SPECIAL PROJECT PROGRESS REPORT

Reporting year	2014
Project Title:	Upscale transport of uncertainty
Computer Project Account:	**SP DEADEN**
Principal Investigator(s):	Prof. George Craig
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Name of ECMWF scientist(s) collaborating to the project (if applicable)	
Start date of the project:	2011
Expected end date:	2016

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)	600.000	600.000	400.000	80.000
Data storage capacity	(Gbytes)	2TB	500GB	2TB	500GB

Summary of project objectives

Although several studies have identified latent heat release as a main source of rapid small-scale error growth, it is still less clear how fast these errors move upscale and if and under which conditions they make a significant contribution to the inherent meso- and large-scale uncertainty from imperfect initial conditions. In addition, latent heat release itself can occur on very different time- and spatial scales and by very different physical processes, ranging from a bunch of isolated convective cells over mesoscale convective systems up to large-scale regions of synoptically forced ascent. To investigate their roles and mechanisms in limiting predictability is the basic objective of our Special Project “Upscale transport of uncertainty”.

Summary of problems encountered

No problems.

Summary of results of the current year

ECMWF computing resources were used for two subprojects. The first one continues the investigation of characteristics of vertical motions in clouds of mid-latitude cyclones. The second subproject (as part of a PhD thesis) is a highly idealized study on upscale error growth from convection.

1) High-Resolution Trajectory Analysis of Vertical Motions in Different Weather Situations

The study on vertical motions in midlatitude cyclones with an online trajectory tool which started last year was continued by simulating another warm conveyor belt during the winter season (JAN, see below). Together with the case simulated the year before (OCT) and another summertime case simulated on our local computing facility (JUL) we now have investigated three different examples of vertical motion characteristics in the atmosphere of the mid-latitudes.

Latent heat release and associated vertical motions are the major actuators of error growth on scales below the Rossby radius of deformation. In mid-latitude cyclones, ascent occurs on convective time scales (<1h), as a result of conditional instabilities, and/or on synoptic time scales (~1d), driven by baroclinic motions as described by the warm conveyor belt (WCB) concept. The goal of this study was to investigate and compare characteristics of air mass ascent associated with these two different ascent mechanisms using convection-resolving simulations and Lagrangian air parcel trajectories.

COSMO-2.8km simulations with a recently developed “online” trajectory tool were run for three cases where different ascent characteristics are expected: one summer case (JUL), in which high convective available potential energy (CAPE) is released by a prefrontal squall line, one winter case (JAN) representing an Atlantic cyclone associated with a strong “rearward-sloping” WCB and one autumn case (OCT), in which both convective and slantwise ascent occur.

A statistical analysis of cross-tropospheric ascent (defined by an ascent of 600 hPa) reveals that parcels in the convective JUL case typically ascend more than one order of magnitude faster than parcels in the non-convective JAN case (see Fig. 1). The ascent time distribution for OCT has two peaks, one at less than 1 h and one at 24 h. Using an objectively defined criterion we were able to separate the maxima, showing that OCT ascent time distribution is a superposition of two physical phenomena, namely convective and slantwise ascent.

A more detailed analysis of embedded fast ascent shows that most of the JAN and the non-convective OCT parcels, which need on the order of one day to ascend 600 hPa, have embedded rapid ascent phases with a vertical extent of about 2 km. In the JAN case, the rapid ascent mostly occurs in the line convection from the boundary layer to a height of ~2 km. The non-convective OCT trajectories experience embedded mid-level convection caused by conditional instabilities.

Diabatic heating rates (DHR) and the associated potential vorticity (PV) peak are approximately one order of magnitude larger in the convective parcels because of a faster conversion of water vapor to cloud water, snow and ice. The vertical location of the PV peak is concurrent with the DHR maximum. In the outflow, PV matches inflow values, which represents a negative PV anomaly at upper levels. This behaviour is consistent across all three cases and confirms previous case studies and theoretical arguments.

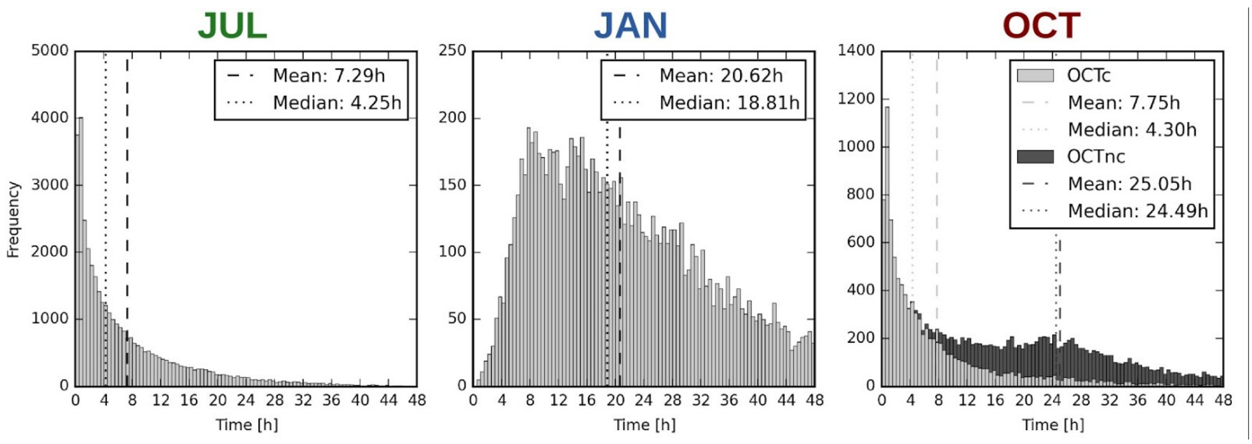

Fig. 1: *Cross-tropospheric (Δp > 600 hPa) ascent time distribution for the three cases. The OCT distribution is split into a convective (OCTc) and non-convective branch (OCTnc), according to the objective criterion.*

A publication on this study is currently in preparation. The results were already presented at the PANDOWA Final Symposium in May 2015 in Karlsruhe.

2) Idealized simulation on upscale error growth and geostrophic adjustment

For the purpose of creating a link between analytic results predicting the time and length scales of upscale error growth with simulations of a real-time weather event on a large domain over Europe (Selz and Craig, 2015a), high-resolution idealized simulations of a convective cloud field have been conducted with the COSMO 5.0 model. In order to generate a stationary background state (control run), cloud fields generated by homogeneous and patch heating scenarios have been run up to 10 days. After this spin-up time the 3D simulated temperature field has been perturbed with an uncorrelated grid scale noise with zero mean and a variance of 0.01 K (perturbation run). In order to test the hypothesis, that gravity waves are being generated on small scales in the difference field, propagate upscale and ultimately adjust on a length scale of the Rossby Radius of deformation, the background runs and perturbation experiments were performed on a large domain of the size comparable to the real-case simulations of Selz and Craig, 2015 (4000 x 4000 km).

This subproject has been paused since February due to a stay abroard of the PhD student (Lotte Bierdel) and will be continued in September.

List of publications/reports from the project with complete references

Groenemeijer, P.; Craig, G. C., 2011: Ensemble forecasting with a stochastic convective parametrization based on equilibrium statistics, Atmos. Chem. Phys., 12, 4555-4565, 2012

Selz, T., and G. Craig (2015a), Upscale error growth in a high-resolution simulation of a summertime weather event over Europe, Mon. Weather Rev., 143, 813–827, doi:10.1175/MWR-D-14-00140.1.

Selz, T., and G. C. Craig (2015b), Simulation of upscale error growth with a stochastic convection scheme, Geophys. Res. Lett., 42, doi:10.1002/2015GL063525.

Summary of plans for the continuation of the project

With the remaining computational resources the idealized study on upscale growth and geostrophic adjustment will be continued. It is planned to carry out a small ensemble of idealized simulations as described above using different values of the Coriolis parameter f to investigate its impact on the amplitude of the developing balanced vortex and the timescale of geostrophic adjustment.