# A Novel Approach for Detecting Unexpected Model Results in E3SM Climate Model

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## Abstract

Comprehensive model testing is essential in maintaining simulation quality and numerical accuracy in a computer model. This can be a challenging task for complex numerical models such as those used for climate simulation. Traditional approaches such as unit tests that evaluate small chunks of source code, or system level testing (e.g. regression testing) that checks for bit for bit solution reproduction are valuable tools for maintaining solution integrity. The approaches are less useful when modifications to the source code is expected to change the model results because model equations support chaotic solutions, or conditional operators that can introduce large changes with small perturbations. These traditional testing tools do not give any insights into whether the source code modifications under these circumstances. A common scenario complicating model testing occurs when model developers are re-factoring the source code (e.g. rearranging do-loops) to augment model's performance. In this case, the results can be non-BFB but they should not be different in an unexpected way.

A resource intensive approach (computationally expensive as well as involving significant number of man hours) to find these unexpected cases is to run ensembles of long simulations and analyze model output to characterize the statistical similarity of those simulations compared to previous model behavior every time a source code modification is made. Rosinski and Williamson (1997) suggested that many pathologies could be detected when models are changed (by changing compilers, optimization levels, code refactoring, hardware, etc) by comparing two very short simulations, and evaluating their solution divergence, which is much less expensive than a statistical evaluation of long simulations. In this talk, we will describe a new and even faster method to detect such issues in a very complex E3SM (Energy Exascale Earth System Model) climate model. Our method is based on the technique described by Rosinski and Williamsons (1997) but it differs by using an ensemble of single time step simulations. The test is capable of detecting source code modifications, changes in model parameters and other computational environment related changes (compilers, OS, libraries etc.) which can significantly alters the model simulations.

## References

1. Rosinski J. M. and Williamson D. L.. The accumulation of rounding errors and port validation for global atmospheric models. SIAM J. Sci. Comput., 18, 552–564(1997), doi:10.1137/S1064827594275534..