REQUEST FOR A SPECIAL PROJECT 2016–2018

MEMBER STATE: ……**Norway**……………………………………………………………..…

Principal Investigator[1]**:** ……**Roger Randriamampianina** ……………………………….……

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Other researchers:

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Project Title:

…**Testing and developing the HARMONIE data assimilation system at MET Norway**………………………………………….……
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If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** __________________	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	**2016**	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2016-2018: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2018.)	**2016**	**2017**	**2018**
High Performance Computing Facility (MSBU)	15	15	15
Data storage capacity (total archive volume) (Tbytes)	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):

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Continue overleaf

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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.

Principal Investigator: …**Roger Randriamampianina**……………………………………

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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 LAM called MetCoOp is operated together with Sweden, while the development of the system is done at each Institute. We also developed an Arctic LAM system (domains are shown on Fig 1.), which we intend to use in operational regime very soon. 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: *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. While the advanced microwave radiances from NOAA and MetOp satellites are already in operational use, the IASI radiances are in the pre-operational system during the period of application (June 2015). 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) 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. We do not assimilate the channels 5 and 10, although the model top is 10 hPa. When having the sea surface and sea ice temperatures improved (*see Activity 4 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, which is not yet available in the IFS/ARPEGE/AROME assimilation scheme.

We plan to perform at least 6 experiments of at least 20 days in this activity.

Activity 2: ***Assimilation of radar data***

From 17th of June 2015, the reflectivity data from Norwegian an Swedish meteorological radars are assimilated in our operational system. We have started to look at the efficiency of the quality flags associated to the reflectivity and radial wind in radar data from Norwegian sites. Our preliminary monitoring results show differences between the rainy-flagged data and "clear echo"-flagged data, for example. The same for partially-blocked- and clutter-flagged data. Interaction between radar processing colleagues and NWP developers is indispensable to further improve the radar data flagging technique. This collaboration work will start in the second part of the year 2015, which probably continue in the following years. From 2016 we also would like to work on two different systems: i) assimilation of radar data in a rapid refresh (see below some details) and 1 hour cycling DA and ii) assimilation of radar data in four-dimentional variational (ex. 3D-FGAT, 4D-VAR, or 4DEnsVAR) DA system.

We plan to perform at least 4 experiments of at least 20 days in this activity.

Activity 3: ***Assimilation of scatterometer winds***

Scatterometer winds have a potential to improve forecasting of rapidly developing storms. The work towards operational utilization of Advanced Scatterometer (ASCAT) A/B winds has started within a EUMETSAT fellowship project (*Valkonen and Schyberg,* 2015).

We have found several challenges related to the assimilation of ASCAT winds in the HARMONIE system. The settings regarding the use of ASCAT winds, inherited from the ARPEGE global model, are not believed to be optimal over a limited area in high latitudes. We have found issues related to observation errors, thinning and data rejection. In addition, the difference between the observation and model analysis times affects the success of the ambiguity removal, and limits the impact of ASCAT winds in the 3D-VAR system.

Further experimentation in different cases is needed to ensure the best possible approach for operational usage of ASCAT data in the 3D-VAR system. Later, we hope to work with a flow dependent system (4D-VAR) also with scatterometer wind data.

We plan to perform at least 4 experiments of at least 20 days in this activity.

Activity 4: ***Assimilation of atmospheric motion vectors (AMV) data***

We have recently seen progress in international research which has lead to improved AMVs and new products from recent satellite programs (*Forsythe et al., 2014)*. There are now products with better horizontal resolution and in addition novel AMV products from polar orbiting satellites which have increased the coverage at high latitudes dramatically. There has also been an evolution in the ground infrastructure and processing, giving a potential for faster delivery well suited for our purposes in LAM rapid refresh scheme and rapid update cycling (RUC). There is reason to believe that there is a significant potential for benefit from assimilating these data in our regional numerical weather prediction (NWP) system for application both in RUC over a Nordic area and over an Arctic domain.

For more flexibility of testing different types/quality of data, we have set up a local AMV processing package for the geostationary Meteosat satellite. It seems that there is no stand alone processing package developed for polar-orbiting satellites, but we aim at purchasing such a package with the hope to reduce the long latency, which these data do have today.

We plan to perform at least 4 experiments of at least 20 days in this activity.

Activity 5: ***Participation in OOPS code development***

MET Norway has decided to participate 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 of 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.

Activity 6: ***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. Implementation of a simple sea ice scheme in SURFEX (SURFace Externalisée) will allow the surface temperatures on the ice surface to evolve through the forecast and improve the near sea ice surface temperatures, and thereby also improve the modelling of the stable boundary layer. The introduction of fractional sea ice cover in SURFEX will give the possibility to use ice concentration data of higher resolution and potentially better quality than currently achieved from ECMWF (using OSTIA SST). The following tasks are planned: i) improve the simple sea ice scheme by including snow layers on top of the ice; ii) include features from HIGHTSI in the simple sea ice scheme or HIGHTSI in SURFEX; iii) consider the use of satellite data, e.g. sea ice thickness and sea ice surface temperature.

We plan to perform at least 6 experiments of at least 20 days in this activity.

Data and methods

HARMONIE shares the assimilation system with IFS/ARPEGE/ALADIN systems.

AROME-MetCoOp 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.

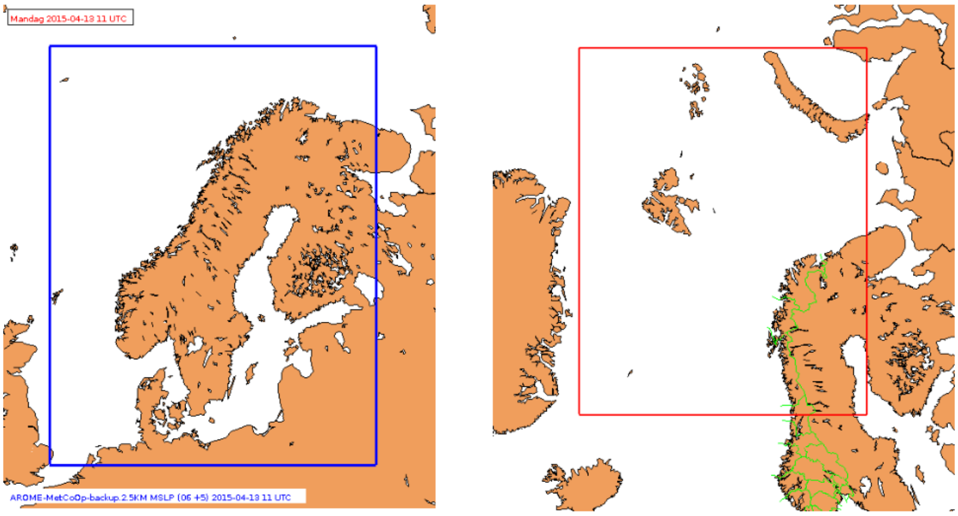

Figure 1. The AROME-MetCoOp (left) and AROME-Arctic (right) model domains.

Resource requirements

Here is the HARMONIE resources requirement with the AROME-MetCoOP 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	35100 / day	245 / day
One full experiment of 20 days	702200	4893
Doing two experiments per (6) activities	8424000	58714

References

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