REQUEST FOR A SPECIAL PROJECT 2014–2016

MEMBER STATE: United Kingdom

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Project Title:

Incorporating land-surface model uncertainty into the IFS

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** _____	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2014	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2014-2016: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2016.)		**2014**	**2015**	**2016**
High Performance Computing Facility	(units)	8,000 000	12,000 000	18,000 000
Data storage capacity (total archive volume)	(gigabytes)	10,000	15,000	23,000

*An electronic copy of this form **must be sent** via e-mail to:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date): 12th June 2013

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

Principal Investigator: Dr. Antje Weisheimer

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Extended abstract

It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

Summary:

The land surface is a key source of seasonal predictability. However, uncertainty in the land surface component of the IFS is not well represented and it is not clear how it should be incorporated into the forecast system. We propose to explore this question firstly with perturbed parameter experiments, and following this by developing stochastic parameterisations. Work will be done as part of the EU-FP7 SPECS project, in collaboration with ECMWF scientists and is expected to feed into development of the new seasonal forecasting system, System 5.

Project description

An approach to representing model uncertainty has emerged in recent years and relies on the idea of stochastic parameterization (Palmer et al., 2009). In this approach the underlying deterministic bulk-formulae are replaced by an inherently stochastic formulation, recognising that the problem of representing sub-grid tendencies as a function of the resolved variables may not be consistent with the underlying dynamical equations or with observations of the real atmosphere.

Stochastic parameterizations in the atmosphere have been shown to reduce biases, increase the spread and improve the skill of ensemble forecasts. It has also been shown that a single simulator with stochastic parameterization outperforms a multi-simulator ensemble on the monthly timescale (Weisheimer et al., 2011a)

Recent studies of the summer 2003 heat wave (Weisheimer et al., 2011b) have shown how seasonal simulations of key climatic extreme events are sensitive to the representation of land surface processes in climate models. From this case study, it would appear that the simulation of such extreme seasonal anomalies is more sensitive to uncertainties in land surface processes than oceanic processes.

Focusing primarily on the seasonal timescale, it is proposed to develop a stochastic soil parameterization scheme for System 4, in collaboration with scientists at ECMWF. The work will be funded through the EU FP7 project SPECS: Seasonal to decadal Prediction for European Climate Services (specifically WP4.4: Addressing

model inadequacy). SPECS began in November 2012 and is due to finish in January 2017.

In the first phase of the work, we will carry forward previous work carried out at ECMWF (Cloke, 2011). Here a simple perturbed parameter experiment was carried out with System 4, focusing on two land-surface parameters in the land-surface scheme HTESSEL (the hydraulic conductivity, K and the Van-Genuchten α parameter, affecting the shape of the soil moisture release curve). Results from this experiment have not yet been fully analysed, this would be done as part of this project by using the seasonal diagnostics package at ECMWF on the new ecgate server.

Following this, experiments using more sophisticated perturbation of these and other parameters would be carried out. This would be carried out in a more coherent way: generating the perturbations to these parameters using the spectral pattern generator used in the Stochastically Perturbed Parameterised Tendencies scheme. Some modifications to the pattern generator from the version used for the atmosphere may be necessary, such that the temporal and spatial scales of the patterns generated are more appropriate to the land surface.

In the second phase of the work, stochastic representations of key processes will be considered, embedded within the parameterization scheme. For example, the soil hydrological module of HTESSEL ignores non-Darcian soil flow such as macropore flow and relies on values of hydraulic conductivity that are uncertain and have been estimated based on applying the Richards equation outside its scale of applicability. Experiments where the overall tendencies from the ECMWF HTESSEL scheme are stochastically perturbed will also be carried out.

Technical requirements

The estimate for the computer resource requirements is based on the costs of running the ECMWF seasonal forecasting system of the IFS CY36R4 in resolution T255L91 coupled to the NEMO ocean model in 1° resolution, similar to the System 4 set-up. To run one single month with this set-up requires approx. 421 SBUs.

In order to foster collaboration and inter-compare within the SPECS project, we are going to provide a set of seasonal hindcasts with different methods to account for model uncertainty in the land surface module of the IFS following the default seasonal hindcast experiment protocol of the SPECS project. This involves a 32-year hindcast period (1981-2012) for 7-month long forecasts started twice a year (November and May) using 10 ensemble members. Such a common SPECS experiment uses approx. 1,900 000 SBUs.

For research testing purposes, we plan to perform hindcast experiments over a similar hindcast period but focus on the May start dates only. The forecast length would be 4 months to cover the entire first season (JJA). However, in order to explore the

uncertainty related to model errors, we need a larger ensemble size than 10. Previous experiments with bivariate perturbations of key land-surface parameters explore 25 perturbed ensemble members. The requirements for one research experiment in this set-up mode are approx. 1,300 000 SBUs.

It is expected that the work from this project will feed, towards the end of the project life time, into the development of the new seasonal forecasting system 5. It is very likely that System 5 will use higher horizontal and vertical resolution in the atmosphere than System 4. The ocean resolution will most probably be increased to ¼ degree in the horizontal. The lack of knowledge of the precise configuration of this new system makes it impossible at this stage to give a precise of the required resources for the projects in the later years of the project. However, based on past experience about the increase in resolution from System 3 to System 4, we believe that our estimates are reasonable.

References

Cloke, H., Weisheimer, A. and Pappenberger, F. Representing uncertainty in land surface hydrology: fully coupled simulations with the ECMWF land surface scheme, 2011, ECMWF Workshop proceedings (online)

Palmer, T. N., Buizza, R., Doblas-Reyes, F., Jung, T., Leutbecher, M., Shutts, G. J., Steinheimer M., & Weisheimer, A., 2009: Stochastic parametrization and model uncertainty. ECMWF Research Department Technical Memorandum n. 598,

Weisheimer, A., T. N. Palmer, and F. J. Doblas-Reyes (2011a), Assessment of representations of model uncertainty in monthly and seasonal forecast ensembles, Geophys. Res. Lett., 38, L16703, doi:10.1029/2011GL048123.

Weisheimer, A., F. J. Doblas-Reyes, T. Jung, and T. N. Palmer (2011b), On the predictability of the extreme summer 2003 over Europe, Geophys. Res. Lett., 38, L05704, doi:10.1029/2010GL046455.