REQUEST FOR A SPECIAL PROJECT 2021–2023

MEMBER STATE: Sweden

Principal Investigator[1]: Fuxing Wang

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Project Title: Evaluation of HCLIM43 over the Nordic regions

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.)	2021	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2021-2023: (To make changes to an existing project please submit an amended version of the original form.)		**2021**	**2022**	**2023**
High Performance Computing Facility	(SBU)	9.9 million		
Accumulated data storage (total archive volume)[2]	(GB)	10 000		

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.

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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.

Background and motivation

High resolution convection permitting models resolve a majority of deep convection systems explicitly and improve the representation of fine scale surface fields (Kendon et al. 2017). The benefits of convection permitting models have been identified in simulations of convective precipitation at sub-daily scale, rainfall spatial structure (Kendon et al. 2017) and hourly precipitation extremes (Fosser et al. 2015).

HCLIM is the climate-adapted version of the numerical weather prediction (NWP) model HARMONIE and its main focus is convection permitting modelling (Lindstedt et al., 2015). HCLIM consists of three configuration options: HCLIM-ALADIN, HCLIM-ALARO and HCLIM-AROME. HCLIM-AROME is used with non-hydrostatic dynamics at convection-permitting scales (1-4 km). HCLIM-ALADIN and HCLIM-ALARO configurations run with hydrostatic dynamics and are used as intermediate downscaling models from the coarse resolution General Circulation Model to km-scale convection permitting model. The current HCLIM version HCLIM38 (Belušić et al., 2020) has shown very promising results in the simulation of sub-daily and extreme precipitation over Fenno-Scandinavia (Lind et al., 2020, under review; Toivonen et al., in preparation).

The new HCLIM version under development is HCLIM43. Compared with HCLIM38, several new features are implemented in HCLIM43 including the replacement of the land cover data ECOCLIMAP V2.2 by the latest version Second Generation produced at 300-meter resolution, the change of sand and clay dataset from FAO to SOILGRID, the implementation of Multi-Energy Balance scheme (Boone et al., 2017) in SURFEX land surface model, just to name a few. HCLIM43 is developed based on the cycle 43 of the NWP version of HARMONIE. Adapting the Harmonie NWP convection permitting model for climate applications requires a number of modifications in the code and scripting system, despite the ongoing activities in creating a seamless modelling system for both NWP and climate purposes. Furthermore, long climate simulations frequently reveal systematic model biases that are not always apparent in NWP simulations due to their much shorter length together with using the data assimilation techniques. Therefore, a comprehensive evaluation of the new cycle HCLIM43 benefits both the climate and NWP communities.

The main objective of this project is to evaluate the systematic bias of HCLIM43 simulations and compare them to HCLIM38 simulations with the main focus on convection permitting modelling (i.e. the AROME package). These evaluation activities are in line with the HCLIM annual working plan (task: Testing and evaluation of HCLIM43). Although some evaluations of HCLIM43 were

done over the Spanish domain, the comprehensive evaluation of HCLIM43 has not been done yet. In order to compare it with existing HCLIM38 simulations, we choose the same domain (the Nordic domain) as the Nordic Convection Permitting Climate Projections (NorCP) project which uses HCLIM38.

The HCLIM consortium has close collaboration with the ALADIN-HIRLAM NWP model development and consists of seven institutes: the State Meteorological Agency (AEMET) in Spain, the Danish Meteorological Institute (DMI), the Finnish Meteorological Institute (FMI), the Royal Netherlands Meteorological Institute (KNMI), Met Éireann in Ireland, the Norwegian Meteorological Institute (MET Norway), and the Swedish Meteorological and Hydrological Institute (SMHI). Due to the high cost of the computing time and storage capacity of HCLIM simulations, the different institutes need to collaboratively evaluate the model over different domains and for different applications. For example, the simulations in NorCP project were carried out collaboratively by several institutes. Using the ECMWF resources is crucial for such collaboration to share the source code, the experiment setup and the input/output of the simulations.

The HCLIM43 code

Different from HCLIM38 code which is managed by the subversion version control system, HCLIM43 code is in a git repository and organized by a git workflow. This git workflow allows the HCLIM code to be close to NWP development and to participate in the HARMONIE testbed as well as to develop specific features that are only used for HCLIM (e.g., settings like SIMULATION_TYPE=climate). Although HCLIM43 is adapted from the NWP configuration of HARMONIE cy43, changes are needed for HCLIM43. For example, the sea surface temperature and sea ice concentration do not update with time in the NWP setup, while modifications were done in HCLIM43 to allow them to vary with time.

The HCLIM43 code to be used in this project is the HCLIM_develop branch which was built in April 2020 by Bert van Ulft at KNMI. HCLIM_develop is created upon the branch CY43HCLIMh2.1.target.1 on hirlam.org which was used by Samuel Viana at AEMET. The HCLIM_develop branch includes all the modifications in CY43HCLIMh2.1.target.1 made by Samuel Viana. Since April 2020, several developments and technical tests have been made in HCLIM_develop branch in order to establish a stable HCLIM43 version that can be used for climate production simulations and scientific studies.

The simulations

The simulations will consist of:

(1) The HCLIM43-ALADIN experiment (12 km)

This run will use the HCLIM43-ALADIN package. The simulation resolution is 12 km.

(2) The HCLIM43-ALARO experiment (12 km)

This run is the same as (1) above but will use the ALARO package (version 1) in HCLIM43.

(3) The HCLIM43-AROME (3 km) nested in HCLIM43-ALADIN

This run will use the AROME package in HCLIM43. It will use HCLIM43-ALADIN as input and will run at 3km.

(4) The HCLIM43-AROME (3 km) nested in HCLIM43-ALARO

This run is the same as (3) above but will use HCLIM43-ALARO as input.

The simulation period for all experiments is 4-5 years starting from 1985. These simulations will be compared with observations and other products (e.g., reanalysis).

Justification of the resources requested

The HCLIM43 development work is going smoothly. We expect the stable version will be available before the end of 2020. The simulations are planned to start in 2021. We apply for a one year project and will apply for extensions if needed.

Based on the experience of HCLIM38 simulations on ECMWF computer, the HCLIM-AROME (3km) and HCLIM-ALADIN (12km) simulations on NorCP domain cost about 2-2.5 million and 46,000 SBU per simulated year, respectively. The 4-5 years simulation will result in nearly 8-10 million SBU for HCLIM-AROME and 0.18-0.23 million SBU for HCLIM-ALADIN. The estimated model output (NetCDF files) will require about 1.5 TB for HCLIM-AROME and 180 GB for HCLIM-ALADIN per simulated model year without taking into account the temporal files for downscaling. The HCLIM-ALARO (12 km) simulation cost is estimated to be similar to HCLIM-ALADIN.

Simulation	Years	Total SBUs	Total archive volume
HCLIM43-ALADIN 12 km	4-5	0.18-0.23 million	720 - 900 GB
HCLIM43-ALARO 12 km	4-5	0.18-0.23 million	720 - 900 GB
HCLIM43-AROME 3 km (ALADIN)	4-5	8 - 10 million	6-7.5 TB
HCLIM43-AROME 3 km (ALARO)	4-5	8 - 10 million	6-7.5 TB

References:

Belušić, D., de Vries, H., Dobler, A., Landgren, O., Lind, P., Lindstedt, D., Pedersen, R. A., Sánchez-Perrino, J. C., Toivonen, E., van Ulft, B., Wang, F., Andrae, U., Batrak, Y., Kjellström, E., Lenderink, G., Nikulin, G., Pietikäinen, J.-P., Rodríguez-Camino, E., Samuelsson, P., van Meijgaard, E., and Wu, M.: HCLIM38: a flexible regional climate model applicable for different climate zones from coarse to convection-permitting scales, Geosci. Model Dev., 13, 1311–1333, https://doi.org/10.5194/gmd-13-1311-2020, 2020.

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