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Practical session

Optical agriculture

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8th ESA Training Course on Radar and Optical Remote Sensing, 5 - 9 September, 2016 European Space Agency

Sentinel-2 data set for the exercise Sea



Sentinel-2 data set for the exercise Sea



1. Explore the image reflectances Cesa

- Open Quantum GIS Desktop
- From /01_Exploration/, load S2A_L2A_35UQR_20160617_10M.TIF (R-G-B-NIR)





Display Surface reflectance image in the esa background

These icons allow you to explore the product easily



Explore the spectral profile



- Install Value Tool Plugin (Plugins > Manage and Install Plugins)
- From /01_Exploration/, load each band image and class them by order.
- Select the band of interest
- Explore the diversity of spectral profiles by enabling the Graph function of *Value Tool* plugin



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Explore the image reflectances

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Compute a Vegetation Index



NDVI = (NIR band-Red band)/(NIR band+Red band)

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V				* / sin :	asin	
	SCP news				acos	
	Welcome to the Semi-Automatic Classification Plugin for QGIS Changelog				atan	
	-new interface			In n nodat		Sala lan T
	-new input file (extension .scp) which is a zip file contern -possibility to create multipart ROIs (pressing CTRL + mound)			Index calculation		
	-C ID is automatically incremented after saving a ROI -function to merge ROI polygons from table	Decision rules				Jacob Marin
	-new Land Cover Signature classification based on the range valu -new tab for the definition of range values for Land Cover Signa	Output raster				
	-new tab for FCA (Principal Components Analysis) of Band set -new tab for FCA (Principal Components Analysis) of Band set	Set NoData Value 0	Extent: Intersection 👗 Same a	as "Map extent"		
	-enhanced signature plot that allows for interactive definition -enhanced Band calc allowing for the use of variables "#BLUE#",	"#RED#", and "#NIR#" in expression	ns			
	-Band calc option to use custom file names for multiple expression -in Band calc added Decision rules for calculating raster based of	on adding @fileName at the end of e on conditions (e.g. "raster1 >0" or	expression r multiple rule			
	-direct search of Landsat images from NASA CMR Search	projection and spectral signatures)	, csv, and ext		1 Maria	
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	Classification dock					
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2. Perform a land cover classification Cesa

- Open Quantum GIS Desktop
- Install Semi-Automatic Classification Plugin
- From the menu All, select the Semi-Automatic Classification Plugin and click the button Install plugin;



 The SCP should be automatically activated; however, be sure that the Semi-Automatic Classification Plugin is checked in the menu Installed (the restart of QGIS could be necessary to complete the SCPinstallation);





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Supervised Classification

A semi-automatic classification (more appropriately named **supervised classification**) is an image processing methods that allows for the identification of land type according to their spectral signatures. There are several kinds of classification algorithms, but the general purpose is to produce a thematic map of the land cover. SCP allows an interactive approach of the concept.



1. Load the input raster in SCP

02_Classification/S2A_L2A_35UQR_20160617_10M_Subset.tif

- 2. Create a new Training Input that will contain the ROIs
- 3. Create your Training Areas (ROIs)
- 4. Perfom the classification



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Your First Land Cover Classification Cesa

QGIS 2.8.3-Wie

3. Create your Training Areas (ROIs)

- In order to **create manually a ROI** inside the dark area, click the button in the Working toolbar (you can ignore a message about wavelength unit not provided). Left click on the map to define the ROI vertices and right click to define the last vertex closing the polygon. You create a orange semi-transparent polygon, which is a temporary polygon
- Region growing algorithm can be also used to delineate your polygon.
- It is required to define the Classes and Macroclasses for each polygon. Macroclasses can be defined in the Macroclasses tab.
- You can save each Training shapefile : Click the button Save ROI
- \rightarrow Create multiple polygon encompassing the diversity of landcover

Water bodies, bare soils, Crops, Build-up areas, Forests, grasslands















ROI nomenclature

SCP allows for the definition of Macroclass ID (i.e. MC ID) and Class ID (i.e. C ID), which are the identification codes of land cover classes.

A Macroclass is a group of ROIs having different Class ID, which is useful when one needs to classify materials that have different spectral signatures in the same land cover class.

Macroclass name	Macroclass ID	Class name	Class ID
Vegetation	1	Grass	1
Vegetation	1	Trees	2
Built-up	2	Road	3





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Your First Land Cover Classification Casa

More details and tutorials in the SCP manual (available in 00_Documentation)

4. Perform a classification

ROI Signature list	1				
S Type MC ID C ID C Info Color	٦				
1 🗶 B 1 1 Crop					
2 🗶 B 2 2 Water body					
3 🗙 B 2 3 Forest					
4 🗶 B 1 4 Road					
5 🕱 B 1 5 Build-up areas					
6 🕱 B 2 6 BareSoil					
7 🕱 B 1 7 Crop Type 2					
ROI creation					
Macroclasses					
Classification algorithm	1				
Use MC ID C ID					
Land Cover Signature Classification	I				
Use LCS Algorithm only overlap					
Classification output					

	S	F (MC ID	C ID	C Info	Color
1	×	в	1	1	Crop	
2	×	в	2	2	Water body	
3	×	в	2	3	Forest	
4	×	в	1	4	Road	
5	×	в	1	5	Build-up areas	
6	×	в	2	6	BareSoil	
7	×	в	1	7	Crop Type 2	
DI	creat	ion				
DI	creat	ion				
DI ac	creat roclas	ion sses tion alg	porithm			
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3. Sen2-Agri products exploration @esa



Vegetation status map at 20m delivered every 10 days (NDVI, LAI, pheno index)

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Sen2-Agri Product Types



Name	High-level Description	Production & Distribution
Level-1C	Top-of-atmosphere reflectance in cartographic geometry	Systematic generation and on-line distribution (ESA)
Level-2A	Bottom-of-atmosphere reflectance with snow, water, cloud and cloud shadow masks	Sentinel-2 for Agriculture system through MACCS algorithm (CNES)
Level-3A	Monthly composite product	Sentinel-2 for Agriculture System
Level-3B Level-3C Level-3D	Vegetation status map at 20m delivered every 10 days (NDVI, LAI, pheno index). Monodate – Multidate - Fitted	Sentinel-2 for Agriculture System
Level-4A	Dynamic binary map identifying annually cultivated land at 10m updated every month started from the middle of the season	Sentinel-2 for Agriculture System
Level-4B	Crop type map at 10m for the main regional crops including irrigated/rainfed discrimination	Sentinel-2 for Agriculture System

Sentinel-2 2016 time series over 35UQR tile in Ukraine





2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ __20160129.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR__ 20160418.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ __20160630.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ __20160218.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR____20160428.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ __20160717.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ 20160312.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ __20160521.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ _20160329.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ __20160610.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ __20160408.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ __20160617.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ __20160411.DBL



S2A_OPER_SSC_PDTQLK_L2VALD_35UQR_ __20160620.DBL





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Sampling strategy for crop Type and cropland mapping CESA







UCL



Structure of the in situ data set



Crop Mask (L4A)







CS

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Kilometers







Sources: In situ data collected by Space Research Institute of the National Academy of Science & State Space Agency, Ukraine





Product exploration and manipulation

Consult the Product sheets and the Product data structure summary



Let's explore the Cropland mask product





Display Surface reflectance image in the esa background

These icons allow you to explore the product easily



Set transparency to no crop pixels

esa



Check the quality indicator masks @esa



663654,5566173

Scale 1:490.700 💌 Rotation

📥 🕱 Render 🔘 EPSG:32635 🌒

Check the quality indicator masks @esa

*Select band 1 if you want to know the number of dates associated to the land status (i.e. without any cloud, water, snow or cloud shadow)



How many cloud free dates are used for the esa classification ?



🚖 🗶 Rende

How accurate is my cropland mask?

Have a look on the delivered quality metrics (QI_DATA > S2AGRI_L4A_QLT_....xml)



From \S2AGRI L4A PRD S01 20160825T194615 V20160129 20160717 \TILES \S2AGRI L4A V20160129 20160717 T35UQR \QI DATA

```
<CropMask xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
   <ConfusionMatrix>
       <ReferenceLabels>
           <RowLabel>0</RowLabel>
           <RowLabel>1</RowLabel>
       </ReferenceLabels>
       <ProducedLabels>
           <ColumnLabel>0</ColumnLabel>
           <ColumnLabel>1</ColumnLabel>
       </ProducedLabels>
       <Data>
           <Row>
                <Column>20445</Column>
                <Column>12</Column>
           </Row>
            <Row>
                <Column>6611</Column>
                <Column>94969</Column>
           </Row>
       </Data>
   </ConfusionMatrix>
   <QualityMetrics>
       <Precision class="0"> 0.755655</Precision>
       <Recall class="0"> 0.999413</Recall>
       <F-score class="0"> 0.860607</F-score>
       <Precision class="1"> 0.999874</Precision>
       <Recall class="1"> 0.934918</Recall>
       <F-score class="1"> 0.966306</F-score>
       <Kappa> 0.827716</Kappa>
       <Accuracy> 0.94573</Accuracy>
   </QualityMetrics>
</CropMask>
```

2/3 of the data set = calibration 1/3 of the data set = validation

Confusion matrix

Quality metric: Precision – Recall – F-Score – Kappa – OA





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1.1 Overall accuracy

The Overall Accuracy (OA) is calculated as the total number of correctly classified pixels (diagonal elements of the confusion matrix) divided by the total number of test pixels:

 $OA = \frac{\sum_{i=1}^{r} n_{ii}}{\sum_{i=1}^{r} \sum_{j=1}^{r} n_{ij}}$

1.1 F-Score

The F-Score (also known as F-1 score or F-measure) is the harmonic mean of the Precision and Recall and reaches its best value at 1 and worst score at 0:

$$FScore = 2x \frac{Precison * Recall}{Precision + Recall}$$

Precision or User's Accuracy (UA) for the class i it is the fraction of correctly classified pixels with regard to all pixels classified as this class i in the classified image:

$$UA_i = \sum_{j=1}^r \frac{n_{ii}}{n_{ij}}$$

Recall or Producer's Accuracy (PA) for the class i it is the fraction of correctly classified pixels with regard to all pixels of that ground truth class i:

$$PA_i = \sum_{j=1}^r \frac{n_{ii}}{n_{ji}}$$





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Crop Type (L4B)











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1. Introduction to the product



- Open and display a crop type image
- Assign a style

🏑 Propriétés de la couche - S2	AGRI_L4B_CT_V20130131	_20131231_TT0000 Transparen	ce	? 💌	(
Général	 Transparence globale 		 Aucune valeur de données 		
😽 Style	Aucun	0% Pempli	Valeur nulle : non défini		
Transparence	Aucun	o /o			
A Pyramides	 Options de transparent 	e personnalisée			
	Bande de transparence	nts		· ·	
	De Vers	Tran	sparence (%)		
Métadonnées					
	Style 🔻		OK Annuler Appliquer	Aide	
	Charger le style Enregistrer le style				
	Enregistrer comme défa	ut			
	Restaurer le style par de Aiouter	Load a	style		
	Renommer l'actuel				
	🗶 (défaut)			day and Optical	Domet
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- Set transparency to no crop pixels
- Visual analysis of the image
- Display monthly color composite image in the background
- Overlay ground data used for the calibration and validation: add TDS_35UQR.shp





How accurate is my Croptype map?

Have a look on the delivered quality metrics (QI_DATA > S2AGRI_L4B_QLT_....xmI)



<CropType xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"> <ConfusionMatrix> <ReferenceLabels> <RowLabel>11</RowLabel> <RowLabel>12</RowLabel> <RowLabel>72</RowLabel> <RowLabel>114</RowLabel> <RowLabel>225</RowLabel> <RowLabel>791</RowLabel> </ReferenceLabels> <ProducedLabels> <ColumnLabel>0</ColumnLabel> <ColumnLabel>11</ColumnLabel> <ColumnLabel>12</ColumnLabel> <ColumnLabel>72</ColumnLabel> <ColumnLabel>114</ColumnLabel> <ColumnLabel>225</ColumnLabel> <ColumnLabel>791</ColumnLabel> </ProducedLabels> <Data> - <Row> <Column>655</Column>

<?xml version="1.0" encoding="UTF-8"?>

<Column>17894</Column> <Column>0</Column> <Column>0</Column> <Column>167</Column> <Column>0</Column> <Column>5</Column> </Row>- <Row> <Column>0</Column> <Column>124</Column> <Column>466</Column> <Column>0</Column> <Column>0</Column> <Column>0</Column> <Column>0</Column> </Row> - <Row> <Column>11</Column> <Column>119</Column> <Column>13</Column> <Column>0</Column> <Column>4</Column> <Column>0</Column>

<Column>9</Column>

</Row>

Code of the crop (Jecam guidelines)

Confusion matrix

</ConfusionMatrix>

 <QualityMetrics> <Precision class="11"> 0.89287</Precision> <Recall class="11"> 0.990479</Recall> <F-score class="11"> 0.939145</F-score> <Precision class="12"> 0.968815</Precision> <Recall class="12"> 0.789831</Recall> <F-score class="12"> 0.870215</F-score> <Precision class="72"> 0</Precision> <Recall class="72"> 0</Recall> <F-score class="72"> 0</F-score> <Precision class="114"> 0.687956</Precision> <Recall class="114"> 0.167854</Recall> <F-score class="114"> 0.269864</F-score> <Precision class="225"> 1</Precision> <Recall class="225"> 1</Recall> <F-score class="225"> 1</F-score> <Precision class="791"> 0.935115</Precision> <Recall class="791"> 0.856643</Recall> <F-score class="791"> 0.894161</F-score> <Kappa> 0.480783</Kappa> <Accuracy> 0.890488</Accuracy> </QualityMetrics> </CropType>

Quality metric : Precision – Recall – F-Score – Kappa – OA





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2. Simple processing

2.1 Filtering of crop type image

Remove all patches below , for instance

Processing -> ToolBox -> GDAL/OGR -> Sieve

Input Layer: the crop type image

Threshold: 25 (the minimum size if the patches to be kept) = 25 pixels of 10x10 m = 0,25 hPixel connection: 8 (consider all neighbours of a pixel)

Compare to unfiltered crop type image

2.2 Create and display a single crop image

- Find the class number you wish to consider Raster-> Raster Calculator "S2AGRI L4B CT V20160129 20160717 T35UQR" = 12 12 is the number of the crop type class
- Define a style







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Crop type : Qgis processing

2.3 Group crops per categories

- Gather summer crops and winter crops in two classes
 - Creates a txt file
 - 12 14 41 438 = 1 (summer crops are grouped under class #1)
 - 11 15 77 11 435 =2 (winter crops are grouped under class #2)
 - = 3 (other classes are grouper under class #3)

```
    Processing -> ToolBox -> GRASS -> Raster -> r.reclass
    Set a style
```

OR Gather potentially irrigated crops

```
o Creates a txt file
```

- 12 41 = 1 (maize and soybean crops are grouped under class #1)
- * = NULL (other classes as no data)
- o Processing -> ToolBox -> GRASS -> Raster -> r.reclass
- \circ Set a style



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Vegetation Status

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Display the LAI monodate (SLAIMONO) (1) 1. Add the LAI .TIF product from TILES>IMG_DATA>S2AGRI_L3B_SLAIMONO..... TIC esa



Display the LAI monodate (SLAIMONO) (2)

🌠 Propriétés de la couche	- \$2AGRI_L3B_SLAIMONO_A20160328_T35JNK Style	🌠 Load layer properties from style file	
X Général	Rendu par bande	🕞 🔵 🗣 🎉 « 00_Sen2Agri 🕨 Seminars_and_meetings 🕨 30_ESA_Training 🕨	TrainingESA 🔸 Legend_Fil
😻 Style	Type de rendu Bande grise unique	Organiser Nouveau dossier	
Iransparence Pyramides Histogramme Métadonnées	Bande grise Bande 1 (Gray) Charger les valeurs min/max Bornes d'exclusion Min / max Moyenne +/- écart-type × 2,00 + Amélioration Ettrer jusqu'au MinMax Emprise Précision Précision Bornes d'exclusion Bornes d'exclusion	WP4400_PVAR Nom 03_SystemOperationel QIDATA_FLAG_LAND_transparent.qml 00_ProduitBenchmarkini styleCropType.qml cropland_masks_Sen2Ag styleLAI.qml	Modifié le T 23/08/2016 15:23 F 22/04/2016 12:47 F 27/04/2016 10:16 F
		CCN2_CzechAgri	LAI value
sent	Style Charger le style Enregistrer le style Enregistrer le style par défaut Restaurer le style par défaut Ajouter Renommer l'actuel Reformer l'actuel Reformer l'actuel	SZAGRI L3B SLAIMONO A20160328 T35JNK 0.000000 250.000000 500.000000 2000.000000 5000.000000	- 0.5 - 0.25

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QGIS 2.8.3-Wien

Project Edit View Layer Settings Plugins Vector Raster Database Web Processing RasterStats SCP Help



Lets continue exploring

1. Display the corresponding L2A images

2. Display le QI « MLAIERR » giving you the error on the LAI estimation for each pixel

- > 0 : the model over-estimate the real value
- < 0 : the model under-estimate the real value

3. Display the **NDVI** product



Cloud free composite

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Let's explore the monthly cloud composite

- 1. Explore the folders of the product to be more familiar with the structure and the available information
- 2. Open the L3A products over one tile
 - a. Display a true color composite (bande 3-2-1) and/or
 - b. Display a false color composite (bande 4-3-2)
- 3. Open the **QI** « **MFLG** » allowing to identify the final status of the pixel over the period.
- 4. Open the **xml** « Image Processing Parameters » (*AUX_DATA > S2AGRI_L3A_IPP_*) Typically using NotePad++, Internet Explorer, Google Chrome or Firefox.
 - Look at the information about the L2A products used the generate the composite
 - Display one or two L2A images
- 5. Afficher le **QI « MDAT »** qui donne la moyenne des dates utilisées pour chaque pixel





Display the Monthly composite (1)

1. Add the L3A .TIF product from TILES>IMG_DATA>S2AGRI_L3A_SRFL... .TIF





Display the Monthly composite (2)



3. Go to *Transparency* property to set the -10000 value as transparent > Click Apply

🧭 Propriétés de la couche - S2A	.GRI_L3A_SR	FL_V20160	323_T35JNK_10M Transparence		? 🗙
🔆 Général 💙	 Transpare Transpare Aucun 	nce globale	0% Rempli	Aucune valeur de données Valeur nulle : non défini Valeur nulle supplémentale -10000	
Transparence Transparence Pyramides Instance	Options de Bande de tra Liste des pix	e transparer ansparence els transpar	Aucun		
Métadornées	Rouge V	art Blue		Transparence (%)	
	Style 🔹		[OK Annuler Appliquer	Aide

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4. Go back to style property to improve the color stretching by clicking on the *Load* option

Propriétés de la couche - S	RI_L3A_SRFL_V20160323_T35JNK_10M Style
Général	Rendu par bande
🖍 Style	ype de rendu Couleur à bandes multiples 🔹
Transparence	nde rouge Bande 4
Pyramides	Min/max 176 413 ● Bornes d'exclusion 2,0 🜩 - 98,0 🜩 %
Histogramme	ande verte Bande 3 💌 Min / max
Miledon in	Min/max 28 196 Moyenne +/- écart-type × 2,00 🖨
Metadonnees	ande bleue Bande 2
	Min/max 38 133 O Complète Estimée (plus rapide)
	nélioration Étirer jusqu'au MinMax
	Rendu de la couleur ode de fusion Normal
	minosité 0 🔷 Contraste 0 🗣
	aturation Dégradé de Gris Off
	inte Coloriser Force Coloriser
	Ré-échantillonage
	-Maishan Balatta
	yle 🔻 OK Annuler Appliquer Aide

Display the flag mask(QI>MFLG)



5289-Wien	
Éditer Vue Couche Préférences Extension Vecteur Raster Base de données Internet Traite	ement Ajde
	א 😂 🔍 🔍 - 🔣 - 👡 🖏 🗐 🖾 🖬 - 🖵 😘 🗂 🔟 - 📔 א?
	🆷 🖂 🍓
Parconit Image: Control of Cont	couche - S2AGRI_L3A_MFLG_V20160323_T35JNK_10M Style Rendu par bande Type de rendu Bande grise Bande 1 (Gray) Graduation de couleur Noir vers blanc Min 0 Max 4 Max 6 three jusqu'au MinMax Emprise Précision Complète Réelle (plus lente) Charger
Layer value 1 SZAGRI_ISA_IMF 4.0 2 SZAGRI_ISA_SR -10000.0 3 SZAGRI_ISA_SR -10000.0 4 SZAGRI_ISA_SR -10000.0 5 SZAGRI_ISA_SR -10000.0	▼ Rendu de la couleur Mode de fusion Normal Luminosité 0 ◆ Contraste 0 ◆ Dégradé de Gris Off Teinte Coloriser ▼ Ré-échantillonage Zoom avant Plus proche voisin ▼ arrière Plus proche voisin ▼ Suréchantillonnage 2,00 ◆
Coordinate: (501740.943396, 6991946.273585)	Ministura I ánnada Dalatta V

Indicates the status of the

<u>pixel</u>

- 0 = No data
- 1 = Cloud or cloud shadow
- 2 = Snow
- 3 = Water
- 4 = Land valid pixel





What are the L2A acquisitions used to generate this cloud free composite ?



Information contains in the Image Processing Parameters .xml file



AUX DATA > S2AGRI_L3A_IPP_V20160323.xml ---- Internet Explorer, Google

Easy to open/visualize with Chrome, Firefox, NotePad++,...

🖹 C:\Users\nbellemans\Desktop\S2AGRI_L3A_PRD_S3_20160510T110604_V20160323\AUX_E 🔎 🛪 🖒 🛛 🧟 C:\Users\nbellemans\Deskt... > <?xml version="1.0"?> <metadata> <General:

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Display the date mask(QI>MDAT)





Indicates the weighted average of the dates used for each pixel Here :

- 83 = 2016-03-23 = central date

Pixel value < 83 = higher weight for the dates before the central date
Pixel value > 83 = higher weight for the dates after the central date

Value tool plugin allows displaying in a table or plot the values from the visible raster layers at the current mouse position

9 September, 2016