REQUEST FOR A SPECIAL PROJECT 2019–2021

MEMBER STATE: ITALY (INTERNATIONAL COORDINATED ORGANIZ.)
This form needs to be submitted via the relevant National Meteorological Service.

Principal Investigator[1]: ANDREA STORTO

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Project Title: ENHANCING REGIONAL OCEAN DATA ASSIMILATION IN HIGH AND MID LATITUDE EUROPEAN SEAS (ERODS)

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 (in case of acceptance and subject to your HPC availability, starting during the last quarter of 2018 would be very good for us)	
Would you accept support for 1 year only, if necessary?	YES X	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	(SBU)	700 000	700 000	700 000
Accumulated data storage (total archive volume)[2]	(GB)	15 TB	20 TB	25 TB

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): 26-JUN-2018

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.
[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.

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Extended abstract

Introduction & Motivation

The NATO Centre for Maritime Research and Experimentation (CMRE) is an established, world-class scientific research and experimentation facility that organizes and conducts scientific research and technology development, centred on the maritime domain. CMRE operates two research vessels that enable science and technology solutions to be explored and developed at sea, and conducts relevant, state-of-the-art scientific research in ocean science, modelling and simulation, acoustics and other disciplines, which is potentially game changing.

In particular, there are continuous efforts to develop regional (limited area) ocean analysis and forecast systems to i) support the sea-trial activities with oceanographic analyses and forecasts; ii) exploit the observations collected during the campaign to assess their benefits in terms of gain in ocean predictability and iii) improve the ocean characterization, especially at the scales relevant for acoustic propagation. Real-time high-resolution ocean analysis and prediction systems are also crucially important for a variety of applications ranging from ecosystem and fishery forecasts, security, search-and-rescue, tourism and industry, and a few more. Initial conditions for the forecast integration are provided through data assimilation methods, which combine information from available observations with a prior knowledge of the state of the ocean. Ingesting all possible sources of observational information in such systems is becoming increasingly demanding because of the never-ending developments of the ocean observing networks, which include remotely sensed data from altimetry, infrared and microwave instruments sensing the sea surface, and surface current-measuring (HF) radars, in addition to in-situ measurements from sensors mounted on floats, buoys and drifters. This picture is further complicated by occasional deployments of vehicles equipped with CTD instruments (e.g. gliders, ScanFish, etc.) that measure temperature and salinity, among other parameters, along with exceptional mounting of ADCP current profilers on research vessels and/or buoys.

Objective

Consistently with the two main sea-trials operated by the EKOE (Environmental Knowledge and Operational Effectiveness) Programme of CMRE, respectively in the Atlantic sector of the Arctic Ocean and in the Ligurian Sea, two analysis and forecast systems in these respective areas have been implemented, based on the NEMO ocean model coupled to the OceanVar variational data assimilation code. For the Arctic implementation, NEMO is also coupled to the LIM3 multi-category dynamic and thermodynamic sea-ice model. The goal of the project is thus to support the research activities aiming at enhancing the data assimilation schemes in both the Arctic and the Ligurian model. In particular, selected tasks that will be investigated are listed below:

Task A. Test the feasibility of assimilating small-scale current data collected by HF radars, drifters and ADCP profilers mounted on vessels and buoys;

Task B. Include uni (aka “weakly coupled”) and multi-variate (aka “strongly coupled”) data assimilation of sea-ice parameters in the Arctic analysis system exploiting the synergy of the ocean (temperature/salinity from in-situ profiles, sea level anomaly from altimeter missions, sea surface temperature from infrared and microwave sensors and sea surface salinity from microwave sensor) and sea-ice (SIC from microwave sensors, sea-ice drift from satellite imagery, freeboard sea-ice thickness from Cryosat2 for thick sea-ice and SMOS for thin sea-ice) observing networks;

Task C. Experiment multi-scale data assimilation in order to simultaneously ingest both the large- and the small- scale information collected by gliders during the observational campaign;

Task D. Run ensemble variational experiments with stochastic physics in order to i) retune the background-error covariances for use in data assimilation and ii) provide an ensemble of realizations

for forcing downstream acoustic models and characterize the uncertainty and the cross-covariances between physical and acoustic parameters;

Task E. Test optimal ways to assimilate SST observations (L2, also daytime) in the analysis systems, exploiting the synergy with in-situ profiles to verify the methodology, and in particular data from gliders piloted to follow the satellite tracks.

Note that especially the tasks **B**, **C** and **E** are among the crucial research activities of common interest between CMRE and ECMWF, for the latter potentially beneficial to both the short- and the long- range prediction systems.

Work plan

The research activities planned for the forthcoming years were outlined above.

We plan to focus on

Multi-scale DA (**C**) and ensemble ocean-acoustic simulations (**D**)	**Year 1**
Ocean current DA (**A**) and sea-ice DA (**B**)	**Year 2**
SST DA (**E**) and prosecution of previous activities	**Year 3**

Note however that the order and time allocation of the previous research activities may be subject to changes, due to the yearly work planning at CMRE and internal reorganization and requirements.

Numerical Models

The variational data assimilation code used at CMRE supports either MPI or OpenMP parallelization, is written in Fortran90, and has also been recently upgraded to include four-dimensional variational data assimilation, either with strong- or weak- constraint formalism. The NEMO ocean model code is also written in Fortran90 and allows also for massive MPI parallelization. NEMO is maintained by a European consortium that ensures its developments as state-of-the-art and scalable ocean model, and it is used by ECMWF as ocean model component in all Earth's system forecasting activities. The systems have run on supercomputer machines (e.g. the CINECA HPC in Italy).

Resources

Below we detail the expected number of experiments and resources usage. Note that the regional numerical models do not require massive parallelization, being their domain generally small.

No cores	**No cores**	**Time (min) per day of assimilation and forecast**	**Days of experiments**	**Number of experiments (including ensemble) per fiscal year**	**SBU**
Arctic analysis system	36	8	180	40	560 000
Ligurian analysis system	12	5	180	40	116 000
Total	48				**676 000**

Based on the previous table, we apply for 700 000 SBU per year, considering test and portability issues. Note that we ask for relatively high data storage (20 TB) in order to have the possibility to store several experiments simultaneously with high-frequency (sub-daily) outputs. The latter is required for investigating the diurnal cycle of ocean fields, for use for instance with SST data assimilation, and acoustic downstream runs.