REQUEST FOR A SPECIAL PROJECT 2019–2021

MEMBER STATE: …Denmark……..……...…

Principal Investigator[1]: …Rasmus A. Pedersen……..……

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…DK-2100 Copenhagen……..……

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Other researchers: …… ……..……

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Project Title: …The Danish Climate Atlas: HCLIM experiments……..……

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If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** _____	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2019	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2019-2021: (To make changes to an existing project please submit an amended version of the original form.)		**2019**	**2020**	**2021**
High Performance Computing Facility	(SBU)	9 million	9 million	9 million
Accumulated data storage (total archive volume)[2]	(TB)	20	40	60

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.

[2] If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.

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Extended abstract

The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used.

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF as well as the Scientific and Technical Advisory Committees. The evaluation of the requests is based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, disciplinary relevance, and justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

Requests asking for 1,000,000 SBUs or more should be more detailed (3-5 pages). Large requests asking for 10,000,000 SBUs or more will receive a detailed review by members of the Scientific Advisory Committee.

The Danish Meteorological Institute will in the coming years (2018-2021) develop a so-called Climate Atlas with detailed information on future climate projections for Denmark. The work will have a particular focus on extreme events, e.g. precipitation extremes and cloud bursts. Global climate models predict a future increase in extreme precipitation events over Denmark (Olesen et al. 2014), but we seek to detail this finding by using models with higher geographical detail, higher temporal resolution (for selected output variables) and physics that improve the treatment of convective processes.

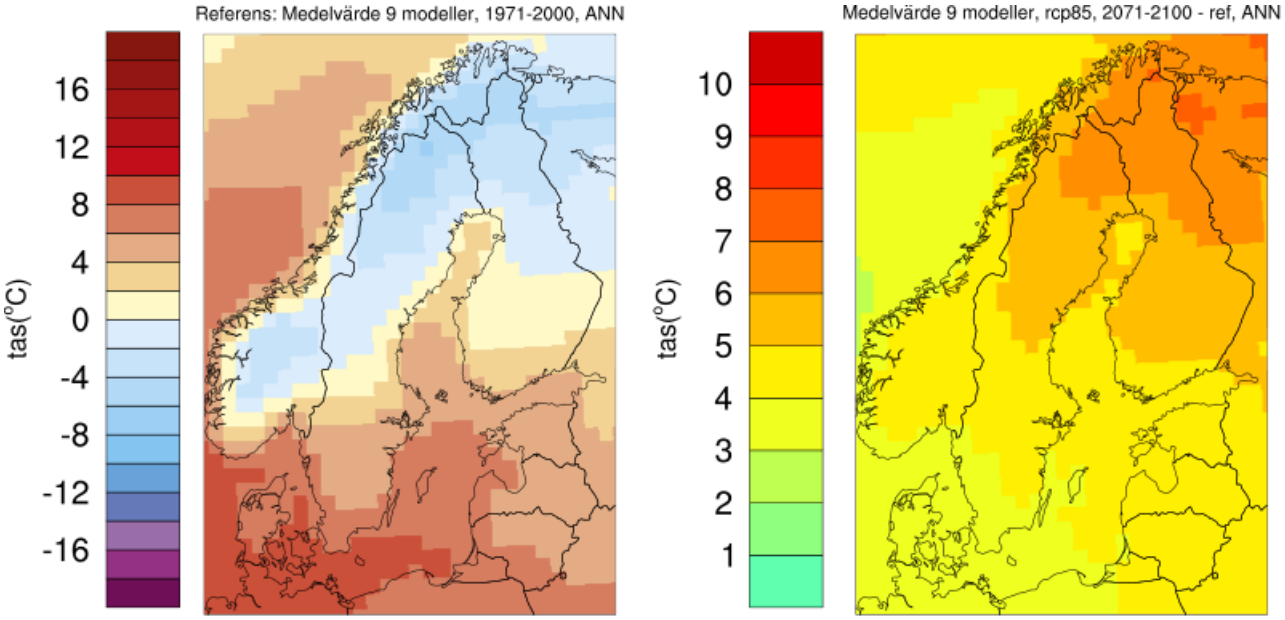

Figure 1 An example of climate information from the Swedish equivalent of the upcoming Danish Climate Atlas. Left: Annual mean reference climate near-surface air temperature [°C]. Right: Simulated anomalies for the period 2071-2100. From: SMHI

As part of the basis for these projections, we will perform a series of high resolution regional climate model simulations with HCLIM; the climate-adapted version of the numerical weather prediction model HARMONIE (Bengtsson et al. 2017). The aim is to improve in particular the projections of future precipitation changes by employing this regional state-of-the-art non-hydrostatic and high-resolution model. Lindstedt et al. (2015) have previously evaluated HCLIM's model performance compared to observations and found good agreement on both regional and smaller spatial scales. We plan to run HCLIM in convective permitting resolutions (horizontal grid resolution $\leq$ 3 km) using the physical parametrisation package optimized for these high spatial resolutions (HCLIM-AROME, with physics based on the AROME model [Seity et al., 2011]).

We will employ the most recent version HCLIM v38h1, developed and tested at the Rossby Center at SMHI (Sweden). Model improvements include changes in radiation code and surface schemes making the model more adapt for out-of-the-box climate experiments [cf. HCLIM wiki webpage], such as the historical and future RCP scenario experiments, we will be running for the Climate Atlas. Furthermore, the pre- and postprocessing components of the code have been optimized for climate purposes, including on-the-fly conversion to NetCDF output. Specifically for usage at ECMWF, the model execution is now more easily managed with ecFlow as the default scheduler.

Part of the planned work will be done as part of a Nordic collaboration on HCLIM involving DMI (Denmark), SMHI (Sweden), MetNO (Norway), and FMI (Finland); all of whom plan to work at ECMWF's facilities, due to the convenient sharing of model code, input and output data. Furthermore, this ensures that the four institutes combined can make a consistent ensemble using the same model code, in the same setup, on the same machine. These simulations will cover historical and future scenarios in a Scandinavian domain in 3 km horizontal resolution. For the first group of experiments, DMI is responsible for running a 20-year mid-century future projection following RCP8.5 from 2040 – 2060.

These Scandinavian simulations will be supplemented by simulations focusing solely on Denmark. Depending on the results from the initial Scandinavian simulations, these might be performed using even higher horizontal resolution (in a smaller domain). The high spatial resolution is desired due to our focus on local extreme events and effects, such as cloud bursts and coastal wind patterns (important for local storm surge projections).

As the newest version HCLIM38h1 has only very recently been finalized (June 2018), we have not got an accurate estimate of the run cost at ECMWF (i.e. the amount of SBU required). Additionally, the initial experiments will guide our further choice of domain sizes and resolution; both of which have a crucial impact on the required computational resources. Hence, we have made the request for the later years assuming approximately the same amount of simulation as included in the initial Scandinavian experiment.

As the planned analysis, especially the precipitation analyses, require information on both high spatial and temporal resolution (down to sub-hourly resolution for selected variables), we expect a considerable amount of storage for these runs. Depending on domain size and resolution this could be up to the order of 1 TB per simulated model year. Due to the relatively high costs of running these simulations (in both real time and SBU's), we will likely start by conservatively storing relatively large amounts of fields, and gradually reducing and cleaning up those that eventually do not prove important for the analyses.

References:

- Bengtsson, Lisa, et al. (2017). *The HARMONIE-AROME Model Configuration in the ALADIN-HIRLAM NWP System*. Monthly Weather Review, 145, 1919-1935. DOI: 10.1175/MWR-D-16-0417.1

- Lindstedt, David, Petter Lind, Colin Jones and Erik Kjellström (2015). *A new regional climate model operating at the meso-gamma scale; performance over Europe*. Tellus A, 67, 24138. DOI: 10.3402/tellusa.v67.24138

- Olesen, Martin, et al. (2014). *Fremtidige klimaforandringer i Danmark ("Future climate change in Denmark")*. Danish Meteorological Institute, Scientific Report, ISBN:978-87-7478-652-8, www.dmi.dk/klimaforandringer

- Seity, Y., et al. (2011). *The AROME-France convective-scale operational model.* Monthly Weather Review, 139(3), 976-991.

- SMHI (Swedish Meteorological and Hydrological Institute) webpage for future climate change, https://www.smhi.se/klimat/framtidens-klimat/klimatscenarier [available in Swedish & English]

- HCLIM wiki webpage, https://hirlam.org/trac/wiki/HarmonieClimate