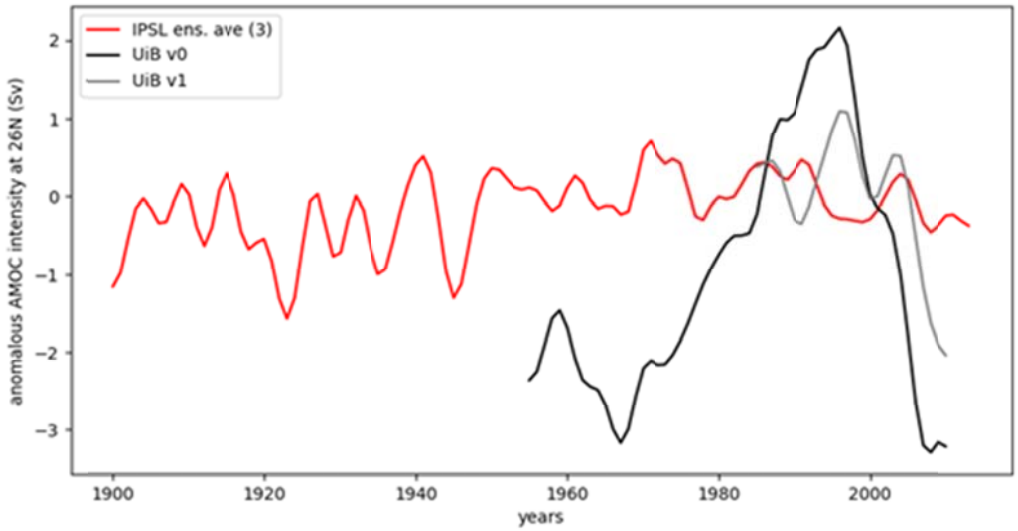
Blue-Action Milestone MS9

Coupled Reanalysis of the Arctic Climate



Anomalous amplitude of the Atlantic meridional overturning circulation, measured at 26°N in the three reanalysis provided: two versions from the UiB (in black and in grey) and one version from the IPSL, defined as an aeraged of three ensemble member. Here, the annual mean maximum extracted from each reanalysis has been low pass-filtered with a cutoff frequency of 5 years. Credits: J. Mignot

Blue-Action: Arctic Impact on Weather and Climate is a Research and Innovation action (RIA) funded by the Horizon 2020 Work programme topics addressed: BG-10-2016 Impact of Arctic changes on the weather and climate of the Northern Hemisphere. Start date: 1 December 2016. End date: 28 February 2021

The Blue-Action project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 727852.

Milestone: MS9
Work package in charge: WP2 Lower latitude drivers of Arctic changes
Actual achievement date of this milestone: 8 September 2019 (project month 34)

Partner organisation in charge of the milestone
Centre national de la récherche scientifique (CNRS): Victor Estella Perez, Juliette Mignot, Didier Swingedouw

Other contributing authors
University of Bergen (UiB): Tor Eldevik, Francois Counillon

Reviewer
Danmarks Meteorologiske Institut (DMI): Chiara Bearzotti

Milestone Type
Report

Dissemination level
Public

Means of verification of attainment of the milestone:

Two novel climate reanalyses made available to the project for evaluation (WP2), process analysis (WP3) and predictability studies (WP4).

Reanalysis data published on Zenodo in open access:

- UiB: https://zenodo.org/record/2686864 Contact person: Tor Eldevik tor.eldevik@gfi.uib.no
- CNRS-IPSL: https://zenodo.org/record/2673209 Contact person: Juliette Mignot, Juliette.mignot@locean-ipsl.upmc.fr

The links to the reanalysis and the present report have been circulated to WP2, WP3 and WP4 on 15 Sept. 2019.

Achieved: Yes

Milestone achievement report

The UiB reanalysis are produced by assimilating monthly data using the Ensemble Kalman Filter (Evensen 2003) into a 30 member ensemble of the NorESM model version used in CMIP5 (NorESM1-ME, Bentsen et al. 2013). Observations are assimilated with an anomaly framework.

- The v0 system uses SST assimilation from 1955 to 2010 based on *Counillon et al., 2016*
- The v1 system uses SST and hydrographic profiles assimilation from 1985 to 2010 based on *Wang et al. 2017*

Both reanalyses are able to provide a reliable reconstruction of the Subpolar Gyre strength and controls well the variability of hydrography in the North Atlantic. Both reanalyses captures well - although they slightly underestimate its amplitude - the strong decrease of AMOC at 26N observed in the RAPID array data from 2005. The v1 system contributes to the ocean reanalysis intercomparison (Jackson et al. sub) and will be used in CMIP6 DCPP with updated forcing.

The IPSL reanalysis is based on the IPSL-CM6 climate model, developed in 2018 by the IPSL climate modeling group for the CMIP6 international project of climate models' intercomparison. To construct the reanalysis, sea surface temperature and salinity observation-based reconstructions over the historical era were nudged (Newtonian relaxation) within the climate model. The protocol was developed in a perfect model framework based on the IPSL climate model (Estella-Perez et al., in prep.). We used a recent compilation of SSS observations, covering the period 1896 to 2016, for the North and tropical Atlantic (Friedman *et al.*, 2017). This record has very coarse spatial and temporal resolutions but it has the advantage of being relatively long and based on direct observations only. In the perfect model framework, using a pseudo-data approach mimicking the characteristics of the SSS dataset, we eventually reconstruct the AMOC with a correlation coefficient of 0.76 and Root Square Mean Error (RSME) of 0.99 Sv (Estella-Perez et al. in prep.). These values can be compared to the AMOC reconstruction using global SSS and SST covering the whole ocean model grid at the same resolution where a correlation coefficient of 0.84 and RSME of 1 Sv are obtained. These results thus give confidence in the possibility of using the observed SSS and SST data to try to reconstruct the AMOC using the IPSL model over the historical era. Application of the procedure to the historical era has implied minor adjustments of the procedure. In the current version of the reconstruction, an offset of -0.5 to +0.5 psu can have been introduced in specific grid points. The consequences of this offset are not yet fully understood. This first reanalysis do show a lower variability of the AMOC than the historical simulations, which may be related with the fact that SSS observations have lower variability than what the model simulates. It is also showing lower variability than UiB reanalysis.

References

- Bentsen M, et al. (2012). 'The Norwegian earth system model, NorESM1-M-Part 1: Description and basic evaluation'. Geoscientific Model Development Discussions, 2843-931.

- Counillon, F. *et al.* (2016) 'Flow-dependent assimilation of sea surface temperature in isopycnal coordinates with the Norwegian Climate Prediction Model', *Tellus A*, 68, pp. 1–17.
- Estella-Perez V. et al. Advances in Reconstructing the AMOC using Sea Surface Observations of Salinity, in prep.
- Jackson et al. (sub). ORA-IP on the North Atlantic , JGR.
- Evensen G (2003). The ensemble Kalman filter: Theoretical formulation and practical implementation. Ocean dynamics. 53(4):343-67
- Friedman, A. R. *et al.* (2017) 'A new record of Atlantic sea surface salinity from 1896 to 2013 reveals the signatures of climate variability and long-term trends', *Geophysical Research Letters*, 44(4), pp. 1866–1876. doi: 10.1002/2017GL072582.
- Wang Y, et al. (2017). 'Optimising assimilation of hydrographic profiles into isopycnal ocean models with ensemble data assimilation'. Ocean Modelling, 114.

We support the Blue Growth!
Visit us on: www.blue-action.eu

Follow us on Twitter: @BG10Blueaction

Access our open access documents in Zenodo:
https://www.zenodo.org/communities/blue-actionh2020