Release note of the high-resolution oceanic model in the Mediteranean Sea NEMO-MED12 based on NEMO_v3.2 version

T. Arsouze
J. Beuvier, K. Béranger, R. Bourdallé-Badie, C. Deltel, Y. Drillet, P. Drobinski, N. Ferry, C. Lebeaupin-Brossier, F. Lyard, F. Sevault, S. Somot

Acknowledgments

The numerical work was supported by the 'Groupe de Mission Mercator Coriolis' (GMMC). This work was granted access to the HPC resources of IDRIS (Institut du Développement et des Ressources en Informatique Scientifique) of the Centre National de la Recherche Scientifique (CNRS) under allocation 2009 to 2012 (project number 010227) made by Grand Equipement National de Calcul Intensif (GENCI). The financial support of J. Beuvier's Ph.D was provided by Météo-France within the framework of MORCE-MED project. The financial support of C. Lebeaupin Brossier's postdoc was provided by the 'Groupement d'Intérêt Scientifique' (GIS - GMMC), within the framework of SIMED project. We thank Michel Déqué from Météo-France for running the ARPERA simulation with ARPEGE-Climate. The realization of GLORYS1 global ocean reanalysis had the benefit of the grants that Groupe Mission Mercator Coriolis, Mercator Ocean, and INSU-CNRS attributed to the GLORYS project, and the support of the European Union FP7 via the MYOCEAN project ; computations for GLORYS1 were performed with the support of Météo-France HPC Center. We thank Bruno Levier from Mercator Océan for gathering the bathymetry products. We acknowledge the GEBCO-08 Grid, version 20081212, http ://www.gebco.net, for providing the GEBCO-08 bathymetry. The altimeter products were produced by Ssalto/Duacs and distributed by AVISO, with support from CNES (http ://www.aviso.oceanobs.com/duacs/). This work is a contribution to the HyMeX international program on the study of the water cycle in the Mediterranean area and the MED-CORDEX program.

Table des matières

Table des figures

1 NEMO-MED12 configuration

The code of the NEMO-MED12 model is based on the tagged version nemo_v3.2 of the NEMO ocean general circulation model [Madec et al., 2008]. You can find a description of the code directly on the official NEMO website : http ://www.nemo-ocean.eu/.

The horizontal and vertical grids of NEMO are presented in the following (Fig. 1). On the horizontal is used a C-Arakawa grid stretched to the poles (ORCA grid standard NEMO configuration) while a stretched grid is used on the vertical. The surface layer thickness is finer than at sea bottom. These projections, geographical longitude glam[tuvwf] and latitude gphi[tuvwf] of each grid points T- U- V- W- and F-, then introduce scale factors e[123][tuvwf] for each grid points T- U- V- W- and F-. They are given in the coordinates.nc file. Note also that the parameterization of partial-cells is used in standard in NEMO.

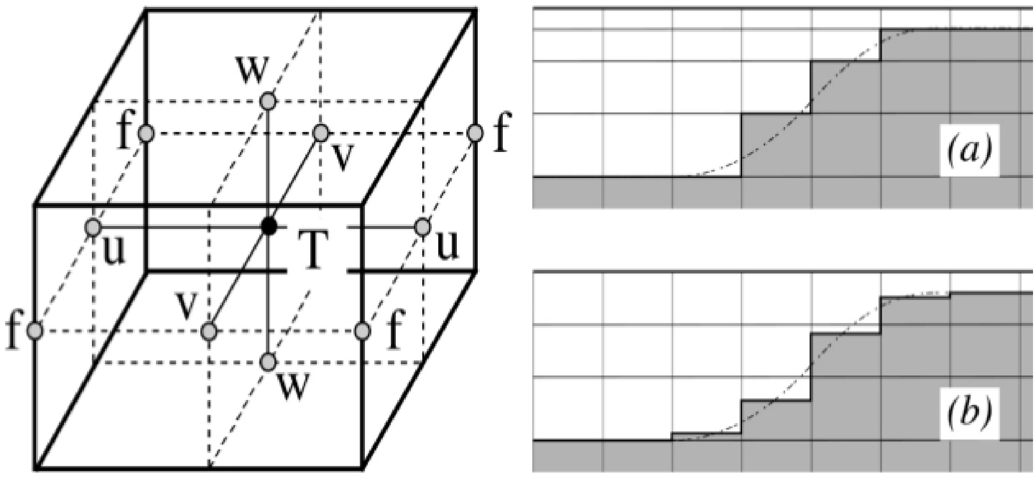

FIGURE 1 – Horizontal and vertical grid for T-, U-, V-, W- points, from [Madec et al., 2008].

First results with MED12 are shown in several papers [Lebeaupin Brossier et al. 2011, 2012a, 2012b, 2012c ; Beuvier et al. 2012] and the PhD report of Beuvier [2011]. This configuration is also used in the coupled ocean-atmosphere MORCE platform with the WRF model [Skamarock et al., 2005 ; Drobinski et al., 2012], and will be implemented at CNRM in a coupled model with ALADIN.

2 Grid, bathymetry, and initial conditions

The NEMO-MED12 grid (1/12 degree resolution), located on the Mediterranean Sea, is an extraction (ncks) from the global ORCA 1/12 grid (the coordinates_ORCA_R12_lbclnk.nc, coming from MERCATOR). This corresponds to a grid cell size between 6 to 7.5km from 46°N to 30°N (i.e. equivalent to a real resolution between 1/14° and 1/18°, from South to North). This represents a grid size of 567×264 points. MED12 covers the whole Mediterranean Sea plus a buffer zone including a part of the near Atlantic Ocean, from 30°N to 47°N, and from 11°W to 36°E. Black Sea is not represented.

There are 50 vertical levels defined in z-coordinates with partial-steps formulation, ranging from 1m at the surface to 450m at depth (cf. Tab. 1). The bathymetry is provided by the MERCATOR-LEGOS group, at a resolution of $30'' \times 30''$. The version used is composed of the GEBCO-08 database, the MEDIMAP bathymetry [Medimap Group, 2005] and the Ifremer bathymetry of the Gulf of Lions [Berné et al., 2004] (Fig 2).

Inital condition is set to a monthly mean of potential temperature and salinity in the Mediterranean domain from the MEDATLAS climatology [MEDAR/MEDATLAS Group, 2002] and in the Atlantic domain from the climatology of Levitus et al. [2005]. The ocean is at rest.

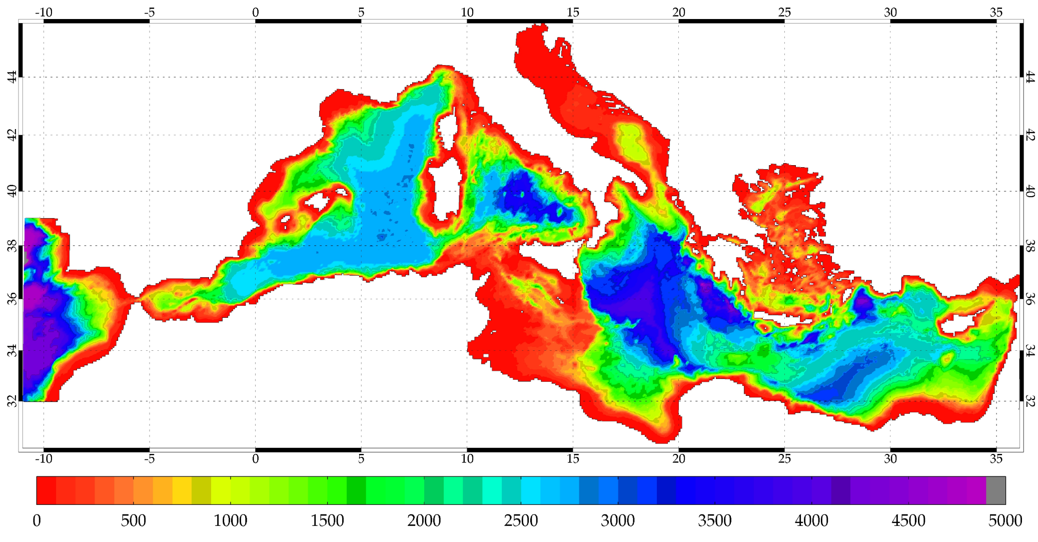

FIGURE 2 – Map of the bathymetry (in meters) of the MED12 domain.

3 Boundary conditions

3.1 Bottom friction

The bottom friction is parameterized by a quadratic function :

$$\vec{F} = C_D \sqrt{u_H^2 + u_H^2 + E}\vec{U_H}$$

with the horizontal bottom velocity $\vec{U_H} = u\vec{i} + v\vec{j}$, C_D the bottom drag coefficient set to 0.001, and E the 2D bottom turbulent kinetic energy background computed from the tidal model of Lyard et al. [2006](Fig. 3). This parameter can be taken either constant (value of 25 $cm^2.s^{-2}$). This option is handled in the zdfbfr.F90 routine.

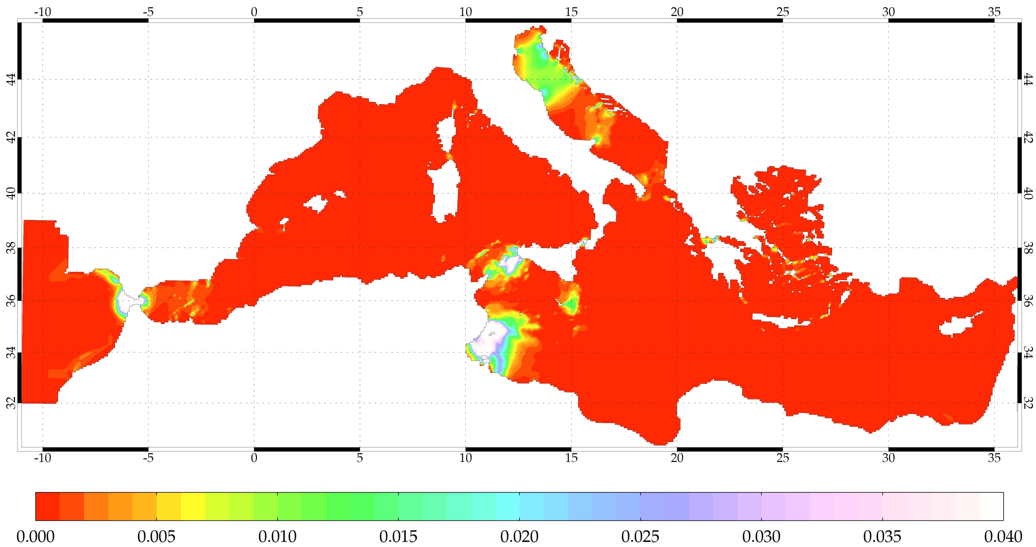

FIGURE 3 – Bottom turbulent kinetic energy background E (in $cm^2.s^{-2}$).

3.2 Atmospheric forcing

The atmospheric forcing ARPERA is obtained by performing a dynamical downscaling (spectral nudging method) of ECMWF products (reanalyses or analyses) above the Mediterranean area [Herrmann and Somot, 2008]. It uses the ARPEGE-Climat atmospheric model [Déqué and Piedelievre, 1995] to produce daily fields of momentum, freshwater and heat fluxes. For the surface temperature condition, a relaxation term toward the ECMWF Sea Surface Temperature (SST) is used to model the air-sea interactions. The value of the relaxation coefficient is spatially constant and taken equal to -40 $W.m^{-2}.K^{-1}$ that corresponds to a 1.2 day restoring time-scale for a surface layer of 1m thickness. No salinity damping is applied.

3.3 River runoff and Black Sea input

River inputs are introduced as surface freshwater gain at the river mouths. We use the climatological average of the interannual dataset of Ludwig et al. [2009] to compute monthly runoff values, split in two parts. First, for the 33 main Mediterranean rivers listed in the RivDis database [Vörösmarty et al., 1996], we directly take the values of the database. Second, the values of the inputs of the other rivers are gathered and averaged in each Mediterranean subbasin (as defined in Ludwig et al. [2009]) and put as a coastal runoff in each MED12 coastal grid point of these subbasins. Total amount of freshwater via runoff is $+0.14 \mathrm{m.yr}^{-1}$ (cf. Fig. 4). The Black Sea is not included in MED12 but in the model, exchanges between the Black Sea and the Aegean Sea consist of a two-layer flow across the Marmara Sea and the Dardanelles Strait. Thus, the Black Sea is considered as a river for the Aegean Sea. We use the climatological average of the interannual dataset of Stanev and Peneva [2002] to compute monthly values of the Black Sea net water inflow. The annual average of this input corresponds for the surface freshwater budget of the Mediterranean Sea to $+0.10 \mathrm{~m.yr}^{-1}$.

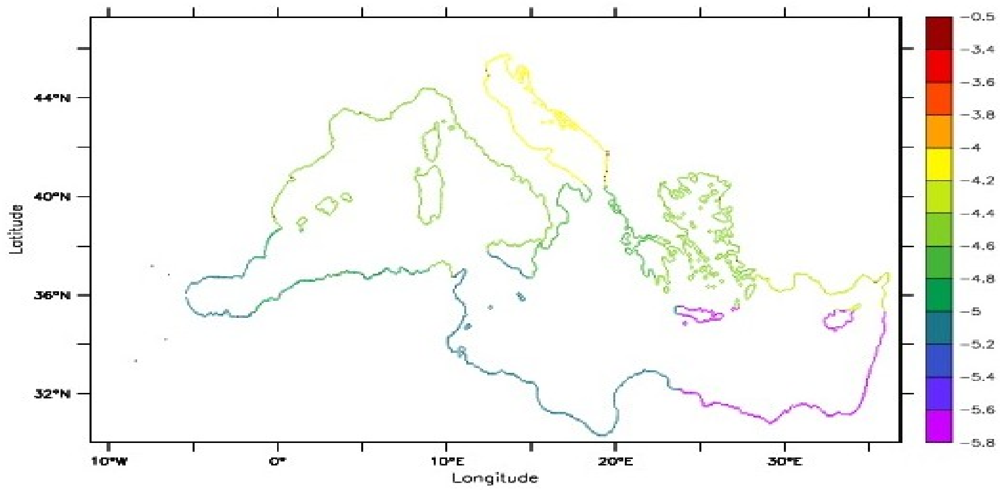

FIGURE 4 – Annual mean of the runoff (in $\mathrm{m.yr}^{-1}$, log scale).

3.4 Exchanges with the Atlantic and freshwater budget

Exchange with the Atlantic Ocean is apprehended via a buffer zone west from Gibraltar strait. 3D temperature and salinity are relaxed toward climatological fields of Levitus et al. [2005], with a restoring time constant and equal to 2 days between 11°W and 7.5°W and linearly decreasing to 90 days from 7.5°W to 6°W (Fig. 5).

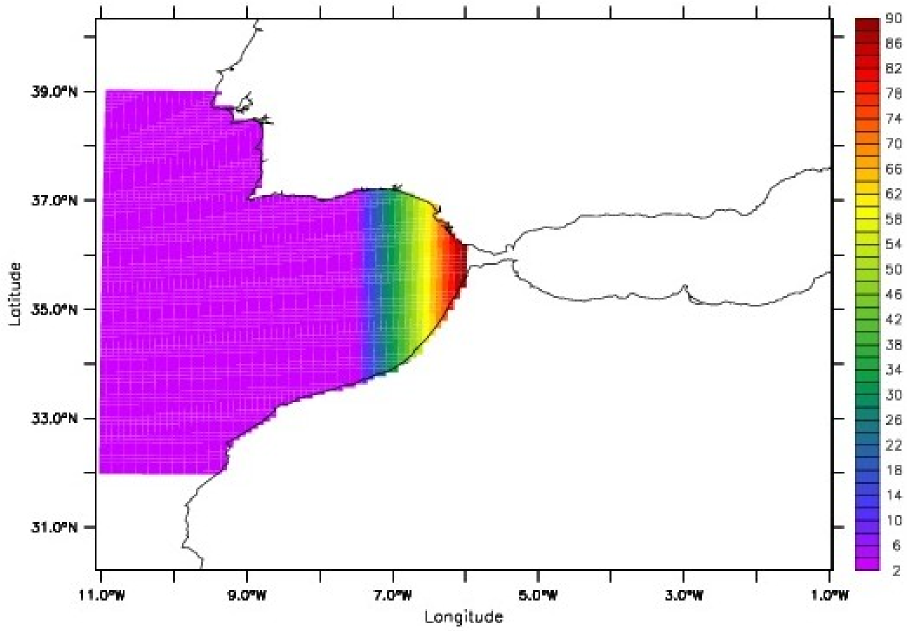

FIGURE 5 – Restoring time (in days) to climatological T and S fields in the Atlantic buffer zone.

To ensure that the total volume of seawater is preserved, damping of the SSH between 11°W and 7.5°W (Atlantic buffer zone) towards a prescribed SSH (based on GLORYS reanalysis of sea level anomalies, [Ferry et al. 2009]) is applied, with a restoring term set to 2 seconds. This relaxing time decreases to 90 days at 6°W.

3.5 Parameterizations

The parameterizations are resumed in Table 3 and are those used in the MED12-ARPERA simulation [Beuvier et al., 2012] or Beuvier [2011] for the 1998-2008 period.

A time step of 12 minutes is used. The horizontal eddy diffusivity coefficient is applied with a laplacian operator along iso-neutral surfaces for the tracers while it is applied with a bi-harmonic operator for the momentum. The TVD (Total Variance Dissipation) scheme is used for the tracer advection while the EEN (Energy and ENstrophy conservative) scheme is used for the momentum advection [Arakawa and Lamb, 1981 ; Barnier et al., 2006]. A 1.5 turbulent closure scheme [Blanke and Delecluse, 1993] is used for the vertical eddy diffusivity and the vertical diffusivity coefficient is enhanced up to $10m^2.s^{-1}$ in case of unstable stratification. The solar radiation can penetrate into the ocean surface layers [Bozec et al., 2008]. A no-slip lateral boundary condition is used. The evolution of the sea surface is parameterized by a filtered free-surface [Roullet and Madec, 2000] and the conservation of the model volume is assumed through the damping of SSH in the Atlantic buffer zone.

3.6 On-line diagnostics : Moorrings and transports

Total in and out volumic transports are calculated along several sections (Fig. 6) resumed in the file section_ijglobal.diadct.

And 121 moorings are also saved every day (Fig. 6). The positions of these moorings are given in the file position.moor.

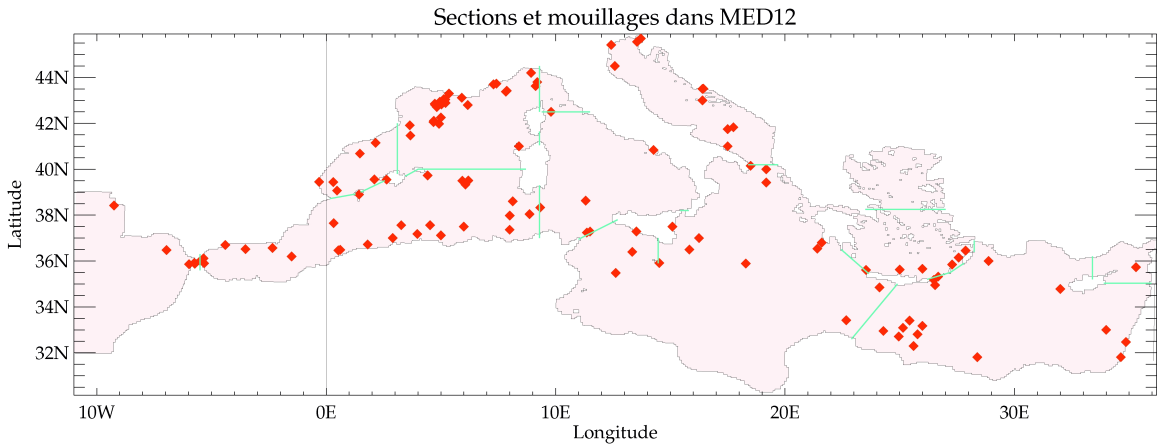

FIGURE 6 – Localization of the moorings (red diamonds) and sections (green lines) for output analyses.

4 How to install the code and run a job at IDRIS ?

Before you download this code, make sure you already registered at the official NEMO website as a user of the code. The procedure to install the code is the same as for the official NEMO version.

4.1 To install the code

1) Create and go to the working directory
   mkdir TEST ; cd TEST

2) Download the NEMO-MED12 code available on the DODS serveur at IDRIS (French computational center) in your current directory, and unarchive it.

tar -xvf NEMO_v3.2_med12.tar

3) Choose the ORCA2-LIM configuration
../modeles/UTIL/fait_config ORCA2_LIM

4) Install the makefiles (the following argument *target host* usually corresponds to your platform name resulting from the command ./w_i_h)
./ins_make [-t "target host"]

5) Compile
cd ../config/ORCA2_LIM
gmake

6) Run your executable located in ../../bin and called *opa*.

4.2 To get the input files

You can download the input files on the DODS server at IDRIS from the INPUTS_MED12_nemo_v3.2 file. These files (Tab. 4) are the one used to reproduce the MED12-ARPERA simulation described in Beuvier et al. [2012], for the first month of simulation (October 1998). If you want additional files for longer runs, send a mail (cf. Contact section).

The input fields interpolated on the MED12 grid are the following : the grid and bathymetry of MED12, the T,S,SSH climatological fields for initial conditions and restoring areas , the tide energy background field, the atmospheric and runoff forcing fields, and the positions of moorings and transport sections or on-line diagnostics.

An example of script and namelist are provided as well as the necessary input files for an example run. The job aims to work on vargas supercomputer at IDRIS french computational center but only needs few changes to work on any computer. In addition, two other files needed for the run are provided. First one thets the variables for the calendar of the run, called *MED12.db*, which can be generated with the *calendrierdb.f* fortran file. Second one called *streamjob*, defines which is the current run in the calendar file.

4.3 What are the output files

Model outputs are organized in the following way :
– ⋆2D.nc file includes all the 2D variables, defined on the T- points of the grid,

- ⋆S.nc, ⋆T.nc and ⋆rho.nc files contains all the 3D variables defined on the T- points of the grid,
- ⋆grid_U.nc file for variables defined on the U- points of the grid,
- ⋆grid_V.nc file for variables defined on the V- points of the grid,
- ⋆grid_W.nc file for variables defined on the W- points of the grid,
- ⋆.mooring⋆ files for each mooring,
- ⋆diadct file contains the daily average of the transport calculated through all the sections.

Details can be found in Tab. 5 for the saved variables and to what they correspond in Tab. 6.

5 Graphic tools

An IDL toolbox adaptated to ORCA grid specificities (among which is the MED12 grid) and called SAXO has been developped at IPSL. It is aimed to easily visualize and analyse model outputs and data.

6 Contacts

In case of problem with the installation of the code on your local machine, we suggest you contact directly the NEMO team : nemo_st@locean-ipsl.upmc.fr

For whatever concerns the code related to the Mediterranean configuration or the input files, send a mail to : thomas.arsouze@ensta-paristech.fr

7 References

Arakawa A., Lamband V.R. (1981) A Potential Energy and Enstrophy Conserving Scheme for the Shallow Water Equations, Monthly Weather Review, 109, 18-36.

Barnier B., et al. (2006) Impact of partial steps and momentum advection schemes in a global ocean circulation model at eddy-permitting resolution, Ocean Dynamics, 56, 543-567.

Beuvier J., Béranger K., Lebeaupin Brossier C., Somot S., Sevault F., Drillet Y., Bourdallé-Badie R., Ferry N., Lyard F. (2012) Spreading of the Western Mediterranean Deep Water, Journal of Geophysical Research, in revision.

Berné S., Carré D., Loubrieu B., Mazé J.-P., Morvan L., Normand A. (2004) Le golfe du Lion - Carte morpho-bathymétrique, Ifremer/Conseil Régional du Languedoc-Roussillon Edition.

Blanke B., Delecluse P. (1993) Low frequency variability of the tropical Atlantic ocean simulated by a general circulation model with mixed layer physics, Journal of Physical Oceanography, 23, 1363-1388.

Bozec A., Bouruet-Aubertot P., Iudicone D., Crépon M. (2008) Impact of penetrative solar radiation on the diagnosis of water mass transformation in the Mediterranean Sea, Journal of Geophysical Research, 113 (C06012), 1-14.

Déqué M., Piedelievre J. (1995) High resolution climate simulation over Europe, Climate Dynamics, 11, 321-339.

Drobinski P., Anav A., Lebeaupin Brossier C., Samson G., Stefanon M., Bastin S., Baklouti M., Béranger K., Beuvier J., Bourdallé-Badie R., Coquart L., D'Andrea F., de Noblet-Ducoudré N., Diaz F., Dutay J.-C., Ethé C., Foujols M.-A., Khvorostiyanov D., Madec G., Mancip M., Masson S., Menut L., Palmieri J., Polcher J., Turquety S., Valcke S., Viovy N. (2011) Model of the Regional Coupled Earcth system (MORCE) : application to process and climate studies in vulnerable regions, Environmental Modelling and Software, 10.1016/J ;envsoft.2012.01.017.

Ferry N., Parent L., Garric G., Barnier B., Jourdain N.C., and the Mercator Ocean team (2010) Mercator Global Eddy Permitting Ocean Reanalysis GLORYS1V1 : Description and Results, Mercator Ocean Quarterly Newsletter, 36-January 2010, pp 15-28.

Herrmann M.J., Somot S. (2008) Relevance of ERA40 dynamical downscaling for modeling deep convection in the Mediterranean Sea, Geophysical Research Letters, 35 (L04607), doi :10.1029/2007GL03244.

Lebeaupin Brossier C., Béranger K., Deltel C., Drobinski P. (2011) The Mediterranean response to different space-time resolution atmospheric forcings using perpetual mode sensitivity simulations, Ocean Modelling 36 (1-2), 1-25.

Lebeaupin Brossier C., Béranger K., Drobinski P. (2012a) Ocean response to strong precipitation events in the Gulf of Lions (North-Western Mediterranean Sea) : a sensitivity study, Ocean Dynamics, 62, 213-226.

Lebeaupin Brossier C., Béranger K., Drobinski P. (2012b) Sensitivity of the Northwestern Mediterranean coastal and thermohaline circulations as simulated by the 1/12° resolution oceanic model NEMO-MED12 to the space-time resolution of the atmospheric forcing, Ocean Modelling, 43-44, 94-107.

Lebeaupin Brossier C., Bastin S., Béranger K., Drobinski P., Orain F. (2012c) Ocean memory effect on the dynamics of coastal heavy precipitation preceded by a Mistral event in the North-Western Mediterranean, Roy. Meteo.

Levitus S., Antonov J., Boyer T. (2005) Warming of the world ocean, 1955-2003, Geophysical Research Letters, 32 (L02604).

Ludwig W., Dumont E., Meybeck M., Heussner S. (2009) River discharges of water and nutrients to the Mediterranean and Black Sea : Major drivers for ecosystem changes during past and future decades ?, Progress in Oceanography, 80, 199-217.

Lyard F., Lefevre F., Letellier T., Francis O. (2006) Modelling the global ocean tides : modern insights from FES2004, Ocean Dynamics, 56 (5-6), doi :10.1007/s10236- 006-0086-x.

Madec G., and the NEMO Team (2008) NEMO ocean engine, Note du Pole de modélisation, Institut Pierre-Simon Laplace (IPSL), France, n° 27 ISSN N° 1288-1619.

MEDAR/MEDATLAS Group (2002) MEDAR/MEDATLAS 2002 Database, Mediterranean and Black Sea database of temperature salinity and bio-chemical parameters, Climatological Atlas, IFREMER Edition, Brest, France, 4 CDRom.

Roullet G., Madec G. (2000) Salt conservation, free surface, and varying levels : a new formulation for ocean general circulation models, Journal of Geophysical Research, 105 (C10), 23,927-23,942.

Skamarock W. C., Klemp J. B., Dudhia J., Gill D. O., Barker D. M., Wang W., Powers J. G. (2005) A Description of the Advanced Research WRF Version 2, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH BOULDER CO MESOSCALE AND MICROSCALE METEOROLOGY DIV, Technical note

Stanev E.V., Peneva E.L. (2002) Regional sea level response to global climatic change : Black Sea examples, Global and Planetary Changes, 32, 33-47.

Vörösmarty C., Fekete B., Tucker B. (1996) Global river discharge database, RivDis, UNESCO, Paris, international Hydrological Program, Global Hydrological Archive and Analysis Systems.

8 Tables

level	gdept	gdepw	e3t	e3w
1	0.49	0.00	1.02	1.00
2	1.54	1.01	1.07	1.05
3	2.65	2.09	1.14	1.10
4	3.82	3.22	1.21	1.17
5	5.08	4.44	1.31	1.26
6	6.44	5.75	1.42	1.36
7	7.93	7.17	1.56	1.49
8	9.57	8.73	1.73	1.64
9	11.41	10.46	1.94	1.83
10	13.47	12.40	2.19	2.06
11	15.81	14.60	2.50	2.34
12	18.50	17.11	2.88	2.68
13	21.60	19.99	3.34	3.10
14	25.21	23.33	3.90	3.61
15	29.44	27.24	4.59	4.23
16	34.43	31.84	5.42	4.98
17	40.34	37.26	6.43	5.90
18	47.37	43.70	7.67	7.02
19	55.76	51.38	9.16	8.38
20	65.81	60.56	10.98	10.03
21	77.85	71.56	13.18	12.03
22	92.33	84.76	15.85	14.45
23	109.73	100.63	19.06	17.38
24	130.67	119.71	22.93	20.91
25	155.85	142.68	27.58	25.15

Table 1 – Table of the vertical properties (in meters : deptht of T- points, deptht of W- points, thickness of the layer corresponding to the T- points and thickness of the layer corresponding to the W- points, respectively) of the 25 first levels defined in the MED12 grid.

level	gdept	gdepw	e3t	e3w
26	186.13	170.29	33.14	30.23
27	222.48	203.47	39.75	36.30
28	266.04	243.28	47.59	43.51
29	318.13	290.93	56.83	52.03
30	380.21	347.82	67.62	62.02
31	453.94	415.51	80.13	73.65
32	541.09	495.72	94.49	87.07
33	643.57	590.29	110.79	102.40
34	763.33	701.17	129.07	119.68
35	902.34	830.31	149.26	138.93
36	1062.44	979.64	171.22	160.03
37	1245.29	1150.93	194.71	182.79
38	1452.25	1345.69	219.37	206.92
39	1684.28	1565.09	244.78	232.01
40	1941.89	1809.88	270.44	257.61
41	2225.08	2080.31	295.85	283.21
42	2533.34	2376.12	320.51	308.30
43	2865.70	2696.58	344.00	332.42
44	3220.82	3040.52	365.96	355.19
45	3597.03	3406.40	386.15	376.29
46	3992.48	3792.47	404.42	395.53
47	4405.22	4196.82	420.73	412.82
48	4833.29	4617.46	435.09	428.15
49	5274.78	5052.47	447.60	441.57
50	5727.92	5500.00	458.39	453.20

TABLE 2 – Table 1 continued for the 25 last vertical levels defined in the MED12 grid.

Variable/Parameterization	Name (namelist/BB_make.ldef)	Value
Time step (12 min)	rn_rdt	720
Horizontal diffusivity for tracers (T,S) laplacian / iso-neutral	ln_traldf_lap ln_traldf_iso	true true
Horizontal eddy diffusivity coefficient	rn_aht_0	60 $m^2.s^{-1}$
Horizontal diffusivity for momentum bilaplacian	ln_traldf_bilap	true
Horizontal eddy diffusivity coefficient	rn_ahm_0	-1.25 $\times 10^{10}$ $m^4.s^{-2}$
Tracers advection - TVD scheme	ln_traadv_tvd	true
Momentum advection - EEN scheme	ln_dynvor_een	true
Eddy diffusivity - TKE scheme	key_zdftke	
Vertical diffusivity coefficient enhanced	ln_zdfevd rn_avevd	true 10 $m^2.s^{-1}$
Penetration of solar radiation	ln_traqsr	true
No-slip lateral boundary condition	rn_shlat	2
Filtered free-surface	key_dynspg_flt	
Heat and freshwater fluxes and wind stress	ARPERA	daily
Coefficient of relaxation to ERA40 SST	ln_ssr rn_dqdt nn_sstr	true -40 $W^{-2}.K^{-1}$ 1
No salinity damping	rn_deds	0
2D mean tidal energy	ln_tide_2D	true
SSH damping in the Atlantic buffer zone	key_dtassh nn_fwb	 0
Daily diagnostic for moorings	nwmoor	120
Daily diagnostic for transport	ndctwri	120
Partial steps	ln_zps	true
Surface boundary condition Flux formulation	ln_flx	true
Bottom friction non linear	nn_bfr rn_bfri2	2 0.001

TABLE 3 – Summary of the main parameterizations used in the NEMO-MED12 code

what is it	name of the file
namelist of the NEMO code	namelist_MED12
script to launch a job	launch_MED12.ll
variables for the calendar of the run	MED12.db
to define the current run in the calendar file	streamjob
Levitus and MEDATLAS potential temperature	data_1m_potential_temperature_nomask.nc
Levitus and MEDATLAS salinity	data_1m_salinity_nomask.nc
SSH for the damping in the Atlantic	data_1m_sea_surface_height_nomask.nc
scale factors and geographical locations	coordinates.nc
bathymetry field	bathy_meter.nc
Climatological rivers runoffs	runoff_1m_nomask.nc
ARPERA zonal wind stress (Oct. 1998)	taux_1d.nc
ARPERA meridionnal wind stress (Oct. 1998)	tauy_1d.nc
ARPERA shortwave radiation, net downward heatflux and net upward water flux (Oct. 1998)	flx_1d.nc
ECMWF SST (only consider Oct. 1998, not the previous ones)	sst_12m.nc
2D E field on U- points	totalKE_grid_U.nc
2D E field on V- points	totalKE_grid_V.nc
definition of the transport sections	section_ijglobal.diadct
definition of the mooring locations	position.moor

TABLE 4 – Brief description of the input files

output files	grid	what is in the file
netcdf files		
⋆2D.nc	T	2D variables
⋆S.nc	T	3D salinity
⋆T.nc	T	3D potential temperature
⋆rho.nc	T	3D potential density
⋆grid_U.nc	U	2D zonal wind stress and 3D zonal current
⋆grid_V.nc	V	2D meridional wind stress and 3D meridional current
⋆grid_W.nc	W	3D vertical velocity 3D vertical eddy diffusivity 3D vertical eddy viscosity 2D lateral eddy diffusivity
binary files		
⋆.mooring_⋆	T	sampling of T,S,U,V,W,KZ at the nwmoor frequency (one file per mooring)
⋆_diadct⋆	T	average daily transports

Table 5 – Brief description of the output files obtained with the diawri.F90 program

name of the variables	what is the variable
2D fields	
sosstsst	sea surface temperature (SST - C)
sosaline	sea surface salinity (SSS - PSU)
sodensity	sea surface density ($kg.m^{-3}$)
sossheig	sea surface height (SSH - m)
sowaflup	net upward water flux ($kg.m^{-2}.s^{-1}$)
sowaflcd	concentration/dilution water flux ($kg.m^{-2}.s^{-1}$)
sosalflx	surface salt flux ($kg.m^{-2}.s^{-1}$)
sohefldo	net downward heat flux ($W.m^{-2}$)
soshfldo	shortwave radiation ($W.m^{-2}$)
somixhgt	turbocline depth (m)
somxl010	mix layer depth ($\Delta < 0.01$ - m)
soicecov	ice fraction ($[0, 1]$)
sohefldp	surface heat flux : damping ($W.m^{-2}$)
sowafldp	surface water flux : damping ($kg.m^{-2}.s^{-1}$)
sosafldp	surface salt flux : damping ($kg.m^{-2}.s^{-1}$)
sobowlin	Bowl index
sosstcli	climatological SST (C)
sossscli	climatological SSS (PSU)
sozotaux	zonal wind stress (taux - $N.m^{-2}$)
sometauy	meridional wind stress (tauy - $N.m^{-2}$)
soleahtw	lateral eddy diffusivity ($m^2.s^{-1}$)
3D fields	
vosaline	salinity (PSU)
votemper	potential temperature (C)
vodensity	potential density ($kg.m^{-3}$)
vozocrtx	zonal component of the current ($m.s^{-1}$)
vomecrty	meridional component of the current ($m.s^{-1}$)
vovecrtz	vertical velocity ($m.s^{-1}$)
votkeavt	vertical eddy diffusivity ($m^2.s^{-1}$)
votkeavm	vertical eddy viscosity ($m^2.s^{-1}$)

TABLE 6 – Brief description of the netcdf variables