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Effect of Atmospheric Feedbacks on the Stability of the Atlantic Meridional Overturning Circulation

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The impact of atmospheric feedbacks on the multiple equilibria (ME) regime of the Atlantic meridional overturning circulation (MOC) is investigated using a fully-implicit hybrid coupled model (HCM). The HCM consists of a global ocean model coupled to an empirical atmosphere model that is based on linear regressions of the heat, net evaporative, and momentum fluxes generated by a fully-coupled climate model onto local as well as Northern Hemisphere averaged sea surface temperatures. Using numerical continuation techniques bifurcation diagrams are constructed for the HCM with the strength of an anomalous freshwater flux as bifurcation parameter, which allows for an efficient first-order estimation of the effect of interactive surface fluxes on the MOC stability. The different components of the atmospheric fluxes are first considered individually and then combined. Heat feedbacks act to destabilize the present-day state of the MOC and to stabilize the collapsed state, thus leaving the size of the ME regime almost unaffected. In contrast, interactive freshwater fluxes cause a destabilization of both the present-day and collapsed states of the MOC. Wind feedbacks are found to have a minor impact. The joint effect of the three interactive fluxes is to narrow the range of ME. The shift of the saddle-node bifurcation that terminates the present-day state of the ocean is further investigated by adjoint sensitivity analysis of the overturning rate to surface fluxes. It is found that heat feedbacks primarily affect the MOC stability when they change the heat fluxes over the North Atlantic subpolar gyre, whereas interactive freshwater fluxes have an effect everywhere in the Atlantic basin.