GEO – Help

1. Introduction.

This menu supports the import of the various Geostationary satellites disseminated through EUMETCast, like Meteosat 2nd and 3rd Generation, GOES East and West, Electro-L, Fengyung 2 G and H as well as Himawari. For Meteosat Third Generation (MTG) also an option has been included to import the images recorded by this satellite from the EUMETSAT Data Access Client (EUMDAC) repository at EUMETSAT (https://user.eumetsat.int/resources/user-guides/eumetsat-data-access-client-eumdac-guide). For both the MTG and GOES satellites selected data from the Lightning Imager can be imported as well.

To facilitate the import of the data use is made of various python site-packages like Satpy, Ilwispy, gdal, numpy and hdf5plugin for NetCDF data decompression of MTG data disseminated through the EUMETCast Terrestrial Service.

2. Import Meteosat 3rd Generation

Meteosat 3rd Generation is the latest Geostationary satellite which is gradually becoming operational. The satellite was launched on 13 December 2022 and provides the 0-degree service. The toolbox allows the retrieval of data recorded by the Flexible Combined Imager (FCI) and the newly deployed Lightning Imager (LI) to detect lightning events. The FCI has enhanced capabilities compared to Meteosat 2nd Generation SEVIRI instrument in terms of spatial, spectral and temporal resolution resulting in an increased data volume.

Further information on the Flexible Combined Imager can be obtained at: https://user.eumetsat.int/resources/user-guides/mtg-fci-level-1c-data-guide

Further information on the Lightning Imager can be obtained at: https://user.eumetsat.int/resources/user-guides/mtg-li-level-2-data-guide

2.1 FCI data import from EUMDAC

To visualize the various spectral channels of MTG using the data obtained from EUMDAC, the toolbox menu "MTG-Import-EUMDAC" can be used. For both the Normal Resolution (NR), for all spectral channels and the High Spatial Resolution Fast Imagery (HRFI), containing a higher spatial resolution spectral subset of VIS06, NIR22, IR38 and IR105 channels, the data is assumed to be locally available and downloaded as a Zip file, containing for the full disk 40 body segments each. The zip file sizes for the full disk are in the order of 1 GB as the FCI data itself is not compressed.

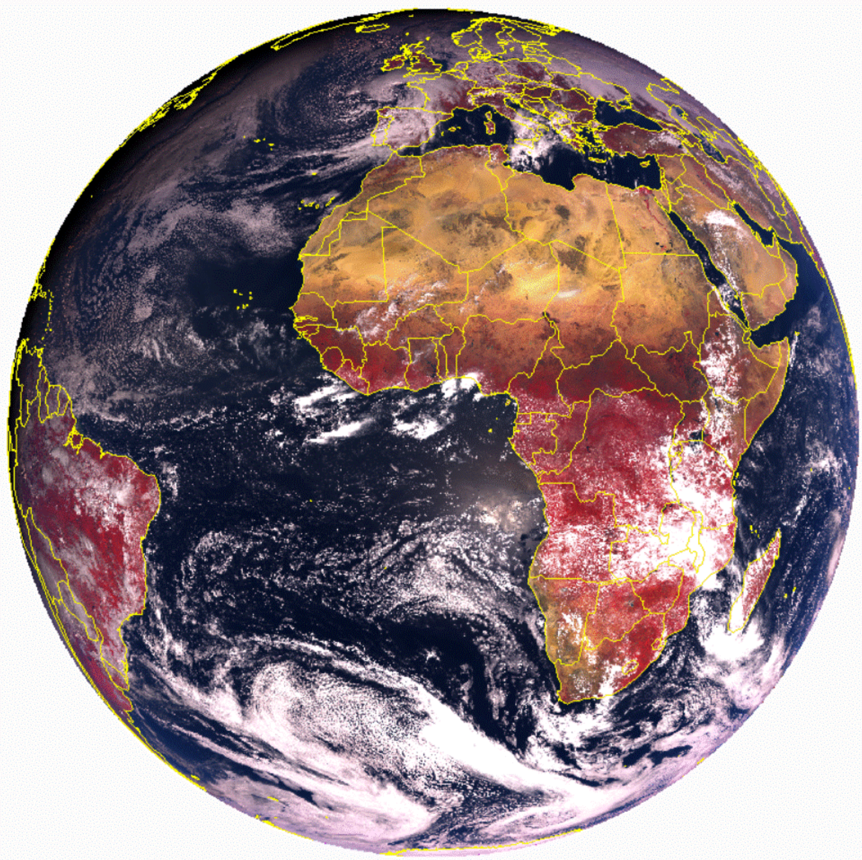
Once the data is locally available the High Resolution (HR) and Normal Resolution (NR) VIS-NIR and TIR channels can be imported. The spectral channels and their sub-satellite spatial resolutions are given in the table below.

Table 1: MTG NR and HR sub-satellite spatial resolutions and spectral channels

MTG mode	Spatial resolution	Spectral Channels
NR VIS-NIR	1 km	VIS04, VIS05, VIS06, VIS08, VIS09, NIR13, NIR16, NIR22
NR TIR	2 km	IR38, WV63, WV73, IR87, IR97, IR105, IR123, IR133
HR VIS-NIR	0.5 km	VIS06, NIR22
HR TIR	1 km	IR38, IR105

After import of the VIS and NIR channels the rectified radiance values are given for each pixel, for the TIR channels the pixel values represent the temperature (in Kelvin).

Figure 1: MTG NR color composite VIS08, VIS06 and VIS05 in RGB



Next to import of the individual spectral channels, another tab called "MTG-Visualization-EUMDAC", allows the creation of image visualizations, like the Daytime True Color Composite, 24hr Microphysics Composite, Colorized Clouds Composite and a Cloud Top Composite. The visualizations are created using the SatPy plugin.

2.2 LI AFA and LFL import from EUMDAC

The Accumulated Flash Area (AFA) and Lighting Flashes (LFL) data from the Lightning Imager onboard on Meteosat 3rd Generation can be retrieved as well. The AFA routine creates a raster image with the number of flashes observed for a given pixel (at 2 km spatial resolution) over the integration period (10 minutes). When conducting the LFL import routine a CSV file is created over a 10 minutes integration period, indicating the latitude, longitude, flash id, flash time, flash duration (ms), flash footprint (km2), scaled radiance and number of events amongst others. The CSV file can be imported as an ILWIS table and can be converted to a point map by the user.

2.3 FCI data import from EUMETCast Terrestrial

The same routines as described for the FCI import above (in section 2.1) are also available for the data provided through the EUMETCast Terrestrial Service. In most instances the data will be situated on a server and the data can be selected based on a time stamp (UTC time). The respective body segments are copied to the destination folder and the data is processed. It should be noted that the individual body segments are lossless compressed and the ‘hdf5plugin’ site package is used which provides the HDF decompression filter ‘FCI-Decomp’.

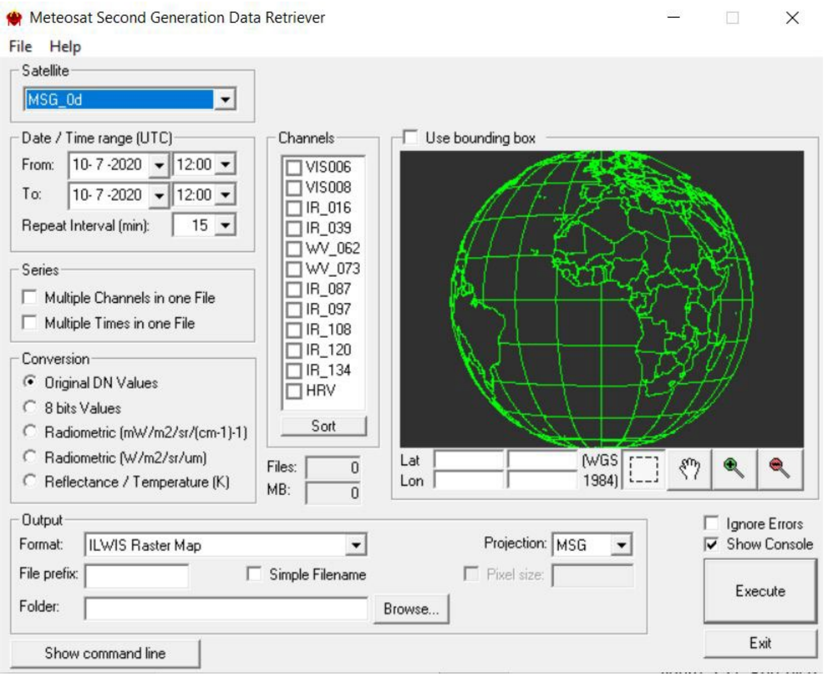
2.4 LI AFA and LFL data import from EUMETCast Terrestrial

In a similar manner as described above also the AFA and LFL data can be imported from EUMETCast Terrestrial. Here also the time stamp needs to be provided, and the data is retrieved from the source folder and copied to the destination drive prior to the data import. The main difference is that for the AFA the integration time is 30 seconds only.

3 Import of data from Meteosat 2nd Generation from EUMETCast

To import the various spectral channels from MSG at 0-degree (prime service), 45-degree (current location of MSG for the Indian Ocean Data Coverage - IODC) and the Rapid Scanning Service (RSS), the so-called 'MSG Data-Retriever' can be used, available under the Tab "MSG-Import-EUMETCast". This utility is a tool for converting raw Meteosat Second Generation (MSG) SERVIRI HRIT Level 1.5 files received through EUMETCast into a known raster-GIS or raster image file format.

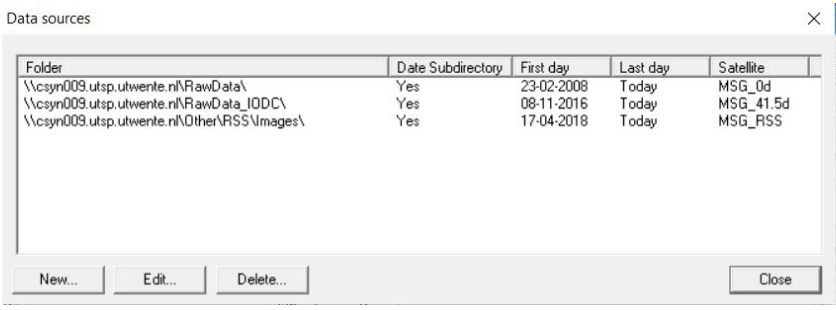
Figure 2: Meteosat Second Generation Data Retriever



In the Satellite dropdown list, situated in the top left portion of the MSG Data Retriever window MSG_0d, MSG_41.5d, MSG_45d and MSG_RSS can be selected. These settings refer to the MSG satellite situated at 0 degree, scanning the whole field of view of MSG at 15 minutes temporal intervals, MSG 8, previously situated at 41.4 degree but now situated at 45 degree, also called the Indian Ocean Data Coverage (IODC), scanning the whole field of view of MSG at 15 minutes temporal intervals and MSG satellite, the so-called Rapid Scanning Service (RSS) situated at 9.5 degree East, only scanning the northern 1/3 portion of the field of view of MSG at 5 minutes temporal intervals, respectively.

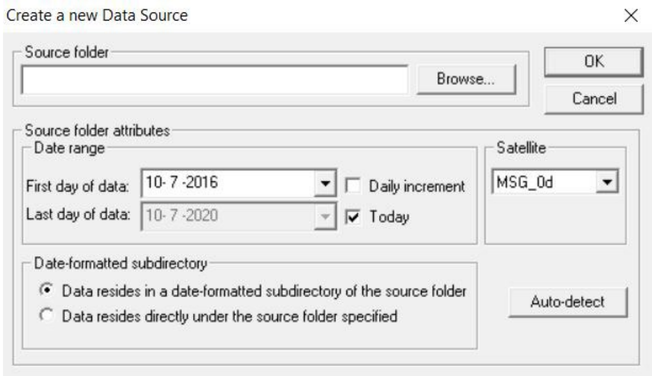
The advanced settings of the data sources of the MSG data stream must be configured separately. To configure the appropriate data source for example for the MSG_0d satellite, select from the top left menu, the "File" Option and open the "Data Sources" menu.

Figure 3: Data Sources Menu



In this submenu delete any folder that might appear, select "New". In the "Create a new data source" menu, browse to your "*drive:\folder*" that contains the raw MSG_0d data (see also figure 4) and note that under the "Satellite" option the appropriate MSG satellite is selected.

Figure 4: Create a new MSG data source folder



When the source folder is provided, the "First day of data" should be specified. The "Last day of data" can be obtained using the option "Auto-detect" situated at the lower right portion of the "Create a new Data Source" Window. When using the "Auto-detect" option this is automatically detected. If "Last day of data" equals the current day it will automatically keep updating the "Last day of data" to be the present date.

If the data source is correctly specified, the settings can be accepted by pressing "OK". Note that when use is made of a date-formatted sub-directory structure (each day a new sub directory is created storing the MSG data of that specific day), in such case the option "Data resides in a date-formatted subdirectory of the source folder" should be activated. In case all the MSG data is situated directly under a source folder the other option can be activated ("Data is situated directly under a source folder specified").

In a similar way also the source folders for the "MSG_RSS" satellite (Rapid Scanning Service) and MSG IODC, currently situated at 45 degrees can be specified. The help function in the main MSG Data Retriever Window is providing additional information on the functionality offered by this utility.

At this moment Meteosat-8 is situated at 45-degree East, scanning the Indian Ocean and the Middle East and Eastern part of Africa, the so-called Indian Ocean Data Coverage (IODC). It is a replacement of Meteosat-7. Meteosat-9 is currently in a back-up status. Meteosat-10, situated at 9.5-degree East, has taken over the Rapid Scanning Service, only scanning the northernmost 1/3 portion of the full disk. Meteosat 11 is currently used as the prime geostationary satellite, providing full disc imagery every 15 minutes from the 0-degree position. This satellite coverage configuration will ensure continuous satellite observations till the launch of Meteosat Third Generation, which is composed of six new geostationary satellites, to be launched from 2022 onwards (4 Imaging Satellites and 2 Sounding Satellites).

The advanced SEVIRI radiometer on board the MSG series of geostationary satellites enables the Earth to be scanned in 12 spectral channels from visible to thermal infrared (including water vapour, ozone and carbon dioxide channels). The specifications of SEVIRI have been chosen carefully to match operational requirements. Each of the 12 channels (table 2) has one or more specific applications in mind, either when used alone or in conjunction with data from other channels. Each has a well-established heritage, ensuring that their characteristics are well understood so that the data can be used on an operational basis. The actual instrument includes a primary mirror with a diameter of 51 cm and infrared detectors. The raw images are generated through a combination of an east-west scan obtained from the spinning of the entire satellite at 100 revolutions per minute, together with a stepping of a telescope mirror from south to north after each scan line. The spatial resolution of the SEVIRI instrument has been slightly increased (at intervals of 3 km) compared to its predecessors, the High Resolution Visible (HVR) channel even has a sampling distance interval of just 1 km.

The problem with the MSG data is that the file format is not standard. None of the commonly used remote sensing packages is able to open or process the raw compressed images. Therefore, a driver was developed for reading the images in the Geospatial Data Abstraction Library (GDAL, http://www.gdal.org). GDAL is a translation library for raster geospatial data formats that is released under an MIT style Open-Source license. All source code is in C++, and great effort is put into keeping the code platform independent. Drivers for writing files in popular RS formats (e.g. ENVI, ERDAS, ILWIS, GeoTiff) but also picture formats like JPEG, GIF and BMP have already been implemented by the community, so appending a driver for reading MSG image files to this driver was seen as the most appropriate solution.

Table 2: SEVIRI channels and their applications

Band	Center	Min	Max	Nadir Res	Row x Cols	Repetition	Application
1	0.635	0.56	0.71	3000	3712 x 3712	15	Surface, clouds, windfield
2	0.81	0.74	0.88	3000	3712 x 3712	15	Surface, clouds, windfield
3	1.64	1.5	1.78	3000	3712 x 3712	15	Surface, cloud phase
4	3.9	3.48	4.36	3000	3712 x 3712	15	Surface, clouds, windfield
5	6.25	5.35	7.15	3000	3712 x 3712	15	Water vapor, high level clouds, atmospheric instability
6	7.35	6.85	7.85	3000	3712 x 3712	15	Water vapor, atmospheric instability
7	8.7	8.3	9.1	3000	3712 x 3712	15	Surface, clouds, atmospheric instability
8	9.66	9.38	9.94	3000	3712 x 3712	15	Ozone
9	10.8	9.8	11.8	3000	3712 x 3712	15	Surface, clouds, windfield, atmospheric instability
10	12	1100	13	3000	3712 x 3712	15	Surface, clouds, atmospheric instability
11	13.4	12.4	14.4	3000	3712 x 3712	15	Cirrus cloud heights, atmospheric instability
12	-	0.4	1.1	1000	11136 x 7700	15	Surface, clouds

An algorithm developed is correctly re-composing the images from the multiple compressed data files / segments. According to the provided documentation the algorithm must take care of scan direction, image compression, bit-depth, image size and proper alignment of the image strips of the high-resolution band. A second algorithm developed performs the radiometric calibration using the relevant header / footer (PRO / EPI) parameters and applying appropriate formulas that calculate the resulting pixel values into the required unit. A third algorithm determines the geo-location of each pixel. Automatic geo-location has the advantage that no manual steps are needed to transform the images to a known projection. This utility can be used to import the recordings from the SEVIRI instrument on board Meteosat-8, the 41.5-degree IODC service, the Meteosat-10 Rapid Scanning Service (RSS) and Meteosat 11, covering the 0-degree service. Also, when there are changes, and Meteosat-9 is used given (maintenance) issues for the 0 degree or RSS service, the data retriever can be applied, irrespective of the actual satellite providing the service. Also, downward compatibility is provided, e.g. the data from Meteosat-8, providing the initial 0-degree service, can still be retrieved, using the satellite settings for 'MSG-0d', etc.

The command-line utilities that come with GDAL facilitate the use of the library to transform MSG images into widely applied RS data formats. The GDAL version used supports 25 output formats in the library. In-house experiences with these command-line utilities revealed that composing such a command-line string is an error-prone process (given the many options available). Therefore, a Microsoft Windows based user-interface was developed that generates the necessary command-line syntax (see figure 2). The user only needs to express the "query" by making appropriate choices using checkboxes, radio buttons, list boxes, selection of area of interest, etc. Through the user interface all relevant parameters can be adjusted, and a time series can be easily constructed. The user interface facilitates retrieval of original DN values (10 bit-depth), compressed DN values to 8 bit-depth, Top of Atmosphere radiances in 2 different units (W/m2/sr/um or mW/m2/sr/cm-1)-1), computation of Top of Atmosphere reflectance for the visible channels or Top of Atmosphere temperature (in Kelvin) for the thermal channels. The geometric precision is within a pixel for the low-resolution bands and

Geographic coordinates and UTM projection conversion is possible (a pixel size dimension must be entered).

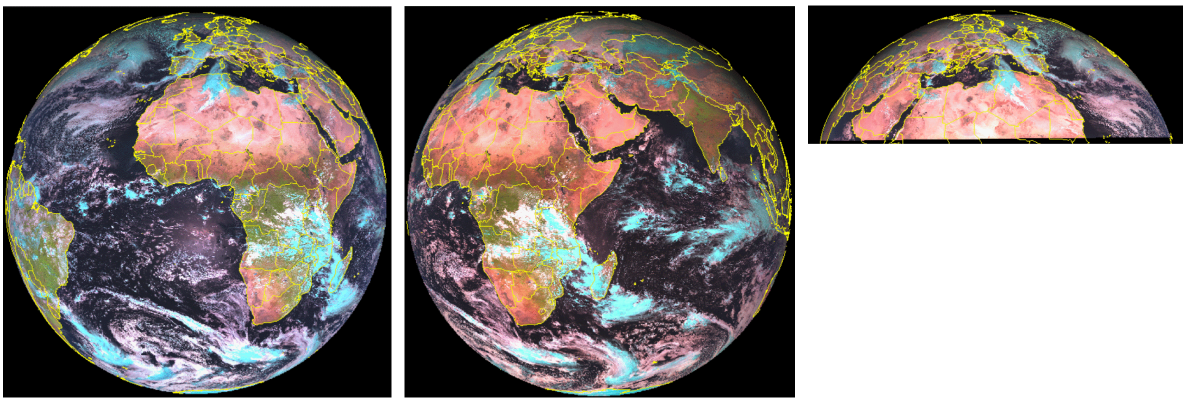
For more flexibility, showing the option “Resulting Command Line”, the corresponding command-line string for performing a certain import is revealed. This string can then be copied into a batch file which can be executed or called from within an ILWIS script to perform similar imports multiple times in a semi-automated manner. The GDAL-driver and Windows-based Data Retriever interface facilitate easy geometric and radiometric calibrated data retrieval of MSG into e.g. ILWIS format.

The MSG Data Retriever can be invoked when pressing the button “Start MSG Data Retriever” Using the option “File”, “Data Sources” the linkage can be established to the central archive, where the data is stored. Multiple data sources can be configured. Under the drop-down menu of “Satellite”, 4 options are available to select the respective services. Also, the map window changes, to allow for extraction of only a specific portion of the field of view of the satellite. Note should be taken furthermore that the temporal resolution of the RSS is set to 5 minutes.

A known issue is that on some new computers systems the Data Retriever does not start as some required resources are not locally available. The Microsoft Visual C++ redistributable packages, also known as VCredist, are runtime components in support of Windows applications and the “vcredist_1_x86.exe” and “vcredist_2_x86.exe” and are available under the gnc_py folder \extern\MSGDataRetriever. These can be executed and required resource components are downloaded and installed. Ensure that your system is online and after running the two executables, start the MSG Data Retriever again.

A manual describing the functionality of the MSG data retriever can also be obtained from: https://filetransfer.itc.nl/pub/52n/ILWIS386/documents/gnc-toolbox-manual-v2.pdf. Note chapter 4.1.1. for the MSG data retrieval operations and options available. A sample of each of the MSG satellites and their field of view is provided in the figure below.

Figure 5: MSG full disk from 0 and 45 degrees and RSS (left to right)



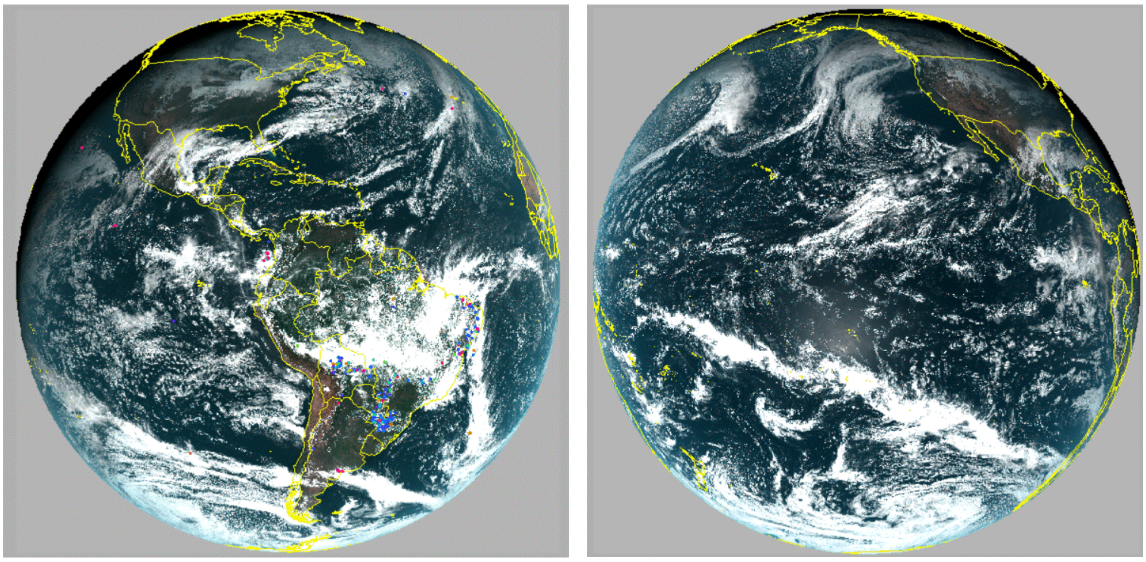
Under the Tab “MSG-Visualization” available routines facilitate the creation of image visualizations, like the Daytime Overview Composite, Daytime Natural Enhanced Composite, Convection Composite and Daytime Microphysics Composite. The visualizations are created using the SatPy plugin.

4. Import of data from GOES East and GOES West from EUMETCast

Import routines to process the data from GOES satellites situated at 75 degree West and 137 degree West respectively are available under the toolbox menu options “GOES-East” and “GOES-West”. When using the option “GOES-ABI .. all Channels” the 16 spectral channels of the Advanced Baseline Imager (ABI) can be imported. The ABI includes two visible channels, four near-infrared channels and ten infrared channels all at 2 km spatial resolution. The data provided through EUMETCast has a temporal resolution of 10 minutes and upon import the visible and near infrared channels are providing (Level 1B) Bidirectional Reflectance values, the longer wavelength thermal channel values are converted to temperature (Kelvin). During import use is made of Satpy. Additional information on the GOES ABI spectral channels van be obtained from: https://www.weather.gov/media/crp/GOES_16_Guides_FINALBIS.pdf.

A number of approaches have been documented to generate true color images for the daytime images from the ABI since the instrument does not have a “green” (0.55 μm) spectral band. The fractional combining approach as described by Bah, Gunshor and Schmit (https://aos.wisc.edu/aosjournal/Volume32/Bah_nonthesis_MS.pdf) is applied when selecting the import option “Simulate Natural Colors”. First the data is converted into radiance for channels 1, 2 and 3. Then a green radiance channel is derived using the formula: 0.45 * ABI_B02_rad+0.1 * ABI_B03_rad+0.45 * ABI_B01_rad. Subsequently a linear stretch is applied transforming the data range 5 to 150 into a new range from 0 to 254. The range selected was providing the best visualization results.

Figure 6: GOES East (and GLM) and GEOS West



The GOES Lightning Mapper (GLM) instrument is a single-channel, near-infrared optical transient detector that can detect the momentary changes in an optical scene, indicating the presence of lightning. GLM measures total lightning (in-cloud, cloud-to-cloud, and cloud-to-ground) activity continuously over the Americas and adjacent ocean regions with near-uniform spatial resolution of approximately 10 km.

Running the GOES GLM East or West import routine two 5 minutes integration time GLM zip files are retrieved and the resulting 10 minutes of GLM data is concatenated, and a single CSV file is created with attributes like latitude, longitude, flash energy as well as the transformed coordinates (X, Y) in GOES projection. The CSV file can be imported as an ILWIS table and can be converted to a point map by the user.

5. Import of data from Electro-L from EUMETCast

The Russian geostationary satellite Electro-L N3 (the third satellite in the series) is situated at 76-degree East. Of the 10 channels of the MSU-GS imager the following channels are provided every 30 minutes through EUMETCast: 3: 0.8 – 0.9, 4: 3.5 – 4.0, 6: 7.5 – 8.5, 8: 9.2 – 10.2, 9: 10.2 – 11.2, 10: 11.2 – 12.5, for channel number and spectral region (in μm) respectively. The HRIT (wavelet compressed) data segments (36) and Epi and Pro are retrieved from the source repository based on the time stamp (in UTC) and copied into the target folder. The data segments are subsequently processed using Satpy and finally an Ilwis maplist is created. For the NIR channel the pixels are transformed into reflectances and for the thermal channels the data is converted into temperature (in Kelvin).

6. Import of data from Fengyun 2G and 2H from EUMETCast

The data from the Chinese geostationary satellites disseminated through EUMETCast are from Fengyun 2G, situated at 104.5-degree East and Fengyun 2H situated at 79-degree East. The spatial resolution from the full disk image of the high-resolution visible channel is 1.25 km and 5 km for the low resolution visible as well as the 4 infrared channels. The data is imported using the h5py python site package. It should be noted that the satellite orbit model used for Fengyun was developed by ‘trial and error’. The parameters now defined show a good agreement with a vector file showing the country boundaries over the field of view (FOV), but for the high resolution (1.25 km resolution) panchromatic data, still a slight discrepancy is observed. Data provided through EUMETCast has a temporal resolution of 1 hr. Upon import of the Fengyun 2G or 2H using the respective import routines for the low-resolution data a maplist is created containing the 5 spectral channels, for the high-resolution dataset only the panchromatic channel is extracted. No data calibration can be performed as no information is provided in the meta-data.

7. Import of data from Himawari from EUMETCast

The Japanese geostationary satellite, currently the Himawari-9 (Himawari 8 as backup), is situated at 140.7 East. The toolbox offers the options to import all spectral channels or to create a daytime composite only of the Level 1 data from the Advanced Himawari Imager (AHI). When importing all spectral channels, a maplist is created of 16 spectral channels. Use is made of Satpy during import. For further information on the 16 channels at 2 km resolution, see also: https://www.data.jma.go.jp/mscweb/en/himawari89/space_segment/spsg_ahi.html.

Upon import the band assignment is kept when band number is provided, else channels are renamed - Vis=B03, IR4=B07, IR3=B08, IR1=B13 and IR2=B15 respectively. 160 segments are retrieved,10 for each spectral channel. The initial Himawari Standard Format (HSD) is converted to HRIT format at EUMETSAT and disseminated through EUMETCast every 30 minutes. The visible and NIR channels are transformed into reflectances, the thermal channels represent the temperature (in Kelvin).

For the daytime composite use is made of the channels B1, B2 and the 'VIS' channel (as band 3) as blue, green and red respectively. A user defined stretch is applied, the data range from 0-150 is linear stretched to 0-255 using ILWISPy.

Figure 7: Himawari daytime color composite