NASA / USGS Landsat-8

Spectral Discovery for Landsat-8 Imagery

(DOS- and GUI-based Version 3.1)

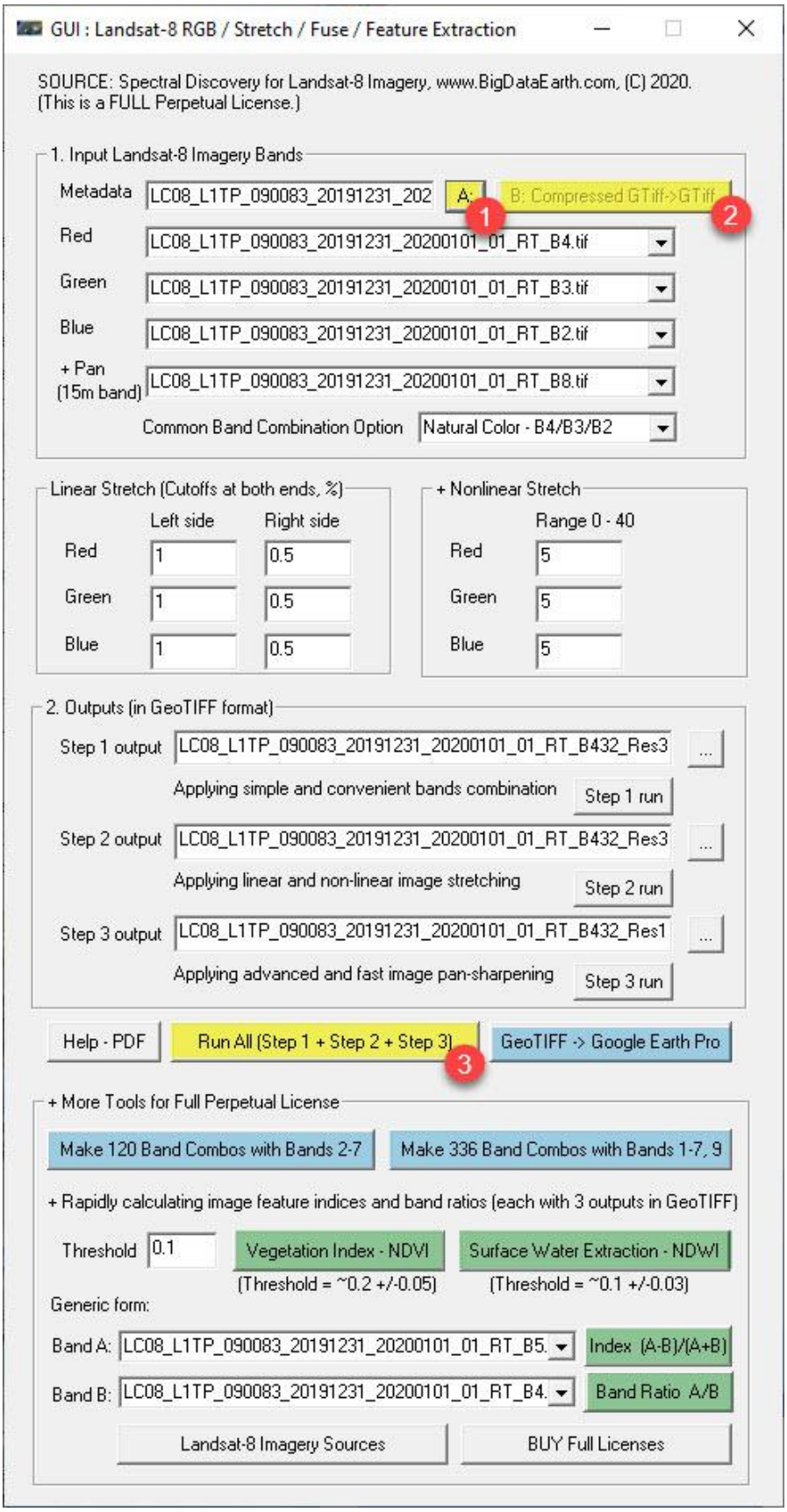
Unique software tool to easily and rapidly make colourful and detail-rich **Landsat-8** imagery composites at **15m**-resolution, with **3** simple button clicks:

- Band Combination
- Image Stretching
- Image Pan-sharpening
- Exploratory Image Feature Extraction

Developers: BigData Earth | GeoSage
http://www.BigDataEarth.com/ | http://www.GeoSage.com/

Updated 1 March 2020

BigDataEarth®



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1. Download Landsat-8 Level-1 Imagery Data

The U.S. Geological Survey (USGS) distributes Landsat-8 data in a number of open and accessible ways, including:

- Browse and download data - **GloVis** - http://glovis.usgs.gov demo
- Search and bulk-download data - **EarthExplorer** - http://earthexplorer.usgs.gov useful tutorial

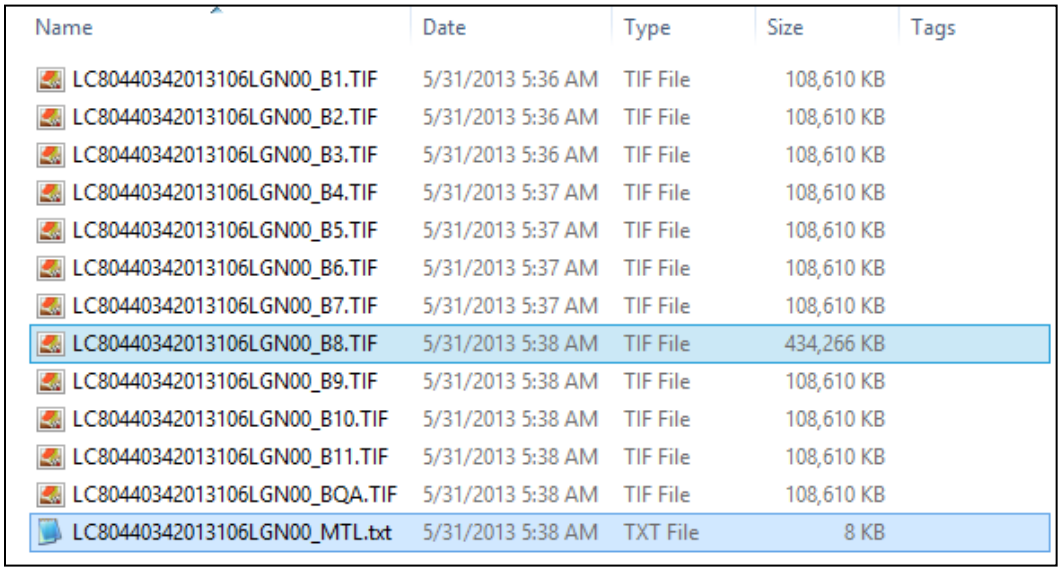
Recently, there are many other options to download Landsat-8 data. The most convenient way is probably via Amazon Web Services and Google Earth Engine.

- **Landsat-8 on AWS:** public bucket `landsat-pds`
  https://registry.opendata.aws/landsat-8/

  The use of GUI-based tools (e.g. S3 Browser) or AWS Command Line Interface can make data download very quickly and efficiently. Please refer to our similar User Guide for Sentinel-2 imagery about this (link).

- Landsat-8 imagery on Google Earth Engine and Google Cloud Platform
  https://cloud.google.com/storage/docs/public-datasets/landsat

Downloadable Landsat-8 imagery data is typically included **in a single/bundled zip file**. Once unzipped, it contains the following separate imagery bands and the *_MTL.txt file:



Name	Date	Type	Size	Tags
LC80440342013106LGN00_B1.TIF	5/31/2013 5:36 AM	TIF File	108,610 KB	
LC80440342013106LGN00_B2.TIF	5/31/2013 5:36 AM	TIF File	108,610 KB	
LC80440342013106LGN00_B3.TIF	5/31/2013 5:36 AM	TIF File	108,610 KB	
LC80440342013106LGN00_B4.TIF	5/31/2013 5:37 AM	TIF File	108,610 KB	
LC80440342013106LGN00_B5.TIF	5/31/2013 5:37 AM	TIF File	108,610 KB	
LC80440342013106LGN00_B6.TIF	5/31/2013 5:37 AM	TIF File	108,610 KB	
LC80440342013106LGN00_B7.TIF	5/31/2013 5:37 AM	TIF File	108,610 KB	
LC80440342013106LGN00_B8.TIF	5/31/2013 5:38 AM	TIF File	434,266 KB	
LC80440342013106LGN00_B9.TIF	5/31/2013 5:38 AM	TIF File	108,610 KB	
LC80440342013106LGN00_B10.TIF	5/31/2013 5:38 AM	TIF File	108,610 KB	
LC80440342013106LGN00_B11.TIF	5/31/2013 5:38 AM	TIF File	108,610 KB	
LC80440342013106LGN00_BQA.TIF	5/31/2013 5:38 AM	TIF File	108,610 KB	
LC80440342013106LGN00_MTL.txt	5/31/2013 5:38 AM	TXT File	8 KB	

Note that the **Metadata File** in *_MTL.txt and the **Panchromatic (Pan) band** *_B8.TIF.

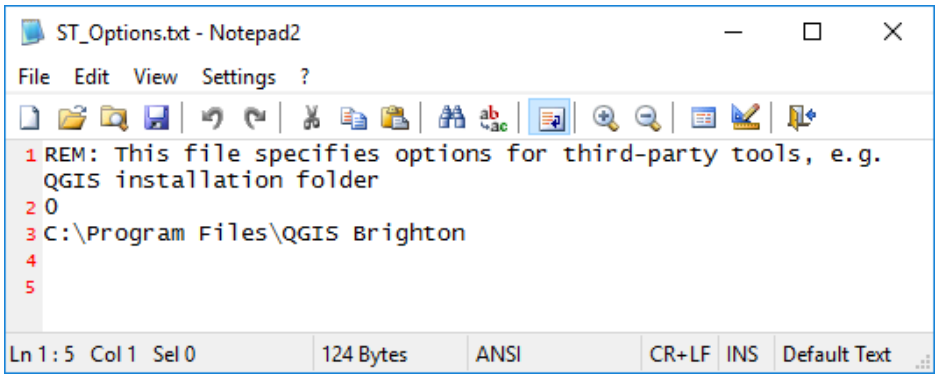
2. Install DOS-/GUI-based Spectral Discovery for Landsat-8 Imagery

The software is available at http://www.GeoSage.com/

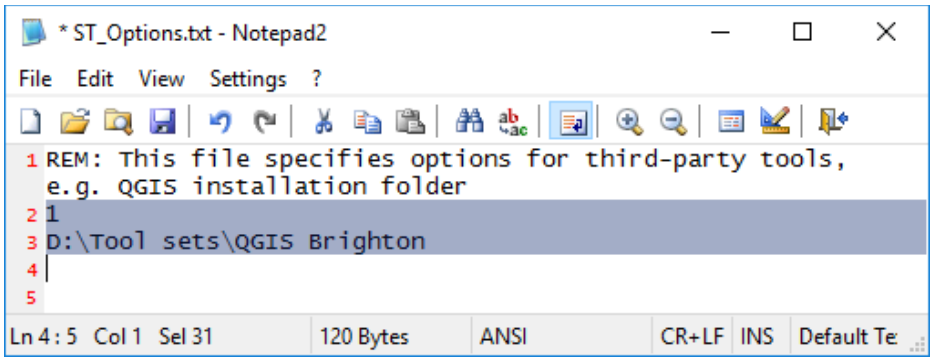
- Prerequisite: Install free Microsoft VC++ 2015 Redistributable (x86)

- Required for processing **compressed** Landsat-8 data downloaded from **Amazon Web Services (AWS)**: Install the popular open-source GIS software **QGIS**. *Spectral Discovery for Landsat-8 Imagery* will use the *GDAL_translate.exe* tool included in QGIS to convert downloaded Landsat-8 data from compressed GeoTIFF format to uncompressed, analysis-ready GeoTIFF format. (Ignore this step if a user has installed QGIS already, or has made such conversions already with other geospatial software.)

  It is expected that a version of QGIS will be installed under the default "Program Files" or "Program Files (x86)" folder. *Spectral Discovery for Landsat-8 Imagery* software can automatically detect its location. However, if a user has installed QGIS under a folder other than the above, the following change is required for the "ST_Options.txt" file located in the program folder: for the last two lines, from the current



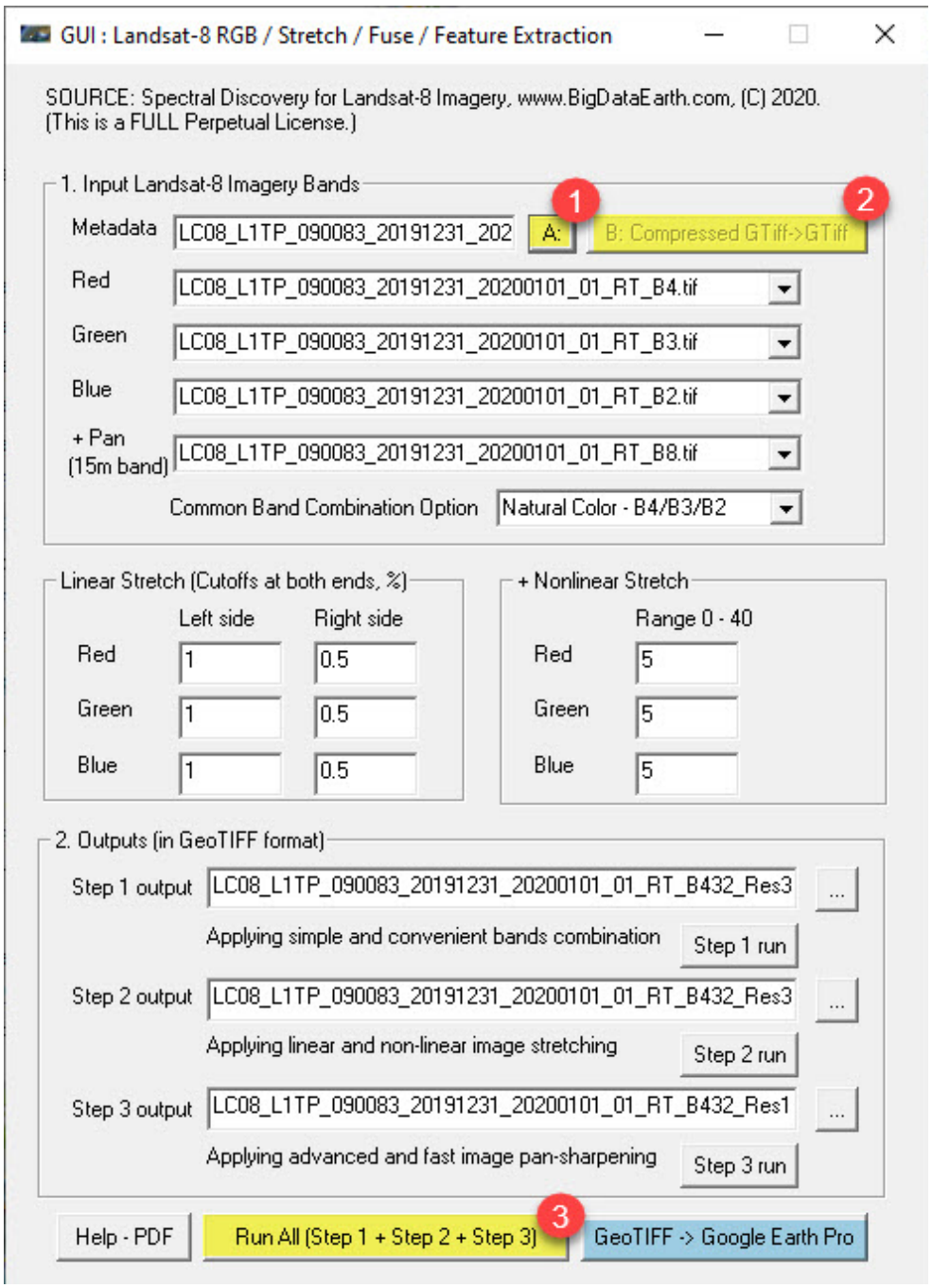
  to something like this indicating where QGIS is installed:



- Optional: Install free Google Earth Pro for displaying and verifying outputs

3. Run GUI (with 3 simple button clicks)

- **Button 1**: Select Metadata file (*_MTL.txt) of your Landsat-8 imagery data downloaded, and the rest of GUI fields will be automatically populated.
- **Button 2:** Convert imagery in **compressed** GeoTIFF to **uncompressed**, analysis-ready GeoTIFF format. This applies to imagery downloaded from AWS; otherwise, no need.
- **Button 3**: Run three steps altogether (Band Combination, Image Stretching, and Image Pan-sharpening) and output files in GeoTIFF format.



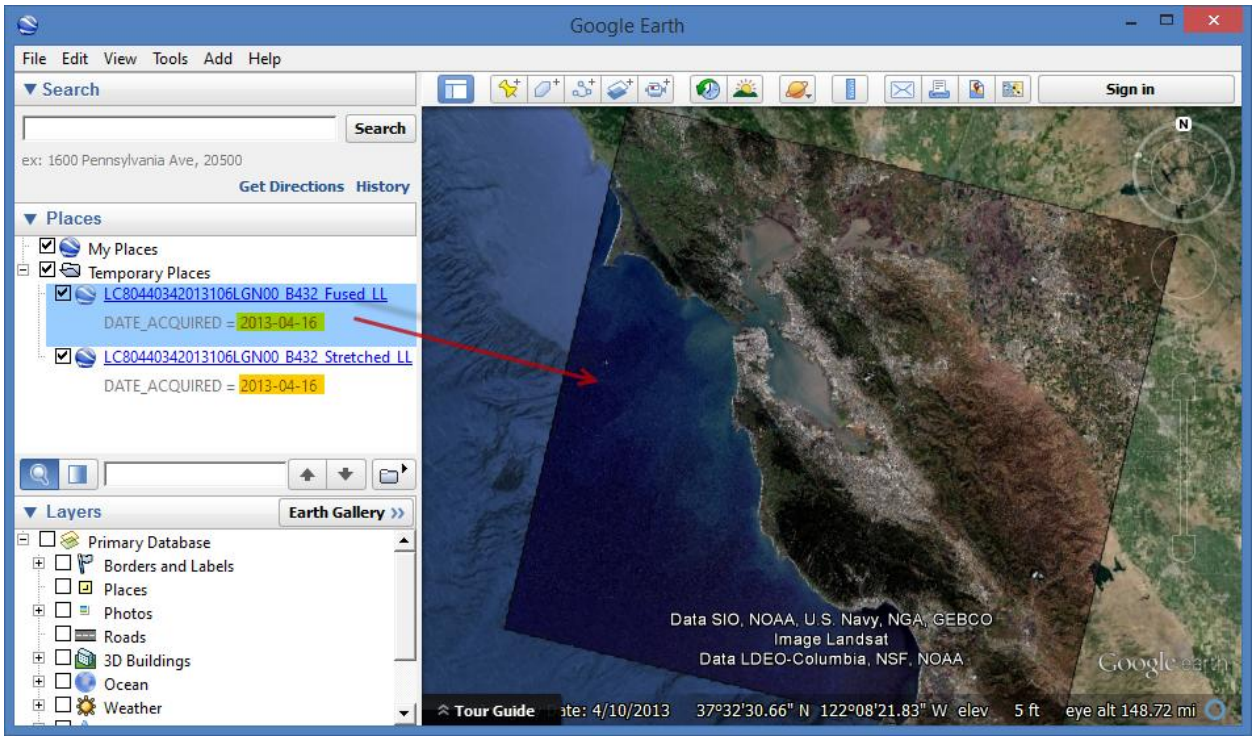
Users may modify and optimise image stretching parameters for various visual styles of the output.

The command-line of each run is stored in a **log.txt** file under the data folder. Users who are experienced with DOS batch runs will find this file very handy (e.g. with this file the runs can be repeated entirely in DOS console without the GUI). Users may also use the log file to edit DOS batch command-lines for more efficient implementation when dealing with 100s or 1,000s of Landsat-8 scenes.

4. Display Stretched and Pan-sharpened Imagery Composites (GeoTIFF format) Directly in Google Earth Pro

Google Earth Pro can import geospatial data in many formats, including GeoTIFF. Users can just simply drag the stretched or pan-sharpened imagery composite into Google Earth Pro, for easy display and comparison with the rich basemaps provided by Google Earth. (The imported imagery may be exported to KMZ format in Google Earth Pro.)

Google Earth Pro is free (since 30 January 2015) and a copy can be downloaded from Google: http://www.google.com/earth/



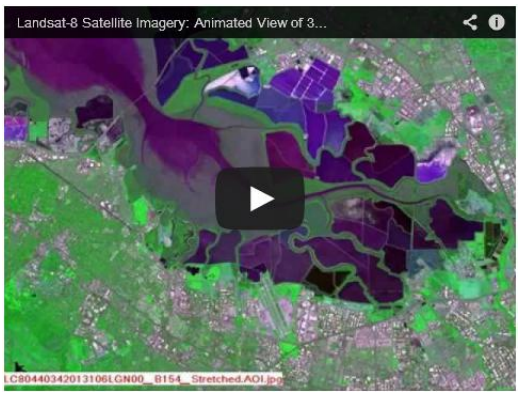
Rapidly-processed daily fresh Landsat-8 imagery can be easily displayed in Google Earth Pro

5. Additional Features for Innovative Applications

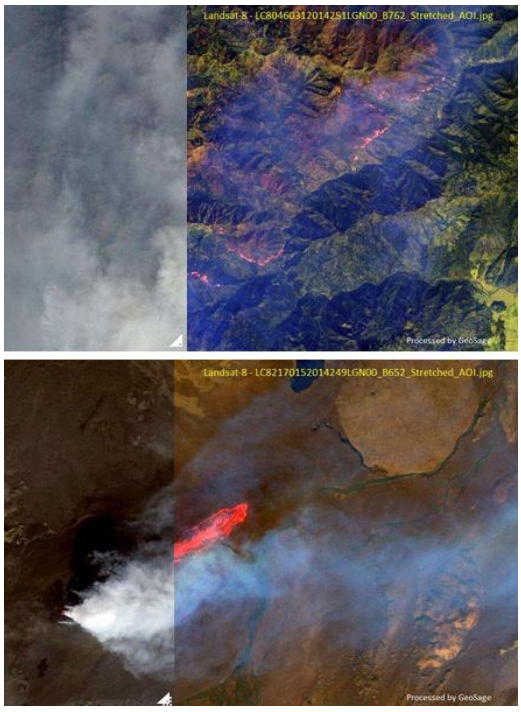
5.1 Two more button clicks: Prepare DOS batch files to rapidly make 120 or 336 band combinations using the full spectral bands of Landsat-8 imagery in a batch mode:

- 120 = 6x5x4, using 6 multispectral bands - Bands 2, 3, 4, 5, 6, 7 (~20GB disk space required for each scene)
- 336 = 8x7x6, using 8 multispectral bands - Bands 1, 2, 3, 4, 5, 6, 7, 9 (~60GB disk space required for each scene)

The outputs show the full range of band combinations that are usually invisible to human eyes. They can be used to make interesting image animation, and an example is provided in this YouTube video



5.2 See the invisible

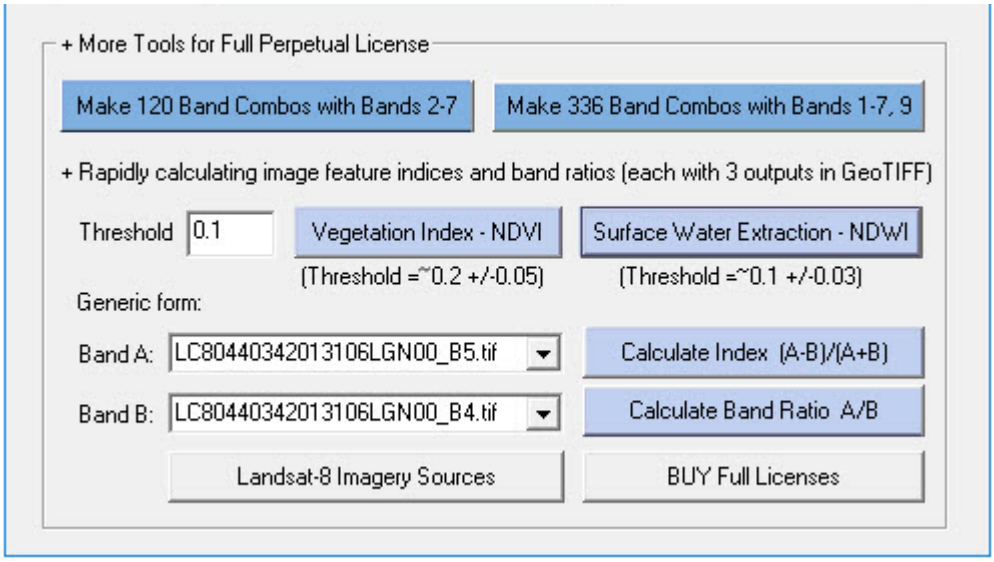


A simple yet extremely powerful way of image (visual) analysis: Through rapid, various band combinations, important features/phenomena of interest on Earth land surface can be **better highlighted and revealed**.

e.g. Landsat-8 short-wave infrared (SWIR) bands are capable of revealing wildfire hotspots and lava flows/heat through thick smoke.

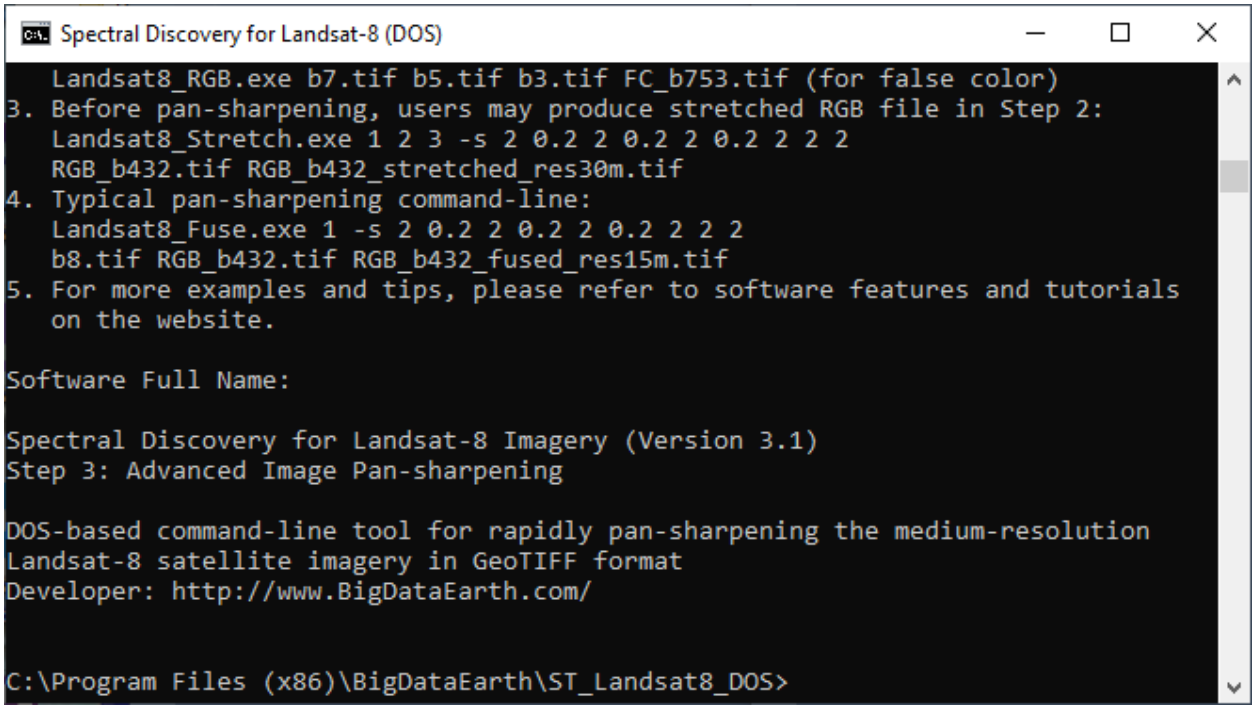
Left Figure: Comparison between natural-colour composite (showing full smoke) and false-colour composite (containing SWIR bands)

5.3 Exploratory image feature extraction with image feature indices and band ratios



Classifying and estimating water surface areas in an automated workflow. **Left**: Extracted water surface shown in light blue; **Right**: Natural-colour image with RGB bands. Location: Sundarban, Bangladesh; Image source: Landsat-8 (scene DATE_ACQUIRED = 2015-11-12).

Appendix - Main Steps in DOS-based Spectral Discovery for Landsat-8 Imagery



Step 1: Simple Band Combination

DOS-based command-line tool for simple and convenient band combinations

Landsat8_RGB.exe
<red_band_in> <green_band_in> <blue_band_in> <RGB_out.tif>

Help

1. This tool specifically targets Landsat-8 imagery in GeoTIFF format.
2. <red_band_in> <green_band_in> <blue_band_in>:
   Each multispectral input should be 16-bit, single-band GeoTIFF file.
   <RGB_out.tif>:
   Output RGB file will be 16-bit, three-band GeoTIFF file.
3. Since multispectral data are provided in separate bands, users need to combine related multispectral bands together in order to make a three-band multispectral input file, using the band combination tool, e.g.
   Landsat8_RGB.exe b4.tif b3.tif b2.tif RGB_b432.tif (for natural color)
   Landsat8_RGB.exe b5.tif b4.tif b3.tif CIR_b543.tif (for color infrared)
   Landsat8_RGB.exe b7.tif b5.tif b3.tif FC_b753.tif (for false color)

Step 2: Adaptive Image Stretching

DOS-based command-line tool for adaptive linear and nonlinear image stretching

Landsat8_Stretch.exe
<red_band_order> <green_band_order> <blue_band_order> -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>
<RGB_in.tif> <RGB_stretched_out.tif>

Parameters - Band order

<red_band_order>:
Order of the Red band in the multi-band input file, range [1-3]
<green_band_order>:
Order of the Green band in the multi-band input file, range [1-3]
<blue_band_order>:
Order of the Blue band in the multi-band input file, range [1-3]

Parameters - Specific to adaptive image stretching
The following parameters are used for both linear and non-linear image histogram stretching.

<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 0.2
<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 0.2
<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 0.2

<nonlinear_stretch_band1>

Nonlinear stretching coefficient/weight for band1
Value range [0.0-40.0], typical values 2, 5, 10, ...
<nonlinear_stretch_band2>
Nonlinear stretching coefficient/weight for band2
Value range [0.0-40.0], typical values 2, 5, 10, ...
<nonlinear_stretch_band3>
Nonlinear stretching coefficient/weight for band3
Value range [0.0-40.0], typical values 2, 5, 10, ...

Parameters - Specific to input and output in GeoTIFF format

<RGB_in.tif>
Multispectral input prepared in Step 1 (band combination).
It must contain 16-bit, three-band data.
<RGB_stretched_out.tif>
Stretched output file name. Output will be 8-bit, three-band GeoTIFF file.

Examples/Tips

1. This tool specifically targets Landsat-8 imagery in GeoTIFF format.
2. Since multispectral data are provided in separate bands, users need to combine related multispectral bands together in order to make a three-band multispectral input file, using the band combination tool in Step 1, e.g.
   Landsat8_RGB.exe b4.tif b3.tif b2.tif RGB_b432.tif (for natural color)
   Landsat8_RGB.exe b5.tif b4.tif b3.tif CIR_b543.tif (for color infrared)
   Landsat8_RGB.exe b7.tif b5.tif b3.tif FC_b753.tif (for false color)
3. Typical image stretching command-line:
   Landsat8_Stretch.exe 1 2 3 -s 2 0.2 2 0.2 2 0.2 2 2 2
   RGB_b432.tif RGB_b432_stretched_res30m.tif
   Landsat8_Stretch.exe 1 2 3 -s 2 0.2 2 0.2 2 0.2 0 0 0
   RGB_b432.tif RGB_b432_stretched_res30m.tif
4. If a scene contains a large proportion of white areas (e.g. cloud and snow), try to increase the right-end cut-off values for their exclusion. This may be automated along with the estimated % of cloud cover of the scene.
   Landsat8_Stretch.exe 1 2 3 -s 2 5 2 5 2 5 2 2 2
   RGB_b432.tif RGB_b432_stretched_res30m.tif
5. If an initial image stretching result appears bluish, try to increase the left-end cut-off values for the BLUE band only, e.g.
   Landsat8_Stretch.exe 1 2 3 -s 2 0.2 2 0.2 5 0.2 2 2 2
   RGB_b432.tif RGB_b432_stretched_res30m.tif
6. For more examples and tips, please refer to software features and tutorials on the website.

Step 3: Advanced Image Pan-sharpening

DOS-based command-line tool for rapidly pan-sharpening the medium-resolution Landsat-8 satellite imagery in GeoTIFF format

Landsat8_Fuse.exe
<pan-sharpening_method> -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>
<pan_band_in.tif> <ms_in.tif> <fused_out.tif>

Parameters - Specific to algorithms

<pan-sharpening_method>
1 - Optimization 1 (recommended); 2 - Optimization 2

Parameters - Specific to adaptive image stretching

The following parameters are used for both linear and non-linear image stretching, identical to those of the image stretching tool (Step 2) included in this package. Type Landsat8_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 0.2
<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 0.2
<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 0.2

<nonlinear_stretch_band1>
Nonlinear stretching coefficient/weight for band1

Value range [0.0-40.0], typical values 2, 5, 10, ...
<nonlinear_stretch_band2>
Nonlinear stretching coefficient/weight for band2
Value range [0.0-40.0], typical values 2, 5, 10, ...
<nonlinear_stretch_band3>
Nonlinear stretching coefficient/weight for band3
Value range [0.0-40.0], typical values 2, 5, 10, ...

Parameters - Specific to input and output in GeoTIFF format

<pan_band_in.tif>
Band 8 in the Landsat-8 band designations.
Panchromatic input must contain 16-bit, single-band data.
<ms_in.tif>
Multispectral input prepared in Step 1 (band combination).
It must contain 16-bit, three-band data.
<fused_out.tif>
Pan-sharpened output file name. Output will be 8-bit, three-band GeoTIFF file.

Examples/Tips

1. This tool specifically targets Landsat-8 imagery in GeoTIFF format.
2. Since multispectral data are provided in separate bands, users need to combine related multispectral bands together in order to make a three-band multispectral input file, using the band combination tool in Step 1, e.g.
   Landsat8_RGB.exe b4.tif b3.tif b2.tif RGB_b432.tif (for natural color)
   Landsat8_RGB.exe b5.tif b4.tif b3.tif CIR_b543.tif (for color infrared)
   Landsat8_RGB.exe b7.tif b5.tif b3.tif FC_b753.tif (for false color)
3. Before pan-sharpening, users may produce stretched RGB file in Step 2:
   Landsat8_Stretch.exe 1 2 3 -s 2 0.2 2 0.2 2 0.2 2 2 2
   RGB_b432.tif RGB_b432_stretched_res30m.tif
4. Typical pan-sharpening command-line:
   Landsat8_Fuse.exe 1 -s 2 0.2 2 0.2 2 0.2 2 2 2
   b8.tif RGB_b432.tif RGB_b432_fused_res15m.tif
5. For more examples and tips, please refer to software features and tutorials on the website.

Step 4: Calculating image feature indices and band ratios

DOS-based command-line tool for rapidly calculating image feature indices and band ratios, with the medium-resolution Landsat-8 satellite imagery in GeoTIFF format.

Landsat8_Feature.exe
<calculation_method> <input_band1.tif> <input_band2.tif> <threshold>

Parameters

<calculation_method>
1 - Normalized Difference Image Feature Indices (A-B)/(A+B), e.g.
NDVI (Normalized Difference Vegetation Index) = (NIR-RED)/(NIR+RED)
NDWI (Normalized Difference Water Index) = (GREEN-SWIR1)/(GREEN+SWIR1)
2 - Calculating simple band ratios in the form of A/B

<input_band1.tif> <input_band2.tif>
For NDVI calculation, <input_band1.tif> should be Landsat-8 Band 5 (NIR band)
<input_band2.tif> should be Landsat-8 Band 4 (RED band).

<threshold>
The threshold value to be used for making a binary output image that shows classified features. E.g. in NDWI calculation, if a pixel value is greater than a defined threshold of 0.1, it is classified as water.

Help

1. This tool specifically targets Landsat-8 imagery in GeoTIFF format.
2. Three output files are automatically produced by the software. Each is a single-band GeoTIFF file, ready to be displayed in Windows Photo Viewer, GIS and remote sensing software, or Google Earth Pro.
   - First output: 32-bit Float data type, useful for further analyses.
   - Second output: 8-bit Byte data type, a color palette is applied.
   - Third output: 8-bit Byte data type, a binary image to show classified features after a user-defined threshold is applied.
3. For NDVI color palette, the greener the pixel, the more dense vegetation is present. For the generic form, a general color palette ("rainbow", from min to max, below) is used to highlight the wide distribution of pixel values.