Evaluation of the NATL12-BRD81 simulation

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1 Introduction

NATL12 is a new 1/12° configuration developped in the DRAKKAR team. It has been adapted from the ATL12 configuration created at MERCATOR Ocean. This configuration has two open boundaries (north and south) where we apply climatological boundary conditions. Those are monthly means from the global 1/4° simulation ORCA025-G70 over the 1980-2004 period. Surface forcing is done with the Drakkar Forcing Set (hereafter DFS, see [Brodeau et al.(2010)] for details) The first long interannual simulation (years 1980 to 2006) was produced in the summer of 2008 and is called NATL12-BAMT20. It uses version 2.3 of NEMODRAK, has a smoothed bathymetry and uses DFS4. Some adjustements were performed in the bathymetry and in the slip condition (see [Treguier(2008)] for details) to improve the behavior of the overflows. However, this experiment has shown several problems. Firstly, the Med waters outflow was too warm and salty and the transport at the strait was probably too strong. Secondly, after 15 years of run, eddies from the North Atlantic Current began to flow into the Irminger sea and the Labrador sea thus modifying the water masses properties in the subpolar gyre. Those are the two main problems we wanted to solve in the new simulation. There are several other issues such as convection in the Labrador sea and nordic seas overflows that were described in the NATL12-BAMT20 analysis report [Dussin and Treguier(2008)].

In the summer of 2009, we have decided to start twin simulations with smoothed (BRD80) and unsmoothed (BRD81) topography with version 3.1 of NEMODRAK. The forcing set used was DFS4.3. After five years of run, we have decided to go on with the unsmoothed topography. Thus NATL12-BRD81 is also a long interannual experiment (years 1980 to 2008). In this experiment, we have performed only a few adjustements in the bathymetry (opening of Charlie-Gibbs fracture zone, removing spurious island near greenland) Our special treatment of the Mediterranean waters overflow consisted in adding bottom friction and changing the bathymetry around Gibraltar strait (see Annex 1 for details). Shortly after this simulation, we have performed the regional 1/4° run NATL025-BRD80. This run uses the same version of the code (only a few customisations specific to the 1/12° were not reported), the same forcing set and open boundaries. Topography and runoffs were taken from ORCA025L75-G85 experiment.

In this report, we focus on the main issues describe above. Section 2 deals with the North Atlantic Current issue and its consequences on the subpolar gyre. We compare the NATL12 runs with AVISO, Reynolds SST (NOAA Optimum Interpolation Sea Surface Temperature Analysis monthly fields) and OVIDE data, global 1/4° runs ORCA025-G70 [Molines et al.(2006)] and ORCA025-B83 [Dussin et al.(2009)] and with NATL025-BRD80. Section 3 describes the improved results obtained in the Mediterranean waters overflow issue. We compare with Levitus WOA05, SEMANE data and other simulations such as AMEN-BVT18 (thanks to Virginie Theetten-Thierry) and ATL12-T46 (thanks to Olivier Le Galloudec of MERCATOR Ocean). Section 4 deals with Meridional Overturning Circulation and Nordic Seas Overflows in NATL runs.

2 Dynamics and water masses properties in the subpolar gyre

2.1 Analysis of Sea Surface Height variability

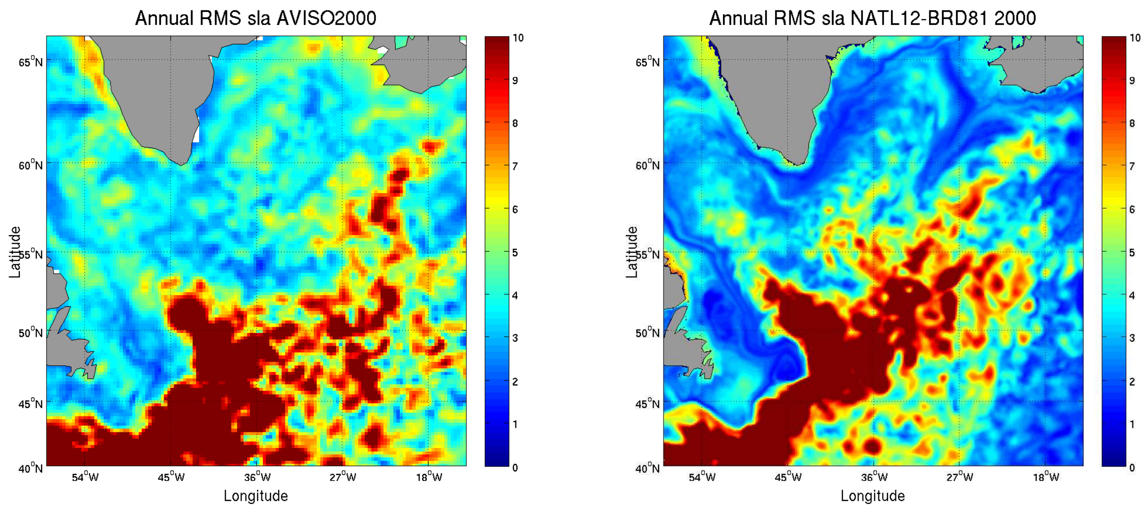

FIG. 1 – Mean SSH standard deviation in AVISO and NATL12-BRD81 in year 2000

The first key issue that we wanted to solve in this new simulation was the problem of North Atlantic Current which feeds the Irminger sea with eddies. Figure 1 is an annual mean of the Sea Surface Height standard deviation in observations (AVISO) and in the model that illustrate the problem. The unsmoothed bathymetry, as well as a special treatment at Charlie-Gibbs fracture zone, was expected to improve the path of the NAC and thus limit the export of eddies in the Irminger sea. In the previous simulation, no-slip boundary conditions had been used over a large area in the subpolar gyre with the aim of reducing the tranport of high salinity water from the east to the west (especially into the Labrador Sea). The no-slip boundary condition has not improved the model and it is removed in the new simulation (free slip is used everywhere excepted at Gibraltar Strait). To evaluate the behavior of this simulation, we compare it with various Drakkar or Mercator runs and observations. We summarize hereafter the main specs of those runs :

Run	Resolution	Forcing Set	Initial Conditions	Duration	Topography
NATL12-BRD81	1/12	DFS4.3	Levitus PHC3 Medatlas	1980-2008	unsmoothed
NATL12-BAMT20	1/12	DFS4	Levitus PHC3 Medatlas	1980-2006	smoothed
NATL025-BRD80	1/4	DFS4.3	Levitus p2.1	1980-2006	smoothed
ORCA025-G70	1/4	DFS3	Levitus p2.1	1958-2004	smoothed
ORCA025-B83	1/4	DFS4.1	Levitus p2.1	1958-2006	smoothed
ATL12-T46	1/12	ERAinterim	Levitus 2005	1995-2008	smoothed

Firstly, we compare the evolution of the Sea Surface Height standard deviation (SSHstd) at 54°N over the 1980-2001 period, taking ORCA025-G70 as our reference. The expected results are a high SSHstd in the eastern part of the basin (east of -28°W , confirmed by AVISO) that reflects the path of the NAC and low SSHstd elsewhere. High values of SSHstd in the interior of the basin are associated with a northward export of eddies. On the western boundary, the SSHstd is related to the southward boundary current variability. Figure 2 clearly shows that the SSHstd in the 1/12° resolution model is stronger than what is computed in the 1/4° model. NATL12-BAMT20 has very strong SSHstd south of the Labrador Sea, which is unrealistic and this has been improved in NATL12-BRD81. However, the maximum of the SSHstd is still located at $-30°$W with a widening of the high SSHstd area in 1995. This feature is also found in

NATL025-BRD80 but which slightly lower values.

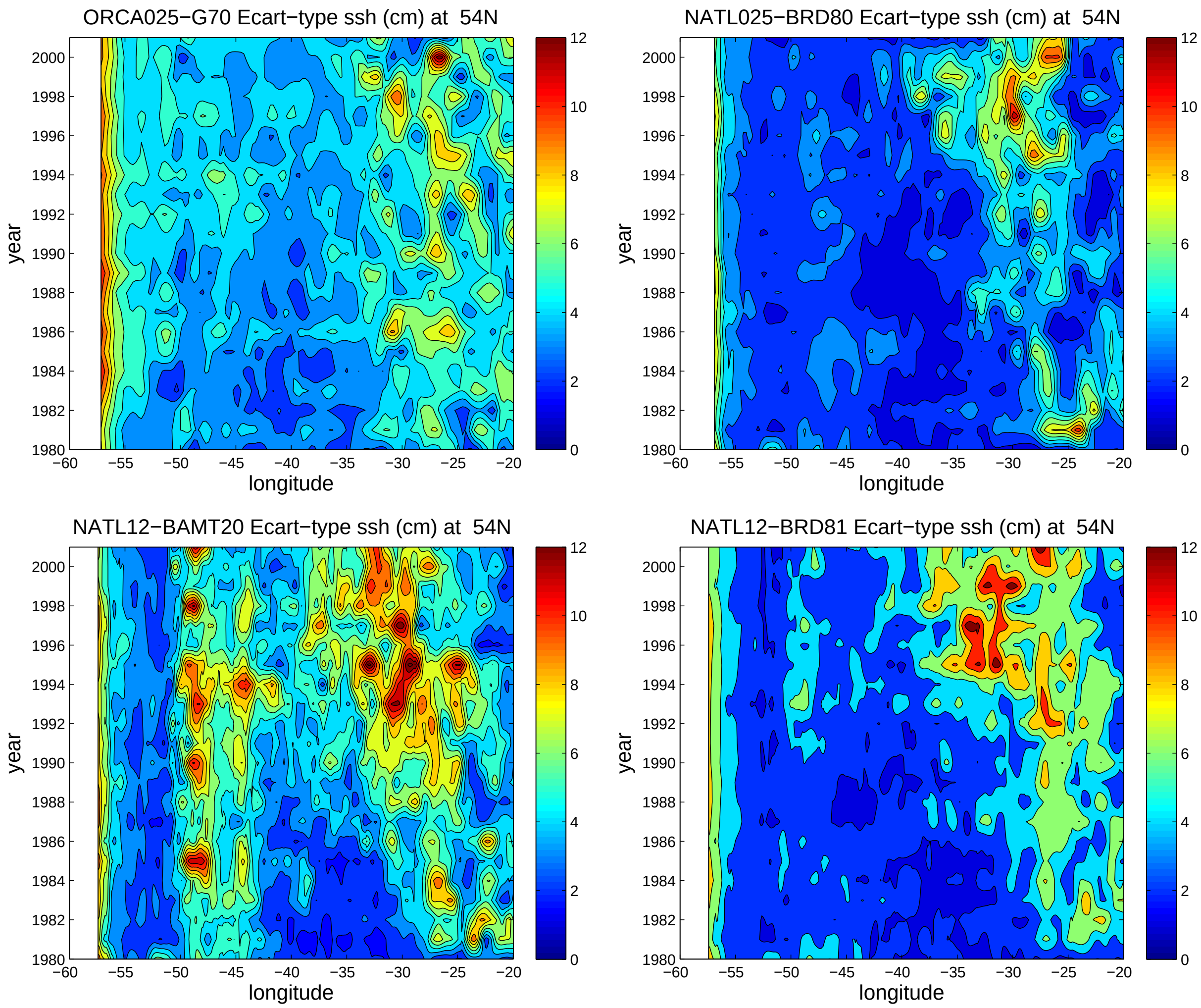

Fig. 2 – SSHstd at 54°N in ORCA025-G70, NATL025-BRD80, NATL12-BAMT20 and NATL12-BRD81

It is not clear which of the slip boundary condition around greenland or the unsmoothed bathymetry is responsible for the improvement of the NAC. Removing the no-slip boundary condition on Greenland may have help to strenghten the subpolar gyre thus leading to a drop in the export of eddies in the Labrador Sea. However, the strong SSHstd in the Irminger sea and its increase in 1995 are features that are common in NATL runs, which have DFS4 forcing set whereas ORCA025-G70 has DFS3. Even if increasing the resolution tends to increase SSH variability, the evolution of NATL025-BRD80 is much more similar to NATL12-BRD81 than to the 1/4° run ORCA025-G70.

Figure 3 is a focus on the 1995-2006 period with AVISO as a reference. It allows to confirm that the maximum of SSH variability is located at the wrong position. The interannual global run ORCA025-B83 using DFS4.1 exhibits slightly more variability than ORCA025-G70. NATL025-BRD80 is the closest to the observations and, despite a misplaced location of its maximum of variability, reproduces quite well the observed pattern. It is the only run in which the SSHstd after 2001 is realistic. The value of background SSHstd cannot be compared with AVISO given the noise on this derived quantity. As expected, the NAC in NATL12-BRD81 has diverged from the correct trajectory and still export eddies in the Irminger sea. It is however better than NATL12-BAMT20, in which eddies are also exported in the Labrador sea. Finally, we can remark that Mercator run ATL12-T46 has the same problems that NATL12-BAMT20 but it is going even worse as the solution strongly degrades only after 5 years of simulation (15 years in NATL12 years) and reaches values of 20 cm (saturated in the figure).

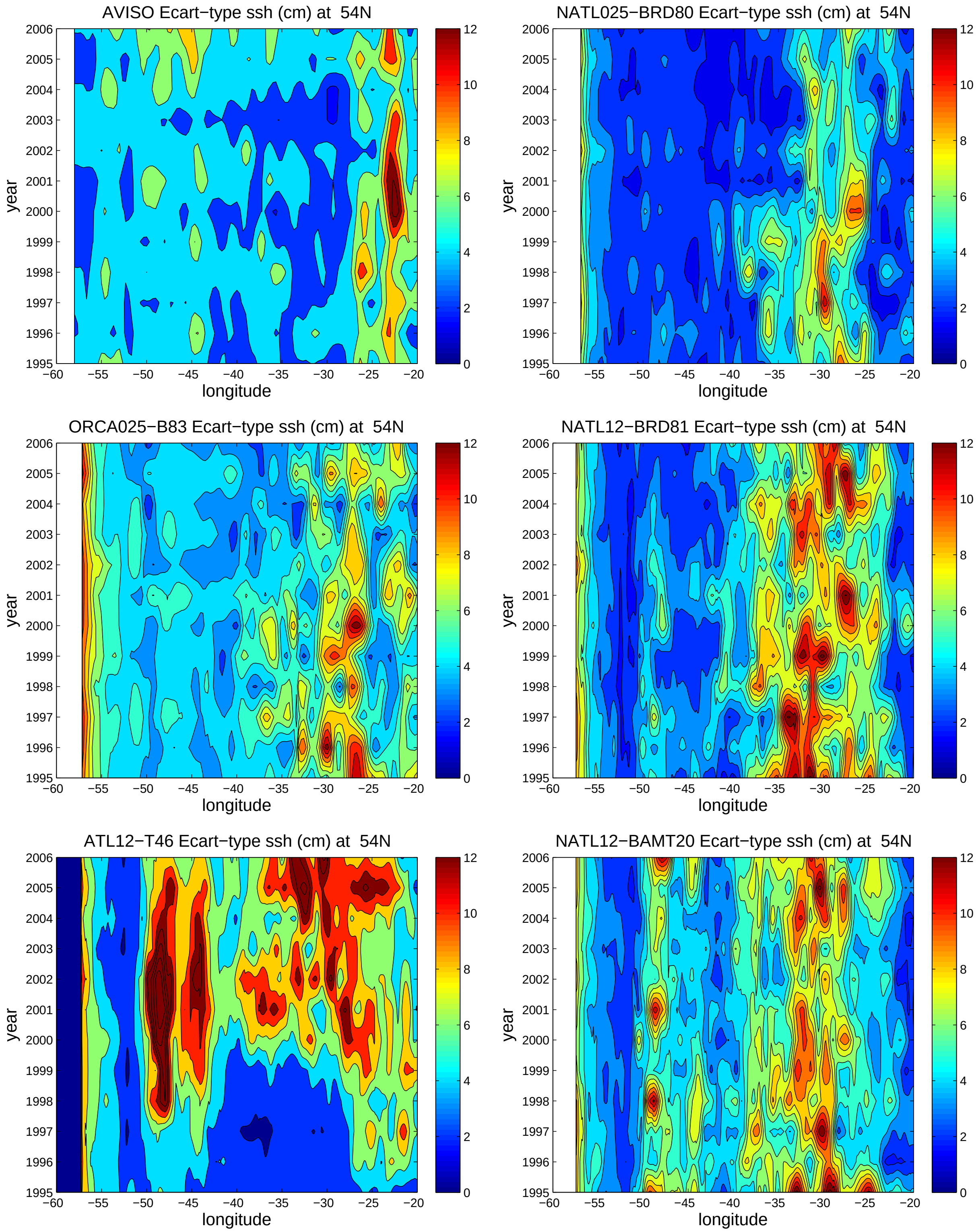

Fig. 3 – SSHstd at 54°N in AVISO, NATL025-BRD80, ORCA025-B83, NATL12-BRD81, ATL12-T46 and NATL12-BAMT20

2.2 Sea Surface Temperature trends in the Irminger sea

In order to investigate the trends in Sea Surface Temperature, we separate the domain in four boxes (see figure 5). We chose to define the first box where the SST drift is maximum. The three other boxes are areas that are affected by the North Atlantic Current, depending on its path. We do not include the East Greenland Current in box number 2 because we have a large difference in SST in the boundary current (the model is 3 to 6 degrees colder than the observations). Reynolds SST product is likely not to have enough resolution to capture the details of this boundary current and adding the EGC in the mean would be incorrect because we want to focus on the drift due to the export of eddies in the interior of the Irminger sea. In addition, even if the model had bias in the EGC, there is no evidence that it could be relied to the export of eddies so it is a different problem that we are not going to investigate.

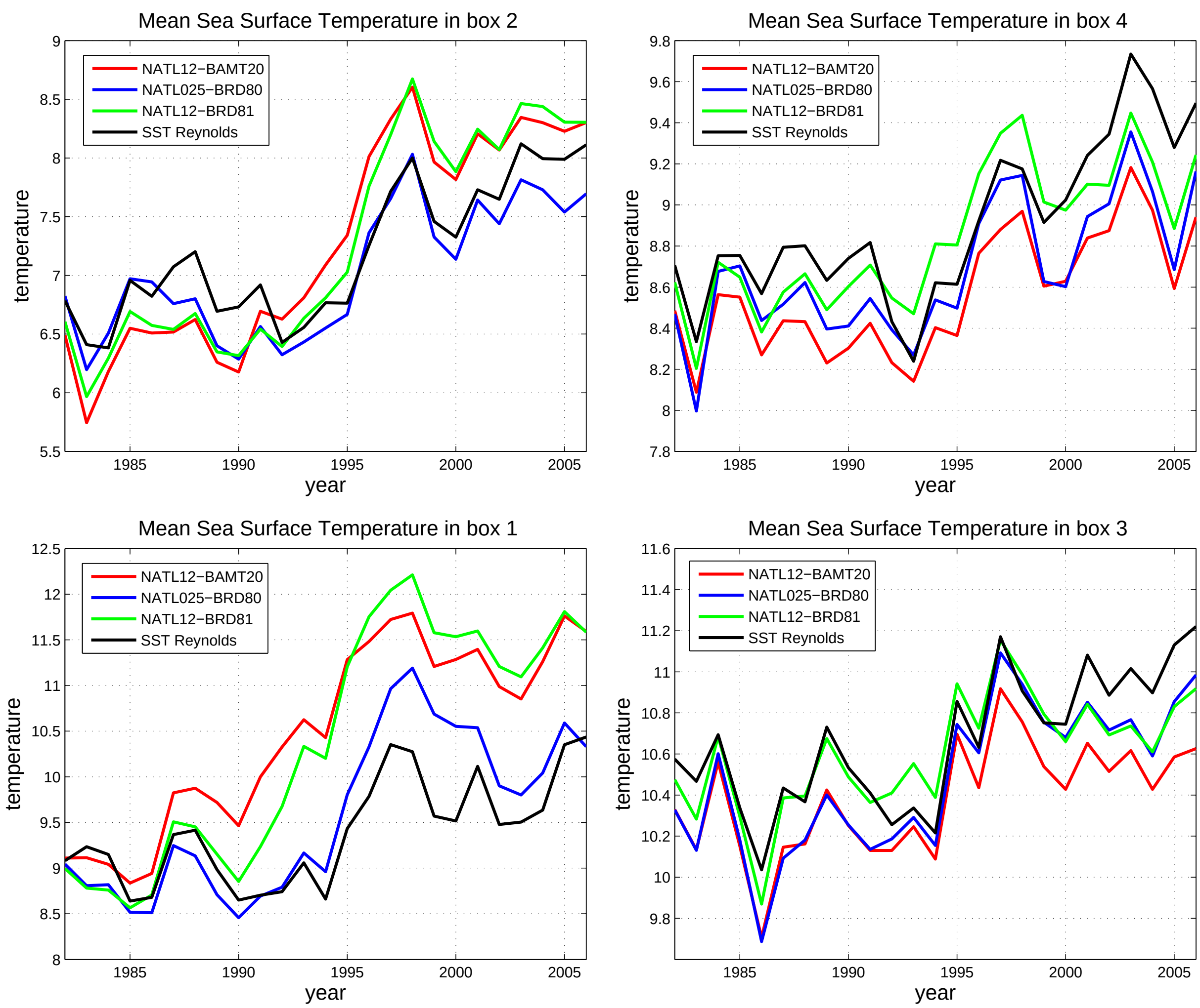

FIG. 4 – Mean SST in NATL025-BRD80, NATL12-BAMT20, NATL12-BRD81 and Reynolds

In figure 4, we compare the mean SST of NATL12-BRD81, NATL12-BAMT20 and NATL025-BRD80 with Reynolds in the four boxes. Overally, the interannual variability is well reproduced in all of the simulations and NATL025-BRD80 seems to be the closest to the observations. Figure 6 shows the SST difference to Reynolds in the models and is more convenient to evaluate the biases in the different boxes. As expected, the drift in box 1 is the most important in all 4 boxes and reaches between 1.5 and 2 degrees in NATL12 runs, only 1 degree in NATL025. NATL12 runs begin with 4 to 6 years of weak negative anomaly, then there is a continuous increase toward a maximum in 1995 (BAMT20) or 1996 (BRD81) and finally the anomaly stabilises around a value of 1.5 degrees. In NATL025, the drift is very similar to NATL12-BRD81 until 1985 but then it stabilises and become positive only in 1992. The maximum positive anomaly is reached in 1999, then it decrease to almost zero at the end of the run.

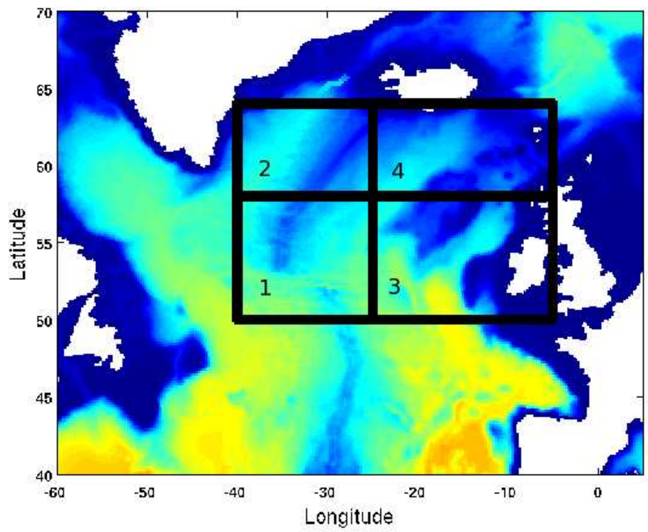

FIG. 5 – Location of the 4 boxes used for dignostics

In box number 2, the anomaly in NATL12 runs is negative and stable until 1990 then dramatically increase between 1990 and 1995 to reach its maximum of roughly 0.7 degrees in 1996 (BAMT20) or 1998 (BRD81). Then both decreases to 0.2 degrees in the end of the run. NATL025 has a much better behavior and its anomaly fluctuates around -0.2 degrees and remains quite stable. In boxes 3 and 4, anomalies are mostly negative except in NATL12-BRD81 which has positive anomalies in the 90ies. This tends to confirm that the North Atlantic drift does not bring enough hot water in this areas.

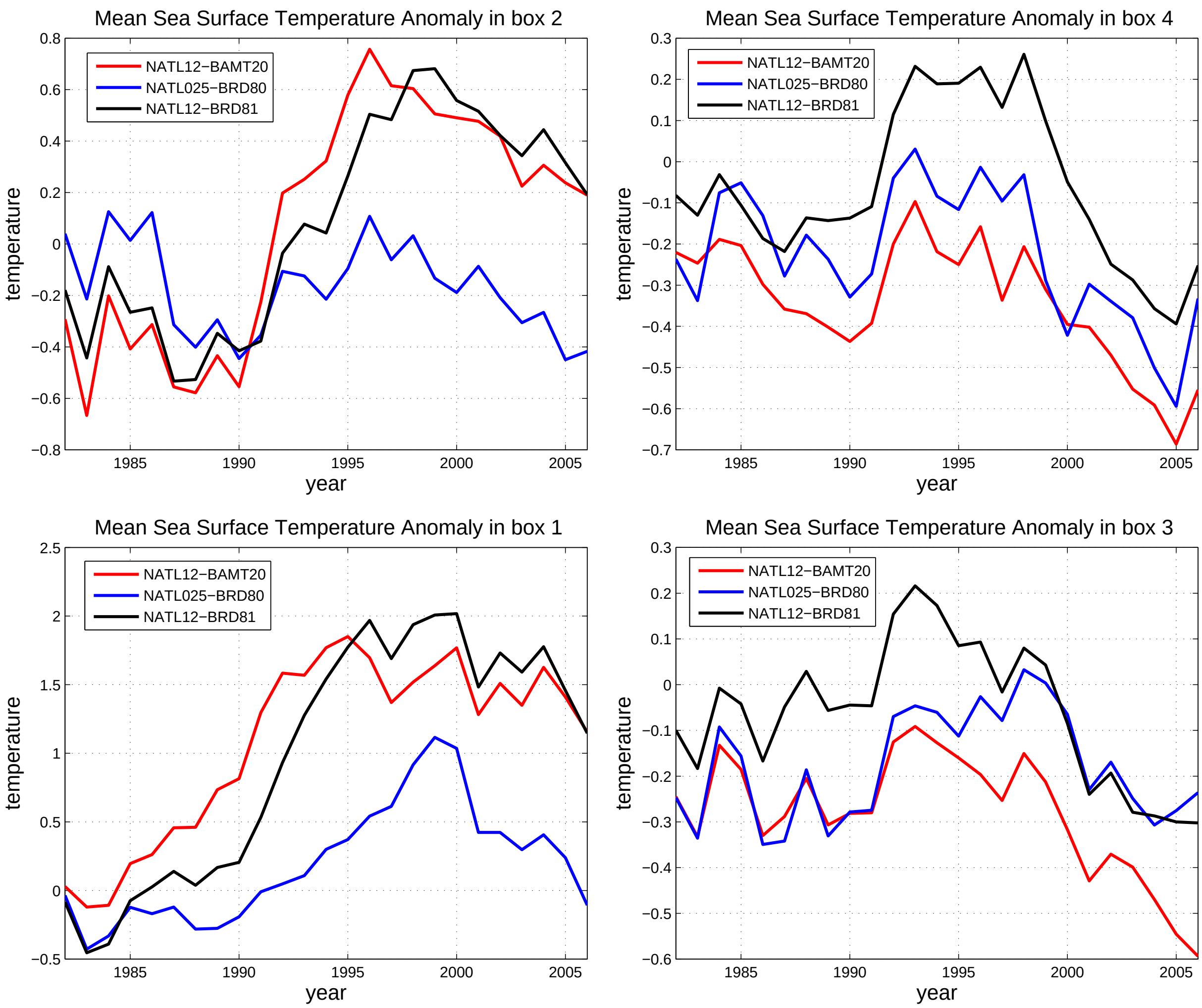

Fig. 6 – SST anomaly in NATL025-BRD80, NATL12-BAMT20, NATL12-BRD81 compared to Reynolds

Figures 7 and 8 shows the evolution of the difference between the meridionnal mean of the SST in the model and Reynolds. In box 1, we can see some discrepancies between the behavior of NATL12 and NATL025. NATL025 has a positive temperature anomaly located at $-31°$W that appears between 1995 and 2000 then slowly vanishes. It contrasts with the strong negative anomaly located in the western part. In BAMT20, the run starts with a small negative anomaly then most of the subdomain has a positive anomaly. The maximum of the anomaly is located at $-37°$W . In BRD81, the negative anomaly phase lasts 5 years longer then there is also a positive anomaly whose maximum is shifting eastward.

In box 2, there is a net evidence of the warming in the Irminger sea that we have in NATL12. We can remark that the amplitude in the difference is much weaker in NATL025. In NATL12, we have both a strong negative bias in the beginning of the run followed by a strong positive bias. In BRD81, there is an improvement compared to BAMT20. Box 3 and 4 are more difficult to analyse.

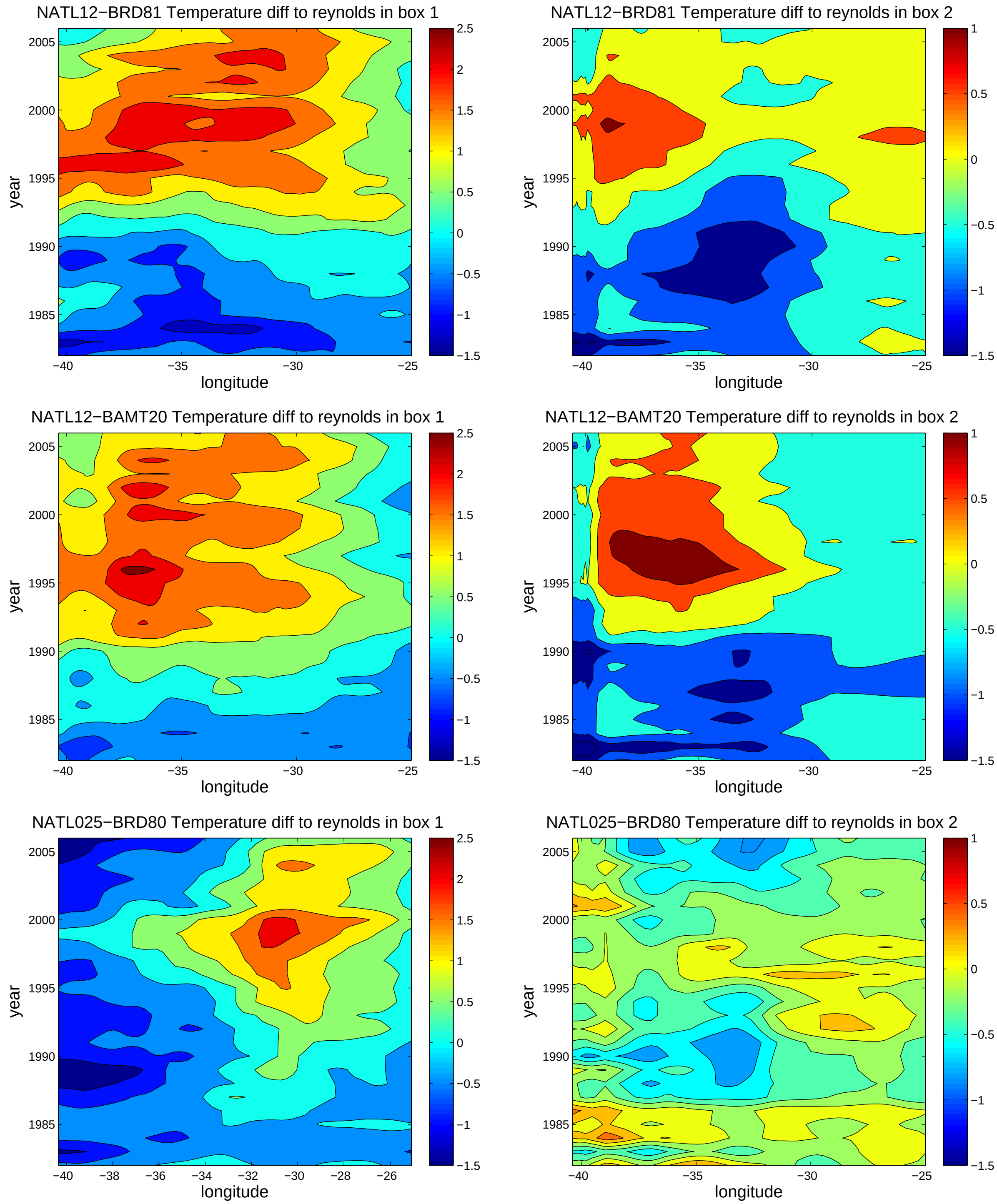

FIG. 7 – Hovmuller of SST difference to Reynolds in boxes 1 and 2

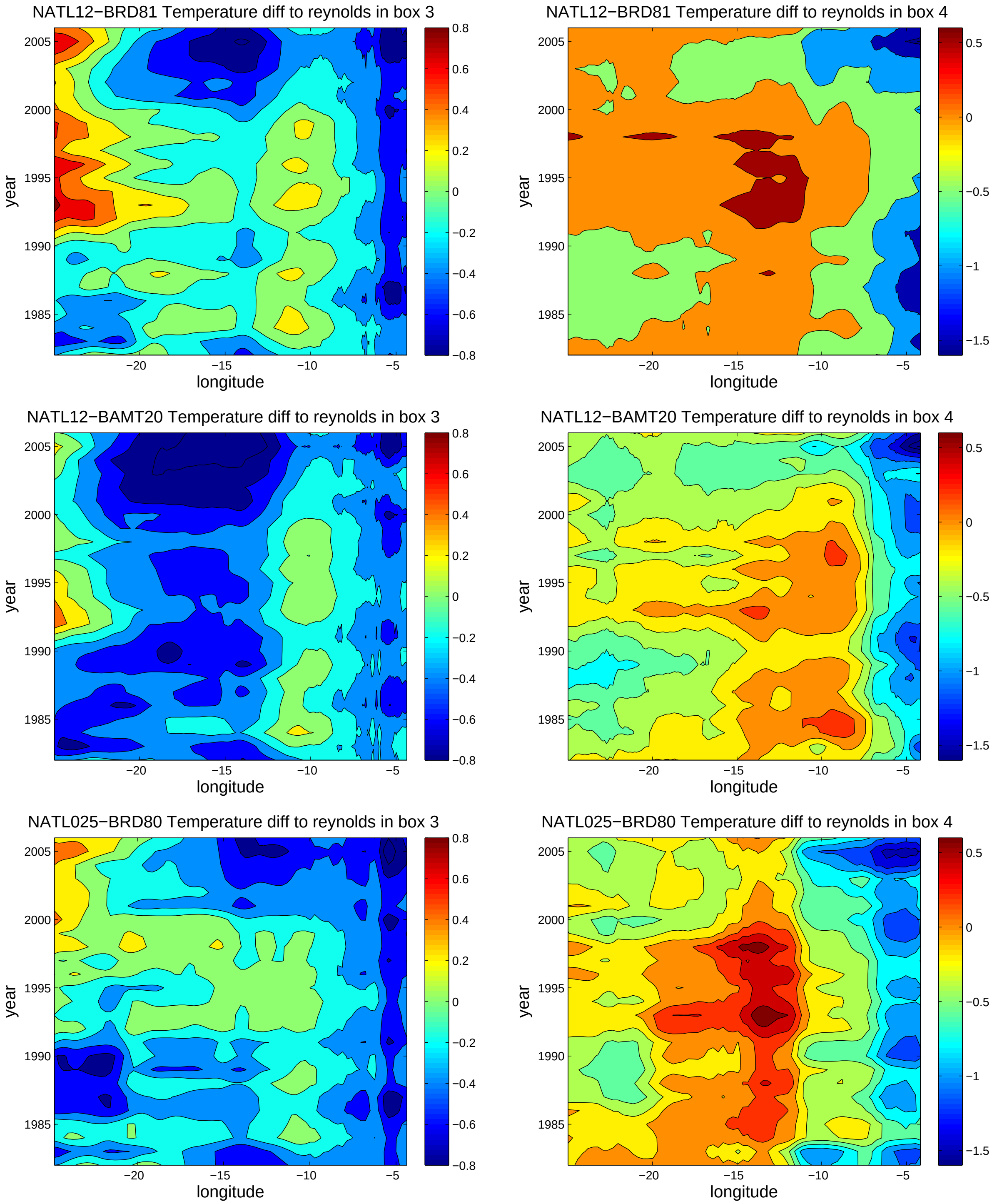

FIG. 8 – Hovmuller of SST difference to Reynolds in boxes 3 and 4

2.3 Vertical structure of the temperature trends in the Irminger sea

First, we are going to consider the mean temperature integrated over the volume of each of the four boxes defined in the previous part (see figure 9). In eastern boxes, there is a small divergence in the mean temperature trends. NATL12 runs are warmer and the difference with NATL025 is roughly 0.05 degrees. The key period in these boxes is 1988-1990 as we see the temperature in NATL12 runs becoming greater than in NATL025.

In western boxes, the divergence is more intense as it reaches 0.4 degrees in box 1 and 0.15 degrees in box 2. In 1995, a contraction of the subpolar gyre was observed. We can see that there is a drastic increase of the mean temperature in 1995, which means that the models reproduce this contraction but we believe that NATL12 runs overestimate it. However, NATL12-BRD81 is slightly colder than NATL12-BAMT20 and the rise in temperature occurs later in the run. This can be seen as a tiny improvement compared to the previous run.

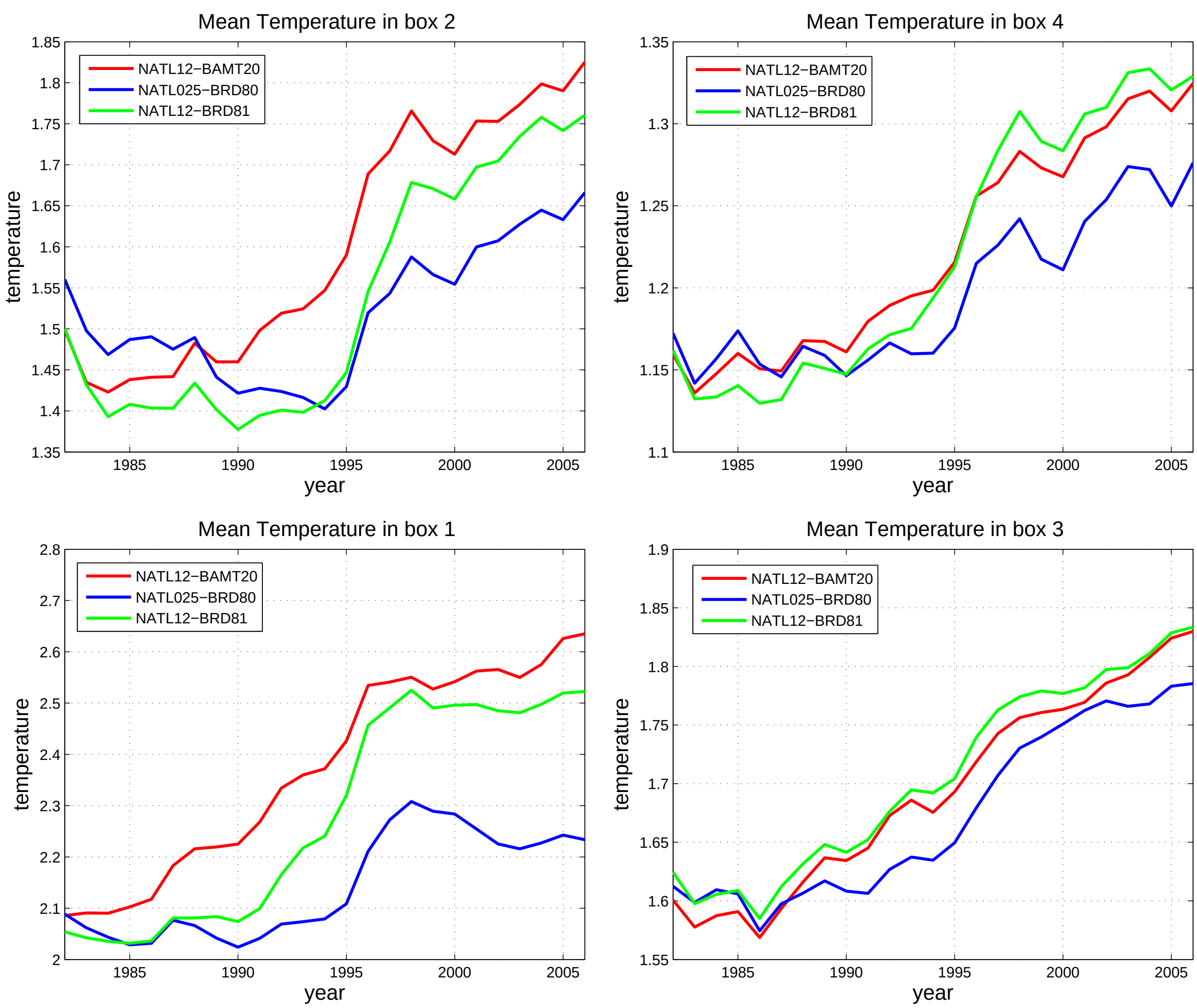

Fig. 9 – SST anomaly in NATL025-BRD80, NATL12-BAMT20 and NATL12-BRD81

2.4 Comparison with Ovide

2.4.1 Water masses properties along Ovide section in 2002 and 2004

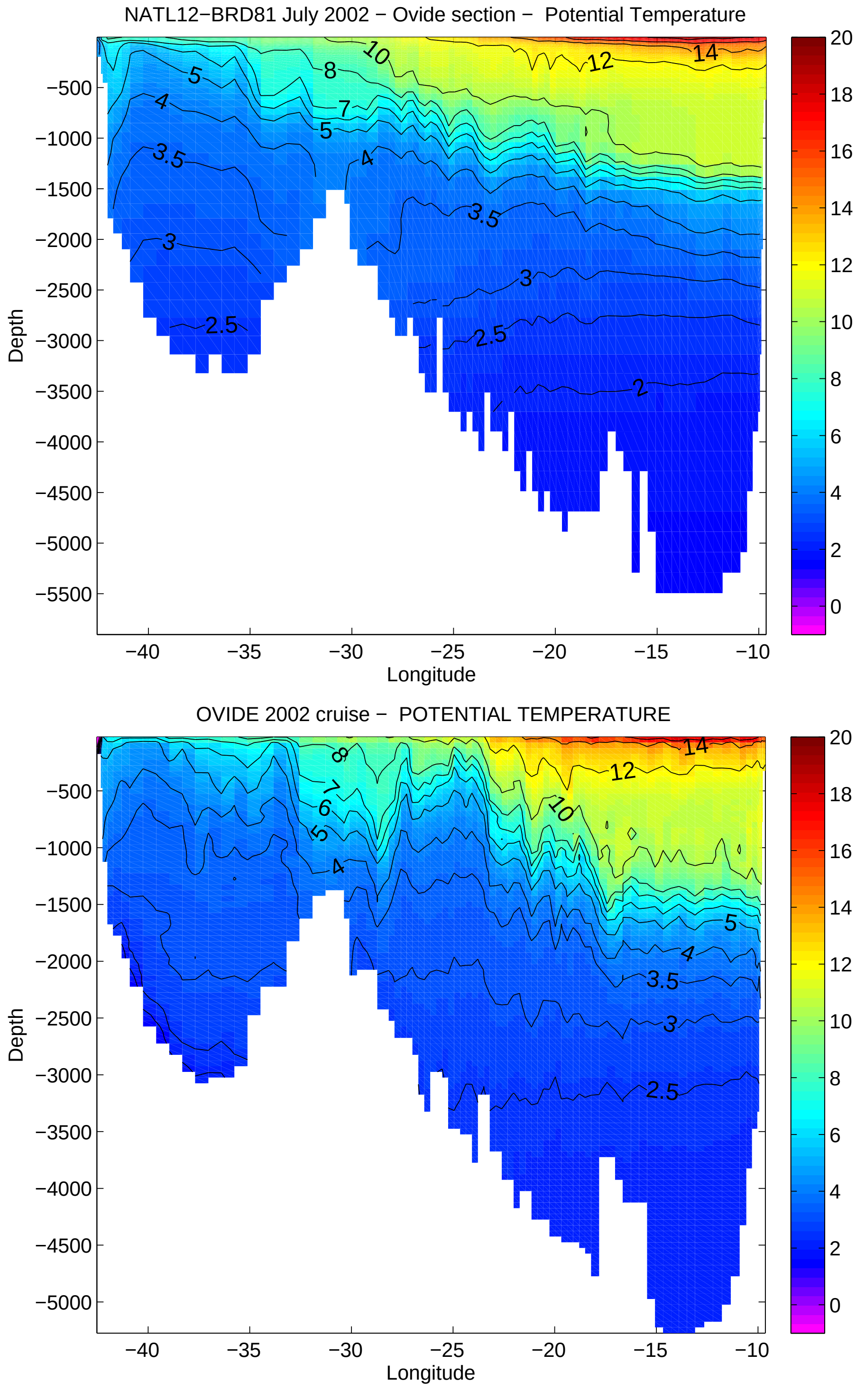

FIG. 10 – Temperature in NATL12-BRD81 in july 2002 (top) along OVIDE section and original data (bottom)

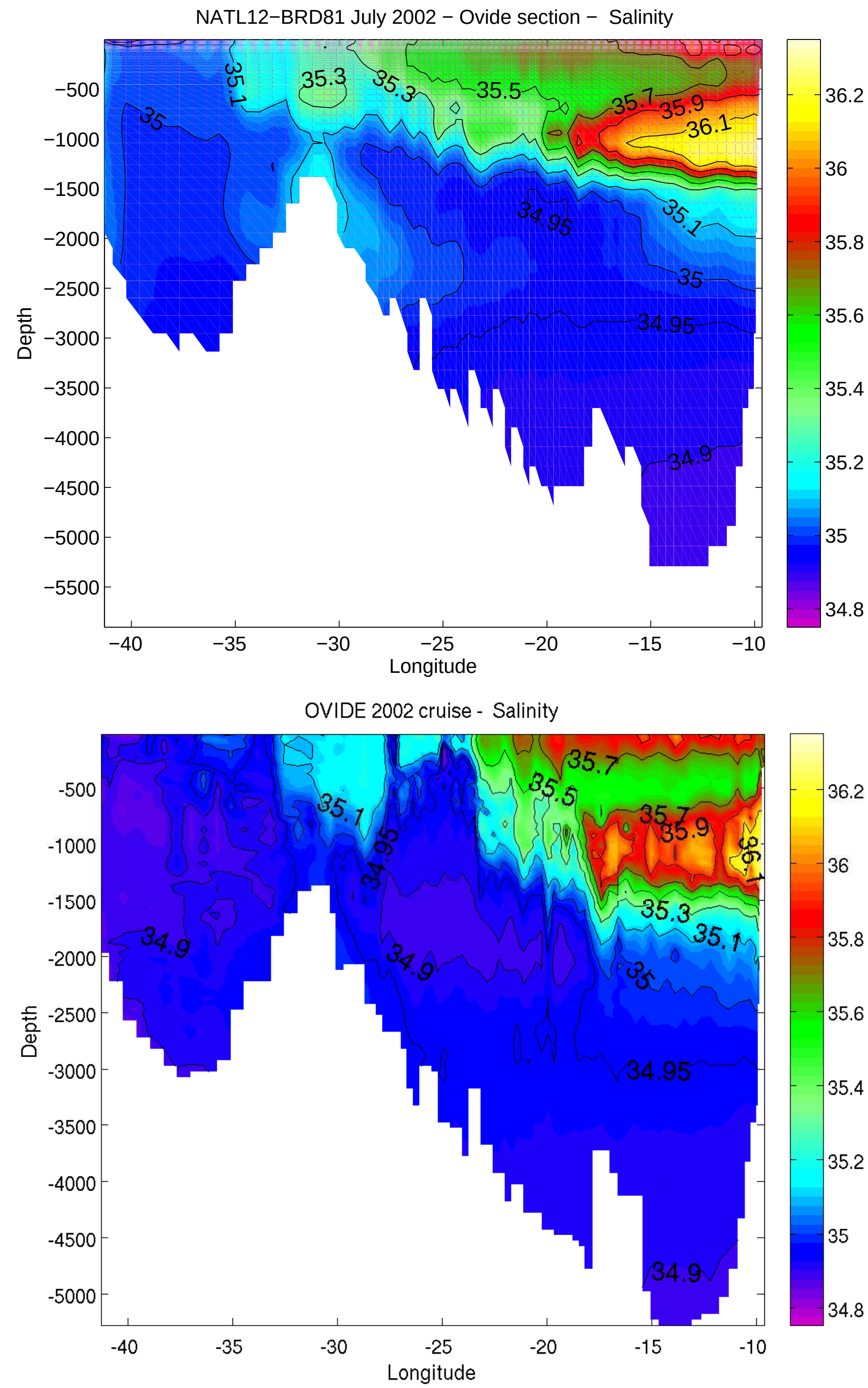

FIG. 11 – Salinity in NATL12-BRD81 in july 2002 (top) along OVIDE section and original data (bottom)

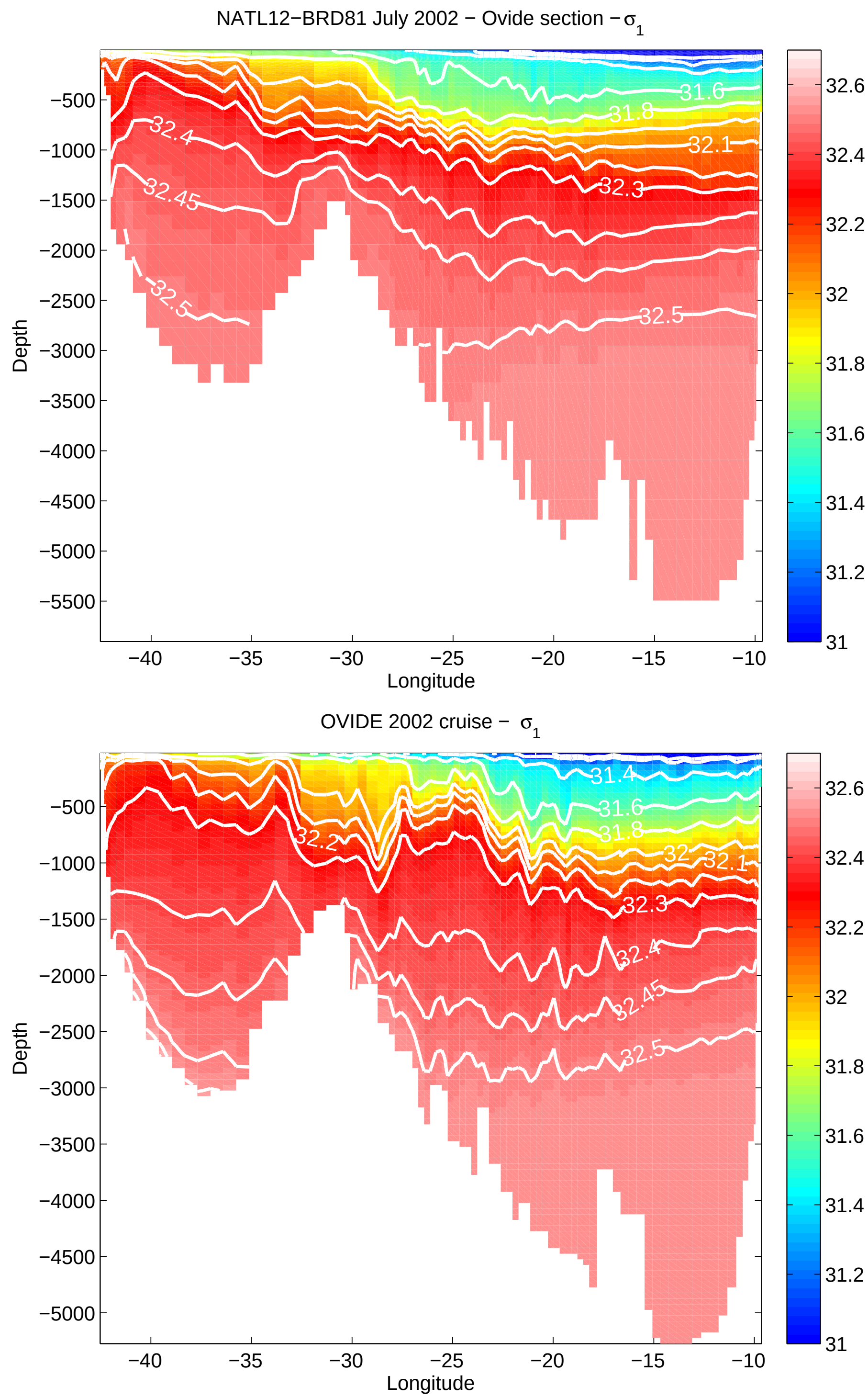

FIG. 12 – Potential density (referenced at 1000m) in NATL12-BRD81 in july 2002 (top) along OVIDE section and original data (bottom)

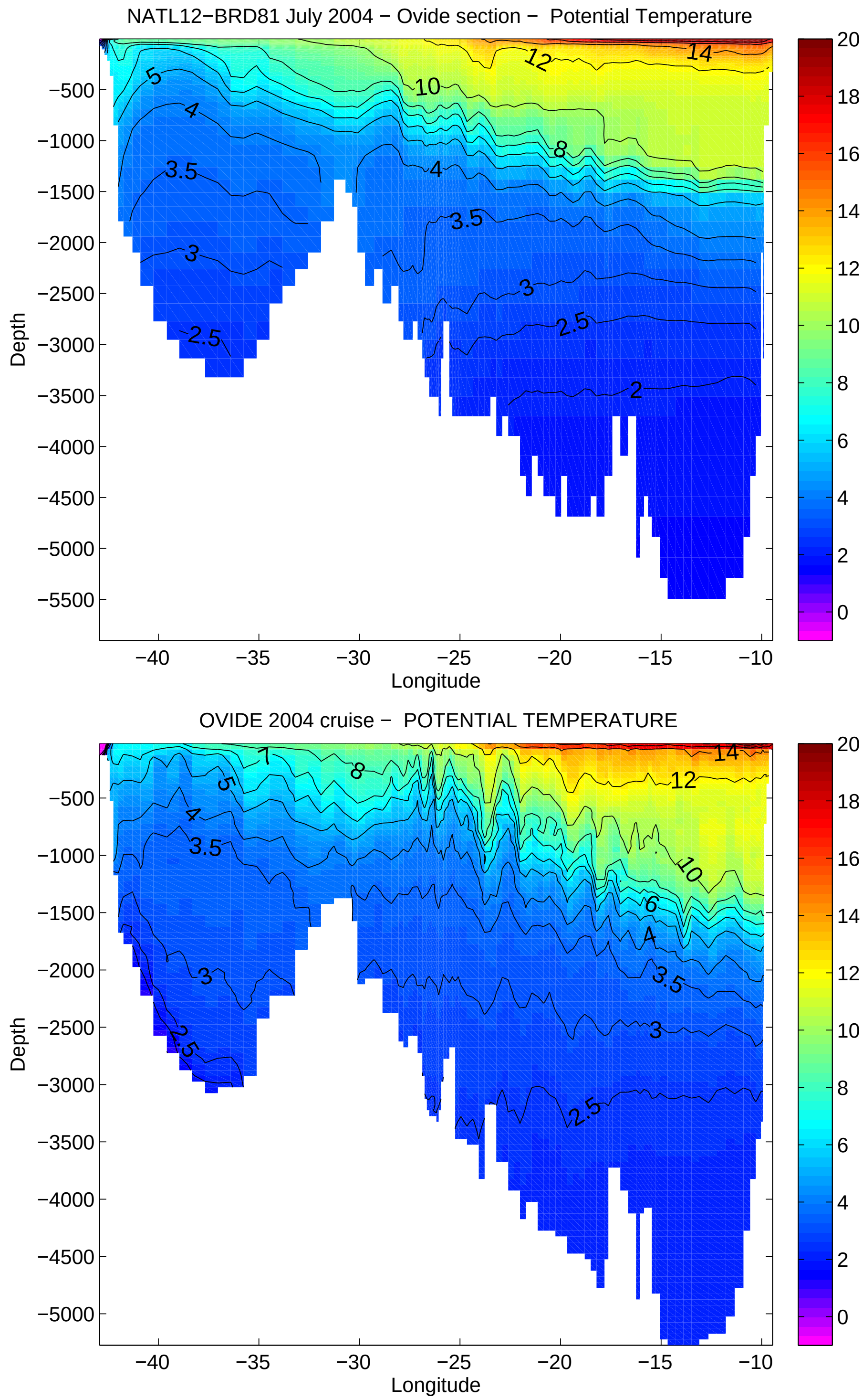

Fig. 13 – Temperature in NATL12-BRD81 in july 2004 (top) along OVIDE section and original data (bottom)

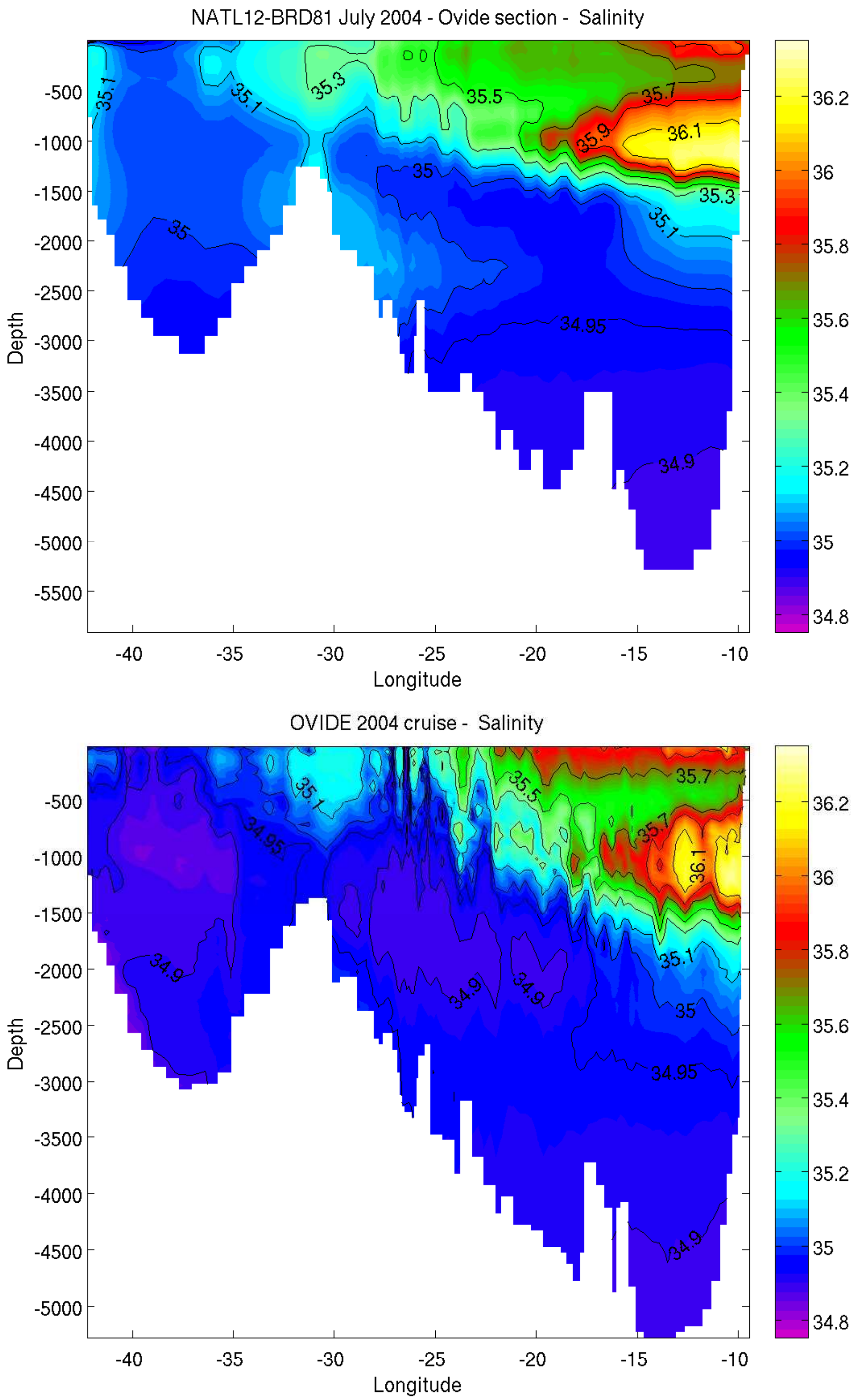

FIG. 14 – Salinity in NATL12-BRD81 in july 2004 (top) along OVIDE section and original data (bottom)

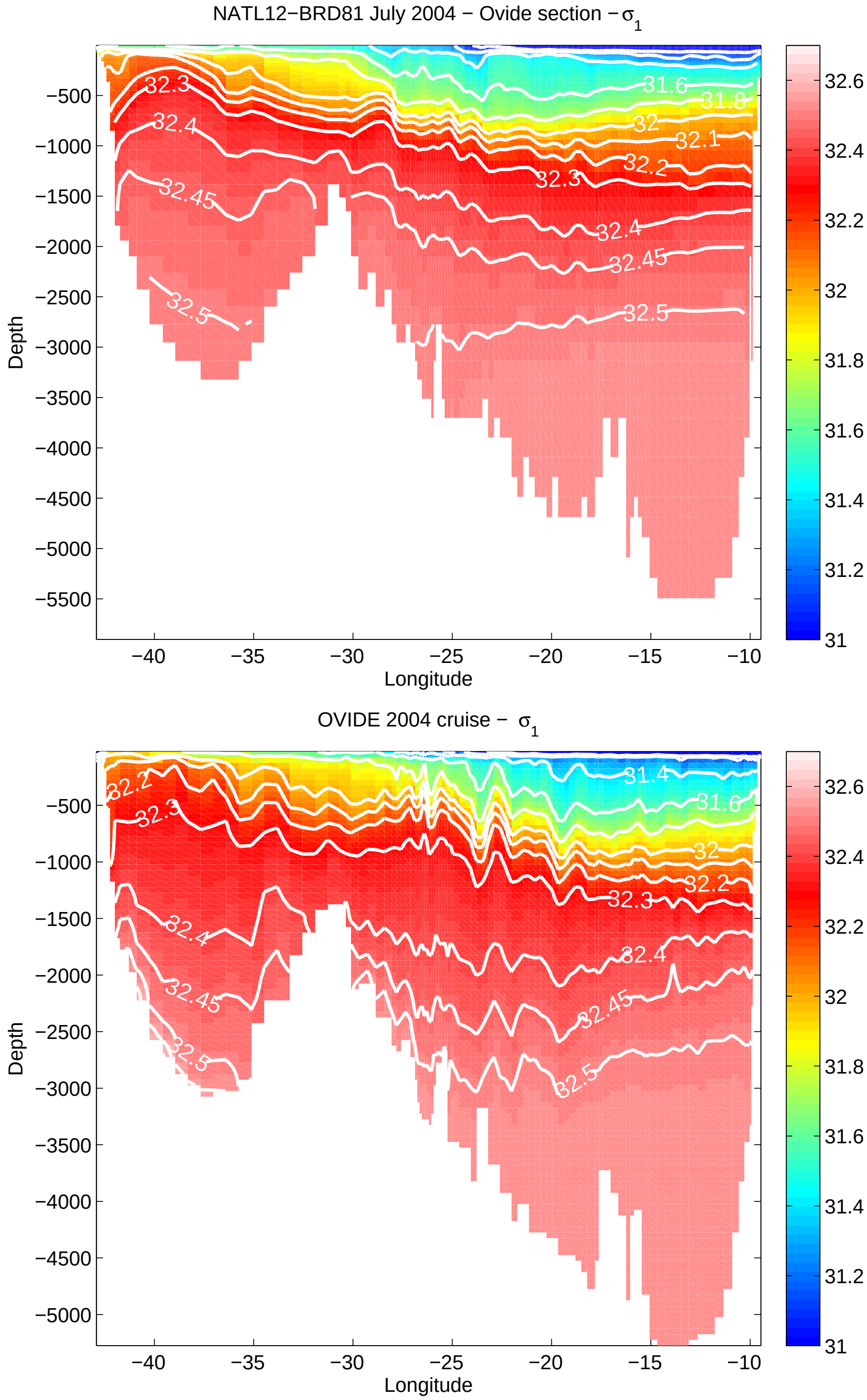

FIG. 15 – Potential density (referenced at 1000m) in NATL12-BRD81 in july 2004 (top) along OVIDE section and original data (bottom)

2.4.2 Intercomparison of temperature and salinity profiles in key areas

In this part, we will compare results from ORCA025-G70, NATL12-BAMT20 and NATL12-BRD81 with the observed data. Model outputs used are the monthly means of july 2002, 2004 and 2006. We show temperature and salinity profiles of spatial means over 5 areas of particular interest :

1. the East Greenland Current (black points)
2. the center of Irminger Sea (red points)
3. the western side of the Reykjanes ridge (yellow points)
4. the eastern side of the Reykjanes ridge (green points)
5. the Mediterranean Waters outflow (blue points)

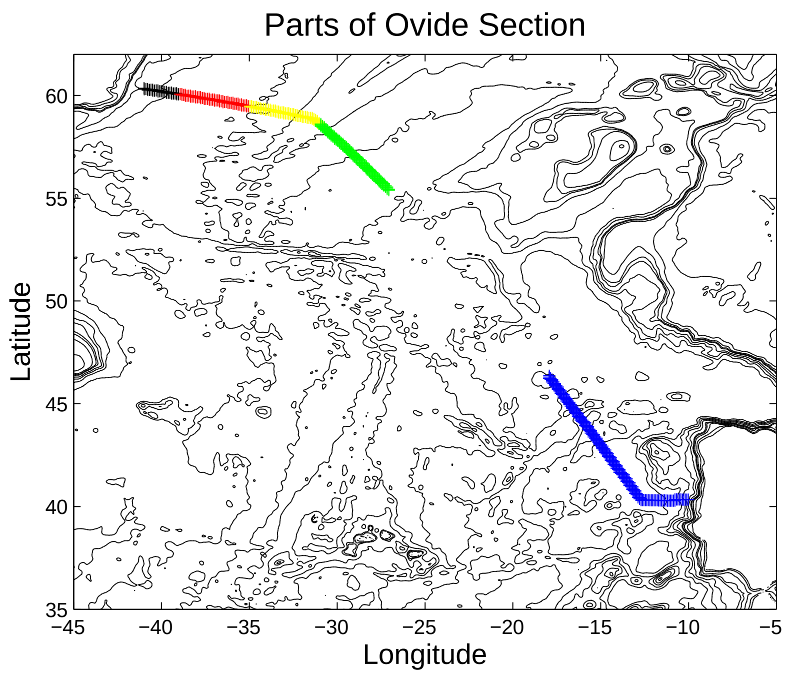

Fig. 16 – map of key areas along the Ovide section

If we look to figures 17 to 20, we can see that NATL12 runs are too warm and salty in those areas. The profiles in ORCA025-G70 are closer to the observations although the shape of the profiles in NATL12 runs are more similar to the observations. Finally, 21 shows that the Mediterranean waters outflow has been improved in NATL12-BRD81. This will be discussed more in details in the next section.

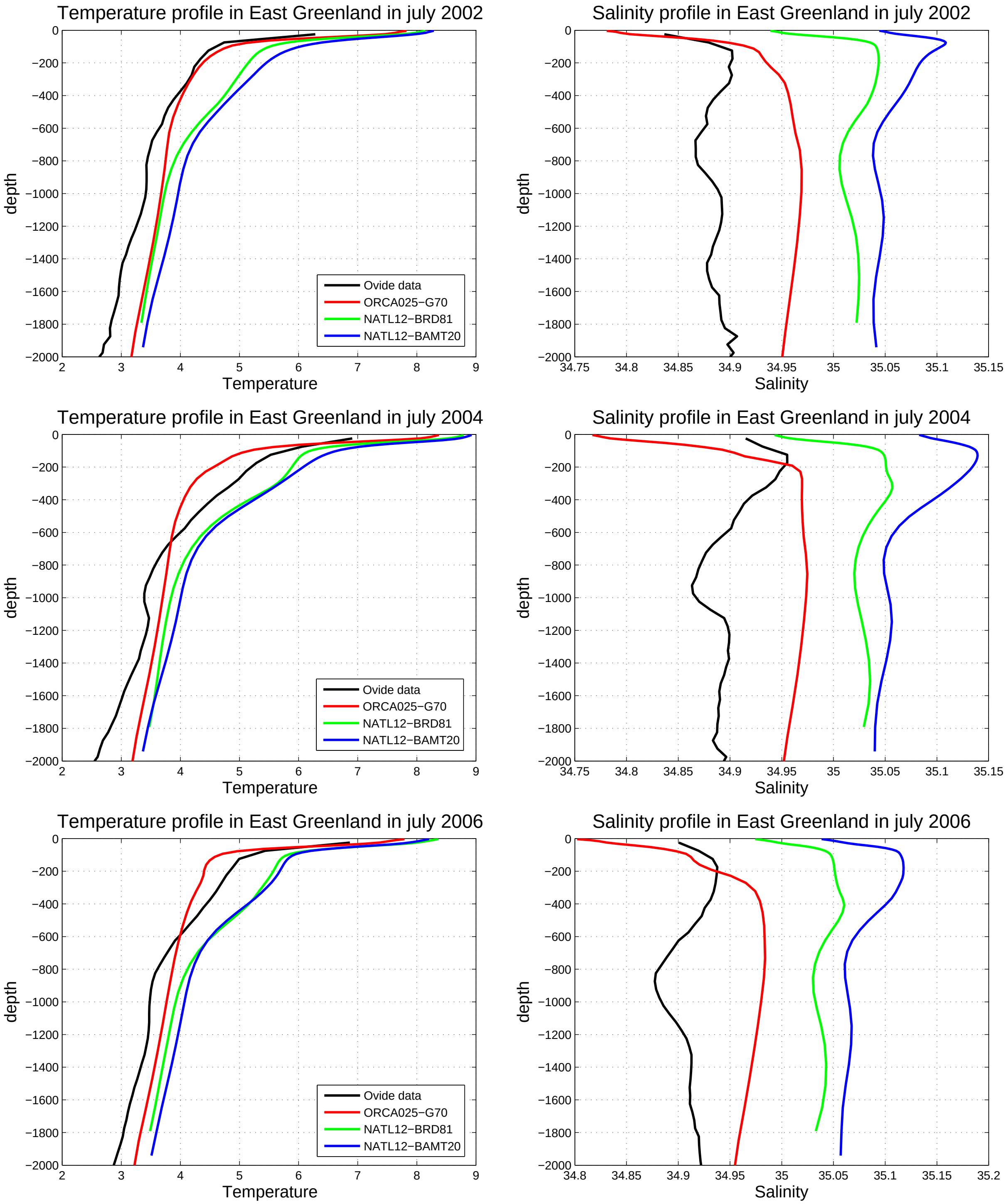

FIG. 17 – Temperature and salinity profiles in 2002, 2004 and 2006 in East greenland

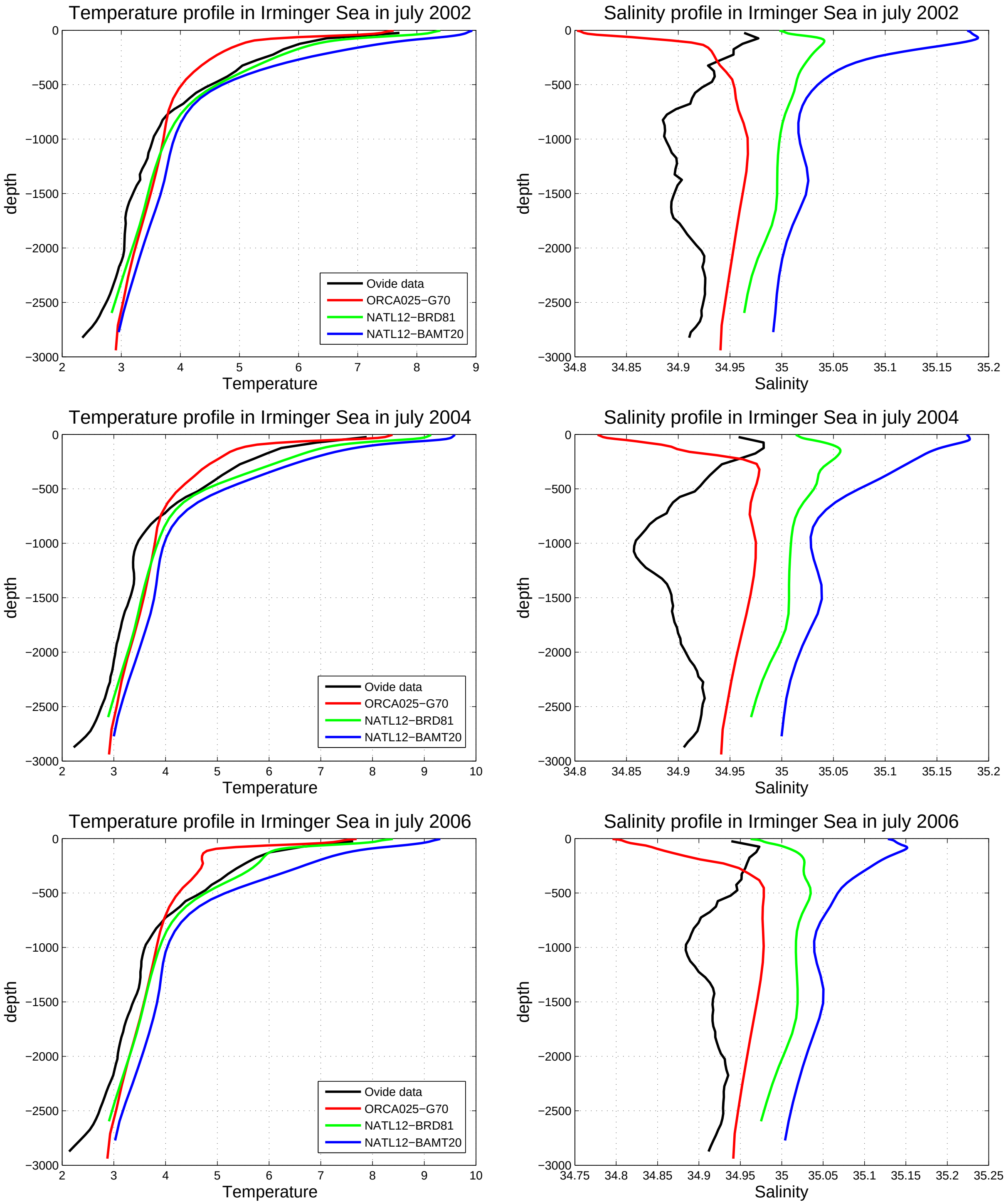

FIG. 18 – Temperature and salinity profiles in 2002, 2004 and 2006 in Irminger sea

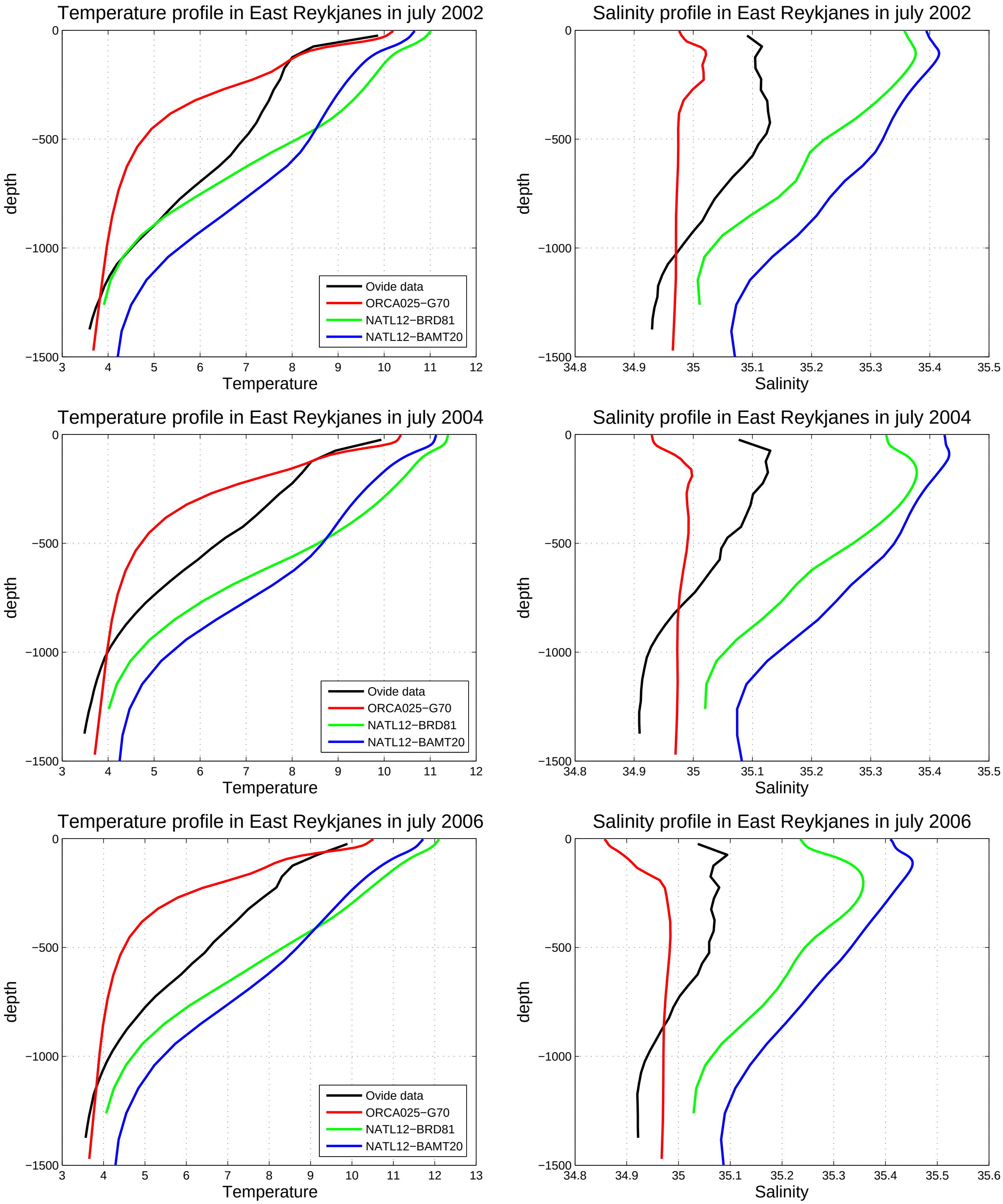

FIG. 19 – Temperature and salinity profiles in 2002, 2004 and 2006 in East Rekjanes

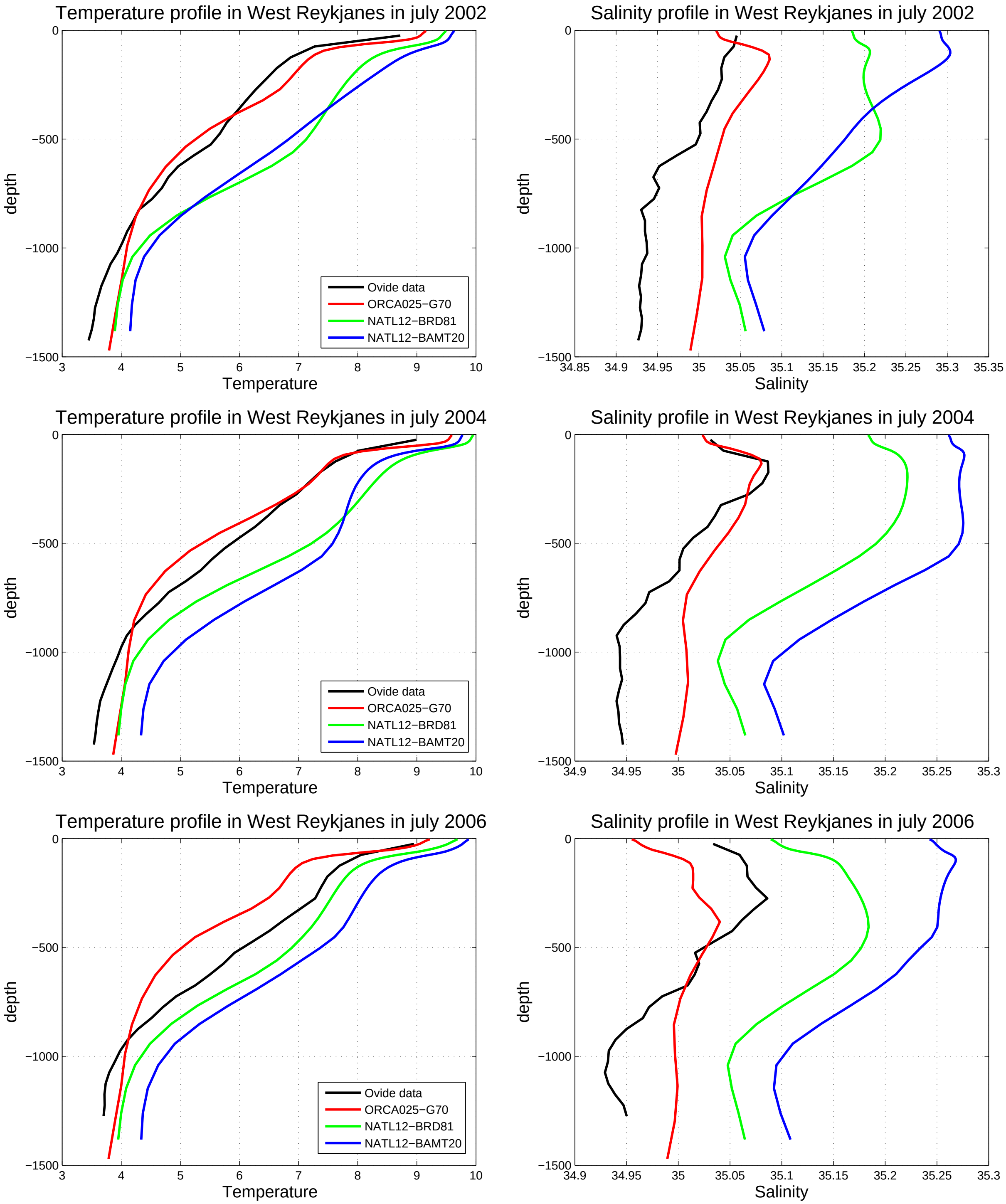

FIG. 20 – Temperature and salinity profiles in 2002, 2004 and 2006 in West Rekjanes

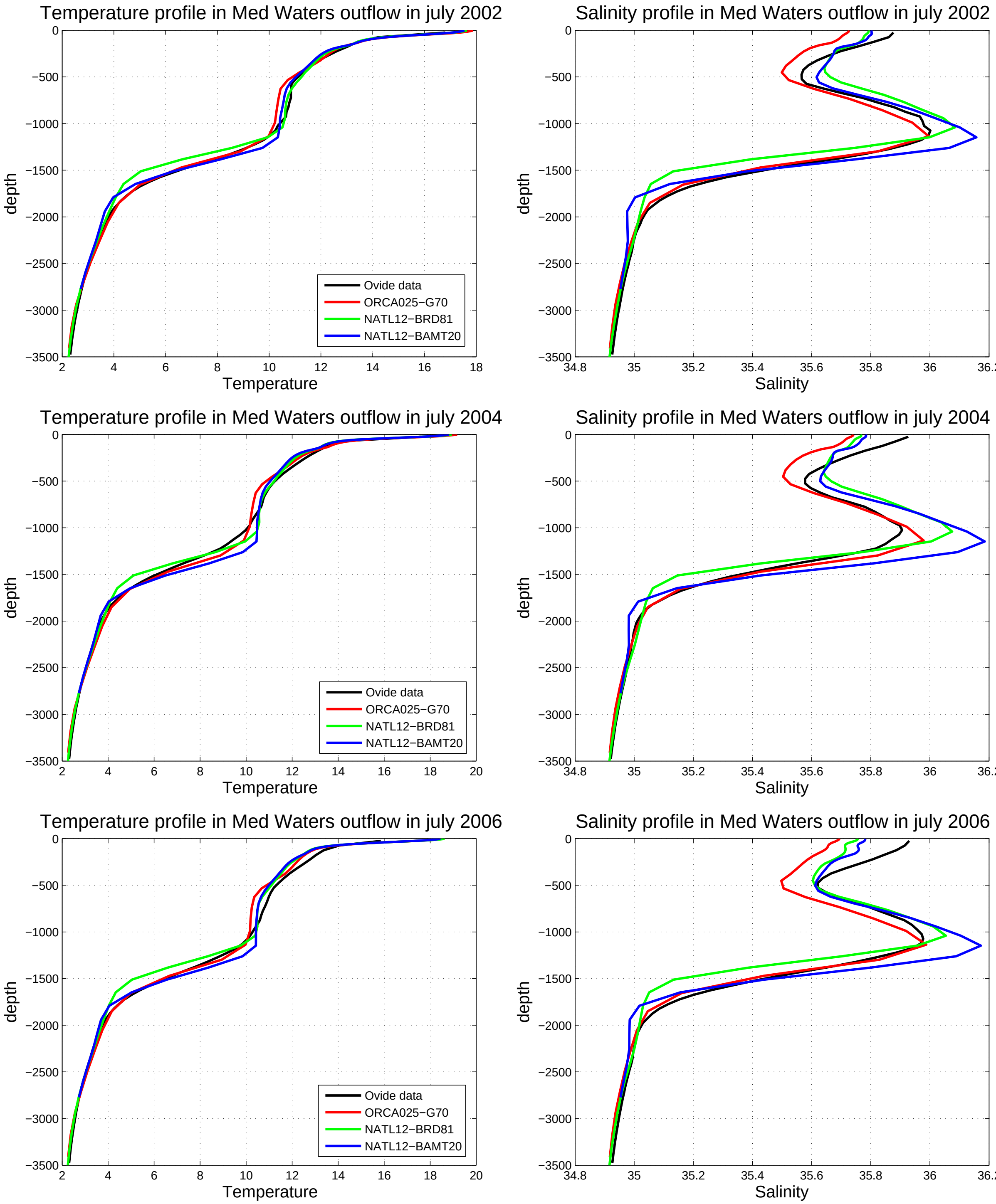

FIG. 21 – Temperature and salinity profiles in 2002, 2004 and 2006 in Med Waters outflow

3 Mediterranean Waters outflow

Most of the configurations in the Drakkar hierarchy uses restoring in the gulf of Cadiz to reduce drifts in temperature and salinity. NATL12 does not use restoring in this area. In this new experiment, we have used an unsmoothed bathymetry and an enhanced bottom friction at Gibraltar strait The result is a major improvement in our Mediterranean Waters outflow. We describe here some key results of the simulation and compare with data, previous Drakkar simulations and the Mercator simulation ATL12-T46.

3.1 Salinity anomalies downstream of Gibraltar strait

In the previous simulation, namely NATL12-BAMT20, Med Waters outflow was too warm and too salty despite our adjustements in the slip condition in the Gibraltar strait. This induced major biases in water masses properties in the eastern atlantic. In this simulation, we decided to add an enhanced bottom friction (2 times stronger) at Gibraltar and downstream eastward to cape St Vincent. Hence, we managed to reduce the transport at the strait from 0.82 Sv to 0.59 Sv (computed over the 1990-2006 period). We have also computed a new bathymetry for the NATL12-BRD81 experiment, with less smoothing.

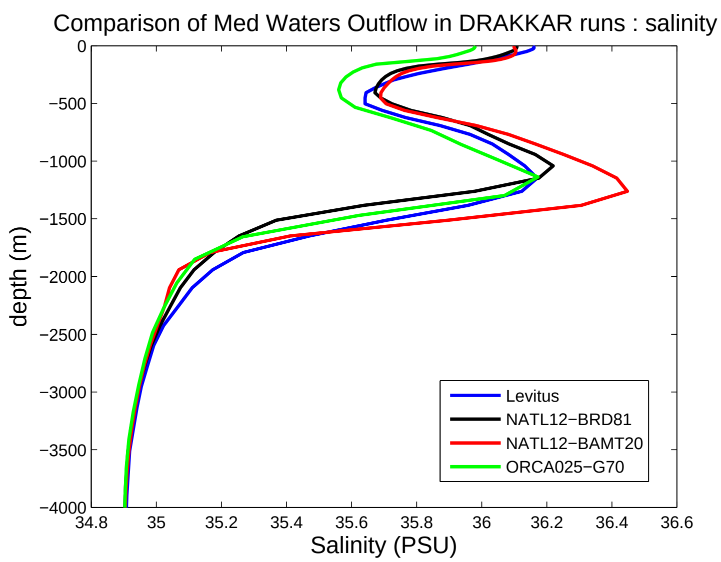

Fig. 22 – Salinity profile in the control box (10°W - 13°W , 35°N - 40°N) in NATL12-BRD81, NATL12-BAMT20, ORCA025-G70 and Levitus climatology.

The salinity map at 1000 m (see figure 23 top) shows the extent of the Med Waters outflow obtained in this experiment. It has been strongly reduced compared to BAMT20. Salinity profile in the (10°W - 13°W , 35°N - 40°N) control box (see figure 22) also shows that the Med Waters has much better properties. It is now comparable with ORCA025-G70, which has restoring in the gulf of Cadiz. However, there is a salinity anomaly at 1000 m that extends from the bay of Biscay to the Azores (see figure 23 bottom). Vertical sections shows that this positive anomaly is above a negative anomaly (see figure 24), which suggests that the overall export of Med Waters is correct but the dynamics downstream of the strait need to be improved. It is not clear yet what are the processes responsible for those discrepancies but our guess is that we have a lack of Meddies and Med Waters properties are advected in the bay of Biscay and diffuse upwards.

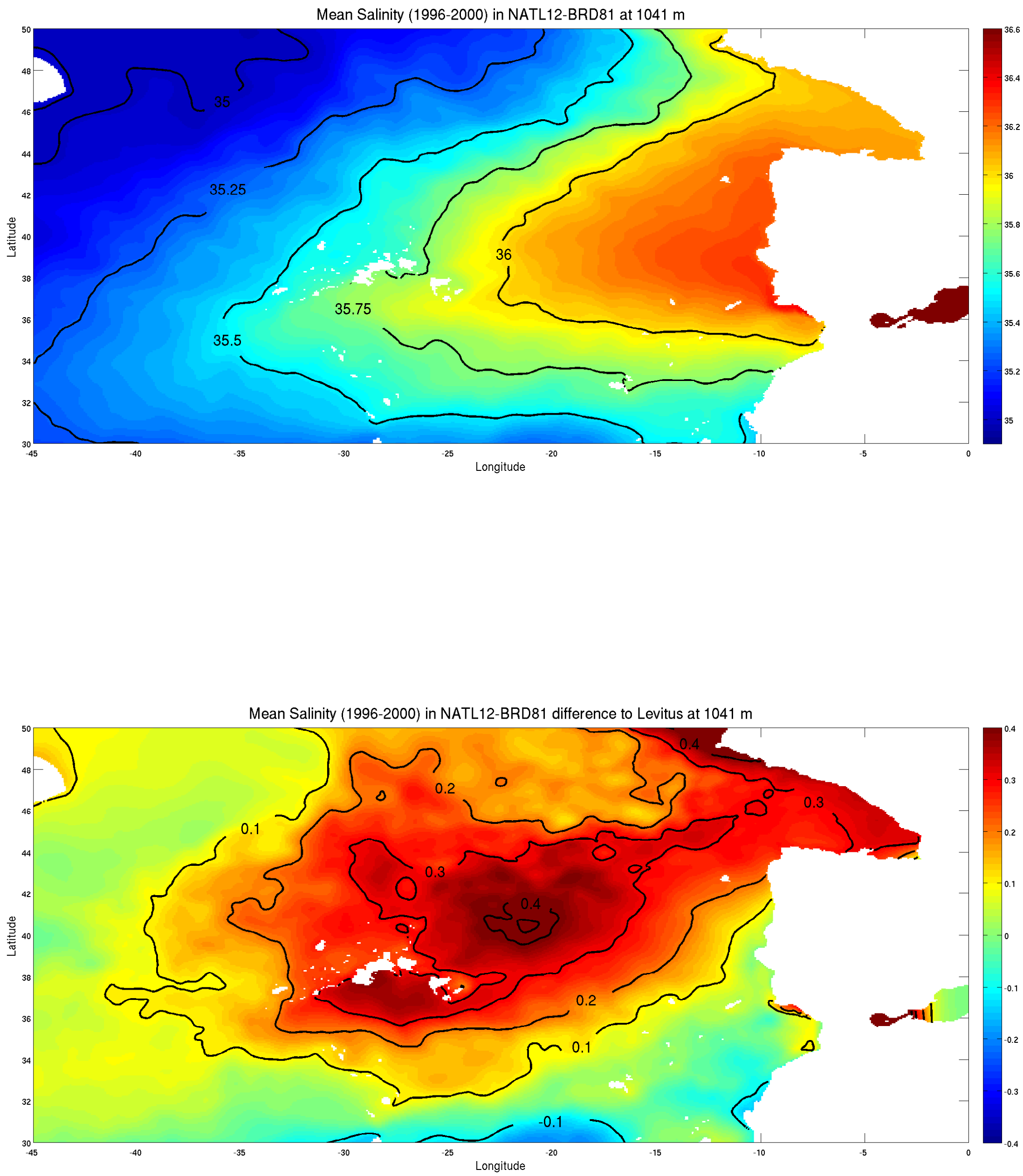

Fig. 23 – Mean Salinity at 1000 m in NATL12-BRD81 (years 1996 to 2000) and difference to Levitus climatology

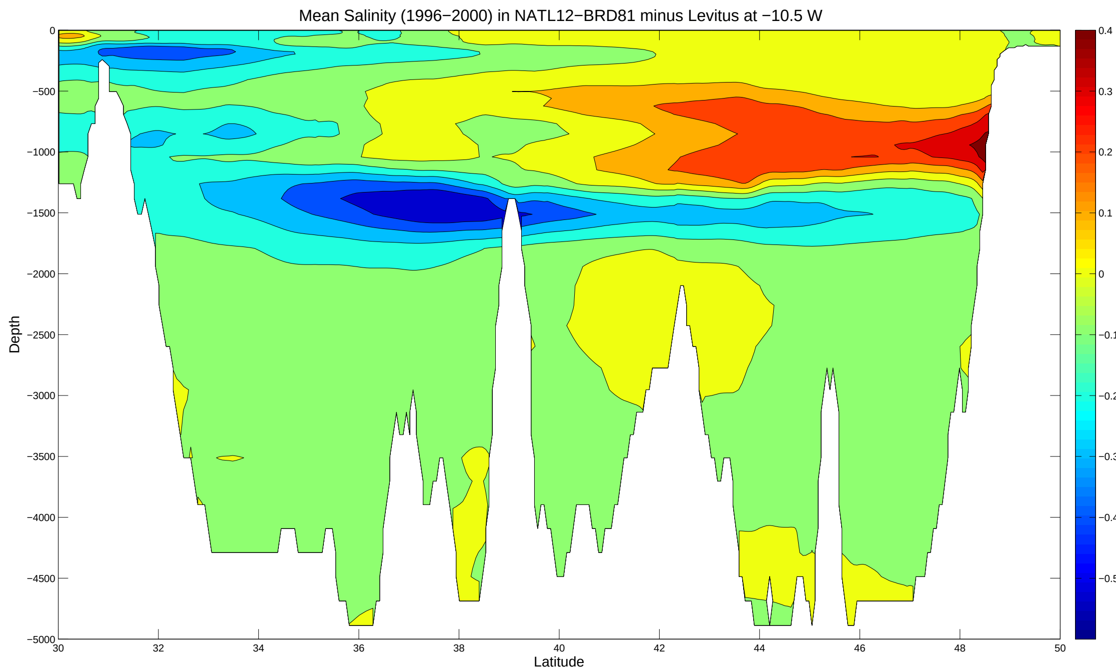

FIG. 24 – Mean salinity (years 1996 to 2000) minus Levitus climatology at 10.5°W .

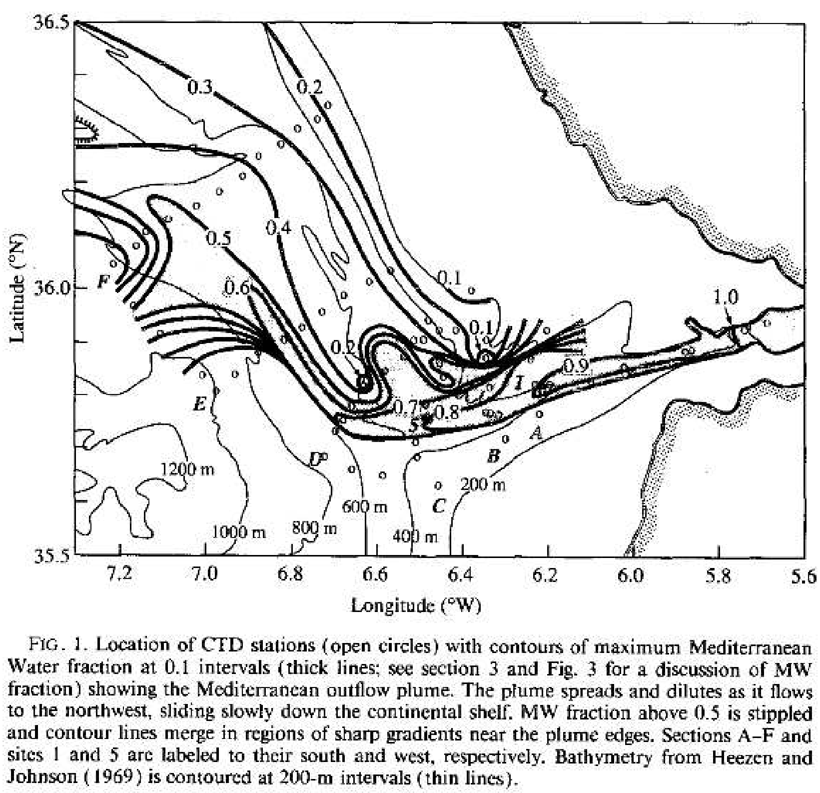

FIG. 25 – Figure from johnson et al. JPO 1994

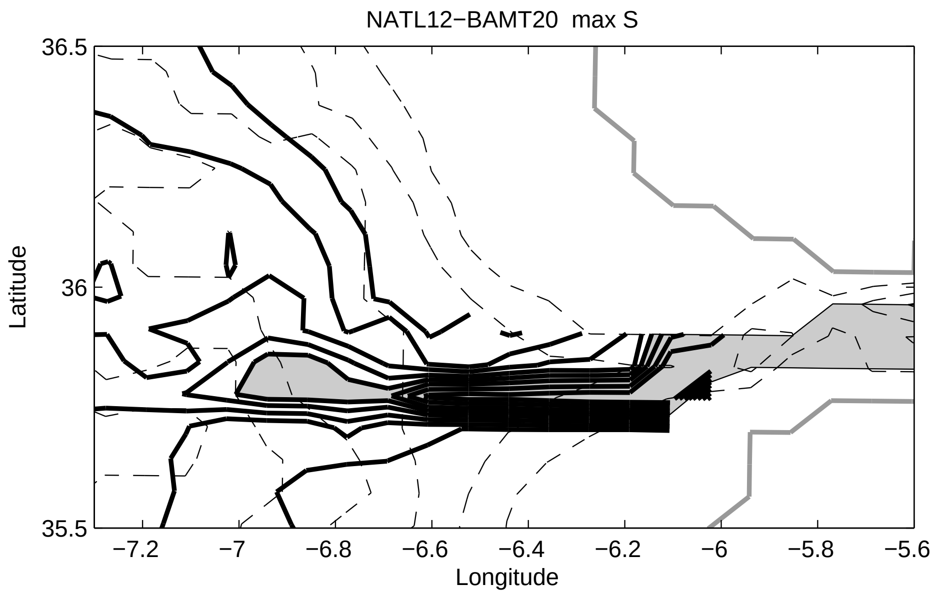

Fig. 26 – Maximum salinity in NATL12-BAMT20 in 1999

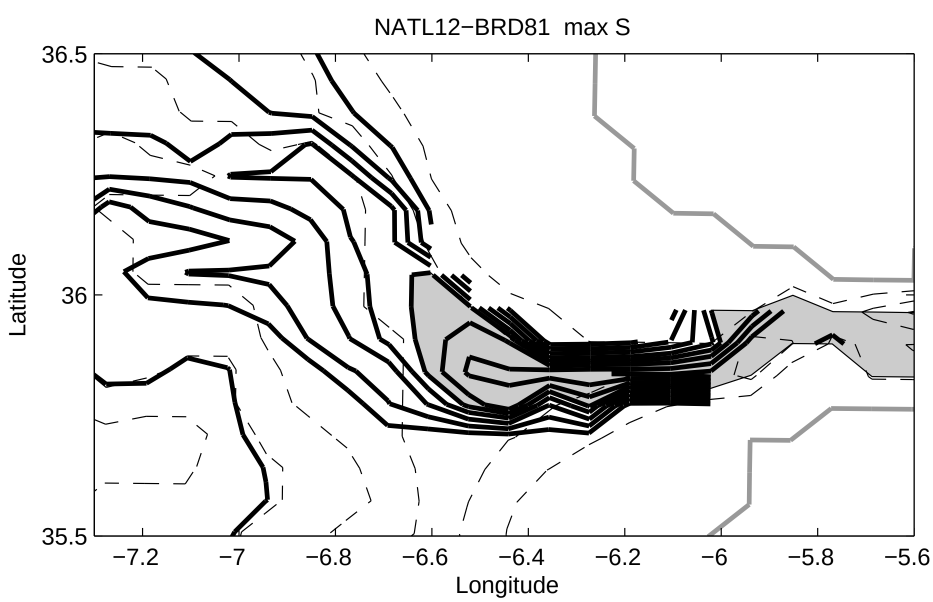

Fig. 27 – Maximum salinity in NATL12-BRD81 in 1999

3.2 Comparison with SEMANE data

In figure 28, we compare salinity sections at 8°W in various experiments with observations of the SEMANE 2002 cruise [Carton et al.(2002)]. In NATL12-BAMT20, the salinity between 1000 and 1500 meters has very strong values due to the excessive transport at Gibraltar strait. The decrease of this transport in NATL12-BRD81 leads to a better agreement between the salinity section in the model and the observations. In ATL12-T46, which has a similar transport at the strait that BRD81 (mean of 0.59 Sv computed over the 1995-2007 period), the salinity is much weaker than in the observations and the core of Med Waters along the shelf is too high.

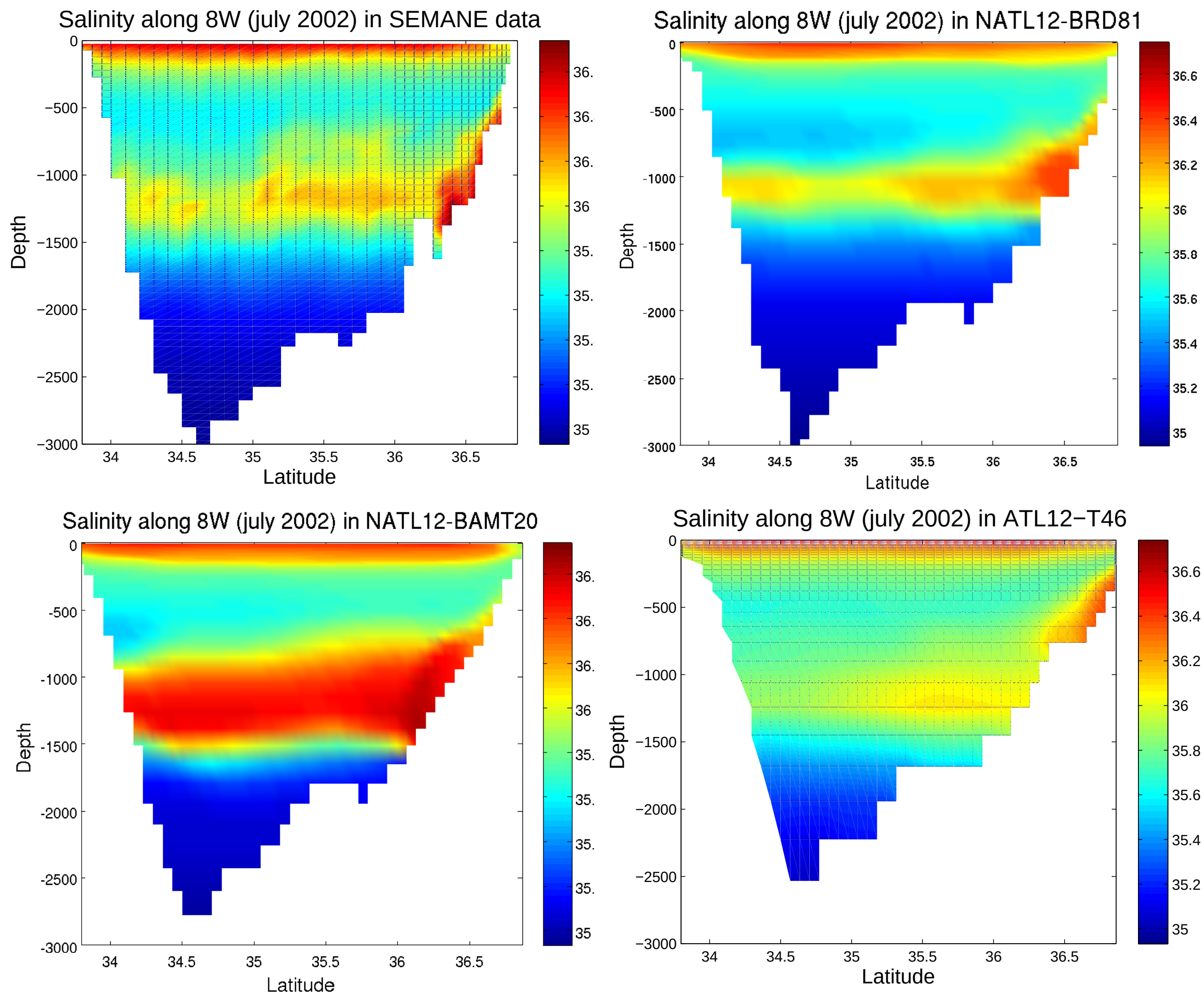

FIG. 28 – Comparison of salinity section at 8°W in july 2002 between SEMANE data, NATL12-BRD81, NATL12-BAMT20 and ATL12-T46

3.3 Impact on Eddy Kinetic Energy

A striking feature of removing the restoring in the gulf of Cadiz is the enhancement of Eddy Kinetic Energy at cape St Vincent and Tejo Plato. While Drakkar runs with restoring have very low EKE at 750 meters deep (less than 20 $cm^2.s^{-2}$ in AMEN-BVT18), NATL12 simulations have much stronger values at cape St Vincent (100 $cm^2.s^{-2}$ in BAMT20) or Tejo Plato (50 $cm^2.s^{-2}$ in BRD81). Sensivity experiment showed that the lack of EKE at cape St Vincent in BRD81 was due to the enhancement of bottom friction. Hence reducing the area where we apply this stronger friction allows the EKE to grow up to $25 - 30$ $cm^2.s^{-2}$ after two years of run. In ATL12-T46, which has a different restoring, the EKE is in good agreement while observed values of 100 $cm^2.s^{-2}$ at cape St Vincent and 50 $cm^2.s^{-2}$ at Tejo Plato given in [Bower et al.(2002)Bower, Serra, and Ambar].

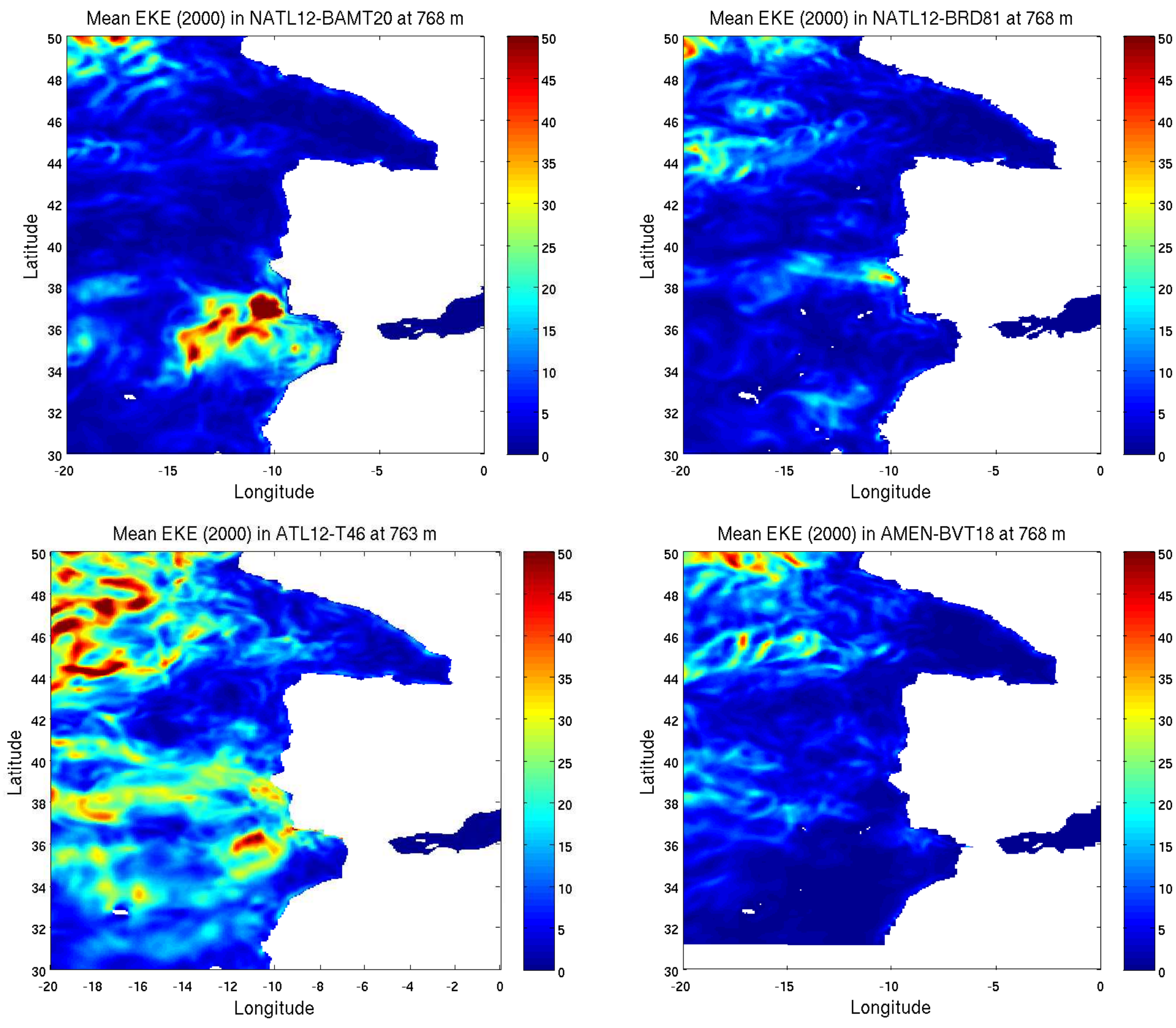

Fig. 29 – Mean EKE in 2000 in NATL12-BAMT20 (top left), NATL12-BRD81 (top right), ATL12-T46 (bottom left) and AMEN-BVT18 (bottom right)

In the NATL12 configuration, an enhanced bottom friction acts efficiently to reduce transport at Gibraltar strait. Comparison with observations shows that the properties of the outflow have been significantly improved. However, some care should be taken when choosing the area of stronger friction as it has consequences on the Eddy Kinetic Energy downstream of the strait. In Drakkar runs, the EKE is reduced when restoring is added, which is not the case in ATL12-T46.

4 Other issues

4.1 Meridionnal Overturning Circulation

In figures 30 and 31, we can see that

1. the maximum MOC in NATL12 runs is very strong compared to NATL025
2. the maximum MOC in BRD81 is slightly stronger than in BAMT20
3. the increase of MOC at 15°S and in the southern boundary is not found in NATL025

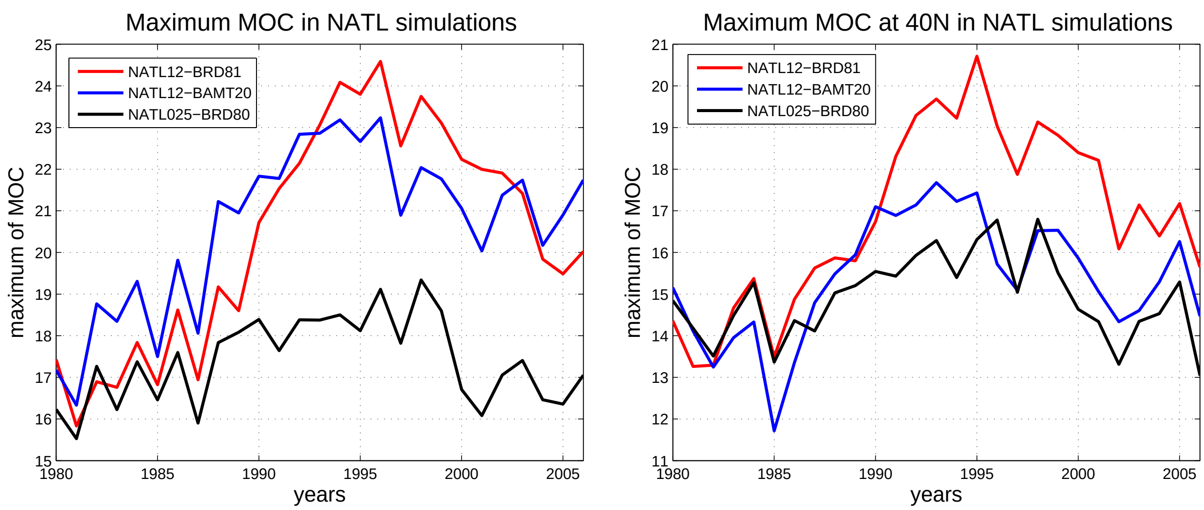

Fig. 30 – Maximum MOC (left) and Maximum MOC at 40°N (right) in NATL12-BRD81, NATL12-BAMT20 and NATL025-BRD80

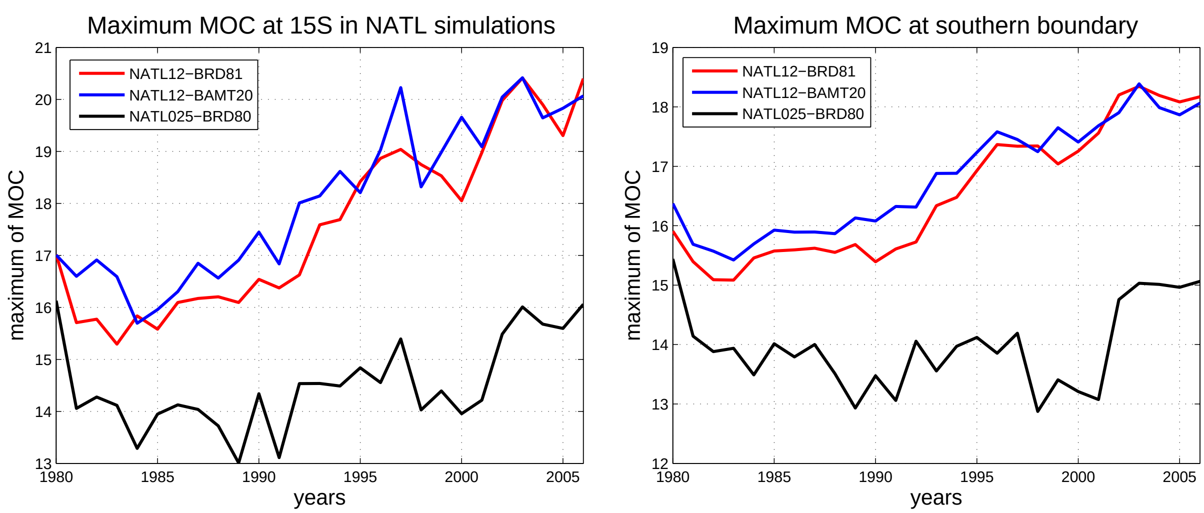

Fig. 31 – Maximum MOC at 15°S (left) and MOC at the southern boundary (right) in NATL12-BRD81, NATL12-BAMT20 and NATL025-BRD80

4.2 Nordic Seas Overflows

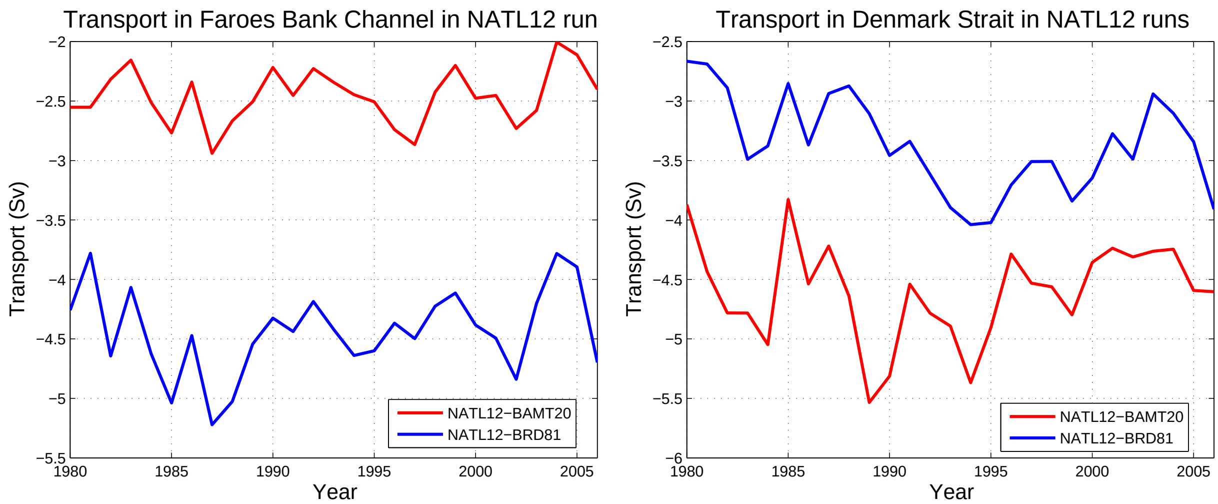

FIG. 32 – Integrated transport at Faroe Bank Channel and Denmark strait in NATL12 runs

Appendices

A Annex 1 : Details of the bathymetry at Gibraltar

A.1 Parameters used

```
!-----------------------------------------------------------------------
&nambfr        !   bottom friction
!-----------------------------------------------------------------------
nn_botfr  =    2  !  type of bottom friction :   = 0 : no   slip,  = 2 : nonlinear friction
                  !                              = 3 : free slip,  = 1 :    linear friction
rn_bfri1  =    4.e-4  !  bottom drag coefficient (linear case)
rn_bfri2  =    1.e-3  !  bottom drag coefficient (non linear case)
rn_bfeb2  =    2.5e-3 !  bottom turbulent kinetic energy background  (m^2/s^2)
! Drakkar enhancement
ln_bfr2d  = .true. !  horizontal variation of the bottom friction coef (read a 2D file )
rn_bfrien =  2. !  multiplying factor of bfr
```

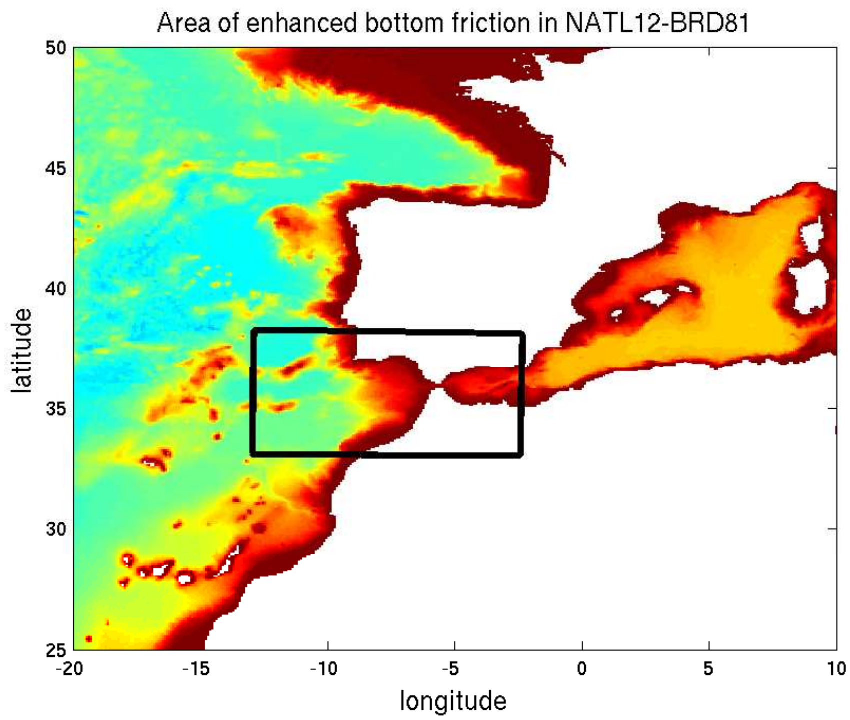

FIG. 33 – Location of enhanced bottom friction

A.2 Close-up view of the bathmetry

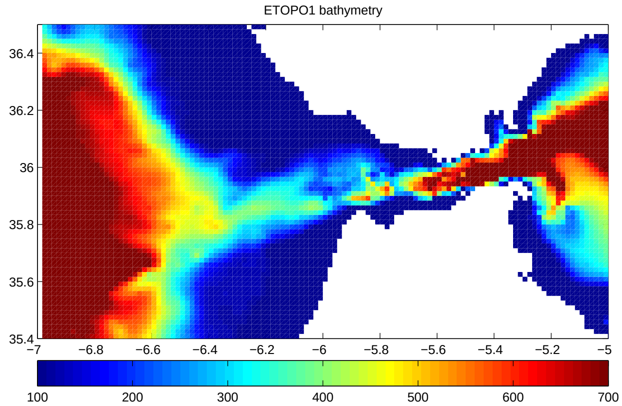

FIG. 34 – Bathymetry Etopo1

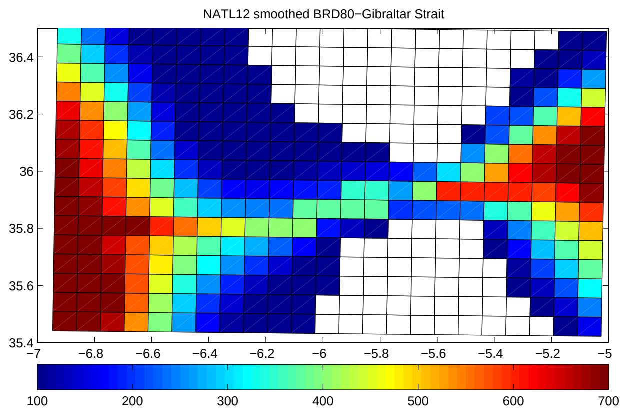

FIG. 35 – Bathymetry NATL12-BAMT20

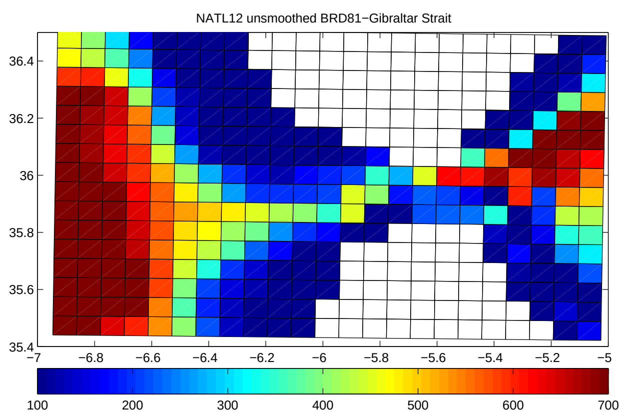

FIG. 36 – Bathymetry NATL12-BRD81

B Annex 2 : Details on NATL025-BRD80

B.1 Input files

- The Open Boundary Condition are taken from ORCA025-G70. We compute a monthly climatology from 1980 to 2004 in order to keep the seasonal cycle.
- Bathymetry is taken from ORCA025.L75-G85, which is (in october 2009) the latest global 1/4° DRAKKAR simulation. At the open boundaries, we took the bathymetry of ORCA025-G70, repeat it on 4 gridpoints for radiation and merge with the new bathymetry using a linear combination on 3 gridpoints.
- Runoff is alsotaken from ORCA025.L75-G85. This file comes from Romain Bourdalle-Badie of MERCATOR Ocean, who has corrected a bug in Rhone and Gironde location.
- The forcing set used is DFS4.3, weights for interpolation are done using nocs weights v1.0.
- We extracted ice damping files from the NATL025XL_ice_dmp_YYYY.nc that were used for NATL12 simply removing the extra 2 gridpoints all around the NATL025 domain. We also could have done an extraction from ORCA025-G70 icemod files.
- We use Levitus_p2.1_1m_S_correc_natl025.nc and Levitus_p2.1_1m_Tpot_natl025.nc files. sss_1m.nc and sst_data.nc are just the first vertical level of those files.

B.2 NEMO

The reference configuration is NATL025-GREF3.1. We explain here what are the customisations in the following routines :

```
brodie:/home/rech/cli/rcli600/CONFIG_NATL025/NATL025-BRD80/ ls
*.*0@       dommsk.F90@  dynspg_flt.F90@  iceini_2.F90@    LIM_SRC_2/  obcini.F90@   par_oce.F90@  trabbl.F90@
3.1       domwri.F90@  *.[Ffh]@     IOIPSL/      LIM_SRC_3/  obc_par.F90@  restart.F90@  tradmp.F90@
BB_make.ldef  domzgr.F90@  fldread.F90@     ldfdyn_c3d.h90@  makefile  obcvol.F90@   sbcblk_core.F90@  trazdf.F90@
C1D_SRC/      dynldf.F90@  ice_2.F90@     limdmp_2.F90@    NST_SRC/  OPA_SRC/      TOP_SRC/  WORK@
```

1. obc_par.F90 was copied from NATL12-BRD81 because reference has OBC indexes hardcoded. This is not useful anymore.
2. limdmp_2.F90 was copied from NATL12-BRD81 (USE dom_ice2 missing + fix on ice concentration)
3. ice_2.F90 OK
4. iceini_2.F90 OK
5. dommsk.F90 OK (NATL12 custom not useful)
6. domwri.F90 was copied from NATL12-BRD81 (writing of e3 as a 3D array)
7. domzgr.F90 was copied from NATL12-BRD81 (writing of e3 as a 3D array)
8. dynldf.F90 OK (NATL12 custom not useful)
9. dynspg_flt.F90 OK
10. fldread.F90 was copied from NATL12-BRD81 (correct bug IOF)
11. ldfdyn_c3d.h90 OK (NATL12 custom not useful)
12. obcini.F90 OK
13. obcvol.F90 OK
14. restart.F90 OK
15. sbcblk_core.F90 was copied from NATL12-BRD81 (correct bug IOF)
16. trabbl.F90 was copied from NATL12-BRD81 (correction on bbl)
17. tradmp.F90 has a problem when defining the restoring in the gulf of Cadiz. Indexes are hardcoded for NATL4. We change as :

```
!             DO jj = mj0(ij0) , mj1(ij1)
!               DO ji= mi0(ii0), mi1(ii1)
             DO jj = mj0(1) , mj1(jpj) !RD
               DO ji= mi0(1), mi1(jpi)
```

After the run we found out that this was wrong and the correct way to do it is :

```
             DO jj = 1 , jpj
               DO ji= 1, jpi
```

18. trazdf.F90 was copied from NATL12-BRD81 (JMM ugly fix on salinity)
19. par_oce.F90 modified to run on 8 processors on brodie

B.3 namelist

1. ln_shlat2d was removed (not coded in NATL025)
2. nn_fsbc = 6
3. deds = -56.67
4. ln_kriteria = .false.

B.4 CPP keys

```
P_P = key_natl025 \
      key_dynspg_flt \
      key_dtasal \
      key_dtatem \
      key_tradmp \
      key_zdftke \
      key_traldf_c2d \
      key_dynldf_c3d \
      key_trabbl \
      key_trabbl_adv \
      key_ldfslp \
      key_dimgout \
      key_mpp_mpi \
      key_bfr_nocs \
      key_obc \
      key_lim2 \
      key_vectopt_loop \
      key_vectopt_memory
```

C bugs in NATL12-BRD81

C.1 Runoffs

In this simulation, we have used **runoff_coast1pt_ant3pt_obtaz_12m_NATL12.nc** provided by Mercator Ocean. In the previous simulation (NATL12-BAMT20) we have used **runoff_mercator_ATL12_oct2006_corrAMZ_shift_1m_NATL12_amt.nc**

The problem lies in a shift of one gridcell in the first file. When NATL12 was extracted from Mercator's ATL12, there was a forgotten -F option in the ncks command (C or Fortran indexing of arrays) so that both bathymetry and runoffs have to be shift of one gridcell northward and eastward. This has not be done with the runoffs file and thus leads to a deficit in the freshwater flux.

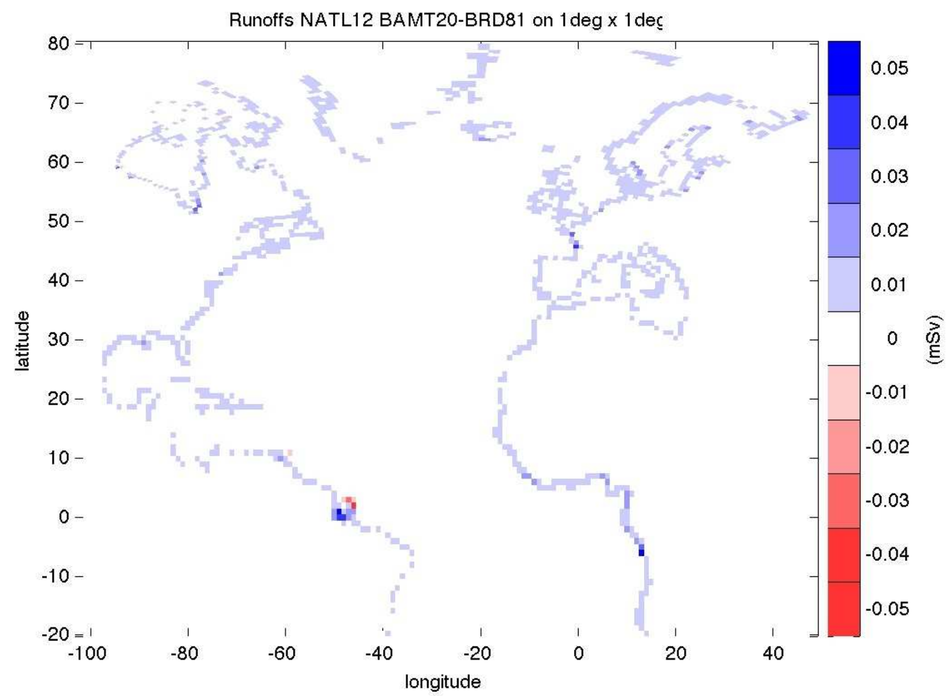

FIG. 37 – Map of difference of mean runoffs averaged on a (1 deg × 1 deg) grid between BAMT20 and BRD81 : we can see that the freshwater flux is greater in BAMT20

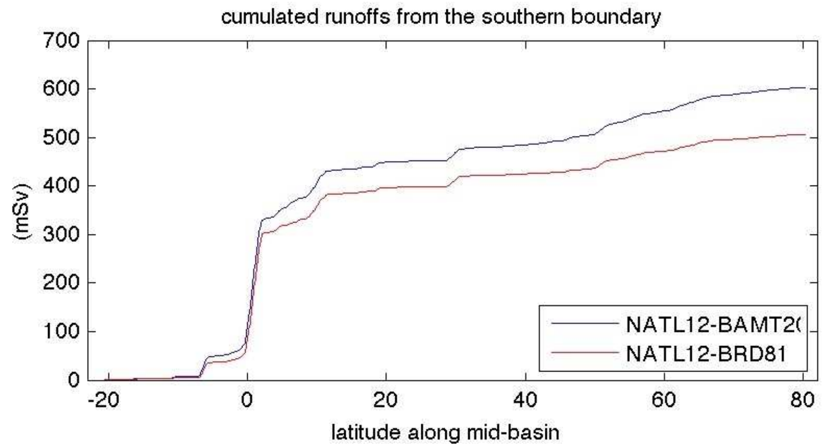

FIG. 38 – Cumulated runoffs from the southern boundary

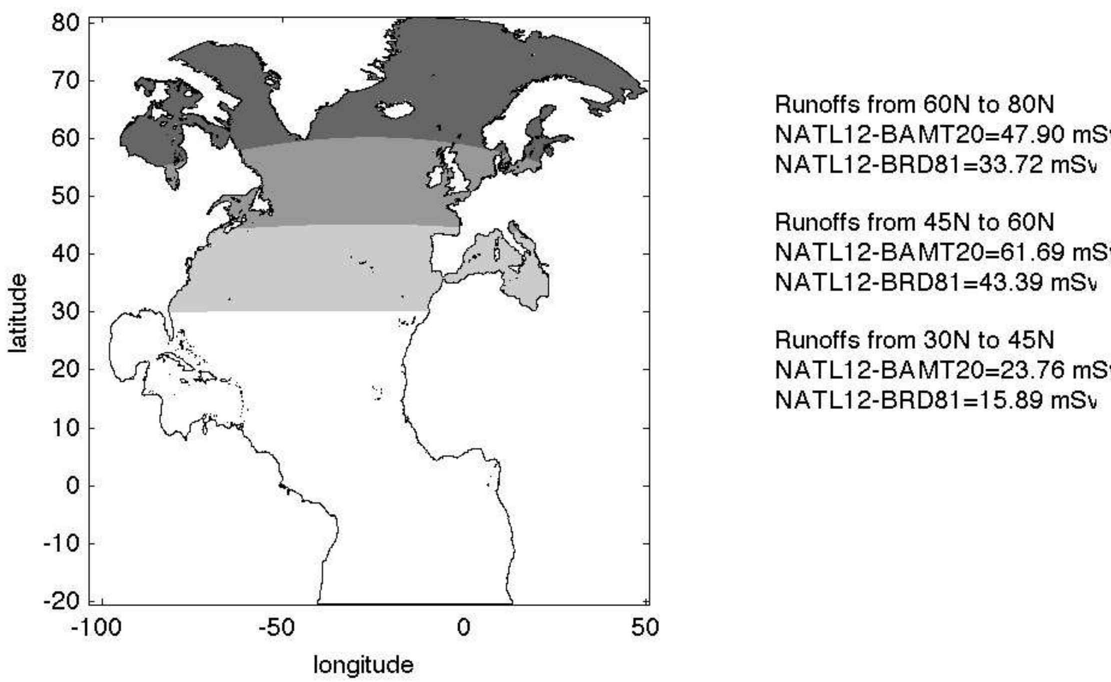

FIG. 39 – Integrated runoffs on latitude stripes

C.2 Ice damping

The ice damping files in NATL12-BAMT20 were interpolated online (in NEMO 2.3) from a grid called NATL025XL (NATL025 grid with 2 extra gridpoints on each side). In NATL12-BRD81 (NEMO 3.1) we had to interpolate them offline on the 1/12 ° grid. To do it, I've build a script (Ice_Dmp_IOF) using the SCRIP interpolation package. Computations were made on Idris' ulam (pre/post treatment machine) in three jobs (1980-1988,1989-2000, 2001-2006). Jobs 1 and 3 worked out fine but in the second job, files were corrupted with ice thickness being zero everywhere. The error was produced during the transfert from ulam to gaya (storage machine). Thus the ice damping did not work for the period 1989-2000 and this caused a huge salinisation of the East Greenland Current. In addition, Ice Damping files from 2007 to 2009 are climatology from 1980-2004 files and thus have also wrong values.

C.3 Bathmetry

For NATL12 in july 2007, Sebastien Theetten prepared a new bathymetry using a bathymetry field provided by MERCATOR (O. Le Galloudec ?), extracted from the ORCA12 domain. The ORCA12 bathy had been recalculated with an updated version of ETOPO2 to eliminate a bug found in Hudson Bay in the old version of ETOPO2. This file, ATL12_ok_theeten.nc, has no "netcdf history". Its grid point (1,1) has longitude -98.167 and latitude -20.467, one grid point to the east and north of NATL12 (-98.25 and -20.545) : the extraction has not been done properly using the "-F" option of netcdf.

This bathymetry has been processed by S. Theetten using IDL to correct the mask (fill the Pacific, fill some ponds near the northern boundary). The information of nav_lon and nav_lat present in the initial bathymetry is lost in the process, and replaced by nav_lon and nav_lat taken from the NATL12 coordinate file. Thus in the file bathy_NATL12_270707.nc used in 2007, the bathymetry is shifted and does not correspond to the coordinates.

All hand corrections made in 2008 by A.M. Treguier have been done using this shifted bathymetry. The problem has been discovered in july 2008 when the model started to run, and because there was no time to recalculate the bathymetry properly the runoff file has been shifted one grid point too, in order to fit the bathymetry (hence the "shift" in the name 'runoff_mercator_ATL12_oct2006_corrAMZ_shift_1m_NATL12_amt.nc').

in 2009, for experiment BRD81 a new bathymetry has been prepared :

bathy_natl12_unsmooth_corrected_obc_mask_aug2009.nc

The basis is MERCATOR ORCA12 unsmoothed bathymetry and this time the NATL12 domain has been extracted properly. However (forgetting about the bug in the 2008 bathymetry) the mask of the 2008 bathymetry has been applied in order to fill the Pacific ocean, and thus the bathy is slightly wrong (the bathy and the mask don't fit, they are one grid point off).

In 2009, a new runoff file has been used, and again because we had forgotten about the 2008 bug, the runoff file was not shifted to fit the mask.

Références

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[Brodeau et al.(2010)] Brodeau, B., L.and Barnier, et al., 2010 : An ERA40-based atmospheric forcing for global ocean circulation models. *Ocean Modelling*, **31**(3-4), 88–104.

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[Dussin and Treguier(2008)] Dussin, R. and A. Treguier, 2008 : Evaluation of a North Atlantic 1/12 model simulation. Tech. Rep. LPO-2008-07, LPO.

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[Treguier(2008)] Treguier, A., 2008 : Experiments with the DRAKKAR NATL12 configuration in 2008. Tech. rep., LPO.