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Landsat Multitemporal Color Composites

The use of three images of different dates in the construction of a color composite produces an image in which features changing through time are displayed as various colors and areas of no change are displayed as gray tones.

Introduction

A method for constructing multitemporal color composites in which the colors represent changes through time rather than differences in spectral reflectance is presented. This is not a new concept; color composites have been generated using two and three Landsat multispectral scanner system (MSS) images of different dates in order to display change (Deutsch, 1976; Adams *et al.*, 1980). The approach used herein is different in that images of *three* different dates, but recording the same spectral reflectance band, are composited using cyan, magenta, and yellow positive transparencies. For example, multitemporal composites can be constructed using MSS band 7 images of three different dates, using MSS band 5 images of three different dates, or using return-beam vidicon (RBV) images of three different dates. The resulting composite exhibits different colors where change has occurred and gray tones for areas of no change. Because three subtractive primary transparencies are involved in the construction of the composite, a full range of color is possible dependent, of course, on the actual changes that have taken place within the scene. If no changes have occurred from one date to another, the resulting color composite would appear as a black-and-white image identical to each of the black-and-white positive transparencies used to produce the composite.

Abstract: *Landsat MSS and RBV images can be photographically color composited using scenes of the same spectral band obtained at three different dates. The resulting composite exhibits temporal information only, with areas of change displayed as various hues and areas of no change displayed as black and white tones. Anniversary date images from three different years and images acquired at three different periods within the same year were used to construct several examples of a multitemporal color composite. All of the composites displayed a wide range of colors containing a considerable amount of temporal information. This technique is particularly useful when applied to the single band, high resolution Landsat-3 RBV scenes.*

Methodology

All of the composites used to illustrate this article were constructed from cyan, magenta, and yellow diazo films. Positive black-and-white transparencies were contact printed to the diazo film using an ultraviolet light source and then developed in ammonia fumes. No special color assignment was used for the different dates although yellow was usually assigned to the image containing the least detail and contrast. In order to preserve the final diazo image, each composite was copied onto Ektachrome Professional Tungsten 50 film. Figure 1 shows the steps in constructing the composite.

Registration of the three scenes is a major problem in creating multitemporal composites. Landsat MSS images of different dates are easier to reg-

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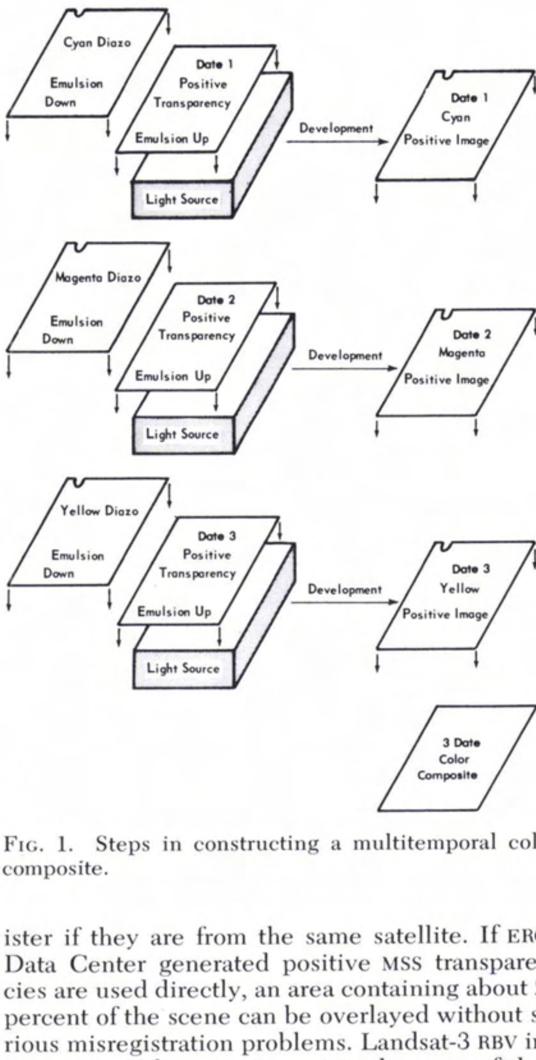

FIG. 1. Steps in constructing a multitemporal color composite.

ister if they are from the same satellite. If EROS Data Center generated positive MSS transparencies are used directly, an area containing about 25 percent of the scene can be overlayed without serious misregistration problems. Landsat-3 RBV images are much easier to register because of their higher resolution, and approximately half of an RBV scene can be satisfactorily registered as a multitemporal composite.

Figure 2 indicates the reconstruction of the colors in a simple multitemporal color composite in which the differences from one date to another are shown as binary reflectance changes. The black areas in the figure represent images of features that reflect little or no radiation as recorded on a particular MSS band or RBV scene. Conversely, the white areas in Figure 2 represent features of high reflectance imaged within each scene. If no change has occurred, the final color composite will show a neutral black or white, depending on the reflectance of the feature. If change has occurred (shown here as a binary response from high to low or vice versa), the multitemporal color composite will display this change as a subtractive or additive primary color. An actual multitemporal composite exhibits a full range of hues and tones with major reflectance changes appearing as bright colors and minor changes showing as subtle color differences. The only features that consistently appear as a neutral gray are urban areas; other features, even if exhibiting little change, are often displayed as a slightly colored neutral.

EXAMPLES

Table 1 indicates the location, sensor, date, and color code for the multitemporal color composites shown in Plates 1 through 6. Each of these composites is discussed in turn.

Plate 1, Georgetown, South Carolina: Three RBV images were selected for March-April anniversary dates over a three-year period in an attempt to examine change in this coastal region. The resulting multitemporal color composite displayed a considerable number of color differences which facilitated the differentiation of most of the vegetation types within the scene. Anniversary date composites should show an overall neutral or slightly colored neutral with brighter colored changes; however, March-April is the spring of the year and considerable variation in greening times occurred from year to year. Rain falling 42 hours before the acquisition of the 4 March, 1980 image may have altered the contrast of this particular scene.

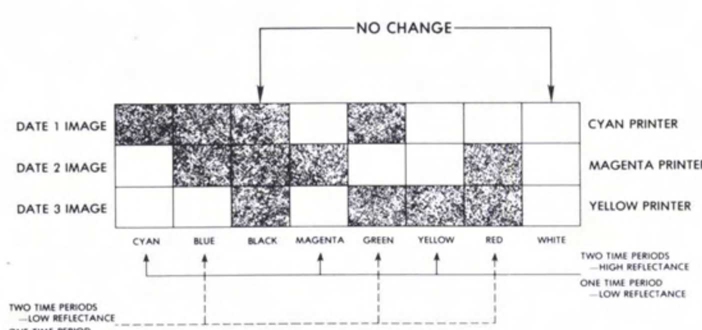

FIG. 2. Color code for a simple multitemporal color composite.

PLATE 1. RBV anniversary date multitemporal composite, Georgetown, South Carolina.

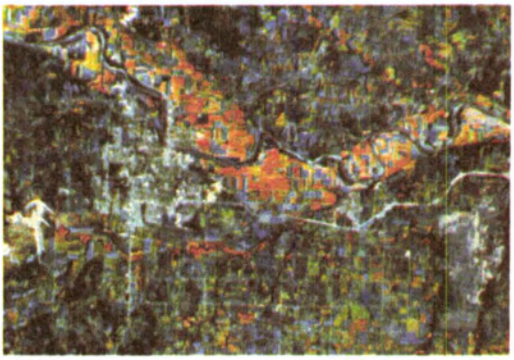

PLATE 2. MSS band 5 seasonal multitemporal composite, Eudora, Kansas.

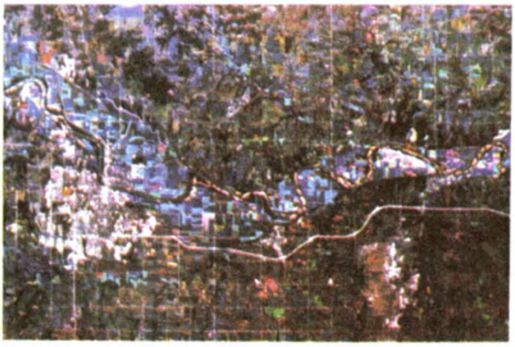

PLATE 3. RBV seasonal multitemporal composite, Eudora, Kansas.

PLATE 4. RBV seasonal multitemporal composite, Sandy Hook, New Jersey.

PLATE 5. MSS band 7 seasonal multitemporal composite, St. Louis, Missouri.

PLATE 6. RBV anniversary date multitemporal composite, Mt. St. Helens, Washington.

TABLE 1. LOCATION, SENSOR, DATE AND COLOR CODE FOR MULTITEMPORAL COMPOSITES

Plate Figure	Location	Sensor	Date	Color
1	Georgetown, SC	RBV	02 APR 78	Y
			28 MAR 79	M
			04 MAR 80	C
2	Eudora, KS	MSS-5	11 MAY 76	C
			16 JUN 76	M
			23 JUL 76	Y
3	Eudora, KS	RBV	02 MAY 78	Y
			18 AUG 78	C
			23 SEP 78	M
4	Sandy Hook, NJ	RBV	06 APR 80	M
			13 FEB 80	C
			24 JUL 80	Y
5	St. Louis, MO	MSS-7	02 OCT 72	C
			31 MAR 73	Y
			24 MAY 73	M
6	Mt. St. Helens, WA	RBV	29 JUL 79	M
			09 AUG 80	Y
			10 AUG 80	C

Plates 2 and 3, Eudora, Kansas: MSS band 5 transparencies were used to construct a multitemporal color composite (Plate 2) of an agricultural area situated predominantly in the flood plain of the Kansas River. Ground truth of this region was available from a previous study (Eyton *et al.*, 1979) for the 1976 growing season. The rationale for using the MSS band 5 images to produce a multitemporal color composite for agricultural crop identification can be found in Table 2; no other MSS band used alone produced a more accurate classification. The confusion matrix shows the results of a supervised discriminant analysis classification using band 5 data for three dates (20 May 1976, 25 June 1976, 19 August 1976) at Eudora, Kansas. The MSS band 5 multitemporal color composite for the same region shows corn as blue and wheat/beans as orange-yellow. The city of Lawrence (left side of Plate 2) and the Sunflower Ordnance Works (right side of Plate 2) appear in gray tones. A multitemporal color composite for the same region was constructed using 1978 RBV imagery (Plate 3). The light blue, dark blue, and green tones differentiate the crop types and the increased resolution enables the clear delineation of field boundaries and structure within the urban environment.

Plate 4, Sandy Hook, New Jersey: This multitemporal color composite was constructed from RBV images acquired in the spring, summer, and fall of 1980 in order to obtain maximum seasonal differences. The principal differences visible in the composite are the bright red areas corresponding to the fresh water ice build-up in the Navesink River, the Shrewsbury River, and Sandy Hook Bay. Seasonal differences in vegetation appear yellow on a brown background and the city of Longbranch, immediately south of the Shrewsbury River, is displayed as a purple hue.

Plate 5, St. Louis, Missouri: Three MSS band 7 images corresponding to "before," "during," and "after" stages of the 1973 Mississippi flood were used to construct this color composite. The extent of the flood at the confluence of the Illinois, Missouri, and Mississippi Rivers is visible as various shades of red and orange, resulting primarily from the high water March scene and the May scene which shows a wet flood plain with extensive areas of standing water. Considerable detail can be seen in this band 7 composite; flood plains of tributaries are reddish orange in color, vegetation appears yellow, the St. Louis urban area appears in neutral black-and-white tones, and the blue patches in the upper right of the figure are clouds present only in the March scene.

Plate 6, Mt. St. Helens, Washington: This composite was constructed from one pre-eruption RBV scene and two post-eruption RBV scenes. Seasonal differences in the images are at a minimum as the scenes were obtained within the same two week summer period (but from two different years). The areas of little or no change in the scene show up as a dark green or dark brown color, whereas the pink coloration delineates the denuded and ash covered areas resulting from the explosions of the volcano. The pink color is also visible in river channels and in clear cutting areas outside the main area of devastation.

CONCLUSION

The use of three images of different dates in the construction of a color composite produces an image in which features changing through time are displayed as various colors and areas of no change are displayed as gray tones. The wide

TABLE 2. CONFUSION MATRIX: MULTITEMPORAL BAND 5 DATA, EUDORA, KANSAS

	River	Forest	Corn	Wheat/Beans	Sand-Highway
River	96.4	0.0	0.0	3.6	0.0
Forest	4.3	95.7	0.0	0.0	0.0
Corn	23.2	0.0	76.8	0.0	0.0
Wheat/Beans*	3.8	0.0	0.8	95.4	0.0
Sand-Highway	0.0	0.0	0.0	0.0	100.0

* The wheat fields were harvested at the end of June and then planted with soybeans.

range of colors displayed in the RBV multitemporal composites in conjunction with their high resolution makes these products particularly useful. Multitemporal composites made from MSS band 5 or MSS band 7 images also displayed a wide range of colors containing a considerable amount of temporal information. The principal problems using currently available image products are the inability to register the entire overlapping portions of the images and the generally poor quality of the RBV scenes. These problems can be partially corrected through photographic copying and can be almost entirely eliminated if digital image processing techniques are used.

ACKNOWLEDGMENTS

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REFERENCES

Adams, J., R. H. Rogers, M. Walsh, and R. Reinhold, 1980. Evaluation of Multidate Data for Water Quality Modeling Applications, presented at the ASP 46th Annual Meeting, St. Louis, MO, March 9-14. (A reproduction of the multitemporal composite is included as the July plate in the 1980 ERIM calendar).

Deutsch, M., 1976. Optical Processing of ERTS Data for Determining Extent of the 1973 Mississippi River Flood in ERTS-1, *A New Window on Our Planet* (R. S. Williams, Jr. and W. D. Carter editors), U.S. Government Printing Office, Washington, D.C., pp. 209-213.

Eyton, J. Ronald, R. Li, and F. T. Ulaby, 1979. *Combined Radar and Landsat Multitemporal Crop Classification*, RSL Technical Report 360-10, The University of Kansas Center for Research, Inc., Lawrence, KS, 55 p.

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