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Macrophotography of Satellite Images

The enlargement of Landsat and Skylab images on high-definition, high-contrast film enhances details and aids in interpretation.

LANDSAT AND SKYLAB imagery may be enlarged to improve the examination of detail contained in the images. For continuous tone photography, such as obtained by the Skylab missions, the limit of enlargement is determined by the resolution of the film product and the final resolution of the enlargement acceptable to a viewer or interpreter. The resolution of an enlarged photograph acceptable for interpretation or viewing is a resolution (approximately 8 line pairs per millimetre) slightly better than the resolution of the human eye (5 to 6 line pairs per millimetre). The maximum enlargement a photograph should undergo would then be equal to the film product resolution divided by the acceptable viewing resolution of 8 line pairs per millimetre. For example, the maximum factors of useful enlargement for the Skylab high-resolution color photography obtained by the multispectral camera and the Earth terrain camera are shown in Table 1.

The resolution of images obtained from an electro-optical sensor such as the Landsat multispectral scanner is usually more difficult to assess. For Landsat the nominal ground resolution is about 100 metres with the equivalent photographic resolution for the Landsat 70 mm film product (1:3 369 000) estimated at 34 line pairs per millimetre. This would be a resolution of 10 line pairs per millimetre for the 1:1 000 000 product and 5 line pairs per millimetre for the 1:500 000 product. By conventional standards the 1:500 000 products have less than an acceptable viewing resolution.

For purposes of mapping detail, both the Skylab and Landsat images can be enlarged beyond the limits of normal viewing resolutions. If a high contrast film material is used to copy the satellite image, the results may be a duplicate with less than "acceptable" viewing resolution but an image that shows an increase in acutance or sharpness. We have found that carefully produced macrophotography will produce useful images at scales of 1:60 000 and, in some instances, at scales larger than 1:60 000. Although a number of conventional methods and materials are readily available for closeup photography, this note discusses an inexpensive but unconventional method of copying and some unconventional film materials.

ABSTRACT: *A simple method for the production of high quality macrophotography of satellite images using an enlarger is outlined. A list of unconventional films found to be useful for copying and enhancing detail is included.*

COPYING

We have used two methods for the macrophotography of Landsat and Skylab images. The first method uses a conventional 35 mm single lens reflex camera and macro lens for copying 1:1. Several useful films are available in 35 mm format only and this type of camera system requires little fussing for small magnification (down to 1:1) photography.

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TABLE 1. ENLARGEMENT FACTORS FOR HIGH RESOLUTIONS COLOR IMAGES FROM THE SKYLAB MISSIONS

Camera	Estimated Ground Resolution[1]	Estimated Photographic Resolution[2]	Nominal Contact Scale	Enlargement Factor	Enlargement Scale
Multispectral (S-190A)	43 metres	66 lp/mm	1:2 850 000	8.2×	1:350 000
Earth Terrain (S-190B)	21 metres	45 lp/mm	1:950 000	5.6×	1:170 000

[1] Low contrast estimated resolutions from *Skylab Earth Resources Data Catalog* GPO 3300-00586

[2] $r = \dfrac{\text{scale \#}}{R \times 1000}$

r = photographic resolution (line pairs per millimetre)
R = ground resolution (metres per line pair)

A second method especially suitable for higher magnification photography employs an enlarger and film magazines (sheet and roll) as the camera system. Figure 1 shows the necessary components. One side of the 4 by 5 inch sheet film holder can be used for focussing by inserting a white 4 by 5 inch sheet of paper in the film slot with the dark slide removed permanently. The dark slide (usually aluminum) of the roll film holder can be used to focus the image. However, the dark slide will be at least ⅛ in. above the film emulsion; therefore, before exposure the film holder should be raised ⅛ in. by placing a spacer (cardboard sheet) beneath it. Centering of the image can still be done on the dark slide (do not refocus) before exposure.

FIG. 1. Film holders for macrophotography under the enlarger: left, 4 by 5 sheet film holder; right, 120 roll film holder.

The Landsat or Skylab transparency should be placed in the enlarger correct-reading down; or another way to visualize the proper positioning of the transparency would be to take out the enlarger lens and look through the lens holder at the transparency in the film holder—the transparency should be the correct reading. The proper positioning of the transparency in the enlarger is important if the copy film is a negative material from which prints are to be made at a commercial laboratory.

LIGHTING

Copying imagery is usually done with photo-materials balanced for either tungsten (3200°K) or daylight (5800°K) lighting. When using the 35mm single lens reflex camera, either an Aristo DA-110 transparency illuminator (5800°K light) or a light box with a white plexiglass diffuser and 250 watt 3200°K bulb is used to illuminate the image. The enlarger method of copying requires that color balancing filters be attached to the enlarging lens to match film and lighting. Table 2 shows the necessary filtration for three standard enlarging bulbs.

FILMS

For general purpose copying most color negative and transparency films will yield useful results. It is usually not necessary to use special copying films for control of contrast and, although there will be an increase in contrast using conventional films, we have usually found this to be desirable when copying satellite images. Several unconventional films that have produced good to excellent results are given in Table 3. A film with which we have experimented that is particularly useful for enlarging images is

TABLE 2. ENLARGER BULBS AND COLOR BALANCING FILTERS FOR BALANCING TUNGSTEN AND DAYLIGHT FILMS

Enlarger Bulb	Bulb Color Temperature	Color Balancing Filters: Daylight Films (5800°K)	Color Balancing Filters: Tungsten Films (3200°K)
211 (75 WATTS)	2950°K	80B & 80C	82B
212 (150 WATTS)	2950°K		
300 (150 WATTS)	3100°K	80B & 82B	82

TABLE 3. FILMS FOR COPYING SATELLITE IMAGES

Film	Lighting	Format	Use
Eastman Kodak 5247 color negative film (used in the motion picture industry and readily available from special distributors).*	3200°K	35mm	An excellent film for copying which yields images that faithfully reproduce the original's color. Most distributors of this film offer a full range of services including slides and prints from the negatives at exceptionally low prices.
Eastman Kodak Photomicrography Color Film 2483	5800°K	35mm 4 × 5	A very high contrast color transparency film for copying and enhancing images. Some experimentation with color correcting (CC) filters may improve the renditions. (Cover photo.)
Eastman Kodak Vericolor II Professional Type L	3200°K	120 4 × 5	A color negative film for long exposures (longer than 1/10 second). Useful for producing color negatives under the enlarger.
Eastman Kodak High-Contrast Copy Film 5069	3200°K	35mm	A panchromatic very high contrast copy black and white film useful for close-up photography and enhancing detail.

* Most popular photographic magazines carry several advertisements of companies that sell and process this film.

Eastman Kodak Photomicrography Color film (2483). This high-definition, high-contrast transparency film can be used for the enhancement of detail and the further differentiation of boundaries between areas on the image that differ slightly in tone and color. Careful exposure is required (bracket all shots ±½ and 1 stop) because of the small exposure latitude. The cover photo (Champaign-Urbana, Illinois, population 100,000) was obtained on Photomicrography Color Film from a Landsat 7.3 inch color print copying at 1:1 with two 3200°K floods and an 80A filter.

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