

User vs. COMSOL® Developed Automated Verification of COMSOL Multiphysics® Software

M. W. Crowell

Oak Ridge National Laboratory, Research Reactors Division, Oak Ridge, TN, USA

Introduction: Verifying that a local software installation performs as the developer intended is a potentially time consuming but necessary step for safety related codes. Automating this process not only saves time, but can increase reliability and scope of verification compared to ‘hand’ comparisons. We now have for comparison both a user developed tool using LiveLink™ for MATLAB® and a COMSOL developed App (in beta) for automated installation verification of COMSOL 5.2.

Computational Methods: Both tools take models with included solutions in the model database, re-solve locally, and compute differences for all solution variables:

$$dmax^{u_i} = \max(|\bar{u}_i^{local} - \bar{u}_i^{included}|)$$

$$dmax_r^{u_i} = \frac{dmax^{u_i}}{\max(|\bar{u}_i^{included}|)}$$

where u_i/\bar{u}_i is the i th dependent variable/vector over all nodes and cases. If the maximum absolute/relative difference is sufficiently small for all solution variables, the local COMSOL installation is considered verified for the physics involved in the model.

	COMSOL App	User Scripts
Default <i>absolute</i> difference tolerance	1.0E-6	None
Default <i>relative</i> difference tolerance	2.0E-2	1.0E-3

Table 1. Default Verification Tolerances

Verification Example: Local COMSOL 5.2 installation for ORNL High Flux Isotope Reactor safety calculations:

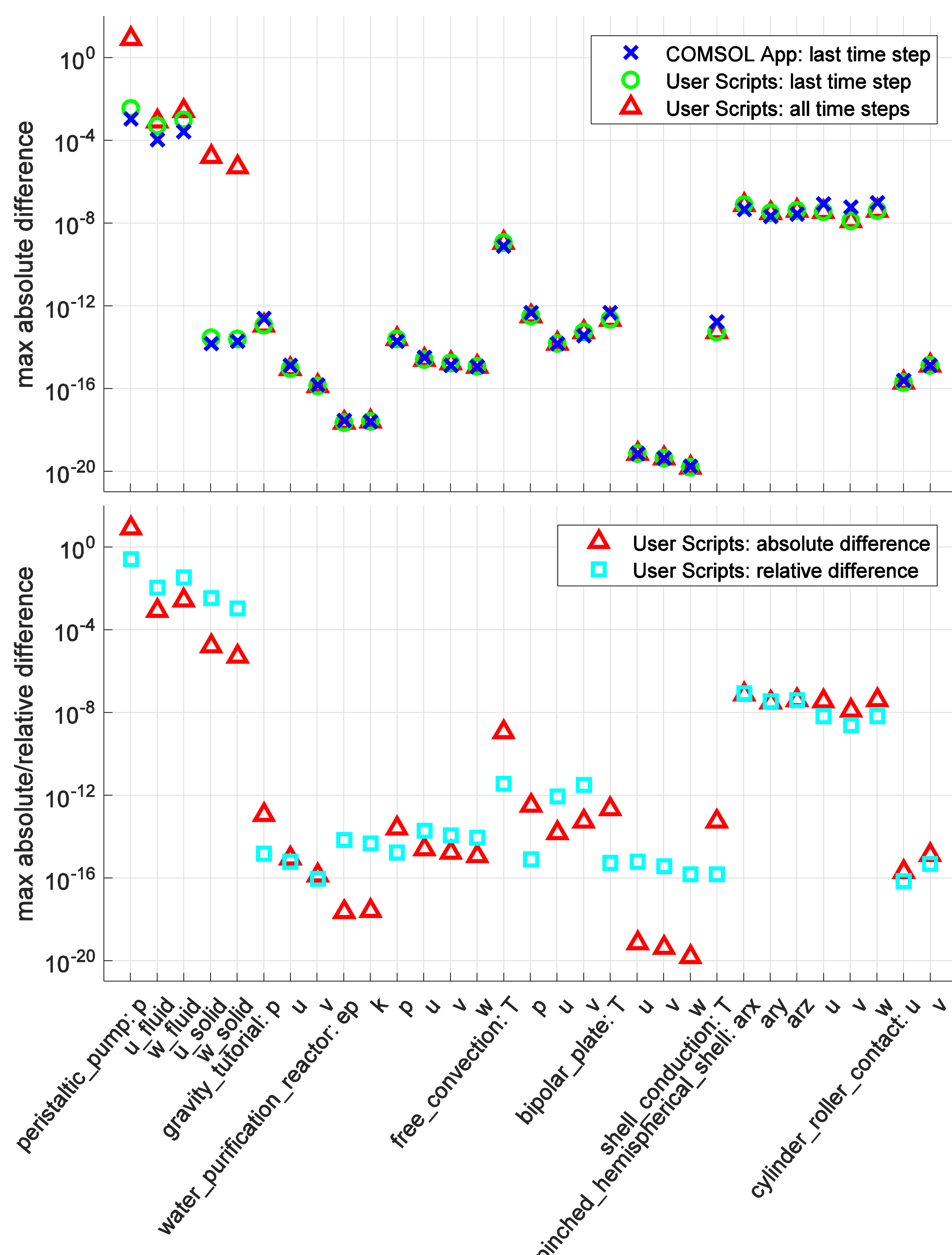


Figure 1. Absolute Differences at Last vs All Time Steps (top), and Absolute vs. Relative Differences (bottom)

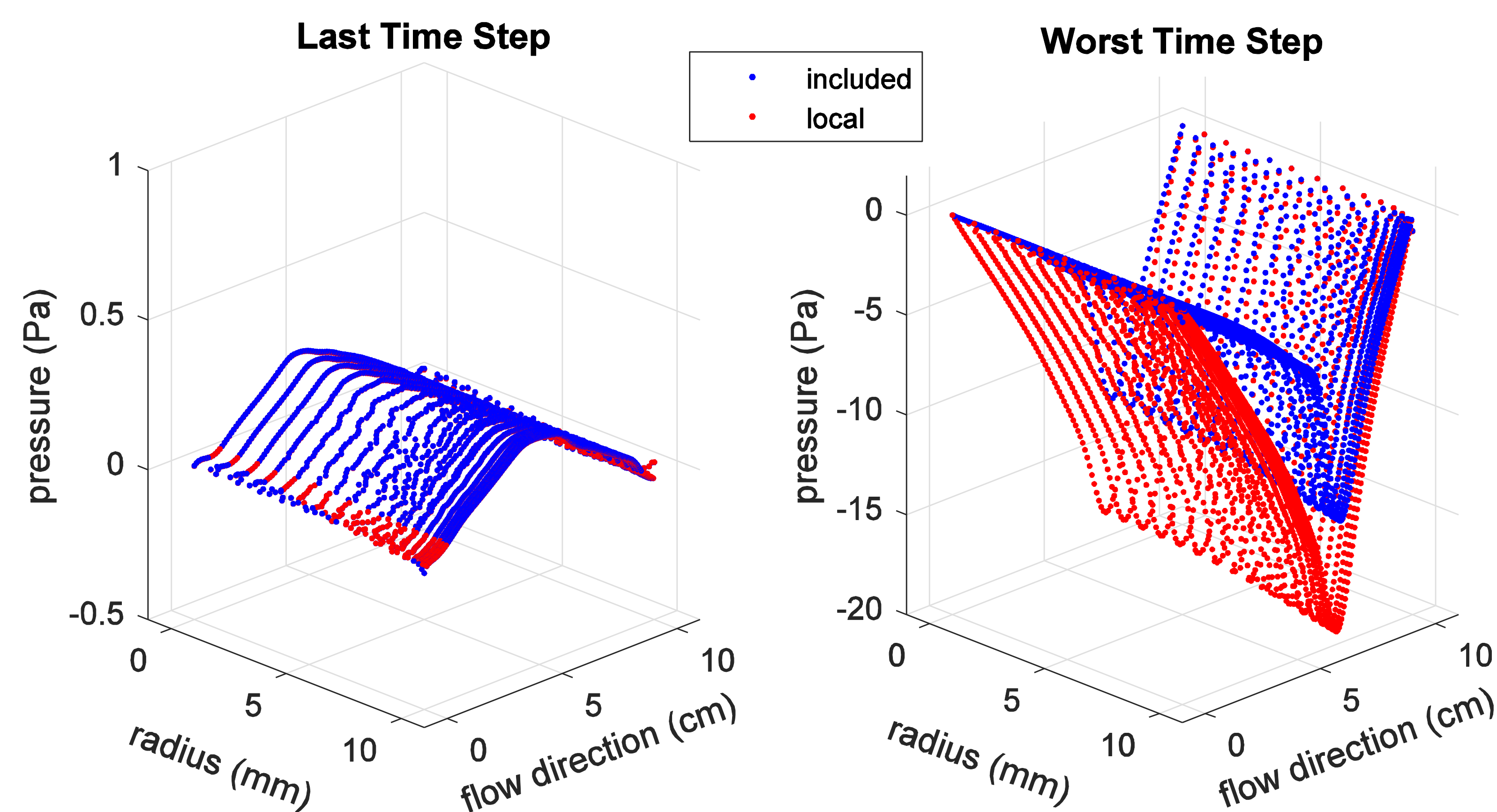


Figure 2. *peristaltic_pump*: Last vs. Worst Time Step (note the difference in pressure scales)

Results: With both tools we see a problem with the *peristaltic_pump* model while the other models produce favorable verification results. The relative difference metric is preferred, although the absolute difference is often adequate, and checking solutions at all solution steps is important.

COMSOL App: Pros	COMSOL App: Cons
More user friendly	More difficult to customize
Developed/Maintained by COMSOL	Outputs absolute but not relative differences
Auto Report Generation	Looks at results from final instead of all steps
User Scripts: Pros	User Scripts: Cons
Easy to customize	Less user friendly
All calculations accessible	Requires expert user development/maintenance
Looks at results from all steps	May require additional software (like Matlab)

Table 2. Pros and Cons of the COMSOL App and User Scripts

Conclusions:

- *Installation verification is critical!*
- Tools for automating verification make the process both painless and more thorough.
- The current cons of the COMSOL Verification App can be readily addressed to provide an excellent verification tool for all users from novice to expert.