Acceleration of the Navy's ocean 4DVAR system using reduced numerical precision

The four-dimensional variational (4DVAR) method of data assimilation is widely used in operational meteorology and oceanography. 4DVAR can correct the environmental model for all scales represented by the model resolution and available observations. 4DVAR is limited, however, by the cost of the underlying tangent linear (TL) and adjoint (AD) models. This can be mitigated by truncating the integration time of the TL and AD models and/or by reducing the spatial resolution of the TL and AD models relative to the forecast model. These mitigating factors reduce the effectiveness of the 4DVAR approach by limiting the amount of observations that can be used to correct the model and also by reducing the extent of the spatial scales that can be corrected by 4DVAR. In order for the linear solver to converge, the TL and AD models must be symmetric and this symmetry can be maintained, in part, by maintaining double-precision in the TL and AD codes. Substantial computational savings can be found, however, by relaxing this requirement and performing the computations in the TL and AD models in single-precision. This approach is applied to the Navy Coastal Ocean Model (NCOM) 4DVAR in a real-world application of the Northeast Atlantic domain in June-August, 2019. Experiment results show that the single-precision 4DVAR is able to perform in a nearly identical manner with double-precision 4DVAR in terms of analysis and subsequent forecast accuracy. The single-precision 4DVAR is able to produce an analysis, however, in roughly half the time of the double-precision 4DVAR. The single-precision 4DVAR assimilation window is lengthened in a subsequent experiment such that the overall run-time is nearly equivalent to the double-precision 4DVAR (which uses a shorter assimilation window). The longer-window/single-precision 4DVAR produces a better analysis and resulting forecast than the shorter-window/double-precision 4DVAR, exhibiting the potential of the single-precision approach.

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