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	2018
Project Title:	Extreme weather and the midlatitude response to recent decadal warming in OpenIFS
Computer Project Account:	SPDEKJEL
Principal Investigator(s):	Dr Joakim Kjellsson
	……
Affiliation:	GEOMAR Kiel, Germany
Name of ECMWF scientist(s) collaborating to the project (if applicable)	…… ……
Start date of the project:	2018-01-01
Expected end date:	2018-12-31

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)			10000000	3347856
Data storage capacity	(Gbytes)			15	2.1

Summary of project objectives

Simulate the response of the atmosphere to surface warming in recent decades. Particular focus is on extreme weather events, such as heavy precipitation or wind storms.
Investigate the sensitivity of simulated extreme weather events to horizontal resolution of the model and assess biases.
We will use the OpenIFS model for our investigations, and the results will guide the development of a new coupled model, FOCI, comprising OpenIFS and NEMO.

Summary of problems encountered (if any)

We experienced initial difficulties when compiling OpenIFS on the ECMWF CCA cluster. Short 5-day forecasts with varying number of MPI tasks showed very long run times when OpenIFS was compiled with the Intel compilers, but much shorter run times when using the Cray compilers. However, using the Cray compilers required some of the compiler flags to be changed. We now use the Cray compilers and 2304 MPI tasks, for which we have found an acceptable model performance (Fig. 1). Furthermore, in order to control the horizontal resolution of the surface boundary conditions (SST and sea ice), we wished to use the NOAA OI data set, which requires this data to be interpolated to a reduced N640 Gaussian grid. We explored various interpolation methods, and found conservative remapping to be very problematic, and therefore we will use bilinear remapping, which is commonly used when remapping between the atmosphere and ocean components in a coupled climate model.

We are very grateful to the ECMWF helpdesk and the OpenIFS support team for all their help and advice on compiling OpenIFS on ECMWF CCA.

Summary of results of the current year (from July of previous year to June of current year)

We have compiled and extensively tested the OpenIFS model (CY40R1) using several short 5-day forecasts with varying configurations, and some of the results are planned to appear in the reference paper ”Carver et al., The ECMWF OpenIFS numerical weather prediction model release cycle 40r1: description and use cases”. Our tests of the scalability of OpenIFS is shown in Fig. 1.

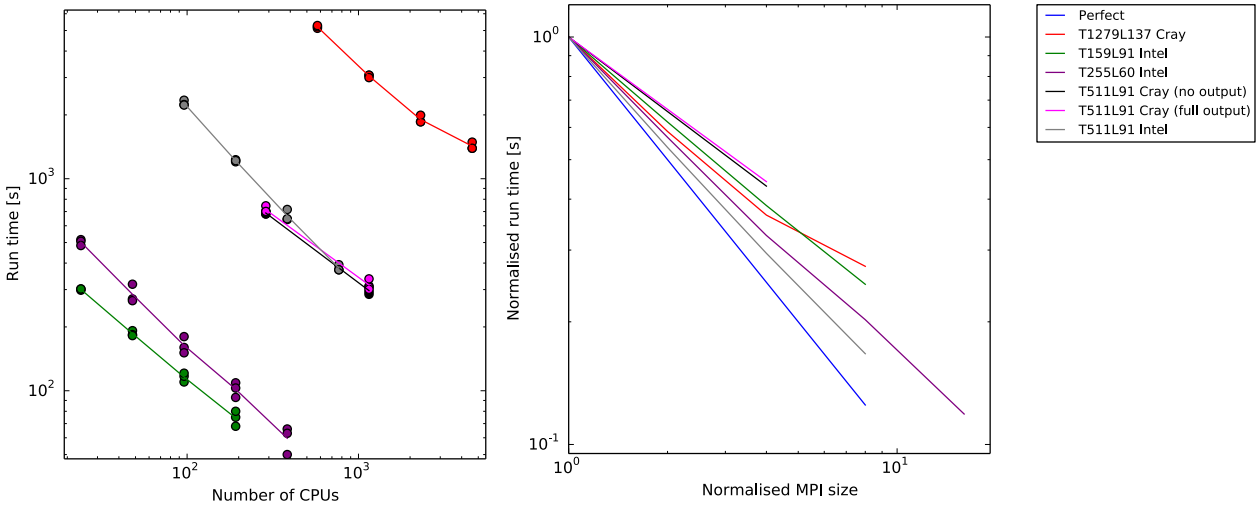

Fig1: Left: Run time and number of MPI tasks for 5-day forecasts using OpenIFS. Right: Same as left, but all data have been normalised. Simulations with the Intel compilers were performed at the HLRN cluster (Cray XC30), while all simulations with the Cray compilers were done at ECMWF CCA. Each dot represents one simulation, while solid lines are drawn using the ensemble means. Perfect scalability is indicated by a blue line in the right panel.

We have also completed most of our proposed companion simulations at HLRN in Berlin, Germany, with the T159, T255 and T511 configurations, and examined European precipitation events in the DJF and JJA seasons. While the simulations agreed relatively well in terms of total precipitation over the entire seasons, we found stark differences between the configurations when studying precipitation at various percentiles as well as how the precipitation intensity at different percentiles responds to surface warming. For each grid cell, we calculate the 80th percentile of daily precipitation in each season in each year (i.e. ~ 90 days), and then average the results over the 5 years in each time period, i.e. 1982-1987 or 2012-2017. Fig. 2 shows the change in 80th percentile DJF daily precipitation events from the period 1982-1987 to 2012-2017. Daily observations are taken from the ENSEMBLES project, and 12-hourly ERA-Interim reanalysis is based on IFS CY31R2 with 4DVAR (T255L60). Note that ERA-Interim assimilates e.g. specific humidity and wind velocities, but not precipitation. Note also that we have stored 6-hourly precipitation from our simulations, but will analyse daily data to agree with the frequency of the observational data set. We find that ERA-Interim and observations are in a reasonable agreement in the change in 80th percentile precipitation, with only some biases in the Alp regions and the Balkan region. The T159L91 simulation shows significant biases over most of the European continent, which is largely due to an overestimation of the intensity of 80th percentile DJF precipitation events in the period 1982-1987. We are still investigating if this can be explained by biases in the large-scale circulation, e.g. jet stream position etc. The T255L60 simulation shows intensification of the 80th percentile precipitation over central Europe while observations show a decrease. This overestimation is largely due to an overestimation of the 80th percentile precipitation in the period 2012-2017. The T511L91 simulation accurately simulates intensifying 80th percentile daily precipitation events over the Alp regions and decreasing intensity over Germany and France. However, both T255 and T511 show biases over the Balkan, Spain and Scandinavian regions. It remains to be studied how the midlatitude atmospheric circulation is represented in these simulations, and also to study if using the T1279L137 configuration can further reduce some of the biases. We also propose to extend this project in 2019 and 2020 to simulate the summer season, JJAS, and

also test a newer version of OpenIFS (CY43R3).

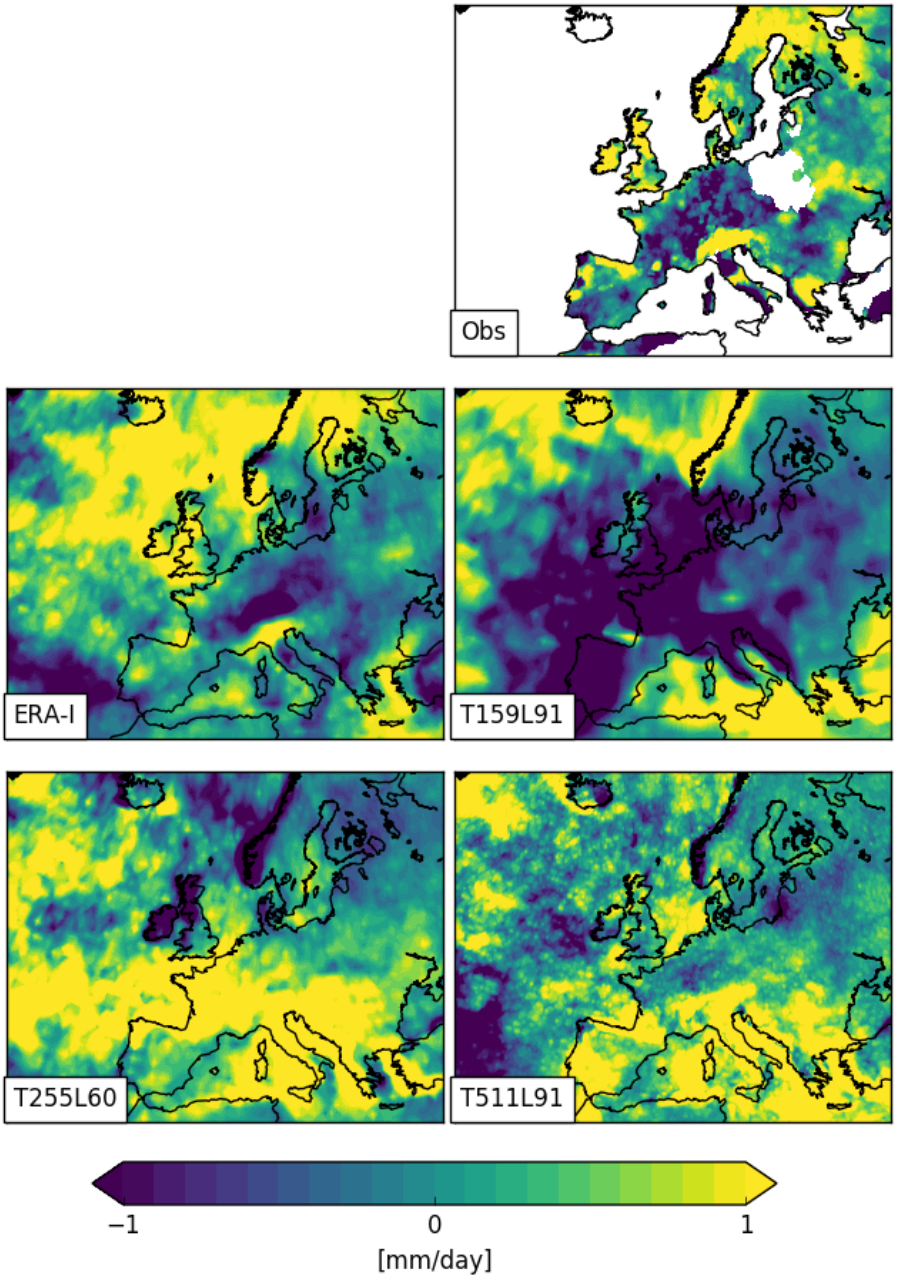

Figure 2: Simulated change from 1982-1987 to 2012-2017 in daily precipitation at the 80th percentile level for the DJF season. Observations are taken from the ENSEMBLES project, and ERA-Interim is based on IFS CY31R2 at T255L60.

During the first 6 months of our project we have been able to complete two of our 20 proposed simulations with the T1279 configuration at the ECMWF HPC. These two simulations were both run for the DJF season 1982-1983 using observed SST and sea ice concentration, with the difference being the horizontal resolution of the SST and sea ice

concentration (0.25˚ vs. 2˚). The remaining simulations will cover the DJF seasons between 1982-1987 and 2012-2017 using 0.25˚ and 2˚ resolution SST, in total 20 simulations. Having overcome the initial technical difficulties in compiling and testing as well as postprocessing the model output, we are confident to finish the remaining simulations well before the project ends in December 2018.

Lastly, our experience in installing and running OpenIFS and post-processing the data has helped us in configuring our coupled modelling system, FOCI, which is based on OpenIFS and NEMO. We are currently performing initial test simulations using OpenIFS at T159L91 and NEMO at ORCA05L42 (Fig. 3).

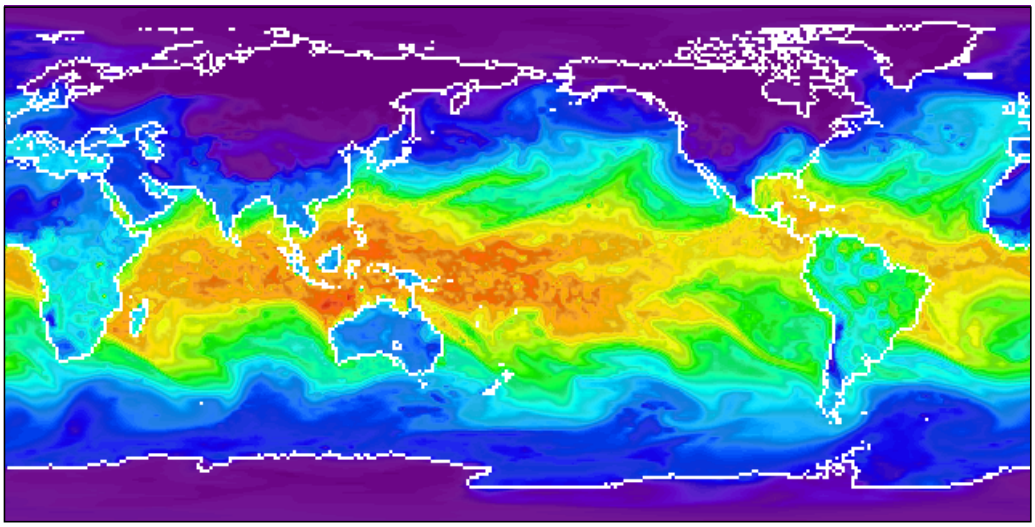

Figure 3: A snapshot of simulated surface specific humidity in FOCI using OpenIFS T159L91, NEMO/LIM2 ORCA05L42 and the OASIS3-MCT2.8 coupler. Contour levels range from 0kg/kg to 0.023kg/kg.

List of publications/reports from the project with complete references

EGU abstract: “Recent trends in extreme weather: A model study“ by Joakim Kjellsson, Wonsun Park and Mojib Latif. Geophysical Research Abstracts Vol. 20, EGU2018-597, 2018

Summary of plans for the continuation of the project

In the last 6 months of this project, we will complete the remaining 18 simulations and begin analysing the data. A manuscript is currently in preparation on the change in 80th percentile precipitation over Europe in the different model configurations, and our T1279L137 configuration will be a good additional experiment. We are also submitting a request to extend this special project into 2019 and 2020, where we propose to simulate also the summer season, JJAS, and also a climate change scenario.