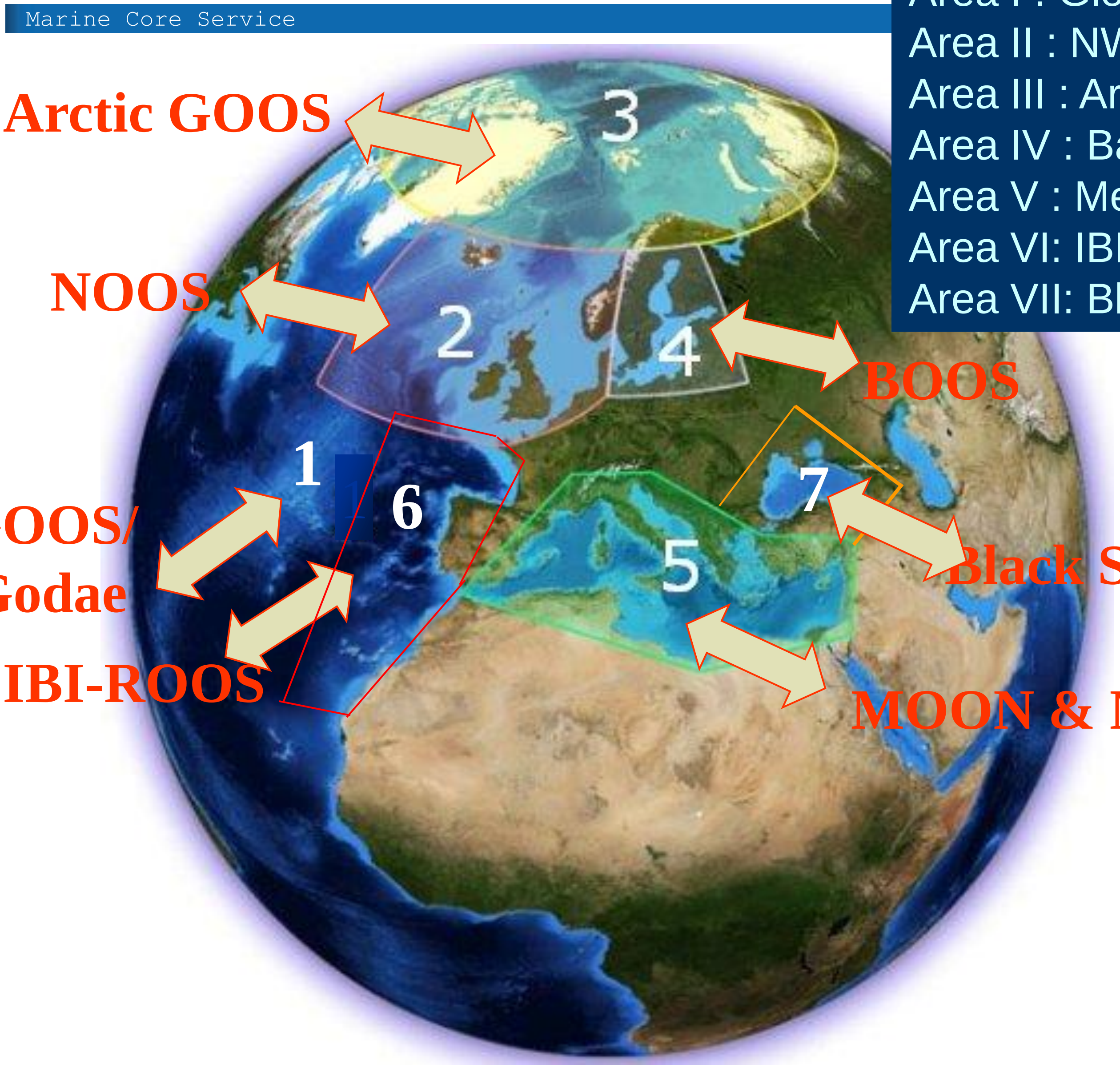
WP4 - Benchmarks (lead - CNRS)

- **Objective**: assessment of data assimilation methods on systems of different complexity from small-scale to realistic large-scale systems (*close to operational configurations*)
- **Configurations**: Lorenz-95, NEMO double-gyre, NEMO North Atlantic 1/4° (will be detailed by Jean-Michel Brankart afterwards) - *NEMO is central to medium and large scale config, making WP4 quite relevant for MyOcean*
- **Benchmarks**: first specification proposed in Deliverable 4.1 (do we need to be more specific ?)
- **Metrics**: first definition proposed in Deliverable 4.1, complient with probabilistic methods only (to de developped by Guillem Candille tomorrow)
- **All SANGOMA partners involved in WP4** (especially in medium-size benchmark, to be shared by all partners): are we ready to run the proposed benchmarks ?
- **WP4 extended to variational methods (+ global configuration)** in OSTST proposal dedicated to altimetric DA, to be funded by NASA/CNES (2013-2016)
- **Medium-case configuration**: corresponds to the NEMO SEABASS reference configuration of the NEMO-ASSIM component (decision from last NEMO-ASSIM WG, to be confirmed by NEMO steering soon)
- **NEMO-ASSIM** invites SANGOMA to contribute to the next meeting (or maybe a joint workshop could be organized earlier ?): which tools could we share (ASM or OBS interface modules, TAM etc.) ?

MyOcean: regional coverage

Area I : Global & N. Atlantic
Area II : NW Shelves
Area III : Arctic
Area IV : Baltic Sea
Area V : Mediterranean Sea
Area VI: IBI
Area VII: Black Sea



A2.1 - Physical Ocean Modelling
Development plan

Marine Core Service

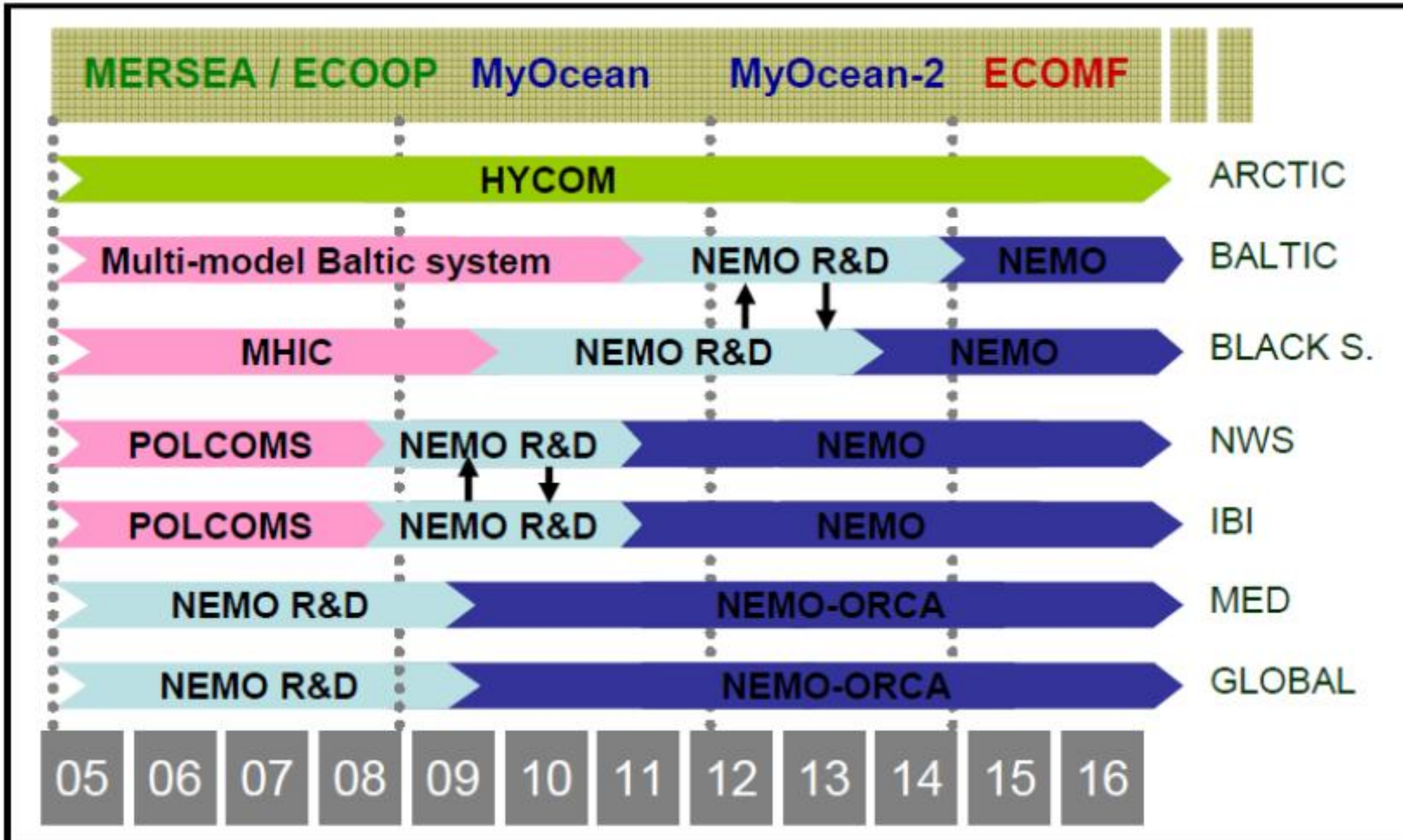
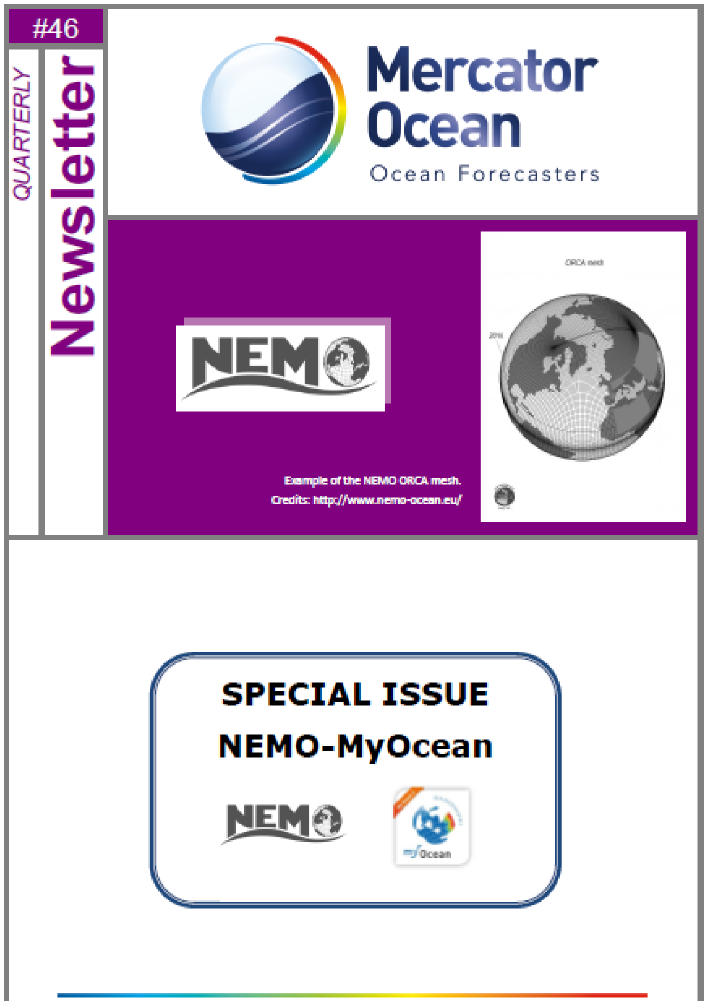


Table 1. Development plan for physical model system evolutions in the MyOcean MFCs

NEMO-ASSIM component

Marine Core Service



TOWARD A DATA ASSIMILATION SYSTEM FOR NEMO

By P.-A. Bouttier[1], E. Blayo[2], J. M. Brankart[3], P. Brasseur[3], E. Cosme[3], J. Verron[2] and A. Vidard[2]

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Abstract

In this note, we discuss the project that has been conceived and the first achievement steps that have been carried out to set up a data assimilation system associated to NEMO. Of specific interest here are applications to operational oceanography. This data assimilation system is schematically made of three subcomponents: Interface Components, Built-in Components and External Components. Several elements of this NEMO data assimilation system have already been developed by various groups in France and in Europe and several of them could be introduced in the system (the linear Tangent and Adjoint Model, TAM, is one of the most important of them as far as variational assimilation is concerned), some others will require specific developments. Finally, we introduce the SEABASS reference configuration that is proposed to be the NEMO data assimilation demonstrator and the experimentation and training platform for data assimilation activities with NEMO. These various thoughts take advantage of the advances and discussions that have been carried out by the NEMOASSIM working group.

Introduction

Other contributions of this issue discuss how the NEMO modeling platform can be used to simulate the time evolution of the ocean circulation including its variability from global to regional scales. Due to the non-linearity of the equations governing the ocean dynamics, a wide range of such temporal and spatial scales interact together in such a way that the ocean evolution is partly chaotic and beyond some limit, unpredictable. Therefore, the routine monitoring and forecasting of oceanic variables, which is the essential goal of Operational Oceanography, must be treated as a series of inverse problems that require observed data at regular intervals to re-initialize the model state "close" to the observed ocean using all available data combined with the latest model predictions. In this respect, operational ocean monitoring is similar to numerical weather forecasting.

The terms "Data Assimilation" (DA) designate the range of objective methods enabling optimal combination of observations, model simulation and error statistics, in order to reduce as much as possible the uncertainty of ocean state estimations involved in short-term predictions or more or less long-term reanalyses. Very significant progress has been accomplished in ocean data assimilation during the past 20 years in the framework of a variety of pre-operational projects, such as the French SIMAN/QADRAN program in the nineties (e.g. Blayo et al., 1994), the DIADEM, TOPAZ (Brusdal et al., 2003), ENACT (Davey et al., 2006) and MERSEA European projects (Brasseur et al., 2005), and more recently the GMES MyOCEAN and on-going MyOCEAN2 and SANGOMA projects. The choice made in Europe to routinely monitor the ocean down to the meso-scales has strongly guided the first stages of the assimilation strategy in place today in most operational centres. At international level, the effort of the nations involved in the development of DA for Operational Oceanography were coordinated in the framework of GODAE (Cummings et al., 2009), demonstrating the relevance of the concept which is further developed in the framework of the on-going GODAE Oceanview.

Briefly speaking, two different categories of algorithms can be distinguished to solve the DA inverse problems: the optimal control approach, most often based on the variational adjoint method (Le Dimet and Talagrand, 1986) and the stochastic methods mostly derived from the Kalman filter concept. In its 4D-Var formulation, the variational method requires the adjoint of the linear tangent model to compute the gradient of the cost function to be minimized, and in that case can therefore be designated as a « model-dependent » DA method. By contrast, stochastic methods such as the Ensemble Kalman filter introduced by Evensen (1994) or the SEEK filter introduced by Pham et al. (1998) can be considered as « model-independent » DA methods which intensively use the direct model code to propagate ensemble statistics, while the update of these ensemble statistics requires additional « model-independent » algebraic operations. The EU SANGOMA project has been set up during the period 2012-2015 to advance stochastic assimilation methods, focusing on non-linear and non-Gaussian assimilation schemes to be used in the next operational systems of the GMES Marine Core Services.

Due to the fast evolution of ocean models during the past 20 years, thanks mainly to computer power increases, the flexibility of « model-independent » DA methods has been an asset to follow the successive updates of ocean model versions without much recoding. Today, the convergence of some of the oceanographic community in Europe toward the NEMO modeling platform provides the opportunity to revisit the overall assimilation strategy, since a more stable and smoother evolution of the model platform can be expected in the future. This is in essence the primary motivation of the project described in the present paper.

Despite some earlier attempts, no assimilation system had ever been formally included in the NEMO system so far. However, a number of DA frameworks already use NEMO as model component: e. g. SESAM (Brankart et al., 2001), SAM (Drillet et al., 2008), OPAVAR/NEMOVAR (Weaver et al., 2003, Mogensen et al., 2009), OceanVar (Dobricic and Pinardi, 2008) and many papers have been published discussing data assimilation results within OPA/NEMO. Since some common components are required by every system, there was therefore some duplication of

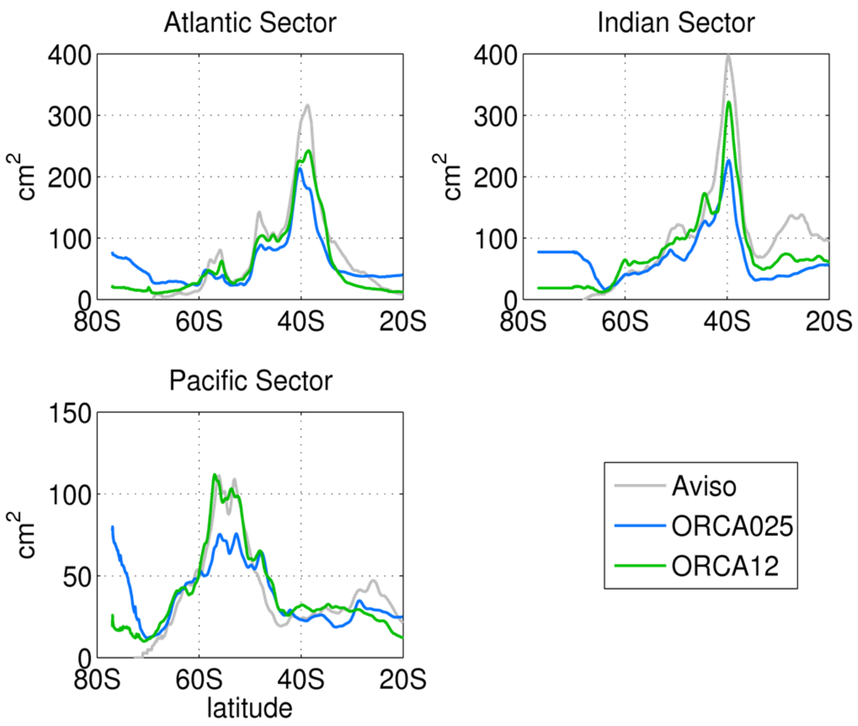
Some questions for tomorrow

- What are the users that SANGOMA intends to consider as a priority ?
- How does SANGOMA address assimilation issues of the MyOcean MFCs ?
- Is the NEMO-ASSIM initiative an opportunity to be considered by SANGOMA ?

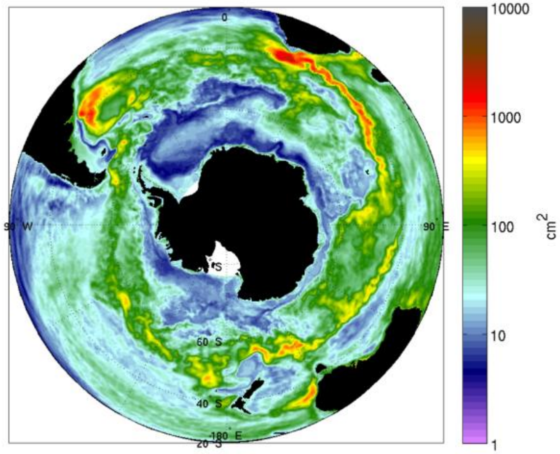
In case of questions

ORCA12 vs ORCA025 ?

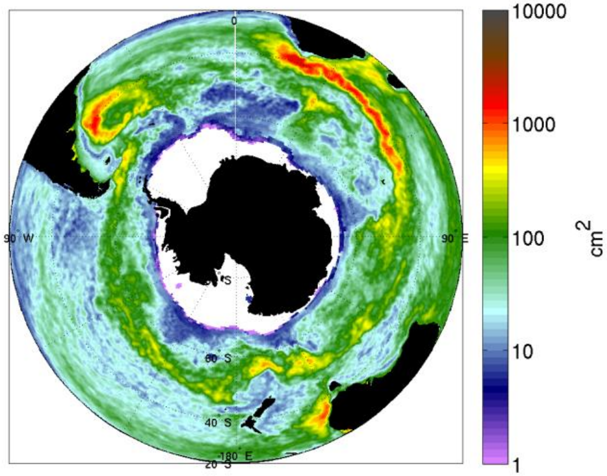
Conclusion 1: Significant improvements in SSH variability and circulation patterns



ORCA12



AVISO



BaltiX project: implementation of NEMO in the Baltic Sea (Open Call 2010: SMHI, FMI, DMI)

Achievements:

- **Implementation/validation of NEMO/LIM3 (2 nm resol., 84 z-levels)**

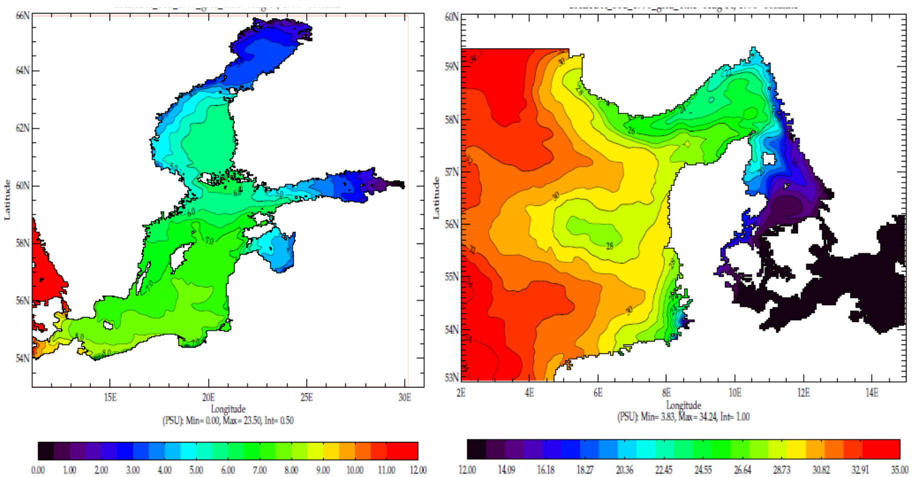
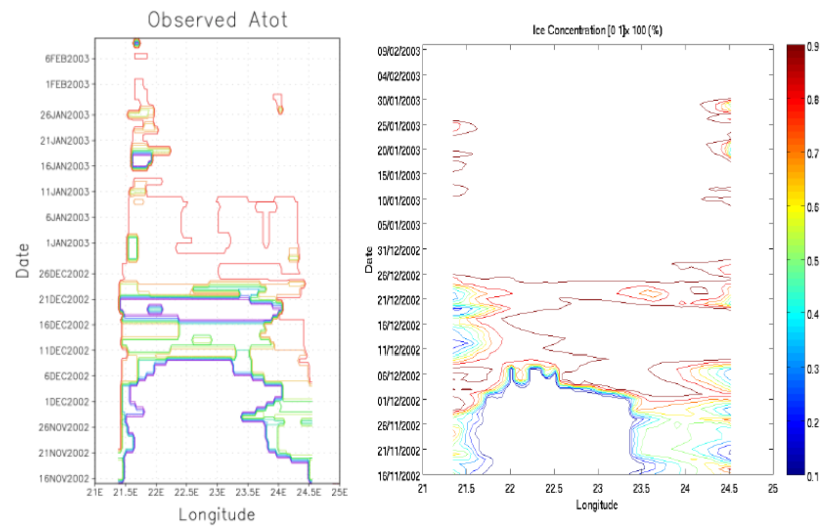


Figure 16: BaltiX simulated surface salinity for August 1990, whole domain and zooms over the Baltic Sea, and the North Sea



(a) Observed ice concentration

(b) NEMO/LIM3 ice concentration

Figure 26: The observed and NEMO/LIM3 modelled evolution of ice concentration.

Main conclusions/lessons:

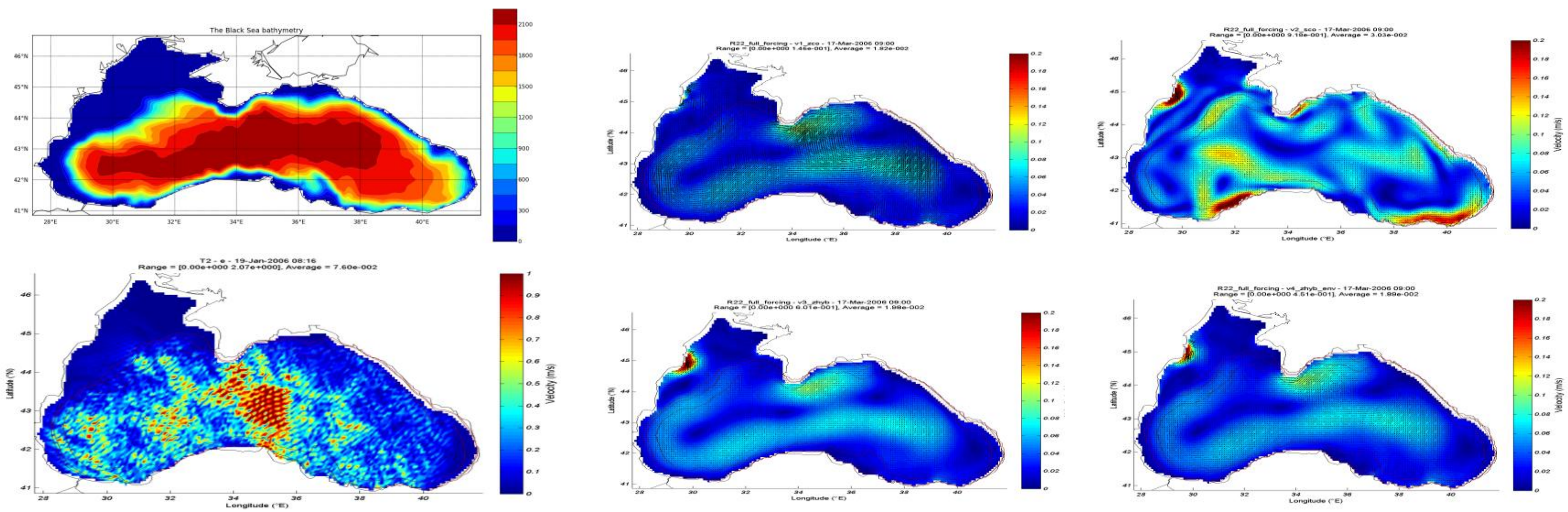
- Higher resolution needed (~0.5 nm) for local forecasting ;
- LIM3 has to be improved (too diffuse ice thickness, maybe ice advection problem)
- **Built-in assimilation scheme required for operational transition** ;

A2.1 - Physical Ocean Modelling
Regional configurations: Black Sea

Black Sea project: implementation of NEMO in the Black Sea (Open Call 2009: <u>UoP</u>, MHI, IMS-METU, INGV)

<u>Achievements</u>:

- **Implementation/tuning of NEMO-BS12 (1/12°x1/16°, 33 levels)**
- **Sensitivity studies w.r.t. vertical coordinate and horizontal diffusion**



<u>Main conclusions/lessons</u>:

- Vertical coordinate (z vs sigma vs. hybrid z-sigma) is still an issue ;
- **Built-in assimilation schemes required for operational transition (target = VAR)** ;

WP4: Benchmarks: Distribution of the model configurations

CNRS-LEGI, Grenoble, France

SANGOMA 1st year meeting – November 26-28, 2012

Benchmarks: distribution of the model configuration

1. The NEMO ocean model
2. SANGOMA webpage on benchmarks
3. Small case benchmark
4. Medium case benchmark
5. Large case benchmark

1. The NEMO ocean model

Ocean Modelling System developed and managed by the NEMO Consortium

Mercator	CNRS	CMCC	INGV	UKMO	NERC
Operational	Research	Research	Operational	Operational	Research

WIDE and DIVERSE COMMUNITY OF USERS

Research ⟷ **Operational**

NEMO home page

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About NEMO | About Us

What is NEMO?

NEMO (Nucleus for European Modelling of the Ocean) is a state-of-the-art modeling framework for oceanographic research, operational oceanography seasonal forecast and climate studies.
NEMO includes:

- 5 major components
  - the blue ocean (ocean dynamics, NEMO-OPA)
  - the white ocean (sea-ice, NEMO-LIM)
  - the green ocean (biogeochemistry, NEMO-TOP) ;
  - the adaptative mesh refinement software (AGRIF) ;
  - the assimilation component NEMO_TAM
- some reference configurations allowing to set-up and validate the applications ;
- a set of scripts and tools (including pre- and post-processing) to use the system.

NEMO is used by a large community: 240 projects in 27 countries (14 in Europe, 13 elsewhere), 350 registered users (numbers for year 2008). See "NEMO Projects"

NEMO is available under the CeCILL license (public license).
To gain access to the system, you need to register (click here or on "Register" in top right panel).

The evolution and reliability of NEMO are organised and controlled by a European Consortium created in 2008 between

- CNRS (France),
- Mercator-Ocean (France),
- NERC (UK)
- UKMO (UK). , and since 2011
- CMCC (Italy)
- INGV(Italy)

"Purpose of the Consortium
The purpose of this Agreement is to set up appropriate arrangements for the successful and sustainable development of the NEMO System as a well-organised, state-of-the-art ocean model code system suitable for both research and operational work."

Text of the Consortium Agreement is here:

AC_NEMO_VF.txt.pdf 3.35 MB

NEMO is a shared reliable evolving system. These objectives rely on the work of the **NEMO System Team**.

Centro Euro-Mediterraneo per i Cambiamenti Climatici | CNRS | INGV | Mercator Ocean | Natural Environment Research Council | Met Office

News

NEMO Consortium
INGV and CMCC new members

2011 NEMO Users meeting
2011 NEMO Users meeting 29-30 June 2011

NEMO release nemo_v_3_3_1
Annoucement of nemo_v3_3_1 12 April 2011

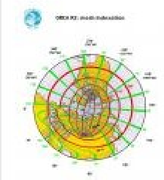
NEMO release nemo_v3_2_2 and its adjoint model (for dynamics)
Annoucement of nemo_v3_2_2 and adjoint 12 April 2011

« November »

Mon	Tue	Wed	Thu	Fri	Sat	Sun
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Gallery

North pole meshmask



NEMO user guide

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User Guides | Configurations | FAQ | NEMO Browser | NEMO Mailing List Archives | Pre and post processing packages

Basics

NEMO Quick Start Guide

To allow easy set up of NEMO in your environement.

CPP keys V3_3

List cpp keys and functions

Detailed Launching Guide

This article is designed to give you the principal steps to install and lauch a simulation.
NEMO System (codes and environment) is available throught a general structure called MODIPSL, used for all models and configurations at IPSL.

Target platforms

Some computers on which NEMO is in use

Examples

You can find here some examples on common operations. This article is meant to be regularly updated as more typical use-cases can be found. Feel free to contribute !

ARCHIVES

Previous versions

Advanced

Using Trac

To start with Trac for NEMO

Using and developping with dynamical allocation

Implementation of dynamical allocation in NEMO (since tag v3_3_1)

How to set up one simulation

This article deals with setting up your simulation, from input files to run configuration (with comments for each parameter), as well as restart files and parallel runs.

How to add/modify [new] modules or new cpp keys

Check out this article to know everything there is to know on CPP keys.

How to build a new configuration

Read this if your looking for information about building your configuration and preparing the necessary input files.

Getting and installing NEMO

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NEMO Quick Start Guide

Table of contents

Installing NEMO using FCM (since nemo_V3_3)

For general information on the content of NEMO reference and differences between reference and specific configurations, see here

Requirements:

- bash installed
- perl installed
- svn installed
- fortran90 compiler installed
- netcdf installed

FCM (Flexible Configuration Manager, developped at UKMO ©Crown Copyright 2005-10) is used for build process only, i.e. from the source code to the executable.

Installation

Extract NEMOGCM (using the "my_login" /pw registered on this web site):

```
svn --username "my_login" co http://forge.ipsl.jussieu.fr/nemo/svn/tags/nemo_v3_3/NEMOGCM
```

The main script is called **makenemo,** located in the CONFIG directory.To identify the source code you need, build the makefile and run it:
RUN makenemo:

```
cd NEMOGCM/CONFIG; ./makenemo [options, see below]
```

2. SANGOMA webpage on benchmarks

Stochastic Assimilation for the Next Generation Ocean Model Applications

Benchmarks

Comparison and assessment of impacts of assimilation methods on systems of different complexity:

- Small case benchmark: Lorenz-40 model
- Medium case benchmark: double-gyre NEMO configuration
- Large case benchmark: North-Atlantic 1/4° NEMO/LOBSTER configuration

The benchmarks include (i) the detailed specification of the model configurations and assimilation alogrithm, (ii) the definition of a set of metrics to assess the performance of the assimilation systems, and (iii) the eveluation of the results of the experiments:

- Detailed specification of benchmarks
- Definition of metrics
- Evaluation of the results

3. Small case benchmark

SANGOMA Stochastic Assimilation for the Next Generation Ocean Model Applications

Small case benchmark: Lorenz-40 model

The small case benchmark is based on the portable Lorenz-40 model (Lorenz and Emmanuel, 1998). The model is available:

- in Fortran, in the PDAF software,
- in Java, in the openDA software, or
- in Matlab, in the EnKF Matlab code.

References

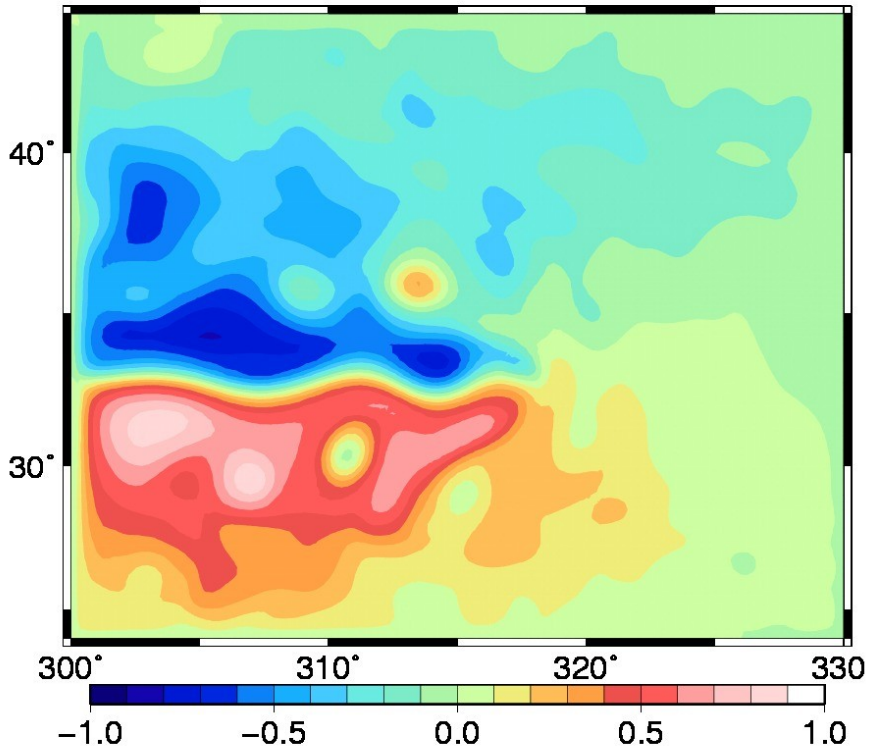
- Lorenz, E. N. and K. A. Emanuel, 1998: Optimal sites for supplementary weather observations: Simulation with a small model. J. Atmos. Sci., 55, 399-414.

4. Medium case benchmark

SANGOMA Stochastic Assimilation for the Next Generation Ocean Model Applications

Medium case benchmark: Double-gyre NEMO configuration

The medium case benchmark is based on an idealized configuration of the NEMO ocean model: a square and 5000-meter deep flat bottom ocean at mid latitudes (the so called square-box or SQB configuration).



Medium case benchmark: Double-gyre NEMO configuration

1) Download the NEMO model

svn --username "my_login" co http://forge.ipsl.jussieu.fr/nemo/svn/

2) Prepare the SQB configuration

./makenemo -j0 -m ifort_linux

./makenemo -j0 -r GYRE -n SQB

copy the additional source files

Medium case benchmark: Double-gyre NEMO configuration

3) Compile the SQB configuration

edit compilation options

./makenemo

4) Run the SQB configuration

edit NEMO namelist

./opa

This is just a starting point...

5. Large case benchmark

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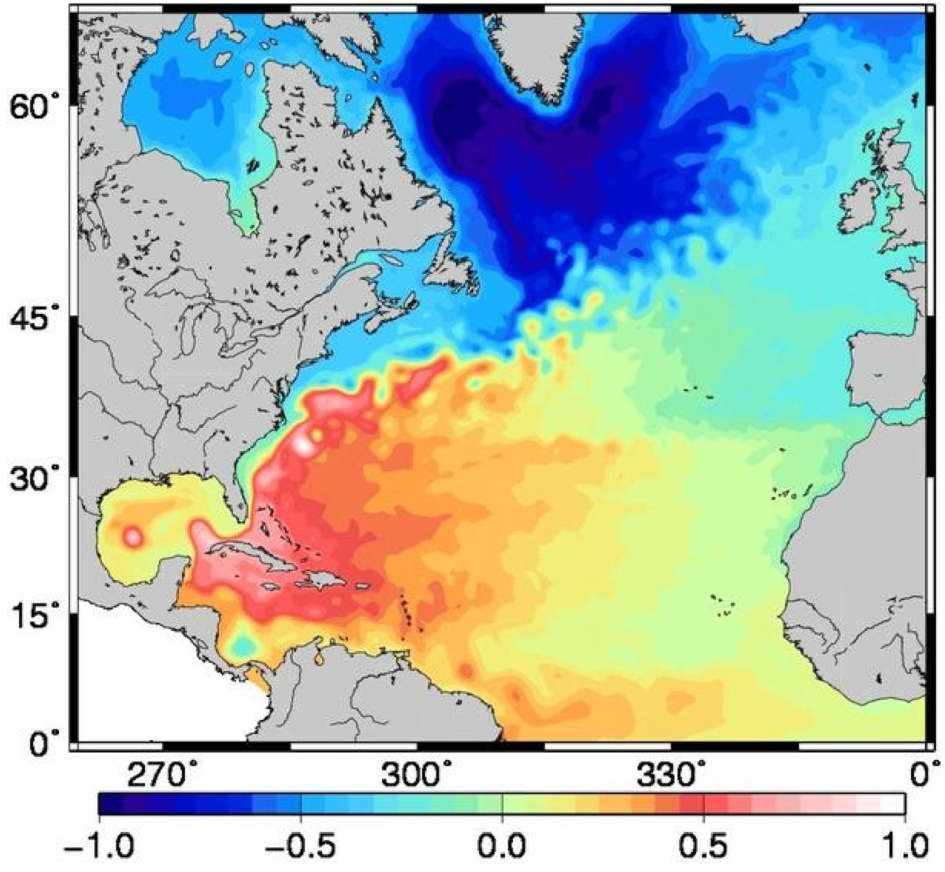
Large case benchmarks: North-Atlantic 1/4° NEMO/LOBSTER configuration



Large case benchmarks: North-Atlantic 1/4° NEMO/LOBSTER configuration

1) Download the NEMO model

2) Prepare the NATL025 configuration

3) Compile the NATL025 configuration

4) Run the NATL025 configuration

Definition of benchmarks and metrics

by Guillem Candille

tomorrow