SPECIAL PROJECT PROGRESS REPORT

Reporting year	2021
Project Title:	HARMONIE-AROME improved data assimilations of scatterometer winds
Computer Project Account:	spptmont
Principal Investigator(s):	Isabel Monteiro
Affiliation:	IPMA
Name of ECMWF scientist(s) collaborating to the project (if applicable)	
Start date of the project:	01/04/2020
Expected end date:	31/12/2022

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)	1 310 000	599 455 (45%)	2 170 000	0
Data storage capacity	(Gbytes)	96 700	NA	NA	NA

Summary of project objectives

HARMONIE-AROME 4D-Var operational feasibility tests are ongoing in different NWP centres anticipating its operational implementation for soon. Our goal is to investigate optimal strategies to use scatterometer winds with a focus on HARMONIE-AROME latest developments in 4D-Var.

Summary of problems encountered

The project started in April 2020, so far no critical problems were found……...

Summary of plans for the continuation of the project

This year, experiments focus on optimizing 4D-Var performance. The following year will be dedicated to run long experiments and run forecast verification.……..……

List of publications/reports from the project with complete references

No publications yet.……

Summary of results

1) 4D-Var data assimilation setup

The HARMONIE-AROME setup used in this study is the default CY43 HARMONIE-AROME 4D-Var configuration. It has two outer loops at 6 and 3 times the forecast grid resolution of 2.5 km, respectively 15 km and 7.5 km. The outer loop resolution is a trade-off between the computational cost of the minimization and the number of iterations needed in the minimization to reach a satisfactory level of convergence. The choice of 6 and 3 times the forecast grid resolution for the two outer loops was found to be a good compromise. For detailed discussion of HARMONIE-AROME 4D-Var setup the reader is referred to [Barkmeijer et al., 2021]. HARMONIE-AROME 4D-Var has the option between a 2-hour and a 3-hour window for the observations to be used in DA. In the 2-hour window configuration, the analysis, at time HH, is in the centre of the observations window, between HH-60min and HH+60min. Conversely, the 3-hours configuration has a window from HH-120 min to HH+60 min and the analysis, HH, is no longer in the centre. Observations are sorted into ten time-slots sub-dividing the window in 10 min intervals at the beginning and the end and 20 min otherwise. When a 3-hourly cycling is used in a 2-hours window setup, observations between HH-120 min and HH-60min, and between HH+60 min and HH+120 min are not used. The 3-hours window, on the other hand, enables the use of ASCAT observations from all Metop passes over the domain.

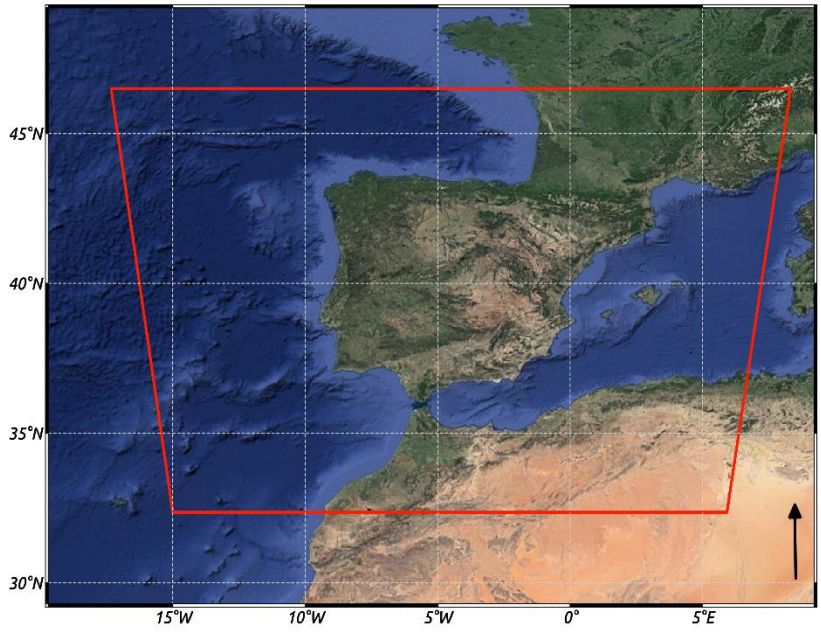

Figure 1 - HARMONIE-AROME mesoscale model domain centred at 40 degrees latitude and -4.5 degrees longitude. Composed of 648x800 grid points with a grid size of 2.5 km, covering a 1620kmx2000km area.

2) Experimental design

To evaluate the different settings for HARMONIE-AROME 4D-Var, experiments were carried out for the two observation window options. This evaluation is performed investigating the forecast impact of each 4D-Var setup and performing analysis diagnostics. A twin experiment using 3D-Var was carried out to assess the overall benefit of 4D-Var. Three experiments were conducted covering a period from 07 February to 25 March 2020, a 7-days warm-up period was applied to spin-up surface fields. Observations used in the three experiments comprise all conventional observations and ASCAT winds on-board the 3 Metop satellites. The experimental design is summarized in Table 1

Table 1 – Experiments configuration and observing systems considered

Main settings	3D-Var	4D-Var-2-hour window	4D-Var-3-hour window
Observing system	Radiosondes; Aircraft reports; Synop stations; Drifting buoys ASCAT-A/B/C winds	Radiosondes; Aircraft reports; Synop stations; Drifting buoys ASCAT-A/B/C winds	Radiosondes; Aircraft reports; Synop stations; Drifting buoys ASCAT-A/B/C winds
Observation window	3-hour	2-hour	3-hour
Period	07 Feb- 25 Mar	07 Feb- 25 Mar	07 Feb- 25 Mar

3) Preliminary results.

3.1. Use of observations

Figure 2 shows, for 1 March 2020 at 0900 UTC and 1200 UTC analysis, the number of ASCAT observations used in the 3D-Var and in the two 4D-Var configurations. It clearly highlights the 4D-Var-2-hours window caveat described below. In fact, ASCAT winds between 1000 UTC - 1100UTC (and 2200 UTC – 2300 UTC) are not considered in the assimilation, hence reducing data coverage substantially.

Figure 2 - For 1 March 2020 ASCAT winds use in 3D-Var (left); 4D-Var 2-hour window assimilation window (centre) and 4D-Var 3-hour window (right) configurations, at analysis time at 0900 UTC analysis (upper panels) and 12 UTC analysis (lower panels) 1200 UTC

3.2. Verification

Comparison between 3D-Var and the 4D-Var configurations, was performed over the ocean and over land. Over the ocean, independent wind data from ScatSat were used as reference. It should be noted that this scatterometer has approximately the same overpassing time as the 3 ASCATs, i.e., 0845 LTDN, which translates to around 0900/1200 UTC and 2100/2200 UTC, thus scores obtained are only valid at those times. Over land, comparisons were performed against synop observations in Portugal and Spain. Shown in Figure 3 are the verification statistics,10-m wind speed root mean square error (RMSE), over the ocean and over land.

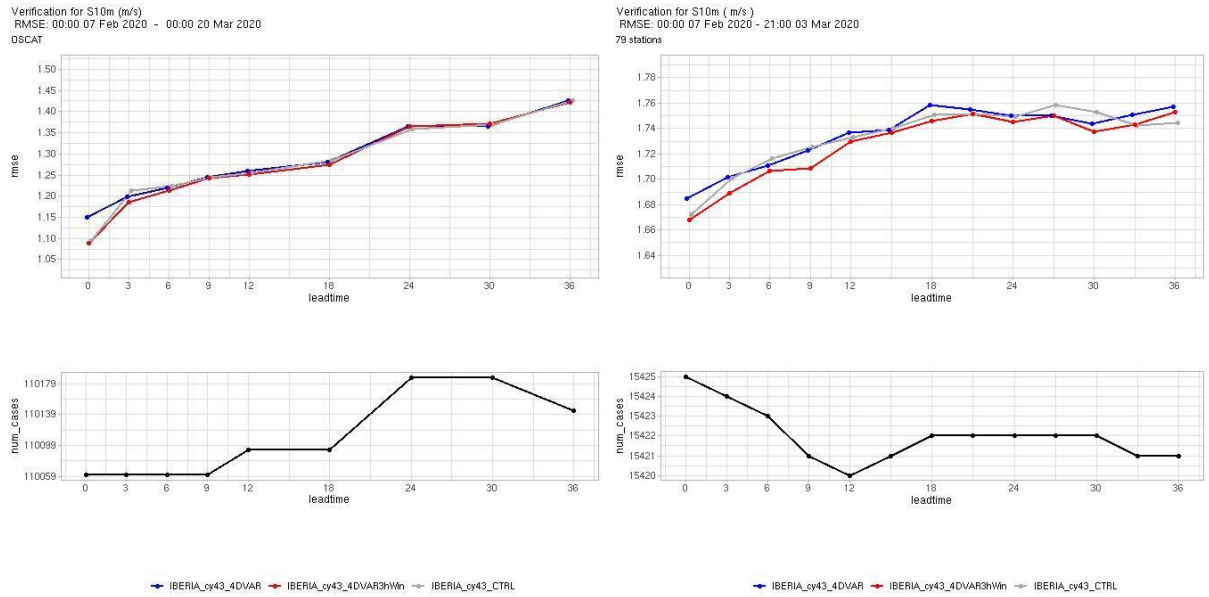

Figure 3 – Upper panel: 10-m wind speed forecast minus observation minus (f-o) root mean square errors (RMSE), over the ocean (left) and over land (right). Forecast (f) is obtained through spatial interpolation to the observation (o) location and measurement time. In a 3D-Var configuration (grey); 4D-Var 2 hour observation window (blue); and 4D-Var 3-hour observation window DA (red). Lower panel shows the number of observations used to compute the statistics. Over the ocean the verification period is from 7 February to 20 March 2020 and over land form 7 February to 3 March 2020.

Over land, 4D-Var-3hours improves statistics for all lead times. 4D-Var-2hours and 3D-Var have similar performance. In verification against 2m temperature and 2 m specific humidity (not shown), 4D-Var configurations performed slightly worse than 3D-Var. Over the ocean, 4D-Var-3hours outperforms 3-Var specially for short lead times. The ocean part of the domain has poor insitu observations coverage. Therefore, since ASCAT winds are the only satellite data taken in our experiments the sensitivity to the number of observations used in DA is a likely explanation for the poor performance of 4D-Var-2hours for short lead times.

References

Barkmeijer, J., M. Lindskog, N. Gustafsson, J. Bojarova, R. Azad, I. Monteiro, P. Escribà, E. Whelan, M. Ridal, J. Sánchez Arriola, O. Vignes, Roel Stappers. 2021 HARMONIE-AROME 4D-Var. ALADIN-HIRLAM newsletter nº16. http://www.umr-cnrm.fr/aladin/IMG/pdf/nl16.pdf

Courtier, P., Thépaut, J.-N. and Hollingsworth, A., 1994. A strategy for operational implementation of 4D-Var using an incremental approach. Quart. J. Roy. Meteorol. Soc., 120, 1367-1388.