Summary of 2020-2021 OASIS dedicated supports (IS-ENES3)

E. Maisonnave°, J. Kjellsson*

° CECI, UMR CERFACS/CNRS No5318, France
** GEOMAR, Helmholtz-Zentrum für Ozeanforschung, Kiel, Germany*

Abstract

Despite bad weather conditions, a second round of dedicated support (ODUS) for a better use of the OASIS climate model coupler is provided for two laboratories (NERSC Bergen and GEOMAR Kiel). During this period, the calling of OASIS API routines in models (ocean-ice and runoff mapper-ocean) is re-design to enhance the physical interface (NERSC) or make the most of the last OASIS functionalities, e.g. the locally conservative interpolation (GEOMAR). Computing performance is checked, with more accuracy since the new OASIS event timeline is made available. Modifications are saved in the host repositories for a further use in the laboratories of their respective communities. We regret the obvious limitations experienced in our effort to advertise the capabilities of our community coupler and hope that the last year of the program will be more favourable from this point of view.

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Introduction

As described in the report related to its first year [1], the Horizon 2020 European infrastructure project IS-ENES3 (2019-2022) is organising the extension of the existing OASIS support (hotline, training) to a dedicated support, at user site. In 2020, a total of 3 person-months of Dedicated User Support was supposed to be offered to 3 different groups, following a procedure already described in [1].

From the 3 proposals originally selected for one month long on-site supports, only one could take place on time (NERSC, Bergen), but remotely. A second one (GEOMAR, Germany) was organised on site, but after a one year long delay. The last one (Brandenburg Technical University, Germany) was totally canceled, because of the impossibility to organise the community integration that was originally planed. The effect of the pandemic on our dedicated support program is briefly discussed in § Community Impact.

We provide in this report a detailed description of the two technical collaborations that were provided, together with their main results. In appendix, we also tried to briefly document the practical issues (from which energy resource sustainability) that had to be addressed this year.

Mission #16 : Nansen Environmental and Remote Sensing Center, Bergen (Norway), Ocean modelling group

April – June, 2020

Main Goal: To design and test a coupling interface between ocean & sea-ice HYCOM-neXtSIM models

Summary

The coupling interface of the HYCOM model is modified to allow the exchanges at surface with the neXtSIM ice model. A first order validation is performed in a stable one year long simulation and its computing performance optimise by reducing the components load imbalance.

HYCOM model	neXtSIM sea-ice model
devel branch of the v2.2 code available at https://github.com/nansencenter/NERSC-HYCOM-CICE	Master branch of the code available (private) on https://github.com/nansencenter/nextsim
Atlantic ocean domain, from 1° to 12Km, 100x110 (LR) to 380x400 (HR), 32 vertical levels	Lagrangian grid but internally interpolated to HYCOM grid before OASIS exchange
For reference description see [2]	For reference description see [3]

```
Supercomputer:
"fram", Uninett sigma2 network, Tromsø, Norway
1004 nodes of 16 cores - Intel E5-2683v4 2.1 GHz - Memory per node: 64 Gb
https://www.top500.org/system/179072
```

The aim of this dedicated user support is to validate the OASIS interface that connects the ocean model HYCOM to the sea-ice model neXtSIM. We start from a version of HYCOM that runs without the ESMF coupling framework, originally implemented to couple the CICE model [4], and from a draft OASIS interface, already implemented at NERSC, for sending and receiving fields in HYCOM. Through this interface, the writing of HYCOM outgoing coupling fields to netCDF files is already available. The present support mainly consists in extending this function to a full exchange with the ice model and check that the coupling effect stays realistic. On the other model, the neXtSIM coupling interface we need for the HYCOM coupling has to be adapted from the one in use for exchanges with the ocean model NEMO.

Model description

HYCOM [2] is an ocean model using hybrid coordinates, isopycnal coordinates in the deep stratified waters, and z-level coordinates in the upper mixed layer. A description of the NERSC setup of HYCOM can be found in [5] and user guides for the different versions of HYCOM are available online at `http://hycom.org/hycom/documentation`.

HYCOM can include a biogeochemistry (BGC) component (ECOSMO), using the framework for Aquatic BGC Models (FABM), which is not a coupler in the same sense than OASIS, but a set of routines that allows to include in HYCOM different BGC models (or use ECOSMO with a different ocean model). When compiled with FABM, the BGC model is included in the HYCOM executable. Optionally, the HYCOM model can be coupled with ESMF to the CICE model but this existing set of routines is replaced, in our starting version, by an OASIS interface, made to connect neXtSIM.

NeXtSIM [3] is a continuous and fully Lagrangian model, whose momentum equation is discretised with the finite-element method. In this model, sea ice physics are driven by the combination of two core components: a model for sea ice dynamics built on a mechanical framework using an elasto-brittle rheology, and a model for sea ice thermodynamics providing damage healing for the mechanical framework.

The trunk version of the model was used during this support. In this version, the interpolation from the neXtSIM Lagrangian grid to the HYCOM grid was already made available by the NERSC ice modeling group. This operation takes place in the neXtSIM model in such a way that there is no need to perform any interpolation with OASIS. The coupling fields are gathered in the whole domain on the MPI master process so that OASIS is only required for communicating with the neXtSIM executable and scattering the arrays to each MPI subdomains of the HYCOM executable.

Interface upgrade

The neXtSIM OASIS interface was already prepared for an HYCOM coupling. Derived from the one already implemented to allow NEMO exchanges, the neXtSIM interface only has to be extended to take into account the reception of the first ocean layer depth (with observed but no significant effect on model output) and the providing of two new fields (mean sea level pressure and wind module). The C++ coding language used by the neXtSIM developers differs from the usual FORTRAN language, mostly preferred in our community. This forbided a quick access and modification to adapt the coupling interface to the HYCOM coupling needs. We mostly rely on the NERSC ice modelling group to realise this part of the interface upgrade. Nevertheless, it was possible to propose and implement in neXtSIM a solution to select the OASIS coupling fields sent to NEMO or HYCOM, based on the `namcouple` definition.

The 4th version of our coupler (revision 2561) was already in use when this support started. No upgrade was needed in this coupling work.

Most of our work focused on HYCOM interface adjustments. In the following paragraph, we list all the coupling fields modified by this upgrade or added during this operation. In a preliminary work, we had to shift the internal model counting of coupling time steps (equal to the model time step count, minus one time step) to allow the correct ending of the simulation, with the production of OASIS restart file. Please notice here that OASIS restart files were necessary to let the two models start and perform their calculation concurrently (or said differently, in parallel). This parallel execution of the two models implies that both were using coupling field values calculated during the previous time step of their counterpart. It was not possible to estimate the impact on model output of such shift in comparison of the sequential coupling (see for example [1], MetOffice support, for an example of such estimation with NEMO ocean and SI3 sea ice). However, the beneficial effect on computing performance is presented in the corresponding paragraph.

In Table 1, we list the coupling fields sent by the two models. HYCOM provides surface or near surface quantities calculated by the ocean model, while neXtSIM delivers sea-ice quantities or atmospheric fluxes read in forcing files and possibly modified by the sea-ice model.

From HYCOM	From neXtSIM
Sea surface temperature	Wind stress (i,j components)
Sea surface salinity	Evaporation minus precipitations
Sea surface height	Long wave flux
Sea surface current (i,j components)	Short wave flux
Depth of the first level	Sea ice cover
Fraction of solar net radiation absorbed in the first level	Salt flux
	Mean sea level pressure (needed by BGC)
	Wind module

Table 1: coupling fields exchanged between HYCOM ocean and neXtSIM ice models in the present NERSC setup

It was not necessary to change any input file of both model to let them run in a single MPMD command. We only proceed to the appropriate modification of the two parameter files (`cpl_run.cfg` for neXtSIM and `blkdat.input` for HYCOM) to set up the model in coupled mode, in particular, in HYCOM:

- the `wndflg` flag is equal to 7 to use the coupled neXtSiM stresses instead of the forced data
- the `iceflg` value to 0 to avoid calculating wrong fluxes over ice in the `icloan` subroutine
- the `ustflg` must be equal to 4, to let `ustar` be calculated with the coupled stress components. A warning in `blkdat.F` must be adapted to use this flag in conjunction with `flxflg` = 3

Water flux

After a unit change (in OASIS) from mm/s to m/s, we introduced the neXtSIM evaporation minus precipitation variable[1] in the HYCOM `thermfj` routine. A one month long simulation test was performed and revealed significant effect on other quantities (such as surface salinity). In a closer validation, we compared the precipitation values taken from the forcing files (ERA-I) of neXtSiM and HYCOM model, given that evaporation is calculated differently in the two models. The difference (a mismatch in data set version) can explain the differences observed between our forced and coupled simulation.

Salt flux

The salt flux quantity is calculated in `thermf.F`, at each unmasked grid point, to convert, at the interface, the whole water budget into a salt quantity. But a specific salt budget is needed[2] to take into account the salt rejection/absorption under the sea ice. The effect on sea surface salinity, after one month, can be seen in Figure 1. As expected, the effect is limited to the Arctic area (and river mouths), since the spatial treatment of the salt flux over ice also implies a modification of the river mouth salt flux processing.

1 `emnp` model variable
2 `sflice` model variable in `thermf_oi` subroutine

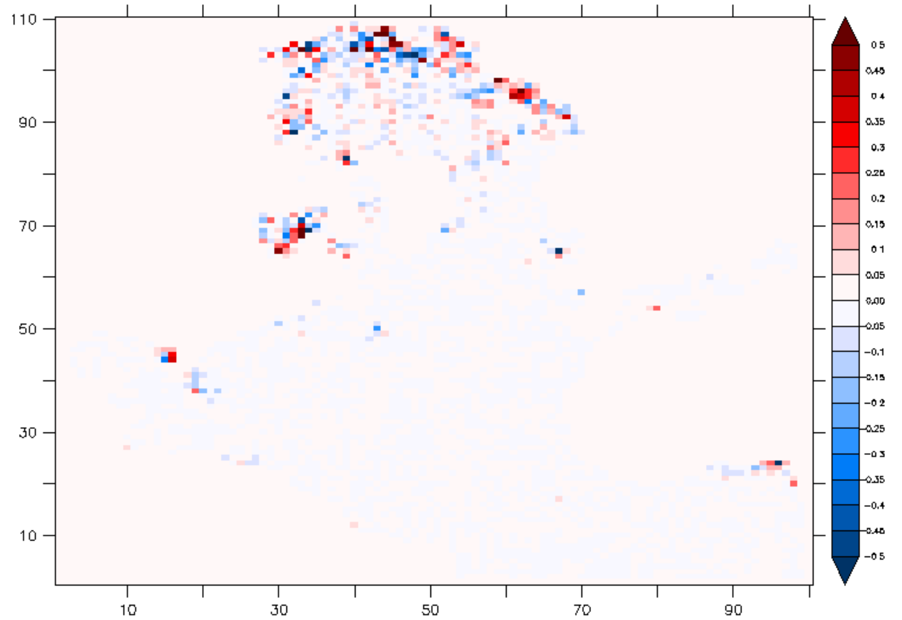


Figure 1: Effect of neXtSIM salt flux budget under sea-ice on neXtSIM sea surface salinity, i,j axes, Arctic ocean on the top of the plot

Wind stress module

In neXtSIM `finiteelement.cpp` subroutine, it is explicitly required to match `namcouple` fields with the neXtSIM declared fields, for both sent and received quantities. This operation is totally mandatory for received fields. But for the sent fields, OASIS allows a model to send a field that will not be used by any other model of the coupled system (in this case, the field simply does not appear in the `namcouple).` In our case, HYCOM does not use the wind stress module. neXtSIM explicitly controls that this field is in the `namcouple` and the simulation is stopped. To avoid controlling the `namcouple` matching (and simply print a warning), a set of modifications were proposed in our `git` branch for not sending the model declared fields if they are not declared in the `namcouple`, so that it is possible to select the neXtSIM sent field by the `namcouple` according to the need of the coupled ocean model.

Short wave

Even though the total heat flux was provided to HYCOM in the draft interface, the short wave field is needed separately in HYCOM, in the mixing routines. We filled the related `sswflx` variable in `thermf_j` routine with the coupled quantity. A significant change in both sea surface temperature and salinity can be observed after this modification, even though the impact of this modification on variable more directly related to mixing was not checked.

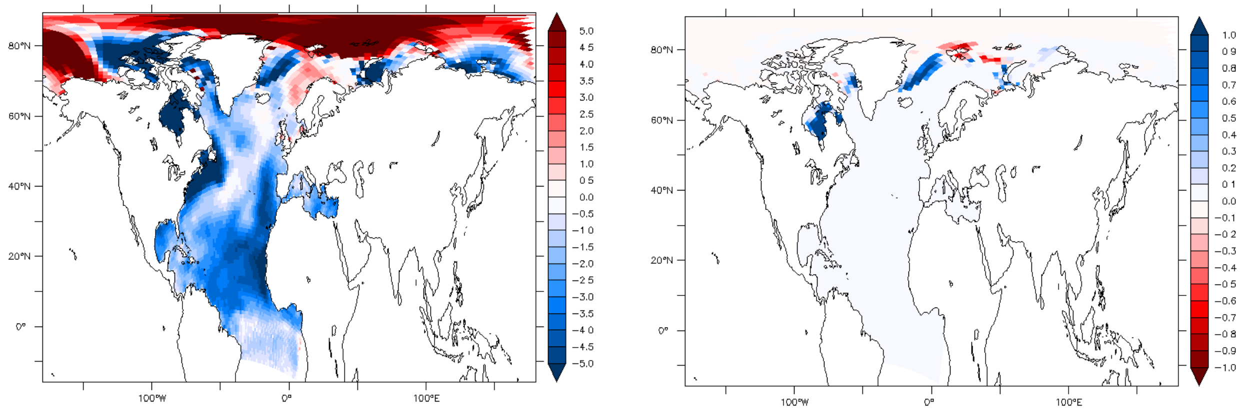
Mean sea level pressure & wind speed module

To enable the BGC model in our coupled system, these two additional fields must be provided to the HYCOM model. They allow to calculate the CO_2 concentration needed by the BGC model ECOSMO. A received coupling field is added to the existing list and its effective reception enabled if the model includes passive tracers (`ntracr` set to 1). They are used in the `update_fabm_data` subroutine, if are activated the CPP keys for OASIS coupling and BGC modelling. Checking the content of the `atmco2_fabm` variable makes visible the impact of our coupling. In addition, the CO_2 concentration in first ocean level is diagnosed. A shift in min/max values makes obvious the exchange by a coupled field. Both MSLP and wind speed module were extracted by the NERSC ice modelling group from neXtSIM, in an ad hoc modification of the coupling interface. The `namcouple` was adapted accordingly. A simple unit conversion is done in OASIS before sending the MSLP related information to HYCOM. After a one month long test, the two new coupling fields have no effect on SST, but a change is visible in min/max values of the CO_2 water concentration output (for each coupling field).

Validation

A one year long simulation is performed to check the model stability. A rough estimate of the model biases is checked comparing the first and the last 6 days of the simulation (Fig 2).

Despite an decrease ocean surface temperature, and regional differences in ice cover, the ice model recovers most of its extension at the end of the simulation. A different tuning of stress flux computation (HYCOM namelist) would lead to the opposite result in surface temperature and ice thickness, which shows, by contrast and as usual in such climate model, the weak impact of our coupling options. Even though it is not possible to attribute how much the neXtSIM coupling contributes to this bias, we can certify at least that no obvious coupling error (field mismatch, unit) remains in our setup.



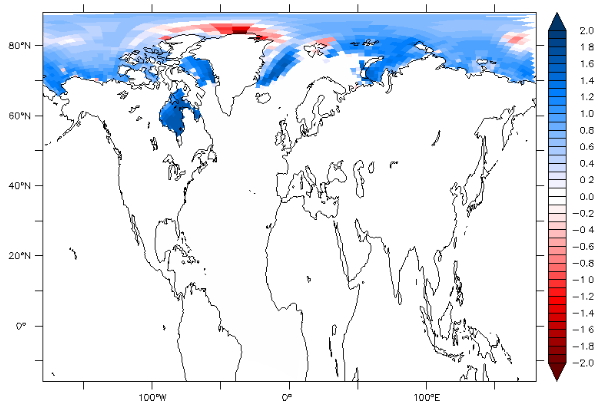


Fig 2: One year bias, 6 day average, for temperature (C°, upper left), sea ice cover (%, upper right) and sea ice thickness (m, lower left)

Performance

Since the interpolation from the neXtSIM Lagrangian to the HYCOM grids is already performed in the ice model, there is no need to activate any SCRIP or other external interpolation via OASIS. Due to the low resolution of the model, and considering analogous measurements taken on similar machine (see for example [1], GEOMAR support), we consider that the communication cost (time spent by MPI to communicate the 7+8 coupling fields at each time step) is negligible. The so called *coupling time* [6] is entirely included in the load imbalance between the two models. The OASIS post-processing tool `lucia` [7], compiled in the Norwegian machine helped to reduce the load imbalance at a minimum (for low resolution, see Figure 3). A better load balance is certainly possible, but the ideal ratio of neXtSIM/HYCOM resources would require to use more computing cores.

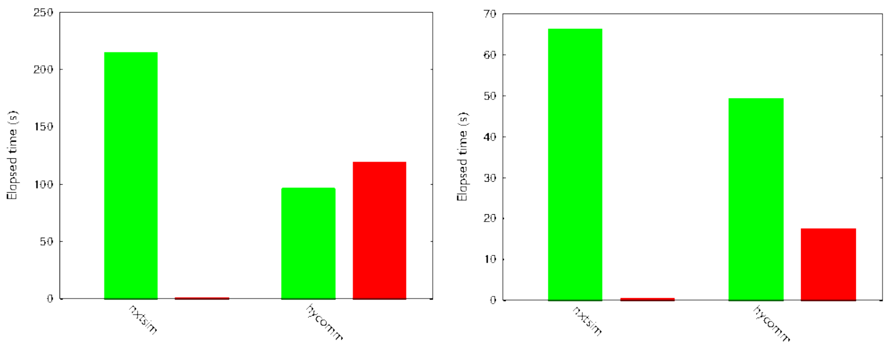


Figure 3: Computing (green) and waiting (red) time (s) of neXtSIM & HYCOM models in a one month long coupled simulation, for two different decomposition (2 & 4 cores, left and 4 & 4 cores, right)

Perspectives

Coupling originally independent models via a coupling software such as OASIS means that some quantities needed at one or several model boundaries are replaced by an information coming from another model of the coupled system. The original boundary quantities are usually taken from a set of data available in forcing files and read from disk during the simulation. A preliminary work, not done in this support, consists in preventing the model to read these files (and deliver these quantities via OASIS instead). A complementary work to our support would aim to unplug these unnecessary file reading operations and check that the model results are not affected by these changes.

Mission #18 : GEOMAR, Kiel (Germany), Marine Meteorology team

From October 4 to October 29 , 2021

Main Goal: Modification of the river runoff interpolation and its duplication in direction to the AGRIF zoom included in the NEMO model

Summary

A new runoff interpolation algorithm is introduced in the existing OpenIFS-NEMO coupled model. It relies on the new locally conservative method implemented recently in OASIS3-MCT v5. The number of debouch grid points per basin is tuned to avoid numerical instabilities while keeping a realistic spatial spread in the global ORCA05 grid as well as in the North Atlantic 10Km resolution AGRIF zoom.

OpenIFS, atmosphere	NEMO, ocean	Runoff mapper
cy43r3 of the global model, https://confluence.ecmwf.int/display/OIFS	v3.6 of the global ocean model, https://www.nemo-ocean.eu	
T191 (100km), 91 vertical levels	ORCA05, 46 vertical levels. Includes AGRIF zoom (VIKING 10X, North Atlantic, 10km)	0.7° regular grid
For reference description of the IFS version from which OpenIFS is derived see [8]	For reference description of the whole model see [9]	For reference description, see [10]

```
Supercomputer:

“lise”, HLRN - Zuse-Institut, Berlin, Germany

1236 nodes of 96 cores - Intel Cascade Lake Platinum 9242, 2.3GHz - Memory per
node: 384 GB

https://www.top500.org/system/179702
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A one an a half year delay in the ODUS delivery has made necessary a re-focus of its main goal. Since a new version of the OpenIFS component was under integration in the Flexible

Ocean and Climate Model Infrastructure (FOCI) [11], we propose to contribute to the coupling system definition and set up. A concomitant increase in resolution required modifications in the coupling parametrisation. But the main task, already planed in the initial ODUS proposal, focused on the modification of the river runoff interpolation and its duplication in direction to the AGRIF zoom included in the NEMO model.

Model description

The FOCI2 coupled system [12], currently under testing at GEOMAR, was ported on the HLRN supercomputer just before the support period. A high resolution configuration was chosen to test a new runoff interpolation on both NEMO ORCA global grid and on the North Atlantic zoom defined with AGRIF. A larger description of this model can be found in the report of the previous ODUS given at the laboratory [1]. We detailed here the functioning of the small executable that makes possible the distribution to the ocean of the OpenIFS land surface water that is supposed to overflow the soil reservoirs. This simple runoff mapper (RM), briefly described in [10], is compiled on a separated executable. It receives the atmosphere coupled field from OASIS on its 66 hydrological drainage basins, discretised on a regular grid (0.7°). An instantaneous and conservative redirection of the per basin sums is performed internally every 3h long time step toward river mouth grid points, defined on a grid similar to the NEMO global one. The basin to river mouth association is hard coded. To avoid to mix up the last land grid point including the river mouth and the first ocean grid point receiving the runoff field, we call in this document "river mouth" the former and "debouch" the latter.

Rationale

The RM performs two operations in a single step: (i) the area weighted averaging of each basin runoff content (on its regular grid) and (ii) the interpolation of these quantities to one or several debouch grid points per basin (on the NEMO grid).

The main drawback of this solution is the ocean grid dependency of the RM FORTRAN code. There is no possible parametrisation of the output grid and the model has to be recompiled after an explicit and hand made redefinition of all basin/debouch associations.

In addition, a large number of debouch grid points are defined for each basin, with the aim to distribute the fresh water far away from the coast and avoid model instabilities in link with low or even negative salinity in these areas. The number of debouch grid point is independent of the raw value of the runoff field. In many cases, this could lead to unrealistic dispersion of the river outflow.

The outgoing runoff coupling field is not directly provided to NEMO but a bilinear interpolation is performed by OASIS when the field is communicated from the RM to the ocean. This interpolation, done with identical source and target grid, probably further smooths the coupling field in space dimensions. A final global conservation is prescribed during the OASIS post-processing stage, but the locality of the river outflow may be lost during these series of non local computations.

We propose to change the runoff mapping algorithm to (i) make the RM program independent of the NEMO grid and (ii) substitute in OASIS the set of non local operations with the newly developed locally conservative interpolation.

Implementation

Modification of the Runoff Mapper program

The RM FORTRAN program must be modified to associate land grid point river mouths to each basin, which makes the program independent of the ocean grid supposed to collect the river runoff (see Fig 4 below, blue rectangle).

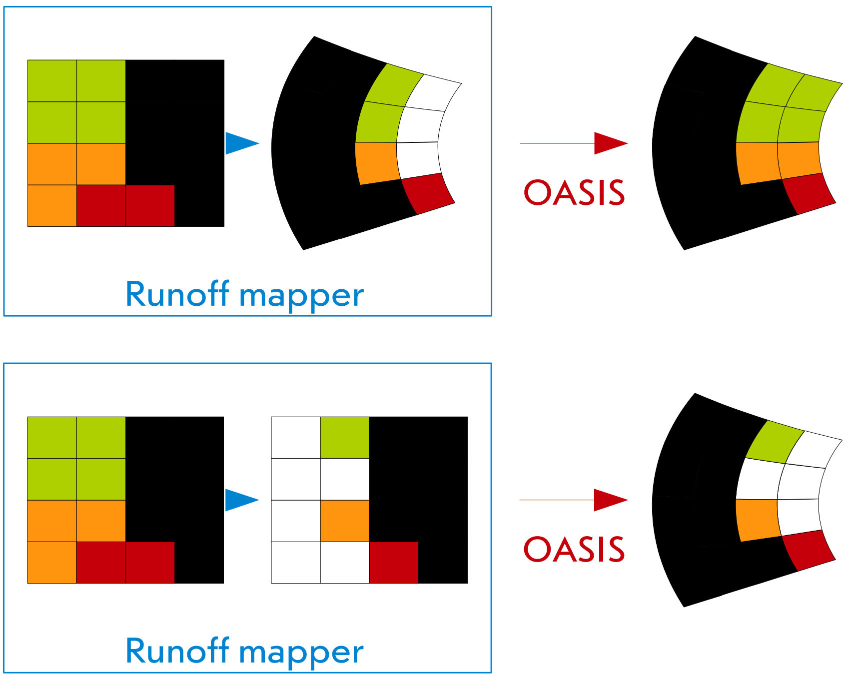

Figure 4: Existing (upper) and proposed (lower) operations to distribute basin runoff (left grids) to NEMO debouch grid points (right grids)

It is of course still necessary to explicitly associate one or several river mouth grid points to every basin. This operation can be facilitated by selecting the land grid point neighbours of, at least, one ocean (masked) grid point. The "`persona`" tool [13] includes several spatial filters to perform the best choice, depending on grid and mask variables of the model. The second operation, which consists in selecting some of these boundary points as actual river mouths, cannot be let to algorithms, as far as we know. It is however a remarkable occasion to remind our now old geography lectures and to behold one of the oldest books of the GEOMAR library [14]. The selection choice, and particularly the number of river mouth points to select amongst all the coastal grid points of a basin, is guided by our knowledge of the average raw value of the outflow. In case of no major river outflow, all coastal grid points are selected. For the particular case of Lake Chad basin, which misses any debouch in ocean, the whole (but supposedly small) river runoff value is redirected to the Mediterranean Sea. The outflow of the Antarctica basin is treated as a separated coupling field and spread all over the Southern Ocean grid points.

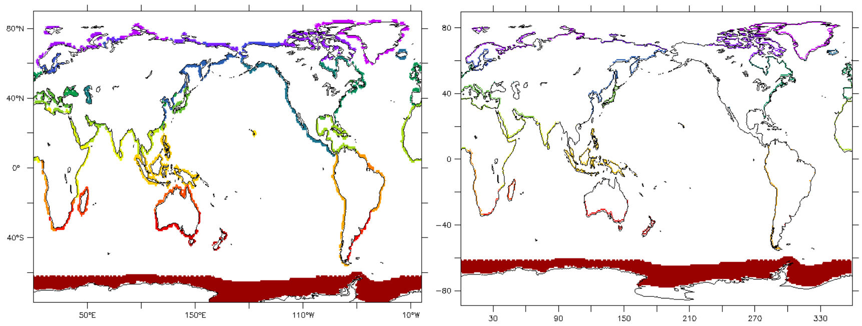

Fig 5: Grid point position of debouch (original, left) and river mouth (proposed solution, right). Each colour represents one basin

Due to the arbitrary merge of many small basins into larger ones, the reduction of the target grid point number does not appear at first sight on Fig 5. However, runoff of rivers with major outflow (Amazon, Congo, Yangtse, etc) are now represented on single river mouth grid points. For various reasons, it also happened that the automatically selected boundary grid points of some basins (Amur, Yangtse) were located on an erroneous position. Figure 6 shows the correction given. We assume that these corrections, and the reduction of the debouch grid points, will necessarily have a regional impact at high resolution, for example in AGRIF zooms.

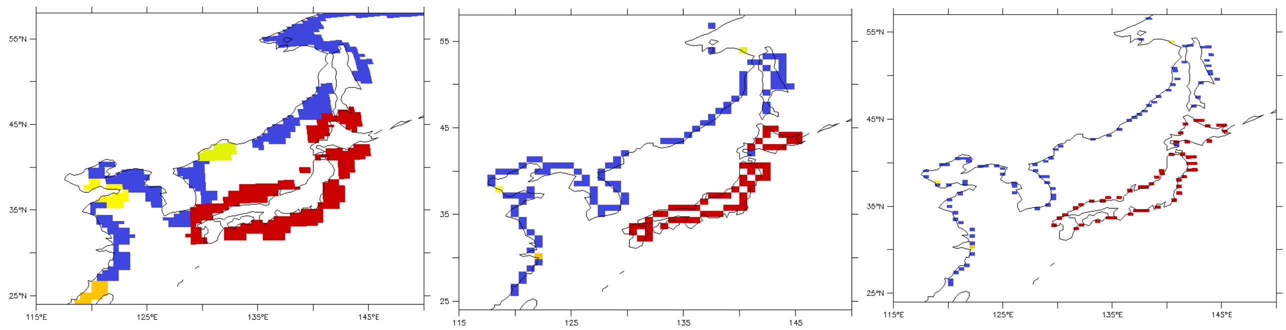

Fig 6: Zoom to the Eastern Seas of grid point position of debouch (original, left and proposed solution, right) and river mouth (proposed solution, centre)

OASIS interpolation to the NEMO global grid

The first interpolation involved in the river runoff management of the coupled system, between the OpenIFS atmosphere model and the RM, was kept unchanged. This paragraph only deals with the new RM/ocean locally conservative interpolation, described in [15], which allows to fill the geographical gap between river mouth grid points (located over lands) and debouch grid points (located over oceans). The interpolation weights are automatically calculated by OASIS3-MCT (version 5[3]) to associate a user defined number of NEMO non masked grid points to every river mouths defined on land grid points of the regular RM grid.

The primary study of [16] suggests that an interpolation with only one single target grid point per basin could tolerate the maximum values of river runoff on ORCA1 (with associated river runoff model grid resolution of 0.5 degrees). As a first guess, a simple one nearest neighbour interpolation is set up in the OASIS parameter file.

In a first one month long test simulation, the existing OASIS global conservation diagnostic is kept to check that our locally conservative interpolation also conserves the river runoff global average[4]. Since differences are only noted at the last significant digit of the sums, we conclude that the OASIS global conservation post-processing can be avoided from now on.

In a second simulation, the old RM version is added to the coupled system, but its results (the runoff coupling field on the ORCA grid) is only output by OASIS and not used by our ocean model. Such experimental set up offers the possibility to compare 2 interpolations of the same set of incoming runoff fields. In addition to the global average, the local fields are globally identical, although spread on a larger number of debouch grid points. The locality of the conservation of the original runoff mapping + bilinear interpolation is roughly identical to the one proposed in this work, which invalidates our initial assumption but ensures that the model physics will not be deeply changed by our modification.

A separated interpolation is required for the Antarctic basin runoff. This field is provided by the RM to the NEMO surface boundary interface in the specific coupling field named "calving". Since it is not yet possible to enable the iceberg model for an optimal representation of this coupling, we prefer, as it was done before, to uniformly spread the water quantity to a large area around Southern Oceans, until the supposed limit of the marginal ice zone (MIZ). Since it is not yet possible to define a uniform interpolation in OASIS, several operations are needed to actually define the needed interpolation:

1- a specific mask must be defined to limit the NEMO debouch grid points to the MIZ,
2- in a preliminary run, we let OASIS calculate any kind of interpolation (e.g. a simple nearest single neighbour) from the RM regular grid to the ORCA grid (with the special MIZ only mask),

3 A modification of the OASIS3-MCT version 4.0 recently installed at GEOMAR to upgrade the `SCRIP` and `PSMILE` library was necessary to enable the new `LOCCUNIF` interpolation
4 In the OASIS debug file, with `NLOGPRT` parameter set to a bigger value than 20, the "`DEBUG src sum`" character chain can be selected to compare the calculated global values on source (RM) and target (ORCA) grids

3- every weight of this interpolation is manually set to zero and reused (`MAPPING` option) in association with a global conservation post-processing.

In the first operation, a field is interpolated to the ORCA grid (unmasked grid point of the MIZ), with every value set to zero. In the latter, a uniform value is applied to each, equal to the difference between the average calving field calculated in the source (RM) grid and the average value of the interpolated field (here always equal to zero).

OASIS interpolation to the AGRIF zoom

Profit is taken from the modularity introduced by the discretisation change in the RM grid, to also send the runoff (and possibly calving) coupling field to the AGRIF zoom. It is clear that this coupling is required to better represent ocean circulation in the refined model. In the current implementation, the runoff coupling field provided onto the master grid has only an indirect effect to the zoom, through the boundary limits. In the zoom, the missing coupling field was replaced by climatological values. Our new coupling proposes to actually pour into the AGRIF zoom the runoff quantities provided by the atmosphere through the RM.

How to conserve the runoff provided to the zoom model is an open question. It is obvious that this water quantity must fulfil some conservation rules, in order to avoid drifts in the global system, particularly in long term simulations. However, it is difficult to select which basins (mostly located outside of the zoom limits) must contribute to the zoom water flux, and what to do with the river mouth located on the sponge zone. The implemented procedure is the following:

1- we interpolate the zoom limits (from the already existing coupling field which describes the AGRIF zoom and its buffer zone on the AGRIF grid) to the RM regular grid. Even though it should be possible to exchange this field only once at run start, the AGRIF buffer zone field comes from NEMO at every time step, to simplify the exchange sequence and avoid possible deadlocks,
2- on the RM grid, we multiply a binary transformation of this field (with a threshold equal to 0) with the runoff field. This operation allows to select this modified runoff field from all river mouths located inside the AGRIF zoom boundaries,
3- this spatially limited runoff field is then sent to the AGRIF zoom grid, performing a new locally conservative interpolation from the RM grid (river mouth grid points only). This interpolation involves 30 AGRIF grid points as a first guess, to take into account the huge resolution gap between the two grids (see Fig 7 below). This number can be adjusted, regarding simulation results and Saint Laurent debouch salinity as a possible origin of model crashes.

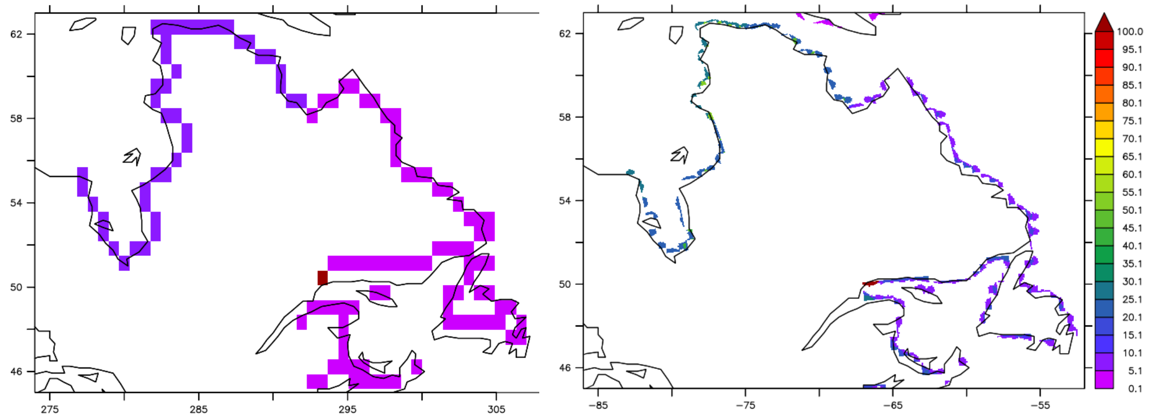

Fig 7: Time slice example of the runoff coupling field, reduced to the Quebec area, on source RM grid (left) and target AGRIF zoom (right)

Results and perspectives

A 30 year long simulation (with AGRIF zoom) is performed under the same forcing conditions than a reference, but including the new RM implementation and the interpolations described above. A look at the single Amazon river debouch grid point clearly shows a numeric effect of the river outflow concentration: on Fig 8 (right, red line), the sea surface temperature reaches unrealistic values and finally stops the simulation. To get closer to the [16] experimental setup (ORCA1 grid), the number of debouch point per river mouth of our ORCA05 grid is set to 4. The unrealistic SST are avoided, as it can be seen in Figure 8 (right, green line) and the simulation can be performed until the end with a modified river outflow (Figure 8, left, green line).

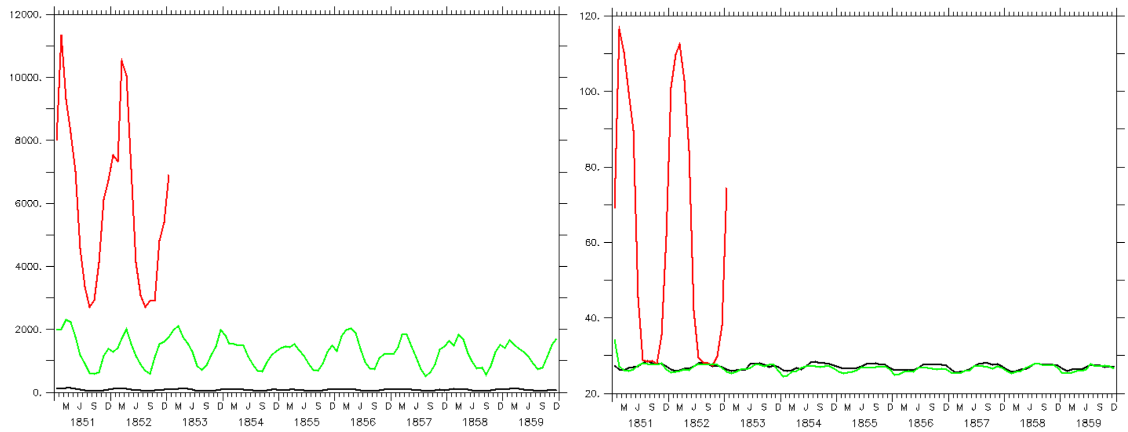

Fig 8: Runoff (mm/day, left) and sea surface temperature (C°, right) of the single ocean grid point debouch of the Amazon river defined with locally conservative interpolation, with original (black), single neighbour locally conservative (red) and 4-neighbours locally conservative interpolation

A larger analysis of the new simulation will be done after the ODUS period, but preferentially with the target configuration of the coupled model, which includes the North Atlantic ocean

AGRIF zoom. This configuration, already in function, will help to better estimate the influence of the new runoff coupling on a realistic North Atlantic ocean circulation.

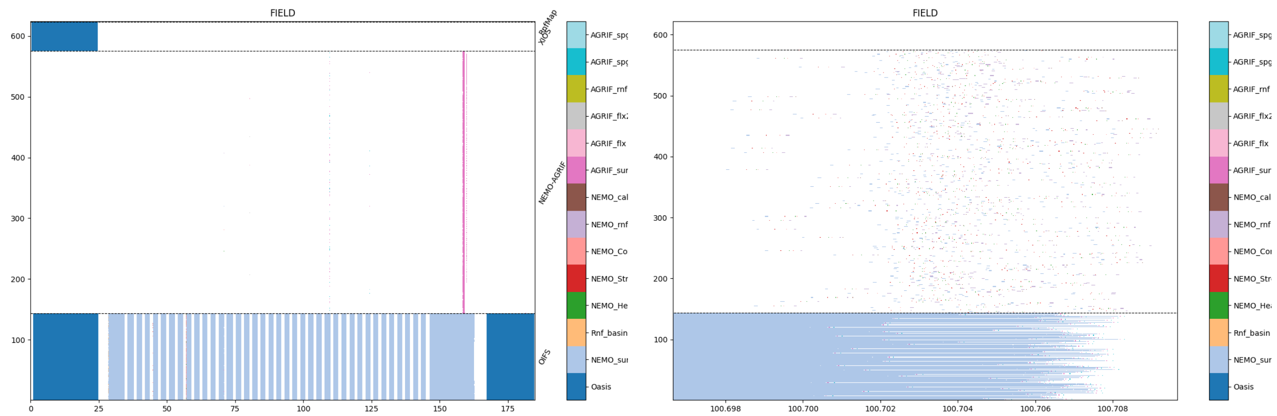

Fig 9: Timeline of every OASIS-related event occurring during a 5 day long simulation (each group of coupling fields associated to the events, mainly put or get routines, are represented by one distinct colour, white areas show model computing). The left graphic shows the whole timeline, the right one details a time slice during a coupling field sending operation processed by NEMO.

Concerning computing performance, the new OASIS load balancing analysis [17] was deployed on the HLRN supercomputer. These results on a simple 5 day long testing simulation (Fig 9, left) shows the major cost of the AGRIF-ocean computations in comparison to the low resolution atmosphere one (mostly waiting the availability of ocean surface coupling fields), suggesting to attribute a larger number of resources to the ocean component. A zoom over one of the coupling field sending sequence in the ocean (Fig 9, right) suggests the relatively large time spreading of the operations, mainly due to the duration imbalance of model computations between its MPI processes. Nevertheless, the so called *coupling time* [6] is small and mostly due to a resource load imbalance that can be corrected in future production configurations.

Further developments in the RM model will be necessary to coupled the calving coupling field in AGRIF zoom such as the one in preparation at GEOMAR in the Weddell sea region. In addition, the ratio of the total Antarctic calving that would have to be directed to this sea must be defined. This could be done by defining a new OASIS mask in the RM grid.

From the OASIS development point of view, the definition of a new uniform interpolation could be useful to avoid the set of workaround needed to exchange and conserve the global calving.

Community effect

During the laboratory selection procedure, the panel emphasised the importance of not restraining the support to a one to one collaboration but rather prefer actions that could have a broader impact on communities. We tried to quantify this community impact, in a table that summarises (i) the oral communications organised and the origin of the participant/audience, (ii) code updates in official centralised repositories, from which OASIS `gitlab` and (iii) written communications (emails) to laboratories making part of the hosting laboratory working network. The first support given remotely restrained contacts to the host core team involved in the support action. The second support, on site but with a smaller number of people actually working in the laboratory, leads to more exchanges, but clearly reduced compared to the same support provided 2 years ago in the same laboratory.

	NERSC	*BTU*
Talks/meetings	Support provided remotely	* Persona mask file modifier [13] (2 people, internal meeting)
Repository updates	`github.com/nansencenter/nextsim`	`git.geomar.de`
Networking activities	none	* NEC SX-Aurora TSUBASA porting [18] (1 people) * Replacement of the OpenIFS model by the ECHAM6 new version in the FOCI coupled model (1 day, 1 people)

Table 2: Quantification of community level communications during the support

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Appendix

Costs/Sustainability

Budget, energy consumption and carbon footprint are provided in the following table. Computations and train transport are the only two items considered in this summary. Everyday consumption, from which electricity supply for workstation (Intel Atom N270 or Arm Cortex A53) and supercomputer login nodes, is neglected. Energy/CO2 emission conversion (Carbon Intensity) for transport and supercomputing is country and machine dependant.

As already observed in the 2019 report, the effort to limit emissions by choosing the more efficient mean of transportation is jeopardised by the use of carbon intensive power supply for supercomputing. This is particularly obvious when half of the exercise is done remotely. However, as also observed in our previous report, the cost of our work must necessarily be put in balance with its quality. In that sense, the intensive use of telework (from both host and support side) probably prevented to achieve all the secondary tasks that normally happens during our dedicated support sessions (networking, support on model themselves, training …) The less we can say it that a full recovery of movement freedom inside and between the Union country would greatly facilitated the third and less part of our program.

	Cost	Travel		Computing			Total Carbon footprint
	(€)	(Km)	(KgCO2e)[5]	(Core.h)	(kWh)	(KgCO2e)[6]	(KgCO2e)
NERSC	0	0	0	1 200	7	0	0
GEOMAR	3 000	2 200	15,5	12 000	142	85	90,5
Total	3 000	2 200	15,5	13 200	149	85	90,5

5 SNCF carbon intensity high speed train : 2,4 gCO2equ/Km, intercity : 8.1 gCO2equ/Km, from https://www.oui.sncf/aide/calcul-des-emissions-de-co2-sur-votre-trajet-en-train and https://ressources.data.sncf.com/explore/dataset/emission-co2-tgv/

6 Carbon intensity of High voltage in Norway (9) and Germany (599), according to Moro A., Lonza L., 2018: Electricity carbon intensity in European Member States: Impacts on GHG emissions of electric vehicles, Transportation Research Part D: Transport and Environment, 64 , pp. 5-14.