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	2019
Project Title:	Impact of model Resolution on Ocean Dynamics (IROD)
Computer Project Account:	spitdavi
Principal Investigator(s):	Paolo Davini
Affiliation:	Istituto di Scienza dell'Atmosfera e del Clima, Consiglio Nazionale delle Ricerche (CNR-ISAC)
Name of ECMWF scientist(s) collaborating to the project (if applicable)	………………………………………………………………… …………………………………………………………………
Start date of the project:	01/01/2018
Expected end date:	31/12/2019

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)	29.5 millions	29 millions	29.5 millions	3 millions
Data storage capacity	(Gbytes)	80,000	50,000	100,000	75,000

Summary of project objectives (10 lines max)

This 2-year special project aims at investigating the impact of both atmospheric and oceanic model resolution on the ocean circulation and dynamics. This will be carried out analysing the Tropical Pacific Ocean and the North Atlantic Ocean, which are the most relevant oceanic regions affecting the global climate. To this aim we will perform both high (TL511L91 ORCA025L75) and standard (TL255L91 ORCA1L75) resolution coupled simulations with the EC-Earth Global Climate Model (Hazeleger et al. 2010) following the HighResMIP protocol (Haarsma et al. 2016).

Summary of problems encountered (10 lines max)

The HR simulations produce a massive amount of data that fill quite fast the 30TB on the $SCRATCH space of the CCA HPC machine. Consequently the simulations must be run in series and not in parallel to avoid the saturation of the temporary space. We thus decided to initially focus on the 1950-CONST HR resolution integration. The complete run it took slightly more than 6 months to be completed. In addition, we had a numerical crash in CONST-1950 LR version so that this is being re-run in these weeks.

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

Following new agreements inside the EC-Earth consortium, the initially proposed simulations covering the historical future period (1950-2014 TRANSIENT and 2015-2050-FUTURE) have been already ran by other consortium partners so that they are no longer needed. We thus decided to focus on a set of HR (TL511-ORCA025) simulations part of the Decadal Climate Prediction Project component C1 (DCPP-C) which are based on the methodology by Ruprich-Robert et al. (2016). They will be focusing on the effect of the Atlantic Multidecadal Variability (AMV) relaxing the North Atlantic SSTs towards a specified AMV state, while the rest of the coupled system is left free to drift. We will perform two series of 10-year experiments where the North Atlantic SSTs are forced with the signal associated with twice the positive and twice the negative phase of the AMV respectively. At least 5 members will be run.

List of publications/reports from the project with complete references

None – Simulations are still running.

Summary of results

During the first 18 months we focused on the 1950-CONST experiments. An important note regards the model used: given the time constraints it was not possible to take advantage of the CMIP6 version of the EC-Earth Global Climate Model. Indeed, a definite version has been only release in late June 2019. We thus opted for an older configuration, namely the EC-Earth 3.2.3 version. This version present mainly some differences in terms of tuning and has therefore named EC-Earth-3P (the TL255ORCA1 configuration) and EC-Earth-3P-HR (the TL511-ORCA025 configuration).

Initial conditions provided by two specific spin-up simulations have been provided allowing the start of the runs in July 2018. The first integrations carried out has been the high resolution (T511L91 ORCA025L75) 1950-CONST simulation, that spans from 1950 up to 2049 for a total length of 100 years. Radiative forcing prescribed by the CMIP5 protocol is used, with GHG concentration for the year 1950 (namely HR CTRL-1950). This will be part of the HighResMIP protocol as the control-1950 of the EC-Earth3P-HR model. All the output has been postprocessed following the cmor requirement taking advantage of the ecec2cmor package that has been developed for CMIP6 (https://zenodo.org/record/1051094#.XRSQqJMzb1I). Finally, the data have been transferred to the BADC Jasmin server from where they will be published on the ESGF portal being part of CMIP6.

The simulation does not show any significant drift in sea surface temperatures (Figure 1a). Of course, due to the short extension of the previous spin-up simulations (only 52 years) a slight positive drift in the global ocean heat content is still observed: this can be appreciated looking at the globally-averaged temperature of the ocean, that show an increase of about 0.15K/100y (Figure 1b).

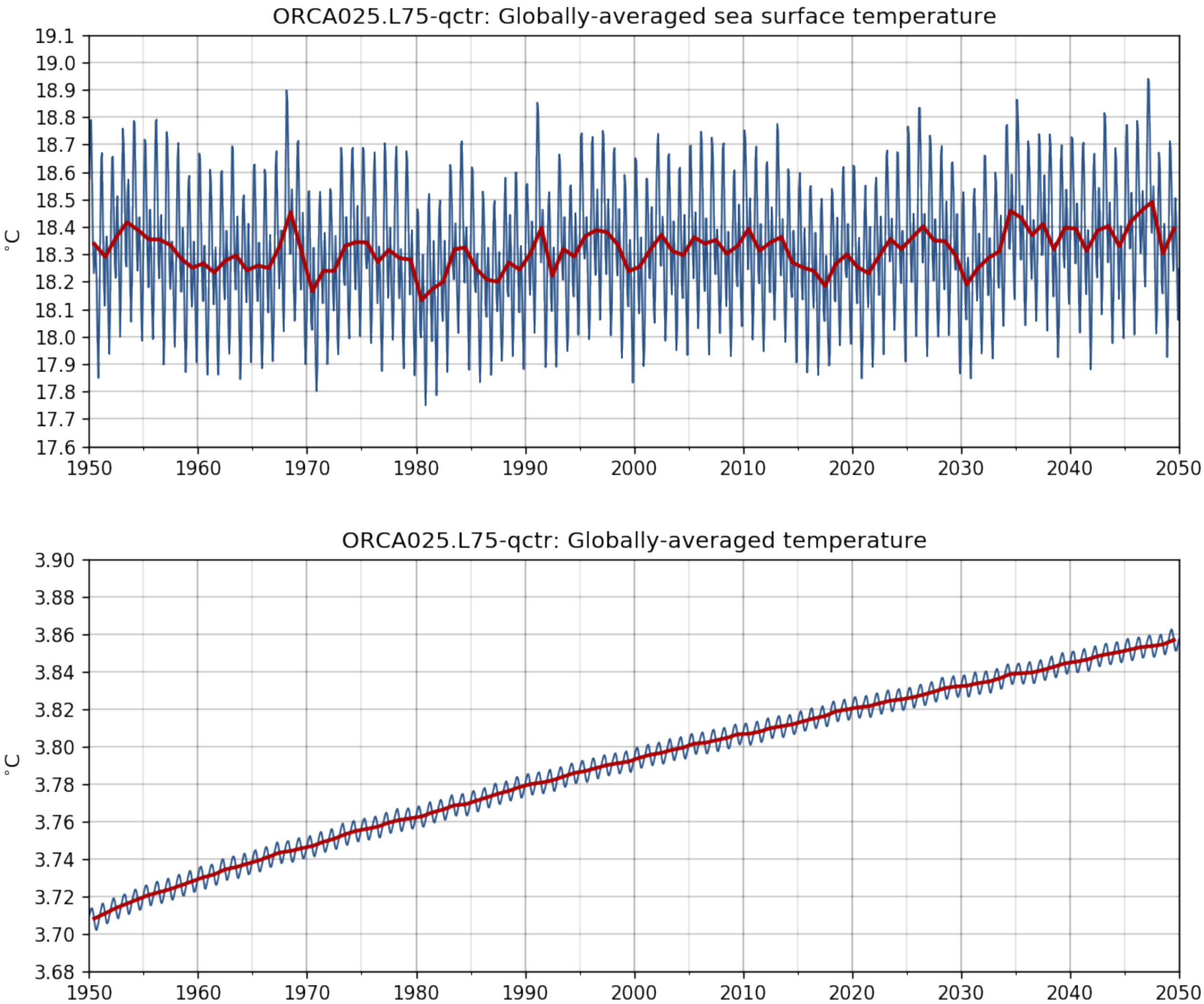

Figure 1(a) evolution of SST in the 100-year HR control simulation **(b)** evolution of globally averaged oceanic temperature in the 100-year HR control simulation.

Other oceanic key features as the Atlantic Meridional Overturning Circulation (Figure 2a) presents a stable and constant transport of about 15Sv at 40N, suggesting that the HR control run has a negligible drift also in this important dynamic component. However, long term variability as the one measured via the Atlantic Multidecadal Variability (Figure 2b) show a quite low signal, approximately the half than observed in reanalysis data.

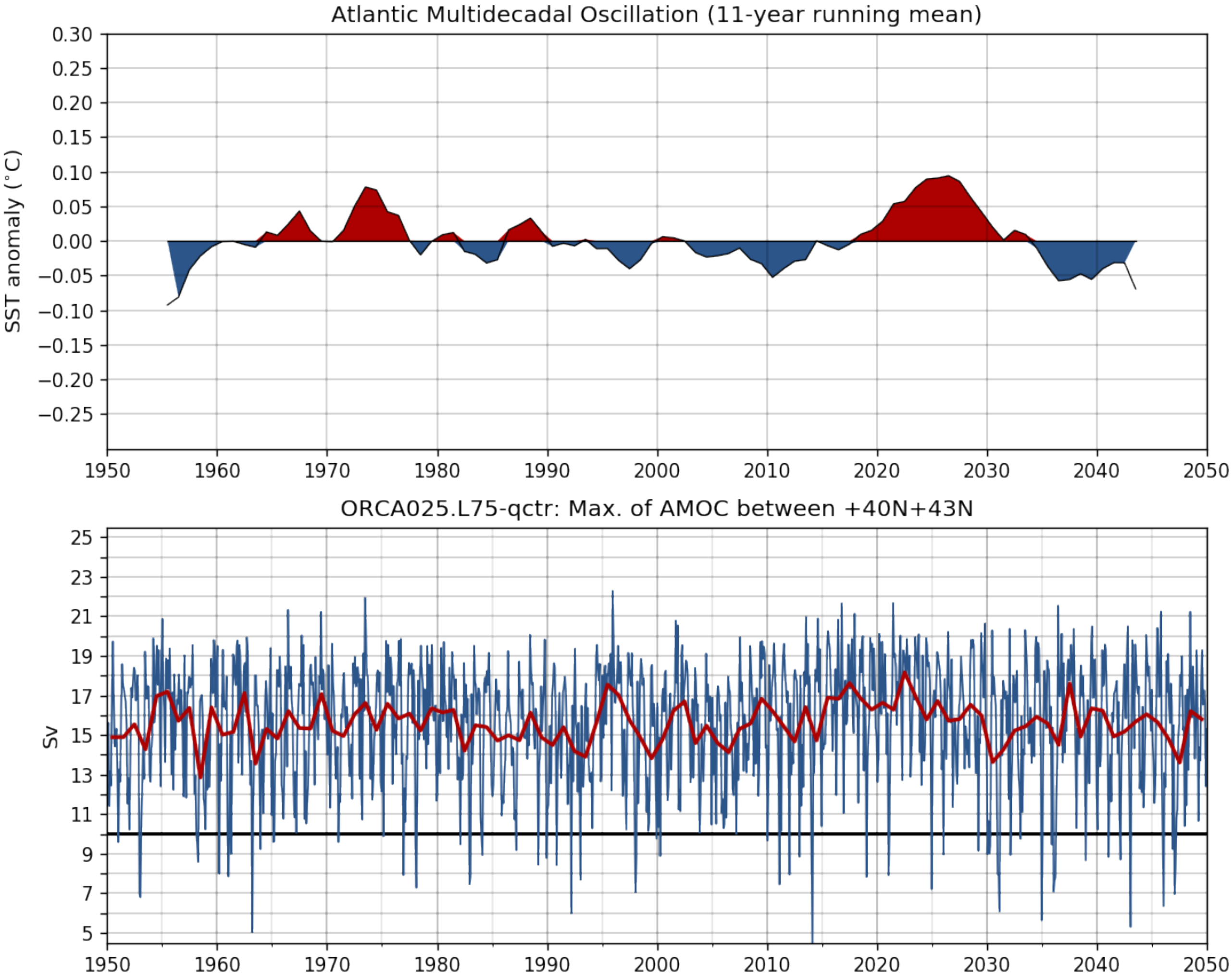

Figure 2(a) evolution of Atlantic Multidecadal Variability index in the 100-year HR 1950-CONST simulation **(b)** evolution the Atlantic Meridional Overturning Circulation (AMOC) at 40N in the HR 1950-CONST control simulation.

In the winter 2018-2019, following a series of updates within EC-Earth consortium – discussed above – we shifted our attention to a group of Atlantic Multidecadal Variability (AMV) sensitivity experiments part of the DCPP-C project. In these runs the oceanic mixed layer is relaxed toward a specific state of the AMV applying a heat and freshwater flux corrector (i.e. nudging a subdomain of the ocean model). In such way it is possible to run an experiment where the whole ocean but the North Atlantic is free to drift, and where a AMV positive phase or negative phase are obtained. These runs, part of the DCPP-C project, are run with the same forcing as the 1950-CONST: this simulation is taken as initial conditions for each ensemble member spanning 10 years each. The integrations only last 10 years and, given the elevated cost of the high resolution, it was decided to apply a forcing that is twice the AMV signal in order to strengthen the significance of the results. An example of the methodology can be seen in Figure 3: the heat flux adjustment is applied only on the North Atlantic sector warming locally the SST field in the way to keep the model close to the positive AMV sta. The first 2 runs, one with AMV+ (i.e. positive) and one with AMV- (i.e. negative) have been successfully run, cmorized and archived.

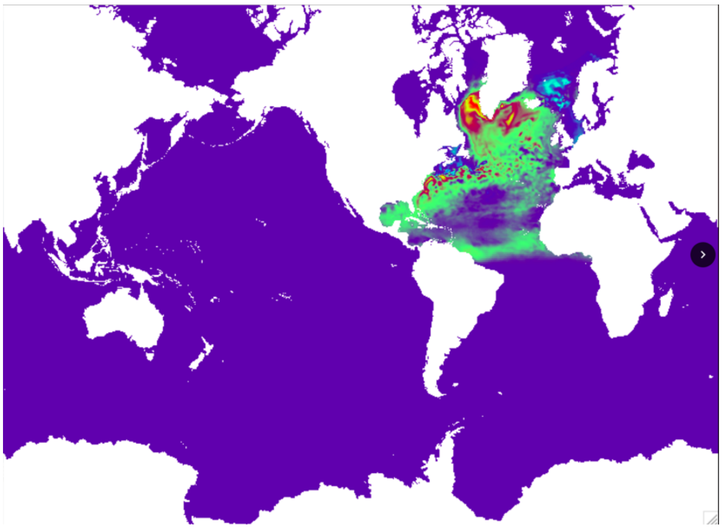

Figure 3: heat flux correction in a single year of AMV+ simulation

References

- Haarsma, R. J., Roberts, M. J., Vidale, P. L., Senior, C. A., Bellucci, A., Bao, Q., Chang, P., Corti, S., Fučkar, N. S., Guemas, V., von Hardenberg, J., Hazeleger, W., Kodama, C., Koenigk, T., Leung, L. R., Lu, J., Luo, J.-J., Mao, J., Mizielinski, M. S., Mizuta, R., Nobre, P., Satoh, M., Scoccimarro, E., Semmler, T., Small, J., and von Storch, J.-S.: High Resolution Model Intercomparison Project (HighResMIP v1.0) for CMIP6, Geosci. Model Dev., 9, 4185-4208, doi:10.5194/gmd-9-4185-2016, 2016.
- Hazeleger, W. et al., 2010, 91, (2010), Bull Amer Meteor Soc 91: 1357-1363.
- Ruprich-Robert, Y., Msadek, R., Castruccio, F., Yeager, S., Delworth, T., and Danabasoglu, G. (2016): Assessing the climate impacts of the observed Atlantic multidecadal variability using the GFDL CM2.1 and NCAR CESM1 global coupled models, J. Climate,