

HighView User Guide
(Version 2.5.3)



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DOS-based HighView Utility Programs

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1. Introduction

HighView is an advanced image fusion and pan-sharpening software program. It successfully merges low-resolution multispectral bands with high-resolution panchromatic band of recent satellite images (e.g., QuickBird, IKONOS, KOMPSAT-2, FORMOSAT-2, ALOS, SPOT-5 and Landsat 7 ETM+).

HighView uses GeoSage's state-of-the-art and highly efficient image fusion algorithms that have been developed over the past few years, and it has been extensively tested with a variety of images.

1.1 Image fusion and pan-sharpening

Image fusion is a concept of combining multiple images into composite products, through which more information than that of individual input images can be revealed.

As an example of image fusion, pan-sharpening describes a process of transforming a set of coarse (low) spatial resolution multispectral (colour) images to fine (high) spatial resolution colour images, by fusing a co-georegistered fine spatial resolution panchromatic (black/white) image. Typically, three low-resolution visible bands - blue, green and red - are used as main inputs in the process to produce a high-resolution natural (true) colour image. Figure 1.1 illustrates this: the middle image is a natural colour image with a spatial resolution of 2.4 m (resampled 400%), and the left image a panchromatic image with a spatial resolution of 0.6 m; by combining these inputs, a high-resolution colour image is produced. In the fused output, spectral signatures of the input colour image and spatial features of the input pan image, as the best attributes of both inputs, are (almost) retained. The spectrally and spatially enhanced image is often visually appealing, starting to compete with high-resolution aerial photographs.



Image Source: ©2004 DigitalGlobe, Inc. All RIGHTS RESERVED

Figure 1.1: Image pan-sharpening with QuickBird images. The left and middle input images are obtained from DigitalGlobe, and the right-hand image is the fused result from *HighView*. All images are subject to the same histogram stretch.

1.2 Methods

The past few decades have seen quite a few image fusion and pan-sharpening methods in the public domain, including those based on multi-resolution wavelet transforms, PCA (Principal Component Analysis) transforms, and IHS (Intensity-Hue-Saturation) transforms. These methods, however, largely disregard important spectral characteristics of specific satellite sensors, therefore no consistent, colour-preserving results can be achieved. In other words, a simple data-driven approach without referring to spectral evidence can hardly produce satisfactory outcomes. This becomes more apparent when the recent generation of high- and medium-resolution satellite images is available, where there are marked spectral disparities between colour bands and the panchromatic band.

For more information on spectral features and curves of recent satellite sensors, please refer to websites of major image vendors as follows:

www.digitalglobe.com

www.spaceimaging.com

www.orbimage.com

landsat7.usgs.gov

www.spot.com

HighView searches physical evidence of spectral characteristics and applies optimisation methods to perform ideal image pan-sharpening.

HighView has two versions: GUI-based *HighView* (up to version 2.5.3) and DOS-based *HighView* (version 3.0, the latest version). The former is ideal for casual users while the latter is designed for active professional users.

It is hoped that *HighView* will help explore our innate fascination with images of our land.

2. Framework

GUI-based *HighView* adopts a comprehensive image fusion workflow which includes three steps - band combination, pan-sharpening, and assessment. To operationalise them, *HighView* contains a series of analytical modules (Figures 2.1).

- Band combination: Prepares low-resolution natural or false colour composites, which can be used to compare with pan-sharpened results;
- Pan-sharpening: Forms the core of our image fusion program. *HighView's* single step pan-sharpening incorporates four efficient optimisation methods, and a number of spatial and spectral enhancement options; and
- Assessment: Includes both visual and quantitative appraisals. Three convenient tools are provided for facilitating quantitative assessments.

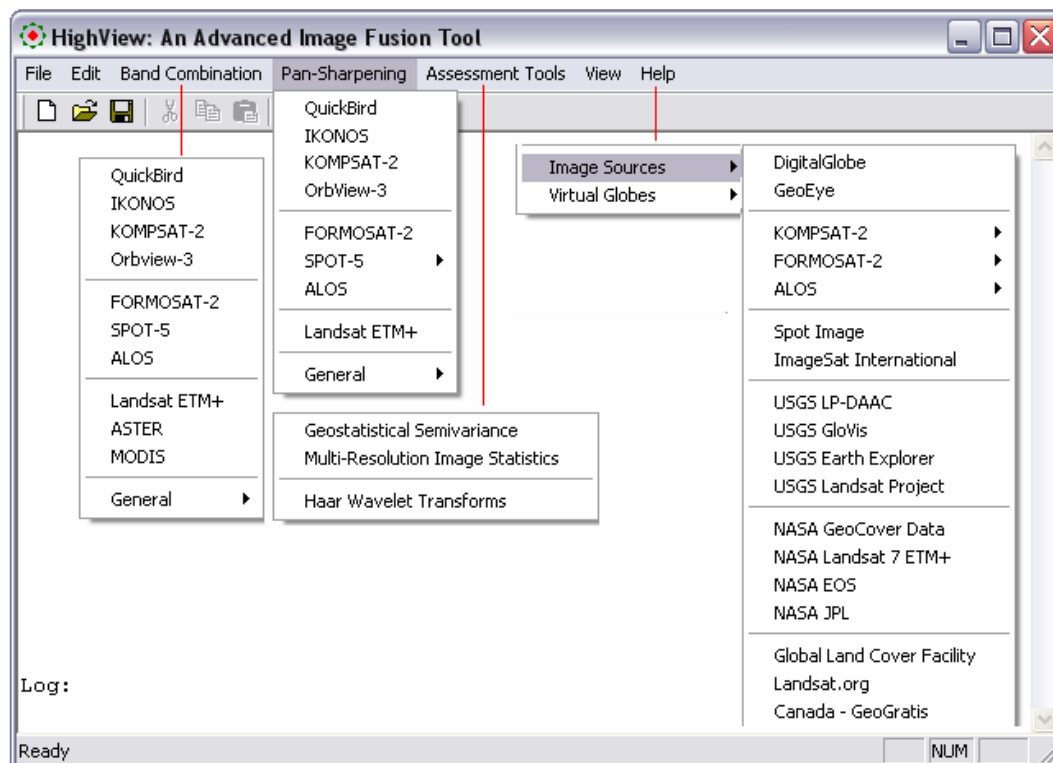


Figure 2.1: GUI-based *HighView* menus (Version 2.5.1)

GUI-based *HighView* reads 8- or 16-bit generic image matrices, including ENVI's *.img/*.hdr format and Idrisi32's *.rst/*.rdc format. Images in GeoTIFF format from major image vendors are also supported.

The main window of GUI-based *HighView* is a text file editor (log file editor), displaying progress information of individual runs. An example of the log file is shown below:

```
Log File:
----- Pan-Sharpening Run (1) -----

(a) Input High Resolution Panchromatic Band:
PAN:   C:\tmp\view\pan.img
Width:          17312 pixels
Height:         15338 pixels
Image Size:     265531456 pixels
File Size:     265531456 bytes

(b) Input Low Resolution Multispectral Bands:
Blue:  C:\tmp\view\b1.img
Green: C:\tmp\view\b2.img
Red:   C:\tmp\view\b3.img
Width:          8656 pixels
Height:         7669 pixels
Image Size:     66382864 pixels
File Size:     66382864 bytes

(c) Key Parameters:
Pan-Sharpening Method:   Optimisation 1
Resampling Method:      Improved Bilinear
Spatial Filtering:      None
- Blue:                  No
- Green:                 No
- Red:                   No

(d) Output Pan-Sharpened Colour Images:
Blue:  C:\tmp\view\b1_Fused.img
Green: C:\tmp\view\b2_Fused.img
Red:   C:\tmp\view\b3_Fused.img

BMP:   C:\tmp\view\pan_Fused.bmp
Display it?      No
Stretch:
  Colours match with those of inputs more closely? No
  Histogram stretching: cutoffs at both ends (%)
  - Blue:           left-side: 2 right-side: 2
  - Green:          left-side: 2 right-side: 2
  - Red:            left-side: 2 right-side: 2
  Nonlinear stretching: 0 (None)

(e) Analytical Steps
Step 1: ..... Finished
Step 2: ..... Finished
Step 3: ..... Finished
Step 4: ..... Finished
Step 5: ..... Finished (24-bit BMP output)

(f) Seconds spent: 400 s
Start time:        Sat Jul 10 13:51:20 2004
Post-processing:   Sat Jul 10 13:56:57 2004
End time:          Sat Jul 10 13:58:00 2004

Notes:
```

3. Download and Installation

GUI-based *HighView* (current version 2.5.3) is a Windows-based program, compatible with all recent Windows operation systems, such as Windows XP and Windows Server 2003.

If you are interested in GUI-based *HighView* and wish to test it, its free trial version can be downloaded at GeoSage's website. You may use the trial version to test with your own data before making any decision of purchase.

Four easy steps to download and install the trial version

Step 1: Read the license agreement.

Step 2: After you accept the license agreement, you can start to download a zipped file containing the software (size ~1.0 MB).

Step 3: Use WinZip to unpack the downloaded file, and extract a single setup program "setup.exe" to a temporary folder (e.g., C:\tmp\).

Step 4: Double click "setup.exe" to install *HighView*.

The installation includes *HighView* User Guide in PDF format, an installation key file, and a small Landsat sample data set.

Free Trial Version

The free trial version of GUI-based *HighView* is fully functional for band combination of 8- or 16-bit satellite images (e.g., global orthorectified Landsat 7 ETM+ imagery available at USGS GloVis and the Global Land Cover Facility, ASTER, SPOT, QuickBird and IKONOS)), having no limitations on image size and output format. Stretched output images in 24-bit BMP format and/or un-stretched output in native GeoTIFF format can be readily used as base maps or backdrops in major GIS software, such as ArcGIS and MapInfo. Various options of linear and nonlinear stretches are also allowed during the band combination.

GeoSage is committed to advocating the wider use of free imagery for the general public: "free imagery, free utility, and real results".

The free trial version of GUI-based *HighView* has no expiry date.

For other modules, the trial version has the following limitations:

- Pan-sharpening with local & global optimisation methods: The maximum size of input images is 32768*32768 pixels. Outputs will be limited to 24-bit BMPs only (with white grids).
- Maximum number of scenes to be processed in a batch mode is five.

- Maximum size of input images for quantitative assessment modules is 128*128 pixels.
- False-to-true colour simulation for G/R/NIR input is disabled.

Installation of General/Professional Version

If you have successfully placed an order of GUI-based *HighView*, we will inform you the website address where you can download the software package. Meanwhile, a password to unzip the software package and a licensee-specific installation key file will be sent to you.

Once you have received the software package and the installation key file, here are the four steps you should follow:

Step 1: Use the password to unzip the software package, then extract the setup program "setup.exe" to a temporary folder (e.g., C:\tmp\).

Step 2: Double click "setup.exe" to install GUI-based *HighView*.

Step 3: Save the installation key file in the same folder of the program "HighView.exe", e.g., C:\Program Files\Geosage\HighView\.

Step 4: Double click GUI-based *HighView* desktop shortcut or GUI-based *HighView* program menu in Windows Start | Programs, ready to run.

4. Input Requirements and Output Format

4.1 GUI-based *HighView* Input Requirements

Image format

- GUI-based *HighView* reads input images in ENVI's *.img/*.hdr format, IDRISI32's *.rst/*.rdc format, and generic matrix format (i.e., raw raster data). Image file type should be binary, not ascii. GUI-based *HighView* can be used complementary to your existing image analysis software.
- Images in GeoTIFF format from major image vendors (e.g., DigitalGlobe, Space Imaging, Global Land Cover Facility) are also supported. In band combination and pan-sharpening analyses, input images in GeoTIFF format are first converted to raw raster data, and once pan-sharpening is finished, fused images in raw raster data format are converted back to GeoTIFF format. This process can be slow, and is now improved with the latest version of *HighView*, which is DOS-based and reads/writes GeoTIFF files directly.
- If your images are in other formats, such as those of IMAGINE and PCI, you have to convert them to the above formats supported. Almost all major image analysis programs have related export functions. If you cannot convert them, you may wish to download and use some versatile image display and analysis programs available in the public domain, such as OpenEV and GRASS. Both are equipped with very powerful conversion functions for raster images. For example, you can open or import images in OpenEV, then export them to generic matrix formats, such as Atlantis MFF format (consisting of an ascii header file and band-specific data files). If you use images in this generic matrix format, you need to supply image width and height from the related header file.

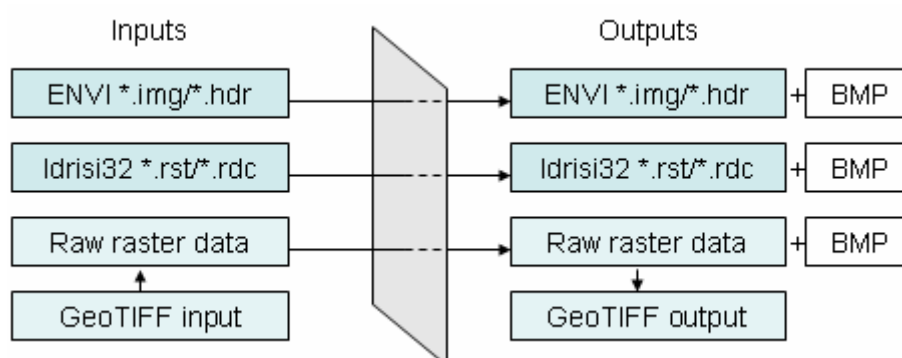


Figure 4.1: Image formats supported in GUI-based *HighView* image pan-sharpening

Georegistration

All input images in a pan-sharpening run should be co-georegistered, covering the same area of interest. Poorly georeferenced inputs will not produce any valid outputs.

Image size

The size ratio of input Pan band to input Ms bands is sensor-specific. For example, if you are using QuickBird or IKONOS images, the size ratio should be exactly 4:1; for Landsat ETM+ inputs, the size ratio is 2:1. If your input images are not compatible with these size ratios, you may wish to use your own software or publicly available tools to subset the input images. For example, if you are using OpenEV, you can subset images in its Export function.

You may wish to manually check the image size and the file size of input bands before analysis. For example, for 16-bit QuickBird images in a generic matrix format, if the image size of Pan band is 4096 x 4096 pixels, then the image size for input Ms bands should be exactly 1024 x 1024 pixels; in this case, the file size of Pan band is 32 MB (4K*4K*2 bytes), and the file size of each Ms band is 2 MB (1K*1K*2 bytes).

Data type

For 16-bit high-resolution imagery: QuickBird and IKONOS

Major image vendors, such as DigitalGlobe and Space Imaging, distribute their fine spatial resolution images in either 16- or 8-bit format. 16-bit imagery holds the original 11-bit dynamic range (i.e., 2^{11} or 2048 possible intensity values for each pixel, or with the digital number (DN) range 0-2047). With its full dynamic range, 16-bit inputs would produce better pan-sharpening outcome than that of 8-bit inputs. Therefore, for the best practice, try to use the 16-bit inputs with the DN range 0-2047 in pan-sharpening high-resolution imagery. If your inputs are in indeed 8-bit, a general pan-sharpening tool is also provided (GUI-based HighView Version 2.5 or latter). Just bear in mind that the distribution of DN of each input multispectral band has an impact on final pan-sharpening results.

For 8-bit medium-resolution imagery: Landsat 7 ETM+, and SPOT-5

As original Landsat ETM+ and SPOT-5 data are distributed in 8-bit (i.e., 256 possible intensity values for each pixel, or with the DN range 0-255), only 8-bit data are allowed in pan-sharpening. If your inputs are in 16-bit or in other data types, convert them to 8-bit first.

4.2 GUI-based HighView Output Format

- If input images are in ENVI's *.img/*.hdr format or IDRISI32's *.rst/*.rdc format, the image format for fused outputs will remain the same, with updated header files. Each fused band is saved as a separate file. This treatment has advantages if fused images are very large. For example, a single 16-bit band with the size of 16K x 16K pixels reaches 512 MB (16K*16K*2 bytes); a single file with such four bands together will have the file size of 2,048 MB. For many image analysis programs, it is easier to manage small-size images.

- If input images are in a generic matrix format other than the above two formats, the fused images will be generated with no header files.
- If input images are in GeoTIFF format, the image format for fused outputs will be GeoTIFF format.
- All band combination and pan-sharpening modules output *stretched* 24-bit BMPs for convenient visualisation.

5. Features

There are three categories of analytical functions in GUI-based *HighView*.

- ❖ Band combination and image stretching
- ❖ Pan-sharpening
- ❖ Assessment

5.1 Band combination & image stretching in GUI-based HighView

- Linear stretching: Users can set any % of band-specific total image pixels to be excluded in the stretch range.
- Nonlinear stretching: Users can adjust the level to display the full range of image intensities from very dark to white, and to make colour composites photographic for better visualisation by human eyes.
- Stretched output imagery in 24-bit BMP and/or un-stretched output in GeoTIFF format: Users can display and edit bitmaps in popular software such as Microsoft Paint and Adobe PhotoShop, and display GeoTIFF images in most remote sensing and GIS software programs.
- A batch processing mode enabling users to process hundreds or thousands of images overnight.
- Advanced simulation method for making true-colour composite from false-colour Green/Red/Near Infrared bands: Specifically for SPOT-5 imagery, but also applicable to the G/R/NIR bands of Landsat ETM+, ASTER and others. Six colour templates are provided. (Only included in GUI-based *HighView Professional* version.)

Most image analysis programs apply the above two stretching methods separately; however, the combined use of these two methods for individual R/G/B bands often results in output images with stronger visual appeal.

Notes:

- If your inputs are in ENVI's *.img/*.hdr format or Idrisi32's *.rst/*.rdc format, the program reads related header file automatically and obtains the width and height of the input image.
- If your inputs are in a generic matrix format other than the above two formats, you have to manually provide the image dimension (width and height).
- If inputs are in GeoTIFF format, HighView reads image sizes automatically.

- Input image in ENVI's *.img/*.hdr format:
16-bit input: a single band or 4 bands (interleave type: BSQ); data type = "12"
(unsigned short)
8-bit input: a single band or 3-8 bands (interleave type: BSQ); data type = "1" (byte)
Input data should not be compressed.
- Input image in Idrisi32's *.rst/*.rdc format:

16-bit input: data type should be unsigned short (2 bytes)
8-bit input: data type should be unsigned char (1 byte)

For multispectral band input, *HighView* also reads Idrisi32's Group Raster File (*.rgf).
All images within the Group Raster File should have the same size.
- When using raw raster inputs, enter image width and height correctly, ensure not to have them swapped.
- Specify bands correctly for band combination. For QuickBird and IKONOS imagery: band 1 (blue), band 2 (green), band 3 (red), and band 4 (NIR); for Landsat ETM+ imagery: band 1 (blue), band 2 (green), and band 3 (red); for SPOT-5 imagery: band 1 (green), band 2 (red), band 3 (NIR), and band 4 (short-wave infrared – SWIR).
- If the output is in GeoTIFF format and contains three bands, the order is Red band, Green band, and Blue band.

Tips:

- Linear stretching: In most cases, it is not necessary to change the % cutoffs.
- Nonlinear stretching: One or two levels of nonlinear stretching would be always helpful to improve image rendering in many cases.
- If each R/G/B band is the same, a 24-bit black/white BMP will be generated.

5.2 Pan-sharpening Modules in GUI-based HighView

- Local spectral/spatial optimisation method
- Global spectral/spatial optimisation method
- An efficient, improved bilinear resampling scheme
- Spatial enhancements (sharpen, detail, or none) for any selected set of bands
- Colour enhancements by adjusting R/G/B factors
- Option for matching histogram stretches used during band combination
- For Landsat ETM+ inputs, four options of spatial enhancements (including two for noises reduction)
- Pan-sharpened output imagery with full, unstretched dynamic range
- Pan-sharpened output imagery in 24-bit BMP format under linear and nonlinear stretches and/or GeoTIFF format
- A batch processing mode that can be easily integrated with enterprise workflows.
- Applicable to QuickBird, IKONOS, Landsat ETM+ imagery and many others
- Applicable to increasingly popular SPOT-5 imagery: image fusion at spatial resolutions of 5m and 2.5m, including the simulation of true-colour composite from false-colour input bands. (Only included in GUI-based *HighView* Professional version.)
- Option for either intensive or low memory usage in processing large size inputs (e.g., image size of 32,768 by 32,768 pixels)

- If the file size of fused multi-band output is close to or larger than 2GB, *HighView* automatically produces outputs with separate bands.

Notes:

- Requirements for input images are the same as those for band combination.
- For QuickBird and IKONOS data, the order of colour bands in fused GeoTIFF output is Blue, Green, Red, and NIR.

Tips:

- In most cases, it is not necessary to change the default settings in pan-sharpening modules. Users just need to change the output name if necessary.
- Spatial enhancements

As a standard process, R/G/B bands need to be sharpened. This option will likely produce a composite with stronger visual appeal.

If you select "Detail" or "None" option, the results would be more suitably used for further quantitative image analyses, such as image classification and segmentation, and object feature extraction.

- Colour enhancements

By default, colour adjustment factors for R/G/B are zero. In most cases, it is not necessary to change them. The increase of adjustment factors would likely make the output composite greener.

The use of colour enhancement will slow the pan-sharpening process.

- Histogram matching

In most cases, it is not necessary to enable this option, unless you explicitly wish to keep colours of fused images consistent with those of low-resolution colour inputs from band combination.

It will not make sense to enable this option if you have already used colour enhancements above. In other words, if this option is enabled, colour enhancement options should not be selected.

- Pan-sharpening with 8-bit Landsat ETM+ image

In the current version of *HighView*, only three Ms bands are allowed. In fact, users can select any three of the six Ms bands of 30- or 28.5-m resolution for pan-sharpening.

If the input Pan band has strong "noises" or "speckles" (depending upon image source and pre-processing levels), users can apply two noises reduction options provided in *HighView*. While image fusion is intended to reveal more information content from inputs, there is a danger of increasing information uncertainty. Further research is needed in this regard.

- Pan-sharpening with images from different sensors

Merging images from different sensors (e.g., 30-m resolution Landsat Ms image and 10-m resolution SPOT Pan image) or from different dates *is not recommended*. To achieve the best image fusion result, both Pan and Ms images should be captured (almost) simultaneously, such as the case of QuickBird and IKONOS sensors, or within a short time period.

- Image stretches for pan-sharpened results

The same set of image stretch options used in band combinations can be applied in fused results. For example, for comparison purposes, if a particular level of nonlinear stretching is used in band combination, the same level of nonlinear stretching should also be selected for pan-sharpened results.

If you wish to try different options of image stretches for the same set of pan-sharpened results in order to see how corresponding colour composites change, you do not need to run pan-sharpening module every time. Instead, you can use "Band Combination" menus, and use pan-sharpened, high-resolution Ms bands as the inputs.

- BMP/GeoTIFF outputs

Users can simply open and enhance 24-bit BMP in popular software such as Microsoft Paint or Adobe PhotoShop.

If you wish to use a colour-rich 24-bit BMP as a backdrop of other GIS data (e.g., census tracts, street networks), you need to georeference the BMP in GIS software by using the projection and coordinates information provided in the related header file. If your output is in GeoTIFF format, image georeferencing becomes unnecessary because most GIS software can read and display GeoTIFF files directly. For instance, you can read GeoTIFF files in ArcGIS and then select any colour bands for visualisation.

If a GIS software program cannot appropriately display GeoTIFF imagery that contains multiple colour bands, you can always rely on the output in BMP format. Manual image registration can be used. For example, if you wish to register a BMP image in MapInfo, you need to open the BMP in MapInfo and then register it by selecting image projection, and the coordinates of four corners of the image.

Specifically, if your original Pan/Ms image is in GeoTIFF format and you wish to georeference a BMP output in MapInfo, you do not need to manually enter coordinates, and here are two simple steps you can follow: (1) Open the GeoTIFF image in MapInfo, a Table file (*.tab) with the information of image projection and coordinates will be automatically generated; and (2) Open the ascii Table file in Notepad, change the image file name (within the Table file) from the GeoTIFF file to the BMP file. Once you open the Table file again, the georeferenced BMP will be displayed instead, ready to add other GIS layers on the top of it.

Likewise, these image georeference tips can be applied to any image outputs straight from band combinations.

5.3 Assessment in GUI-based HighView

Visual or qualitative assessment - Tips

Visual assessment on pan-sharpened results is important. As the saying goes, "**seeing is believing**".

Perceiving and assessing fused results by human eyes is a subjective process and is affected by a multitude of factors. Here we offer some practical tips that should be taken into consideration during visual assessment:

- Before adjusting software parameters on image contrast, think of hardware-related factors - brightness and contrast of your computer monitor. This is especially important for conventional monitors, which have less sharp contrast than LCD monitors. Try to set the display setting the same or similar before comparing images on different computers. If you are using a conventional monitor and wish to see image details, try to set brightness 100% and contrast 85%, for example. Also, you may wish to adjust the brightness and contrast of your computer monitors during the day or at night.
- Try to reduce natural lights near computer screen. This is similar to the fact that when TV or movie screens are put outdoors, one can hardly see pictures clearly.
- More importantly, human eyes perceive colours different from sensors. Outputs straight after linear stretching are often not too appealing visually. To achieve the "best" visual rendering of pan-sharpened results, a wide range of nonlinear stretching methods (such as photographic transforms, gamma correction, and hyperbolic sine enhancement) should be vigorously explored. There are numerous realisations with slight differences, but the determination of the "best" one is user-specific. Also, by applying some level of nonlinear stretches, objects in shadows could become discernable.
- Every image scene is captured under a unique set of environmental and instrumental conditions, such as the sun's elevation and azimuth, sensor's position and orientation. For the same area, the spectral feature of the image scene at 10 am could be very different from that of 3 pm. Therefore, when assessing the spectral consistency of pan-sharpened results, the only valid, reliable reference is low-resolution multispectral data.

Quantitative assessment - Tools

Three convenient tools are included for evaluating and comparing spatial, spectral, and textural attributes of input and fused images. These research-level tools can also be used for general image analysis.

- (1) Calculating image-based geostatistical semivariances
- (2) Calculating nine image-based statistics at multiple resolution levels
- (3) Performing popular Haar wavelet transforms

These tools support input images in a generic matrix format, not GeoTIFF format.

(1) Semivariances

Image semivariances calculated at four orientations (0, 45, 90, and 135 degrees) can be copied/pasted to spreadsheet software for further analysis.

(2) Multi-resolution image statistics

Image fusion and pan-sharpening typically uses images at multiple spatial resolutions. Although many image analysis programs are equipped with functions for calculating image statistics, very few offer a single straightforward command that calculates statistics at multiple resolutions.

The current version of *HighView* includes nine statistics - min, max, mean, variance, standard deviation, coefficient of variation, skewness, kurtosis, and entropy. In Table 1, M is the total number of pixels in an image, and x_i represents the intensity value of a pixel i .

Entropy measures the information content of an image, and an equation based on the Shannon's entropy is used (see the bottom row of Table 1): where G is the number of gray levels of a stretched 8-bit image with intensity values ranging between 0 and 255 (input data in 16-bit format are also stretched to 8-bit), $h[i]$ is the normalised frequency of intensity level i .

Calculated image statistics at multiple resolution levels can be exported to spreadsheets for further analysis.

(3) Haar wavelet transforms

Salient image textures can be effectively examined using multi-resolution wavelet transforms. *HighView* includes a module that performs simple yet effective Haar wavelet transforms. A down-sampling process is illustrated in Figure 5.1: at Level 1, an input image with the size of 128*128 pixels is decomposed into four sub-images with the size of 64*64 pixels - approximation, horizontal, vertical and diagonal details; at Level 2, the approximation image with the size of 64*64 is further down-sampled into four sub-images with the size of 32*32 pixels, and so on.

HighView outputs down-sampled images in two forms:

- Full intensity ranges in float (4-byte) format: Users can use this output for further analysis, such as image classification and segmentation.
- 24-bit BMP: Each sub-image is already stretched for convenient overview. Image stretching is based on the intensity range between min and max.

Table 1: Image-based statistics

Statistics	Equations
Mean	$\bar{x} = \sum_{i=1}^M x_i$
Variance	$\sigma^2 = \frac{\sum_{i=1}^M (x_i - \bar{x})^2}{(M - 1)}$
Standard deviation	σ
Coefficient of variation	$\frac{\sigma}{\bar{x}}$
Skewness	$\frac{\sum_{i=1}^M (x_i - \bar{x})^3}{(M - 1) \sigma^3}$
Kurtosis	$\frac{\sum_{i=1}^M (x_i - \bar{x})^4}{(M - 1) \sigma^4}$
Entropy	$E = -\sum_{i=1}^G h[i] \log_2(h[i])$

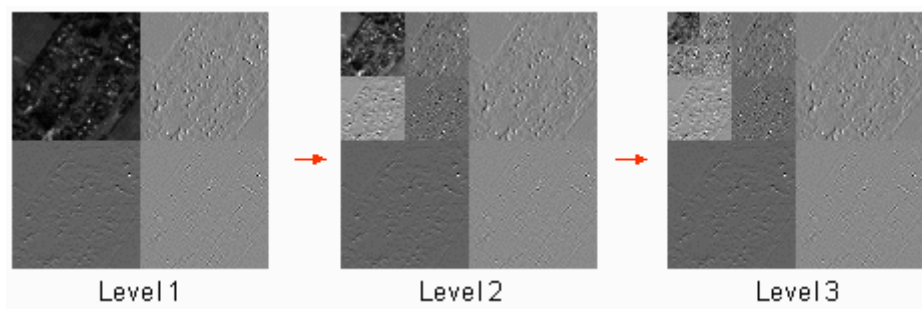


Figure 5.1: Three levels of down-sampling using multi-resolution Haar wavelet transforms

6. Speed Testing

We used two PCs with different configurations to test the efficiency of GUI-based *HighView* (Version 1.5) in pan-sharpening runs. 8- and 16-bit input images with various sizes were tested.

- Modern PC: Pentium (R) IV, CPU 3.2 GHz, 1 GB RAM
- Old PC: Pentium (R) III, CPU 800 MHz, 384 MB RAM

8-bit Landsat 7 ETM+ images as inputs

Size of Pan image (pixels)	Modern PC	Old PC
16,384 x 16,384 (A full scene)	289 seconds	- (not tested)
5,600 x 5,600	43 seconds	63 seconds
3,000 x 3,500	10 seconds	20 seconds

16-bit QuickBird or IKONOS images as inputs

Size of Pan image (pixels)	Modern PC	Old PC
12,228 x 12,228	193 seconds	-
8,192 x 8,192	64 seconds	261 seconds
4,096 x 4,096	19 seconds	47 seconds
2,048 x 2,048	7 seconds	15 seconds

Real running speed depends on analytical options employed and computer settings. In each of the above tests, running duration includes seconds spent on pan-sharpening, saving fused results in original input image format, generating and saving a 24-bit bmp on hard disk. Note that if inputs are in GeoTIFF format, the running duration will increase because of the time spent on conversions between GeoTIFF data and raw raster data. The latest version of HighView (DOS-based, Version 3.0) has rectified this limitation.

To minimise the frequency of file I/O and to make full use of large RAMs of modern PCs. By default, GUI-based *HighView* reads/writes images on a large block basis. For 16-bit inputs with the size of 8192 x 8192 pixels in a single pan-sharpening run, the peak RAM use is 128 MB; for 8-bit inputs with the size of 16,384 x 16,384 pixels, the peak RAM use reaches 256 MB. If you intend to perform pan-sharpening with large-size inputs (e.g., image size 30,000 by 30,000 pixels), an option of adjusting RAM usage is included (refer to the File | Preferences menu). Send a request to developers for more flexible setups on RAM usage.

7. Case Studies

Once you have opened the GUI-based HighView, you can go straight to "Band Combination" and "Pan-Sharpener" modules. The main window of GUI-based *HighView* is actually a text file editor, and you can disregard the "File" and "Edit" menus at the onset.

If you do not have an image viewer, we encourage you to check websites of major software developers and install your favourite image viewer. For information only, some examples include:

ER Viewer from Earth Resource Mapping (ER Mapper, <http://www.ermapper.com>)
FreeLook from Research Systems (<http://www.rsinc.com/>)
FreeView from PCI Geomatics (<http://www.pcigeomatics.com>).
ViewFinder from ERDAS (<http://www.erdas.com/>)

7.1 Sample data

The Trial Version includes a small Landsat ETM+ data set in GeoTIFF format, covering part of Washington, D.C. By default, the data set is located at C:\Program Files\Geosage\HighView\example\.

- For the first run, you can select the "Band Combination | Landsat ETM+" menu to perform band combination. In the input dialog, select blue, green, and red bands, and make no change on other options; by clicking OK button, band combination results in 24-bit BMP format and GeoTIFF format will be generated.
- Use the "Pan-Sharpener | Landsat ETM+" menu to perform image pan-sharpening. In the input dialog, enter the Pan image first (image width and height will be automatically filled in), then select blue, green, and red bands, and make no change on other options; by clicking OK button, pan-sharpening results in 24-bit BMP format and/or GeoTIFF format will be produced (for the trial version only a 24-bit BMP with white stripes is produced).

Next, you can conduct visual comparisons between the above band combination and pan-sharpening results.

7.2 A full Landsat ETM+ scene

Once you have got an overview of *HighView* modules and options, you may wish to analyse large images, such as a full Landsat ETM+ scene. We suggest you explore publicly available Landsat images first, such as those offered by the Global Land Cover Facility (GLCF).

Step 1: Visit the GLCF website at <http://glcf.umiacs.umd.edu/index.shtml> and download Landsat ETM+ imagery of your interest;

Step 2: Unzip the downloaded GeoTIFF files. For a full Landsat scene, the Pan band has a typical size of ~240 MB, and a single Ms band has the size of ~60 Mb.

Step 3: Use *HighView's* "Band Combination" and "Pan-sharpening" menus to make true colour and pan-sharpened composites. Just fill in input file names and use default settings of image stretching, outputs in both BMP format and/or GeoTIFF format will be produced.

Pan-sharpened results are heavily dependent upon the source and quality of input images. If the input GLCF Landsat ETM+ images appear "granulated", the pan-sharpened output is likely to be "noisy". This may be caused by the NN (nearest neighbour) resampling used in input Pan and Ms bands. Changing the source of Landsat imagery or applying noise-reduction techniques will improve pan-sharpened results significantly; an example of this can be viewed at GeoSage's website http://www.geosage.com/highview/imagefusion_landstatetm+.html.

A fairly modern PC is required when analysing a full Landsat scene, especially when you wish to display the fused 24-bit BMP with a typical size of ~700 MB. For many software programs other than the above image viewers introduced, to display the image of this size efficiently needs a machine with more than 1 GB RAMs.

7.3 High-resolution images

You may wish to obtain QuickBird and IKONOS sample images by visiting the websites of DigitalGlobe and Space Imaging. Purchasing images from DigitalGlobe and Space Imaging can be made online.

A set of tools and analysis options included in *HighView* will help you explore the potential of recent generation of high-resolution imagery.

8. Batch Processing in GUI-based HighView

If you are working with hundreds or thousands images on a daily basis, you may wish to grasp this flexible batch processing function included in GUI-based *HighView* Version 2.0.

All you need is to prepare a batch input file (*.bif) in any text editor, such as Notepad. A batch processing mode can be initiated by selecting the file type of “Ascii Batch Input File (*.bif)”, in the first input “Open File” dialog of band combination and pan-sharpening GUIs.

File structures for input images with the Pan/Ms size ratio 2:1 (e.g., Landsat ETM+) and for input images with the Pan/Ms size ratio 4:1 (e.g., QuickBird and IKONOS) are slightly different, as illustrated below.

8.1 Batch input file structure for images with the Pan/Ms size ratio 2:1

```
Total_number_of_images_to_be_processed Output_format_indicator
ID_for_1st_image
PAN_band_filepath/name
BLUE_band_filepath/name
GREEN_band_filepath/name
RED_band_filepath/name
OUTPUT1_in_24bit_BMP_filepath/name
OUTPUT2_in_GeoTIFF_filepath/name
ID_for_2nd_image
...
...
```

An example – “sample_size_ratio2to1_inputs.bif”

```
199 0
1
D:\HighView_data\BacthMode_8bit\ p183r034_7t20000520_z34_nn80.tif
D:\HighView_data\ BacthMode_8bit\ p183r034_7t20000520_z34_nn10.tif
D:\HighView_data\ BacthMode_8bit\ p183r034_7t20000520_z34_nn20.tif
D:\HighView_data\ BacthMode_8bit\ p183r034_7t20000520_z34_nn30.tif
F:\HighView_data\ BacthMode_8bit_Output\ p183r034_7t20000520_z34_nn123.bmp
F:\HighView_data\ BacthMode_8bit_Output\ p183r034_7t20000520_z34_nn123.tif
2
...
...
199
H:\External Drive\LandsatETM+_8bit\pan band.tif
H:\External Drive\LandsatETM+_8bit\blue band 1.tif
H:\External Drive\LandsatETM+_8bit\green band 2.tif
H:\External Drive\LandsatETM+_8bit\red band 3.tif
```

M:\Network Drive\LandsatETM+_8bit_outputs\output in 24 bit bmp.bmp

M:\Network Drive\LandsatETM+_8bit_outputs\output in geotiff.tif

All input files (Pan, Blue, Green and Red bands) only in GeoTIFF format can be processed in a batch mode. Outputs can be in 24-bit BMP format and/or GeoTIFF format, which are controlled by an "Output_format_indicator" as follows:

"Output_format_indicator"	0	- output both BMP and GeoTIFF images
	1	- output BMP only
	2	- output GeoTIFF only

The filepath/name in each line should be filled in. If you really do not wish to specify it, you should still use some characters for the line, for example "N/A" or "Unknown". To take an example, if a batch input file is prepared for an automatic band combination only and you do not have a real Pan band, in this case you still need to use indicative texts to fill in the line for the Pan band, for example "Pan N/A". The main reason for doing so is that we just need to prepare the same *.bif file once for both image band combination and pan-sharpening; In band combination operation, the line for Pan file will be skipped while in pan-sharpening the Pan file will be read.

Tips

- If the *.bif file and all input files are located within in a single folder, you may just use file names only, rather than the full filepath and names.
- With the full filepath specified in a *.bif file, *HighView* can effectively read any input file and write output file on different disks - hard disks, network disks or external hard disks.
- The length of each filepath/name should be less than 255 characters. File names can contain space characters.
- Image IDs are not necessarily to be in a consecutive order, as long as they are valid digital numbers, for example 20050402, followed by 20050502, 20050602, and so on.
- Long filepath can be easily copied from the Address box in Windows Explorer. If you wish to change the filepath within an entire batch input file, you may use the Copy/Paste or Find/Replace functions in text editors.
- Users can adjust the total number of images to be processed in a *.bif file, which can be equal to or less than the real number of images included in the file. If this number is 1, only the first image will be processed (regardless of the remaining image files); this effectively creates a new easy way for file inputs in GUIs, as opposed to the standard manner of file inputs in a non-batch mode. In this batch mode, users can have control over output formats – whether outputs are in BMP only and/or GeoTIFF format.

8.2 Batch input file structure for images with the Pan/Ms size ratio 4:1

The batch input file structure for input images with the Pan/Ms size ratio 4:1 is essentially similar to that with the Pan/Ms size ratio 2:1, except the following two aspects in coping with Ms bands:

- If all four Ms bands – Blue, Green, Red, and NIR – are separated (in the case of IKONOS data directly distributed by Space Imaging), an additional line for NIR file in the *.bif file should be inserted.

- If all four Ms bands are combined in a single GeoTIFF file (in the case of QuickBird data directly distributed by DigitalGlobe), it is not necessary to include other three lines for Green, Red and NIR bands. *HighView* can automatically check the total number of bands in an Ms input image.

Here are the file structures:

(1) Four Ms bands are separated (e.g., IKONOS data from Space Imaging)

```
Total_number_of_images_to_be_processed Output_format_indicator
ID_for_1st_image
PAN_band_filepath/name
BLUE_band_filepath/name
GREEN_band_filepath/name
RED_band_filepath/name
NIR_band_filepath/name
OUTPUT1_in_24bit_BMP_filepath/name
OUTPUT2_in_GeoTIFF_filepath/name
ID_for_2nd_image
...
...
```

(2) Four Ms bands are combined in a single GeoTIFF file (e.g., QuickBird data from DigitalGlobe)

```
Total_number_of_images_to_be_processed Output_format_indicator
ID_for_1st_image
PAN_band_filepath/name
MS_bands_filepath/name (this file should contain 4 Ms bands)
OUTPUT1_in_24bit_BMP_filepath/name
OUTPUT2_in_GeoTIFF_filepath/name
ID_for_2nd_image
...
...
```

An example – “sample_size_ratio4to1_inputs.tif”

```
999 2
1
E:\CD-ROM1\QuickBird_16bit\Pan file with a single band.tif
E:\CD-ROM1\ QuickBird_16bit\Ms file with 4 bands.tif
M:\Network Drive\ QuickBird_16bit \output in 24 bit bmp.bmp
M:\Network Drive\ QuickBird_16bit \output in geotiff.tif
2
...
...
999
D:\HighView_data\IKONOS_16bit\ pan.tif
D:\HighView_data\ IKONOS_16bit\ blue band.tif
D:\HighView_data\ IKONOS_16bit\ green band.tif
D:\HighView_data\ IKONOS_16bit\ red band.tif
D:\HighView_data\ IKONOS_16bit\ nir band.tif
```

F:\HighView_data\IKONOS_16bit_Output\fused1.bmp

F:\HighView_data\IKONOS_16bit_Output\fused1.tif

Both formats above can be mixed and included in a single *.bif file. *HighView* can automatically identify whether the first Ms input file has a single band or four bands.

It is important to keep all input and output files in order, i.e., Pan band, followed by Blue band, Green band, Red band, NIR band, output BMP file, and output GeoTIFF file.

Even if the output format indicator is 2 (i.e., output GeoTIFF only), the file name for 24-bit BMP should still be provided. By so doing, users do not need to prepare a new *.bif file when they want to output BMP only (i.e., output format indicator being 1), or output both GeoTIFF and BMP (i.e., output format indicator being 0).

Once a *.bif file is prepared, *HighView* GUIs allow users to freely select or swap the order of Ms bands for band combination and pan-sharpening. This is a very flexible and powerful feature as some users may wish to produce true colour composites as well as false colour composites using the same *.bif file. Users just need to prepare a batch input file once. This feature is not available for 8-bit Landsat ETM+ images.

If users wish to produce another set of outputs under different spatial and spectral enhancements or different image stretching options, they may just change the filepath of outputs using Copy/Paste or Find/Replace functions in text editors.

More tips refer to Section 8.1.

8.3 How to prepare the batch input file efficiently?

If you are working with only a few images to be included in a small *.bif file, you would probably be better off by just copying/pasting file names in a text editor. However, if you are faced with routine tasks of automatically processing 100s or 1000s of images daily or weekly (e.g., processing all Landsat ETM+ scenes covering a whole continent or an entire world, or processing all images daily from the receiver), you might find the following instructions useful.

Because of the simplicity of the batch input file format, you may wish to explore other methods including some self-programming to achieve the objective.

Step 1: Prepare image IDs and file names in a spreadsheet (e.g., using Microsoft Excel)

Your familiarity with DOS “dir” command is extremely helpful. The “dir” command is used to display a list of files and subdirectories in a directory. If you are not familiar with the “dir” command, in a DOS environment you can type the following for its uses.

For example: C:\help dir > temp.txt | notepad temp.txt

It means you want to re-direct (write) the help information of “dir” command to a temporary text file called “temp.txt”, and then use Notepad to display it.

Many options are included in the powerful “dir” command:

```
DIR [drive:][path][filename] [/A[:attributes]] [/B] [/C] [/D] [/L] [/N] [/O[:sortorder]] [/P] [/Q] [/S]
[/T[:timefield]] [/W] [/X] [/4]
```

For example: the DOS command line “dir *pan* /b > temp.txt | notepad temp.txt” means to re-direct all file names with the “pan” string and in a bare format to a temporary file and then

display it using Notepad. You can copy all selected files in Notepad and paste them in a spreadsheet column, as illustrated in Figure 8.1.

To display all files (including file paths) with the “pan” string located in a specified directory and all sub-directories, you may use the command line “dir *pan* /b /s > temp.txt | notepad temp.txt”. Various sorting options in the “dir” command are also very useful.

Alternatively, if users wish to customise full file paths, the CONCATENATE() function in Excel will be very handy.

	A	B	C	D	E	F	G	H
1							Output folder:	D:\Output\
2								
3		ID	Pan	Blue	Green	Red	BMP output	GeoTIFF output
4		1	p183r034_pan.tif	p183r034_b1.tif	p183r034_b2.tif	p183r034_b3.tif	D:\Output\1.bmp	D:\Output\1.tif
5		2	p183r035_pan.tif	p183r035_b1.tif	p183r035_b2.tif	p183r035_b3.tif	D:\Output\2.bmp	D:\Output\2.tif
6		3	p183r036_pan.tif	p183r036_b1.tif	p183r036_b2.tif	p183r036_b3.tif	D:\Output\3.bmp	D:\Output\3.tif
7	
8	
9	
10		7	p163r043_pan.tif	p163r043_b1.tif	p163r043_b2.tif	p163r043_b3.tif	D:\Output\7.bmp	D:\Output\7.tif
11		8	p163r044_pan.tif	p163r044_b1.tif	p163r044_b2.tif	p163r044_b3.tif	D:\Output\8.bmp	D:\Output\8.tif
12		9	p163r045_pan.tif	p163r045_b1.tif	p163r045_b2.tif	p163r045_b3.tif	D:\Output\9.bmp	D:\Output\9.tif
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

In DOS environment:
 in a chosen data folder, type
dir *pan* /b >temp.txt | notepad temp.txt
 Then, copy all file names with "pan" in Notepad and paste them to this Pan field.
 Similarly, if you type
dir *b1* /b >temp.txt | notepad temp.txt
 to fill the Blue band field above. Same can be done for other bands.

=CONCATENATE(H1,B4:B12,".bmp")

=CONCATENATE(H1,B4:B12,".tif")

Figure 8.1: Preparing a batch input file in Excel

Step 2: Copy image IDs and file names to a Notepad window

Copy all images IDs and file names (shown in light green in Figure 8.1) to Notepad in order to remove all underlying cell format. As a result, all file names in Notepad will be Tab-delimited.

Step 3: Copy all texts in Notepad to Microsoft Word to replace Tab Character (^t) with Paragraph Mark (^p) (Figure 8.2)

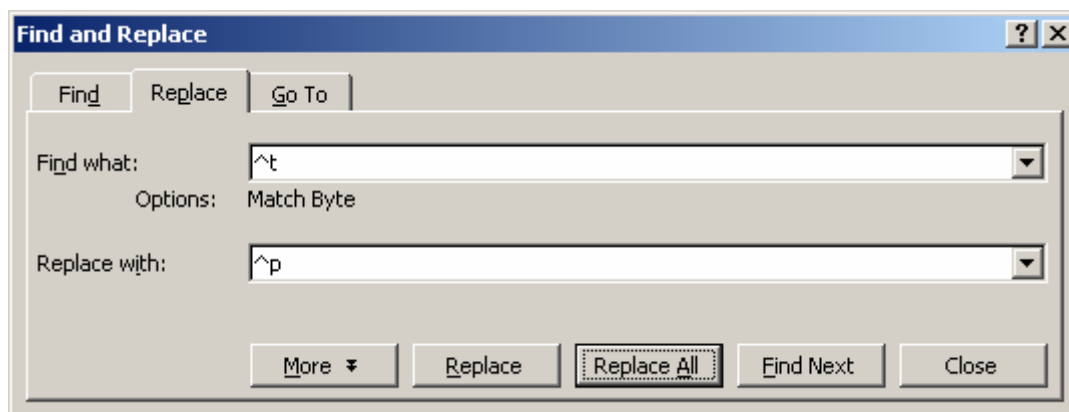


Figure 8.2: Replacing all tabs in texts with paragraph marks in Microsoft Word

After this replacement, all file names previously in a Tab-delimited form in Step 2 are moved to individual lines.

Step 4: Copy all texts in Microsoft Word and paste back to a new Notepad window

After pasting all texts in a new Notepad window, then move the mouse to the beginning of the file, and insert a new line and manually enter the total number of images to be processed in this batch processing AND the output format indicator (0, 1 or 2), as defined in Section 8.1.

9. Support

If you experience any problem of running *HighView*, or you wish to know more about *HighView*, you can reach us using the following contact information.

Web: <http://www.geosage.com/>

General enquiries,
Support,
Sales,
Bugs reporting, web pages, etc. info360@geosage.com

Our land is so real and abundantly beautiful, and the imagery of our land is so captivating; as human being each of us has the potential to be a great artist and scientist, so let's explore the imagery of our land together.

History of this document

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Version 2.0: April 2005 (Added a section on batch processing)
Version 1.5: July 2004 (First release of this document)

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Web: <http://www.geosage.com/>

E-mail: info360@geosage.com



Image source: © DigitalGlobe, All Rights Reserved. Boulder - demo samples.

DOS-based *HighView* (Version 3.0, Released 1 July 2008)

The **latest** version of *HighView* for rapidly processing the recent high-resolution satellite imagery – QuickBird, IKONOS, and the future GeoEye-1 and WorldView-2

A dedicated utility program in the form below

```
C:\Fuse.exe <optimization_method> <output_image_type> -e
<enhanced_spatial_filter_option> <enhanced_green_color_option>
<enhanced_pixel_offset_x_option> <enhanced_pixel_offset_y_option> -s
<image_stretch_band1_left_cut> <image_stretch_band1_right_cut>
<image_stretch_band2_left_cut> <image_stretch_band2_right_cut>
<image_stretch_band3_left_cut> <image_stretch_band3_right_cut>
<nonlinear_stretch_band1> <nonlinear_stretch_band2>
<nonlinear_stretch_band3> <in_PAN.tif> <in_MS.tif>
<out_PanSharpened.tif>
```

- Processing QuickBird and GeoEye-1/IKONOS imagery DIRECTLY from DigitalGlobe and GeoEye data vendors. Both 16-bit panchromatic and multispectral inputs in GeoTIFF format contain full 11-bit dynamic ranges. Pan-sharpened R/G/B output in GeoTIFF format can be directly used by GIS software (e.g., ArcGIS, MapInfo) and popular image manipulation software (e.g., PhotoShop). Maximum image size is about 36,500 x 36,500 pixels, and max file size for the output is 4Gb.
- Local and global optimization methods
- Natural- or false-color R/G/B composites
- Options for spatial and spectral enhancements
- Options for pixel offset adjustment in X/Y directions
- Options for both linear and non-linear image stretching
- Low memory usage, highly efficient running, ideal for intensive professional users
- RGB Image Stretching Tool and RGB Image Composition Tool included

DOS-based HighView (Version 3.0, Released 1 July 2008)

The latest version of HighView for rapidly processing the recent high-resolution satellite imagery – QuickBird, IKONOS, and the future GeoEye-1 and WorldView-2



```
Fuse.exe Help.txt - Notepad
File Edit Format View Help
C:\Fuse.exe
<optimization_method> <output_image_type> -e
<enhanced_spatial_filter_option> <enhanced_green_color_option>
<enhanced_pixel_offset_x_option> <enhanced_pixel_offset_y_option> -s
<image_stretch_band1_left_cut> <image_stretch_band1_right_cut>
<image_stretch_band2_left_cut> <image_stretch_band2_right_cut>
<image_stretch_band3_left_cut> <image_stretch_band3_right_cut>
<nonlinear_stretch_band1> <nonlinear_stretch_band2> <nonlinear_stretch_band3>
<in_PAN.tif> <in_MS.tif> <out_PanSharpened.tif>
Version 3.0, Released 1 July 2008

Parameters - specific to algorithms

<optimisation_method>
0 - local optimization; 1 - global optimization

<output_image_type>
0 - true (natural) color composite, e.g., QuickBird MS Bands 3/2/1;
1 - color-infrared composite, e.g., QuickBird MS Bands 4/3/2.

<enhanced_spatial_filter_option>
0 - none; 1 - detail; 2 - sharper

<enhanced_green_option>
Usually this value should be set to zero. If the user wishes to highlight
vegetation in TOTAL green based on NDVI thresholds, set this value within the
range (0.0-1.0) with a typical value of 0.2; i.e., vegetated areas with NDVI
greater than 0.2 will be shown in TOTAL green. If the user just wishes to
highlight vegetation GREENER, set this value within the range [1-10],
typical value 4.0. If the output image type is set to 1 (color-infrared),
this value should always be zero.

<enhanced_pixel_offset_x_option>
Usually this value should be set to zero. This option is to slightly adjust
horizontal pixel shifts between PAN and MS inputs, when necessary. Rare usage
recommended. For QuickBird and IKONOS inputs directly from data vendors, set
this value to zero. If slight pixel mismatches exist between PAN and MS inputs,
the user may set this value within the range [-0.25, 0.25]

<enhanced_pixel_offset_y_option>
Usually this value should be set to zero. This option is to slightly adjust
vertical pixel shifts between PAN and MS inputs, when necessary. Rare usage
recommended. For QuickBird and IKONOS inputs directly from data vendors, set
this value to zero. If slight pixel mismatches exist between PAN and MS inputs,
the user may set this value within the range [-0.25, 0.25]

Parameters - specific to adaptive image stretching

The following parameters are used for both linear and non-linear image
stretching, identical to those of the RGB Image Stretching Tool included
in this package. Type RGB_stretch.exe for more information.

<image_stretch_band1_left_cut>
Linear stretching, % of pixels to be excluded at left-end for band1
value range [0.0-40.0], typical value 2.0
<image_stretch_band1_right_cut>
Linear stretching, % of pixels to be excluded at right-end for band1
value range [0.0-40.0], typical value 2.0
<image_stretch_band2_left_cut>
Linear stretching, % of pixels to be excluded at left-end for band2
value range [0.0-40.0], typical value 2.0
<image_stretch_band2_right_cut>
Linear stretching, % of pixels to be excluded at right-end for band2
value range [0.0-40.0], typical value 2.0
<image_stretch_band3_left_cut>
Linear stretching, % of pixels to be excluded at left-end for band3
value range [0.0-40.0], typical value 2.0
<image_stretch_band3_right_cut>
Linear stretching, % of pixels to be excluded at right-end for band3
value range [0.0-40.0], typical value 2.0
```

(Continued)



```
Fuse.exe Help.txt - Notepad
File Edit Format View Help
<nonlinear_stretch_band1>
Nonlinear stretching coefficient/weight for band1
Value range [0.0-20.0], typical value 2.0
<nonlinear_stretch_band2>
Nonlinear stretching coefficient/weight for band2
Value range [0.0-20.0], typical value 2.0
<nonlinear_stretch_band3>
Nonlinear stretching coefficient/weight for band3
Value range [0.0-20.0], typical value 2.0

Parameters - Specific to input and output GeoTIFF files

All GeoTIFF files should be untiled, uncompressed.

<in_PAN.tif>
Panchromatic input must contain 16-bit, single-band data.
Pixel data range [0-2047] (or 11-bit) is expected.
<in_MS.tif>
Multispectral input must contain 16-bit, four-band data.
Pixel data range [0-2047] (or 11-bit) is expected.
<out_PanSharpened.tif>
Pan-sharpened output file name. Output will be 8-bit, three-band GeoTIFF file.

Examples/Tips

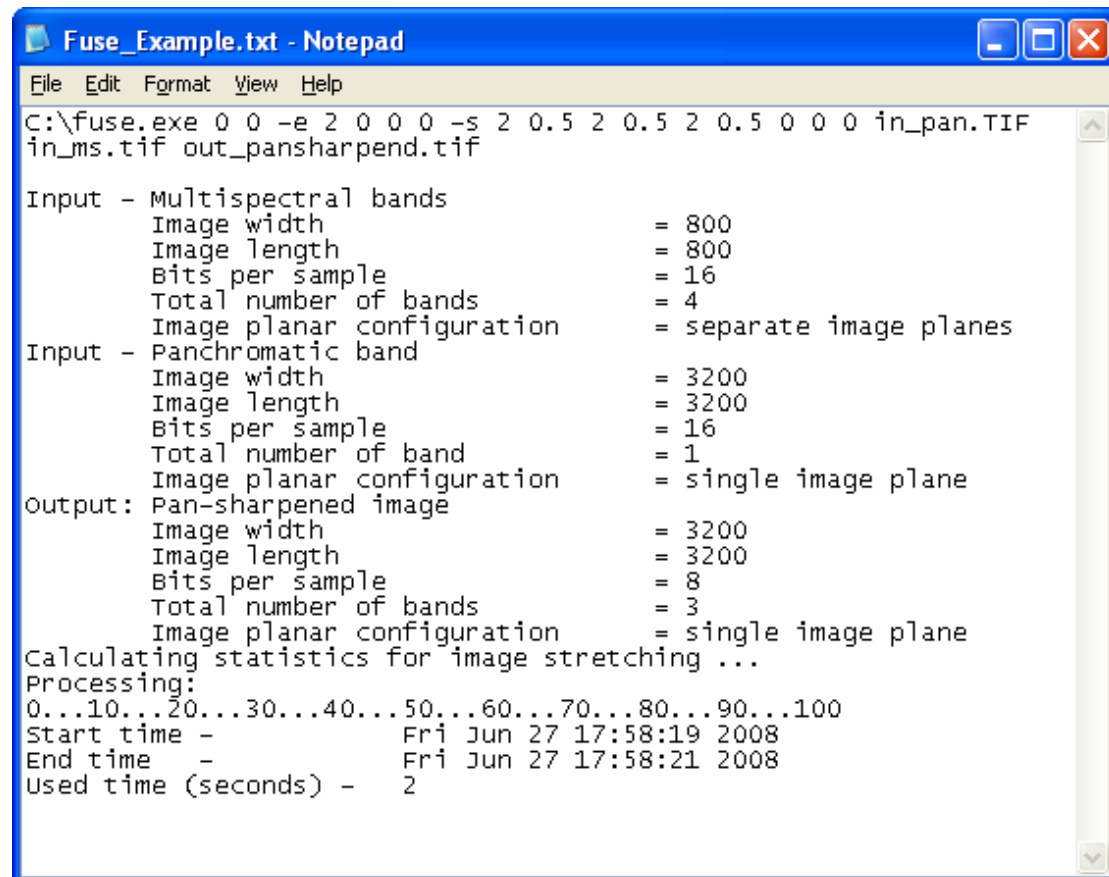
1. This tool targets QuickBird and IKONOS imagery DIRECTLY supplied by DigitalGlobe and GeoEye data vendors. For the majority of cases, both panchromatic and multispectral inputs are 16-bit GeoTIFF files, and meet the EXACT image size ratio of 4:1. Maximum image size for PAN band is about 36500 x 36500 pixels, and max file size for output is 4GB.
2. Before pan-sharpening, users may wish to perform simple band combination and produce R/G/B true-color composite using the multispectral input:
RGB_Stretch.exe 3 2 1 -s 2 1 2 1 2 1 0 0 0 in_MS.tif in_MS_RGB.tif
3. For QuickBird imagery, typical pan-sharpening commandlines are as follows:
Fuse.exe 0 0 -e 2 0 0 0 -s 2 1 2 1 2 1 0 0 0 in_PAN.tif in_MS.tif out.tif
Fuse.exe 1 0 -e 2 0 0 0 -s 2 1 2 1 2 1 2 2 2 in_PAN.tif in_MS.tif out.tif
4. For IKONOS imagery, since multispectral data are usually provided with four separate bands - blue, green, red and near-infrared, users need to combine all multispectral bands together in order to make a new, four-band multispectral input file first, using RGB Image Composition Tool included in the package, i.e.,
RGB_Make.exe blue.tif green.tif red.tif nir.tif in_MS.tif
Then, use this tool for image pan-sharpening, e.g.,
Fuse.exe 0 0 -e 1 0 0 0 -s 2 1 2 1 2 1 2 2 2 in_PAN.tif in_MS.tif out.tif
5. To highlight vegetation in TOTAL green based on NDVI threshold, use
Fuse.exe 0 0 -e 0 0.2 0 0 -s 2 1 2 1 2 1 0 0 0 in_PAN.tif in_MS.tif out.tif
Just to highlight vegetation greener, use
Fuse.exe 0 0 -e 0 4 0 0 -s 2 1 2 1 2 1 0 0 0 in_PAN.tif in_MS.tif out.tif
6. To produce a color-infrared output, use
Fuse.exe 0 1 -e 2 0 0 0 -s 2 1 2 1 2 1 0 0 0 in_PAN.tif in_MS.tif out.tif
7. For more examples and tips, please refer to software features and tutorials on the website.

Software Full Name:
Highview - An Advanced Image Fusion and Pan-Sharpening Tool
(RGB Image Stretching Tool and Image Composition Tool included)

DOS-based commandline utility programs for rapidly pan-sharpening the recent high-resolution satellite imagery (QuickBird and IKONOS) and the future GeoEye-1 and worldview-2.

Developer: http://www.GeoSage.com/
```

Example:



```
Fuse_Example.txt - Notepad
File Edit Format View Help
C:\fuse.exe 0 0 -e 2 0 0 0 -s 2 0.5 2 0.5 2 0.5 0 0 0 in_pan.TIF
in_ms.tif out_pansharpend.tif

Input - Multispectral bands
  Image width           = 800
  Image length          = 800
  Bits per sample       = 16
  Total number of bands = 4
  Image planar configuration = separate image planes
Input - Panchromatic band
  Image width           = 3200
  Image length          = 3200
  Bits per sample       = 16
  Total number of band  = 1
  Image planar configuration = single image plane
Output: Pan-sharpened image
  Image width           = 3200
  Image length          = 3200
  Bits per sample       = 8
  Total number of bands = 3
  Image planar configuration = single image plane
Calculating statistics for image stretching ...
Processing:
0...10...20...30...40...50...60...70...80...90...100
Start time -          Fri Jun 27 17:58:19 2008
End time   -          Fri Jun 27 17:58:21 2008
Used time (seconds) - 2
```



Web: <http://www.geosage.com/>

E-mail: info360@geosage.com



Image source: USGS GloVIS, Landsat ETM+ bands 3/2/1. Washington, D.C.

RGB Image Stretching Tool:

Containing a hybrid of linear and nonlinear stretching methods

Highlights:

A powerful, easy-to-implement utility tool in the form below

C:\RGB_Stretch.exe

```
<band_selection_red> <band_selection_green> <band_selection_blue> -s  
<image_stretch_band1_left_cut> <image_stretch_band1_right_cut>  
<image_stretch_band2_left_cut> <image_stretch_band2_right_cut>  
<image_stretch_band3_left_cut> <image_stretch_band3_right_cut>  
<nonlinear_stretch_band1> <nonlinear_stretch_band2>  
<nonlinear_stretch_band3> <in.tif> <out.tif>
```

- 1. Directly processing multiple bands (≥ 3), 8- or 16-bit input imagery in untiled, uncompressed GeoTIFF format. R/G/B output is in GeoTIFF format as well, without losing any georeference information.**
- 2. Selection of any band combination**
- 3. Settings of linear stretching specific to each R/G/B band**
- 4. Nonlinear image stretching option designed to improve overall brightness of the output and rendering effect**
- 5. Applicable to all types of remotely sensed imagery**
- 6. Processing input files up to 4Gb in size**
- 7. Super fast in running (e.g., processing 8,500+ Landsat ETM+ scenes with a global coverage takes less than 24 hours on a typical office PC)**
- 8. Support of batch processing, without limit on the # of images to be processed.**
- 9. Great tips and generous technical support.**

RGB Image Stretching Tool:

Containing a hybrid of linear and nonlinear stretching methods



```
C:\RGB_Stretch.exe
<band_selection_red> <band_selection_green> <band_selection_blue> -s
<image_stretch_band1_left_cut> <image_stretch_band1_right_cut>
<image_stretch_band2_left_cut> <image_stretch_band2_right_cut>
<image_stretch_band3_left_cut> <image_stretch_band3_right_cut>
<nonlinear_stretch_band1> <nonlinear_stretch_band2> <nonlinear_stretch_band3>
<in.tif> <out.tif>
Version 3.0, Released 1 July 2008

Parameters

<band_selection_red>:
Band selection number for the Red band from input, range [1-256]
<band_selection_green>:
Band selection number for the Green band from input, range [1-256]
<band_selection_Blue>:
Band selection number for the Blue band from input, range [1-256]

<image_stretch_band1_left_cut>:
Linear stretching, % of pixels to be excluded at left-end for band1
Value range [0.0-40.0], typical value 2.0
<image_stretch_band1_right_cut>:
Linear stretching, % of pixels to be excluded at right-end for band1
Value range [0.0-40.0], typical value 2.0
<image_stretch_band2_left_cut>:
Linear stretching, % of pixels to be excluded at left-end for band2
Value range [0.0-40.0], typical value 2.0
<image_stretch_band2_right_cut>:
Linear stretching, % of pixels to be excluded at right-end for band2
Value range [0.0-40.0], typical value 2.0
<image_stretch_band3_left_cut>:
Linear stretching, % of pixels to be excluded at left-end for band3
Value range [0.0-40.0], typical value 2.0
<image_stretch_band3_right_cut>:
Linear stretching, % of pixels to be excluded at right-end for band3
Value range [0.0-40.0], typical value 2.0

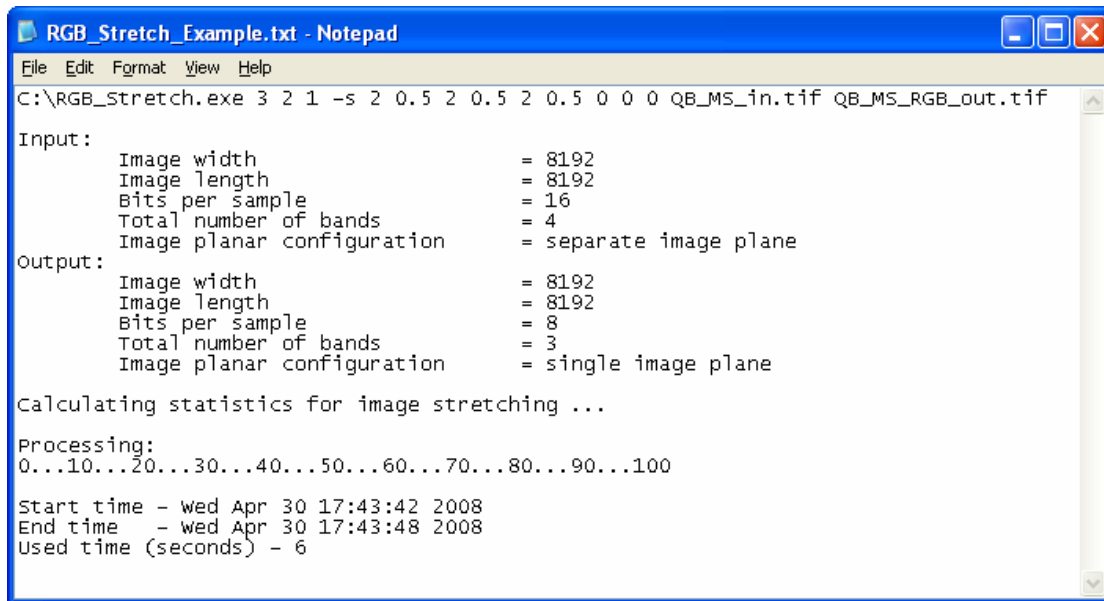
<nonlinear_stretch_band1>:
Nonlinear stretching coefficient/weight for band1
Value range [0.0-20.0], typical value 2.0
<nonlinear_stretch_band2>:
Nonlinear stretching coefficient/weight for band2
Value range [0.0-20.0], typical value 2.0
<nonlinear_stretch_band3>:
Nonlinear stretching coefficient/weight for band3
Value range [0.0-20.0], typical value 2.0

Examples/Tips

1. If a scene contains a small percentage of information-rich white pixels
(e.g. those showing built-up areas), try to use smaller right-end cut-off
values. Such data are popular, including Landsat ETM+ imagery in NASA
GeoCover series and 16-bit QuickBird imagery with populated areas.
IMPORTANT: This option will probably work best for the majority of scenes.
RGB_stretch.exe 1 2 3 -s 2 0.5 2 0.5 2 0.5 0 0 0 in.tif out.tif
RGB_stretch.exe 1 2 3 -s 2 0.2 2 0.2 2 0.2 2 2 2 in.tif out.tif
2. If a full scene or its large part is about desert land cover, try to
use smaller right-end cut-off values, e.g.
RGB_stretch.exe 1 2 3 -s 2 0.2 2 0.2 2 0.2 0 0 0 in.tif out.tif
RGB_stretch.exe 1 2 3 -s 2 0.1 2 0.1 2 0.1 2 2 2 in.tif out.tif
3. If a scene contains a large proportion of white areas (e.g. clouds, snows),
try to increase the right-end cut-off values for their exclusion, e.g.
RGB_stretch.exe 1 2 3 -s 2 4 2 4 2 4 0 0 0 in.tif out.tif
RGB_stretch.exe 1 2 3 -s 2 6 2 6 2 6 0 0 0 in.tif out.tif
4. If an initial image stretching result appears bluish, try to increase
the left-end cut-off values for the BLUE band only, e.g.
RGB_stretch.exe 1 2 3 -s 2 2 2 2 5 2 0 0 0 in.tif out.tif
5. Input GeoTIFF file should be untiled, uncompressed.
6. Planar configuration for the output: single image plane.

Full Name: RGB Image Stretching Tool
Containing a hybrid of linear and nonlinear stretching methods
Developer: http://www.GeoSage.com/
```

Example



```
RGB_Stretch_Example.txt - Notepad
File Edit Format View Help
C:\RGB_Stretch.exe 3 2 1 -s 2 0.5 2 0.5 2 0.5 0 0 0 QB_MS_in.tif QB_MS_RGB_out.tif

Input:
  Image width           = 8192
  Image length          = 8192
  Bits per sample       = 16
  Total number of bands = 4
  Image planar configuration = separate image plane

Output:
  Image width           = 8192
  Image length          = 8192
  Bits per sample       = 8
  Total number of bands = 3
  Image planar configuration = single image plane

Calculating statistics for image stretching ...

Processing:
0...10...20...30...40...50...60...70...80...90...100

Start time - wed Apr 30 17:43:42 2008
End time   - wed Apr 30 17:43:48 2008
Used time (seconds) - 6
```

Tutorial

Step 1: Download GeoTIFF files and combine all separate bands into a single file. Many tools are available in the public domain for this task, e.g.,

- Use RGB_Make.exe (next page)

RGB_Make.exe tm_band3.tif tm_band2.tif tm_band1.tif out.tif

- Or, use versatile GDAL_merge.py (http://www.gdal.org/gdal_merge.html)

GDAL_merge -o out.tif -separate tm_band3.tif tm_band2.tif tm_band1.tif

Step 2: Perform image stretching, e.g.,

Landsat ETM+ multispectral imagery in NASA GeoCover series

C:\RGB_Stretch.exe 1 2 3 -s 2 0.5 2 0.5 2 0.5 0 0 0 in.tif rgb_out.tif

QuickBird multispectral imagery (Data directly from data vendors usually have four MS bands and use 16-bit data type for 11-bit pixel values ranging from 0 to 2047)

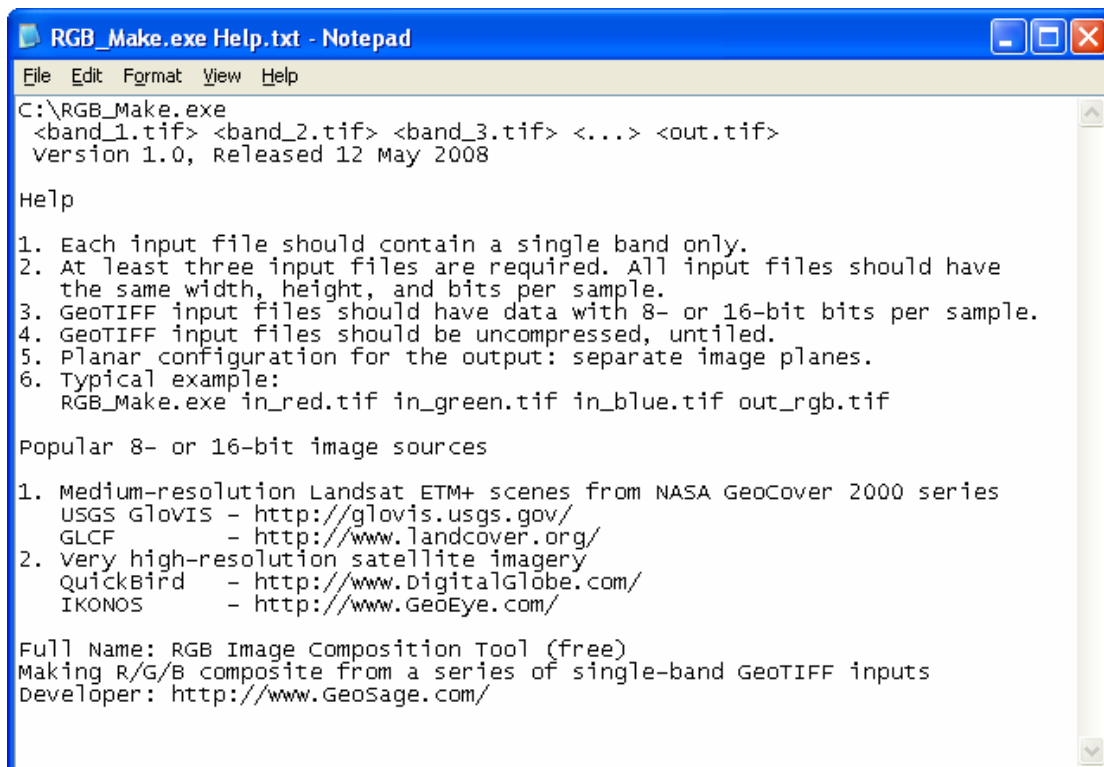
Natural color composite -

C:\RGB_Stretch.exe 3 2 1 -s 2 0.5 2 0.5 2 0.5 2 2 2 in.tif rgb_out.tif

False color composite -

C:\RGB_Stretch.exe 4 3 2 -s 2 0.5 2 0.5 2 0.5 2 2 2 in.tif rgb_out.tif

RGB Image Composition Tool (free)



```
RGB_Make.exe Help.txt - Notepad
File Edit Format View Help
C:\RGB_Make.exe
<band_1.tif> <band_2.tif> <band_3.tif> <...> <out.tif>
Version 1.0, Released 12 May 2008

Help

1. Each input file should contain a single band only.
2. At least three input files are required. All input files should have
   the same width, height, and bits per sample.
3. GeotIFF input files should have data with 8- or 16-bit bits per sample.
4. GeotIFF input files should be uncompressed, untiled.
5. Planar configuration for the output: separate image planes.
6. Typical example:
   RGB_Make.exe in_red.tif in_green.tif in_blue.tif out_rgb.tif

Popular 8- or 16-bit image sources

1. Medium-resolution Landsat ETM+ scenes from NASA GeoCover 2000 series
   USGS GloVIS - http://glovis.usgs.gov/
   GLCF       - http://www.landcover.org/
2. Very high-resolution satellite imagery
   quickBird  - http://www.DigitalGlobe.com/
   IKONOS     - http://www.GeoEye.com/

Full Name: RGB Image Composition Tool (free)
Making R/G/B composite from a series of single-band GeotIFF inputs
Developer: http://www.GeoSage.com/
```