Investigation of hydrology simulated by the Canadian Regional Climate Model over Québec and Labrador.

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We present here an investigation of the Canadian Regional Climate Model's (CRCM) surface hydrology over the vast Québec territory using a basin approach. The analysis is based on an additional year from the validation found in Frigon et al. (2002). In the experiment, the CRCM simulations were computed on a 100 X 100 point grid domain with a horizontal grid-point spacing of 30 km that covers mainly the Québec province and the Labrador territory. The model was configured with 18 vertical levels ranging from the surface to the model top at 29 km. The simulation starting on the 1st June 1992 and ending on the 31st May 1995 uses a 10-minute time step. The first three months, needed to spin-up the model and allowing the different fields to adjust to each other, were not retained for analysis. This version of the model (v3.5) was run with the Bechtold-Kain-Fritsch (Bechtold et al. 2001) mesoscale convective scheme along with a large-scale condensation process for stratiform precipitation formation. The other characteristics of the CRCM can be found in Caya and Laprise (1999). The CRCM was nested at its boundaries with atmospheric objective observational analyses from the National Center for Environmental Protection (NCEP), available every 12 hours with an initial horizontal grid-point spacing of 2.5° X 2.5° (approximately 275 km) and 12 vertical levels. The NCEP horizontal winds were blended over a nine-point nesting zone. Monthly climatological values of sea surface temperature (SST) and sea-ice cover were used for ocean grid points.

Amongst the 10 river basins that were studied, the Churchill Falls basin, covering an area of 69 300 km^2, is of particular interest owing to its enhanced precipitation network of 17 monthly surface stations. Fig. 1 shows that the CRCM precipitation agrees with the observations in winter but that the model produces too much precipitation from April to October. We are presently implementing a new stratiform precipitation scheme (Lohmann and Roeckner 1996) into the CRCM and preliminary results are promising; this should reduce some of the precipitation biases.

We also examined the CRCM's thermal regime at screen level. With more than one weather station in its vicinity, the Bell and Waswanipi basins (Western Québec, covering respectively 22 200 km^2 and 31 900 km^2) were of particular interest. Fig. 2 shows that the CRCM monthly mean temperatures generally follow the observations in winter but remain too warm in summer. It is generally minimum temperature that is too warm and this behavior seems related to a too important cloud cover in the model; we are currently trying to verify this. Moreover, with its one layer surface scheme, the CRCM is generally too warm in fall and too cool in spring. This behavior can be explained, in fall, by the ground layer that must freeze throughout before cooling its surface below 0°C; the reverse situation happens in spring.

If the CRCM's temperature were not as warm in October and November (when the model starts to freeze the ground), the model would generate solid instead of liquid precipitation, reducing its runoff and contributing to a more important snow cover. We have examined the combined quantity of the CRCM's snow cover and runoff starting in October over the Churchill Falls basin. At the end of winter, we find that this combined quantity is close to the observed snow cover (from the 17 obs. stations) for the three winters simulated by the CRCM. Hence, if it were less warm in fall, the CRCM could produce a good snow cover. For hydrological purposes, it is essential to generate a good snow cover at the end of winter as it is the major source for the spring runoff, which represents about 50% of the annual volume in this area of the globe.

Globally, over the ten basins studied (covering a total area of 314 010 km^2), we find that the CRCM is able to reproduce the observed runoff at the annual scale. The model's runoff resulting from the atmospheric water flux convergence over the domain is correct but the model overestimates precipitation and evaporation, because it recycles too much water, a known deficiency of the CRCM single-layer surface scheme. For example, in the 1993-1994 hydrologic year (from April till March), on the Churchill Falls basin, the CRCM overestimates annual runoff observations by only 68 mm (for an obs. value of 477 mm) while it overestimates total annual precipitation observations by 470 mm (for an obs. value of

848 mm) and total annual surface evaporation data (Willmott and Matsuura 2000) by 316 mm. However, the difference between the CRCM simulated annual runoff and the observations is quite variable from one basin to the other and from one year to the next. It is difficult to interpret these results with just a few years of simulation. On one hand, by using monthly climatological SSTs and sea-ice cover, the CRCM's ocean grid points have an annual cycle that repeats itself each year which influences the climate simulated in the basins of interest. On the other hand, because of regional model's internal variability (Giorgi and Bi 2000), we must not expect them to reproduce exactly each precipitation event passing over the basins. In that sense, regional models are not deterministic at a relatively small spatial scale, especially in summer because of the convective nature of precipitation. With more weather events passing over an area, the internal variability's effect decreases. Hence, to take into account the CRCM's internal variability, we plan to produce a 10 year CRCM simulation to evaluate the model's climate by comparing it to the observed climate.

The analysis of the CRCM's hydrology has allowed us to note its potential despite some weaknesses mainly attributed to the over simplification of surface processes parameterized by a single-layer surface scheme. We plan to generate a longer CRCM simulation nested not only with atmospheric observational analyses but also with sea surface temperature and sea-ice observations. This should produce a more realistic climate over Québec which, we know, is influenced by great water masses such as the Atlantic Ocean, the Labrador Sea and Hudson's Bay.

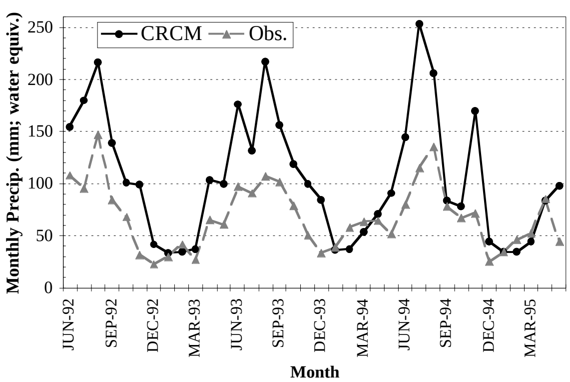

Fig. 1. Monthly precipitation over the Churchill Falls basin from the CRCM and the observations from June 1992 to May 1995.

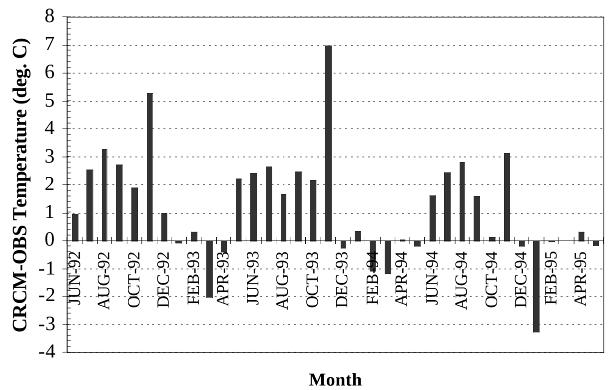

Fig. 2. Monthly mean screen temperature difference from June 1992 to May 1995 between the CRCM simulated value on the Bell/Waswanipi combined basins and the obs. from the Joutel, Chapais, Val d'Or surface weather stations.

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