SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year 2021

Project Title: Simulations of extreme precipitation over Denmark and its dependence on resolution

Computer Project Account: spdkchri

Principal Investigator(s): Ole B. Christensen

Affiliation: Danish Meteorological Institute

Name of ECMWF scientist(s) collaborating to the project (if applicable) N/A

Start date of the project: 1/1/2020

Expected end date: 31/12/2021

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)	9000000	10937502	9000000000	1576485
Data storage capacity	(Gbytes)	15000	0	15000	0

Summary of project objectives (10 lines max)

Improving the understanding and future projections of extreme precipitation over Denmark through simulations with the Harmonie-Climate convection-permitting regional climate model. The aim is to simulate 4 years April-October in a spatial resolution of 750m, which is unprecedented for climate simulations.

The simulations are run in two nestings starting from ERA5, with an intermediate Harmonie-Climate area in 5km resolution setup covering an area around Denmark, the North Sea and the Baltic Sea.

Summary of problems encountered (10 lines max)

There have been serious problems with numerical crashes, mostly related to the unprecedentedly high resolution. In the autumn of this year, we will continue working towards a resolution of these problems.
Currently, we only have 8 completed months out of the planned 28.

Summary of plans for the continuation of the project (10 lines max)

This project lay dormant during the first half of 2020 and again in the first half of 2021. We will take it up again after the summer break.

List of publications/reports from the project with complete references

N/A

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

Recent research has shown that kilometer-scale regional climate models, so-called convection permitting models (CPRCM), improves the simulation of precipitation on sub-daily scales (Ban et al., 2014; Coppola et al., 2018; Prein et al., 2015). We have employed HARMONIE-Climate (HCLIM, Belusić et al., 2019), the regional climate model based on the HARMONIE numerical weather prediction model system (Bengtsson et al., 2017), using the AROME physics setup which allows for very high resolution, non-hydrostatic simulations.

We are aiming for simulations of a total of 28 months in a resolution of 750m, which for climate scale simulations is extremely high. The plan is to simulate the period April-October for the years 2007, 2011, 2014, and 2017 with one-week atmospheric spinup in the end of March each year. These are years where one or more very-heavy precipitation events happened over areas of Denmark, such that these simulations have a hope of catching such events, even though the climate-simulation setup does not guarantee this.

We are using ERA5 as boundary conditions for a 5km 360x324 points intermediate model simulation also with HARMONIE-Climate/AROME. The innermost domain covering Denmark consists of 768x648 points and runs in 20 second time steps. The domains are indicated in Fig. 1.

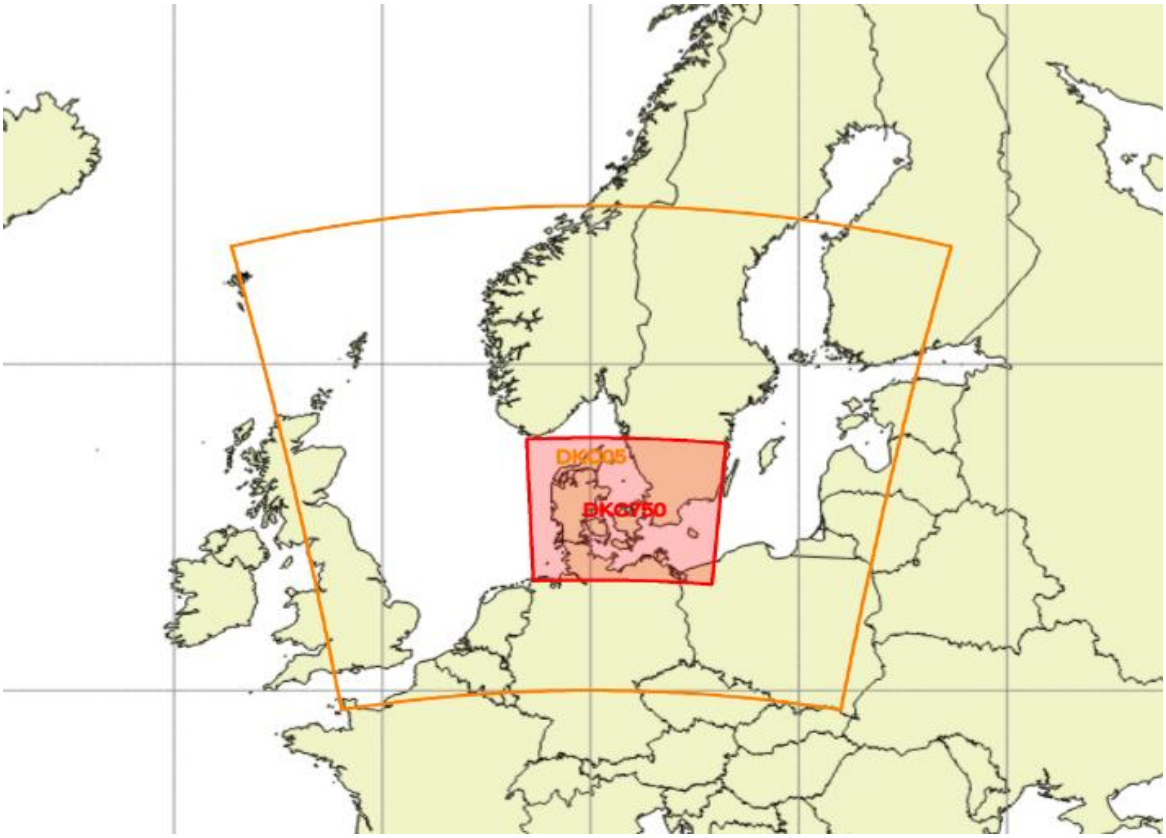

Figure 1 The intermediate 5km domain and the high-resolution 750m domain.

It has, unfortunately, not yet been possible to simulate more than 8 months distributed over three of the four years. 2007/04; 2011/04-06, 2014/04-06; 2017/04. There have been unexpected problems with running the model, which has necessitated repeated re-runs with modifications to parameters, in collaboration with the HARMONIE-Climate code and project managers. As mentioned, the 750m resolution is uncharted territory for HARMONIE-Climate. This also means that a fraction of the allocated computing resources have been "wasted" on crashing runs. It is still the plan to complete the planned simulations. Note that the project has been dormant in the first halves of 2020 and 2021 for external reasons; we are therefore in reality half way and not ¾ way through the project.

Analysis of the results are progressing, specifically the work aiming at improving the "reality" used for bias adjustment of model simulations which form the basis of the Danish Climate Atlas. Previously, a purely observation-based reality has been used, interpolated to points without stations. The aim is to interpolate the bias adjustment function itself, use this distributed function on frequency spectra from these high-resolution HARMONIE-Climate simulations, and hence obtain a reality, which is more physically consistent between stations.

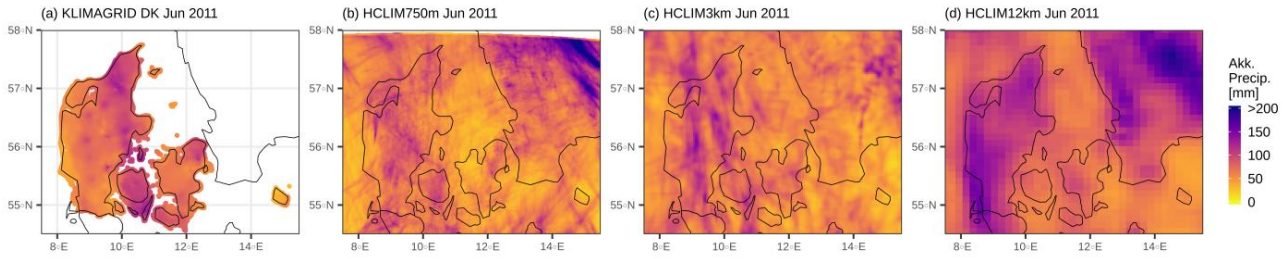

Figure 2 Intercomparison for the month 2011/06 between gridded observations, the 750m model, and existing 3km and 12km HARMONIE-Climate simulations, all driven by ERA on the boundary.

Fig. 2 shows that the simulation in the new very high resolution seems realistic. Whether it is better is not known yet, but intensity analyses are forthcoming.