The Canadian Land Surface Scheme (CLASS) for Cold-Climate Regional Modelling

D. Verseghy, Environment Canada

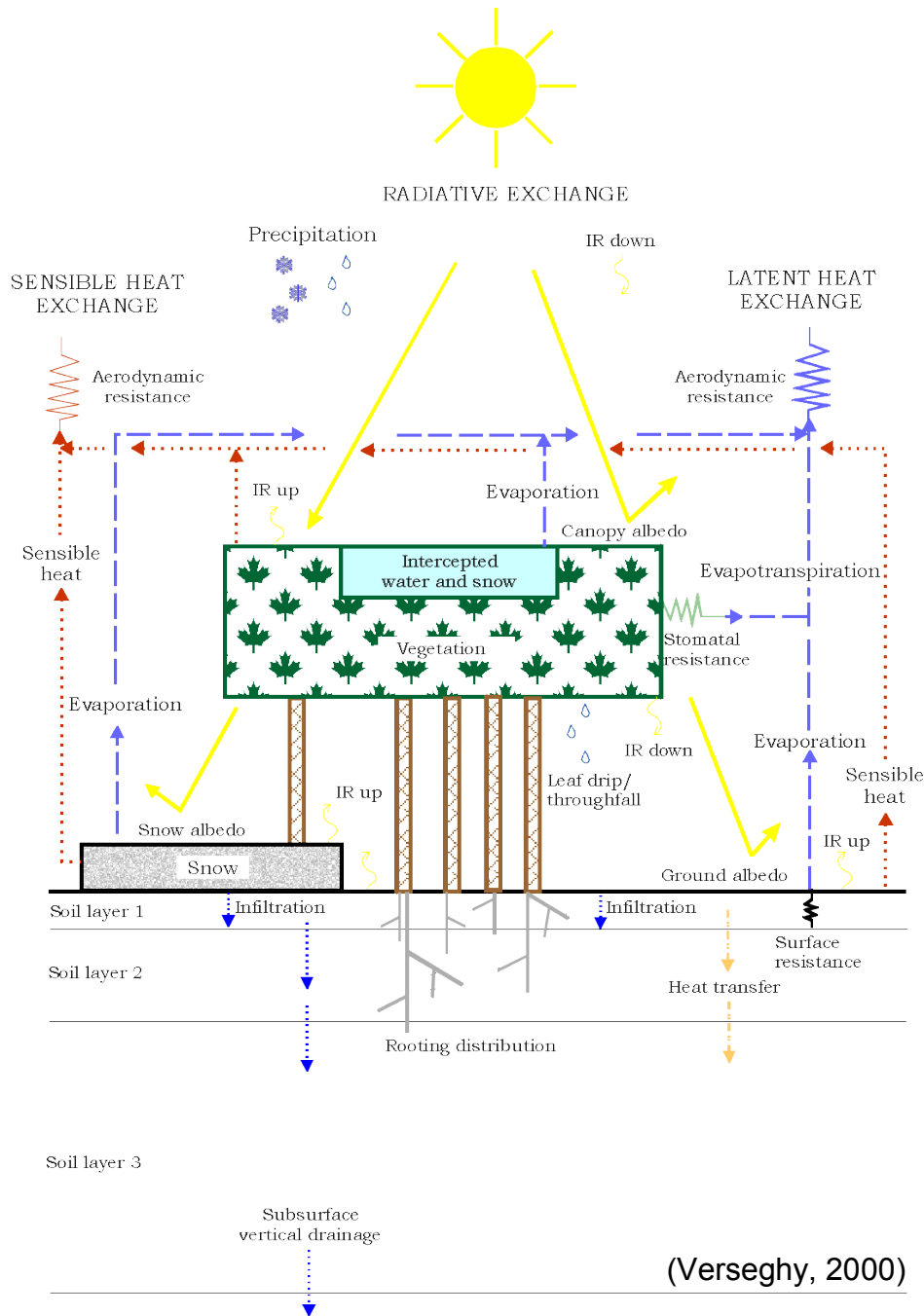# The Canadian Land Surface Scheme (CLASS)

Originally developed for the CGCM; treats fluxes of energy and water at the land surface

Thermally separate vegetation canopy, snow cover and three soil layers.

Four main vegetation structural types identified (needleleaf trees, broadleaf trees, crops and grass); parameters are aggregated at each time step to define representative canopy characteristics.

Up to four subareas allowed over each model grid cell: vegetation covered, bare soil, snow with vegetation and snow over bare soil.

One soil type for each grid cell.

RADIATIVE EXCHANGE

Precipitation

IR down

SENSIBLE HEAT EXCHANGE

LATENT HEAT EXCHANGE

Aerodynamic resistance

Aerodynamic resistance

IR up

Evaporation

Canopy albedo

Sensible heat

Intercepted water and snow

Evapotranspiration

Vegetation

Stomatal resistance

Evaporation

Evaporation

IR down

Sensible heat

IR up

Leaf drip/ throughfall

Snow albedo

Snow

Ground albedo

IR up

Soil layer 1

Infiltration

Infiltration

Surface resistance

Soil layer 2

Heat transfer

Rooting distribution

Soil layer 3

Subsurface vertical drainage

(Verseghy, 2000)

CLASS enhancements since version 2.7 (last GCM version)

- Ability to model organic soils
- New formulations for snow density, interception, sublimation, thermal structure, liquid water
- Improved vegetation turbulent fluxes, soil evaporation
- Revised soil thermal conductivity calculations
- Optional mosaic formulation
- Option for multiple soil layers at depth

CLASS version 3.4

- New frozen version with full documentation

- Parallel work on C-CLASS, CN-CLASS

- Incorporated into MEC at RPN; targetted for implementation in GEM

- Will eventually be included in CGCM

- Regional off-line land surface modelling project currently underway for IPY

IPY modelling window

- Domain chosen: centred over Quebec (snow course data collected by Hydro-Quebec available from 1965 to 2006)

- Time interval chosen: one-year spin-up period, June 1991 - June 1992, six-year modelling period, June 1992 – June 1998

- 5-year overlap with daily SWE reconstruction done by Brown et al. for AMIP-2 (ends 1997)

- Includes warm El Nino winter of 1997/98 (lowest snow year on record in Quebec)

Atmospheric forcing data

- Derived from ERA-40 reanalyses

- GEM used as temporal and spatial integrator; resolution increased from 1 degree, six hourly to ¼ degree, ¼ hourly

- Saved fields: incoming shortwave and longwave radiation, air temperature, humidity and wind speed, rainfall, snowfall, fractional cloud cover, surface pressure, height of lowest model level

Background data

- 1-km North American land cover and soils dataset, produced by Szeto et al. for MAGS

- Land cover fields derived from CCRS and USGS datasets

- Soil fields derived from CANSIS and USGS datasets

Land cover
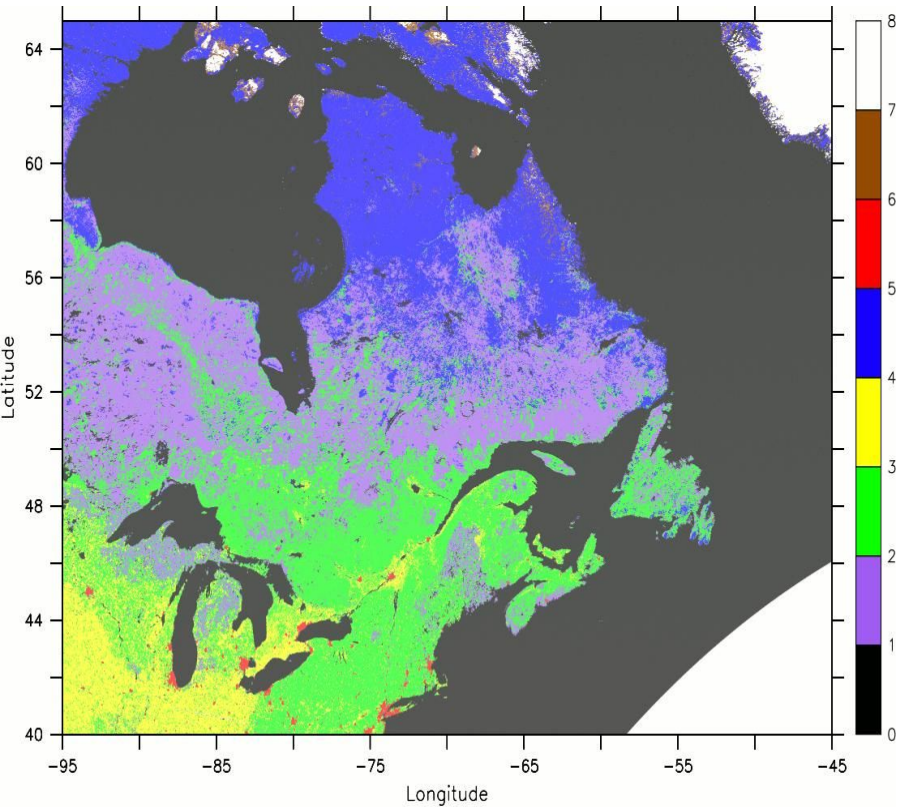
1-km base data
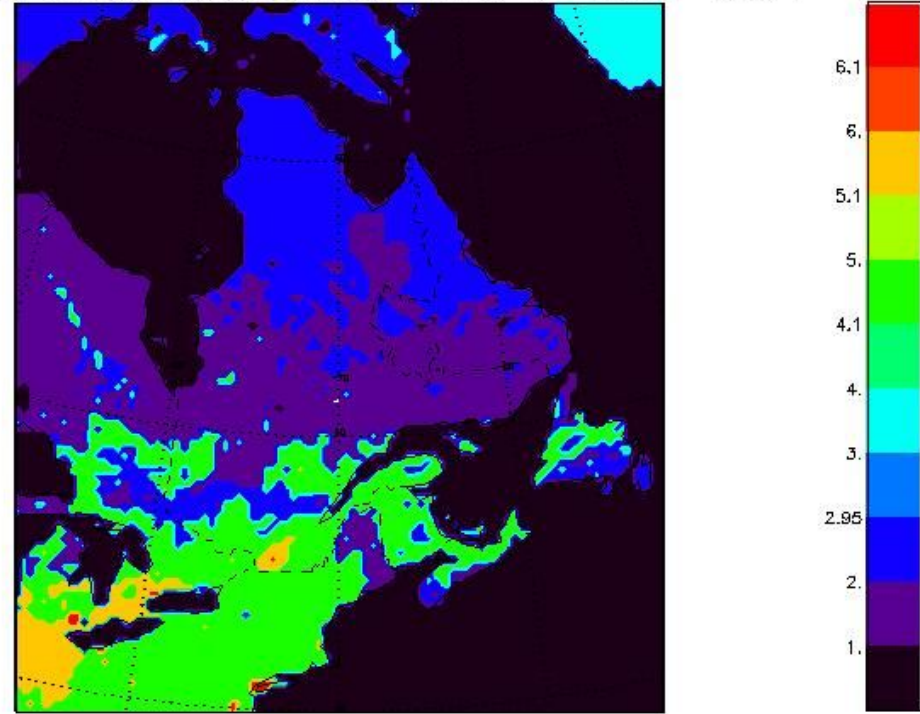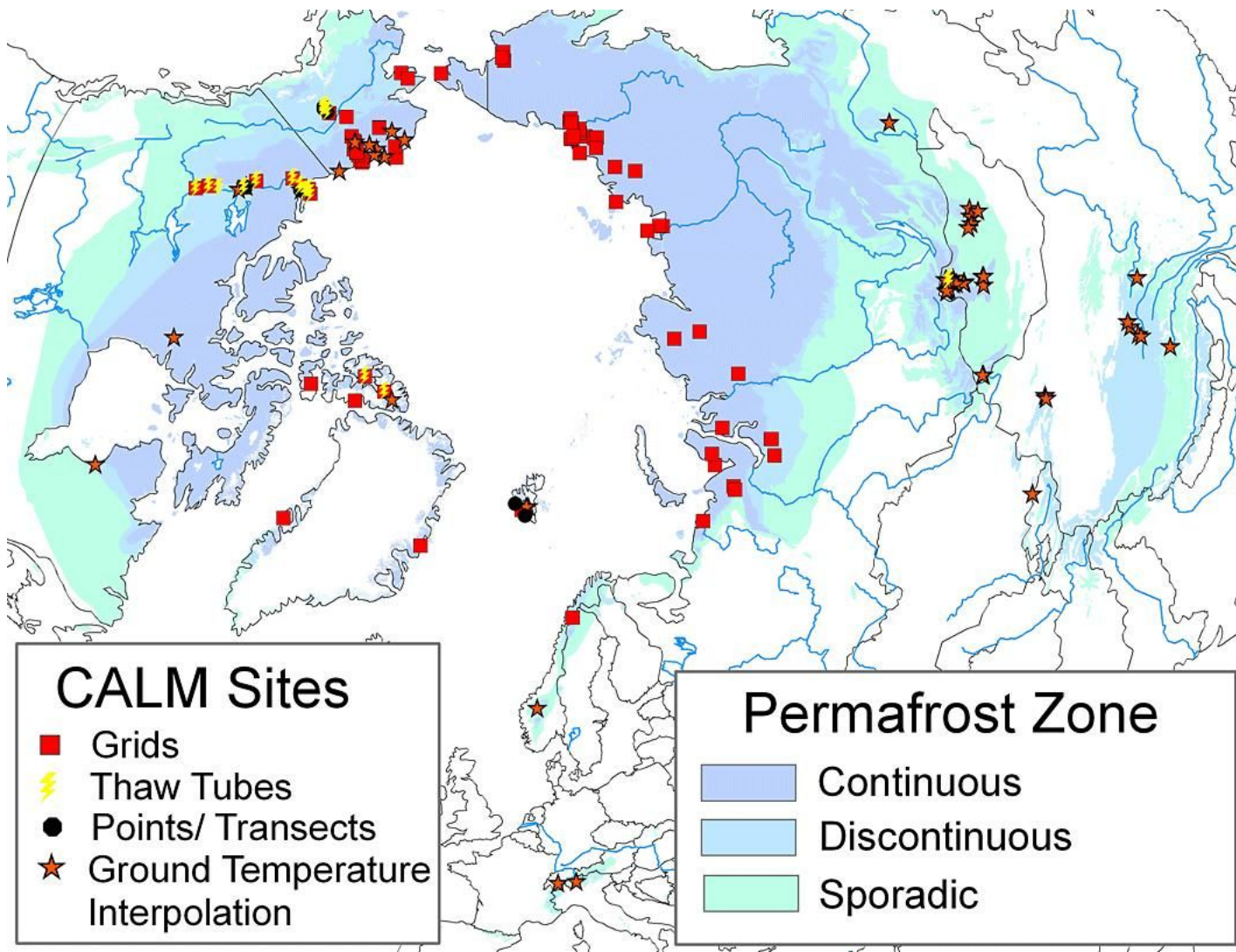
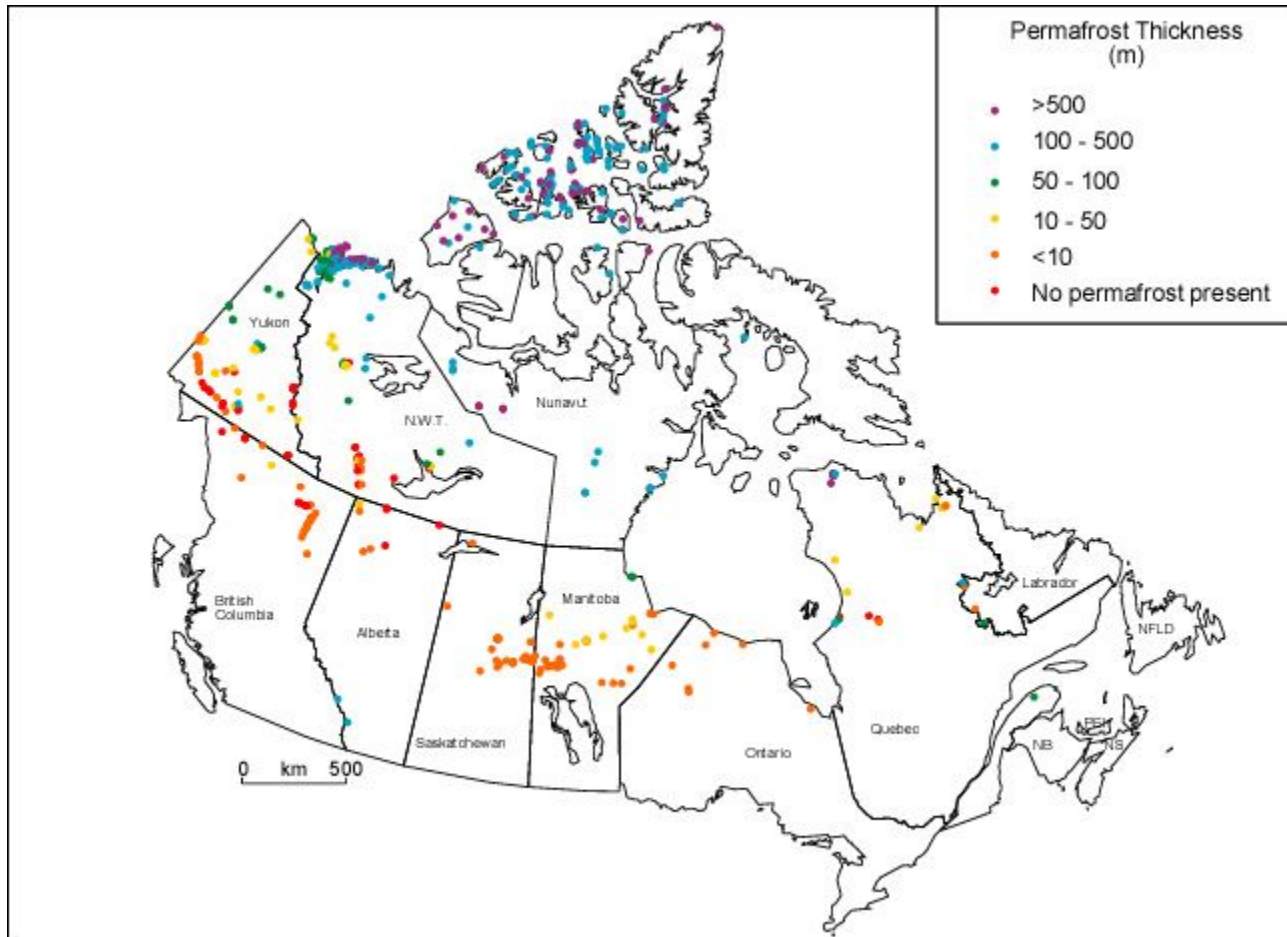Data at model resolution

Soil type in layer 3
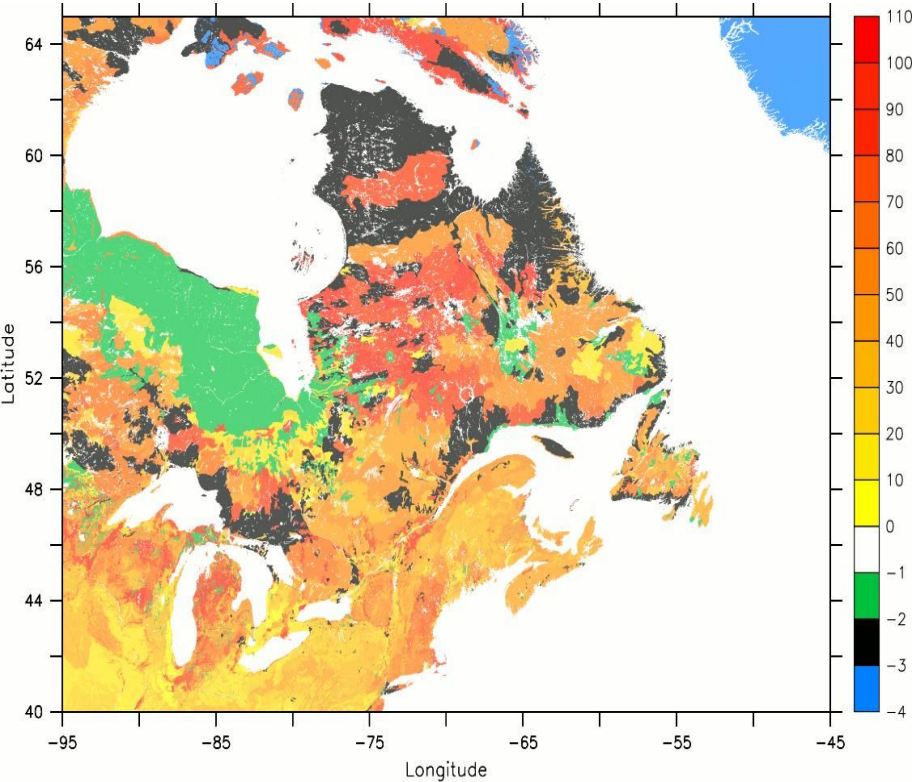
1-km base data
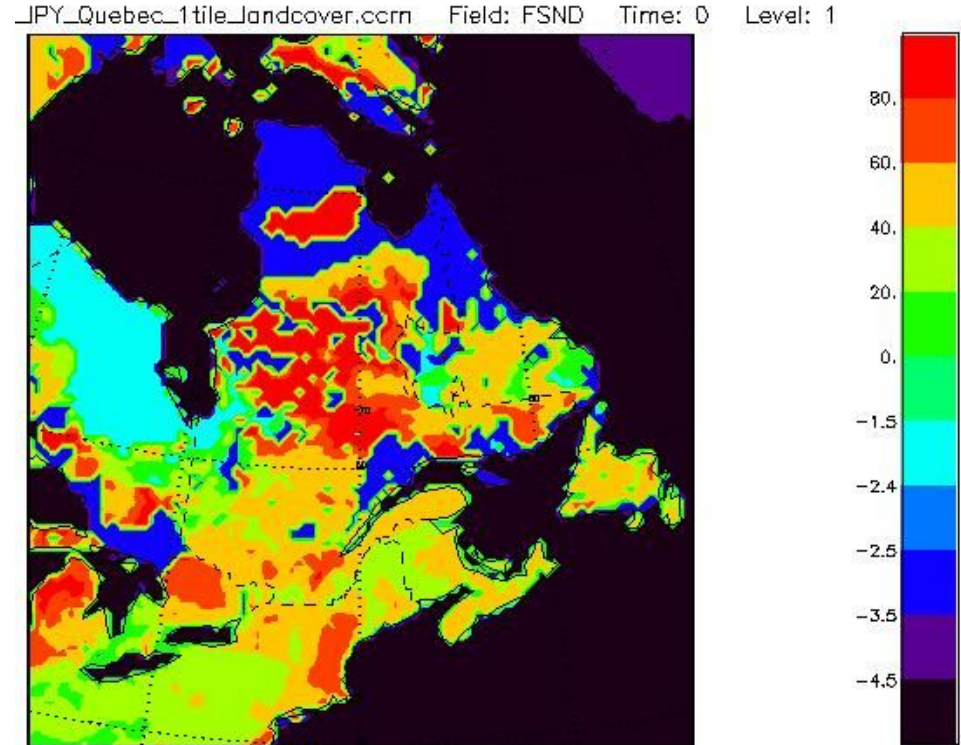
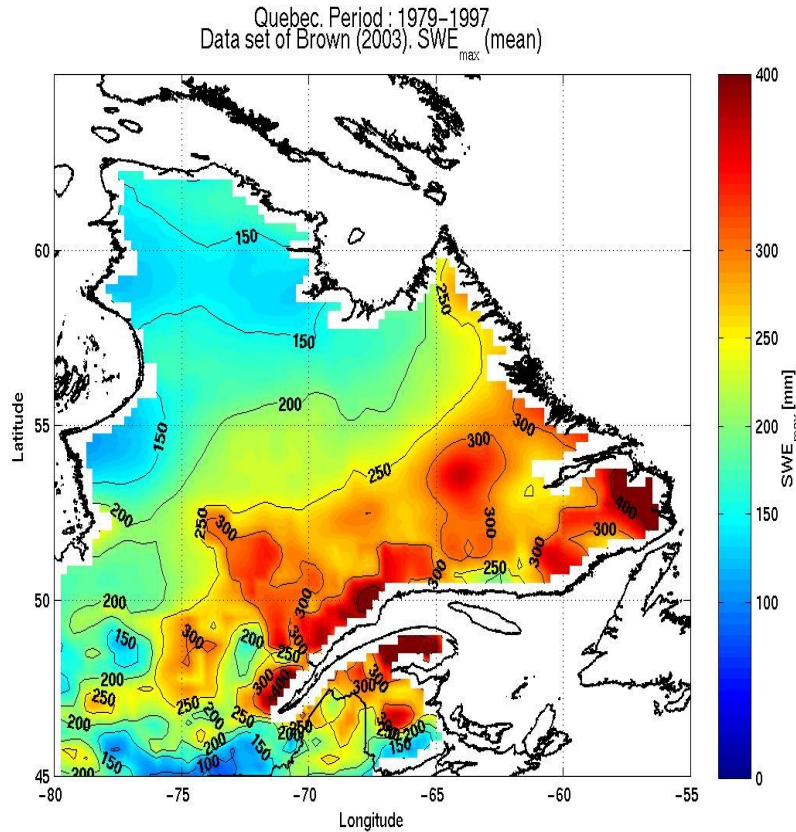Data at model resolution

Validation data

- CANGRID monthly minimum, maximum and mean air temperatures and precip
- NOAA daily snow cover
- Daily snow depth and SWE reconstruction by Brown et al. (2003)
- Bimonthly SWE over Quebec from snow course data
- Data from 41 stations in Digital Archive of Canadian Climatological Data (radiation, soil temperature, snow depth)

CALM Sites

- 🟥 Grids
- ⚡ Thaw Tubes
- ⬤ Points/ Transects
- ✰ Ground Temperature
  Interpolation

Permafrost Zone
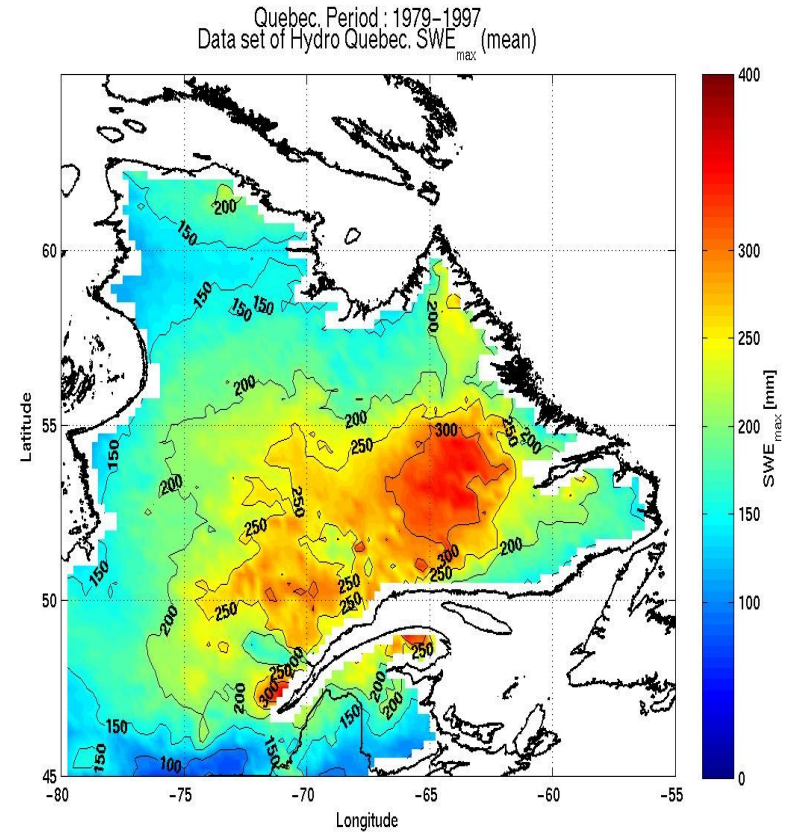
- Continuous
- Discontinuous
- Sporadic

Digital Database of Permafrost Thickness in Canada
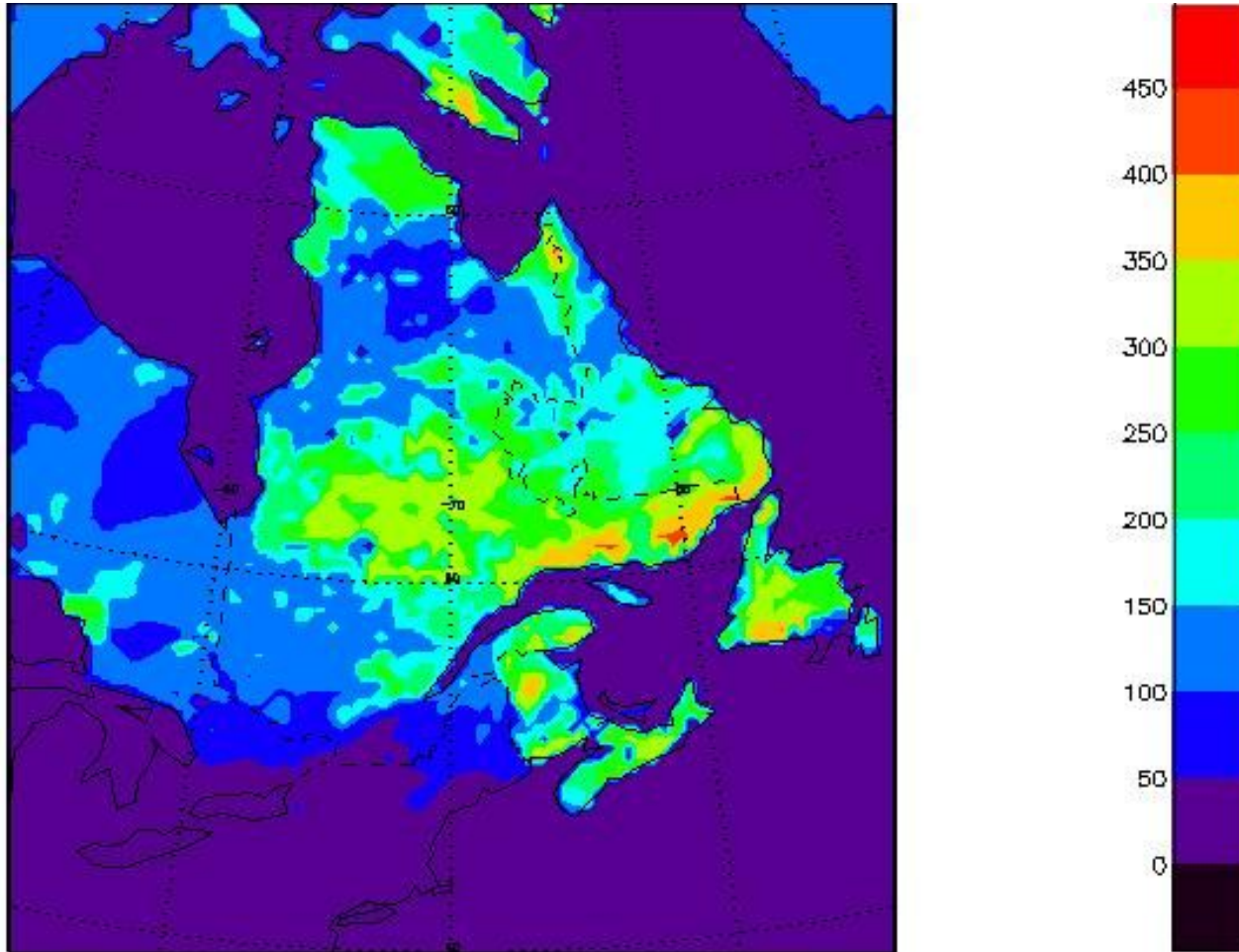
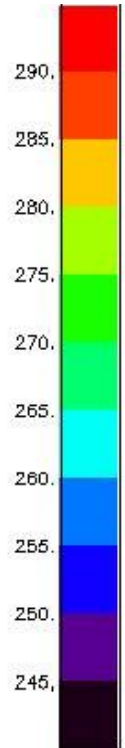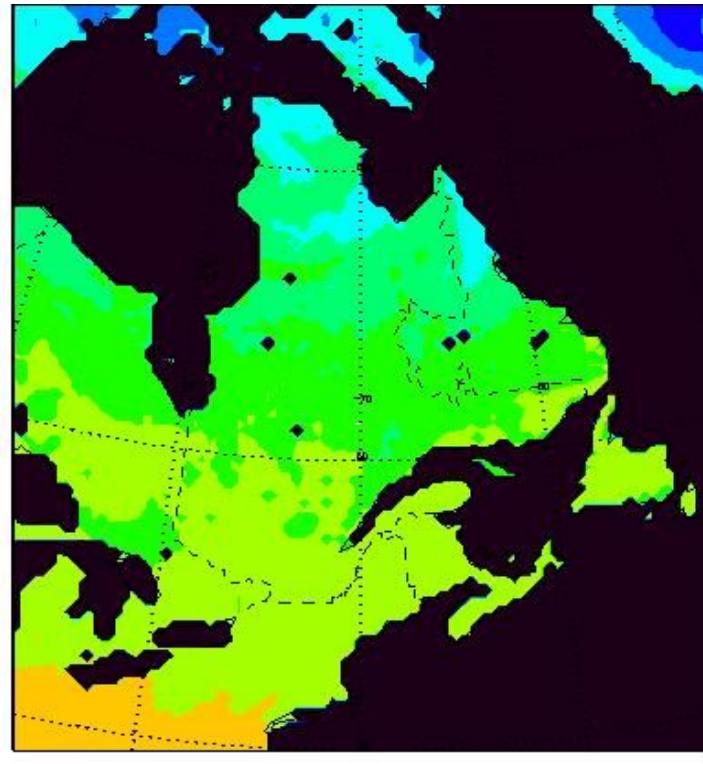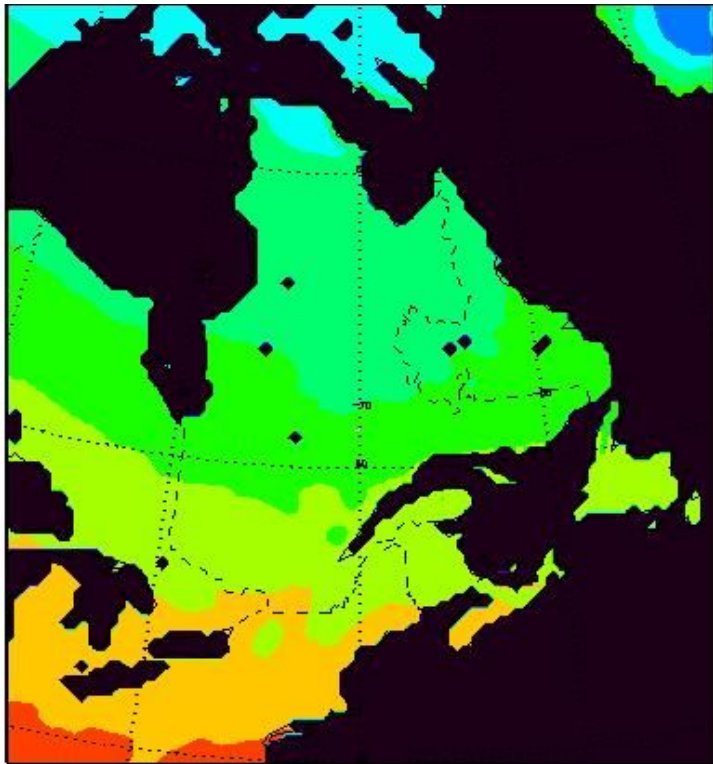# Mean annual maximum SWE, 1979-1997

Brown and al. (2003)

Hydro-Quebec

Maximum SWE to mid-February

3ʳᵈ layer soil T at start and end

Experiments planned:

- Run with precipitation derived from CANGRID (ERA-40 derived precipitation may have biases)
- Add in subgrid lake fraction, using satellite-derived lake temperatures (NOAA Pathfinder)
- Investigate the effect of incorporating a sub-grid land cover mosaic
- Extend soil column deeper to determine effect on soil climate

Application to IP3

- Regional driver now in place for use over IP3 research basins
- Atmospheric fields can potentially be provided from GEM runs
- Land cover and soil data needed from basin modellers
- Initialization problem for soil fields needs to be investigated
- Analogous tests to those being done for IPY can be run over the IP3 basins, and other basin-specific questions can be addressed