REQUEST FOR A SPECIAL PROJECT 2019–2021

MEMBER STATE: SPAIN

Principal Investigator[1]**:** Marcos Portabella Arnús

Affiliation: Institute of Marine Sciences (ICM-CSIC)

Address: Passeig Marítim de la Barceloneta 37-49

08003 Barcelona

Spain

Other researchers: Isabel Monteiro (IPMA), Javier Calvo (AEMET), Ad Stoffelen (KNMI), Gert-Jan Marseille (KNMI)

Project Title: On the 4-D Consistency of Satellite Wind Products for Regional NWP Data Assimilation (WIND-4D)

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports 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 etc.

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.)	2019
Would you accept support for 1 year only, if necessary?	YES ☐ NO ☒

Computer resources required for 2019-2021: (To make changes to an existing project please submit an amended version of the original form.)		**2019**	**2020**	**2021**
High Performance Computing Facility	(MSBU)	2.5	10	10
Accumulated data storage (total archive volume)[2]	(TB)	2	10	18

Continue overleaf

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Extended abstract

The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used.

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF as well as the Scientific and Technical Advisory Committees. The evaluation of the requests is based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, disciplinary relevance, and justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

Requests asking for 1,000,000 SBUs or more should be more detailed (3-5 pages). Large requests asking for 10,000,000 SBUs or more will receive a detailed review by members of the Scientific Advisory Committee.

The resolution of regional numerical weather prediction (NWP) models has continuously been increased over the past decades, in part, thanks to the improved computational capabilities. At such small scales, the fast weather evolution is driven by wind rather than by temperature and pressure. Over the ocean, where global NWP models are not able to resolve wind scales below 150 km, regional models provide wind dynamics and variance equivalent to 25 km or lower. However, although this variance is realistic, it often results in spurious circulation (e.g., moist convection systems), thus misleading weather forecasts and interpretation. An accurate and consistent initialization of the evolution of the 3-dimensional (3-D) wind structure is therefore essential in regional weather analysis. The research fellow would focus on a comprehensive characterization of the spatial scales and measurement errors for the different operational space-borne wind products currently used and/or planned to be used in regional models. In addition, the fellow would thoroughly investigate and improve the 4-D (including time) consistency between the different horizontal and/or vertical satellite wind products under study. Such products include OSI SAF scatterometer-derived sea-surface wind fields, NWC SAF Atmospheric Motion Vectors (AMVs), the upcoming ADM-Aeolus and/or IASI wind profiles. Densely sampled aircraft wind profiles (Mode-S) will be used to verify and characterize the satellite products. To this end, the experience of the NWC, OSI, and NWP SAFs will be exploited. Moreover, data assimilation experiments of the consistent datasets into the Harmonie-AROME regional model will be carried out in two different regions, i.e., the Netherlands and the Iberian Peninsula regional configurations.

Scientific Rationale

The non-hydrostatic convection permitting Harmonie-AROME regional NWP model is a joint effort of the HiRLAM and ALADIN consortia, which builds upon model components that have largely initially been developed in these two communities [1]. At this stage, a 3D-Var data assimilation (DA) scheme is currently being used [2] although there are plans to transition to 4D-Var in the near future. While satellite wind information has been successfully assimilated in global (hydrostatic) models, it is more challenging to assimilate in regional (non-hydrostatic), which use small grid sizes and explicitly resolve atmospheric convective processes that evolve more rapidly and on much smaller spatial scales than those resolved by global models [2]. While regional models can resolve realistic mesoscale wind variance, they often result in spurious circulation, e.g., in moist convection systems, therefore misleading short-range weather forecasts and interpretation (see presentations in http://meteo.fmf.uni-lj.si/en/workshop). The correct initialization of small-scale weather phenomena requires a dense network of observations in all four dimensions, in particular for wind observations. Accounting for the different satellite instrument footprints in data assimilation rather than considering them as point measurements has been shown to improve mesoscale deterministic analysis [2].

This 3-year Eumetsat-funded project, i.e, WIND-4D (2019-2021), aims at thoroughly characterizing the spatial scales and errors of the different satellite wind observations that are fed into Harmonie-AROME. Moreover, it will benefit from the upcoming 4D-Var DA scheme in order to analyze and improve the spatial and temporal (4-D) consistency of these observations, with the ultimate goal of improving wind data assimilation into regional NWP models.

The project will interact with and build upon a number of planned synergistic European research activities, aimed at providing, on the one hand, an interpretation and error attribution of the different satellite wind products, i.e., scatterometer [3, 4], AMV [5, 6], the upcoming ADM-Aeolus [7] and/or IASI [8], and on the other hand, an improved 4-D consistency of these observation for improved mesoscale analyses purposes. To this end, tools and techniques developed within the EUMETSAT SAFs and the HiRLAM/ALADIN community would be exploited by the fellow.

Benefits to the user community

Consistent and well-characterized 4-D winds are of outmost importance for regional NWP data assimilation. In particular, KNMI, IPMA, and other HiRLAM partners will benefit from assimilating the consistent wind datasets into Harmonie-AROME over their own regional configurations. Moreover, both the well-characterized NRT wind products (with relevant information on scales and errors) and the regional model output can be used for nowcasting purposes.

Besides the operational community, a wide variety of users/applications can benefit from the mentioned products and NWP output in both open sea, ocean and coastal areas, including, energy applications, off-shore activities, coastal infrastructure, trade, fisheries, search and rescue, recreational boats, tourism, etc. In addition, a wide scientific community interested in atmospheric, ocean, and regional climate studies is expected to benefit from these data/output.

Work plan

[Note that the underlined bullets below are related to the use of ECMWF computing facilities]

Year 1

- Development of the matchup database
- Assessment of the spatial scales and measurement errors assessment of the different wind products
- <u>Preliminary Harmonie 3D-VAR/4D-VAR experiments</u>.

Year 2

- <u>Development of the model-based tools to characterize the spatial consistency of the different wind products</u>;
- <u>Comprehensive analysis of the 4-D wind structure used in regional NWP wind data assimilation</u>;
- <u>Improvement of the dynamical consistency of assimilated winds by using the Harmonie-AROME 3D-VAR/4D-VAR approach</u>.

Year 3

- <u>Impact tests in Harmonie-AROME</u>.

Scientific Expertise

The satellite winds group at ICM has over 20 years of experience in quantitative retrieval, assimilation and validation of winds, e.g., [10-12]. Furthermore, the group is currently involved in the development of high-resolution ocean-forcing products, GNSS-R and SAR wind retrievals, and the development of extreme-wind capabilities for C-band scatterometry, through various national and international projects. The group is also represented in the

ESA/EUMETSAT SCA Science Advisory Group, the International Ocean Vector Winds Science Team (IOVWST), and the Steering Committee of the Barcelona Expert Centre (BEC) on remote sensing.

The satellite winds group has established a strong collaboration with KNMI through the OSI and NWP SAF VS/AS schemes over the last 10 years, with a particular focus on scatterometer wind inversion, QC, and the improvement of the scatterometer observation operator for global NWP [13]. Also, the group has recently started collaboration with The Spanish Meteorological Centre (AEMET) on ASCAT and AMVs intercomparison through the NWC SAF VS/AS scheme. Furthermore, AEMET, the Dutch (KNMI) and the Portuguese (IPMA) meteorological Centres have recently started collaborating on the assimilation of satellite winds into the Harmonie-AROME over the Iberian Peninsula domain [14].

Justification of the computer resources requested

Through the WIND-4D project, ICM-CSIC, in collaboration with AEMET, KNMI and IPMA, aims to improve regional NWP initialization by: 1) Developing a matchup database of the different satellite and aircraft wind data, together with NWP model output, and in situ wind data; 2) Performing multiple triple collocations analyses to characterize the spatial scales and measurement errors of the different wind datasets; and 3) Analysing and improving the spatial and temporal consistency of the overall 4-D wind fields for improved regional NWP initialization. In order to accomplish such goals, a number of relevant HARMONIE experiments is required.

In the WIND4D project we will need to run the latest available cycle (currently CY40) of the HARMONIE-AROME over two domains: one over the Netherlands and the other over the Iberian Peninsula (see the model domains in Figure 1). The Netherlands and the Iberian domains have 800x800 and 1152x864 grid points, respectively. Both systems have 65 vertical level at 2.5 km grid resolution. We plan to perform at least 6 experiments of at least 30 days for each of the two domains. For each experiment we will need ~60000 SBU, therefore a total of 2*30*6*60000 ~22.5 MSBU will be required. The final estimate includes a small buffer of about 5% to account for failing jobs that will need to be repeated. Finally, the accumulated data storage required is 18 TB for the period 2019-2021.

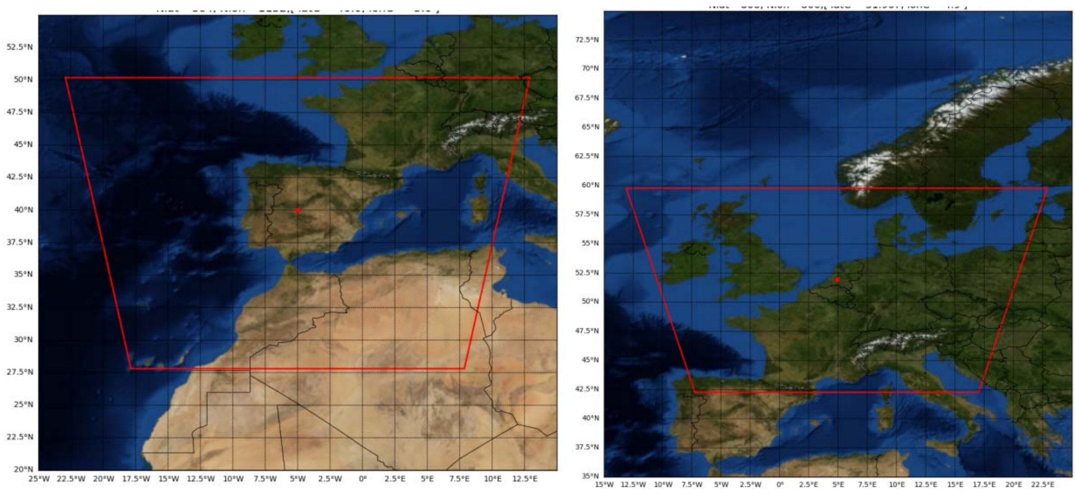

Figure 1. The Iberian (left) and The Netherlands (right) model domains.

Technical characteristics of the Harmonie-AROME code

The Harmonie code is integrated in the operational ECMWF IFS system. Development for the limited area non-hydrostatic part of the code is done within the HIRLAM consortium. The Harmonie-AROME code is used for operational short range weather forecasts by several European National Meteorological Centres (NMCs) [1]. It is developed, maintained and validated as part of the shared ALADIN-HIRLAM system through a collaboration of 26 countries in Europe and Northern Africa on short range mesoscale NWP. Harmonie-AROME is based on the model AROME-France developed within the ALADIN consortium. In the reference cycle of Harmonie-AROME cycle 40h1.1

lateral boundary conditions are used from the ECMWF model. Sixty five levels are used in the vertical, with model top at ca 10 hPa and lowest level at 12 m. The horizontal grid resolution is 2.5 km, and the model time-step is 75 seconds .

Compiling the code from the repository includes libraries for GRIB reading and writing (grib-api and eccodes among others). The resulting executable is easily executed from command-line with user-specified settings and monitored using the graphical user interface, named ecflow. The output format of the model fields is in GRIB and/or NETCDF format. Note also that there is support from Harmonie specialist and through Wiki pages.

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