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 …2020……..…...…

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

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Computer Project Account: …SPDKPEDE……..…..…

Principal Investigator(s): …Rasmus A. Pedersen ..……..……

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

Name of ECMWF scientist(s) collaborating to the project (if applicable) ……..……

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Start date of the project: …January 1, 2019..……..……

Expected end date: …December 31, 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)	9,000,000	9,000,000	9,000,000	8,880,121.72
Data storage capacity	(Gbytes)	20,000	20,000	20,000	20,000

Summary of project objectives (10 lines max)

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. Consequently, model simulations with high geographical detail, high temporal resolution and physics that improve the treatment of convective processes are needed. We will perform a series of regional climate model simulations with HCLIM (Belusic et al. 2020). Part of the planned work is done in a Nordic collaboration on HCLIM involving DMI (Denmark), SMHI (Sweden), MET Norway (Norway), and FMI (Finland); creating a consistent future projection ensemble of 3 km simulations over a Fenno-Scandinavian domain. DMI is responsible for two simulations covering 2081-2100 following the RCP4.5 and RCP8.5 emission scenarios (van Vuuren et al., 2011).

Summary of problems encountered (10 lines max)

N/A

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

The allocated resources for 2021 will be used for additional HCLIM simulations contributing to the Danish Climate Atlas. This will either be through an additional expansion of the Fenno-Scandinavian ensemble, or higher resolution experiments focusing on Denmark only – as mentioned in the original application.

List of publications/reports from the project with complete references

The Special Project resources are contributing to the ensemble of Nordic Convection-Permitting climate projections (*NorCP*), performed in collaboration between DMI (Denmark), SMHI (Sweden), MET Norway (Norway), and FMI (Finland). Several additional publications and presentations are planned; the following are selected references from the last year:

- Lind P., D. Belušić, O.B. Christensen, A. Dobler, E. Kjellström, O. Landgren, D. Lindstedt, D. Matte, **R.A. Pedersen**, E. Toivonen, F. Wang, *Benefits and added value of convection-permitting climate modeling over Fenno-Scandinavia*, Climate Dynamics (in review), 2020
- **Pedersen, R.A.,** D. Belušić, O.B. Christensen, A. Dobler, P. Lind, D. Lindstedt, E. Toivonen, F. Wang. *Future climate change in the Nordic region - new insights from a convection-permitting climate model*. Latsis symposium, ETH, Zürich, Switzerland, August 2019.
- D. Lindstedt, P. Lind, D. Belušić, F. Wang, E. Kjellström, A. Dobler, O. Landgren, E. Toivonen, J.-P. Pietikäinen, **R.A. Pedersen**, R. Mottram, D. Matte; *Validation of the snow climate in a regional climate model at 3 km grid spacing over Scandinavia*, EMS2019-506, EMS Annual Meeting 2019. DTU, Copenhagen, Denmark, 9 – 13 September 2019.
- P. Lind, D. Belušić, E. Toivonen, **R.A. Pedersen**; D. Lindstedt; F. Wang; A. Dobler; E. Kjellström. *Future response of precipitation extremes over the Nordic region in a convection-permitting regional climate model*. REKLIM 2nd International Conference, Berlin, Germany, 23 – 25 September 2019.
- E. Toivonen, D. Belušić, E.D. Thomassen, P. Berg, O.B. Christensen, A. Dobler, A.V. Dyrrdal, J.E. Haugen, K. Jylhä, E. Kjellström, O. Landgren, P. Lind, D. Lindstedt, D. Matte, A. Mäkelä, J. Olsson, **R.A. Pedersen**, F. Wang, and W. Yang; *Evaluation of extreme precipitation over the Nordic region using a convection-permitting regional climate model*, EGU2020-10506, EGU General Assembly 2020

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.

The resources of this special project contribute to the high computational cost of running a convection-permitting climate model over the entire Fenno-Scandinavian region. The annual 9

MSBU provide approximately 5 years of simulation with our setup, corresponding to ¼ of DMI's contribution to the ensemble.

The NorCP consortium is working on evaluating the model performance (cf. Lind et al. 2020 in the publication list above) and assessing future climate change. The model ensemble currently consists of 8 different 20-year experiments: a reanalysis-driven experiment for evaluation and a set of GCM-driven experiments, covering historical (1986-2005), mid (2041-60) and late century (2081-2100) time slices. All future projections follow the RCP8.5 high emission scenario, except one simulation which follows the RCP4.5 for the end of the century (this simulation is part of the DMI contribution, and this year's resources have been spent in contribution to this still on-going simulation).

Analysis of the finalized experiments is in progress among all the partners, and is expected to result in several publications, with various assessments of future climate change and the added value of using of convection permitting models as the basis for climate information. The figure below is an example of the high-resolution output from the model, and how it represents future climate change in the Fenno-Scandinavian region.

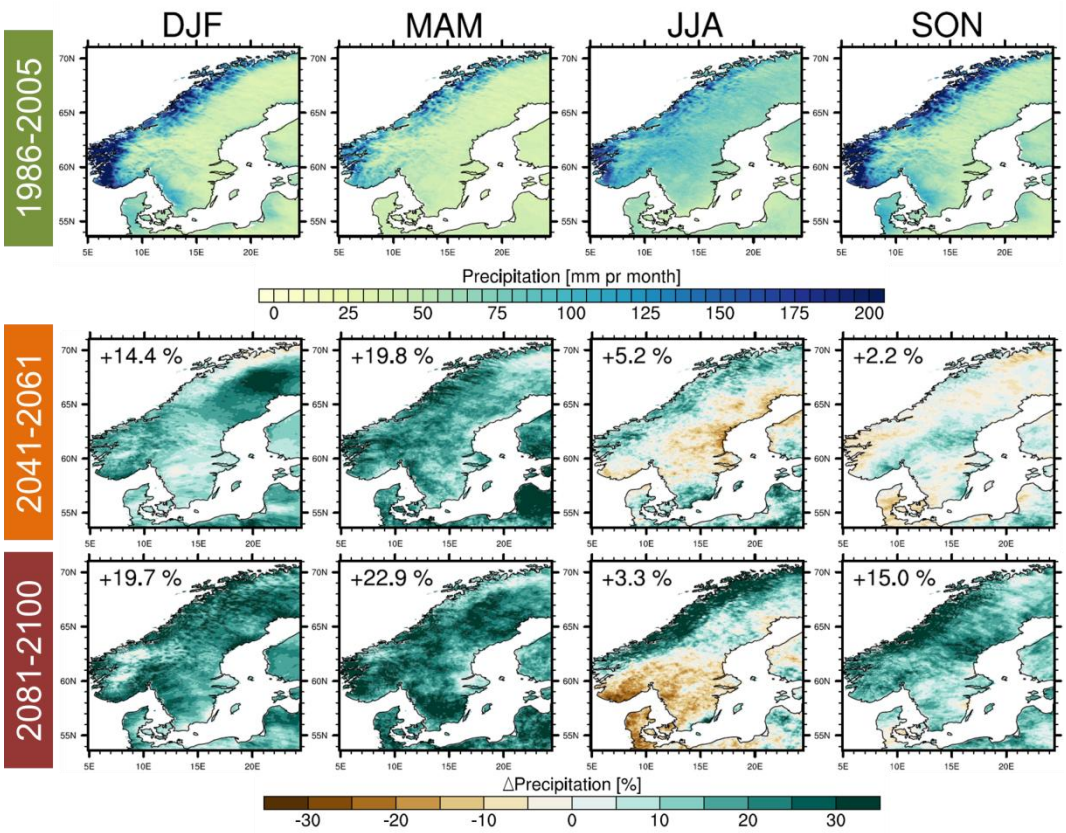

Figure 1 Seasonal precipitation: Relative changes (mid and lower rows) in the middle and late parts of the current century, as simulated by HCLIM following the RCP8.5 scenario down-scaled from the GCM EC-Earth, compared to the reference period (absolute values, top row). Numbers in the upper left corner of the panels show the domain-wide, area-weighted average.

References

Belušić, Danijel, Hylke de Vries, Andreas Dobler, Oskar Landgren, Petter Lind, David Lindstedt, Rasmus A. Pedersen, et al. "HCLIM38: A Flexible Regional Climate Model Applicable for Different Climate Zones from Coarse to Convection-Permitting Scales." *Geoscientific Model Development* 13, no. 3 (March 20, 2020): 1311–33. https://doi.org/10.5194/gmd-13-1311-2020.

van Vuuren, Detlef P., Jae Edmonds, Mikiko Kainuma, Keywan Riahi, Allison Thomson, Kathy Hibbard, George C. Hurtt, et al. "The Representative Concentration Pathways: An Overview." *Climatic Change* 109, no. 1–2 (November 2011): 5–31. https://doi.org/10.1007/s10584-011-0148-z.