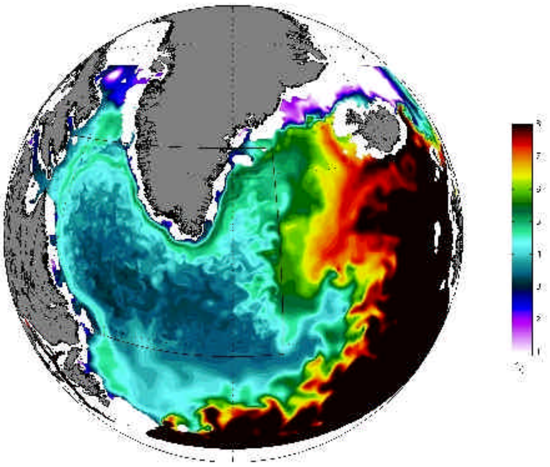
DRAKKAR Project

The ocean circulation in the North Atlantic and the Nordic seas: Variability, processes and interactions with the global ocean.



Report of Activity For Year 2004
Contribution of LEGI, LPO, LODyC, IFM-Geomar, UoF , SIORAS
No DRA-R1-2004

January 2005

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1. Reminder of Drakkar's 2004 science program

The present activity report concerns the tasks of *Phase I* of the Drakkar project which were carried out at LEGI, LPO and LODyC. This phase is dedicated in 2004 to the development and validation of new global and north Atlantic configurations at eddy permitting resolutions, and to sensitivity experiments to new numerical schemes, new parameterizations and forcing fields with various model configurations. Results from these experiments will be used by the Drakkar group in 2005 to *(i)* carry out 50 year-long experiments driven with atmospheric forcing fields representative of the atmospheric variability for the period 1950 to present, and *(ii)* to define the high resolution model on the North Atlantic and the Nordic Seas (NATL12/20), with a resolution to be decided from 1/12° to 1/20°.

The major tasks planned in 2004 were:

- To finish the development and carry out the validation of the global ocean 1/4° model configuration with sea ice ORCA025-LIM at LEGI.
- To validate the regional 1/4° North Atlantic configuration NATL4 at LPO.
- To carry-out the 1/2° global ocean/sea-ice model ORCA05-LIM at IFM, with a series of long term experiments (several decades).
- To continue studies on the forcing parameterization and forcing fields at SIO and LEGI.
- To run sensitivity experiments to various parameterizations and grid resolution (full steps, partial steps, vorticity scheme, BBL, GM90, slip and no-slip boundary conditions) at LEGI.
- To implement the 1/2° global ocean/sea-ice model ORCA05-LIM at University of Helsinki to evaluate the sigma coordinate.
- To carry out a joint analysis of all model results in order to
- To implement the coupling between the Drakkar ½° global configuration ORCA-R05 with the atmospheric model ECHAM5 in Kiel.
- To carry out CFC experiments with ORCA-R05 in an Off-line mode at LSCE.

2. Summary of Activities at LEGI-LPO-LODYC

2.1. Development of NEMO

NEMO (Nucleus for European Models of the Ocean) is an *ocean modelling framework* which is composed of ‘engines’ nested in an ‘environment’. The ‘engines’ provide numerical solutions of ocean, sea-ice, tracers and biochemistry equations and their related physics. The ‘environment’ consists of the pre- and post-processing tools, the interface to the other components of the Earth System, the user interface, the computer dependent functions and the documentation of the system.

The initial version of NEMO is based on version 9.0 of OPA and consists of:

- source codes: an ocean general circulation model (OCE_SRC), its tangent linear and adjoint model (TAM_SRC), on/off-line ocean tracer and biochemistry models (TRC_SRC, TRC_OFF_SRC) and a sea-ice model (ICE_SRC).
- a built-in interface to the PRISM couplers and IOIPSL library
- scripts to compile, create executables and run the experiment on target platforms.
- pre- and post-processing tools built on IDL (INTERP, REVTERP, SAXO) to configure input file and analyse output files.
- standard configurations, including a 3 polar global ocean (ORCA2). They are provided for illustrative purposes enabling one to verify that the code flow is correct.
- a configuration control system based on CVS
- on-line and off-line documentation of the model formulation and codes

In coordination with the ESOPA team in LODYC, the implementation and validation of the various Drakkar configurations by the Drakkar scientists contributed to identify bugs, to improve of the vorticity scheme (motivated by the use of partial step topography), to finalize the new outputs in *dimg* format for massively parallel configurations, and develop tools to convert those outputs into standard netcdf files, to optimize the Drakkar configuration manager, to rewrite the input routines for open boundaries to handle netcdf format input, ...

2.2. Global configuration ORCA-R025

2.2.1. Implementation on the IDRIS MPP Computer

Our objective of this year was to develop the ¼ ° global configuration ORCA-R025 and to carry out sensitivity experiments to confirm the choices made about parameterizations and numerical schemes. This large configuration counts 1442x1021x46 grid points on an ORCA-type 3 polar grid (Fig. 1). Grid, topography, masking and initial conditions are inherited from the POG global configuration of Mercator-Ocean. We chose a strategy of calculation on massively parallel machines (MPP), and the targeted machine is the 194 proc. IBM at the IDRIS computer Center. Taking into account the scientific constraints of the project (in particular the use "partial steps"), and of the technical constraints (computing time), it was essential to work with the new version of the code NEMO (i.e. its ocean component OPA 9.0 and its sea-ice component LIM2). The efforts related to the numerical model in 2004, mainly carried out by Jean Marc Molines, are summarized afterwards, and can be found in a note (Molines et al., 2004).

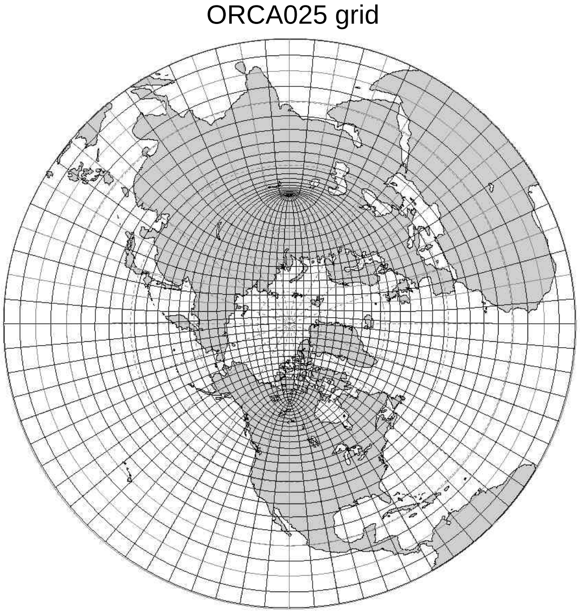

Fig. 1: Polar sight of the northern hemisphere of the computational grid of ORCA-R025 (resolution 1/4°, 1 point out of 20 is represented). The parallelization of the code implies specific procedures of exchange between the processors located in the folding zone of imposed by the two geometrical poles of the grid.

January - June 2004: Parallelization of the sea-ice model in a *jpni*×*jpnj* cutting (Gurvan Madec). The parallelization was available before only for a cutting along latitude bands). Intensive testing of the MPP version of the code, with the partials steps and sea-ice produced exactly reproducible experiments, independently of the way the cutting onto processors is done. These tests required the development of a 'red-black' solver for the free surface.

July 2004: Test of the ORCA-R025 configuration on 186 processors (Fig.2). These tests contributed to the identification of hardware problems on the IBM machine which were solved in August 2004.

September - December 2004: Seven sensitivity experiments, each 10 year long, have been carried out with ORCA-R025, stating from rest, with climatic CLIO forcing. These experiments are being analyzed to determine the adjustments of parameterizations and the setting of the experiments planned with the interannual forcing.

Performance: Improvements in communications (lib_mpp) between processors, provided by the Mercator group, improved the efficiency of the model on the IBM by 30%. The time step is 1440 s (60 time steps per day).One year of model simulation requires 2200h CPU on 186 processors, and take about 12 h of elapsed time).

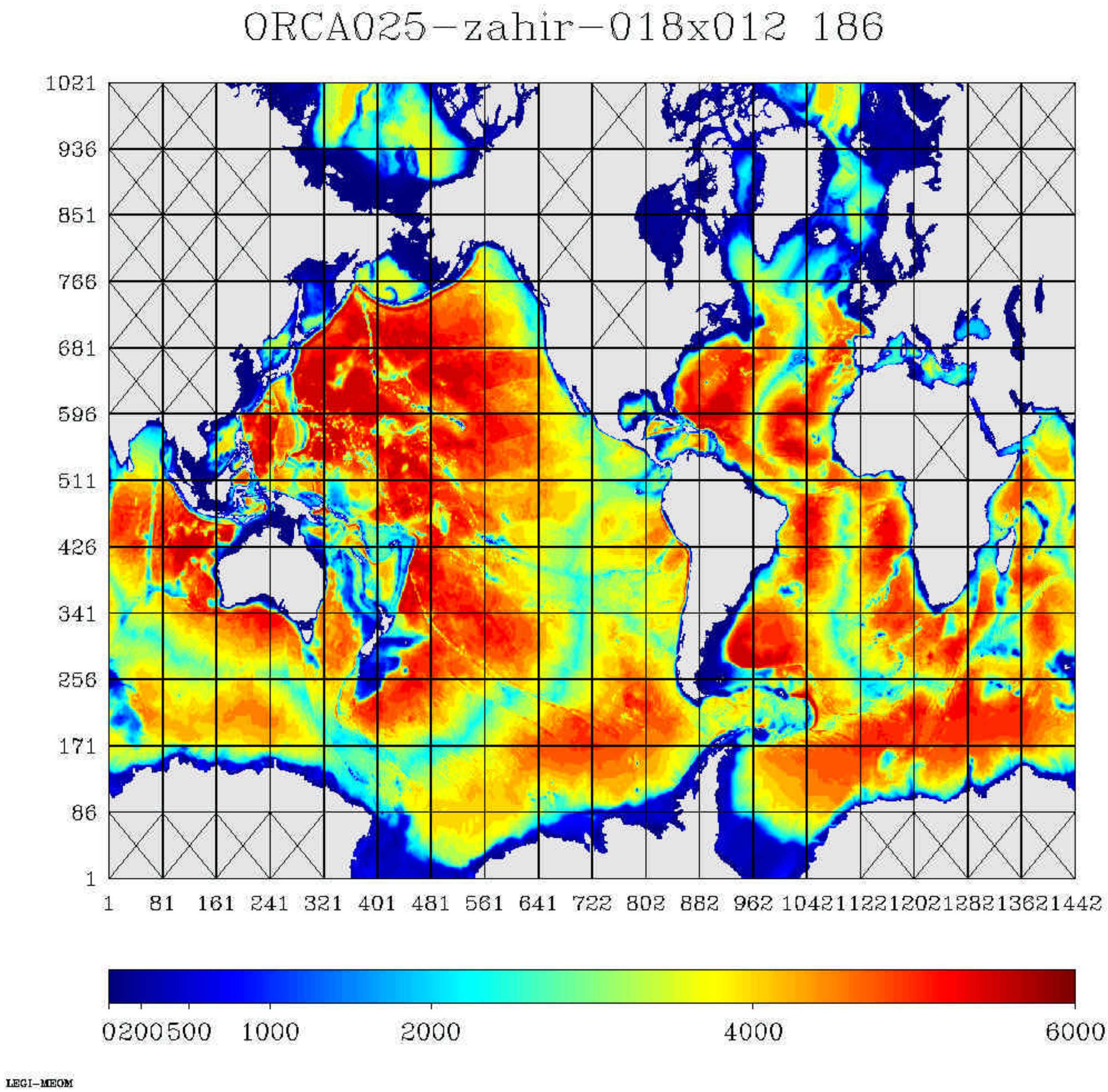

Figure 2. Decomposition on 186 IBM processors of the DRAKKAR global ¼° ocean circulation model. Colours indicate the ocean depth. Boxes represent the domain account for by a processors. Crossed boxes are 'land processors' not retained in the calculation. Numbers in abcissa and ordinate indicate model grid points.

2.2.2. Test experiments

A series of seven 10-years experiments have been run by Jean Marc Moline. All experiments use the same climatological forcing (the Drakkar forcing set 1, Talandier et al., 2003), with no relaxation to salinity in the freshwater forcing. Common features and specific details of the configurations listed in Table 1 are described in detail in a note by Molines et al. (2004).

Table 1: List of the 10 year long sensitivity experiments carried out with ORCA-R025

Run	Scheme UÑU	T,S Advection	Side-Wall Boundary Condition	Bottom Topography*	Maximum depth**	Relaxation to SSS	Fresh water budget correction***
G03	New	TVD	Free-slip	Full Step	5750 m	no	Yes
G04	Old	TVD	Free-slip	Full Step	5750 m	no	Yes
G22	New	TVD	Free-slip	Partial Step	5720 m	no	Yes
G23	New	MUSCL1	Free-slip	Partial Step	5720 m	no	Yes
G24	New	TVD	No-slip	Partial Step	5720 m	no	Yes
G30	New	TVD	Free-slip	Partial Step	5750 m	no	No
G31	New	TVD	Free-slip	Partial Step	5750 m	yes	No

*partial steps. This option is used with criterion that the thickness of the bottom level is the minimum between 25 m or 20% of the level above)

**Maximum depth. The vertical grid has been defined with maximum depth of 5720m instead of 5750m as required. The difference between the level depths of the two grids is 5m at 1000m, 10m at 2000m and 30m at the bottom. As a result, the model grid (5720m) is not exactly the one that has been used to generate the initial conditions (5750m), but this is not a problem since the Levitus dataset has a resolution of 500m below 2000m. The full step bathymetry for run ORCA025-G03 has also been calculated assuming a maximum depth of 5750m. This causes a small horizontal shift of the places where the bottom depth jump from one vertical layer to the next, noticeable in the deep basins but not on the continental slopes where the topography varies rapidly. The differences between the various sensitivity experiments, including the full-step and partial-step experiments should not be influenced much by this small inconsistency. This has been corrected for run G30 and beyond.

***Fresh water budget (*fwb*) correction. The fwb correction has been wrongly operating for the series G0x and G2x. The main effect is to introduce shifts linked to the model restarts (i.e. at the scale of 256 days) in the freshwater budget, noticeable on the annual mean of the zonally averaged sea surface salinity. It however likely limited the drift of the surface elevation. This should not have an impact when comparing experiments from the series G0x and G2x. However, it introduces a significant year to year variability in the freshwater transport as derived from the surface freshwater budget. This series of run experiments are thus not appropriate to study the freshwater forcing of the model. For this reason, the new series of experiments G3x has been started, after a proper application of the *maximum depth offset* and the *fwb correction* totally removed. This way to apply this *fwb correction* needs to be discussed at the January 2005 meeting, and will require more testing.

All experiments have in common a laplacian lateral isopycnal diffusion on tracers (300 m^2s^{-1}), an horizontal biharmonic viscosity for momentum (-1.5×10^{11} m^4s^{-1}). In the equatorial wave guide, an extra laplacian viscosity (500 m^2s^{-1}) is applied on the first three levels.

2.2.3. Early results:

The analysis of the G0x and G2X series experiments is going on, whereas the G3X series is still runing and is expected to finish in late 2004 before new year. Results will be presented and discussed by the whole group at the next Drakkar meeting in January 2005. Very early conclusions are listed below.

- The new *vorticity scheme* in momentum equation represent the most drastic improvement compared to the CLIPPER era, in particular on the western boudary current systems (comparison G03 and G04, see Fig. 3).

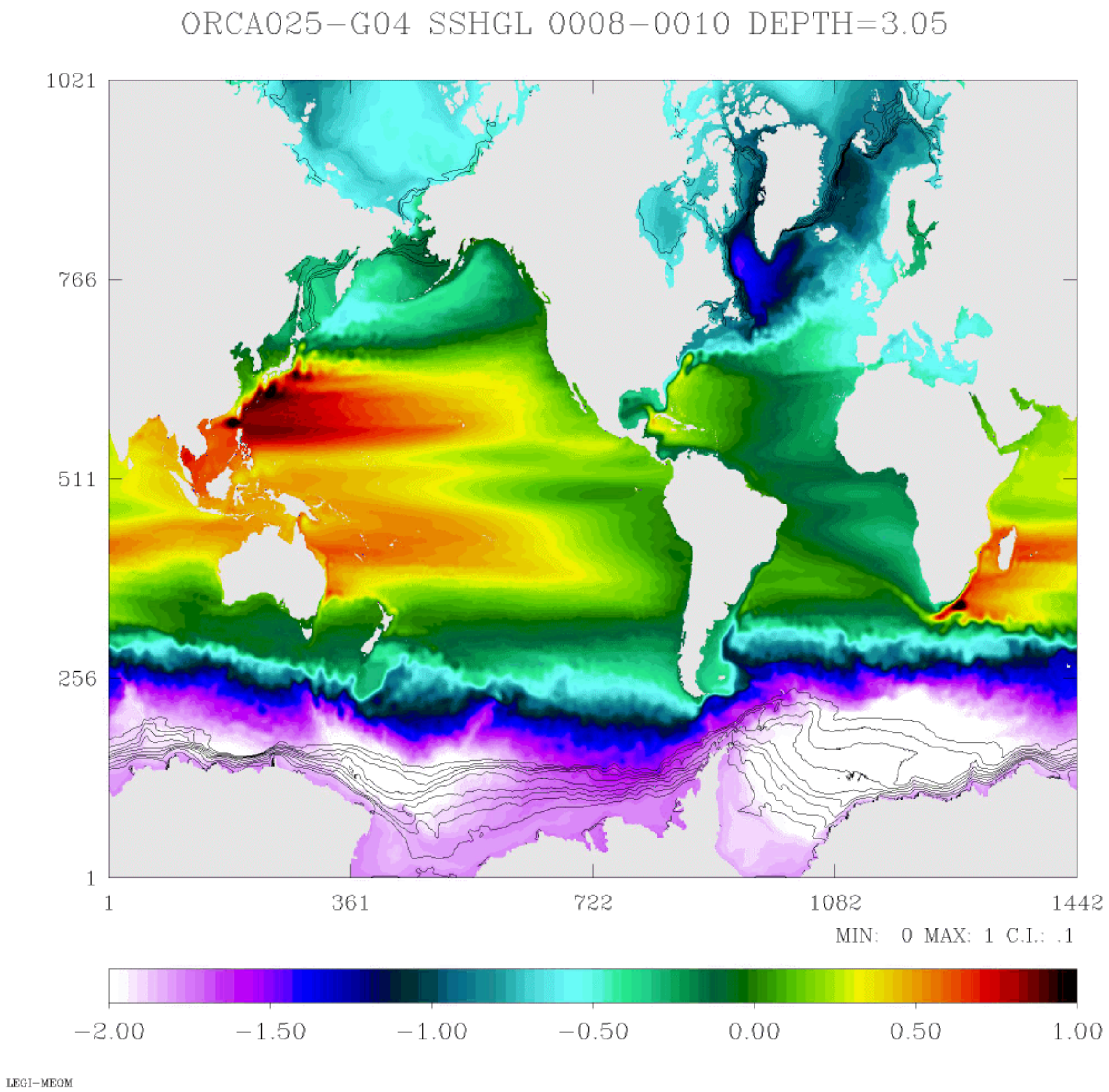

Fig. 3a. Simulation G04 (full step, old vorticity scheme): Time mean (year 8 to 10) of the sea surface height (ssh, in meters). This solution presents the usual biases noticed at ¼° resolution. In the Atlantic, the most noticeable biased features are the strong inertial standing eddy of Gulf Stream overshoot off Cape Haterras, the position too poleward of the confluence of the Brazil and the Malvinas Currents, and a single path of the Agulhas Rings.

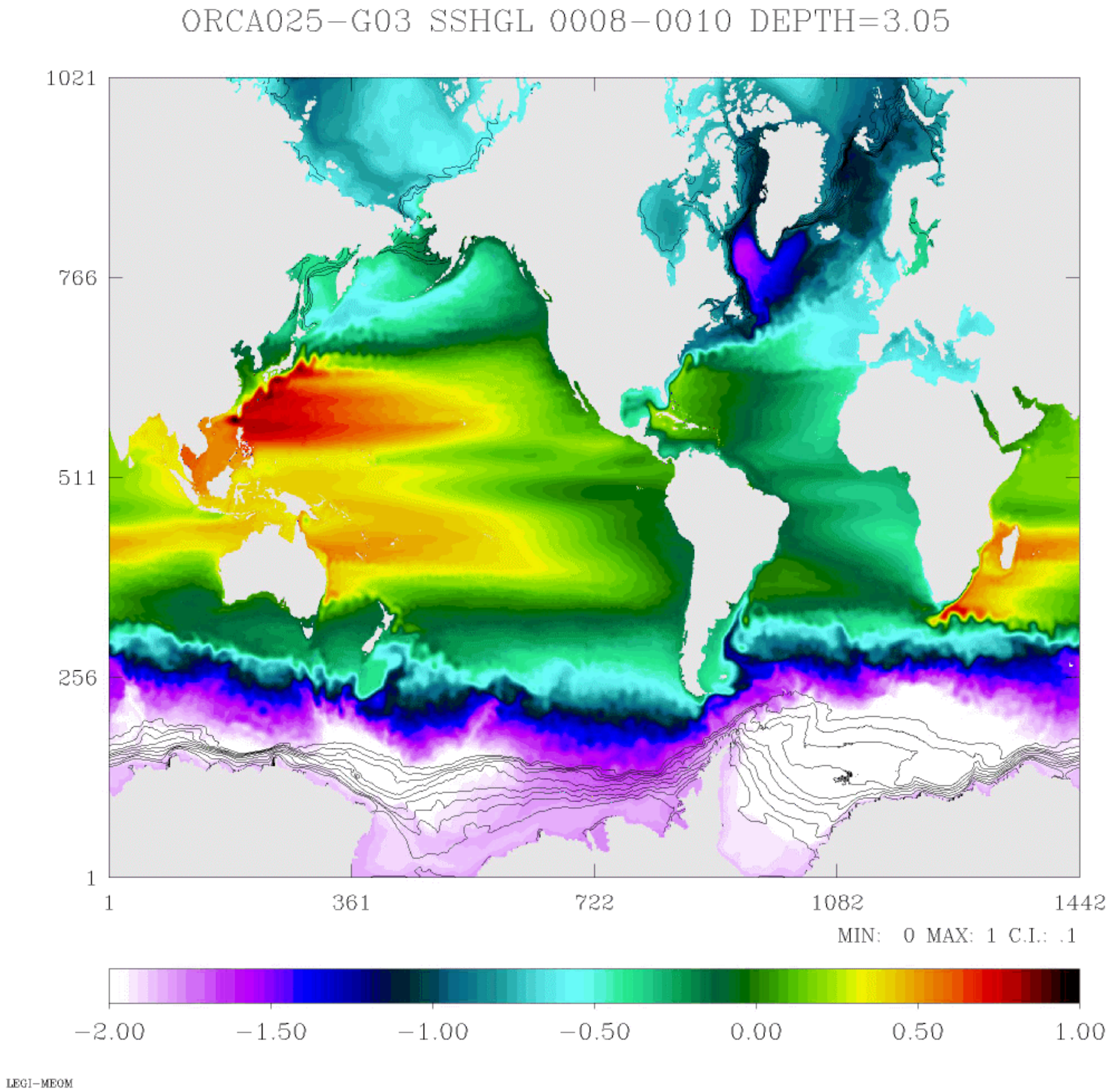

Fig. 3b. Simulation G03 (full step, new vorticity scheme): Time mean (year 8 to 10) of the sea surface height (ssh, in meters). Compared to the G04 solution, this solution represents a remarkable improvement of the major dynamical biases, such as the Gulf Stream inertial recirculation, the location and pattern of the Confluence region, and of the path of the Agulhas Rings.

- The use of *partial steps* represents another undeniable improvement with regards to full steps representation of the bottom topography. In the Atlantic, this is particularly clear in the Argentine basin and the representation of the permanent Zapiola eddy, and in the "North West Corner" off Flemish Cap (comparison G03 and G22, see fig 3).

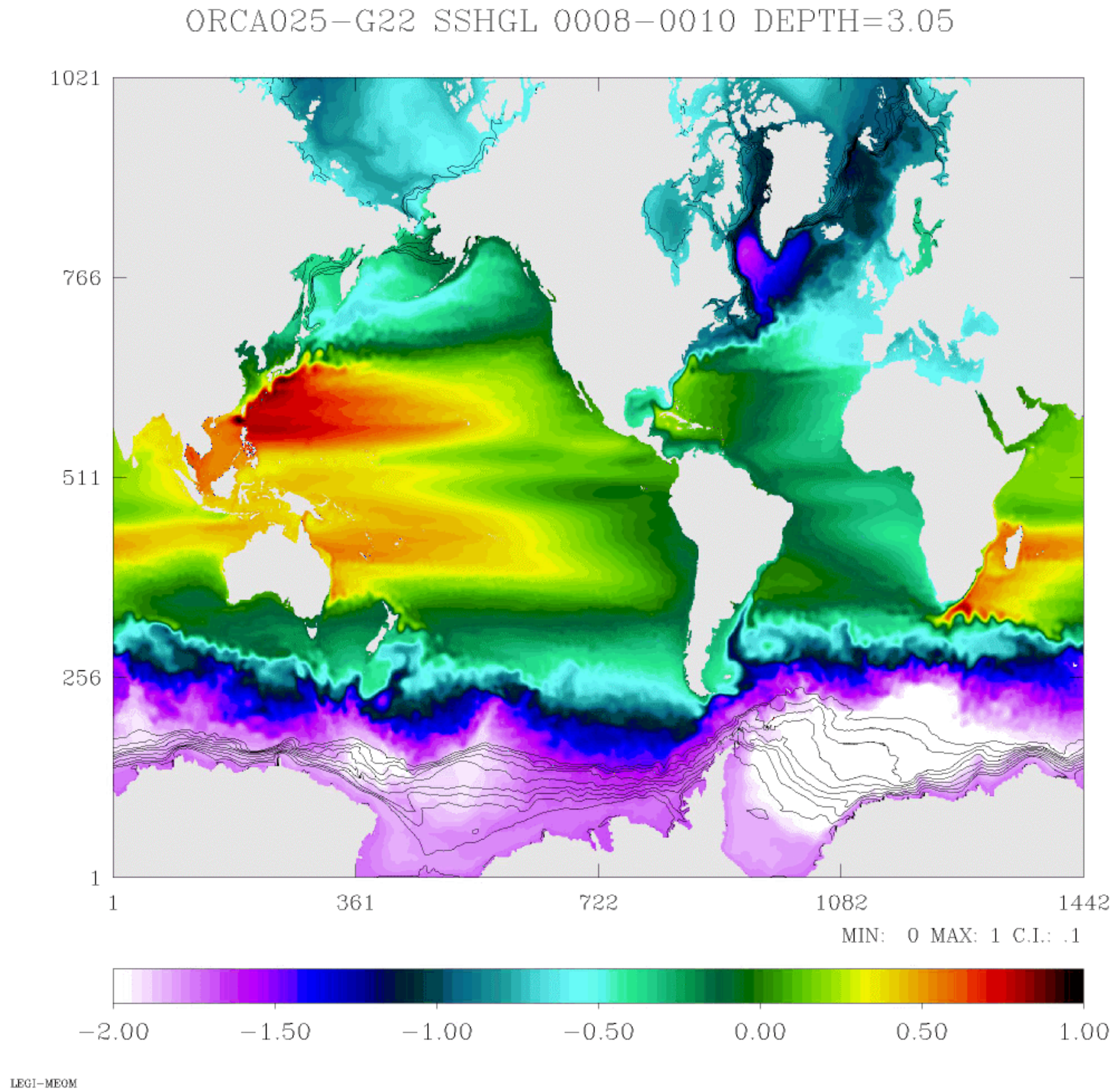

Fig. 3c. Simulation G22 (partial step, new vorticity scheme): Time mean (year 8 to 10) of the sea surface height (ssh, in meters). With regards to full steps representation of the bottom topography (G03 and G04), this solution represents a remarkable improvement of the dynamical circulation features. In the Atlantic, this is particularly clear in the Argentine basin and in the "North West Corner".

- The *TVD sche*me for tracers is far less diffusive than the *MUSCL sche*me which is clearly not recommended at the present resolution (Comparison G22 and G23).

- The *free-slip boundary condition* yields most consistent flow through most of the straits, like at Drake Passage and the Florida Strait, when compared to the *no-slip* boundary condition, and appears as the default choice until a more realisitc lateral boundary layer parameterisation is developped (comparison G22 and G24).

- The impact of the relaxation to sea surface salinity will be investigated later from the comparison of G30 and G31 when the runs will be finished.

2.3. Development of the 1/4° North Atlantic - Nordic Seas configuration NATL4

The main part of the scientific objectives of the DRAKKAR project relate to the North Atlantic and the Nordic Seas. It is thus necessary to lay out a coupled ocean-ice regional configuration for these areas, which is not too expensive, in order to carry out experiments on interannual variability and also to prepare the future DRAKKAR configuration with very high resolution. We developed to this end the NATL4 configuration, which comprises the North Atlantic and the Nordic Seas with a 1/4° resolution. It is in fact a sub-domain of the global configuration ORCA -R025 (Fig. 4), using the same grid, bathymetry and forcing. The code used is OPA9, coupled with the LIM sea-ice model. The development required a great number of tests. We attempted to improve the representation of topography by using the "partial steps" (a representation more precise than the usual "full steps"). The first experiment was run in 2003 and confirmed the incompatibility between the vorticity advection scheme and the partial steps topography, with the development of spurious barotropic circulation cells. A new experiment has been performed in may 2004 and analyzed in a report (Theetten et al, 2004). Vorticity diagnostics have been implemented (L. Brunier, 2004) that will help understand the effect of the partial step topography and new vorticity advection scheme.

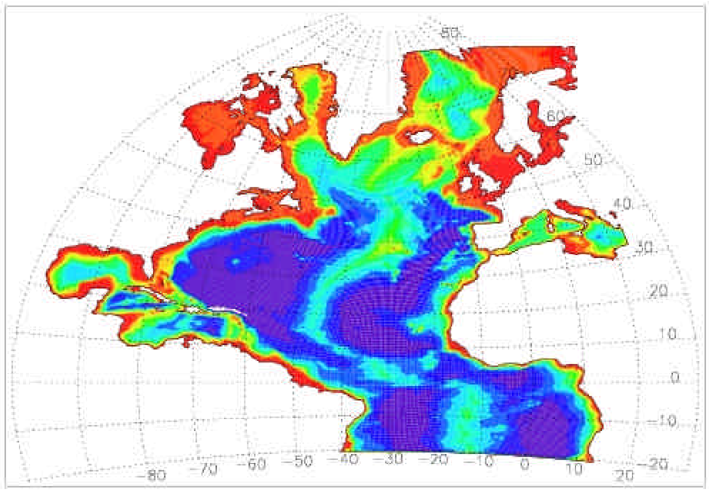

Figure 4: Model domain and bathymetry of NATL4 configuration.

The first results are encouraging. In particular, the sea-ice model was used for the first time at such a high resolution and buffer zones were implemented with the strait of FRAM (towards 80°N), which allow a realistic flow of ice in the NATL4 domain. Figure 5 shows the extension of the sea-ice cover in winter, and underlines the character of the surface currents, intensified along Greenland and turbulent in the North Atlantic Current (in the south of Iceland).

The main defects of the models are also present in ORCA025: salinization of the subpolar gyre, inaccurate representation of the overflows, and excessive convection in the Labrador, Irminger and Nordic seas. The NATL4 configuration will be a good tool to test improvements to be implemented in ORCA025.

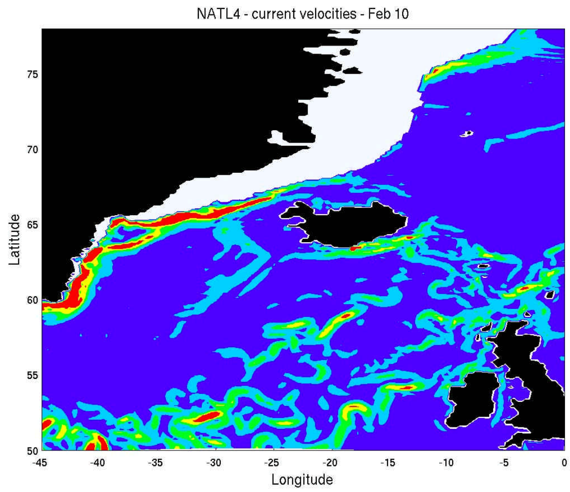

Figure 5: Extension of the cover of sea-ice during February of the 5th year (in white), superimposed on the speed of surface currents (in color).

A 10 years experiment exactly similar to ORCA025 G30 has been run. The comparison between NATL4 and ORCA025 will help assess the behavior at the boundaries and develop suitable open boundaries for the NATL4 domain. A preliminary study with ORCA05 has shown that this lower resolution model could not provide suitable open boundary conditions at FRAM Strait.

2.4. Forcing function.

2.4.1. Drakkar forcing fields for model development

Drakkar project uses *bulk formulae* for heat and freshwater forcing. The basic atmospheric variables needed are *air temperature*, *relative humidity*, *total cloud cover*, *scalar wind spe*ed and *precipitation*. The momentum equation uses direct estimate of the *wind stress vec*tor as boundary condition. In 2003, *Claude Talandier* built the BULK-TEST tool using OPA forcing routines for the purpose of evaluating the forcing parameters entering the calculation of the model surface fluxes. BULK-TEST computes the forcing fields applied to the model, on the model grid, for a given SST and a given set of atmospheric variables. Performing diagnostics like MHT calculation, comparison with climatic flux estimates, one can get a quick evaluation of the impact of a particular forcing parameter on the forcing fields. A small correction relative to the calculation of relative humidity has been implemented by Laurent Brodeau (Voir note de Brodeau, 2004). The interpolation scheme and the process of making continents which are used in BULK-TEST have been completely revised in 2004 by Laurent Brodeau and Sergei Gulev (see Section 5).

Based on the results of a study carried out in 2003 (Talandier et al., 2003), it was decided at the 2004 January meeting that the forcing parameters used for model development would be referred to as the Forcing Set N°1; defined below:

Bulk formula : The default bulk formula for OPA9 and LIM, referred to as the CLIO formulas
Forcing parameters: Air temperature: Daily mean value from NCEP
Precipitation: monthly from CMAP
Humidity: monthly from CLIO
Cloud cover: monthly mean from CLIO
Wind Speed: daily from a merging of ERS and NCEP winds.
Wind stress in I direction: daily from a merging of ERS and NCEP winds.
Wind stress in J direction: daily from a merging of ERS and NCEP winds.

The winds are from the ERS scatterometer between 50°N and 50°S. A linear combination with NCEP is performed between 50° and 60°, and NCEP winds are used poleward of 60°. The forcing fields have been interpolated onto the ORCA-R05 grid by Christian Ethe (LODyC). Then, a linear interpolation has been performed from the ORCA-R05 to the ORCA-R025 grid by Sébatien Theetten (LPO). No particular effort has been made to balance the net heat flux provided by this data set at global scale. An estimate of heat fluxes based on Reynolds SST by Talandier et al. (2003) showed a global imbalance of -14 Wm^{-2}.

2.4.2. Drakkar forcing fields for interannual experiments

It was decided at the Drakkar Kiel meeting of September 2004 that the CORE forcing set (Large and Yeager, 2004) would be the default choice for Drakkar for the interannual experiments. This forcing set has its own bulk formulas and largely uses the NCEP re-analysis. It covers the period 1958-2000 (43 years). The CORE forcing has been implemented in the ½° Drakkar configuration ORCA-R05 2004 by the Kiel group in 2004, and this forcing set is presently being evaluated from several simulations (see section 3).

The strategy regarding (*i*) the recent re-analysis ERA40 (1950-2002) and a (*ii*) the construction of a new forcing set for the satellite era (1990 to present) will be updated in January 2005. See Section 5 for more Drakkar activities in 2004 on the continuous improvement of forcing fields.

2.5. Conclusion

The Drakkar project carried out an important number of studies in 2004 which will help to finalize main choices with regard to the present and future Drakkar model configurations. In particular, the choice of a partial steps representation of the topography associated to the new vorticity scheme, and the choice of a TVD advection scheme are clearly a minimum requirement.

ORCA025 is up and running with high performances on the IBM machine at IDRIS. Although only eddy permitting, this model displays features usually only seen in higher resolution experiments (good representation of the North west corner, of the Zapiola eddy and the pattern of currents in the Confluence region, a strong and continuous deep western boundary current, a significant reduction of the inertial eddy at the separation of surface western boundary currents, etc...). Results from the sea-ice model are encouraging, but will be discussed more precisely at the January 2005 meeting in Grenoble. However improvements still need to be made before performing inter-annual runs in 2005. A parameterization of the type of GM90 will have to be adapted with a space (and possibly time) varying coefficient to improve deep winter convection at high latitudes. Although improved by the new vorticity scheme, the overshoot of western boundary currents is still a problem, and no solution is foreseen right now. Deep overflows are still not reproduced correctly, a thorough investigation of the joint use of partial steps with the advective/diffusive BBL is required. A key issue to be addressed early in 2005 concerns the freshwater forcing. The ORCA025 results will be used to specify boundary conditions for many local studies (Indonesian throughflow, for instance).

NATL4 is ready to serve mutiple purposes: test improvements in parameterizations as well as prepare the future high resolution configuration.

For the High resolution North Atlantic model NATL12/15, it is interesting to note that a 1/12° resolution with 100 levels (NATL12-100) and a 1/15° resolution with 50 levels (NATL15-50) would have a similar cost.

The forcing set for the first inter-annual experiment to be carried out in 2005 is the CORE forcing by Large and Yeager (2004). However, studies concerning a continuous improvement of the forcing fields (bulk formula and atmospheric data) need to be pursued (Ph.D. of Laurent Brodeau).

These issues should be discussed during the January 2005 Drakkar meeting in Grenoble. The project team expects to be able to start long term simulations with inter-annual forcing with NATL4 and with

ORCA05-LIM and ORCA025-LIM in the first semester of 2005, and to implement the high resolution North Atlantic during 2005.

2.6. Notes and reports

Brodeau L., 2004: A comparison between two interpolation tools, *Internal Note, Drakkar project*, LEGI

Brodeau L., 2004: Erratum to the 2003 report of Talandier et al., "Preparing surface flux fields by using bulk formulae for the Drakkar project", *Internal Note, Drakkar project, LEGI.*

Brunier, L, 2004: Equilibre de la vorticité dans le tourbillon subpolaire de l'Atlantique Nord. Rapport de stage de l'Ecole Nationale de la Météorologie.

Molines J. M., A. M. Treguier and S. Theeetten, 2004: Drakkar ORCA-R025 experiments. Internal report LEGI 04.

Penduff : MERCATOR newsletter.

Talandier C., A.M. Treguier, and B. Barnier, 2003: Preparing surface flux fields by using bulk formulae for the Drakkar project. Internal report DRO/LPO 03 – 13.

Theetten, S. and A.M. Treguier, 2004: validation and analysis of the first NATL4 run of the DRAKKAR project. Internal report DOPS/LPO 05-01.

3. Summary of Activities at IfM-Geomar

Ocean model group: Claus Böning, Joachim Dengg, Arne Biastoch, Ulf Schweckendiek, Sabine Hüttl, Markus Scheinert.
Coupled model group: Mojib Latif, Noel Keenlyside, Wonsun Park.

For the Kiel group, 2004 was the major year for the migration of its modeling activities to the OPA9 system. Especially the global configurations ORCA2 and ORCA05 have been intensively tested and run in a series of production runs (Table 2).

The main focus of the activities was switching the atmospheric forcing to Bulk formulation and embedding it in the community intercomparison projects OMIP (Ocean Model Intercomparison Project) and its successor CORE (Coordinated Ocean Reference Experiments). After implementing OMIPs Kara (2000) bulk formulae and interpolation of the input data onto the global model grids several long-term experiments - o(100 yrs) for ORCA2, o(40 yrs.) for ORCA05 - have been performed following the OMIP protocol. In this context the specification of a strong sea surface salinity restoring of 0.5 m/day was the most stringent point in the OMIP protocol, that lead to a short time scale of 12 days for the 46-level vertical axis. ORCA2 and ORCA05 were compared with the Hamburg model MPI-OM. It was found that both performed well (within their respective limits due to resolution) and simulated reasonable mean states.

CORE was initiated at the "CLIVAR Ocean Climate Model Workshop" (GFDL, Princeton, June 2004) and is supposed to act as the successor of OMIP, but with a less stringent protocol. The most important difference to OMIP is the use of a new data set based on the NCEP/NCAR reanalysis data set and corrected using independent data sets to form a consistent and globally closed data set in climatological and interannually varying daily resolution (Large and Yeager, 2004). CORE, that also comes with specific Bulk formulae, was implemented into the code and integrated in several long-term simulations of ORCA2 and ORCA05. Hereby, the large-scale circulation showed a drastic difference between both model versions when a weak (o(150-180 days)) sea surface salinity restoring was used: In ORCA2 the meridional overturning cell collapsed after 15-20 years (Fig. 6), a behavior very similar to several other models at future climate model resolution (~1°) under CORE forcing (e.g. GFDL MOM4, HYCOM). In contrast to that ORCA05 had a stable overturning cell. The causes for this contrasting behavior are still unclear and are currently being examined, e.g. by additional sensitivity experiments and analyses of the Arctic freshwater budget. (U. Schweckendiek, A. Biastoch).

In addition to the OMIP and CORE experiments several short-term sensitivity tests have been performed using ORCA05 and NATL4. These include variations of the horizontal parameterizations, advection schemes and BBL. For the tropical Atlantic a comparison with the eddy-permitting (1/3°) and eddy-resolving (1/12°) versions of FLAME was made. For the detailed structure of equatorial counter- and undercurrents it was shown that ORCA05 does compare well to observations and is even closer in its structures to the 1/12° model than to the 1/3° FLAME model. (S. Hüttl, A. Biastoch, J. Dengg).

In addition to the climatological and interannually varying experiments a waterhosing experiment has been formulated by CORE (Gerdes et al., 2004) where a 0.1 Sv freshwater anomaly is released around Greenland. Hereby the collapse and recover of the MOC should be studied in o(100 yr.) experiments. The formulation of this additional freshwater release is currently build into the code and tested. Target models will be ORCA2 and ORCA05. (M. Scheinert).

In other to study interannual to multidecadal variability of the ocean-atmosphere system, a fully coupled model is currently developed, which uses ECHAM for atmosphere, OPA ocean, LIM sea-ice, and PRISM-OASIS coupler. In 2004, the physical interface for coupling has been defined and new exchange fields in ECHAM5 and OPA9 have been implemented in collaboration with the ocean model group, NEC, and MPI. A preliminary version with T31-atmosphere and ORCA2-ocean resolution runs but still needs stabilization. The final target resolution is T63L31 atmosphere and ORCA05-L46 ocean. (N. Keenlyside, W. Park, M. Latif with contributions by R. Redler (C&C NEC), V. Gayler, S. Legutke, L. Kornblueh (Model and Data, MPI Hamburg)).

Table 2: Production runs with ORCA05

	Code	Forcing	Runtime	
KAB006	1.5	OMIP	40 yrs.	with GM
KAB010	1.5	OMIP	40 yrs.	without GM
KAB013	1.8	CORE	20 yrs.	restoring time scale 6d
KAB018	1.8	CORE, internal runoff	50 yrs.	restoring time scale 24d (0.25 m/d)
KAB020	1.8	CORE, internal runoff	50 yrs.	restoring time scale 150d (0.033 m/d)
KAB021	1.9	CORE interannual, internal runoff	1958-2000	based on KAB020
KAB022	1.10	CORE	10 yrs.	as KAB020, but CORE runoff

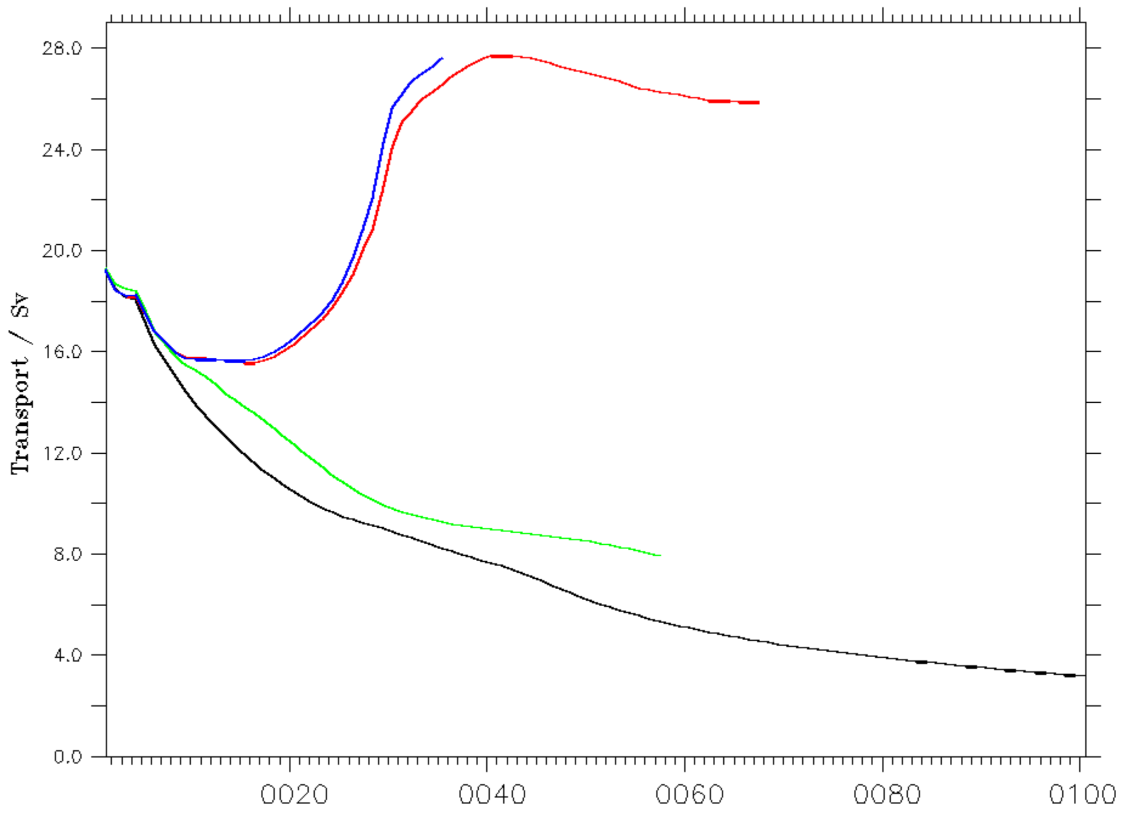

Fig. 6: Merdidional overtuning strength at 45°N in ORCA2 under different runoff: standard runoff (black), OMIP (red), CORE (green), no runoff (blue)

4. Summary of the Drakkar activities at UoH

The Helsinki group now consists of Aike Beckmann, Byoung Woong An (Post-Doc) and Angelika Renner (MSc student). At the University of Helsinki, the work on DRAKKAR topics began in autumn 2004, with analysing a first 50 year Arctic sea ice data set which was produced with ORCA2 in Kiel. The results show that while the mean annual cycle is systematically smaller than obtained from climatology, the interannual variations are in reasonable agreement with observations. Analyses of the Arctic ice in higher resolution experiments are underway.

In parallel, and with significant help by Jean-Marc Molines (LEGI-Grenoble), the latest version of the OPA9 code was installed on the IBM at the Finnish Center for Scientifc Computing (CSC), and will be used for production runs in 2005. We have begun to debug and evaluate the terrain-following coordinate version of OPA9 in a periodic channel configuration, with a tall isolated seamount. Several corrections have been applied and currently the compatibility of the sigma version with various other options is being tested.

5. Summary of activities at SIO, with LEGI and LPO

In 2004, SIO, LEGI and LPO pursued joint studies aiming at improving the atmospheric forcing fields and parameterization for the Drakkar models. The focus has been the interpolation of forcing fields on the ORCA tri-polar grid, and on the definitions of bulk formulas for the calculation of the surface fluxes. This work was mainly done by Laurent Brodeau, Ph.D. student at LEGI, who visited SIO for a month in summer.

5.1.1. Interpolation of the forcing fields

An effective tool comprising an interpolation routine for 2D-fields based on the methods of the local procedures and a routine for masking continents (GAP routine) was worked out and tested. This tool is made simple to use and easy to configure by the use of a "namelist" and is continuously improved. A report describing this tool and more particularly the method of masking has been placed on the Drakkar Web site. This tool is used to prepare any atmospheric field to enter the BULK-TEST tool which was developed by Claude Talandier (2003) to evaluate the forcing parameters.

5.1.2. Bulk formulation of the Drakkar forcing

A set of FORTRAN routines (IOIPSL format) to estimate surface fluxes with bulk formulas is currently developed and implemented in the BULK-TEST tool.

A library was built to make possible the use of various bulk formulas proposed by various authors. For the moment, the focus is mainly on the calculation of turbulent fluxes (wind stress, sensible and latent heat). On the basis of common iterative method suggested by Large (2004), various ways of calculating the exchange coefficients can be called (Smith 1988, Broad & Pond 1981-82, Bumke 2002, Large & Yeager 2004, Gulev, etc).

Regarding radiative fluxes, several formulations are coded. For long wave radiation, the formulations of Berliand (1952), Clark et al. (1974) and Malevsky et al. (1992) are available at the moment. For solar radiation, the formulations of Dobson & Smith (1988) and Malevsky et al. (1992) are available. Both use a "2 steps" parameterization and estimate the albedo with the tables of Payne (1972). One can also plan to use radiative fluxes directly. In this case the modification of BULK-TEST would be minor.

Regarding the validation of the fluxes produced by BULK-TEST, additional diagnostics need to be developed, since for the moment they are limited to the net heat flux, meridional heat transport for ocean basins, and comparison with maps from climatological atlases.