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The use of a flow field correction technique for alleviating the North Atlantic cold bias with application to the Kiel Climate Model

Annika Drews, Richard Greatbatch, Hui Ding, Mojib Latif, and Wonsun Park
GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany (adrews@geomar.de)

The North Atlantic cold bias, associated with a too zonal path of the North Atlantic Current and a missing "northwest corner", is a common problem in coupled models. It affects the North Atlantic and European climate mean state, variability and predictability, as this severe model error is located in the North Atlantic storm track. In the standard model version of the Kiel Climate Model (KCM), like in many other climate models, the surface heat flux is reversed in the northwest corner; the ocean gains heat in the model, instead of releasing heat to the atmosphere as observed.

We investigate the use of a flow field correction to adjust the path of the North Atlantic Current as well as additional corrections to the surface heat and freshwater fluxes. The flow field correction consists of three steps. First, climatological potential temperature (T) and salinity (S) fields for use with the model are produced using a three-dimensional restoring technique. Second, these climatological T, S fields are used to modify the momentum equations of the ocean model. In the third stage, the correction term is diagnosed to construct a flow-independent correction. The flow field correction can be regarded as a way to correct for model error, e.g. associated with the deep water mass pathways and their impact on the circulation, and unresolved processes such as eddy momentum flux convergence. The flow field correction does not depend on the state of the coupled model.

Results using the Kiel Climate Model show that the flow field correction allows a northward flow into the northwest corner, largely eliminating the subsurface bias. A cold bias remains at the surface but can be eliminated by additionally correcting the surface freshwater flux, without adjusting the surface heat flux seen by the ocean model. A model version in which only the surface fluxes of heat and freshwater are corrected continues to exhibit the incorrect path of the North Atlantic Current and a strong subsurface bias. Sea ice and convection occurs in more realistic positions in the corrected model versions, connected to a more northward extension of the meridional overturning circulation. We also show that the bias in the atmospheric circulation is reduced in the corrected model versions. Such a corrected model can be used for further studies of North Atlantic and European climate variability and predictability.