activities contributing to present and future progress. Thus many ongoing and exciting activities were left out, and indeed this rate of growth and change and the need for timeliness of publication would readily justify a second special issue such as this.

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