Surface Temperature calculation in Raster calculator.

This is an Example to show the user how surface temperature is calculated. Besides, to show where the constant values come from and how we use them in raster calculator**.** This example is based only on Landsat 8.

1.- Calculation of TOA (Top of Atmospheric) spectral radiance.

TOA (L) = M_L * Q_{cal} + A

where:

M_L = Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_**x**, where x is the band number).

LC08_L1TP_010063_20161120_20170318_01_T1_MTL.txt

```
165   GROUP = RADIOMETRIC_RESCALING
166     RADIANCE_MULT_BAND_1 = 1.2865E-02
167     RADIANCE_MULT_BAND_2 = 1.3174E-02
168     RADIANCE_MULT_BAND_3 = 1.2139E-02
169     RADIANCE_MULT_BAND_4 = 1.0237E-02
170     RADIANCE_MULT_BAND_5 = 6.2643E-03
171     RADIANCE_MULT_BAND_6 = 1.5579E-03
172     RADIANCE_MULT_BAND_7 = 5.2509E-04
173     RADIANCE_MULT_BAND_8 = 1.1585E-02
174     RADIANCE_MULT_BAND_9 = 2.4482E-03
175     RADIANCE_MULT_BAND_10 = 3.3420E-04
176     RADIANCE_MULT_BAND_11 = 3.3420E-04
177     RADIANCE_ADD_BAND_1 = -64.32359
```

Q_{cal} = corresponds to band 10.

A_L = Band-specific additive rescaling factor from the metadata (RADIANCE_ADD_BAND_**x**, where x is the band number).

RADIANCE_ADD_BAND_**x**, where x is the band number).

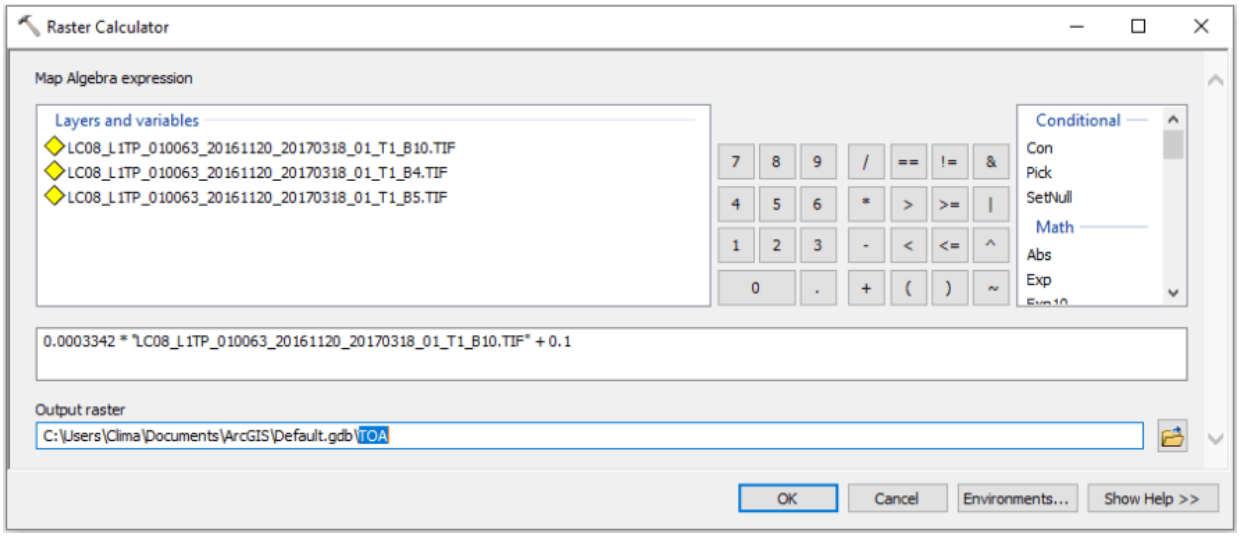
LC08_L1TP_010063_20161120_20170318_01_T1_MTL.txt

```
177     RADIANCE_ADD_BAND_1 = -64.32359
178     RADIANCE_ADD_BAND_2 = -65.86814
179     RADIANCE_ADD_BAND_3 = -60.69693
180     RADIANCE_ADD_BAND_4 = -51.18307
181     RADIANCE_ADD_BAND_5 = -31.32149
182     RADIANCE_ADD_BAND_6 = -7.78937
183     RADIANCE_ADD_BAND_7 = -2.62543
184     RADIANCE_ADD_BAND_8 = -57.92515
185     RADIANCE_ADD_BAND_9 = -12.24115
186     RADIANCE_ADD_BAND_10 = 0.10000
187     RADIANCE_ADD_BAND_11 = 0.10000
188     REFLECTANCE_MULT_BAND_1 = 2.0000E-05
189     REFLECTANCE_MULT_BAND_2 = 2.0000E-05
```

TOA = 0.0003342 * “Band 10” + 0.1

Therefore the equation must be solved using the Raster Calculator tool in ArcMap.

ArcMap.



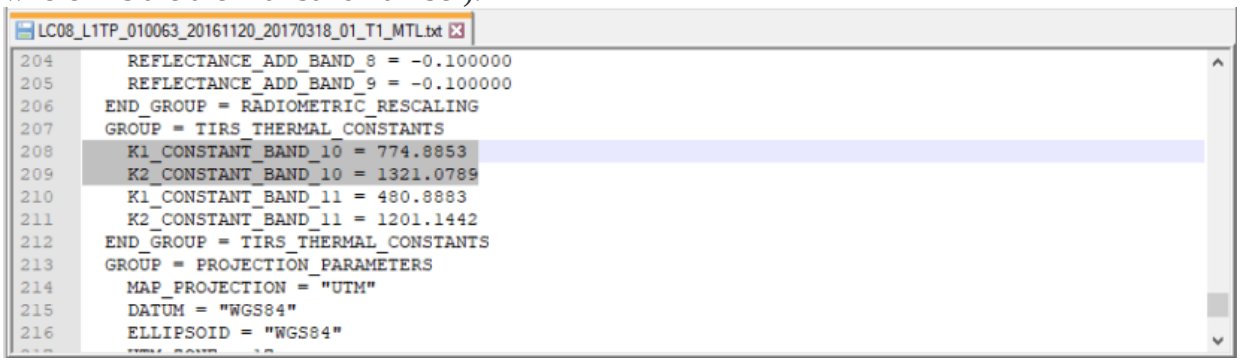
2.- TOA to Brightness Temperature conversion

$BT = (K_2 / (\ln (K_1 / L) + 1)) - 273.15$

where:

K_1 = Band-specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_**x**, where x is the thermal band number).

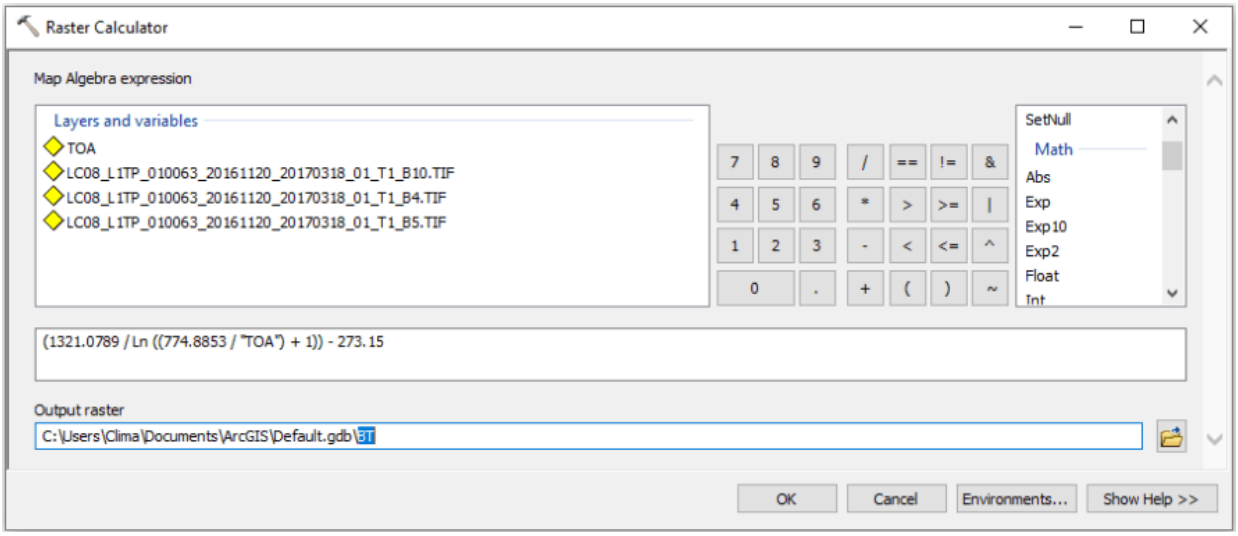
K_2 = Band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_**x**, where x is the thermal band number).



L = TOA

Therefore, to obtain the results in Celsius, the radiant temperature is adjusted by adding the absolute zero (approx. -273.15°C).

BT = (1321.0789 / Ln ((774.8853 / “%TOA%”) + 1)) – 273.15

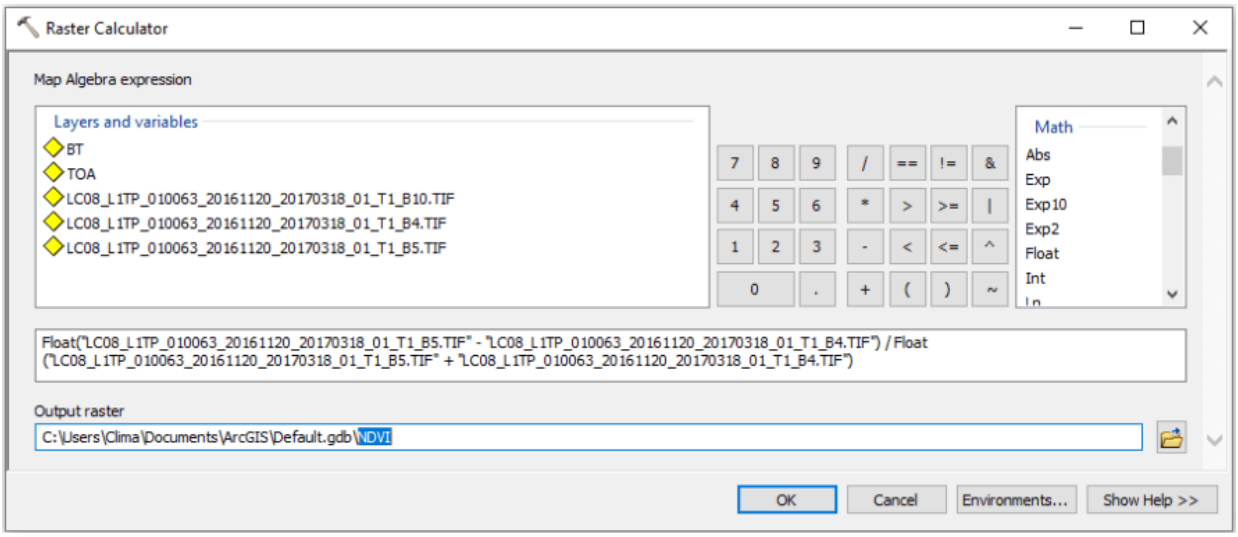


3.- Calculate the NDVI

NDVI = (Band 5 – Band 4) / (Band 5 + Band 4)

Note that the calculation of the NDVI is important because, subsequently, the proportion of vegetation (P_v), which is highly related to the NDVI, and emissivity (ε), which is related to the P_v, must be calculated.

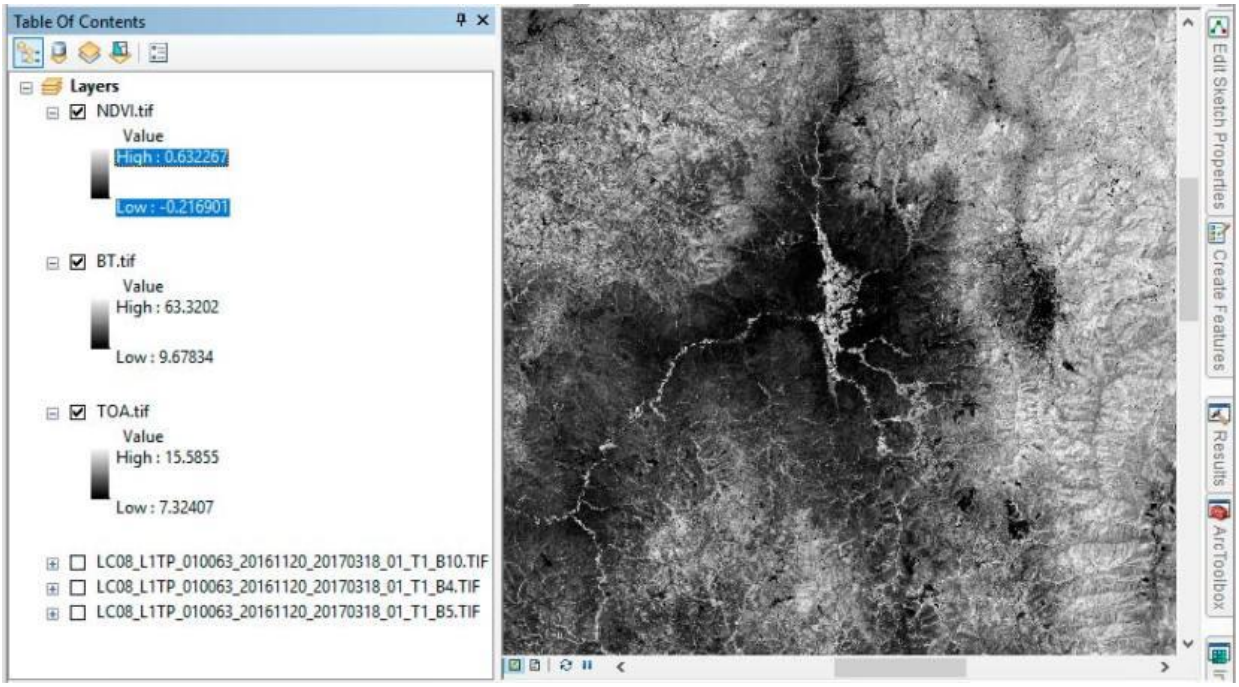
NDVI = Float(Band 5 – Band 4) / Float(Band 5 + Band 4)



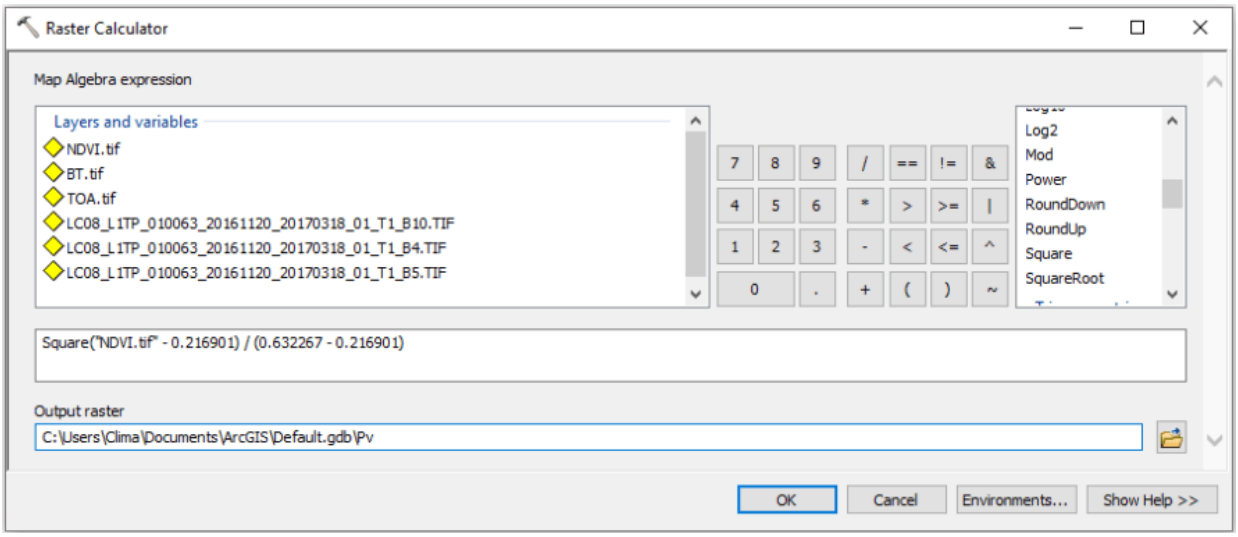
4.- Calculate the proportion of vegetation P_v

P_v = Square (($NDVI - NDVI_{min}$) / ($NDVI_{max} - NDVI_{min}$))

Usually the minimum and maximum values of the NDVI image can be displayed directly in the image (both in ArcGIS, QGIS, ENVI, Erdas Imagine), otherwise you must open the properties of the raster to get those values.



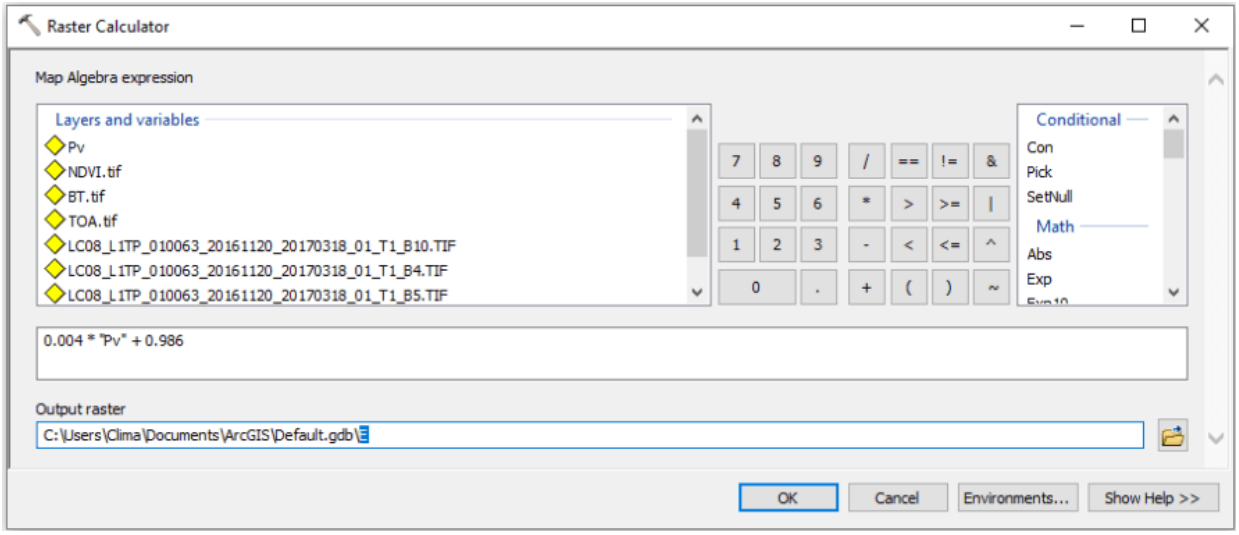
P_v = Square("NDVI" – 0.216901) / (0.632267 – 0.216901)



5.- Calculate Emissivity ε

$\varepsilon = 0.004 * P_v + 0.986$

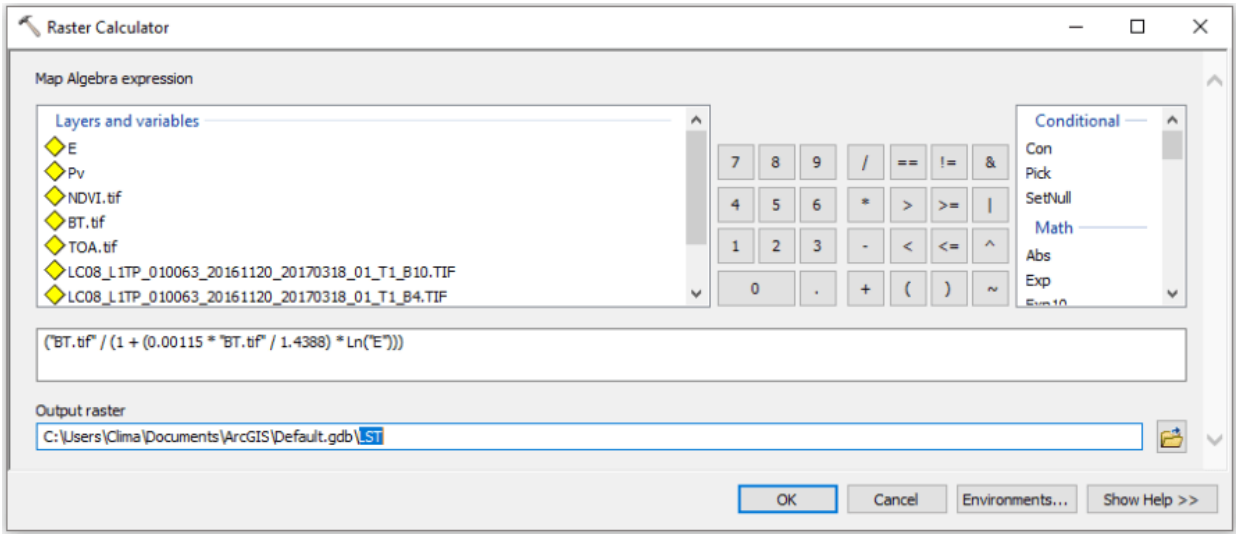
Simply apply the formula in the raster calculator, the value of 0.986 corresponds to a correction value of the equation.



6.- Calculate the Land Surface Temperature

$LST = (BT / (1 + (0.00115 * BT / 1.4388) * Ln(\varepsilon)))$

Finally apply the LST equation to obtain the surface temperature map.



As a result of the process developed, this is a map of the Land Surface Temperature, it should be noted that it is not equal to the air temperature.