

Practical exercises Lesson 2: Introduction MSG, Meteosat 7 and METOP-AVHRR

Version 1 - 2010

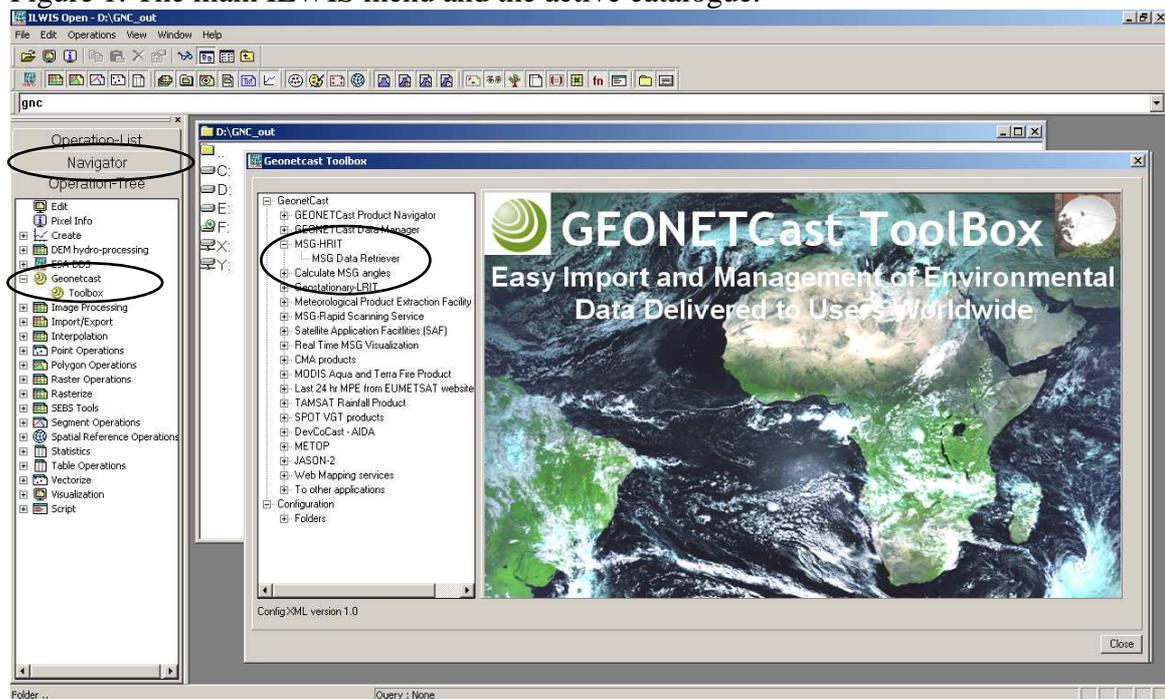
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Import and visualization of data from MSG, Meteosat-7 and METOP.

1. Data import and visualization from Meteosat Second Generation (MSG).

Open ILWIS and use the Navigator to select your working directory. See also ellipses indicated in the figure below pointing to the main menu items that will be used during this exercise. Note that in this figure the active working directory is “d:\GNC_out”. Copy the content of this directory available on your DVD into your active working directory. Some ancillary files needed during the exercises are located in this directory on your DVD.

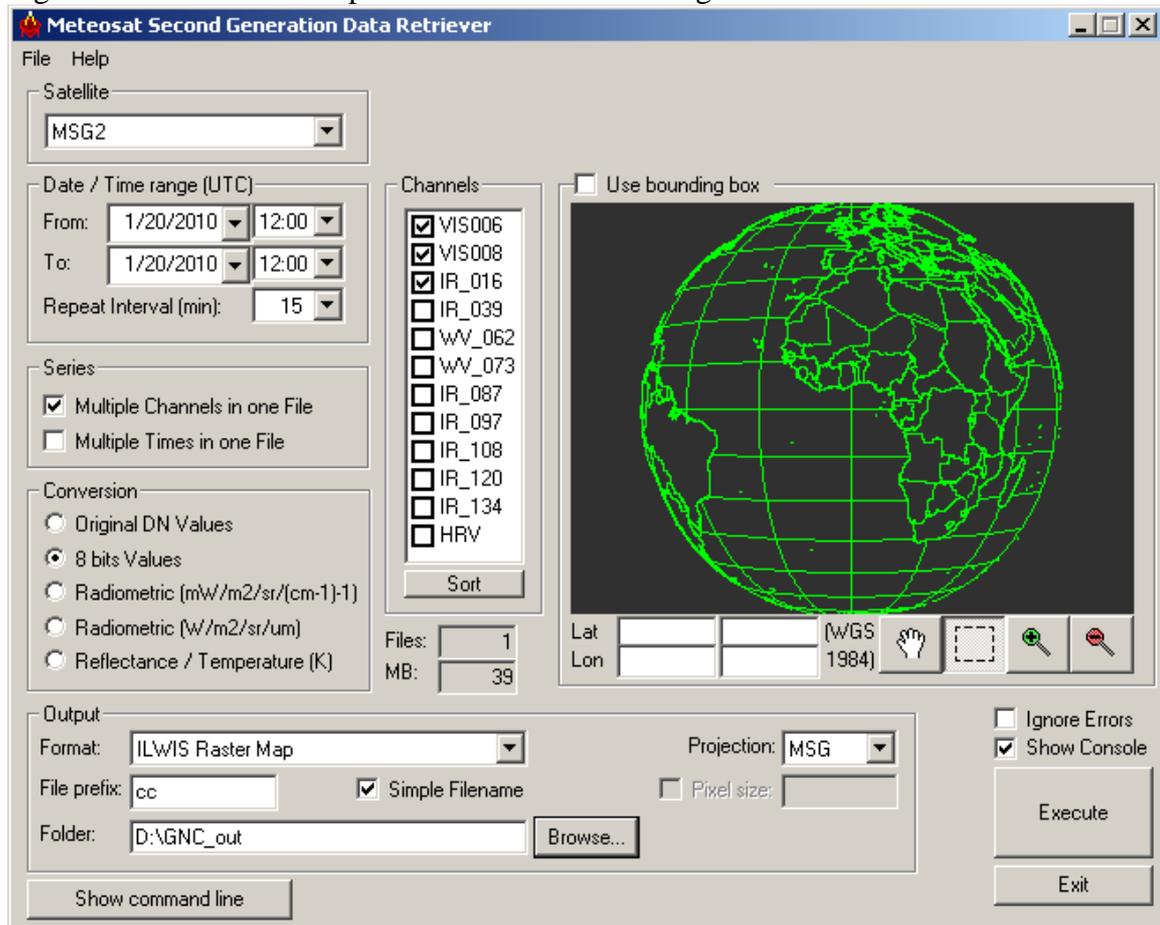
Figure 1: The main ILWIS menu and the active catalogue.



In order to import data from MSG open the “*Geonetcast and Toolbox*” tabs from the main-menu and select “*MSG-HRIT*” and “*MSG Data Retriever*”. The so-called MSG Data Retriever window will be activated which can be used to import the data recorded by MSG (both 8 and 9). Specify the settings as indicated in figure 2, for the 12:00 UTC image.

If you did not configure the “*Data Sources*” of the MSG Data Retriever consult the document describing the step by step installation and configuration.

Figure 2: Selection and import of MSG channels using the Data Retriever.

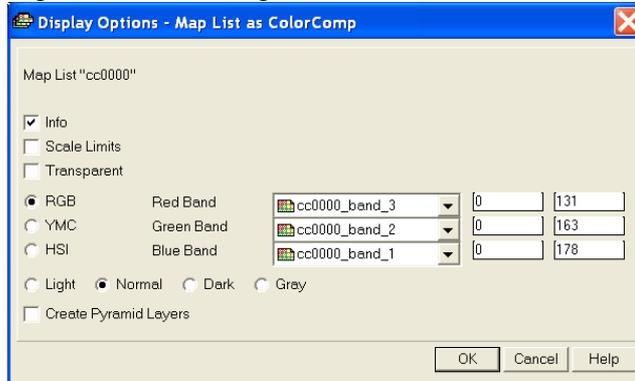


Note the following from these import settings: the “*Satellite*” selected is MSG2, which refers to Meteosat Second Generation – 9. The “*Date / Time Range*” is 1/20/2010 and 12:00 UTC respectively. The three channels that have been selected are often used to generate a Daytime Standard Colour Scheme composite. The multiple imported channels, converted to 8 bits, is stored as “*Multiple Channels in one File*” with a “*File Prefix*” cc and the option “*Simple Filename*” is activated. As output format an ILWIS Raster Map is selected and the appropriate “*Folder*” is selected to store the output data generated. The “*Projection*” MSG allows you to look at the data from a Geostationary perspective and in this case the whole disk as recorded by MSG is selected.

After you have specified the appropriate settings, press “*Execute*” to conduct the import. Close the Geonetcast toolbox window, note that in the tray bar the Meteosat Second Generation Data Retriever is still active, keep it as such as you will need it later.

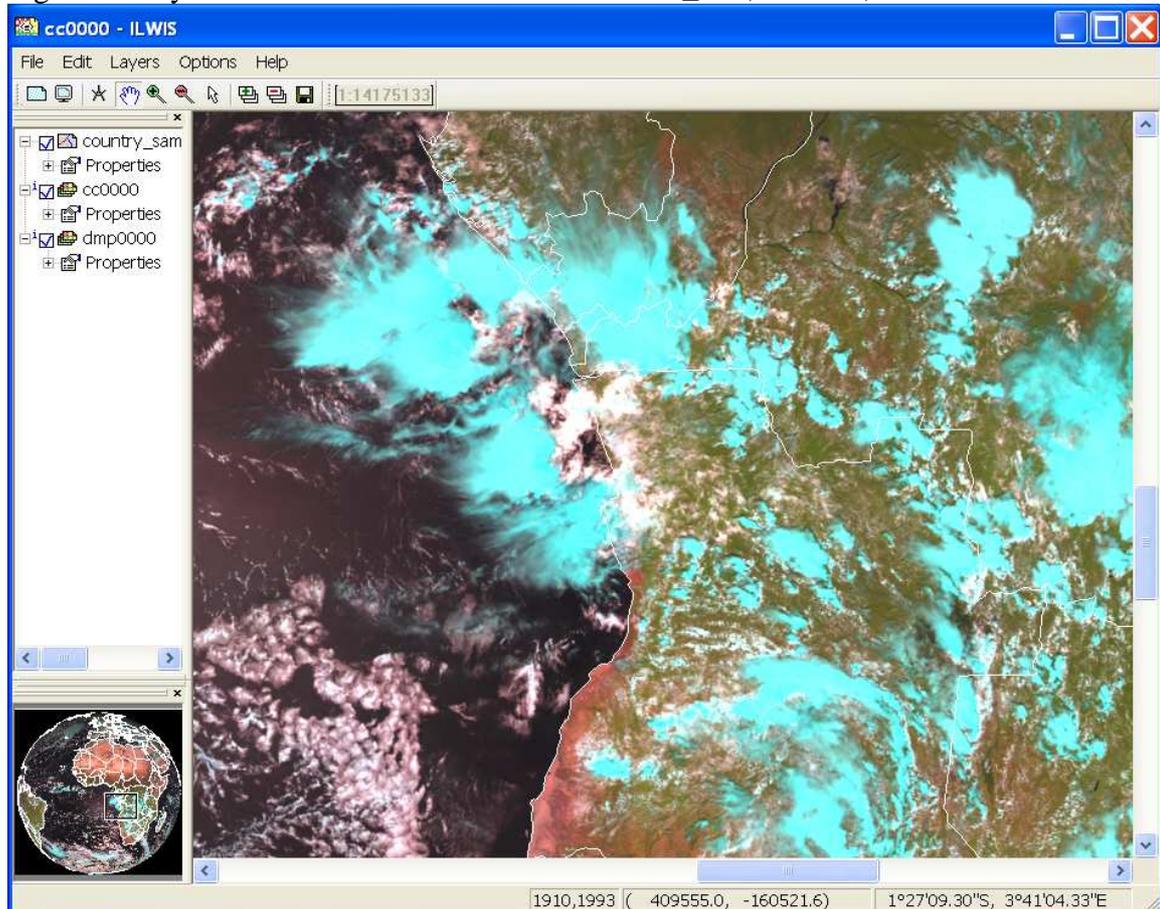
Upon completion of the import, select from the ILWIS main menu, the option “*Window*” and from the drop down menu “*Refresh F5*”. To display the image double click the maplist icon  “cc0000” and in the Map List “cc0000” menu select the “*Open as ColorComposite*” option . Display the bands according to the assignment in the figure 3 below.

Figure 3: Band assignment for visualization.



Note that using the “*Simple Filename*” option during import band_1 now represents VIS006, band_2 is VIS008 and band_3 is the IR_016 channel (see also figure 2). The default stretch function for each of the channels can be used and press “OK” to show the image. Figure 4 is showing a portion of the MSG disk, using a similar colour assignment, but for 1/20/2010 at 12:00 UTC.

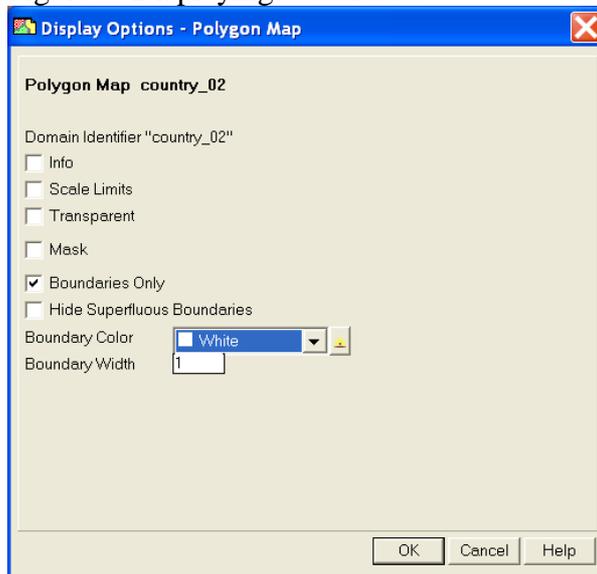
Figure 4: Daytime standard colour scheme MSG: IR_016, VIS008, VIS006 in RGB



Check the features on the image, e.g. the water, (bare) land – vegetated surfaces and (various) clouds. Add to this image view also the country boundaries. In order to do so, select from the active map display window menu, the option “*Layers*”, and “*Add Layer*”, select an available segment or polygon map layer, e.g. Country_02. Note that when displaying a Polygon map, set the “*info*” option off, and to display only the boundaries,

activate the option “*Boundaries Only*”, you can also specify the “*Boundary Color*”, select a white colour. See also figure 5.

Figure 5: Displaying vector data



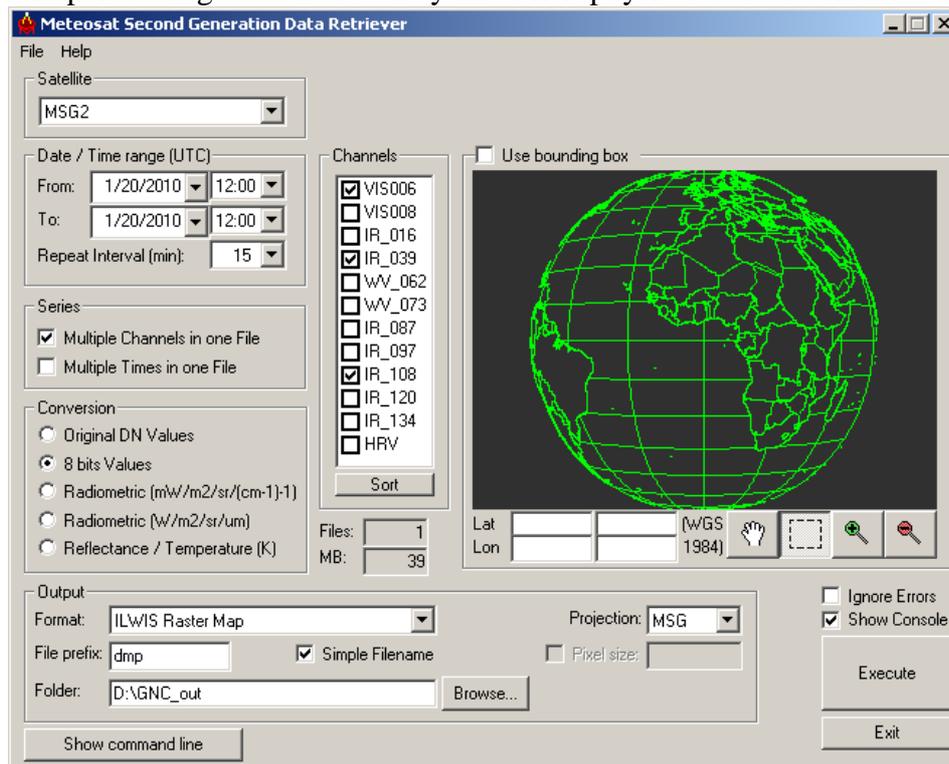
With the vector layer active you can zoom to your area of interest, check the colour composite. Activate the  “*Normal*” option from the active map display window. When you move the mouse cursor over the image and simultaneously press the left mouse button you can also see the values (note the unit: 8 bits values, see also the “*Conversion*” option as of figure 2) for RGB respectively.

Close all active layers when you have finished browsing through the colour composite.

2. Construct a Daytime Microphysical (DMP) Colour Scheme composite

Once more open the “*Meteosat Second Generation Data Retriever*”. Now specify for the “*Date / Time range UTC*” the same date as used for the previous exercise. The other settings are indicated in figure 6.

Figure 6: Import settings to construct Daytime Microphysical Colour Scheme composite.



Upon completion of the import, select from the ILWIS main menu, the option “*Window*” and from the drop down menu “*Refresh F5*”. To display the new map list created, double click the map list called dmp0000, display band 1 (VIS006) as Red, band 2 (IR_039) as Green and Band 3 (IR_108) as Blue, use the default stretch options. Also display the country boundaries (info off and boundaries only) and zoom in as well. Figure 7 is showing this visualization (for the identical time – part of MGS disk) of this MSG channel combination.

Note that this band combination can be used to determine in a qualitative manner some of the cloud properties. The VIS006 can be used to derive information about the optical thickness and the amount of cloud water and ice of the clouds, IR_039 can be used to get an idea of the particle size and the phase of the clouds (e.g. consisting of water vapour, small ice, large ice) and the IR_108 channel records the cloud top temperature.

Table 1 is showing the daytime convective development stages (I to IV) of clouds and the associated colouration that can be observed on a colour composite. When using this colour scheme for the respective MSG channels, note that an increasing Red colour contribution is an indication of larger visible reflectance; an increased Green colour

contribution indicates smaller cloud top particles and with an increased Blue colour contribution the cloud top are warmer.

Figure 7: DayTime Microphysical Colour Scheme, VIS006, IR_039 and IR_108 in RGB

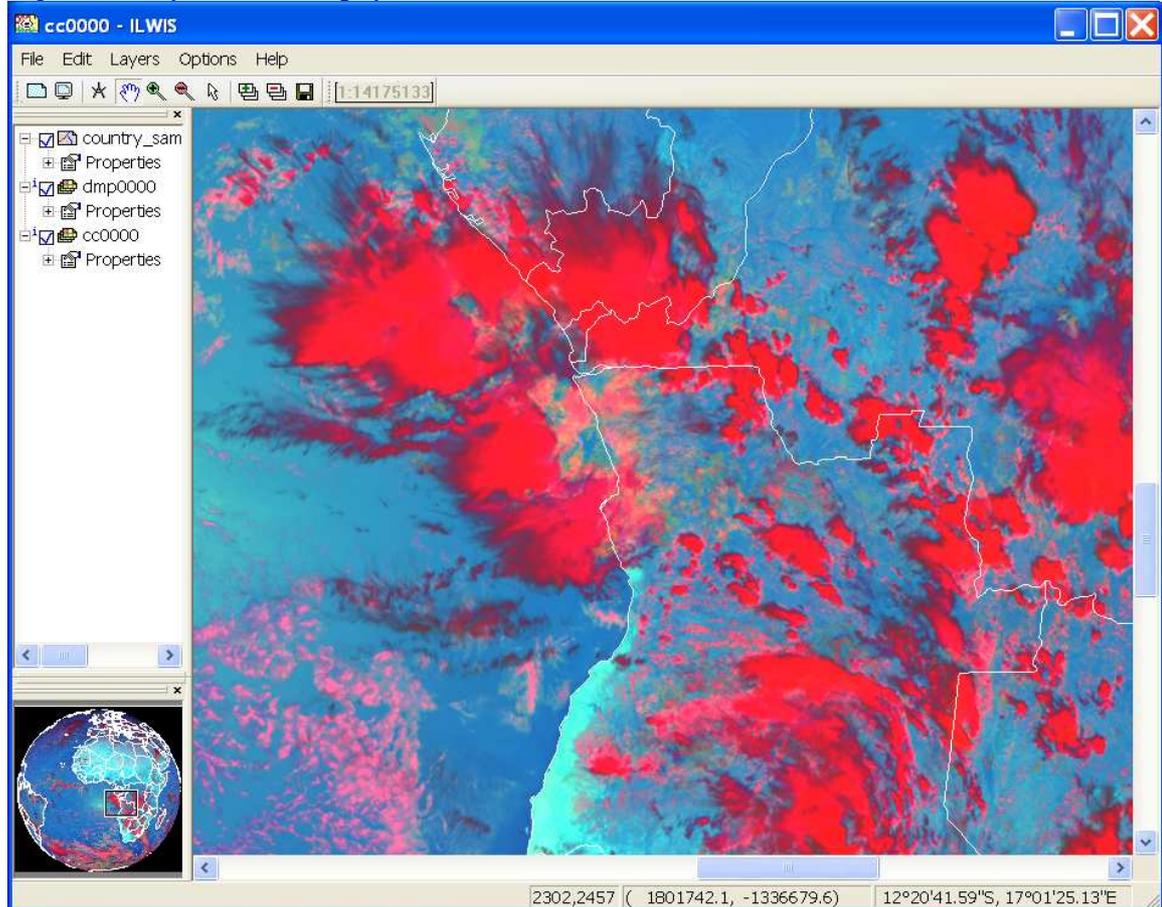
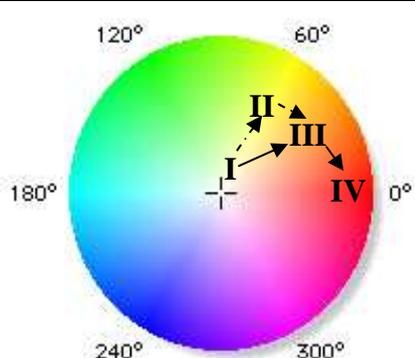


Table 1: Typical daytime convective development of clouds and related colour scheme

	VIS006 (Red)	NIR016	IR_039 (Green)	IR_108 (Blue)	
I. Very early stage (low, warm water cloud)	White <i>opt thick</i>	White <i>water</i>	White <i>water</i>	Light Grey <i>warm</i>	 <p>Related colour scheme for various stages of convective development</p> <p>Cb = Cumulonimbus</p>
II. First convection (first convective towers)	White <i>opt thick</i>	White <i>super cooled water</i>	White <i>super cooled water</i>	Dark Grey <i>cold</i>	
III. First icing (transformation into Cb)	White <i>opt thick</i>	Light Grey <i>small ice</i>	Grey <i>small ice</i>	Black <i>very cold</i>	
IV. Large icing (Cb anvils)	White <i>opt thick</i>	Dark Grey <i>large ice</i>	Black <i>large ice</i>	Black <i>very cold</i>	

Interaction of the solar radiation with clouds is presented in figures 8 and 9 for the various parts of the Electromagnetic Spectrum (EM). Figure 8 shows that at 1.6 μm (NIR) much more solar radiation is absorbed by the clouds than in the visible part of the EM, ice absorbs even more strongly than water in the NIR. At 3.9 μm even more solar radiation is absorbed and here also ice is a stronger absorber compared to water. Figure 9 indicates the changes in reflectivity of snow clouds in the visible and NIR part of the EM.

Figure 8: Absorption of water and ice by clouds for the various MSG channels (from: Daniel Rosenfeld, The Hebrew University of Jerusalem, HUI)

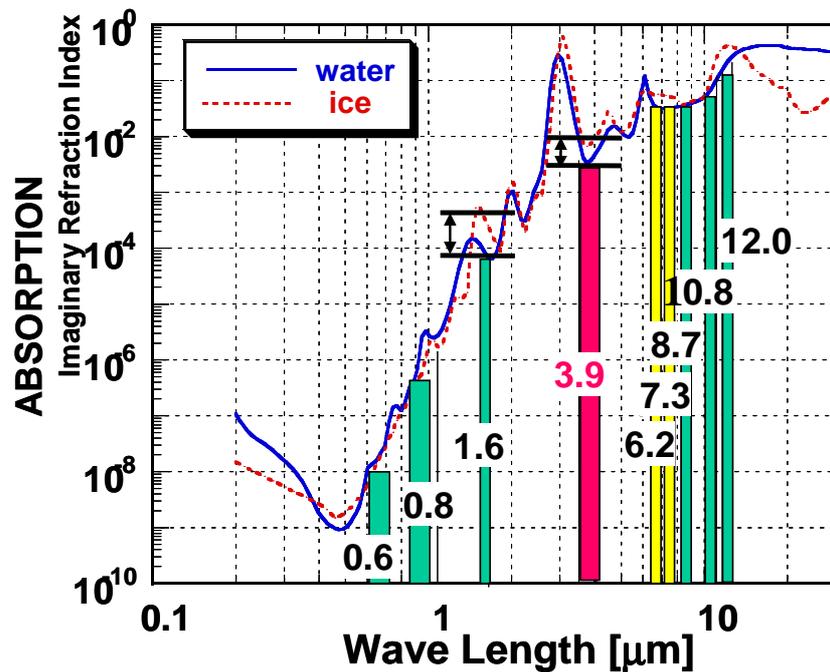
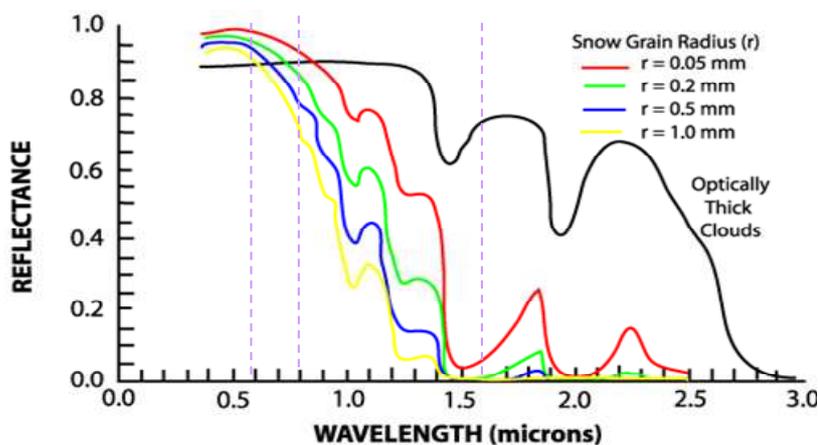


Figure 9: Different reflectivity of snow clouds at 0.6, 0.8 and 1.6 microns (from Rob Roebeling: Royal Netherlands Meteorological Institute, KNMI)

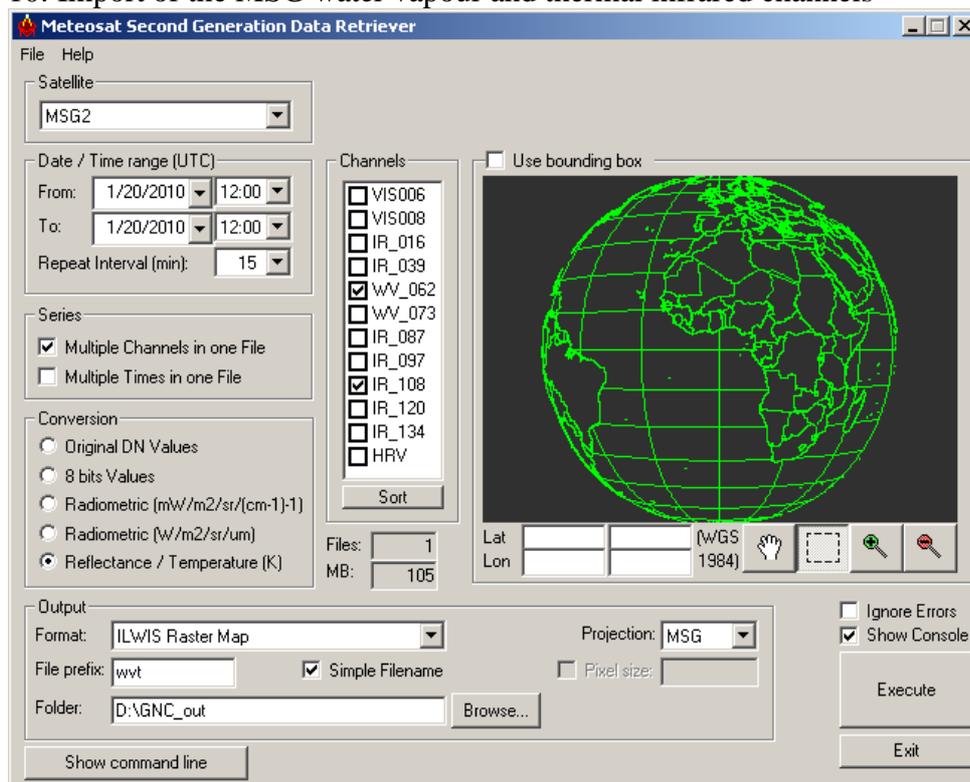


Explain using figures 8 and 9 why a daytime standard colour scheme (displayed as a colour composite, using as band assignments: IR_016, VIS008 and VIS006 in RGB) snow and ice clouds will have a cyan appearance and water clouds will be white.

3. The MSG water vapour channel (WV_062 and the Thermal channel (IR_108)

MSG is recording the Visible to the Infrared region of the electromagnetic spectrum into a number of discrete channels. Import the WV_062 and the IR_108 channels for the same day as for the previous exercises and specify the other import options according to the specification given in figure 10.

Figure 10: Import of the MSG water vapour and thermal infrared channels



Note that the “*Conversion*” option used now is converting the WV and IR channels to Top of Atmosphere (TOA) brightness temperatures. The data is now converted to Kelvin, note the offset with Celsius of approximately 273. After the import is completed, refresh the catalogue.

Display the imported image, from the ILWIS catalogue select the imported water vapour channel raster layer directly by double clicking on the file: wvt0000_band_1, using as “*Representation*” “*gray*”, and use default stretch values (note the minimum and maximum units of this image). Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in red). The image should be comparable with the left image of figure 11.

Check the values of the image and also check the patterns. What can you observe? Do you see any features from the Earth surface?

Also display the wvt0000_band_2 image, this is the thermal IR image and add also the country boundaries, in an identical manner as done for the previous image. The IR_108 image is given in figure 11 on the right side. Also compare the values of this image and note especially the differences between the clouded (the very dark toned pixels on both images) and the non-clouded areas, like those over the Sahara.

Figure 11: Imported WV channel (left) and TIR channel (right) for the same timestamp

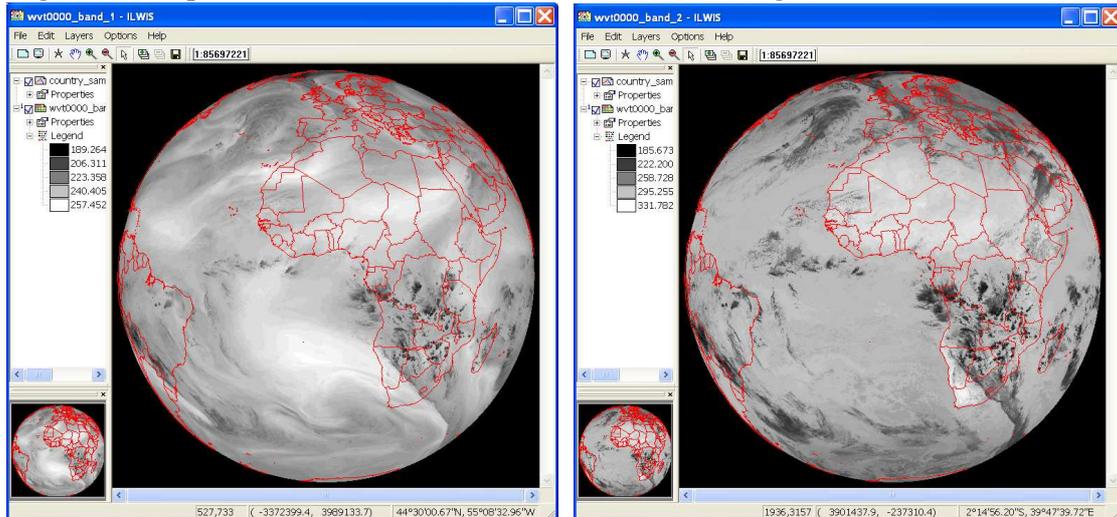
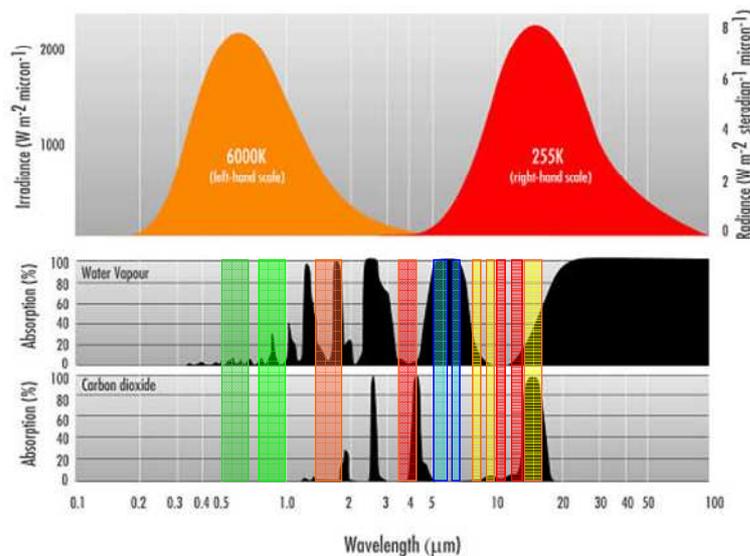


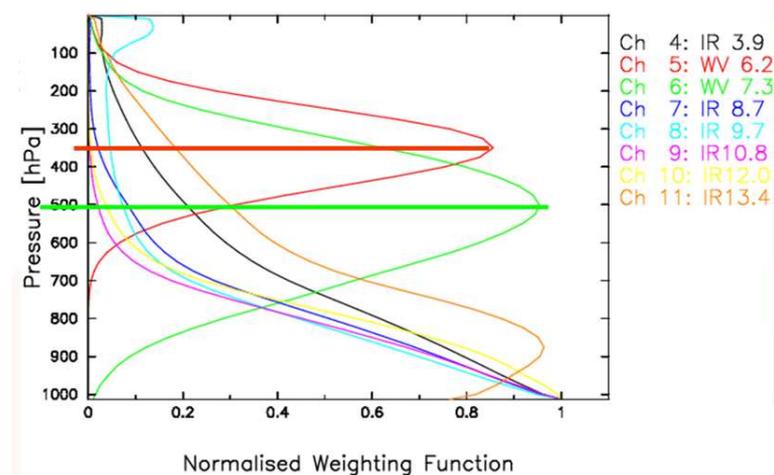
Figure 12: Irradiance and absorption for the various MSG channels (from: Rob Roebeling, Royal Netherlands Meteorological Institute, KNMI)



Note from figure 12 that the Water Vapour channels are strongly affected by absorption of the water vapour in the troposphere and therefore all radiation from the Earth itself is absorbed. The channels record the radiation that is emitted from certain layers within the troposphere. Therefore the water vapour channels are indicative of the water vapour content in the upper part of the troposphere. The maximum signal from WV_062 is at

350 hPa, and for WV_073 at 500 hPa (assuming normal pressure at sea level approximate elevation is at 8980 m and 5965 m amsl respectively), see also figure 13. If there would be no water vapour in the troposphere, radiation from far below can reach the satellite (source: Veronika Zwatz-Meise, ZAMG, available at: [http://oiswww.eumetsat.org/WEBOPS/msg_interpretation/PowerPoints/Channels/WVguide.ppt#283,1,Introduction into the Absorption Channels](http://oiswww.eumetsat.org/WEBOPS/msg_interpretation/PowerPoints/Channels/WVguide.ppt#283,1,Introduction%20into%20the%20Absorption%20Channels)). The IR_108 channel has its maximum contribution from the ground surface. Note the effect of the carbon dioxide absorption in the IR_134 channel.

Figure 13: Contributions to Water Vapour and IR channels

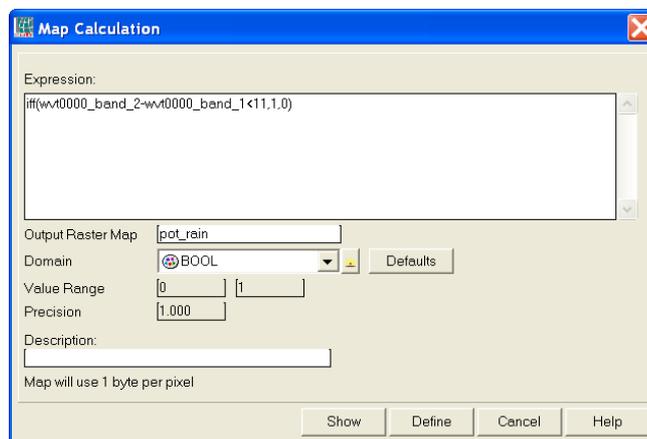


The thermal channel records the emitted energy from the Earth surface itself. Based on a classification using MSG channel 108 and 062, applying a threshold on the temperature difference of less than 11 Kelvin (an empirically determined threshold by Kidder, et al, 2005) an approximation of the clouds that have a high likelihood of precipitation can be obtained (see:

Kidder, S., Kankiewicz, J.A., Eis, K. (2005): Meteosat Second Generation cloud algorithms for use in AFWA. In BACIMO 2005, Monterey, CA. on your DVD, lesson2\practical\ [BACIMO2005.pdf](#)).

To calculate the potential precipitating clouds select from the ILWIS main menu the option “*Raster Operations*” and from the drop down menu “*Map Calculation*”. Type the indicated algorithm as indicated in figure 14 in the Expression window, specify an output map, select as Domain “*Bool*” and execute the command by pressing “*Show*”.

Figure 14: Map Calculation window.



Display the map “*pot_rain*” calculated, for the “*True Color*” select “*Blue*” and for the “*False Color*” select “*White*”. Also add the country boundary layer, using the options, no info, boundaries only and as boundary colour black.

Open in a new map window the map list showing the Daytime Microphysical Colour Scheme (dmp0000) and display band 1 (VIS006) as Red, band 2 (IR_039) as Green and Band 3 (IR_108) as Blue, use the default stretch options. When you compare both what can you conclude?

You can close the “*Meteosat Second Generation Data Retriever*” if this is still active.

4. Multi temporal data import, processing and analysis

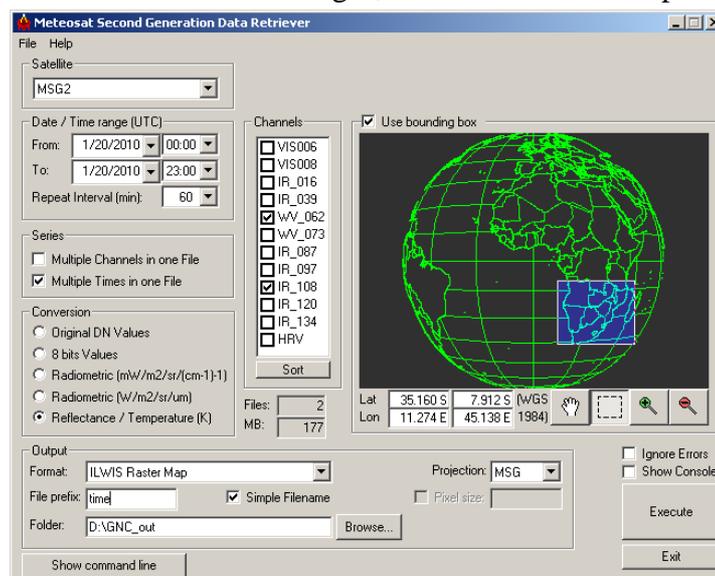
Within the ILWIS 3.7 additional tools are at your disposal to perform dedicated analysis using time series of e.g. Meteosat-9 data. To deal with multi temporal image files ILWIS utilizes the concept of a map list, identical to the way a colour composite is handled. This list provides the temporal reference to a sequence of individual files in a time series. An algorithm can be entered through the command line and is executed for all of the maps in the map list. This map list can be created if in the Data Retriever the option: “*multiple times in one file*” is selected to create the co-registered image stack.

The map list can be visualized using an animation, by right clicking the map list icon, Visualization / as Slide Show; the user can define the image refresh rate and select a suitable colour representation and stretch in the Display Options.

Most of the regular Map calculation statements can be applied to map lists as well, making this a very powerful toolbox for data analysis.

In order to import a time series of data from MSG open the “*Geonetcast and Toolbox*” tabs from the main-menu and select “*MSG-HRIT*” and “*MSG Data Retriever*”. You are now going to import the same bands as used during the previous exercise, but now an image for each hour. Specify the import settings as given in the figure below and execute the import. Given the time needed for import otherwise, here a subset of the field of view is selected; also try to select a subset, covering e.g. the SADC region. Note the “*Date / Time Range*” settings!

Figure 15: Import time series of MSG images, transformed into temperature



Upon completion of the import, select from the ILWIS main menu, the option “*Window*” and from the drop down menu “*Refresh F5*”. To display the map list as an animated sequence double click the maplist icon  “*time0000*” and in the Map List “*time0000*”

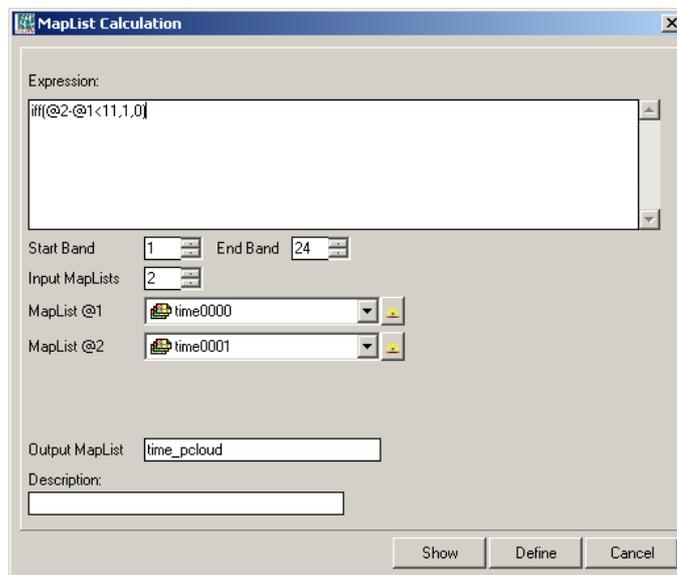
menu select the “Open as SlideShow” option . Use as Representation “Gray”, the other display options can be kept default, press “OK” twice. Note that the map list is containing 24 maps; each map represents one hour starting from 01/20/2010 00:00hr to 23:00hr. Furthermore, note that the map list “time0000” represents the WV_062 channel and the map list “time0001” represents the IR_108 channel.

Press the left mouse button over the active map window to see the values of the image, note that you look here at the temperature (unit in Kelvin). Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in red).

Also display the map list “time0001” as an animated sequence to see for example the development of the clouds during this 24 hr period, with one hour intervals. Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in red).

To calculate the potential precipitating clouds from this map list, select from the ILWIS main menu the option “Raster Operations” and from the drop down menu “Map List Calculation”. Type the algorithm as indicated in figure 16: “ $iff(@2-@1<11,1,0)$ ”, in the Expression window, specify the appropriate Map Lists (time0000 is the WV; time0001 is the IR, as @1 and @2 respectively) and specify an output map list. Execute the command by pressing “Show”.

Figure 16: MapList Calculation window.



Note that a map list is defined by the “@” symbol. The syntax of the expression is the same as that of figure 14!

Upon completion of the calculation display the map list “time_pcloud” using default Representation (Gray). Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in red). Note that the potential precipitating clouds have been assigned 1 and the background is 0.

5. Import of the HRV channel

One of the channels on MSG is the so-called High Resolution Visible channel. This is a broadband channel, recording the electromagnetic spectrum from 0.4 – 1.1 μm , with a sub-satellite spatial resolution of 1 km. Its primary use is with respect to surface and clouds.

In order to import a HRV image from MSG open the “*Geonetcast and Toolbox*” tabs from the main-menu and select “*MSG-HRIT*” and “*MSG Data Retriever*”. Specify the settings as given in the figure below. Note that the data is now imported as 10 bit, data range from 0 to 1023.

Figure 17: MSG Data Retriever settings for HRV import

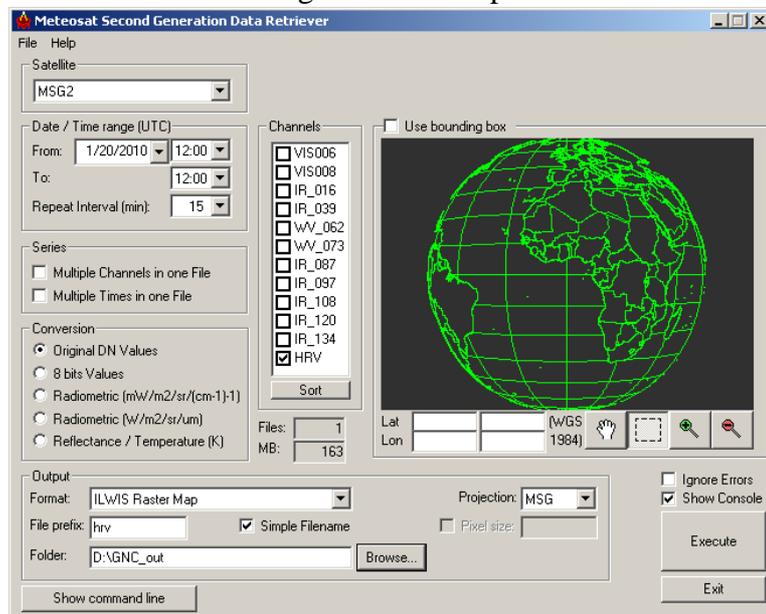
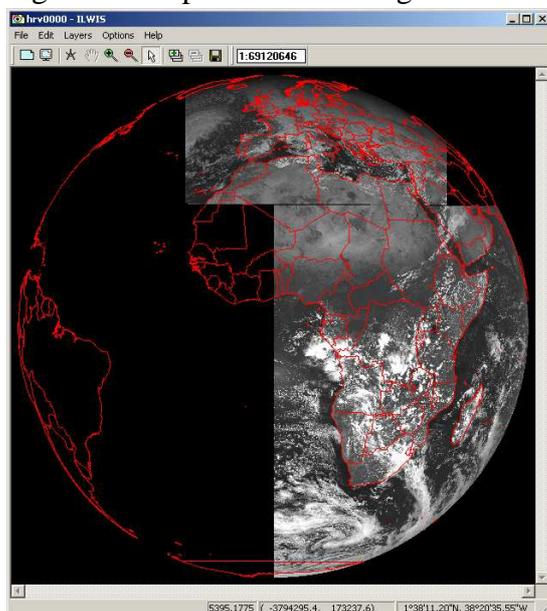


Figure 18: Imported HRV image



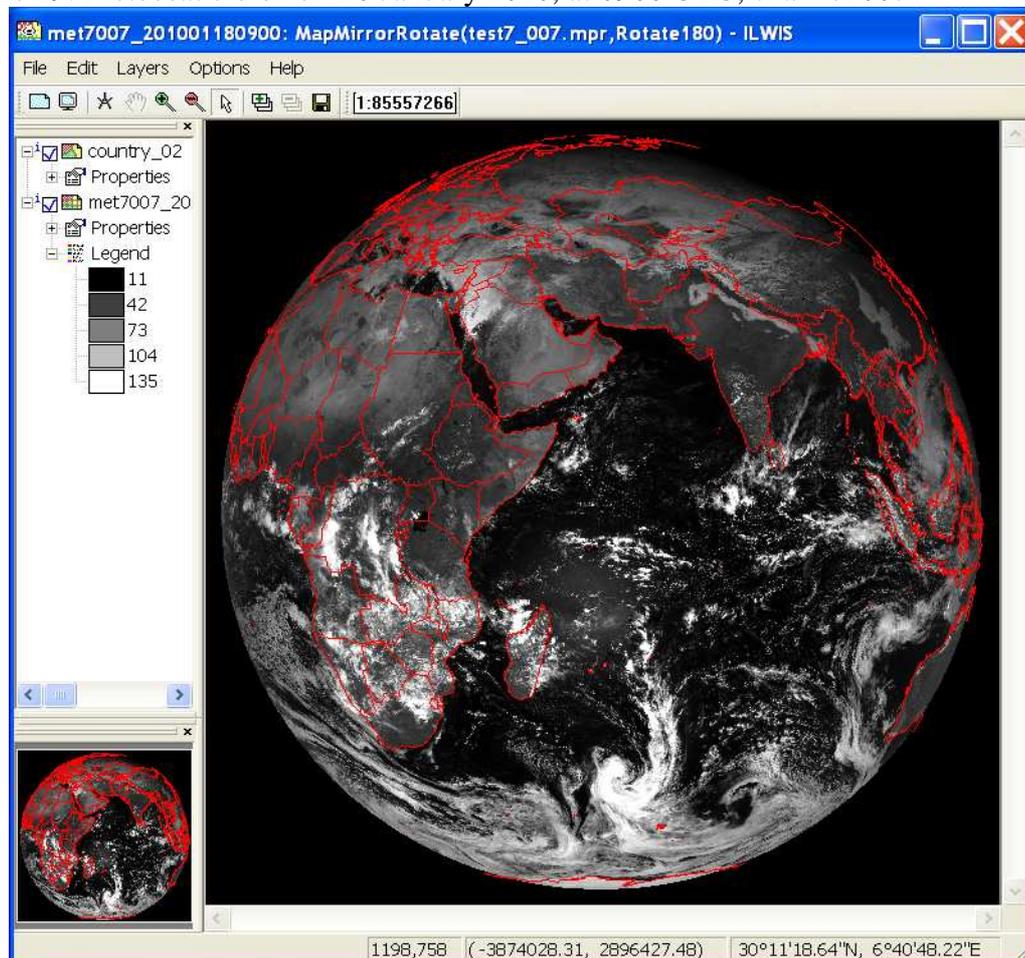
Upon Completion of the import double click the imported image “*hrv0000*”, as Representation use “*Gray*” and press Show to see the image. Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in red). Note that the image does not completely cover Africa. Zoom to the SADC region: from the active map window, select “*Options*” and “*No Zoom*” to see the image in the full resolution.

4. Geostationary LRIT, example of Meteosat 7

From the “*Geonetcast, Toolbox*” tabs the menu item “*Geostationary LRIT*” and “*MET7*”. Specify the appropriate time stamp according to the format required: “*201001200900*”. Also note if the input and output directories are correctly defined.

After the import is completed, update your ILWIS catalogue (Refresh F5) and note the file names of the newly imported images, e.g. met7, followed by channel ID, year, month, day and time in UTC. Display the met7007_* (*=yyyymmddhhmm) image, use as “*Representation*” “*gray*”, also add the country boundaries. Check the coverage of Meteosat-7. The results obtained should resemble those of figure 19. Note the image values (8 bits). Also display the other two imported channels.

Figure 19: Meteosat 7 disk of 20 January 2010, at 0900 UTC, channel 007



Which are the corresponding channels on MSG for the 3 imported Meteosat-7 channels?

Before you continue close all active layers.

5. Optional Exercise: Import of METOP AVHRR/3.

The images collected by the AVHRR/3 sensor on METOP is not disseminated via GEONETCast to Africa, it can be obtained from the archive at EUMETSAT. To get an idea of the images an example is included in these exercises.

The table below shows the spectral channels of the AVHRR/3 sensor on METOP. It has six channels (three visible and three infra-red) but only five are transmitted. Channel 3 is the visible channel during daytime and the infra-red channel at night time.

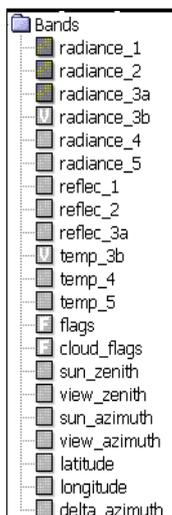
Table 2: Spectral channel details and their primary use

Channel	Spectral Bandpass (micrometers)	Primary Use
1 (Visible)	0.580 - 0.68	Daytime cloud/surface mapping
2 (Near IR)	0.725 - 1.00	Surface water delineation, ice and snow melt
3A (Near IR)	1.580 - 1.64	Snow / ice discrimination
3B (IR-Window)	3.550 - 3.93	Sea surface temperature, night time cloud mapping
4 (IR-Window)	10.300 - 11.3	Sea surface temperature, day and night cloud mapping
5 (IR-Window)	11.500 - 12.5	Sea surface temperature, day and night cloud mapping

Pre-processing of the data is done using VISAT-BEAM. This process is not described here. The data is having Geographic coordinates, using the WGS72 Datum and for resampling a Nearest Neighbour method is used and the output format selected is Geotiff.

If not already active, open ILWIS, from the “*Geonetcast, Toolbox*” tabs select the menu item “*METOP*” and subsequently select “*AVHRR/3 import from BEAM*”. Select as input file, from your DVD in the sub-directory GNC_data\METOP\ the file:

AVHR_XXX_1B_M02_20100510073403Z_20100510073703Z_N_O_20100510091042Z.tif



As output file name specify: avhrr_SA1. Note that as output an ILWIS map list is created, consisting of 19 bands. These band numbers refer to legend given in the left hand figure.

For correct interpretation one needs to know if it is a day or night time image given the transmission of channel 3 differs during day or night. This can be derived from the file name, as the recording time in UTC is given; see the year-month-day-hour-minutes-seconds notation. This imported image was recorded, starting from “20100510073403” to “20100510073703”. Being a day time image, band 3A, recording the NIR, is the transmitted band. Therefore in the imported image the “radiance_3b” and “temp_3b” do not exist!

To create a colour composite, double click the map list icon of “avhrr_SAI”, in the map list select the option “*Open as ColorComposite*” and select for red: “*avhrr_SAI_band_3*”, for green: “*avhrr_SAI_band_2*” and for blue: “*avhrr_SAI_band_1*”. Leave the default stretch values, note that the data values represent radiances! Press OK to see the image. Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in white).

Once more create a colour composite, double click the map list icon of “avhrr_SAI”, in the map list select the option “*Open as ColorComposite*” and select for red: “*avhrr_SAI_band_8*”, for green: “*avhrr_SAI_band_7*” and for blue: “*avhrr_SAI_band_6*”. Leave the default stretch values. What do the band values now represent? Carefully study the legend provided above!

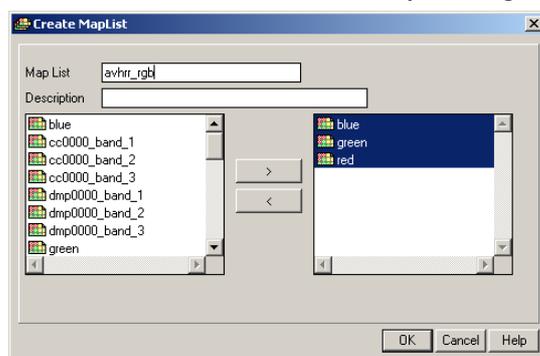
Press OK to see the image. Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in white). In order to create a better quality colour composite the selected bands need to be stretched.

From the ILWIS catalogue, right click using the mouse the “*avhrr_SAI_band_8*” image, from the context sensitive menu, select “*Image Processing*” and “*Stretch*”, specify as “*output Raster Map*”: “*Red*”, all other options can be kept as default. Press Show, note that the data is now transformed into a byte image. Close the image once you have inspected the results.

Repeat the same procedure for the bands “*avhrr_SAI_band_7*” and “*avhrr_SAI_band_6*” and specify “*Green*” and “*Blue*” as output maps respectively.

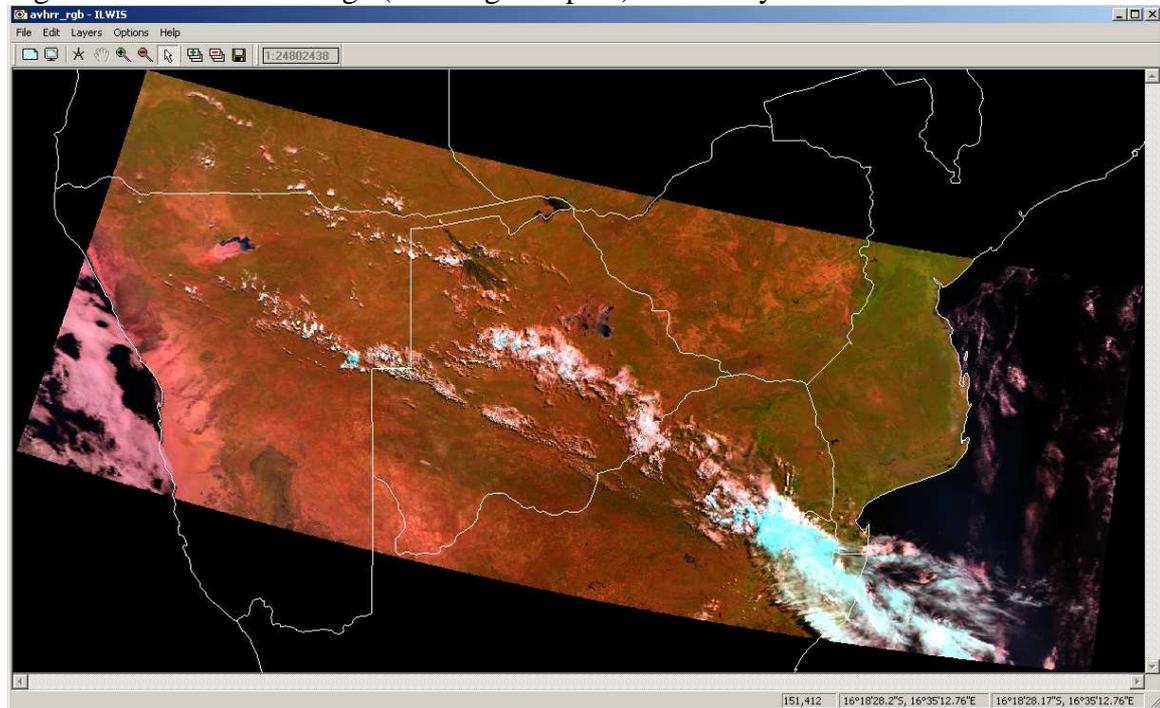
Now create a new map list of the 3 newly created images, red, green and blue respectively. In order to do so, select from the ILWIS main menu, the option “*File*”, “*Create*”, “*MapList*” and select the image called “*Blue*”, press the > sign in the middle of the window to move this layer to the right hand side. Repeat this procedure for the “*Green*” and “*Red*” images. Specify an appropriate Map List file name, e.g. “*avhrr_RGB*” (see also the figure below).

Figure 20: Create MapList of the visible and NIR channels, transformed to byte images



Press OK to store this map list. In the ILWIS catalogue double click the map list icon “*avhrr_RGB*”, select the option “*Open as ColorComposite*” and select the appropriate bands for the colour assignment. Press OK to see the image. Also put a vector layer showing the country boundaries on top (info off, boundaries only and boundary colour in white). Your results should represent those of figure 21.

Figure 21: AVHRR/3 image (morning overpass) of 10 May 2010



Display also a thermal channel (e.g. band “*avhrr_SAI_band_10*”), using as Representation “*Gray*”. In the active map window, roam the mouse over the map and keep the left mouse button pressed. What do the values indicate?

The other image in the METOP directory is the one which has been recorded for the next three minutes, covering the South Africa. If interested you can import it as well and have a look at it. Note that the AVHRR instrument covers most of the SADC region in 6 to 9 minutes of scanning and METOP records the morning and evening overpasses.