NEMO Sea Ice Working Group meeting

University of Reading, 6-7th March, 2018

Goals of the meeting

- Progress on the design of a common evaluation strategy for the NEMO sea ice model.
- Exchange information about current funding plans for NEMO sea ice activities and future developments
- Agree on a name for the NEMO sea ice model
- Agree on the structure of a revised strategy document; explore how we could improve contents, in particular through a rough design of our 2019 workshop.

Meeting notes/minutes

Attendance:

Ed Blockley (co-chair)	Met Office, Exeter, UK
Martin Vancoppenolle (co-chair)	LOCEAN-IPSL, Paris, France
Paul Holland	BAS, Cambridge, UK
Dorotea Iovino	CMCC, Bologna, Italy
Danny Feltham	CPOM, Reading, UK
David Schroeder	CPOM, Reading, UK
Clément Rousset	LOCEAN-IPSL, Paris, France
Gurvan Madec	LOCEAN-IPSL, Paris, France
Jeff Ridley	Met Office, Exeter, UK
David Salas	Météo France, Toulouse, France
Matthieu Chevallier	Météo France, Toulouse, France
Yevgeny Aksenov	NOC, Southampton, UK
Thierry Fichefet	UCL, Louvain-la-Neuve, Belgium
François Massonnet	UCL, Louvain-la-Neuve, Belgium
Gilles Garric (via phone)	Mercator Ocean, Toulouse, France

1. Review of Transition Phase activities since last meeting

Updates were provided on progress made to-date on the transition phase activities as follows:

1. HadGEM/JULES coupling:
    a. CNRS have modified SBC code and LIM BL99 thermodynamic routine to allow JULES-style coupling
    b. This has been coded so that it can be tested in forced mode.
    c. All code included for v4 merge party for inclusion in NEMO trunk
    d. HadGEM/JULES coupling is technically working with prototype NEMO v4.
    e. Scientific evaluation will need to follow.
2. Melt-ponds:

    a. Code infrastructure is ready for melt-ponds
    b. Empirical formulation of Holland et al. (2012) is coded/working/included
    c. Flocco et al. scheme is coded but still needs upgrading to v4 and testing
3. Form-drag:
    a. Infrastructure required for form-drag is in place (proportion of ridged ice etc.)
    b. Tsamados et al. scheme is working ok at v3.6 but needs upgrading to v4 and testing
    c. Lupkes et al. (2012 and 2015) schemes available within v4.0 release
4. C-grid remapping/advection:
    a. Scoping work performed which reveals that this will take more work than planned
    b. CNRM have improved the conservation in the native GELATO formulation
    c. Much work is needed to convert to NEMO standards and for testing etc.
    d. However it was noted that there is potential to include this in the NEMO code (in a branch), whilst still uncompliant with coding standards, for the purpose of inter-comparison with Prather & UM5
5. NEMO 4.0 status of code
    a. To be released this summer
    b. Physics: lateral melting, ice-atmosphere drag, land-fast ice, melt ponds, coupling interface
    c. Numerics: UM5 advection scheme, adaptive EVP rheology
    d. Infrastructure: All thermodynamics is 1D, reduced MPP communications, comprehensive set of outputs, revised architecture and namelist parameters, enabling decoupling of processes through namelist parameters, ice categories, open boundaries, AGRIF.

2. Funding opportunities for NEMO sea ice

An update on work done to source potential funding opportunities was provided by EB and MV.

Two Horizon 2020 projects were introduced: IS-ENES3 and IMMERSE. Involvement in both of these projects has involved expansion of existing consortia to include sea ice. If funded these projects will provide funding for SIWG members to support transition activities as follows:

- IS-ENES3 (CMCC, CNRM, CPOM, IPSL, Met Office) will provide technical infrastructure support and training for the groups using CICE and GELATO to use the new NEMO model and contribute sea ice model developments within the NEMO framework. It will also provide T&S support for the large NEMO SIWG workshop planned for 2019.
- IMMERSE (CMCC, IPSL, Met Office, NOC) will support implementation of EAP and VP rheologies into the NEMO sea ice model and some scientific inter-comparison of EVP with EAP and VP.

Additional to the activities proposed under H2020, we shall be responding to the CMEMS GLO call for sea ice model development and evaluation. This activity will involve CPOM, UCL and IPSL, and will provide support for evaluation of the new model.

3. Sea ice model evaluation

Plans, ideas and requirements for model development were presented by each group to address questions circulated in advance. These were focussed on how we will know if the model is good enough for use (technical and scientific) and, in particular, how we should assess the impact of new changes proposed under the transition phase (melt-ponds, form-drag, rheology, advection, coupling changes).

A brief summary of the group presentations is as follows:

- BAS: Paul Holland explained how they have evaluated processes in the Antarctic sea ice zone using an ice concentration budget analyses.
- CNRM: David Salas insisted that the model should be SIMIP-compliant - in particular with regard to the definition and naming of diagnostics, and the possibility to track conservation offline. CNRM propose to use satellite, but also airborne and in-situ products for evaluation (e.g. Unified sea ice thickness Climate Data Record, Lindsay, 2010).
- CPOM: David Schroeder insisted that the new model should be thoroughly tested in terms of conservation properties, but also in terms of physics, at a very process level.
- LLN: François Massonnet proposed an evaluation plan based on 3 classes. Class 1: robustness/technical testing, Class 2: broad-scale metrics and diagnostics, Class 3: process-based assessments (see below for further details).
- LOCEAN-IPSL: Martin Vancoppenolle insisted on the evaluation of model conservation, reproductibility, restartability. Class 2 evaluation: use observations. Rheologies need to be intercompared. Advection schemes need to be qualified. Melt ponds and form drags need to be tested and compared to other existing approaches.
- Mercator Ocean: Gilles Garric explained that the model needs to be robust for assimilation activities, including at the subgrid-scale level, which may not currently be the case.
- NOC: Yevgeny Aksenov stressed that different observational products should be used, and that different resolutions, and different configurations, may require alternative tuning and evaluation.
- CMCC: Dorotea Iovino insisted that evaluating the surface ocean is as important as the sea ice.
- Met Office: Ed Blockley suggested that new processes could be evaluated by comparison with existing models (LIM3 for new functionality or against CICE/GELATO for functionality that exists there already). He further stressed that comparing modelled differences of relevant processes is important even when no observations exist – in particular for the sea ice volume budget, the sub-grid-scale thickness distribution, the ice-atmosphere coupling interface, and for Fram Strait export. He also provided details of the Met Office sea ice model evaluation tool.

Evaluation: synthesis of overarching aspects

Following François' definitions, model evaluation will be split into 3 different classes as follows:

- Class 1: robustness & technical testing. This would include conservation, standard NEMO SETTE testing, and possibly something related to computational performance.
- Class 2: broad-scale "classical" metrics and diagnostics.
- Class 3: process-based assessments for better understanding model simulations.

Class 1
It was agreed that the standard SETTE testing was sufficient for reproducibility etc. The conservation tests already in the code should be extended so that energy and freshwater conservation is tested for each grid-cell during thermodynamics (1D processes). Conservation within the dynamics would remain at the large-scale but, instead of being global only, should be reported separately for the Northern and Southern Hemispheres.

Class 2

The list of broad-scale diagnostics and metrics proposed by UCL were agreed and expanded upon (Table 1).

Table 1: list of metrics to be used with "Class 2" evaluation.

	Standard error metric	*Needs interp. ?*	NH	SH	*Input model field*	*Reference Product*	*Comment*
1	**Spatial mean of RMSE of SIC annual cycle**	Yes	x	x	Sea Ice Concentration	OSI-SAF, NSIDC	
2	**RMSE of annual cycle of mean SIA**	No	x	x	Sea Ice Area	Computed from OSI-SAF, NSIDC	
3	**RMSE of annual cycle of mean SIE**	No	x	x	Sea Ice Extent	Computed from OSI-SAF, NSIDC	
4	**Error of trend of SIA anomalies (all months)**	No	x	x	Sea Ice Area	Computed from OSI-SAF, NSIDC	
5	**Error of trend of SIE anomalies (all months)**	No	x	x	Sea Ice Extent	Computed from OSI-SAF, NSIDC	
6	**Mean of annual cycle of Integrated Ice Edge Error**	Yes	x	x	Sea Ice Concentration	OSI-SAF, NSIDC	IIEE metric: Goessling et al., GRL, 2016
7	**RMSE of SIT (all months, all locations)**	co-location	x	x	Sea Ice Thickness	Unified Sea Ice Thickness Data Record, ASPeCt	
8	**Error of trend of SIV anomalies (all months)**	No	x	x	Sea Ice Volume	PIOMAS, GIOMAS, 12 ORA-IP Reanalyses	
9	**RMSE of snow depth (all months, all locations)**	co-location	x		Snow depth on sea ice	Operation Ice Bridge	
10	**Vector correlation of annual mean drift**	Yes	x	x	Sea Ice x-y velocity (daily)	IABP buoys	Holland & Kwok, Nature Geosci, 2012
11	**RMSE of annual cycle of monthly mean sea ice speed**	no	x	x	Sea Ice x-y velocity (daily)	IABP/IBAP buoys	Docquier et al., The Cryosphere, 2017
12	**Error on PDF of rate of deformation**	no	x		Sea Ice x-y velocity (daily)	RGPS data (lagrangian...)	
13	**RMSE of annual cycle of Fram strait volume export**	no	x		Fram strait volume export	IceSat + AMSR	Spreen et al., GRL, 2009
14	**Length of ice free season**	no	x	x	Daily ice concentration	OSI-SAF, NSIDC	Stroeve et al., GRL, 2016

15	**Melt pond maximum area**	no	x		Pond fraction	MODIS	
16	**Surface temperature**	no	X	X	Sea Ice surface temperature	CMEMS product?	

It was recognised that many of these will not be applicable for all model simulation (coupled/climate/forced/etc.) and that caution/expert judgement would need to be exercised in the interpretation of the results. It was agreed that observations are never perfect. In polar regions and for sea ice, the situation is even worse with larger errors and – in many cases – sparsity of coverage. To deal with this we would try to use multiple observational datasets for quantities that have observations. We should produce diagnostics still for quantities without observations for assessment by expert judgement. There should be the functionality to compare diagnostic fields between model simulations - in particular for things that are not observed. As well as sea ice diagnostics it was recognised that we'd need to put these in context with surface ocean fields (such as SSH, SSS, SST, …) as well.

UCL will lead on development of metrics/diagnostics and a common protocol within the CMEMS proposal. These will involve assessment of runs performed under the OMIP protocol for ORCA1 and ORCA025. However, it is unclear how we will run/share simulations with ORCA12, which is specifically mentioned in the CMEMS call.

A plan to commit plotting and metrics code – in portable/collaborative python – back to the NEMO repository (under tools?) was discussed. Another possibility is to use the Met Office/UK sea ice (python) evaluation tool, which is freely available on MOSRS.

The possible use of the NEMO OBS operator was also mentioned for specific products with uneven sampling in time and space (i.e., IceBridge, PSC thickness climate data record).

Class 3

These will be process-oriented assessments planned to dig deeper into the model behaviour. These techniques can be useful for identifying model bugs, thorough assessment of new parameterisations/physics and for a deeper evaluation of the model to be sure the 'right' answer isn't being obtained for the wrong reason(s).

Class 3 evaluation may involve things like: comparison of volume terms between model runs; comparison of surface-energy budgets against SHEBA & satellites; ice concentration budgets against satellite observations; or a detailed evaluation of ITD.

It was agreed that use of class 3 evaluation will be essential for ensuring that new physics proposed for transition phase (melt-ponds, form-drag, EAP). This work would be done by CPOM for the CMEMS proposal using the stand-alone sea ice model.

Other than this, these class 3 evaluation methods would not be included in the CMEMS proposal but will be performed/required by the various centres looking to implement the new model.

It was agreed that emergent constraint type evaluation wouldn't be included here within class 3 (or at all).

Extra points

It was noted that finding means to sharing simulations would be useful, but not easy to implement. It was also noted it would be useful to progress on a common configuration. The ideal one would include a mixed layer ocean and probably the upcoming ALBATROS atmospheric boundary layer capabilities.

4. Naming the NEMO sea ice model

Naming of the NEMO sea ice model was discussed at length. A vote was held and results were:

- SI^3 (11 votes)
- NICE (3 votes)
- FUSION (1 vote)

There was abstention (the chairman).

Therefore, the NEMO sea ice model will be named **SI^3: "Sea Ice modelling Integrated Initiative**". The 3 can also be related to the merge of 3 sea ice models (LIM/CICE/GELATO) – in particular that all models said "Si" to sign up - or that the model represents linkages between 3 different media (ocean, ice, snow).

The model will be spelt "SI3" in situations where the superscript could be problematic (i.e., within code and svn repository etc.)
The model name would be pronounced as "si-cube" for short (or "sea ice cubed" for slightly longer).

5. Future NEMO sea ice model developments

A list of upcoming developments was compiled (see Table 2).

It was noted that there were several areas where very similar developments were being undertaken by different groups and that this will need further debate. This will be carried out later and will likely involve smaller, more focussed, video conferences.

It was noted that in the longer term we would like to tie the planned developments to the model evaluation.

*Table 2: proposed future developments for the SI^3 model. *notation denotes items that may have overlap that requires discussion*

Development	Proposed by	Framework
Upgrade thermodynamic basis to use TEOS-10	CNRS	
Implementation of Rees-Jones & Worster brine drainage	CNRS	Thesis Max Thomas
Embedded sea ice	CNRS	
Development of test cases and reference configurations (including using AGRIF)	CNRS	
VP rheology	CNRS	IMMERSE

*New snow model	CNRM	
C-grid remapping	CNRM	
Land-fast ice improvements	CNRM, LLN	
Conservation checks for energy and water based on trends	CNRM	
EAP rheology	NOC, CPOM	IMMERSE
Wave-ocean interaction	NOC, CPOM, CMCC	
*Floe size distribution (FSD)	NOC	
Collisional rheology	NOC, CPOM	
Frazil ice formation	CPOM	
Ocean drag from internal waves	CPOM	
Melt-ponds within thermodynamics (BL99?)	CPOM	
Improved lateral melt (with FSD?)	CPOM	
*Multi-level snow scheme (Lecomte et al.)	LLN	
*FSD parameterisation	LLN	
MEB rheology?	LLN	
Coupling interfaces	MetO, CNRM, CMCC, CNRS	ALBATROS
Data assimilation increments	MetO, CMCC, Mercator?	
Interactive ocean boundary layer	CPOM	

6. Sea ice model development workshop

To inform the NEMO Development Strategy for sea ice, we plan to have a workshop on sea ice model development in 2019. This will have an international focus and will hopefully be funded through the IS-ENES3 project (if accepted)

A discussion of the aims and objectives of the proposed workshop were discussed. Four key questions were introduced by the Chairs: What are the big questions?; How do we pose them?; Who do we need to invite?; Where/when shall we hold this?

It was identified that we need to find a way to pose the questions to be sure we can get something useful out of the meeting.

The proposed list of attendees was broadly supported with a few additions.

It was agreed that we would need an interesting venue/location to help pull in external folks. [NB. this may be problematic if we do not get the IS-ENES3 funding to pay for them.]

Action: MV to investigate interesting venues including CNRS Alps location and somewhere nice/interesting in Paris (not Jussieu/Locean!).

The proposed questions and suggested participants should be circulated for comment and more focussed debate initiated over email and videoconferencing.

7. Future SIWG meetings

It was agreed to have another SIWG meeting in 1 year's time (early 2019). This would further review the transition period, the projects discussed earlier (if funded) and make more clear recommendations for future direction.

It would also have a particular focus on planning for the international sea ice future model development workshop.