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N94-16601

APPLICATION OF SPLIT WINDOW TECHNIQUE TO TIMS DATA

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1. INTRODUCTION

Absorptions by the atmosphere in thermal infrared region are mainly due to water vapor, carbon dioxide, and ozone. As the content of water vapor in the atmosphere greatly changes according to weather conditions, it is important to know its amount between the sensor and the ground for atmospheric corrections of TIMS data (i.e. radiosonde). On the other hand, various atmospheric correction techniques have already been developed for sea surface temperature estimations from satellites. Among such techniques, Split Window technique, now widely used for AVHRR(Advanced Very High Resolution Radiometer), uses no radiosonde or any kind of supplementary data but a difference between observed brightness temperatures in two channels for estimating atmospheric effects.

In this paper, applications of Split Window technique to TIMS data are discussed because availability of atmospheric profile data is not clear when ASTER operates. After these theoretical discussions, the technique is experimentally applied to TIMS data at three ground targets and results are compared with atmospherically corrected data using LOWTRAN7 with radiosonde data.

2. SPLIT WINDOW TECHNIQUE

The theory of Split Window technique is based on equations of radiative transfer at two different wavelengths(for a detailed theory, see *McMillin et al. 1984*). To eliminate atmospheric terms from these equations, several approximations and assumptions(surface emissivities in two channels are unity, atmospheric absorptions are small and so on) are introduced, and equation (1) is derived:

$$T_1 - T_2 = \frac{k_2 - k_1}{k_1}(T_s - T_1) \qquad (1)$$

where T_1 and T_2 are observed brightness temperatures in channel 1 and 2, T_s is surface brightness temperature, and k_1 and k_2 are absorption coefficients in channel 1 and 2. Equation (1) shows that the difference between surface and observed temperatures(T_s-T_1) is proportional to the difference between observed temperatures in different channels(T_1-T_2).

A coefficient of (T_s-T_1) is usually determined by linear regressions of computer-simulated data(*Deschamps et al. 1980*) or buoy and satellite data set(*Strong et al. 1984*). In this aspect, this technique is an empirical one. As a result, a constant value is added to (1) because of approximation errors and (1) becomes equation (2).

$$T_s = T_1 + a(T_1 - T_2) + b \quad \text{or} \quad T_s = a_1T_1 + a_2T_2 + b \qquad (2)$$

3. TIMS CHANNEL COMBINATIONS FOR SPLIT WINDOW TECHNIQUE

To determine suitable channel combinations of TIMS for Split Window technique, brightness temperatures observed in TIMS channels were calculated using LOWTRAN7 for six model atmospheres, three surface temperatures for each model atmospheres, two looking angles(nadir and 45°), and the airplane altitude 4km. Results are shown in Fig. 1a and Fig. 1b. Linear relationships between temperatures are almost satisfied for TIMS channel 5 and 6 combination(5/6), and combination 1/3. Non-linearities for combination 1/5, 3/4, and 4/5 probably come from differences between model atmospheres and atmospheric ozone. These figures suggest combinations 1/3 and 5/6 are best combinations for Split Window technique.

4. ESTIMATION OF LAND/WATER SURFACE TEMPERATURE USING TIMS DATA

TIMS data used in this study were acquired over the Jasper Ridge area(between San Francisco and San Jose, California), at 11:30 a.m., August 30, 1990. Surface radiation temperatures were simultaneously measured at three locations(Searsville Lake, rubber running track, and asphalt parking lot) and a radiosonde was launched from near the lake. TIMS data were converted into radiance and brightness temperature using internal reference data(air blast effects on reference surface temperature were corrected according to *Schmugge et al. 1990*). Radiance values were atmospherically corrected using LOWTRAN7 with radiosonde data and converted into brightness temperatures at the ground level.

Coefficients of equation (2) were determined by LOWTRAN7 simulations. In this case, five relative humidity profiles based on Mid Latitude Summer model were used in the simulations instead of six model atmospheres. Simulation results are shown in Fig. 2, and coefficients were determined as follows (subscripts indicate TIMS channel):

$$T_s=T_3+1.705(T_3-T_1)-0.94 \quad \text{and} \quad T_s=T_5+3.238(T_5-T_6)+0.03 \quad (3)$$

Results of temperature estimations are shown in Table1. Temperatures atmospherically corrected with Mid Latitude Summer model are higher than with radiosonde data because the model overestimates the amount of water vapor. Estimated temperatures using Split Window technique agree with temperatures atmospherically corrected with radiosonde data within 2°C for Searsville Lake and the running track. But for the parking lot, the discrepancy is relatively large probably because of spectral variations of the surface emissivity.

5. CONCLUSION

Split Window technique can be applied to TIMS data if the channel combination is suitable. But equation (3) may not be used for other cases because coefficients of equation (2) depend on the type of the atmosphere and the altitude of the airplane.

Acknowledgments

We would like to thank Dr. A. B. Kahle for giving a permission to use TIMS data, and Dr. C. D. Elvidge, Dr. S. J. Hook, G. Hoover, Z. Yu, Dr. H. Watanabe, and Y. Kannari for their field works and helpful discussions.

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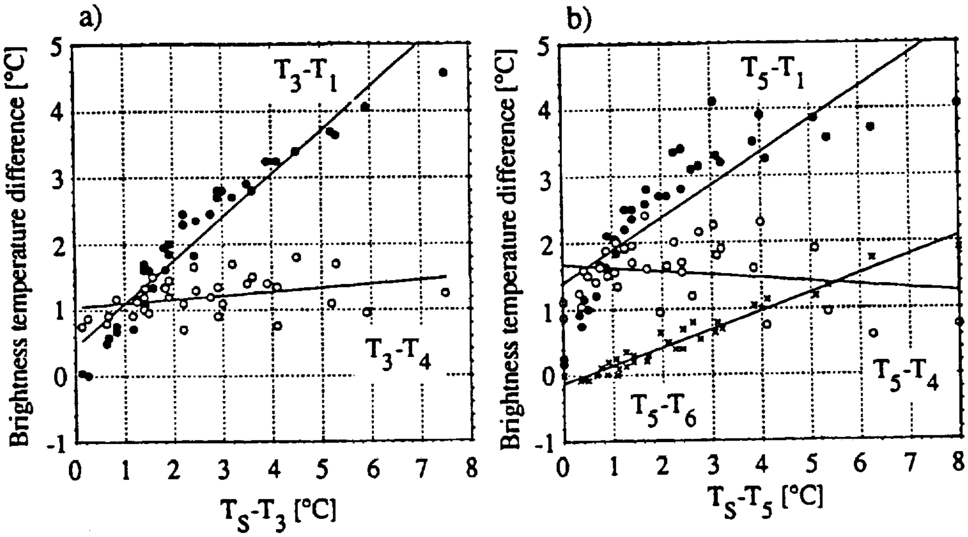

Fig. 1. Results of LOWTRAN7 simulations: T_S is surface brightness temperature and T_1, T_3, T_4, T_5 and T_6 are remotely observed brightness temperatures in TIMS Ch. 1, 3, 4, 5 and 6, respectively.

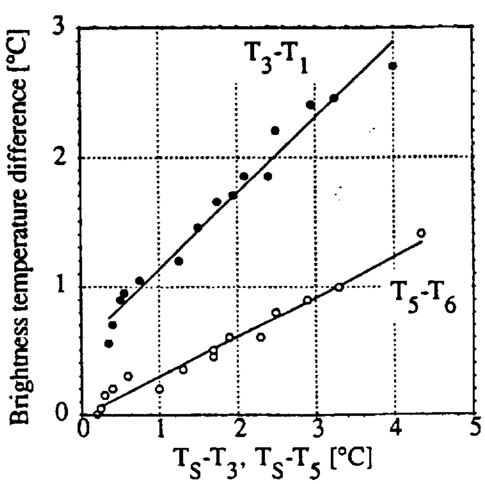

Fig. 2. Results of LOWTRAN7 simulations using five relative humidity profiles for TIMS Jasper Ridge data.

Table 1. Surface Temperature Estimation using Split Window Technique

[°C]	Lake	Track	Lot
TIMS observed			
average	18.9	40.7	31.7
(low)	(17.6)	(37.3)	(29.6)
(high)	(19.6)	(42.3)	(33.1)
Ch. 3 - Ch. 1	1.6	5.0	2.0
Ch. 5 - Ch. 6	0.6	1.8	-0.1
Ground Truth	22.0	48.0	38.0
Midlat. Summer			
average	21.6	51.7	39.6
(low)	(21.2)	(50.5)	(37.3)
(high)	(22.0)	(53.4)	(43.3)
Radiosonde			
average	20.6	48.2	36.8
(low)	(20.3)	(47.8)	(35.6)
(high)	(20.9)	(48.6)	(39.1)
Split Window			
Ch.1 and 3	21.0	49.9	34.1
Ch. 5 and 6	21.3	47.9	32.6