Chapter 19

Mapping of Surface Albedo over Mackenzie River Basin from Satellite Observations

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Abstract This chapter presents the approach and results of mapping surface albedo and bi-directional reflectance distribution function (BRDF) properties over the Mackenzie River Basin (MRB). Satellite observations from three types of sensors were used: (1) the Advanced Very High Resolution Radiometer (AVHRR) sensor onboard the NOAA platforms, (2) the VEGETATION (VGT) sensor onboard the SPOT platforms, and (3) the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor onboard the TERRA platform. The data collected using these sensors span the period of 1985 to 2004. Seasonal and interannual variability of spectral and broadband albedo over the MRB was analyzed. Broadband albedo averaged over the region changed from 0.11±0.03 in summer to 0.4-0.55 in winter. No substantial long-term systematic trends in surface albedo could be detected over the study period, mainly due to large interannual variability, uncertainties in sensors properties, atmospheric correction, and retrieval procedure.

1 Introduction

Albedo is defined as a ratio of reflected upward hemispheric solar flux (termed the surface radiant exitance $M$) to downward solar flux (termed the surface irradiance $E$). Surface albedo is an important property of the Earth climate system, as it influences the radiation budget of the surface, serves as an indicator of vegetation phenological processes, and affects the surface hydrologic and energy cycles. The accurate parameterization and representation of surface albedo in Global and Regional Climate Models (GCM and RCM) is important for the overall reliability of model prediction. The validation of model results against observations is a crucial indicator of model strength and weakness. However, ground point albedo measurements are scarce and represent only very small areas. Satellite observations are therefore indispensable for characterizing spatial and temporal variations in albedo (Luo et al. 2005; Wang et al. 2006). Since albedo is
a ratio of hemispherical quantities, it cannot be inferred directly from satellite observations obtained from scanning radiometers. Instead, it is obtained by constructing the bi-directional reflectance distribution function (BRDF) (Nicodemus 1970) of the surface from a series of satellite observations, which is then integrated over angles to derive albedo. Frequently, the BRDF is expressed as a combination of kernel functions. Weights for each kernel are derived by fitting a set of atmospherically-corrected clear-sky satellite observations for a particular point or land cover type (Luo et al. 2005).

The main objective of this work was to produce time series of surface albedo and BRDF parameters over the entire Mackenzie River Basin (MRB) from historical and current satellite sensors that cover the complete annual cycle. Since the MRB region contains a diversity of land cover types, the surface properties over the region are highly variable, and can change substantially between seasons due to the variability of snow cover and vegetation phenology. For the period 1985 to 2004 we produced surface albedo at 1-km spatial resolution every 10 days from historical satellite sensors such as the Advanced Very High Resolution Radiometer (AVHRR) onboard the NOAA satellites and the VEGETATION (VGT) sensor onboard the SPOT platforms. For the period 2000-04 we produced surface albedo at 1-km spatial resolution every 16 days using the MODIS product MOD43B1/MYD43B1 from TERRA/AQUA spacecraft. This work was a component of a Natural Resources Canada (NRCan) project conducted at the Canada Centre for Remote Sensing (CCRS) that focused on producing national-scale satellite data products in the framework of the scientific program “Reducing Canada’s Vulnerability to Climate Change” (http://ess.nrcan.gc.ca/2002_2006/rcvcc/index_e.php).

2 Study Area

The study area covers the entire Mackenzie River Basin, extending from 52°N to 69°N where the Mackenzie Delta reaches the Beaufort Sea. Figure 1a shows the distribution of land cover types in the region, extracted from datasets described by Latifovic and Poulion (2005). Surface elevation extracted from the GTOPO30 database is shown in Fig. 1b (http://edcdaac.usgs.gov/gtopo30/gtopo30.html). The eastern part of the basin is a low-lying area containing three major lakes: Athabasca, Great Slave and Great Bear Lakes. The western sector covers part of the Western Cordillera.