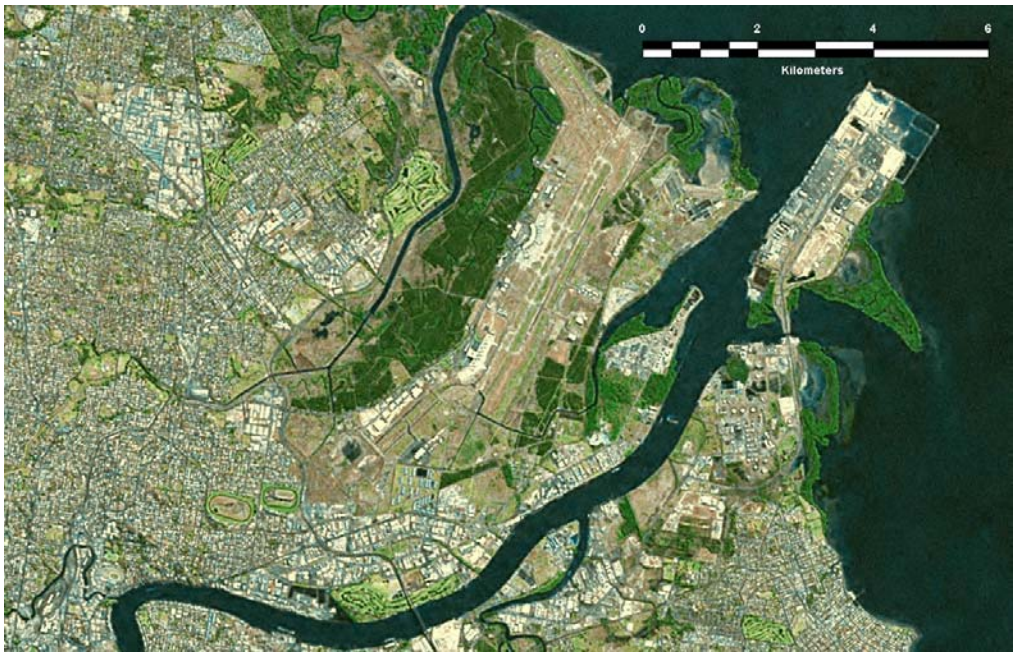
TerraColor® White Paper

TerraColor® is a simulated true color digital earth imagery product developed by Earthstar Geographics LLC. This product was built from imagery captured by the US Landsat 7 (ETM+) remote sensing satellite, and provides nearly seamless coverage of most of the world's land areas (excluding Antarctica) at 15-meter spatial resolution. TerraColor can be used for a wide variety of applications, including land use analysis, vegetation mapping, military/defense logistics, flight simulation, accurate cartographic mapping and many others. The imagery provides colorful, detailed and visually pleasing views of the earth, and is suitable for mapping at scales of 1:50,000 and higher.



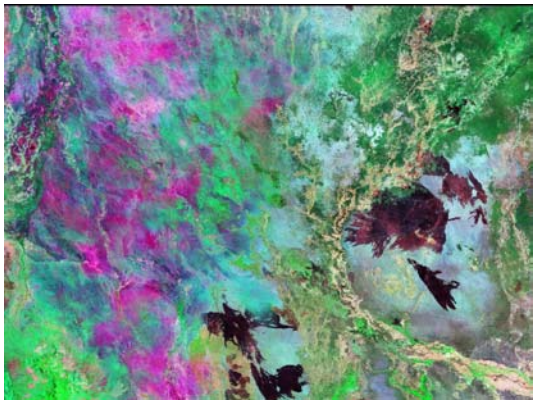
Brisbane, Australia

TerraColor was produced from the GeoCover public domain mosaic products developed for NASA's Earth Science Enterprise Scientific Data Purchase Program. Use of this accurate, high quality public domain imagery as a base greatly reduces the cost of creating a global dataset, and enables us to provide TerraColor at affordable pricing. NASA selected bands 7, 4 and 2 of the Landsat satellite (false color) for the 3-band RGB mosaics because they provide a wealth of spectral (color) information about vegetation, geology and other features not visible to the human eye. However, the "false" colors can be difficult for average people to interpret, so TerraColor was created to provide an alternative dataset that simulates the natural colors of the earth. Below are some examples of the TerraColor imagery and the standard 742 false color imagery from which they are derived:

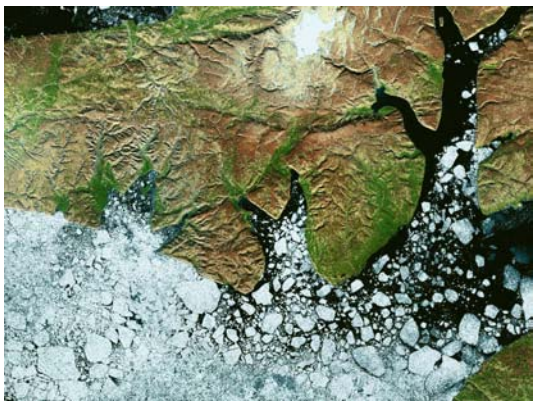
TerraColor (San Francisco Bay, USA)

NASA 742 image

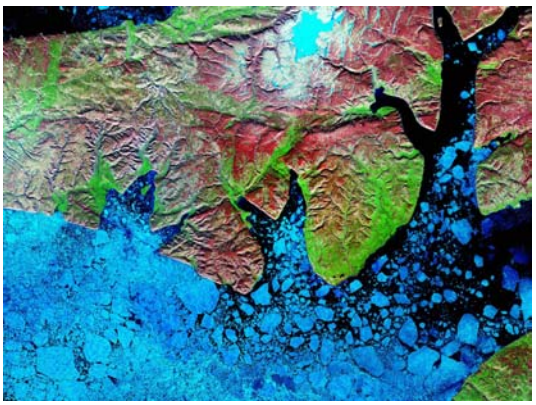
TerraColor (southern Sudan, Africa)



NASA 742 image



TerraColor (Melville Island, Canada)



NASA 742 image

TerraColor was carefully developed to retain the best characteristics of the false color input imagery while presenting the data in a natural color scheme that is easy for anyone to interpret. Since the source false color imagery (bands 742) contains information not discernable to the human eye, TerraColor actually contains more color/spectral information about many landcover types than true color imagery. (True color uses bands 3, 2 and 1 of the Landsat sensor which are sensitive to the same red, green and blue wavelengths of light as the human eye.)

One of the benefits of simulated true color imagery built from some infrared components is the outstanding information on vegetation type, abundance and health. TerraColor emphasizes the difference between vegetation types, and contains much more overall information about vegetation health, growth stage and other factors than true color imagery.

One of the compromises of simulated true color imagery is the reduced information on water depth and turbidity when compared to true color imagery. In true color imagery, water may be many shades of blue, green or brown. In TerraColor, water is generally a blue-green tone and slightly darker than it would be in true color. Due to the infrared components, TerraColor has better discrimination between land and water bodies, so may provide a preferable presentation of the land-water interface for analysis and cartography.

Use of the infrared bands in the source 742 imagery also reduces problems with clouds and atmospheric haze that can be much more pronounced in true color imagery, and adds to the overall clarity of the TerraColor imagery. This is especially apparent in hazy, humid tropical areas with persistent cloud cover, as well as areas with high particulate air pollution such as parts of China.

Processing Techniques

TerraColor was created using a proprietary method involving linear band combinations, image thresholding and other image processing techniques. The two most important components of the simulated true color imagery are the color scheme and the overall contrast and brightness.

True color imagery can be dull or bland without saturation enhancements or other color amplification techniques. The RGB colors of TerraColor were computed using algorithms to convert the RGB false color input values into a color scheme close to true natural color, but with more color variation and definition. So rather than *suppressing* the spectral information content to make it look more like true color and reduce vegetation information, we *translated* it to retain the information content while simulating true color. TerraColor is therefore more colorful than true color imagery, which makes it easier to differentiate land features and vegetation types for the average person and adds to the product's general interest and ease of interpretation.

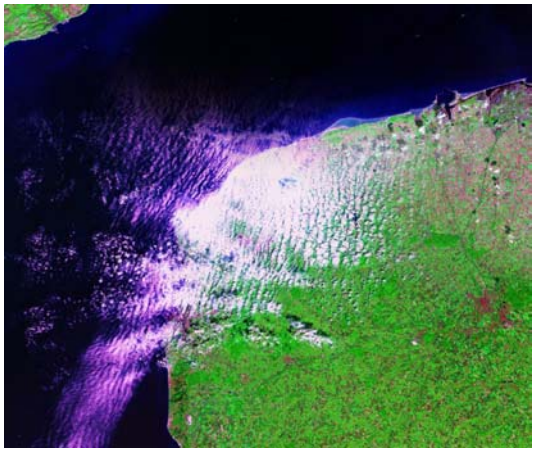
The NASA 742 mosaic products were created using a proprietary "LOCAL" contrast stretch (Locally Optimized Continously Adjusted Look-up-tables) that does an excellent job of pulling out the detail contained in the Landsat data without causing overly dark, light or saturated imagery. To retain these qualities, we developed a Red Green Blue Intensity (RGBI) technique to convert the brightness of the 742 data to roughly simulate the brightness of true color. This results in a bright, colorful image with almost no areas where details are obscured by being to dark or light. This technique also ensures that brightness and contrast are consistent across the entire global dataset, without regional or local variations.

During the production of TerraColor, we also repaired many of the errors and inconsistencies inherent in the NASA 742 mosaic imagery. These include areas of corrupted data, streaks in the data, and noticeable seam lines between adjacent images. Repairs for corrupted data and streaks were made primarily by borrowing "clean" data from overlapping areas of adjacent tiles or using alternate Landsat scenes from the same NASA orthorectified data pool. Most seams were repaired using a technique to feather the brightness/color changes.

Seam in adjacent NASA tiles (Somalia)

TerraColor with seam repaired

In a few areas, enhancements were made to insert clear imagery into areas covered by clouds. These modifications were made using alternate Landsat scenes from the same NASA orthorectified data pool.



Cloud in NASA data (English Channel)

TerraColor cloud filled with alternate scene

Product Specifications

The TerraColor global coverage encompasses approximately 8,500 individual Landsat scenes divided into roughly 800 TerraColor tiles (each a mosaic of 10-12 Landsat scenes). The product is offered in ECW and JPEG2000 compressed image formats for ease of use and delivery. (GeoTIFF and BIL/HDR are also available depending on the size of the area.) The TerraColor mosaic tiles are offered in UTM and Geographic map projections and the WGS84 datum.

- The Universal Transverse Mercator (UTM) mosaic tiles generally extend north-south over 5 degrees of latitude, and span east-west for the full width of the UTM zone. The pixel resolution (GSD) is 14.25 meters. For mosaic tiles between 60 degrees north and 60 degrees south latitude, the width of the tile is the standard UTM zone width of 6 degrees of longitude. For mosaic tiles above 60 degrees of latitude, the UTM zone is widened to 12 degrees, centered on the standard UTM meridian. To ensure overlap between adjacent UTM zones, each mosaic extends for at least 50 kilometers (31 miles) to the east and west, and 1 kilometer (0.62 miles) to the north and south.

- The Geographic mosaic tiles are cast in a generic Latitude Longitude projection with units of decimal degrees. The pixel resolution (GSD) is 0.5 arc-seconds (0.0001388 decimal degrees). Each mosaic tile extends approximately 5 degrees north-south and 6 degrees east-west. (A small amount of overlap between tiles was added so they are slightly larger than 5 x 6 degrees.)

Complete mosaics of large countries and continents are also available as single image files in ECW or JPEG2000 formats.

Note: Adjacent east-west image pairs are only guaranteed to be seamless in the Geographic projection. Minor seams may be visible in a few areas when UTM tiles from adjacent zones are laid side by side.

Data Specifications

The public domain source imagery used to create TerraColor was produced for NASA's Earth Science Enterprise Scientific Data Purchase Program. The following are specifications on this dataset, and also specifications that apply to TerraColor:

- **Year of data acquisition** - Primarily year 2000, with some scenes from 1999, 2001 and 2002.

- **Cloud cover** - 90% of the source Landsat scenes used have less than 10% cloud cover. Cloud cover is heaviest over equatorial tropical rain forest areas, while temperate regions can be up to 99% cloud free in some areas.

- **Data quality** - Overall data quality is excellent, but occasional errors inherent to the Landsat sensor (scan line errors, etc.) can be found in some areas. The imagery is virtually seamless for the most part due to use of sophisticated contrast adjustment and edge feathering algorithms, and use of scenes from the growing season where possible.

- **Registration accuracy** - All Landsat scenes used as input to the mosaic products were rigorously orthorectified using the best geodetic control and elevation data available to the US government. The products have been verified to have absolute positional accuracies of +/- 50 meters RMSE, with RMSEs under 25 meters validated in some parts of the world.