Tellus (2005), 57A, 217–218
Printed in UK. All rights reserved

TELLUS

PREFACE

This special issue of Tellus is devoted to research arising from the project DEMETER (Development of a Multi-model Ensemble System for Seasonal to Interannual Climate Prediction) funded by the European Union (EU) Vth Framework Programme.

The origins of DEMETER lie in the Tropical Ocean Global Atmosphere (TOGA) project of the World Climate Research Programme (WCRP). In TOGA it was shown from coupled ocean–atmosphere models of intermediate complexity that interannual time-scale anomalies in the tropical Pacific were predictable using coupled ocean–atmosphere models. In turn, the associated sea surface temperature (SST) anomalies force teleconnection patterns that perturb the atmospheric circulations globally. This led (through the ongoing WCRP project, CLIVAR) to the more general notion of seasonal climate predictability arising from the coupling of the atmosphere to relatively slow components of variability in the oceans and land-surface worldwide. In order to exploit such predictability, comprehensive global coupled ocean–atmosphere models and ocean data assimilation systems were developed, paralleling earlier developments in numerical weather prediction.

As in weather forecasting, the usefulness of seasonal climate predictions is dependent on being able to make reliable estimates of forecast uncertainty. Because climate is a non-linear system, its predictability is flow-dependent. In order to make flow-dependent estimates of forecast uncertainty, ensembles of predictions must be produced, sampling the uncertainties in both initial conditions and in our models. One pragmatic tool for representing model uncertainty is the multi-model ensemble. In Europe, a number of weather and climate institutes have developed, somewhat independently, the type of climate model that can be used for seasonal prediction. The ensemble of such models encompasses a range of numerical techniques and subgrid parametrizations; if they truly span the uncertainty in representing climate with today's models, then the multi-model ensemble is a viable and useful tool.

The potential for the use of the multi-model ensemble in seasonal climate prediction was first addressed in the EU IVth framework project, PROVOST. In this project, a set of multi-model seasonal ensemble integrations was made using atmospheric climate models with prescribed observed SSTs as lower boundary conditions. Results gave a first indication of how much more reliable were the simulations of the observed atmospheric seasonal climate anomalies using the multi-model ensemble, than using any of the single-model ensembles alone.

The DEMETER project proceeded directly from PROVOST. In DEMETER, a multi-model ensemble of fully coupled global climate models was developed, and an extensive set of reforecasts over the ERA-40 reanalysis period (1957–2001) was made. The papers in this special issue describe detailed and imaginative analyses of these and related reforecast data sets. Results demonstrate conclusively the value of multi-model ensemble forecasting for improving the reliability of seasonal climate predictions.

However, the DEMETER project was much more than a project on multi-model ensemble forecasting. As described in a number of papers in this issue, the DEMETER project has provided some ground-breaking demonstrations of the benefits of linking climate model output to end-user application models, specifically for predicting crop yield and malaria incidence. In both types of application, the end-user models were also run in ensemble mode, using output from individual members of the multi-model ensemble. In this way, probabilistic forecasts of end-user variables become possible. The underlying philosophy behind this development is that the ultimate assessment of whether a seasonal climate forecast has useful predictability is determined by the end-user: can the forecast influence the relevant decision makers?

To get to the stage where global climate models can successfully interface with user application models, then either the output from the climate models has to be downscaled, or the user application models have to be upscaled. There are two basic methodologies for downscaling: statistical–empirical relationships linking variability on the grid scale to variability on subgrid scales, and dynamical methods based on limited-area models. Both techniques are described in this issue, and it is still a matter of discussion as to which is optimal, taking considerations of cost and accuracy into account. By contrast, upscaling is a technique for adapting the user model to provide output on the scale of the climate model. An example of the upscaling technique is discussed in this issue related to crop yield prediction.

Another type of post-processing concerns the issues of ensemble calibration and combination. For example, the simplest way to compute probabilities from a multi-model ensemble is to treat each member of the ensemble as equally likely. However, perhaps some models are better at predicting certain variables than other models. Similarly, perhaps some models do better in certain regions than other models. In this way, the optimal probability product would not be a simple equal-weight combination. Of course, estimating an optimal probability product requires sufficient back statistics of model performance. These matters are discussed in these papers.

Some remarkable end-user results for both tropical and extratropical regions are shown in these papers. There are indications, for example, that malaria incidence is predictable a season or more ahead in parts of Africa. In this way, it may be possible for seasonal prediction systems to be used to determine, ahead of the rainy season, which regions are most at risk of a malaria epidemic, thus providing guidance on where preventative efforts should be targeted. Other results concern the predictability of crop yields; this information is clearly of value to the farmers who grow the crops, and to the food producers and distributors down the line.

DEMETER has left a significant legacy:

(i) the research described in this special issue of Tellus (and many other papers recently published and in preparation in the scientific literature);
(ii) a real-time operational multi-model seasonal forecast system being run routinely at the European Centre for Medium-Range Weather Forecasts (ECMWF);
(iii) a multi-model reforecast data set (freely available from http://www.ecmwf.int/research/demeter), which has been and will continue to be a valuable aid for scientists worldwide in assessing regional climate predictability.

The EU-funded research on multi-model ensemble-based climate prediction continues through the integrated project, ENSEMBLES. ENSEMBLES has the ambitious goal of developing a unified ensemble system for climate prediction across a range of time-scales, from seasons, through decades to centuries. This will be important for validating probabilistic climate change forecasts based on multi-model ensembles which feature extensively in the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC). In ENSEMBLES, different emerging methodologies for representing model uncertainty (such as stochastic-dynamic parametrization) will be explored and compared with the multi-model technique. Finally, the range of quantitative linkages to end-user applications will be expanded, and the end-user analysis of probabilistic climate forecasts further developed.

As coordinator of DEMETER, I would like to acknowledge the tireless enthusiasm and intellectual insights of my colleagues within the DEMETER project for making DEMETER such a successful project. I would also like to thank many other colleagues worldwide (some of whom are presenting results in this special issue) for contributing to the scientific analysis of DEMETER data. Thanks also to colleagues at the European Commission for enabling the DEMETER project and providing essential logistic support. My thanks also to the staff at Tellus for help in preparing this special issue.

Science in general, and climate science in particular, thrives when scientists are motivated to collaborate, and have the means to collaborate. The unique multidisciplinary nature of DEMETER, its challenging scientific goals, and the societal importance of the project, provided the motivation. The EU Vth framework programme provided the means. Through DEMETER, basic climate science and societally relevant applications science have been taken forward in ways which would not otherwise have been possible. I am sure you will find the description of these advances, in the various papers in this special issue, both stimulating and inspiring.

Tim Palmer
Coordinator of DEMETER
European Centre for Medium-Range Weather Forecasts
Shinfield Park
Reading
RG2 9AX
UK