Available online at www.sciencedirect.com

SCIENCE DIRECT®

Remote Sensing of Environment 98 (2005) 344 – 355

Remote Sensing of Environment

www.elsevier.com/locate/rse

Flood monitoring over the Mackenzie River Basin using passive microwave data

Marouane Temimi *, Robert Leconte, Francois Brissette, Naira Chaouch

École de Technologie Supérieure, Montreal, Canada Montreal, Québec, Canada

Received 21 October 2004; received in revised form 23 June 2005; accepted 24 June 2005

Abstract

Flooding over the Mackenzie River Basin, which is situated in northwestern Canada, is a complex and rapid process. This process is mainly controlled by the occurrence of ice jams. Flood forecasting is of very important in mitigating social and economic damage. This study investigates the potential of a rating curve model for flood forecasting. The proposed approach is based on the use of a Water Surface Fraction derived from SSM/I passive microwave images and discharge observations. The rating curve model is based on an existing correlation between flooded areas and measured discharge. However, a time lag can be observed between these two variables. Thus, the rating curve model has been modified by the introduction of a lag term that could vary depending on the flooding intensity and the features of the basin. Hence, the lag term is computed dynamically using a cross-correlation function between Water Surface Fraction values which are derived from SSM/I observations and the discharge vectors. The rating curve model is based on two empirical parameters that depend on the site features, which vary in both space and time. To overcome this dependency, the rating curve model was linked to a Kalman filter in order to dynamically estimate the empirical parameters according to the forecasting errors encountered at each time step. With the Kalman filter, the dynamic rating curve model continuously readjusts its parameters to satisfy the non-stationary behavior of hydrological processes. The model is thus sufficiently flexible and adapted to various conditions. Simulations were carried out over the Mackenzie River Basin (1.8 million km^2) during the summers of 1998 and 1999. NOAA-AVHRR images were used to validate the forecast WSF values. The predicted flooded areas agree well with those derived from the NOAA-AVHRR images. Further simulations were carried out from 1992 to 2000 using the rating curve model to predict discharge at a downstream location. Even though an interannual variability of the water surface fractions was observed over the PAD area, the modified model was sufficiently flexible to be readjusted and to reproduce satisfactory results. This implies that a combination of passive microwave data and discharge observations presents an interesting potential in flood and discharge prediction.

© 2005 Elsevier Inc. All rights reserved.

Keywords: Flood monitoring; Passive microwave data; Discharge observations; Rating curve; Kalman filter

1. Introduction

This work is part of the Mackenzie GEWEX Study, MAGS. MAGS is the Canadian contribution to the GEWEX international program. The main objective of the MAGS project is to provide an understanding of the hydrological and climatological processes occurring within the Mackenzie River Basin (MRB), in northwestern Canada. The estimation of the Water Surface Fraction (WSF) over a basin is of great importance for modeling hydrological and climatological processes. WSF is a useful indicator of water storage fluctuations and a crucial parameter in flood monitoring as it indicates the variation of flooded areas in both space and time. However, hydrological processes can vary rapidly. Moreover, ice jamming significantly controls the occurrence of flooding in northern climates. To predict the evolution of these processes, a real-time forecasting of the WSF is needed. Remote sensing presents an interesting potential for flood prediction.

Usually, the WSF is estimated using a combination of one or multiple frequencies at different polarizations. Fily et al. (2003) proposed an approach to estimate WSF based

---

* Corresponding author. Tel.: +1 514 396 8800x7690; fax: +1 514 396 8584.

E-mail address: Marouane.temimi.1@ens.etsmtl.ca (M. Temimi).

0034-4257/$ - see front matter © 2005 Elsevier Inc. All rights reserved.
doi:10.1016/j.rse.2005.06.010

on the ratio ($e_{\text{soil}} - e_{\text{dry soil}} / e_{\text{wet soil}} - e_{\text{dry soil}}$), where e_{soil}, $e_{\text{dry soil}}$, $e_{\text{wet soil}}$ are the emissivities of the observed, dry and wet soils, respectively. The emissivity, in the work of Fily et al. (2003), was estimated from a relationship established between 19 and 37 GHz brightness temperatures vertically and horizontally polarized, provided by SSM/I sensor. Tanaka et al. (2003) tested two different methods. The first was based on the use of the SSM/I 37 GHz channel as a single frequency. The 37 GHz horizontally polarized channel was considered optimal as it has a smaller effective field of view (EFOV) and a horizontal polarization that presents a greater contrast between water and dry soil. The second method was based on the use of a polarization difference at the 37 GHz frequency level, also using SSM/I data. Both of these methods showed a good agreement with WSF derived from NOAA-AVHRR data. SSM/I data were used also by Jin (1999) to compute a flooding index (FI), defined as the difference between vertically polarized brightness temperatures measured at 37 and 85 GHz frequencies, respectively. The FI was compared to predetermined threshold F_0 indicating flood detection.

A Basin Wetness Index (BWI) was suggested by (Basist et al., 1998). The BWI is based on the correlation between the emissivity decrease and the presence of water at or near the soil surface which affects the brightness temperature differences measured at 19, 37 and 85 GHz. The moisture in the soil reduces its emissivity and affects the differences between emissivities estimated at different frequencies. Furthermore, this index allows the calculation of the WSF, which is a potential indicator of water storage within the upper soil layer. In this work, a particular interest has been given to the wetness index proposed by Basist et al. (1998). This index was selected because of its simplicity and the availability of data allowing its application.

This work aims to provide a real-time forecast of the WSF over the Mackenzie River Basin, which is situated in northwestern Canada (Fig. 1), using passive microwave data. The method is based on a rating curve relating discharge measurements to water extent derived from microwave data. In addition, a Kalman filter has been used to update the empirical parameters of the rating curve model. Section 2 of this article will discuss firstly the potential of passive microwave to estimate WSF over large watersheds and secondly the use of the Kalman filter to take into account the temporal variability of the empirical parameters of the rating curve model. Finally, the results of the application of the proposed method will be presented in Section 3.

2. Methodology

2.1. Estimation of the water surface extent using passive microwave data

Basist et al. (1998) proposed an approach based on the correlation between the decrease of emissivity and the brightness temperature differences. The gradual change in

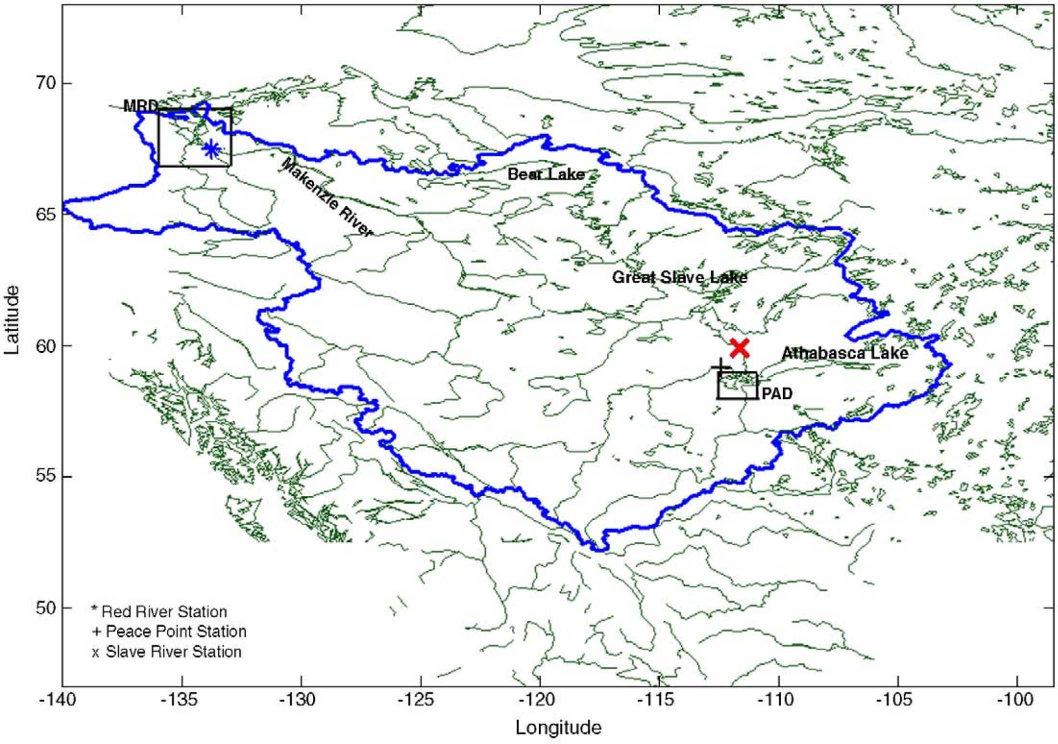

Fig. 1. The Mackenzie River Basin.

Download English Version:

https://daneshyari.com/en/article/10114092

Download Persian Version:

https://daneshyari.com/article/10114092

Daneshyari.com