

## Tangent Linear and Adjoint Model Development of POP Ocean Model: Application of Automatic Differentiation

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The derivative enhanced modeling approach is an efficient method for the large-scale sensitivity studies with global ocean model. The automatic differentiation (AD) technique provides an algorithmic method to augment the existing modeling code with the derivative computation for any combination of dependent (cost function/model output) and independent modeling variables (modeling parameters and variables). We have developed the tangent linear and adjoint derivative codes (TLM/ADM) of the POP ocean model with the TAPENADE AD tool. While the TLM code is used for perturbation propagation analysis with a small number of independent variables and a large number of dependent variables, the ADM code provides a powerful derivative (or sensitivity) computation scheme for the problems with a large number of independent variables and a small set of dependent variables. The test result shows that the TLM code is less than twice as slow and the ADM takes about 5~10 times as the original forward run with a satisfactory accuracy level of  $1E-07$ . The TLM and ADM codes were tested for the sensitivity computation of the fresh water forcing term with regard to the calculation of the meridional overturning circulation.