Course title: EOTIST Standard course

Course subject: Remote Sensing

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LESSON SR2 - EXERCISE
REMOTE SENSING DATA SOURCES

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OBJECTIVES

Read quality bands coded in bits

Work with quality bands

Export image to a common .tif file format

Read datatypes from the metadata

KEY ELEMENTS

Bit-coded bands, format exchange, metadata

SOFTWARE

SNAP & QGIS

DATA

Level-1 and Atmosphere Archive & Distribution System Distributed Active Archive Center (LAADS DAAC)

1. OPEN AND EXPLORE IMAGE FORMAT

Go to materials folder and search for the original Landsat 8 image file *'LC08_L2SP_190022_20200723_20200911_02_T1.tar'*.

Open the compressed file and inspect the content files. Extract the compressed .tar file in a new folder.

- *Can you see any image insdie? Which file format does It have? Do you see any other files?*

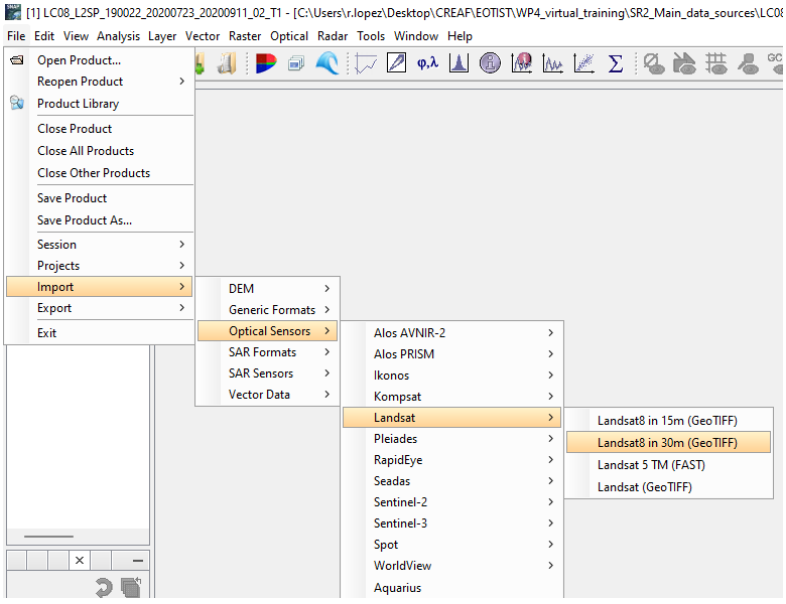
Open a SNAP session and import the image by clicking to 'Import -> Optical Sensors -> Landsat -> Landsat 8 in 30m'.

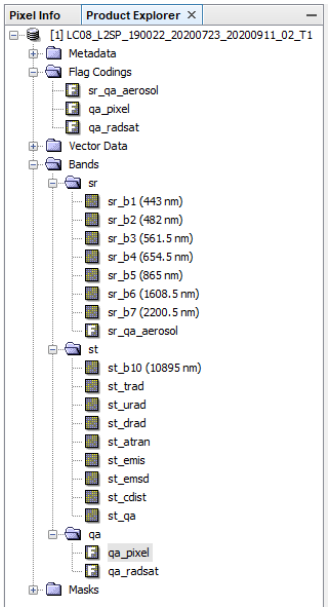
Open the uncompressed folder location and select one of the MTL or ANG files.

Explore the object:

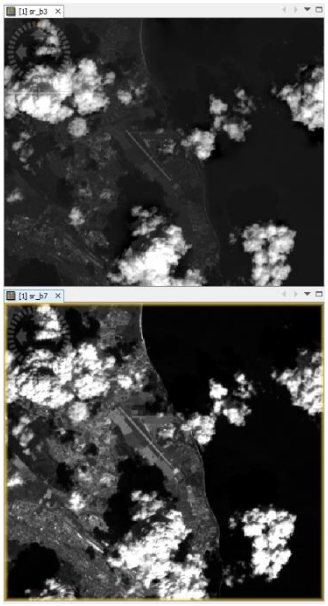
- *Can you link all the rasters present in the 'Bands' and 'Masks' folders of the object to the .tif files in the uncompressed tar file folder?*

Check on the Landsat 8 Collection 2 Level 2 Science Product (L2SP) Guide the bands delivered in the the product. *Can you guess which bands should be opened to display a true colour image?*





2. DATA VISUALIZATION



Open a single band of the 'Bands/sr' folder by double click upon it in the product explorer window. As it can be seen, this folder contains the surface reflectance bands.

Can you spot differences in the differnt spectral bands? Could you link this difference in reflectance values to the wavelength captured?

By picking one image tab and moving it, you can tile windows and link zooms, which makes easier to compare different images or bands.

Now open the termic band from the 'Bands/st' folder. *Which is the main dfference with the solar spectrum wavelenths? What can you observe in the clouds?*

Oppen an RGB combination: Right-click to the image object and click 'open RGB image window'. Select the correspondant landsat bands to display a true colour image (R: Band 4, G: Band 3 and B: Band 2).

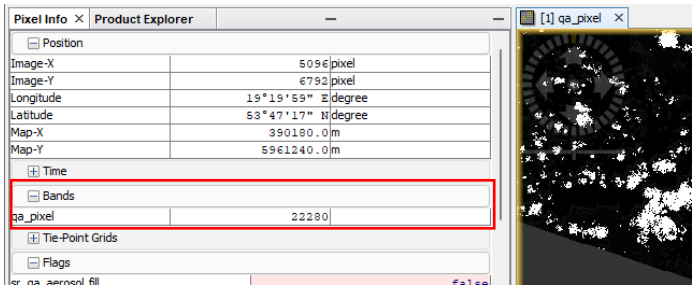
Can you see clearly the true clolur image? Which influence do you think the high amount of clouds have in the image display?

3. AUXULIARY DATA

Landsat 8 Collection 2 level 2 data provide auxiliary quality and atmosferic state bands:

- QA_RADSAT: Radiometric saturation
- QA_AEROSOL: Aerosol presence
- QA_PIXEL: Pixel quality

(check L2SP Guide, page 11).



QA_PIXEL band, in the 'bands/qa' folder, is a bit coded band with information about several quality parameters. Display the band and open the pixel info window ('View -> Tool windows -> Pixel info'). Navigate through the image and check the different values of the image. Open the statics of the image ('Analysis -> Statistics') and select the band or reload the plot ( ) to check the values distribution.

To read the image properly, it has to be considered the bit-coding of the image. Bit coding is usefull to pack auxillary information as masks or quality flags in bits, which can be concatenated to merge all masks in a single band. QA_PIXEL is a 16 bit band, but when reading the band in decimal format it is presented as 2^{16} values (65536 possible bits combination). The band is coded as follws:

Being the fist column the bit position, and the third column the possible combinations and the meaning of it:

Bit	Flag Description	Values
0	Fill	0 for image data 1 for fill data
1	Dilated Cloud	0 for cloud is not dilated or no cloud 1 for cloud dilation
2	Cirrus	0 for Cirrus Confidence: no confidence level set or Low Confidence 1 for high confidence cirrus
3	Cloud	0 for cloud confidence is not high 1 for high confidence cloud
4	Cloud Shadow	0 for Cloud Shadow Confidence is not high 1 for high confidence cloud shadow
5	Snow	0 for Snow/Ice Confidence is not high 1 for high confidence snow cover
6	Clear	0 if Cloud or Dilated Cloud bits are set 1 if Cloud and Dilated Cloud bits are not set
7	Water	0 for land or cloud 1 for water
8-9	Cloud Confidence	00 for no confidence level set 01 Low confidence 10 Medium confidence 11 High confidence
10-11	Cloud Shadow Confidence	00 for no confidence level set 01 Low confidence 10 Reserved 11 High confidence
12-13	Snow/Ice Confidence	00 for no confidence level set 01 Low confidence 10 Reserved 11 High confidence
14-15	Cirrus Confidence	00 for no confidence level set 01 Low confidence 10 Reserved 11 High confidence

Table 6-2. Landsat 8 Pixel Quality Assessment (QA_PIXEL) Bit Index

For example, considering the cloud flag, the bit in the fourth position, each combitanion of bits with a 1 in the fourth position will indicate that the pixel is covered by cloud. (XXX1XXXXXXXXXXX).

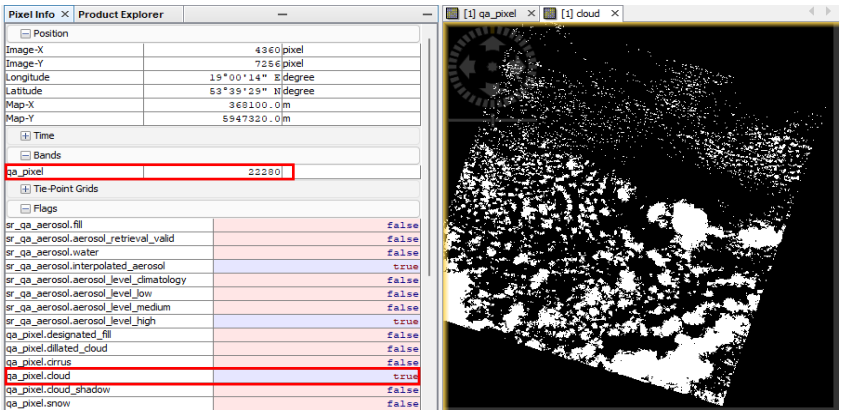
This results in $2^{16}/2$ theoretical possible combinations for a cloudy pixel. Nevertheless, some combinations are rare or hardly impossible under certain terrain conditions or occurence probability (for example, combination of cloudy and clear pixels) . Some of the most common values are listed in the table 6.3.

SNAP can read this band and build the correspondant masks, located in the 'Masks' folder of the image. Open this folder and display 'clear' and 'cloud' bands. By visual inspection. It can be seen that this two bands are almost complementary, considering (table 6.2) that clear pixels aslo include non-dilated clouds.

Open both QA_PIXEL and cloud and move the cursor over the detected clouds in the mask. Check in the Pixel info window if you can see the correspondant QA_PIXEL values for cloudy pixels. To find less common values, you can use other overlapping masks, as cloud_shadow, or water (see in Table 6.3 in the L2SP Guide).

Pixel Value	Fill	Dilated Cloud	Cirrus	Cloud	Cloud Shadow	Snow	Clear	Water	Cloud Conf.	Cloud Shadow Conf.	Snow/ Ice Conf.	Cirrus Conf.	Pixel Description
1	Yes	No	No	No	No	No	No	No	None	None	None	None	Fill
21824	No	No	No	No	No	No	Yes	No	Low	Low	Low	Low	Clear with lows set
21826	No	Yes	No	No	No	No	Yes	No	Low	Low	Low	Low	Dilated cloud over land
21888	No	No	No	No	No	No	No	Yes	Low	Low	Low	Low	Water with lows set
21890	No	Yes	No	No	No	No	No	Yes	Low	Low	Low	Low	Dilated cloud over water
22080	No	No	No	No	No	No	Yes	No	Mid	Low	Low	Low	Mid conf cloud
22144	No	No	No	No	No	No	No	Yes	Mid	Low	Low	Low	Mid conf cloud over water
22280	No	No	No	Yes	No	No	No	No	High	Low	Low	Low	High conf Cloud
23888	No	No	No	No	Yes	No	Yes	No	Low	High	Low	Low	High conf cloud shadow
23952	No	No	No	No	Yes	No	No	Yes	Low	High	Low	Low	Water with cloud shadow
24088	No	No	No	Yes	Yes	No	No	No	Mid	High	Low	Low	Mid conf cloud with shadow
24216	No	No	No	Yes	Yes	No	No	Yes	Mid	High	Low	Low	Mid conf cloud with shadow over water
24344	No	No	No	Yes	Yes	No	No	No	High	High	Low	Low	High conf cloud with shadow
24472	No	No	No	Yes	Yes	No	No	Yes	High	High	Low	Low	High conf cloud with shadow over water
30048	No	No	No	No	No	Yes	Yes	No	Low	Low	High	Low	High conf snow/ice
54596	No	No	Yes	No	No	No	Yes	No	Low	Low	Low	High	High conf Cirrus
54852	No	No	Yes	No	No	No	Yes	No	Mid	Low	Low	High	Cirrus, mid cloud
55052	No	No	Yes	Yes	No	No	No	No	High	Low	Low	High	Cirrus, high cloud
56856	No	No	No	Yes	Yes	No	No	No	Mid	High	Low	High	Cirrus, mid conf cloud, shadow
56984	No	No	No	Yes	Yes	No	No	Yes	Mid	High	Low	High	Cirrus, mid conf cloud, shadow, over water
57240	No	No	No	Yes	Yes	No	No	Yes	High	High	Low	High	Cirrus, high conf cloud, shadow

Table 6-3. Landsat 8 Pixel Quality Assessment (QA_PIXEL) Value Interpretations



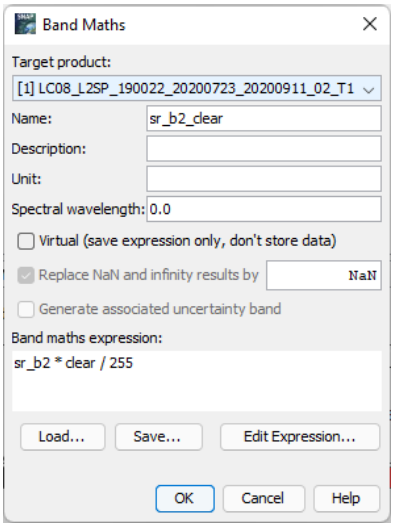
4. MASKS AND VISUALIZATION

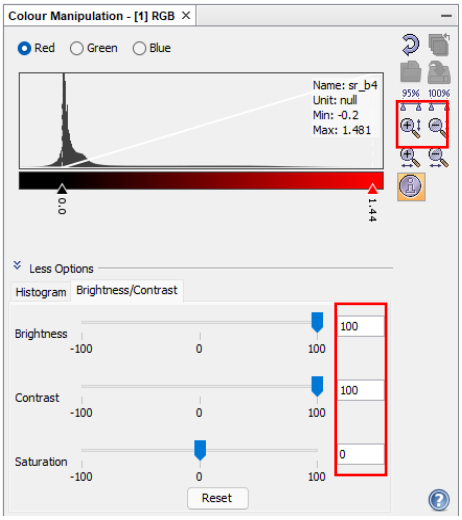
To avoid cloud influence in reflectance derived products, such as NDVI or spectral classification this provided bands can be used to set these pixels to NODATA.

Open the 'Raster -> Band Math' module and mask the non-clear pixels using the clear band for the bands 2,3, and 4, corresponding to the true colour RGB bands. Introduce the following Expression: *sr_b2 * clear,* and a recognizable band name. Notice the divisor parameter '/255' in the Expression formula. This parameter is needed because the synthetic mask is coded in 8-bit (0 to 255) even though it just contains TRUE and FALSE values, represented by 255 and 0 respectively. Make sure to untick the 'Virtual' box.

Open the resulting raster and repeat this operation with the *sr_b3* and *sr_b42_clear* bands.

Make true colour RGB combinations both for masked and original bands. Modify the colour parameters in the Colour Manipulation window to get more contrasted images. *Which of the two RGB combinations can you see more clearly?*

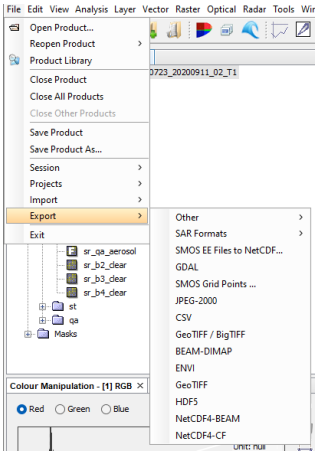




5. FORMAT CONVERSION

To export the true colour images in a single file, it can be used the multiband GeoTiff file format, among others.

Go to' File -> Export -> Geo Tiff' and click to 'Subset'. Here it is possible to choose the area to export, the spectral and quality bands and the linked metadata. Select the True RGB bands (see it on the description) and export to GeoTiff. Make a spatial subset of the total area by selecting in the image. Repeat this operation with the three masked bands.



Tip: You can see the estimated file size of the export in the lower-right side of the window.

Check the total image size of the new files. *Why do you think the cloud-masked image is twice the size of the original bands one? Do you think it is related to the data format? (Integer, Float…)*

Open and visualize the files in a new Qgis session. Check the Image info the data type of each file.