# GIS of Snow Cover in James Bay (Canada)

ROBIN FORTIER[1]

## ABSTRACT

James Bay has great economical potential due to its hydroelectricity power generation. Because of its mass of water availability, this Northern region is being used to fill up huge reservoirs that feed hydroelectric power dams along La Grande River. This vast area could be described as being covered with thousands of lakes, wetlands, rolling hills combining bare rocks with evergreen boreal forest and open tundra at higher ground. The snowmelt fills manmade reservoirs as well as feeding lakes, ponds and bogs. The methodology combines the use of two Environment Canada Meteorological Stations (LG2 and LG4) and Landsat images. A simple algorithm is used to simulate hourly snow water equivalent (SWE), accumulation and melt at both stations. Hourly adjustments of precipitation and snowmelt are based on available information received from Landsat images and used as index for terrain exposure to wind, rain and sun. Field data would be an asset to calibrate and check accuracy of the model.

**Keywords**: Snow Water Equivalent, James Bay, Snow Cover, Meteorological Station.

## INTRODUCTION

Snow cover estimation over a remote area like Northern Quebec is a major concern for Hydro-Quebec since electricity generation is dependent on water. Multiple factors such as land topography and vegetation could affect snow cover in that kind of environment. The exposure to wind, radiant energy and forest density change the snow water equivalent (SWE). These could be estimated based on available cloud free Landsat images.

## STUDY SITE

La Grande River's watershed is located between latitude 53 and 54 and longitude -66 and -79 (figure 1). To the east is the Caniapiscau reservoir (4318 km$^2$), the main feeder of La Grande River, at an elevation of 535 meters above sea level. The closest Meteorological Station is in Schefferville. This northern part can account for 1497 hours of sunlight per year (International Lake Environment Committee). Below is the breakdown of temperature and precipitation for Schefferville (table 1).

**Table 1 Climatic data at Schefferville Airport (<100 km east of Caniapiscau Reservoir), 1951−1980.**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Ann. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean temp. [deg C] | -22.8 | -21.2 | -15.1 | -7.2 | 1.2 | 8.6 | 12.6 | 10.8 | 5.2 | -1.4 | -9.0 | -19.0 | -4.8 |
| Precipitation [mm] | 47 | 43 | 42 | 45 | 49 | 74 | 97 | 98 | 83 | 76 | 66 | 49 | 769 |

[1] Sherbrooke University, 2500 blvd de l'Université, Sherbrooke, QC, J1K 2R1 Canada

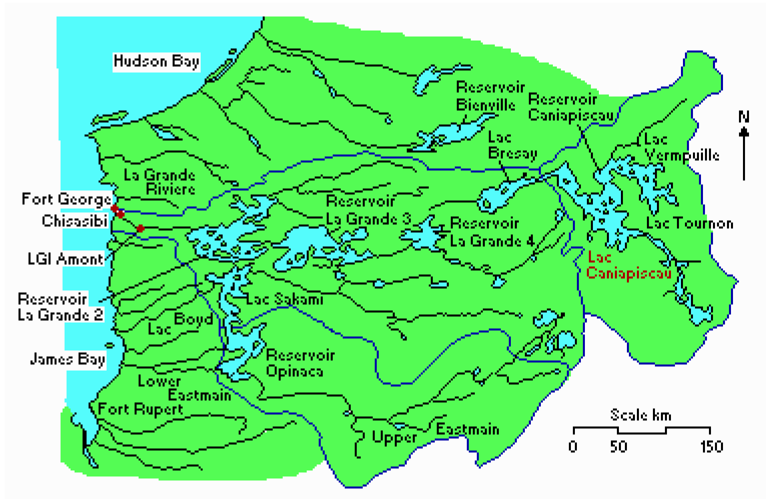


Fig. NAM-35-1 Sketch map of La Grande Complex (Q).

(International Lake Environment Committee)

Figure 1. The study area.

Breakdown of solar radiation for Schefferville is tabulated here (table 2).

**Table 2 Solar radiation (Schefferville)*[MJ $m^{-2}$ $day^{-1}$].**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Ann. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.71 | 7.83 | 12.98 | 18.80 | 19.63 | 19.01 | 16.98 | 14.46 | 9.30 | 5.21 | 3.26 | 2.72 | 11.2 |

* This observation station is in the basin.

## DATA AND METHODS

Available Landsat images are obtained from Global Observatory for Ecosystem Services Landsat products (figures 2 and 3).


Figure 2. Landsat path row searching over La Grande River James Bay.

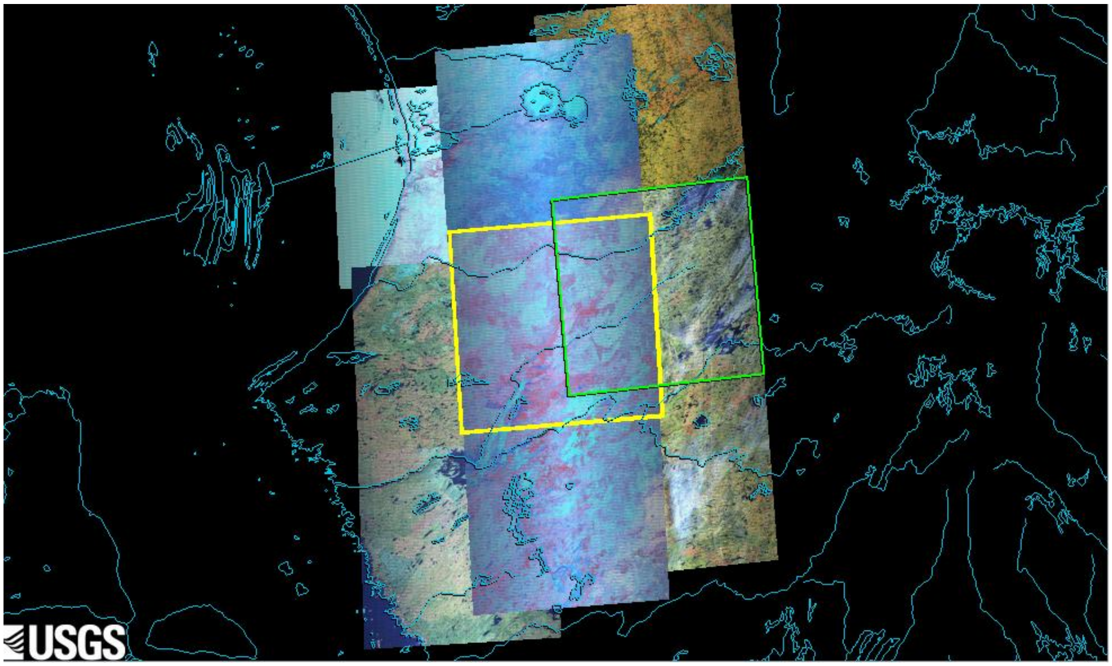


Figure 3. USGS Landsat Mapping over La Grande River James Bay region.

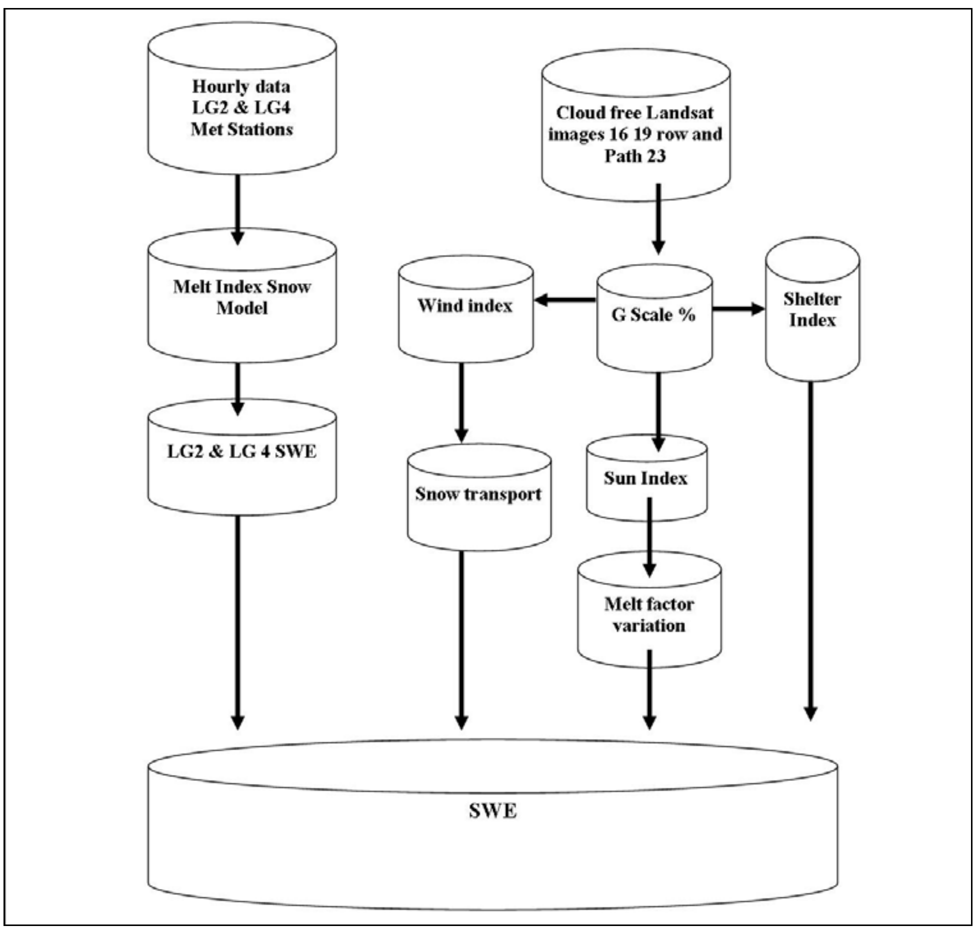


Figure 4. Methodology.

The weather data of winter 2010-2011 come from the two weather stations of Environment Canada located in La Grande River region:

- La Grande 2 (Latitude 53 degrees and 38 minutes, Longitude 77 degrees and 42 minutes).
- La Grande 4 (Latitude 53 degrees and 45 minutes, Longitude 73 degrees and 41 minutes).

Data gathering of hourly air temperature, dew, atmospheric pressure, wind speed and direction, quantity and type of precipitation come from the two Environment Canada Meteorological Stations at La Grande 2 and at La Grande 4.

The snow model described here is partly based on the S17 model (Anderson, 1973). This model only requires air temperature and precipitation and is adapted to represent a large territory. Furthermore, interactions between snow, ground and vegetation are not modelled. This simplified model evaluates snow cover accumulation for each hourly precipitation, adding or subtracting SWE. Sublimation processes are not considered.

SWE corresponding to the area of the Landsat image and time period of the LG2, LG4 simulation are done by multiplying results from the snow model with the Landsat images data.

## RESULTS

Figure 5 and figure 6 represent SWE for winter 2010-2011 at the position La Grande 2 (LG2) and La Grande 4 (LG4).

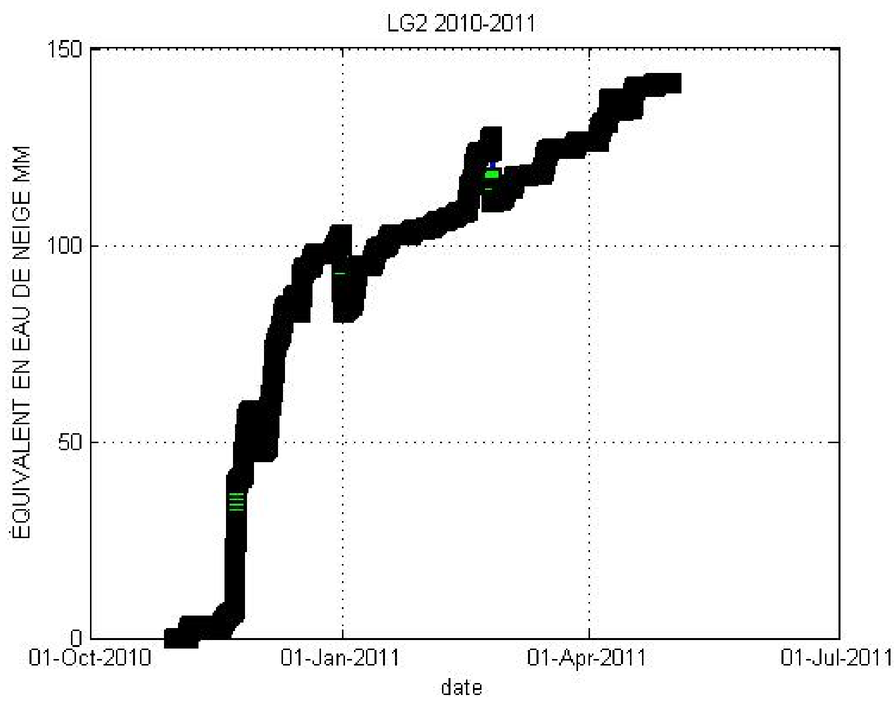


Figure 5. Snow water equivalent (SWE) in La Grande 2 (LG2) winter 2010-2011.

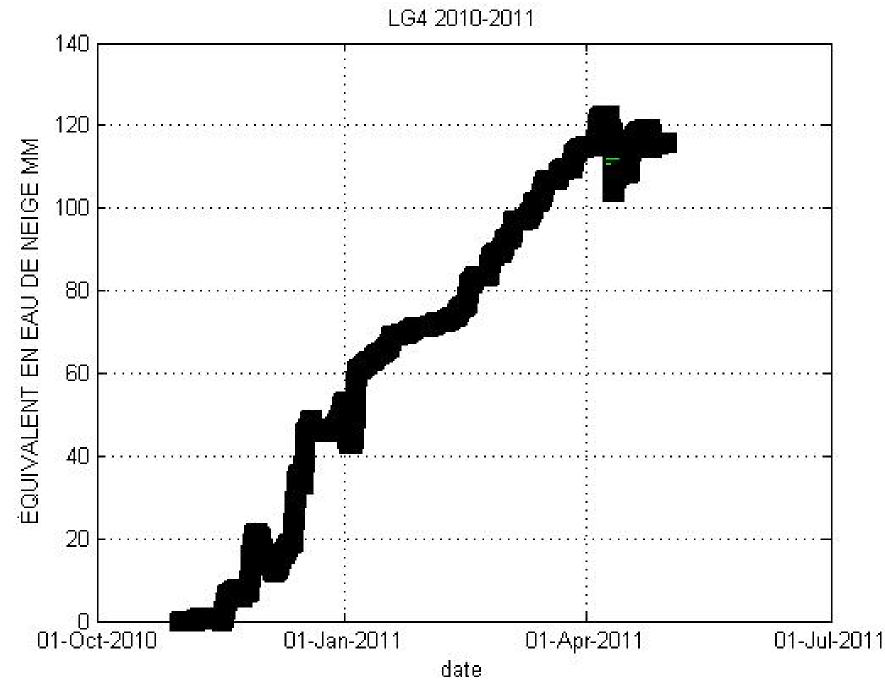


Figure 6. Snow water equivalent (SWE) in La Grande 4 (LG4) winter 2010-2011.

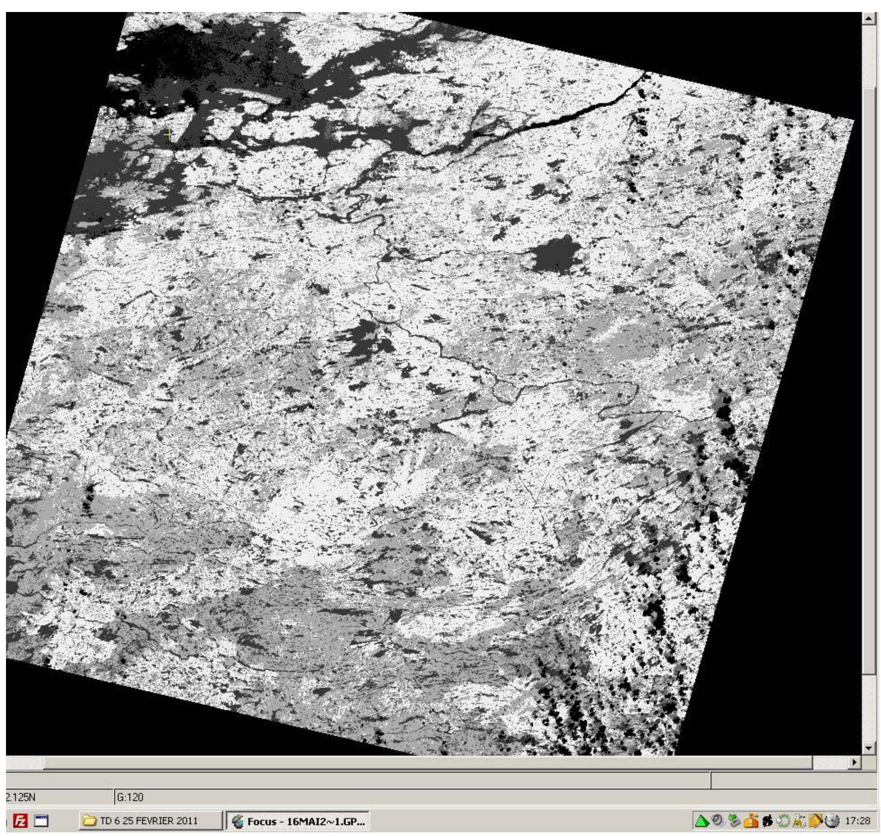

Figure 7. The Landsat image row 19 path 23.

## CONCLUSION

This simple snow model simulates the snow water equivalent (SWE) in James Bay using La Grande 2 (LG2) and La Grande 4 (LG4) meteorological stations and considering Landsat images. Wind is considered as a major factor for snow transport and this could be monitored with Landsat.

The relationship between the two meteorological stations is linked to each pixel of satellite images. Mapping of SWE at La Grande 2 (LG2) and or at La Grande 4 (LG4) according to an index is very easy. Equally, the melt is found to be inaccurate in open area. It is assumed that snow cover is thin over a lake reservoir. Snow transport is then very important because it would migrate from the reservoir to the forest. Another factor to consider is that there is a small amount of northern precipitation. The snow cover would be thicker in dense areas.

## REFERENCES


International Lake Environment Committee
http://www.ilec.or.jp/database/nam/nam-35.html

Global Observatory for Ecosystem Services
Michigan State University
1405 S. Harrison Ave Room 101
East Lansing, MI 48823
USA
http://landsat.org/

Anderson EA. 1973. Snow accumulation and ablation model. NOAA tech. Memo. NWS HYDRO-17.

Liston G, and Sturm M. 1998. A snow transport model for complex terrain. *Journal of Glaciology* **44**:148: 498−515.