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Derivation of split window algorithm and its sensitivity analysis for retrieving land surface temperature from NOAA-advanced very high resolution radiometer data

Zhihao Qin[1], Giorgio Dall' Olmo[2], and Arnon Karnieli

Remote Sensing Laboratory, Department of Energy and Environmental Physics, J. Blaustein Institute for Desert Research, Ben Gurion University of the Negev, Sede Boker Campus, Israel

Pedro Berliner

Wyler Laboratory for Arid Land Conservation and Development, Department of Dryland Agriculture, J. Blaustein Institute for Desert Research, Ben Gurion University of the Negev, Sede Boker Campus, Israel

Abstract. Retrieval of land surface temperature (LST) from advanced very high resolution radiometer (AVHRR) data is an important methodology in remote sensing. Several split window algorithms have been proposed in last two decades. In this paper we intend to present a better algorithm with less parameters and high accuacry. The algorithm involves only two essential parameters (transmittance and emissivity). The principle and method for the linearization of Planck's radiance equation, the mathematical derivation process of the algorithm, and the method for determining the atmospheric transmittance are discussed with details. Sensitivity analysis of the algorithm has been performed for evaluation of probable LST estimation error due to the possible errors in transmittance and emissivity. Results from the analysis indicate that the proposed algorithm is able to provide an accurate estimation of LST from AVHRR data. Assuming an error of 0.05 in atmospheric transmittance estimate and 0.01 in ground emissivity for the two AVHRR thermal channels, the average LST error with the algorithm is 1.1°C. Two methods have been used to validate the proposed algortihm. Comparison has also been done with the existing 11 algorithms in literature. Results from validation and comparison using the standard atmospheric simulation for various situations and the ground truth data sets demonstrate the applicability of the algorithm. According to the root mean square (RMS) errors of the retrieved LSTs from the measured or assumed LSTs, the proposed algorithm is among the best three. Considering the insignificant RMS error difference among the three, the proposed algorithm is better than the other two because they require more parameters for LST retrieval. Validation with standard atmospheric simulation indicates that this algorithm can achieve the accuacry of 0.25°C in LST retrieval for the case without error in both transmittance and emissivity estimates. The accuary of this algorithm is 1.75°C for the ground truth data set without precise in situ atmospheric water vapor contents. The accuracy increases to 0.24°C for another ground truth data set with precise in situ atmospheric water vapor contents. The much higher accuracy for this data set confirms the appplicability of the proposed algorithm as an alternative for the accurate LST retrieval from AVHRR data.

1. Introduction

The extensive requirement of temperature information on a large scale for environmental studies and management activities of the Earth's resources has made the remote sensing of land surface temperature (LST) an important issue in recent decades. Many efforts have been devoted to the establishment of methodology for retrieving LST from remote sensing data [*Qin and Karnieli*, 1999; *Vogt*, 1996]. Examples of this aspect include the works of *Price* [1983, 1984], *Becker* [1987], *Holbo and Luvall* [1989], *Cooper and Asrar* [1989], *Ottlé and Vidal-Madjar* [1992], *Prata* [1993 and 1994], *Coll et al.* [1994], *França and Cracknell* [1994], *Seguin et al.* [1994], *Choudhury et al.* [1995], *Calvet and Jullien* [1996], etc.

The United States National Oceanic and Atmospheric Administration (NOAA) has an on-going operational program of polar-orbiting meteorological satellites with advanced very high resolution radiometer (AVHRR) on board to monitor the global meteorological change [*Cracknell*, 1997]. NOAA-AVHRR has two thermal channels operating in wavelengths 10.5-11.3 and 11.5-12.5 μm, respectively. Though spatial resolution of its High-Resolution Picture Transmission (HRPT) format is relatively low (1.1×1.1 km under nadir), NOAA-AVHRR has the advantages of high revisit time (about two images a day) and easy access (public domain data

[1]Now at Department of Land, Air and Water Resources, University of California, Davis, CA 95616, USA.
[2]at Center for Advanced Land Management Information Technologies, University of Nebraska, Lincoln, NE 68588, USA.

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