Attachment 2

RES detailed response to the criticisms of the Stability Enhancing Two Step (SETS) numerical method used in TRACE.

The author of the anonymous email criticized the SETS Numerical Method. In particular the author criticizes the lack of theoretical rigor used to describe the SETS solution method and its historical development and asserts that the SETS method does not satisfy the original finite difference equations (FDEs), the TRACE solution does not satisfy the nonlinear equation-of-state (EOS), and the void fraction computed by TRACE is not meaningful.

RES response:

Although the development of the SETS solution method used in TRACE lacks the rigor desired by the author of the email, there are no known concerns with the accuracy of the TRACE solution scheme beyond those associated with first order accuracy in the finite difference scheme used for the equations. Furthermore, a numerical scheme to increase the order of accuracy associated with the difference scheme is currently underway.

It is true that there is no rigorous convergence testing for the finite difference equations individually in the default TRACE code options. However, the email ignores the fact that TRACE has an outer nonlinear iteration loop that adjusts the solution variables so that changes in these variables required to satisfy the equation become acceptably small. TRACE also has an optional convergence scheme that relies upon the actual residuals of the FDEs. This scheme is currently undergoing testing. Preliminary results have shown that convergence of the pressure iteration also corresponds to convergence of the residuals. There is also an implicit scheme under development to better control convergence between the FDEs and the constitutive models for each time step.

The author of the email also seems to be confused about the method used to update the void fraction at the end of a TRACE timestep. The EOS has already been satisfied at this point of the solution. The solution of the linear equations is only used to get a new time estimate of the void fraction for use in constitutive relations. Information on void fraction consistent with conservation of mass and energy is passed to the next time step via macroscopic densities and energies ($\alpha\rho_g$, $(1-\alpha)\rho_l$, $\alpha\rho_g e_g$, $(1-\alpha)\rho_l e_l$). Any inaccuracy in determining the void fraction in this manner should show up as a mass error. TRACE is not known to have mass error problems.

In summary, the SETS numerical method used in TRACE has been extensively used in practice for more than 20 years and has undergone extensive comparisons to analytical solutions, numerical solutions with the more traditional Semi-Implicit method (also available in TRACE), and to experimental data. An extensive amount of assessment and testing has been and will continue to be performed for TRACE. As part of our addition of fully implicit capabilities to TRACE, SETS and the Semi-Implicit numerical methods will also be tested through the Method of Manufactured Solutions. Any previously unidentified problems with the SETS method should show up in this testing and assessment.

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