REQUEST FOR A SPECIAL PROJECT 2026–2028

MEMBER STATE: Italy

Principal Investigator[1]: Luigi Cavaleri

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Project Title: A wave by wave evaluation of the wind input to a sea state – consequences on wave modelling at ECMWF

To make changes to an existing project please submit an amended version of the original form.)

If this is a continuation of an existing project, please state the computer project account assigned previously.	No continuation	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2026	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for project year:		**2026**	**2027**	**2028**
High Performance Computing Facility	[SBU]			
Accumulated data storage (total archive volume)[2]	[GB]			

EWC resources required for project year:		**2026**	**2027**	**2028**
Number of vCPUs	[#]	20	20	20
Total memory	[GB]	200	200	200
Storage	[GB]	10,000	10,000	10,000
Number of vGPUs[3]	[#]	10	10	10

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 annual progress reports of the project's activities, etc.

[2] These figures refer to data archived in ECFS and MARS. 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.

[3] The number of vGPU is referred to the equivalent number of virtualized vGPUs with 8GB memory.

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Extended abstract

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

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF and its Scientific Advisory Committee. The requests are evaluated based on their scientific and technical quality, and the 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 exceeding 5,000,000 SBU should be more detailed (3-5 pages).

Project description

For a number of years we have pursued the possibility of identifying the reason(s) behind the underestimate of ECMWF surface winds when blowing to offshore from coast to sea. With the present project that will conclude at the end of this year 2025, we have reached a full picture of the situation whose solution cannot be the effort of simple Special Project. Of course this underestimate has regular consequences on the associated and regularly derived wave fields. At the same time, although two of us (L.C. and L.B.) have closely followed and partecipated to the ECMWF effort for improving waves forecast and, most of all, the coupled atmosphere-ocean system, we have a clear view of the present, although widely accepted, wind input function in the ECMWF operative WAM model. This source function, for shortness Sin, is based on the spectral approach used to describe the sea surface, at given time and location, as the linear superposition of a large number of spectral components with different frequency (hence length) and amplitude. While the overall sea (waves) conditions determines the kind of interaction between atmosphere and ocean (this is true particularly in strong and extreme conditions), the input function is still conceived as a distributed input to the surface where changes in time are appreciated only at the spectral level. We are far, both as theory and modelling, from being able to simulate the single waves of an active wave field (we neglect special cases in harbours and similar situations with measured input conditions at a narrow entrance). However, an analysis of the input by wind at a wave by wave level can provide useful insights about the limits of the present related formulation, suggesting where to look at in the future and explaining why in some conditions model results are less good than required.

Suggesting to measure wave by wave the input by wind is a tremendously difficult task that requires very sophisticated instruments. Indeed, after a few brave efforts several years ago, the subject has not been pursued further. Such experiments would not be of interest for ECMWF modelling. However, many years ago one of us (LC, the principal investigator) carried out very detailed measurements of wind wave conditions during episodes varying from swell to mild wind sea and very strong storms. These measurements were carried out from the ISMAR (proposers' institute) oceanographic tower (see Fig.1) located 15 km offshore from the Venice coast in the northern Adriatic Sea. The data include 4 Hz data of surface elevation, 3-dimensional orbital field and pressure measurements at different depths , all on exactly the same vertical. The analysis of these data (see Cavaleri and Zecchetto reference) revealed that in active wave generation conditions the vertical and orbital motion components were such to provide an estimate of the wave by wave input by wind to the developing wave field. Recently, laso discussing with ECMWF and other colleagues the matter of wind input to waves, I conceived the possibility of a much more detailed analysis of these data. The purpose is to analyse wave by wave, considering all the related details as wave height, steepness (front and back), speed and wind and wave speed relationship (varying from wave to wave), estimating (from the orbital values) the wave by wave input by wind. While this is no hyper-computer work, the purpose in the duration of the project is to compare the derived input with the present modelled formulations and to repeat the modelling of specific storms trying to formulate the input according to the results of the described analysis. The input may result not only wave, but also wind dependent.

With this we do not mean the (relatively) simple change of the input function in the ECMWF model, but also its modulation according to the type of wind, e.g. stable or unstable air-sea conditions, hence to the level of gustiness. We envisage as a possibility the implication that a different input may imply also a different dissipation (white-capping) function.

We acknowledge that this is a real bet in that “touching” the present wave model is a delicate matter. Of course all this will be done with our version that in any case, apart from the subtleties of the overall ECMWF operational system, is adherent to the same principles. However, the potential implications are large and would have a substantail influence of the input, and possibly dissipation, functions of wave modelling in the world.

References:

Cavaleri, Luigi and Stefano Zecchetto, "Reynolds stresses under wind waves"

J.Geoph.Res., April 15, Vol. 92, No. C4, p. 3894-3904.

Figure 1 – The ISMAR oceanographic tower “Acqua Alta” in the northern Adriatic Sea, 15 km offshore the venice lagoon coastline.