Remote Sensing Brief

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Field Standards of Reflectance

Note on the use of a Kodak Neutral Test Card as a reference for reflectance measurements in remote sensing applications.

NUMEROUS GEOPHYSICAL APPLICATIONS of multispectral radiometry in the field include the measurement of reflectance of various terrain features. Reflectance, as used herein, refers to a combination of bidirectional reflectance with the sun as the source and hemispherical-directional reflectance with the sky as the source. With proper instrumentation, this quantity can be derived from a measurement of solar irradiance (perhaps with some spectral resolution) and a measurement of reflected radiance. A somewhat simpler method of measuring terrain reflectance is to compare the radiance of the ground to that of the radiance of a portable reflectance target having known characteristics (Jackson *et al.*, 1980). Desired characteristics of a reflectance target include (1) a Lambertian surface; (2) a known reflectance, preferably near the mean reflectance of the sample (approximately 0.2) to minimize linearity requirements on the instrumentation; (3) a stable, renewable surface; (4) rugged and transportable; (5) an adequate size such that the instrumentation can view only the target from a reasonable distance; (6) freedom from solar-induced luminescence; and (7) inexpensive and readily obtainable. The instruction sheet furnished with the Kodak Neutral Test Card (R-27) states that "The Kodak Neutral Test Card is designed to provide a reference area of known reflectance for making exposure meter readings in scenes or for inclusion in pictures as an aid in controlling their reproduction. It is especially useful where precision is required, as in color photography. Manufacture of the Test Card is controlled within close limits to produce neutral surfaces of standardized reflectance values. To prevent specular or mirrorlike reflections, both sides have a matte finish." The quoted values of reflectance are 18 percent for the gray side and 90 percent for the white side. This paper describes some preliminary measurements on Kodak Neutral Test Cards to determine their suitability for use as field standards.

Several of the above requirements are easily fulfilled. The cards are widely available and quite inexpensive, and can be treated as disposable if the card-to-card differences are small. They are quite rugged due to the printed surface, have a reasonable size (20 by 25 cm), and the ability to use either side depending upon the sample reflectance is convenient. The unknown quantities are the departure from a Lambertian surface, the freedom from solar-induced luminescence, and the actual values of reflectance. Initial field measurements using a Radiometrics RMR-10 Multispectral Radiometer showed that the ratio of the white side of the card to the gray side was not the expected value of 5 (from the Kodak data) but some smaller number. A laboratory test was devised to determine whether the card did not conform to the manufacturers stated values or the radiometer was nonlinear.

The laboratory setup is shown in Figure 1. The pertinent operational characteristics of a typical RMR-10 radiometer are shown in Table 1, and the spectral passbands are shown in Figure 2. A 2-degree field-of-view was selected for this test, and data were taken in each of the six spectral bands. The source was a DXW tungsten-halogen lamp operated at a color temperature of approximately 3200K from stabilized 110VAC.. The reference was a 9-cm diameter target of Halon G-80 pressed to a density of 1.06 g/cc and a thickness of 5 mm. Its absolute reflectance was assumed to be 0.99 over the entire spectral range of interest (Weidner and Hsia, 1981). Four cards from one lot were tested at a 0/30 degree configuration. Two different orientations (vertical and horizontal) for the cards were used. The cards were placed directly in

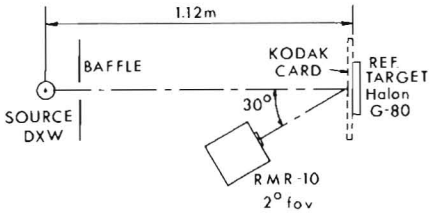

FIG. 1. Laboratory set-up for reflectance measurements.

PHOTOGRAMMETRIC ENGINEERING AND REMOTE SENSING,
Vol. 48, No. 10, October 1982, pp. 1623-1625

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TABLE 1. PERTINENT CHARACTERISTICS OF RADIOMETRICS RMR-10 MULTISPECTRAL RADIOMETER

Fields-of-View (full-angle at half-max):
1 degree
2 degrees
5 degrees
10 degrees
20 degrees
2 sr (cosine corrected)

Spectral Passbands:

BAND	NOMINAL	ACTUAL*
1	400–500 nm	418–489 nm
2	500–600 nm	507–580 nm
3	600–700 nm	597–690 nm
4	700–800 nm	686–790 nm
5	800–1000 nm	752–1027 nm
6	400–1000 nm	399–980 nm

* Based upon actual spectral responsivity measurements and bandwidth determinations using the method described in Palmer, J.M. and M.G. Tomasko, *Broadband radiometry with spectrally selective detectors*, Opt. Ltrs 5, 208 (1980).

TABLE 2. REFLECTANCE OF KODAK NEUTRAL TEST CARDS (REFERRED TO HALON G-80. AVERAGE OF FOUR CARDS, SHOWING DIFFERENCES BETWEEN SPECTRAL BANDS)

BAND	1	2	3	4	5	6
White	1.009	0.946	0.936	0.943	0.936	0.921
Gray	0.315	0.242	0.224	0.249	0.283	0.258

TABLE 3. REFLECTANCE OF KODAK NEUTRAL TEST CARDS (REFERRED TO HALON G-80. AVERAGE OF SPECTRAL BANDS 2–5, SHOWING DIFFERENCES BETWEEN CARDS)

CARD	1	2	3	4
White	0.940	0.940	0.937	0.944
Gray	0.252	0.245	0.248	0.259

TABLE 4. REFLECTANCE OF KODAK NEUTRAL TEST CARDS (REFERRED TO HALON G-80. AVERAGE OF ALL CARDS IN SPECTRAL BANDS 2–5)

White—0.940
Gray— 0.250
Ratio (White/Gray) = 3.76

front of the Halon target, and the maximum error in irradiance created due to the differing distances between the source and the target was less than 0.3%. Tables 2, 3, and 4 give the reduced data from the different bands and for the different cards. As can be seen from these data, the uniformity from card to card is quite good, with a total deviation of less than 6 percent on the gray side and less than 1 percent on the white side. Spectrally, the cards are somewhat less satisfactory, with the total deviation from Band 2 through Band 5 being about 25 percent on the gray side. The white side is much more neutral, with about 1 percent deviation from Band 2 to Band 5. The Band 1 data appear anomalous, as reflectances exceeding the Halon are not expected. Further work is needed to determine the cause of the anomaly. Suspects include the departure of the directional characteristics from Lambertian or perhaps a luminescence effect. The latter seems unlikely with tungsten irradiation, but cannot be ruled out until appropriate tests are made.

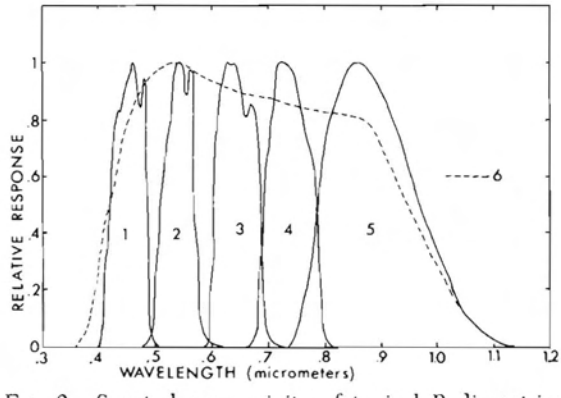

FIG. 2. Spectral responsivity of typical Radiometrics RMR-10 Multispectral Radiometer.

The orientation of the cards is of some importance. The readings obtained when the cards were oriented vertically (long dimension perpendicular to the plane containing the source, target, and radiometer) were about 2.5 to 3 percent higher than for the horizontal orientation. No significant spectral variation was observed. This dependence on orientation indicates that the surfaces are not truly diffuse, as can be readily verified by visual observation. It is also suspected that some "grain" from the printing process may be responsible for this observation.

The conclusion reached is that the Kodak Neutral Test Card is not suitable for exacting field work unless the individual card is fully characterized and used in a reproducible manner. If high accuracies are required, the use of a standard of Halon or pressed $BaSO_4$ is indicated. For work that is less demanding, the card can be of value. It is recommended that the reflectance for the white side be taken as 94 percent and for the gray side as 25 percent rather than the values as stated by Kodak. These values give a ratio (white/gray) of 3.76, which can readily be checked in the field (assuming stable solar irradiance).

Further work is needed to fully characterize the Kodak Neutral Test Card for field use as a rugged reflectance standard. Important characterizations required are (1) freedom from luminescence under solar irradiation, (2) departure from Lambertian, (3) departure from neutrality, and (4) repeatability from card to card. Future work planned at this laboratory also includes measurements of BRDF at 632.8 nm for various orientations. A procedure will then be developed, if possible, for more accurate application of the Kodak card to field measurements.

References

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(Received 30 October 1981; accepted 27 February 1982; revised 26 March 1982)