REQUEST FOR A SPECIAL PROJECT 2016–2018

MEMBER STATE: **UK**…………………..…………………………………………...…

Principal Investigator[1]: **Prof V. I. Shrira**……………………………………………….……

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Other researchers: **Dr Sergei Annenkov** …………………………………………….……

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Project Title: **Direct numerical simulation of wind wave fields in a rapidly changing environment** ……………………………………………

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If this is a continuation of an existing project, please state the computer project account assigned previously.	**SPGBVSSA** ________________	
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	(units)	**300000**	**300000**	**300000**
Data storage capacity (total archive volume)	(gigabytes)	**100**	**100**	**100**

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):

2 July 2015 …………………………

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 an annual progress report of the project's activities, etc.

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Extended abstract

It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

For practical applications, it is important to know the probability of wave height in seas and oceans, at a given place and time. It is essential to predict the probability density function (p.d.f.) of surface elevations, along with the meteorological forecasting. Meanwhile, almost all studies of oceanic broadband wave fields were mostly concentrated on the evolution of the energy or wave-action spectrum. Within the framework of wave turbulence paradigm, where the wave field is considered as a continuum of resonantly interacting random weakly nonlinear waves, the evolution of wave spectra is described by the kinetic (Hasselmann) equation. The kinetic equation cannot describe reaction of wave fields to rapid perturbations (e.g. abrupt changes of wind, wind gusts, sharp boundaries, etc). On the other hand, the models based on it can predict evolution of wave spectra only, while it is highly desirable to model the evolution of the wave height probability density function. These limitations can be overcome either with a generalized statistical theory, or by direct numerical simulation. In the previous project (2012-2014), a new numerical algorithm for the study of the evolution of wind wave spectra, as well as the p.d.f., has been successfully created. This algorithm is based on the conceptually new approach to modelling random wind wave fields, the generalized kinetic equation (GKE). It was shown that rapid changes of wind lead to the increased probability of extreme wave events. Direct numerical simulations (DNS) of wind wave fields, based on the Zakharov equation, allow tracing the evolution of spectra and higher-order moments of the field for many thousands of wave periods (at least an order of magnitude longer than is possible with other DNS approaches), so a direct comparison of the DNS and the generalized statistical theory becomes possible. Preliminary experiments show that although the spectral evolution within the GKE model can be successfully verified by DNS, there are essential differences between the two models, due to the presence of coherent processes in the wave field, resolved by the DNS but completely filtered out in the statistical approach. These processes result in the difference in the timescales of the evolution of spectra, and affect higher statistical moments. At present, the role of these processes is not understood. First, we plan to adapt the existing DNS algorithm for more efficient use of memory and parallelization, and to test it on a few model cases. Then, we will perform numerical experiments with a careful comparison of the two models, to study the formation of narrow-band wave fields resulting in the increased probability of extreme wave events, to find when sharp changes of forcing may result in spikes of higher statistical moments of wave fields. Special attention will be paid to the transition from quasi-Gaussian wave fields to formation of coherent patterns. Results of the simulations will be compared to specially designed laboratory experiments carries out by our partners.