# SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

| | |
|---|---|
| **Reporting year** | 2023 |
| **Project Title:** | NEMO4 sensitivity experiments |
| **Computer Project Account:** | spitmecc |
| **Principal Investigator(s):** | Virna Loana Meccia |
| **Affiliation:** | Institute of Atmospheric Sciences and Climate, National Research Council (ISAC-CNR), Italy. |
| **Name of ECMWF scientist(s) collaborating to the project** (if applicable) | - |
| **Start date of the project:** | 01-01-2022 |
| **Expected end date:** | 31-12-2023 |

## Computer resources allocated/used for the current year and the previous one

(if applicable)
Please answer for all project resources

| | | Previous year | | Current year | |
|---|---|---|---|---|---|
| | | Allocated | Used | Allocated | Used |
| **High Performance Computing Facility** | (units) | 8,600,000 | 8,036,444 | 9,500,000 | 0 |
| **Data storage capacity** | (Gbytes) | 36,500 | 36,500 | 59,000 | 36,500 |

## Summary of project objectives (10 lines max)

In his special project (SP), we perform sensitivity experiments with NEMO4 to different parameters, focusing on the different vertical mixing parameterizations. This SP aims to help design the tuning experiments with EC-Earth4. EC-Earth4 is the new version of the EC-Earth climate model currently under development and will participate in the next phase of the Coupled Model Intercomparison Project, CMIP7.

## Summary of problems encountered (10 lines max)

Because the main objective of this SP is to help with the tunning of the EC-Earth4 climate model, the simulations we planned to run are OMIPs (ocean only) experiments of EC-Earth4 and the new extended ocean grid eORCA1. EC-Earth4 is still under development, and the OMIP configuration with eORCA1 is still being tested. This issue caused some delays in starting the experiments, but in the end, we could get an OMIP configuration of EC-Earth4 running on Atos by mid-December 2022.

## Summary of plans for the continuation of the project (10 lines max)

We plan to continue with the original plan.

## List of publications/reports from the project with complete references

There are no publications from the project so far.

## Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

The experiments planned in this SP aimed at evaluating the model sensitivity in reproducing the strength and low-frequency variability of the Atlantic Meridional Overturning Circulation (AMOC). During the first year, we run a set of standalone ocean experiments with NEMO4.2 and eORCA1 grid. We needed several tests to get EC-Earth4, which is still under development, running and to prepare the OMIP configuration with the new eORCA1 grid. After that, we took the *namelists* of NEMO, for both the ocean and sea-ice models as they are and changed the vertical eddy viscosity and diffusivity coefficients for temperature and salinity, respectively. We run seven experiments of 200 years forced by the Corrected Normal Year Forcing Version 2.0 (CNYF_2.0, Large and Yeager, 2004). They are oriented to explore the sensitivity to the vertical mixing:

- *tke0*: Turbulent Kinetic Energy (TKE) closure (*ln_zdftke*) with the turbulent length scale bounded by the distance to surface and bottom (*nn_mxl=0*);
- *tke1*: Turbulent Kinetic Energy (TKE) closure (*ln_zdftke*) with the turbulent length scale bounded by the local vertical scale factor (*nn_mxl=1*);
- *tke2*: Turbulent Kinetic Energy (TKE) closure (*ln_zdftke*) with the turbulent length scale computed as the first vertical derivative of mixing length bounded by *nn_mxl=0* with the same upward and downward length scales (*nn_mxl=2*) ;
- *tke3*: Turbulent Kinetic Energy (TKE) closure (*ln_zdftke*) with the turbulent length scale as in *tke2* but with distinct dissipative and mixing length scale (*nn_mxl=3*)
- *tke4*: Turbulent Kinetic Energy (TKE) closure (*ln_zdftke*) with the penetration of the TKE below the mixed layer (*nn_etau=1*);
- *ric1*: Richarson number dependent (*ln_zdfric*) without enhanced mixing in the Ekman layer;
- *npcT*: Non-penetrative Convective algorithm (*ln_zdfnpc*).

We computed the meridional streamfunction in each basin using the CDFTOOL and the AMOC index as the maximum meridional streamfunction in the Atlantic at 26.5N and between 30N and 40N in the depth range of 500 and 2000 meters.

Figure 1 and 2 shows the Atlantic meridional streamfunction averaged for the first and last 50 years of simulation, respectively and all the experiments. Figure 3 shows the timeseries of the AMOC index computed at two latitudes in the northern hemisphere.

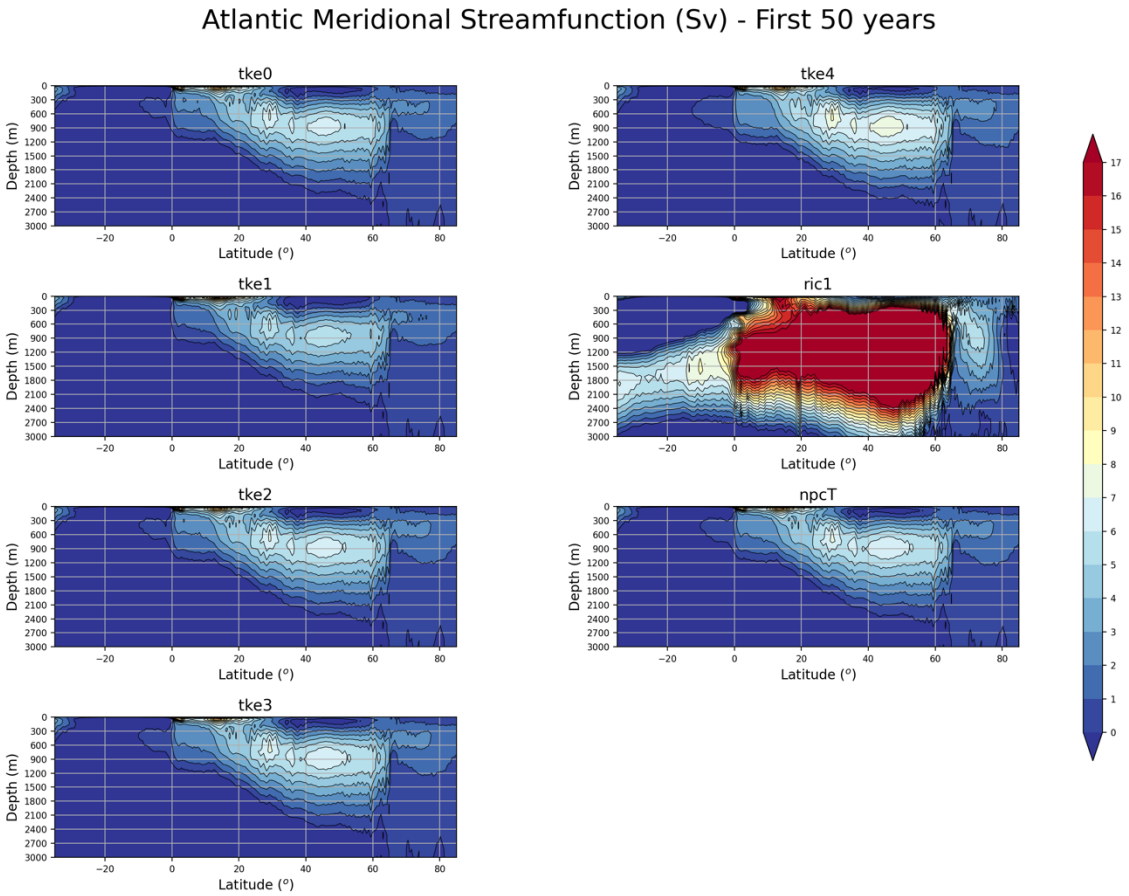


*Figure 1: Mean Atlantic meridional streamfunction for the first 50 years of simulation and the seven experiments.*

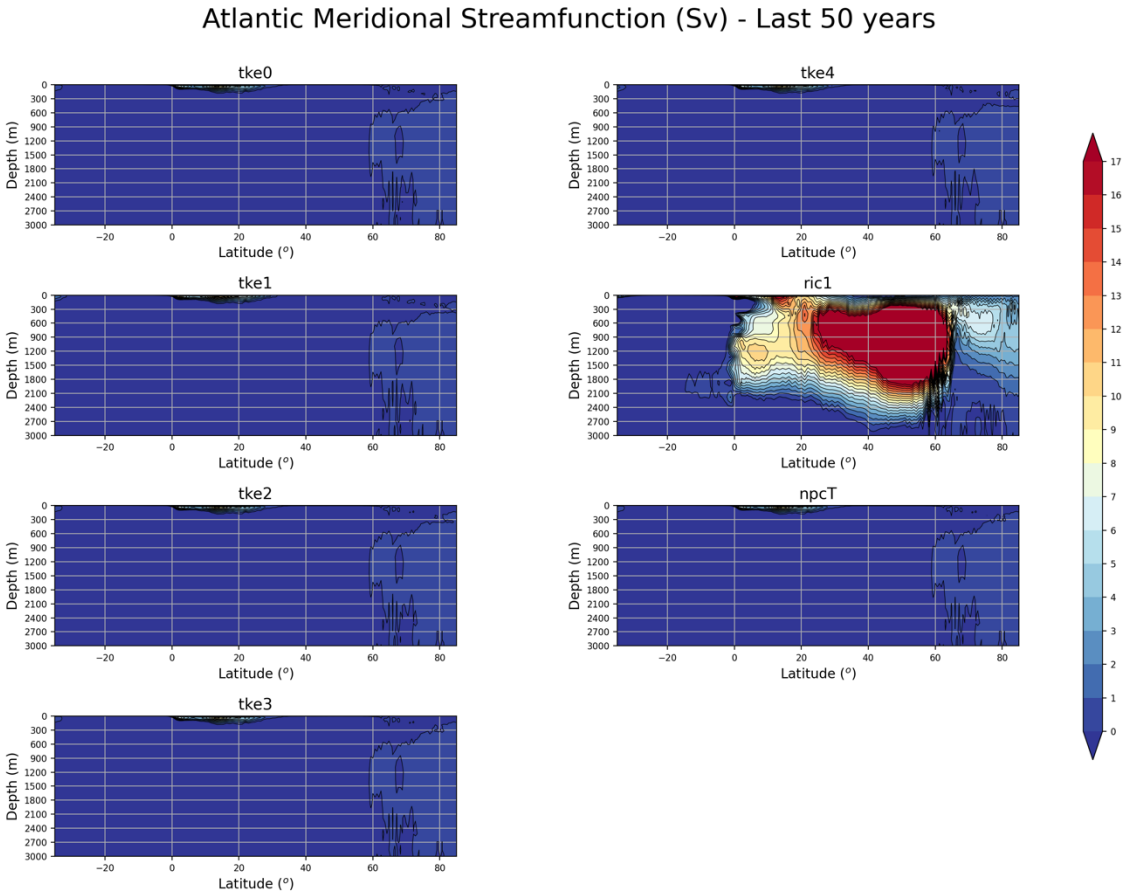


*Figure 2: Mean Atlantic meridional streamfunction for the last 50 years of simulation (years 151 to 200) and the seven experiments.*

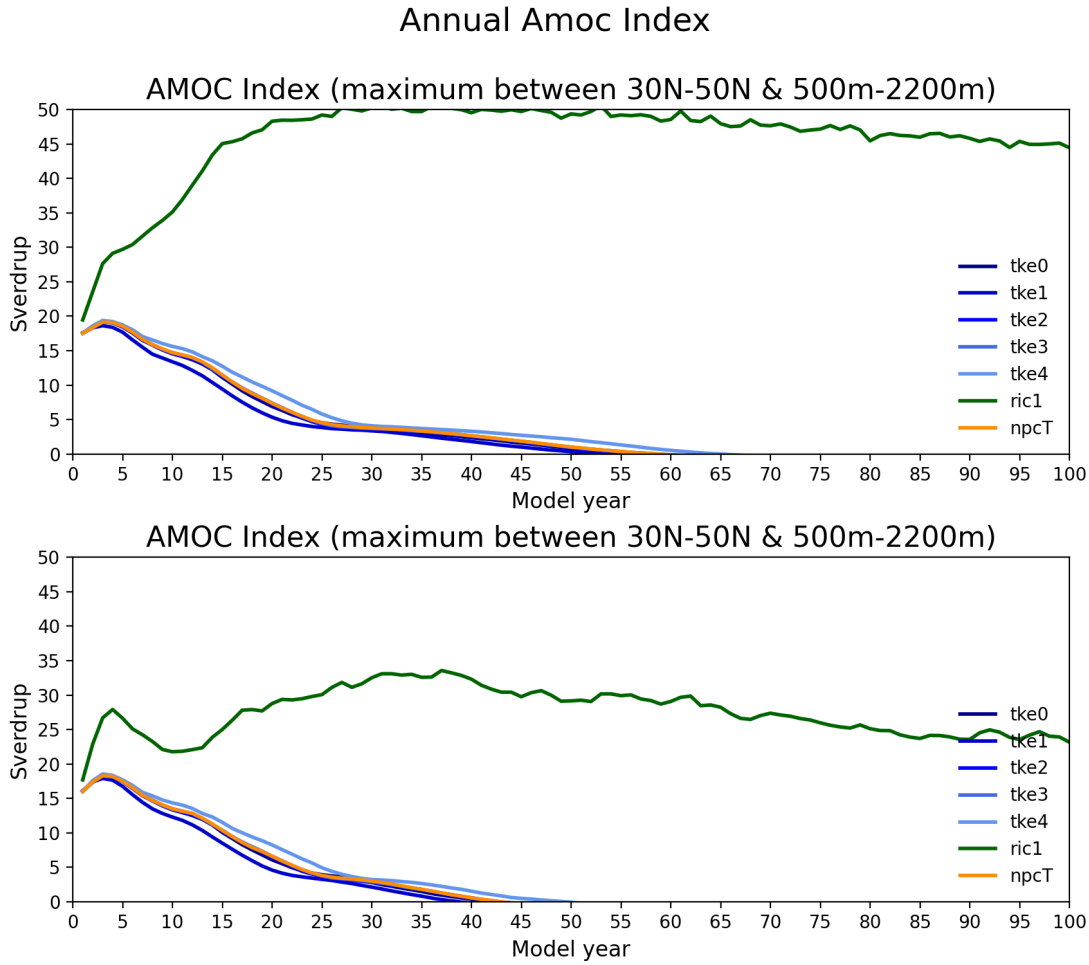


*Figure 3: AMOC index at 26.5N (upper panel) and between 30N and 50N in the depth range of 500-2000 meters for the first 100 years of simulation and the seven experiments.*

The initial AMOC strength is lost in the first years, except for the *ric1* experiment. Therefore, we need to test other default parameters apart from the vertical mixing parameterizations set in the *namelist* to obtain realistic values of the AMOC. With this aim, we will collaborate with other groups inside the NEMO consortium to share experience and get an adequate tunning of the AMOC, and new experiments will be designed for the current year of this SP.

References

Large, W., and S. Yeager, 2004. Diurnal to decadal global forcing for ocean and sea-ice models: the data sets and flux climatologies. NCAR Technical Note: NCAR/TN-460+STR. CGD Division of the National Center for Atmospheric Research.