Sensitive Analysis of Various Measurement Errors on Temperature and Emissivity Separation Method with Hyperspectral Data

Xiaoying OuYang[a, b], Xinhong Wang[d], Ning Wang[a, b], Bo-Hui Tang[a], Zhao-Liang Li[a, c],

a. Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, 100101, China

b. Graduate University of Chinese Academy of Sciences, China

c. TRIO/LSIIT, Bld Sebastien Brant, BP10413, 67412 Illkirch, France Email: li@lsiit.u-strasbg.fr

d. Academy of opto-electronics, Chinese Academy of Sciences, Beijing, 100190, China

One of the main objectives of the thermal infrared (TIR) remote sensing is to extract land surface temperature and spectral emissivity from airborne/spaceborne hyperspectral TIR data. The central problem of temperature and emissivity separation (TES) is that we obtain *N* spectral measurements of radiance and need to find $N + 1$ unknowns (*N* emissivities and one temperature) if the atmospheric perturbations are well corrected for. Thus, one constraint must be introduced into the retrieval procedure to obtain the realistic solution for the temperature/emissivity separation problem. Most of presently used TES methods are inherently designed for multispectral thermal sensors such as TIMS, ASTER, etc. [1][2]

In the recent years, we have developed a new method for land surface temperature/emissivity separation, based on accurately atmospherically corrected hyperspectral TIR data [3]. An index named as "Downwelling Radiance Residual Index" (DRRI) has been used to give an additional constraint to the above-mentioned nondeterministic inverse problem, thus a unique solution could be achieved. Since the natural land surface could not be a blackbody, the at-surface leaving radiance contains both the surface thermal emission and the reflected atmospheric downwelling radiance, then if the land surface temperature is not accurately estimated, the corresponding retrieved emissivity spectrum will exhibit "downwelling radiance residual feature" (that is, the estimated emissivity spectrum is smooth on major parts but at certain areas there lie sharp convexities or concavities, which are caused by atmospheric downwelling radiance). The index value has been designed, which is constructed with the estimated emissivity values of eighteen well-chosen channels, to depict the direction and magnitude of the downwelling radiance residual feature. The eighteen channels are divided into six groups (three in each group), and each group can produce one DRRI component, then the six components sum to the total DRRI value. When the estimation of land surface temperature changes with a little increase amount step by step (initial temperature value can be obtained through supposing certain proper channel's emissivity as unity), the corresponding DRRI value will be calculated and tend to change from a positive value to a negative value, whereas we can find two temperature values whose corresponding DRRI values are nearest to zero (one of which is positive DRRI value, the other is negative DRRI value), and using these two temperature values we can interpolate out the eventual temperature estimation with the condition DRRI = 0. Once the temperature is determined, the land surface spectral emissivities can be resolved easily.

Tests using simulated hyperspectral TIR data sets have proved that this Temperature/Emissivity Separation algorithm is precise and fast. In this article, we first construct a synthetic target for various types of systems. It is organized as a 10*10 matrix with 10 different types of surfaces (4 soils, 2 rocks, 1 water, 2 types of vegetation, 1 ice). For the atmosphere, we choose 3 types of atmospheres (dry, moderately moist, moist). Attention will be paid to choose surface temperature in relation to the bottom of the air temperature (Ta(0)) in order to avoid non-physical situations. Then, based on the synthetic target, we will present an error analysis where we add noise to the downwelling radiance and the at-surface radiance. It is shown that if the atmospheric correction has been well-done, the use of DRRI method leads to satisfactory results because the retrieval of land surface temperature is not sensitive to the downwelling radiance. The error of estimated land surface temperature, either on heterogeneous surfaces or homogeneous surfaces, is less than 0.3K. We also found that the overestimation of downwelling radiance could lead less land surface temperature error than underestimation of downwelling radiance.

REFERENCE

[1] P. S. Kealy and A. R. Gabell, "Estimation of emissivity and temperature using alpha coefficients", *Proc. 2nd TIMS Workshop,* JPL Publication 90-55, 1990.

[2] A. R. Gillespie, T. Matsunaga, S. Rokugawa and S. J. Hook, "A Temperature and Emissivity Separation Algorithm for Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Images", *IEEE Trans. Geosci. Remote Sens*., vol. 36, no. 4, pp. 1113-1126, 1998.

[3] X. Wang, X.Y. OuYang, Z.-L. Li, R. Zhang, B.H. Tang, "A new method for temperature/emissivity separation from hyperspectral thermal infrared data", Paper ID: 2402, *IGARSS 2008*, July 6-11, 2008 Boston, Massachusetts, U.S.A..