REQUEST FOR A SPECIAL PROJECT 2013–2015

MEMBER STATE: Finland

Principal Investigator[1]: Mr. Pirkka Ollinaho, MSc

Affiliation: Finnish Meteorological Institute

Address: PO Box 503

FI-00101 Helsinki

Finland

E-mail: pirkka.ollinaho@fmi.fi

Other researchers:

prof. Heikki Haario (Lappeenranta University of Technology)

prof. Heikki Järvinen (Finnish Meteorological Institute)

Project Title: Model parameter perturbations in ensemble prediction

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SPFIOLLI** ________________	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2012	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☐

Computer resources required for 2013-2015: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2015.)		**2013**	**2014**	**2015**
High Performance Computing Facility	(units)	1 250 000	1 250 000	
Data storage capacity (total archive volume)	(gigabytes)	8 000	8 000	

*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):

27 Apr 2012

Continue overleaf

Principal Investigator: Mr. Pirkka Ollinaho, MSc

[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.

Project Title: Model parameter perturbations in ensemble prediction

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.

Sub-grid scale physical processes, such as boundary layer turbulence or cloud microphysics are represented in numerical weather prediction (NWP) models by physical parameterization schemes. These schemes contain so-called closure parameters to express some unresolved variables by predefined parameters rather than by explicit modeling. The increasing complexity of NWP models makes it very demanding to optimally specify parameters values by manual techniques using limited samples of test forecasts. This may partly explain the increasing difficulties encountered in integration of new physical parameterizations schemes into model dynamics (Järvinen et al. 2010; Solonen et al. 2011)

In general, several approaches have been proposed for joint estimation of static parameters and dynamic state variables. It is relatively straightforward to augment the state vector in filtering applications with the static model parameters and treat them as artificial model states [e.g. Berzuini et al., 1997, Dee, 2005]. A drawback is that parameter values tend to change from one filtering step to the next, in accordance with the changing atmosphere and observing network, although they are static or quasi-static, as pointed out by Liu and West [2001]. We take the view that closure parameters are specified as overall values that should perform well in all weather types, seasons, etc. They are considered to be characteristically distributed around an optimum value.

In this project, we will focus on ensemble prediction systems to understand the effect of model parameter perturbations on subsequent forecasts. Ensemble prediction systems simulate errors in the initial state by running the NWP model many times from slightly different initial conditions. Simulation of the uncertainties in the model formulation is another mechanism to generate spread in the ensemble of forecasts. This is achieved so that each member of the ensemble of forecasts is produced using slightly different model equations. At ECMWF, for instance, stochastic noise is added to the numerical tendencies of the state variables due to parameterized physical processes.

In this basic research project, we will test an ensemble prediction system which is added with a functionality to perturb model parameters, on top of the initial state and stochastic physics perturbations. For the ease of implementation, our ensemble prediction system is built around the ECHAM5 atmospheric general circulation model. Additionally, we will deploy the ECMWF data archive to retrieve operational EPS initial states for our ensemble prediction system. The aim is to better comprehend the role of parametric perturbations in ensemble forecasting, and perhaps to make statistical inference of their posterior probability distributions.

Technical details

We plan to run ECHAM5 on T63 spherical truncation with 31 vertical levels. Benchmarks on C1A suggest a computation cost of approximately 30 SBUs per model run for a 10-day forecast. Our experimentational setup would be the following: compute a 10-day forecast twice daily over one year, with one additional month for the algorithm spinup. Thus, a total of 395*2 model evaluations for 50+1 EPS members would motivate a need of (395*2*51*30) 1208700 SBUs. Taking into account small perturbations in computation costs etc. we would need 1250000 SBUs for performing a single experiment. We plan on making two of these experiments (one per year, 2013-2014) to evaluate performance and behaviour of different parameter sets.

Järvinen, H, P Räisänen, M Laine, J Tamminen, A Ilin, E Oja, A Solonen and H Haario, 2010: Estimation of ECHAM5 climate model closure parameters with adaptive MCMC. *Atmos. Chem. Phys*., **10**, 9993–10002. doi:10.5194/acp-10-9993-2010.

Solonen, A, Ollinaho, P, Laine, M, Haario, H, Tamminen, J and H Järvinen, 2011: Efficient MCMC for climate model parameter estimation: parallel adaptive chains and early rejection. *Bayesian analysis* (submitted 20 February 2011).