REQUEST FOR A SPECIAL PROJECT 2020–2022

MEMBER STATE: …Denmark..……….…………………………………………...…

Principal Investigator[1]: …Ruth Mottram.…………………………………………….……

Affiliation: …Danish Meteorological Institute.…………………………….……

Address: …Lyngbyvej 100……………………………………………….……

…DK-2100 Copenhagen……………………………………….……

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Other researchers: …Rasmus A. Pedersen, Fredrik Boberg, Peter Langen.……….……

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Project Title: Greenland climate modelling: assessing and developing HCLIM

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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.)	2020
Would you accept support for 1 year only, if necessary?	YES ☒ NO ☐

Computer resources required for 2020-2022: (To make changes to an existing project please submit an amended version of the original form.)		**2020**	**2021**	**2022**
High Performance Computing Facility	(SBU)	9,5 million	9,5 million	9,5 million
Accumulated data storage (total archive volume)[2]	(TB)	8	12	16

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] These figures refer to data archived in ECFS and MARS. 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.

Principal Investigator: Ruth Mottram

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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 Advisory Committee. 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 might receive a detailed review by members of the Scientific Advisory Committee.

The Danish Meteorological Institute is in a transition phase towards using HARMONIE-Climate (HCLIM, Belusic et al., 2019) as our main regional climate model. A central element in our climate research is climate modelling in the Arctic and in particular over Greenland. This is of demonstrable interest to policymakers and general public via the PolarPortal.org website where DMI and partners present a daily updated near real-time surface mass budget and melt area of the Greenland ice sheet. These products are based on the HARMONIE-AROME numerical weather prediction model (HARMONIE-NWP, Bengtsson et al., 2017).

However for climatology applications, the HIRHAM5 model (Christensen et al., 2006; Lucas-Picher et al., 2012) is currently the main tool, and a substantial effort has gone into improving the model performance over the Greenland Ice Sheet (Boberg et al., 2018; Langen et al., 2017, 2015; Mottram et al., 2017a) focusing in particular on surface processes essential for ice sheet modelling and assessment of the ice sheet mass budget. With this application, we will be able to dedicate computational resources to (1) assessment of the performance of HCLIM over Greenland, and (2) developing and improving the surface scheme utilizing the experience from the HIRHAM5 development.

Climate modelling over Greenland is challenging with few long-term observations, complex topography and an extreme weather environment. Previous studies have pointed to the importance of a detailed surface scheme accounting for glacial processes, kilometre-scale resolution and, consequently, non-hydrostatic physics for capturing the complex climate on and around the Greenland Ice Sheet (Lenaerts et al., 2019; Lucas-Picher et al., 2012; Noël et al., 2018; Rae et al., 2012). With further development of the HCLIM surface and subsurface schemes over the ice sheet, HCLIM thus has potential to be the ideal tool for Greenland climate simulations.

The ultimate aim is to run high-resolution, kilometre-scale climate simulations that can serve as a reference for climate and ice sheet surface mass balance studies and provide future projections. The computational cost of such simulations will go beyond these project resources, but the resources in the later years of this project may be used to contribute to such runs.

The work will build on the lessons and output from the CARRA project (Copernicus Arctic Regional ReAnalysis, https://climate.copernicus.eu/copernicus-arctic-regional-reanalysis-service). CARRA aims to build a 24-year reanalysis over two complementary domains to cover the European sector of the Arctic using the HARMONIE-NWP model running at 2.5 km horizontal resolution. The regional model runs use ERA5 (C3S, 2017) as lateral boundary conditions, and thus serve as an obvious reference for evaluation of a climate simulation with HCLIM forced by the same boundary conditions. Specifically, we will test the performance of HCLIM using intermediate resolutions in the range 5-15 km between the global ERA5 (~30 km) and CARRA (~2.5 km) model setups.
To limit the computational costs, tests of the performance in higher resolution will be performed in smaller regional domains, nested from the intermediate resolution runs or directly from ERA5. These will focus on regions with available atmospheric observational data and regions that are notoriously challenging to model either due to complex processes, e.g. the Summit region, or complex topography, e.g. northeastern and southwestern Greenland.

Standard evaluation will also rely on data from the automatic weather stations in the PROMICE network (Fausto and Van As, 2019; van As et al., 2011). This dataset contains temperature, precipitation, and radiative fluxes from more than 20 locations on the ice sheet. These will be utilized for a detailed assessment; expanding on the preliminary evaluation presented in Belusic et al. (2019).

Previous work with HARMONIE-NWP has illustrated that an accurate treatment of surface processes is a key element in simulating weather and climate over the Greenland Ice Sheet (Mottram et al., 2017b). In particular, this highlights the need for accurate albedo-schemes for various stages of snow and ice. Building on this work, Olandersson et al. (2019) have recently compared how the Greenland ice sheet surface mass balance obtained from HARMONIE-NWP output compares to that obtained from HIRHAM5 (Figure 1), as shown on the Polar Portal in a pilot study. The results of Olandersson et al. (2019) highlight that the treatment of the ice sheet surface in particular requires improvement in HCLIM and this and other insights have led to the suggested improvements planned within this special project.

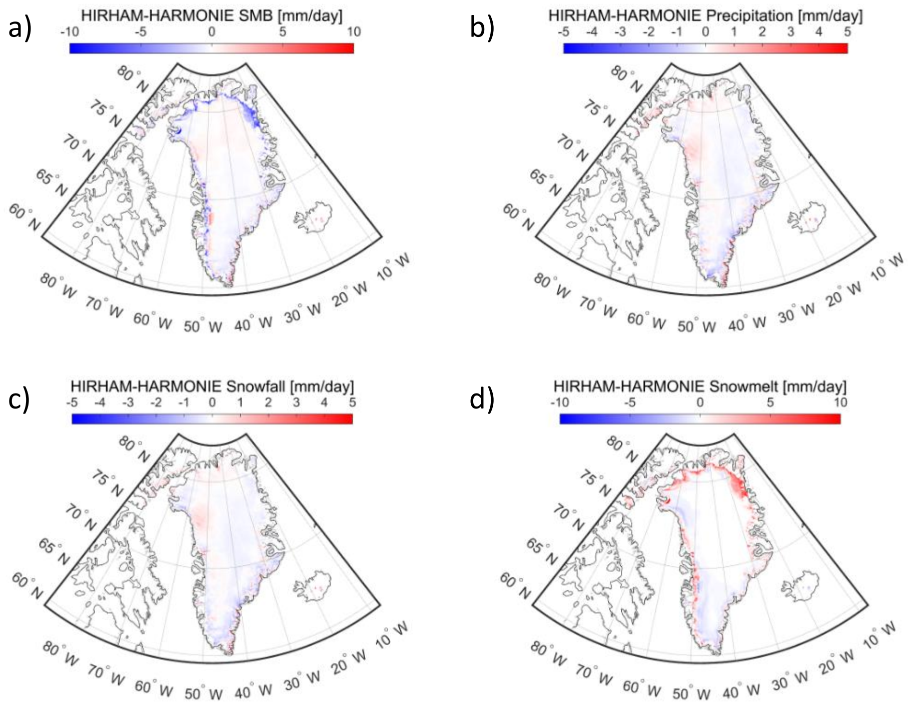

Figure 1 Comparison of surface mass balance (SMB) and its components between HARMONIE-NWP and HIRHAM. (a)-(d) are showing anomalies for HIRHAM – HARMONIE-NWP: (a) SMB [mm/day], (b) precipitation [mm/day], (c) snowfall [mm/day], and (d) snowmelt [mm/day]. Figure from Olandersson et al. (2019).

The resources suggested for this projected are estimated to cover the equivalent of a 15-year simulation in a 5-km domain over Greenland per year. The computational cost per model year is estimated to 650,000 SBU, with an estimated storage requirement of 500 GB (high-end estimate). As we will perform development and testing, we can reduce the amount of storage needed for the later years.

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