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IR and Pan Films

A comparison between infrared- and panchromatic-sensitive films for aerial photography.

Abstract: *Aerial photographs of several scenes were made on both a clear and a hazy day with panchromatic- and infrared-sensitive aerial films. These photographs illustrate that the increased range that can be obtained with the infrared-sensitive film results both from the inverse wavelength dependence of the scattered light and the greater contrast between certain elements in the scene in the infrared spectral region.*

Introduction

The use of infrared-sensitive (IR) photographic film in aerial photography is well established. In general, infrared film is used for one of two reasons: (1) the black-and-white tone rendition of the ground scene is altered from that obtained with panchromatic film and certain objects are made more distinct owing to enhancement of the contrast between these objects and the background; (2) infrared film is sensitive to longer wave length light than is panchromatic film. Under atmospheric conditions where scatter from the haze depends on wavelength, infrared film will reduce the effect of the haze to a greater extent than will the panchromatic film.

Although striking examples of long-distance photographs are often used to show the advantage of infrared film over panchromatic film in recording more distant detail (see, for example, page 254 of Clark's book[2]), several authors have disputed the widely held belief that useful haze penetration can be obtained with infrared film in aerial photography of average-range scenes.

Harrison,[3] for example, presents data relating *visual range* to the ranges obtained with different film–filter combinations. Visual range has been found to correspond closely to the range achieved with panchromatic film and a yellow filter. The data show that the ratio of the photographic range that can be obtained with infrared film and a red filter to that obtainable with panchromatic film and a minus blue filter slowly increases as the visual range increases. At short visual ranges (less than 5 miles), Harrison's data indicate this ratio to be about 1.2. At a visual range of about 75 miles, which could be achieved only under very clear conditions, the infrared-to-panchromatic film range ratio is about 2. Harrison concludes that "the advantage of infrared does not become appreciable until conditions of exceptional clarity of the atmosphere are encountered."

Middleton[4] presents data like those of Harrison and reaches a similar conclusion, except that he adds an important qualification, to wit, "the photographic range of some types of scenery in the infrared will be further increased by the circumstance that green leaves have a very high reflectance in this region, resulting in high intrinsic contrast" (between the leaves and background).

Brock[1] discusses at some length the subject of haze penetration and the usefulness of infrared film for this purpose. He states that inasmuch as the extension of the photographic range which results from the use of the longer wavelength infrared radiation has been shown to be relatively minor except where the visibility is greater than about 30 miles, infrared photography would seem to offer most at long ranges. He continues by pointing out the unfortunate circumstances that at long ranges the detection and recognition of average-size objects are usually limited by the photographic resolution capabilities rather than by atmospheric haze. Thus, it would seem that infrared photography does not offer much advantage over panchromatic photography, at least from the standpoint of improvement due to the reduced scatter of the longer wavelength radiation.

Brock emphasizes the point made by Middleton that the real advantage of infrared film is its ability to alter dramatically the apparent brightness and contrast characteristics of the scene. The effect is particularly striking when the scene contains vegetation and/or water, both of which photograph much differently with infrared than with panchromatic film. Brock summarizes his discussion by stating that "the increase of contrast by infrared accounts for much of the improved clarity in infrared photographs taken under hazy conditions, quite apart from any genuine haze penetration due to smaller scatter of the relatively long wave light by the aerosols."

Experimental Procedure

In an attempt to verify these conclusions about infrared aerial photography, as well as to obtain several photographic comparisons between infrared and panchromatic film, two aerial tests were made in which simultaneous, long-range oblique photographs of different scenes were obtained on both types of film. One of the test flights was made on a very hazy day in August and the second, on a clear day a few days later.

A Cessna, Model 180, airplane was used for both aerial tests. The flying altitude was 4,000 feet on the hazy day and between 3,500 and 4,000 feet on the clear day. (It was necessary to fly at a somewhat lower altitude on the clear day to avoid scattered cumulus clouds.) Two Leica M-3, 35-mm. cameras fitted with 90-mm., $f/2.0$ Summicron lenses were used. The optimum focus setting for the camera used with the infrared film had been determined in an earlier experiment. The two cameras were mounted together in a bracket which enabled the operator to make simultaneous photographs of a scene on both films. One camera was loaded with Kodak Infrared Aerographic Film 5424, and the other with Kodak Plus-X Aerographic Film, Type 5401. A Kodak Wratten Filter No. 25 (red) was used with the former film and a Wratten Filter No. 12 (yellow) with the latter. An exposure series of four stops was made with each film and scene. All films were subsequently developed for eight minutes in Kodak Developer D-19 with Nikor Tank equipment. This process yields similar contrasts (gamma of about 2.2) and speeds (aerial exposure index of about 40) for the two films. Figure 1 shows the sensitometric curves.

Selected images from each of the films were subsequently enlarged about eight diameters on single-weight Kodabromide Paper. Enlargements from the negatives exposed under clear conditions were made on grade F-1 paper, whereas grade F-3 paper was used for those exposed under hazy conditions in an effort to regain some of the contrast lost through the effect of the haze.

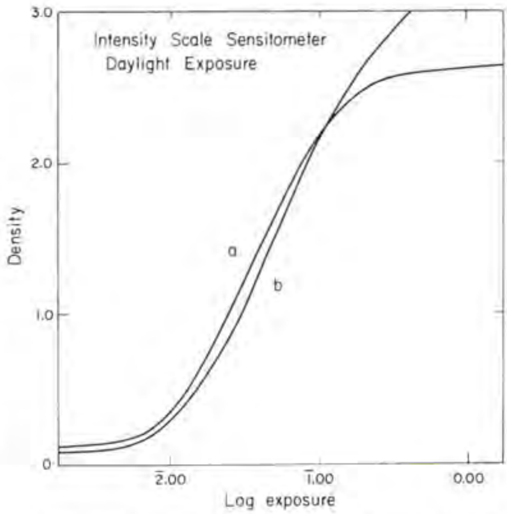

FIG. 1. Characteristic curves of (a) Kodak Infrared Aerographic Film 5424 exposed through a red filter (Kodak Wratten No. 25) and (b) Kodak Plus-X Aerographic Film, Type 5401 exposed through a yellow filter (Kodak Wratten No. 12). Both films were developed in Kodak Developer D-19 for 8 minutes.

Discussion and Results

Figures 2 through 5 present comparison photographs made with the pan and IR films under both clear and hazy conditions.

Figure 2 presents a northwest view from Rochester, N. Y., of the Lake Ontario shoreline. The increase in photographic range obtained with the IR film is apparent in both sets of pictures although it is more striking in that made under hazy conditions. These photographs illustrate that the IR film enhances the contrast between distant objects, which contributes significantly to the improvement in range. In particular, the contrast between water, which reflects virtually no infrared light, and the farmland vegetation, which has high infrared reflectance, is much greater in the IR spectral region than in the region defined by the sensitivity of the pan film.

Figure 3 depicts downtown Rochester from a vantage point south of the city. The IR pictures made under both the clear and the hazy conditions show the shoreline of the lake and the Genesee River (especially north of the city) more clearly than do the pan pic-

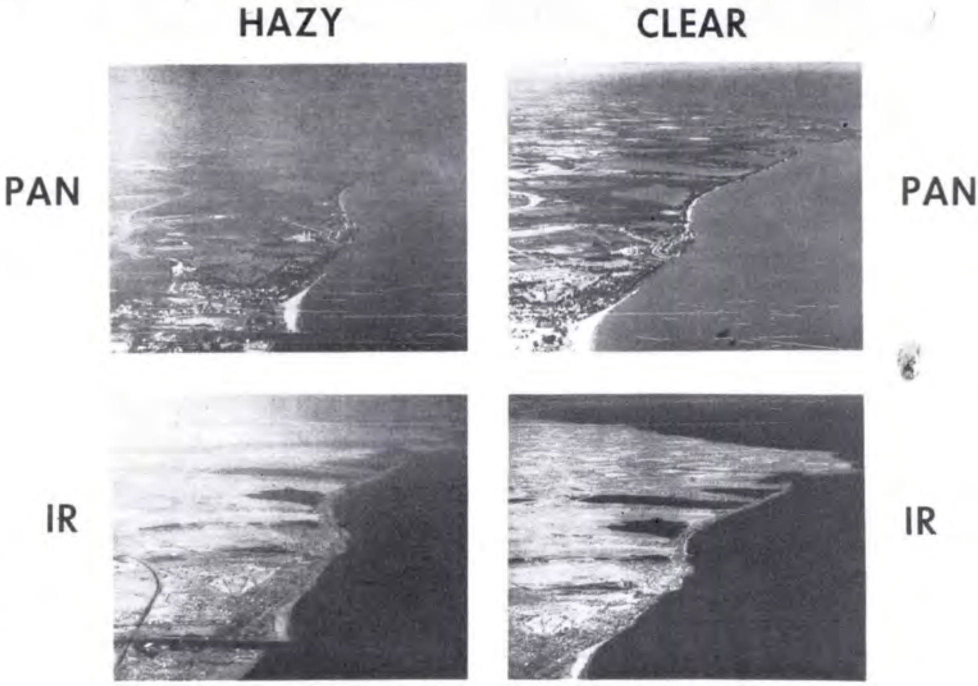

FIG. 2. Infrared and panchromatic photographs of Lake Ontario shoreline made under hazy and clear conditions.

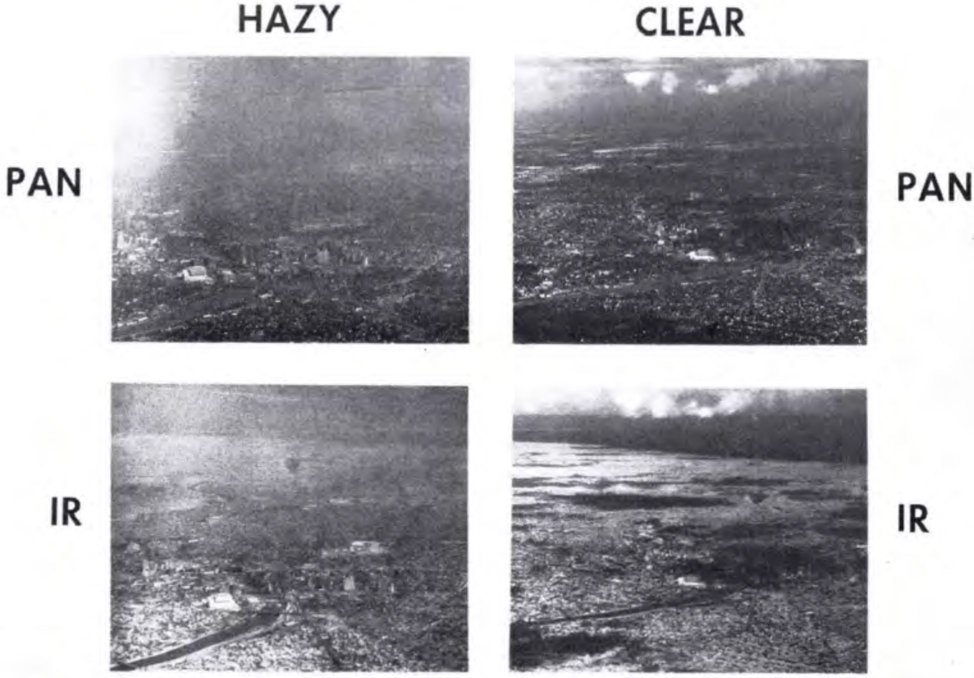

FIG. 3. Infrared and panchromatic photographs of the city of Rochester, New York, made under hazy and clear conditions.

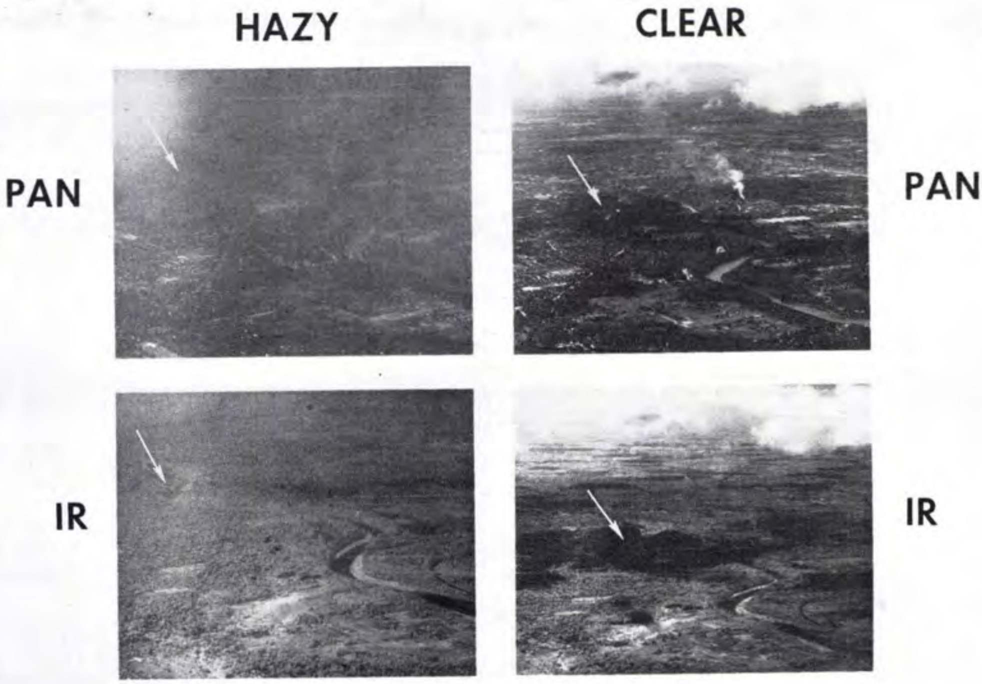

FIG. 4. Infrared and panchromatic photographs of the Genesee River and suburban Rochester, New York, made under hazy and clear conditions.

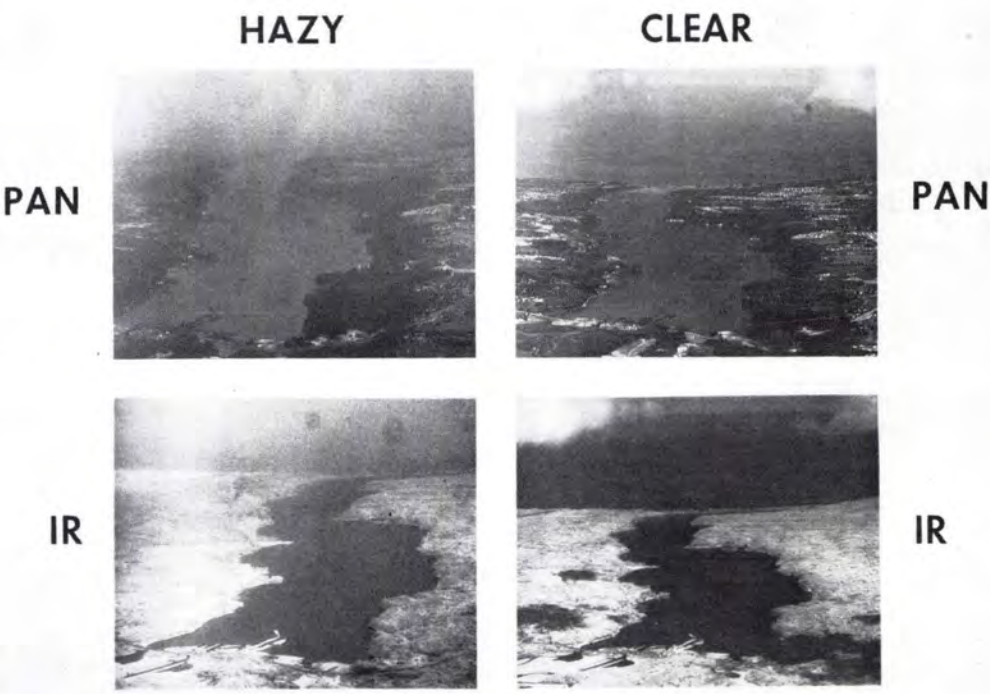

FIG. 5. Infrared and panchromatic photographs of Irondequoit Bay in Rochester, New York, made under hazy and clear conditions.

tures. If the clear-condition photographs are used as a reference, it appears that the shoreline in the IR, hazy picture is detectable primarily because of the greater contrast between the water and vegetation.

Figure 4 presents photographs of the Genesee River and sections of suburban Irondequoit and Greece. The view is approximately southwest and includes the Kodak Park Division of Eastman Kodak Company (in about the center of the photographs). In the clear pictures, the Monroe County Airport is visible near the top border. In this set, the photographic range of the pan and IR pictures taken under clear conditions is about the same. Under the hazy condition, however, the range is greater with the IR photograph.

A few items in this set of photographs are noteworthy. (1) the Veterans' Memorial Bridge, which is indicated by an arrow in the photographs, is more clearly identifiable on the clear day in the pan picture and on the hazy day in the IR picture. This is probably because on the clear day the bridge and its surround lie in a cloud shadow in which there is much less incident infrared radiation than there is in sunlit areas. As a result, this part of the scene is significantly underexposed on the IR film compared to the same area on the pan film. (2) The pictures taken on a clear day show the smoke from the stacks in Kodak Park. It is interesting to note that there is real penetration of this smoke with the IR film. This result indicates that the smoke particles were small enough to scatter light selectively with wavelength. (3) The IR pictures tend to hide the presence of man-made objects in the scene (in particular the roads and houses). This occurs because the trees and grass have apparently the same reflectance in the infrared spectral region as the roads and dwellings. These photographs illustrate that the panchromatic film has a distinct advantage over IR film for the detection and identification of uncamouflaged buildings.

Figure 5 presents photographs of Irondequoit Bay from the south. In the clear-day pictures, the horizon is visible in both photographs but is more distinct with the IR film. The Lake Ontario shoreline is more clearly defined on the hazy day with the IR film. It is again apparent that the IR film tends to obscure the presence of buildings and roads. The increase in contrast between the water and vegetation that can be obtained with IR film is strikingly illustrated in this set of pictures.

Conclusion

It is not possible to generalize about atmospheric scatter as a function of wavelength because of the varying nature and size of the particles which form the hazy atmosphere. Under some atmospheric conditions, haze penetration will be considerably greater with infrared film than it is with panchromatic film owing to the lesser scatter of the infrared radiation.

A second factor which contributes to the greater range of the IR film is the contrast enhancement between scene elements which is brought about by the higher (and lower) reflectances of certain objects in the IR spectral region than in the pan film sensitivity range.

We cannot draw conclusions from the photographs presented in this paper about the relative significance of the two effects which combine to increase the photographic range with IR film. This is so because we are able to detect the presence of atmospheric scatter in the photographs made on the clear day as well as those made on the hazy day. As a consequence, the two effects contributing to the improvement in range cannot be separated.

References

1. Brock, G. C., *Physical Aspects of Air Photography*, Longmans, Green and Co., London, 1952.
2. Clark, W., *Photography by Infrared*, Chapman and Hall, London, 1939.
3. Harrison, G. B., "The Scattering of Light in the Atmosphere" *Photographic Journal*, 85B, 57–62 (1945).
4. Middleton, W. E. K., *Vision Through the Atmosphere*, University of Toronto Press, Toronto, 1952.

Coming ISP Symposiums

Comm. I—Columbus, Ohio, U.S.A.; May 25–28, 1970.
Comm. II—Munich, Germany; Sept. 16–19, 1970.
Comm. III—London, England; Aug. 9–13, 1971.
Comm. IV—I.T.C., Delft, The Netherlands; Sept. 9–11, 1970.
Comm. V.—Paris, France; Sept. 21–23, 1970. To be followed by a joint meeting of the Council and the Commission Presidents, Sept. 24–26.
Comm. VI—Bratislava, Czechoslovakia; Sept. 1–3, 1970 (tentatively).
Comm. VII—Dresden, East Germany; Sept. 10–16, 1970.