

***Update on
CLASS for MESH
and IP3***

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The Canadian Land Surface Scheme (CLASS)

Monin-Obukhov
similarity theory

Canopy interception
evaporation
melt
condensation
sublimation
unloading

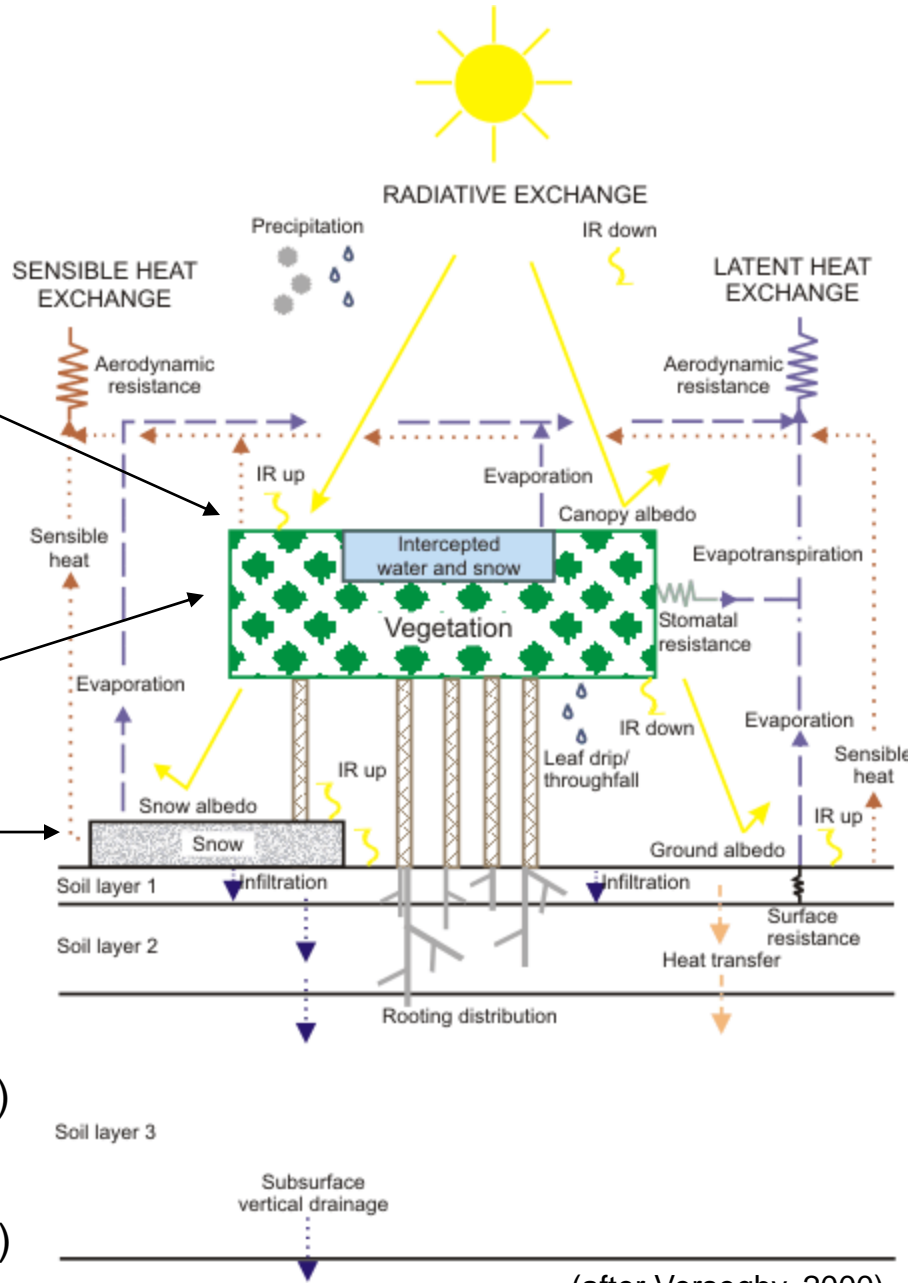
Big Leaf canopy

Explicit snow layer
4th soil layer

3 soil layers

Heat (thermal diffusion)

Drainage (Darcy's Law)



Version 3.x

Mosaic

Canopy conductance
varies with species

Improved snow
algorithms

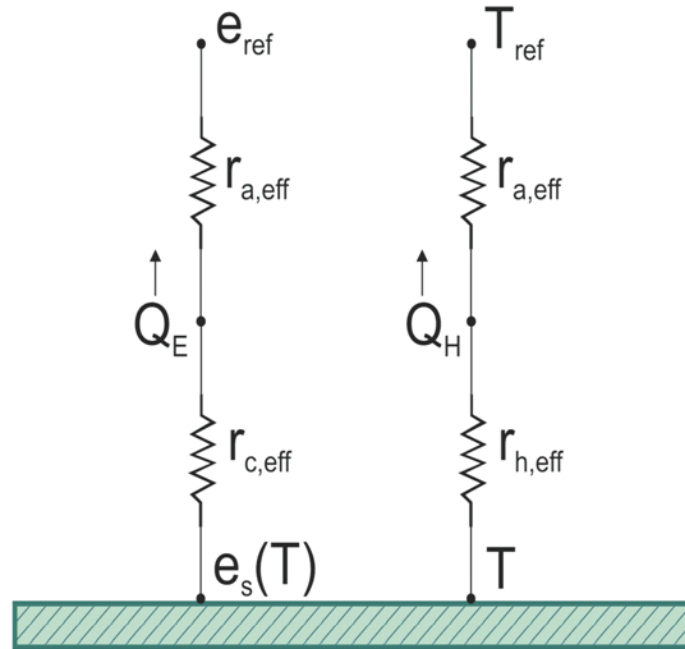
Organic soils

WATFLOOD
water routing

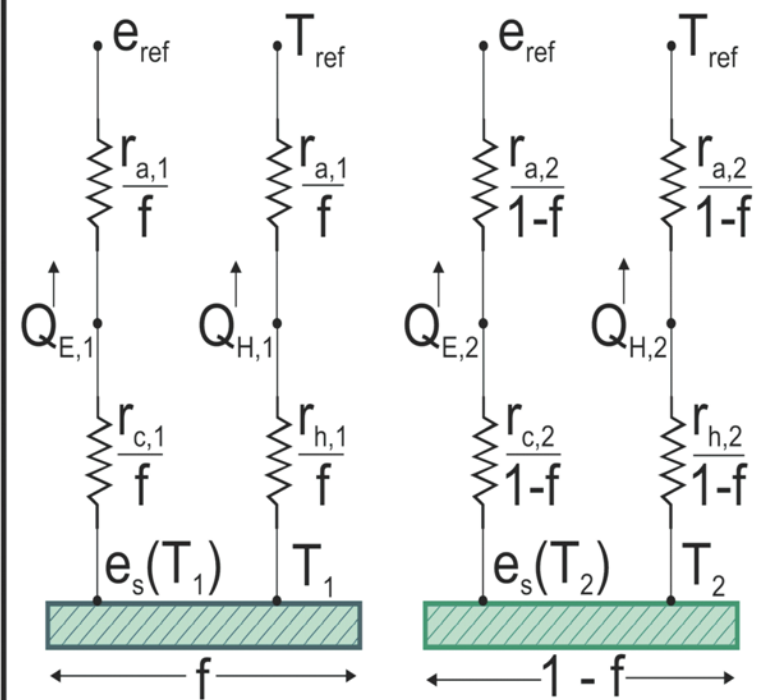
CLASS documentation

- Completion in December 2007
- Over 13,000 lines of code
- Description, dictionary of variables, equations and references for each subroutine
- Instructions for assembly of input data, use of flags
- Guidelines for setup of mosaic tiling and soil layering

Aggregated: one patch containing dominant or aggregated surface parameters



Mosaic: multiple patches, each containing individual surface parameters



e vapour pressure
 $e_s(T)$ saturation vapour pressure at T
 f fraction of grid-cell occupied by patch 1
 Q_E latent heat flux
 Q_H sensible heat flux
 r_a aerodynamic resistance

r_c canopy resistance to latent heat
 r_h resistance to sensible heat transfer
 T temperature
 eff denotes an effective value
 ref denotes a reference height
 1, 2 refers to patch 1 or patch 2

Grid-cell averages calculated

$$\overline{X}(i) = \sum_m X(i, m)$$

$X(i,1)$

$X(i,2)$

$X(i,3)$

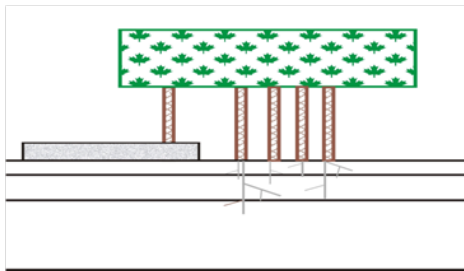
Prognostic variable arrays scattered
back onto original matrix grid

$X'((i-1) \cdot nm + 1)$

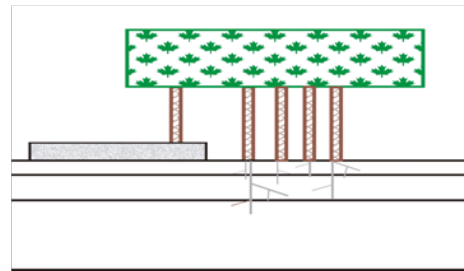
$X'((i-1) \cdot nm + 2)$

$X'((i-1) \cdot nm + 3)$

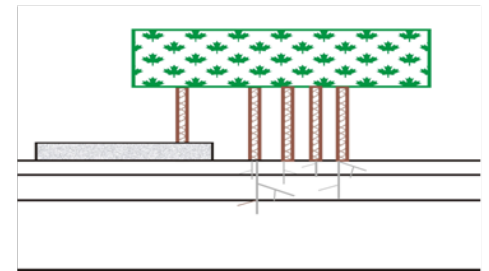
CLASS



Patch 1



Patch 2



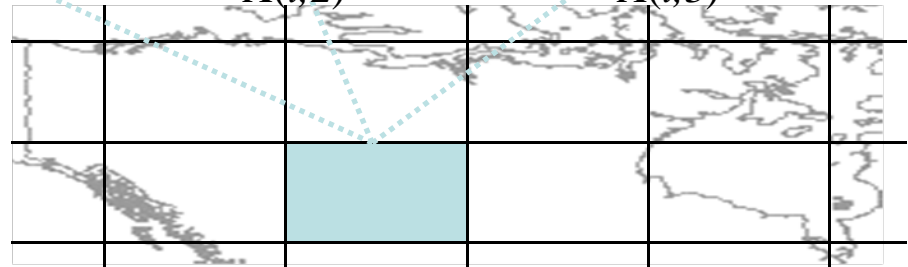
Patch 3

Prognostic variable matrix arrays gathered
from mosaic grid onto vector array

$X(i,1)$

$X(i,2)$

$X(i,3)$



For the i^{th} grid-cell:

- ni is the number of grid elements (grid cells)
- nm is the number of mosaic elements (patches in each grid-cell)

The Canadian Land Surface Scheme (CLASS):

- one of the first Land Surface Parameterization schemes to represent surface heterogeneity

vegetated	bare soil
vegetated with snow	bare soil with snow

- within the vegetated sub-areas, up to four broad categories of vegetation are aggregated

1. needleleaf trees 2. broadleaf trees 3. crops 4. grass

Atmospheric forcing data

- Downwelling shortwave radiation (visible and near-IR if possible, cloud cover)
- Downwelling longwave radiation
- Air temperature
- Specific humidity of air
- Wind speed
- Reference height
- Precipitation (rainfall and snowfall)
- Pressure

Land surface data

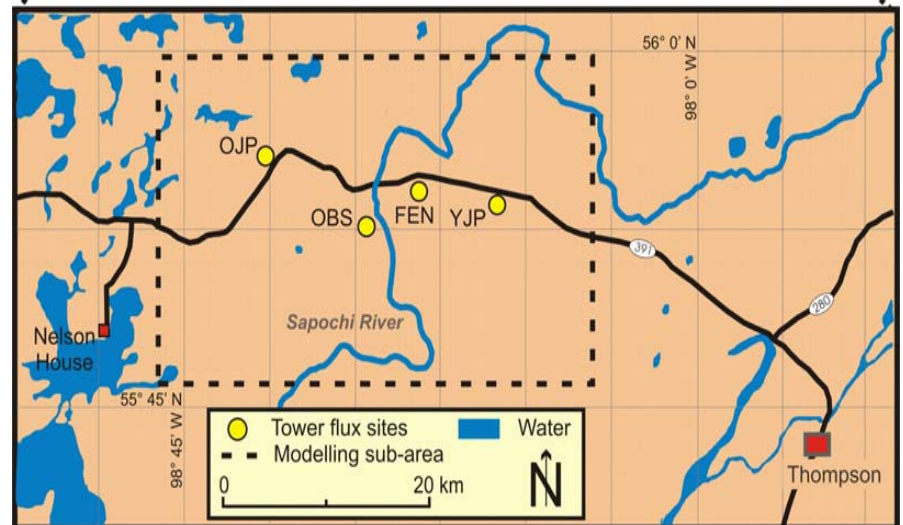
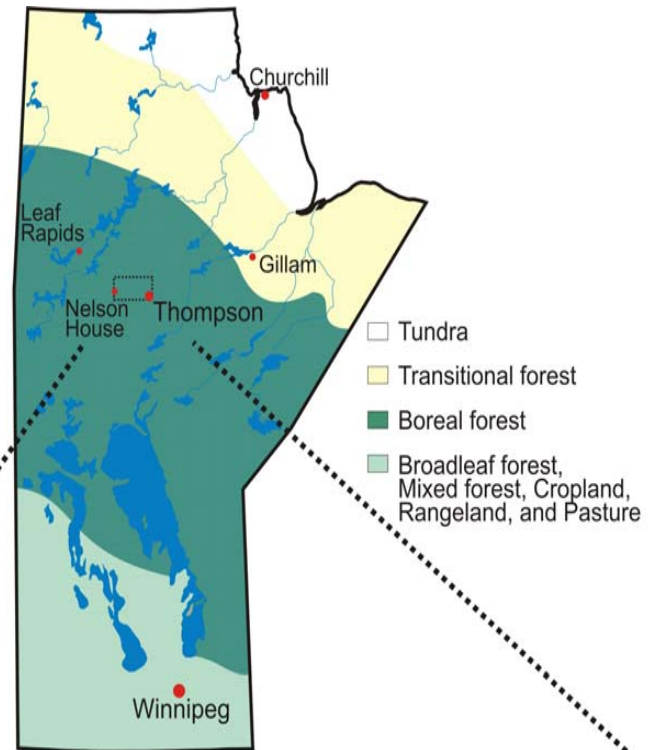
- Vegetation type and coverage (and height, leaf area index, albedo, mass, rooting depth, minimum stomatal resistance if available)
- Soil texture, type, albedo, permeable depth, slope, aspect
- Initial conditions for prognostic variables (esp. deep soil temperature and moisture, snow mass and properties)

Study area

- North-central Manitoba
- a 1200 km² region of boreal forest in the BOREAS Northern Study Area known as the modelling sub-area

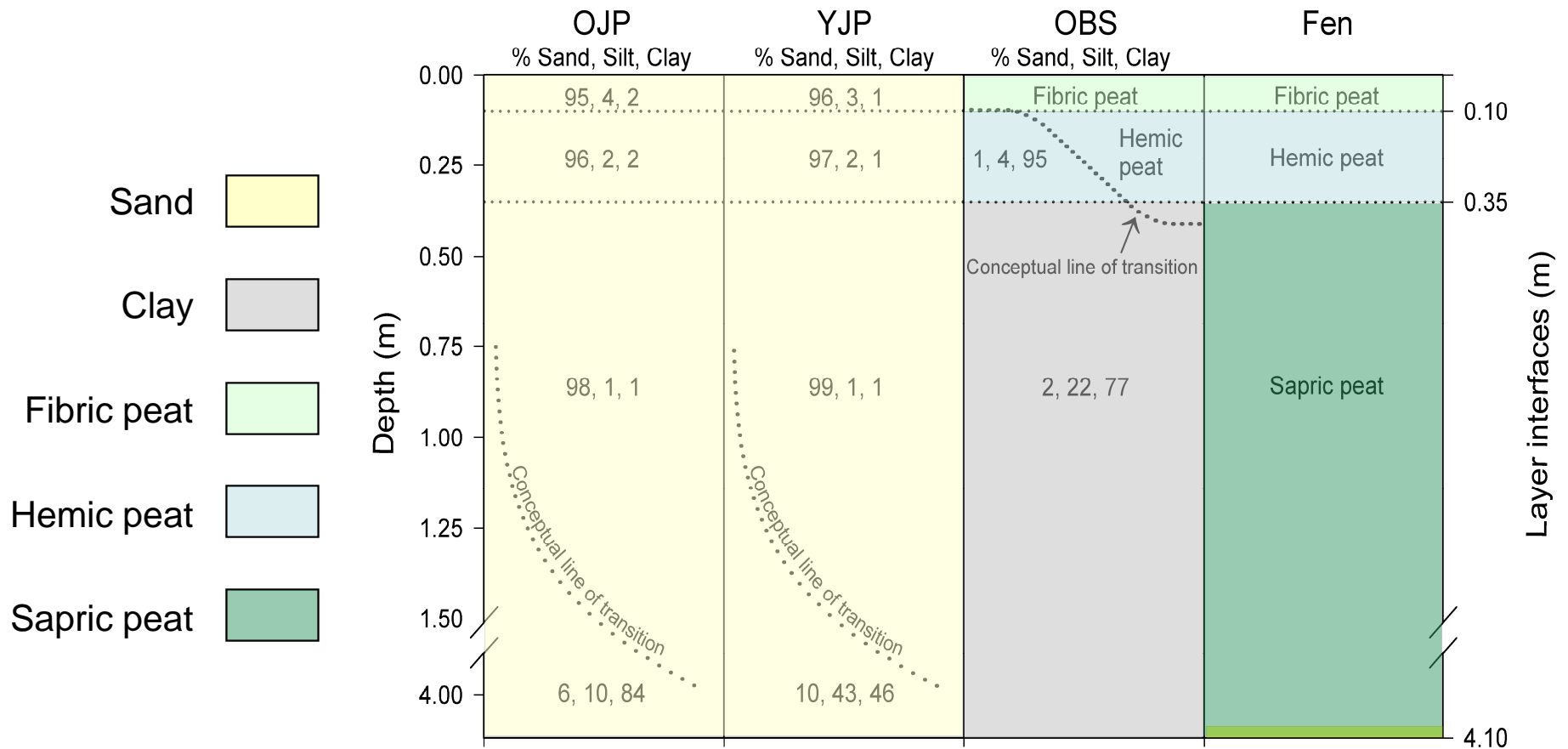
Four tower flux sites

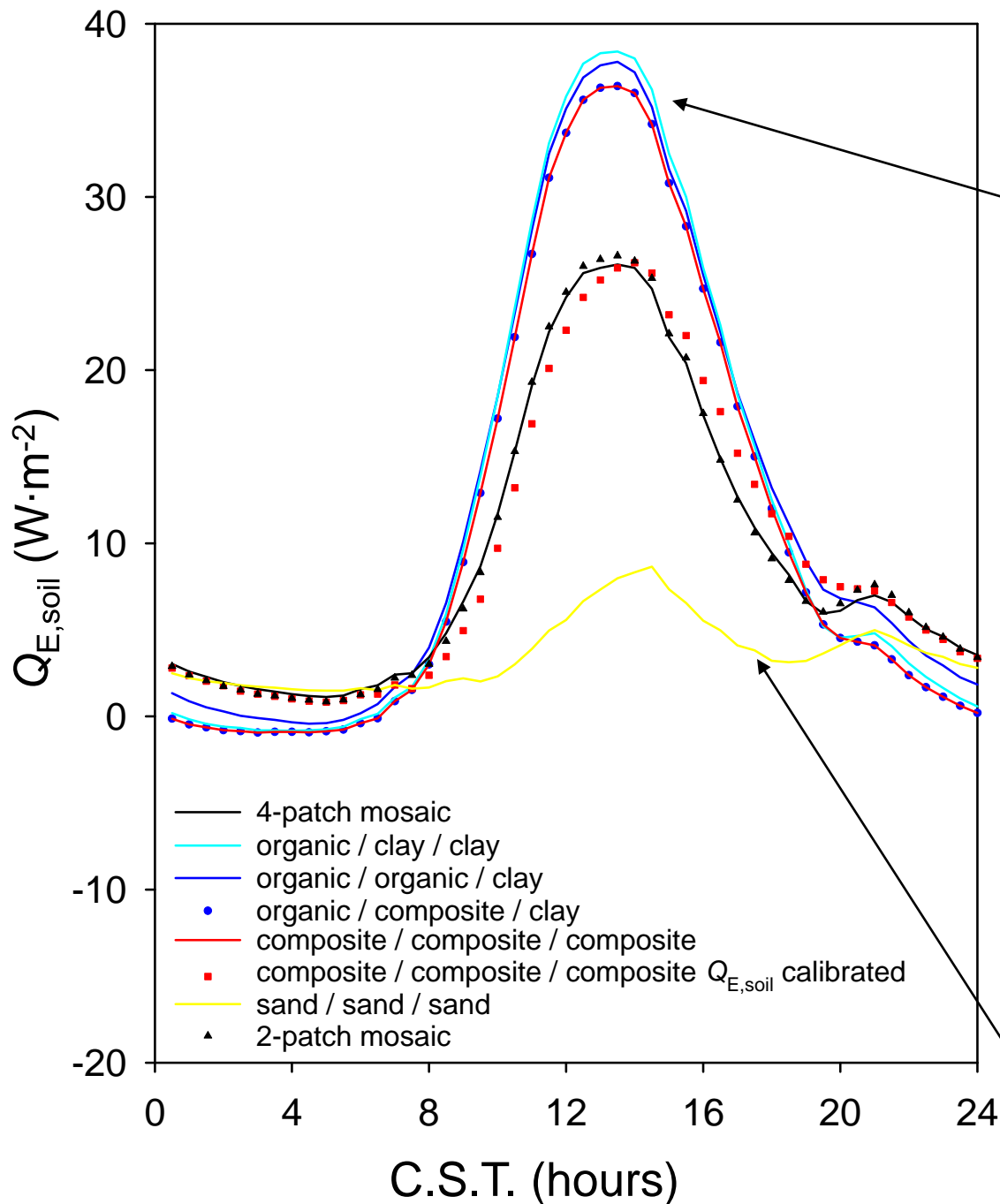
- Old Jack Pine (OJP)
- Old Black Spruce (OBS)
- Fen
- Young Jack Pine (YJP)
- observed surface fluxes and meteorological variables
- detailed surface characterization



Site properties at each of the four flux tower sites

	OJP	YJP	OBS	FEN
Canopy height (m):	13.5	3	12	0.5
Leaf area index:	1.9	1.2	4.6	1.5
RCMIN (s·m⁻¹):	165	200	270	130





Soil evaporation

- With an organic soil layer or a composite soil layer at the surface, $Q_{E,soil}$ is overestimated.
- The 4-patch and 2-patch mosaic model runs have almost identical behaviour.
- We were able to tune the algorithm for soil evaporation so that the composite soil behaved similarly to the mosaic.
- This is not meant as a solution to soil evaporation, but merely to minimize one source of error while examining modelled Q_E .
- With a sand soil column, $Q_{E,soil}$ is underestimated due to rapid drainage.

CLASS version 3.4

- Slight streamlining to improve readability and understandability
- Deletion of old work arrays and trial pieces of code
- Removal of option for net longwave forcing
- Change sequence of canopy water storage calculations

Further research topics

- Sensitivity tests on mosaic formulation, soil and canopy discretization
- IPY snow modelling study over Quebec, using assimilated atmospheric data and MAGS NA vegetation and soils database
- Offline runs over each IP3 research basin, focussing on CLASS-atmosphere coupling