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Using an atmospheric boundary layer model to force global ocean models

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Current practices in the atmospheric forcing of ocean model simulations can lead to unphysical behaviours. The problem lies in the bulk formulation of the turbulent air-sea fluxes in the conjunction with a prescribed, and unresponsive, atmospheric state (as given by reanalysis products). This can have impacts both on mesoscale processes as well as on the dynamics of the large-scale circulation. First, a possible local mismatch between the given atmospheric state and evolving sea surface temperature (SST) signatures can occur, especially for mesoscale features such as frontal areas, eddies, or near the sea ice edge. Any ocean front shift or evolution of mesoscale anomalies results in excessive, unrealistic surface fluxes due to the lack of atmospheric adaptation. Second, a subtle distortion in the sensitive balance of feedback processes being critical for the thermohaline circulation. Since the bulk formulations assume an infinite atmospheric heat capacity, resulting SST anomalies are strongly damped even on basin-scales (e.g. from trends in the Atlantic meridional overturning circulation). In consequence, an important negative feedback is eliminated, rendering the system excessively susceptible to small anomalies (or errors) in the freshwater fluxes.

Previous studies (Seager et al., 1995, J. Clim.) have suggested a partial forcing issue remedy that aimed for a physically more realistic determination of air-sea fluxes by allowing some (thermodynamic) adaptation of the atmospheric boundary layer to SST changes. In this study a modernized formulation of this approach (Deremble et al., 2013, Mon. Weather Rev.; 'CheapAML') is implemented in a global ocean-ice model with moderate resolution (0.5°; ORCA05). In a set of experiments we explore the solution behaviour of this forcing approach (where only the winds are prescribed, while atmospheric temperature and humidity are computed), contrasting it with the solution obtained from the classical bulk formulation with a non-responsive atmosphere.