SPEEDY-NEMO: performance of a fully-coupled intermediate-complexity climate model

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Introduction

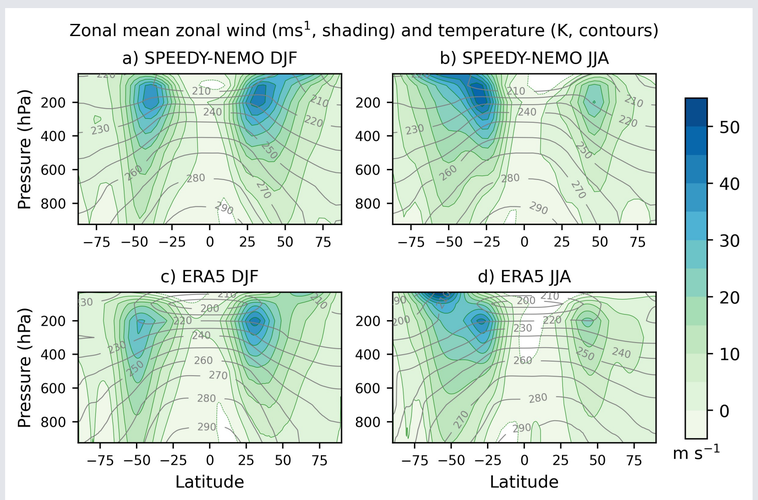
A fully-coupled general circulation model of intermediate complexity is documented. A set of simulations has been performed to validate the SPEEDY-NEMO model. The model setup and the analysis have been designed to evaluate in particular: i) the major climatological features of the atmospheric and oceanic circulation, ii) the surface climate and iii) the leading modes of interannual and multi-decadal variability. Potential applications of the model are discussed, with emphasis on the possibility to generate sets of low-cost large-ensemble retrospective forecasts. We argue that the presented model is suitable to be employed in traditional and innovative model experiments that can play a significant role in future developments of seasonal-to-decadal climate predictions.

Methods

A spin-up simulation is run and the model stabilisation is diagnosed via global-mean near-surface air temperature (GSAT), Arctic sea-ice cover and global top-of-atmosphere (TOA) net energy flux. After this spin-up, the model is run for additional 340 years and this simulation is used for analysis and validation of the model performance. The model parameters are those in Kucharski et al. (2016) and the radiative forcing has been specified to be representative of current climate conditions (approx. 1980-2010) through a CO2 optical thickness/absorptivity parameterization. The model integrations are performed with a serial execution of the atmosphere component and a parallel execution of the ocean-ice component with 16 core. The model is validated against a combination of observational datasets and reanalyses.

Results

Figure 1 and 2 show elements of the performance of the model in simulating key features of the atmospheric circulation, of the surface climate and of the oceanic decadal variability.



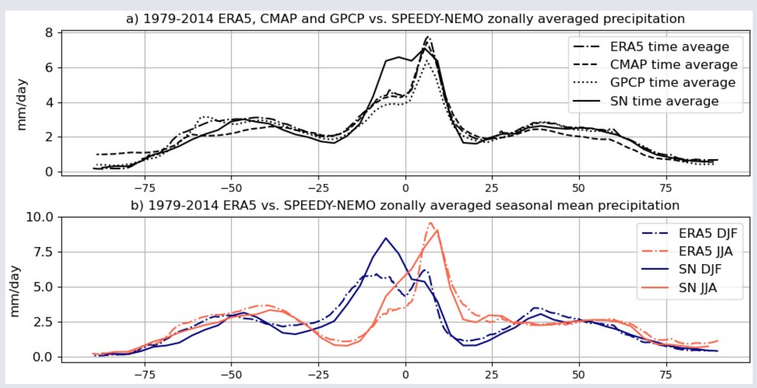


Figure 1. Validation of zonal mean zonal wind and temperature (zonal) and zonal mean total precipitation (bottom)

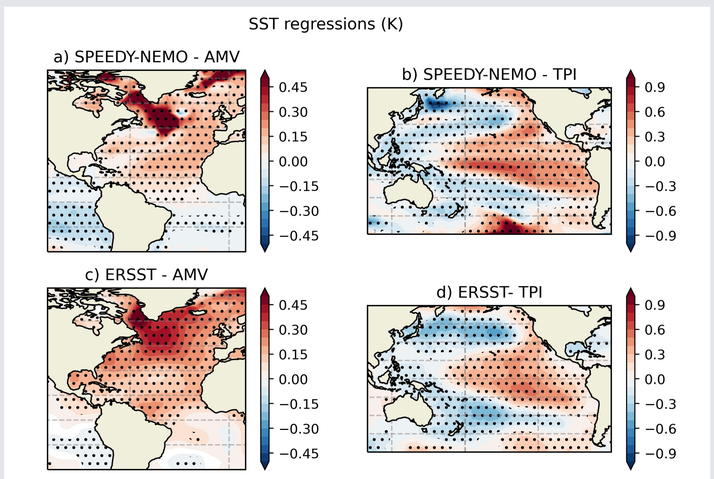


Figure 2.
Decadal modes of variability in SPEEDY-NEMO and the reconstructed SSTs

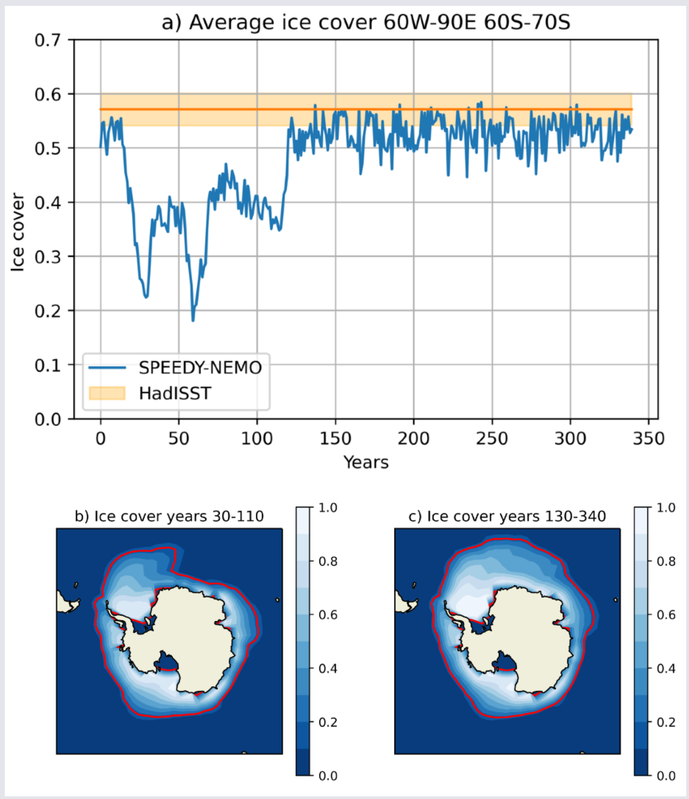


Figure 3.
Example of abrupt climate change simulated

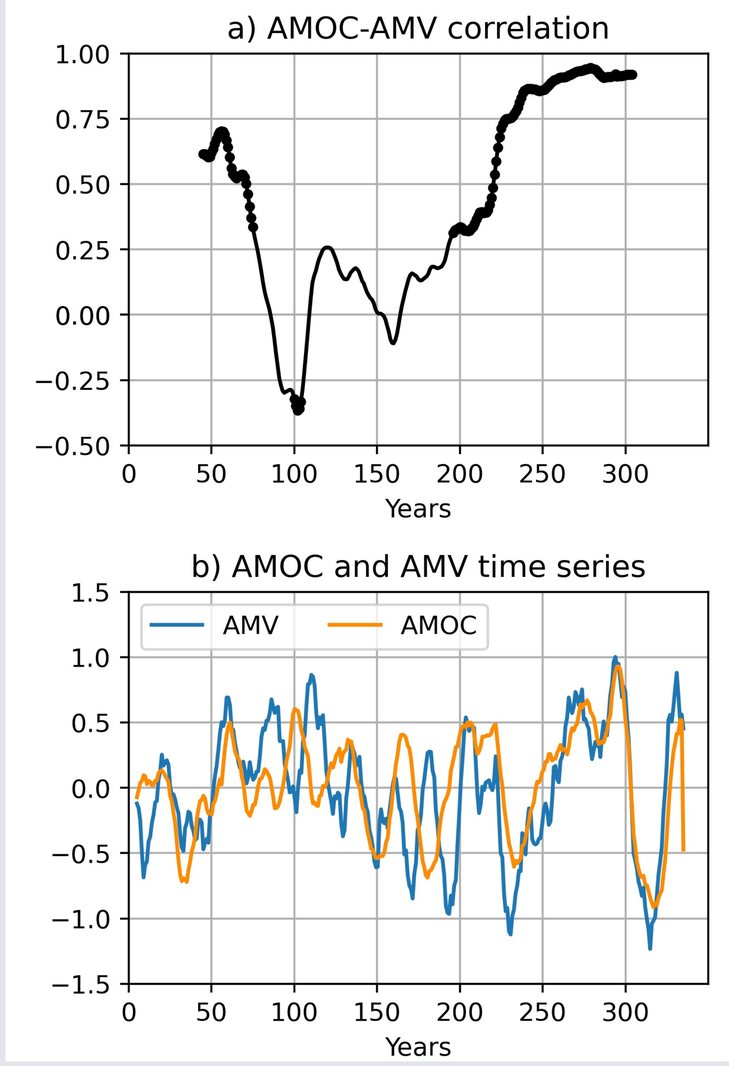


Figure 4.
Non stationarity of the running correlation between AMV and AMOC indices

Figure 3 and 4 show examples of non-stationary processes in the sea-ice domain and in the relationship between the Atlantic Multi-decadal Variability (AMV) and the Atlantic Meridional Overturning Circulation (AMOC).

Concluding remarks

We suggest that phenomena of S2D climate variability, that are often investigated in idealised setups, could be studied with SPEEDY-NEMO by producing sets of long simulations and/or large-ensemble hindcasts over the past decades. Further development with a relatively small effort may lead to a flexible modelling tool to comprehensively assess climate variability, predictability, prediction and change with large enough sampling to test robustness.

Contacts and references

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References:

Kucharski, Fred, et al. "Atlantic forcing of Pacific decadal variability." Climate Dynamics 46 (2016): 2337-2351.