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

2022

Project Title:

NUMERICAL INVESTIGATION OF CIRCULATION CHANGES IN THE NORTH WESTERN MEDITERRANEAN THROUGH DOWNSCALING OF CMEMS REANALYSIS DATA

Computer Project Account:

SPITBRAN

Principal Investigator(s):

Carlo Brandini

Affiliation:

CONSORZIO LAMMA / CNR

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

Alessio Innocenti
Michele Bendoni
Valerio Capecchi
Stefano Querin (OGS)

Start date of the project:

01/01/2022

Expected end date:

31/12/2024

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)			3000000	0
Data storage capacity	(Gbytes)			2000	0

Summary of project objectives (10 lines max)

The objective of this project is to perform a high resolution downscaling of the circulation and biogeochemical reanalysis data (available through CMEMS) for the period 1987-2021 (physics) and 1999-2021 (biogeochemistry) over the North Western Mediterranean. Circulation and biogeochemistry will be modelled with the non-hydrostatic MITgcm model (Adcroft et al. 2018) coupled with the BFM biogeochemistry model (Vichi et al. 2015) through the BFMcoupler (Cossarini et al. 2017), while atmospheric forcing data were produced in a previous special project for the dynamical downscaling of the ERA5 reanalysis data (Vannucchi et al. 2021). The comparison of model results with multiple observations, such as HF radars, satellite data, temperature and salinity profiles, will allow us to validate model performances. Downscaled dynamics will be employed to characterize long-term circulation trends in the coastal areas, and their impact on biogeochemical fluxes, in order to better understand the effect of climate change on coastal circulation and biodiversity.

Summary of problems encountered (10 lines max)

We did not encounter significant problems related to the implementation and running of the model on the Atos platform. We initially had some issues and unreliable results of the simulations with different compilers setups, but we finally found that the problem was due to a bug in the code that was highlighted only by the particular AMD architecture of the cluster and ignored in previous simulations on different intel clusters. Regarding the SBU accounting, we started directly to implement and test the model on Atos, since it was initially planned to be operative in May, but maybe we will need to switch to Cray due to the delay in Atos start. Therefore at present the official SBU used are 0, even if we have used 205000 SBU on Atos for testing.

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

After the phase concerning model compilation and installation on the Atos cluster, we will perform several computational experiments tested against observations to identify an adequate set of parameters, starting from the values suggested in literature. Once the model setup will be defined, we will produce the dataset of the reanalysis, taking care to gradually check model results with respect to available observations.

List of publications/reports from the project with complete references

None

Summary of results

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For the SPITBRAN Special Project we are using the MITgcm circulation model coupled with the BFM biogeochemistry model through the BFMCoupler. In this first period of the project we have compiled and tested the coupled software on the Atos cluster, testing different compilers to find the best performances for the actual model. In particular we have compiled the model with the following set of combinations:

- gnu with openmpi;

- intel with openmpi;
- intel with intelmpi;

In a project planning to perform such long climatological analysis, at such high resolution, it is crucial to firstly assess the performances of the computing platform with the model, which might be largely different from our previous experience.

Model implementation

We have setup a first tentative domain covering the Ligurian Sea with longitude ranging in 6.06-12.18°E and latitude in 41.88-44.50°N, with a resolution of 1/128°, resulting in a domain size of 784 x 336 grid cells in the two horizontal directions with 60 vertical layers. Figure 1 shows the extension of the domain with the employed EMODNET 2018 bathymetry. This first setup is the same that is being used in the Interreg Med "Sharemed" project, where the present model has been made operational in various NWMed areas. In this way it will be possible to compare and cross-validate these first test runs of the model and to establish the performances of Atos cluster for this configuration, also with respect to another platform. With the results obtained in this first stage it will then be possible to find the optimum in terms of size and resolution in order to be able to cover the whole expected 34 years of hindcast as planned, taking into account the allocated SBU.

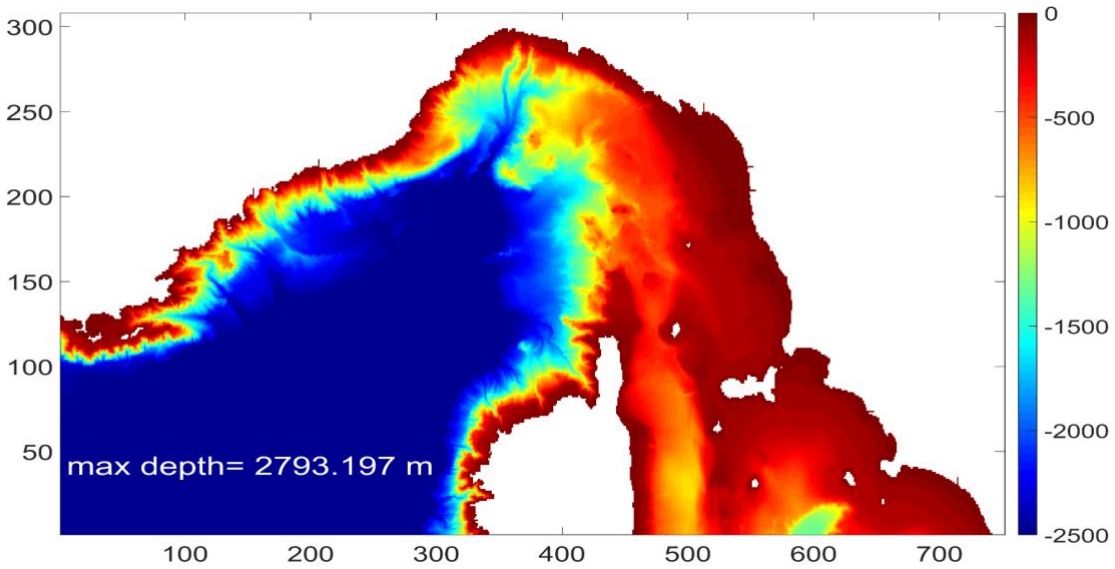

Fig.1: Bathymetry of the first tentative domain covering the Ligurian Sea and the Tuscan Archipelago.

Concerning rivers, we have added the most important ones, using climatological data for the discharge rates. At the present stage the model preprocessing routines download automatically from CMEMS initial and boundary condition, cutting and interpolating the Mediterranean products on the restricted domain we are using. The same is done for the atmospheric forcing which are the BOLAM / MOLOCH models obtained from the downscaling done in a previous Special Project and still present on ecfs data storage.

Parallel performance of the code

We have performed tests of strong scaling, i.e. for a fixed overall problem size we have varied the number of processors used, therefore varying the size of the subdomain handled by each processor. The different tests are reported in Table 1, with number of processors used, tile size and duration of a reference simulation of 1 day hindcast, and are plotted in Figure 2.

N° procs	Tile size (x,y,z)	duration (min)
28 (7 x 4)	112 x 84 x 60	77
56 (8 x 7)	98 x 48 x 60	53
112 (16 x 7)	49 x 48 x 60	50
168 (14 x 12)	56 x 28 x 60	20
224 (16 x 14)	49 x 24 x 60	23

Tab.1: summary of strong scaling tests

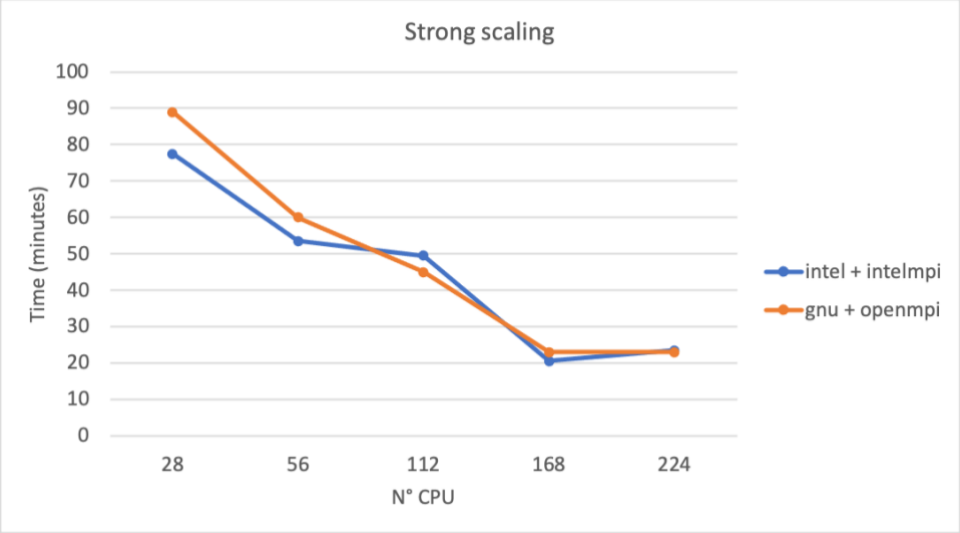

Fig.2: strong scaling tests

References

ADCROFT, Alistair, et al. MITgcm documentation. *Release checkpoint67a-12-gbf23121*, 2018, 19.

COSSARINI, Gianpiero, et al. Development of BFMCOUPLER (v1. 0), the coupling scheme that links the MITgcm and BFM models for ocean biogeochemistry simulations. *Geoscientific Model Development*, 2017, 10.4: 1423-1445.

VICHI, M., et al. The Biogeochemical Flux Model (BFM): equation description and user manual. *BFM version*, 2015, 5: 104.

VANNUCCHI, Valentina, et al. Dynamical downscaling of ERA5 data on the North-Western Mediterranean Sea: from atmosphere to high-resolution coastal wave climate. *Journal of Marine Science and Engineering*, 2021, 9.2: 208.