

Definition of the interannual experiment ORCA025-B83, 1958-2007

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1 Introduction

This report describes the ORCA025-B83 model configuration. This is a global $1/4^\circ$ model configuration using an interannual forcing function from 1958 to 2007. The numerical experiment has been performed in the frame of the DRAKKAR project. This report describes this configuration and particularly points the differences between this run and the first DRAKKAR ORCA025 inter-annual run (ORCA025-G70, Molines *et al.*, 2006).

The ORCA025-G70 experiment has been performed in the summer of 2006 and results were widely distributed to the group of associated investigators. It has been analysed by Treguier *et al* (2007) for the Southern Ocean, Lique *et al* (2009) for the Arctic Ocean, Michel *et al* (2009) in the Bay of Biscay, and Tsimplis *et al* (2008) or Lombard *et al* (2009) for the variability and trends in sea level. Many other scientific studies based on ORCA025-G70 are still under way. These works points the qualities and defects of the G70 simulation. Since 2006, substantial work has been done to improve both the forcing function and the model parametrizations. This B83 simulation is an attempt to improve G70 results, using an updated code and a more realistic forcing function.

ORCA025-B83 mainly differ from ORCA025-G70 by the forcing function: B83 uses Drakkar Forcing Set 4.1 (DFS4.1) whereas G70 uses Drakkar Forcing Set 3 (DFS3). Differences between these 2 data set are widely described in Brodeau *et al.*, 2009, and will be synthetised in this document.

Another driving idea for ORCA025-B83, was to realize an interannual experiment with the model configuration as close as possible to a climatological experiment (ORCA025-MJM01, performed on the new super computer 'Jade' at CINES), forced with DFS4.1 daily climatology, for 310 years, in order to assess model drifts. ORCA025-MJM01 and its comparison to ORCA025-B83 is the topic of another report (Molines *et al.*, 2009, to be written). We had the

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opportunity to run the climatological run (more than 1 500 000 CPU hours) during fall 2008, and we did it previous to B83.

For this latter reason, we hardly touch the B83 code, compared to MJM01 : Elimination of 3D relaxation in the Mediterranean sea because recent studies (Tsimplis et al.,2008) have shown that the Mediterranean sea representation in ORCA025-G70 (no 3D restoring) was quite fair in many aspects; note that the relaxation in the Gulf of Cadiz between 600 and 1200m is maintained, so that the modifications in the Mediterranean sea are not propagated to the whole Atlantic Ocean. We also maintain ice model parameters identical to MJM01, despite the fact that they were far from being optimal (more details below).

Besides the forcing set and some parameterization changes, there is one important difference between ORCA025-B83 and ORCA025-G70: the effect of ocean sea surface velocities is not taken into account in the computation of the wind stress, while it was in ORCA025-G70. This is also to be coherent with the climatological run ORCA025-MJM01, which uses wind module climatology (hence without sea surface current influence). We acknowledge that sea surface velocities do have an effect on the wind stress, but it is not clear how it is best taken into account. The influence of surface waves, for example, is not taken into account in the usual bulk formulae, and we suspect that these formulae result in too much damping of the ocean mesoscale turbulence (B. Barnier, B. Chapron, personal communications).

This is a technical report: users that are not familiar with the NEMO modelling system (www.nemo-ocean.eu) should refer to the model documentation (Madec, 2008). The code is based on version NEMO 2.3.

2 Basic settings

The list of CPP keys used for this run is found in table 1. With respect to ORCA025-G70 we add the last 2 keys, concerning a BBL advection of momentum (*key_dynbbl_adv*, (Hervieux, 2007) and the parametrization of the effects of tides on the vertical mixing (*key_zdfmix*, Koch-Larrouy *et al.*, 2007). For run B83, we do not simulate passive tracers (CFC11 and BombC14) as it was done in G70. This latter choice allows the completion of run B83 before the end of 2008 and its computing time allocation, and is coherent with the fact that the climatological run MJM01 was not designed for passive tracers.

2.1 Horizontal grid (like G70)

The horizontal grid was defined as a generic 'ORCA' type mesh with 3 poles, using a t-point pivot for the north fold condition. The horizontal grid resolution is 1/4 deg at the equator, leading to horizontal dimensions of 1442 x 1021. The minima of the the scale factors (ocean points) are 5.6 km (zonal direction) and 3.1 km (meridional direction). The maximum is 27.8 km at the equator.

2.2 Vertical grid (like G70)

There are 46 levels on the vertical, with grid spacing ranging from 6 m near the surface to 250 m at 5750 m. The maximum depth allowed in the model is 6000 m. to reach that depth with partial

Key	Description
key_orca_r025	Configuration name
key_dynspgflt	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_dtasss	Use monthly surface salinity data for relaxation
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_c2d	2D lateral diffusion for dynamics (depends on dx ³)
key_ldfslp	Need to calculate isopycnal slope
key_trabbl_dif	diffusive bottom boundary layer parameterization
key_trabbl_adv	advective bottom boundary layer parameterization
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_dynbbl_adv	advective bottom boundary layer
key_zdftmx	update momentum and tracer Kz with tidal induced Kz

Table 1: CPP keys for ORCA025-B83 run.

cells, the deepest cell can have a thickness as large as 500 m in the deep basins. The details of the vertical levels as well as the vertical metrics are given in annex A.

2.3 Bathymetry

The model bathymetry for ORCA025-B83 is the same than for ORCA025-G70. The only difference have no impact on the run : The Caspian sea has been removed from the bathymetric file in order to optimize domain decomposition on several hundred of processors. In G70, the Caspian sea was masked afterward. The construction of the ORCA025-G70 bathymetry is recalled below. It is derived from two input files:

- The 2-minute bathymetry file (etopo2) of NGDC, combination of Smith and Sandwell (1997) satellite-based bathymetry (8.2 version), IBCAO (in the Arctic region) and other data in the Antarctic region. The MERCATOR project team has applied additional corrections near the Antarctic (Remy et al, 2003). This file is used for the deep ocean (below 300m) because its spatial scales are consistent over the globe.
- The GEBCO 1mn bathymetry file provided between 88S and 88N. This file is used for bathymetry on the shelf because it is found to be more accurate there (above 200m).

The interpolation onto the model grid has been conducted by taking all the original grid points falling into an ORCA025 grid box, and taking the median of those points. This procedure produces a smoothing of the sub-grid scale topography. The two bathymetries are combined with a linear ramping between 200m and 300m to transition from Gebco to Etopo2. The topography has been smoothed by two passes of a uniform shapiro filter with weight $w=0.6$, and hand editing has been performed in key areas. The land/sea mask has been edited by hand by the MERCATOR team.

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

A list of hand editions made for this run is given in Annex B. There are substantial modifications compared with the original version of 2004 found on the DRAKKAR web site. A first series of modifications was made in the Indonesian Throughflow region by Ariane Koch Larrouy who runs a limited-area model forced at the boundaries by ORCA025-G32 (Larrouy, Madec et al, in preparation). A second series was made in the Gulf of Cadiz following the work of R. Almar and S. Theetten (2005). This work was initiated following our finding that Mediterranean waters as well as overflow waters did not sink to the right depth in ORCA025. The results of the tests, as well as the experiments of G. Hervieux (LEGI) confirmed the small influence of the existing parameterizations in the NEMO code: advective and diffusive bottom boundary layer, as well as enhanced bottom friction downstream of the straits. A "cliff" approach was attempted for the Mediterranean outflow, which is to dig a narrow channel from the Gibraltar Strait to the right depth (1200m). This was found to produce mediterranean water at the right depth but too warm and too saline. Despite these flaws we have preferred it to the previous solution (mediterranean water with more or less the right temperature and salinity but too high in the water column). Results of the first years of the ORCA025-G70 experiment shows that a relaxation to annual

Levitus T and S is necessary. This has been introduced successfully in ORCA025-G70 in layers 21 to 26 (637 to 1297m), in a gaussian patch of radius 80 km centered at 36°N, 7°W and with a maximum relaxation coefficient of 6 days.

The cliff approach is also applied to Denmark Strait. The strait is widened and a channel is dug downstream of the deep outflow. We note that in a short experiment with NATL4, the effect of widening Denmark Strait by a factor of two did not lead to an increase of the overall transport because the velocities became smaller in the same proportion as the increase in area. The properties of the waters downstream improved somewhat, and the overturning increased by at least one Sverdrup.

Finally, two islands have been added in the Torres Strait in order to reduce the barotropic transport, but leaving the strait open.

file used : ORCA025_combined_etopo_gebco_coast_corrected_july08_G70.nc

2.4 Initial conditions (like G70)

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 Mediterranean Sea, **medatlas** climatology was used. The initial condition for the sea ice is taken from ORCA025-G45b, a previous run with a climatological CORE forcing. This initial condition corresponds to mean January of year 10 of the G45b experiment.

3 Forcings

3.1 Runoffs (like G70)

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

runoff_coast1pt_ant3pt_obtaz_1m_ORCA025.nc. It includes 99 major rivers and coastal runoffs; the total annual mean input is 1.31 Sv. It is a monthly climatology. A report describing the method is found on the DRAKKAR web site (Bourdalle-Badie and Treguier, 2006). 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. Since we do not use the centered scheme, there is no need to revert to upstream near runoffs (the TVD advection scheme is used everywhere). In our case the special treatment consists in an enhanced vertical diffusion at the interface of layers 1 and 2 applied in step.F90 (Drakkar configuration manager version):

$$\text{avt}(:, :, 2) = \text{avt}(:, :, 2) + 2.e-3 * \text{upsrnfh}(:, :)$$

The vertical mixing is then set to 10^{-3} below the top level at runoff points.

`upsrnfh` is also used to avoid SSS restoring in the vicinity of river mouths (which tends to cancel the runoff effect !)

3.2 DFS4.1 Atmospheric forcing

The forcing dataset is called DRAKKAR forcing set 4.1 (DFS4.1), documented in a paper by Brodeau et al (2009). In the following we will just indicate the driving ideas to build DFS4.1 forcing function.

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; see Large and Yeager, 2004, or Griffies et al, 2009); others come from the ECMWF reanalysis ERA40, and for recent years ECMWF analyses.

The input files are the following, as they were for DFS3:

- **Air temperature and specific humidity (2m)** 6 hourly values from ERA40: In DFS4, relative to DFS3, corrections have been applied to remove biases in ERA40 (regarding tropical humidity, for example) and to improve the continuity between reanalysis and analysis (Brodeau et al, 2009). We also improved air temperature representation in the northern hemisphere. 2D correction was applied in the Arctic (north of 70°) by taking advantage of the POLES climatology of Rigor et al. 2000. A zonal increase of air humidity and temperature was also globally applied between 50°N and 70°N to limit excessive turbulent heat/water loss in regions such as the Labrador sea.
- **Wind velocity components u10 and v10 (10 m)** 6 hourly values from ERA40: When making the CORE forcing, Large and Yeager (2004) corrected the NCEP winds to bring the wind module to values closer to the Quikscat scatterometer observations. We have done the same with ERA40 winds. This increases evaporation in the tropics and considerably reduces the biases in SST that were found in ORCA025-G70, in the Indian ocean for example.
- **Solar and infra-red downwelling radiation** : Daily values from satellites (ISCCP, Zhang et al. 2004) are used up to year 2006. Whereas DFS3 was using CORE v1 dataset with respect to the radiative fluxes (a corrected version of the ISCCP data), in DFS4.1 we used our own correction, applied on the raw ISCCP data. A zonal correction is applied to the ISCCP downwelling longwave radiation corresponding to an increase by a factor of 1.02 (20%) between 40°S and 25°S. The downwelling shortwave radiation is decreased by a factor of 0.93 (-7%) between 15°S and 25°N, and by a factor of 0.95 (-5%) between 25°N and 40°N.
- **Precipitation (total precipitation and snow) (identical to DFS3)** : Monthly fields from CORE, but with correction. Southward to 20°N, the standard CORE product is used. Northward to 30°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°N and 30°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. Note that for the period 1958-1978, we use a monthly mean climatology deduced from 1979-2004.

The turbulent fluxes, outgoing radiation and albedo are calculated using the formulae proposed with the CORE dataset (Large and Yeager, 2004). With respect to the G70 version of these formulae, many bugs have been fixed: bug correction in the computation of the exchange coefficients (C_e and C_h), bug fix in the computation of the latent heatflux concerning the sublimation of ice. Additionally to these bug fixes, we decided not to use the ocean surface velocity in the computation of the exchange coefficient and on the wind stress. We observed from sensitivity experiments that when using the surface velocity for computing the wind stress for example, the eddy kinetic energy is drastically reduced (Jouanno et al. 2008), and does not compare so well with altimetric estimates of the EKE.

3.3 Interpolation

The forcing fields are preprocessed and interpolated using the sosie interpolation package (Brodeau 2004), available at :

<http://www-meom.hmg.inpg.fr/Web/Outils/SOSIE/sosie.html>

The algorithm used follows Akima, 1974 : “A method of bivariate interpolation and smooth surface fitting based on local procedures”. Prior to the interpolation, the DROWN procedure implemented into sosie 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°N for ORCA grids).

3.4 Katabatic winds

A modification is made to the wind forcing to improve the representation of the katabatic winds around Antarctica (Mathiot, 2005). This is done by multiplying the two components of the wind stress by a coefficient read on `katamask.nc` file. This coefficient and its area of application around Antarctica has been determined by comparison over the period 1980-1989 of ERA40 with a downscaling of ERA40 on the Antarctic carried out with the regional atmospheric model MAR designed for the simulation of katabatic winds (H. Gallée, LGGE). The coefficient is constant in time, but has a geographical dependence and an extent over the ocean which fits the results of

MAR. This correction of the katabatic winds has been validated by a series of simulations long of 10 years, carried out with a model of the ACC extracted from ORCA05, and driven at its open boundary by the solution of ORCA05-G42 (Mathiot, 2009). This correction is applied over the period 1958-2001. When switching wind forcing to ECMWF analysis products, (2002-2004), it was turned off: these higher resolution (than ERA40) products have almost correct katabatic winds, and the correction was not tuned for these winds.

3.5 Forcing parameters

The forcing routine and the ice model are called only once every two hours, 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 namelist:

```
&namsbc  
  cdmpr = 0.1666666667
```

This value is chosen by consistency with the "strong relaxation" cases in the CORE papers by Griffies *et al.*, 2006. It amounts to a decay time of 60 days for 10 m of water depth. We decided to maintain SSS restoring under the ice cover with a 5-time enhanced coefficient (12 days for 10 m). We also have an enhanced SSS relaxation (x3) on semi enclosed seas: Mediterranean, Red Sea and Persian Gulf. For these latter 2 seas, we even have a mild 3D restoring (time scale of 180 days) for T and S.

3.6 Miscellaneous

We use the standard NEMO scheme for penetrative solar radiation, based on clear water only. 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).

Finally, there is relaxation to climatological temperature and salinity in a small region in the Gulf of Cadiz (see details in the "bathymetry" section). We relax to the Levitus annual temperature and salinity, the seasonal cycle being small in the relaxation zone (below 637 m). The restoring time scale is 6 days as a maximum and the strength of the relaxation decays to 0 on a 100 km diameter circle centered somewhat downstream the Strait of Gibraltar.

3.7 Sea surface height adjustment

We do not use any SSH adjustment. We set `ln_fwb = .false.` in the namelist. No attempt is made to ensure that the correction term (erp) by relaxation to observed SSS had a zero integral over the global ocean (suppression of the adjustments using "aplus" and "aminus" in routine `ocesbc.F90`). All experiments with CORE forcings had an increase of the global SSH, and so was the case of an hybrid forcing experiment with the 1/2° global model (ORCA05-G60). To minimize this drift, precipitations have been reduced compared with previous cases (section 3.2).

4 Ice model

A few general remarks about the ice parameters (Martin Vancoppenolle, personal communication):

- `pstar` sets the ice resistance to deformation. For a given convergence of ice velocities, a smaller `pstar` will allow ice to pile up and produce a thicker ice, say, along the Canadian coast. Inversely, a large `pstar` produces lower gradients of ice thickness. A usual value is 5000 N/m, it may be up to 20000 N/m.
- `creepl` is a parameter for the viscous-plastic (VP) rheology. Usually `creepl`= $1. \cdot 10^{-9}$. It may be set higher (up to $2. \cdot 10^{-8}$ - to help stabilize the VP rheology?) but in that case the dynamic regime is no longer plastic, it becomes viscous.
- `hiccrit` is the thickness of the ice that forms in leads in one time step. This parameter allows to calibrate the ice formation in open channels. The mean ice thickness depends quite strongly on that parameter for the following reason. Assume a specified amount of cooling over an ice-free area. The larger `hiccrit`, the lower the area occupied by newly formed ice, and the larger the area of leads where cooling and ice production can continue. The value of `hiccrit` should depend on the time step and be 5 or 10 cm; however, it is often set higher (30 to 50 cm) to account for the unresolved high frequency motions (sub-diurnal frequencies) that produce net divergence. Here we set `hiccrit`=0.6 m for the Arctic, which is quite high.

The ice parameters chosen for run B83 are identical to ORCA025-MJM01 and are not the same than those used in ORCA025-G70, the differences are mainly in the ice dynamics. `dm` was put to zero instead of $0.6 \cdot 10^3$, `pstar` was reduced from $1. \cdot 10^4$ to $5. \cdot 10^3$, `creepl` was reduced from $2. \cdot 10^{-8}$ to $1. \cdot 10^{-9}$ and `ahi0` was reduced from 200 to 50. This set of parameters was proposed by T. Fichefet (personal communication) as a sensitivity experiment for ORCA025. The first conclusion of this sensitivity experiment was that the ice solution was worse in general than when running with the standard set of coefficients. The major flaw was a far too thick ice in the Beaufort Gyre, in the Arctic Sea (nearly 20 m !). When running the long term climatological experiment we did the mistake to take this wrong set of parameters, but we discover the problem when starting to run B83: default are amplified in the inter-annual run with respect to the climatological one. However, we stick to this set, as we need an inter-annual simulation as close as the climatological one, for our scientific goals. Once we pointed out the problem of this bad choice we did a climatological sensitivity experiment during 30 years, using G70 set of parameter (ORCA025-MJM04) and the results (surprisingly) showed very small differences in the global ocean, except of course in the Arctic. Even the Antarctic was pretty much unchanged. We do see in this result a strong stabilizing impact of the SSS restoring, under ice, which finally probably clamp the fresh water flux to the ocean.

```
&namicerun
  ln_limdyn   = .true.
  acrit       = 1.0e-06 , 1.0e-06
  hsdif       = 0.0
```

```

    hicdif = 0.0
    ln_limdmp = .false.
/
&namiceini
    ln_lim_ini = .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.
    nbiter = 1
    nbitdr = 100
    om = 0.5
    resl = 5.0e-05
    cw = 5.0e-03
    anvgv = 0.0
    pstar = 5000
    c_rhg = 20.0
    etamn = 0.0e+07
    creepl = 1.0e-09
    ecc = 2.0
    ahi0 = 50.e0
/
&namicetrp
    bound = 0.
/
&namicethd
    hmelt = -0.15
    hiccrit = 0.6 , 0.3
    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
    alphas = 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.`).

5.2 Lateral mixing:

-tracer : a laplacian isopycnal diffusion is used with $aht0= 300\text{m}^2/\text{s}$ at the equator. The coefficient decreases polewards proportionally to the grid size. Associated keys are `key_traldf_c2d` and `key_ldfslp`.

-dynamics : A biharmonic horizontal viscosity is used with $ahm0= -1.5 \cdot 10^{11} \text{ m}^4/\text{s}^2$. The viscosity depends on the grid size with δx^3 .

5.3 Bottom boundary layer:

A diffusive bottom boundary layer is activated using `key_trabbl_dif` with $atrbbl=1000 \text{ m}^2 \cdot \text{s}^{-1}$. The advective boundary layer has been tested in the North Atlantic regional configuration NATL4 with only a small effect (small compared with the improvements found in the FLAME model). Despite the weakness of this effect, we keep the advective BBL scheme all the same (`key_trabbl_adv`), as it produces a small improvement.

In run B83, we also used the bottom boundary layer advection of momentum: This parametrization was first tested by B. Ferron (pers. comm.) in a Clipper like North Atlantic model configuration with quite good results. B.Ferron code has been ported to NEMO and the DRAKKAR configurations (Hervieux, 2008) and used in the present run. The improvement is small but significant, in term of increase of the bottom density, downstream the overflow regions.

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. No changes were made since ORCA025-G70.

```
!-----  
!          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
! nhtau    =
! fr_emin  fraction of TKE surface value which penetrates inside the thermocline
! ln_lc    flag to take into account Langmuir circulation
! rc_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

```

-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)
! n_evdm     = 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.
  n_evdm    = 1
  ln_zdfexp = .false.
  n_zdfexp  = 3

```

Again, no changes were made since G70. 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.

-zdfmx: In run B83, we implement the parametrization of tidally induced vertical mixing, developed by A. Koch-Larrouy (2008). This is a parametrization of the vertical mixing produced by the breaking of internal waves generated by barotropic-baroclinic conversion of tidal energy. This parametrization requires a mapping of the available energy. Those maps were provided by F. Lyard as a result of the finite element global tidal model, for tidal components M_2 and K_1 . In Ariane work, in the Indonesian throughflow region, the assumption was made that all the tidal energy is converted in vertical mixing (based on observations). Away from this region, we assume that only 1/3 of the energy is converted in mixing. This value is a rather crude estimate that may probably be improved.

files used : *M2rowdrg_R025_modif.nc* *K1rowdrg_R025_modif.nc*

5.5 Bottom friction and lateral boundary condition

The namelist is the following. We use a spatially variable coefficient: the bottom friction coefficient is multiplied by `bfricn=50` in Torres Strait: this is to reduce the flow through this strait, that is observed to be small. No changes compared to G70.

```

!-----
!          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)
! ln_bfr2d: flag for 2d coef enhancement read in file
! bfrien:  enhancement coefficient (real > 1)
&nambfr
  nbotfr =      2
  bfri1 =  4.e-4
  bfri2 =  1.e-3
  bfeb2 =  2.5e-3
  ln_bfr2d = .true.
  bfrien = 50.

```

The lateral boundary condition is free slip (a test with no-slip was made in 2004 and the results were not good, Thierry Penduff, publication in preparation). We modify it locally to decrease the transport at some straits. The following modifications were made in dommsk.F90 in ORCA025-G70 and are still used in this experiment :

```

IF( cp_cfg == "orca" .AND. jp_cfg == 25 ) THEN ! ORCA R025 configuration
!          ! =====
  ii0 = 212 ; ii1 = 212 ! East of Ombai strait
  ij0 = 464 ; ij1 = 465 ; fmask( mi0(ii0):mi1(ii1) , mj0(ij0):mj1(ij1), 1:jpk ) = 2.0
  IF(lwp) WRITE(numout,*)
  IF(lwp) WRITE(numout,*) '          orca_r025: fmask = 2 at the East Ombai Strait'
  ii0 = 210 ; ii1 = 211 ! West of Ombai strait
  ij0 = 466 ; ij1 = 466 ; fmask( mi0(ii0):mi1(ii1) , mj0(ij0):mj1(ij1), 1:jpk ) = 2.0
  IF(lwp) WRITE(numout,*)
  IF(lwp) WRITE(numout,*) '          orca_r025: fmask = 2 at the West Ombai Strait '
  ii0 = 210 ; ii1 = 210 ! exit of Ombai strait
  ij0 = 464 ; ij1 = 465 ; fmask( mi0(ii0):mi1(ii1) , mj0(ij0):mj1(ij1), 1:jpk ) = 2.0
  IF(lwp) WRITE(numout,*)
  IF(lwp) WRITE(numout,*) '          orca_r025: fmask = 2 at the exit of Ombai Strait '
  ii0 = 172 ; ii1 = 175 ! Lombok strait
  ij0 = 463 ; ij1 = 463 ; fmask( mi0(ii0):mi1(ii1) , mj0(ij0):mj1(ij1), 1:jpk ) = 2.0
  IF(lwp) WRITE(numout,*)
  IF(lwp) WRITE(numout,*) '          orca_r025: fmask = 2 at the Lombok Strait'
!
ENDIF

```

and further modifications:

```

! Locally modify shlat :
IF( cp_cfg == "orca" .AND. jp_cfg == 025 ) THEN
!          ! =====
! Increased lateral friction in          ! ORCA_R025 configuration
! the vicinity of some straits          ! =====
!

```

```

!! Gibraltar strait and Gulf of Cadiz
ij0 = 652 ; ij1 = 654
ii0 = 1125 ; ii1 = 1127
zshlat=3
DO jj = mj0(ij0),mj1(ij1)
  DO ji = mi0(ii0), mi1(ii1)
    IF( fmask(ji,jj,jk) == 0. ) THEN
      fmask(ji,jj,jk) = zshlat * MIN( 1., MAX( zwf(ji+1,jj), zwf(ji,jj+1), &
        & zwf(ji-1,jj), zwf(ji,jj-1) ) )
    ENDIF
  END DO
END DO
!
ENDIF

```

6 miscellaneous:

-timestep : The time steps is set to 1440 s (60 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

The present run starts in 1958 (first year of ERA40 and CORE), directly with the interannual varying forcing. We prefer to avoid a long spin up with either climatological or repeated year (the 8 years spin up using year 1958 in ORCA025-G50 was not conclusive).

8 Model outputs

8.1 Archived fields

Files are stored every 5 days (nwrite = 300 steps). 3D variables are U , V , T , S , W , K_z . K_z is a time-average of the total vertical mixing including convection events (suitable for off-line tracer calculations). Two dimensional fields are τ_{ux} and τ_{uy} (in U and V files) and in the "grid T" files:

soosheig Sea surface height (in meters)

somxl010 Mixed layer depth (in m) based on a σ_θ difference of 0.01 with the surface

sohefldo Net Downward Heat Flux (in $W.m^{-2}$)

soshfldo Short wave downward radiative flux (in $W.m^{-2}$)

sowafgup Net upward water flux in $kg.m^2.s^{-1}$ (forcing of the sea surface height)

sowafldp Surface water flux damping in $\text{kg.m}^2.\text{s}^{-1}$

iowaflup Ice-ocean water flux in $\text{kg.m}^2.\text{s}^{-1}$

sowafld Concentration-dilution water flux (the product of this flux with surface salinity is the forcing term in the salinity equation)

solhflup Latent heat flux (in W.m^{-2})

solwfldo Long wave downward radiative flux (in W.m^{-2})

sosbhfulp Sensible heat flux (in W.m^{-2})

8.2 Storage strategy

Although we have thought about storage in 16 bits, for now the netcdf variables are floats with 32 bits. For best performances, the output are written by each processor in direct acces files. Those files are recombined immediately after the experiment (see Molines (2004) [19] for more details). The output files stored on gaya at IDRIS are 5 days averages. They are netcdf files very similar to classical OPA netcdf output, excepted for a few differences:

- one file for each 5-day average
- definition of time_counter: The time_counter gives the number of seconds since the begining of the run.
- naming convention for the files: There are 5 types of files; 4 corresponds to the different grid points: gridT, gridU, gridV and gridW; a fifth type of file corresponds to the ice model output. File names are almost self explanatory: (*e.g.* ORCA025-G22_y0010m10d03_gridT.nc or ORCA025-G22_y0010m10d03_icemod.nc). The time indicated in the name of the file corresponds to the date at the **end** of the period used to time-average the data.
- archiving the results: The results are archived on rcli600@gaya:ORCA025/. Data are organized in many directories. Raw results from the run are stored under ORCA025-CASE-S (one sub-directory per year then). Mean values computed from the raw results are stored in ORCA025-CASE-MEAN. There are monthly means and annual means (one sub-directory per year). Interannual means are also computed. The implementation of this directory tree for archiving the results, is part of the strategy used in DRAKKAR to share different configurations between groups of users (see Molines *et al.*(2004) [20]).

Note that the special value on land is zero. This is properly referenced in the header of each file (and causes problems with older versions of the "ncra" software).

ORCA025-VARGAS-018x017 0256

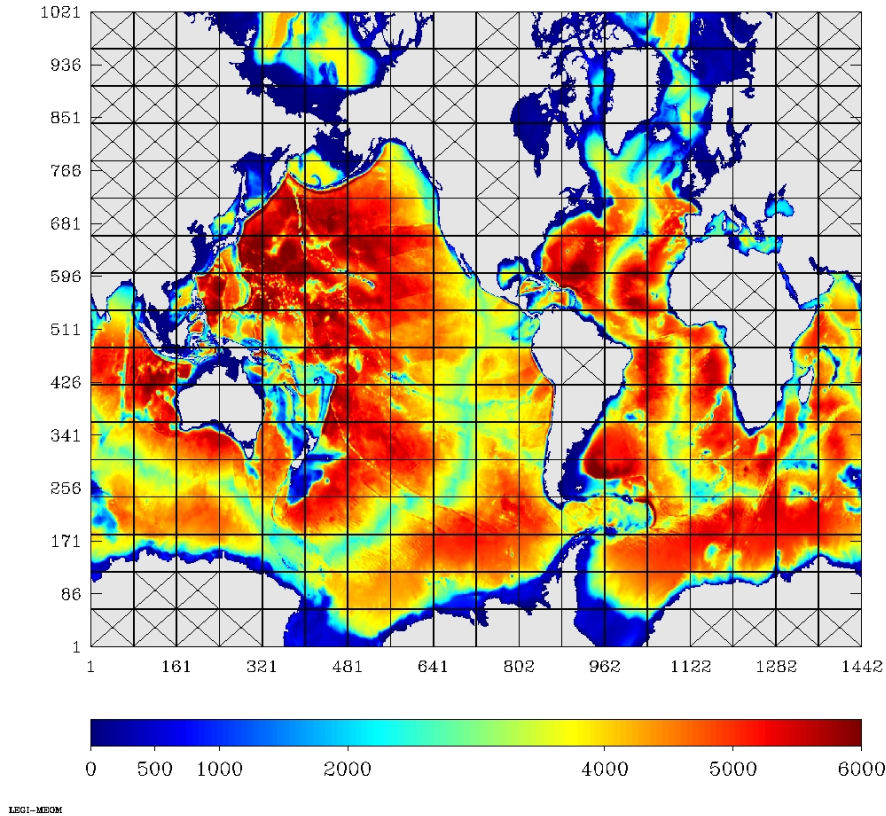


Figure 1: Domain decomposition on 256 processors

9 Numerics

9.1 Domain decomposition

ORCA025 runs on massively parallel computer, using a domain decomposition technique. Processors that corresponds to land are eliminated in the initialisation procedure; in the ORCA025-B83 case, the decomposition is done on 18×17 processors, but only 256 are used. The choice of the best processor layout is done during a pre-processing phase (see details in Molines (2004) [18]). The message passing between processors is explicitly done using the MPI library (option "isend").

9.2 Performance on the IDRIS IBM (vargas)

This configuration is implemented on the IDRIS IBM (vargas), and run on 256 processors. The best performance is achieved using the namelist option `c_mpi_send = 'I'`, for message passing. The performance has been tested with the other solver (`nsolv=2`) and extra halos to reduce

communications: it does not bring a significant gain.

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A Annex A

vertical levels

```

zgr_z      : Reference vertical z-coordinates
~~~~~
zsur, za0, za1 computed from
  zdzmin = 6.000000000000000000
  zhmax  = 5720.0000000000000000
Namelist namzgr : value of coefficients for vertical mesh:
  zsur = -2143.95922194325158
  za0  = 127.451110365423233
  za1  = 123.075814004137086
  zkth = 23.56299999999999988
  zacr = 9.000000000000000000

```

Reference z-coordinate depth and scale factors:

level	gdept	gdepw	e3t	e3w
1	3.05	0.00	6.19	6.00
2	9.45	6.19	6.64	6.40
3	16.36	12.83	7.19	6.90
4	23.88	20.03	7.88	7.52
5	32.18	27.92	8.74	8.29
6	41.44	36.68	9.80	9.25
7	51.87	46.49	11.12	10.43
8	63.78	57.62	12.74	11.89
9	77.48	70.38	14.73	13.69
10	93.39	85.13	17.18	15.89
11	112.01	102.33	20.16	18.60
12	133.92	122.52	23.78	21.88
13	159.82	146.33	28.14	25.86
14	190.49	174.50	33.36	30.63
15	226.85	207.90	39.54	36.32
16	269.92	247.48	46.78	43.02

17	320.80	294.31	55.16	50.83
18	380.63	349.52	64.70	59.78
19	450.57	414.27	75.38	69.90
20	531.74	489.69	87.11	81.12
21	625.09	576.84	99.72	93.32
22	731.40	676.59	112.98	106.29
23	851.17	789.58	126.59	119.76
24	984.59	916.17	140.22	133.42
25	1131.50	1056.38	153.54	146.94
26	1291.46	1209.89	166.25	159.99
27	1463.71	1376.10	178.10	172.29
28	1647.31	1554.16	188.92	183.65
29	1841.17	1743.03	198.61	193.91
30	2044.14	1941.59	207.13	203.01
31	2255.05	2148.67	214.51	210.96
32	2472.80	2363.14	220.82	217.79
33	2696.36	2583.92	226.15	223.60
34	2924.82	2810.03	230.62	228.49
35	3157.35	3040.62	234.32	232.56
36	3393.25	3274.92	237.38	235.93
37	3631.93	3512.27	239.89	238.70
38	3872.87	3752.14	241.93	240.96
39	4115.66	3994.06	243.60	242.81
40	4359.96	4237.64	244.95	244.31
41	4605.47	4482.58	246.04	245.52
42	4851.97	4728.61	246.92	246.50
43	5099.25	4975.52	247.63	247.29
44	5347.18	5223.15	248.20	247.93
45	5595.62	5471.34	248.66	248.44
46	5844.47	5720.00	249.03	248.86

B Annex B

```

!
! Hand modifications by Anne Marie Treguier and Thierry Penduff,
! as well as Ariane Koch Larrouy for the Indonesian throughflow region.
! on ORCA_R025 bathymetry for partial steps.
!
! #####
! Name of the zoomed area : Torres staitis
! zoom ratio :          2
! Thierry: Put some islands in G47
bathy( 279, 460) = 0 !
bathy( 279, 458) = 0 !
bathy( 279, 456) = 0 !
!
! #####
! Name of the zoomed area : Vema fracture zone

```

```

! zoom ration :          2
! i min :          946
! i max :          1012
! j min :          507
! j max :          573

bathy( 976, 543) = 4400 ! instead of 4279
bathy( 977, 543) = 4400 ! instead of 4189
bathy( 978, 543) = 4400 ! instead of 4042
bathy( 979, 543) = 4400 ! instead of 3889
bathy( 979, 542) = 4400 ! instead of 4205
bathy( 980, 542) = 4400 ! instead of 4103
bathy( 981, 542) = 4400 ! instead of 4093
bathy( 982, 542) = 4400 ! instead of 4126
bathy( 983, 542) = 4400 ! instead of 4008
bathy( 984, 542) = 4400 ! instead of 3870
bathy( 985, 542) = 4400 ! instead of 3632
bathy( 986, 542) = 4400 ! instead of 3691
bathy( 987, 542) = 4400 ! instead of 3883
bathy( 988, 542) = 4400 ! instead of 3969
bathy( 989, 542) = 4400 ! instead of 4141
bathy( 990, 542) = 4400 ! instead of 4273
! Thierry: new bathy G45
bathy( 992, 542) = 4482 ! instead of 4273
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
! #####
! Name of the zoomed area : Fifteen twenty fracture zone
! zoom ration :          2
! i min :          934
! i max :          1000
! j min :          522
! j max :          588

bathy( 960, 562) = 3800 ! instead of 3782
bathy( 961, 562) = 3800 ! instead of 3630
bathy( 961, 561) = 3800 ! instead of 3597
bathy( 962, 561) = 3800 ! instead of 3542
bathy( 963, 561) = 3800 ! instead of 3560
bathy( 964, 561) = 3800 ! instead of 3636
bathy( 965, 561) = 3800 ! instead of 3703

! #####
! Name of the zoomed area : Lesser Antilles
! zoom ration :          2
! i min :          868
! i max :          934
! j min :          524
! j max :          590

```

```

bathy( 903, 547) = 200 ! instead of 670
bathy( 904, 549) = 200 ! instead of 965
bathy( 905, 550) = 200 ! instead of 799
bathy( 905, 551) = 200 ! instead of 909
bathy( 905, 553) = 200 ! instead of 1686
bathy( 906, 554) = 600 ! instead of 1089
bathy( 906, 556) = 200 ! instead of 1331
bathy( 905, 561) = 200 ! instead of 1127
bathy( 905, 563) = 200 ! instead of 636
bathy( 904, 564) = 200 ! instead of 364
bathy( 904, 566) = 400 ! instead of 673
bathy( 893, 574) = 200 ! instead of 1062
bathy( 898, 574) = 200 ! instead of 849
bathy( 898, 572) = 200 ! instead of 403
bathy( 899, 572) = 200 ! instead of 405
bathy( 899, 571) = 200 ! instead of 454
bathy( 900, 570) = 489 ! instead of 489
bathy( 900, 571) = 200 ! instead of 502
bathy( 878, 574) = 300 ! instead of 541
bathy( 881, 573) = 200 ! instead of 414

```

```

! #####
! Name of the zoomed area : Florida Straits
! zoom ration :      2
! i min :      796
! i max :      862
! j min :      560
! j max :      626

```

```

bathy( 827, 599) = 800 ! instead of 707
bathy( 828, 599) = 800 ! instead of 643
bathy( 829, 599) = 800 ! instead of 552
bathy( 829, 600) = 800 ! instead of 610
bathy( 830, 600) = 800 ! instead of 719
bathy( 831, 600) = 800 ! instead of 740
bathy( 832, 601) = 800 ! instead of 747
bathy( 832, 602) = 800 ! instead of 773
bathy( 831, 602) = 800 ! instead of 761
bathy( 832, 603) = 800 ! instead of 762
bathy( 832, 604) = 800 ! instead of 714
bathy( 832, 605) = 800 ! instead of 638
bathy( 832, 606) = 800 ! instead of 598
bathy( 832, 607) = 760 ! instead of 602
bathy( 832, 608) = 760 ! instead of 610
bathy( 832, 609) = 760 ! instead of 618
bathy( 832, 610) = 760 ! instead of 627
bathy( 832, 611) = 730 ! instead of 620
bathy( 832, 613) = 730 ! instead of 585
bathy( 832, 614) = 730 ! instead of 592

```

```

bathy( 832, 615) = 730 ! instead of 622
bathy( 832, 616) = 730 ! instead of 652
bathy( 832, 617) = 730 ! instead of 681
bathy( 832, 612) = 730 ! instead of 603
bathy( 839, 591) = 600 ! instead of 334
bathy( 840, 591) = 600 ! instead of 351
bathy( 840, 590) = 600 ! instead of 554
bathy( 838, 592) = 540 ! instead of 358
bathy( 837, 592) = 500 ! instead of 311
bathy( 836, 593) = 500 ! instead of 342
bathy( 837, 593) = 500 ! instead of 340
bathy( 835, 593) = 500 ! instead of 344
bathy( 834, 594) = 500 ! instead of 434
bathy( 834, 593) = 500 ! instead of 336
bathy( 833, 594) = 500 ! instead of 451
bathy( 833, 595) = 500 ! instead of 483
bathy( 832, 595) = 500 ! instead of 475
bathy( 831, 595) = 500 ! instead of 469
bathy( 830, 595) = 500 ! instead of 485
bathy( 838, 591) = 500 ! instead of 182

```

```

! #####
! Name of the zoomed area : Gibraltar
! zoom ration :      2
! i min :      1092
! i max :      1158
! j min :       616
! j max :       682

```

```

bathy(1127, 654) = 300 ! instead of 194
bathy(1126, 654) = 280 ! instead of 144
bathy(1126, 653) = 280 ! instead of 170

```

```

!
!   Water flowing downstream of Gibraltar into the Atlantic.
!   Create an artificial deep channel based on work by Sebastien Theetten
!   and Raphael Almar (2005), revised by Thierry Penduff.

```

```

bathy(1125, 653) = 800 ! instead of 320
bathy(1124, 653) = 1100 ! instead of 415
bathy(1123, 653) = 1200 ! instead of 659
bathy(1122, 653) = 1200 ! instead of 881
bathy(1121, 653) = 1200 ! instead of 881
bathy(1120, 653) = 1200 ! instead of 881

```

```

! #####
! Name of the zoomed area : Wyville-Thompson ridge, Faroe bank channel
! zoom ration :      2
! i min :      1064
! i max :      1130

```


! j min : 768
! j max : 834

! Thierry
bathy(1099, 803) = 1050 !
bathy(1100, 803) = 1050 !
bathy(1101, 803) = 910 !

! Anne Marie
bathy(1108, 799) = 870 ! instead of 737
bathy(1108, 800) = 870 ! instead of 737
bathy(1108, 801) = 870 ! instead of 689
bathy(1107, 802) = 870 ! instead of 602
bathy(1107, 801) = 870 ! instead of 565
bathy(1106, 802) = 870 ! instead of 536
bathy(1105, 802) = 870 ! instead of 437
bathy(1105, 803) = 870 ! instead of 575
bathy(1104, 803) = 870 ! instead of 605
bathy(1103, 803) = 870 ! instead of 644
bathy(1102, 803) = 870 ! instead of 777
bathy(1112, 793) = 600 ! instead of 760
bathy(1111, 794) = 600 ! instead of 714
bathy(1108, 795) = 600 ! instead of 727
bathy(1107, 795) = 600 ! instead of 714
bathy(1106, 796) = 600 ! instead of 668
bathy(1113, 793) = 600 ! instead of 615
bathy(1106, 797) = 600 ! instead of 660
bathy(1110, 794) = 600 ! instead of 671
bathy(1109, 794) = 600 ! instead of 662

!!!!!!!!!!!!!!!!!!!!!!!!!!!! VERSION T.PENDUFF july 12 2006
!! Create an artificial channel to bring dense water
!! down and widen the strait.
!! Name of the zoomed area : Denmark Strait

bathy(1047,834:835) = 670 ! entrance
bathy(1046,833:835) = 670 ! entrance
bathy(1045,832:834) = 670 ! entrance
bathy(1044,831:833) = 670 ! entrance
bathy(1043,830:832) = 670 !
bathy(1042,829:831) = 670 !
bathy(1041,828:830) = 670 !
bathy(1040,828:829) = 670 !

bathy(1040,827) = 1950 ! first flat step (BBLadv)
bathy(1039,827:828) = 1950 !

bathy(1039,826) = 2158 ! second flat step (BBLdiff)
bathy(1038,826:827) = 2158 !

```
bathy(1038,825 ) = 2595 ! outflow channel
bathy(1037,824:826) = 2595 !
bathy(1036,824:825) = 2595 !
bathy(1035,824:825) = 2595 !
bathy(1034,824:825) = 2595 !
bathy(1033,823:825) = 2595 !
bathy(1032,822:824) = 2595 !
bathy(1031,821:823) = 2595 !
bathy(1030,820:822) = 2595 !
bathy(1029,819:821) = 2595 !
bathy(1028,818:820) = 2595 !
```

```
! #####
! Name of the zoomed area : NORTH POLE !!!!!!!!!!!!!!!
! TPENDUFF 19 JULY 2006
```

```
bathy(1062,1019) = 0.5 * ( bathy(1061,1019) + bathy(1063,1019) )
```

```
! #####
! Name of the zoomed area : Gibbs Fracture zone
! zoom ration :      2
! i min :      982
! i max :     1048
! j min :      708
! j max :      774
```

```
bathy(1008, 742) = 3650 ! instead of 3615
bathy(1009, 742) = 3650 ! instead of 3568
bathy(1010, 742) = 3650 ! instead of 3535
bathy(1011, 742) = 3650 ! instead of 3514
bathy(1011, 741) = 3650 ! instead of 3603
bathy(1012, 741) = 3650 ! instead of 3602
bathy(1013, 741) = 3650 ! instead of 3615
bathy(1014, 741) = 3650 ! instead of 3611
bathy(1015, 741) = 3650 ! instead of 3565
bathy(1016, 741) = 3650 ! instead of 3581
bathy(1017, 741) = 3650 ! instead of 3582
bathy(1018, 741) = 3650 ! instead of 3651
bathy(1020, 741) = 3650 ! instead of 3608
bathy(1021, 741) = 3650 ! instead of 3458
bathy(1022, 741) = 3650 ! instead of 3318
bathy(1023, 740) = 3650 ! instead of 3278
bathy(1022, 740) = 3650 ! instead of 3274
bathy(1024, 740) = 3650 ! instead of 3279
bathy(1025, 740) = 3650 ! instead of 3240
bathy(1026, 740) = 3650 ! instead of 3017
bathy(1027, 740) = 3650 ! instead of 2963
bathy(1028, 740) = 3650 ! instead of 3043
```

bathy(1029, 740) = 3650 ! instead of 3029
bathy(1030, 740) = 3650 ! instead of 3110
bathy(1030, 739) = 3650 ! instead of 2832
bathy(1031, 739) = 3650 ! instead of 3005
bathy(1032, 739) = 3650 ! instead of 3019
bathy(1033, 739) = 3650 ! instead of 3155
bathy(1034, 739) = 3650 ! instead of 3302
bathy(1035, 739) = 3650 ! instead of 3383
bathy(1036, 739) = 3650 ! instead of 3442
bathy(1037, 739) = 3650 ! instead of 3534
bathy(1038, 739) = 3650 ! instead of 3621

! #####
! Name of the zoomed area : Oceanographer fracture Zone
! zoom ration : 2
! i min : 982
! i max : 1048
! j min : 616
! j max : 682

bathy(1001, 650) = 3000 ! instead of 2924
bathy(1002, 650) = 3000 ! instead of 2882
bathy(1003, 650) = 3000 ! instead of 2864
bathy(1004, 650) = 3000 ! instead of 2892
bathy(1006, 650) = 3000 ! instead of 2904
bathy(1007, 650) = 3000 ! instead of 2736
bathy(1007, 649) = 3000 ! instead of 2453
bathy(1008, 649) = 3000 ! instead of 2655
bathy(1009, 649) = 3000 ! instead of 2766
bathy(1010, 649) = 3000 ! instead of 2754
bathy(1010, 648) = 3000 ! instead of 2687
bathy(1011, 648) = 3000 ! instead of 2662
bathy(1012, 648) = 3000 ! instead of 2704
bathy(1013, 648) = 3000 ! instead of 2811
bathy(1014, 648) = 3000 ! instead of 2907

! #####
! Name of the zoomed area : Vema channel
! zoom ration : 2
! i min : 978
! i max : 1044
! j min : 331
! j max : 397

! #####
! Name of the zoomed area : Valvis ridge South
! zoom ration : 2
! i min : 1092

```
! i max :      1158
! j min :       305
! j max :       371
```

```
bathy(1119, 341) = 3500 ! instead of 3607
bathy(1123, 344) = 3500 ! instead of 3801
bathy(1126, 346) = 3500 ! instead of 3665
bathy(1141, 362) = 3500 ! instead of 3932
bathy(1142, 362) = 3500 ! instead of 3832
bathy(1143, 363) = 3500 ! instead of 3693
bathy(1141, 361) = 3500 ! instead of 3891
bathy(1140, 361) = 3500 ! instead of 3699
```

```
! #####
! Name of the zoomed area : Rio de Janeiro fracture Zone
! zoom ration :          2
! i min :      1064
! i max :      1130
! j min :       375
! j max :      441
```

```
bathy(1107, 408) = 3900 ! instead of 3714
bathy(1108, 408) = 3900 ! instead of 3805
bathy(1109, 408) = 3900 ! instead of 3882
bathy(1106, 408) = 3900 ! instead of 3593
bathy(1105, 408) = 3900 ! instead of 3533
bathy(1104, 408) = 3900 ! instead of 3561
bathy(1103, 408) = 3900 ! instead of 3570
bathy(1102, 408) = 3900 ! instead of 3539
bathy(1101, 408) = 3900 ! instead of 3399
bathy(1100, 408) = 3900 ! instead of 3282
bathy(1097, 408) = 3900 ! instead of 3529
bathy(1098, 408) = 3900 ! instead of 3404
bathy(1096, 408) = 3900 ! instead of 3722
bathy(1095, 408) = 3900 ! instead of 3815
bathy(1094, 408) = 3900 ! instead of 3777
bathy(1093, 408) = 3900 ! instead of 3871
bathy(1099, 408) = 3900 ! instead of 3336
```

```
! #####
! Name of the zoomed area : Romanche fracture zone
! zoom ration :          2
! i min :      1030
! i max :      1096
! j min :       459
! j max :      525
```

```
bathy(1057, 496) = 3700 ! instead of 3849
bathy(1058, 496) = 3700 ! instead of 3925
```

bathy(1059, 496) = 3700 ! instead of 3937
bathy(1060, 496) = 3700 ! instead of 3942
bathy(1061, 496) = 3700 ! instead of 4060
bathy(1062, 496) = 3700 ! instead of 4177
bathy(1063, 497) = 3700 ! instead of 3995
bathy(1064, 497) = 3700 ! instead of 4011
bathy(1065, 497) = 3700 ! instead of 4041
bathy(1066, 497) = 3700 ! instead of 4044
bathy(1067, 497) = 3700 ! instead of 4051
bathy(1068, 497) = 3700 ! instead of 4306
bathy(1069, 498) = 3700 ! instead of 4106
bathy(1070, 498) = 3700 ! instead of 4153
bathy(1070, 499) = 3700 ! instead of 3847
bathy(1071, 499) = 3700 ! instead of 3871
bathy(1072, 499) = 3700 ! instead of 3977
bathy(1073, 499) = 3700 ! instead of 4142
bathy(1074, 499) = 3700 ! instead of 4280
bathy(1075, 499) = 3700 ! instead of 4403
bathy(1076, 500) = 3700 ! instead of 4133
bathy(1077, 500) = 3700 ! instead of 3974
bathy(1078, 500) = 3700 ! instead of 3919
bathy(1079, 500) = 3700 ! instead of 3820
bathy(1082, 500) = 4200 ! instead of 4183
bathy(1083, 500) = 4200 ! instead of 4070
bathy(1084, 500) = 4200 ! instead of 3850
bathy(1085, 500) = 4200 ! instead of 3668
bathy(1086, 501) = 4200 ! instead of 3755
bathy(1087, 501) = 4200 ! instead of 3832
bathy(1088, 501) = 4200 ! instead of 3853
bathy(1089, 501) = 4200 ! instead of 3906
bathy(1090, 501) = 4200 ! instead of 4013
bathy(1086, 500) = 4200 ! instead of 3665

! #####
! Name of the zoomed area : Red Sea North
! zoom ration : 2
! i min : 1266
! i max : 1332
! j min : 558
! j max : 624

bathy(1291, 608) = 1080 ! instead of 991
bathy(1291, 610) = 1080 ! instead of 988
bathy(1308, 577) = 1080 ! instead of 974
bathy(1308, 575) = 1080 ! instead of 951

! #####
! Name of the zoomed area : Red Sea south
! zoom ration : 2

! i min : 1290
! i max : 1356
! j min : 514
! j max : 580

bathy(1319, 556) = 160 ! instead of 94
bathy(1320, 556) = 140 ! instead of 87
bathy(1320, 555) = 140 ! instead of 59
bathy(1320, 554) = 140 ! instead of 45
bathy(1321, 554) = 140 ! instead of 56
bathy(1321, 553) = 140 ! instead of 58
bathy(1322, 553) = 140 ! instead of 66
bathy(1322, 552) = 140 ! instead of 44
bathy(1323, 552) = 140 ! instead of 42
bathy(1323, 551) = 140 ! instead of 48
bathy(1323, 550) = 140 ! instead of 52
bathy(1324, 550) = 140 ! instead of 71

!!!!!!!!!!!!!! New THIERRY

!bathy(1325, 549) = 140 !
!bathy(1325, 548) = 206 !
!bathy(1325, 547) = 246 !

!bathy(1324, 549) = 172 !
!bathy(1324, 548) = 245 !
!bathy(1324, 547) = 292 !
!bathy(1324, 546) = 348 !
!bathy(1325, 546) = 400 !
!bathy(1326, 546) = 553 !

!bathy(1326, 545) = 676 !
!bathy(1327, 545) = 676 !
!bathy(1327, 546) = 676 !
!bathy(1326, 547) = 553 !

!!!!!!!!!!!!!! VERSION T.PENDUFF july 12 2006

!! #####

!! Name of the zoomed area : Red Sea south

bathy(1329, 547) = 790
bathy(1328, 547) = 790
bathy(1327, 547) = 790
bathy(1326, 547) = 790
bathy(1325, 547) = 790
bathy(1324, 547) = 790
bathy(1323, 547) = 790
bathy(1323, 548) = 790
bathy(1323, 549) = 790

```
! #####
! Name of the zoomed area : Agulhas
! zoom ration :      2
! i min :      1212
! i max :      1278
! j min :      303
! j max :      369
```

```
! #####
! Name of the zoomed area : Mozambique/Comores
! zoom ration :      2
! i min :      1292
! i max :      1358
! j min :      413
! j max :      479
```

```
bathy(1341, 448) = 200 ! instead of 1094
bathy(1342, 449) = 200 ! instead of 521
bathy(1341, 449) = 450 ! instead of 1067
bathy(1337, 449) = 200 ! instead of 2751
bathy(1336, 449) = 200 ! instead of 2196
bathy(1335, 449) = 1200 ! instead of 2371
bathy(1331, 448) = 400 ! instead of 1244
bathy(1330, 448) = 400 ! instead of 1298
bathy(1328, 449) = 400 ! instead of 2117
bathy(1327, 450) = 400 ! instead of 1827
bathy(1326, 449) = 400 ! instead of 2056
```

```
! #####
! Name of the zoomed area : Mascarene Ridge
! zoom ration :      2
! i min :      1362
! i max :      1428
! j min :      409
! j max :      475
```

```
bathy(1391, 461) = 200 ! instead of 770
bathy(1391, 462) = 200 ! instead of 606
bathy(1391, 463) = 200 ! instead of 693
bathy(1376, 476) = 200 ! instead of 753
bathy(1376, 477) = 200 ! instead of 426
bathy(1363, 477) = 200 ! instead of 1070
bathy(1363, 476) = 200 ! instead of 885
bathy(1362, 475) = 200 ! instead of 1250
bathy(1395, 450) = 280 ! instead of 508
bathy(1395, 449) = 350 ! instead of 936
bathy(1395, 448) = 600 ! instead of 1714
bathy(1394, 443) = 400 ! instead of 614
```

bathy(1394, 444) = 600 ! instead of 978
bathy(1393, 444) = 450 ! instead of 825
bathy(1393, 445) = 450 ! instead of 1165
bathy(1393, 446) = 500 ! instead of 1546
bathy(1394, 447) = 1100 ! instead of 1823

! #####
! Name of the zoomed area : Seychelles
! zoom ration : 2
! i min : 1346
! i max : 1412
! j min : 437
! j max : 503

bathy(1363, 478) = 800 ! instead of 1683
bathy(1363, 476) = 200 ! instead of 885
bathy(1362, 475) = 200 ! instead of 1250
bathy(1362, 474) = 400 ! instead of 1537

! #####
! Name of the zoomed area : Ninety east ridge north
! zoom ration : 2
! i min : 35
! i max : 101
! j min : 479
! j max : 545

bathy(68, 501) = 3400 ! instead of 3507
bathy(68, 500) = 3400 ! instead of 3571
bathy(67, 490) = 3000 ! instead of 3537

! #####
! Name of the zoomed area : ninety east ridge middle
! zoom ration : 2
! i min : 29
! i max : 95
! j min : 425
! j max : 491

bathy(67, 479) = 3650 ! instead of 3698
bathy(67, 477) = 3650 ! instead of 3607
bathy(67, 478) = 3650 ! instead of 3756
bathy(65, 460) = 3400 ! instead of 3600

!
!
! Hand modification by Ariane Koch-Larrouy on
! ORCA_R025 bathymetry combined coast for


```

! partial step
!
! #####
! Name of the zomed area : Indonesian Throughflow
! i min : 89
! i max : 290
! j min : 395
! j max : 602

! Timor passage
bathy( 202, 453) = 1300.00 ! instead of 1078.23
bathy( 202, 454) = 1300.00 ! instead of 1027.36
bathy( 203, 454) = 1300.00 ! instead of 1176.71
bathy( 204, 454) = 1300.00 ! instead of 1275.38

! Torres is not closed in ORCA025-G44
! bathy( 280, 456) = 0.00000 ! instead of 5.00000
! bathy( 279, 457) = 0.00000 ! instead of 5.00000
! bathy( 279, 458) = 0.00000 ! instead of 5.00000
! bathy( 279, 459) = 0.00000 ! instead of 5.00000
! bathy( 279, 460) = 0.00000 ! instead of 5.00000
! bathy( 279, 461) = 0.00000 ! instead of 5.00000

! land retrieved between Lombok and Sape
bathy( 177, 463) = 195.000 ! instead of 0.00000
bathy( 178, 463) = 300.000 ! instead of 0.00000
bathy( 179, 463) = 400.000 ! instead of 0.00000
bathy( 180, 463) = 566.531 ! instead of 0.00000

! Sape
bathy( 187, 464) = 0.00000 ! instead of 202.594
bathy( 188, 464) = 0.00000 ! instead of 123.500
bathy( 187, 465) = 0.00000 ! instead of 104.000
bathy( 188, 465) = 0.00000 ! instead of 197.500

! Iles d'Alor
bathy( 203, 465) = 0.00000 ! instead of 241.048
bathy( 205, 465) = 0.00000 ! instead of 1010.97

! Ombai
bathy( 209, 465) = 1800.00 ! instead of 1759.98
bathy( 211, 465) = 1800.00 ! instead of 1671.20
bathy( 212, 465) = 1800.00 ! instead of 1401.44
bathy( 213, 465) = 1800.00 ! instead of 1193.37
bathy( 211, 466) = 1350.00 ! instead of 2057.59
bathy( 212, 466) = 0.00000 ! instead of 2003.67
bathy( 213, 466) = 1800.00 ! instead of 1728.50
bathy( 214, 466) = 1800.00 ! instead of 1682.30
bathy( 216, 466) = 1800.00 ! instead of 1758.57

```

bathy(213, 467) = 0.00000 ! instead of 1995.10
bathy(213, 468) = 0.00000 ! instead of 2735.98

! Molucca strait

bathy(219, 505) = 4.00000 ! instead of 1758.61
bathy(220, 505) = 0.00000 ! instead of 761.723
bathy(217, 500) = 2300.00 ! instead of 2168.49
bathy(217, 501) = 2300.00 ! instead of 2114.26
bathy(216, 502) = 2300.00 ! instead of 2176.77
bathy(217, 502) = 2300.00 ! instead of 2148.22
bathy(216, 503) = 2200.00 ! instead of 2018.43
bathy(217, 503) = 2300.00 ! instead of 2071.52
bathy(216, 504) = 2200.00 ! instead of 1894.76
bathy(217, 504) = 2300.00 ! instead of 1991.11
bathy(213, 505) = 1760.00 ! instead of 1847.67
bathy(214, 505) = 1650.00 ! instead of 1759.12
bathy(216, 505) = 2200.00 ! instead of 1727.12
bathy(217, 505) = 2300.00 ! instead of 1999.43
bathy(218, 505) = 2300.00 ! instead of 2070.33
bathy(216, 506) = 2200.00 ! instead of 1792.68
bathy(217, 506) = 2200.00 ! instead of 2139.05
bathy(218, 506) = 2300.00 ! instead of 2162.49
bathy(217, 507) = 2200.00 ! instead of 2176.00
bathy(218, 507) = 2300.00 ! instead of 2191.92
bathy(217, 508) = 2200.00 ! instead of 2114.59
bathy(218, 508) = 2300.00 ! instead of 2241.65
bathy(219, 508) = 2300.00 ! instead of 2258.27
bathy(217, 509) = 2200.00 ! instead of 2028.10
bathy(218, 509) = 2200.00 ! instead of 2270.84

! Malacca Strait

bathy(120, 506) = 0.00000 ! instead of 9.00000

! Sangihe Ridge

bathy(210, 506) = 2.00000 ! instead of 295.509
bathy(211, 507) = 1000.00 ! instead of 1368.63
bathy(212, 508) = 2.00000 ! instead of 1442.14
bathy(212, 510) = 2.00000 ! instead of 1160.36
bathy(213, 514) = 50.0000 ! instead of 254.383
bathy(213, 515) = 500.000 ! instead of 825.242
bathy(213, 516) = 200.000 ! instead of 815.492
bathy(213, 517) = 4.00000 ! instead of 839.386
bathy(218, 517) = 0.00000 ! instead of 996.012
bathy(213, 518) = 800.000 ! instead of 1035.70
bathy(213, 519) = 1300.00 ! instead of 1526.46
bathy(218, 519) = 0.00000 ! instead of 2027.63
bathy(212, 520) = 4.00000 ! instead of 1947.67
bathy(218, 520) = 0.00000 ! instead of 2984.29
bathy(212, 521) = 0.00000 ! instead of 1521.66

bathy(217, 521) = 0.00000 ! instead of 3147.63
bathy(217, 522) = 0.00000 ! instead of 3276.00
bathy(217, 523) = 0.00000 ! instead of 3154.99
bathy(217, 524) = 0.00000 ! instead of 3272.37
bathy(215, 525) = 0.00000 ! instead of 1061.76
bathy(215, 526) = 0.00000 ! instead of 249.692

! Sumba

bathy(189, 462) = 610.000 ! instead of 520.226
bathy(190, 462) = 610.000 ! instead of 496.277
bathy(191, 462) = 610.000 ! instead of 571.018
bathy(190, 463) = 167.000 ! instead of 466.042

! sortie Savu

bathy(197, 456) = 0.00000 ! instead of 770.963
bathy(198, 456) = 0.00000 ! instead of 859.907
bathy(199, 456) = 1041.11 ! instead of 956.650
bathy(204, 457) = 100.000 ! instead of 299.308
bathy(195, 458) = 1100.00 ! instead of 1023.69

! Luzon strait

bathy(194, 575) = 200.000 ! instead of 667.179
bathy(195, 576) = 100.000 ! instead of 239.656
bathy(196, 577) = 0.00000 ! instead of 625.711
bathy(196, 578) = 850.000 ! instead of 826.502
bathy(196, 579) = 650.000 ! instead of 1396.10
bathy(196, 580) = 1100.00 ! instead of 1909.46
bathy(196, 581) = 850.000 ! instead of 2351.54
bathy(196, 582) = 650.000 ! instead of 2642.53
bathy(196, 583) = 2.00000 ! instead of 2756.72
bathy(196, 584) = 150.000 ! instead of 2773.34
bathy(194, 586) = 1200.00 ! instead of 1533.90

! Molucca Strait

bathy(232, 496) = 7.00000 ! instead of 50.0000
bathy(231, 497) = 2.00000 ! instead of 111.500
bathy(230, 498) = 2.00000 ! instead of 313.281
bathy(231, 498) = 2.00000 ! instead of 13.0000
bathy(229, 499) = 147.000 ! instead of 405.520
bathy(228, 500) = 2.00000 ! instead of 691.682
bathy(225, 501) = 2.00000 ! instead of 289.244
bathy(226, 501) = 300.000 ! instead of 560.011
bathy(227, 501) = 700.000 ! instead of 730.845

! Lifamatola

bathy(204, 492) = 3.00000 ! instead of 57.0000
bathy(205, 492) = 4.00000 ! instead of 192.000
bathy(206, 492) = 3.00000 ! instead of 189.000
bathy(207, 492) = 50.0000 ! instead of 14.5000

bathy(214, 492) = 4.00000 ! instead of 861.835
bathy(215, 492) = 700.000 ! instead of 1153.23
bathy(216, 492) = 1829.00 ! instead of 1525.74
bathy(217, 492) = 1200.00 ! instead of 1851.48
bathy(218, 492) = 200.000 ! instead of 1758.53
bathy(219, 493) = 0.00000 ! instead of 1105.22
bathy(203, 494) = 60.0000 ! instead of 62.0000
bathy(220, 494) = 2.00000 ! instead of 329.407
bathy(222, 494) = 500.000 ! instead of 373.465
bathy(222, 495) = 500.000 ! instead of 364.917

! Island around Belitung in Java Sea

bathy(137, 487) = 0.00000 ! instead of 7.00000
bathy(139, 487) = 0.00000 ! instead of 16.0000
bathy(140, 487) = 0.00000 ! instead of 1.00000
bathy(143, 489) = 0.00000 ! instead of 27.0000

! Island isolated rattached to the coast

bathy(134, 487) = 0.00000 ! instead of 3.00000
bathy(135, 487) = 0.00000 ! instead of 6.00000
bathy(133, 488) = 0.00000 ! instead of 6.00000
bathy(134, 488) = 0.00000 ! instead of 7.50000
bathy(133, 489) = 0.00000 ! instead of 6.00000
bathy(130, 490) = 0.00000 ! instead of 6.00000
bathy(131, 490) = 0.00000 ! instead of 8.00000
bathy(132, 490) = 0.00000 ! instead of 7.00000
bathy(133, 490) = 0.00000 ! instead of 5.00000

! Balabac Strait

bathy(179, 530) = 15.0000 ! instead of 25.5000

! Sulu Archipelago

bathy(188, 519) = 13.0000 ! instead of 155.383
bathy(196, 523) = 7.00000 ! instead of 126.000
bathy(193, 521) = 2.00000 ! instead of 17.5000

! Lombok Strait

bathy(173, 464) = 0.00000 ! instead of 435.309
bathy(174, 464) = 160.000 ! instead of 29.0000

! Philippine Archipelago

bathy(213, 539) = 0.00000 ! instead of 1.00000
bathy(213, 540) = 0.00000 ! instead of 1.00000
bathy(213, 541) = 0.00000 ! instead of 1.00000
bathy(213, 542) = 2.00000 ! instead of 4.00000
bathy(207, 550) = 0.00000 ! instead of 2.00000

! Taiwan Strait

bathy(179, 595) = 5.00000 ! instead of 16.0000

bathy(187, 595) = 22.0000 ! instead of 35.0000
bathy(188, 595) = 5.00000 ! instead of 22.0000

! Sunda Strait

bathy(133, 474) = 0.00000 ! instead of 38.0000
bathy(133, 475) = 0.00000 ! instead of 28.0000
bathy(133, 476) = 0.00000 ! instead of 37.5000