LATE REQUEST FOR A SPECIAL PROJECT 2020–2022

MEMBER STATE: Portugal..

Principal Investigator[1]: Isabel Monteiro..

Affiliation: IPMA - Instituto Português do Mar e da Atmosfera..........................

Address: Rua C ao Aeroporto, 1749-077 – Lisboa

Portugal ....

Other researchers: Vanda Costa (IPMA), Gert-Jan Marseille (KNMI), Jan Barkmeijer (KNMI) and Ad Stoffelen (KNMI)..

Project Title: HARMONIE-AROME improved data assimilations of scatterometer winds...

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** _______________	
Starting year:	2020	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for the years: (To make changes to an existing project please submit an amended version of the original form.)		**2020**	**2021**	**2022**
High Performance Computing Facility	(SBU)	1 310 000	2 170 000	723 000
Accumulated data storage (total archive volume)[2]	(GB)	96 700	260 700	314 700

Continue overleaf

.

Principal Investigator: Isabel Monteiro……………………………………………………

Project Title: HARMONIE-AROME improved data assimilations of scatterometer winds ………………………………………………………

Extended abstract

Background

The Portuguese Institute for the Sea and Atmosphere (IPMA), is testing the use of scatterometer winds in its local configuration of HARMONIE-AROME Data Assimilation (DA) system. For domains with large portions covered by ocean the use of scatterometer winds has proven to be beneficial. Nevertheless, optimal use of these observations in mesoscale models remains a challenge and strategies to effectively use them needs investigation. To address this need, IPMA and the Royal Netherlands Meteorological Institute (KNMI) are collaborating in the framework of the 2-years EUMETSAT funded project MIDAS - Mesoscale Improved Data Assimilation of Scatterometer winds (MIDAS).

HARMONIE-AROME mesoscale model

HARMONIE-AROME is a non-hydrostatic convection-permitting model developed in a cooperation between Météo-France and the ALADIN-HIRLAM consortium. A detailed description of the HARMONIE-AROME forecast model setup can be found in http://www.hirlam.org, Gustafsson et al. (2018) and Bengtsson et al. (2017). At IPMA, the HARMONIE-AROME is running pre-operationally for a domain over the Iberian Peninsula displayed in Figure 1. The model has a 2.5 km grid size and 65 levels with model top at 10 hPa (~26 km) and the lowest model level around 12 m. Lateral boundary conditions are obtained from the global ECMWF HRES forecasts. Background error statistics, also denoted B-Matrix, were obtained by downscaling forecasts from the ECMWF ensemble DA system and applying the HARMONIE configuration of the AROME forecast model. The conventional observations assimilated into the system are surface observations from synoptic stations, ships, and drifting buoys, and upper air observations from radiosondes and aircraft reports. In IPMA’s local implementation the observation usage for upper-air DA includes ASCAT winds. The system currently uses 3D-Var. To partially overcome the lack of the temporal dimension, this scheme is used in a forward intermittent cycle (3 h).

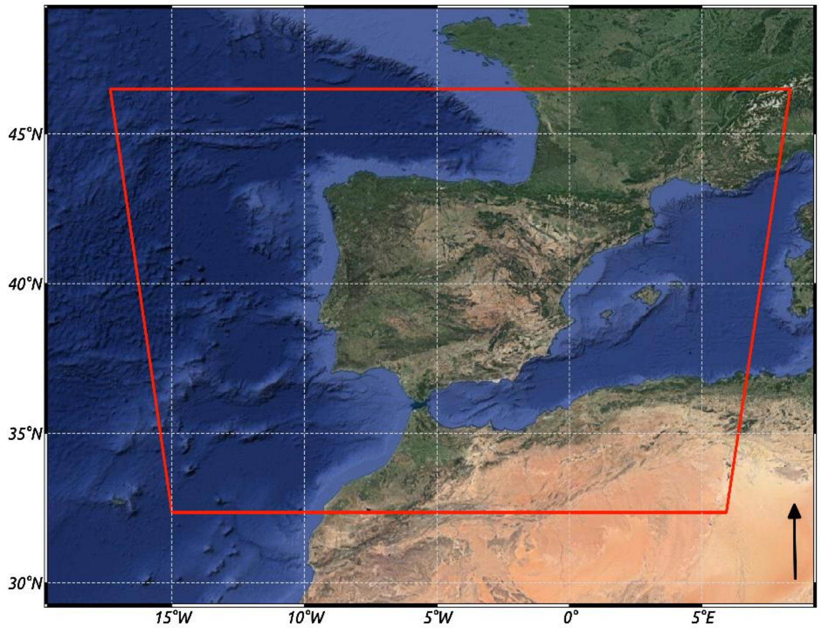

Figure 1 - HARMONIE-AROME mesoscale model domain centred at 40 degrees latitude and -4.5 degrees longitude. Composed of 648x800 grid points with a grid size of 2.5 km, covering a 1620kmx2000km area.

Ocean Winds from scatterometers

Space-borne scatterometers regularly provide a large number of measurements in regions where other wind observations are scarce. The Advanced Scatterometer (ASCAT) is the EUMETSAT C-band (rain insensitive) scatterometer on-board the Metop-A, Metop-B and Metop-C satellites, which were launched into a sun-synchronous orbit in October 2006, September 2012 and November 2018 respectively. The 3-satellite constellation offers, since the launch of Metop-C, close to 100% coverage of the seas around 09:30 Local Time of Descending Node (LTDN) and 21:30 Local Time of Ascending Node (LTAN). Several other scatterometers from international agencies ensure overpasses near 06:00 and 12:00 (LTDN), and 18:00 and 00:00 (LTAN). Namely, the Chinese-French Ocean SATellite (CFOSAT) around 07:00 LTDN /19:00 LTAN, the Chinese HY-2A/B at 06:00 LTDN /18:00 LTAN, are already successfully launched as was the Indian scatterometer OSCAT-2 in September 2016 at 9:30 LTDN /21:30 LTAN and drifting slowly. The Indian OSCAT-3 at 12:00 LTDN /00:00 LTAN winds are planned for late 2020, as well as the Chinese FY2E WindRad at 06:00 LTDN /18:00 LTAN and HY-2C in a slightly inclined and therefore drifting orbit.

Strategy for scatterometer ocean winds DA in HARMONIE-AROME

Several weather forecasting centres assimilate scatterometer winds in their global NWP models successfully, inter alia, ECMWF De Chiara et al. (2018); Météo France Payan (2017); and UK Met. Office Cotton (2013). For limited area models, positive impacts have been reported from high-resolution version of the Unified Model, referred to as the UKV Cotton (2014) and from HARMONIE-AROME Valkonen et al. (2016), Marseille and Stoffelen (2017) and Monteiro and Marseille (2018). Nevertheless, the success of scatterometer DA in global models is not yet reproduced in mesoscale models. HARMONIE-AROME default settings for the use of ASCAT winds are inherit from Météo France and ECMWF global models. However, several differences distinguish HARMONIE-AROME (and Limited Area Models in general) from global models. Over the ocean, global models do not resolve scales typically below 100-150 km (Stoffelen et al., 2018), whereas HARMONIE-AROME has an effective spatial resolution of 15-25 km (Marseille and Stoffelen, 2017). On the other hand, ASCAT-coastal product has an effective resolution of 28 km, substantially higher than the effective resolution of global models, but slightly smaller than the HARMONIE-AROME resolution. Ignoring the observation footprint, and treating ASCAT winds as point observations can be an acceptable strategy in global models, but it is not adequate in HARMONIE-AROME. Another weakness of the current use of scatterometer winds in HARMONIE-AROME is the time mismatch between observations and analysis time. Currently, in HARMONIE-AROME 3D-Var implementation assumes that all observations are taken at analysis time, introducing a substantial time shift for asynoptic observations. For scatterometer winds over the Atlantic, Marseille and Stoffelen (2017) shown that the time shift is in the order of 0.7-1 hour on average, depending on the satellite orbit, for a 3-hour assimilation window. Ignoring such time shift increases the innovation standard deviation by up to 33%. This major limitation will be overcome using 4D-Var as this data assimilation algorithm is capable of ingesting the observations at the measurement time. The development of 4D-Var, as described by Gustafsson et al. (2018) and Courtier et al. (1994), is far advanced in HARMONIE-AROME and will be used in our study. It allows for a multi outer-loop approach with several choices for the inner-loop grid resolution. In this way the extra computational costs for 4D-Var as compared to 3D-Var can be kept under control.

Project Plan

During the proposed special project, the following activities are planned:

1) Prepare the HARMONIE-AROME 4D-Var data assimilation system

- Prepare the interface and code for adding different scatterometers observations in the assimilation system.
- Prepare different settings for running HARMONIE-AROME 4D-Var for a domain over the Iberian Peninsula.
- Test the B-Matrix and revisit its computation if needed.
- Tune settings for scatterometer use in the DA system.
- Perform single observation experiments to infer the validity of the scatterometer implementation in 4D-Var.

2) Perform Observation System Experiments and evaluate the different options on scatterometer use in HARMONIE-AROME 4D-Var system.

- Assess the differences of using a 3rd ASCAT in the observation system taking the opportunity of 3 operational Metops on orbit during the project time frame.
- Assess the improved temporal coverage, HY-2A/B, OSCAT-2, OSCAT-3 and CFOSAT.
- Test different approaches of data thinning, superobbing (averaging in observation space) and supermodding (averaging in model space)
- Assess the HARMONIE-AROME 4D-Var approach for different weather conditions.

Benefits of the Project

4D-Var operational feasibility tests are ongoing in different NWP centres using HARMONIE-AROME, anticipating its operational implementation for soon. The study of optimal strategies to use scatterometer winds in this context may lead to improvements in the operational weather forecasts in different NMS. In addition, lessons learned from this study might contribute to well-defined scatterometer winds user requirements from the LAM NWP community and therefore to the future transition to Metop-SG.

Justification of computational resources

Considering the Project Plan described earlier, HARMONIE-AROME 4D-Var computer requirements for the 648X800 grid domain showed in Figure 1, for each year of the project can be summarized as follows:

2020: We will run mostly test experiments. During this first year we are considering to run at least 10 experiments. Part of the experiments will be designed to tune 4D-Var settings, about 7 experiments of 14 days with 3-h forecasts, to determine optimal configurations of HARMONIE-AROME 4D-Var. The remaining experiments will be designed to test the selected optimal configurations, about 3 experiments of 21 days with 30-h forecasts and 1 experiment of 90 days with 30-h forecasts.

2021: Based on the outcomes of the test experiments we expect to perform 4 experiments of 90 days with 30-h forecasts, to test different approaches of scatterometer data in the HARMONIE-AROME 4D-Var system.

2022: Based on the results obtained in the previous years we expect to perform full experiments of 180/90 days with 30-h forecasts, to evaluate different 4D-Var configuration**.**

The computer resources for the project are summarized in Table 1.

Table 1 – Summary of project main tasks and computer resources required.

Task	**High Performance Computing Facility (SBU)**	**Data storage capacity - total archive volume (GB)**
Compilation of full source code package	250	--
Compilation of modified source code	4300	---
7 experiments, 4D-Var with 8 assimilation cycles of 14 days and 3h forecasts	78772	3773
3 experiments, 4D-Var with 8 assimilation cycles of 21 days and 30h forecasts	506394	38279
5 experiments, 4D-Var with 8 assimilation cycles of 90 days and 30h forecasts	3617103	273422
Total	**4206820**	**315454**

References

Bengtsson, L., U. Andrae, T. Aspelien, Y. Batrak, J. Calvo, W. de Rooy, E. Gleeson, B. Hansen-Sass, M. Homleid, M. Hortal, K. Ivarsson, G. Lenderink, S. Niemelä, K.P. Nielsen, J. Onvlee, L. Rontu, P. Samuelsson, D.S. Muñoz, A. Subias, S. Tijm, V. Toll, X. Yang, and M.Ø. Køltzow, 2017: The HARMONIE–AROME Model Configuration in the ALADIN– HIRLAM NWP System. Mon. Wea. Rev., 145, 1919–1935, https://doi.org/10.1175/MWR-D16-0417.1

Cotton, J.,"Assessment of ASCAT coastal wind products in the UKV," Satellite Appl. Tech. Memo No. 23, Met Office, 2014

Cotton, J. "The impact of ASCAT winds from Metop-B and a new scatterometer thinning scheme," Met Office, Exeter, U.K., Forecasting Res. Tech. Rep. 580, 2013. [Online]. Available: http://www.metoffice.gov.uk/learning/library/publications/

Courtier, P., Thépaut J-N, Hollingsworth A. 1994. A strategy for operational implementation of 4D-Var, using an incremental approach. Q. J. R. Meteorol. Soc.120: 1367 – 1387.

De Chiara, G., W. Lin, M. Portabella and A. Stoffelen, "Assessment of new ASCAT wind products for assimilation in global NWP" EUMETSAT Conference 17-21 September 2018, Tallin. [Online]. Available: https://www.eumetsat.int

Gustafsson, N. , T. Janjic, C. Schraff, D. Leuenberger, M. Weissmann, H. Reich, P. Brousseau, T. Montmerle, E. Wattrelot, A. Bucanek, M. Mile, R. Hamdi, M. Lindskog, J. Barkmeijer, M. Dahlbom, B. Macpherson, S. Ballard, G. Inverarity, J.b Carley, C. Alexander, D. Dowell, S. Liu, Y. Ikutao and T. Fujitao, "Survey of data assimilation methods for convective-scale numerical weather prediction at operational centres" ,Q. J. R. Meteorol. Soc. (2018) DOI:10.1002/qj.3179

Marseille, G.J. and A. Stoffelen, "Toward Scatterometer Winds Assimilation in the Mesoscale HARMONIE Model," IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens., 10 (5), 2017.

Monteiro, I. and G.J. Marseille, 2018. Scatterometer Assimilation Experiments with HARMONIE-AROME Mesoscale Model over south-western Europe. EUMETSAT Meteorological Satellite Conference, 17-21 September 2018. [Online]. Available: https://www.eumetsat.int/website/home/News/ConferencesandEvents/PreviousEvents/index.html?Y=all

Payan, C. "The satellite winds in the operational NWP system at Météo-France" in Proc. 13th Int. Winds Workshop, California 26 Jun – 1 Jul 2017. [Online]

http://cimss.ssec.wisc.edu/iwwg/iww13/talks/02_Tuesday/1600_IWW13_MeteoFrance_Payan.pdf

Stoffelen, A., J. Vogelzang and Gert-Jan Marseille, "High resolution data assimilation guide", Doc ID: NWPSAF-KN-UD-008. Version: 1.2 Date : 10-09-2018

Valkonen, T., H. Schyberg, and J. Figa-Saldaña, Assimilating Advanced Scatterometer Winds in a High-Resolution Limited Area Model Over Northern Europe. IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens., 2016.