

Report of the DRAKKAR meeting Grenoble, January 2012

This report summarizes the discussions and modeling issues. The agenda and the talks are available through the Drakkar web site, www.drakkar-ocean.eu ; direct link: <http://www-meom.hmg.inpg.fr/Web/Events/Drakkar2012/January-2012-Agenda.html>

1. Model results and discussions

1.1 Session on ORCA12 (chair: Anne Marie Treguier)

Group	Duration	Vertical grid	Forcing	Other parameters
Kiel ORCA12-K001	1978-2007	46 levels	CORE v2 relative wind	ice Lim2 VP. No SSS restoring under sea ice. partial slip (shlat=0.5)
Grenoble ORCA12.L46- MAL95	1989-2007 from restart K001	46 levels	ERA-I relative wind	ice Lim2 VP. partial slip (shlat=0.5)
Grenoble ORCA12.L46- MAL85	1978-1992	46 levels	DFS4.1 relative wind	Flux form momentum advection, free slip (shlat=0)
Mercator ORCA12.L50- T321	1999-2009	50 levels	ERA-I absolute wind	free slip (shlat=0)
NOCS ORCA12.L75-	1978-2007	75 levels	DFS4.1	VVL option

Table 1: summary of ORCA12 long experiments. All runs use the filtered free surface (excepted NOCS) and the vector form EEN of the momentum advection (excepted MAL85).

Global results from the Kiel experiment (Markus Scheinert)

- SSH variability is good but still lower than Aviso in many places;
- The decrease of Drake Passage transport during the first 10 years is similar to what is found in lower resolution runs. Probable cause: loss of volume of Antarctic bottom Water south of the ACC.
- The AMOC at 26.5N is lower in ORCA12 (13.7 Sv) compared with RAPID (18.7 Sv).
- The Gulf Stream separation is not very good, presence of a large eddy north of Cape Hatteras.

Documentation is available on the server: <https://svn.geomar.de/trac/orca12>
(ask Markus Scheinert for access).

Global results from the Grenoble experiments (Albanne Lecointre).

The comparison of various sensitivity experiments motivate the following recommendations for future ORCA12 experiments:

- the vector form should be preferred for the momentum advection scheme;
- Between 75 levels and 46, mixed results. Pacific EUC profile is somewhat better with 75 levels, some improvement also in temperature biases. Note, the 75 levels run was made without the diurnal cycle.
- The new V3.2 bathymetry modified at Gibraltar Straits should be used;
- for lateral boundary conditions, free slip is best excepted for a few limited no-slip patches (to be defined - Med Sea, and Cape Desolation west of Greenland and Indonesian Throughflow are candidates).

Results at the regional scale

- Regional configuration MED12 based on ORCA12 (Jonathan Beuvoir). Results are very good, could ORCA12 benefit from using the same forcing (ARPERA), initial conditions, bathymetry and parameters?
- Analysis of ORCA025 and a preliminary comparison with ORCA12 in the Arctic (Yevgenei Aksenov).

Two ongoing scientific studies with ORCA12 have been presented: a study of freshwater transports at 30°S (J Deshayes and A. Biastoch) and a study of the variability of western boundary currents (J. Hirshi). Two joint papers are in preparation.

Discussion

The lateral boundary condition has been discussed (the no-slip boundary condition, $shlat=2$, seems better in regions of very steep topographic slope? is it because mean currents are not well represented in free slip and do not have the right stability properties?).

The calculation of wind stress is still an open question. Should we use absolute wind speed or the relative wind speed (difference between wind speed and surface current speed)? There is a need to exchange relevant references and start a discussion on this issue (Anne Marie Treguier, Sergei Gulev, Arne Biastoch, Laurent Terray, Bernard Barnier, Gurvan Madec...), with specialists such as Fabrice Ardhuin. Gurvan mentions that he will perform a test in coupled mode with WRF over the Indian ocean, that could perhaps settle the issue.

1.2 Focus on ORCA025 physical and Coupled Ocean/Atmosphere studies (Chair: Thierry Penduff)

ORCA025/ORCA05 experiments done in Kiel with a focus on high latitudes.

a) Gas Hydrates in the warming middepth Arctic ocean (Christina Roth).

- sensitivity to CORE forcing dataset (v1/v2b), SSS restoring, initial sea-ice field?
 - three 40+-year NEMO3.1.1 ORCA05L46 runs
 - strong sensitivity of Arctic FW budget to these slight changes.
 - Atlantic Water layer not well reproduced. Better with a spun-up sea-ice initial field.
- sensitivity of bottom warming to vertical resolution?
 - ORCA025 with 46 vs 300 levels (10 levels within top 100m, 20m resolution below).

→ memory issues + CFL issues took time. 300-level model is running now.

b) Response of the ACC to decadal wind changes (Lavinia Patara). Role of eddies.

- Spurious drift in pivot ORCA025 run (ACC transport : -3Sv/decade)
 - Drift limited to 1.7Sv/decade with 1-yr relaxation to TS Levitus south of ACC, below 900m & away from Antarctica
 - Impact of relation somewhat stronger in ORCA05
 - How does this strategy compare to a relaxation of near-bottom AABW only? (see C. Dufour, Drakkar 2011)
- Drifts due to wind intensification in COREv2
 - 1948-2007 ACC transport increase: less in ORCA025 (15%) than in ORCA05 (30%)
 - EKE trend in ORCA025: positive despite strong intrinsic and regional variability
 - GM thickness diffusivity is large in ORCA05 where EKE is large in ORCA025. However, it is capped at 1000m²/s which might be too restrictive.
 - Present work: impact of shifting winds on southern ocean and AMOC at high resolution? (1) ORCA025+AGRIF1/12° in South Atlantic extended to the Antarctic. (2) Circumpolar AGRIF 1/12° in ORCA025.

Large-scale budgets

a) Ocean energetics, new framework (Fabien Roquet); analytics + idealized MITgcm tests

- Main ingredients : hydrostatic, Boussinesq
 - write energetics as a function of horizontally-averaged fields (pressure, vertical velocity, density) and deviations from them
 - concept of dynamical potential energy (DPE)
 - wind- and buoyancy-driven circulations energetics may be extracted (horizontal anomalies of pressure)
- To be implemented in NEMO (postdoc in Stockholm with Nycander).
- Can it be used for subgridscale param? (e.g. DPE-based GM ?)

b) North Atlantic Freshwater Content and dynamical variabilities: multi-model comparison

- Study lagged correlations between subpolar FWC, divergence of advective fluxes, atm+seaice fluxes, at various timescales (T<10yr, 10<T<50yr, T>50yr)
- Do so in NEMO at coarse resolution in coupled and forced modes + ORCA025 in forced mode.
- Use of FCVAR (Matlab-based diagnostic package to compute timeseries of heat/FW contents, circulation components, MOCs, etc across arbitrary sections). This tool is available.
- Result : FWC, MOC and gyre transports are very sensitive to the model setup.
- Julie : isn't there a tendency for ORCA2 (forced and coupled) to yield qualitatively comparable results ? It seems that ORCA1 and 025 exhibit less and less connection between FWC and circulation patterns.(?)

Correcting precipitations with REMSS Passive Microwave Water Cycle data (A. Storto)

- Dataset : 1987-2009, ¼° monthly. Rain retrieved from SSM/I sensors.

- REMSS used to correct large-scale ERA-interim precipitation seasonal cycle (small scales untouched)
- Several biases are reduced in ORCA025L50+LIM2 (Mercator setup forced by ERAinterim) : too fresh Tropics; global E-P imbalance; SSH root-mean-square error w.r.t. AVISO; ACC surface current speeds w.r.t. OSCAR dataset. Global meridional transport of Freshwater gets much closer to Large & Yeager 2009.

ORCA025 at the UK Met Office (D. Storkey)

- NEMO3.2 ORCA025L75 + CICE4 configuration used in applications at all timescales.
- Short-term forecasts (FOAM) soon to be coupled to atmosphere.
- Seasonal forecasts (operational summer 2012): ORCA025 coupled to N216 atmosphere
- Coupled climate: ORCA1-N96; ORCA025-N96; ORCA025-N216 (60 to 100years):
**ACC warm SST bias (with coupling to N96) worse in ORCA025 (reaches 1-4°C) compared to ORCA1*
**Negative trend in Drake Passage transport + warm full-depth bias around Antarctica similar in coupled and forced modes (70Sv and 0.75°C after 30 years). Low Drake Passage total transport mainly due to spinup of westward coastal Antarctic current. No trend in ORCA1 (150Sv).*
- Daley Calvert has identified a bug in the TKE scheme whereby the enhanced diffusion from the EVD scheme is fed back to mix the TKE. He has also done tuning studies on the *htau* parameter in the TKE scheme.

Is the geostrophic Sverdrup transport a good proxy for RAPID upper-mid ocean transport? (A. Ducez)

- Objective: extend RAPID measurements before 2004 and to decadal timescales
- Use of 2 forced (interannual and climatological forcing) and 1 coupled ORCA025 runs
- These runs exhibits different trends in AMOC.
- Upper-mid ocean transport dominates MOC variability between ~100days and 10 yrs
- Interannual-to-decadal: 0.86 correlation between real value and 1-year lagged proxy
 → wind data may be used with cable measurements to estimate MOC var. since 1982

Tropical cyclones (TC) and SST cooling (G. Madec)

- Almost no TC in atmospheric reanalyses → filter reanalyses then add 6-hourly analytic TC winds based on observed trajectories and strength (3000 TCs over 1978-2007). This forcing method will be available in NEMO 3.5
- With this forcing, ORCA05 simulates much better TC-induced local SST drops (forcing). TCs induce local vertical mixing which warms subsurface + far-reaching 3D advective temperature and SSH anomalies + 10% reduction of SST seasonal cycle.
- No significant impact on MHT.

1.3 Focus on Regional Model Simulations and AGRIF (Chair: Arne Biastoch)

Recent developments for regional modelling in NEMO (Jerome Chanut)

- Advise new capabilities in NEMO for shelf/regional modeling
- Example: IBI36: 1/36° European shelf, 50 levels, NEMO 2.3, but with v3 developments

- Tides compare very well with tidal model (FES2004): North Sea amphidromic points simulated, amplitude off by just 5%, baroclinic tides remove energy → currents lower by up to 15 cm/s
- 100-level version to test Med Outflow

The impact of eddy processes on the freshwater distribution and AMOC in Greenland melting scenarios (Erik Behrens)

- ORCA05-ORCA025-VIKING20 comparison study under CORE forcing, Greenland hosing experiments
- VIKING20 nested in ORCA025: numerical costs ~25-30 times ORCA025, Ro-Radius well resolved everywhere, Path of the NAC improved, NW-Corner visible.
- AMOC similar in ORCA05 and ORCA025, increased in VIKING20, decreased in all hosing experiments by 6-10 Sv in 40 years (40-50%), strongest in ORCA025

North Atlantic DWBC Variability (Claude Talandier)

- Interaction between DWBC and surface currents, e.g. NAC
- ERNA configuration: ORCA05 and 1/8 North Atlantic, with sea-ice refinement
- AGRIF uses absolute wind, ORCA05 uses relative wind
- ORCA05 base model shows good detachment of the GS, NW-Corner, (but less variable Antilles Current), improvement of the MLD in the Labrador Sea, but still too deep
- Plan: higher resolution in the LS → will become pilot model for the vertical refinement

Salinity restoring : a new approach (Gildas Mainsant)

- New approach: Corrective flux is solved prognostically, equivalent to damped oscillator → better representation of the Sobc and conservation of the fine horizontal scales
- tested in PERIANT, no clear improvement: much worse meridional FW transport south of 65S and north of 38S, but better seasonal cycle
- Plan: test in ORCA025

More regional studies

- Seasonal and interannual modulation of the eddy kinetic energy in the Caribbean Sea (Julien Jouanno) in an ORCA12.L75 zoom, with ORCA05 obcs
- Weather regimes impact on North-Atlantic Ocean circulation (Nicolas Barrier) in a 1/2 North Atlantic configuration with closed boundaries
- Salinity variations along the coasts of the Gulf of Guinea, observations and mechanisms (Henrick Berger) in a 1/12 AGRIF nest in the Gulf of Guinea.

Freshwater Exchange through the Canadian Arctic Archipelago into the Labrador Sea (Paul Myers)

- Focus on the western routes connecting the Atlantic and Arctic
- Pan-Arctic configuration, forced with ORCA025 at obc, 1-way embedded Canadian Arctic regional model
- No SSS restoring → strong drift, strong decrease in the FW content
- Important: use correct shortwave radiation (rather than CORE) in summer
- FW transports along the Atlantic shelves in ORCA025-G70/KAB001 and GLORYS → float studies to illustrate pathways

Discussion

- Erik's results show a good correspondence between ORCA05 and VIKING20 → test GM in ORCA025? (→tests have been done at MetOffice, but not with focus on the LabSea, Paul Myers reports NATL4 tests with Visbeck capping)

- Need for mixing schemes arising from the high-resolution experiments (e.g. on bottom friction)? → useful for ORCA025?
- Discussion on the ability to simulate the overflow at high vertical (and horizontal) resolution
- Scepticism on new salinity restoring approach (more tests needed before routinely being used)

1.4 Focus on ORCA025 coupled Physical/Biogeochemistry studies (Chair: Julien Le Sommer)

Summary of the talks :

Joel Hirshi - Coupled physical and Biogeochemical activities at NOCS presents results obtained with MEDUSA at NOCS.

MEDUSA exists in two versions :

- V1 is published. it includes N, Si, Fe cycles. (11 tracers) (Yool, Popova and Anderson 2011 - doi:10.5194/gmd-4-381-2011)
- V2. not published. it also describes C, Alk and O₂.

The solution show to much nutrients in the Southern Ocean.

Carolina Dufour - Sensitivity of CO₂ fluxes to the SAM in the Southern Ocean

presents results obtained with PERIANT05 coupled to PISCES.

a paper will soon be submitted to GBC.

she investigates the response of natural CO₂ fluxes to the SAM in the Southern Ocean.

she find that the response is mostly intensified South of the polar front

she describes the response of various contributions to MLD DIC budget to the SAM

William McKiver - PELAGOS025: Using the biogeochemical flux model (BFM) at ORCA025 resolution

presents starting projects at CMCC (Bologna) with BFM within the frame of Green Seas projects

he is running PELAGOS025 BFM with NEMO 3.3.1

CMCC has switched from ORCA2 to ORCA025.

BFM describes 57 pelagic state variables.

the configuration runs on 960 physical core sur IBM P6. (23hr / 1month sur 224 procs.)

The aim is to redefine biogeochemical provinces with model results.

James Orr - Global-scale eddy transport of carbon in ORCA05- and ORCA025-PISCES

presents results about the Eddy transport of carbon in ORCA05-PISCES.

this study builds up on

- Lahkar et al. 2009 BG who investigated eddy fluxes of Anthropogenic CO₂
- Ishida et al. 2007 JPO who investigates eddy fluxes of CFC11

ORCA05-PISCES run with NEMO3.2.1 with DFS4.2 and GM parameterization

He noticed that DFS4.2 do not exhibit a significant trend in Southern Ocean winds as compared to NCEP.

He show that the DIC transport is very similar in ORCA05 and PERIANT05 with some discrepancies in the subtropical cell.

He uses Marotzke's decomposition : barotropic versus baroclinic component.

He finds that the baroclinic component is the largest except south of 40°S.

Olaf Duteil - Oxygen interannual variability in the eastern tropical Atlantic

shows results obtained at GEOMAR with Andreas Oschlies on sub-oxy regions.

He uses ORCA05-PISCES with CORE over 1958-2007

The model solution exhibits a spurious drift.

He show that there exist poorly ventilated regions in the Atlantic.

Future work will involve running a high resolution nest in ORCA05 with F. Shwarzkopf configuration at $1/10^\circ$

Summary of the discussion

The following groups mention their interest about biogeochemical applications with DRAKKAR models :

CMCC, NOCS, GEOMAR, LSCE, LEMAR/LPO, LEGI

the discussion focuses on the following questions :

- (a) are the groups willing to share a common ORCA025 physical setting for coupled biogeochemical applications
- (b) what key problems in the physics should be tackled for improved biogeochemical simulations ?
- (c) how can we proceed for defining and for sharing this setting

regarding (a), all the group agree that they would benefit from a standard ORCA025 setting being collectively defined.

The LEGI group proposes to host the material defining this setting on its web site.

The Kiel group would do the same for ORCA05. Twin ORCA05/ORCA025 setting would be highly profitable.

The actual ingredient of the configurations have been discussed. Several points would require additional discussion.

Among the issues that are not sorted :

- what kind of sss restoring should be used ?
- should we include the ice model and the forcing in the definition of the std configuration
- what model version should be used ?
- could we share a spin-up state ?

regarding (b), the key parameters for biogeochemical applications are : surface temperature and mixed layer depth.

in terms of water masses formation, a key element is the ventilation of the thermocline; most group seem not to care

to much about the problems with overflows (even for AABW). There might also be problems we don't know about yet.

Biogeochemical models should be viewed as indicators of physical biases.

regarding (c), it is clear that there exist no "reference" ORCA025 setting at the time of the meeting. we should aim at

defining this setting and make sure it is suited to biogeochemical applications. We agree on the following approach :

- by summertime, the LEGI group will define what they consider a good starting point.

- a videoconference will be organized for sharing results about ORCA025 settings and initiating the detailed discussion on the ingredients.
- by the next DRAKKAR meeting we will have defined a std ORC025 for biogeochemical applications

NB : we should make sure that NOCS biogeochemist are involved in the process if they want to. James Orr will discuss that point during his next visit at NOCS.

NB : Laurent Memery specifically asked to be associated to the process.

1.5 NEMO and other modelling issues

Development of NEMO (Rachid Benschila). Version 3.4 beta is available (for the new functionalities and development perspectives, see Rachid's presentation).

Development of the OASIS coupler (Sophie Valcke): Now OASIS 3 has been interfaced with MCT (Model Coupling Toolkit, developed at Argonne for the NCAR model). MCT does not need to gather all the 2D fields on one processor. This removes the bottleneck that existed in OASIS3. The new version OASIS3-MCT can be implemented without any change in the model components for the users of OASIS3.

Development of the IO server for NEMO (Sebastien Masson). The server does not use ioipsl anymore. Scalability is very good. It uses netcdf4 with the hdf library, which is not standard on all machines. This new IO server will be in NEMO version 3.5 next year.

2. Recommendations for a common ORCA025 model configuration and future simulations

There should be a reference ORCA025 configuration, distributed by the LEGI, and associated with a "reference" long experiment (if possible of better quality than ORCA025-G70).

Recent simulations that can be distributed to users are:

- ORCA025.L75-G85: NEMO 3.1, 50 years run with DFS4.3 forcing, but some corrections to the E-P budget during the run. There is no documentation of this run.
- ORCA025.L75-MJM95: the reference "free" run for Glorys V2 reanalysis, 1989-2009, ERA Interim forcing. There is a report describing it (it will be made available on the Drakkar web site).
- ORCA025.L75-GRD100: Ongoing run to be finished early 2012 , forced by DFS4.3 (ERA40 based) from 1958 to 1988, and continued with ERAi forcing from 1989 to 2009. NEMO3.2, new sea surface salinity restoring, and customisation drawn from the most recent experience at LEGI (increased bottom friction in Bering Strait, ...). Documentation will be written.

There will be a reference ORCA025 configuration that will be used by the U.K. Met Office for coupled model runs. The parameters will be proposed by NOCS. It will probably be close enough to the standard DRAKKAR version (but with CICE for the ice model).

For the future reference configuration:

- NEMO 3.4
- use tidal mixing
- Verify the bug found by the Met Office in the TKE scheme in version 3.3 is corrected;
- Verify the value for the penetration of TKE, following Keith Haine's findings (Gurvan, MetOffice)
- Increase even more the bottom friction in Bering Straits? The transport is still too large in ORCA025.L75-GRD100, even with increased bottom friction and an extra island.
- use the Neptune effect (Gurvan)? Suggestion: NOCS could test it first, doing a 10-years long simulation.
- The bathymetry was redone and re-checked for Glorys: it is O.K.
- Griffies form of the diffusion tensor: not ready to use yet - should be tested first on low resolution configurations (Gurvan).
- Ocean color for light penetration: need to make a correction following Olivier Aumont's suggestion (Gurvan).
- absolute or relative winds? Since the group has no strong recommendation on that issue, we recommend that sensitivity studies be carried out in coordination with all partners when possible.
- use a GM parameterization? not yet, it needs to be tested further in NATL025. Tests made by Paul Myers were inconclusive.

3. Evolution of the Drakkar forcing sets

- There is a need to correct the wind stress to match satellite observations such as Quikscat, in the manner of Large and Yeager;
- Work to ensure the continuity between ERA40 and ERA-Interim is underway;
- Remaining questions: are, what is the latest information on radiative flux corrections? what about the correction of precipitation proposed by Storto in his talk? Evaluation of flux variable corrections based on FOTO and ORCA246 will continue at LEGI for the first half of 2012 to elaborate the DFS5 forcing set based on ERAi.
- Regarding SSS restoring, we recommend a weak SSS restoring with a smoothing of the model SSS in the calculation of the relaxation.

4. Recommendations for future ORCA12 simulations

Planned work for the Grenoble team:

- keep 46 levels in the vertical
- include recent improvements in NEMO: tidal mixing,
- include parameterizations (shlat=0), bathymetry and forcing (including runoff) from the MED12 configuration over the Mediterranean Sea (remark: is this possible if MED12 uses flux forcing rather than bulk formulae?).
- Absolute/relative wind is still an open question... Bernard suggests to use relative wind but with spatial smoothing (a test is necessary with ORCA025...)
- Increase the bottom friction at Bering Strait, as sensitivity test (GRD100) shows good results.
- Switch to NEMO_3.4 !

(For the moment the Grenoble team is going to extend (10 supplementary years) the ORCA12.L46-MAL84 simulation (vector form) in order to have a 15-year simulation directly comparable to its flux form counterpart ORCA12.L46-MAL85 over the period 1978-1992.)

Planned ORCA12 work at NOC

Analysis of the 1979 to 2007 simulation with a particular emphasis on the comparison of the strengths and weaknesses of the NOC simulation with respect to the simulations performed in Grenoble and Kiel. Preliminary results so far have shown pronounced differences in the separation and variability of western boundary currents as well as in the strength of the Antarctic Circumpolar Current. One goal for 2012 is to produce two papers (in collaboration with the French and German groups) relating to western boundary currents:

- Paper 1: Assessment of WBCs in the suite of ORCA12 runs performed in France, Germany and the UK. The main focus will be on the position, strength and variability of surface and deep WBC.
- Paper 2: Meridional coherence of WBC variability. Main focus on link between WBC strength and position of eastward extensions and link between WBC strength/position and atmospheric forcing.

Other work will be dedicated to assess the impact of using tidal forcing (ideally, in combination with z -tilde coordinates). This work will involve short simulations (order 1 year). These runs will allow us to follow up to following research interests:

- Assessment of ORCA12's ability to reproduce baroclinic tides.
- Interaction of tides with near inertial gravity waves (NIGWs). Particular interest here is to find out whether the striking patterns of the very coherent NIGWs described in a recent paper by Blaker et al. (2012) are affected by tidal forcing (e.g. would NIGWs still travel virtually unhampered from mid-to high latitudes to the Equator and even beyond when tidal forcing is switched on).

Finally, we are planning to take first steps towards the coupling of ORCA12 to the N512 atmosphere run at NCAS in Reading. This is work that would be part of a proposal that has just been submitted and what we will do obviously depends on whether the proposal gets reviewed favourably but the first stage will involve early testing of the new IO-server code (due in version 3.5) which should alleviate IO-bottlenecks and permit scalability up to the many thousands of cores necessary to make such a coupled model viable.

Drakkar/MyOcean Workshop 2012, list of participants

Registered Participants (68)

LEGI - Grenoble (13): Bernard Barnier, Jean Marc Molines, , Albanne lecoindre, Julien Le Sommer, Thierry Penduff, Raphael Dussin, Gildas Mainsant, Pierre Brasseur, Carolina Dufour, Filippa Fransner, Pierre Antoine Bouttier, Aurélie Albert, Sandy Gregorio

LJK - Grenoble (2): Laurent Debreu, Arthur Vidard

GEOMAR - Kiel (8): Eric Behrens, Arne Biastoch, Markus Scheinert, Wonsun Park, Franziska Schwarzkopf, Christina Roth, Olaf Duteil, Lavinia Patara

LPO - Brest (5): Claude Talandier, Anne Marie Treguier, Henrick Berger, Julie Deshayes, Nicolas Barrier

LEMAR - Brest (2): Laurent Memery, Thomas Gorgues

LOCEAN - Paris (8): Sebastien Masson, Gurvan Madec, Rachid Benshila, Dorotea Iovino, Stephan Pous, Martin Vancoppenolle, Clément Rousset, Xavier Capet

Environnement Canada (1): François Roy

University of Alberta (1): Paul Myers

LSCE - Orsay (3) : James Orr, Marion Gehlen, Jennifer Simeon

NOC - Southampton (3): Joel Hirschi, Yevgeny Aksenov, Aurélie Duchez

ESSC - Reading (3): Keith Haines, Hao Zuo, Maria Valdivieso

University of Reading (1): Remy Tailleux

UKMO (2): Dave Storkey, Pat Hyder

MERCATOR-Ocean - Toulouse (6): Nicolas Ferry, Jonathan Beuvier, Jérôme Chanut, Eric Dombrowsky, Laurent Parent, Clément Bricaud

CERFACS Toulouse (2): Laurent Terray, Sophie Valcke

UNSW/CCRC Sydney (1): Paul Spence

MIT Boston (1): Fabien Roquet

CICESE - Ensenada (1): Julien Jouanno

CMCC - Bologne (3): Simona Masina, Andrea Storto, William McKiver

CNRM - Toulouse (2): Aurore Voltaire, Matthieu Chevallier