# Numerical issues associated with strongly compensating processes in climate models: an example from ECHAM-HAM

Hui Wan[1,2] (hui.wan@pnnl.gov), Phil Rasch[1], Kai Zhang[1,2], Jan Kazil[3,4], and Ruby Leung[1]

[1] Pacific Northwest National Laboratory, Richland, WA
[2] Max Planck Institute for Meteorology, Hamburg, Germany
[3] Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO
[4] NOAA Earth System Research Laboratory, Boulder, CO

**Abstract**

The purpose of this presentation is to draw attention to the need for appropriate numerical techniques for representing process interactions in climate models.

In two versions of the ECHAM-HAM model, different time integration methods are used to solve the sulfuric acid gas evolution equation, which lead to substantially different results in the gas concentration and aerosol nucleation rate. Using convergence tests as well as sensitivity experiments with various time stepping schemes, we found that such discrepancies are related to the fact that the strong compensation between sulfuric acid gas production and condensation in polluted regions results in a severe mismatch between the model time step and the time scale of variation of the H2SO4 gas. The combination of sequential operator splitting and long time step, commonly used in current climate models, leads to significant systematic biases. Our experiments indicate that implicit integration method can help to represent the balance between compensating processes. For nonlinear problems, the use of sub-stepping with dynamically determined step size can provide a good compromise between numerical accuracy and computational efficiency. Lessons learnt in this work underline the need for more caution when treating multi-time-scale problems involving strongly compensating processes, a common occurrence in current climate models.

**Preferred type of presentation:** oral
**Presenter:** Hui Wan (hui.wan@pnnl.gov)