Understanding Color-Infrared Photographs

U.S. Department of the Interior
U.S. Geological Survey

NASA color infra-red photo - New Orleans, LA

Images obtained by satellites and high-altitude aircraft give engineers and scientists a tool to study landforms, vegetation health patterns, environmental pollution, and other effects of human activities on the planet's surface.

Satellites and high-altitude aircraft equipped to record scenes of the Earth use both visible and invisible portions of the electromagnetic spectrum. Near-infrared light is invisible to the human eye, but adding it to these images allows scientists to "see" the surface of the Earth in other than natural colors. The result is "color-infrared" photography.

The electromagnetic spectrum is the scientific term for the collective types of light and energy emitted from the Sun. The portion of the spectrum visible to the human eye is the normal rainbow of colors we see every day. Passing sunlight through a prism separates white light into individual colors, just as sunlight through raindrops creates a rainbow. More technically, a prism divides light into its component wavelengths. Ripples on a lake can be close together or far apart and are analogous to light wavelengths and how closely they are spaced.

Other parts of the spectrum—such as the invisible near-infrared wavelengths—can be recorded by either electronic sensors or special photographic films sensitive to these wavelengths. These sensors and films record the energy reflected by the ground and the Sun's spectral energy. Near-infrared and visible wavelengths that are simultaneously recorded combine to provide a unique view of the Earth's vegetation and other features of the planet's surface.

This unique aerial view, created by a combination of wavelengths, gives scientists a means to better understand what is happening on the Earth's surface. For example, leaves of healthy, growing vegetation reflect a high level of near-infrared wavelengths and appear red on color-infrared film. Unhealthy or dormant vegetation may appear light red or a light shade of blue-green (cyan) depending on the plant's degree of good health. These color distinctions make color-infrared photograph, useful in assessing the health of plants. Water on the other hand, absorbs near-infrared wavelengths and appears black in the image. Water with varying amounts of suspended particles appears as shades of blue. Also, near-infrared wavelengths penetrate atmospheric haze and result in clear, crisp images. This is an important consideration when collecting satellite images and high-altitude aerial photographs.

Satellite electronic sensors and aerial color-infrared films both record visible and near-infrared wavelengths, but each of these systems requires different laboratory processes. Here is how they work.

Color-Infrared Photographs

Both standard-color and color-infrared films are manufactured to have three distinct layer or emulsions.

Color photo - near Burlington, Vt.

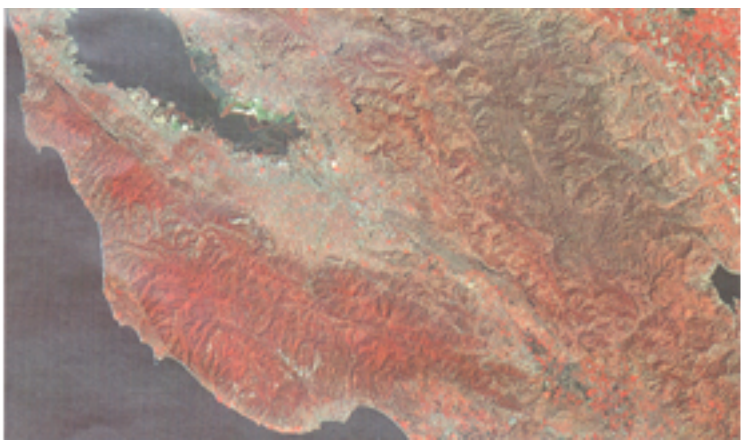
Color-infrared photo - same area

Each layer is sensitive to different wavelengths of energy. Standard-color film emulsions normally record the visible wavelengths as red, green, and blue. After recording the scene ("taking the picture"), chemical processing of the film generates cyan, magenta, and yellow dyes proportional to the amount of exposure given each layer. Color pictures result when the human eye views the varying combinations of the three dye layers. Color-infrared film has yellow filter over the three emulsion layers to block ultraviolet (UV) and blue wavelengths. The other emulsion layers are sensitive to green, red, and near-infrared wavelengths. Processing color-infrared film after exposure produces yellow, magenta, and cyan dyes. The near-infrared wavelengths and the lack of UV and blue wavelengths result in a clear, crisp color-infrared image. Green, healthy vegetation has a high reflection level of near-infrared wavelengths and appears red on the processed film; red objects with very low near-infrared reflection appear green; green objects with very low near-infrared reflection appear blue; and blue objects with very low near-infrared reflection appear black.

The Federal Government has color-infrared photographic coverage of the entire United States from high altitude (40,000 feet) and is obtaining similar coverage at a lower altitude (20,000 feet).

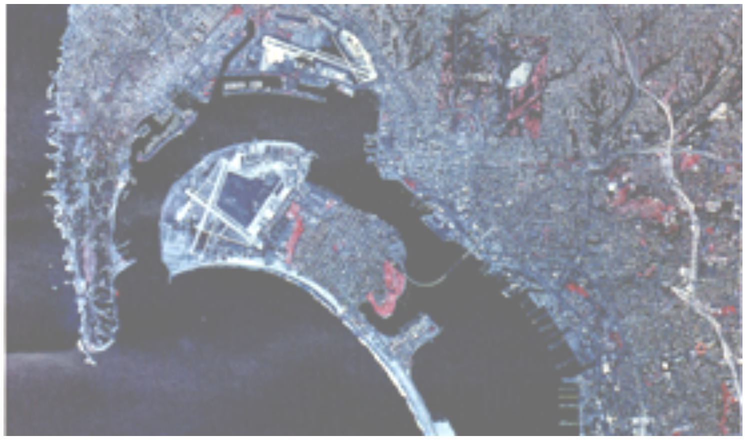
Color-Infrared Composite Images

Another type of color-infrared image is the color-infrared composite of multispectral data collected by electronic sensors on satellites such as Landsat. These sensors record the light levels of Earth's reflected energy (visible and near-infrared) and transmit digital image data to the ground in four to seven wavelength bands (groups) for each typical Landsat scene.



Landsat color-infrared composite - San Francisco, California

On the ground, the digital data convert to images similar in appearance to aircraft-acquired color-infrared photographs. Computerized image recording devices process the bands of green, red, and near-infrared digital data, exposing conventional color film with blue, green, and red light. In the resulting image, growing healthy vegetation appears red, clear water appears black, sediment-laden water appears light blue, and urban areas appear blue-gray.



NASA color-infrared photo - San Diego, California

How to Find More Information

For information about ordering color-infrared composites or color-infrared aerial photographs, please contact any Earth Science Information Center, or call 1-800-USA-MAPS.

More information on color-infrared technology is available from many libraries.

Among the many books addressing this subject are the following:

M. M. Thompson's Maps for America, U.S. Geological Survey (Government Printing Office, Washington, D.C., 1987)

Robert K. Holtz's The Surveillance Science: Remote Sensing of the Environment (John Wiley and Sons, 1985).

For more technical information you might consult the Manual of Remote Sensing, published by the American Society of Photogrammetry and Remote Sensing, 5410 Grosvenor Lane, Bethesda, MD 20814-2160.

Landsat color-infrared composite - Williams, California quadrangle