CLASS for MESH and IP3

Diana Verseghy

Climate Research Division

Environment Canada

The Canadian Land Surface Scheme (CLASS)

Version 3.x

Monin-Obukhov similarity theory

Mosaic

Canopy interception
- **evaporation**
- **melt**
- **condensation**
- **sublimation**
- **unloading**

Canopy conductance varies with species

Big Leaf canopy

Improved snow algorithms

Explicit snow layer
4th soil layer

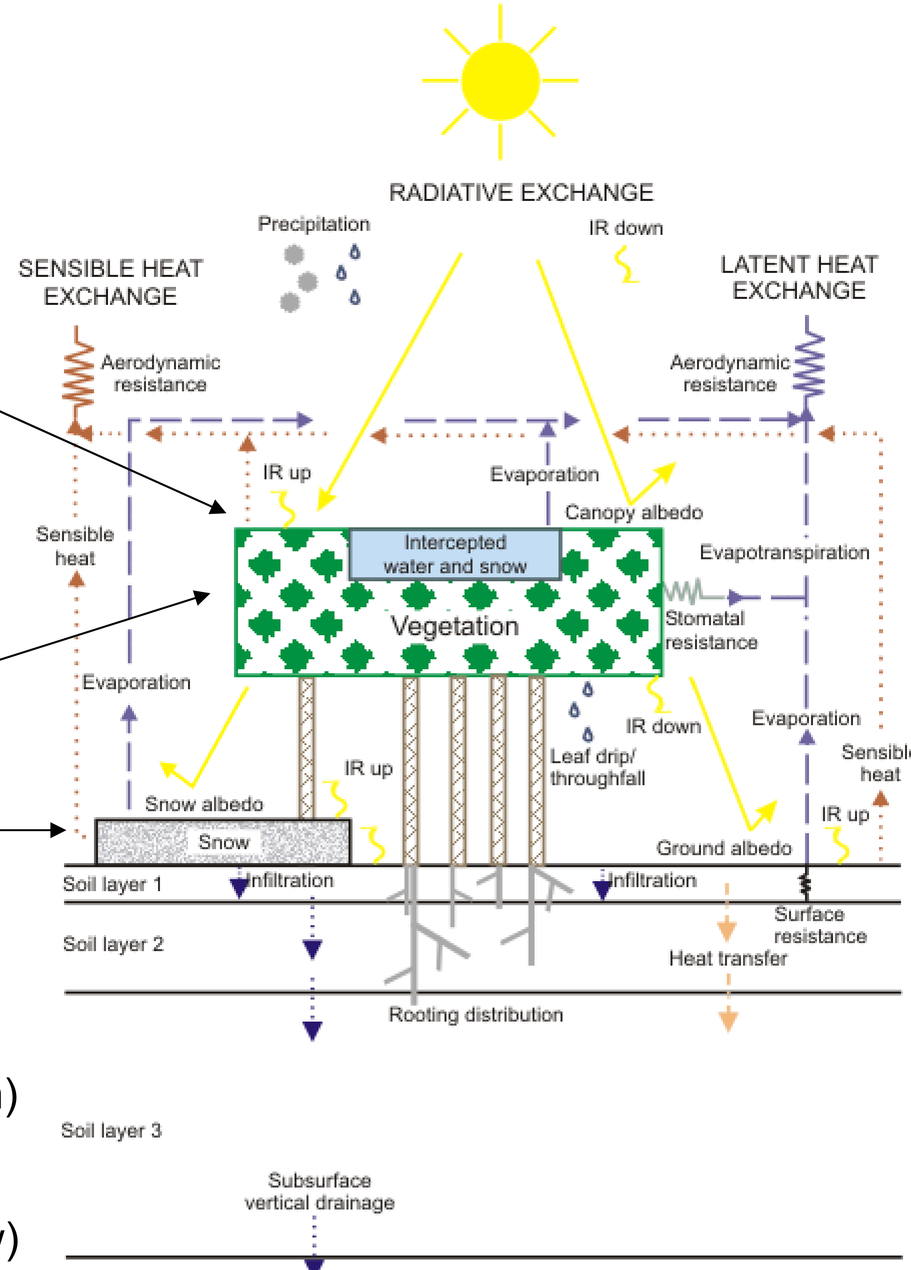
Organic soils

3 soil layers

Heat (thermal diffusion)

WATFLOOD water routing

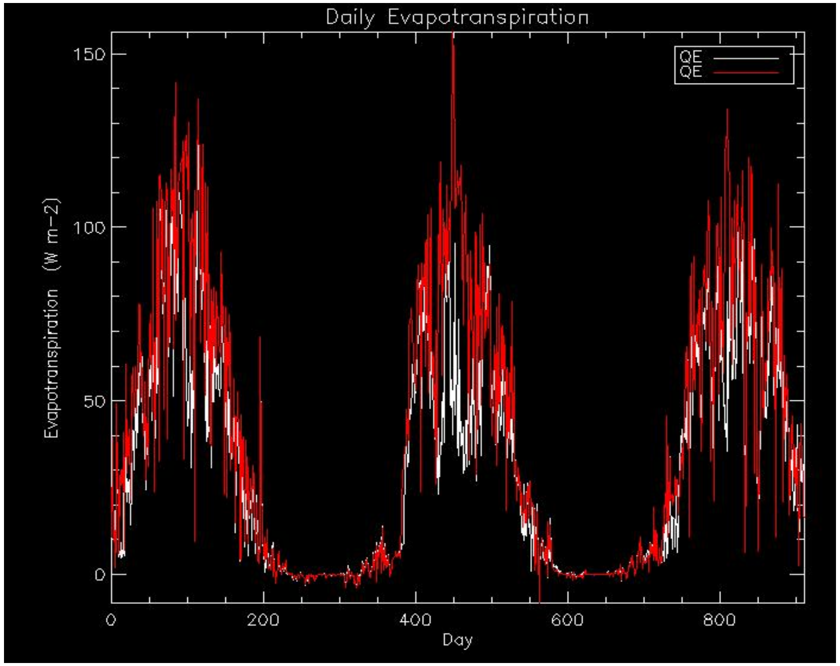
Drainage (Darcy's Law)

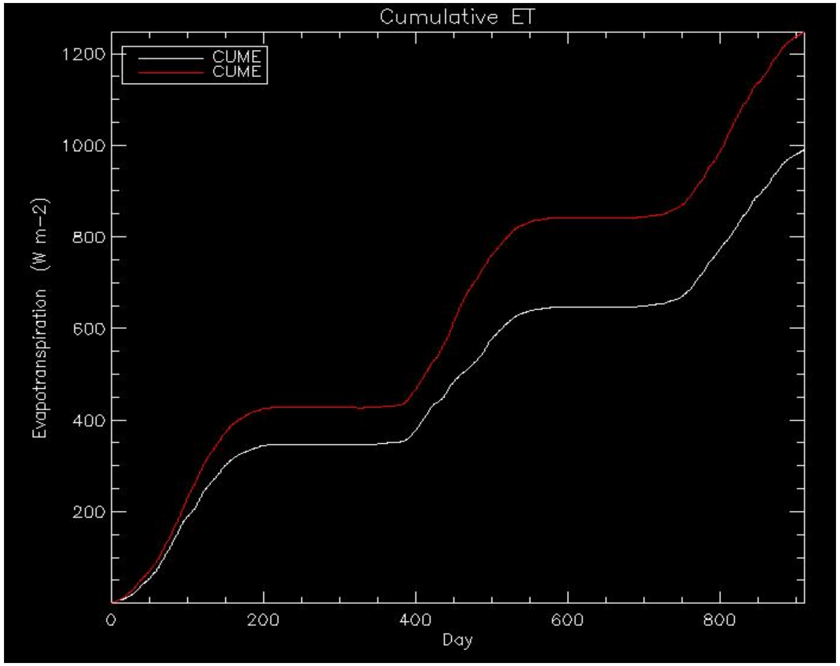


(after Verseghy, 2000)

CLASS version 3.0 (Completed December 2002)

- Improved treatment of soil evaporation
- Ability to model organic soils
- New canopy conductance formulation
- Ability to model lateral movement of soil water
- Enhanced snow density and snow interception
- Improved turbulent transfer from vegetation
- Optional mosaic formulation





Effect of including organic soils.

Control run: Grid cell located near Thompson, Manitoba, with medium-textured mineral soil.

Experiment: Replace mineral soil in the profile with organic soil.

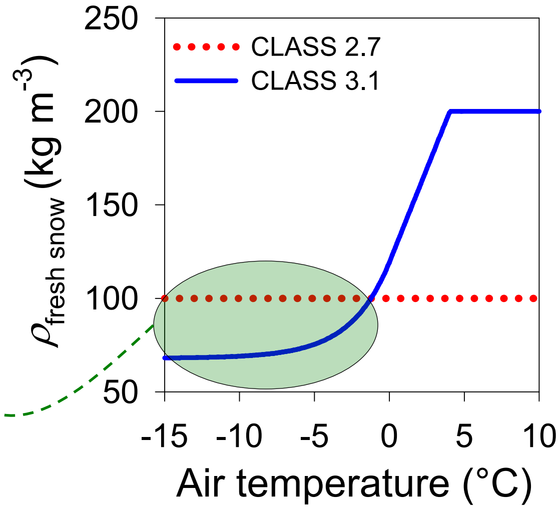
Vegetation identical in both cases: sparse sedge.

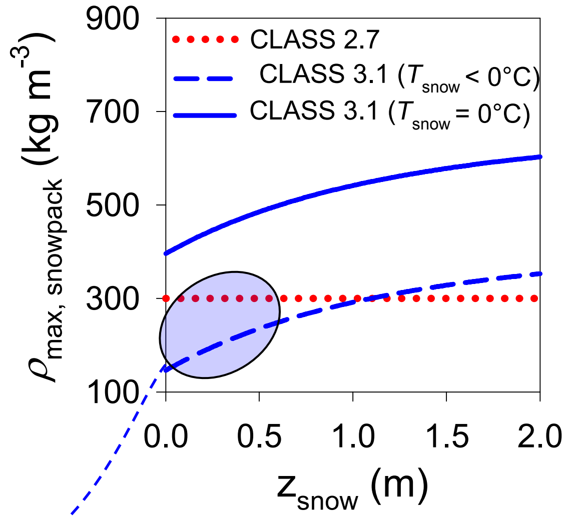
Here differences are seen in daily average and cumulative QE; larger by ~20% in organic soil run.

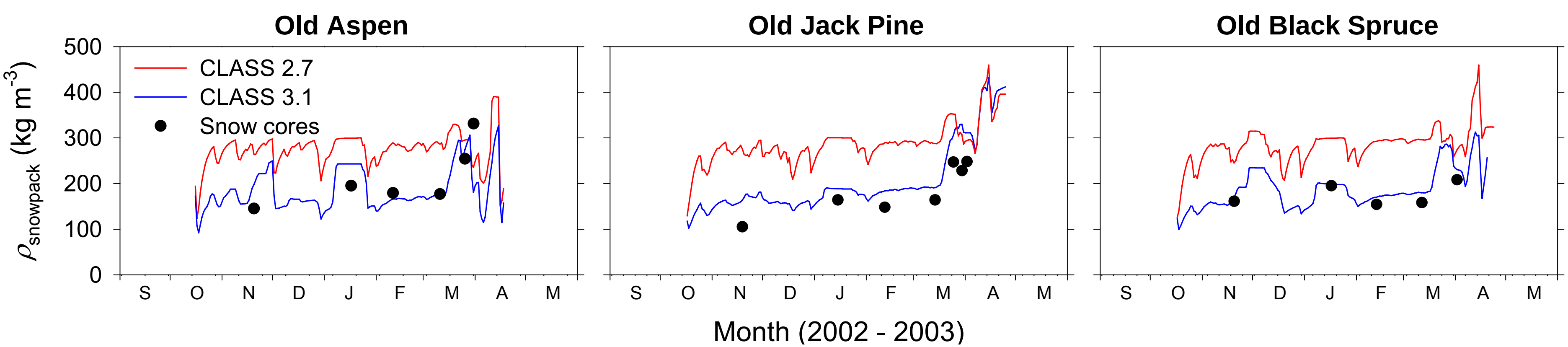
New snowpack density evaluated at BERMS field sites

- $\rho_{snowpack}$ is overestimated in CLASS 2.7 with respect to the snow surveys.
- $\rho_{snowpack}$ is much improved in CLASS 3.1, although sometimes overestimated.

- At the cold temperatures found at these sites, fresh snow is less dense in CLASS 3.1.
- At the shallow snowpack depths during this winter, the maximum snowpack density is smaller in CLASS 3.1.



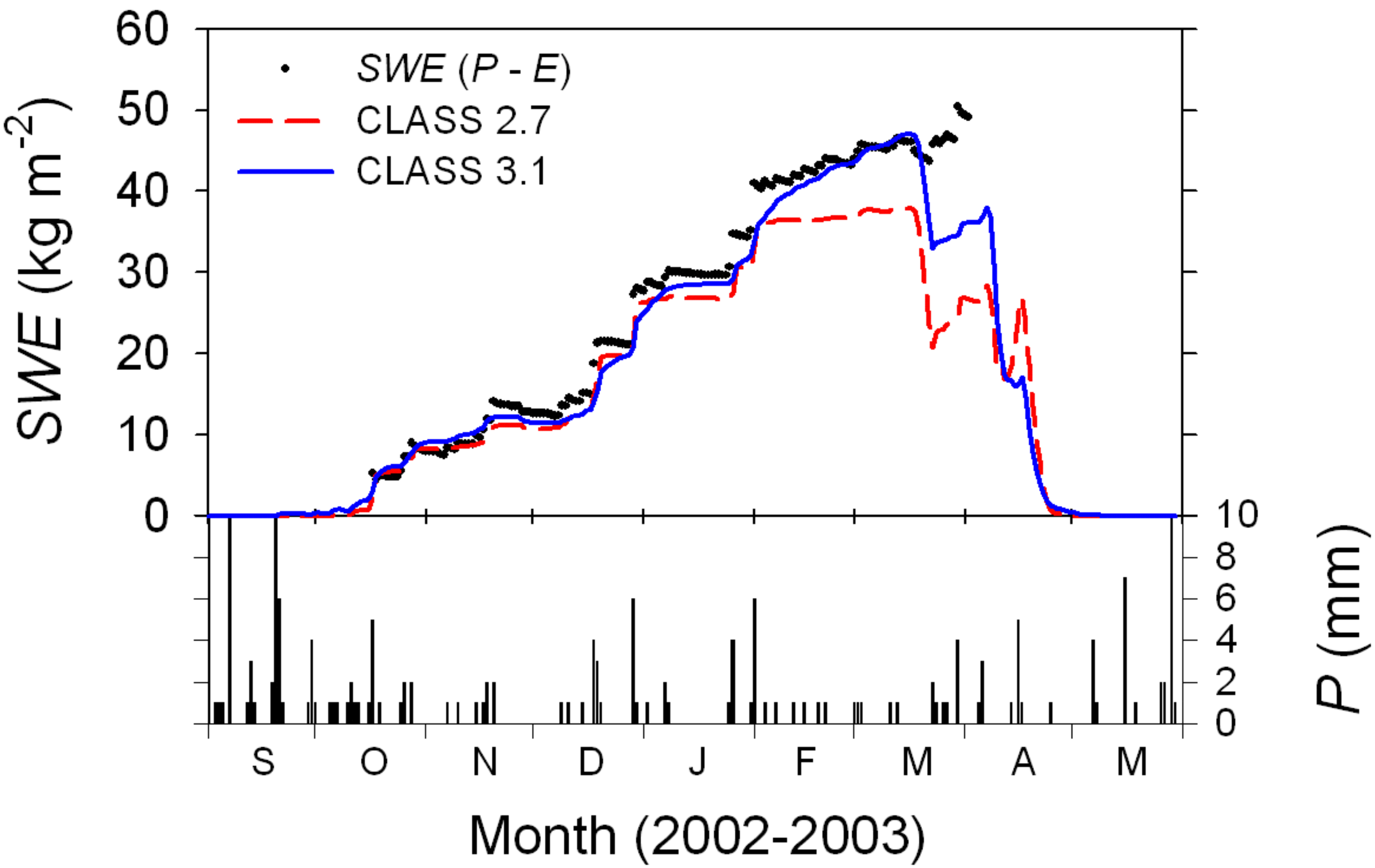




CLASS versions 3.1, 3.2 (Completed April 05, May 06)

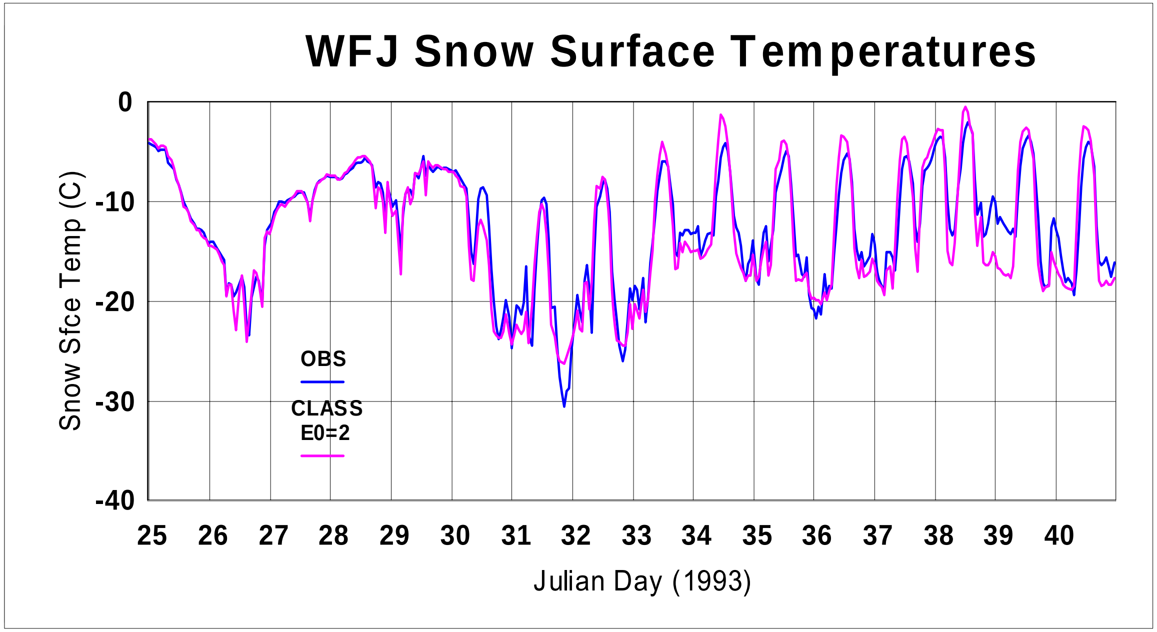
- Faster surface temperature iteration scheme
- Refinements to leaf boundary resistance formulation
- Improved treatment of snow sublimation
- Updated lateral water flow algorithms
- Option for multiple soil layers at depth
- Modelled liquid water content of snow pack
- Revised radiation transmission in vegetation
- Implemented in F90, single precision allowed

Effect of new snow interception parametrization: BERMS Old Black Spruce stand (2002-2003)



- CLASS 3.1 shows better agreement with measurements
- Most of the improvement in this model run comes from the ability to unload snow from small snowfall events before the snow sublimates.

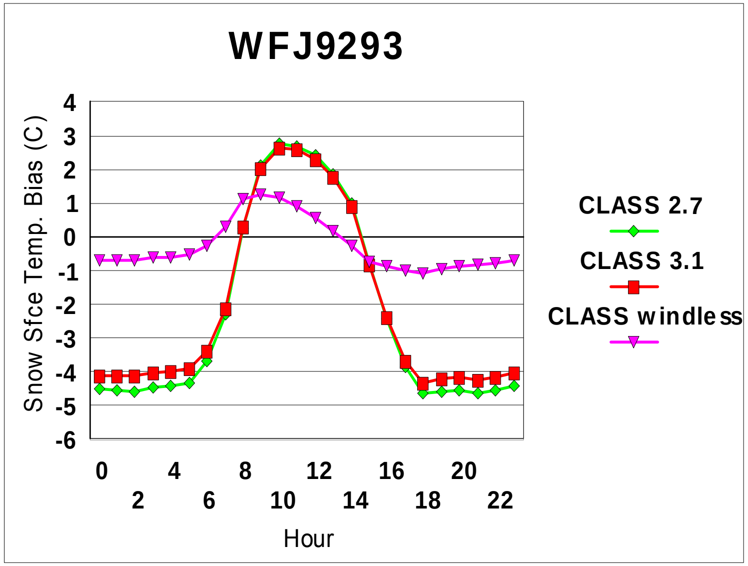
Cold bias observed in snow surface temperatures under stable conditions

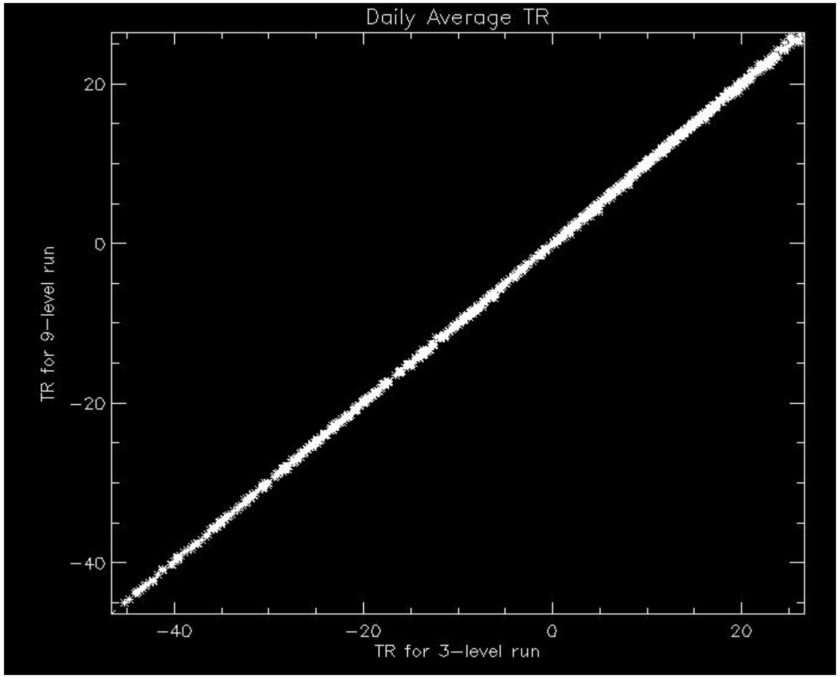


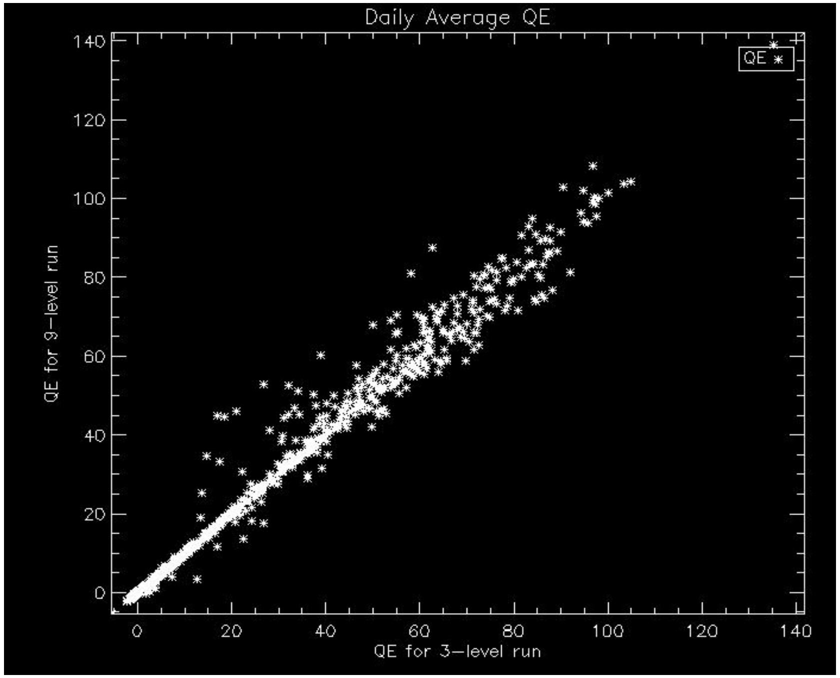
Significant improvement in snow surface temperatures with $E_0 = 2\ \mathrm{W\ m^{-2}\ K^{-1}}$ and albedo modified to represent observed values (CLASS albedo too low by ~0.15 at this site)

$$Q_H = [\,\rho_a\, c_p\, C_H\, U_z + E_0\,]\,(T_{sfce} - T_z)$$

Windless exchange coefficient 1-2 $\mathrm{W\ m^{-2}\ K^{-1}}$ used in a number of snow models.







Effect of number of soil layers

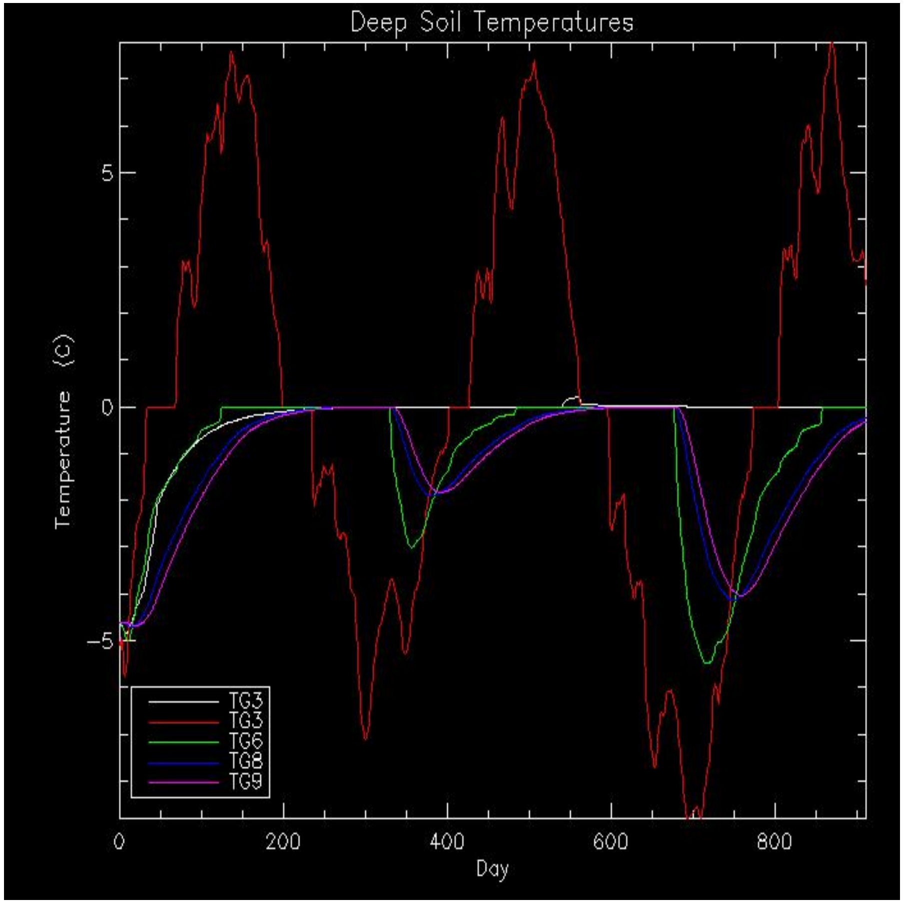
Control run: Standard configuration of CLASS with 3 soil layers, Δz = 0.10, 0.25, 3.75 m.

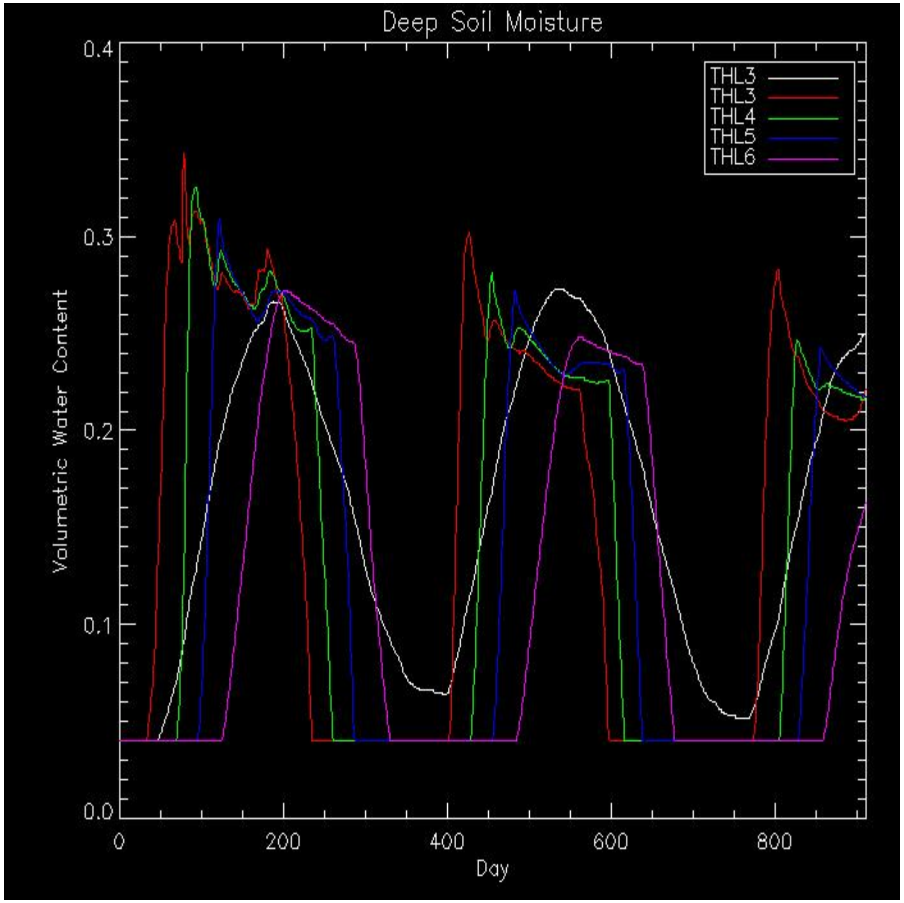
Experiment: 9 soil layers, Δz = 0.10, 0.25, 0.25, 0.25, 0.25, 0.50, 0.50, 1.0, 1.0.

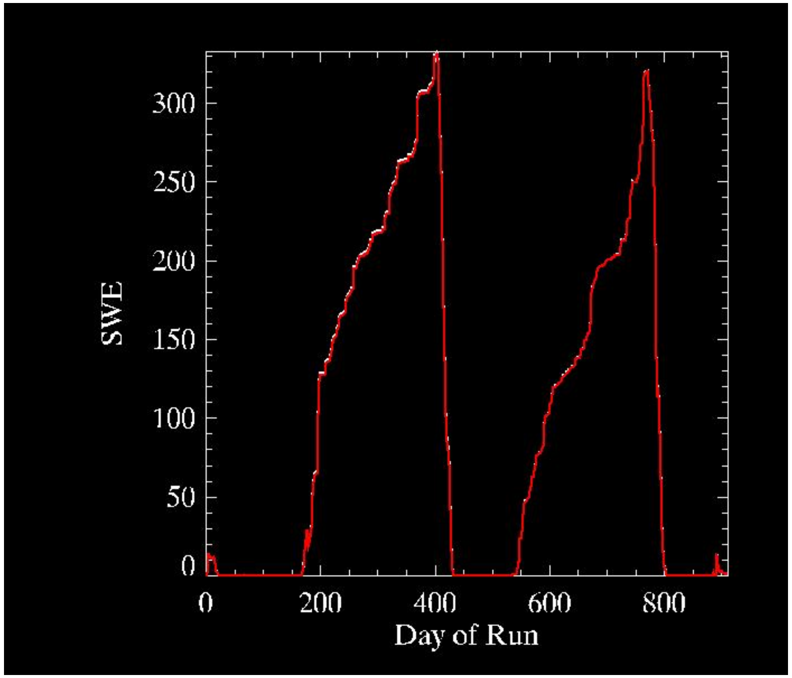
Shown: output for grid cell located in central Mackenzie River basin.

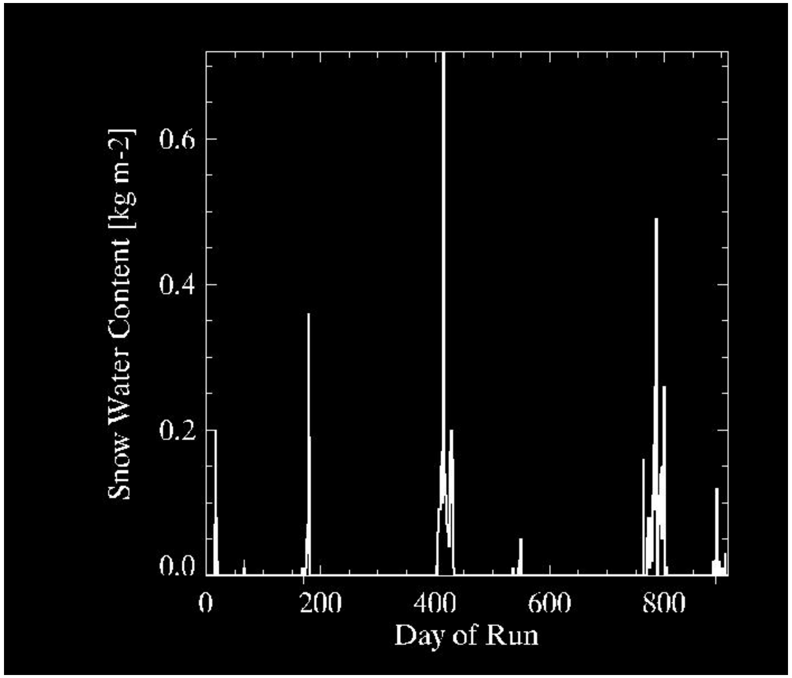
Surface temperatures and fluxes to the atmosphere show little systematic difference.

However, higher resolution of the soil thermal profile at depth allows for more accurate modelling of the depth of freezing and thawing, and of the resulting availability of water for hydrological routing.









Effect of including water retention in snow pack

Control: CLASS 3.2 (red)

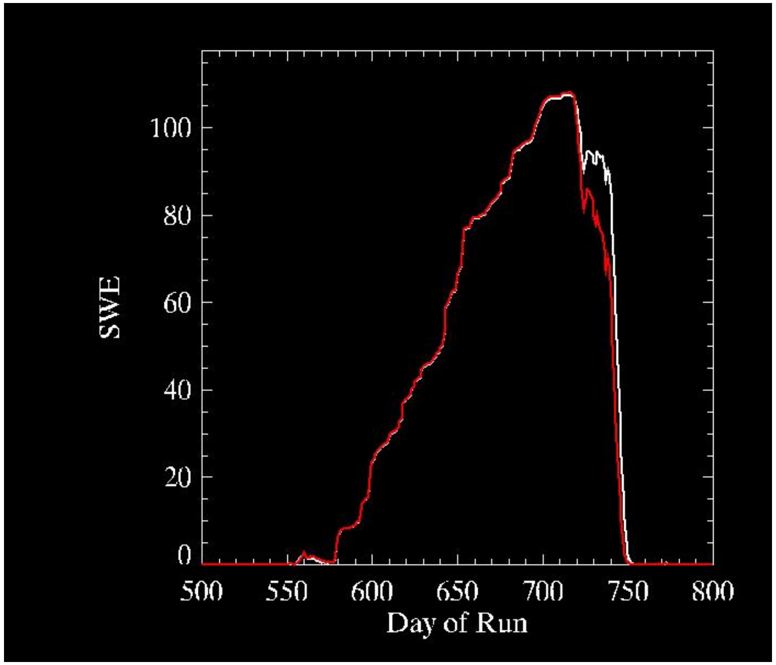
Experiment: CLASS 3.3 (white)

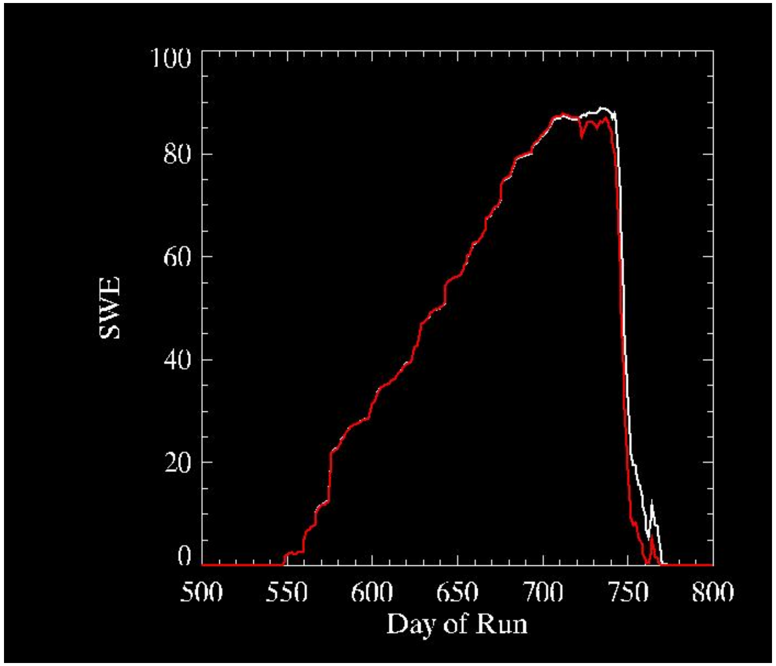
Grid cell located in mainland Nunavut.

Negligible effect on snow pack evolution at this location. Probably greater effect at more temperate locations with deeper snow packs.

CLASS version 3.3 (Completion November 2006)

- Separate thermal treatment of snow and soil
- Implement multiple-layer option for ice sheets
- Water and energy balance checks at each time step
- Finalize CLASS part of hydrology for this version (especially GRDRAN, GRINFL)
- Small numerical fixes identified during testing with CRCM





Effect of separating snow and soil temperature calculations

Control: CLASS 3.2 (red)
Experiment: CLASS 3.3 (white)

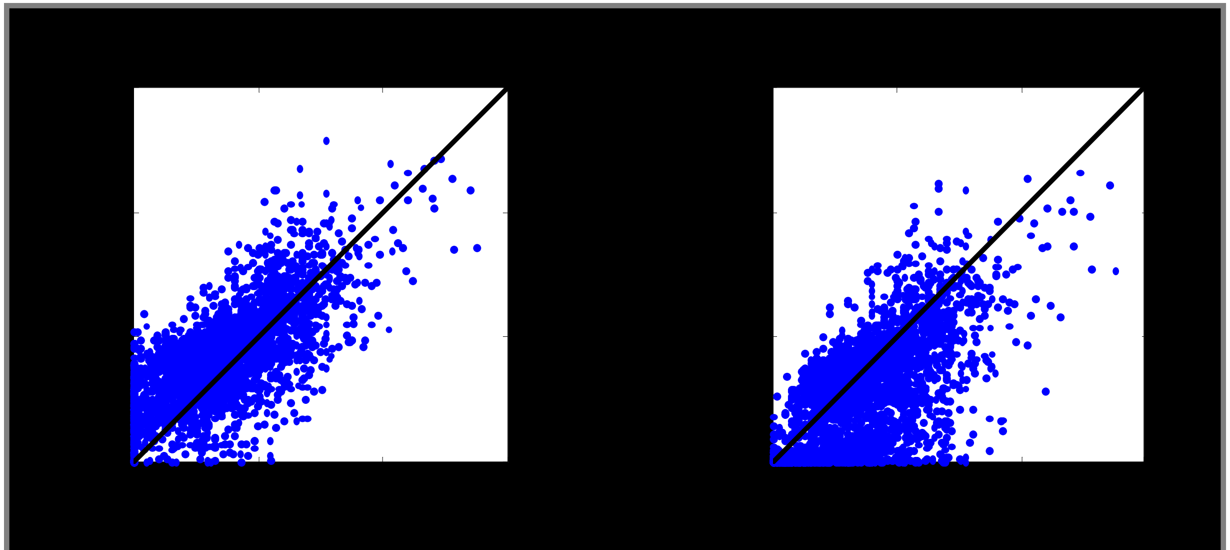
Test grid cells near Peace River, Alberta (top) and in the central Mackenzie River basin (bottom)

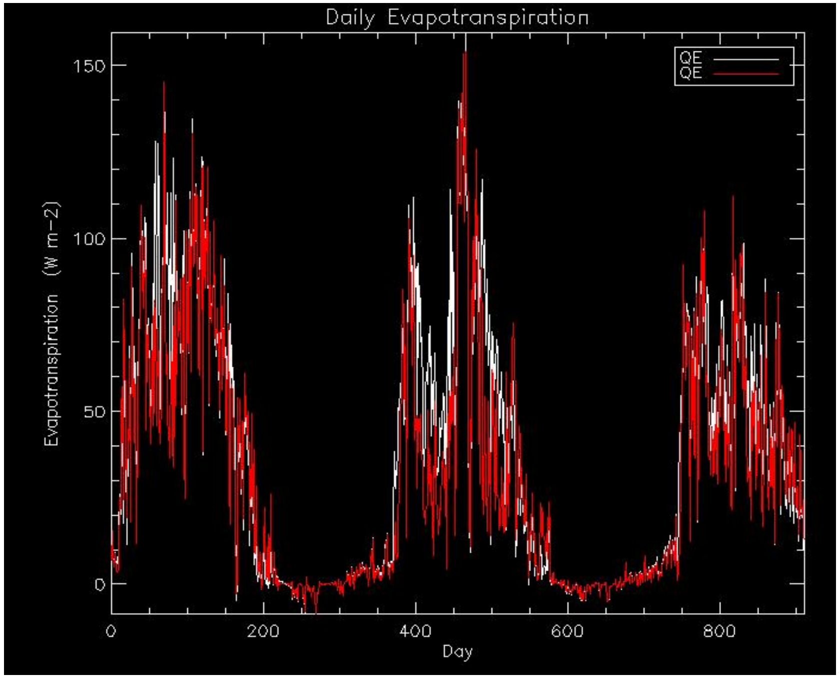
Differences are slight, but snow persists for slightly longer in CLASS 3.3 during the melt period.

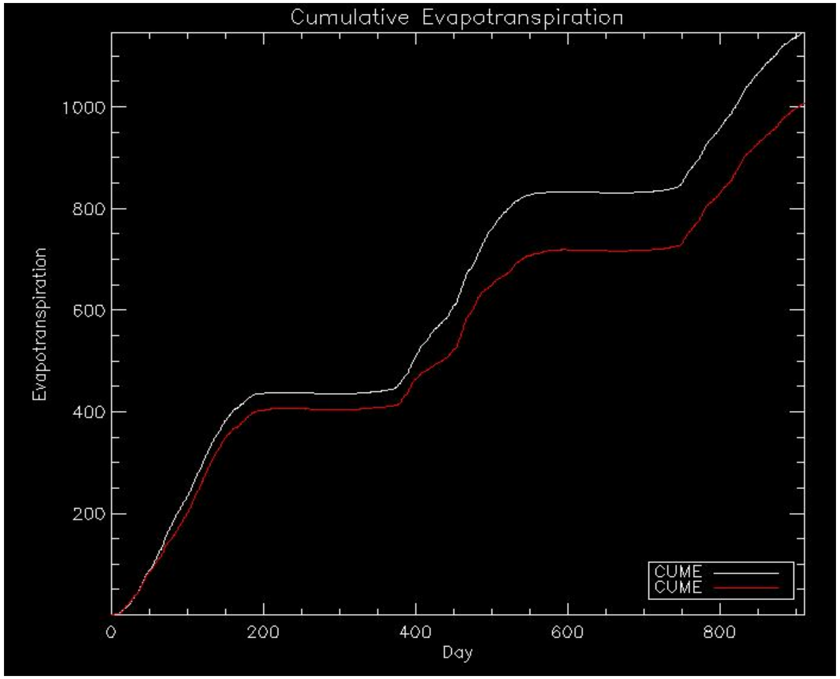
SWE as simulated by ISBA (left) and CLASS 3.1 (right)

Validated against data from 131 snow measurement stations in southern Quebec, 2001-2006 (V. Fortin)

CLASS 3.1 tends to underestimate at small SWE values, notably during the melt period. Improvements to treatment of snow temperature introduced in CLASS 3.3 may address this.







Effect of varying permeable depth of soil

Control: Standard 3-layer configuration of CLASS, with permeable depth = 1.0 m.

Experiment: Permeable depth decreased to 0.2 m.

Grid cell located near Peace River, Alberta.

Differences again seen in daily average and cumulative QE: ~15% less with shallower soil.