Report of the DRAKKAR Workshop
Grenoble, 22-24 january 2018

Link to the workshop website

Organizing committee

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This meeting marks the beginning of the second phase of the DRAKKAR International Network (IRN), 2018-2021. A report of the first phase is available on the DRAKKAR web site www.drakkar-ocean.eu (here)

The agenda was organized in four sessions:

1. Model evolution in the eddy resolving regime
2. Forcing and coupling the ocean with the atmosphere
3. Tides, boundary layers, dense water formation and overflows
4. Sea-ice modelling and sea-ice covered regions

The list of participants is included in this report (annex 1). The list of abstracts is available on the meeting web site (here) , and the presentations as well (the latter with a password that can be provided on request by Bernard Barnier).

1 Sessions summary

1.1 Model evolution in the eddy resolving regime

In session 1 **new analyses of eddy variability** were presented, covering a variety of dynamical regimes of the world ocean, based on model at different resolutions. The evolution toward higher resolution (from 1/4° and 1/12°, to 1/20° and 1/60°) is a strong trend in the second phase of the DRAKKAR IRN. Thierry Penduff (IGE) presented the latest results from the OCCIPUT 50-members ensemble of ORCA025 simulations. The intrinsic variability of ocean heat content, meridional heat transport and AMOC is now quantified, and new results about the chaotic nature of SSH variability have been obtained (S. Close, IGE). Bernard Barnier (IGE) showed how to take advantage of the wealth of DRAKKAR global ORCA12 simulations to investigate the dynamics of the low latitude western boundary current in the Indian Ocean (e.g., the "Great Whirl" and its variability). Moving to higher resolution, the new version of the zoomed configuration VIKING (1/20° in the North and tropical Atlantic) was presented by K. Getzlaff (GEOMAR). The improvement brought about by the increased resolution will allow to disentangle sources of AMOC variability in the South Atlantic and in the North Atlantic. In the Agulhas region, R. Schubert (GEOMAR) evaluated spectra of surface variables in a 1/60° zoom of the Agulhas region.

Another focus of the session was **model development**, with three aspects:

- Algorithms : new methods for the generation of global grids (S. Xu, Tsinghua university, Xu et al, Geosci. Model Dev., 2015); comparison of NEMO with the finite element model FESOM in the Agulhas (A. Biastoch, Geomar); a semi-lagrangian advection scheme in NEMO (F. Roy, Environment Canada)
- Parameterizations: link between eddy viscosity parameterization and effective diffusivity (A. Megann, NOCS) and energetic consistency of parameterizations (R. Tailleux, U Reading)
- Lagrangian analysis of models: a recent review of lagrangian methods and the "PARCELS" software (E. Van Sebille and P. Delandmeter, U. Utrech)

Finally, results of ocean reanalyses run at Mercator-Ocean were presented by Y. Drillet.

1.2 Forcing and coupling the ocean with the atmosphere

Session 2 concentrated on the different ways to **provide atmospheric boundary conditions to ocean models**, either provided through forcing products or interactively coupled to atmospheric models. Jean-Raymond Bidlot (ECMWF) reported on the planned ERA5 reanalysis which is being performed over the period 1979-now (later to be complemented by 1950-1978) at 31-km resolution. The official release will be in 2018 through the C3S Climate Data Store. Patrick Wagner (GEOMAR) informed on the first experience with the new reanalysis product JRA-55-do, here specifically for a SSH analysis in the Pacific. Although providing a generally better structure compared to the old CORE forcing, JRA winds are weaker, hence result in a weaker decadal trend in SSH. Jan Harlaß (GEOMAR) described the new coupled system FOCI at GEOMAR with nesting capability. First configurations, set up in the South Atlantic/Agulhas region (INALT10) and northern North Atlantic (VIKING10) are set up, demonstrating the flexibility to perform high-resolution basin-scale ocean models in coupled mode. Joakim Kjellsson (GEOMAR) presented plans for FOCI to install OpenIFS as an alternative to the existing ECHAM. Paige Martin (Univ.Michigan) presented a frequency-domain analysis of energy transfer in an idealized, eddy-resolving ocean-atmosphere model. Finally, Helene Hewitt (UKMO) provided insight to the PRIMAVERA set of experiments with differing resolution in the ocean (ORCA1/025/12) and atmosphere (N96/216/512). While the full set is not completed yet and analyses are underway, a remarkable result was the AMOC decline in the historical ORCA12 experiment. An ensemble of ORCA025 configurations, however, shows a strong variation in terms of the AMOC behavior.

1.3 Tides, boundary layers, dense water formation and overflows

This session included a variety a presentations, which can be summarized in two broad themes.

1 – **Modelling and parameterizing tides**.

B. Arbic (U of Michigan) gave an invited talk on the numerical simulation of internal tides in the global Hycom model at high resolution. Recent applications of NEMO with tides were presented by A. Holdworth (IOS Canada) and Y. Lu in the bay of Fundy. This type of applications will benefit from the new wetting/drying numerical scheme recently implemented in NEMO (M. Bell, Hadley Centre). Finally, C. de Lavergne (UNSW, Australia) reported progess on parameterizing diapycnal mixing due to internal tides in NEMO.

2 –**Water mass formation and overflows**
Water mass formation depends on the parameterization of processes in the surface mixed_layer. G Nurser (NOC) provided an update on the OSMOSIS boundary layer parameterization, which will complement existing schemes in NEMO. R. Waldman (CNRM) analyzed deep water formation and sinking in the Mediterranean sea using a 1/12° NEMO simulation. P Myers (U Alberta) presented an evaluation of water mass formation and dynamics in the Labrador Sea using NEMO configurations at increasing resolution (the target being a 1/60° AGRIF zoom). Three presentations gave a perspective on the respective benefits of terrain following coordinates (ROMS model, M. Le Corre, LOPS) or a combination of terrain following coordinates and masking (NEMO-shelf in the Arctic to study dense water cascading, M. Luneva, NOC); Denmark Strait overflow,P. Colombo, IGE).

This session set the stage for a dedicated workshop organized the following day by H. Hewitt (MetOffice) and B. Barnier (IGE) to coordinate efforts aiming at the improvement of the representation of dense water overflows in NEMO.

1.4 Sea-ice modelling and sea-ice covered regions

The session presented ongoing work aimed at improving NEMO-based simulations in the polar regions, for example:

- Representing/parameterizing the influence of tides under the ice shelves and on the Antarctic coastal circulation (N. Jourdain, IGE and P.V. Huot, UCL)
- Adjusting parameters to improve the ice velocities in the Canadian Archipelago (N. Grivault, U alberta)
- Exploring the sensitivity of the Arctic ocean stratification to vertical mixing parameterizations (V. Haid, LOPS)
- Tuning/improving a forced and coupled model for a better representation of the Southern Ocean (D. Storkey, Hadley Centre)
- Looking for systematic biases in the air-sea fluxes in the Marginal Sea Ice Zone (MIZ) in forced and coupled simulations (A.M. Treguier, LOPS)
- Improving the representation of the MIZ using new rheology of sea ice and taking into account surface waves (Y Aksenov presentation given by G. Nurser, NOC).

This session was followed the next day by a workshop organized in the framework of the FREDY project (organizers: C. Lique and M. Vancopennolle) gathering users of the LIM3 ice model.

2 Discussions on NEMO-based global eddying simulations

The discussions contribute to the strategy of the Drakkar International Network, 2018-2021.

2.1 DRAKKAR IRN axis 1: coordinating simulations and developments

“Lead the development of a coherent hierarchy of global model configurations based on the NEMO modelling framework, and in particular the development and improvement of the global 1/4° ORCA025 model and the 1/12° ORCA12 model. “

The participating groups have provided tables of the global simulations that they are willing to share with others. The evolution since the beginning of the first phase of the international network (2014) is striking. At that time, only short (10 years) interannually forced ORCA12 simulations were available; now many multi-decadal simulations have been performed. The global configurations at a uniform resolution of 1.4° and 1/12° (tables 1 and 2) are complemented by ORCA025 simulations with zooms developed at GEOMAR (INATL20 for the Agulhas region, VIKING20 for the North Atlantic, etc), run with the CORE forcing, and by the 1/60°, 300 vertical level NATL60 simulations of the North Atlantic basin performed at IGE.

OCCIPUT ensemble 50 members ORCA025.L75	1958-2015	DFS4.4	NEMO3.5 lim 2	IGE Grenoble
eOR025L3P-IA-REF05	1948-2009	CORE	NEMO 3.6, lim3 PISCES	NEMO R&D
eORCA1/025/12, L75	30 to 50 years	CORE coupled	NEMO 3.6 CICE G06, G07 with ice cavities	MetO+NOC
eORCA1/025/12, L75	1948-2009	CORE	G08 prototype. NEMO4 alpha, LIM3	MetO+NOC
ORCA025.L46.LIM2vp.CORE-K002	1948-2009	CORE	NEMO3.6 lim2	GEOMAR
ORCA025.L46.LIM2vp.JRA-K002	1958-2016	JRA55-do v1.3	NEMO3.6 Lim2	GEOMAR
eOR025L3P-IA-REF05	1948-2009	CORE	NEMO 3.6, lim3 PISCES	NEMO R&D

Table 1: ORCA025 simulations available to the community

ORCA12.L46-MJM189 ORCA12.L46-MJM88	1958-2015 1958-2011	DFS5 DFS4	NEMO3.5 lim 2	IGE Grenoble
eORCA12.L75MJMgd16	44 years	DFS5	NEMO4 alpha, lim3	IGE Grenoble
eORCA1/025/12, L75	30 to 50 years	CORE coupled	NEMO 3.6 CICE G06, G07 with ice cavities	MetO+NOC
eORCA1/025/12, L75	1948-2009	CORE	G08 prototype. NEMO4 alpha, LIM3	MetO+NOC
GLORYS12V1 and GLORYS12V1 free	1993-2016	ERA int.	NEMO3.1 lim2	MERCATOR
eORCA12-TRBB36s003b	35 years	ERA Int	NEMO3.6 LIM3	

Table 2: ORCA12 simulations available to the community

Action item 1: make monitoring output for these simulations easily available and inter-compare key variables

A working group will decide on a small number of key variables from the monitoring that we want to have easily available from the shared simulations. These variables will be gathered and examined during 2018, with the aim to propose at the next DRAKKAR meeting a set of scientific studies based on the collection of DRAKKAR simulations (one example could be the statistics of some extreme events?)

(lead: Thierry Penduff and Bernard Barnier. Members: J.M. Molines, M. Scheinert, A.M. Treguier, ……)

2.2 DRAKKAR IRN axis 2: uncertainties

"Quantify the uncertainties in global numerical solutions of high resolution ocean models and their propagation. "

The different practices regarding ensemble strategies have been discussed. Ensembles are seen as a way to evaluate uncertainty in short term forecasts and also in climate projections (ensembles with stochastic physics, different physics, different initial conditions). There is experience in many of the groups (ECMWF, IGE, …). No specific actions were proposed for 2018.

2.3 DRAKKAR IRN axis 3: towards higher resolution

"Develop and generalize the use of grid-refinement strategies (e.g. AGRIF) to study fine scale key ocean processes in their realistic global environment (downscaling) and to understand their role in the large scale circulation (up-scaling). This work will benefit from high resolution basin-scale frontier simulations."

Rationales for moving to higher resolution have been discussed. Most groups are planning simulations at resolution higher than 1/12°: CREG36 in the Arctic (Mercator-Ocean), NATL60 1/60° at IGE Grenoble, 1/20° and 1/60° AGRIF zooms at GEOMAR… There are incentives to increase the resolution (e.g., representation of new processes, new context of high resolution measurements from space such as SWOT) but there are also many obstacles to these developments. Overall Europe is lagging the U.S. in moving forward with high resolution globally (cf the 1/24° global Hycom and 1/48° global MIT-GCM).

Action item 2: a focus on the future of high resolution global models at the 2019 DRAKKAR meeting

By combining invited talks, contributed presentations and discussions, it should be possible to reach a consensus on recommendations regarding the development of higher resolution global models in Europe. These recommendations would be useful in the context of the evolution of marine services (CMEMS). The organizing committee will start discussing the organization during the spring.

2.4 Coordination with NEMO

The NEMO development strategy has been presented by Julien le Sommer. The NEMO development plan for 2018-2022 is now available on the NEMO web site: https://www.nemo-ocean.eu/wp-content/uploads/NEMO_Development_Strategy_Version2_2018-2022.pdf .

Working groups will oversee the progress of each item of the development plan. A European proposal is being written to request funding for the evolution of NEMO. It would be good for the DRAKKAR consortium to build upon recent works (in particular Pedro Monteiro's work) in order to tackle the question of improving overflows with AGRIF and different vertical grids/coordinates. CNRS, Met Office and NOC are keen on collaborating on this and solutions will be sought for a postdoc to work on this question in coming years.

It will be necessary to coordinate the topics of the NEMO user meetings and the annual DRAKKAR meetings. The next NEMO user meeting will take place in the fall of 2018.

ANNEX 1: List of participants

IGE - Grenoble (12): Bernard Barnier, Lionel Favier, Nicolas Jourdain, Thierry Penduff, Pedro Colombo, Sally Close, Julien Le Sommer, Jean Marc Molines, Josiane Brasseur, Ixelt Garcia-Gomez, Aurélie Albert, Adekunle Ajayi
GEOMAR - Kiel (9): Arne Biastoch, Klaus Getzlaff, Joakin Kjellsson, René Schubert, Torge Martin, Wonsun Park, Patrick Wagner, Jan Harlaß, Markus Scheinert
LOPS - Brest (6): Claude Talandier, Anne-Marie Treguier, Camille Lique, Verena Haid, Mathieu Le Corre, Guillaume Boutin
NOC - Southampton (4): Adrian New, Alex Megann, Adam Blaker, George Nurser
Met Office Hadley Center - Exeter: (4): Pierre Mathiot, Dave Storkey, Helene Hewitt, Mike Bell
MERCATOR Ocean Intl - Toulouse (4): Yann Drillet, Jérôme Chanut, Gilles Garric, Romain Bourdallé-Badie
LOCEAN - Paris (3): Gurvan Madec, Anne-Cécile Blaizot, Clément Rousset
Utrecht University (2): Eric Van Sebille, Philippe Delandmeter
AWI - Bremerhaven (2): Natalia Tilinina, Sergey Danilov
University of Michigan - Ann Arbor (2) : Brian Arbic, Paige Martin
NOC - Liverpool (2): Maria Luneva, James Harle
University of Alberta - Edmonton (2): Nathan Grivault, Paul Myers
University of Reading (1): Rémi Tailleux
IORAS Moscow (1): Sergey Gulev
Environement Canada - Montreal (1): François Roy
Tsinghua University - Beijing (1): Shiming Xu
Ocean Next - Grenoble (1): Laurent Brodeau
IOS-DFO Canada - Sidney (1): Amber Holdsworth
UNSW - Sydney (1): Casimir De Lavergne
CNRM - Toulouse (1): Robin Waldman
ECMWF - Reading (1) : Jean-Raymond Bidlot
LSCE - Orsay (1): Elena Alekseenko
BIO-DFO Canada - Bedford (1): Youyu Lu
UCL - Louvain la Neuve (1): Pierre-Vincent Huot
LJK - Grenoble (1): Laurent Debreu
Nansen Center - Bergen (1): Pierre Rampal
Tianjin University - China (1): Hao Wei