Estimation of Absolute Water Surface Temperature Based on Atmospherically Corrected Thermal Infrared Multispectral Scanner Digital Data

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Airborne remote sensing systems, as well as those on board earth orbiting satellites, sample electromagnetic energy in discrete wavelength regions and convert the total energy sampled into data suitable for processing by digital computers. In general, however, the total amount of energy reaching a sensor system located at some distance from the target is composed not only of target related energy, but, in addition, contains a contribution originating from the atmosphere itself (through which the target related energy must pass). Thus, if a researcher is particularly interested in dealing with target-related energy exclusively, some method must be devised for removing or at least minimizing the effect of the atmosphere.

For the purposes of this project, LOWTRAN-6, an atmospheric path radiance model developed by the Air Force Geophysics Laboratory, was used. This model was "designed to estimate atmoshperic transmittance and radiance for a given atmospheric path at moderate spectral resolution" (Kneizys, et al., 1983) over an operational wavelength region from 0.25 to 28.5μm.

In order to compute the TIMS digital values which would have been recorded in the absence of the atmosphere, the parameters derived from LOWTRAN-6 are used in a correction equation of the form:

$$y' = \left[\frac{y - m(\cos\alpha)^{p'} EA - b}{\bar{\tau}(\cos\alpha)^{p}} \right] + b$$

where y is the corrected digital value
- m is the slope of the System Transfer Equation
- b is the intercept of the System Transfer Equation
- α is Angle of Look from Nadir
- EA is additive atmospheric path radiance
- E is average atmospheric transmissivity
- p,p′ are exponents defining behavior of $\bar{\tau}$ and EA, respectively.

TIMS data used to test this technique were collected at 1:00 a.m. local time on November 21, 1983, over a recirculating cooling pond for a power plant in southeastern Mississippi. Twenty-two floating thermometers provided ground truth, and were read within ± 10 minutes of TIMS data acquisition. Readings taken earlier in the day indicated that thermometer measurements were stable over a much longer (1 hour) time frame, so that errors from the time span encompassing ground truth data acquisition were minimal.

The TIMS data were analyzed before and after atmospheric corrections were applied using a band ratioing model to compute the absolute surface temperature of various points on the power plant cooling pond. The results summarized in Table 1, clearly demonstrate the desirability of applying atmospheric corrections, and while tested using water as a target, the technique developed is also applicable to vegetated targets.

	Before Atmospheric Correction	After Atmospheric Correction
Multiple R^2	0.942	0.985
Peak-to-peak residuals	$\pm 1.0^{o}C$	$\pm 0.4^{o}C$
Sample size (thermometers)	22	22

Table 1. Results of a Linear Regression of Estimated (Predicted) Water Surface Temperatures Versus Actual (Observed) Temperature Determined Through the Use of Floating Thermometers. TIMS Channels 2 and 5 Used for Analysis.

<u>Reference</u>

Kneizys, F.X., E.T. Shettle, W.O. Gallery, J.H. Chetwynd, Jr., L.W. Abru, J.E.A. Selby, S.A. Clough, and R.W. Fenn, 1983, Atmospheric Transmittance/Radiance: Computer Code LOWTRAN 6, Optical Physics Division, Air Force Geophysics Laboratory, Hanscom Air Force Base, Massachusetts, 01731, Report No. AFGL-TR-83-0187, 200 pp.