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Predictability and the use of adjoint models in eddy resolving general circulation models

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Adjoint models are a useful tool for calculating climate sensitivities in coarse resolution ocean models, but the well known problems with using adjoint models in chaotic systems would seem to preclude their use with eddy resolving ocean models. However, previous studies conflict as to whether adjoint models may in fact give useful information on time scales longer than the eddy time scale of the system. This study uses the MIT general circulation model, and its adjoint, to examine the time evolution of the adjoint sensitivities of integral quantities, such as the time mean heat content, in an eddy resolving zonally reentrant channel. The adjoint sensitivities are compared to sensitivities calculated from perturbed forward model runs.

After one and a half years the adjoint sensitivities are large with much small scale spatial structure, as would be expected for a chaotic system where sensitivity to initial conditions dominate. The growth of the adjoint sensitivities is not a simple exponential as individual patches of high sensitivity develop, are advected by the adjoint flow field, and eventually decay. In particular the sensitivity to the mean temperature within a layer grows almost linearly with time throughout the 1st year, suggesting that even on this time scale information may remain in the adjoint solution.