REQUEST FOR A SPECIAL PROJECT 2018–2020

MEMBER STATE: NORWAY

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Project Title: Testing and developing the HARMONIE data assimilation system at MET Norway

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.)	2018	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2018-2020: (To make changes to an existing project please submit an amended version of the original form.)		**2018**	**2019**	**2020**
High Performance Computing Facility	(MSBU)	8	8	8
Accumulated data storage (total archive volume)[2]	(TB)	20	20	20

***An electronic copy of this form must be sent via e-mail to**:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date):

…………….30 June 2017……………

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 an annual progress report 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.

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Extended abstract

Introduction

For operational applications and pre-operational testing at the Norwegian Meteorological Institute (MET Norway) we use the supercomputer located in Trondheim. The ECMWF supercomputer is used apart of other applications for testing and development works, which are mainly based on the HARMONIE numerical weather prediction (NWP) system. From the HARMONIE system, MET Norway is exploiting the advantage of mesoscale limited area deterministic and ensemble prediction models (LAM and LAMEPS). The operational LAMEPS called MESP is operated together with Sweden and Finland, while the development of the system is done at each Institute. We also developed an operational Arctic LAM system called Aroem-Arctic (domains are shown on Fig 1.). Since both the systems have similar characteristics, including dimensions (grid points and vertical levels), dynamics, physics parametrisation and data assimilation (DA) components, the computing cost will be very similar. This project will be used to tackle different development activities related to data assimilation as follow.

Data assimilation activities at MET Norway

Activity 1: 5-year hindcast

Through an external project called RADPRO with hydrology and hydropower companies, we need to carry out a 5-year hindcast experiment using HARMONIE system for the METCOOP domain. In the RADPRO project we aim to develop 1) flow-dependent analysis system for our mesoscale NWP model HARMONIE-AROME, 2) optimized analysis of precipitation, 3) post-processed forecasts of precipitation, and 4) hydrological evaluation of precipitation products. This is a unique opportunity for the NWP group at MET Norway to collaborate closely with special users of our forecast in the field of renewable energy. The 5-year hindcast is valuable for the hydropower community so that they can validate and tune their operational hydrological models.

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- *Accumulated data storage 12 TB for 2018-2020*

Activity 2: B-matrix calculations

We are developing an operational NWP based nowcasting system which is of huge interest for aviation and wind-solar energy applications (*Auger etal., 2014)*. The core of this new system is HARMONIE-AROME, but the system will be updated every hour in a Rapid-Refresh mode where the first-guess are used from the operational MEPS system. To perform better than the MEPS system, the new system should be tuned for the very-short range weather forecast, i.e. 6-9 hours. The cost of running the HARMONIE every hour for the METCOOP domain is high which makes the testing of new methods very challenging. Of huge interest is the data assimilation part of the nowcast system where fresher but less observations are used in each cycle. We intend to test different components of the data assimilation system especially with new or combination of different seasonal B-Matrices. The latter will also be used in the RADPRO project where new B matrices will be calculated using the FULL-POS post-processing software instead of gl/gl_grib_api software. We plan to run at least 8 experiments of 20 days period in these activities.

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Activity 3: Improving the sea ice modelling

Assimilation of radiances and, in general, accurate forecasts over sub- and Arctic regions need careful handling of ice surface. Hence, focusing on sea ice modelling is of interest for us. The simple sea ice scheme implemented in SURFEX (SURFace Externalisée) allows the surface temperatures on the ice surface to evolve through the forecast and improves the near sea ice surface temperatures, but absence of ice dynamics and overall simplicity of the scheme reduces the possible positive impact. Remote-sensing data could be used to correct errors in the ice forecast, thus lead to improved representation of the ice surface temperature and surface boundary layer. The following tasks are planned: i) perform a feasibility study on assimilation of remote-sensing snow and ice surface temperature; ii) develop the initialization technique for ice state in Numerical Weather Prediction. We plan to perform at least 4 experiments of at least 20 days in this activity.

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Activity 4: Using more radiances

Polar satellite data are very important for accurate high-latitude analyses and forecasts. We have been working on microwave AMSU-A, AMSU-B/MHS and also IASI radiances assimilation. We have also shown that IASI radiances (both temperature and humidity sensitive) are very important for accurate forecast of polar lows (*Randriamampianina et al.*, 2011; *Randriamampianina et al.*, 2013). Since IASI radiances from MetOp satellites are not available over our model domains (both MetCoOp and Arctic) in the early morning assimilation times, from 00 to 06 UTC, we would like to check the availability of CrIS hyper-spectral infrared radiances to compensate this deficiency. We also would like to check the availability of other microwave data like and Advanced Technology Microwave Sounder (ATMS). We have very conservative solution for AMSU-A radiances assimilation in our operational system. When having the sea surface and sea ice temperatures improved (see Activity 3 description), we would like to check the assimilation of low peaking and surface sensitive channels from both infrared (IASI) and microwave (AMSU-A, ATMS) instruments. Concerning the radiance assimilation in general, we would like to account for the foot-print of each satellite instrument, as well as all-sky assimilation which is not yet available in the AROME assimilation scheme. We plan to perform at least 8 experiments of at least 20 days in this activity.

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Activity 5: Participation in OOPS code development

MET Norway is participating in the code re-factoring work initiated by ECMWF. Mainly we would like to contribute to the LAM-specific parts of OOPS and the re-factoring +part of the observation operators. So far our work with the OOPS system was mainly focused on the toy model framework. We hope that in this task we can developed a working LAM 3D- and 4D-VAR in the OOPS framework, which then need to be tested in the full AROME system. We don't know yet how many “long-run” experiments will be needed in this activity.

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Data and methods

HARMONIE shares the assimilation system with IFS/ARPEGE/ALADIN systems. MEPS and AROME-Arctic have 960x750 grid points guaranteeing a horizontal resolution of 2.5 km. The model domains are shown on Fig.1. Both systems have 65 vertical levels up to 10 hPa. We are considering to use two kinds of observational data. In order to mimic the operational system, for some of the experiments the locally collected and cut-off-dependent observations will be used. But, usually we use data from MARS for most of our experiments. The main idea behind the above mentioned rapid refresh system is that we would like to considerably reduce the production delay caused by mostly the cut-off time used in the operational RUC system. Reducing the cut-off time from 1 hour 15 minutes to only 15 minutes, and providing only up to 7 hours forecasts, we can reduce the production delay from 2 hours 20 minutes to roughly 1 hour. It's important to mention that in rapid refresh system, there is no cycling of the model first-guess, hence the freshest forecast is used as first-guess for the hourly analysis.

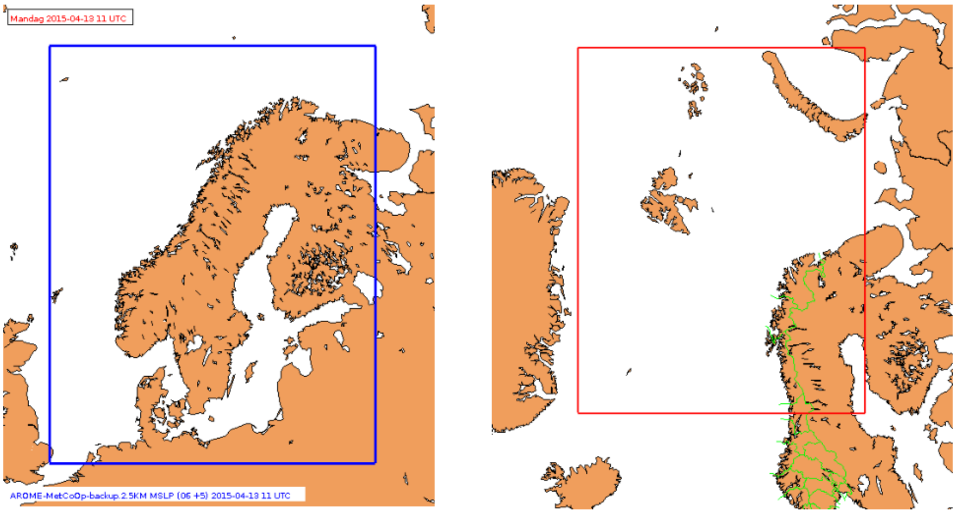

Figure 1. The MEPS (left) and Arome-Arctic (right) model domains

Resource requirements

Here is the HARMONIE resources requirement with the MEPS according to the latest available cycle (CY40). In the tested assimilation system, AMSU-A, AMSU-B/MHS and IASI radiances were used on top of conventional ones:

Task	High Performance Computing Facility (SBU)	Data storage capacity (total archive volume in gigabytes)
48 hours forecast without assimilation	14000	40
Assimilation and 3 hours forecast	850	26
Assimilation and 48 hours forecast	15500	44
RUC and two times 48 hours forecast per day	33100 / day	245 / day
One full experiment of 20 days	662000	4893
Doing two experiments per 5 activities	6620000	58714

References

Auger, L., Dupont, O., Hagelin, S., Brousseau, P. and Brovelli, P. (2015), AROME–NWC: a new nowcasting tool based on an operational mesoscale forecasting system. Q.J.R. Meteorol. Soc., 141: 1603–1611. doi:10.1002/qj.2463

Randriamampianina R, Iversen T, Storto A. 2011. Exploring the assimilation of IASI radiances in forecasting polar lows. *Q. J. R. Meteorol. Soc. 137, pp. 1674–1687*

Randriamampianina R, M Mile and H Schyberg, 2013: The IASI moisture channel impact study in HARMONIE. MET report. 20/2013, available at http://met.no/Forskning/Publikasjoner/MET_report/