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An optimally tuned ensemble of the "eb_go_gs" configuration of GENIE: parameter sensitivity and bifurcations in the Atlantic overturning circulation

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Abstract. The key physical parameters for the "eb_go_gs" configuration of version 2.7.4 of GENIE, an Earth system model of intermediate complexity (EMIC), are tuned using a multi-objective genetic algorithm. An ensemble of 90 parameter sets is

tuned using two ocean and two atmospheric state variables as targets. These are "Pareto-optimal", representing a range of trade-offs between the four tuning targets. For the leading five parameter sets, simulations are evaluated alongside a simulation with untuned "default" parameters, comparing selected variables and diagnostics that describe the state of the atmosphere, ocean and sea ice. Further experiments are undertaken with these selected parameter sets to compare equilibrium climate sensitivities and transient climate responses. The pattern of warming under doubled CO_2 is strongly shaped by changes in the Atlantic meridional overturning circulation (AMOC), while the pattern and rate of warming under rising CO_2 is closely linked to changing sea ice extent. One of the five tuned parameter sets is identified as marginally optimal, and the objective function (error) landscape is further analysed in the vicinity of the tuned values of this parameter set. "Cliffs" along some dimensions motivate closer inspection of corresponding variations in the AMOC. This reveals that bifurcations in the AMOC are highly sensitive to parameters that are not typically associated with MOC stability. Specifically, the state of the AMOC is sensitive to parameters governing the wind-driven circulation and atmospheric heat transport. For the GENIE configuration presented here, the marginally optimal parameter set is recommended for single simulations, although the leading five parameter sets may be used in ensemble mode to admit a constrained degree of parametric uncertainty in climate prediction.

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