ABSTRACT

Hyerspectral remote sensing data offer unique advantages in characterization of land surface and atmosphere in the spectral domain. Unlike existing multi-spectral sensors, hyerspectral sensor provides information with much finer spectral resolution, giving us a chance to improve the quantification of surface shortwave radiation budget, which may otherwise suffered from reduced accuracy of atmospheric and surface component retrievals. In this study, we proposed a method to estimate surface shortwave radiation budget from the Airborne Visible Infrared Imaging Spectrometer (AVIRIS) data. Surface albedo and downward radiation were estimated separately and then converted to net shortwave radiation. Preliminary evaluation on the proposed method that was made using AmeriFlux ground measurements showed that our albedo estimates have a bias of -0.003 with a root mean square error (RMSE) of 0.027 and the net radiation estimates have a bias of 5.59 W/m² with an RMSE of 32.46 W/m². Further improvements will focus on cloud/shadow detection. More validations will be made using other remote sensing data sets.

INTRODUCTION

The energy exchange between the land surface and the atmosphere is a vital component of the climate system. The energy budget components at the land surface (Fig. 1) play significant roles in driving various kinds of land processes, e.g., snow melting, photosynthesis, respiration, ET, and so on. On the other hand, the land system also responds to the climate variability (i.e., drought and extreme heat) through the exchange of energy, matter and momentum. In the past decade, only a few researchers have used hyperspectral remote sensing data to estimate surface broadband albedo (e.g., Painter et al. 2003; Roberts et al. 2004), let alone the net shortwave radiation. However, in these approaches, the atmospheric components must be pre-measured to obtain the surface reflectance.

In this study, we developed some algorithms to estimate the surface shortwave albedo and net radiation from AVIRIS data to help improve our understanding of radiation budget under changing climate.

DATA AND METHODOLOGY

In this study we used a refined direct estimation method (He et al. 2013a) that links AVIRIS top-of-atmosphere (TOA) narrowband reflectance with land surface broadband albedo directly based on a database created from extensive radiative transfer simulations. The direct estimation method doesn’t require surface reflectance that is resulted from atmospheric correction (Liang et al. 1999). The direct estimation algorithm has been improved later and applied on different satellite sensors (Liang 2003; Liang et al. 2005; Qu et al. 2013; Wang et al. 2013a).

Although the direct estimation algorithm has been widely used, it has not been used for hyperspectral data. The nature of the direct albedo estimation algorithm is such that it relies on the data from extensive radiative transfer simulations under different geometries and atmospheric conditions, to overcome the lack of pre-measured atmospheric components needed for atmospheric correction. As the direct estimation algorithm is based heavily on spectral signatures, hyperspectral data would be better than multispectral data to examine its performance in albedo estimation, without using angular signatures.

We applied two methods to estimate surface net shortwave radiation. The first one is based on the similar procedure to the direct estimation method except linking the TOA narrowband radiance to surface net radiation (Wang et al. 2013b). The second method is to estimate surface downward radiation (Zhang et al. 2013) and then calculate net radiation using our surface albedo estimates (He et al. 2013a).

RESULTS

In Fig. 1, AVIRIS flights were from AmeriFlux sites during 2007-2011 with valid ground shortwave albedo measurements.

CONCLUSIONS

Estimation of surface shortwave radiation budget has seldom been attempted in previous research using data of either high spatial resolution or high spectral resolution. In this study, we proposed a refined direct estimation approach to estimate shortwave albedo and net radiation from AVIRIS data. Preliminary validation results based on ground measurements and Landsat data have shown that our algorithms were robust over various atmospheric and geometric conditions.

Direct comparison with ground measurements has been widely used to assess the medium/coarse resolution satellite albedo products; however, significant differences in scale were found. High spatial resolution albedo estimates can help bridge this gap.

In addition, the AVIRIS-based albedo and net radiation estimates in this study can be very useful in urban environmental, ecological, and agricultural applications, which usually require surface energy balance components with a high spatial resolution.

The principle outcome of this study is that our algorithm can be refined and applied on future HypIPII missions, thereby providing accurate surface radiation budget estimations on a global basis. Further study is needed, including the implementation of our algorithm on satellite hyperspectral data, and algorithm validation and refinement on bright surfaces, including snow and desert.

REFERENCES


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