SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year 2019

Project Title: Enhancing regional ocean data assimilation in high and mid latitude European seas

Computer Project Account: spitstor

Principal Investigator(s): Andrea Storto

Affiliation: Centre for Maritime Research and Experimentation (CMRE)

Name of ECMWF scientist(s) collaborating to the project (if applicable) N/A

Start date of the project: 01/JAN/2019

Expected end date: 31/DEC/2021

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)	-	-	700k	100k
Data storage capacity	(Gbytes)	-	-	15 TB	

Summary of project objectives (10 lines max)

The project has several objectives, corresponding to the following tasks, in order to improve the data assimilation systems for the oceanographic configurations in use at NATO/CMRE.

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 different 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.

Summary of problems encountered (10 lines max)

Porting the Atlantic/Arctic ocean modelling system was less straight-forward than expected. In particular, finding the optimal combination of processors/memory for NEMO3.6 and XIOS1 (detached mode) with the PBS submission system available in cca took quite long..

Summary of plans for the continuation of the project (10 lines max)

Task A and E are almost completed, although a few additional experiments are foreseen. The project will continue prioritizing tasks C and D.

List of publications/reports from the project with complete references

Internal Reports:

- Storto A., et al. "Feasibility Studies On Using Very High Resolution Data (Radar, ADCP, Drifters) To Improve Predictability Of Small Scale Ocean Features", CMRE TPR 907.03.02.01, 2019
- Better exploitation of remotely sensed data to improve sonic layer depth and sound speed gradients, TPR 907.03.02.02, 2019

Summary of results

The activities have focussed initially on tasks A and E (see "Summary of the project objectives"). **Task A:** exploiting the potential of seawater velocity data from different observing networks has the potential of improving the small-scale oceanic variability, which is in turn essential for acoustic characterization. Here, we assess the impact of assimilating such data in the Ligurian Sea model and in the nested Gulf of La Spezia model. The results indicate that the assimilation of current data improves the model validation skill scores and enhances the Liguro-Provencal current system, which in turn improves the vertical stratification of the ocean in the nested domain in comparison

with independent observations from Scanfish. These promising results pave the way for real-time assimilation of velocity data and foster additional experiments, in particular in order to better understand the impact of the temporal frequency of data assimilation.
In Figure 1 (left panel), we show current speed RMSE (as a function of depth) in the experiment where all current data are assimilated (BASE+UV) against the experiment where only in-situ profiles and altimetry data have been assimilated (BASE), proving the effectiveness of the data assimilation procedure.

Task E: the assimilation of daytime SST retrievals from infrared sensors into ocean prediction systems requires a specific treatment of the diurnal cycle of skin SST, which is generally underestimated in current ocean models due to poor vertical resolution at the air-sea interface and lack of parameterizations. To this end, an off-line bias correction scheme has been formulated, where the bias predictors include, among others, the warm layer and cool skin warming/cooling deduced from a prognostic model. Furthermore, a localization procedure that limits the vertical penetration of the SST information in a hybrid variational-ensemble data assimilation system is formulated. These two novelties were implemented and assessed the Ligurian Sea regional model for the assimilation of daytime SST data at hourly frequency retrieved from the Spinning Enhanced Visible and Infrared Imager (SEVIRI) on board the geostationary satellite Meteosat-10. Experiments are validated against independent measurements collected by gliders during the Long-term Glider Missions for Environmental Characterization (LOGCMEC17) sea-trial. Results (not shown) suggest that the bias correction scheme is effective in improving both the sea surface and mixed layer accuracy, correctly leading to mixed layer thinner than in the control experiment, outperforming experiments with night-only data assimilation and improving the forecast skill scores. Localization further improves the prediction of the mixed layer depth. It is therefore recommended that sophisticated bias correction and localization procedures are adopted for fruitfully assimilating SST data in operational oceanographic analysis systems. It is also expected that the synergy with sub-surface profile and altimetry data might amplify the benefits of the daytime SST data assimilation.

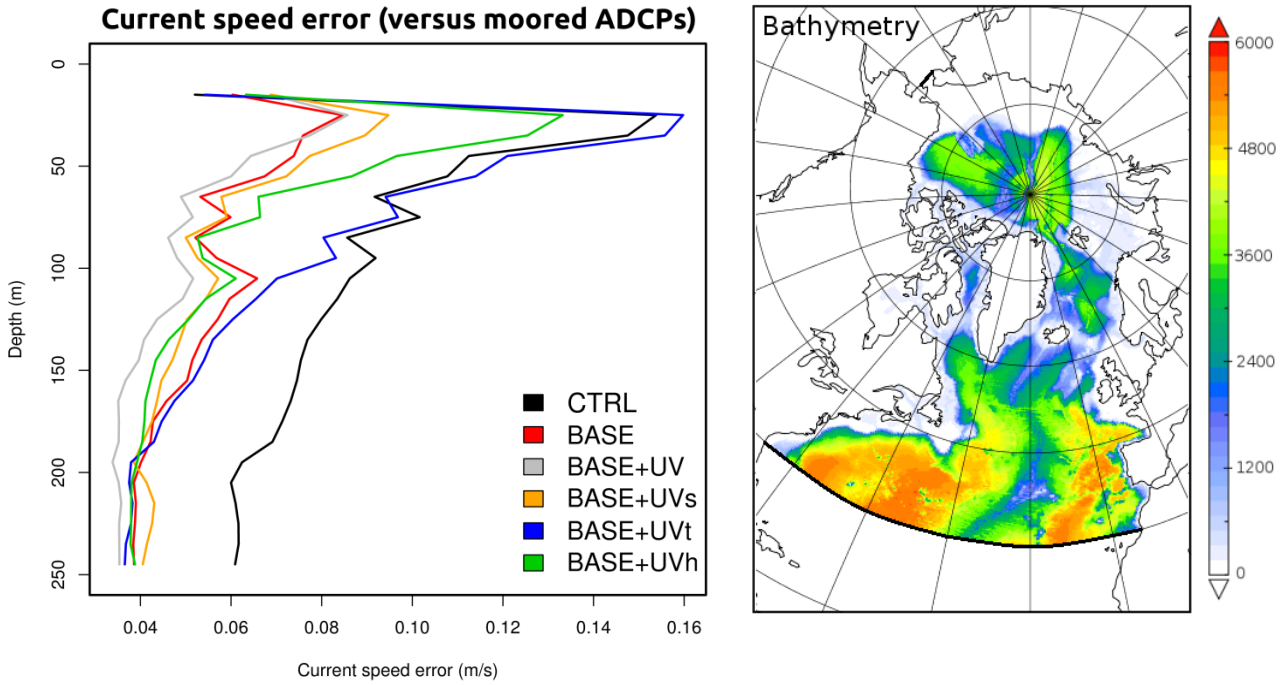

Figure 1. Left: RMSE profiles of current speed against moored ADCP data in experiments assimilating current data from moored and ship-borne ADCPs, HF radars and drifters. Right panel: bathymetry of the North Atlantic NEMO-based model.

Finally, we have started developing a North Atlantic-Arctic model at 1/12 degree of horizontal resolution. The bathymetry of such model is shown in Figure 1 (right panel). The model configuration can optionally include the Mediterranean and the Black Seas, and has been conceived in order to replace the two modelling systems in use at CMRE, which include the Arctic Ocean and the Ligurian Sea, respectively.