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Optimal surface salinity perturbations of the thermohaline circulation

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Recent observations and modeling studies have stressed the influence of surface salinity perturbations on the North Atlantic circulation. Optimal surface salinity perturbations influencing the meridional overturning circulation maximum are exhibited and interpreted on a stable steady state of a 2D latitude-depth ocean thermohaline circulation model. In spite of the stability of the steady state the nonnormality of the dynamics is able to create some transient growth and variability through stimulation by optimal perturbations. Maximization using Lagrange multipliers leads to explicit solutions (rather than eigenvalue problems), involving the integration of the model adjoint for each value to maximize. Three kinds of optimal perturbation are obtained for: (1) initial sea surface salinity, (2) constant surface salinity flux, (3) stochastic surface salinity flux. After this methodological step, optimal initial surface salinity perturbations are computed and described for a realistic mean state of a global ocean general circulation model (OPA); optimality is defined with respect to the meridional overturning circulation intensity. The most efficient transient growth appears for a delay of 10.5 yr after the perturbation by the optimal surface salinity anomaly. This optimal growth is induced by an initial anomaly located north of 50°N. The optimal surface salinity perturbations studied herein yield upperbounds on the intensity of the response in meridional overturning circulation. Using typical amplitudes of the Great Salinity Anomalies, the upper bound for the associated variability is 0.8 Sv (11% of the mean circulation). In both models, the linear and nonlinear responses to the optimal perturbation are compared for various perturbation amplitudes.