GEONETCast-Americas Practical Session – Basic GeoTIFF manipulation using ILWIS

1 - Getting Ready

1.1 Software Download and Installation

Download the ILWIS software at the following link: http://52north.org/downloads/ilwis/ilwis-3-08-03/n52-ilwis-v3-08-03, and extract the executable file **"setup.exe"** in your local computer.
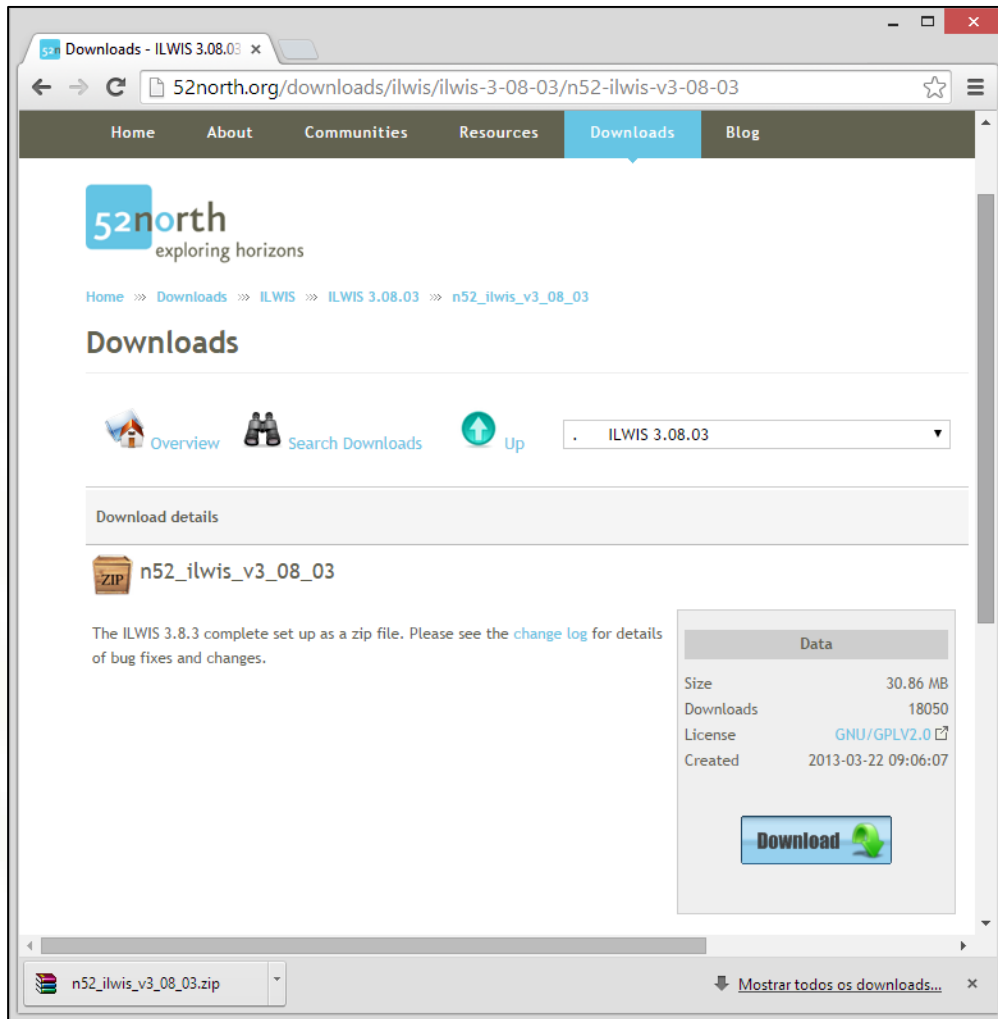

Figure 1: ILWIS download webpage

Follow the standard Windows installation procedure (Next -> Install). After installing it with the standard options, the software directory will be located at "*C:\Program Files (x86)\n52\ILWIS38*".

1.2 Download the tutorial files:

Download the compressed file *"GeoTIFF_Tutorial.zip"* at the following link:
https://www.dropbox.com/s/k9pr2juobw7h3dx/GeoTIFF_Tutorial.zip?raw=1

💡 **Hint:** Create a folder in the **"C:\"** directory called **"VLAB"** and extract the **"GeoTIFF_Tutorial.zip"** files in it. From now on this folder will be referred as "**work folder**" in this tutorial.
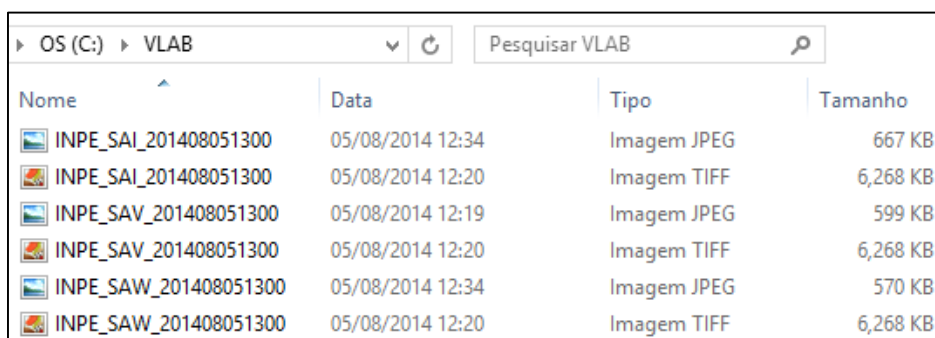
Image 2: Provided files after the extraction in the work folder

Files	Description	Geographical Area	Spectral Region	Wavelenght (µm)
INPE_SAV_YYYYMMDDHHMN.tif	Albedo (0~100% * 100)	South America	Visible	0.52 ~ 0.71
INPE_SAV_YYYYMMDDHHMN.jpg	JPEG Image			
INPE_SAI_YYYYMMDDHHMN.tif	Brightness Temperature (Kelvin * 100)		Infrared Window	10.2 ~ 11.2
INPE_SAI_YYYYMMDDHHMN.jpg	JPEG Image			
INPE_SAW_YYYYMMDDHHMN.tif	Brightness Temperature (Kelvin * 100)		Water Vapor	5.77 ~ 7.33
INPE_SAW_YYYYMMDDHHMN.jpg	JPEG Image			

Table 1: File descriptions

💡 **Hint:** GeoTIFF imagery from South America like the ones used in this tutorial are broadcasted in near real-time in the GEONETCast-Americas system and may be found at **"KenCast\Fazzt\incoming\INPE"** in your local receive station.

1.3 Main window and work folder:

Run the program, and select the work folder created in the previous step. You may find the folder using the main window browser, or using the toolbar in the upper part of the window, clicking in the icon 📂[New Catalog] and browsing to the created folder (**"C:\VLAB"**, in the previous step).

After browsing to the work folder, the imagery extracted in the previous step will not be shown, for we still didn't import them to the format accepted by ILWIS (ILWIS Raster).
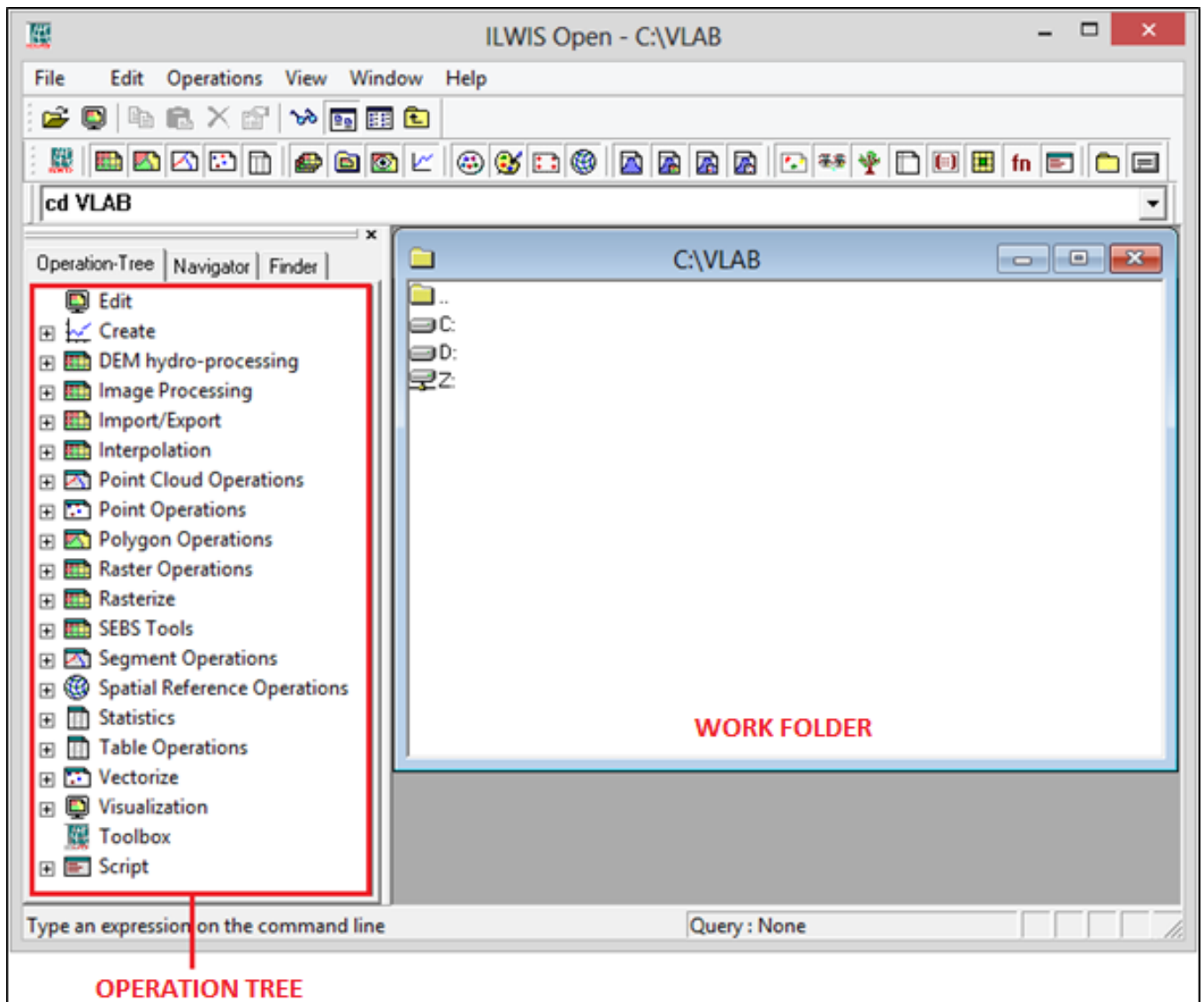
Figure 3: ILWIS Main Window

1.4 Importing the first GeoTIFF file

In the main window, after browsing to your work folder (e.g.: **C:\VLAB**), in the *Operation-Tree* select *"Import / Export" -> "Import via GDAL".* The *"Import"* window will be opened.

In the *"Import"* window, in the item list, click **once** on *"INPE_SAV_201408051300.tif"*, type a name for the imported file (in the example image below, we typed the original name), click in the option *"Convert to ILWIS data format"*, and click *"OK".*
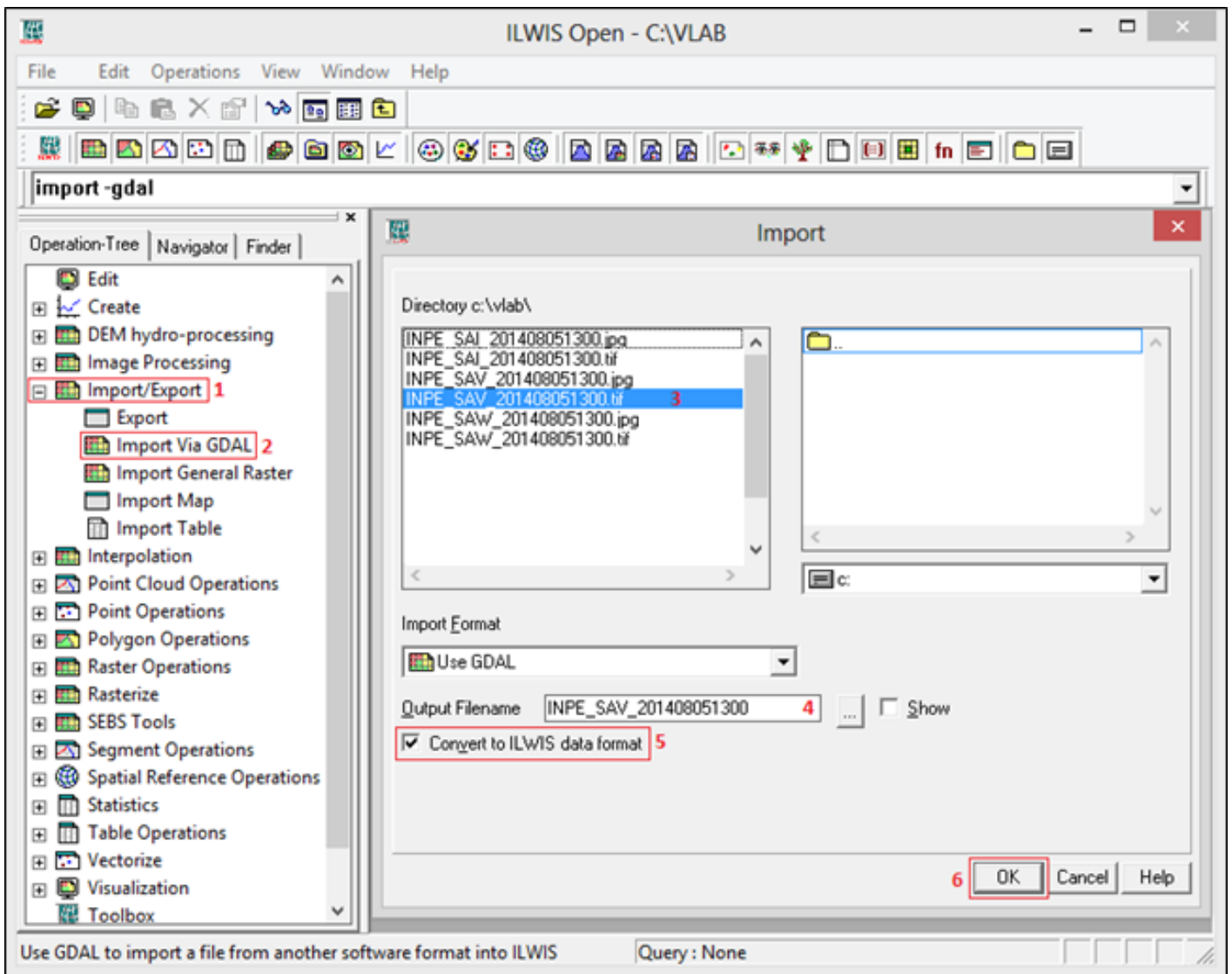
Figure 4: GeoTIFF importing sequence

The imported GeoTIFF will be shown in the work folder.
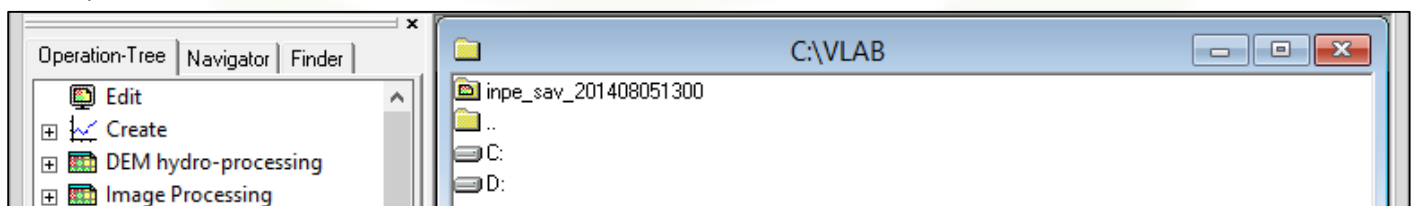

Figure 5: GeoTIFF file successfully imported

After successfully importing the GeoTIFF, click twice on the imported file **"inpe_sav_201408051300"** in the example below. A new window will be opened, showing the file content (three sub-files):
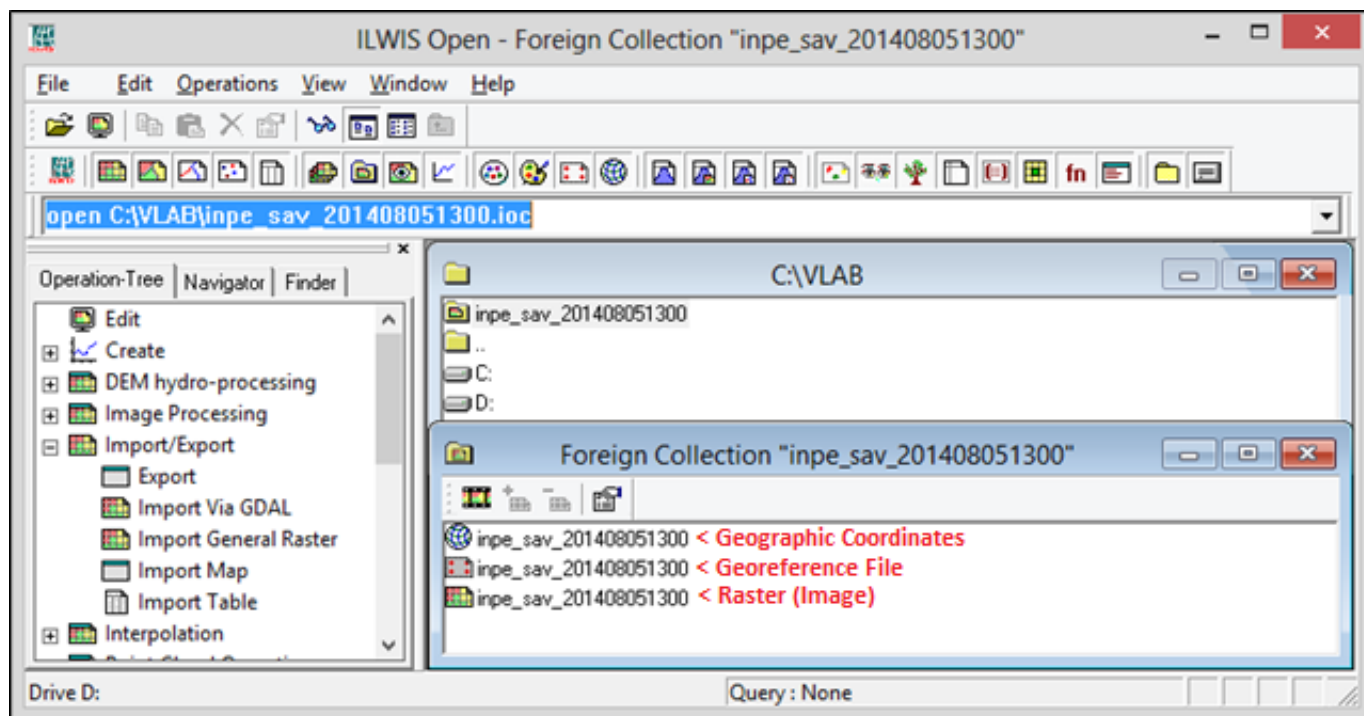

Figure 6: Imported file content

From now on, we're ready to manipulate the imported GeoTIFF.

2 – Manipulating the GeoTIFF's

Lesson 1 - Analyzing the properties of an image before opening it

2.1 The Geographic Coordinate File

Before starting the manipulation, let's briefly check some of the imported GeoTIFF image attributes. This is very important to know when mosaicking, for example.

By clicking on the **Geographic Coordinates** 🌐 icon of the *"INPE_SAV_201408051300"* image imported in the previous step, we obtain the following information:
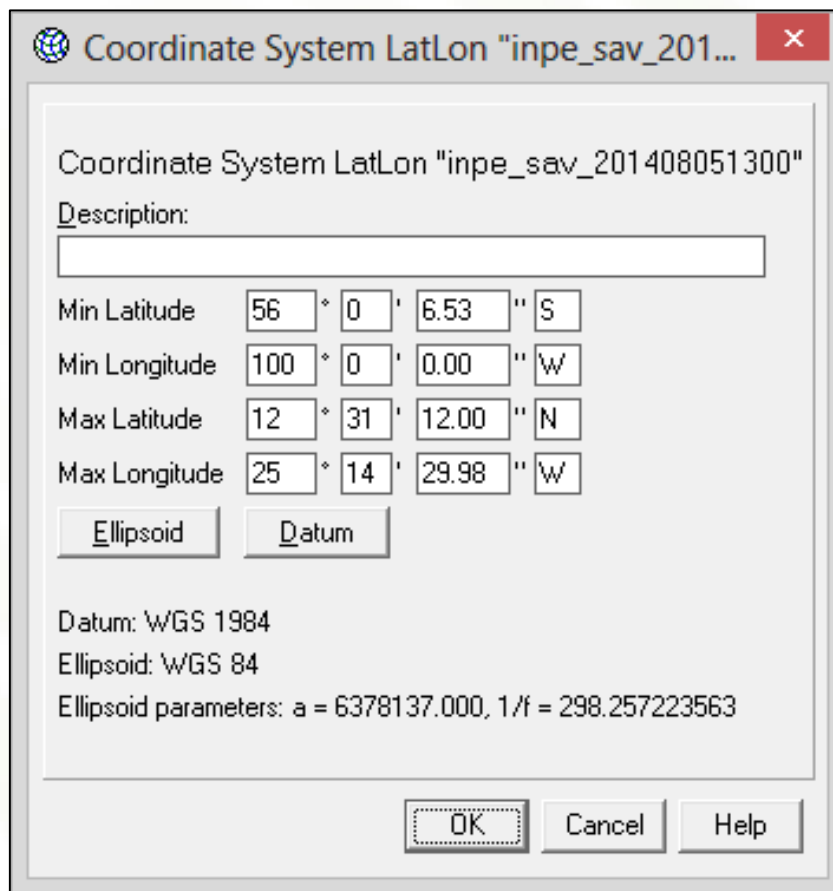

Figure 7: Geographic Coordinates file content

- **First obtained information: Maximum / Minimum Latitudes and Longitudes in Degrees (°), Minutes (') e Seconds (") / North (N), South (S), East (E) e West (W):**

For this image, we have:

Minimum latitude: 56° 0' 6.53" S = 56,001814° S ou - 56,001814°
Maximum latitude: 12° 31' 12" N = 12,52° N ou + 12,52
Minimum longitude: 100° 0' 0" W = 100 W ou - 100°
Maximum longitude: 25° 14' 29,98" W = 25,241661° W ou - 25,241661

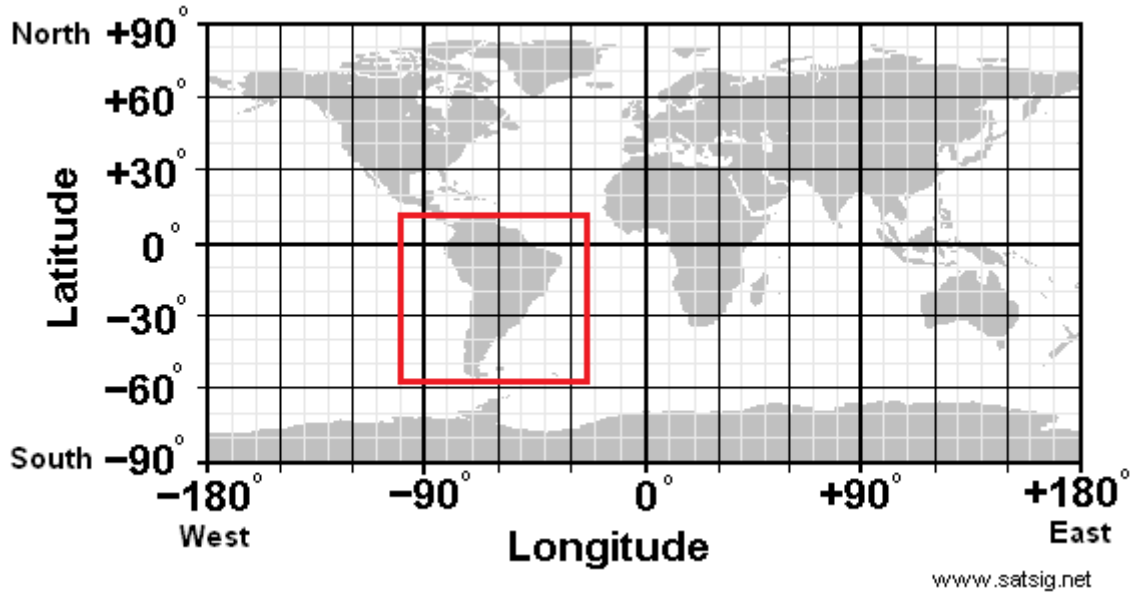Therefore, the approximate geographical location of the imported image is:

Figure 8: Approximate position of the imported image
Note: The image above is representative, and it's not generated by the ILWIS software.

> 💡 **Hint:** To convert degrees and minutes to decimal values, use the following equation:
> **Decimal Value = Degrees + (Minutes / 60) + (Seconds / 3600)**

- **Second obtained information: Datum WGS 1984 and Ellipsoid WGS 84:**

Another information obtained is the Global Coordinate System used, the **WGS 1984**.

> 💡 **Hint:** For more information about the WGS 84 Earth mathematical model, visit:
> http://earth-info.nga.mil/GandG/publications/tr8350.2/wgs84fin.pdf and http://home.online.no/~sigurdhu/WGS84_Eng.html

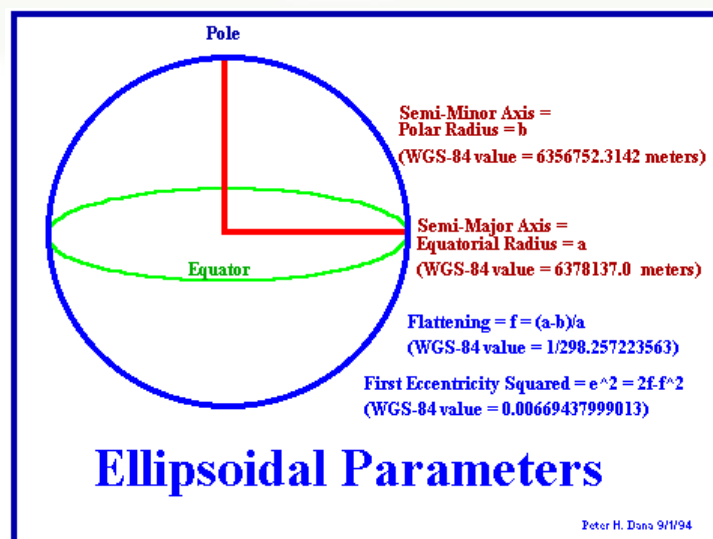- **Third obtained information: Ellipsoidal Parameters of the WGS 84 System**

Figure 9: Ellipsoidal Parameters of the WGS 84 System

Parameters informed by ILWIS:

Equatorial Radius (a): 6378137.0 meters
1 / flattening (f): 298.257223563

Therefore:
(f) = 1 / 298.257223563 = 0,0033528106647475

And **f = (a - b) / a = (1 – f) * a**

Therefore:
Polar Radius (b) = a – (f * a) = 6356752.3142 meters

2.2 The Georeference File

Right-click the **Georeference** file (▦ icon) of the "**INPE_SAV_201408051300.tif**" image. In the **option window**, click in **"Properties"**.
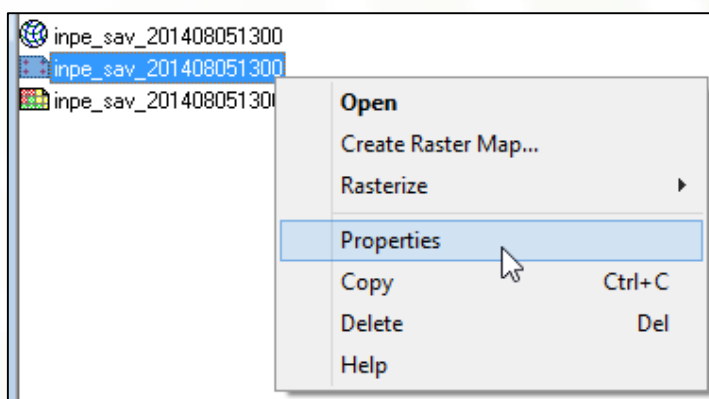

Figure 10: Georeference file options

In addition to the information obtained before, we have the following information:
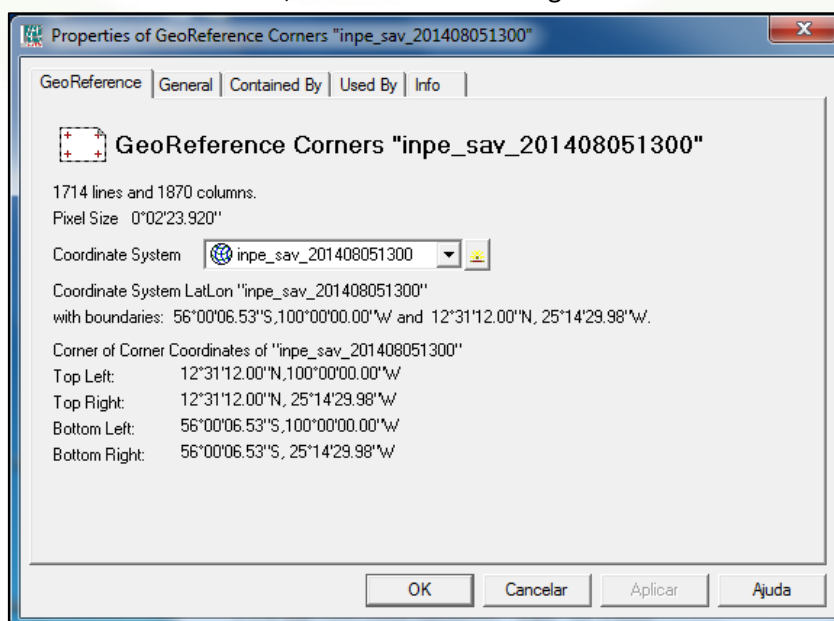

Figure 11: Georeference file content

- **Fourth obteined information: Number of lines and columns of the imported image**

For this image, we have **1714 lines (latitude)** and **1870 columns (longitude)**, totaling **3205180 pixels** (1714 x 1870).

- **Fifth obteined information: Pixel Size**

For this image, the spatial coverage for each pixel is **0° 02' 23,92" x 0° 02' 23,92"**.

Using the WGS 84 model information seen in the previous step, we know that:

Equatorial Radius = 6378137 m = 6378,137 km
Equatorial Circunference = 2 * pi * r = 40075,01669 km

Therefore, in the Equator:

Each degree = (40075 / 2) / 180 = 111,3194908 km
Each minute = (111,3194 / 60) = 1,855324847 km
Each second = (1,8553 / 60) = 0,03092208 km

0° 02' 23,92" = 0 km + 2 * 1,855324847 km + 23,92 * 0,03092208 km = 3,710649694 + 0,739656153
0° 02' 23,92" = 4,450305848 km

1870 * 4,648806574 = **8322,071935 km**

Conclusion: This image covers na longitudinal spatial extension of 8322,071935 km in the Equator, between 100° W e 25,24° W.

As the Earth is not a perfect sphere, the diameter varies between latitudes, so we can not use the same calculation for latitude beyond the equator. However, we can use the ILWIS tool **"Distance Measurer"**, discussed in subsequent activities.

Lesson 2 – Extracting physical information from each pixel

2.3 Opening a Raster and Changing the Color Pallete

Open the Raster file "**inpe_sav_201408051300**" (icon), by double clicking on the file. A new visualization window will be opened. The image will be shown with a standard pseudo color pallete:
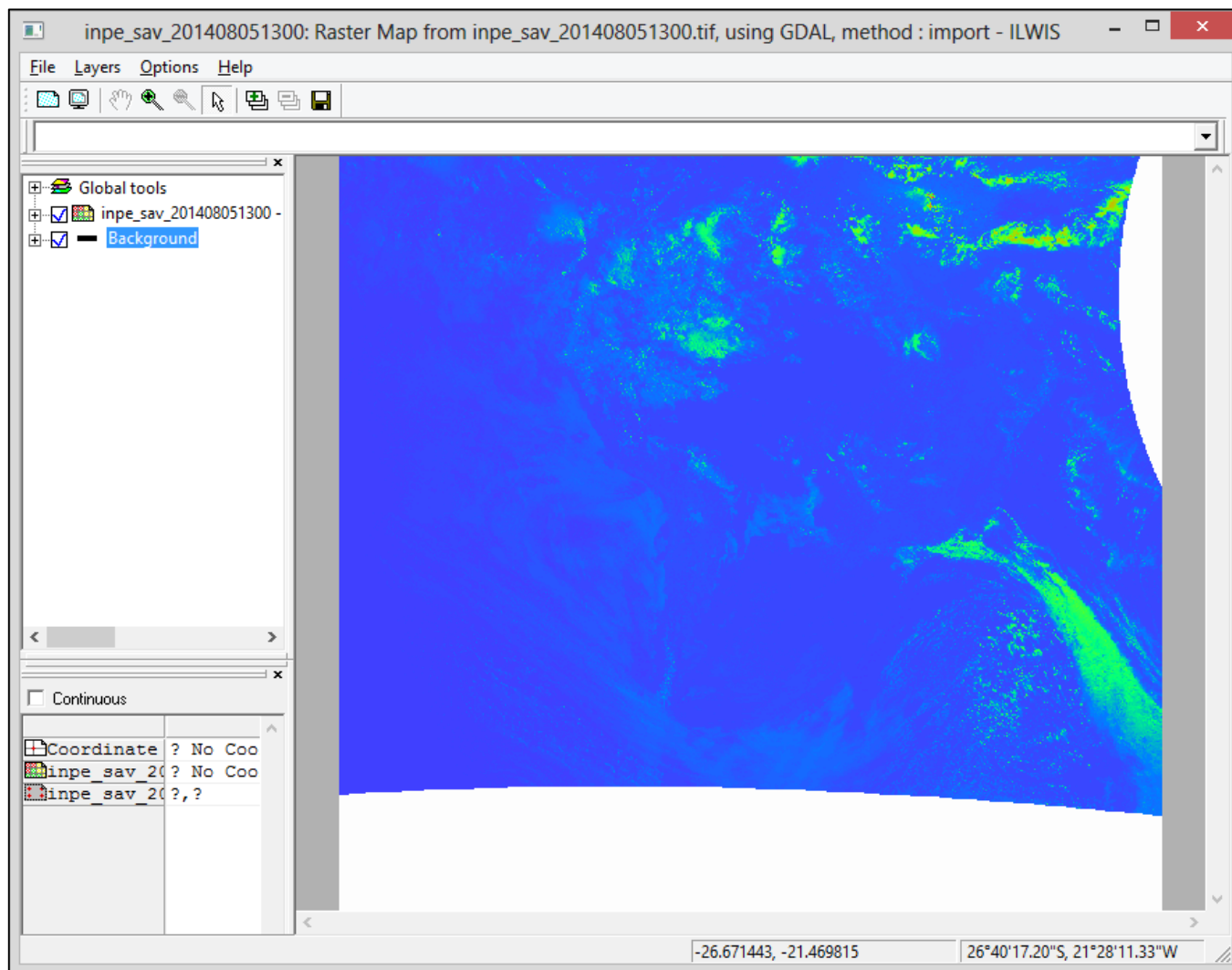
Figur2 12: Visualization / processing window for the Raster file

💡 **Hint:** If you get an error message after following the previous step, please change the following configuration in the main window: **"File"** -> **"Preferences"** -> **"Advanced"**, and activate the **"Use Software Rendering (Compatibily mode)"** checkbox. Try to import the GeoTIFF again following the same procedure. This error may occur due to video card compatibility issues.

For a better visualization of the image, we will change what ILWIS call the image "**Representation**", modifying the collor pallete. We will change from **"PSEUDO"** to **"FINEGRAY"**.

Expand the layer **"inpe_sav_201408051300"**, by clicking on the **"+"** symbol next to it. After expanding it, expand the item **"Display Tools"**, expand the item **"Portrayal"** and double click on **"Representation"**. The **"Set Representation"**

window will be opened. On **"Representation"**, choose the option **"FINEGRAY"** and click on **"Apply"**. The color pallette will be changed. Click on **"Close"**.
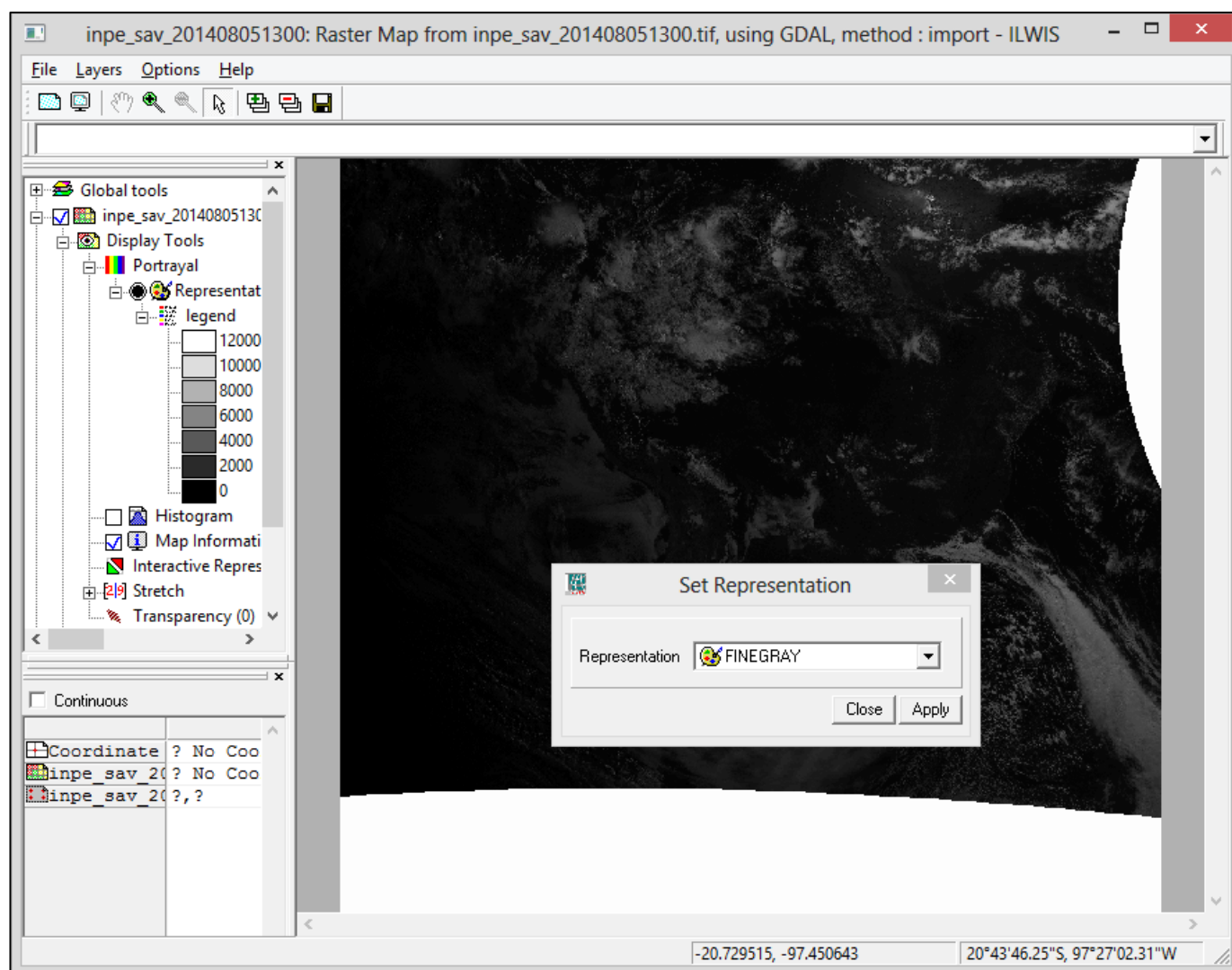

Figure 13: Modified color pallete for a better visualization

2.4 Zooming and Panning

To use the zooming and panning tools in the visualzation windows , right-click on the visualization area, and choose one of the folowing options:

Zoom In (Ctrl + I): Zooms in on the area clicked or selected. After choosing this option, the cursor icon will be replaced with a magnifying glass. With one click, a centralized zoom in the chosen point will be applied. If you want to zoom in on a specific area, after selecting this option, using the left mouse button, select the desired area.

Zoom Out (Ctrl + O): Zoom out gradually after each confirmation.

Pan: When selected, the cursor will be replaced by a hand icon. This option allows you to browse the zoomed area.

Entire Map (Ctrl + E): By selecting this option, the visualization window will show the complete map.

2.5 Basemaps

To facilitate the image interpretation, let's add an ILWIS **"basemap"**. The basemaps are shapefiles converted to ILWIS format. In the upper menu of the visualization window, click on *"Layers"* -> *"Add Layer"*. The **"Add Data Layer"** window will be opened. Find the ILWIS folder **"basemaps"** (in the example below, it is found at **"c:\program files (x86)\n52\ilwis38\system\basemaps"**). Choose the **"country boundaries"** basemap and click **"OK"**.
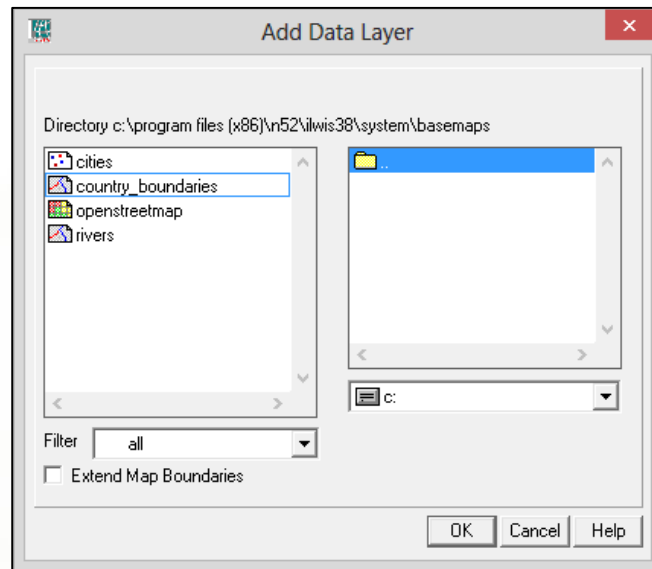

Figure 14: "Add Data Layer" window

The **country_boundaries** basemap layer will be added to the visualization:
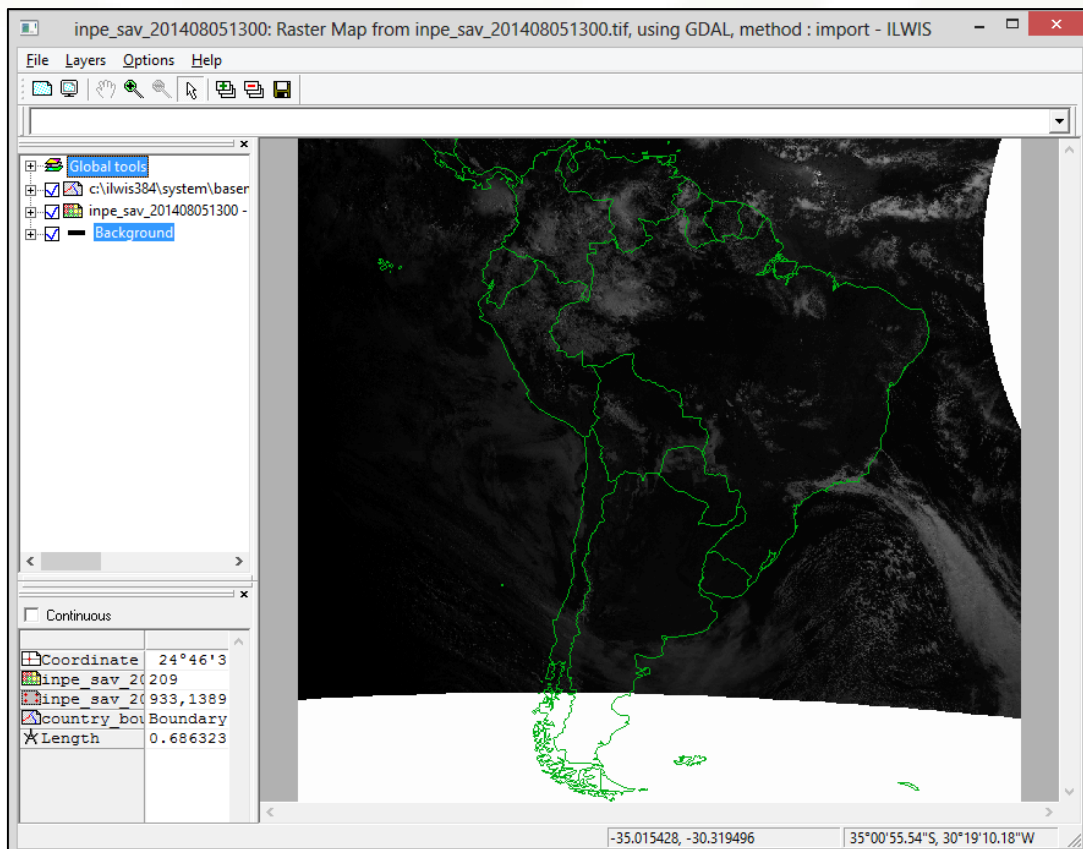

Figure 15: country_boundaries basemap added to the visualization

💡 **Hint:** To import your own custom shapefile (.shp), in ILWIS main window (not the visualization window), go to **"File"** -> **"Import"** -> expand the **"Geospatial Data Absraction Library (GDAL)"** option -> expand the **"vector"** option -> and choose **"ESRI Shapefile"**. Browse the **input** file and click **"OK"**. A new raster will be created. Import the created raster into our visualization window following the previous steps.

Now we have four layers in our visualization window, being:
- **Global Tools**;
- **country_boundaries** (which we just added);
- **inpe_sav_201406261200** (the image);
- **Background** (background visualization configuration).

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2.6 Customizing a Basemap

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The country layer can be customized. To illustrate a configuration, we will change the outline color. Click at the **"+"** simbol next to the **"country_boundaries"** layer to expand it and show the layer options. Expand the item **"Display Tools"**, expand the item **"Portrayal"**, expand the item **"Fixed Colors"**, and double-click on **"Single color"**. In **"Draw color"**, choose your preferred color. In this example, we will choose the **"Yellow"** option. Click in **"Apply"**. Minimize the layer **"country_boundaries"** clicking on the **"-"** simbol next to it.
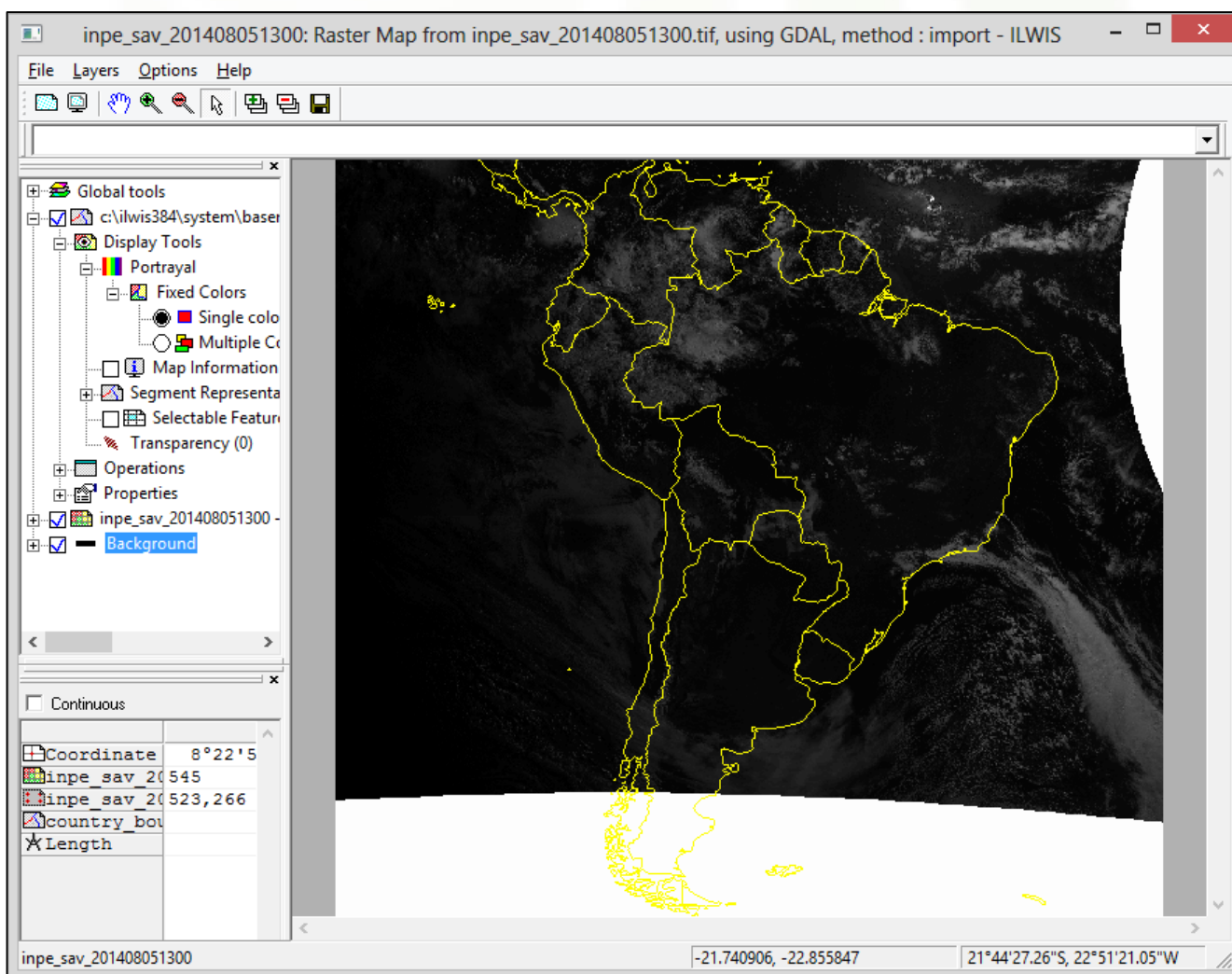

Figure 16: Customized basemap

2.7 First Information Retrieved From Each Pixel – Latitudes and Longitudes

The great advantage of the GeoTIFF format is the information embedded in each pixel. When converting the original image to the ILWIS raster format, this information remains. As a georeferenced raster, the first information that we can see are the latitude and longitude of each pixel. By scrolling the mouse around the viewing area, the latitude and longitude of the ragion indicated by the mouse pointer will be shown at the bottom right of the window, in **decimal degrees** (left) and **degrees, minutes and seconds (right)**.
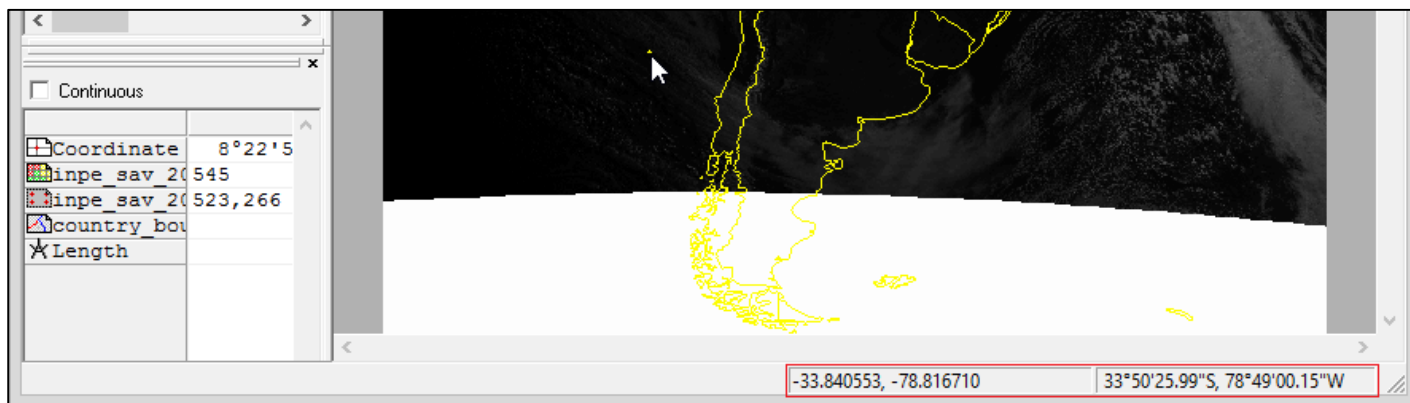

Figure 17: Latitude and Longitude information of the region indicated by the mouse pointer

2.8 Adding a Latitude / Longitude Reference Borders and a Grid

In the **"Global Tools"** layer, expand the item **"Annotations"**, and activate the **"Border"** option.

Note: To **activate** an option, click in the checkbox next to its description ( ). This will add the latitude and longitude reference border to the visualization window. Still in the **"Global Tools"** layer, activate also the option **"Graticule"**. This will add a smooth grid to the visualization window.
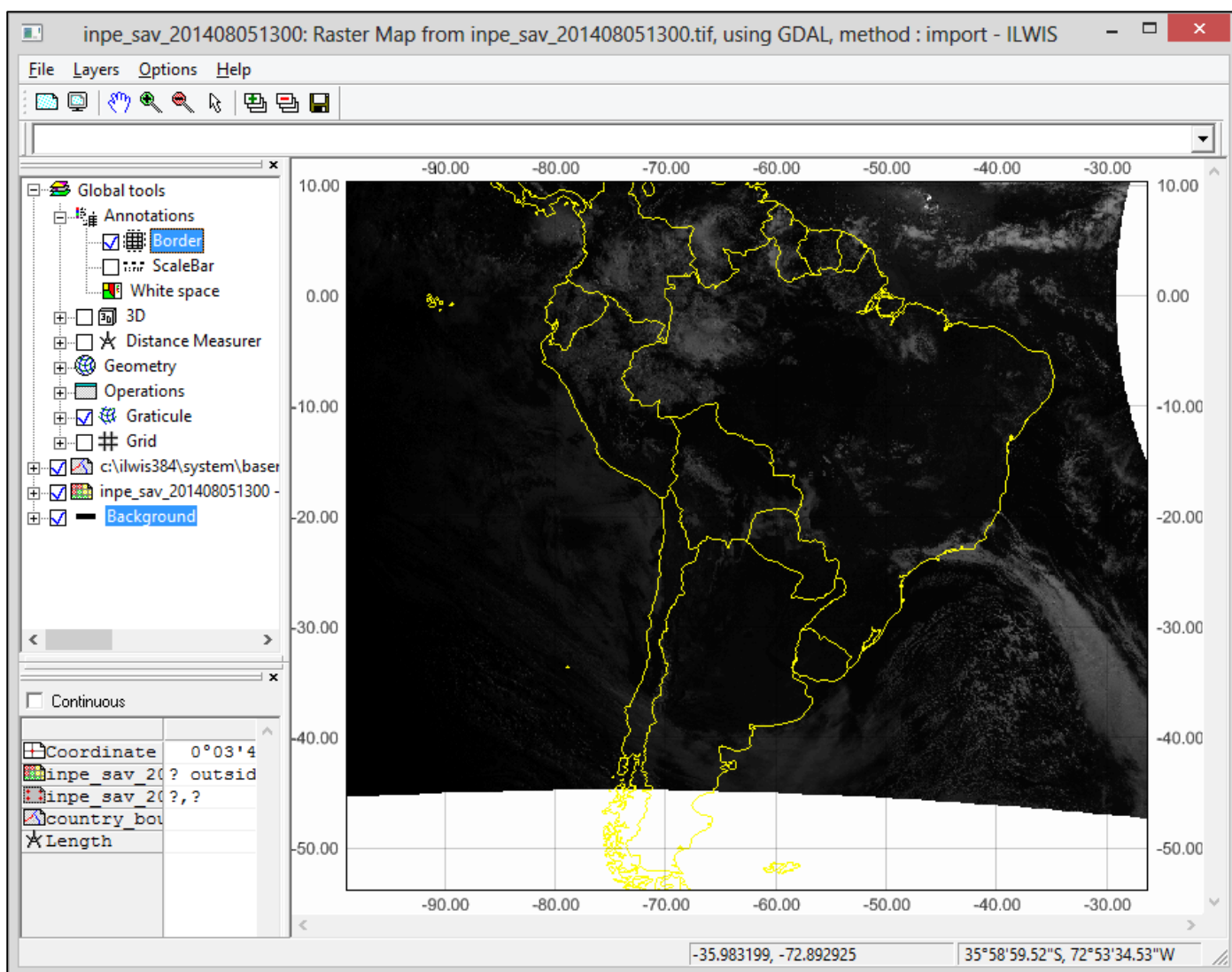
Figure 18: Border and grid added to the visualization

2.9 The "Distance Measurer" Tool

In the previous lesson we concluded that this image covers an spatial longitudinal extent of 8322,071935 km in the Equator, between 100° W e 25,24° W. Let's check it out.

Expand the **"Global Tools"** layer, and activate the **"Distance Measurer"** tool. This tool allows us to measure the distance between two points (in meters). After activating the tool, when moving the mouse over the display area, the mouse pointer will be replaced by a drawing compass symbol. Now that we know to how identify the latitude and longitude and added the reference grid, put the mouse pointer arpoximately over the latitude 0 ° (the equator) on the left edge of the image (-100 ° longitude). Click and hold the left mouse button, drag the cursor to the opposite end of the image (-25 ° longitude) and release the mouse button. The distance shown will be very close to calculated in Lesson 1. If we could position the mouse pointer exactly at -100 and -25.24 degrees, the distance shown would be exactly the same.
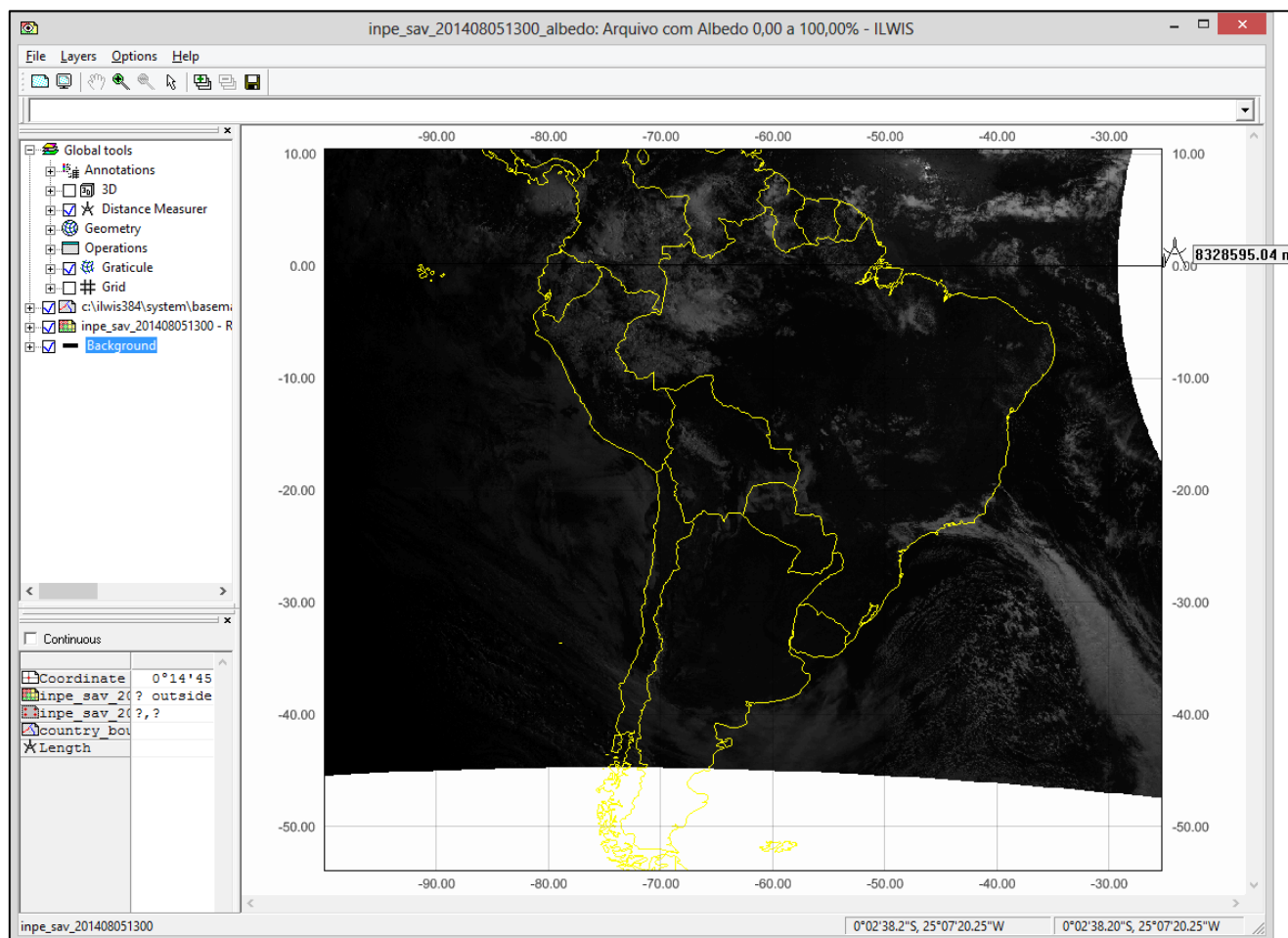
Figure 19: Using the "Distance Measurer" tool

2.10   Retrieving The Physical Variable From Each Pixel

In addition to the latitudes and longitudes, each pixel has a third information, the physical variable. This may be the reflectance, albedo, brightness temperature, radiation, or any other variable calculated by the GEONETCast-Americas Data Provider in the preprocessing stage. In the image **"inpe_sav_201406261200"** the physical variable that can be retrieved is the **Albedo**, which ranges between **0.00%** and **100.00%**.

To retrieve the Albedo values from each pixel, in the visualization window upper toolbar, select th **"Normal"** option (icon) and click anywhere on the image.
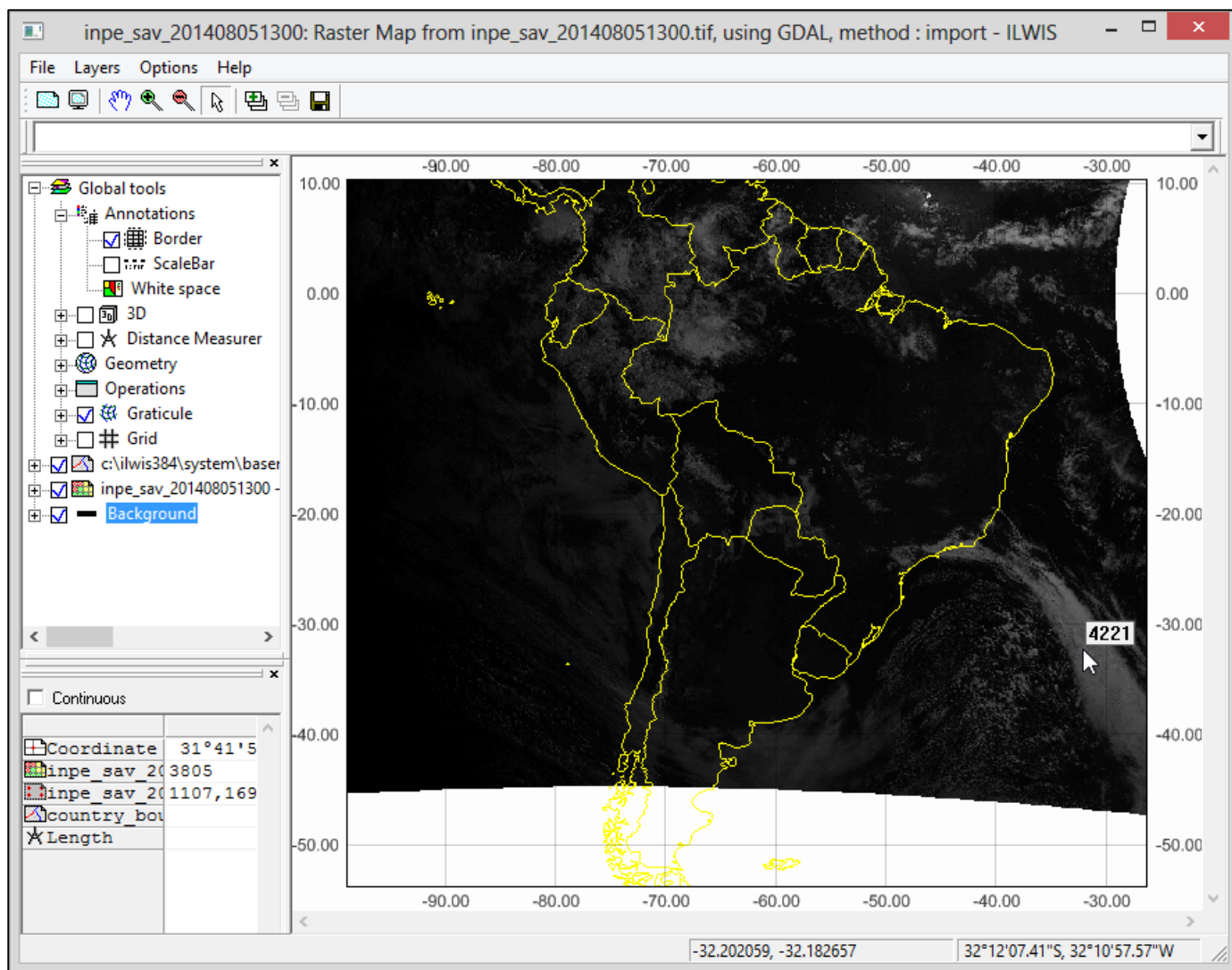
Figure 20: Retrieving the physical variable from each pixel

Note the value obtained in the image above, **4221**. If the Albedo varies between 0,00% and 100,00%, why is this value being shown?

The reason is simple: **In the Data Provider preprocessing stage, it was arbitrated that the physical variable values should be multiplied by 100, using only integer numbers and avoiding using floating points, sparing memory in this stage.**

In the example above, the real value is **42,21%** (4221 / 100).

How can we convert this value back to the original value (between 0,00% and 100,00%)?

In order to achieve this, we will use an important tool for our tutorial, the **"Map Calculation"** tool provided by ILWIS.

2.11   The "Map Calculation" Tool

In the **"Global Tools"** layer, expand (**"+"**) the item **"Operations"**, expand the item **"Raster Operations"**. Select the **"Map Calculation"** option. The "Map Calculation" window will be opened.
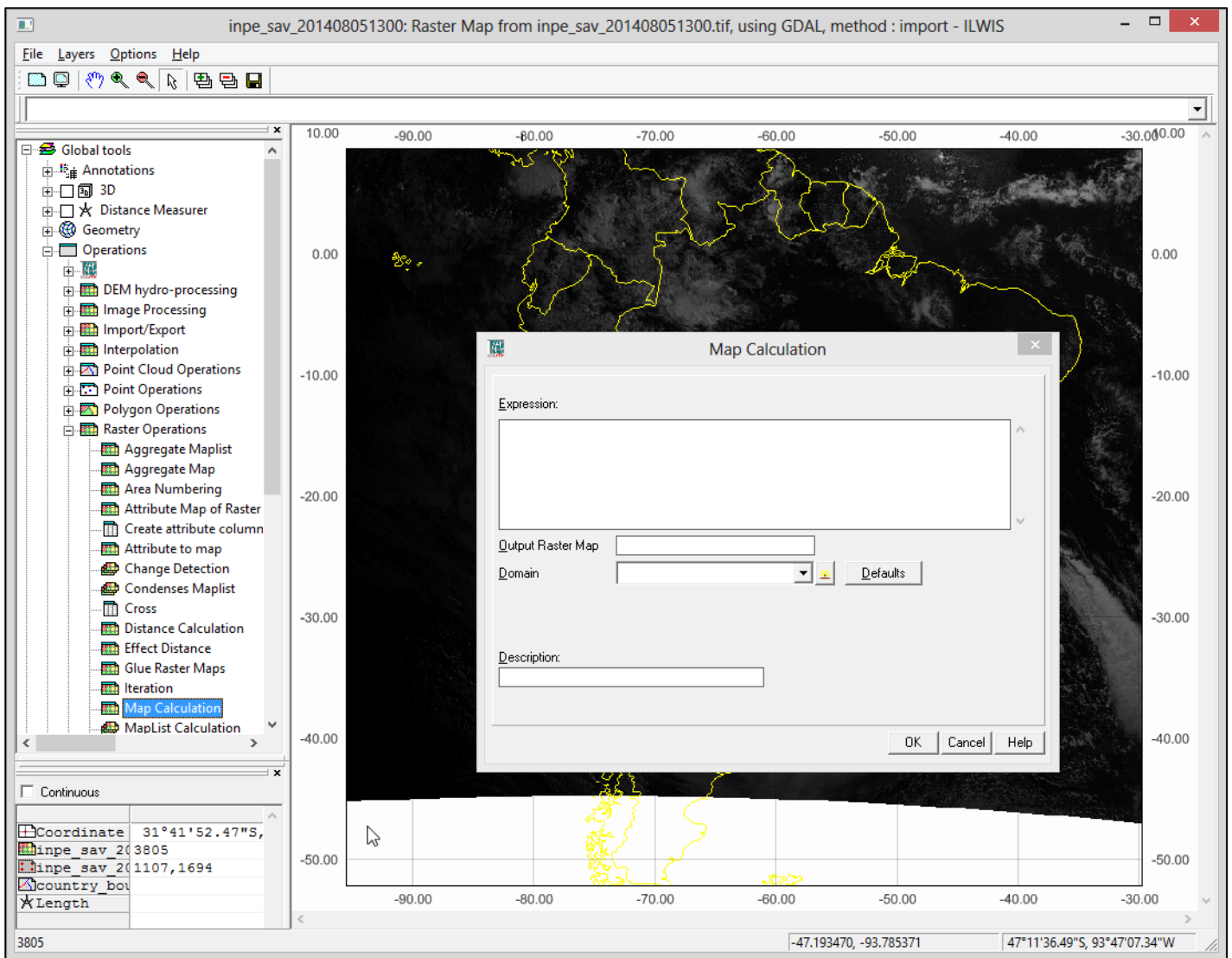
Figure 21: "Map Calculation" window

In the **"Expression"** field, enter the desired mathematical operation. This option executes the entered operation pixel by pixel in an image or between images. Since we want to divide the physical value of all pixels of the image by 100, simply introduce the image name (in single quotes) and the desired operation:

<div align="center">

'inpe_sav_201408051300' / 100

</div>

In **"Output Raster Map"**, type the file name of the new raster that will be created after executing the operation. In this example we will use **inpe_sav_201408051300_albedo**.

By clicking on **"Defaults"** the **"Value Range"** field will indicate the minimum and maximum values of the resulting image (in this case 0,00% and 115,21% respectively). The values higher than 100,00% appear due to the "Sunglint" effect. The **"Precision"** field will show the number of decimal places of the resulting image pixel values (in this case 0.01%).

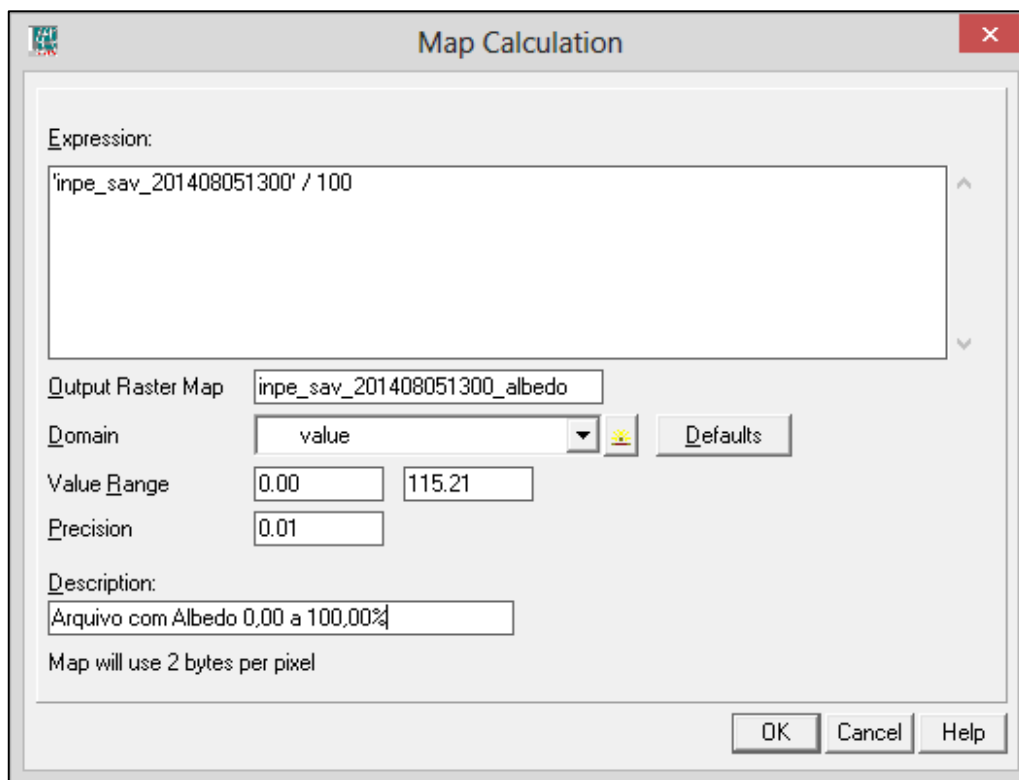Enter a description of the new file in the **"Description"** field if you want and click **"OK"**.

Figure 22: Input parameters for the calculation

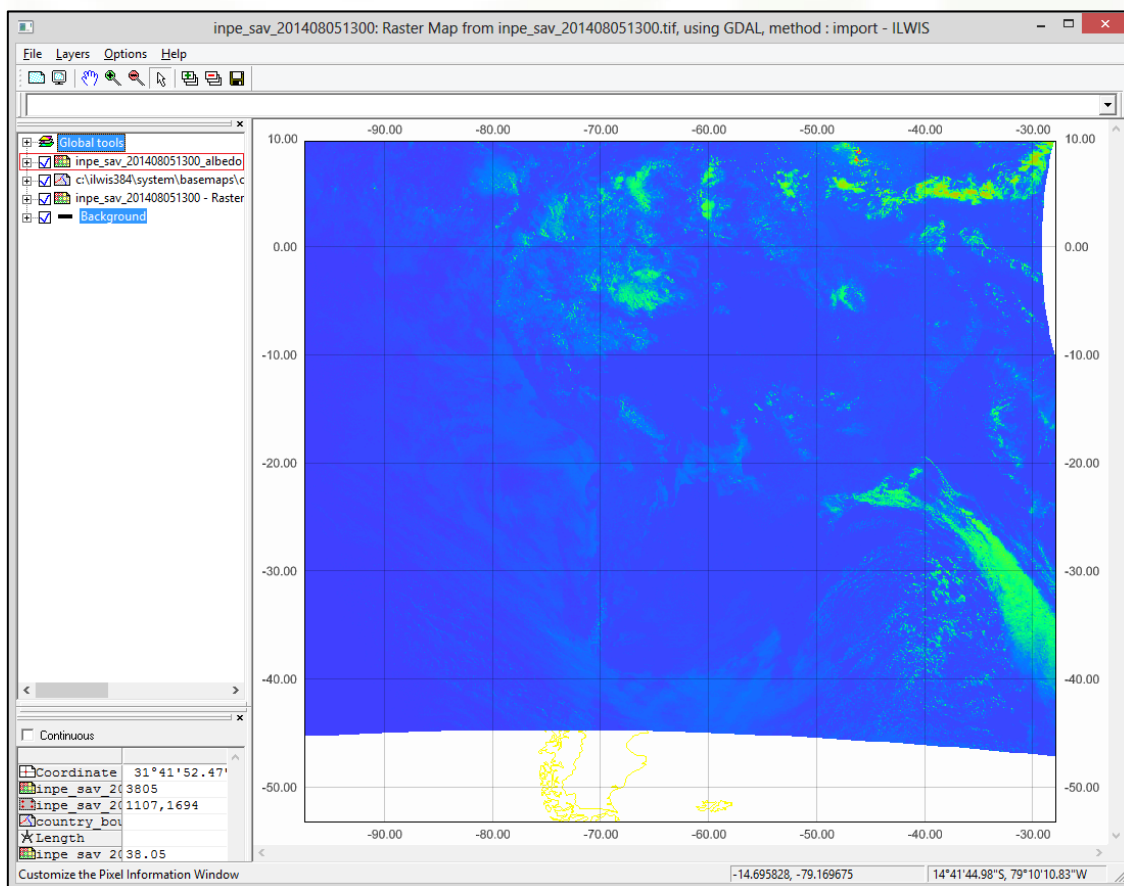A new layer will be created, named "**inpe_sav_201408051300_albedo**".

Figure 23: New layer created

But where is the country basemap? Is not being shown because the **"country_boundaries"** layer is below the newly created "**inpe_sav_201408051300_albedo**" layer. Click on the **"country_boundaries"** layer and drag it above the "**inpe_sav_201408051300_albedo**" layer.
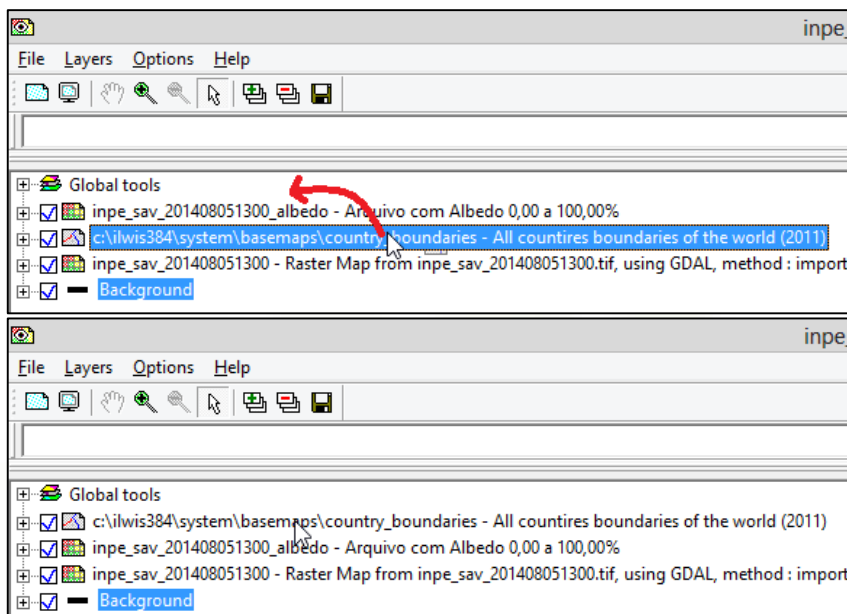

Figure 25: Dragging the "country_boundaries" layer

Furthermore, the new layer has the default **"PSEUDO"** color palette. Switch to the **"FINEGRAY"** palette if you want following the steps shown on the topic 2.3 (just be sure to follow the steps using the newly created layer).
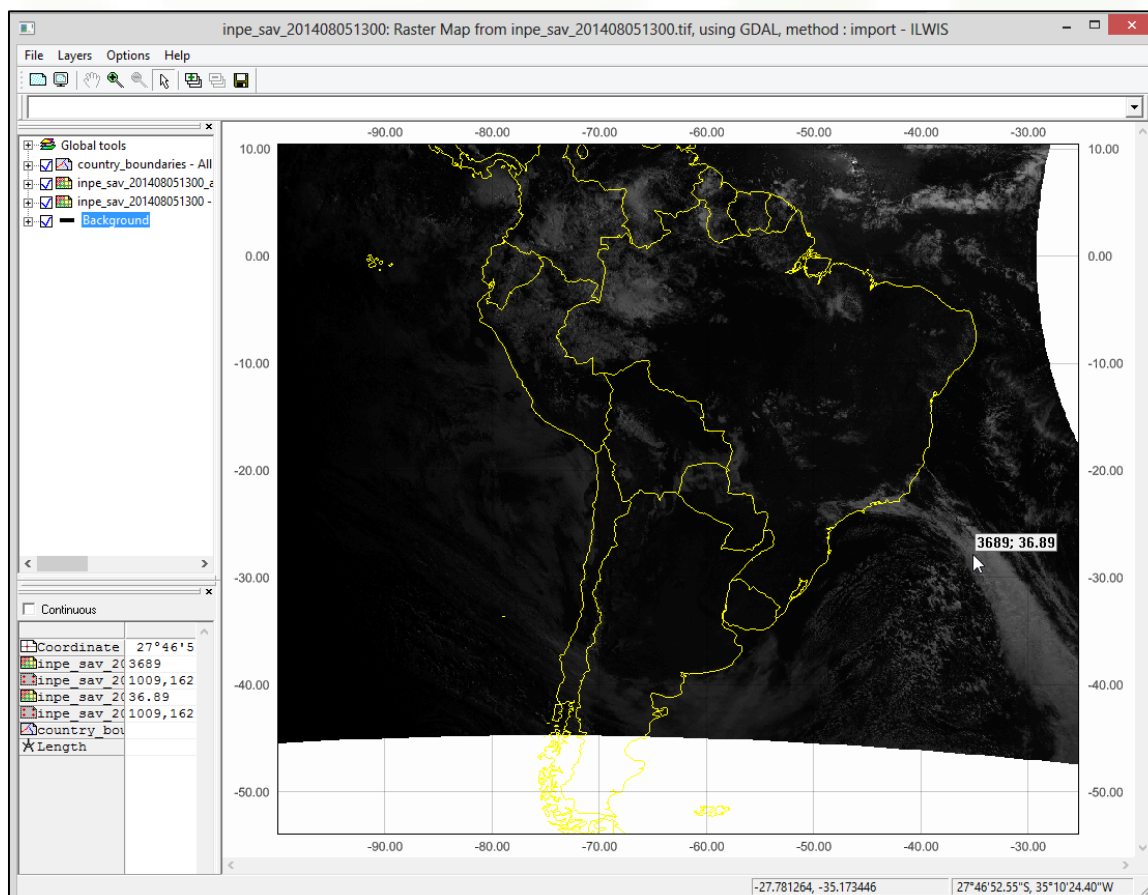

Figure 25: The "country_boundaries" layer visible and the new obtained values

By clicking on any point on the image, now we obtain two values. The value **prior to the calculation** and the value **after the calculation** done with the **"Map Calculation"** tool. In the example above, in the longitude -27,781264° and latitude -35,173446° we have the values **3689** and **36.89%.**

This occurs because both "**inpe_sav_201408051300**" and "**inpe_sav_201408051300_albedo**" layers are activated (☑). If you want to visualize only the percentage value (36.89% in the example), just disable the layer visualization by clicking on the layer checkbox.
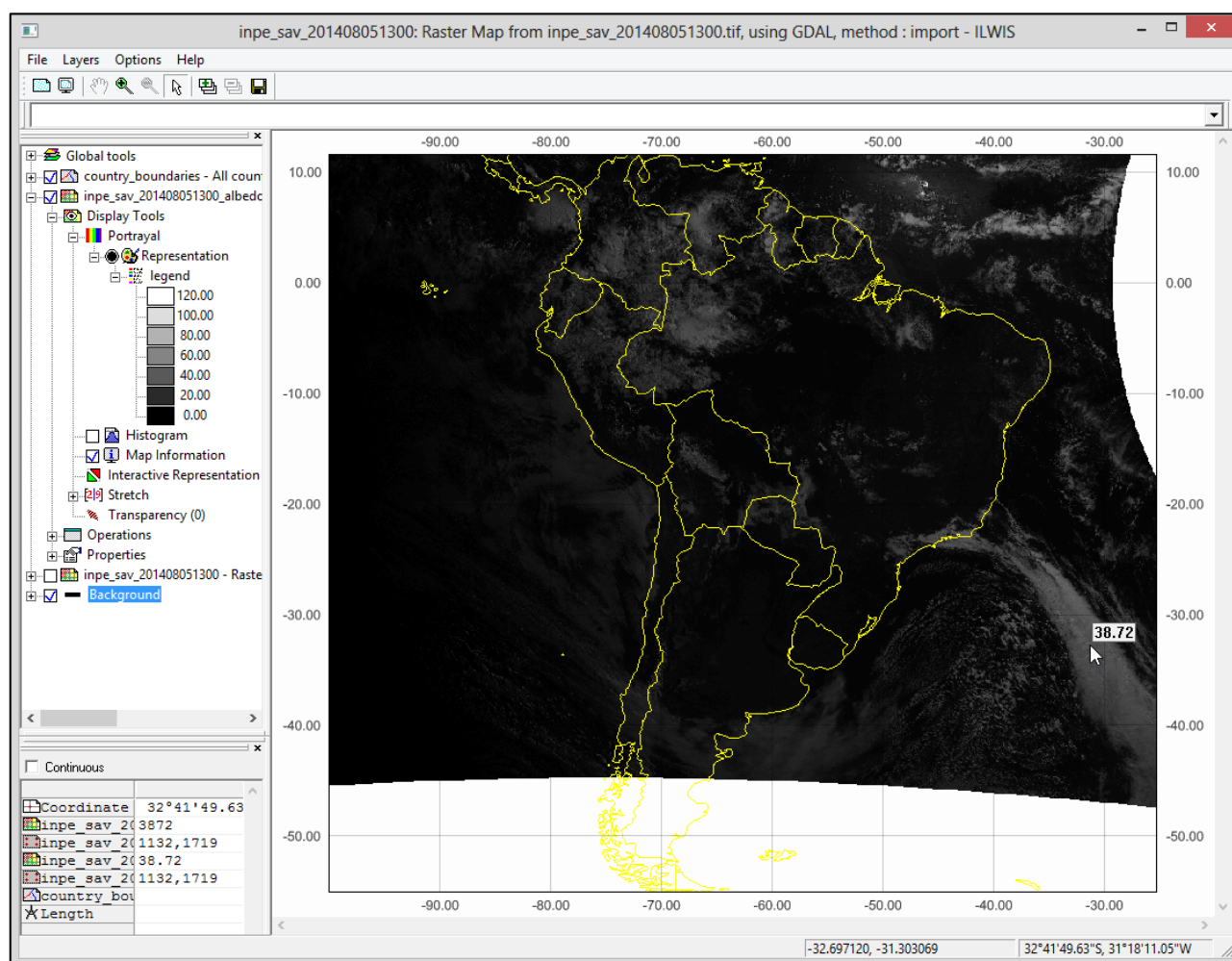

Figure 26: Visualizing the image with the original layer disabled, already in Albedo, with legend

Note: To visualize the scale legend, expand the item **"Display Tools"**, expand the item **"Portrayal"**, expand the item **"Representation"**, and expand the item **"legend"**.

2.12   The "Stretch" Tool

The "Stretch" operation re-distributes values of an input map over a wider or narrower range of values in an output map. Stretching can for instance be used to enhance the contrast in your map when it is displayed.

For the layer "**inpe_sav_201408051300_albedo**", apply a **"Stretch"** (**"Display Tools"** -> Double-click on **"Stretch"**) between **0** and **10** to get a better contrast. This will greatly facilitate to differentiate ocean, surface and clouds.
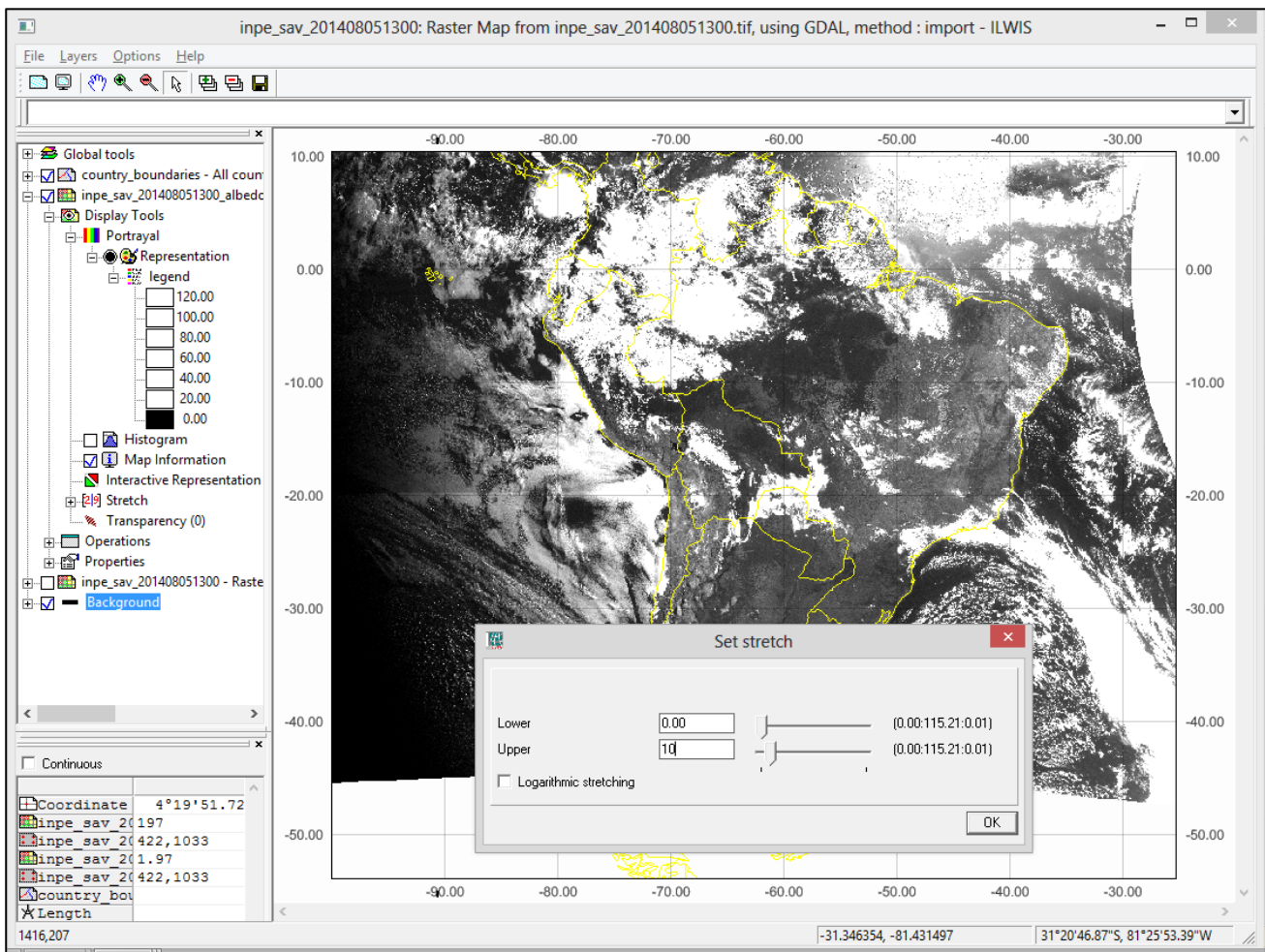
Figure 27: An applied "Stretch" between 0 and 10

2.13   The "Histogram" Tool

A histogram is a dependent table which stores frequency information on values. To view the histogram of the displayed image, expand the layer "**inpe_sav_201408051300_albedo**", expand the item **"Operations"**, expand the item **"Statistics"**, and double-click on **"Histogram"**. The **"Calculate Histogram"** window will be opened. In **"Map"**, select the raster "**inpe_sav_201408051300_albedo**" and click **"OK"**. A histogram always has the same name as the map from which it is calculated.
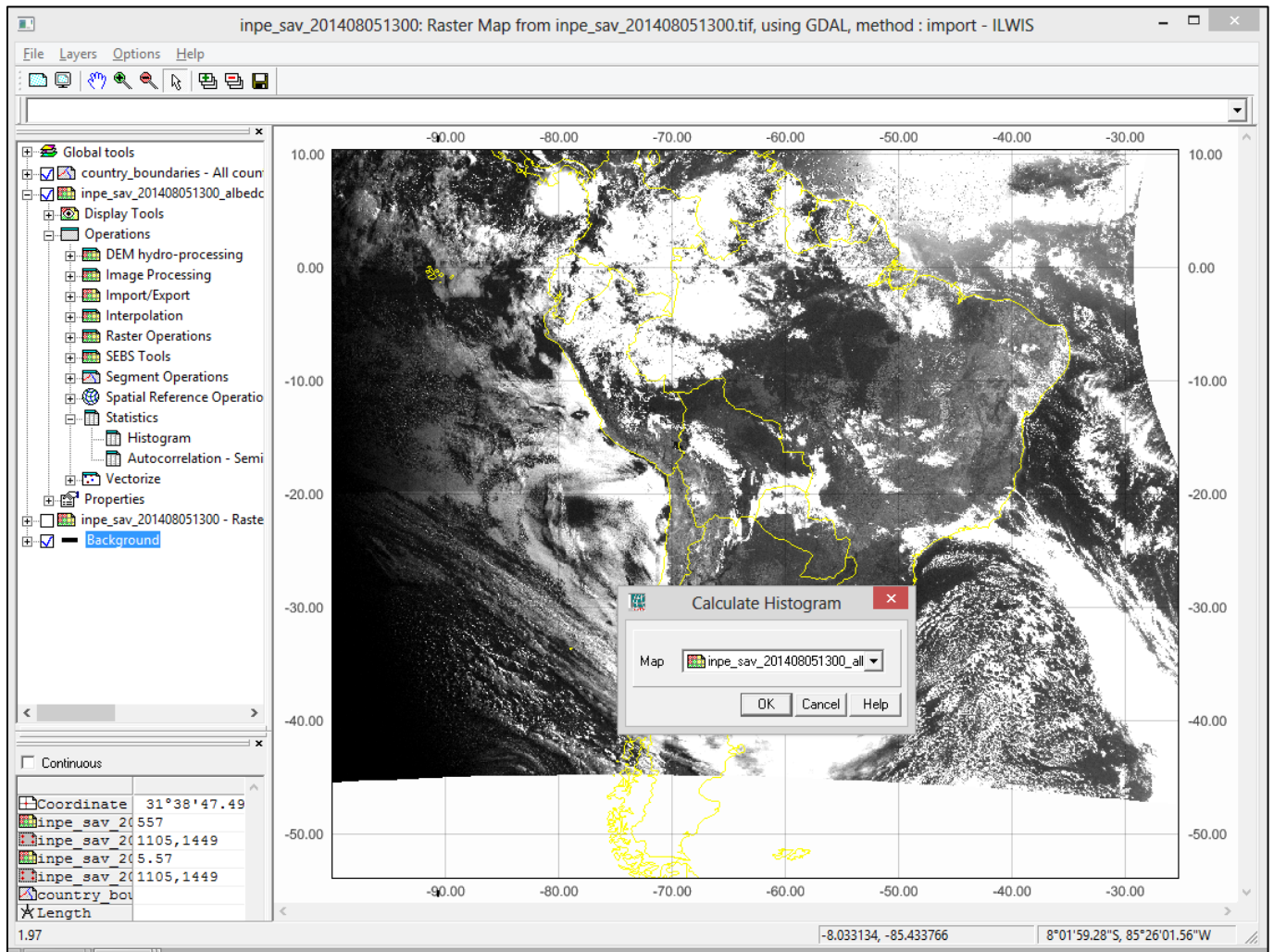
Figure 28: Histogram calculation of the newly created layer
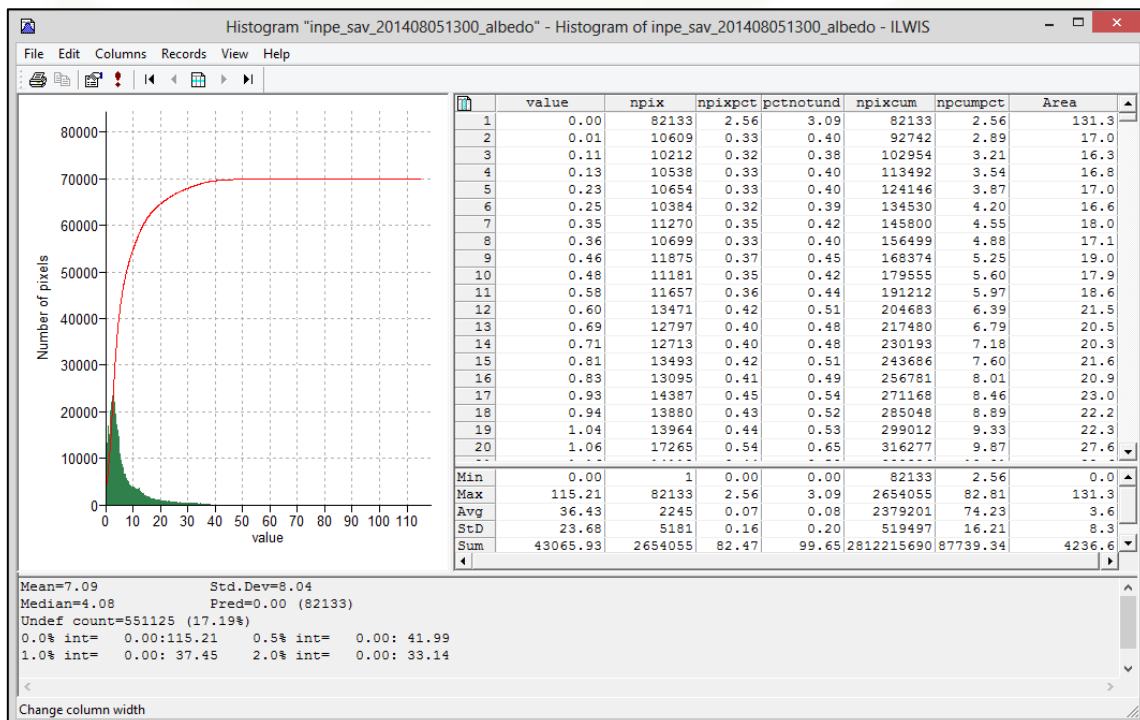
The following window will open:

Figure 29: Histogram analysis for the selected layer

In the analysis, the following information is displayed:

"value": Albedo values found on the image

"npix": The number of pixels with a certain value or meaning (pixel frequencies).

"npixpct": The relative amount of pixels with a certain value or meaning as a percentage of the total number of pixels in the map.

"npixcum": the cumulative amount of pixels with this value or a smaller value.

"npcumpct": the relative cumulative amount of pixels with this value or a smaller value as a percentage of the total number of pixels in the map (to determine for instance the 1%, 5%, 95%, 99% intervals).

"Area": The area of pixels with a certain value or meaning as: `npix*` pixel size `*` pixel size.

"Min": The maximum value of a column

"Max": The minimum value of a column

"Avg": The average value of a column

"StD": The standard deviation of a column

"Sum": Sum of the values of a column

2.14   Advantages of the GeoTIFF format

At this point, we are ready to continue with the other topics. Now the student is able to convert images in the GeoTIFF format to the ILWIS Raster format for further analysis and processing.

What's the big advantage of the GeoTIFF format? To answer this question, open the image **"INPE_SAV_201408051300.jpg"** provided in the download link with your favorite image viewer. This is the JPEG version of the image used so far in our capacity building course.
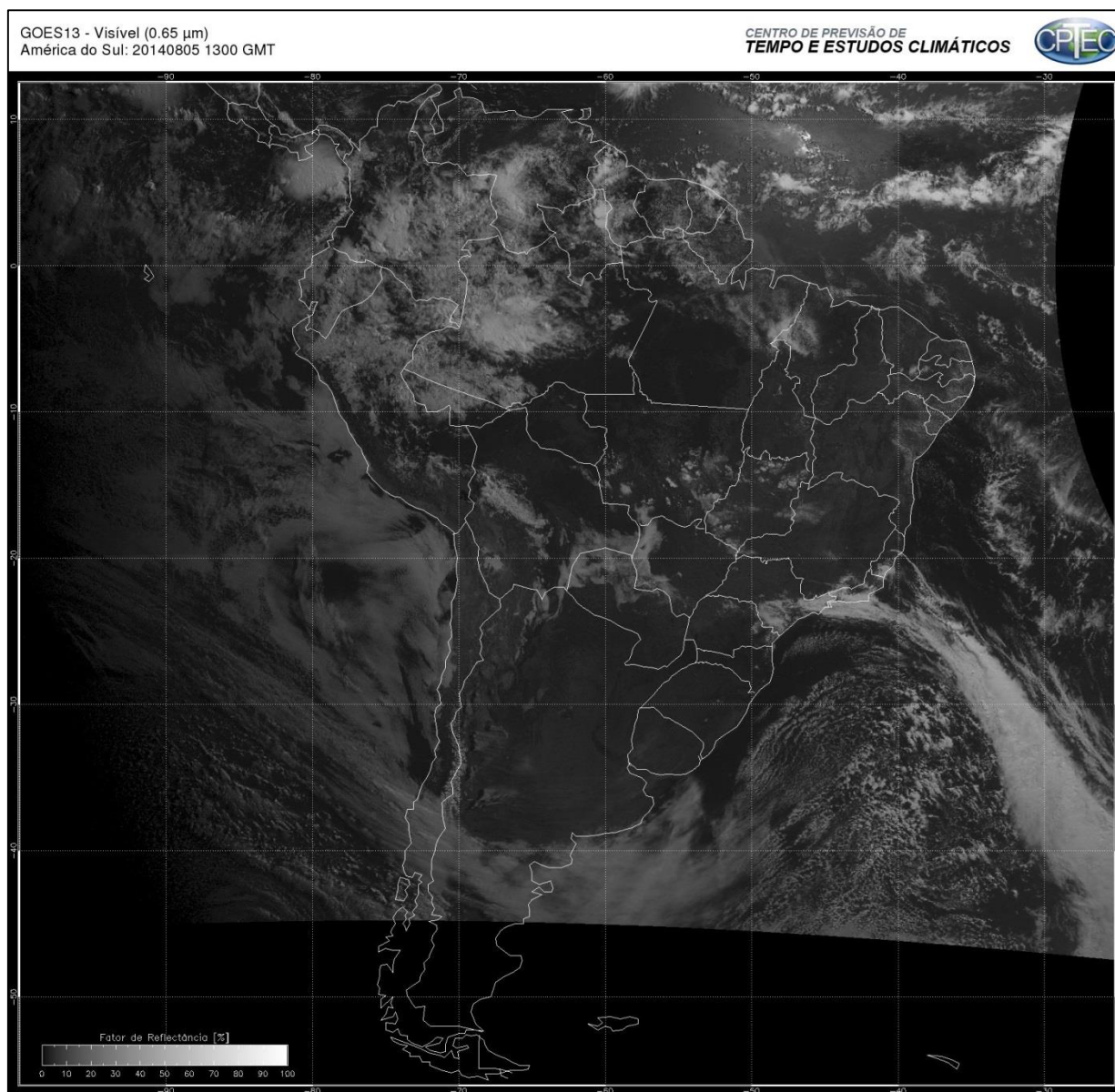
GOES13 - Visível (0.65 µm)
América do Sul: 20140805 1300 GMT

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Figure 30: JPEG version of the image imported in the first lessons

The JPEG image (or PNG, or BMP, etc.) provides a better **immediate visual interaction** in comparison to the images in GeoTIFF format without the need for processing. In the picture above we can clearly see the contrast between regions with and without clouds and regions with water bodies for example. Another advantage is the reduced file size (kB in comparison to the MB in GeoTIFF files), making this an optimal format for creating animations.

On the other hand, the GeoTIFF format provides quick access to information of latitude, longitude and the physical variable (six dimension GeoTIFF's can also provide color values of Red, Green and Blue). Moreover, it's a format that can be opened and processed with the vast majority of Geographic Information Systems (GIS) like ILWIS, Quantum, McIDAS V and other.

All necessary processing after receiving the image using a Direct Readout Station is performed by the GEONETCast-Americas Data Provider, which broadcasts the imagery in GeoTIFF format already georeferenced, calibrated and ready for use.

2.15   Manipulating the Infrared and Water Vapor Imagery

Following the same procedure from the **topic 1.4**, import the images "**INPE_SAI_201408051300.tif**" and "**INPE_SAW_201408051300.tif**" to your work folder.
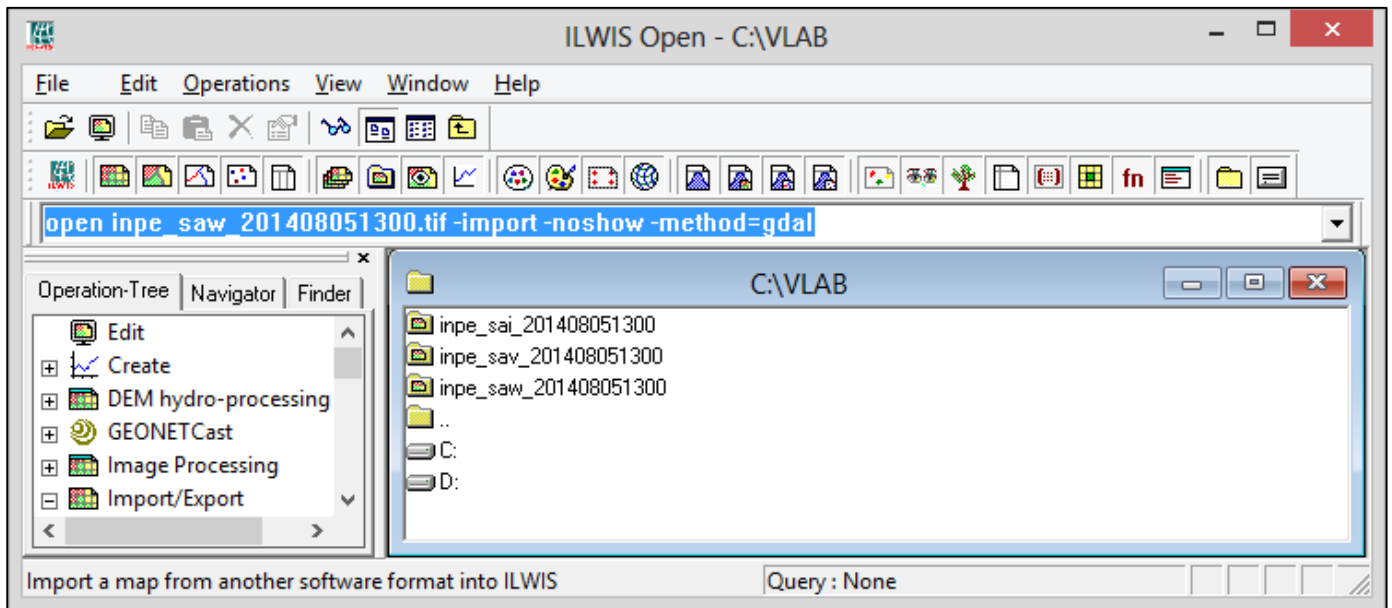

Figure 31: Infrared and Water Vapor Channels converted and imported

Following the same procedure from **topics 2.3 to 2.6**, open the Raster file "**inpe_sai_201408051300**" (icon), insert the **"country_boundaries" basemap** (configure it with a yellow line if you want) and insert the **graticule** and the **border** (**"Global Tools"** layer). Change the color palette to **"INVERSE"** (not **FINEGRAY** like we did in the visible image). Select the **"Normal pointing mode"** tool (button in the upper toolbar) and click anywhere in the image.

For the images "**inpe_sai_201408051300**" and "**inpe_saw_201408051300**", the physical variable for each pixel is the **brightness temperature**, in kelvin.
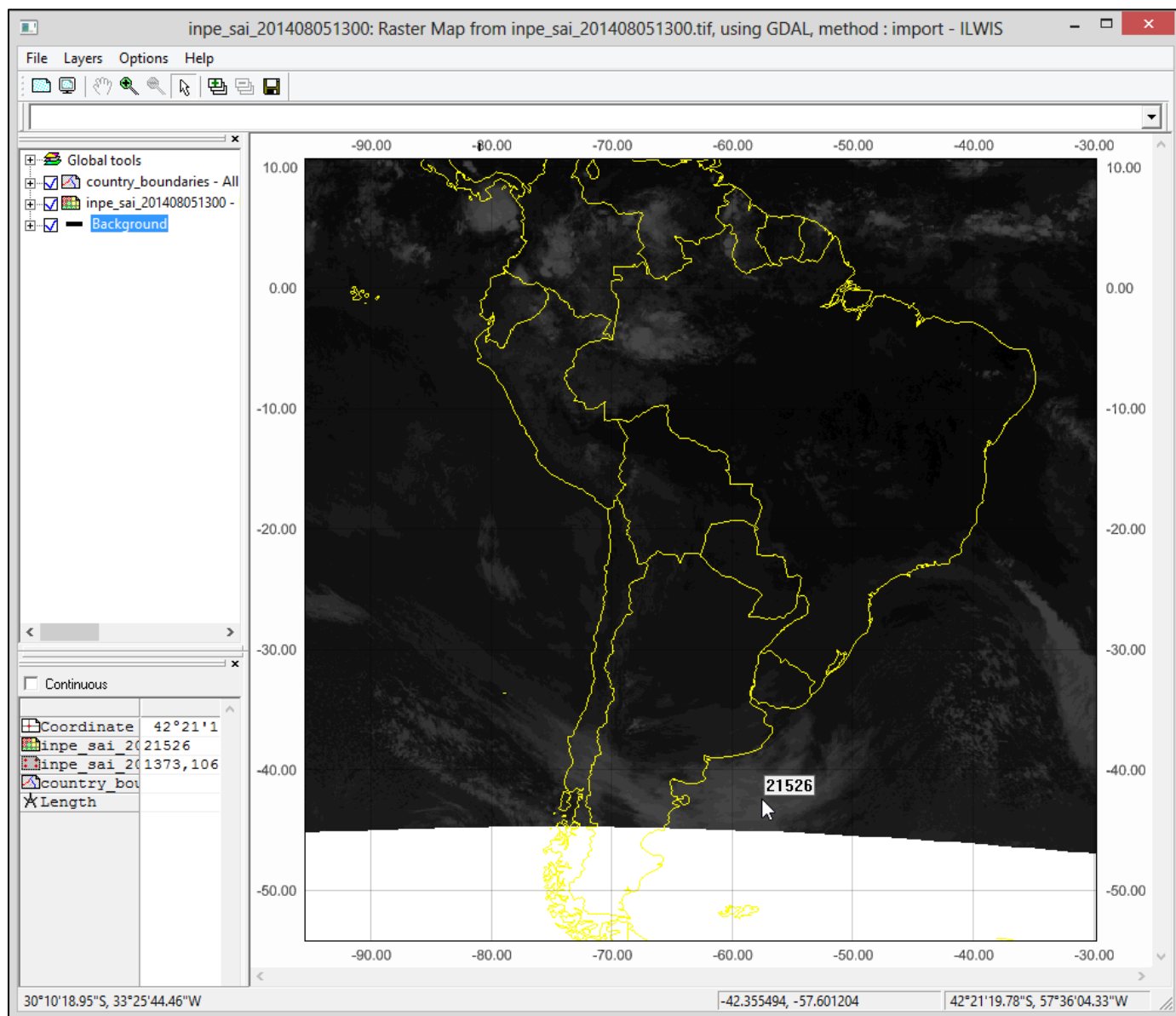
Figure 32: Infrared Channel – Retrieving information from a pixel

Please note that, as in the visible image, the physical variable value is multiplied by 100 (in the example image above the real brightness temperature value is **215.26 K**). We have to follow the procedure from **topic 2.11** to divide the pixel values by 100 using the **"Map Calculation"** tool (**"Global Tools"** layer)
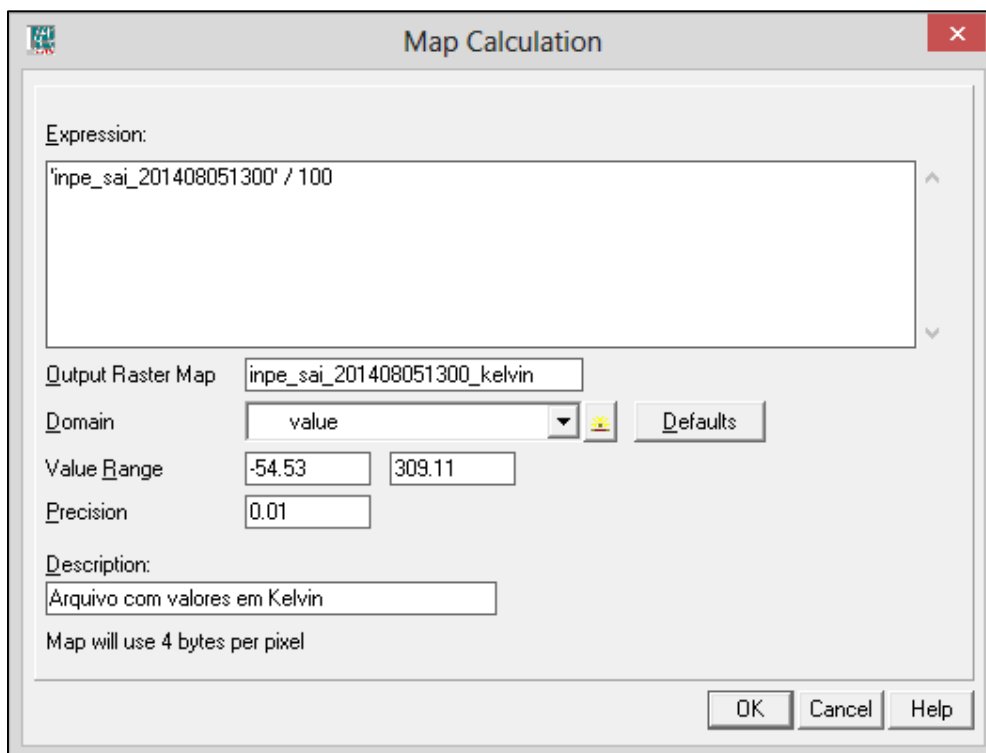
Figure 33: Inserted parameters for the division

In **"Output Raster Map"**, type the file name **inpe_sai_201408051300_kelvin**. By clicking **"Default"**, we see that the minimum and maximum values of the resulting file will be **-54,53 K** and **309,11 K** respectively.

As in **topic 2.11**, after the calculation, drag the **"country_boundaries"** layer above the newly **"inpe_sai_201408051300_kelvin"**, and disable the "**inpe_sai_201408051300**" layer to visualize only the value in Kelvin when clicking in a certain pixel. Change the color palette to **"INVERSE"**.
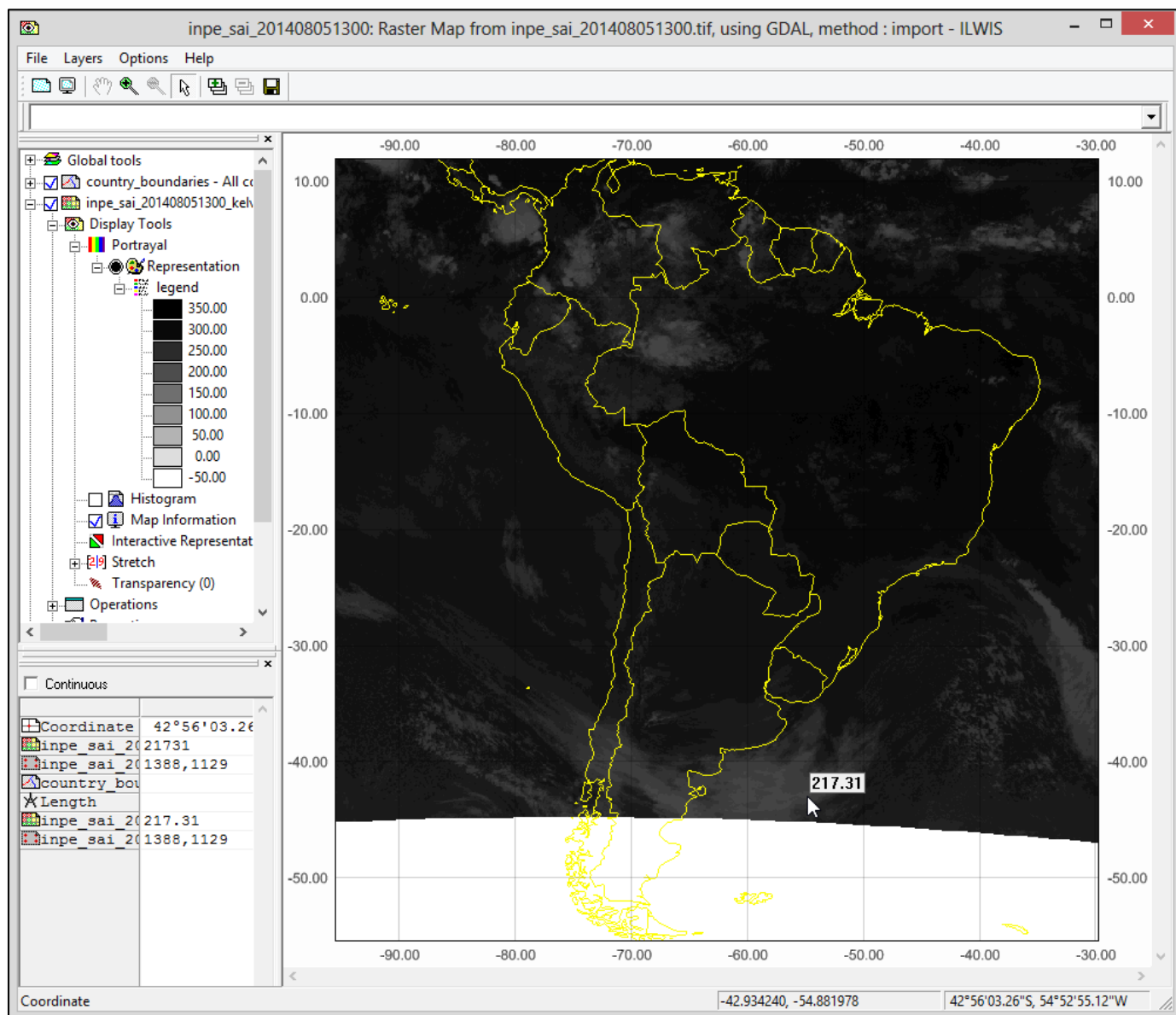
Figure 34: Infrared channel image converted to Kelvin

2.16   Converting from Celsius to Kelvin

Let's convert the brightness temperature from Kelvin to Celsius. We will use again the **"Map Calculation"** tool from the **"Global Tools"** layer. We will use the following expression (**don't forget to use single quotes**):

'inpe_sai_201408051300_kelvin' – 273.15

> ⚠️   **Attention (non-english region students):** Use "." (dot) as decimal separator

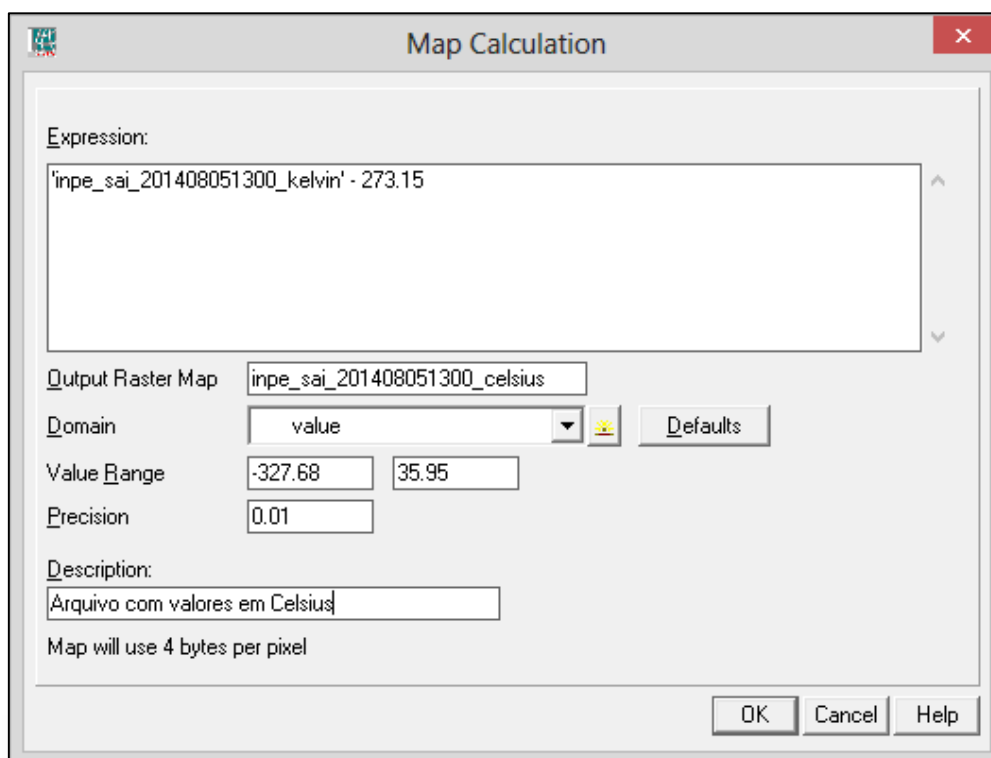For the resulting image file name, type **inpe_sai_201408051300_celsius**.

Figure 35: Inserted parameters for Celsius conversion

> 💡 **Hint:** The previous operations (multiplying by 100 and converting to Celsius) could have been done using only one expression (it was separated for didactic purposes):
> **('inpe_sai_201408051300' / 100) – 273.15**

As in **topic 2.11**, after the calculation is done, drag the **"country_boundaries"** layer above the newly **"inpe_sai_201408051300_celsius"**, and disable the **"inpe_sai_201408051300_kelvin"** layer to visualize only the value in Celsius when clicking in a certain pixel.
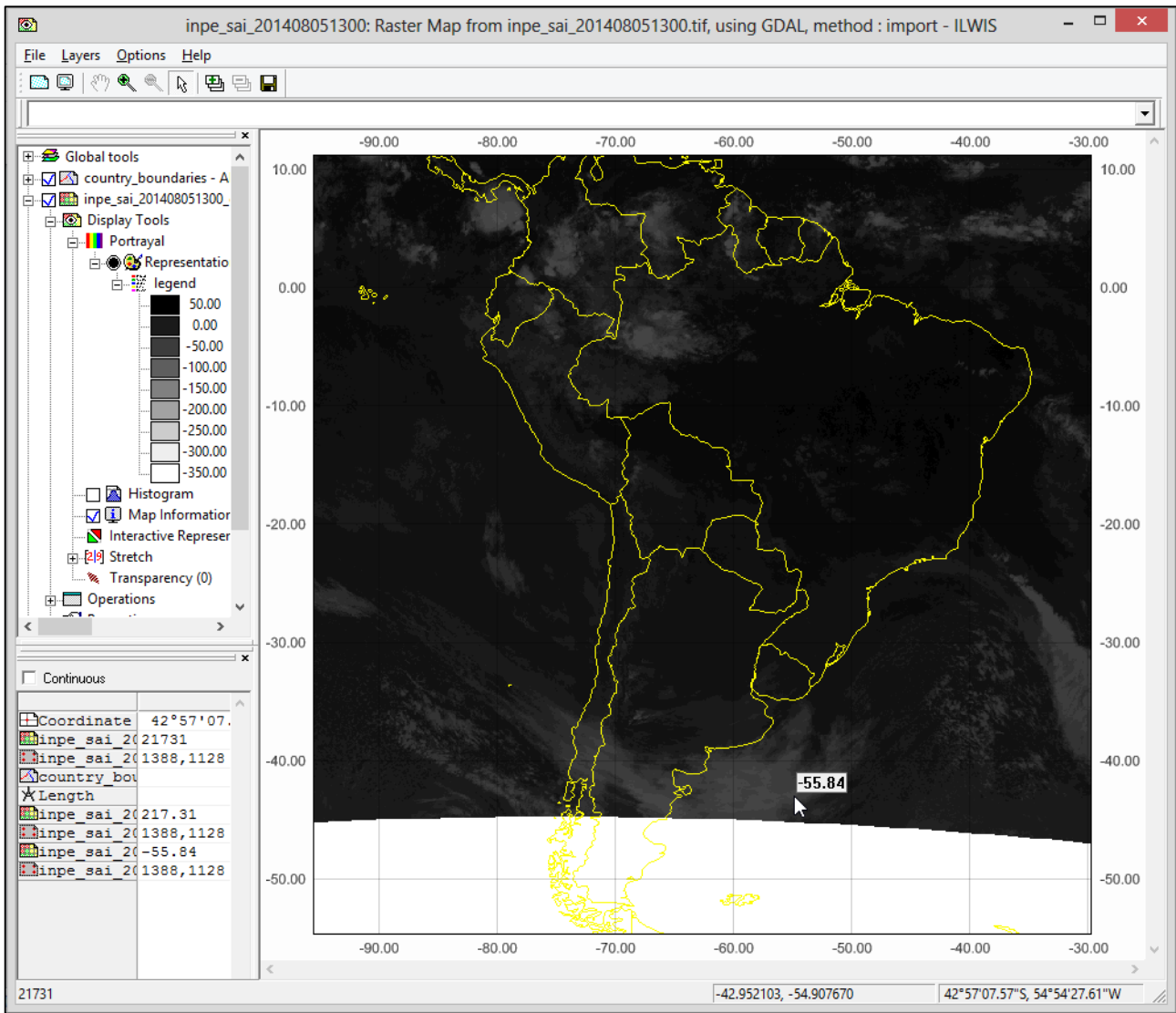
Figure 36: Infrared channel image converted to Celsius, with the legend added

This will be our final work image for the next topics.

💡 **Hint:** If we kept the three layers ("**inpe_sai_201408051300**", "**inpe_sai_201408051300_kelvin**" e "**inpe_sai_201408051300_celsius**") activated, we would visualize three information simultaneously (Kelvin * 100, Kelvin, and Celsius), as shown in the figure below.
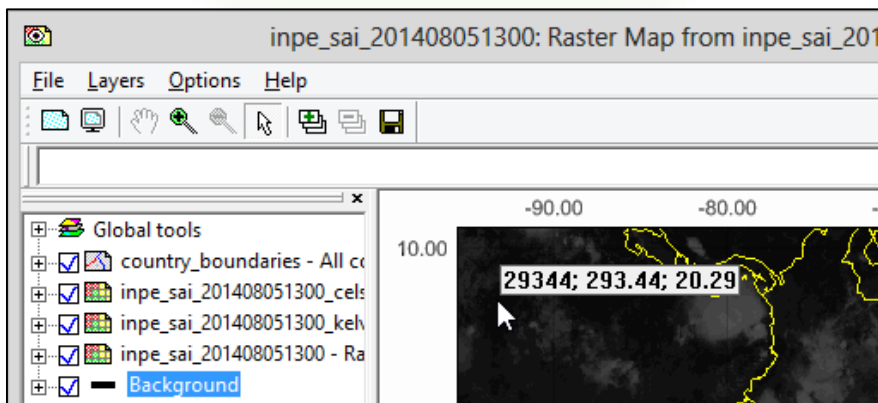

Figure 37: All layers activated

As in **topic 2.12**, apply a **"Stretch"** (**"Display Tools"** -> Double-click on **"Strech"**) between **-30** and **30** to get a better contrast.
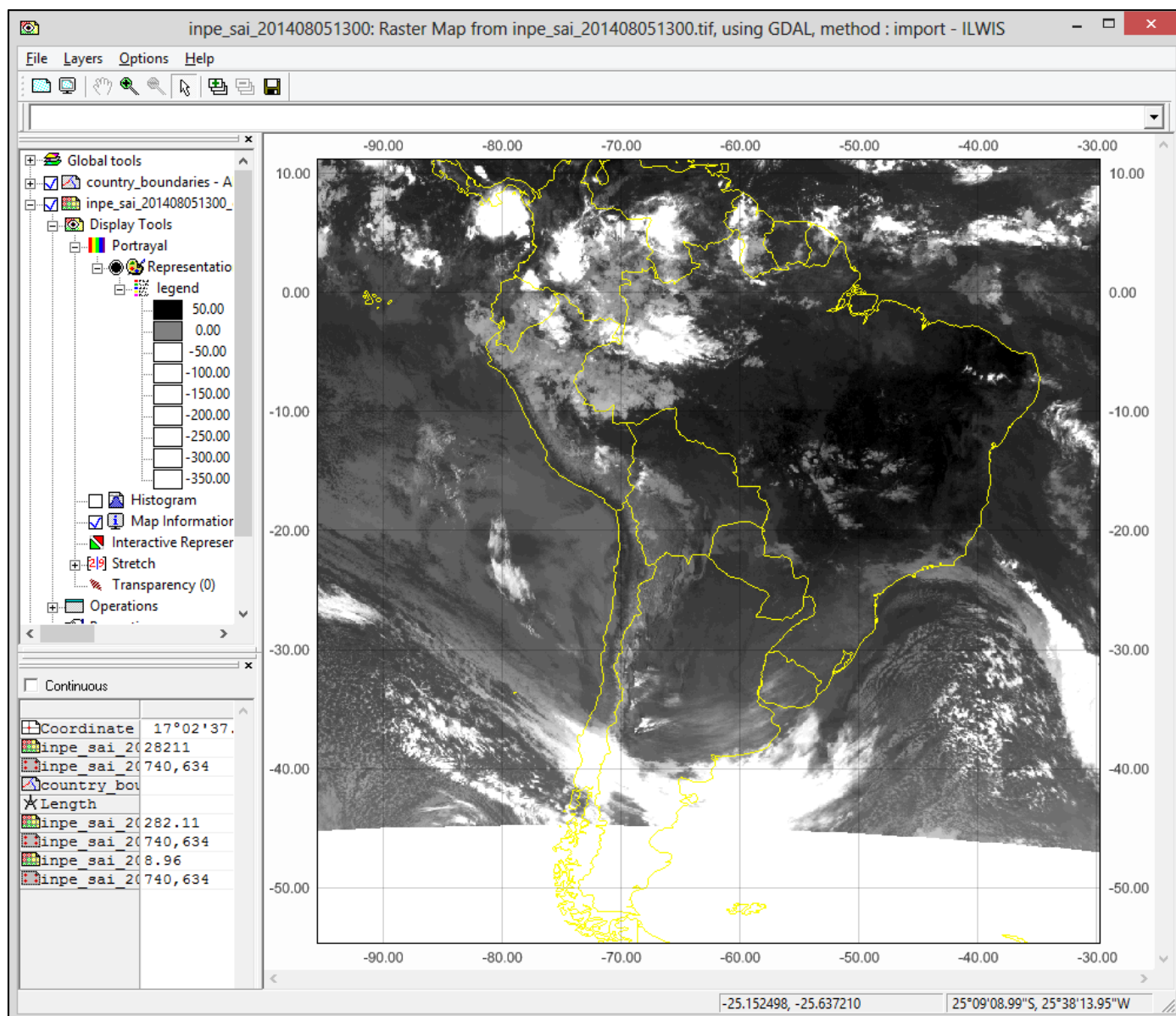

Figure 38: Infrared image with an applied stretch between -30 and 30

Repeat the whole procedure from **topics 2.3** to **2.12** using the image **"inpe_saw_201408051300"** to obtain the Water Vapor image in degrees Celsius. Remember that, in the **"Map Calculation"** window, you may use the following operation: (**'inpe_saw_201408051300' / 100) – 273.15**. Apply a Stretch between **-50** and **7.91** for a better contrast.
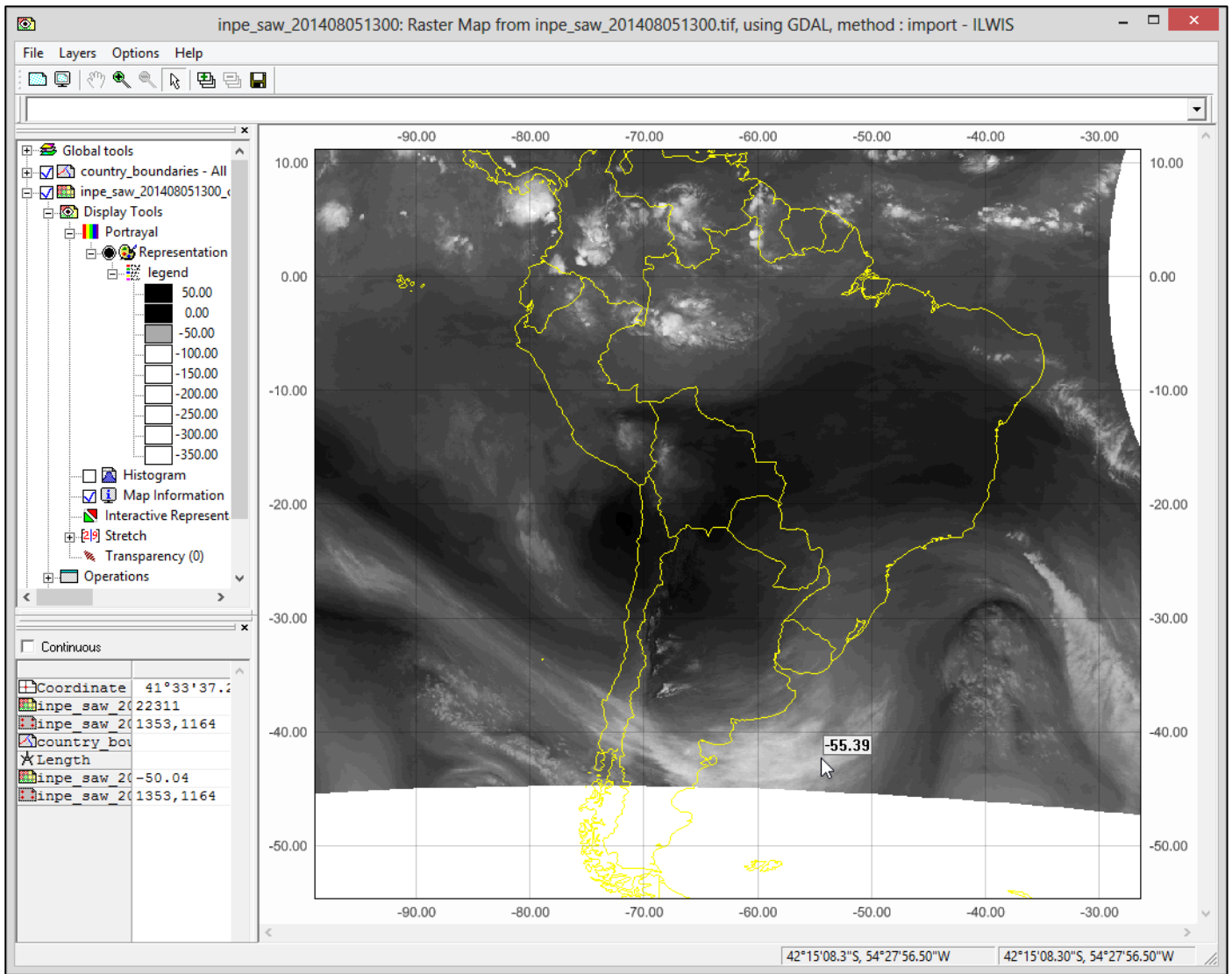
Figure 39: Water Vapor image converted to Celsius, with the Stretch applied

Now we have the three images necessary for the next lesson, the interpretation of physical variables.
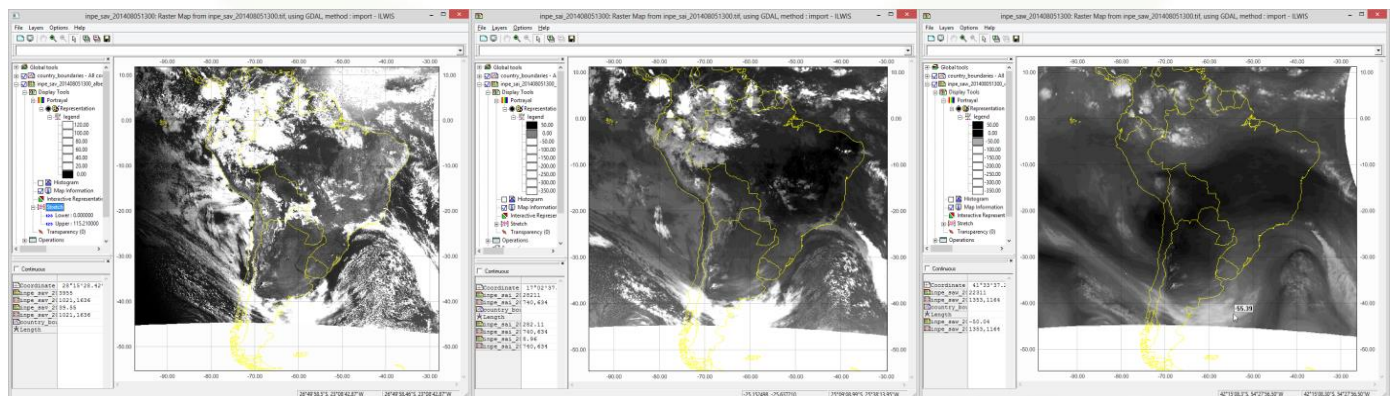

Figure 38: The three images (visible, infrared window and water vapor, manipulated, to be used in the next

Lesson 3 – Interpretation of physical variables
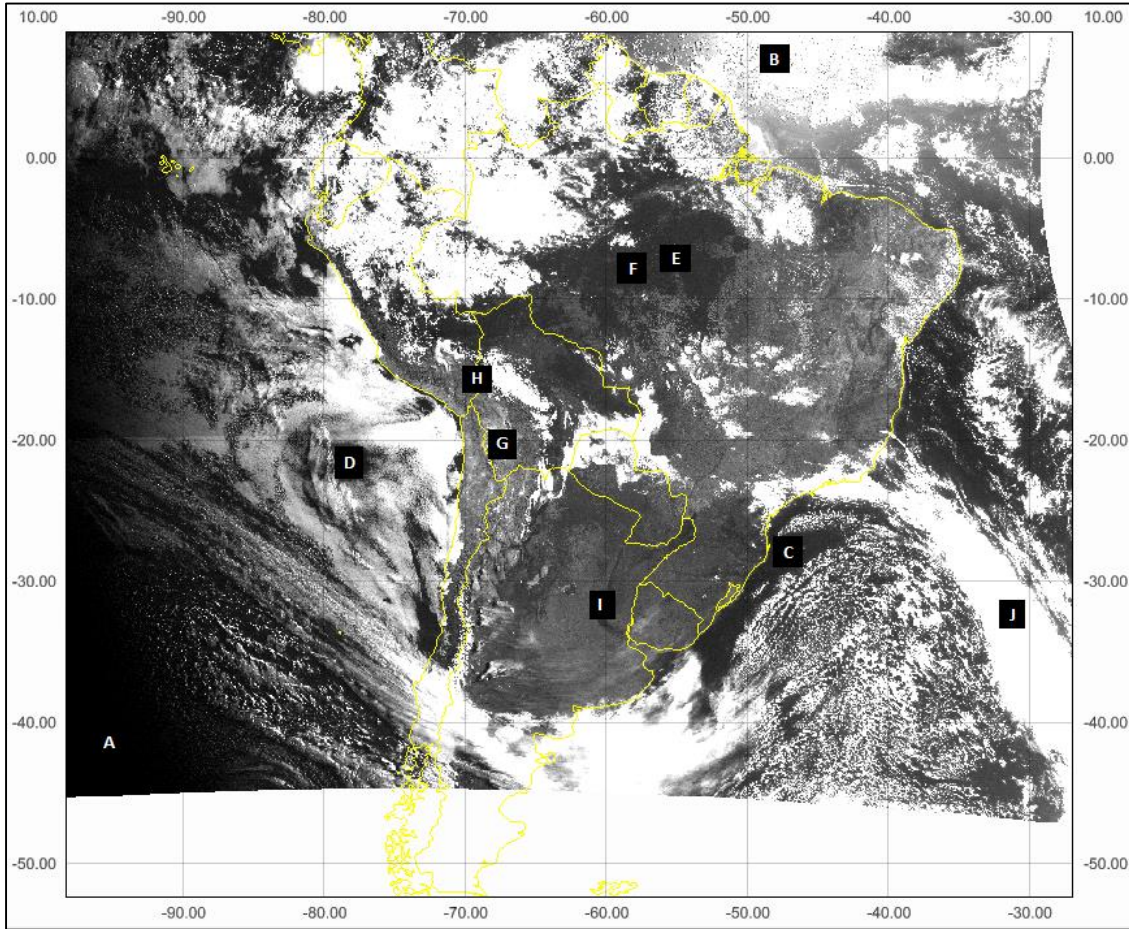
Consider the following areas (**"A"** to **"J"**):

Figure 40: Geographic regions for the analysis

Fill in the table on the next page with the approximate values of albedo and brightness temperature for the geographical positions **"A"** to **"J"**. Identify the targets as in the examples **"C"** and **"H"**. Answer the questions **1** to **5**.

💡 **Hint:** Use the **"Zoom In"** tool (🔍 icon in the upper toolbar, or **"Ctrl+I"**) to view the regions in more detail. After selecting the tool, right-click in the visualization area and drag the cursor, selecting the desired zooming area. The example below shows the displaying of the region "E" and "F". After applying the desired zoom, right-click on the image and select "Normal" to display the pixel values when left-clicking in a given region. To return to the full map visualization right-click on the map and select **"Entire Map"** (or **"Ctrl + E"**).
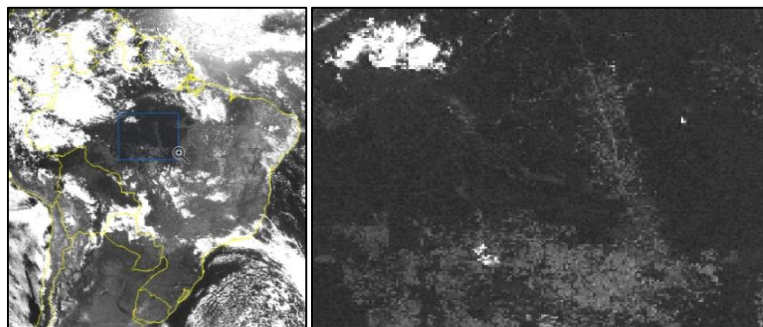

Figure 41: Zooming the regions "E" and "F"

TABLE – TARGET, ALBEDO AND BRIGTHNESS TEMPERATURE VALUES

Region	Approximated Latitude	Approximated Longitude	Target	VIS [%]	I.R. [°C]	W.V. [°C]
A	41°36 S	96°29 W				
B	8°50 N	48°27 W				
C	28°04 S	47°35 W	Atlantic Ocean	1.5	17	-23
D	21°12 S	78°19 W				
E	7°16 S	55°19 W				
F	7°30 S	57°55 W				
G	20°15 S	67°29 W				
H	15°45 S	69°28 W	Lake Titicaca			
I	32°37 S	60°34 W				
J	32°13 S	30°40 W				

Interpretation Questions:

1- Explain the difference between the values obtained in the visible, infrared and water vapor imagery in region **"D"**.

2- Identify two sets of targets which have approximate brightness temperatures values, but reasonably different albedo values.

3- Comment on the ocean regions **"D"** and **"G"**. These are regions with the same brightness temperature in the infrared window (10 um), but the value is not the same in the absorption band of the water vapor (6 um).

4- The regions **"C"** and **"D"** are regions of clear sky. Based on the infrared brightness temperatures, could you argue that this temperature is close to the ocean surface temperature?

5- Verify the maximum and minimum values of reflectance. Justify the obtained values.

Lesson 4 – Enhancing an image to facilitate the interpretation

4.1 Creating a New Color Palette Using the "Slicing" Tool

With the layer "**inpe_sai_201408051300_celsius**" opened in the visualization window, expand it by clicking on the "**+**" symbol next to it. After expanding it, expand the item "**Display Tools**". Before starting the enhancement, apply a "**Stretch**" ("**Display Tools**" -> Double-click on "**Strech**") between **-90** and **30**. Double-click on "**Interactive Representation**". The image's color palette will change to shades of green and the "**Slicing**" window will be opened.
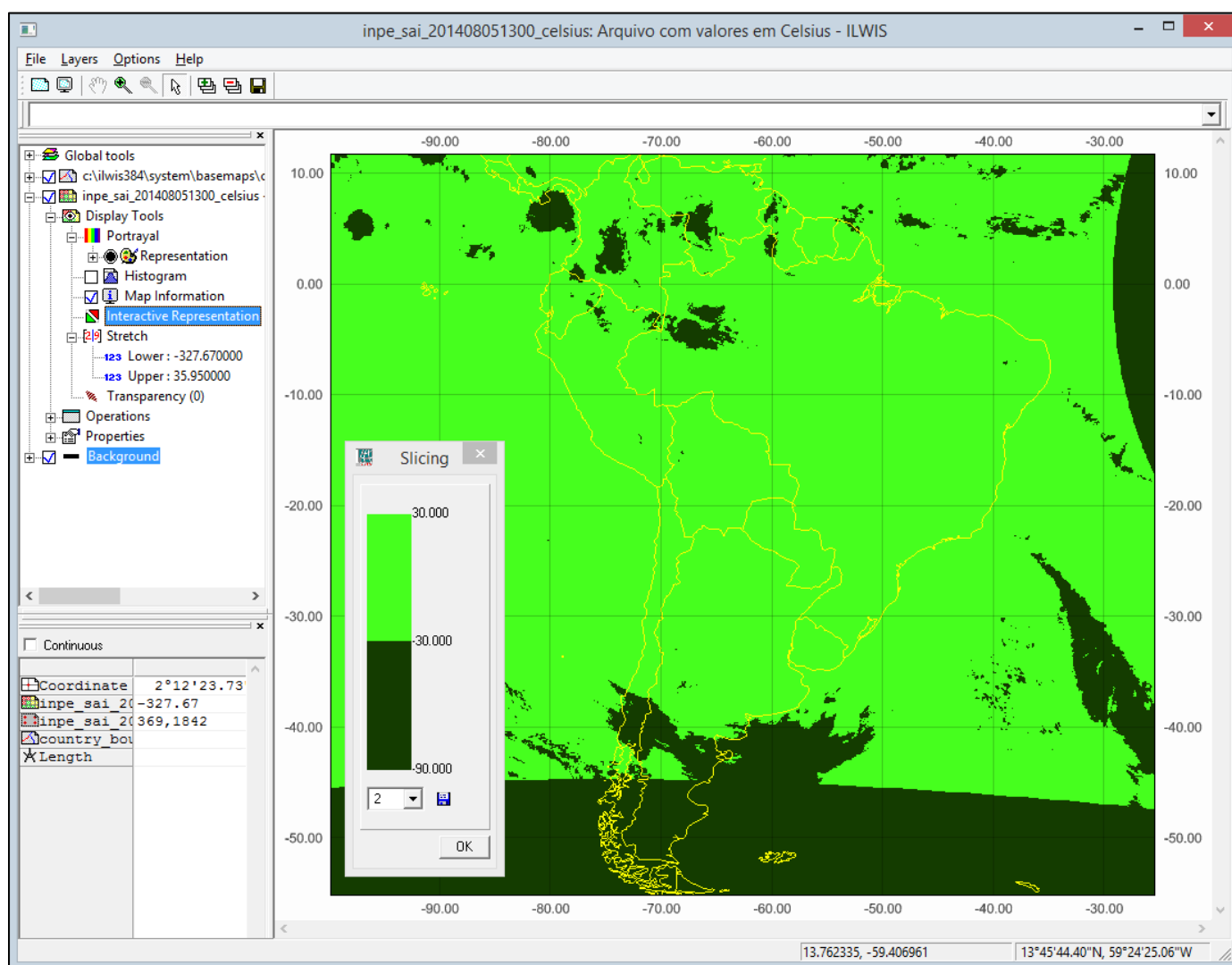
Figure 42: Interactive Representation and the Slicing window opened

In the "**Slicing**" window, change the value of the checkbox from "**2**" to "**7**". The color scale will be divided in six parts. Double-click on the last range of the scale (darker green between **-72.857** and **-90.000**). The "**Step Color**" window will be opened.
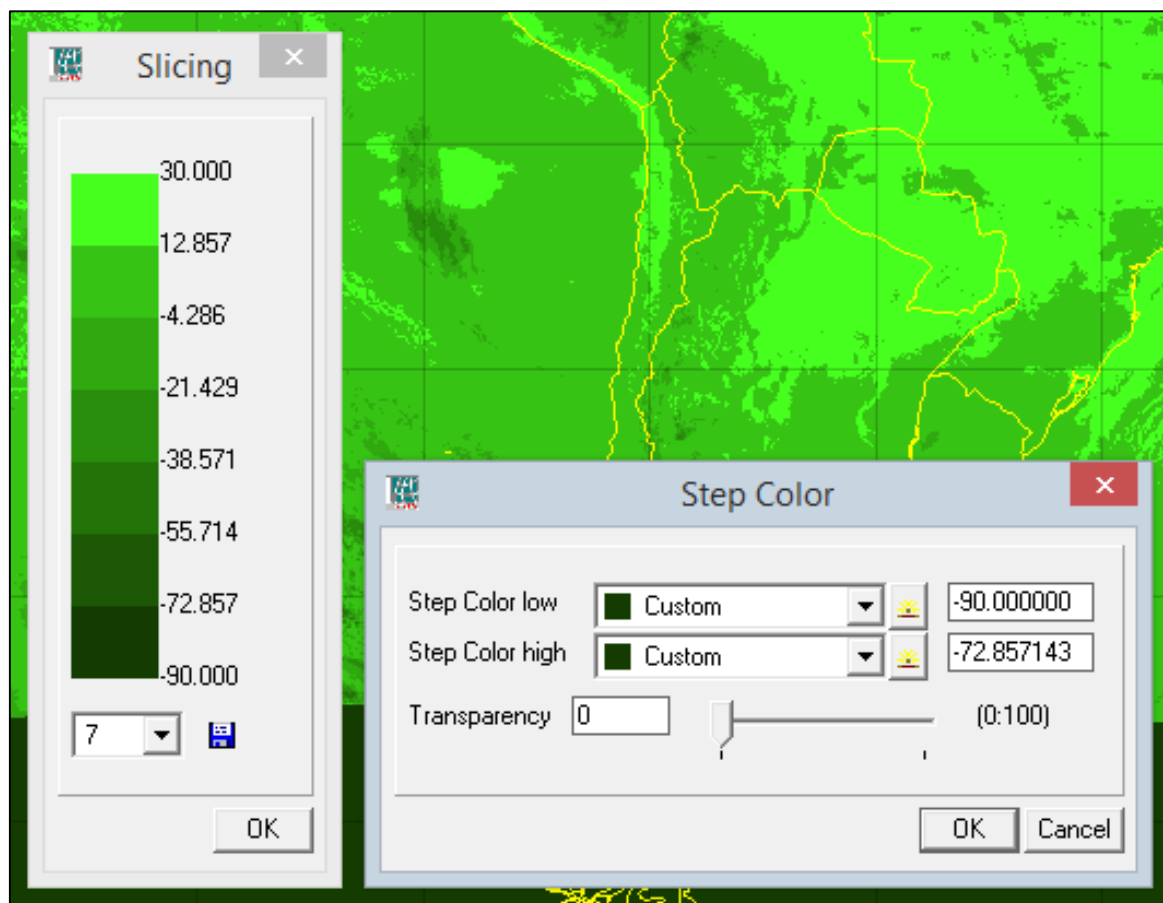
Figure 43: Slicing step changed and "Step Color" window opened

In the right side of the **"Step Color"** window, the value referred to **"Step Color high"** will be **-72.857143**. Change it to **-80**. Change both **"Custom"** colors (darker green) to **"White"** by choosing it on both lists. Click **"OK"**.
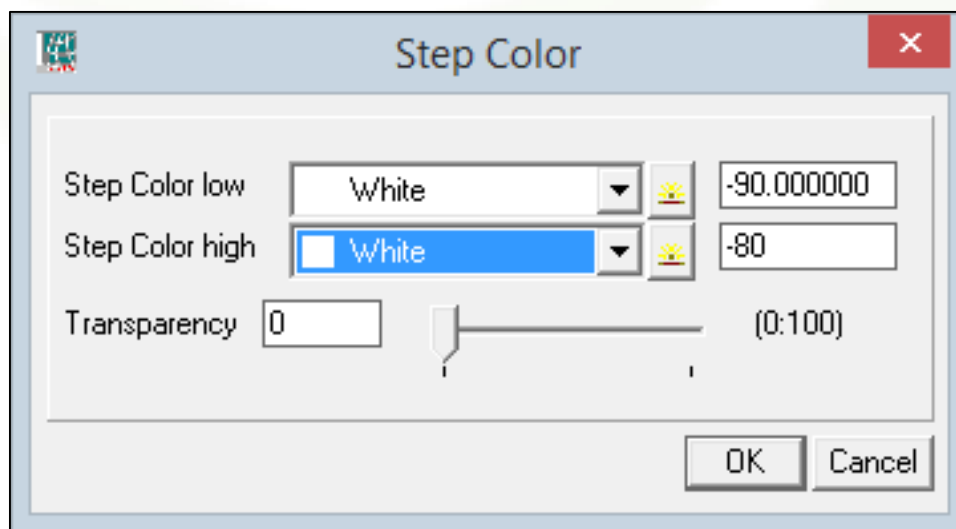

Figure 44: Changing the parameters of the "Step Color" window for the last range of the scale
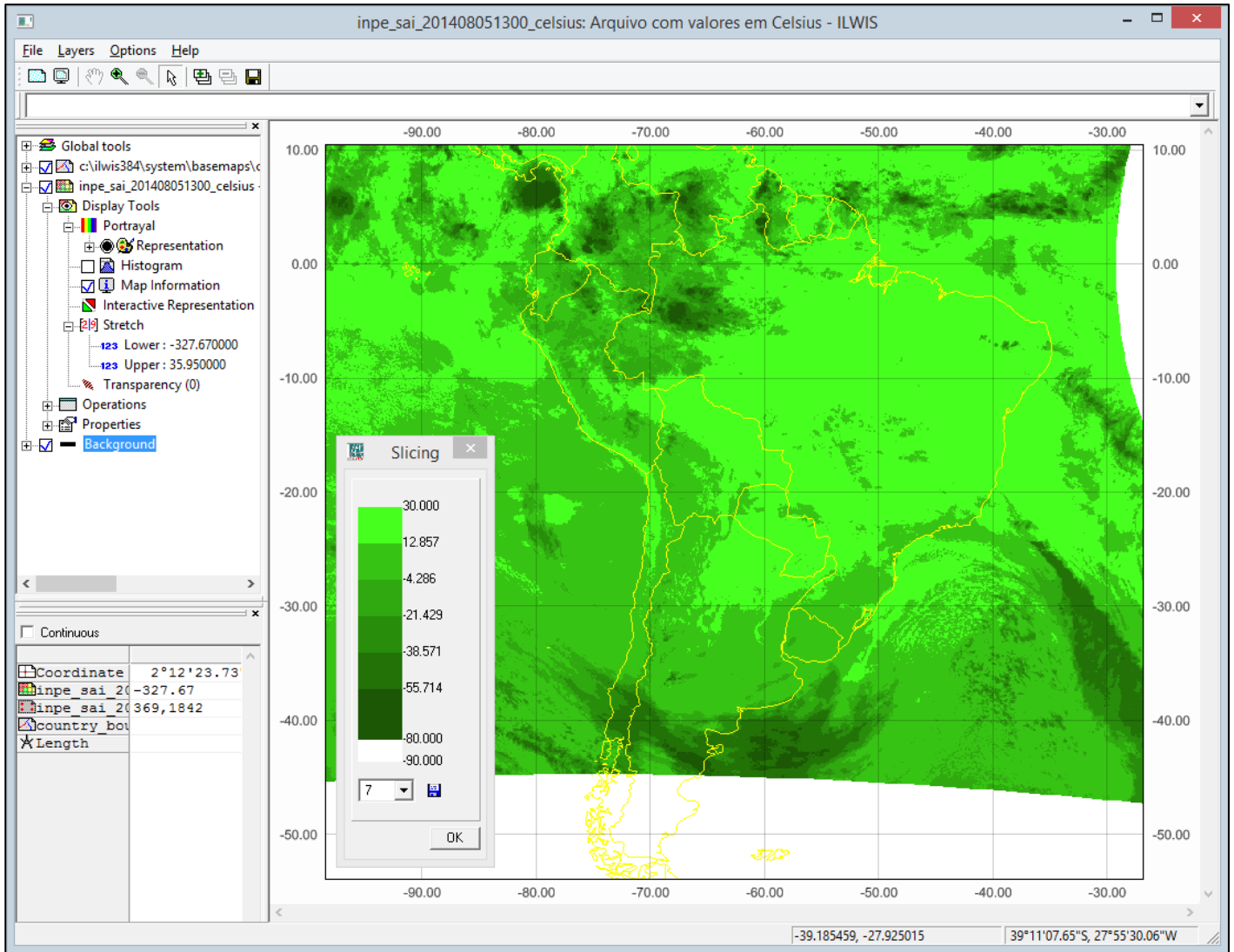
After this change, this will be the appearance of the map:

Figure 45: Visualization map after the first change in the color map

Now, double click on the penultimate range of the scale (between **-55.714** and **-80.000**). The **"Step Color"** window will be opened.

In the right side of the **"Step Color"** window, the value referred to **"Step Color high"** will be **-55.714286**. Change it to **-70**. Change both **"Custom"** colors (darker green) to **"MAgenta"** by choosing it on both lists. Click **"OK"**.
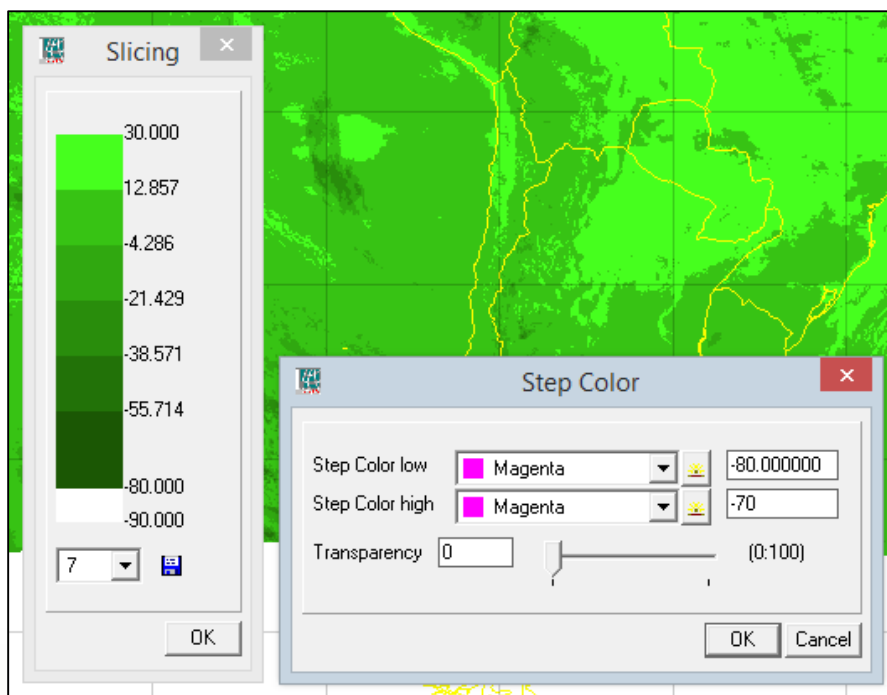
Figure 46: Changing the parameters of the "Step Color" window for the penultimate range of the scale

Double click on the next range of the scale (between **-38.571** and **-70.000**). The **"Step Color"** window will be opened.

In the right side of the **"Step Color"** window, the value referred to **"Step Color high"** will be **-38.571429**. Change it to **-60**. Change both **"Custom"** colors (darker green) to **"Blue"** by choosing it on both lists. Click **"OK"**.
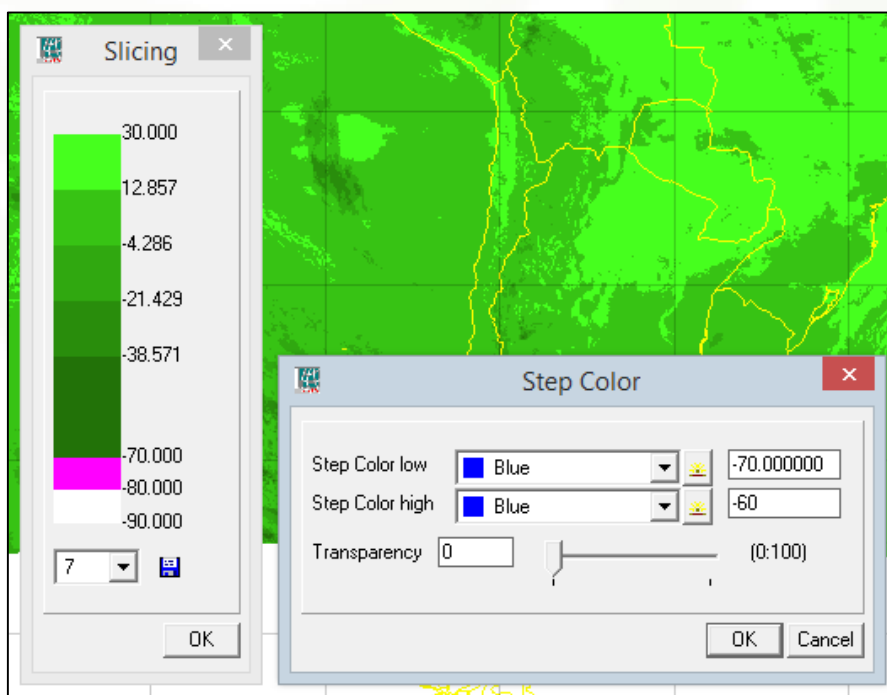

Figure 47: Changing the parameters of the "Step Color" window for the fifth range of the scale

Double click on the next range of the scale (between **-21.429** and **-60.000**). The **"Step Color"** window will be opened.

In the right side of the **"Step Color"** window, the value referred to **"Step Color high"** will be **-21.428571**. Change it to **-50**. Change both **"Custom"** colors (darker green) to **"Cyan"** by choosing it on both lists. Click **"OK"**.
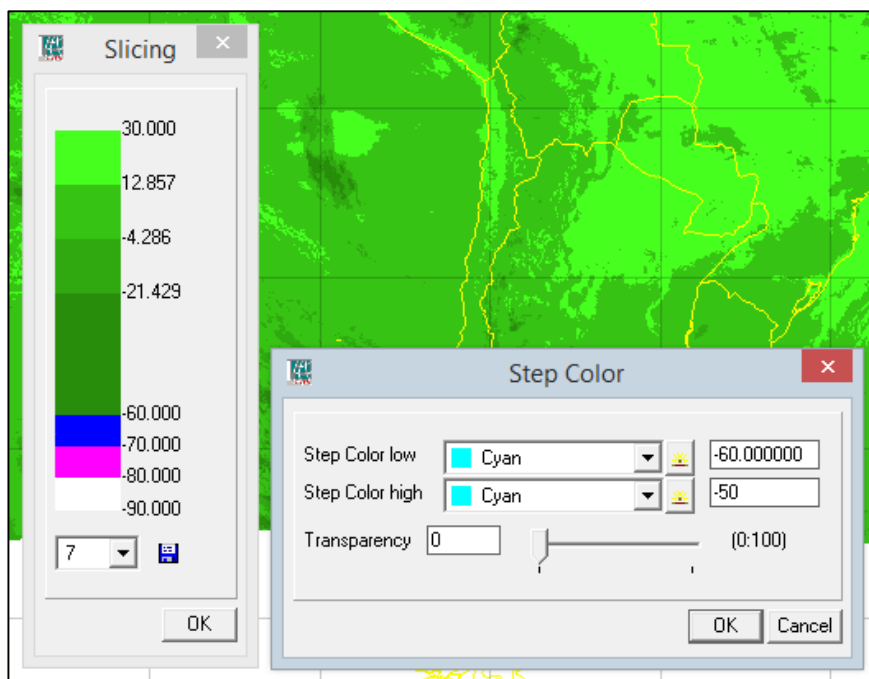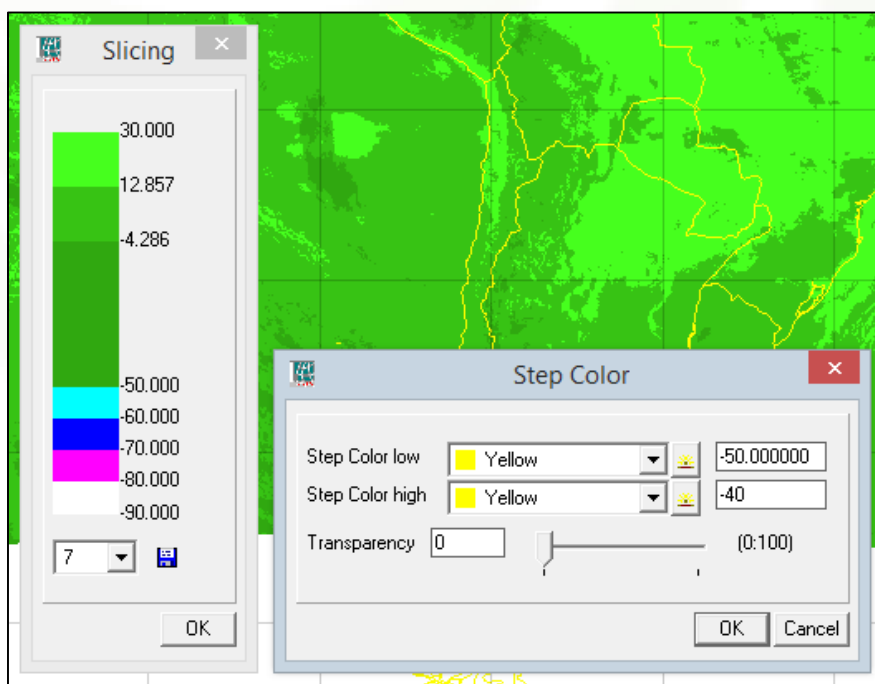
Figure 48: Changing the parameters of the "Step Color" window for the fourth range of the scale

Double click on the next range of the scale (between **-4.286** and **-50.000**). The **"Step Color"** window will be opened.

In the right side of the **"Step Color"** window, the value referred to **"Step Color high"** will be **-4.285714**. Change it to **-40**. Change both **"Custom"** colors (darker green) to **"Yellow"** by choosing it on both lists. Click **"OK"**.

Figure 49: Changing the parameters of the "Step Color" window for the third range of the scale

Double click on the next range of the scale (between **12.857** and **-40.000**). The **"Step Color"** window will be opened.

In the right side of the **"Step Color"** window, the value referred to **"Step Color high"** will be **12.857143**. Change it to **-30**. Change both **"Custom"** colors (darker green) to **"Orange"** by choosing it on both lists. Click **"OK"**.
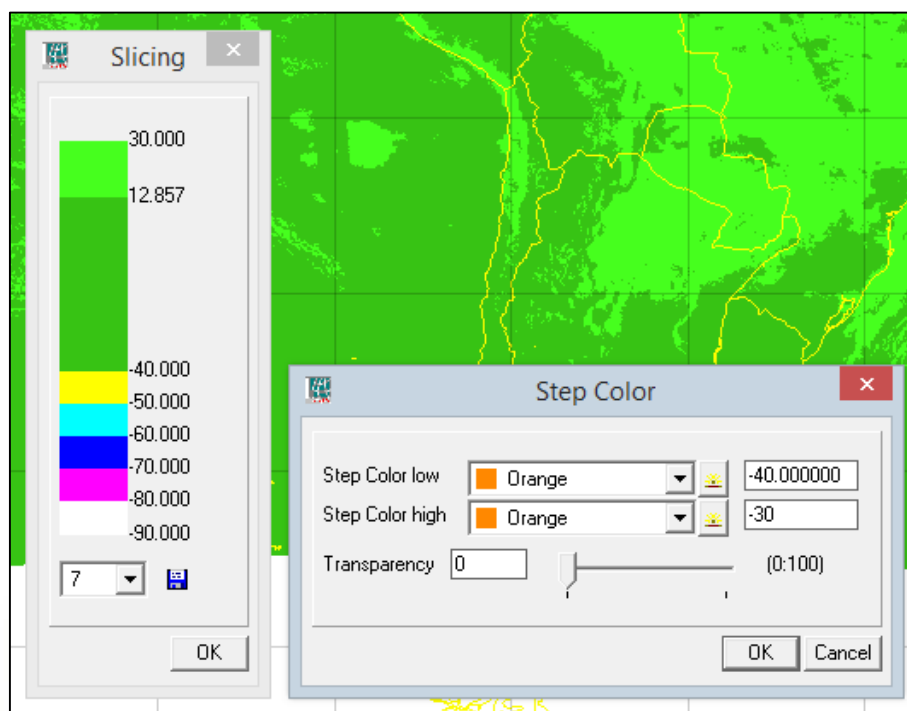
Figure 50: Changing the parameters of the "Step Color" window for the second range of the scale

Double click on the first range of the scale (between **30** and **-30.000**). The **"Step Color"** window will be opened. In the right side of the **"Step Color"** window, the value referred to **"Step Color high"** will be **30**. Keep it as it is. Change the **"Step Color low"** to **"White"** and the **"Step Color high"** to **"Black"**. Click **"OK"**.
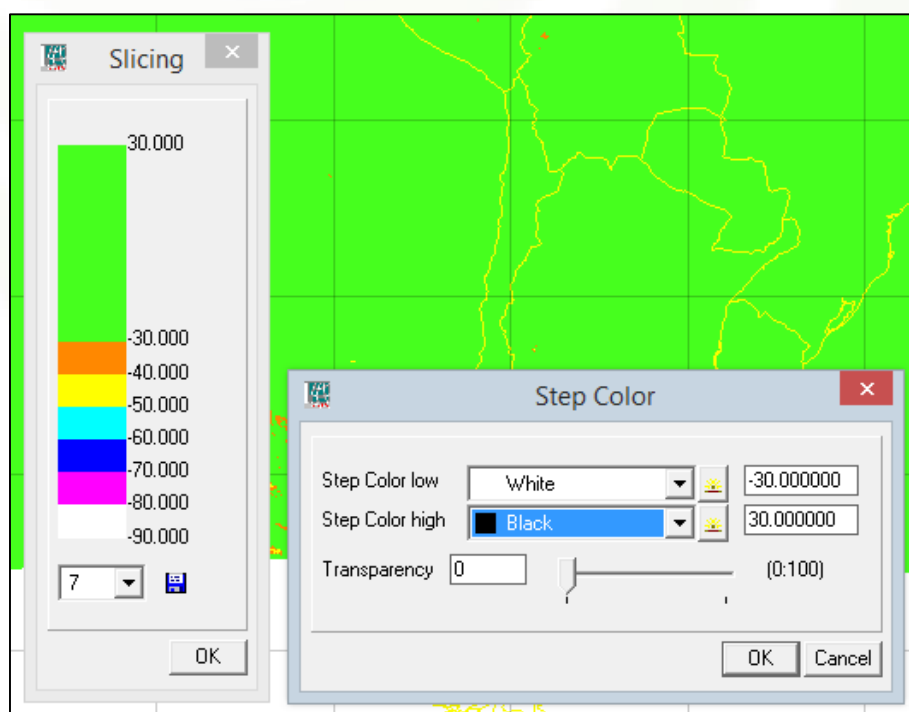

Figure 51: Changing the parameters of the "Step Color" window for the first range of the scale
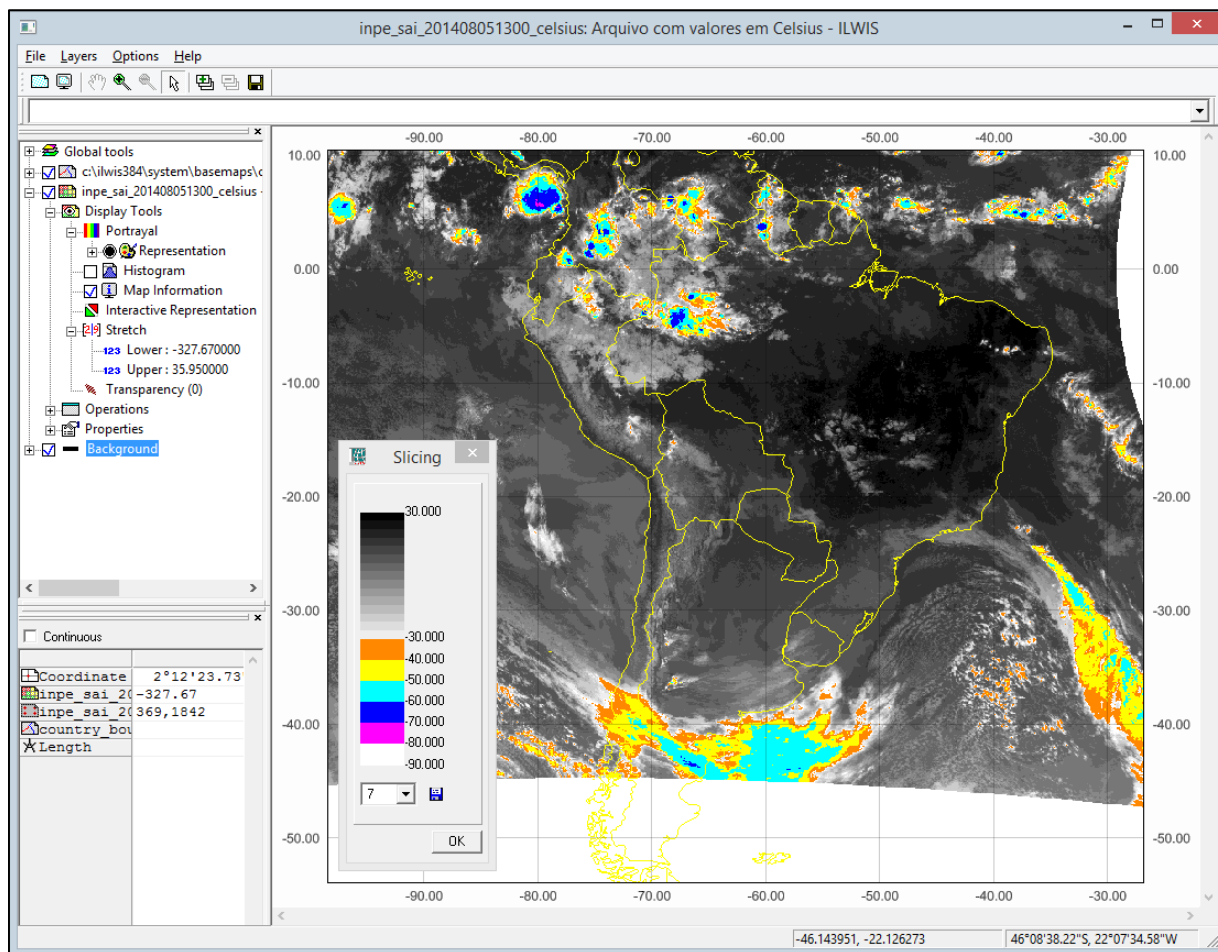
The resulting image will be displayed as follows:

Figure 52: The resulting image, enhanced to facilitate the interpretation

To save the newly created color palette, click on the **floppy symbol** in the **"Slicing"** window. In ILWIS, a color palette is called **"representation"**. Save your new representation (**.rpr** file) in your preferred folder (e.g.: **"C:\VLAB"**). In this example we will save it as **"Infrared_Enhance.rpr"**.
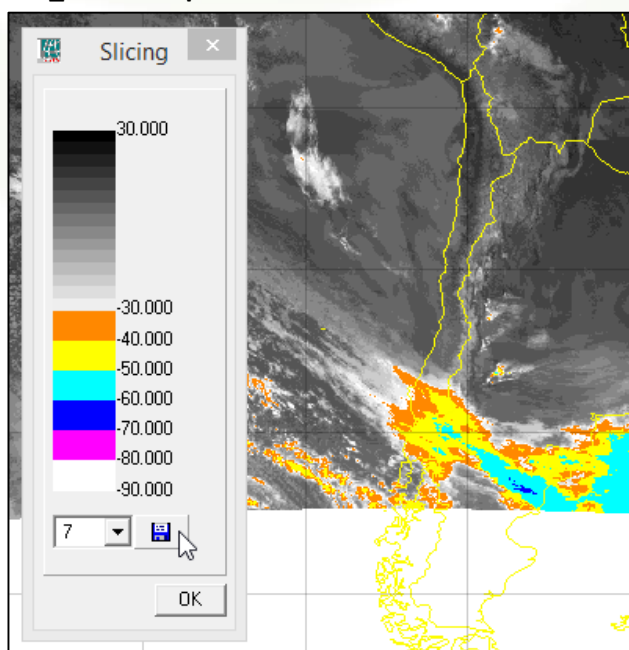

Figure 53: Floppy symbol used to save your representation

💡 **Hint:** You may find the standard ILWIS representations in: **"C:\Program Files (x86)\n52\ILWIS38\system"**. You may save the representations created by you in this folder.

Now you may use this same color palette (**"Infrared_Enhance.rpr"**) to enhance infrared images in Celsius from any satellite, including those from the GEONETCast-Americas broadcast!

4.2 Adding a Legend to the Visualization Window

With the layer "**inpe_sai_201408051300_celsius**" opened and expanded in the visualization window, **right-click** on "**Display Tools**" and click on "**Annotations**". This will activate the "**Annotations**" item (⊞ ⊹ Annotations) in the "**Display Tools**" list.
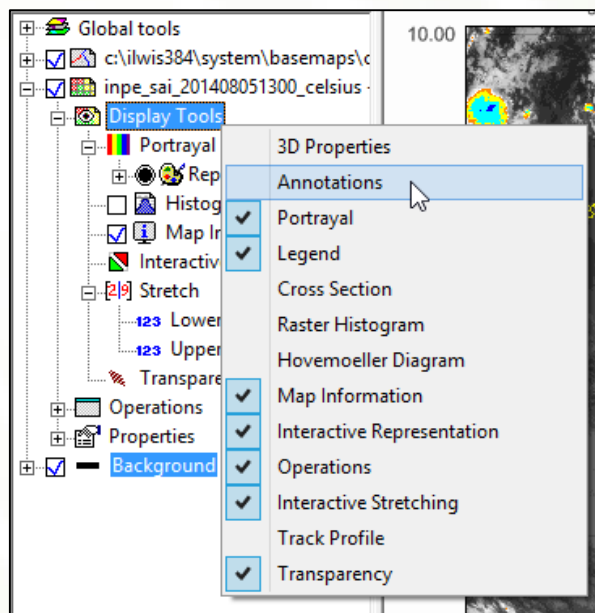

Figure 54: Activating the "Annotations" option

Expand the "**Annotations**" item, expand the "**Legend**" item and activate it. A legend will be shown in the vertical position, unadjusted.
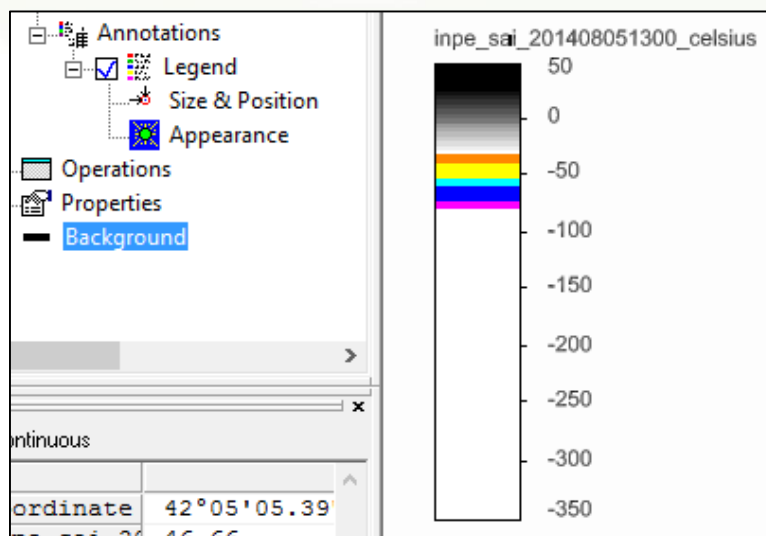

Figure 55: Unadjusted legend added

To adjust the legend for a better view of it, double-click on **"Appearance"**. The **"Appearance of Legend"** window will be opened. Activate the **"Background color"** checkbox, activate the **"Draw Boundary"** checkbox, change the **"Scale"** to **1.2**, change the title to **"BRIGHTNESS TEMPERATURE (C°)"**, change the **"Min"** to **-80**, the **"Max"** to **60** and the **"Step"** to **20**. Click **"Apply"** and click **"Close"**.
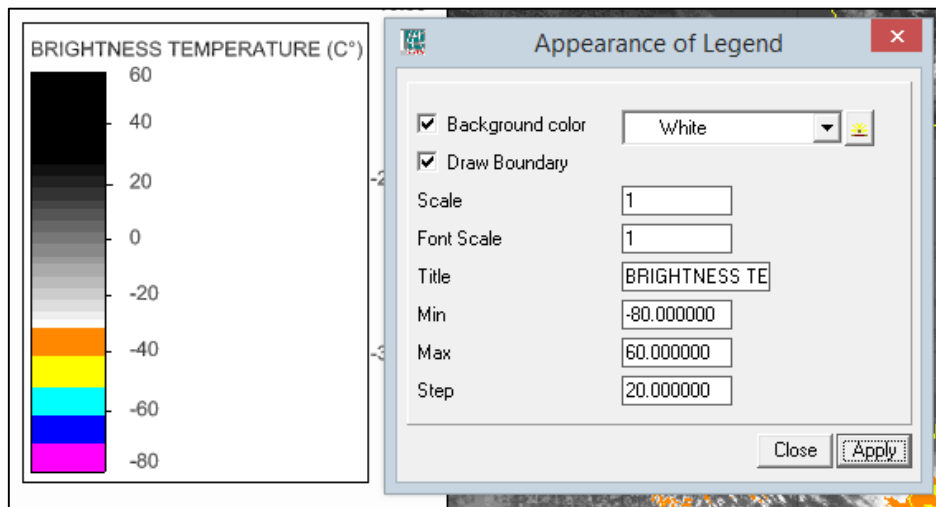

Figure 56: Configuring the legend

You may also change the orientation and position of the legend in the visualization window. Double-click on **"Size & Position"**, in **"Orientation"** choose **"Horizontal"**, and in **"X Position"** and **"Y Position"** choose the values of your preference. I the example below we have positioned the legend in the bottom part of the image.
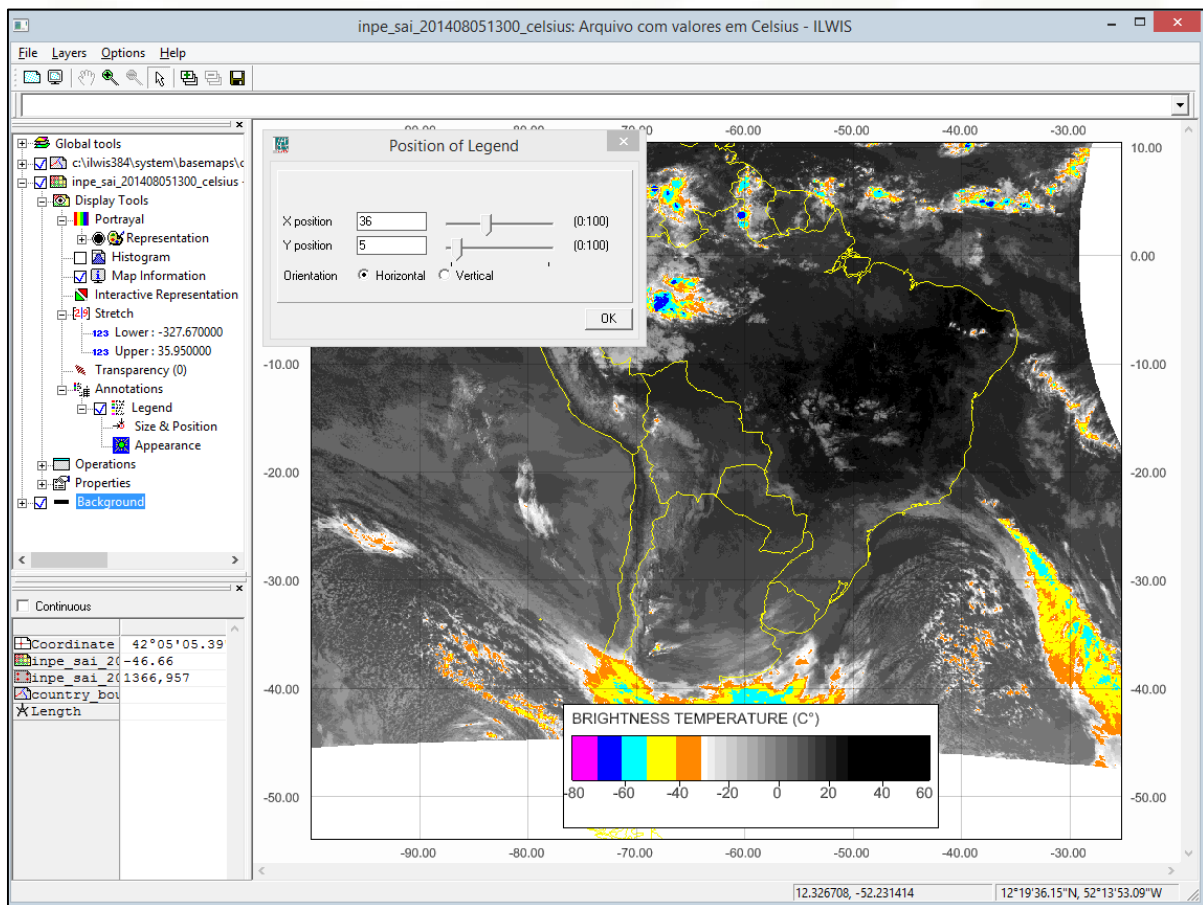

Figure 56: Positioning the legend

EXERCISE: Create a color palette enhancing the Water Vapor image **"inpe_saw_201408051300"**, like in the example below, saving it as **"Water_Vapor_Enhance.rpr"**:
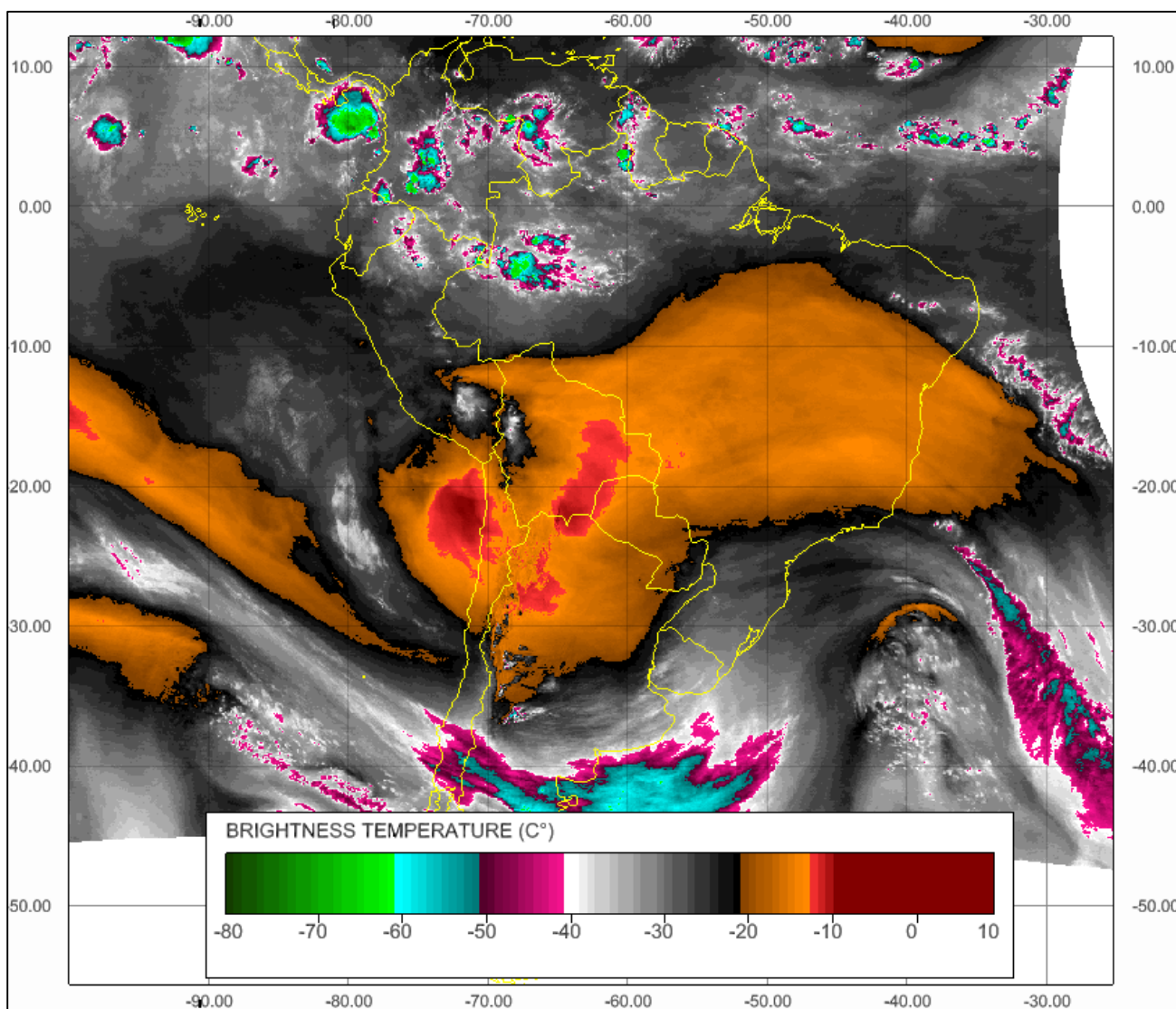

Figure 57: GOES-13 Water Vapor image for South America enhanced