VALIDATION OF THE CANADIAN REGIONAL CLIMATE MODEL (CRCM) SNOW COVER SIMULATIONS USING REMOTE SENSING DATA

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Introduction

Because of its low density and non-optimal spatial distribution, snow observations ground-based network can not provide enough accurate data series suitable for climate change studies i.e. spatially consistent large scale snow cover maps, with good spatial resolution and long observation period. Satellite data constitute an alternative source of such information that could be used to validate simulations of climate models such as the Canadian Regional Climate Model (CRCM). This paper presents the validation results of snow cover simulations made by the CRCM over the Quebec Province (Canada) during the period 1988-1999, using reference data provided by the snow historical mapping derived form the merging procedure of AVHRR and SSM/I mappings.

Methods

CRCM simulations

The snow CRCM simulations were produced with the following configuration: 1) CRCM version 4.1.1 [1, 2] run on the regional domain centered on Quebec (QC 112x88 tiles) with a horizontal resolution of about 45km (60 degrees North); 2) Lateral boundaries controlled by the global reanalysis ERA40 ([3], 2.5 x 2.5 degrees) and run over the 1961-2002 period (heating period of three years and calculation time step of 15 mn); 3) coupled to the surface scheme multi-layered model CLASS 2.7 (Canadian Land Surface Scheme) [4, 5]. This study was conducted on a sub-domain of 734 tiles covering central and southern Quebec and western Labrador (Figure 1). The studied CRCM variable was the snow depth (ZN) calculated at a daily step, from April 1st to May 31st of each year (1988-1999). According to the CRCM 4.1.1-CLASS 2.7 model, the simulation tile is entirely covered with snow (100% coverage) when ZN>10cm. If ZN≤10cm, then it is assumed that the tile is partially covered with snow proportionally linear to the 10cm limit (e.g., 50% coverage if the height is 5cm).

Figure 1 :The CRCM simulation domain used in this study

Remote Sensing Data

Snow cover mapping was obtained by means of an algorithm that combines snow maps derived from optical and passive microwave satellite data (AVHRR and SSM/I) [6-8]. This merging algorithm takes advantage of the characteristics of the two sensors while minimizing the limitations to their

application. The mapping results (referred to in the remaining of the paper as AVHRR-SSM/I) are used here as reference data for validation of CRCM simulations. They cover the period of snow melting i.e. from April 1st to May 31st of each year of the study period (1988-1999). The overall accuracy of the algorithm was estimated at 86% (compared with observations of snow depth at meteorological stations).

Determination of the last day of the melting season

For a given year, we defined the end of the melt period from the CRCM simulations as the last day when the snow depth estimated by the model (indicated by ZN parameter) falls below a threshold value, and remains there. A priori, the threshold should correspond to ZN=0 (complete disappearance of snow from the tile). However we have noticed that often the value of ZN reached very low values (less than 2 cm) and maintained there for several days while the AVHRR-SSM/I mapping indicates the total absence of snow in the tile. Therefore, we decided to vary the threshold on ZN to determine the optimal value. As for AVHRR-SSM/I, the last day of the melt period has been defined as the last day for which the percentage cover of snow within the CRCM simulation tile, passes and remains below a minimum threshold value of 5%. Indeed, the results of mapping the snow melting algorithm have been previously compiled on the 45 km CRCM tiles (AVHRR-SSM/I data have a nominal resolution of 1 km, which corresponds to approximately 1800 pixels for each tile).

Analysis

The comparison between the results provided by the CRCM and the snow maps produced by the AVHRR-SSM/I algorithm has focused on three aspects: 1) The correlation between the melting curves using the two types of data; 2) The date of the end of the melting season and 3) The difference between the dates of the end of the melting season calculated from the two types of data.

Preliminary results

- The analysis of the percentage of snow cover within the tiles (ZN = 0 cm) has shown that the CRCM would tend to declare the end of the melting period later what actually is;
- The previous finding was confirmed by analyzing the snow depth estimated by the CRCM at dates corresponding to the end of the melting by satellite mapping (average depth was 10 cm);
- According to the CRCM, the average ending date occurs 7 to 24 days later than the effective date determined using AVHRR-SSM/I (obtained with ZN = 0 cm) (Figure 2);
- Increasing the threshold value on ZN, resulting in a reduction of average differences.
- The CRCM's minimum threshold on ZN to declare the disappearance of the snow should be greater than 0 cm;
- The tests on the minimum ZN value conducted in order to determine the optimal threshold indicated that this later is ranging from 1 cm to 4 cm, depending on the year.

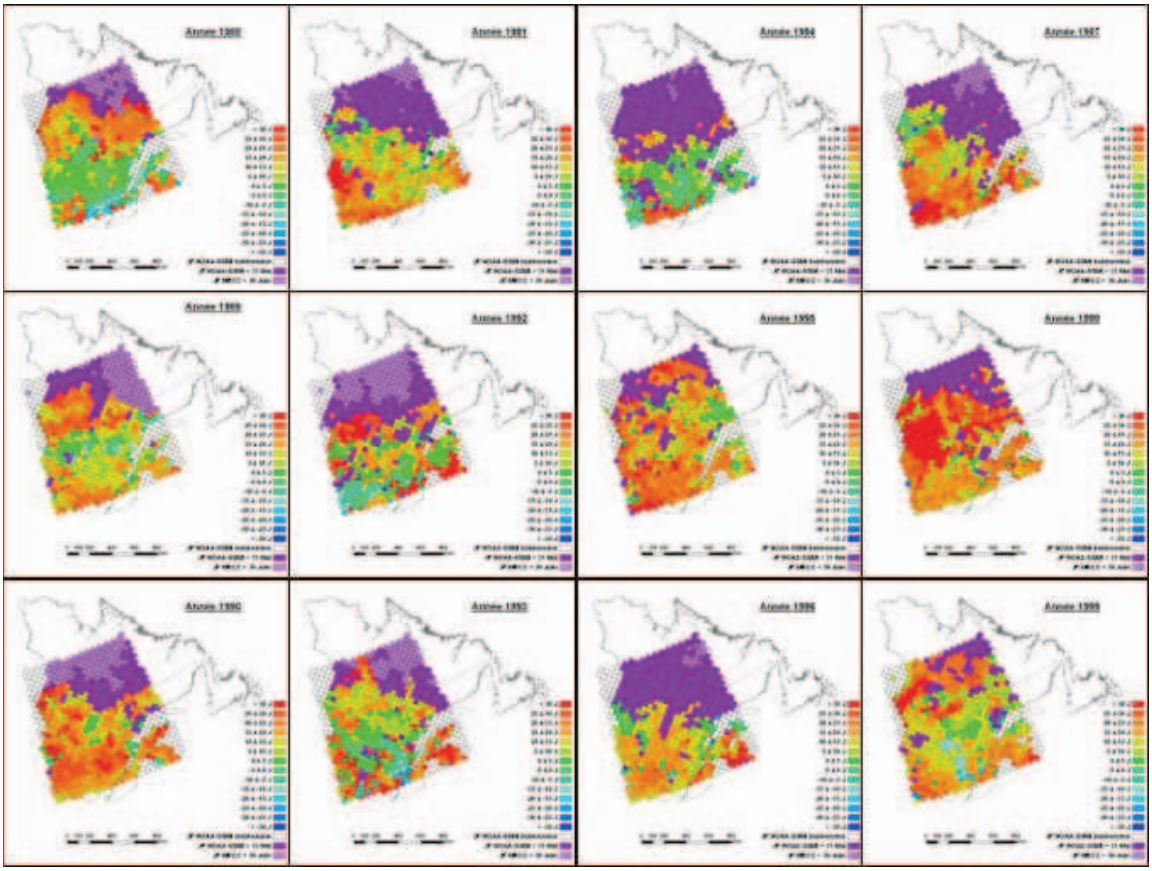

Figure 2 : Difference in days between melting periods ending dates estimated by the CRCM and the effective dates determined using AVHRR-SSM/I

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