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# DRAKKAR NATL12 model configuration for a 27-year simulation of the North Atlantic ocean

A.M. Treguier \*

LPO Report, September 2008  
Reference: LPO-2008-05

## 1 Introduction

This report describes the  $1/12^\circ$  model configuration NATL12 used during the summer 2008 to perform a 27-year long interannual simulation (years from 1980 to 2006). The north Atlantic  $1/12^\circ$  configuration has been created by MERCATOR-Ocean. In 2007, we have obtained this model configuration from MERCATOR and adapted it to the needs of the DRAKKAR project, and a 15-year long experiment has been run (Treguier, Theetten and Guiavarc'h, unpublished report, 2008). An update of the configuration has been performed in june-july 2008. The main differences with the 2007 version are the north and south boundaries (open climatological boundaries), the surface forcing (DFS4 instead of DFS3), and the bathymetry (opening of Faroe Bank Channel).

This is a technical report: users that are not familiar with the NEMO modelling system ([www.locean-ipsl.upmc.fr/NEMO](http://www.locean-ipsl.upmc.fr/NEMO)) should refer to the model documentation. The code is based on version NEMO 2.3, the DRAKKAR version is from july 2008. Various bugs have been corrected, including the latent heat flux over ice.

The experiment was run from years 1980 to 2006 (included) using the forcing fields from Brodeau et al, 2008 (Drakkar forcing set 4, DFS4) based on ERA40 and ECMWF as well as satellite observations. The model has been implemented on the NEC SX8 at IDRIS.

## 2 Basic settings

The list of CPP keys used for this run is found in table 1. We do not use the bottom boundary layer parameterization (`key_bbl_adv` or `key_bbl_diff`), because the improvement it brings seems limited to the vicinity of the overflows, and the behavior of these parameterizations in the case of partial cell bathymetry is not yet fully understood.

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Key	Description
key_natl12	Configuration name
key_dynspg_ft	Filtered free surface
key_zdftke	TKE vertical mixing scheme
key_dtatem	Use temperature data for initial conditions
key_dtasal	Use salinity data for initial conditions
key_tradmp	special relaxation to clim T and S in the Gulf of Cadiz
key_flux_core	Use CORE forcing routines and NCAR bulk formulae
key_traldf_c2d	2D lateral diffusion for tracers (depends on dx)
key_dynldf_c3d	3D lateral diffusion for dynamics (add laplacian at the equator)
key_ldfslp	Need to calculate isopycnal slope
key_dimgout	dimg format for outputs
key_mpp_mpi	multiprocessor MPI run
key_ice_lim	Ice model
key_lim_fdd	Ice model interaction with the ocean.
key_obc	Open boundaries
key_vectopt_loop	Vector optimization of loops (start loops at 1, not 2)
key_vectopt_memory	less computing and more memory use in zdftke

Table 1: CPP keys for NATL12-BAMT20 run

## 2.1 Horizontal grid

The size of the domain is  $1456 \times 1582$  grid points. The horizontal grid has been calculated by MERCATOR-Ocean starting from the  $1/4^\circ$  'ORCA' global mesh with 3 poles. We think the global ORCA12 grid has been calculated numerically by cutting each grid cell of the  $1/4^\circ$  grid into 9 sub-cells. We choose a domain that is different from MERCATOR. Their domain has  $1615 \times 1585$  grid points. We restrict the domain in longitude because we don't need to include the whole Mediterranean sea (by keeping only 1456 grid points in longitude we gain 10% in CPU and storage). We keep only 1582 points in latitude to fit better with boundary conditions calculated from the ORCA025  $1/4^\circ$  global model (need to make a line of "v" fit in the two models).

To go from a MERCATOR ATL12 domain to our domain, use: `ncks -F -d x,1,1456 -d y,1,1582`. The southwestmost index of NATL12 in the global ORCA2 domain is  $i=2267, j=1243$  (longitude -98.25, latitude -20.545 ). The minima of the the scale factors (ocean points) are 3.2 km (zonal direction) and 2.7 km (meridional direction). The maximum is 9.27 km at the equator.

## 2.2 Vertical grid

There are 64 levels on the vertical, with varying thickness (from 6 m at the top to 200 m at the bottom). The details of the vertical levels as well as the vertical metrics are given in annex A.

## 2.3 Bathymetry

The land/sea mask has been edited by hand by the MERCATOR team. The bathy is calculated from file ATL12\_ok.theeten.nc, sent by Romain Bourdalle-Badie (june 24th, 2007). Note that this file has been calculated with an updated version of ETOPO2 avoiding the bug in Hudson bay.

A few modifications have been done using the IDL software:

1. a line of zeroes has been added around the domain
2. The points situated in the Pacific ocean have been filled in
3. some points have been filled up to avoid anomalies in the Eastern part of the Med sea;
4. some lakes and anomalous points in fjords have been filled-in (data from MERCATOR)
5. a hole (5153 m) at 80°N and 0°E has been set to a depth of 3500 m because it tends to make the model blow up.

Note that for the closed boundary version of 2007, it was better to fill the open channels going through the Canadian Archipelago, but we have removed this modification to use open boundaries.

Further modifications have been added in 2008 (matlab programs):

1. deepening of Gibraltar to improve the Mediterranean outflow
2. deepening of Faroe Bank channel with a width of 2 grid points at a depth of 875m
3. fixing the Romanche Fracture zone

The changes in Faroe Bank channel and Med outflow have been tested in a limited area configuration (test duration: 3 months) but the Romanche fracture zone has not been tested.

The experiment is run using the partial cell representation of the topography (`ln_zps = .true.` in the namelist `nam_zgr`). The following values are used to calculate the partial cell layer thicknesses (in namelist `namdom`: `e3zps_min = 25.` and `e3zps_rat = 0.2.`

Finally, the bathymetry is adjusted near the north and south boundary to fit better with ORCA025-G70 at the open boundaries(using a matlab program). The bathymetry is exactly the ORCA025-G70 bathymetry over 3 grid points inside the domain, and a linear fit is performed to the actual bathymetry over the next 3 grid points.

## 2.4 Initial conditions

The initial conditions for temperature and salinity were derived from the Levitus 98 data set for the mean and low latitudes. For high latitudes PHC climatology was used instead. For the Mediteranean Sea, **medatlas** climatology was used. (file names are

Levitus\_phc\_3\_medatlas\_1m\_01\_12\_Tpot\_NATL12.nc and Levitus\_phc\_3\_medatlas\_1m\_01\_12\_S\_correc\_NATL12.nc ). The interpolation has been done using IDL. The initial condition for the sea ice is taken from ORCA025-G70, year 1980. ICEINI=NATL12\_restart\_ice\_from\_ORCA025-G70\_1980.nc.

### 3 Forcings

#### 3.1 Open boundary forcing

The model has open boundaries at the North and South, with data taken from the experiment ORCA025-G70. We use an annual cycle (12 monthly values) calculated from years 1980 to 2004 of the ORCA025-G70 experiment.

The domain of NATL12 is calculated so that index  $j=2$  for meridional velocity points ('v') corresponds exactly to a "v" line of ORCA025. Considering the subdomain NATL025 or ORCA025 (sub-domain beginning at  $i=757$ ,  $j=414$  with  $jpi\_natl025=486$  and  $npj\_natl025=530$ ), then we have exact correspondence between point ( $i=2,j=2$ ) in NATL025 and point ( $i=4,j=2$ ) of NATL12. Similarly, there is exact correspondence between ( $i=2,j=528=npj\_natl025-2$ ) of NATL025 and point ( $i=4,j=1580=npj-2$ ) in NATL12.

The length of the south and north boundary in NATL12 can be set as the domain width (it does not matter since boundary files for the North and South boundaries must contains  $jpi$  values).

The temperature, salinity and velocities have been interpolated horizontally and vertically using a linear interpolation, with extrapolation in land when necessary (using matlab). The total transport has been corrected to make it exactly equal to the transport of ORCA025: -1.509 Sv at the North, -1.119 Sv at the South, a difference of -0.39 Sv close to the value of the net freshwater flux over the domain (0.35 Sv of excess evaporation).

The relevant open boundary parameters in the namelist are as follows:

```
&namobc
  nobc_dta = 1
  rdpnin = 0.
  rdpsin = 1.
  rdpnob = 0.
  rdpsob = 150.
  volemp = 1.
  cffile = 'annual'
  ln_obc_clim = .true.
  ln_vol_cst = .false.
  ln_obc_fla = .false.
```

Parameters relative to the west and east boundaries, of the isolated coaslins, are not relevant to the NATL12 configuration. We choose to prescribe the northern boundary (no radiation) by setting the two relaxation time scales to zero:  $rdpnin=rdpnob=0$ . We prefer to use radiation at the southern boundary to avoid overdetermination. The time scale for inflow conditions is one day, and 150 days for outflow conditions.

### 3.2 Continental runoffs

A runoff file has been calculated using the Dai and Trenberth dataset ([Dai and Trenberth, 2002](#)) by Romain Bourdalle-Badie at Mercator (october 2006):

RUNOFF= runoff\_coast1pt\_ant3pt\_isl20\_obtaz\_1m\_ATL12\_correctAMZ\_200610.nc

It is a monthly climatology. We have corrected a bug (wrong location of the Loire runoff). The array has been shifted one grid point to the north-east (it did not fit with the NATL12 mask, due to a wrong extraction at MERCATOR).

We use the namelist variable `nrunoff=2`. In that case, a special treatment is applied in runoff regions, where the array `upsrnfh` is non zero. This array is read in the runoff file (netcdf variable `socoefr`). It has a value of zero where there is no runoff and 0.5 at runoff points. The idea is to increase the vertical mixing (up to  $10^{-3}$ ) where there are runoffs (this was done in ORCA025). However, it has been found by MERCATOR that this vertical mixing all along the coasts is too large and induces spurious upwelling. We have modified the coefficient `socoefr` in the runoff file so that it is nonzero only at the largest runoffs (cut-off value of  $1.6 \cdot 10^{-3} \text{kg.m}^{-2}.\text{s}^{-1}$ ). The increased mixing is performed by the following line in step.F90:

```
avt (:,:,2) = avt (:,:,2) + 2.e-3 * upsrnfh(:,:)
```

### 3.3 Atmospheric forcing files

The forcing dataset is called DRAKKAR forcing set 4 (DFS4), (Brodeau et al, 2008). We use a blend of data from various origin and different frequencies. Some come from the CORE dataset assembled by W. Large (available on the GFDL web site); others come from the ECMWF reanalysis ERA40. Some ERA40 variables, provided at 2 m height, are corrected to height 10 m. For the correction, the iterative algorithm provided by Large and Yeager (2004) is applied. Prior to this correction, specific humidity at 2m is computed from the dew-point at 2m and atmospheric pressure.

The input files are the following:

- **Air temperature and specific humidity** : 6 hourly values from ERA40, corrected as indicated above.
- **Solar and infra-red downwelling radiation** : Daily values from satellites (ISCCP, Zhang et al. 2004). The corrected version of this product available into the CORE dataset is used. (`qsw_CORE.nc` and `qlw_CORE.nc` for short-wave=solar and long-wave=infra-red).
- **Precipitation (total precipitation and snow)** : Monthly fields from CORE, but with correction. Southward to  $20^\circ\text{N}$ , the standard CORE product is used. Northward to  $30^\circ\text{N}$  the uncorrected CORE product (GXGXS or Serreze) is used, because we believe that the global correction applied by Large and Yeager to the "corrected" CORE dataset is unwarranted in the northern hemisphere. The two products are blended between  $20^\circ\text{N}$  and  $30^\circ\text{N}$ . Using the standard CORE product has proven to lead to highly positive global freshwater imbalance both with

model simulations and fixed SST off-line tests, leading to a consequent sea level rise. It is also emphasized that the standard CORE precipitation is over-estimated on the nordic seas. Using the proposed blending is expected to solve these two issues since the GXGXS provides much less precipitation at every latitude, especially in the north. Off-line flux computation with prescribed SST showed that along the period 1979-2000 the global freshwater imbalance is +17 mm/year with the standard CORE precipitation while it is -12 mm/year with the proposed DFS3 precipitation product. A zero imbalance was not a the purpose of this correction since, in our experience, model simulations react differently than these off-line tests.

The turbulent fluxes, outgoing radiation and albedo are calculated using the formulae proposed with the CORE dataset (Large and Yeager, 2004).

The source directory for forcing fields is on gaya at IDRIS, /u/rech/cli/rcli544/DFS4.

### 3.4 Interpolation

In order to avoid too big forcing files we use on-line interpolation of the forcing fields. We use a grid extracted from the global  $1/4^\circ$  ORCA grid called NATL025XL. This domain is larger than NATL025 in order to allow online interpolation to work correctly. The command to extract this domain from the global domain is: `ncks -F -0 -d x,755,1244 -d y,412,945`.

Routines `iom.F90` and `flx_core.h90` are modified from the DRAKKAR version for online interpolation, as well as adding new routines (`interpmod.F90` and `lib.interp.F90`).

The forcing fields are preprocessed and interpolated onto the NATL025XL grid using the `int2df` interpolation package (Brodeau 2004), available at [sourceforge.net](http://sourceforge.net):

*svn co https://sosie.svn.sourceforge.net/svnroot/sosie sosie*

The algorithm used follows Akima, 1974 : “A method of bivariate interpolation and smooth surface fitting based on local procedures”. Prior to the interpolation, the GAP procedure implemented into `int2df` is used to extrapolate sea values onto an extended land mask, this avoids some coastal land values influencing the interpolation process. Moreover, gridded data fields extracted from spectral models such as NCEP and ECMWF have the disadvantage to propagate erroneous land values onto the sea through spatial features resembling waves especially in the vicinity of coastal mountain ranges. That is why an extended land mask has been created to flag such coastal regions. These regions may be of primary importance, such as the coast of Chile where non-treated winds would hardly generate any upwelling. Another important feature of the interpolation process is the rotation of the wind vector onto distorted regions of the target grid (northward  $40^\circ\text{N}$  for ORCA grids). The interpolation is performed on `zahir`.

The NATL12 code reads the forcings on the NATL025XL grid and performs a simple on-line linear interpolation.

### 3.5 Forcing parameters

The forcing routine and the ice model are called only once every hour, e.g. 5 time steps (`nfice=5` and `nfbulk=5`) in the namelist `namdom`. There is relaxation to sea surface salinity (monthly climatology of Levitus/PHC). The coefficient (m/day) is set in the new namelist.

```
&namsbc  
  cdmp = 0.0566666667
```

This value amounts to a decay time of 180 days for 10 m of water depth. It is three times smaller than ORCA025 to have more variability of sea surface salinity. In the namelist, `icesdmp` is set to zero (damping everywhere including under ice). `ln_aplusetc=.false.` (no correction of the damping term to make its global average zero).

### 3.6 Relaxation in buffer zones

There is relaxation to monthly climatology (`key_tradmp`) in a buffer zone in the Eastern Med Sea near the eastern boundary of the domain. The relaxation coefficient varies linearly between 100 days and 3 days in the buffer zone. The relaxation region was 84 grid points wide at the beginning of the run, but we had some concern about the behavior of the model in the Med sea and the flow across Gibraltar Strait so that the width of the buffer zone was expanded to 165 grid point starting in january 1983 (after 3 years of run).

There is relaxation to sea ice cover and thickness in a buffer zone at the north (we use open boundaries for the ocean but not for sea ice). The relaxation region is 60 grid points wide. The relaxation coefficient varies linearly between 100 days and 1 days in the buffer zone.

### 3.7 Miscellaneous

We use the standard NEMO scheme for penetrative solar radiation, based on clear water only, but with a shorter penetration length of 17 m instead of the usual 23 m (Olivier Aumont, personal communication). It does not take into account data of water colour.

Note that there is no representation of the diurnal cycle in this experiment: this would require a vertical resolution of 1 m in the upper layers (Bernie and Madec, personal communication).

### 3.8 Sea surface height adjustment

We turn off the mechanisms for `ssh` and freshwater budget adjustment that are used in closed regional domains or global domains: `ln_sshneq = .false.` and `ln_fwb = .false.`

We use the correction by routine `obcvol`, variable `volemp = 1.` in the namelist. This means that the inflow through the open boundaries will compensate for the evaporation due to the E-P-R surface flux balance. The routines `obcvol.F90` and `obcini.F90` are modified so that the flux correction is done only at the southern boundary (the northern



boundary is shallow and with very fresh water, so we assume a spurious correction of velocities there could make the freshwater inflow unrealistic).

## 4 Ice model

Modifications of the ice namelist following remain Bourdalle Badie, Mercator. the values are quite different from the ones of the 2007 run. Need to write down an explanation... This affects dm, pstar, creepl, ahi0, hiccrit. (previous values were  $0.6 \cdot 10^3$  for dm (like ORCA025),  $1.5 \cdot 10^4$  for pstar (larger than ORCA025),  $2 \cdot 10^{-8}$  for creepl (same as ORCA025), 150 for ahi0 (200 for ORCA025). We had previously hiccrit=0.9 and 0.6, compared to 0.6 and 0.3 for ORCA025.

```
&namicerun
  ln_limdyn = .true.
  acrit     = 1.0e-06 , 1.0e-06
  hsdif     = 0.0
  hicdif     = 0.0
  ln_lindmp = .true.
  ln_lindmpa= .true.
/
&namiceini
  ln_limini = .true.
  ttest     = 2.0
  hninn     = 0.5
  hginn     = 3.0
  alinn     = 0.05
  hnins     = 0.1
  hgins     = 1.0
  alins     = 0.1
/
&namicedyn
  epsd      = 1.0e-20
  alpha     = 0.5
  dm        = 0.e+03
  nbiter    = 1
  nbitdr    = 100
  om        = 0.5
  resl      = 5.0e-05
  cw        = 5.0e-03
  anvg      = 0.0
  pstar     = 0.5e+04
  c_rhg     = 20.0
  etamn     = 0.0e+07
  creepl    = 1.0e-09
  ecc       = 2.0
  ahi0      = 50.e0
/
&namicethd
  hmelt     = -0.15
  hiccrit   = 0.7 , 0.5
  hicmin    = 0.2
```

```

hiclim = 0.05
amax   = 0.999
swiqst = 1.
sbeta  = 1.
parlat = 0.0
hakspl = 0.5
hibspl = 0.5
exld   = 2.0
hakdif = 1.0
thth   = 0.2
hnzst  = 0.1
parsub = 1.0
alphs  = 1.0
/

```

## 5 Parametrizations

All runs are performed with the free surface, constant volume formulation (`key_dynspgflt` defined).

### 5.1 Advection schemes:

We use TVD for tracers (`ln_traadv_tvd = .true.` ). We use the new momentum advection scheme suitable for partial step topography (`ln_dynvor_eeen = .true.` ). We use `ln_dynadv_vec = .TRUE.` in the new `nam_dynadv` namelist (what is this for???)

### 5.2 Lateral mixing:

**-tracer** : a laplacian isopycnal diffusion is used with `ahm0= 100 m2/s` at the equator. The coefficient decreases polewards proportionally to the grid size. Associated keys are `key_traldf_c2d` and `key_ldfslp`. A value of 125<sup>2</sup>/s is used in experiment ATL12-T07 or MERCATOR. The coefficient was 300 m<sup>2</sup>/s in the 1/4° configuration.

**-dynamics** : A biharmonic horizontal viscosity is used with `ahm0= -1.25 1010 m4/s-1` . At the beginning of the run, we take a viscosity depending on the grid size like  $\delta x^3$ .

In early runs by MERCATOR, the equatorial undercurrent in the Pacific was too energetic. Because of this, an additional laplacian viscosity had been added in a narrow equatorial band (-2 °S, 2 °N) upper layers, with a value of 500 m<sup>2</sup>/s, in the DRAKKAR runs made in 2004. For the first runs in 2007, we hoped that the new advection scheme would slow down the equatorial undercurrent, so we suppressed this additional viscosity. After one year, the EUC seemed to accelerate too much so an additional laplacian was added. For the simulations in 2008, we use `key_dynldf_c3d`, with `ln_dynldf_lap = .true.` and `ahmb0 = 125` in the namelist. We use a modified the code to calculate a laplacian viscosity in the upper layers of the equator with maximum value `ahmb0 = 125 m2.s-1` (this is a

decrease from the 2007 version where the value  $250 \text{ m}^2.\text{s}^{-1}$  was used and found to be too strong).

### 5.3 Bottom boundary layer:

Initial tests show very little effect of the bottom boundary layer (trabbl), presumably due to incompatibility with partial cell topography. We do not use these parameterizations here.

### 5.4 Vertical mixing:

There is no double-diffusive mixing.

**-tke:** TKE is used to compute the vertical mixing. We use the new version of the TKE routine recently proposed by Gurvan MADEC with the following namelist parameters

```

!-----
!      namtke   turbulent eddy kinetic dependent vertical diffusion
!              ( #ifdef "key_zdftke" )
!-----
! ln_rstke flag to restart with tke from a run without tke (default F)
! ediff   coef. to compute vertical eddy coef. (avt=ediff*mxl*sqrt(e) )
! ediss   coef. of the Kolmogoroff dissipation
! ebb     coef. of the surface input of tke
! efave   coef. to applied to the tke diffusion ( avtke=efave*avm )
! emin    minimum value of tke (m^2/s^2)
! emin0   surface minimum value of tke (m^2/s^2)
! nitke   number of restart iterative loops
! ri_c    critic richardson number
! nmxl    flag on mixing length used
!         = 0 bounded by the distance to surface and bottom
!         = 1 bounded by the local vertical scale factor
!         = 2 first vertical derivative of mixing length bounded by 1
! npdl    flag on prandtl number
!         = 0 no vertical prandtl number (avt=avm)
!         = 1 prandtl number function of richarson number (avt=pdl*avm)
!         = 2 same as = 1 but a shapiro filter is applied on pdl
! nave    = horizontal averaged (=1/2) or not (=0) of avt (default =1)
! navb    = 0 cst background avt0, avm0 / =1 profile used on avtb
! ln_lsfc computation surface value of buoyancy lenght scale as function of wind stress
! lmin    buoyancy lenght scale minimum value if ln_lsfc = F
! n_etau  test param. to add tke induced by wind
!         = 0 no add tke induced by wind
!         = 1 add tke induced by wind
!         = 2 add tke induced by wind only at the base of the mixed layer
! fr_emin fraction of TKE surface value which penetrates inside the thermocline
! ln_lc   flag to take into account Langmuir circulation
! c_lc    coef to compute verticla velocity of LC
&namtke
  ln_rstke = .false.

```

```

ediff =      0.1
ediss =      0.7
ebb =       60.
efave =      1.
emin =     1.e-6
emin0 =    1.e-4
nitke =      50
nmxl =       3
npdl =       1
navb =       0
nave =       1
ln_lsfc = .true.
lmin =      0.4
n_etau =     1
nhtau =     3
fr_emin =   0.05
ln_lc = .true.
rc_lc =    0.15

```

The key modification made to tke is `fr_emin`, the proportion of energy allowed to enter into the stratified ocean below the mixed layer. This is meant to represent mixing by unresolved turbulence due to surface waves and swell. It is supposed to improve the depth of summer mixed layers that were too shallow in experiment G42. The parameter `nhtau` is changed from ORCA025-G50 (it used to be 1). It sets the scheme for the penetration of this energy. The depth is hardwired in the routine. It used to be 40m with a decrease to 5m at the equator. With `nhtau=3`, the depth is allowed to be different in different hemispheres, but finally after testing we set it to 30m in both hemispheres. We want to avoid unrealistic mixing under the ice. For this reason, the Langmuir cells contribution is removed under the ice, and the background coefficient is reduced (see next paragraph).

**-background and convection:** The enhanced vertical diffusion is used when convection is diagnosed. The corresponding namelist block is :

```

!-----
!          namzdf   vertical physics
!-----
! ln_zdfevd  enhanced vertical diffusion          (default T)
! ln_zdfnpc  Non-Penetrative Convection          (default T)
! avm0       vertical eddy viscosity for the dynamic (m2/s)
! avt0       vertical eddy diffusivity for tracers (m2/s)
! avevd      vertical coefficient for enhanced diffusion scheme (m2/s)
! nevdm      = 0  apply enhanced mixing on tracer only
!            = 1  apply enhanced mixing on both tracer and momentum
! ln_zdfexp  vertical physics: (=T) time splitting (T)      (Default=F)
!            (=F) euler backward (F)
! n_zdfexp   number of sub-timestep for time splitting scheme
&namzdf
  ln_zdfevd = .true.
  ln_zdfnpc = .false.
  avm0      = 1.e-4

```

```

    avt0      = 1.e-5
    avevd     = 10.
    nevdm     = 1
    ln_zdfexp = .false.
    n_zdfexp  = 3
/

```

In the previous version of TKE there was an enhancement of the background by a factor of 10 in the top layer (and 5 and 2.5 in the second and third) in order to avoid too shallow mixed layers in summer. This is suppressed in the new version of TKE. The background coefficient is divided by a factor of 10 under the ice.

## 5.5 Bottom friction and lateral boundary condition

The namelist is the following. We use the standard bottom friction code with no enhancement of bottom friction.

```

!-----
!      nambfr  bottom friction
!-----
!  nbotfr  type of bottom friction
!          nbotfr = 0 , no slip
!          nbotfr = 1 , linear friction
!          nbotfr = 2 , nonlinear friction
!          nbotfr = 3 , free slip
!  bfri1   bottom drag coefficient (linear case)
!  bfri2   bottom drag coefficient (non linear case)
!  bfeb2   bottom turbulent kinetic energy (m^2/s^2)
&nambfr
    nbotfr = 2
    bfri1  = 4.e-4
    bfri2  = 1.e-3
    bfeb2  = 2.5e-3
/

```

The lateral boundary condition is free slip, excepted downstream of the overflows (in a wide region in the subpolar gyre) and downstream of Gibraltar (in the gulf of Cadiz) where a no-slip condition is applied. These modifications are implemented by reading directly the shlat coefficient in a file (ln\_shlat2d parameter in the namelist). Local modifications of fmask are performed in Gibraltar (shlat=5) and in Faroe bank channel (shlat=0). In Gibraltar we want to limit the flow, while in Faroe Bank channel we need to accelerate it.

## 6 miscellaneous:

**-timestep** : The time steps is set to 720 s ( 120 steps/day).

**-hpg implicit** : The semi-implicit scheme is applied to allow a larger time step (a factor of two on the cfl criterion linked with internal wave propagation).

**-asselin** : the asselin coefficient is taken to 0.1

## 7 Simulation strategy and computer resources

The present run starts in 1980 directly with the interannual varying forcing. The simulation has been run from July 30th, 2008 to September 12th, 2008 (44 days). The job has been interrupted for about 3-5 days (problems with files, one system error, and a bug in the ice model). The bug in the ice model interrupted the run in March 1992. It was due to the `icedmp` option (necessity to force the lead fraction to be smaller than 1 in the `limdmp` routine).

The domain is divided into 24 subdomains without elimination of processors. Preliminary tests had shown that the best performance was when cutting in `i` so we use `jpni=24`, `jpnj=1`. The model takes about 31 to 32 hours (elapsed) to complete one year, in 3 jobs of 125, 120 and 120 days respectively. The generation of the netcdf files and archiving the restart and result files takes some time (about 40mn before the job to get the forcings, climatology and restarts; 10mn to archive restarts at the end of job; up to 45 mn to recompose and archive netcdf result files).

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# A Annex A

## vertical levels

zgr\_z : Vertical z-coordinates  
ppdzmin = 6.0  
pphmax = 5800.0  
ppkth = 37.  
ppacr = 13.

Reference z-coordinate depth and scale factors:

level	gdept	gdepw	e3t	e3w
1	3.02	0.00	6.06	6.00
2	9.15	6.06	6.20	6.13
3	15.43	12.27	6.37	6.28
4	21.89	18.64	6.56	6.46
5	28.56	25.20	6.78	6.67
6	35.48	31.99	7.04	6.91
7	42.67	39.03	7.35	7.19
8	50.18	46.38	7.70	7.51
9	58.08	54.08	8.10	7.89
10	66.42	62.19	8.58	8.33
11	75.26	70.77	9.13	8.84
12	84.70	79.90	9.77	9.44
13	94.83	89.67	10.50	10.12
14	105.75	100.18	11.36	10.92
15	117.59	111.54	12.34	11.83
16	130.49	123.89	13.48	12.89
17	144.61	137.38	14.79	14.11
18	160.14	152.18	16.30	15.52
19	177.28	168.49	18.03	17.13
20	196.27	186.53	20.00	18.98
21	217.38	206.54	22.26	21.09
22	240.89	228.81	24.82	23.50
23	267.12	253.64	27.71	26.22
24	296.44	281.37	30.98	29.30
25	329.21	312.37	34.64	32.76
26	365.86	347.03	38.72	36.63
27	406.81	385.77	43.25	40.93
28	452.51	429.04	48.23	45.68
29	503.42	477.28	53.67	50.89
30	560.00	530.97	59.56	56.56
31	622.68	590.55	65.89	62.67
32	691.90	656.45	72.61	69.20
33	768.02	729.08	79.69	76.11
34	851.38	808.78	87.06	83.34
35	942.22	895.85	94.65	90.83
36	1040.72	990.50	102.37	98.50
37	1146.97	1092.87	110.14	106.26
38	1260.98	1203.01	117.86	114.01

39	1382.66	1320.87	125.45	121.68
40	1511.81	1446.31	132.82	129.17
41	1648.20	1579.12	139.90	136.40
42	1791.50	1719.01	146.63	143.31
43	1941.32	1865.62	152.95	149.84
44	2097.26	2018.55	158.84	155.95
45	2258.86	2177.38	164.28	161.62
46	2425.67	2341.64	169.26	166.83
47	2597.23	2510.88	173.79	171.58
48	2773.10	2684.65	177.87	175.88
49	2952.83	2862.51	181.53	179.75
50	3136.03	3044.02	184.80	183.21
51	3322.30	3228.80	187.70	186.29
52	3511.31	3416.49	190.26	189.02
53	3702.71	3606.73	192.51	191.42
54	3896.23	3799.23	194.48	193.53
55	4091.60	3993.70	196.21	195.38
56	4288.58	4189.90	197.72	196.99
57	4486.97	4387.61	199.03	198.40
58	4686.58	4586.64	200.17	199.62
59	4887.26	4786.80	201.15	200.68
60	5088.85	4987.95	202.01	201.60
61	5291.23	5189.95	202.75	202.39
62	5494.31	5392.69	203.38	203.08
63	5697.97	5596.07	203.93	203.67
64	5902.15	5800.00	204.41	204.18