Approximation of a marine ecosystem model using artificial neural networks

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The prediction of an artificial neural network can approximate the steady annual cycle of a marine ecosystem model. The computation of steady annual cycles of marine ecosystem models is important for the investigation and prediction of the climate change especially of the carbon uptake and storage of the earth's ocean. For a three-dimensional marine ecosystem model, this computation is part of the simulation of marine biogeochemistry as well as part of parameter optimizations for biogeochemical models (e.g. parameter identification are usually done by an optimization algorithm). In this process, the computation of one steady annual cycle - without using the prediction of an artificial neural network - takes several thousand model years and requires several hours on a high performance computing cluster.

These simulations and optimizations are fully coupled simulations of the ocean circulation and the marine biogeochemistry. We used, however, an offline simulation with pre-computed ocean transport based on the transport matrix approach [1]. Using this offline simulation, we calculated 1100 steady annual cycles to train an artificial neural network.

We trained various artificial neural networks applying the sparse evolutionary training algorithm [2] in combination with a genetic algorithm to find a appropriate network topology of the neural network. We obtained an approximation of the steady annual cycle with neglectable computational effort by the prediction of an artificial neural network. However, the accuracy of this approximation was not sufficed. In order to improve the approximation we adapted on the one hand the prediction to conserve mass and, on the other hand, we applied the prediction as initial value for the offline simulation. Thereby, we shortened the computational time of the computation of a steady annual cycle.

References

[1] S. Khatiwala, M. Visbeck, and M. A. Cane: Accelerated simulation of passive tracers in ocean circulation models, Ocean Modelling, 9, 51-69, `https://doi.org/10.1016/j.ocemod.2004.04.002`, 2005.

[2] D. C. Mocanu, E. Mocanu, P. Stone, P. H. Nguyen, M. Gibescu, and A. Liotta: Scalable training of artificial neural networks with adaptive sparse connectivity inspired by network science, Nature Communications, 9, 2383-2394, `https://doi.org/10.1038/s41467-018-04316-3`, 2018.