REQUEST FOR A SPECIAL PROJECT 2014–2016

MEMBER STATE: Germany

Principal Investigator[1]: Prof. George Craig

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Other researchers:

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Project Title:

Upscale transport of uncertainty

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)	400.000	400.000	400.000
Data storage capacity (total archive volume) (gigabytes)	2.000	2.000	2.000

*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):

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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.

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Extended abstract

Predictability of the atmosphere is basically limited by two major instabilities: The baroclinic instability of the large-scale flow and the convective instability of the atmosphere's vertical stratification due to heat and moisture fluxes at the ground. These two phenomena however occur on very different spatial and temporal scales: A cyclone is usually predictable up to several days, the predictability of a convective thunderstorm however is no longer than a few hours. While the downscale impact of the large-scale flow on small-scale convective activity simulated by nested local area models is a daily routine task, the upscale interaction is much more difficult, theoretically as well as computationally.

Two mechanisms appear to provide an efficient upscale growth of small-scale uncertainty: First, gravity waves spread out from convecting areas are trapped by the planetary rotation and spin up balanced motions. Second, potential vorticity anomalies are generated in the upper troposphere by latent heat release in mesoscale structure such as warm conveyor belts. In both cases the perturbations project onto the balanced flow and its baroclinic instability, affecting the downstream development of the baroclinic wave.

The current generation of supercomputers and numerical models allows for the first time numerical experiments that are able to include the whole range of scales from convective systems up to not only a single cyclone but a whole Rossby wave train. The COSMO model from DWD could be run in convection resolving resolution over a domain that covers several Rossby wavelength or even the whole latitude circle. In addition, the newly developed ICON model that is scheduled to be released by DWD for research purposes in autumn 2013 allows for global simulations with a locally refined grid on which convection could be resolved.

The Special Project we are hereby applying for is intended as a continuation and extension of the error growth experiments performed in our expiring Special Project DEADEN, where we investigated upscale error growth from uncorrelated grid-scale noise at the convective scale to synoptic-scale perturbations (paper in preparation). With the increased computing power of the Power7 machine and new model developments we aim to extend the past studies in the following directions:

- Further increase the range of scales simulated: On the one hand the currently used 2.8 km grid spacing does not lead to a very realistic simulation of deep convection since the effective resolution is still lower than the cloud size. Perhaps more importantly the domain size used in previous experiments limits the error growth to a few days until the fixed lateral boundary conditions significantly damp the growing difference in the domain.
- Reduce the complexity of the simulation: To better understand the effect of gravity waves on transferring convective variability to the balanced motions idealized simulations should be performed. In addition, physical processes can be identified by changing parameters like the earths rotation rate, the height of the troposphere or its stratification.
- Include additional stochastic physics: Instead of using white noise as a primary source of uncertainty physical based approaches could be used. A stochastic boundary layer scheme is currently being developed that accounts for moisture variability in the boundary layer. This variability is expected to have under certain conditions a large upscale impact by triggering convection or modifying the release of latent heat in a moist and intense cyclone.

- Additional realizations and case studies: These can be performed to look for dependencies on the meteorological setup or the diurnal cycle, to get statistically more significant results and to enhance the signal to noise ratio.

ECMWF computing resources are requested to perform numerical experimentation on a wide range of scales with COSMO and ICON to study and understand upscale transport mechanisms of small-scale uncertainty in real and idealized settings. A better knowledge of these mechanisms is important to achieve a better model error representation in high resolution ensemble systems or in lower resolution ensembles with stochastic parametrization.