IS-ENES3 Milestone M8.5

Documentation of the NEMO Sea ice Model

Reporting period: 01/01/2022 – 31/03/2023

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Release date: 25/01/2023

ABSTRACT

This milestone describes how the documentation of SI^3 (Sea Ice modelling Integrated Initiative), the new NEMO sea ice model has been put together at different levels (code, namelist, user guide).
Documentation is available on the Zenodo repository: (https://zenodo.org/record/7534900#.Y8GIF-xKg-Q).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824084.

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1. Objectives

The objective of M8.5 is to document how code documentation for SI^3 has been improved. SI^3 is the new sea ice model distributed with NEMO. It suffered from the absence of documentation before IS-ENES3, which was identified by developers, users and review panels as an important shortcoming.

2. Description of work: Methodology and Results

Two levels where code documentation had to be improved were identified: in-code documentation (code and namelist); and a publicly-available user manual (pdf).

In-code documentation.

In-code documentation is the most direct means to document code. NEMO has a long expertise in code self-documentation. SI^3 code has been reviewed to match NEMO guidelines in this respect. This includes a preamble of comments in each routine, the short description of the meaning of all variables upon declaration, as well as commenting key steps of the code (**Fig. 1**).

```
SUBROUTINE ice_thd_zdf_BL99( k_cnd )
   !!-------------------------------------------------------------------
   !!                ***  ROUTINE ice_thd_zdf_BL99  ***
   !!
   !! ** Purpose : computes the time evolution of snow and sea-ice temperature
   !!              profiles, using the original Bitz and Lipscomb (1999) algorithm
   !!
   !! ** Method  : solves the heat equation diffusion with a Neumann boundary
   !!              condition at the surface and a Dirichlet one at the bottom.
   !!              Solar radiation is partially absorbed into the ice.
   !!              The specific heat and thermal conductivities depend on ice
   !!              salinity and temperature to take into account brine pocket
   !!              melting. The numerical scheme is an iterative Crank-Nicolson
   !!              on a non-uniform multilayer grid in the ice and snow system.
   !!
   !!           The successive steps of this routine are
   !!           1.  initialization of ice-snow layers thicknesses
   !!           2.  Internal absorbed and transmitted radiation
   !!           Then iterative procedure begins
   !!           3.  Thermal conductivity
   !!           4.  Kappa factors
   !!           5.  specific heat in the ice
   !!           6.  eta factors
   !!           7.  surface flux computation
   !!           8.  tridiagonal system terms
   !!           9.  solving the tridiagonal system with Gauss elimination
   !!           Iterative procedure ends according to a criterion on evolution
   !!           of temperature
   !!           10. Fluxes at the interfaces
   !!
   !! ** Inputs / Ouputs : (global commons)
   !!           surface temperature                : t_su_1d
   !!           ice/snow temperatures              : t_i_1d, t_s_1d
   !!           ice salinities                     : sz_i_1d
   !!           number of layers in the ice/snow : nlay_i, nlay_s
   !!           total ice/snow thickness           : h_i_1d, h_s_1d
   !!-------------------------------------------------------------------
   INTEGER, INTENT(in) ::   k_cnd     ! conduction flux (off, on, emulated)
   !
   INTEGER ::   ji, jk          ! spatial loop index
   INTEGER ::   jm              ! current reference number of equation
   INTEGER ::   jm_mint, jm_maxt
   INTEGER ::   iconv           ! number of iterations in iterative procedure
   INTEGER ::   iconv_max = 50  ! max number of iterations in iterative procedure
```

Figure 1. *Example of in-code documentation from the icethd_zdf_bl99.F90 SI3 routine, displaying the preamble and the explanation of the meaning of declared variables.*

Namelist self-description.

Another particularly important piece of code where self-documentation is required is namelist. The namelist is a parameter text file, which users can change without re-compiling the code. It is the main place where users would act on model behaviour, and therefore needs particular attention in terms of description. In the framework of IS-ENES3, the SI^3 namelist has been reorganized and the description of the different parameters has largely been improved.

```
!-----------------------------------------------------------------------
&namthd_do       !   Ice growth in open water
!-----------------------------------------------------------------------
   rn_hinew         =  0.1           !  thickness for new ice formation
    ↪  in open water (m), must be larger than rn_himin
   ln_frazil        = .false.        !  Frazil ice parameterization (ice
    ↪  collection as a function of wind)
      rn_maxfraz    =  1.0           !     maximum fraction of frazil ice
       ↪  collecting at the ice base
      rn_vfraz      =  0.417         !     thresold drift speed for
       ↪  frazil ice collecting at the ice bottom (m/s)
      rn_Cfraz      =  5.0           !     squeezing coefficient for
       ↪  frazil ice collecting at the ice bottom
```

*Figure 2. **A typical section of the SI3 namelist** (related to new ice growth in open water)**,** displaying the different parameters, their default values, and the comments to briefly describe their meaning.*

SI3 manual.

The third and most important stream of work regarding SI³ documentation was to provide an exhaustive text document describing the scientific and technical aspects of the code. For a long time, the ocean component has had the widely cited "NEMO book" as a documentation reference. However, there was no equivalent for SI³.

In the framework of IS-ENES3, a documentation has been assembled for SI³ from previous work and newly written material. The first version has been published on a public archive system (Zenodo) in early 2023. The Zenodo archive system is used both by the NEMO System Team and the IS-ENES3 partners to exchange technical documentation and includes a versioning system.

One of the key points is to ensure the sustainability of the documentation. To do so, one must define how to write documentation. To this end, we have produced documentation guidelines to be respected by SI³ developers, included as part of the documentation itself. One of the main aspects is that documentation should avoid repeating the code, but rather explain why the code has been written as it has. Also important is that all namelist parameters must be described in sufficient detail. At present, not all chapters fulfil these criteria. The chapter on thermodynamics is a good example of what we aim to ultimately achieve.

Vancoppenolle, M., Rousset, C., Blockley, E., and the NEMO Sea Ice Working Group, 2023: SI³ – Sea Ice modelling Integrated Initiative – The NEMO Sea Ice Engine, doi:10.5281/zenodo.7534900, 2023.
(https://zenodo.org/record/7534900#.Y8GIF-xKg-Q).

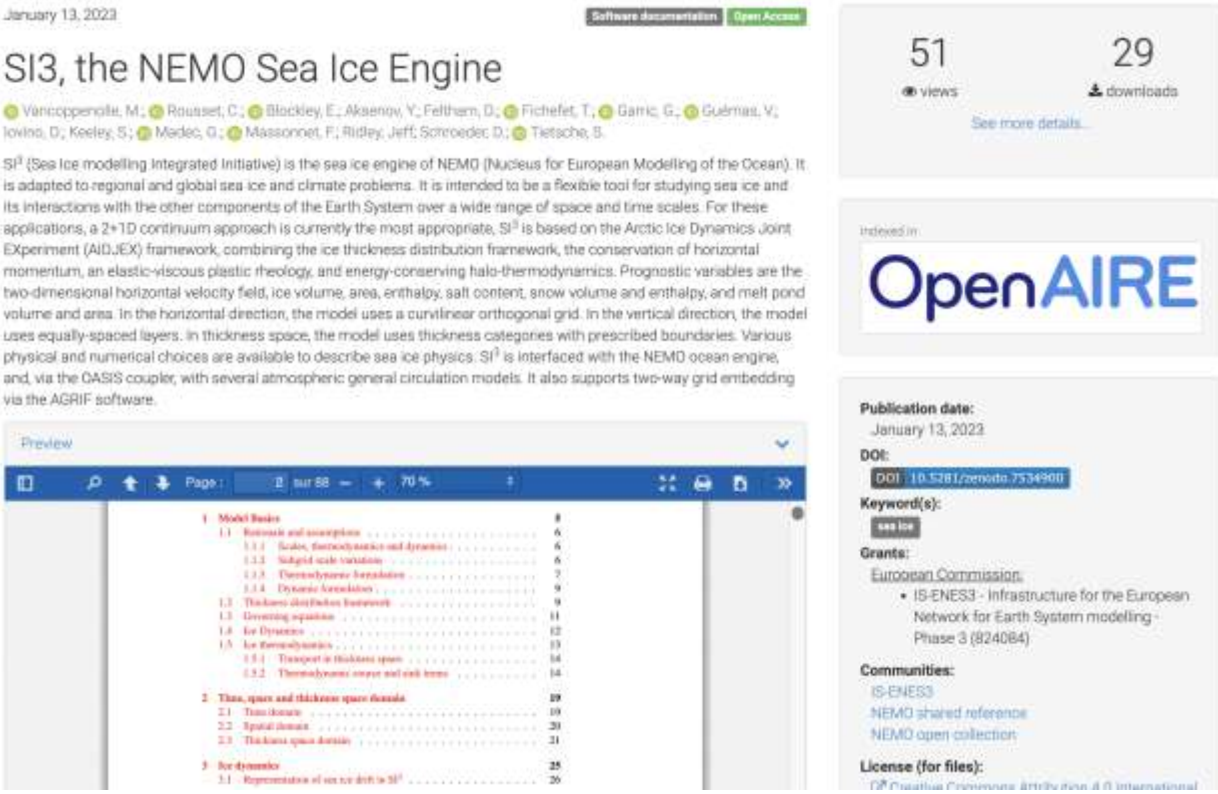

Figure 3. Screenshot of the Zenodo repository page for the SI3 documentation.

3. Difficulties overcome

Difficulties on the documentation are the amount of work that writing represents, and that this work must be done by developers of the code themselves who are already quite busy writing the code. Defining the best way to write and to standardize documentation contents took time because it needed thinking. Technical issues were also encountered, related to the fact that the NEMO code/documentation distribution server changed from SVN to git, and that the latex framework for documentation evolved while we were working. Finally, several pieces of code pulled through from previous models into SI^3 had no or fairly incomplete documentation.

4. Next steps

Next steps are to revise chapters, to organize community review, and to enforce that new developments are systematically documented.