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INFRASTRUCTURE FOR THE EUROPEAN NETWORK FOR EARTH SYSTEM MODELLING

Final General Assembly

16-18 January 2023 Toulouse

An update on work towards:

"A European Platform for Sea Ice modelling"

Ed Blockley (Met Office)
Martin Vancoppenolle (CNRS-IPSL)

Task 2 leads, WP4 & WP8

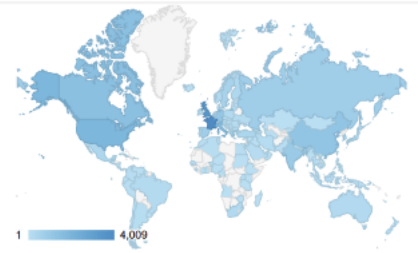
IS-ENES3 has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824084

The Sea Ice modelling Integrated Initiative (SI³)

Building a new community around a European Platform for Sea Ice modelling in NEMO

- Previously NEMO sea ice community was fragmented:
  - LIM (2&3), CICE & GELATO models used routinely with NEMO
- New collaboration within Europe to pool resources and develop unified NEMO sea ice model:
  - **Sea Ice modelling Integrated Initiative (SI³)**
  - Led by NEMO Sea Ice Working Group - Ed Blockley (Met Office) & Martin Vancoppenolle (IPSL) co-chairs
  - Merging functionality from LIM, CICE & GELATO models used with NEMO
  - Bringing sea ice fully within the NEMO Consortium – including long-term development strategy

NEMO web/code access (2016)



Top 10 number of sessions by countries

Country	Sessions
France	4,009
United Kingdom	3,378
United States	1,899
Italy	1,635
Canada	1,490
China	1,222
Germany	1,149
India	983
Spain	772
Russia	770

NEMO

IS-ENES3 provides important funding support for NEMO-SI3

Two main strands:

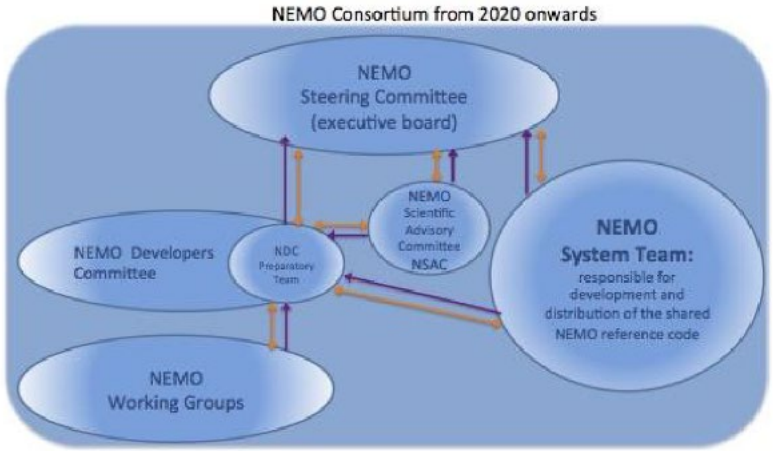
1. Building a community around NEMO-SI3 [WP4/NA3]:
   - Developing a sustainable development strategy for sea ice in NEMO – inc. governance, technical (coding standards, testing,…), scientific
   - Updating sea ice section(s) within NEMO Development Strategy (NDS)
   - **M4.1**: Development strategy workshop for NEMO sea ice modelling [Sept 2019 – *complete*]
   - **D4.2**: Development strategy for sea ice modelling in NEMO [July 2021 – *complete*]
2. Development of key infrastructure for SI3 [WP8/JRA1]:
   - Technical code development & testing: modularity, robustness, coupling interfaces, …
   - Sea ice model documentation
   - **D8.1**: Provision of SI3 code through the NEMO repository [Sept 2021 – *complete*]
   - **M8.5**: SI3 model documentation [Dec 2022 – *complete*]

M4.1 international sea ice modelling workshop

- IS-ENES3 international sea ice modelling workshop
- To inform the NEMO sea ice development strategy
- Agenda Developed within IS-ENES3 in conjunction with NEMO SIWG and external partners
- Two main themes:
  - Scientific and technical validity or limitations of the physics and numerical approaches in current models
  - Physical processes and complexity: Bridging the gap between weather and climate requirements
- Focus on discussion sessions and ideas sharing

- A trans-Atlantic workshop
  - Laugarvatn, Iceland, September 2019
  - Co-hosted with Elizabeth Hunke (US DOE & CICE)
- 32 sea ice modelling scientists attended:
  - 10 experts from North America, 22 from Europe
  - 13 NEMO developers/SIWG members
    10 IS-ENES3 partners

D4.2: Development strategy for sea ice modelling in NEMO



- Three focus areas for SI3 development strategy:

  Political; Technical; Scientific;

- Political:
  - SI3 will be part of NEMO ocean modelling framework
  - Governance, ownership, leadership following NEMO model
- Technical:
  - SI3 will sit within the NEMO repository
  - Development guidelines will follow NEMO (code design/standards, workflow, testing, …)

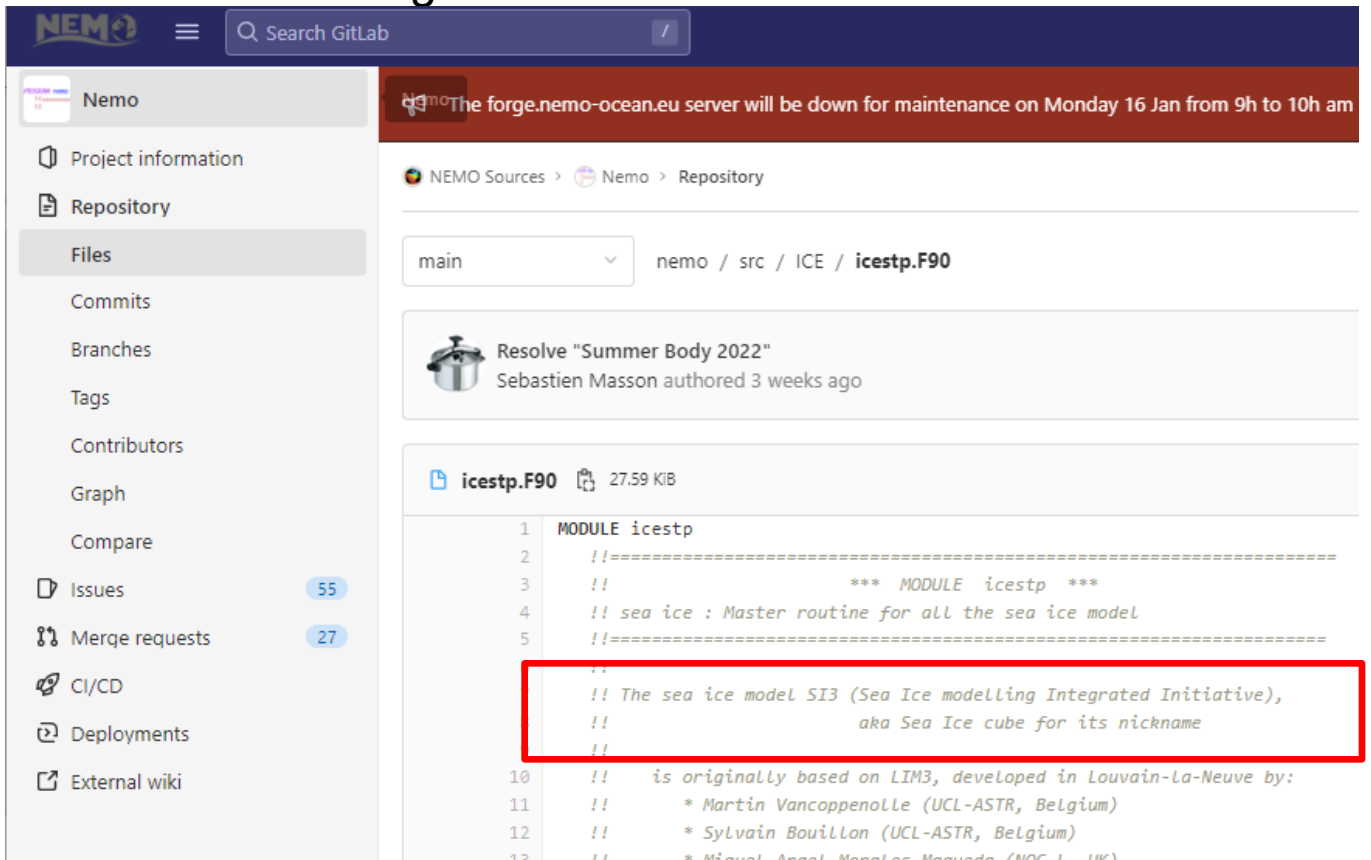
D4.2: Development strategy for sea ice modelling in NEMO

- Scientific:
  - SI3 science strategy tied to the wider NEMO Development Strategy (NDS)
  - Refresh of NDS sea ice chapter performed as part of D4.2

- Development of new NDS version, released November 2022
  - Several rounds of internal & external review
  - Key points:
    - **Favour smooth evolution** of the existing code, but also **encourage research on the feasibility of major structural changes** (e.g., discrete element and hybrid approaches).
    - Most pressing needs for SI3 not only related to evolving the physics, but also **improving access to, and take-up of, SI3**. Recommend **improving code modularity, coupling interfaces, and documentation.**

D8.1: Provision of SI3 code through the NEMO repository

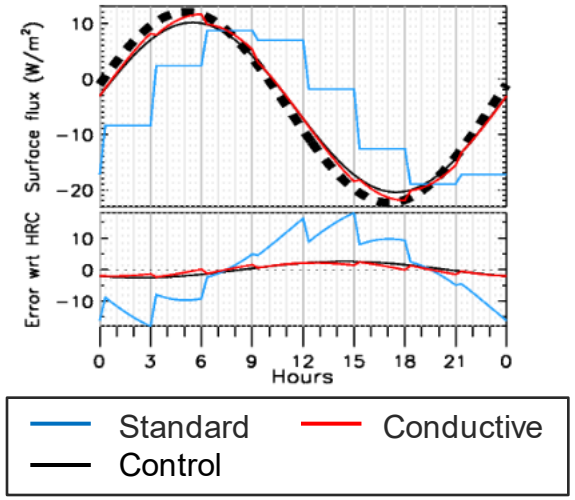
- SI3 available as part of **NEMO 4.2** GitLab repository
  - Modularity and robustness:
    - Code simplification (structure, ice-atmosphere interface)
    - Improved conservation of mass and heat & associated diagnostics



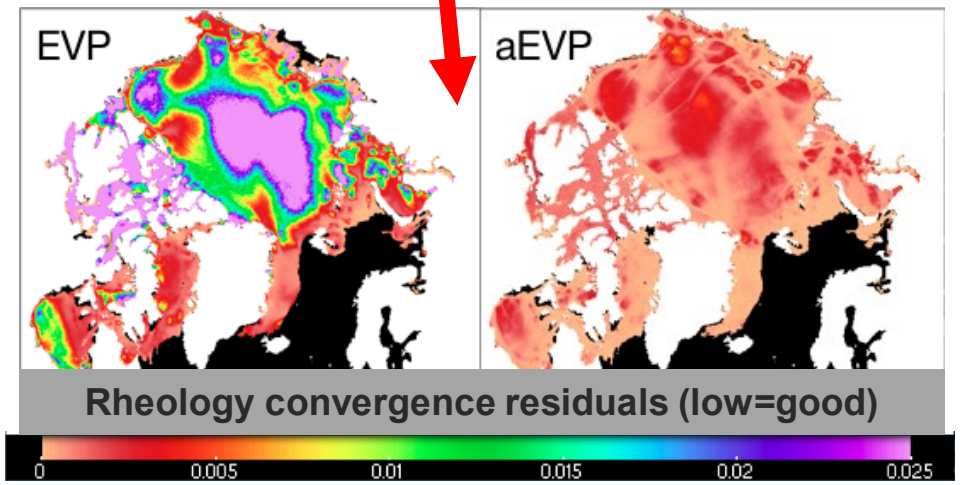
D8.1: Provision of SI3 code through the NEMO repository

- SI3 available as part of **NEMO 4.2** GitLab repository
  - Physics options development:
    - New formulation of ice strength
    - Radiation scheme improvements
    - Conductivity coupling functionality (Met Office/UK coupling)
    - Improved description of melt-ponds (level & topographic)
    - Adaptive EVP sea ice rheology (aEVP)

Conductivity coupling: idealised 1D study

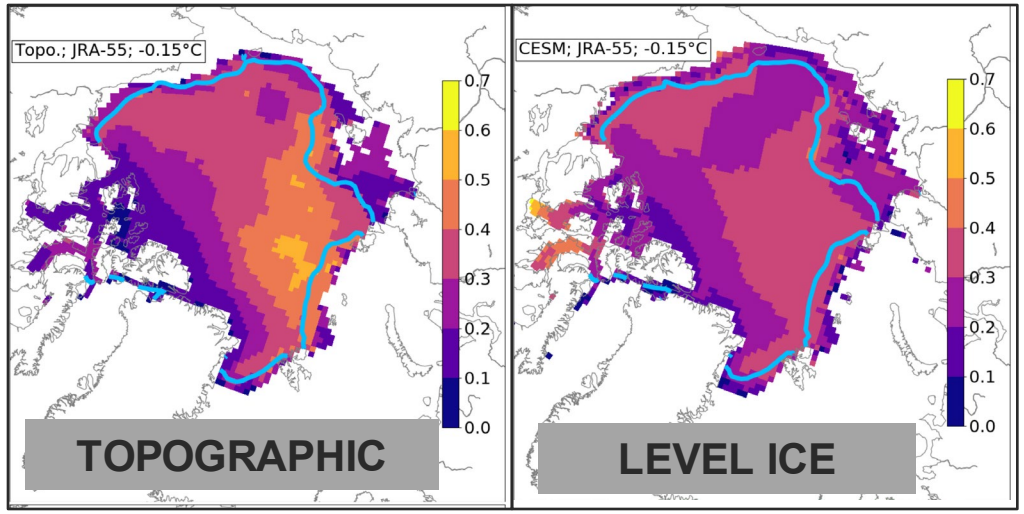


[West et al., (2016)]



[C. Rousset; Blockley et al., (2022)]

[Sterlin et al., (2021)]



M8.5: SI3 model documentation

January 13, 2023

Software documentation | Open Access

SI3, the NEMO Sea Ice Engine

Vancoppenolle, M.; Rousset, C.; Blockley, E.; Aksenov, Y.; Feltham, D.; Fichefet, T.; Garric, G.; Guémas, V.; Iovino, D.; Keeley, S.; Madec, G.; Massonnet, F.; Ridley, Jeff; Schroeder, D.; Tietsche, S.

- 8 Chapters (Model Basics, Domain, Dynamics, Transport, Ridging/Rafting, Thermodynamics, Radiation, Outputs)
- Exhaustive namelist namelist description
- Formulation of documentation guidelines for future consistency
- Community review to be conducted in 2023
- v1.0 on zenodo https://zenodo.org/record/7534900#.Y8GIF-xKg-Q


```
!-----------------------------------------------------------------------
&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
```

Listing 5: SI3 namelist, section ice growth in open water

To convert `qlead_1d` into an ice volume, the enthalpy of the new ice (J/kg) is specified from assumed salinity and temperature for new ice. S_{new} depends on the representation of salinity (`nn_ice_sal`, see Section XX), whereas $T_{new} = T_{fr}(SSS)$. In summary, the volume of new ice is calculated as:

$$V_{new} = \frac{\rho_i Q_{lead}}{E_i(SSS, T_{fr}) - E_w(SSS, T_{fr})}, \qquad (6.2)$$

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THE CONSORTIUM

Coordinated by **CNRS-IPSL**, the IS-ENES3 project gathers **22 partners** in **11 countries**

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