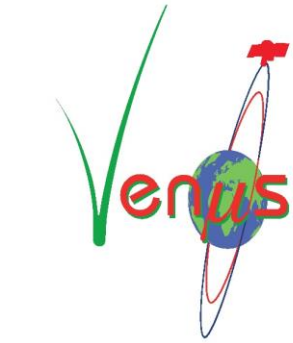


VENμS:
Joint Israeli-French
micro-Spacecraft for Earth
Observation Mission

The VENμS mission and products

https://venus.cnes.fr/en/VENUS/index.htm

January 2023

Centre National d'Etudes Spatiales – France

Israeli Space Agency – Israel

CESBIO, Toulouse University – France

The Remote Sensing Laboratory, Ben Gurion University of the Negev – Israel

Contents

1. The VENµS Mission

VENµS (Vegetation and Environment monitoring New Micro-Satellite) is the first cooperation between Israel and France for the Earth observation using a super-spectral camera, dedicated to vegetation monitoring. The Memorandum of Understanding between CNES and ISA (Israeli Space Agency) was signed in April 2005. The satellite was launched in August 2017.

The VENµS satellite uses the IMPS micro-satellite platform (Improved Multi-Purpose Satellite) of the IAI /MBT space division (Israeli Aerospace Industries).

VENµS scientific objective is the provision of data for scientific studies dealing with the monitoring, analysis, and modeling of land surface functioning under the influences of environmental factors as well as human activities. To fulfill this objective, VENµS acquires multispectral images with high temporal and spatial resolutions of predefined sites of interest all around the world.

Scientific mission requirements have been defined by CESBIO, Ben Gurion University of the Negev and CNES.

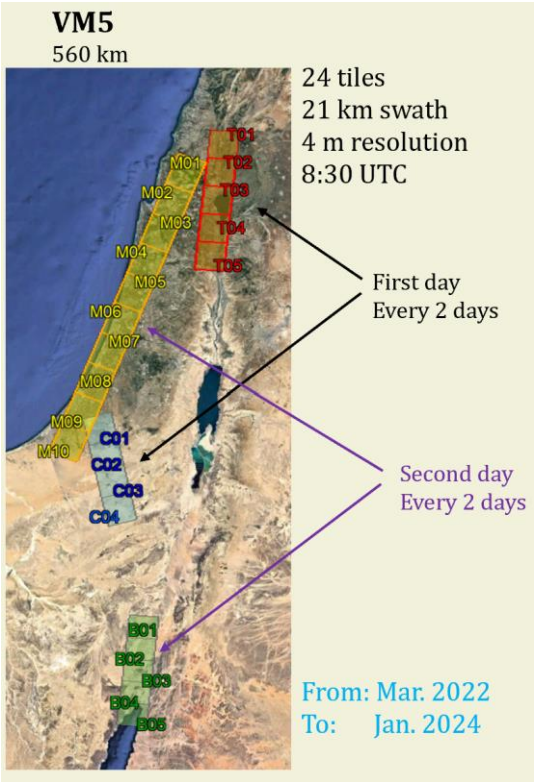
VENµS technological mission is aimed at validating the IHET (Israeli Hall Effect Thruster): qualification of the IHET thruster for low altitude station keeping and evaluation of the IHET performances in space.

CNES is responsible for supplying the super-spectral camera and the science mission centre. ISA is responsible for the spacecraft, the launcher interface and for the satellite control centre.

The following figure depicts the duration, orbital and spatial features of the VENµS mission. The duration of the VM1 scientific mission phase was 36 months after launch. At the end of this period, the Technological Mission begun (VM2). The altitude of the spacecraft was decreased from 720 km to about 410 km. The change of the orbit taken about nine months (VM2 period). The 410 km orbit was kept for two months (VM3 period). Successively, during the Technological Mission VM4, the altitude of the spacecraft was increased to 560 km for the last scientific mission phase, called VM5. This phase, which started in March 2022, will have an estimated duration of 2 years. Due to orbit change, the swath was reduced from 27 km in VM1 to about 21 km in VM5, while the ground resolution was increased to about 4m.

VENμS mission phase	Missions	Altitide (km)	Swath (km)	Spatial resolution (m)	Revisit time (days)	Phase duration (months)	Phase months
VM1	S+T	720	27	5	2	36	Nov. 2017 - Oct. 2020
VM2	T	720 to 410	no imaging			9	Nov. 2020 - Aug. 2021
VM3	S+T	410	15	3	2	2	Sep. 2021 - Oct. 2021
VM4	T	410 to 560	no imaging			3	Nov. 2021 - Jan. 2022
VM5	S	560	21	4	1	24	Feb. 2022 - Jan. 2024
S: Scientific mission							
T: Technological mission							

The following maps show the Israeli scientific sites acquired by the spacecraft in VM1 and VM5.



2. The VENµS Super-Spectral Camera

The satellite will carry a super-spectral camera characterized by 12 narrow spectral bands (B1 – B12). The radiometric resolution for all bands is 10 bits.

At the camera level, each spectral line of an image is made of 5200 pixels. At the nadir, the field of view is 27 km with a ground resolution of 5.3 m. When an image is acquired with an oblique viewing, the native ground resolution decreases a little and the field of view increases.

In VM01, the data have been acquired over existing or planned experimental sites with sizes ranging from 27 x 27 km² kilometers to 27 x 54 km² or more. All data for a given site are acquired with the same observation angle in order to minimize directional effects.

Bands	Central Wavelength (nm)	Bandwidth (nm)	Main Driver
B1	423.9	40	Atmospheric correction
B2	446.9	40	Aerosol, clouds
B3	491.9	40	Atmospheric correction
B4	555.0	40	Land
B5	619.7	40	Land
B6	619.5	40	DEM, image quality
B7	666.2	30	Land
B8	702.0	24	Land
B9	741.1	16	Land
B10	782.2	16	Land
B11	861.1	40	Land
B12	908.7	20	Water vapor

The set of bands includes 4 bands for atmospheric effects removal. The 620 nm band is duplicated with a difference in viewing angle of 1.5°. It is aimed at deriving Digital Elevation Models (DEMs) and image quality assessment. It will also be used to detect clouds using their altitude. Note that most VENµS spectral bands (B1 to B9) are also suited for water colour applications, in situations which do not require a very high SNR.

A brief summary of the interest of every band is given below.

B1, B2, and B3: These bands are sensitive to the scattering of light due to particles (aerosols) and molecules, those effects depend on the wavelength. They will allow estimating the turbidity (aerosols) of the atmosphere, which is then used to apply atmospheric corrections. In addition, these bands are very efficient in detecting clouds and cloud edges over land and water. This is

important for automatic processing of image time series. Cloud screening and aerosol characterization do not require the use of full resolution data. Working with data averaged over 4x4 pixels or even more is sufficient. Therefore, the SNR (Signal to Noise Ratio) at full resolution can be lower than for the other bands.

B4: This band is located in the green peak of vegetation and is useful to characterize vegetation status (LAI, chlorophyll).

B5: Vegetation chlorophyll absorption. Used with B11 to compute vegetation indices

B6: this band is a duplication of B5, and is implemented in the camera focal plane such as the difference of viewing angle is 1.5 degrees.
The interests of the duplicated B5 band are:

- From the small stereoscopic effect it will be possible i) to generate a coarse DEM ii) to help to detect clouds by their altitudes.
- Having a duplicated band has proved to be very useful with the Polder mission for image quality purposes.

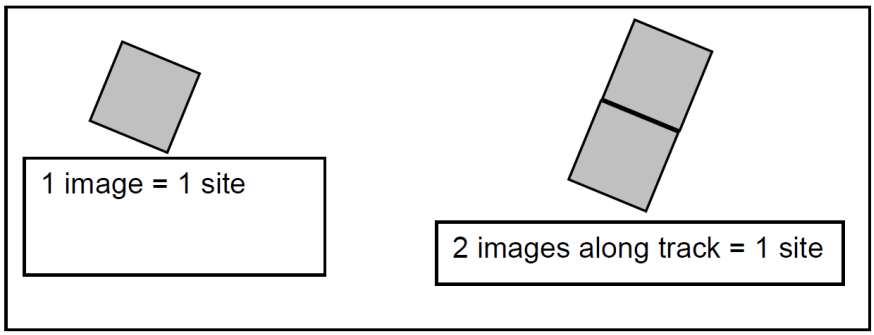
B7, B8, B9, and B10: these red-edge bands are designed for detecting the blue shift of the red edge when vegetation is stressed. They can be useful for computing the chlorophyll index.

B11: near-infrared band, e.g. for NDVI and other vegetation indices computation

B12: water vapour absorption, to help correct absorption effects on other bands

3. The VENµS Products

The VENµS ground segment delivers three levels of products: L1, L2, and L3. Products are available to the users through a web interface and ftp download (see sections 3.4 and 3.5). An **image** corresponds to the acquisition of 5200 rows by 5200 pixels in the twelve spectral bands. At nadir, it corresponds to an area on ground of approximately 27x27km^2 (in VM1). This is the minimal product size which will be delivered to the users. The baseline definition of a **site** is: "an area on the Earth covered by one to two along track contiguous images". A site corresponds to 5200x5200 pixels (1 image) or 5200x10400 pixels (2 images) in the focal plane. Therefore, the minimum size of a site is 27x27 km^2, the maximum size being 27x54 km^2 at nadir (in VM1).



Baseline definition of a site and standard VENµS image acquisitions

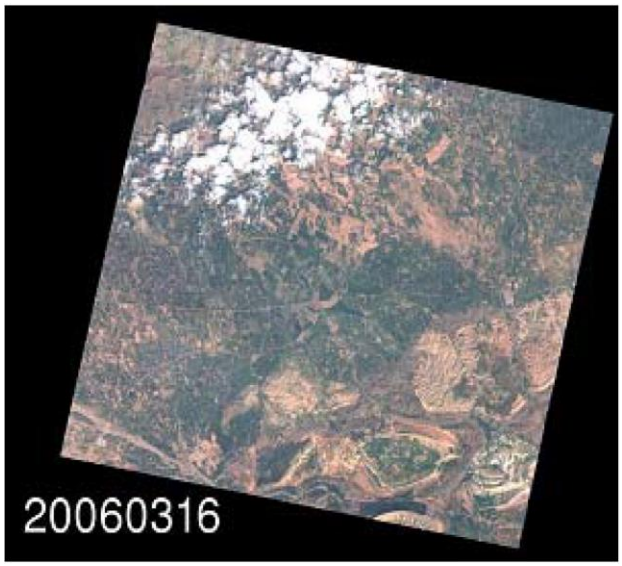
Each site will be observed during the whole period of the mission phase (i.e. VM1 or VM5).

The three levels of products, which will be made available to the users, are summarized in the table below.

Product Level	Temporal characteristics	Content	Ground resolution in VM1	Ground resolution in VM5
Level 1	Single date and single angle acquisition	Top of the atmosphere reflectance, map projection	5 m	4 m
Level 2	Single date and single angle acquisition	Surface reflectance, map projected	5 m	4 m
Level 3	10 day time composite of a single date and single angle acquisition	Surface reflectance, map projected	5 m	4 m

3.1 Level 1

The VENµS level 1 provides geolocated top-of-atmosphere reflectance. Level 1 is used as input to level 2 processors.



Level 1: Top of the Atmosphere reflectances calibrated & geocoded (orthoimage). Formosat-2 data, 8m ground resolution.

The following table details the level 1 product content.

	Code	description	Res.	bands	Format Entête	Format Donnée	bits
Public		Global description of the product	-	-		XML	-
	-	TOA reflectance and masks	5	15	HDR	GEOTIFF	16
		B1=>B12 TOA reflectance					
		SAT Saturated pixels mask					
		PIX aberrant pixels mask					
		CLD clouds mask					
	CLA	Cloud altitude	20	1	HDR	GEOTIFF	16
	SOL	Solar angles grid	100	8 (B05-10-07-06)	HDR	HDF	-
	VIE	Viewing angles grid	500	4 (3000-8000m)	HDR	HDF	-
	QLK	Quick look	100	3	HDR	JPEG	8

The following document shows the formula used to compute the VENµS TOA reflectance from the VENµS TOA radiance: https://theia.cnes.fr/atdistrib/documents/Level_1_processing_Venus.pdf

Additional information on level 1 product format can be found at the following URLs:

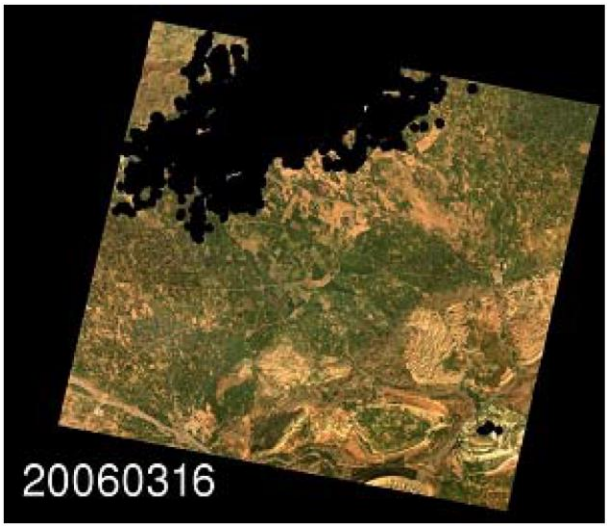
http://www.cesbio.ups-tlse.fr/multitemp/?page_id=12984

https://theia.cnes.fr/atdistrib/rocket/#/documents

3.2 Level 2

The VENµS level 2 products provide:

- a fine cloud and cloud shadow mask, and a water mask
- surface reflectance after atmospheric corrections for all spectral bands (still geolocated)



Level 2: Single date surface reflectances after cloud masking and atmospheric correction on level 1 product. Formosat-2 data, 8m ground resolution.

The following table details the level 2 product content.

	Code	description			Res. en m.	Nb. bands	bits signif.	bits write	Format Entête	Format Donnée
Public	-	Global description of the product								XML
	SRE	Surface reflectance without slope correction			5	12	16	16	HDR	GEOTIFF
	FRE	Surface reflectance with slope correction = « Flat reflectance »			5	12	16	16	HDR	GEOTIFF
	ATB	Atmospheric parameters			5	2	8	8	HDR	GEOTIFF
		VAP	Water vapour content							
		AOT	Aerosol optical thickness							
	CLD	Cloud and cloud shadow mask			5	1	8	8	HDR	GEOTIFF
		(*)	*ALL*	*Summary Logical or of All cloud and shadow masks*		*8*	*8*			
			ALL CLOUDS	*Logical or of All cloud masks*						
			SHADOWS	*Shadows mask from clouds within image*						
			SHADVAR	*Shadows mask from clouds outside image*						
			REFL	*Reflectance threshold*						
			REFL_VAR	*Reflectance variation threshold*						
			EXTENSION	*Extension of the cloud mask*						
			ALT	***Stereoscopic mask***						
	MSK	Geophysical masks			5	1	5	8	HDR	GEOTIFF
			WAT	*Water mask*		*5*	*5*			
			HID	*hidden surfaces*						
			SHD	*shadowed by topography mask*						
			STL	*sun too low flag*						
			TGS	*tangent sun flag*						
	QLT	Quality masks			5	3	12	16	HDR	GEOTIFF
		SAT	Saturation mask copied from L1 (12 useful values)				*12*			
		PIX	aberrant pixels channel copied from level 1 (12 useful values)				*12*			
		OTH	*EDG*	*Edge mask*		*3*	*3*			
			IAO	*AOT pixel mask (0 if computed, 1 if interpolated)*						
			IWC	***VAP pixel mask (0 if computed, 1 if interpolated)***						
	SOL	Solar angles grid (identical to L1 one at L2 scale)			-	-	32	32	HDR	HDF
	VIE	Viewing angles grid (identical to L1 one at L2 scale)			-	-	32	32	HDR	HDF
	-	Quick look			100	3	8	8	HDR	JPEG

The VENµS level 2 products are produced using the MAJA processor, which detects the clouds and their shadows, and estimates aerosol optical thickness (AOT), water vapor and corrects for the atmospheric effects. The processor was jointly developed by CESBIO, CNES and DLR.

The following document provides a detailed description of the methods used in MAJA:

http://www.cesbio.ups-tlse.fr/multitemp/?p=12432

The following URL presents a shorter description of MAJA:

http://www.cesbio.ups-tlse.fr/multitemp/?p=6203

Additional information on level 2 product format can be found at the following URLs:

http://www.cesbio.ups-tlse.fr/multitemp/?page_id=13803

https://theia.cnes.fr/atdistrib/rocket/#/documents

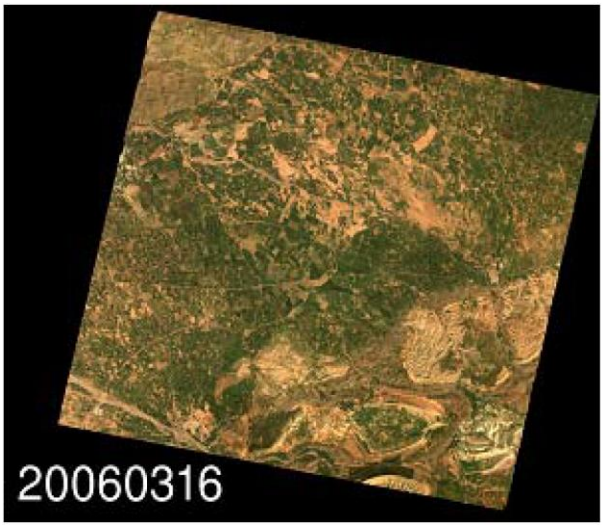
References:

Hagolle, O., G. Dedieu, B. Mougenot, V. Debaecker, B. Duchemin and A. Meygret, 2008, Correction of aerosol effects on multi-temporal images acquired with constant viewing angles: Application to Formosat-2 images. *Remote Sensing of Environment*, Vol. 112, n°4, 1689-1701.

Hagolle O., M. Huc, D.Villa Pascual, and G. Dedieu, "A multi-temporal method for cloud detection, applied to FORMOSAT-2, VENµS, LANDSAT and SENTINEL-2 images," *Remote Sensing of Environment*, vol. 114, Aug. 2010, pp. 1747-1755.

3.3 Level 3

The VENµS level 3 provides the same variables as level 2, every week, maximizing the number of cloud-free pixels. Level 3 is based on level 2 data acquired under the same viewing angle.



Level 3: 10 days time composite of level 2. Formosat-2 data, 8m ground resolution.

The following table details the level 3 product content.

	Code	description		Res.	bands	bits signif.	bits	Format Entête	Format Donnée
Public	-	Global description of the product		-	-		-		XML
	SRE	Surface reflectance without slope correction		5	12	10	16	HDR	GEOTIFF
	FRE	Surface reflectance with slope correction = « Flat reflectance »		5	12	10	16	HDR	GEOTIFF
	-	Quick look		100	3	8	8	HDR	JPEG
	MSK	Geophysical masks		5	4		16	HDR	GEOTIFF
		CLD	Cloud mask						
		CIR	Cirrus mask						
		WAT	Water mask						
		RAI	Rain mask						
	QLT	Quallity/Masks		5	2		16	HDR	GEOTIFF
		SAT	Saturated pixel mask						
		PXD	Pixel dates						

3.4 Data distribution for the VENµS Israeli scientific sites

The VENµS product of the Israeli scientific site are available at the following URL:

https://venus.bgu.ac.il/venus/

3.5 Data distribution for others VENµS scientific sites

The data over all VENµS scientific sites (**except Israel**) are available for free download using the following URL:

https://theia.cnes.fr/atdistrib/rocket/#/home

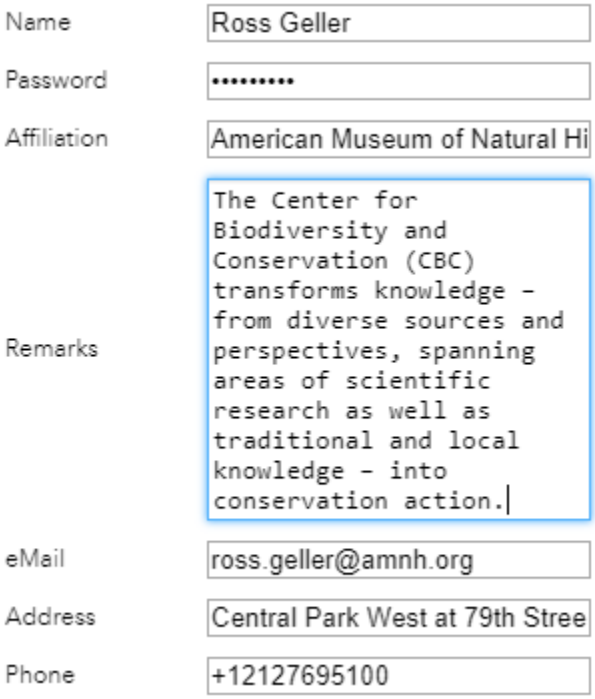
4. How to order, download and extract the Israeli VENµS products

Connect to the website https://venus.bgu.ac.il/venus/

4.1 System registration

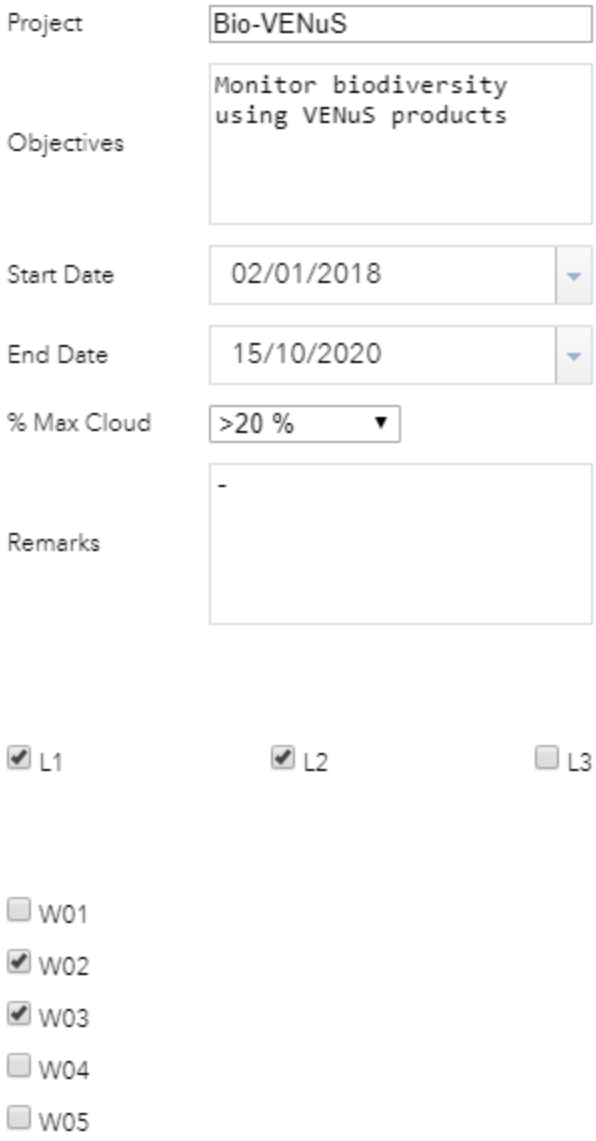
- Click on the "System registration" icon  and fill out all the information in English (**please, don't write in Hebrew**).

A **user** is defined by "Name", "Password", "Affiliation", "eMail, "Address" and "Phone".



A **project** is defined by "Name of the Project", "Objectives", "Dates", "% Max. cloud", "Level of products" (L1, L2, L3) and "name of tiles" (W01, W02, … S10).

More projects can be attached to a single user.



If you are going to create more projects (for a single user), please assure you to fill out correctly all the information of the user, i.e “Name”, “Password”, “Affiliation”, “eMail, “Address” and “Phone”.

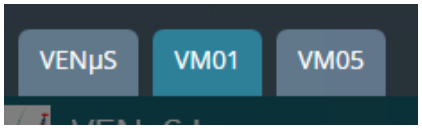
The name of the user and the eMail are unique, this means that it is not possible to have more than one user with the same eMail.

- Fill out the end user agreement form and sent it to venus@post.bgu.ac.il (if not already done).

- You will receive an email from venus@post.bgu.ac.il when your registration will be accepted by the VENµS PI.

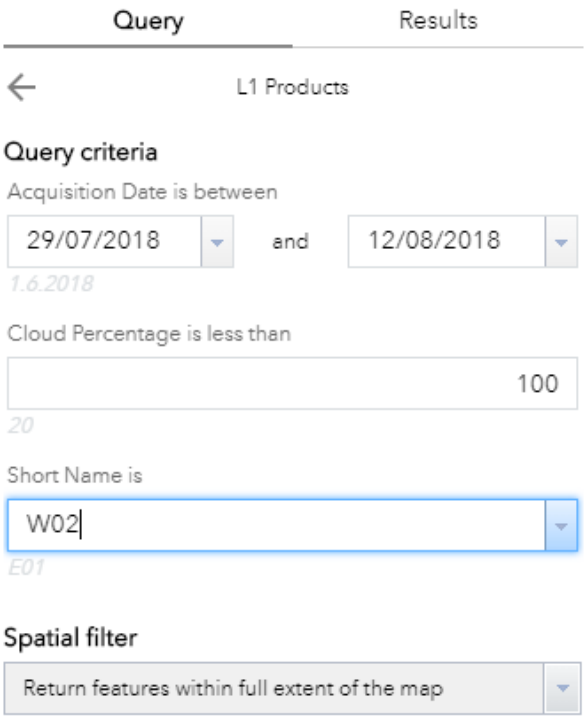
4.2 Querying and Ordering Images

- Select the mission phase are you interested for (i.e. VM01 or VM05)

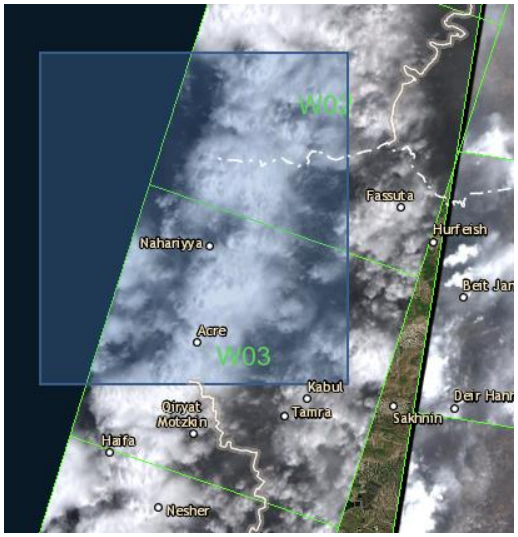


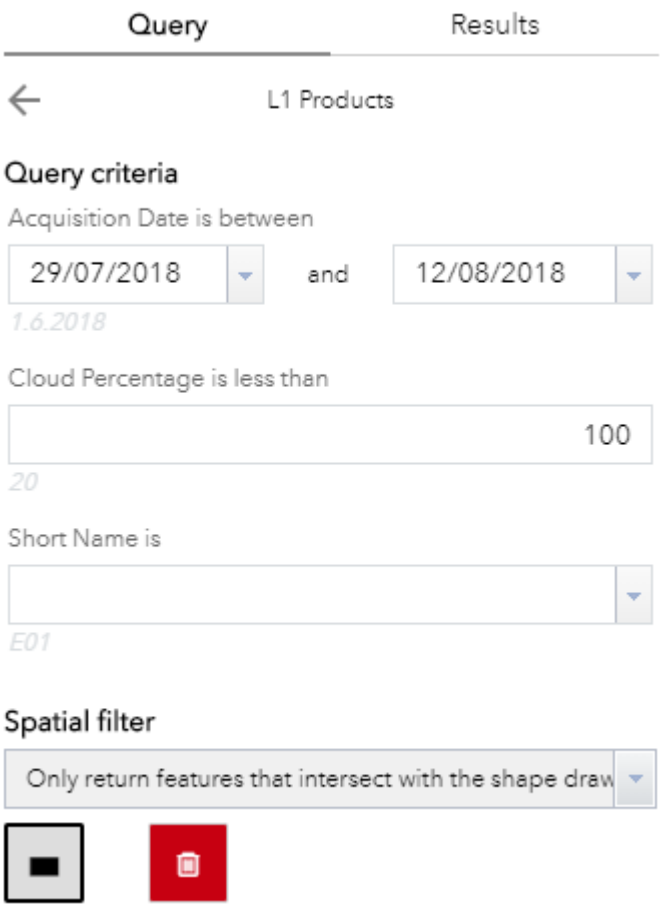
- Click on the "Query and Order Images" icon  .
- Select the level of product that you want to query:

- Fill out the query request information and click "Apply".

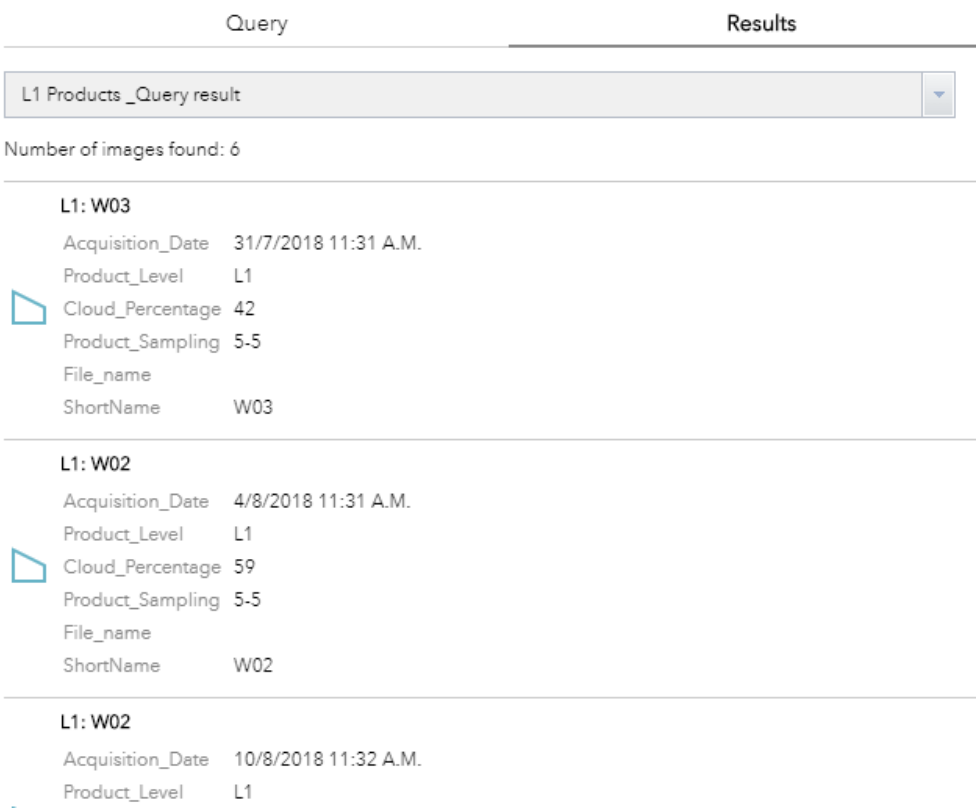


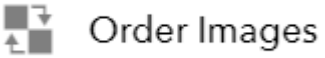
You have the choice to indicate the area of your interest selecting the nickname (E01, E02, ect) or you can do spatial filter and draw rectangle on the map.





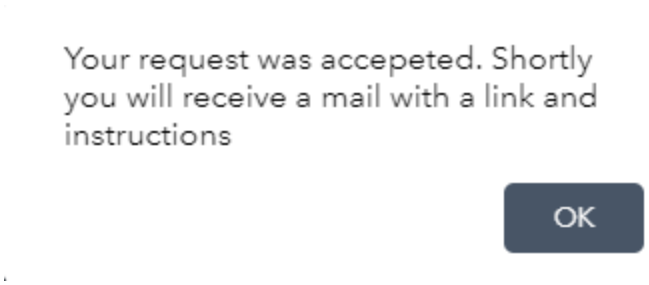
- In “Results” you have the products found in the VENµS archive that correspond to your query request.



- Click on 

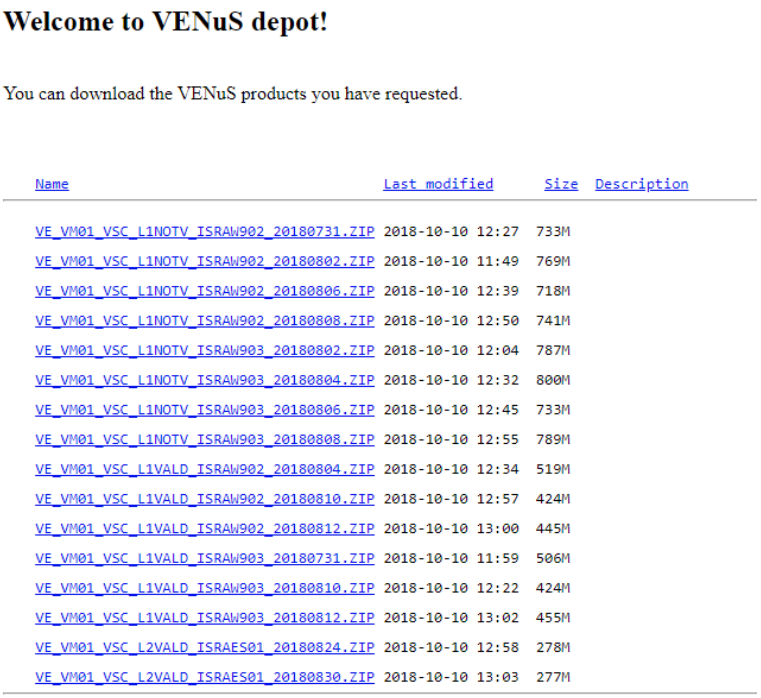
inside the three-dot icon to order all the products of your query.

- Enter your username and password.



4.3 Downloading Images

- In the next few hours, you will receive an email with the instructions on how to download your products. The products will be available on the server, for a period of 7 days, in a dedicated space for each user. So it may happen that older images are displayed, which have not yet been deleted.



Welcome to VENuS depot!

You can download the VENuS products you have requested.

Name	Last modified	Size	Description
VE_VM01_VSC_L1NOTV_ISRAW902_20180731.ZIP	2018-10-10 12:27	733M	
VE_VM01_VSC_L1NOTV_ISRAW902_20180802.ZIP	2018-10-10 11:49	769M	
VE_VM01_VSC_L1NOTV_ISRAW902_20180806.ZIP	2018-10-10 12:39	718M	
VE_VM01_VSC_L1NOTV_ISRAW902_20180808.ZIP	2018-10-10 12:50	741M	
VE_VM01_VSC_L1NOTV_ISRAW903_20180802.ZIP	2018-10-10 12:04	787M	
VE_VM01_VSC_L1NOTV_ISRAW903_20180804.ZIP	2018-10-10 12:32	800M	
VE_VM01_VSC_L1NOTV_ISRAW903_20180806.ZIP	2018-10-10 12:45	733M	
VE_VM01_VSC_L1NOTV_ISRAW903_20180808.ZIP	2018-10-10 12:55	789M	
VE_VM01_VSC_L1VALD_ISRAW902_20180804.ZIP	2018-10-10 12:34	519M	
VE_VM01_VSC_L1VALD_ISRAW902_20180810.ZIP	2018-10-10 12:57	424M	
VE_VM01_VSC_L1VALD_ISRAW902_20180812.ZIP	2018-10-10 13:00	445M	
VE_VM01_VSC_L1VALD_ISRAW903_20180731.ZIP	2018-10-10 11:59	506M	
VE_VM01_VSC_L1VALD_ISRAW903_20180810.ZIP	2018-10-10 12:22	424M	
VE_VM01_VSC_L1VALD_ISRAW903_20180812.ZIP	2018-10-10 13:02	455M	
VE_VM01_VSC_L2VALD_ISRAES01_20180824.ZIP	2018-10-10 12:58	278M	
VE_VM01_VSC_L2VALD_ISRAES01_20180830.ZIP	2018-10-10 13:03	277M	

4.4 Extracting Images

Each ZIP file contains the metadata (HDR) and a TAR file (DBL) with the images for a specific VENµS product (L1, L2 or L3), date and site.

Un-zip the file.

The HDR is an XML file, which contains the necessary metadata, and can be read with any text editor (e.g. Notepad++), and the DBL file (DataBLock) is a tar.bz2 file.

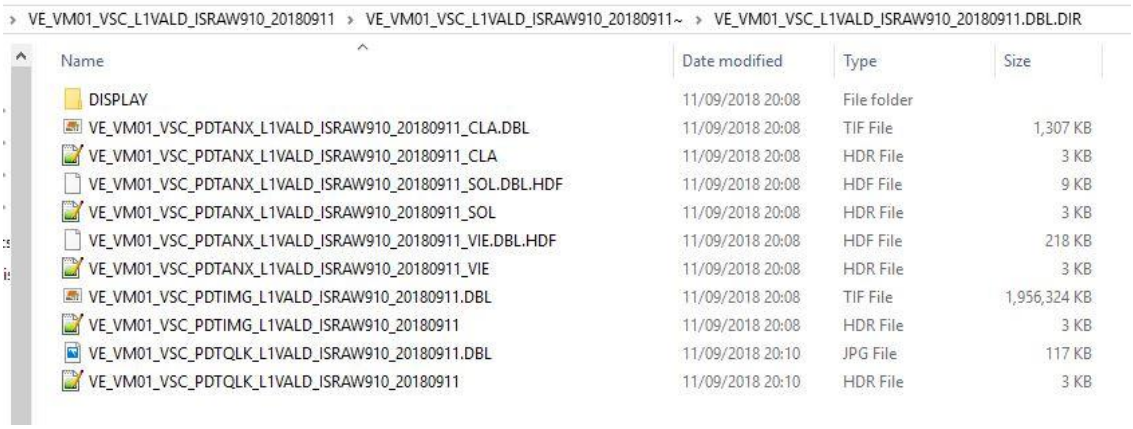
In **Linux**, you can un-zip the DBL file with the following command:

```
tar xvf filename.DBL
```

In **Windows**, you can un-zip the DBL file trough 7Zip (or with others similar software).

ATTENTION: Once you un-zip the file trough 7Zip, a directory that contains another compressed file is created. **You have to un-zip also this file!**

After this **second un-zip** you will obtain all the files of the products in a dedicated directory. For instance:



From now on, you get a good format, but don't forget to remove the ZIP and DBL files, otherwise, VENµS data will occupy a large volume on your disk.

More information on the algorithms, products and uses can be found on the dedicated blog:

http://www.cesbio.ups-tlse.fr/multitemp/?p=6203

http://www.cesbio.ups-tlse.fr/multitemp/?cat=56

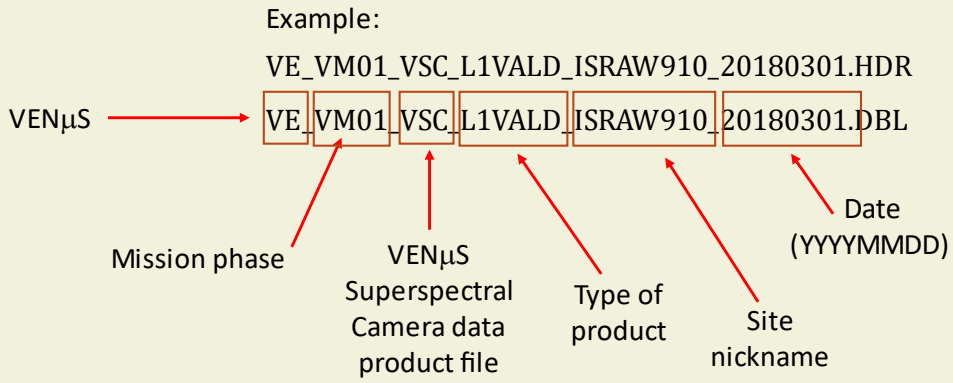
For any information, please do not hesitate to contact us at the following address:

venus@post.bgu.ac.il

BGU WEBSITE: EXTRACT THE IMAGES

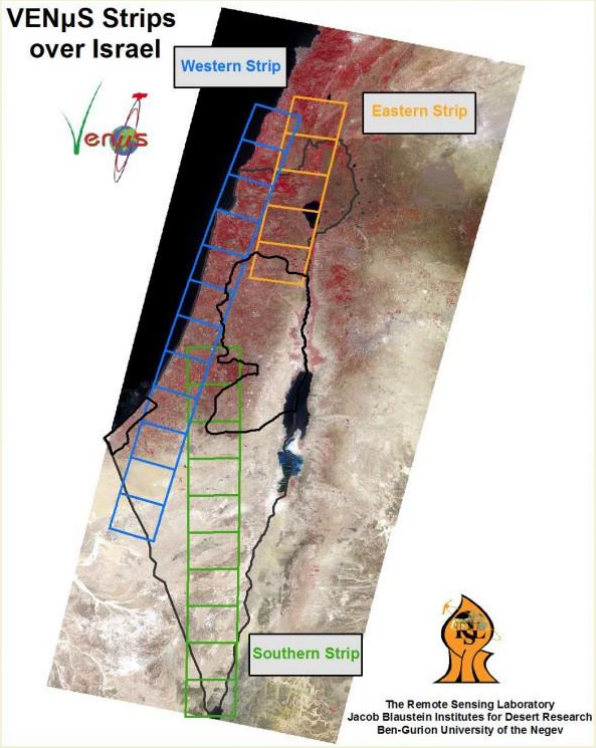
Each ZIP file contains the metadata (HDR) and a TAR file (DBL) with the images for a specific VENµS product (L1, L2 or L3), date and site.

- The HDR is an XML file, which contains the necessary metadata, and can be read with any text editor (e.g. Notepad++)
- DBL file (DataBLock) is a tar.bz2 file.



1

SITE NICKNAMES OVER ISRAEL (VM1)



Eastern Strip
ISRAEE01, ISRAEE02, … , ISRAEE05 (from 20171127 to 20180402)
ISRAEK01, ISRAEK02, … , ISRAEK05 (from 20180406 to 20180504)
ISRAEL01, ISRAEL02, … , ISRAEL 05 (from 20180506 to the end of VM1)

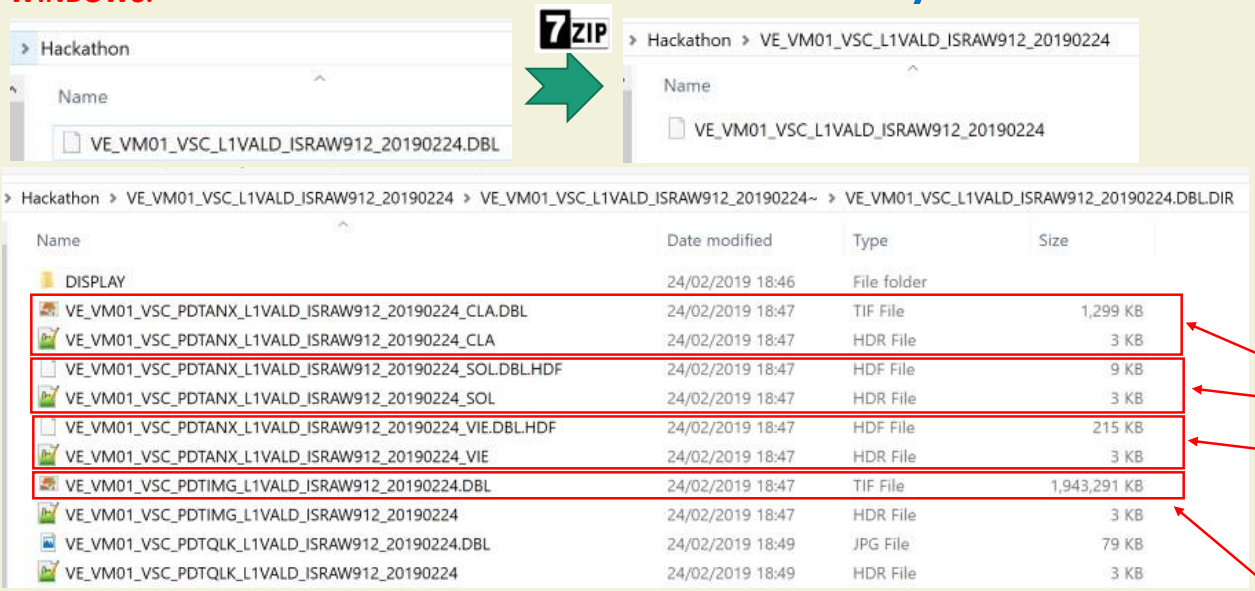
Western Strip
ISRAEW01, … , ISRAEW12 (from 20171101 to 20171217)
ISRAW901, … , ISRAW912 (from 20180128 to the end of VM1)

Southern Strip
ISRAES01, … , ISRAES10 (entire VM1)

2

EXTRACT THE IMAGES / DBL – L1

WINDOWS:

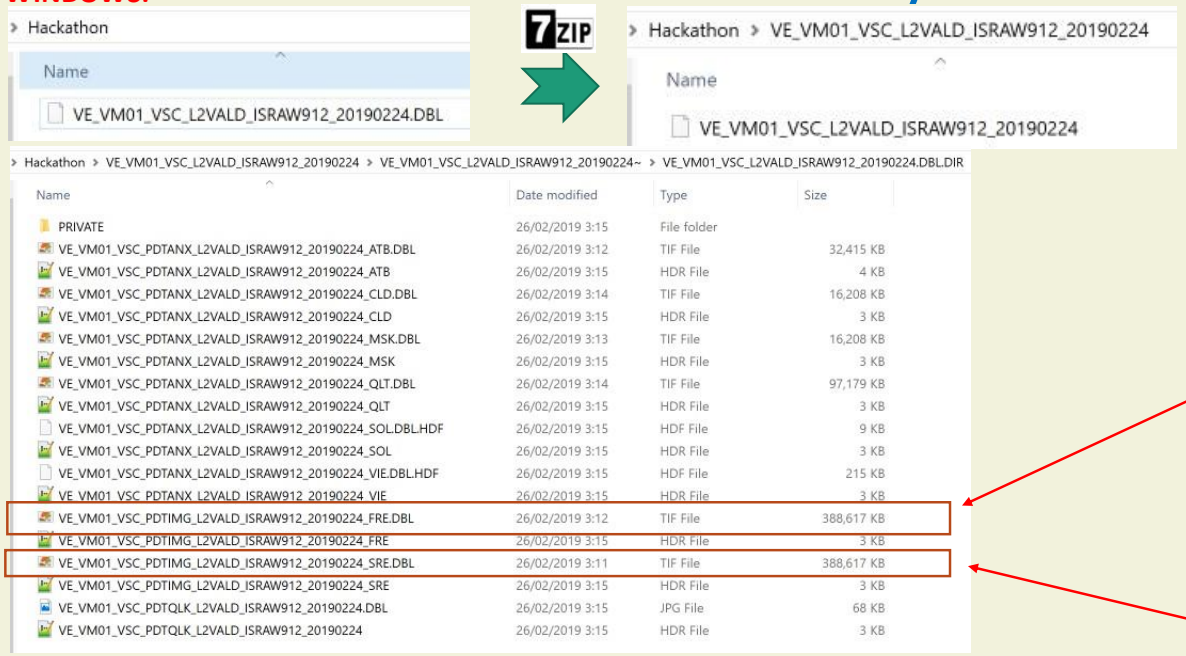


LINUX:

```
tar xvf VE_VM01_VSC_L1VALD_ISRAW912_20190224.DBL
```

EXTRACT THE IMAGES / DBL – L2

WINDOWS:



I suggest using this

surface reflectance with slope correction (12 layers)

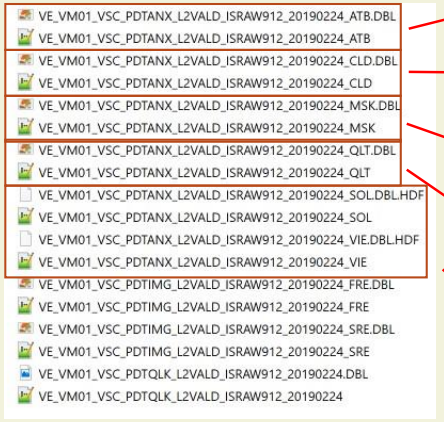
surface reflectance without slope correction (12 layers)

LINUX:

```
tar xvf VE_VM01_VSC_L2VALD_ISRAW912_20190224.DBL
```

4

EXTRACT THE IMAGES / DBL – L2



ATB	Atmospheric parameters		
	VAP	Water vapour content	
	AOT	Aerosol optical thickness	
CLD	Cloud and cloud shadow mask		
	(*)	*ALL*	*Summary Logical or of All cloud and shadow masks*
		ALL CLOUDS	*Logical or of All cloud masks*
		SHADOWS	*Shadows mask from clouds within image*
		SHADVAR	*Shadows mask from clouds outside image*
		REFL	*Reflectance threshold*
		REFL_VAR	*Reflectance variation threshold*
		EXTENSION	*Extension of the cloud mask*
		ALT	***Stereoscopic mask***
MSK	Geophysical masks		
		WAT	*Water mask*
		HID	*hidden surfaces*
		SHD	*shadowed by topography mask*
		STL	*sun too low flag*
		TGS	*tangent sun flag*
QLT	Quality masks		
	SAT	Saturation mask copied from L1 (12 useful values)	
	PIX	aberrant pixels channel copied from level 1 (12 useful values)	
	OTH	*EDG*	*Edge mask*
		IAO	*AOT pixel mask (0 if computed, 1 if interpolated)*
		IWC	***VAP pixel mask (0 if computed, 1 if interpolated)***
SOL	Solar angles grid (identical to L1 one at L2 scale)		
VIE	Viewing angles grid (identical to L1 one at L2 scale)		
-	Quick look		

HDR - METADATA

VE_VM01_VSC_L1VALD_ISRAW907_20180901.HDR

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```

HDR - METADATA

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    <Short_Description>WGS84, World Geodetic System 1984 (2D)</Short_Description>
</Reference_System>
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    <Long unit="deg">34.4387218876</Long>
    <Lat unit="deg">31.4621287096</Lat>
    <Line>-6</Line>
    <Column>1454</Column>
</Upper_Left_Corner>
<Upper_Right_Corner>
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988            <Number_of_Significant_Bits>10</Number_of_Significant_Bits>
989            <Nodata_Value>0</Nodata_Value>
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HDR - METADATA

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711     <Useful_Image>
733     <Product>
751   </Solar_Angles>
```

```
752   <List_of_Viewing_Angles count="4">
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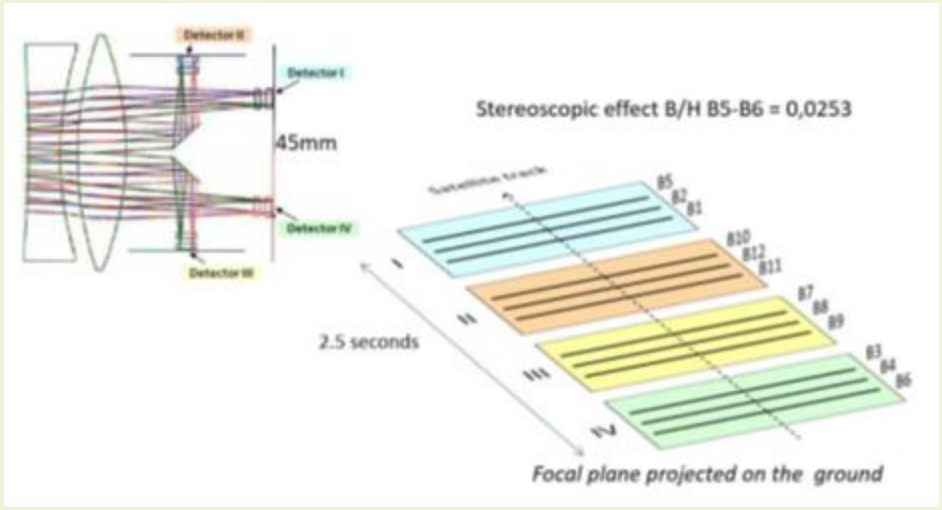
Viewing Angle	Spectral bands
1	5, 2, 1
2	10, 12, 11
3	7, 8, 9
4	3, 4, 6



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