**TP3: Calculate Vegetation indices using QGIS, OTB and SNAP** 

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# **Objective :**

In this TP, we will calculate a few vegetation indices, using the spectral bands of the optical Sentinel-2 images.

The vegetation indices to calculate are :

- > Normalized Differential Vegetation Index (NDVI)
- Normalized Differential Water Index (NDWI)
- Enhanced Vegetation Index (EVI)
- Soil Adjusted Vegetation Index (SAVI)
- Green Chlorophyll index CI\_Green
- CI\_Rededge Chlorophyll index
- Leaf Area Index (LAI)
- Canopy Water Content (CWC)
- Canopy Chlorophyll Content (CAB)

## **Prerequisite for this TP:**

- 1. Installation of QGIS (3.20)
- 2. Installation of OTB (OrfeoToolbox)
- 3. Installation of (SNAP 7.0)

## 1. Normalized Differential Vegetation Index NDVI:

**Objective:** Calculate the vegetation index NDVI

Steps	Manipulation sous QGIS								
1. Definition and formula	Green plants absorb the solar radiation from the visible spectrum range of the radiation (red, green et blue), and uses this radiation as source of energy to accomplish photosynthesis.								
	The cells in the leaves reflect the solar radiation that in near to infrared, because the energy of these photons that a wavelength superior to around 700 nanometer (infrared) and is too weak to be used for the synthesis of molecules by the plant.								
	The index that is used the most in the remote sensing of vegetation is the NDVI NDVI "Normaliz Differential Vegetation Index ". It is in fact the normalized ratio of the difference between the infrar reflectance and the red reflectance.								
	$\mathbf{NDVI} = \frac{Near  Infrared - Rouge}{Near  Infrared + Rouge}$								
	The range of NDVI values are between $-1$ et $+1$ . Negative values correspond to surfaces other than vegetation cover, like snow, water surfaces and clouds, for these surfaces the reflectance of red radiation is bigger than the reflectance of near infrared radiation.								
	For bare soil, the reflectance of red and infrared is almost the same, thus the NDVI will be close to 0.								
	Whereas, vegetation cover will have positive NDVI values, generally varying between 0.1 and 0.9. The higher the value, the denser the vegetation.								
	$\frac{(0.50 - 0.08)}{(0.4 - 0.30)} = 0.14$								
2. Formula of NDVI for Sentinel-2	(0.50 + 0.08) (0.4 + 0.30) For Sentinel-2, the infrared band corresponds to the band B8 whereas the red band corresponds to B4 Using Sentinel-2 data, NDVI is calculated as such :								
	$\mathbf{NDVI} = \frac{B8 - B4}{B8 + B4}$								
3. Calculating NDVI on QGIS	<ul> <li>Launch QGIS</li> <li>In the menu, click on « Layers» [] « Add layer» [] « Add raster layer »</li> </ul>								

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#### 2. Normalized Differential Water Index NDWI:

## **Objective:** Calculating the vegetation index NDWI

Steps	Manipulation sous QGIS								
1. Definition and formula	The Normalized Differential Water Index (NDWI) (Gao, 1996) is an index derived from satellite data from Near-Infrared (NIR) and Short Wave Infrared (SWIR).								
	The reflectance of SWIR reflects the changes in the magnitude of water in the vegetation, whereas the reflectance of NIR is affected by the internal structure of the leaves and the magnitude of dry material in the leaves, but not water content.								
	The combination of NIR and SWIR negates the variations caused by the internal structure of the leaves and by the dry matter content inside the leaves, this increases the precision of capturing the total water content of the vegetation (Ceccato et al. 2001).								
	The quantity of water available in the internal structure of the leaves controls to a great extent the spectral reflectance in the SWIR zone of the electromagnetic spectrum. Thus, the reflectance of SWIR negatively correlated with the quantity of water inside the leaves. (Tucker 1980).								
	The NDWI is useful for monitoring drought and as an early alarm to drought. Since it is calculated using the reflectance in the Near infrared (NIR) and Short Wave Infrared (SWIR) which makes it sensitive to changes in the water content of the vegetation cover.								
	This index varies in function of water content of the leaves. It decreases when the plants are in a water stress state, and so it is useful for following vegetation in dry areas.								
	The NDWI is complimentary to NDVI								
	The formula for NDWI is:								
	$\mathbf{NDWI} = \frac{NIR - SWIR}{NIR + SWIR}$ The values of NDWI are between -1 and +1.								
2. Formula for Sentinel-2	For Sentinel-2, the infrared band corresponds to the band B8 whereas the band SWIR corresponds to B12. Using Sentinel-2 data, the NDWI is calculated as such: $NDWI = \frac{B8 - B12}{B8 + B12}$								
3. Calculating the NDWI index	> Launch QGIS								
in QGIS	➢ In the menu, click on « Layers» □ « Add layer» □ « Add raster layer »								
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	Agouter une couche vecteur Ctrl+Maj+V								
	Couches Ajouter depuis un fichier de Définition de Couche								
	Vo								

A	In the new window click on and navigate to the folder with the S2 images (TP3\SENTINEL-2)
	Select these two images :
	« SENTINEL2B_20200730-111734-503_L2A_T30UXV_C_V2-2_FRE_B8.tif » « SENTINEL2B_20200730-111734-503_L2A_T30UXV_C_V2-2_FRE_B12.tif »
	These images correspond to bands " NIR " et "SWIR".
$\mathbf{A}$	The band B12 of Sentinel-2 has a resolution of 20 m whereas the infrared band has a resolution of 10m. The equation cannot be applied for images with different resolutions, and so we need to de a resampling of the B8 image to make it at a 20m resolution in the aim of calculating NDWI.
	Open the tab « Projection (warp) » : Raster [] Projection [] Projection (warp)
	In the window of « Projection », set the following parameters:
	• Input layer : SENTINEL2B 20200730-111734-503 L2A T30UXV C V2-2 FRE B8.ti
	<ul> <li>Output file resolution in target georaferenced units: « 20 »</li> </ul>
	i o to the last line last line and i i o Be 20 diffe
	• In « Output Image » : click and save the image as « <b>B8_20m.til</b> »
	<ul> <li>check « Open output file after running algorithm »</li> </ul>
	○ click on « <b>Run</b> »
	Q Projection (warp) ×
	Paramètres Journal
	Couche en entree
	SCR d'origine [optionnel]
	SCR cible [optionnel]
	Méthode de ré-échantillonage à utiliser
	Plus proche voisin
	Valeur Nodata pour les bandes de sortie [optionnel]
	Résolution du fichier de sortie dans les unités de géoréférencement de la cible [optionnel]
	20.000000
	Reprojeté
	E:/TP_Caen/TP_3/B8_20m.tif
	Console GDAL/OGR
	gdalwarp -tr 20.0 20.0 -r near -of GTiff E: \TP_Caen\SENTINEL2B_20200730-111734-503_L2A_T30UXV_C_V2-2\SENTINEL2B_20200 730-111734-503_L2A_T30UXV_C_V2-2_FRE_B8.tif E:/TP_Caen/TP_3/B8_20m.tif
	0% Annuler
	Exécuter comme processus de lot Exécuter Fermer Aide
	The images B8 et B12 are now at the same spatial resolution (20 m) and we can calculate the NDWI at a resolution of de 20 m
≻	In the Menu bar, click on « Raster » a « Raster calculator »
	Type the following expression:
	("B8_20m@1" - "SENTINEL2B_20200730-111734-503_L2A_T30UXV_C_V2- 2_FRE_B12@1")/("B8_20m@1"+"SENTINEL2B_20200730-111734-503_L2A_T30UXV_C_V2- 2_FRE_B12@1")

		Calculatrice									
		Bandes	s raster	1	-	Couche	rés	ultat			
		B8_20	m@1	2020072	0.1	Couche en sortie     .ndwi_2020073       Format en sortie     GeoTIFF       Emprise de la couche sélectionnée				\ndwi_20200730.tif 🖾	
		SENTI	NEL2D_	2020073	0-1					GeoTIFF -	
										3	
						min X	6	00000.0	0000	÷	max X 709800.00000 1
						min Y	5	390220	.00000	\$	max Y 5500020.00000 ‡
						Colonne	es 54	490		\$	Lignes 5490
						SCR en	sort	tie			EPSG:32630 - WGS 84 - 💿
						Aiout	or lo	réculta	t au pro	iot	
					•	Ajout	er ie	resulta	it au pro	jet	
		- Opéra	ateurs								
		+	*	2	COS	s si	n	tan	log10	(	
		-	1	^	acc	os asi	in	atan	In	)	
		<	>	_	!=	<	-	>=	AND	OR	
		abs	min	max							
		Expres	sion de	e la calc	ulatri	ice ras	er				
		("B8_ "SENTI ("B8_20	20m@1 NEL2B_ 0m@1"-	" - 2020073 +"SENTII	0-111 NEL2E	.73 <mark>4-50</mark> 3_20200	3_L2 )730	2A_T300 -111734	UXV_C_V 4-503_L2	/2-2_FF 2A_T30	RE_B12@1")/ UXV_C_V2-2_FRE_B12@1")
		Express	ion valio	le							OK Annuler Aide
						20.10					
A	Save the o	utput as	« ndv	vi_202	007.	30.tif	»				
AA	Save the o	utput as	« ndv	vi_202	007.	30.tif	» ula	te the	indev	for th	e extent of the input ba
• •	Save the o	utput as selectec	« ndv l layei	vi_202 r exten	007. t » t	30.tif o calc	» ula	te the	index	for th	e extent of the input ba
V V	Save the o Click on «	utput as selected	« ndv l layer	vi_202 r exten	007. t » t	30.tif	» ula	te the	index	for th	e extent of the input ba

### 3. Soil Adjusted Vegetation Index SAVI:

L

**Objective:** Calculating the vegetation index SAVI

Steps	Manipulation sous QGIS								
1. Definition and formula	The SAVI « Soil adjusted vegetation index » is an index similar to NDVI, but it removes the effect of the ground pixel.								
	The index SAVI minimizes the influence of the ground's luminosity using the spectral indices of vegetation and wavelengths from red to near infrared (NIR).								
	t uses the adjustment factor of canopy « L », which is in function of the vegetation's density. Therefore, it requires preexisting knowledge of the vegetation quantity.								
	Huete (1988) suggested an optimal value of $L=0,5$ in order take into account the variation of the ground. This index is used in zones where vegetation is more or less dispersed and where the ground is visible through the vegetation cover.								
	The formula for SAVI is:								
	$\mathbf{SAVI} = (1 + L) \times \frac{NIR - Red}{NIR + Red + L}$								
	with $L = 0,5$ :								
	$SAVI = 1,5 x \frac{NIR - Red}{NIR + Red + 0,5}$								
2. Formula for Sentinel-2	For Sentinel-2, the infrared band corresponds to B8 and the red band corresponds to B4. SAVI is calculated a such : $SAVI = 1.5 \times \frac{B8 - B12}{B8 + B12 + 0.5}$ Sentinel-2 bands are multiplied by 10000 since they are saved in the 16 bit format. This is why we have to divide the bands by 10000 when we are doing an addition or subtraction with other numbers								
3. Calculating SAVI in QGIS	<ul> <li>Launch QGIS</li> <li>In the menu, click on « Layers» [] « Add layer» [] « Add raster layer »</li> <li>Projet Éditer Vue Couche Préférences Egtensions Yecteur Baster Base de données Internet Mallage Traitement Aide</li> <li>Projet Éditer Vue Couche Préférences Egtensions Yecteur Baster Base de données Internet Mallage Traitement Aide</li> <li>Projet Éditer Vue Couche Préférences Egtensions Yecteur Baster Base de données Internet Mallage Traitement Aide</li> <li>Projet Éditer Vue Couche Préférences Egtensions Yecteur Baster Base de données Internet Mallage Traitement Aide</li> <li>Projet Éditer Vue Couche Préférences Egtensions Yecteur Baster Base de données Internet Mallage Traitement Aide</li> <li>Projet Éditer Vue Couche Active and Projet Préférences Egtensions Yecteur Baster Base de données Internet Mallage Traitement Aide</li> <li>Projet Éditer Vue Couche Active and Projet Préférences Egtensions Yecteur Baster Base de données Internet Mallage Traitement Aide</li> <li>Projet Éditer Vue Couche Active and Projet Préférences Egtensions Yecteur Baster Base de données Internet Mallage Traitement Aide</li> <li>Projet Éditer Vue Couche Active active Raster Base de données Internet Mallage Traitement Aide</li> <li>Ajouter une couche Vue Active active Raster Base de données Internet Mallage</li> <li>Ajouter une couche Valuer une couche raster</li> <li>Cut+Maj+H</li> <li>Ajouter depuis un fichier de Définition de Couche</li> <li>Ajouter une couche de texte delimité</li> <li>Cut+Maj+T</li> <li>Cut+Maj+T</li> <li>Cut+Maj+T</li> <li>Cut+Maj+T</li> <li>Cut+Maj+T</li> <li>Cut+Maj+T</li> <li>Cut+Maj+T</li> <li>Cut+Maj+T</li> <li>Cut+Maj+D</li> </ul> <li>In the new window click on Internet Mallage and navigate to the folder with the S2 images (TP3\SENTINEL-2)</li> <li>Select these two images : <ul> <li>« SENTINEL2B_20200730-111734-503_L2A_T30UXV_C_V2-2_FRE_B4.tif »</li> <li>« SENTINEL2B_20200730-111734-503_L2A_T30UXV_C_V2-2_FRE_B8.tif »</li> </ul> </li>								

	These ima	iges co	rrespo	nd to "R	ed" d	et "NI	R".				
> ]	In the Menu bar, click on « Raster » I « Raster calculator »									»	
	Evne the f	allowir	ισενη	ression							
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	2_FRE_H	84@1''	/1000	0)/("SE	NTI	NEL2	B_2020	00730-1	1117	34-503_L2A_T30UXV_C_V2-	
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					SCR en sortie EPSG:32630 - WGS 84 -						
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		• Opéra	ateurs								
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		- 1.5*("SENTINEL2 "SENTINEL2B_ ("SENTINEL2B_ "SENTINEL2B_20				128_20200730-111734-503_L2A_T30UXY_C_V2-2_FRE_B8@1"/10000 - B_20200730-111734-503_L2A_T30UXV_C_V2-2_FRE_B4@1"/10000)/ B_20200730-111734-503_L2A_T30UXV_C_V2-2_FRE_B8@1"/10000 + 20200730-111734-503_L2A_T30UXV_C_V2-2_FRE_B4@1"/10000 +0.5)					
		Expressi	on valid	е						OK Annuler Aide	
	Save the o	utput a	s « sav	vi_20200	0730	.tif »					
	Click on «	selecte	ed laye	er extent	» to	calcul	late the	index f	for th	e extent of the input bands.	
	check « Ad	dd resu	lt to pi	roject »							

## 4. Enhanced Vegetation Index EVI:

L

**Objective:** Calculating the vegetation index EVI

Steps	Manipulation sous QGIS								
1. Definition and formula	The index EVI « Enhanced Vegetation Index » is an 'optimized' vegetation index, created to better capture the signal of vegetation, with a high sensitivity in region that have a very high vegetation biomass. It allows for an ameliorated monitoring of vegetation.								
	While NDVI is sensitive to chlorophyll, EVI is more sensitive to the structural variations in the vegetation cover, including the Leaf Area Index (LAI), it depends on the type and architecture if the vegetation. NDVI et EVI are complementary indices when studying vegetation, they enhance the ability to detect changes in the vegetation, and allow for the extraction of the biophysical parameters of the canopy.								
	This index was initially developed to be used alongside MODIS data, as an enhancement compared to NDVI, by optimizing the signal of the vegetation in the zones with a high Leaf Area Index (LAI).								
	It is useful in zones with a high LAI, where NDVI becomes saturated. It used the NIR reflectance as well as the red reflectance. It also uses the reflectance in the blue wavelength to correct for the ground effect and to limit atmospheric interference, such as diffusion from particulates.								
	EVI values should be between 0 and 1 for vegetation. Reflective elements such as clouds and white buildings, as well as darker areas like water, might give abnormal values in an EVI image:								
	$EVI = 2,5 \text{ x} \frac{NIR - Red}{NIR + 6 \times Red - 7,5 \times Blue + 1}$								
2. Formula for Sentinel-2	For Sentinel-2, infrared corresponds to B8, Red corresponds to B4 et and blue corresponds to B2. EVI is calculated as such : $EVI = 2,5 \text{ x} \frac{B8 - B4}{B8 + 6 \times B4 - 7,5 \times B2 + 1}$ As previously mentioned, Sentinel-2 bands are multiplied by 10000 since they are saved in the 16 bit format. This is why we have to divide the bands by 10000 when we are doing an addition or subtraction with other numbers								
3. Calculer l'indice EVI avec QGIS et OTB	<ul> <li>Launch QGIS</li> <li>In the menu, click on « Layers» [] « Add layer» [] « Add raster layer »</li> <li>Projet faiter Vue coulde préférences Extensions Yecteur Baster Base de données Internet Mallage Traitement Aide</li> <li>Projet faiter Vue coulde préférences Extensions Yecteur Baster Base de données Internet Mallage Traitement Aide</li> <li>Projet faiter Vue coulde Certification de coulde action of the sources de données Ctrific</li> <li>Ajouter une coulde</li> <li>Ajouter une coulde caster</li> <li>Ajouter une coulde caster</li> <li>Ajouter deuis un fichier de Définition de Couche</li> <li>Ajouter une couche de texte délimité</li> <li>Crif+Maj+T</li> <li>Copier le style</li> <li>Ajouter deuis un fichier de Définition de Couche</li> <li>Ajouter une couche de texte délimité</li> <li>Crif+Maj+T</li> <li>Copier le style</li> <li>Ajouter deuis un fichier de Définition de Couche</li> <li>Ajouter une couche de texte délimité</li> <li>Crif+Maj+T</li> <li>Curl+Maj+T</li> <li>Curl+Maj+T</li></ul>								
	« SENTINEL2B_20200730-111734-503_L2A_T30UXV_C_V2-2_FRE_B8.tif »								

#### « SENTINEL2B\_20200730-111734-503\_L2A\_T30UXV\_C\_V2-2\_FRE\_B2.tif ».

We will now use a new tool called "matrix calculator". OTB, which is integrated in QGIS, also has a tool for calculating images pixel by pixel. The matrix calculator in OTB is called "BandMath".

- In "BandMath", the variables entered (pixels in images) are accessible by image and by channel using the following syntax: imXbY where X is the image number and Y the canal number. Here's a few examples illustrating the principle of identification of images and bands (channels) :
  - im1b1 : Image 1, band 1
  - $\circ$  im1b2 : Image 1, band 2
  - im4b3 : Image 4, band 3

Attention, the order of images is the same that appears in the list of images when entered.

> This table shows a few mathematical operation available in BandMath:

Name	Description
Sin	Sinus
Cos	Cosinus
Tan	Tangent
Ln	Logarithmique
	base e
Log10	Logarithmique
	base 10
Sqrt	Racine

▶ In the Menu Bar of QGIS, click on : Processing □ Toolboxes :

<u>I</u> nternet <u>M</u> aillage	<u>Traitement</u> <u>A</u> ide	- 5
🖾 🌞 \Sigma 🛲 - 🌄 🎞	* <u>B</u> oîte à outils	Ctrl+Alt+T
🦷 📄 🔃 🚷 🜏	* Modeleur <u>G</u> raphique	Ctrl+Alt+G
ਯ ਯ ਯ ∾ 🛙 🛢 →	<u>H</u> istorique	Ctrl+Alt+H
	Visualiseur de <u>R</u> ésultats	Ctrl+Alt+R
	Éditer les entités sur place	

In the toolbox of QGIS, look for the « BandMath » tool under OTB and double-click it to pên « BandMath »

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	Q BandMath	
	<ul> <li>         • Utilisé récemment     </li> </ul>	
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	- 🔹 OTB	
	<ul> <li>Miscellaneous</li> </ul>	
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I		
In the BandMath window	, do the following:	

			× 💽 🛛	
Paramètres Jo	urnal		≥ × @ \?	
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0 élément sélect	tionné			
Expression			Q Ban	
2.5*(im3b1/1000	00-im2b1/10000)/(im3b1/10000+6*im2b1,	10000-7.5*im1b1/10000+1)		
Paramètres a	avancés	Q Sélection multiple	×	
Output Image		<ul> <li>✓ SENTINEL28_20200730-111734-503_L2A_</li> <li>✓ SENTINEL28_20200730-111734-503_L2A_</li> <li>✓ SENTINEL28_20200730-111734-503_L2A_</li> <li>✓ SENTINEL28_20200730-111734-503_L2A_</li> </ul>	T30UXV_C_V2-2_FRE_B2 [EPSG:326 T30UXV_C_V2-2_FRE_B4 [EPSG:326 T30UXV_C_V2-2_FRE_B8 [EPSG:326 Annuler la sélection	
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	0%		Annuler	
Exécuter comme	processus de lot	Exécuter Fermer	r Aide	
<ul> <li>In « Input ima</li> <li>In the « Expra</li> </ul>	age-list » click on and select s	he three bands « B2, B4	4 et B8)	
2.5*(im3b1	1/10000-im2b1/10000)/(im3b1/10	0000+6*im2b1/10000-7	<b>7.5*im1b1/10000+1</b> )	
2.5*(im3b) ➤ In « Output Ir	1/10000-im2b1/10000)/(im3b1/10 mage » save the output as « evi_20	0000+6*im2b1/10000-7 )200730.tif »	7.5*im1b1/10000+1)	
2.5*(im3b) ➤ In « Output Ir ➤ Check « Oper	1/10000-im2b1/10000)/(im3b1/10 mage » save the output as « evi_20 n output file after running algorith	0000+6*im2b1/10000-7 )200730.tif » m»	7.5*im1b1/10000+1)	

## 5. Red-Edge and Green Chlorophyll Index (Cl\_green et Cl\_rededge):

**Objective:** Calculating the vegetation index CI\_green et CI\_rededge

Manipulation sous QGIS							
Chlorophyll is a green pigment present in the leaves, it plays an important role important in photosynthesis, the conversion of luminous energy to chemical energy. Therefore, it is a direct indicator of the primary production of the plant and of its photosynthetic potential.							
It is also used for understanding the nutritional status of the plant, its water stress, disease, etc. Many indices were developed to estimate the chlorophyll content of the leaves. These chlorophyll indices are used for calculating the total chlorophyll content of the leaves.							
The reflectance values in the green band and the red-edge band sensitive to small variation in the chlorophyll content. The « red-edge » is an intermediary band between the red and the NIR band.							
For this reason, there are two main indices for chlorophyll content estimation							
Green Chlorophyll index « CI_Green » and red-edge Chlorophyll index (CI_Rededge)							
The formula of CI_Green is:							
$\mathbf{CI}_{\mathbf{Green}} = \frac{Red_{Edge}(730 nm)}{Green} - 1$							
The formula de CI_Rededge is:							
$Red_{Edae}(850 nm)$							
$CI\_Rededge = \frac{Red_{edge}(730 nm)}{Red_{edge}(730 nm)}$							
For Sentinel-2, Red-edge at 730nm corresponds to band B5, green band is band B3. Rededge band at 850nm is band B6. CI_green et CI_rededge is calculated as such : $\mathbf{CI}_\mathbf{Green} = \frac{B5}{B3} - 1$ $\mathbf{CI}_\mathbf{Rededge} = \frac{B6}{B5} - 1$							
<ul> <li>Launch QGIS</li> <li>In the menu, click on « Layers» [] « Add layer» [] « Add raster layer »</li> <li>Projet Editer Vue couche préférences Extensions Yecteur Baster Base de données Internet Ballage Traitement Aide</li> <li>Projet Editer Vue couche couche</li> <li>Créer une couche</li> <li>Ajouter une couche e des groupes</li> <li>Ajouter une couche e des groupes</li> <li>Ajouter une couche e des groupes</li> <li>Ajouter une couche de des groupes</li> <li>Ajouter une couche de des groupes</li> <li>Ajouter une couche de des groupes</li> <li>Ajouter une couche des groupes</li> <li>Ajouter une couche de texte délimité Ctrl+Maj+T</li> <li>Copier le style</li> <li>Copier le style</li> <li>Ajouter une couche de texte délimité Ctrl+Maj+T</li> <li>Curl+Maj+T</li> <li>Copier le style</li> <li>Alouter deus on and navigate to the folder with the S2 images (TP3\SENTINEL.2B_20200730-1111734-503_L2A_T30UXV_C_V2-2_FRE_B3.tiff »</li> <li>SENTINEL 2B_20200730-111734-503_L2A_T30UXV_C_V2-2_FRE_B3.tiff »</li> </ul>							

m. thus we will res	entinel-2 is at a ample B3 from	a resolution of 20 m n 10 m to 20 m befor	e calculating the index.	olution
Use the "Projection	(warp)" like in	n part 2.3 to resample	e the B3 band to a resolution of	f 20 m
Q Projection	(warp)		×	
Param	iètres Journal		8	
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SCR ci	ble [optionnel]			
Métho	de de ré-échantillon:	age à utiliser		
Plus p	roche voisin		•	
Valeur	Nodata pour les bar	ndes de sortie [optionnel]		
Non re Résolu	enseigné tion du fichier de so	rtie dans les unités de géoré	é férencement de la cible [optionnel]	
20.00	0000		ea  0	
Para Reproi	a <b>metres avances</b> eté			
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✓ Ouvr	ir le fichier en sortie	e après l'exécution de l'algorit	hme	
Consol	e GDAL/OGR			
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		00/	A	
		U%	Annuler	
Type the following ("SENTINEL2B 202")	formula: 00730-111734	-503_L2A T30UXV	/_C_V2-2_FRE_B5@1"/"B3_2	20m@:
<ul> <li>Type the following</li> <li>("SENTINEL2B_202"</li> <li>Save the output image</li> </ul>	formula: 00730-111734 nge as « ci_gre	503_L2A_T30UXV en_20200703.tif »	/_C_V2-2_FRE_B5@1"/"B3_2	20m@1
<ul> <li>Type the following</li> <li>("SENTINEL2B_202"</li> <li>Save the output ima</li> <li>Q Calculatrice Rest</li> </ul>	formula: 00730-111734 nge as « ci_gre «	503_L2A_T30UXV en_20200703.tif »	v_C_V2-2_FRE_B5@1"/"B3_2	20m@1
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#### 6. Calculate the biophysical parameters of the canopy using SNAP

**Objective:** Calculate the biophysical parameters such as the Leaf Area Index (LAI), The Canopy Water Content (CWC) and the leaf Chlorophyll content (Cab) using the program SNAP from ESA.

Steps	Manipulation sous SNAP								
1. Definition	LAI : Leaf Area In	dex							
	LAI is a measure of the total surface of leaves per unite of ground surface. It is directly related to the amount of light that is intercepted by the plant. It is an important valuable when estimating the potential of photosynthetic production, the evapotranspiration and when measuring crop growth.(LAI = surface of leaves / surface of ground, $m^2 / m^2$ )								
	LAI determines the and the atmosphere.	total interacti LAI is not lin	on area of th learly correla	ne plant (inclu nted with refle	ding with radiation) ctance.	between the canopy			
	The LAI can be dete total area of the parc	ermined direct el, but this me	ly by measur thod require	ring the leafy s a lot of time	area of a sample plot and resources, especi	then dividing by the ally for larger areas.			
	CAB: Canopy Chl	orophyll Con	tent:						
	The amount of chlo is directly linked to	rophyll is a ve the amount of	ery good indi Nitrogen in	cator of stress the cell (Houl	s, including Nitrogen lès et al. 2001).	deficiency. because			
	We can calculate th the area of the leave	e amount chlo s.	orophyll by	multiplying th	e amount of chloropl	hyll in the leaves by			
	Some studies have shown that this product could be of great interest for the models that estimate primary production because it estimates the efficiency of photosynthesis. (Green et al. 2003).								
	Canopy Water Content CWC:								
	Since NIR and Medium infrared radiation is absorbed significantly by water, Sentiel-2 allows us to access this variable because water is responsible for 60% to 80% of the total weight of plants.								
	The closest variable to the remote sensing signal is the weight of water per unit of ground (g.m <sup>-2</sup> ).								
	Since an issue of detecting water from remote sensing is the water moisture of the ground, The CWC index is used as a candidate to fix this in the Sentinel-2 product line-up.								
2. Formula in SNAP	ESA developed a tool "Biophysical Processor" for estimating the biophysical parameters of vegetation using Sentinel-2 data.								
		Acronym	Central	Width	Spatial				
		Do	(nm)	(nm)	resolution (m)				
		B3 B4	000	35	10	4			
		D4 	705	15	20	-			
		B6	740	15	20	4			
		B7	783	20	20	1			
		B8a	865	20	20	1			
		B11	1610	90	20	]			
	[	B12	2190	180	20	]			
	This tool is based of	n a neural net	work that uti	lizes the surfa	ace reflectance of Ser	ntinel-2 bands (level			
	2A) for estimating t	he biophysical	l parameters	of vegetation:	: LAI, CWC et Cab.				

	It also observ	uses the acquisi ation zenith and t	tion proprieties he relative azim	and the geometration that angle.	ry of the image, l	ike the solar zenith, th					
	The ou neural	utput will be gene network. Moreov	erated for each er, a quality flag	pixel. Including I g is also generated	LAI, Cab and CW l.	C values derived from					
		Product	Unit	Minimum	Maximum	resolution					
		LAI	mP <sup>2P</sup> .mP <sup>-</sup>	0	8.0	0.01					
		CCC	g/cm²	0	600	1					
		CWC	µg/cm²	0	0.55	0.0025					
3. Calculating the biophysical variables with SNAP	<ul> <li>Lat</li> <li>In to of</li> </ul>	unch SNAP by do the main Menu, ao TP1. ick on File [] Ope	uble-clicking th dd the recently o n Product [] Go	the icon calibrated S2 imag the file directory .	ge at level2A using	Sen2cor, in the section					
	<ul> <li>Click on File II Open Product II Go the file directory .SAFE the result of the calibration of the S2 image(\TP3\ESA_SENTINEL-2) I select the file « MTD_MSIL2A.xml »</li> <li>Calculating the biophysical variables in SNAP requires that all the S2 band have the same resolution. Since we have images that have a spatial resolution of 10 m and other at 20 m, we need to mean the file with the images (a) of the same resolution.</li> </ul>										
	> Th	<ul> <li>Thus, we will do two steps :</li> <li>1. Resampling of all the bands to the same resolution (20m)</li> <li>2. Calculating biophysical variables</li> </ul>									
	1. Re: ✓ ✓	sampling of all the Open « S2Resar SNAP File Edit View Product Explore Select the entry In « Processing	e bands to the sa nple Processor Analysis Layer Vector F C 2 2 2 2 2 er × Pixel Info	ame resolution: » : click on Optical Raster Optical Radar Tools Spectral Unmixin Geometric Preprocessing Thematic Land Pl Thematic Water F dded in the previou	al 🛛 Geomteric 🖓 S2 Window Help	Resampling Processor					
		<ul> <li>Output :</li> <li>Upsamp</li> <li>Downsa</li> <li>Flag do</li> </ul>	resolution : 20 bling Method : N umpling Method wnsampling Method	Nearest I : Mean ethod: First							

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J	The processing needs some time (environ 20 min) for each image	
2. 0	Calculating the biophysical variables:	
	_	
<b>`</b>	✓ Open « S2Resample Processor » : Click on Optical □Thematic Land Processing	
	Biophysical Processor Biophysical Processor S2	

Product Explorer × Pixel Info	Geometric > Preprocessing > Thematic Land Processing > Thematic Water Processing >	Biophysical Processor (LAI, fAPAR) Soil Radiometric Indices Vegetation Radiometric Indices Water Radiometric Indices MERIS/(A)ATSR SMAC Atmospheric Correction Forest Cover Change Processor	Biophysical Processe     Biophysical Processe     Biophysical Processe
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	Biophysical Processor S2
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Visualization of	➢ When « Biophysical Processor S2 » is done and (LAI, CAB et CWC) are calculated, the result will
the three indices	be added to the table of contents (Product Explorer, on the right) in SNAP
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	In « Product Explorer » double click the product « S2B_MSII 2A_20200730T110619_N9999_R137_T30UXV_20201115T224205_s2resampled
	_biophysical.data
	Next, double click on « Bands »
	In this folder, you will find the three outputs
	✓ Lai : LAI estimation image
	✓ lai_cab : CAB estimation image
	$\checkmark$ lai cw : CWC estimation image

