InterFrost spread sheet for participant's code information

File is code related, if you use more than one code please provide one file per code …

Aims: 1°) provide pieces of information that will probably be essential to understand possible differences in the results or performances, 2°) provide info that will be essential to improve the codes from a "best practice" perspective.

Name of the code **SUTRA(ice)**

Participant laboratory **USGS (Voss), McGill University (Jeff), University of Calgary (Barret)**

Participant name(s) **Clifford Voss, Jeffrey McKenzie, Barret Kurylyk**

Is the code used or developed by the team? **BOTH**

Numerical scheme, order of the numerical scheme **Hybrid (finite element and integrated finite difference).**

Time discretization strategy (fixed time steps / if adaptative, provide further information)

FIXED STEPS

Spatial discretization

- 2D / 3D **BOTH**
- external/internal mesh generator **EXTERNAL**
- structured or unstructured grids, what kind of polyhedral mesh (tetra ? hexa ?) **UNSTRUCTURED or STURCTURED, Tetrahedral**

Treatment of non-linearities?

- Method used (Newton, Picard …) **Non-linearities are resolved via the iterative solvers presented below (Direct solution used for benchmarks).**
- Convergence criterion expression and threshold value **USER specified**

Resolution of linear systems

- Linear solvers **Conjugate gradient (CG); generalized minimum residual (GMRES); orthomin; direct (banded Gaussian elimination)**
- pre-conditioner **incomplete LU for GMRES and ORTHOMIN; Cholesky preconditioning for CG.**

How is the TH coupling managed?

- Sequential resolution / iterative process / simultaneous inversion?

List of available boundary conditions options in the code **Specified temperature, specified energy energy source or sink, pressure, specified fluid source or sink. Recent modifications include a generalized head boundary condition which allows for more complex hydraulic or energy boundary conditions (e.g. seepage face).**

Sources of averaging (under relaxation, spatial averaging on variables …)

Constitutive laws implemented **YES**

- Saturation curve **Unsaturated functions (Brooks-Corey, van Genuchten, piecewise linear); Soil freezing curves (Power law, piecewise linear, and exponential), or user defined functions.**
- Permeability as a function of temperature **The relative permeability for partially frozen soils in SUTRA is expressed as a function of the liquid water content. The same functions are used for freezing soils as are used for drying soils (van Genuchten, Brooks-Corey, piecewise linear). SUTRA provides the option to further reduce the permeability of freezing soils compared to the permeability of drying soils at the same liquid moisture content via the inclusion of the impedance factor. Additionally users can add user-defined permeability functions.**

What kind of averaging for the properties (depending on water, ice, bulk parameters)? **Weighted arithmetic mean for heat capacity and weighted arithmetic or geometric mean for thermal conductivity.**

Is (massively)parallel resolution implemented? **NO**

- Which approach (domain decomposition, loop decomposition).
- Indicative number of processors

Papers / reports / web site providing (further) information

McKenzie, J.M., C. Voss, D.I. Siegel. 2007. Ground-water flow with energy transport and water-ice phase change: numerical simulations, benchmarks and application to freezing in peat bogs. *Advances in Water Resources*, 30 (4) : 966-983.

Voss, C.I., Provost, A.M. 2010. SUTRA : A model for saturated-unsaturated, variable-density ground-water flow with solute or energy transport. *U.S. Geological Survey Water-Resources Investigations Report* 02-4231, Available at : http://water.usgs.gov/nrp/gwsoftware/sutra/SUTRA_2_2-documentation.pdf.

Further pieces of information? **A detailed USGS report documenting the unsaturated freezing capabilities as well as modifications listed in McKenzie et al. (2007) is forthcoming.**