



**Sprint 3**

**Booster for FESOM 2.1**

*GPU support for Finite-volumE Sea ice-Ocean Model*



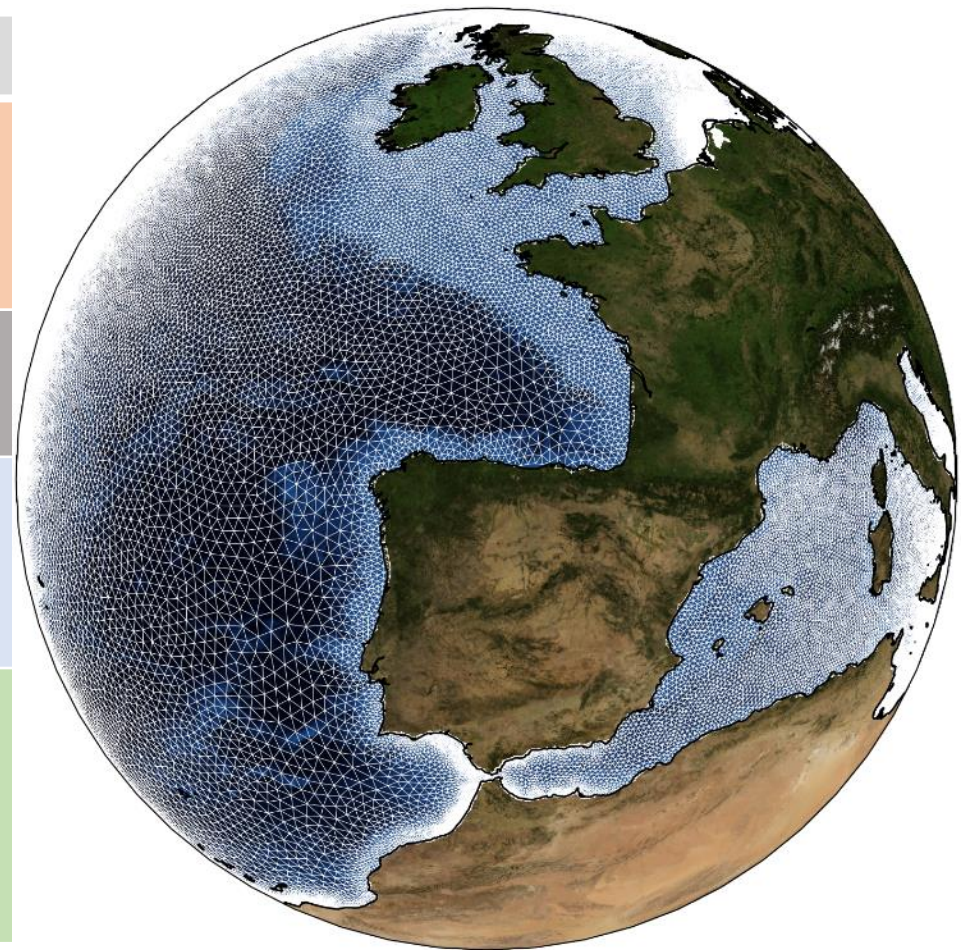
Wilton Jaciel Loch (DKRZ), Enrico Degregori (DKRZ)

&

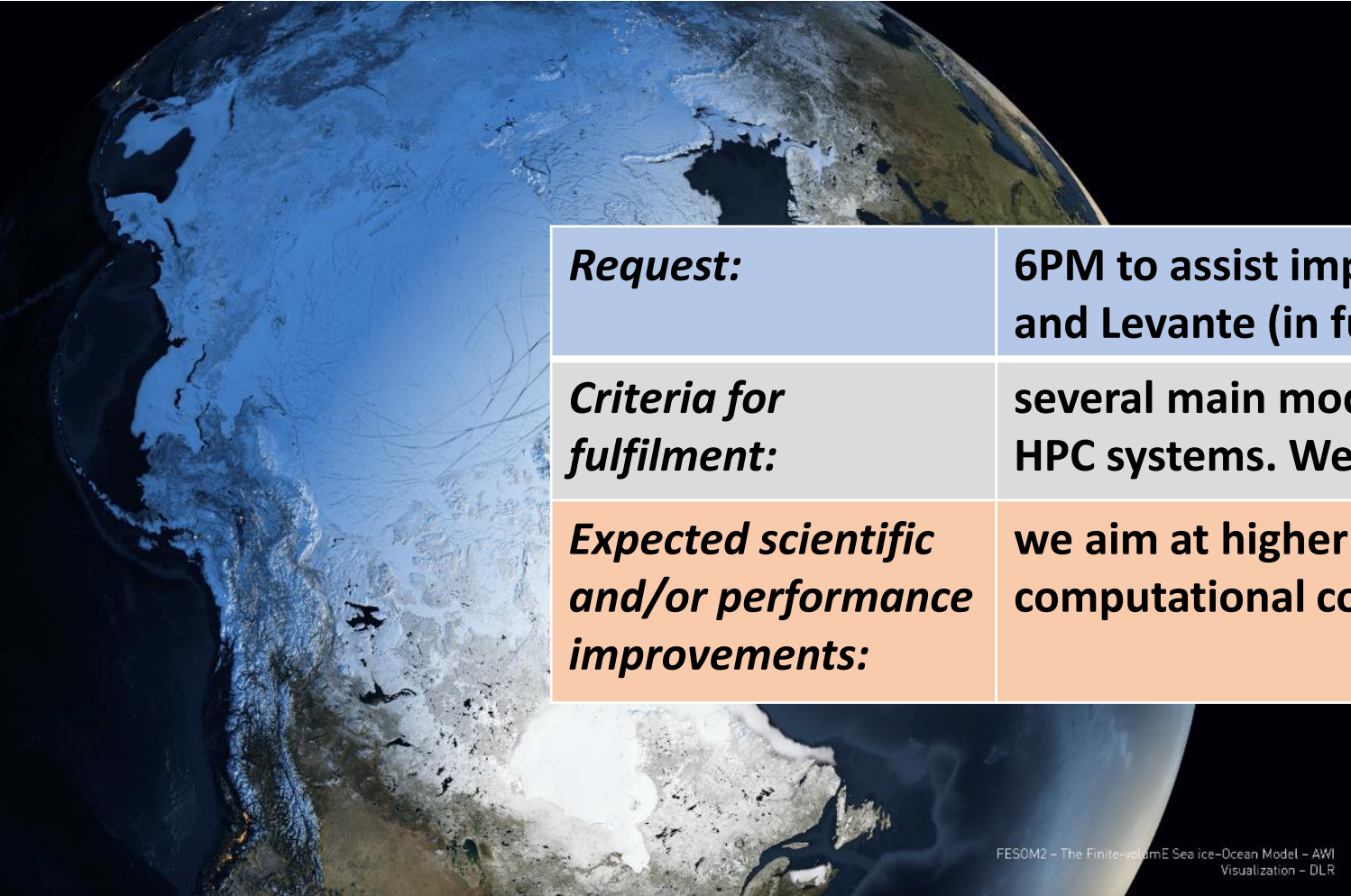
**Dmitry Sidorenko**, Nikolay Koldunov, Patrick Scholz, Suvarchal Cheedela,  
Sergey Danilov, Jan Hegewald, Natalja Rakowsky, Thomas Jung

# Finite-volumeE Sea ice-Ocean Model

<b><i>User group</i></b>	open source, more than 100 active users
<b><i>Targeted simulations</i></b>	very high resolution CMIP, OMIP, HighResMIP type simulations; HPC usage: MPI+OpenMP+(OpenACC) at JSC, DKRZ, HLRN, CSC, BSC etc.
<b><i>Maintenance</i></b>	development supported by AWI (in PoF IV), 5 FTE & 5+ project scientists; open source hosted at GitHub
<b><i>Scientific highlights:</i></b>	contributed to IPCC through CMIP6, HighResMIP, OMIP and PMIP projects; more than 200 scientific publications.
<b><i>Social relevance:</i></b>	aims at improving the weather and climate predictions; a partner of ECMWF (IFS+FESOM); provides information for climate adaptation and mitigation (Digital Twin, CMIP7?)



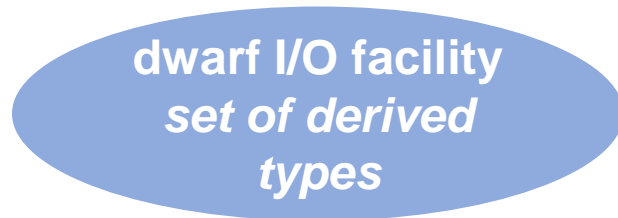
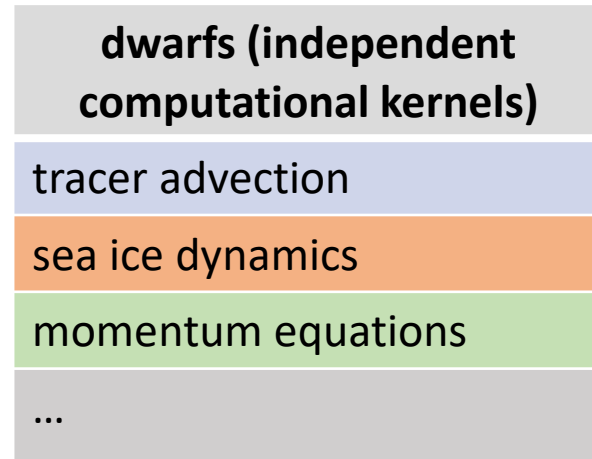
# Challenges



<b><i>Request:</i></b>	<b>6PM to assist implementation of GPU support at JSC Booster and Levante (in future LUMI &amp; Marenostrum5)</b>
<b><i>Criteria for fulfilment:</i></b>	<b>several main model kernels running on GPUs at new generation HPC systems. We are open for OpenACC &amp; OpenMP5.X</b>
<b><i>Expected scientific and/or performance improvements:</i></b>	<b>we aim at higher resolutions, higher throughput and low computational cost („green computing“)</b>

FESOM2 – The Finite-volume Sea ice–Ocean Model – AWI  
Visualization – DLR

## Dwarfs concept

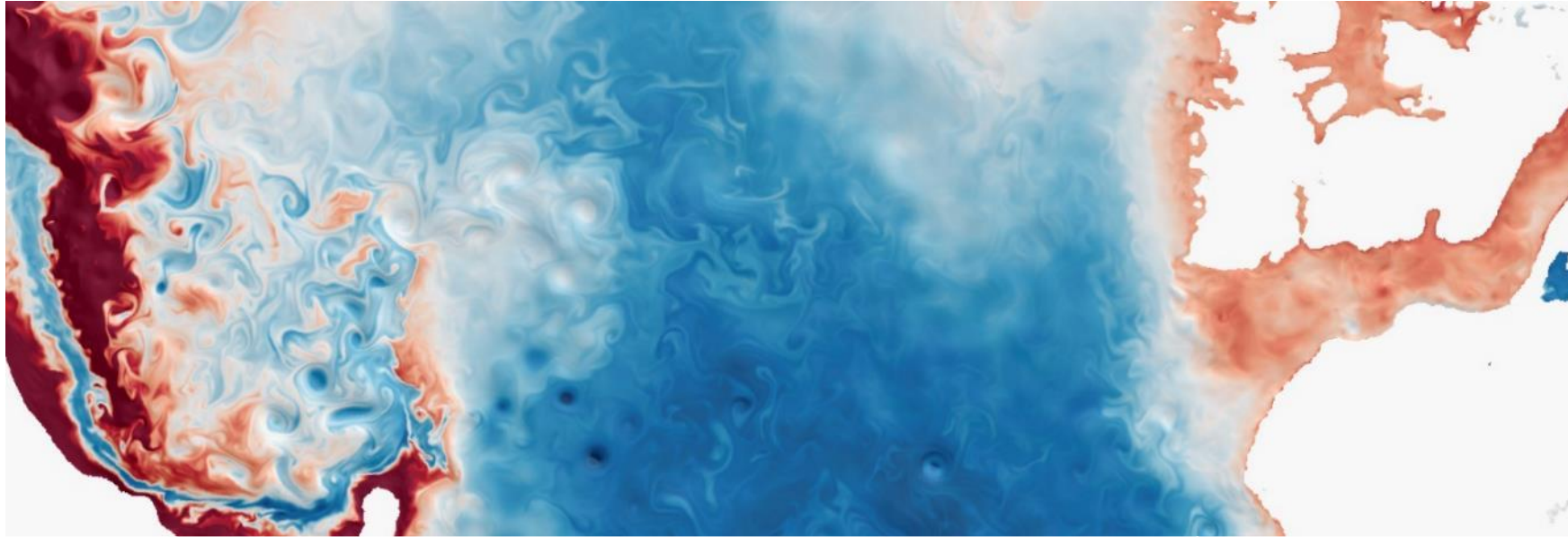


$$\text{FESOM} = \sum \text{dwarfs}$$

# GitHub

- ✓ No need for full model (configuration files etc.)
- ✓ Reduced amount of code as compared to full model
- ✓ Any change in dwarf is linked with the change in FESOM

# Different strategies (OpenACC, OpenMP & CUDA) tested. The choice is **OpenACC**.



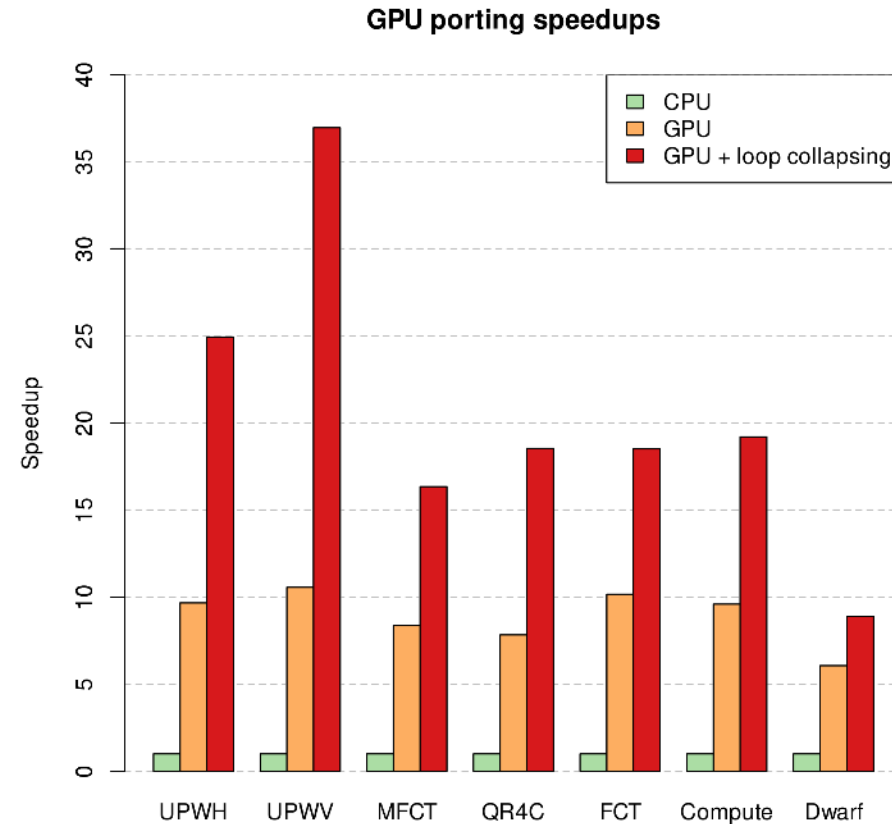
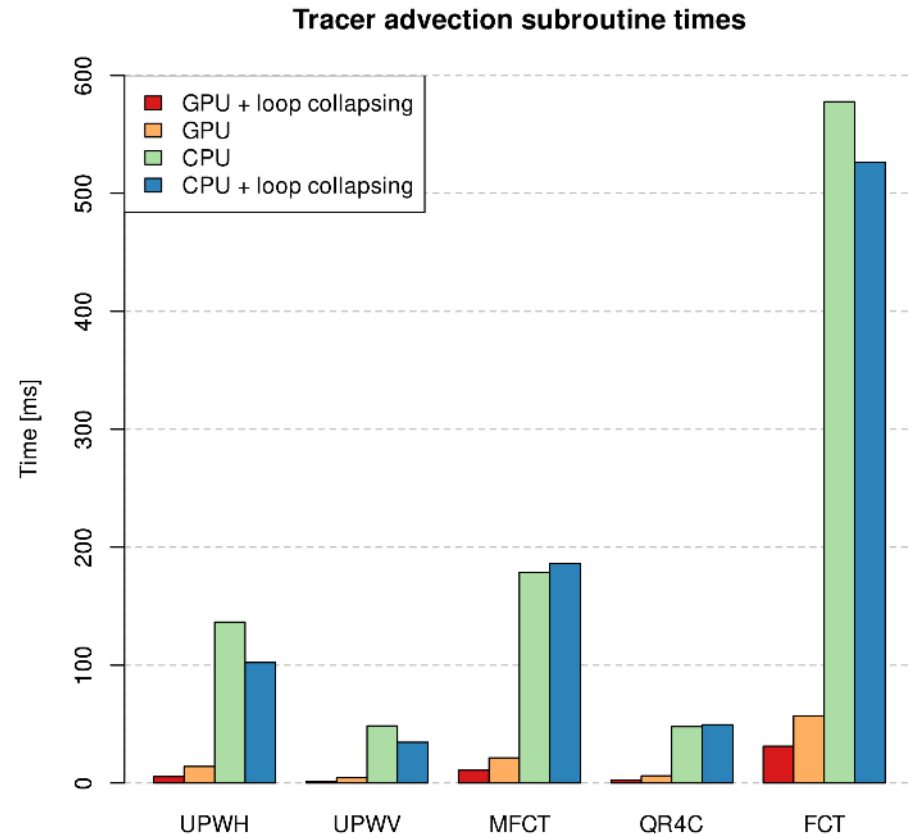
**Status:**

advection of ocean tracers (3D: horizontal, vertical & FCT)	ported, optimized, merged
advection of sea ice (2D: horizontal & FCT)	ported
nonlinear dynamics (density, pressure etc computations)	in process

The progress will be merged to the main FESOM repository:

<https://github.com/FESOM/fesom2>

# Results for advection of FESOM tracers

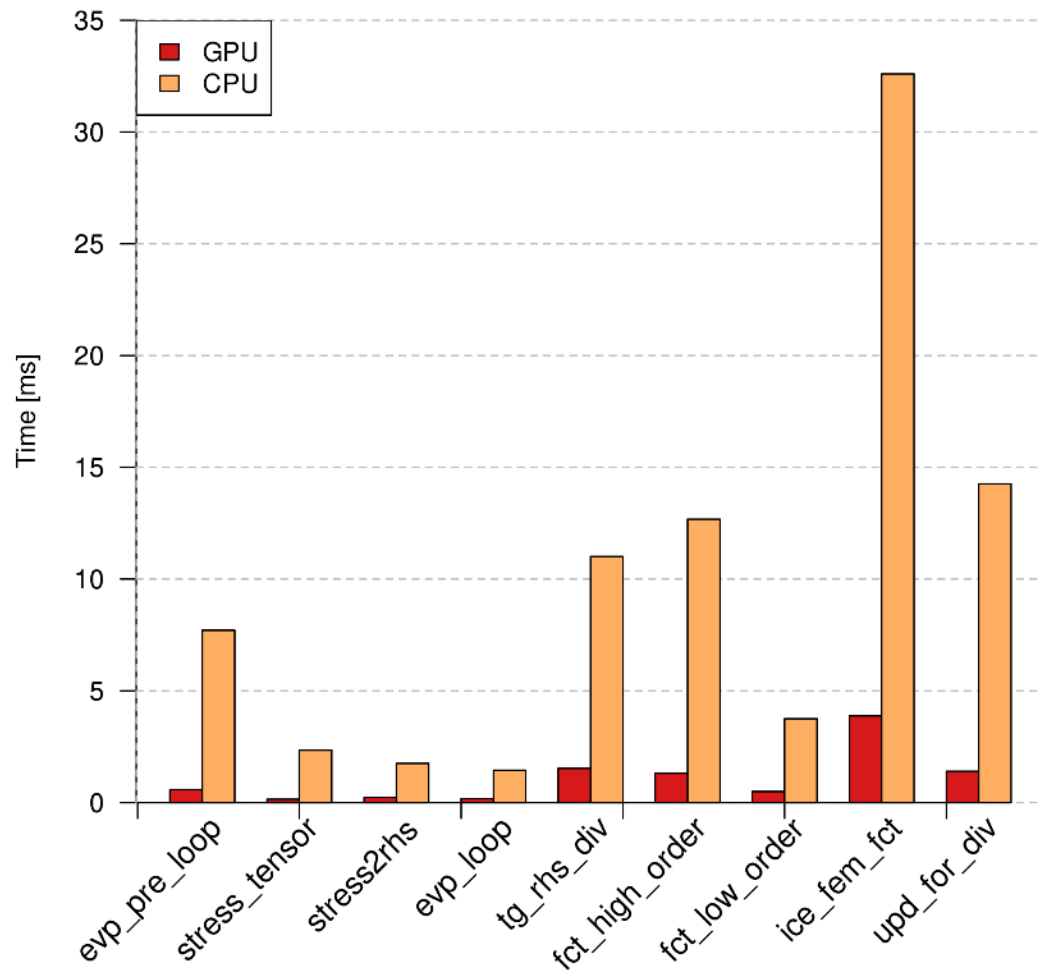


- ✓ FESOM configuration with  $\sim 1/10^\circ$  resolution (**5 mio** surface nodes)
- ✓ **128** processes employed for the CPU execution (1 full Levante compute node, **4.9 TeraFLOPS**)
- ✓ **4** processes employed for the GPU execution (1 full Levante GPU node, **46.6 TeraFLOPS**)

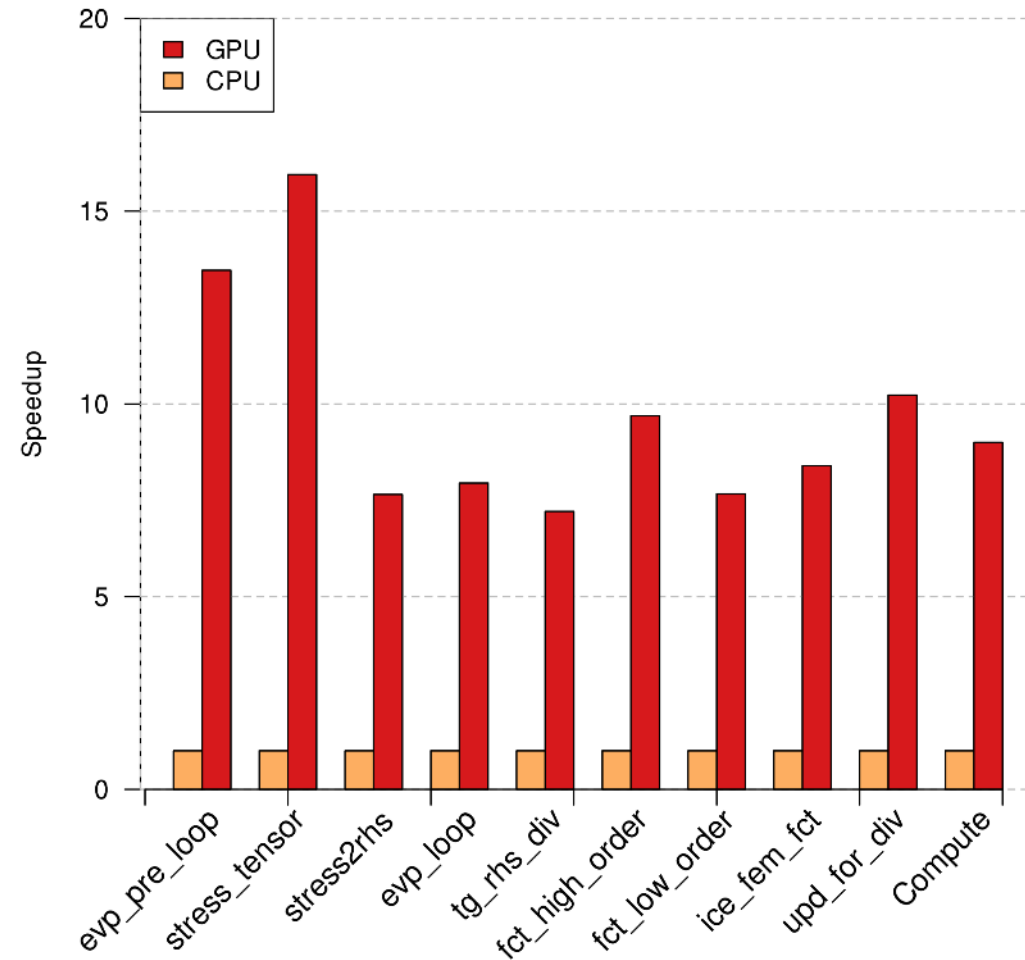
**Surprisingly awesome!**

# Results for FESOM sea ice dynamics

Ice dwarf parallel regions compute time



GPU speedup for ice dwarf parallel regions



**Surprisingly awesome!**

Commits by year:

4	2023
35	2022
3	2023

Commits by month:

4	2023-01
22	2022-12
13	2022-11
3	2023-03

Commits by day of the week:

13	Friday
4	Monday
10	Thursday
7	Tuesday
8	Wednesday

# Sprint statistics on FESOM git

Statistics for WiltonLoch:

Total commits: 77

Lines added: 2289

Lines removed: 2176

<https://github.com/FESOM/fesom2>

Files sorted by lines added:

695	src/oce_ale_pressure_bv.F90
336	src/gen_halo_exchange.F90
196	src/oce_adv_tra_fct.F90
195	src/oce_adv_tra_driver.F90
194	src/oce_adv_tra_hor.F90
188	src/oce_ale_tracer.F90
95	src/oce_adv_tra_ver.F90
91	src/MOD_ICE.F90
73	dwarf/dwarf_tracer/dwarf_ini/fesom.F90
40	src/io_restart_derivedtype.F90
35	src/MOD_DYN.F90
33	src/associate_mesh_ass.h
31	dwarf/dwarf_tracer/dwarf_ini/CMakeLists.txt
28	src/oce_modules.F90
17	src/MOD_MESH.F90
15	src/CMakeLists.txt
9	src/associate_mesh_def.h
7	src/fortran_utils.F90
4	env/levante.dkrz.de/shell
3	CMakeLists.txt
1	src/MOD_WRITE_BINARY_ARRAYS.F90
1	src/MOD_TRACER.F90
1	src/associate_part_def.h
1	configure.sh
0	src/MOD_READ_BINARY_ARRAYS.F90