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	2012
Project Title:	Source Spectra for Convectively Generated Gravity Waves – Adaptive Numerical Simulations
Computer Project Account:	SPDESCAN
Principal Investigator(s):	Andreas Dörnbrack George C. Craig Katrin Scheufele
Affiliation:	DLR Oberpfaffenhofen, Institut für Physik der Atmosphäre Münchner Str. 20 D – 82230 WESSLING
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Christian Kühnlein Piotr K. Smolarkiewicz
Start date of the project:	2012
Expected end date:	2015

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)	100000	100000	1000000	60000
Data storage capacity	(Gbytes)	80	80	80	80

Summary of project objectives

Specific tasks of our project are:

- three-dimensional cloud resolving model simulations of radiative–convective equilibrium of an idealized ensemble of non-interacting, point-like cumulus clouds; simulations with different radiative cooling rates are used to give a range of cloud densities, while imposed vertical wind shear of different strengths is used to produce different degrees of convective organization; this work is based on the numerical simulations by Cohen and Craig (2006a, b) and will be extended by higher model top height and larger spatial resolution,

- comparison with the numerical simulations of Cohen and Craig (2006b) and extension to higher spatial resolution; detailed analysis of the gravity wave properties in the numerical simulation results,

- extension of the setup to non-stationary, propagating cloud systems by applying the possibility of prescribing transient environmental states in the equations solved in EULAG.

Cohen, B. G. and G. C. Craig, 2006a: Fluctuations in an equilibrium convective ensemble. Part I: Theoretical formulation. *J. Atmos. Sci.*, **63**, 1996–2004.

Cohen, B. G. and G. C. Craig, 2006b: Fluctuations in an equilibrium convective ensemble. Part II: Numerical Experiments. *J. Atmos. Sci.*, **63**, 2005–2015.

Summary of problems encountered

Progress of the numerical simulations is slow as many problems with the implementation of a proper surface layer parametrization had to be resolved.

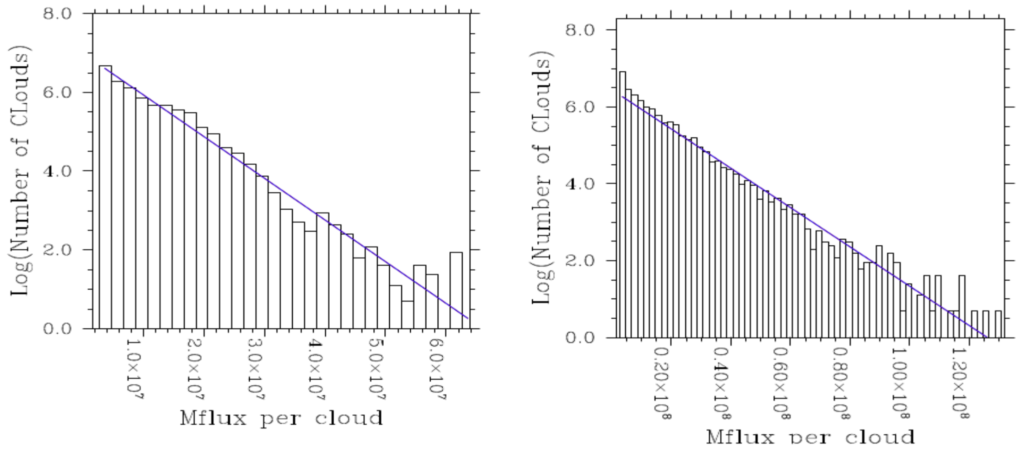
Summary of results of the current year

In numerical modelling of atmospheric processes on global and mesoscales, the effects of moist convection cannot be adequately represented by the resolved-scale motions. Therefore, parametrizations are necessary to obtain realistic results. With the Plant-Craig stochastic parameterization, the theoretical basis is given by statistics of equilibrium fluctuations of a field of cumulus clouds under homogeneous large-scale forcing. It was derived by Craig and Cohen (2006) that in the limit of non-interacting convective cells, statistics of convective fluctuations can be written in terms of the large-scale, externally constrained properties of the system and that the probability density function of individual cloud mass fluxes is exponential.

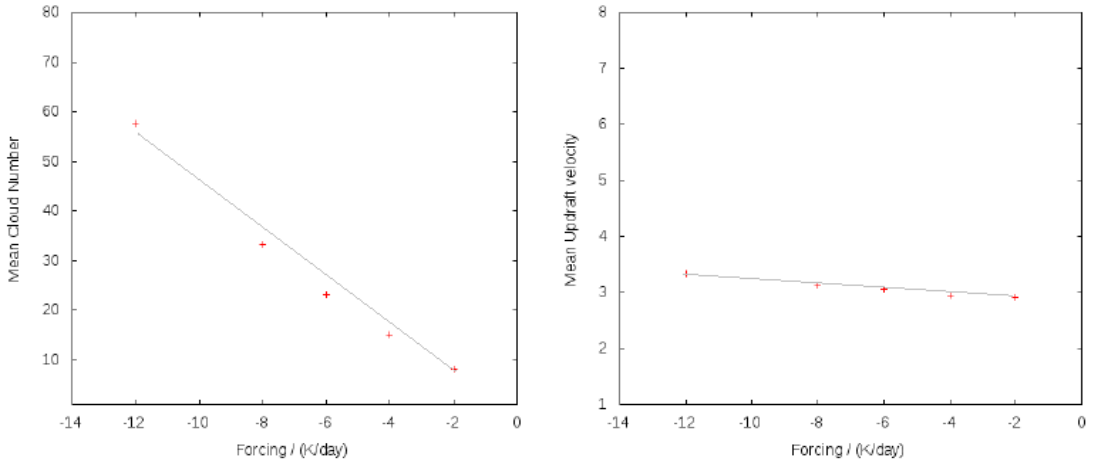
This distribution was validated with a cloud resolving model at a horizontal resolution of 2 km in a state of radiative-convective equilibrium. However, for horizontal resolutions of 2 km, simulated clouds tend to collapse to the grid-scale, so that convective cells are only partially resolved, which motivates testing the sensitivity of cloud statistics on the resolution of the model. In this project an ensemble of cumulus clouds developing over a uniform sea surface is simulated with EULAG. The distribution of mass flux per cloud is found to be exponential for a wide range of forcings (-2 K/day to -12 K/day) for horizontal resolutions of 2 km and 4 km.

Distribution of mass flux per cloud at 2 km horizontal resolution

-2 K/day -8 K/day



As expected the mean number of clouds in the domain is found to scale linearly with the magnitude of the forcing and there is only a very small dependence of the vertical velocity averaged inside the clouds on the amount of radiative forcing.



The convergence of these results is currently tested by stepwise increasing the horizontal resolution, as it is possible that at cloud-resolving resolutions (e.g. 100 m) an increase in forcing will significantly change the strength of the convective clouds instead of primarily affecting the cloud number in the domain.

List of publications/reports from the project with complete references

K. Scheufele, G. C. Craig, A. Dörnbrack - Evaluation of vertical mass flux in high-resolution simulations of convective clouds. 10th SRNWP Workshop in Offenbach, May 2013.

Summary of plans for the continuation of the project

In the future, this will be evaluated in simulations with different cooling rates while stepwise increasing the horizontal resolution. Additionally, entrainment and detrainment rates will be estimated in the high-resolution simulations to determine entrainment/detrainment per cloud.