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# Regional Runs of the Canadian Land Surface Scheme for IPY

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**Environment Canada**



# Research project overview

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- A contribution to the IPY project “State and Fate of the Canadian Cryosphere”
- 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)



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# Atmospheric forcing data

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- Derived from ERA-40 reanalyses
- GEM used as temporal and spatial integrator; resolution increased from 1 degree, six hourly to  $\frac{1}{4}$  degree,  $\frac{1}{4}$  hourly (courtesy of R. Brown and students at Ouranos)
- 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



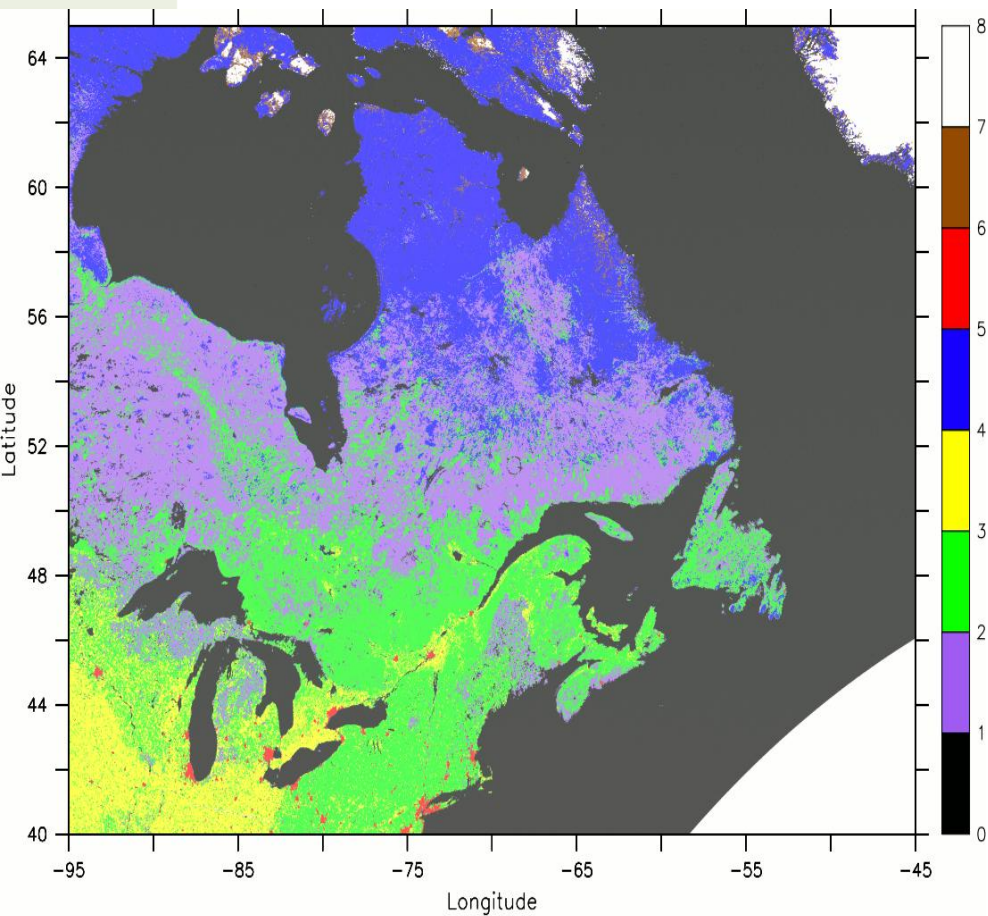
# Background data

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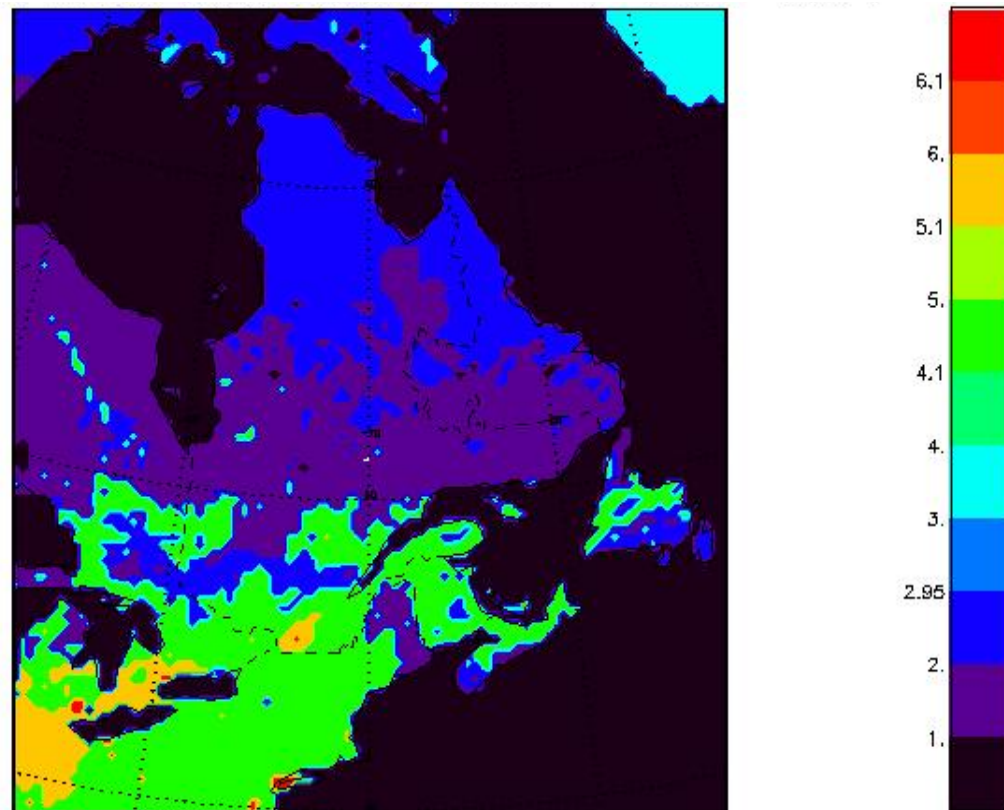
- 1-km North American land cover and soils dataset, produced by Szeto et al. for MAGS
- Land cover fields derived from CCRS and USGS datasets
- Soil fields derived from CANSIS and USGS datasets



# Land cover



1-km base data



Data at model resolution

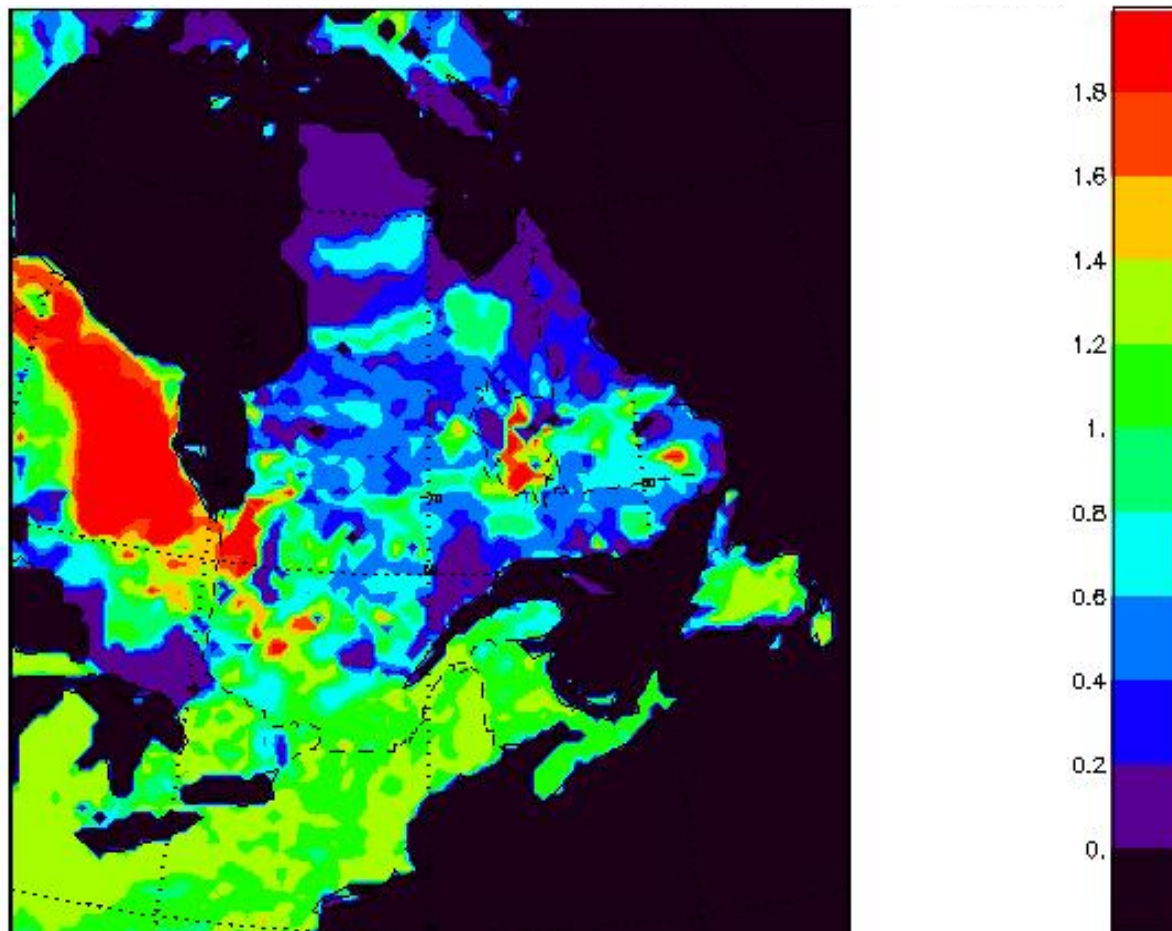


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# Soil permeable depth



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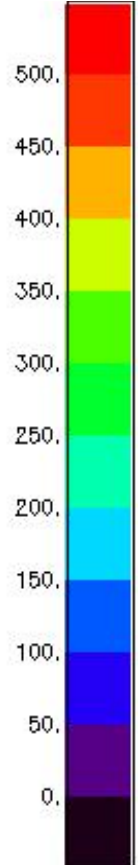
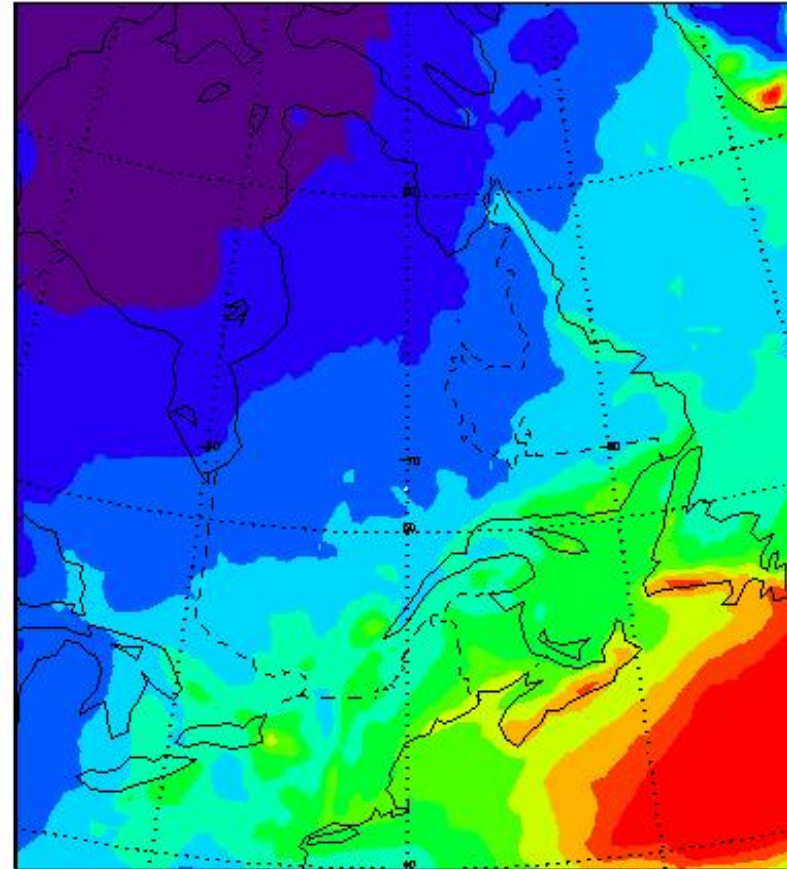
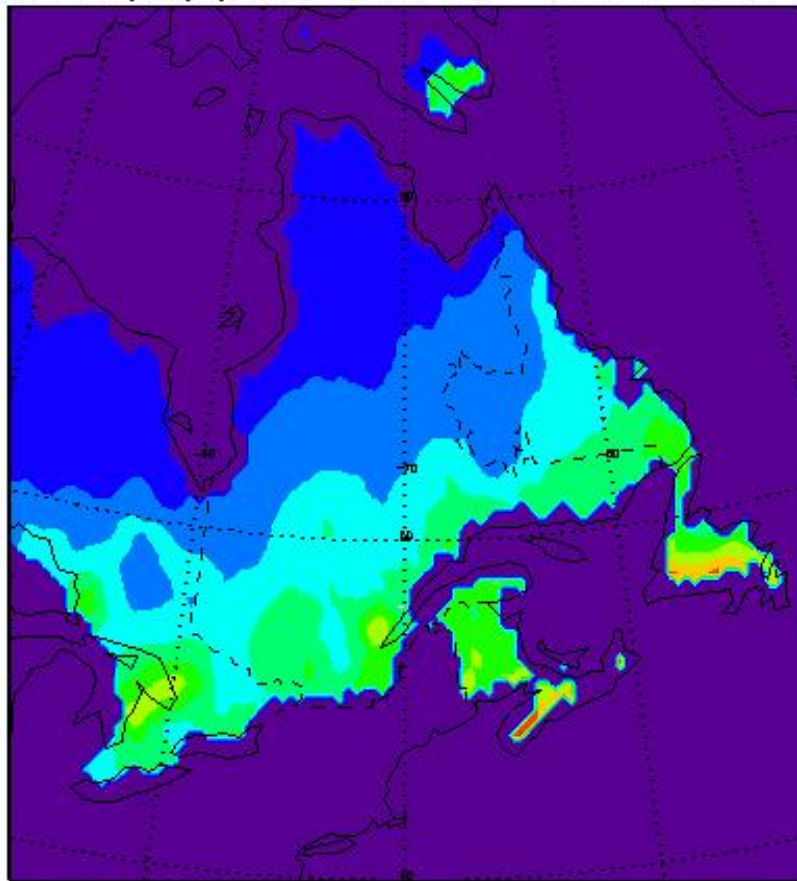


# Validation data

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- CANGRD monthly minimum, maximum and mean air temperatures and precipitation (gridded dataset, 50 km resolution, 1971-2000, produced by EC CRD)
- NOAA daily satellite-derived snow cover (1 degree resolution)
- Daily snow depth and SWE reconstruction by Brown et al. (“B2003”), 0.3 degree resolution (driven by ERA-15 temperature and precipitation reanalyses)
- Bimonthly gridded SWE over Quebec by Brown and Tapsoba (“BT”) from Hydro-Quebec snow course data, 10 km resolution (background from NCEP reanalyses and CANGRD precipitation)

# Average DJF precipitation



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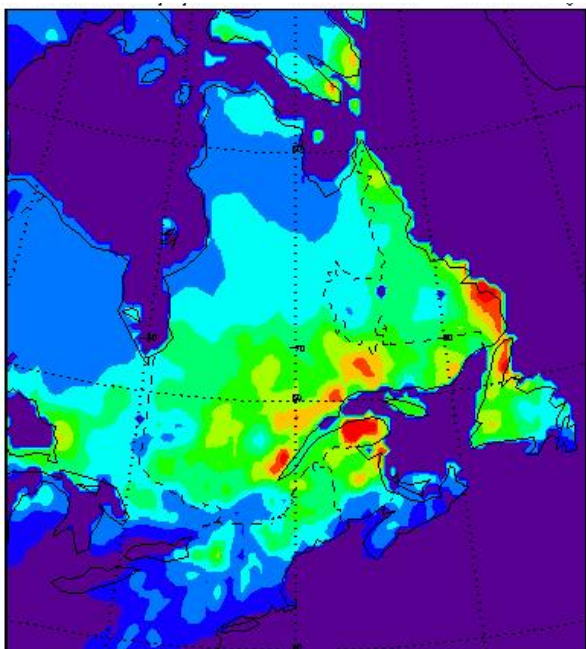
# Soil configurations tested

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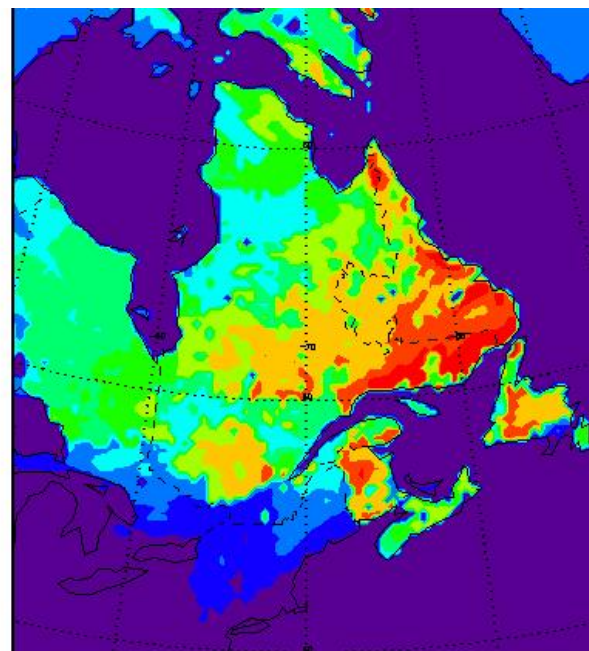
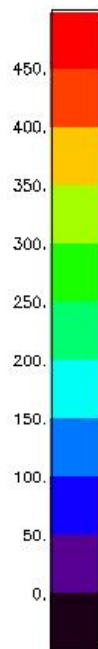
- Base run (“BASE”): standard three-layer soil configuration, thicknesses 0.10 m, 0.25 m, 3.75 m
- First experimental run (“FC”): soil drains instantaneously to field capacity whenever this value is exceeded (as a first approximation to addressing lateral flow)
- Second experimental run (“DEEP”): permeable depth values in soil database are ignored, and soil is everywhere assigned a permeable depth greater than 4.1 m (to allow “normal” vertical redistribution of soil water)
- In all runs: no lateral flow of water (i.e. slopes are not modelled; no streamflow)



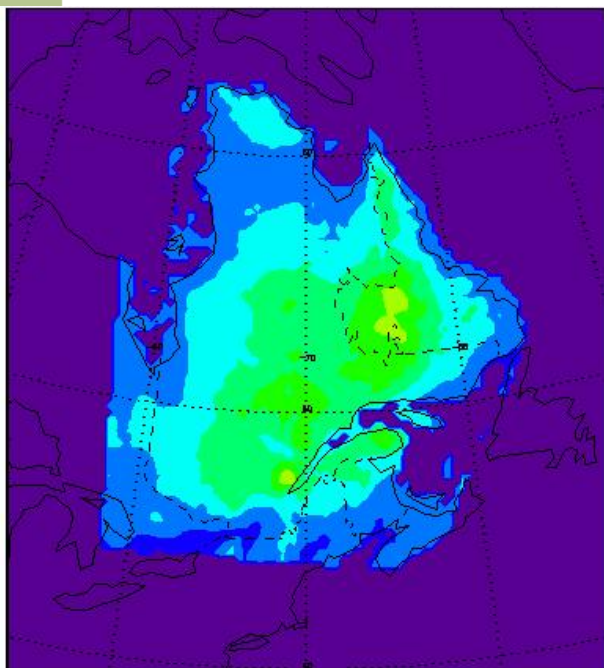
# Annual average maximum SWE



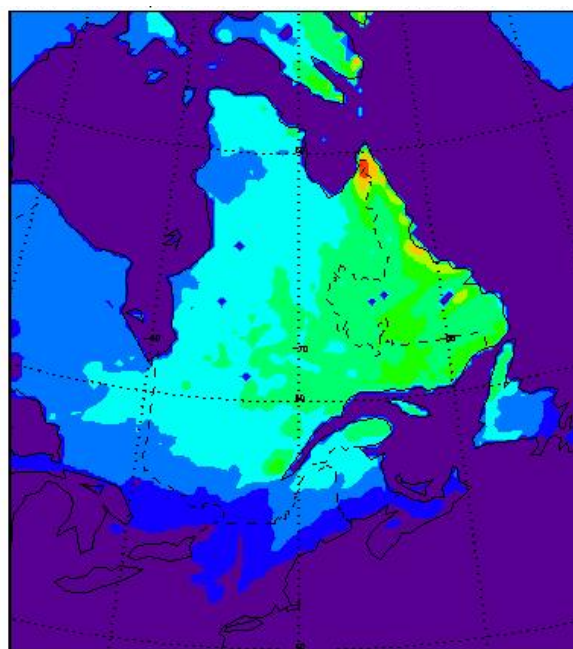
B2003 dataset



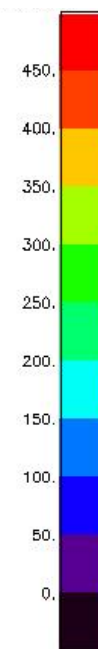
BASE run

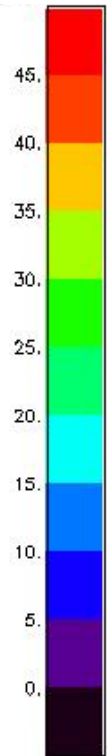
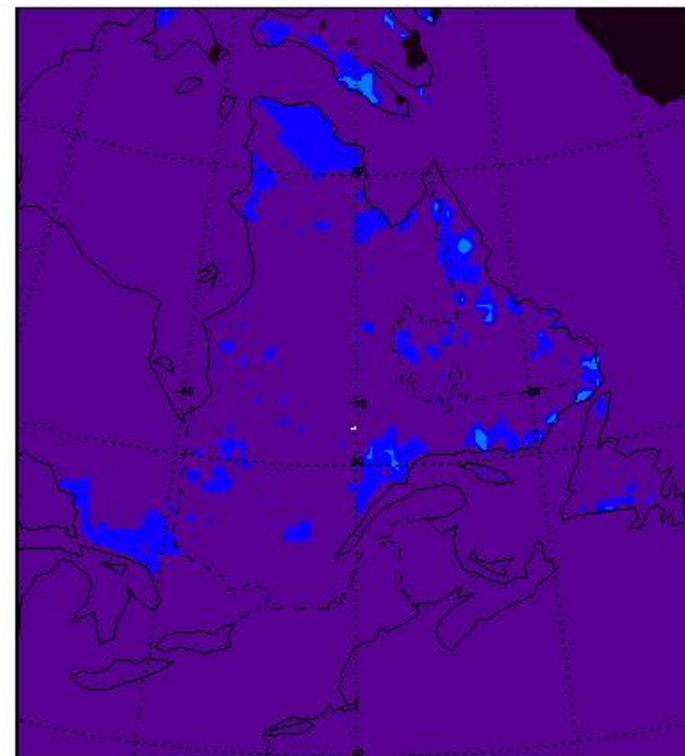
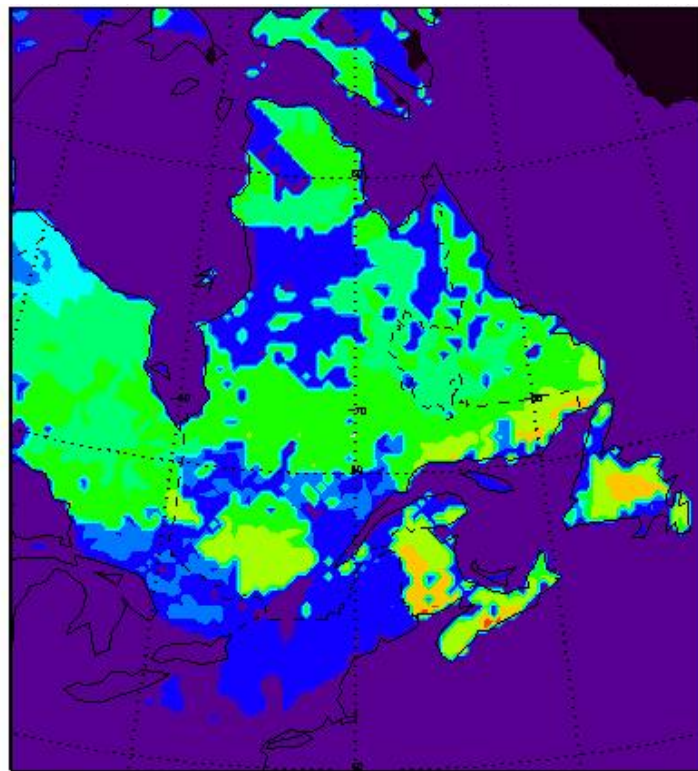


BT dataset



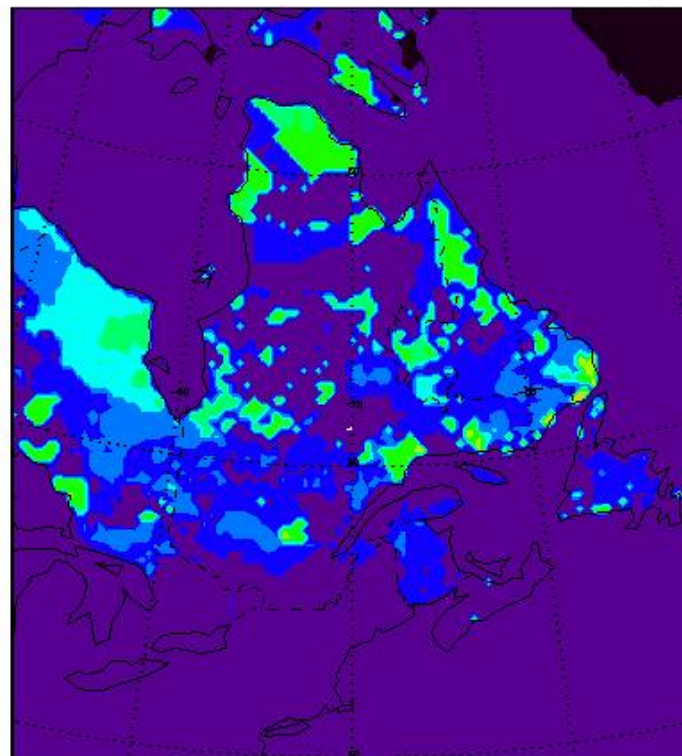
FC run





# Water added to snow pack by freezing

(Base run, FC run,  
DEEP run)

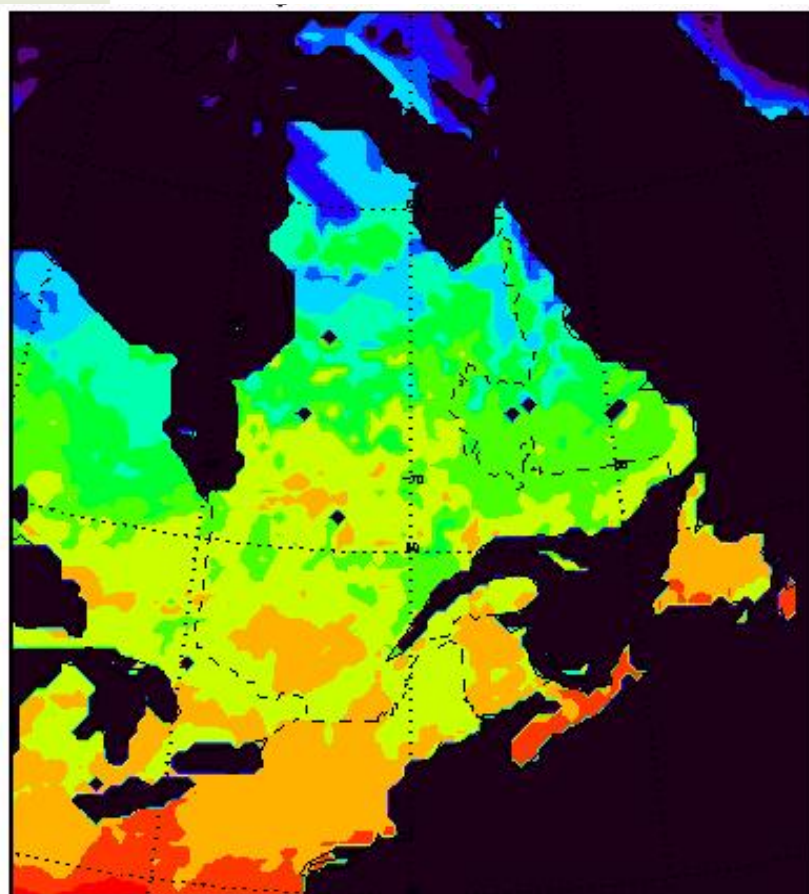


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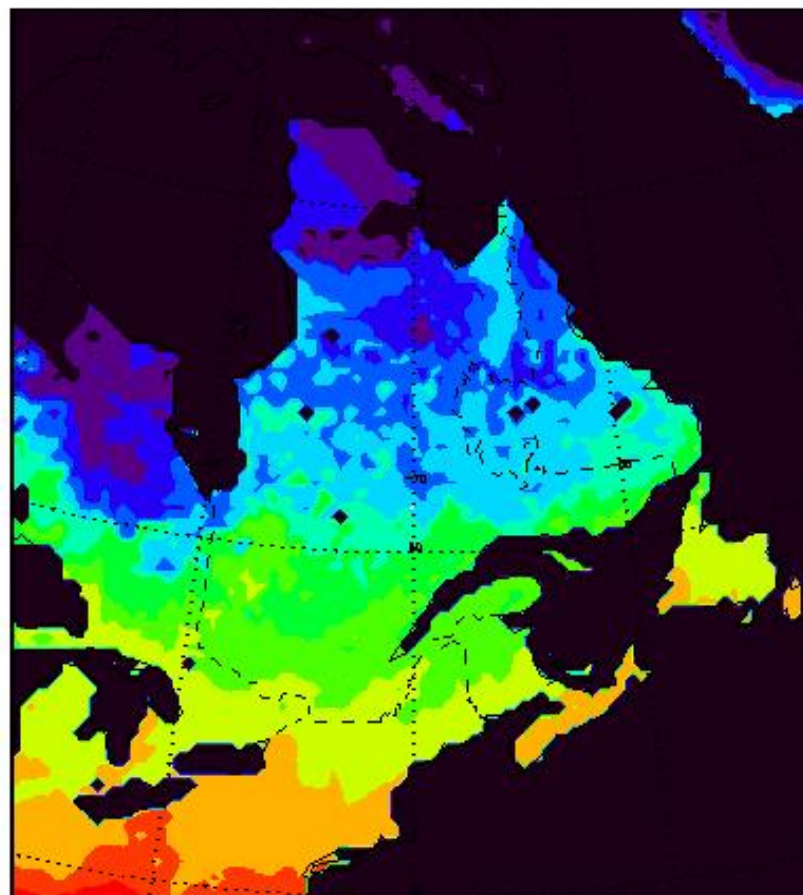
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# Winter soil temperatures (first layer)



Base run



Free-draining run

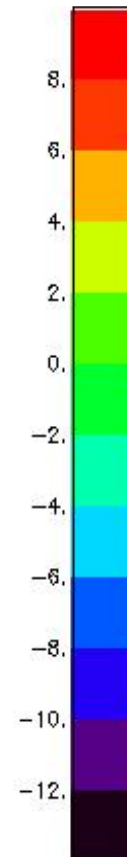
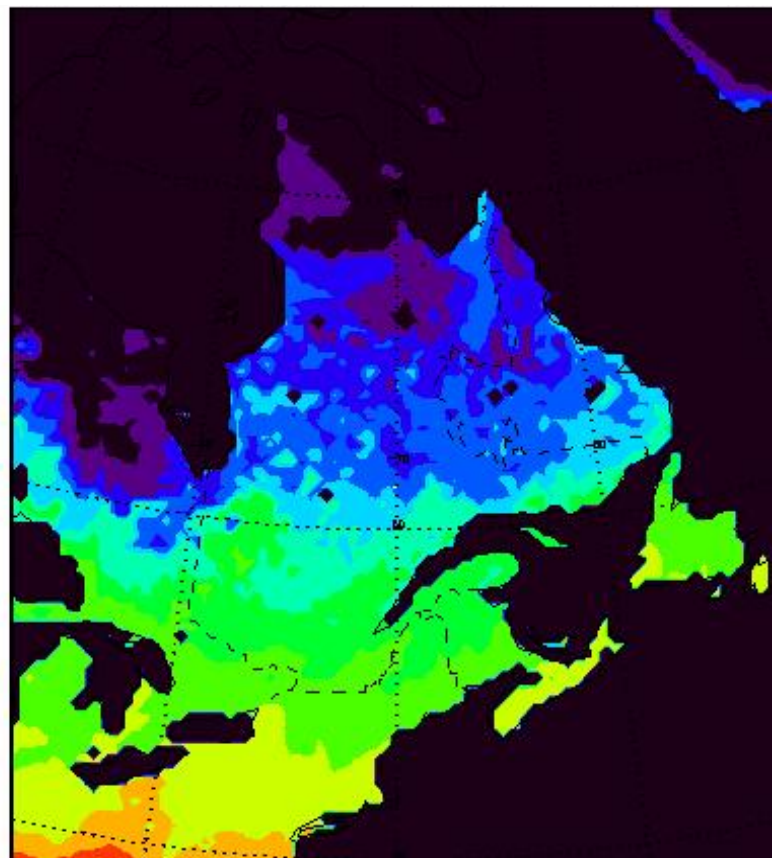
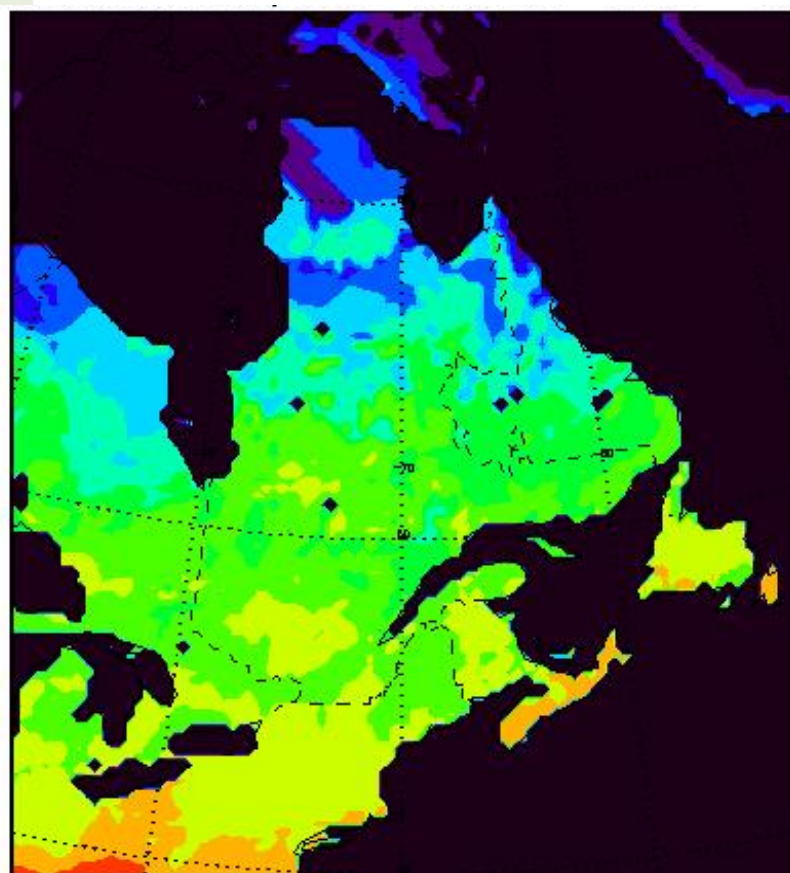


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# Winter soil temperatures (third layer)



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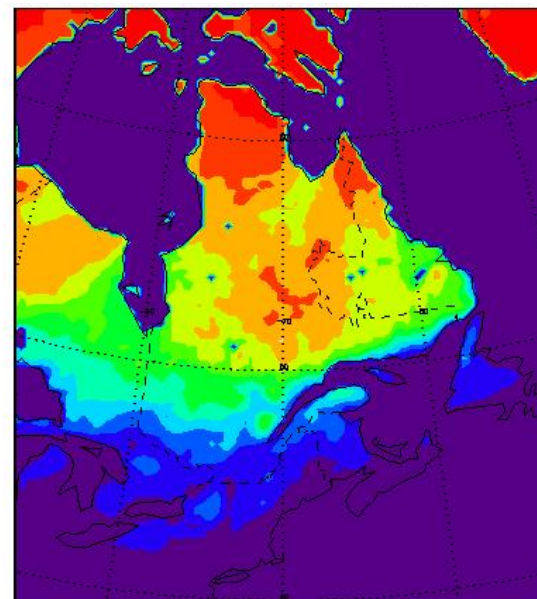
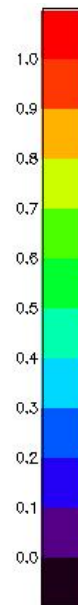
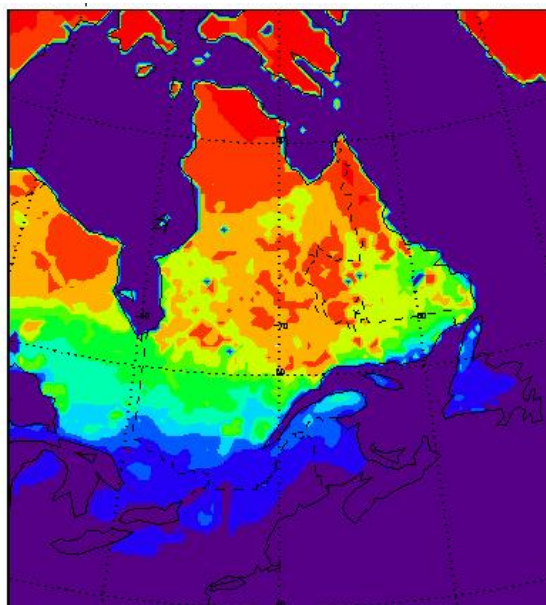
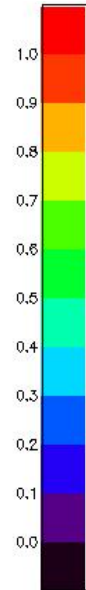
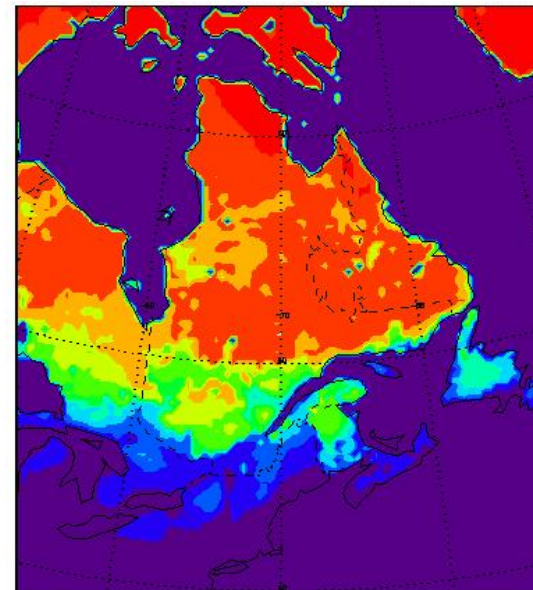
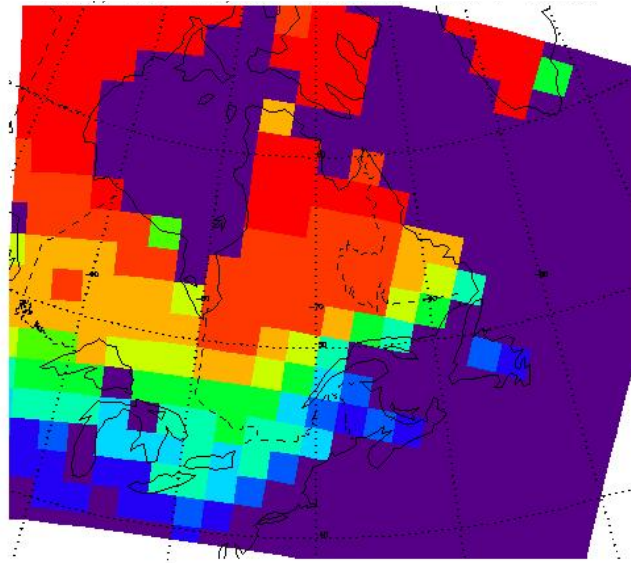
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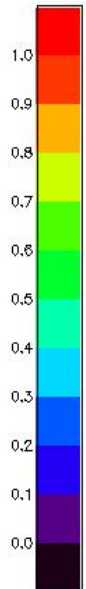
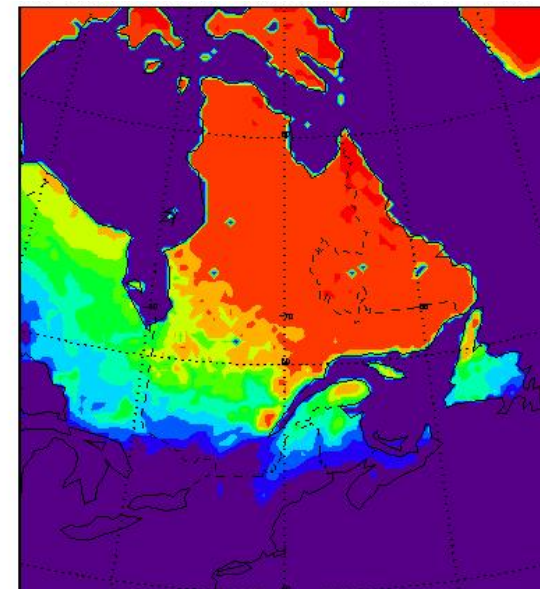
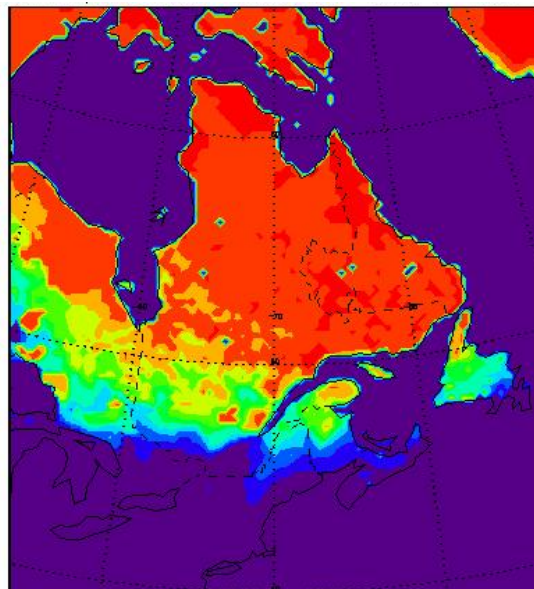
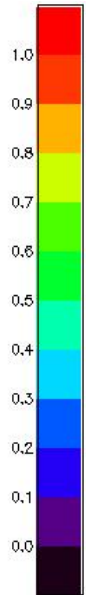
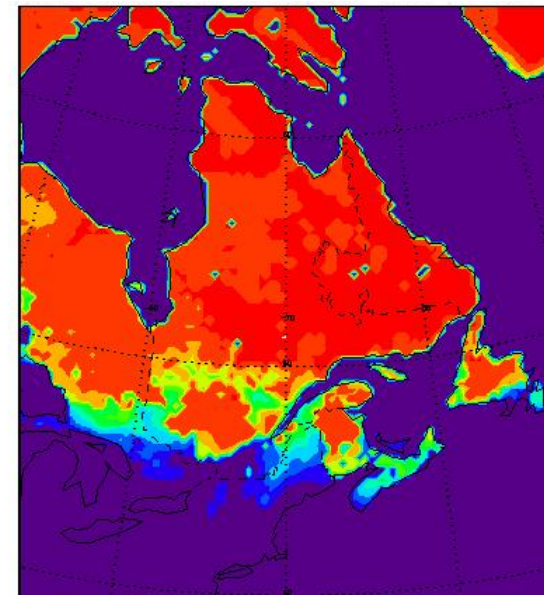
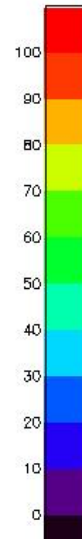
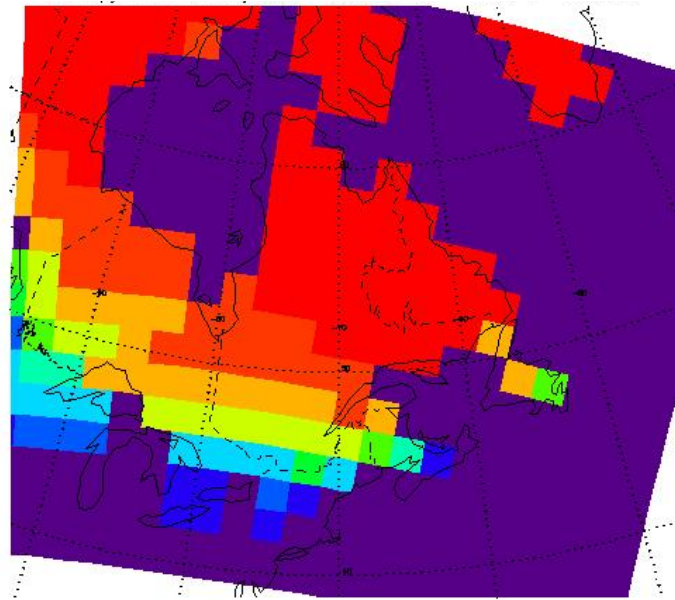
# November fractional snow coverage

(NOAA, BASE run, DEEP run, FC run)



# April fractional snow coverage

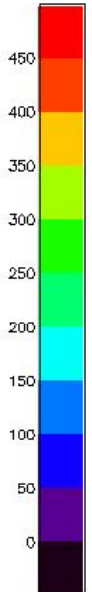
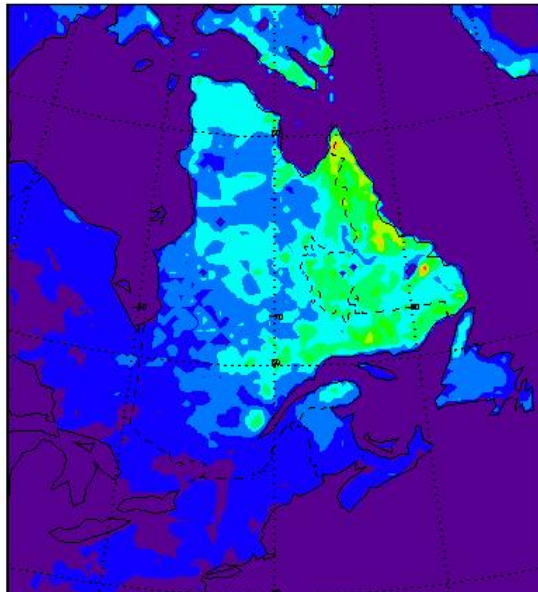
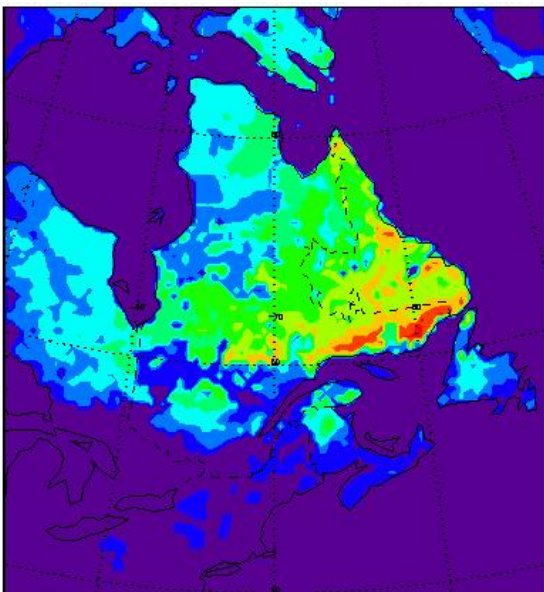
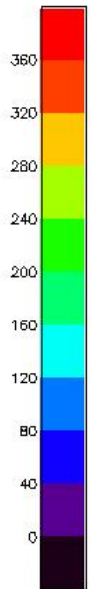
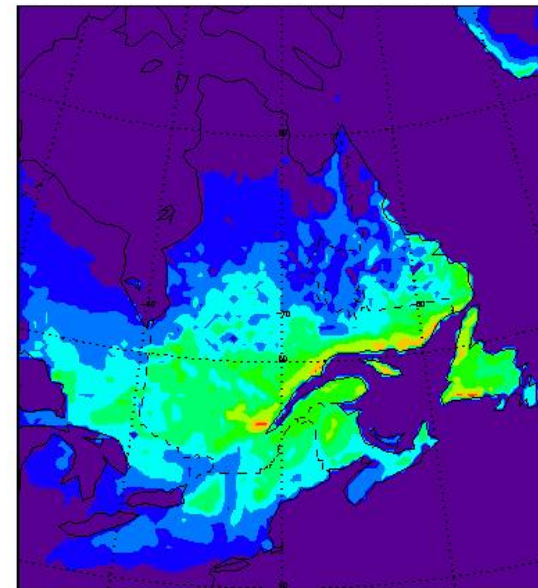
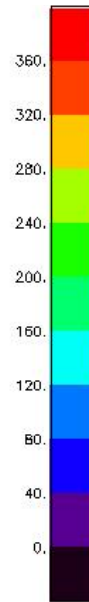
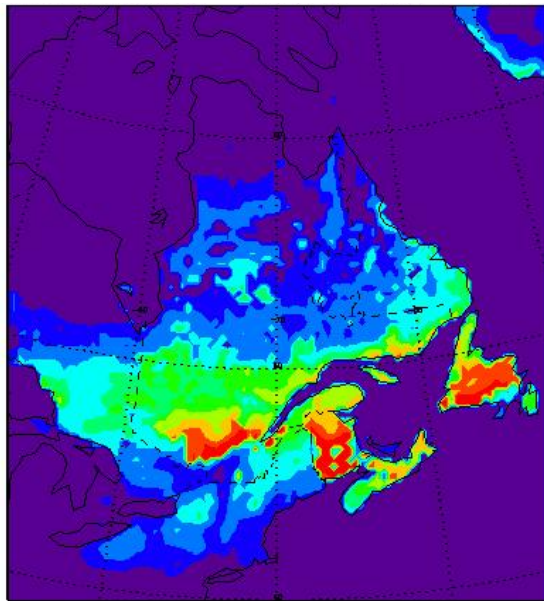
(NOAA, BASE run, DEEP run, FC run)

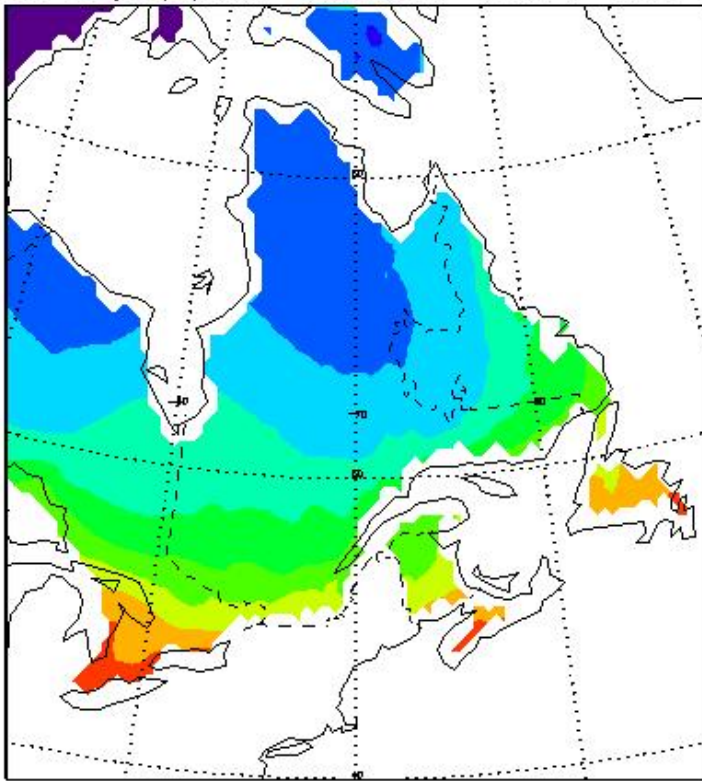




# April and May runoff

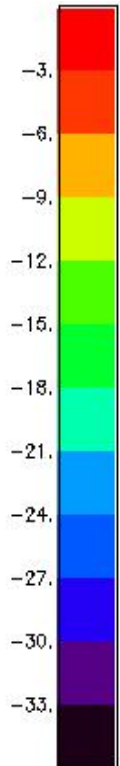
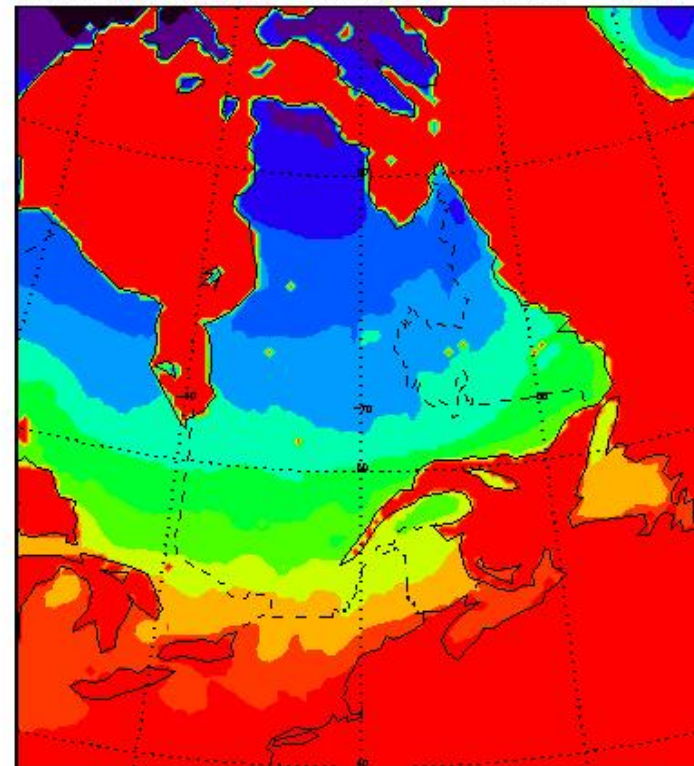
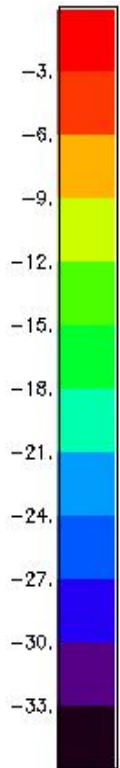
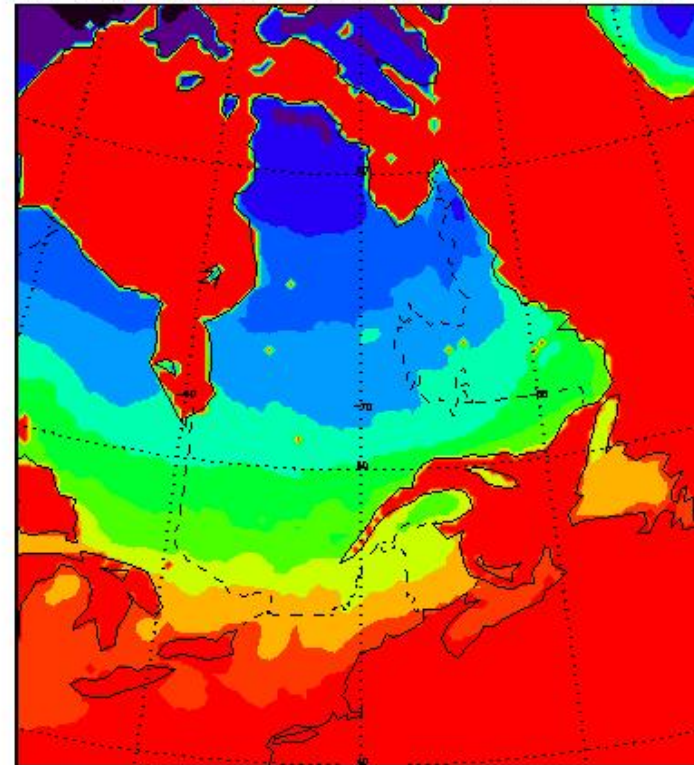
(BASE run, left; FC run, right)





# Mean January screen T

(CANGRD, base run,  
free-draining run)

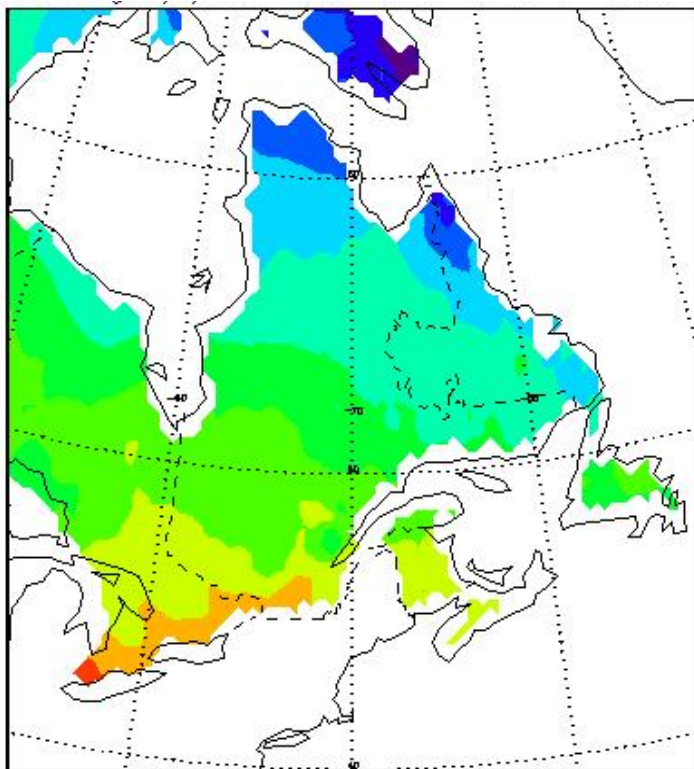


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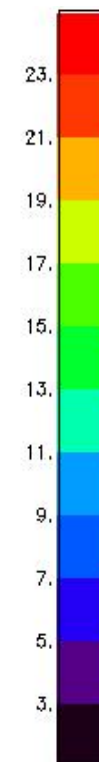
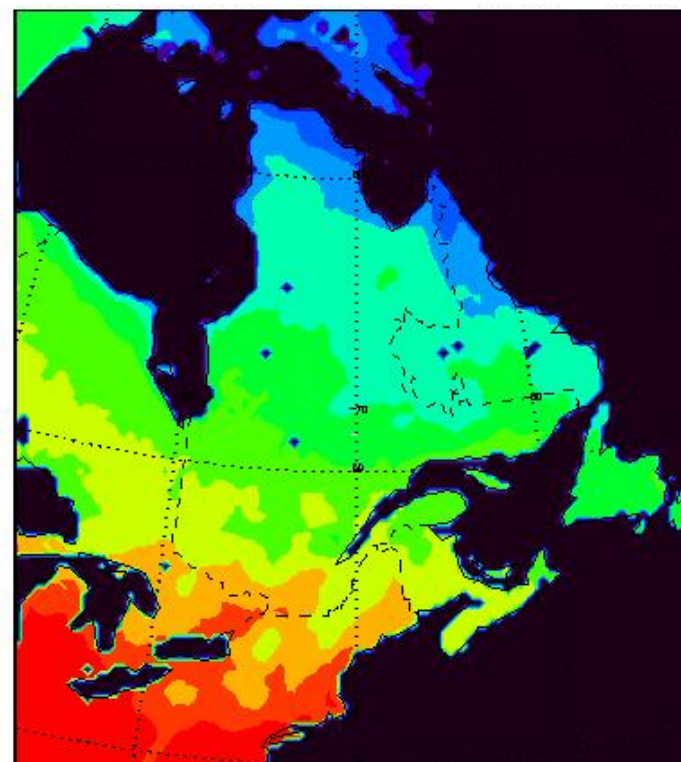
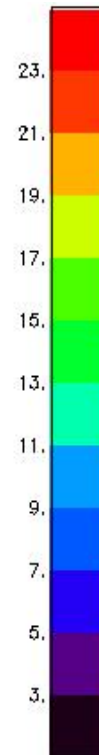
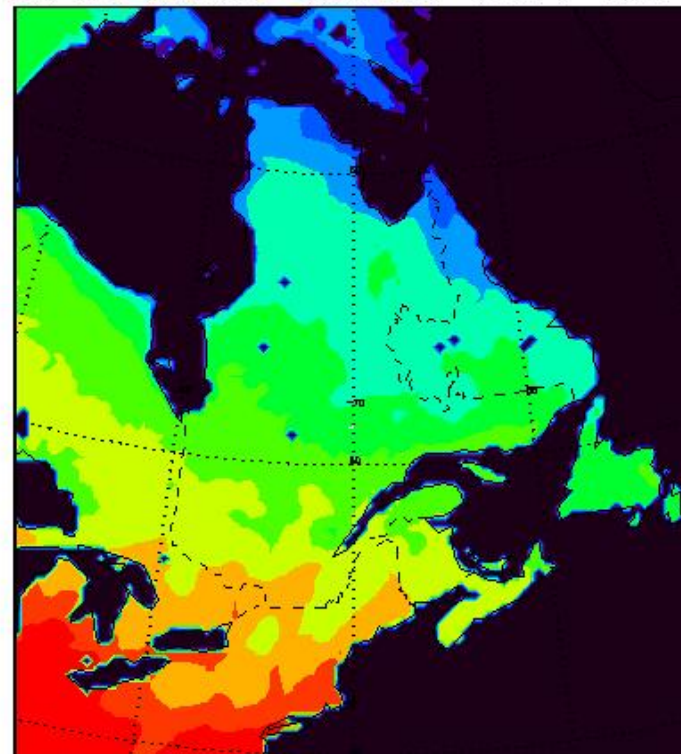






## Mean July screen T

(CANGRD, base run,  
free-draining run)

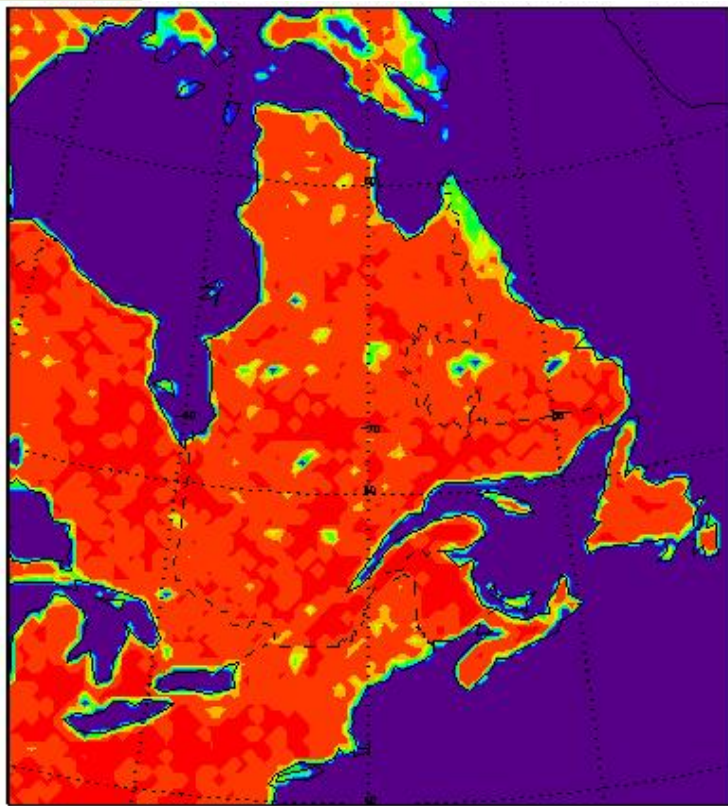


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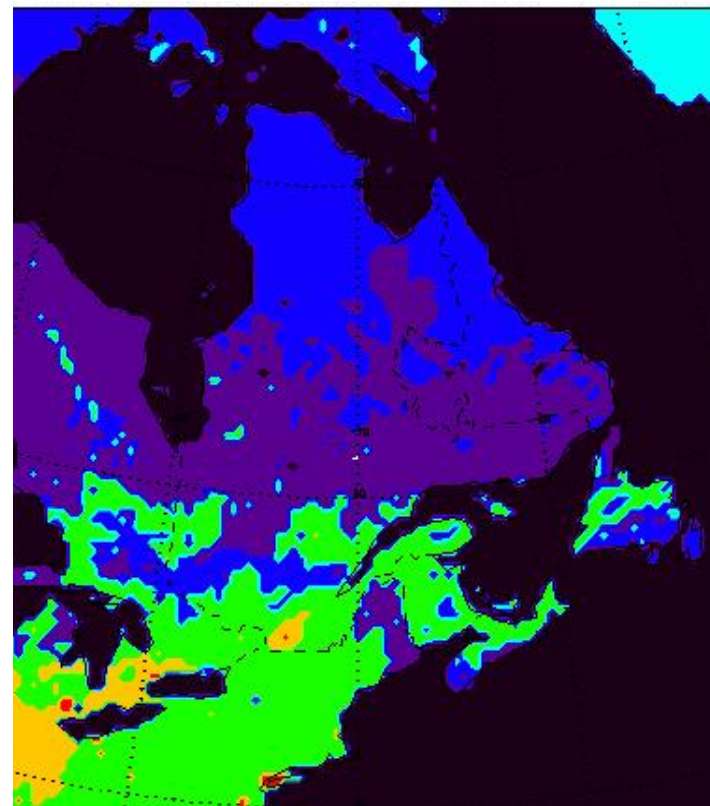
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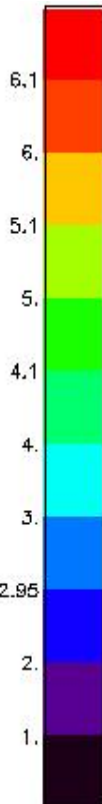
# Vegetation coverage



Fractional coverage



Dominant vegetation type



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# Conclusions and further work

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- Assumption of no lateral flow is probably acceptable for areas of temperate climate with deep soils and high evapotranspiration rates, if the main focus is on modelling atmospheric fluxes
- For cold, wet climates, and/or if the subsurface temperature and moisture regimes are of interest (e.g. in hydrological studies, carbon flux modelling), this assumption is not tenable
- In such cases, a robust parametrization needs to be developed to address lateral water flow in soils where the lower boundary is bedrock

