Regional Runs of the Canadian Land Surface Scheme for IPY

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Research project overview

- 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)
- 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 (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

- 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 permeable depth
Validation data

- 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
Soil configurations tested

• 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
Water added to snow pack by freezing

(Base run, FC run, DEEP run)
Winter soil temperatures (first layer)

Base run

Free-draining run
Winter soil temperatures (third layer)
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)
Mean July screen T

(CANGRD, base run, free-draining run)
Vegetation coverage

Fractional coverage

Dominant vegetation type
Conclusions and further work

- 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.