

**Report on the 2nd NEMO-ASSIM Meeting
Paris, January 20-21, 2011**

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Summary

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. A first meeting between experts engaged in developing data assimilation tools for the NEMO system and members of the NEMO System Team was held in Paris on 22-23 June 2009. An analysis was made, and first priorities were defined (see the synthesis document "Options for development of a NEMO assimilation component", 12pp, November 2009).

Following this first meeting, a second one was held in Paris on 20-21 January 2011. The objectives were to report on the advances since the first meeting, and to define new priorities for the forthcoming year.

It clearly emerges from this meeting that the NEMO-Assimilation initiative is seen as a very positive action. All the groups present at the meeting agreed on that point, confirming that a common effort was needed to develop a sustainable NEMO assimilation component. In particular, the INGV-CMCC group and Mercator-Ocean have affirmed their willingness to join the initiative and to contribute actively.

The work done these last 18 months has led to clear improvement with regard to the situation in 2009. Significant progress has been made on the 3 priority areas that were defined in June 2009. In particular, an assimilation interface is now present in the NEMO code at version 3.3 (no interface previously existed).

Several new priorities have been identified, which represent a further step in the construction of the NEMO assimilation component. It must be noted that a substantial part of the tools that are, or will be in the near future, added to NEMO in the context of this assimilation component are also of interest for the modelling community for various scientific studies.

The list of the meeting participants as well as the meeting programme are given in the appendices.

1. General statements

The different groups involved in data assimilation with NEMO have confirmed their interest in the NEMO-Assimilation initiative, which is seen as a very positive action. They share the willingness of developing a sustainable NEMO assimilation component. In particular, two groups (the INGV-CMCC group and Mercator-Ocean) that were not significantly involved yet have clearly expressed their interest to join the initiative and to contribute actively.

The status of various assimilation kernels used within the NEMO framework was summarized at the meeting. These include the SEEK filter as used at Mercator-Ocean and at LEGI, the OceanVar system used at INGV/CMCC, and the NEMOVAR system used at ECMWF, Met Office, Cerfacs and LJK. Several tools are already existing, or are presently being developed, in the context of research or operational projects. These groups are open to share these tools, and in the longer term it would be logical to include them (or at least part of them) in the NEMO assimilation component.

A difficulty for this project is the lack of manpower specifically dedicated to the code development in view of integration into the official NEMO distribution. This implies some demanding work in terms of development and validation, which obeys strict rules. Some dedicated resources exist to maintain and develop the assimilation interface code for the observation operator and incremental analysis updates. However, no dedicated resources exist for the maintenance and development of the TAM component which is a major concern for the long-term advancement of the project. The future recruitment of a CNRS research engineer, member of the NEMO-team, and located in Grenoble, should address this specific point.

2. Work done since the last meeting

The three main priorities defined in June 2009 were:

1. Integration of the observation operator from the NEMOVAR code system into the NEMO reference version.
2. Integration of NEMOTAM (tangent and adjoint models) into the NEMO reference version.
3. Integration of the increments application code from the NEMOVAR system into the NEMO reference version.

Significant progress has been made in these priority areas, and the present situation is very much improved with regard to June 2009. More precisely, the current status is the following:

1. Observation operator
 - This corresponds to UKMO task 3 of the NEMO work-plan for 2010, with 7 weeks dedicated. The code was implemented in NEMO at version 3.3 (January 2011) and documentation is provided. The observation operators corresponding to several types of data have been included in

the NEMO code:

- profile temperature and salinity
 - sea level anomaly
 - sea surface temperature
 - sea ice concentration
 - velocity
- The code is compatible with the format of several external data-sets (Enact, Coriolis, Aviso, GHRSSST), as well as a format used internally (based on NetCDF, called "feedback" file format).
 - Further work is required to make the code fully compliant with the NEMO code standard, and to provide a test case to ensure that any changes to the NEMO code will not impact on the observation operator.

2. NEMOTAM

- The tangent linear and adjoint models of NEMO 3.0 were included in the NEMO distribution in June 2010. This code was made available at the same time as the NEMO 3.2.1 release of the direct model, with a logical and necessary time shift in terms of the version. The TAM component was subsequently updated to NEMO version 3.2, which took approximately six full weeks of effort. It is estimated that a similar period will be required to adapt the tangent linear and adjoint models to a new release of the direct model. This estimate relies on the continued availability of the expertise which has been developed in this activity at LJK.
- In the current implementation there are no test or demonstration cases, so the use of these models is not advised for inexperienced users.
- Note that this implementation has been made possible only through collaboration with the VODA project (ending April 2012) which was the main contributor. There was also some effort from the NEMO system team to enable this, but there is currently no dedicated time and expertise within the NEMO system team to work on the tangent linear and adjoint models.

3. Application of increments

- The capability to apply increments calculated by data assimilation systems has been added to the NEMO code in 2010 (UKMO NEMO team task 3, 3 weeks) and is available in NEMO version 3.3 (from January 2011). It adds the functionality to apply increments to temperature, salinity, sea surface height, and velocity model variables.

3. Priorities for the 12-18 forthcoming months

The priorities that have been identified for the next period are:

1. *Observation operator*

- 1.1 Add examples of how to use the observation operator to the standard NEMO validation tool kit, now called SETTE, and improve the documentation. (D. Lea, R. Benshila)

- 1.2 Review and improve the existing code to address issues with compliance to NEMO coding standards, and to consolidate existing calendar and mpp functionalities. (R. Benshila, D. Lea)
- 1.3 Include calculation of model counterparts to trajectory data including surface drifters and Argo floats. (S. Dobricic)
- 1.4 Include calculation of profile temperature and salinity model counterparts when using a generalised vertical coordinate. (D. Lea)
- 1.5 Include calculation of the model counterpart of satellite SST data which has a larger footprint than the model grid (e.g. microwave data). (D. Lea)
- 1.6 Include various tools to manipulate, analyse and visualise the output from the observation operator code in the NEMO code. (D. Lea)

2. *Tangent and adjoint models*

- 2.1 Define a tentative strategy for the release of NEMOTAM, and implement it for 2011 (R. Benshila and A. Vidard).
Since NEMO is now released on an annual basis with a systematic beta test phase, two strategies have been discussed:
 - allow one year of time shift between the direct model release and its adjoint.
 - complete the coding of the tangent and adjoint model during the beta test phase and release the TAM and direct model codes at the same time.
- 2.2 Implement demonstration cases for the TAM tools including computation of singular vectors, and computation of gradients. (A. Vidard, E. Blayo and R. Benshila).

3. *Application of increments*

- 3.1 Review and improve the existing code to address issues with compliance to NEMO coding standards (D. Lea, R. Benshila)
- 3.2 Add code to control horizontal divergence when applying assimilation increments. (S. Dobricic)
- 3.3 Add a test case for the increments application to the NEMO test system, SETTE, and improve the documentation. (D. Lea).
- 3.4 In the longer term, include the option of adding multiple sets of increments at the same time. (C.-E. Testut)

4. *Assimilation kernel*

- 4.1 The longer-term objective is to move towards a generic assimilation interface for NEMO, which could handle several assimilation methods. A dedicated workshop will be organized to discuss the definition of such an interface in detail. (A. Weaver, A. Vidard).

4. Additional comments

- It is important to notice that a substantial part of the tools that are, or will be in the near future, added to NEMO in the context of this assimilation component are also of interest for the modelling community for various scientific studies: comparison with observations (observation operators), sensitivity analyses

(computation of gradients), stability analyses and ensemble simulations (singular vectors).

- The issue of whether to include an observation quality control system into the NEMO system was discussed. There was little interest in collaborating on this aspect within the NEMO context, and it was agreed that this is not a priority for the forthcoming period

Appendix A: Meeting participants

Rachid Benshila (NEMO System Team)
Eric Blayo (LJK)
Pierre-Antoine Bouttier (LEGI and LJK)
Jean-Michel Brankart (LEGI)
Pierre Brasseur (LEGI)
Srdjan Dobricic (INGV)
Daniel Lea (Met Office)
Bénédicte Lemieux-Dudon (LEGI and LJK)
Claire Levy (NEMO System Team)
Matt Martin (Met Office)
Isabelle Mirouze (Cerfacs)
Kristian Mogensen (ECMWF)
Elisabeth Remy (Mercator-Ocean)
Charles-Emmanuel Testut (Mercator-Ocean)
Olivier Titaud (Cerfacs)
Jacques Verron (LEGI)
Arthur Vidard (LJK)
Franck Vigilant (LJK)
Anthony Weaver (Cerfacs)

Appendix B: Meeting programme

January 20 (Jussieu central tower, room 2302, 23th floor)

13:30 Welcome

14:00 - 15:00 Work done related to the priorities identified last year (20mn each)

- Observation operator (*Daniel Lea*)
- Management of the increment (*Daniel Lea*)
- NEMOTAM (*Arthur Vidard*)

15:00-15:15 Coffee break

15:15 – 17:15 What was done elsewhere in the community

- Computation of gradients (*Elisabeth Remy*)
- Oops (*Kristian Mogensen*)
- Status of the different assimilation kernels
 - o Mercator Ocean (*Charles-Emmanuel Testut*)
 - o INGV-CMCC (*Sbrjan Dobricic*)
 - o LEGI (*Jean-Michel Brankart*)
 - o NEMOVAR consortium (*Anthony Weaver*)

17:30 – 18:30 Discussion: which will be the next priorities ?

- Additional observation operators into NEMO ?
- Quality control
- Tests (for debugging but also as examples and starting points for users)
- Can we begin to get some type of assimilation kernel code into NEMO ?
- Can some complementary components of the existing kernels be combined ?

January 21 (Jussieu central tower, room1005, 10th floor)

9:00 – 12:00 Definition of the work-plan and priorities (plenary session or 2-3 working groups in parallel, depending on what was decided on Thursday evening)

10:30 Coffee Break

12:00 – 13:00 Synthesis