SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2016
Project Title:	Upscale impact of diabatic processes from convective to near-hemispheric scale
Computer Project Account:	spdecrai
Principal Investigator(s):	Prof. George Craig
Affiliation:	Ludwig-Maximilians-Universität München
Name of ECMWF scientist(s) collaborating to the project (if applicable)	………………………………………………………….…… ………………………………………………………….……
Start date of the project:	Jan 2016
Expected end date:	Dec 2018

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	-	-	2.5 M	0.13 M
Data storage capacity	(Gbytes)	-	-	500 GB	0 GB

Summary of project objectives

(10 lines max)

In this project we will investigate the process of upscale propagation of uncertainty in the atmosphere over three orders of magnitude in spatial scale, from convective clouds to hemispheric waves. This will be possible by recent developments in numerical atmospheric modeling (ICON) and stochastic parameterization (Plant-Craig). The non-hydrostatic ICON model allows for local grid refinements while the Plant-Craig convection scheme is able to emulate convective uncertainty at non-convective permitting resolutions. These two tools will form the basis for a series of error growth experiments to address open questions about basic characteristics, mechanisms and the practical importance of upscale error growth in mid-range global weather prediction.

Summary of problems encountered (if any)

(20 lines max)

We currently experience some problems with initial condition files that are larger than 2GB, which can neither be read by the ICON model nor be written by the interpolation program from IFS analysis. Additionally we have problems with the netcdf-4 format and the hdf5 library. Despite contact to DWD staff the problem is still unresolved, however a work around has been discovered by generation the files on our local facilities, modifying the format and transferring them back to cca.

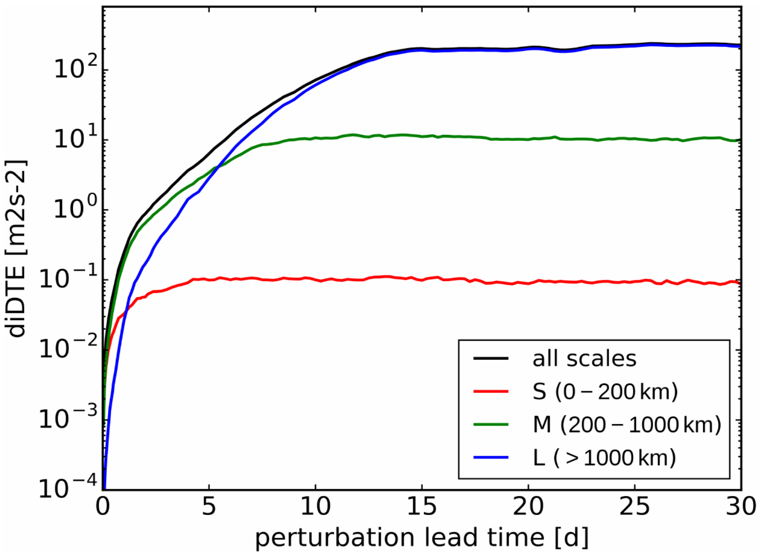
Summary of results of the current year

(from July of previous year to June of current year)

So far two cases have been simulated, one recent boreal summer and one recent boreal winter case (forecast start 1.7.15 and 1.1.16). For each case 31 days of forecast was carried out with two different realizations of convection represented by the Plant-Craig stochastic convection scheme. The ICON model of the German Weather Service (DWD) at a grid spacing of around 40 km was used for this first set of simulations.

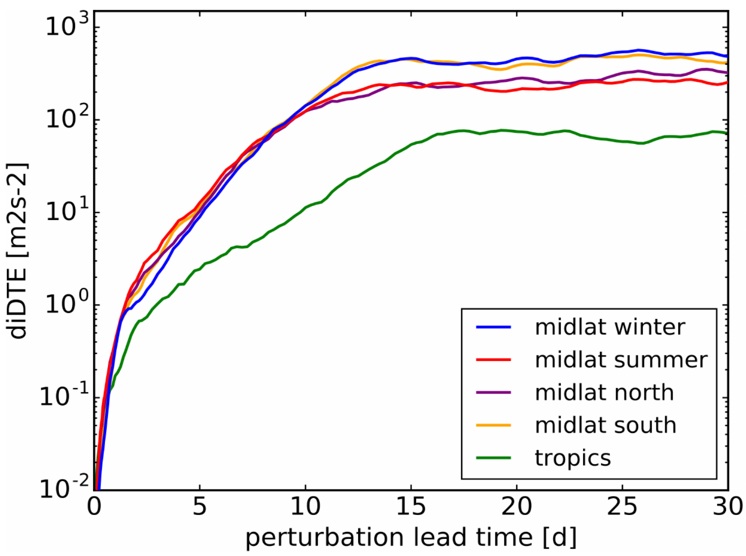
Assuming a perfect model these experiments are suited to estimate intrinsic limits of predictability of the atmospheric flow up to the planetary scale that arise from the short predictability time of convective motions. Even if the initial state of the atmosphere was perfectly known and the model was perfect the low intrinsic predictability timescale of the convection of around 12 hours will generate uncertainties on these scales that will grow upscale and eventually contaminate even the planetary scale and lead to a complete loss of predictability related to atmospheric turbulence (other sources of predictability in other earth systems may however still exist). Since convection-permitting simulations on the globe for such long leadtimes are still far too expensive to conduct we used the Plant-Craig stochastic convection scheme to simulate the uncertainties that arise from the convection without the need to resolve it. A comparison to convection-permitting simulations in a limited-area model has shown that the emerging error amplitudes are similar (Selz and Craig, 2015).

Difference metrics between the two realizations of the Plant-Craig (PC) scheme of each case have been calculated to quantify the error growth that originates from the convection. First consider Difference total energy, defined as DTE=0.5*(du^2+dv^2)+k*dT^2, where du, dv and dT are the zonal wind difference, the meridional wind difference and the temperature difference between the two PC simulations, respectively and k is a constant. The figure below shows the time development of DTE on 300hPa, integrated over the globe and also filtered by spatial scale. It has been averaged over both cases.

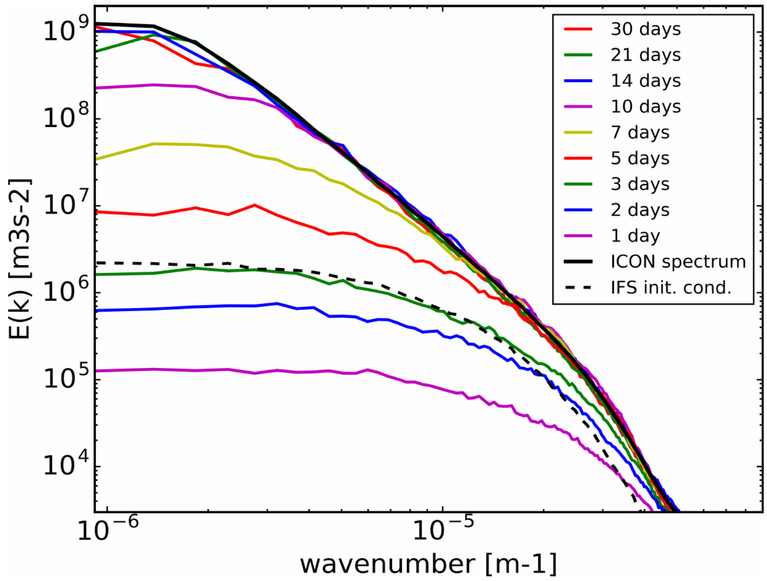


It shows the three stages of upscale error growth proposed by Zhang et al., 2007, with the fast initial growth near the convective scale during the first hours, followed by a transition to a slower growth for 1-2 days and after that a continuous exponential growth for 1-2 weeks due to large-scale instabilities. This growth also saturates after about 15 days which gives us a first very broad estimate of the intrinsic limit of predictability at the planetary scale. At smaller spatial scales this limit gets shorter.

The next figure also shows DTE but this time integrated over different regions and seasons. The saturation time is similar in the mid-latitudes but with a saturation level that is higher in the winter hemisphere and in the southern hemisphere. This probably relates to a stronger jet there in general. Saturation time seems a few days delayed in the tropics. Also the saturation level is about one order of magnitude lower there which means that tropical errors do not contribute much to the global integral of DTE as shown in the Figure above.



Finally we calculate spectra of the mid-latitude difference wind on 300 hPa at different forecast lead times, which displays the relationship between spatial scale and error saturation more clearly (Figure below). Only a Fourier transform in zonal direction is used over the mid-latitdue range. The spectra are averaged over both hemispheres and both cases. Saturation of a certain spatial scale can be identified in this diagnostic as the point in time when the spectrum of the difference wind equals (twice) the kinetic energy spectrum. This equality means that all phase information of the mode is lost while its amplitude is still constraint by the general circulation. Again at about 14 days the error has basically saturated on all scales. The diagram also includes the difference wind spectrum between two random members of the ECMWF initial condition ensemble. This compares basically to an error that has evolved from convection after three days, which suggests that the potential for improving the forecast by perfecting the initial conditions is about three days.



Further and more detailed comparison to the IFS ensemble as an indication of current practical predictability is planned and a cleaner definition of error saturation has yet to be worked out for a more quantitative assessment.

References

Selz, T. and G. C. Craig (2015b): Simulation of upscale error growth with a stochastic convection scheme, Geophys. Res. Lett., 42

Zhang, F., Bei, N., Rotunno, R., Snyder, C., and Epifanio, C. C. (2007): Mesoscale predictability of moist baroclinic waves: Convection-permitting experiments and multistage error growth dynamics. *Journal of the Atmospheric Sciences*, *64*(10), 3579-3594.

List of publications/reports from the project with complete references

The preliminary results described so far have been presented at the “Model Uncertainty” workshop at ECMWF in April on a poster, which is available here:

http://www.ecmwf.int/sites/default/files/filefield_paths/Model%20Uncertainty%20WS_Selz.pdf

Summary of plans for the continuation of the project

(10 lines max)

The cases study experiments described above will be repeated at a higher resolution to test the scale adaptivity of the stochastic convection scheme that has been shown on limited area simulation before. Also an increased number of cases for more robust statements is being considered. After that it is planned to conduct ensemble simulations starting from a sample of the IFS initial condition uncertainty which will be integrated using different realizations of the convection represented by the PC scheme and also the standard Tiedtke-Bechthold scheme. This will enable us to compare these error sources in magnitude and address the practical importance of convective-scale uncertainty in current forecasting methods.