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	January 2017 – June 2017 (project started Jan 2017)
Project Title:	Towards Cloud-Resolving Climate Simulations
Computer Project Account:	spnlcrom
Principal Investigator(s):	Daan Crommelin, Pier Siebesma, Gijs van den Oord
Affiliation:	Centrum Wiskunde & Informatica (Crommelin), KNMI and TU Delft (Siebesma), Netherlands eScience Center (van den Oord)
Name of ECMWF scientist(s) collaborating to the project (if applicable)	N/A
Start date of the project:	1/1/2017
Expected end date:	31/12/2019

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)	N/A	N/A	10 000 000	2400
Data storage capacity	(Gbytes)	N/A	N/A	5000	18

Summary of project objectives
(10 lines max)

The overarching goal of this project is to come to a better understanding of cloud-climate feedbacks, leading to reduced uncertainty in climate sensitivity estimates. To achieve this, we pursue a computational strategy of developing 3-dimensional superparameterization (3dSP) by embedding 3-d convection-resolving Large Eddy Simulation (LES) models in each grid column of a global model (OpenIFS). The LES models are embedded as a two-way nesting (or two-way coupling): the global model column state drives the LES model, and the LES feeds back to the global model. The nested LES models replace traditional convection parameterization schemes in the global model columns. We work with DALES, the Dutch Large Eddy Simulation model, as the convection-resolving LES.

The computer resources of this special project are intended for performing simulations with the coupled (OpenIFS-DALES) 3dSP model for test cases including a cold air outbreak case (previously subject of the WGNE Grey Zone project).

Summary of problems encountered (if any)
(20 lines max)

To couple OpenIFS and DALES, we currently use the AMUSE framework (www.amusecode.org). AMUSE makes it possible to build a Python interface to existing code written in e.g. C or Fortran. The coupling of the two models is handled by a master script written in Python, which communicates with OpenIFS and DALES through the AMUSE framework.

It turned out that AMUSE does not work well with the Cray MPI which is installed on the ECMWF Cray. The reason is that when AMUSE spawns worker processes it connects to them using MPI_Comm_spawn(), which the Cray MPI so far does not support. We have been in contact with Dominique Lucas from ECMWF about this. A possible solution seemed to be to turn on the Cluster Compatibility Mode on the Cray cluster, however we recently heard that Cray will add this function in future MPI releases (Q4 2017, early 2018), and this should solve our problem.

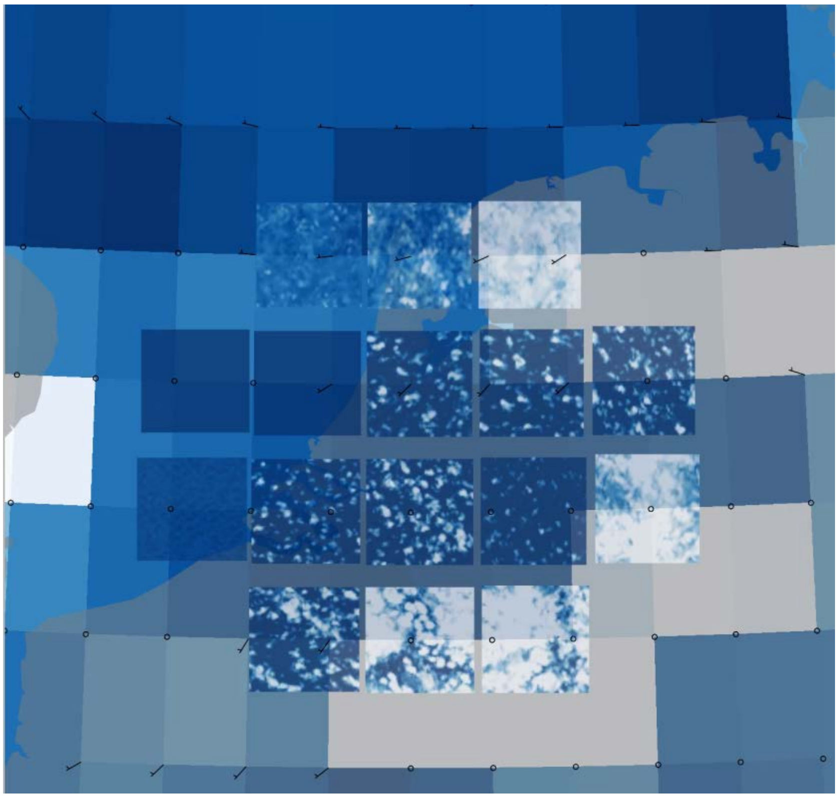
Summary of results of the current year (from July of previous year to June of current year)
This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

The current state of our project is that we have a coupled system set up, where selected OpenIFS grid columns are coupled to DALES simulations. For both OpenIFS and DALES, we have implemented a Python interface using AMUSE. We use the coupling scheme developed by Grabowski [J. Atmos. Sci. 61 (2004), p. 1940]. See the figure below for a snapshot of the coupled system.

Currently, we have all our software set up on the ECMWF Cray, and can run coupled simulations with OpenIFS and DALES as long as we submit them to the fractional queue (nf). In this way, we can use up to half a node (18 CPU cores), which is already useful for code development and also for initial validation tests, e.g. point 1 in the plan below. MPI_Comm_spawn() would be needed to launch jobs spanning multiple nodes with AMUSE.

We are working on getting around the limitations imposed by AMUSE and the current Cray MPI, so that we can run multi-node simulations without waiting for the updated MPI library. We are considering rewriting our coupler without AMUSE, using regular MPI, which would work with the current ECMWF system. We are also in contact with the AMUSE developers, regarding the possibilities to adapt AMUSE to the current MPI library.

Fredrik Jansson from CWI, who works as a postdoc on the 3dSP project, presented the project and preliminary results at the OpenIFS user meeting 2017 (Trieste, Italy, June 2017, presentation title "Superparameterization For OpenIFS – Towards cloud-resolving climate simulations"). He will also present a poster on the project at the workshop “The Future of Cumulus Parametrization” in Delft, The Netherlands,10-14 July 2017.



Snapshot showing liquid water path, from a preliminary test run with OpenIFS on a T255 grid, coupled to 16 DALES instances placed over the Netherlands.

List of publications/reports from the project with complete references

Because of the recent starting date (January 2017) of this project, there are currently no completed publications to report yet. However, preliminary results from the project are presented at the OpenIFS user meeting 2017 and the workshop on “The Future of Cumulus Parametrization”, as mentioned above.

Summary of plans for the continuation of the project

(10 lines max)

We have two test cases planned for the coupled simulation, and regular runs of OpenIFs to be used as a baseline for comparison.

1) A run with a small number of DALES instances around the Cabauw observation site in the Netherlands. This test case can be run on the fractional queue as it needs only a modest amount of LES instances. The results with and without superparameterization can be compared with observations and with other coupled simulation runs which have been performed in other research projects at KNMI.

2) A cold air outbreak over the North Atlantic, 31.1.2010. This event has already been studied in a model intercomparison in the "Grey Zone Project" http://appconv.metoffice.com/cold_air_outbreak/constrain_case/home.html. We will simulate the same time period with and without superparameterization, and compare with observations and the results of the other experiments in the intercomparison. For this study, we want to run between 100 and 1000 DALES instances over the North Atlantic (depending on scaling performance, in particular of the coupling code).

3) Regular OpenIFS runs for the cold air outbreak case, to use as a baseline to which the superparameterization runs can be compared. This will be done at the T511 resolution (which we are using for superparameterization) and at higher resolutions.

We expect that these simulations will consume a (very) large portion of the compute time allocated for 2017 for our special project. For the longer term (2018/2019), we plan to perform simulations over longer timescales and with DALES instances covering large spatial domains (continental scale, and beyond).