DRAKKAR WORKSHOP 2017

SESSION 1
Benefits of high resolution to the science made with ocean/sea-ice models

1. **Bernard Barnier (IGE - Grenoble): Low latitude western boundary current dynamics in the Indian Ocean.**

Abstract: Three hindcast simulations of the global ocean circulation differing by resolution (ORCA025 or ORCA12) or parameterization (free slip or partial slip) or atmospheric forcing (DFS or ERAi) are used to describe the interactions between the large anticyclonic eddies generated by the Somali Current system during the Southwest Monsoon. All three simulations bring to light that during the period when the Southwest Monsoon is well established, the Southern Gyre (SG) moves northward along the Somali coast and encounters the Great Whirl (GW). The interaction between the SG and the GW is a collision without merging, in a way that has not been described in observations up to now. This process is robust throughout the three simulations. The presentation will show that this process of interaction is not inconsistent with the satellite altimetry observations. The presentation will question the impact of the model numerics on the representation of this dynamical process. *(bernard.barnier@univ-grenoble-alpes.fr).*
Co-Authors: Quam Akuetevi, Jean-Marc Molines, Jacques Verron, Albanne Lecointre.

2. **Claudia Wekerle (AWI - Bremerhaven): Eddy-resolving simulation of the Atlantic Water recirculation in the Fram Strait.**

Abstract: The West Spitsbergen Current transports warm and saline Atlantic Water northwards through Fram Strait towards the Arctic Ocean. At Fram Strait, a fraction of the Atlantic Water recirculates and travels southward as part of the East Greenland Current. The mechanism of the recirculation is still not fully understood, and in particular the role of eddies. However, the pathways of Atlantic Water play an important role for the Arctic Ocean's heat budget. Experiments with three configurations of the global Finite Element Sea ice Ocean Model differing in mesh resolution in the Fram Strait area (4.5 km, 2 km and 1 km horizontal resolution) are used to investigate the mechanism of Atlantic Water recirculation. The Rossby radius of deformation, an indication for the size of eddies, is relatively small in high latitudes (around 2-6 km in the Fram Strait); and thus only the simulation with 1 km horizontal resolution can be considered as eddy-resolving. Our results show that this resolution is at least necessary to correctly represent the observed temperature structure and eddy kinetic energy in the Fram Strait. *(claudia.wekerle@awi.de).*

3. **Nicolas Jourdain (IGE – Grenoble): Impact of ice-shelf melt on the Amundsen Sea circulation and sea-ice.**

Abstract: This work is based on a regional 1/12° configuration of the Amundsen Sea, and makes use of the interactive ice shelf capability in NEMO-3.6. First, we quantify the impact of ice-shelf melt on the circulation inside and in front of the cavity (Antarctic Coastal current). Then, we show that more ice-shelf melt leads to less sea-ice in front of the cavities. We also discuss the influence of tides: how explicit tides influence ice-shelf melt, and how we can parameterize this effect in a simulation with no explicit tides. *(nicolas.jourdain@univ-grenoble-alpes.fr).*
Co-authors: Pierre Mathiot, Nacho Merino, Gaël Durand, Julien Le Sommer, Paul Spence, Pierre Dutrieux, Gurvan Madec.

4. **Paul Myers (U Alberta - Edmonton) : Pan-Arctic Exchange, the Labrador Sea and the AMOC**

Abstract: We use several different regional configurations of the NEMO model (including AGRIF nests) to look at Arctic-Atlantic exchange. The role of river runoff, melt from the Greenland Ice sheet (as well as its iceberg discharge) and high-frequency atmospheric forcing is examined to evaluate the model in terms of exchanges at the Arctic Gateways, water formation in the Labrador Sea and the North Atlantic overturning. Water mass pathways are examined through the use of passive tracers. Additionally, a simplified biogeochemical model, BLING, is coupled to NEMO and used to look at questions of productivity. *(pmyers@ualberta.ca).*
Co-authors: the University of Alberta NEMO Modelling Group.

5. **Eric Chassignet (Florida State University - Tallahasse): Impact of horizontal resolution (1/12 to 1/50 degree) on Gulf Stream separation and penetration in a series of North Atlantic numerical simulation**

Abstract: The impact of horizontal resolution (1/12 to 1/50 degree) on Gulf Stream separation and penetration is analyzed in a series of identical North Atlantic HYCOM configurations. The specific questions that will be addressed are as follows: How well do the simulations compare to observations? When is a solution "good enough"? Are the mesoscale and sub-mesoscale eddy activity representative of interior quasigeostrophic (QG) or surface quasigeostrophic (SQG) turbulence? We will show that the increase in resolution (1/50 degree) does lead to a substantial improvement in the Gulf Stream representation (surface and interior) when compared to observations and the results will be discussed in terms of ageostrophic contributions and power spectra. *(echassignet@fsu.edu).*
Co-Autor: Xiaobiao Xu.

6. **René Schubert (GEOMAR – Kiel): Prevalence of Instability-Driven Benthic Storms in the Western North Atlantic.**

Abstract: Mixed barotropic-baroclinic instability accompanied by deep cyclogenesis is a major driver for benthic storms below the Gulf Stream. To show this the output of the 1/20°-horizontal resolution ocean general circulation model VIKING20 was examined to investigate the relation between eddy-current energy transfer and benthic storms in the western North Atlantic. Benthic storms occurred most frequently below the Gulf Stream and the North Atlantic Current. Both currents were found to be associated with very strong eddy-current energy transfers.
Between Cape Hatteras and the New England Seamounts the Gulf Stream predominantly releases its energy to the eddy field. A part of this energy is provided to the development of benthic storms. The relevant physical process is identified to be cyclogenesis: developing meander troughs of the Gulf Stream are accompanied by cyclones that extent over the whole water column and occasionally are associated with large bottom velocities of up to more than 0.6 m/s. Regions of eddy kinetic energy source due to energy transfer were found to be located upstream of the center of the structure of highest benthic storm probabilities and upstream of the near-bottom eddy kinetic energy maxima. The upstream shift is characteristic for baroclinic instability, indicating that benthic storms in this region are mainly driven by instabilities of the Gulf Stream. *(rschubert@geomar.de).*

SESSION 2

OGCM evolution for basin-scale to global eddying simulations

2a - Future evolution of ocean/sea-ice models and of simulation practices.

7. **Marion Donat-Magnin (IGE - Grenoble): Impact of interactive ice-shelves on the ocean response to the SAM trend, and possible feedbacks with the ice-dynamics.**

Abstract: The observed positive trend in the Southern Annular Mode (SAM) may warm the Southern Ocean sub-surface through decreased Ekman downward pumping. Here we use interactive ice-shelves in a 1/12° regional NEMO-3.6 configuration of the Amundsen Sea. Our results show that the inclusion of ice-shelves changes the ocean response to the projected SAM trend, i.e. it inhibits a part of the SAM-induced subsurface warming. Sub ice-shelf melt increases above 400m and decreases below in response to ocean warming. The melt sensitivity to poleward shifting winds is nonetheless small compared to the sensitivity to an ice-sheet instability, i.e. to a projected change in the shape of ice-shelf cavities. Our work suggests the need for including ice shelves into ocean models, and to couple ocean models to ice-sheet models in climate projections. *(marion.donat-magnin@univ-grenoble-alpes.fr).*
Co-Authors: Nicolas Jourdain, Hubert Gallée, Paul Spence, Stephen Cornford, Julien Le Sommer, Gaël Durand.

8. **Pedro Colombo (IGE - Grenoble): Denmark Strait overflow in NEMO: does the type of vertical coordinate matters?**

Abstract: This paper compares the DSOW in realistic settings of NEMO using the different vertical coordinates available in NEMO: Z full cell, Z partial cell and the combination of Sigma-Z. *(pedro.colombo@univ-grenoble-alpes.fr).*
Co-Authors: Bernard Barnier, Thierry-Penduff, Jean-Marc Molines, Julien Le Sommer, Jérôme Chanut.

9. **Qiang Wang (AWI - Bremerhaven): Arctic-Subarctic Ocean fluxes: mechanisms and oceanic linkage.**

Abstract: The CORE-II (Coordinated Ocean-ice Reference Experiments Phase II) project provides a framework to evaluate ocean models and to study mechanisms of ocean phenomena and their variability. Although the performance and common issues in these ocean climate models were studied in a series of joint papers, the simulated oceanic linkage between the Arctic Ocean and North Atlantic has not been discussed. We use one of the CORE-II models (a FESOM configuration) to carry out sensitivity experiments to allow us (1) to better understand the driving mechanism of the variability of the Arctic-Subarctic Ocean fluxes and (2) to illustrate the oceanic linkage between the Arctic Ocean and North Atlantic. Besides the control simulation with CORE interannually variable forcing (IAVF), we did another two simulations. In one simulation we used the IAVF in the Arctic region while the normal year forcing (NYF) outside the Arctic Ocean, and in the other simulation we used the IAVF outside the Arctic Ocean while the NYF in the Arctic region. Using these simulations we identified different atmospheric modes controlling the interannual variability of Arctic-Subarctic ocean fluxes, and elucidated whether the variabilities of the Arctic Ocean and North Atlantic major circulations are linked through the oceanic pathways in the particular ocean model. *(qiang.wang@awi.de).*

10. **Xiaobiao Xu (Florida State University – Tallahassee): Global 1/12 degree HYCOM internannual simulation with Drakkar atmospheric forcing.**

Abstract: Preliminary results of an interannual 1/12 degree HYCOM global simulation forced by the DRAKKAR atmospheric forcing data set will be presented. *(xxu3@fsu.edu).*
Co-Author: Eric Chassignet.

11. **Mike Bell (UKMO – Exeter): Spurious baroclinic instabilities on the Lorenz grid**

Abstract: NEMO uses the Lorenz grid for its vertical discretisation. Spurious short-wave baroclinic instabilities were found to occur on the Lorenz grid by Arakawa and Moorthi (1988). As the vertical resolution of the grid improves, the most active of these instabilities become more and more trapped near one of the boundaries but they continue to grow at almost the same rate as the main, physically realistic, instabilities. We have reproduced these spurious instabilities in an analytical calculation which reduces the stability problem to a quadratic equation for their phase speeds. We outline this calculation and discuss the interpretation of the instabilities and whether they account for noise seen near the surface in equatorial regions of ORCA025. *(mike.bell@metoffice.gov.uk).*
Co-Authors: Andy White, Dave Storkey

12. **Torge Martin (GEOMAR – Kiel): What to consider for a high-resolution Enhanced-Greenland-Runoff simulation with NEMO.**

Abstract: The question of how enhanced melting of the Greenland ice sheet impacts the ocean seems to be answered. And yet, most of the studies implying that enhanced freshwater input to the subpolar North Atlantic yields a slowdown or even shutdown of the Atlantic Meridional Overturning Circulation (AMOC) are based on models of intermediate complexity or have insufficient spatial resolution to simulate mesoscale ocean activity. Böning et al. [2016] demonstrated that eddies spawned off the West Greenland Current play an important role in transporting freshwater into the subpolar gyre, where it affects deep convection. As part of the recently started PALMOD project the ocean and climate modeling group at GEOMAR currently sets up a new 1/10° ocean nest for the North Atlantic embedded in the new global Kiel Climate Model System (ECHAM6.3 T63L47, NEMO3.6-LIM2 0.5°L46) to better understand the role of mesoscale processes in translating Greenland meltwater into AMOC variability and quantify potential freshwater thresholds.
In preparation for Enhanced-Greenland_Runoff (EGR) experiments with this new model setup, a few matters that likely influence the impact of Greenland runoff on the model ocean need to be considered, such as the distribution of the runoff itself, the split between liquid and solid runoff (icebergs), remapping of the runoff to the ocean nest, and surface salinity restoring in the ocean-only reference case. We will discuss the spatial and seasonal inhomogeneity of Greenland runoff, a potential mask for iceberg meltwater input, runoff that gets lost on land, and questionable freshwater export from Arctic under-ice restoring as well as surface salinification of the East Greenland Current due to restoring. *(torge.martin@gmail.com).*
Co-Authors: Christina Roth, Arne Biastoch.

13. **Pierre Mathiot (UKMO – Exeter): Attempt to separate effects of horizontal resolution and bathymetry resolution using eORCA12 and eORCA025.**

14. **Rémi Tailleux (U. Reading): Conceptual issues and pitfalls associated with the use of neutral rotated diffusion tensors.**

Abstract: The impossibility to construct an exactly neutral density variable in the ocean implies that the effective diffusivity of all physically well- defined density variables subjected to neutral rotated diffusion is necessarily controlled --- at least partly --- by isoneutral diffusion. This problem complicates the inference of actual diapycnal mixing from Walin-type water masses analysis, as well as of the spurious diapycnal mixing from numerical advection schemes based on diagnosing the evolution of Lorenz reference state. This talk will report on efforts to quantify the problem by the NERC-funded INSPECT project. *(r.g.j.tailleux@reading.ac.uk).*
Co-Authors: Antoine Hochet (main author), Till Kuhlbrodt and David Ferreira.

2b - Ocean-wave model coupling (will be scheduled on Wednesday afternoon).

15. **Øyvind Breivik (NMI - Bergen): WAVE2NEMO: forcing a regional high resolution NEMO model with WAM fluxes and fields.**

Abstract: The WAVE2NEMO project, funded by Mercator through the Copernicus Marine Environment Monitoring Service (CMEMS), aims to implement a number of wave-related effects in the latest version (3.6) of NEMO for regional applications. We have implemented the Coriolis-Stokes force in the momentum equation (see Breivik et al, 2014, 2015, 2016) as well as modifying the flux of turbulent kinetic energy from breaking waves (following the Craig and Banner, 1994, approach). The water-side momentum flux is also modified to account for the growth and decay of waves. We are also investigating an alternative implementation of the Langmuir production term in the turbulence kinetic energy equation. The project will deliver a version of NEMO which ingests relevant wave parameters from a version of WAM set up on the same grid. The model has been implemented and tested on 4 km resolution for a domain covering the North Sea and the Baltic Sea. The model shows promising results for storm surge applications (Staneva et al, 2016) and sea surface temperature in the Baltic Sea (Alari et al, 2016). *(oyvindb@met.no).*
Co-Authors: Joanna Staneva (HZG), Victor Alari (Tallinn University of Technology), Paolo Pezzutto(ISMAR).

16. **Stéphane Law-Chune: (Mercator Océan – Toulouse): NEMO forced with MFWAM wave model at Mercator Océan.**

Abstract: Météo France was chosen by the Copernicus Marine Environment Monitoring Service to ensure the provision of wave forecasts on a global scale. The consideration of waves in ocean circulation and its feedback on sea states are therefore important topics for the next phases of systems development. In order to answer to this demand, some classical wave-current interaction processes are studied at Mercator-Ocean. These include the taking into account of the wave roughness and their growth in the calculation of surface fluxes, the mixing associated with their dissipation and the introduction of new terms related to the Stokes velocities in the momentum equation. The impact of these coupling terms on waves will be illustrated in oceanic configurations similar to those used in Mercator's systems, in particular in a one-dimensional (vertical) configuration, which makes it possible to estimate their contribution to the reproduction of the seasonal cycle of the mixing layer. Some illustrations at the global scale will also be discussed. *(Stephane.lawchune@mercator-ocean.fr).*

17. **Xavier Couvelard (LOPS – Brest): Toward improving oceanic forecasts through ocean and waves coupling.**

Abstract: The objective of ALBATROS project is to improve the representation of the interactions between ocean, waves, and atmosphere in a global forecasting model at high resolution in the framework of CMEMS (Copernicus Marine Environment Monitoring Service). Part of this project is to couple the waves model WW3 with the ocean model NEMO through OASIS3-MCT. The coupling is set up through the Stand Alone Surface module (SAS) of NEMO. This approach has been chosen by the mid term possibility of coupling it with the simplified Atmospheric boundary layer model SIMBAD (SIMplified Boundary Atmospheric layer moDel for ocean modeling purposes). As a first step toward the global simulations, it has been chosen to implement the coupling on the regional configuration IBI12 (North East Atlantic at 1/12 degree).
The setup of the coupling between the hydrodynamic code (OPA) and the surface module (SAS) will be described. It will be shown that the constraints of the coupling only slightly change the surface forcing, while the differences on the surface velocities can be locally important. The coupling strategy between OPA-SAS and WW3 will be also presented. It will be shown that taking in account only the surface rugosity induced by the waves and the wind stress absorbed by the developing waves, has very little impact on simulated seasonal fields. Taking in account the TKE injection by wave breaking is expected to lead to more significant differences. *(Xavier.Couvelard@ifremer.fr).*
Co-Authors: Jean-Luc Redelsperger, F.abrice Ardhuin, Florian Lemarié, Claude Talandier, Guillaume Samson.

18. E.Clementi (INGV – Bologna): NEMO-Wave coupling Working Group: overview and last achievements.

Abstract: The NEMO consortium dedicates specific efforts in understanding the relevance of Atmosphere-Wave-Ocean exchanges processes and their roles in driving the ocean circulation at both coastal and global scales. To this end a Working Group on NEMO-Wave coupling has been created with the specific goal to identify required actions and code developments.
In particular the working group is exploring the way in which surface gravity waves can influence the ocean circulation.
This presentation is meant to give an overview of the actual NEMO-Wave coupling implementation, in particular focusing on the last improvements achieved: new 3D Stokes Drift formulation, Stokes-Drift term, modified tracer advection, generalization of the surface boundary condition for momentum accounting for the wave effects, vertical enhanced mixing due to waves.
Co-Authors: J. Castillo[3], G. Madec[2], R. Benshila[2], Y. Aksenov[5], L. Aouf[4], L. Bricheno[5], A. Coward[5], D. Delrosso[1], M. Drudi[1], T. Graham[3], C. Guivarch[5], C. Harris[3], J. Hirschi[5], L. Hosekova[5], S. Law Chune[4], G.Mattia[1], A. New[5], G. Nurser[5], N. Pinardi[1], J. Wolf[5], M. Yelland[5] ([1]INGV, [2]LOCEAN, [3]UKMO, [4]MERCATOR-Ocean, [5]NOCS).

SESSION 3

Atmospheric driving of eddying OGCMs

19. Alex Megann (NOCS - Southampton): Evaluating Forcing Datasets for late 20th-Century NEMO integrations.

Abstract: The Atlantic Climate System Integrated Study (ACSIS) is a major new NERC-funded programme in the UK, whose main objective is to understand recent changes in the North Atlantic climate system. A suite of NEMO/CICE configurations is being set up under ACSIS, which will be integrated in forced mode at both 1/4° and 1/12° resolutions from 1959 to the present decade.
The principal aim of the initial stage of the project is to select a forced ocean configuration that reproduces changes in the ocean over the last fifty years with an acceptable realism. An ensemble of trial integrations at 1° and 0.25° using CORE2, DFS5.2 and JRA55 forcing reveals a range of responses to the different forcing datasets. The models all drift, with some showing unrealistic trends in the surface temperature and others having an imbalance in surface heat flux of up to 1 W/m2, leading to excessive long-term tendencies in ocean heat content. The large-scale evolution of the upper ocean is found to be more sensitive to the choice of forcing than to the horizontal resolution.
The downwelling longwave flux in both CORE2 and DFS5.2 datasets is known not to represent well the anthropogenic radiative forcing changes in recent decades. We will describe a modification to the applied longwave flux to make it more consistent with that simulated in the CMIP5 model ensemble, and the changes this brings to the model simulations. *(apm@noc.ac.uk).*
Co-authors: Bablu Sinha, Adam Blaker, Simon Josey.

20. Clark Pennelly (U. Alberta - Edmonton): Numerical modeling in the northern Atlantic: Labrador Sea freshwater and model sensitivity to atmospheric forcing.

Abstract: The northern Atlantic contains regions of deep convection, areas where the surface water exposed to the atmosphere is sequestered to great depths due to winter-time buoyancy loss. The convection strength can be changed due to the stratification at convection locations. We used numerical simulations to understand the input of freshwater, which can strengthen the stratification in the Labrador Sea. Three configurations were used, ANHA4 (Arctic Northern Hemisphere Atlantic ¼ degree), ANHA12, and ANHA4 with an AGRIF nest in the sub-polar gyre to produce 1/12 degree resolution. We examined the freshwater transport, relative to 34.8 g/kg, across the 750m, 1000m, 1500m, and 2000m isobaths in the Labrador Sea. Freshwater transport was calculated using three velocities: the total ocean velocity, the mean velocity (averaged over 25 days), and the turbulent velocity.
We also examine model sensitivity to four different atmospheric forcing datasets and their impacts on ocean processes in the northern Atlantic. We explore differences between the Canadian Meteorological Centre's Global Deterministic Prediction System (CMC-GDPS), ERA-Interim, DRAKKAR forcing set 5.2, and CORE2 atmospheric dataset in both their atmospheric state, as well as the ocean state when forced with identical conditions. *(pennelly@ualberta.ca).*
Co-Authors: Xianmin Hu, Paul G Myers.

21. **Pat Hyder (UKMO – Exeter): Understanding (Atmospheric) drivers of ocean SST and near surface temperature biases.**

Abstract: We use Atmospheric and Coupled Model Inter-comparison Project (AMIP5, CMIP5) output and observations to show, for the first, time that these biases are principally due to systematic errors in the representation of the atmospheric processes which control ocean-atmosphere exchanges. For the region 40-60S variations in simulated net surface heat flux across the AMIP5 models explain ~70% of the variance in sea surface temperature (SST) for the corresponding coupled models. AMIP5 net fluxes also explain ~52% of the variance across coupled models in the latitude of the Southern Ocean westerly wind jet, through associated SST-atmosphere feedbacks. (*patrick.hyder@metoffice.gov.uk*).

22. **Rafael Abel (GEOMAR – Kiel): Feedback of mesoscale ocean currents on atmospheric winds in high-resolution coupled models and implications for the forcing of ocean-only models**

Abstract: The repercussions of surface ocean currents for the near-surface wind speed and the air-sea momentum flux are investigated in two versions of a global climate model with eddying ocean. We find a clear signature of a mesoscale oceanic imprint in the wind fields over the energetic areas of the oceans, particularly along the extensions of the western boundary currents and the Antarctic Circumpolar Current. These areas are characterized by a positive correlation between mesoscale perturbations in the surface currents curl and the wind curl. The positive feedback of mesoscale current features on the near-surface wind acts in opposition to their damping effect on the wind stress. A tentative incorporation of this feedback in the surface stress formulation of an eddy-permitting global ocean-only model leads to a gain in the kinetic energy of up to 10%, suggesting a fundamental shortcoming of present ocean model *configurations.* *(rabel@geomar.de).*
Co-Authors: Claus W. Böning (GEOMAR), Richard J. Greatbatch (GEOMAR), Helene T. Hewitt (Met Office), Malcolm J. Roberts (Met Office).

SESSION 4

The eddy-permitting regime (e.g. ORCA025)

23. **Guillaume Sérazin (LEGOS – Toulouse): A global probabilistic study of the Ocean Heat Content low-frequency variability: atmospheric forcing versus oceanic chaos.**

Abstract: A global 1/4° ocean/sea-ice 50-member ensemble simulation is used to disentangle the low-frequency imprints of the atmospherically-forced oceanic variability and of the chaotic intrinsic oceanic variability (IOV) on the large-scale (10° x 10°) ocean heat content (OHC) between 1980 and 2010. The IOV explains most of the interannual-to-decadal large-scale OHC variance over substantial fractions of the global ocean area that increase with depth: 9%, 22%, and 31% in the 0-700m, 700-2000m and 2000m-bottom layers, respectively. Such areas concern principally eddy-active regions, mostly found in the Southern Ocean and in western boundary current extensions, but also concern the subtropical gyres at intermediate and deep levels. The oceanic chaos may also induce random multidecadal fluctuations so that large-scale regional OHC trends computed on the 1980-2010 period cannot be unambiguously attributed to the atmospheric forcing in several oceanic basins at various depths. These results are likely to raise detection and attribution issues from real observations. *(guillaume.serazin@legos.obs-mip.fr).*
Co-Authors: Thierry Penduff (IGE).

24. **Thierry Penduff (IGE – Grenoble): Atmospherically-modulated oceanic chaos; observational implications.**

Abstract: One of the 3 NEMO-based 1/4° ensemble oceanic simulations performed during the OCCIPUT project is a North Atlantic (NATL025) hindcast, where the 50 ensemble members are slightly perturbed at the beginning and then driven by the same ensemble-mean DFS5.2-based air-sea fluxes from 1993 to 2012. These ensemble simulations are being analyzed to study the respective imprints of the intrinsic/chaotic oceanic variability (which feeds the ensemble spread) and of the atmospheric variability on the ocean state and multi-scale evolution. The analysis of the results in and around the Gulf of Mexico reveal a rich variety of instantaneous ensemble statistics, ranging from quasi-gaussian with a simple temporal modulation of its mean value by the atmospheric variability, to highly non-gaussian (e.g. bimodal) with a more complex atmospheric modulation. We propose an entropy-based metric to identify the regions (and periods) where the atmospheric forcing reduces the inherent ocean chaos (ensemble entropy or disorder). We conclude by a presentation of research projects which aim to valorize such ensemble simulations for observational oceanography in various regions of the Global Ocean. *(thierry.penduff@univ-grenoble-alpes.fr).*
Co-Authors: Pierre-Vincent Huot, Stéphanie Leroux, Ixetl Garcia-Gomez, Jean-Michel Brankart.

25. **Guillaume Maze (LOPS - Brest): Eddy-permitting ORCA025 representation of large-scale stratification features in the North-Atlantic.**

Abstract: We will evaluate how the subtropical mode waters and pycnocline is represented in the ORCA025 GJM189 simulation with 75 vertical levels and present a major resisting flaw with regard to the representation of large-scale stratification features. The evaluation metrics will be computed from (i) the OACP algorithm (Feucher et al, 2016) that diagnoses objectively the properties of the subtropical permanent pycnocline and surface mode waters, (ii) the large-scale un-supervised classification of profiles (Maze et al, 2017) that diagnoses objectively interior ocean heat patterns and (iii) standard mode water diagnostics. These metrics will be assessed over time (from 1958 to 2015) and their climatology compared with Argo-based references. We will (1) show how subtropical surface mode waters and permanent pycnocline are biased toward warmer, shallower and more stratified states compared to observations, (2) document how the correct stratification features present in the initial conditions (1958) are destroyed and replaced by the biased model state, and (3) attempt to interpret these results in terms of wind-driven vs buoyancy-driven subtropical gyre circulations.
(Guillaume.Maze@ifremer.fr).
Co-Authors: Charlène Feucher, Herlé Mercier.

26. **Jens Terhaar (LSCE-IPSL – Orsay): Simulated anthropogenic carbon in the Arctic Ocean in three DRAKKAR model configurations**

Abstract: The Arctic Ocean is projected to experience amplified ocean acidification, more than any other region in the world ocean. To simulate its future changes with ocean models, we must first be able to simulate baseline conditions and Arctic acidification over the industrial era, i.e., at least for the main driver, increasing CO2. Here we compare anthropogenic CO2 uptake in DFS-forced simulations of three global configurations of the NEMO-PISCES model (ORCA2, ORCA05, and ORCA025) and we evaluate results with available observations. The comparison revealed a notable dependence of the simulated anthropogenic carbon inventory (total mass stored in Arctic basin) on resolution. While the 2° configuration stored 1.6 Pg C between 1860 and 2005, the ½° and ¼° versions took up 1.9 and 2.2 Pg C, respectively. Those simulated results are lower than data-based estimates (3.0 Pg C), but the latter may over-predict anthropogenic carbon in the Arctic, as already shown in the Mediterranean Sea. Indeed, evaluation of the models with CFC-12 (another transient tracer) suggests that simulated ventilation of subsurface waters are roughly on target in the ORCA025 configuration, while data-based estimates overestimate deep-water concentrations. These simulations further indicate that about ¾ of the anthropogenic carbon in the Arctic Ocean enters that basin through lateral transport rather than by a flux across the air-sea interface (via gas exchange). In other ocean areas, transfer by gas exchange generally dominates. The simulated inventory increases with resolution as net lateral transport of anthropogenic carbon into the basin increases. Wider comparison to results from CMIP5 (typically coarse-resolution models) reveals larger diversity. Lateral transport is generally the dominant means by which anthropogenic carbon enters the Arctic, and that transport appears particularly sensitive to model resolution and bathymetry as well as an ocean model's forcing or coupling to an atmospheric model.
(terhaar.jc@gmail.com).
Co-Authors: James Orr, Laurent Bopp

27. **Jan Klaus Rieck (GEOMAR – Kiel): Decadal Variability of Eddy Kinetic Energy in ORCA025 - Sensitivity Studies**

Abstract: An ocean-sea ice model (NEMO 3.6, LIM2) at eddy-permitting resolution (1/4°, ORCA025) is used to study decadal variability of oceanic Eddy Kinetic Energy (EKE). In an exemplary region in the South Pacific (25-33°S, 153-180°W) decadal variability of EKE and its relative amplitude of ~100% of the mean EKE are consistently represented across various model resolutions and satellite observations. To investigate the causes for this decadal variability, two sensitivity model runs use either climatological (normal year) wind stress forcing and interannual buoyancy forcing or vice versa. Another experiment aims to show the influence of a reduced biharmonic viscosity operator on EKE. *(jrieck@geomar.de).*

Waiting list