The FROST and FROSTb Models

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Overview

The FROSTb Model

- Developed in the 1990s to model frost and thaw depths, frost heave, and thaw settlement in pavements.
- Original source code provided in the appendix of a technical report [1] written by Guymon et al. in 1993.
- Further code changes made between 1993 and 1996. The current working executable is from January, 1996.
- It is unknown who performed the code changes and made the new executable in 1996.
- We do not recommend trying to restore the source code from the 1996 executable.

The FROST Model

- The FROST model is a thermodynamic finite element model using multiple frost-susceptible soil types.
- The model measures thermal conductivity and temperature through several freeze-thaw cycles.
- The core of the model is based on Fortran code written by Ming Zhu in his 2006 PhD thesis [4].
- The FROST model solves the heat equation through the built-in heat solver included with the Elmer multiphysical simulation software [2].
- In addition to the code written by Ming Zhu, we added custom user defined functions to calculate heat conductivity, heat capacity, and soil enthalpy.
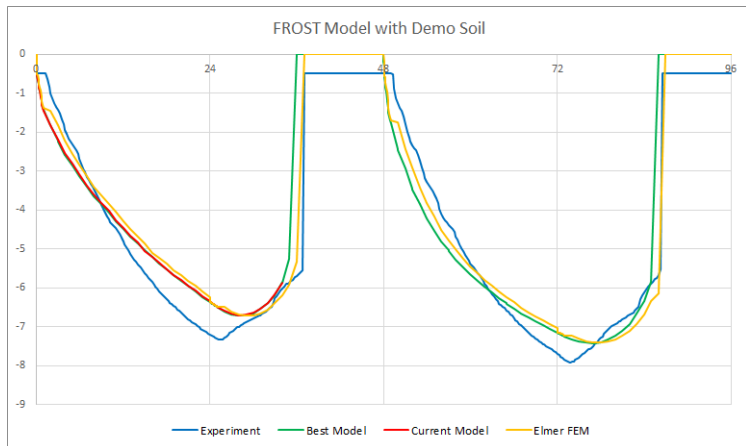
Results

Figure: Comparison of experimental and model data for demo soil. The approximation made by the Elmer finite element software approaches the best model displayed in green.

Future Work

- Investigate the calculation of soil enthalpy in Zhao's paper [3]. See if Zhu has published recent work which includes soil enthalpy.
- Test different solvers outside of BiCGStab and decrease convergence tolerances.
- For the calculation of moisture and ice content, investigate the TemperateIce and DeformationalHeat solvers in Elmer/Ice.
- Create other user defined functions for different soil constants. We currently calculate soil enthalpy, heat capacity, and heat conductivity through custom user defined Fortran code. It may be necessary to write new code to change other soil parameters (such latent heat, density of soil, and the density of water). These parameters are not constant at every node.

References

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