Report on the 3rd NEMO-ASSIM Meeting
Paris, November 20-21, 2012

An initiative towards the development of an assimilation component within the NEMO code system was established in 2009, with the long-term objective of making assimilation tools for NEMO more readily available to the user community. Two meetings between experts engaged in developing data assimilation tools for the NEMO system and members of the NEMO System Team were held in Paris, on 22-23 June 2009 and 20-21 January 2011. These meetings led to the definition of several priorities and to the development of several bricks of a NEMO assimilation component (see the synthesis document "Options for development of a NEMO assimilation component", 12pp, November 2009 and the "Report on the 2nd NEMO ASSIM meeting", 7pp, May 2011).

Following these two meetings, a third one was held in Paris on 20-21 November 2012. The objectives were to report on the advances since the last meeting, and to define new priorities for the future.

It clearly emerges from this meeting that the NEMO-Assimilation initiative has already been successful, in particular in creating 3 components (OBS, ASM and TAM) that are now included in NEMO and that respond to actual needs of the users. It must be noted that a substantial part of these tools is also of interest for the modelling community for various scientific studies.
Several complementary developments regarding these 3 components are identified, which should be addressed in 2013. Discussions regarding the future inclusion of assimilation engines either "in" or "beside" NEMO did not led to the definition of clear actions nor recommendations in the short term. However the development of an assimilation demonstration test case for NEMO (SEABASS configuration) has been approved. Moreover the work done in NEMO-ASSIM could (should) be valorised within the research community and the operational oceanography community. A present opportunity in this direction would be to build links with the SANGOMA EU project.

This report summarizes the presentations and discussions that were held during this 3rd meeting. The list of the meeting participants as well as the meeting programme are given in the appendices. Note that colleagues from CMCC/INGV could unfortunately not attend the meeting.

1. Day 1: Presentations

Day 1 was devoted mostly to mutual information sharing regarding the recent developments performed in the different centres and the future plans, and to the expression of the feelings and the expectations of scientists less directly involved in the development of assimilation tools w.r.t. these tools.

Eric Blayo: general introduction to this meeting

- Recall of the initial long-term objective of the NEMO-Assim initiative (*development and sustainability of an assimilation component for NEMO*), and of the conclusions of the first two meetings.
- A huge amount has already been achieved, which led to the development of OBS, ASM and TAM components.
- We are still far from having assimilation engines easily available for NEMO. Someone who wants to perform assimilation studies with NEMO probably has a hard time.
- However tools exist but are not widely available, due to many good reasons that make it difficult: manpower to build and maintain it, administration...
- Objectives of the meeting:
    - What has been done so far? Is it useful? (*overview of the present status of the assimilation tools within and around NEMO, the current developments, the current use of Nemo-Assim Tools…)*
    - Can we go further? What do we want to build together? (*discuss the ways to go further towards the availability of assimilation tools for NEMO, either for the institutes represented by the attendees or more widely for the oceanographic community)*
    - Define common priorities and the corresponding work plan in the short and mid term.

Claire Levy: introduction from the point of view of the NEMO Team
Would like in particular to have the following points addressed during the meeting:

- What are the expectations from project using NEMO-TAM?
- What about the sustainability of NEMO-OBS?
- What are the expectations and contributions of NEMOVAR, SESAM and other "assimilation engine" groups?
- Which future evolution for this NEMO-Assim group: gather "all" experts in assimilation with NEMO?

Dan Lea: NEMO Assim at UK Met Office

- Status of OBS and ASM
- Plans for 2013:
    - enable OBS / ASM with s-coordinate
    - investigate testing using SETTE and add OBS and ASM options to a reference configuration
    - offline running of the observation operator?
    - add increments to a sea ice model (LIM2/3 or CICE)

Pierre-Antoine Bouttier: status of NEMOTAM

- NEMOTAM phased with 3.2.2 is available. Will be phased with 3.4 by the end of 2012.
- Short-term plans: maintain and consolidate this version; phasing with 3.5 if asked by a large number of people; thinking about scientific tests of TLM (analytical ones for instance? links with what is done in COMODO?); development of a demonstrator for TAM (Seabass configuration).

Pierre-Antoine Bouttier is a new member of the group: he is the new CNRS engineer on a permanent position, allowing in particular to have the NEMO_TAM component alive, updated and developed.

Gurvan Madec: point of view of an ocean modeller

- ASM: probably of little use for ocean modellers
- OBS: terrific tool with high potential: model validation, identification of model biases… There is a clear need for an offline version of OBS, to make it used by a number of modellers.
- TAM: high potential for development of ocean parameterisations, sensitivity studies, optimal perturbations, study of ocean circulation, OSSE…

- ASM:
  - sustainability issues;
  - ASM has its own calendar.
- OBS:
  - same issue about the calendar
  - Needs a re-writing? rationalisation? → mid-term rather than short-term priority?
  - Need for a tutorial: "how to add a new obs?"
- TAM: high potential tool but no user interface → requires to promote its use
  - A demonstrator of use for optimal perturbation
  - A demonstrator of various assimilation methods → SEABASS
  - A demonstrator of parameter optimization?
  - Balanced initial state (like VIFOP)
  - 1D test case (PAPA, IMET…) with TAM of TKE and GLS?
  - Some missing OPATAM modules for regional problems (OBC/BDY, UBS…)
  - NEMO=ocean+bio+ice → what about TAM of PISCES and LIM?

- Evolution of NEMO and consequences on TAM:
  - coordinate: nonlinear ssh, s coordinate, z-tilde coordinate
  - OBC/BDY: split explicit ssh; high order advection schemes
  - System simplification: merge PISCES and LOBSTER, merge LIM2 and LIM3 →better situation for a possible TAM on bio and/or ice
  - CRS: on line coarsening of TOP: cheaper to run BIO
  - I/O server: greatly improve the model efficiency with large I/O → output a model trajectory at high frequency will no more be a CPU issue
  - ICB: new module for icebergs floats (v3.5) → a TAM of ICB ?

Kristian Mogensen: from integrated to object oriented: OOPS

- The current implementation of 4DVar is not scalable enough for the future.
- OOPS: object-oriented prediction system – Encapsulation in C++ → improves maintainability and implementation of new methods/objects
- This is a potential long-term change in NEMOVAR (not decided yet, still on discussion). If fully coupled data assimilation, then should be with OOPS. Rerun model multiple times without memory leaks.
- What are the modifications required in NEMO to use it within OOPS? not clear yet…
- What is the future of this "OOPS compatible NEMO" w.r.t. the NEMO reference?

Elisabeth Remy: NEMO assim tools at Mercator Ocean – SAM2

- OBS operators: interest for validation of operational products and free run simulations. Won't be used in the assimilation scheme in the near future.
- Mercator Ocean will share some specific observation operators for SST and SLA within the NEMO framework
- Mercator Ocean will be using feedback format for validation purposes, when switching to NEMO 3.4. (off-line computations)
- TAM: Mercator Ocean envisages estimating flux correction using the adjoint.
- Generation of ensemble simulations → which tool? ongoing discussion
- Model-Observation diagnostic tools → need for common tools
- Could Mercator envisage to switch to NEMO_OBS for assimilation purposes? Yes, on a long term basis.

Pierre Brasseur: NEMO in MyOcean

- Presentation of the SANGOMA project → develop new sequential assimilation techniques, with applications to a number of configurations and models. This project started one year ago, and will end in 2015. It involves a network of experts in assimilation.
- Several groups in SANGOMA use NEMO.
- Benchmark: 3 models (including NEMO) to compare effects of DA techniques
- Definition of data/model interfaces, of metrics…

2. Day 2: Discussion

The discussion was organized in two parts, the first one being devoted to the definition of future evolutions for existing NEMO-Assim tools (OBS, ASM, TAM), and the second one to possible additional developments.

2.1 Future short-term evolutions for existing NEMO-Assim tools

OBS :

- An offline version will be developed in 2013 by MetOffice (Dan Lea). Gurvan Madec could help.
- Sustainability / reorganisation: go towards object-oriented ideas. Kristian Mogensen will work on it, and will provide suggestions.
- A reference configuration for OBS will be built. It will be based on ORCA2_LIM with SST, SLA and profile data. A tutorial on "how to add a new observation" will be written. (Dan Lea)

The ability to generate pseudo-observations (i.e. model outputs as data to assimilate) for twin experiments has been discussed. It must be kept in mind but it is not an immediate priority.
Note also that Mercator-Ocean is planning to use OBS, not for assimilation (in SAM2) but for modellers and for their validation team. Mercator-Ocean is very interested by an off-line version.
Mercator-Ocean will identify differences between OBS and the corresponding part of their SAM2 system, and will provide a short report.

ASM:

- Need for a reference configuration for ASM. A question is to define what is the reasonable response to check. Dan Lea will work on it.
- Pierre Brasseur asks Mercator-Ocean to write a short report within a few months investigating if there are real reasons for MO to have different tools.
- ECMWF has developed a method for bias estimation and correction. It is already used by MetOffice, and can be made available in NEMO-ASSIM.

TAM:

- All groups agreed on the fact that the permanent update of TAM is NOT a high priority. However TAM should be updated after each major upgrade of NEMO.
- TAM needs a demonstrator to test and promote it. The Grenoble team will develop the SEABASS configuration, in which several assimilation methods will be implemented (lead: P.-A. Bouttier). An associated tutorial will be provided.
- A simple additional validation test and tutorial for TAM could be the minimization a simple energy functional. Anthony Weaver and Arthur Vidard will think about it.
- The ability to compute optimal perturbations (singular vectors, Lyapunov vectors) would be a useful tool for modellers. The development of such a tool "simply" requires the joint use of TAM and some scalapack routines. Florian Sevelec, who has already worked a lot on such optimal perturbations, will be asked if he can contribut to the development of such a tool.
- The development of TAM for sea-ice and biogeochemistry is not a short-term priority, but should be done in the mid-term if there is a clear demand from users.

2.2 Open discussion on additional developments (towards assimilation engines?)

- As reported above, all groups globally agreed on actions to consolidate and promote the existing NEMO-Assim component. The consolidation will occur

through new developments on OBS, ASM and TAM (see list above). The promotion will be done through the development of the SEABASS configuration and of the optimal perturbations computation tool, and possibly through increased interactions with the user community (both research and operational oceanography). A present opportunity in this respect is the EU SANGOMA project, with which links could be built. Another idea is to organize a NEMO-Assim users session within the annual NEMO users meeting.

- No clear additional actions nor recommendations emerged regarding the extension of existing tools towards the inclusion of (or the link with) assimilation engines. A reason for that is the lack of manpower that could be devoted to such developments. Therefore a priority will be perhaps to find such resources, for instance by a common proposal to some European call.

- Miscellaneous:
  - Gurvan Madec indicated that modellers would have a clear interest for balanced initialization (VIFOP like tool). Such a tool is available in NEMOVAR.
  - Gurvan also cited the work done within the French COMODO project towards the definition of common testcases for ocean models, and suggested a similar work for assimilation methods. SEABASS is a step in this direction.
  - A Nemo_assim wiki page will be created https://forge.ipsl.jussieu.fr/nemo/wiki/WorkingGroups/nemo_assim (Resp : Dan Lea and Kristian Mogensen)
  - This report will be sent to colleagues from CMCC/INGV for information and possible reactions.

Appendix A: Meeting attendees

Magdalena Balmaseda (ECMWF)
Rachid Benshila (NEMO Team, CNRS)
Eric Blayo (LJK, U. Grenoble)
Pierre-Antoine Bouttier (LEGI, LJK and NEMO Team, CNRS)
Pierre Brasseur (LEGI, CNRS)
Christian Ethé (NEMO Team, CNRS)
Dan Lea (UK Met Office)
Claire Levy (NEMO Team, CNRS)
Gurvan Madec (LOCEAN and NEMO Team, CNRS)
Kristian Mogensen (ECMWF)
Elisabeth Rémy (Mercator Océan)
Jacques Verron (LEGI, CNRS)
Arthur Vidard (LJK, INRIA)
Jennie Waters (UK Met Office)
Anthony Weaver (CERFACS)

Appendix B: Meeting programme

Tuesday afternoon (November 20):

14:00 – 17:30 Oral presentations and discussions

1. Introduction (E. Blayo)

2. Existing NEMO-Assim components
   (Objectives: present the current status of NEMO-Assim, what is available and what are the short term plans)
   - The NEMO system and its constraints (C. Levy)
   - Observation operator - Analysis Increment (D. Léa)
   - NEMOTAM (P.-A. Bouttier)

3. Users or non-users feedback, future plans and anticipated needs.
   (Objectives: some use the NEMO-Assim interfaces, other not. Are the current interfaces satisfactory? If not what would be missing or which improvements would be suitable?
   Give an overview of the future plans, putting in light what is missing or what can be improved in the current NEMO-Assim tools in order to fulfil the needs)

   - Point of view of modellers, links with the future evolution of NEMO (G. Madec)
   - Mercator-Ocean (E. Rémy)
   - Meom-LEGI + Sangoma European project (P. Brasseur)
   - Nemovar Consortium (K. Mogensen)

Wednesday morning (November 21):
9:00 – 12:00 Plenary discussion

As a guideline for the discussion, we could keep in mind the following questions/points of view:

- from our point of view (i.e. a researcher developing assimilation methods and/or codes and using NEMO): are we happy with the present state of the NEMO system and of its assimilation components? Would we like some improvements, which could be of common interest?
- from the point of view of a "standard" researcher in oceanography, who would intend to perform assimilation experiments with NEMO: are the necessary tools available? Is it feasible for him/her to implement its own assimilation experiments?
- from the point of view of the development of the NEMO platform, what can be done, i.e. mainly who is ready to work on it?

Several aspects could be discussed:

- "formal" aspects:
  - Present licences, consortium agreements and MoUs.
  - What does "within NEMO" mean?
  - Is it possible to have components "beside NEMO"? In such a case, who is in charge? Which evolution? Can it be perennial?
- What does exist presently? (most of it should have been discussed on tuesday, but some other tools may exist)

- What is missing? What would be the means necessary to do it, to make it widely available, to maintain it?
- What are we interested to do ?

12:00 – 13:00 Synthesis