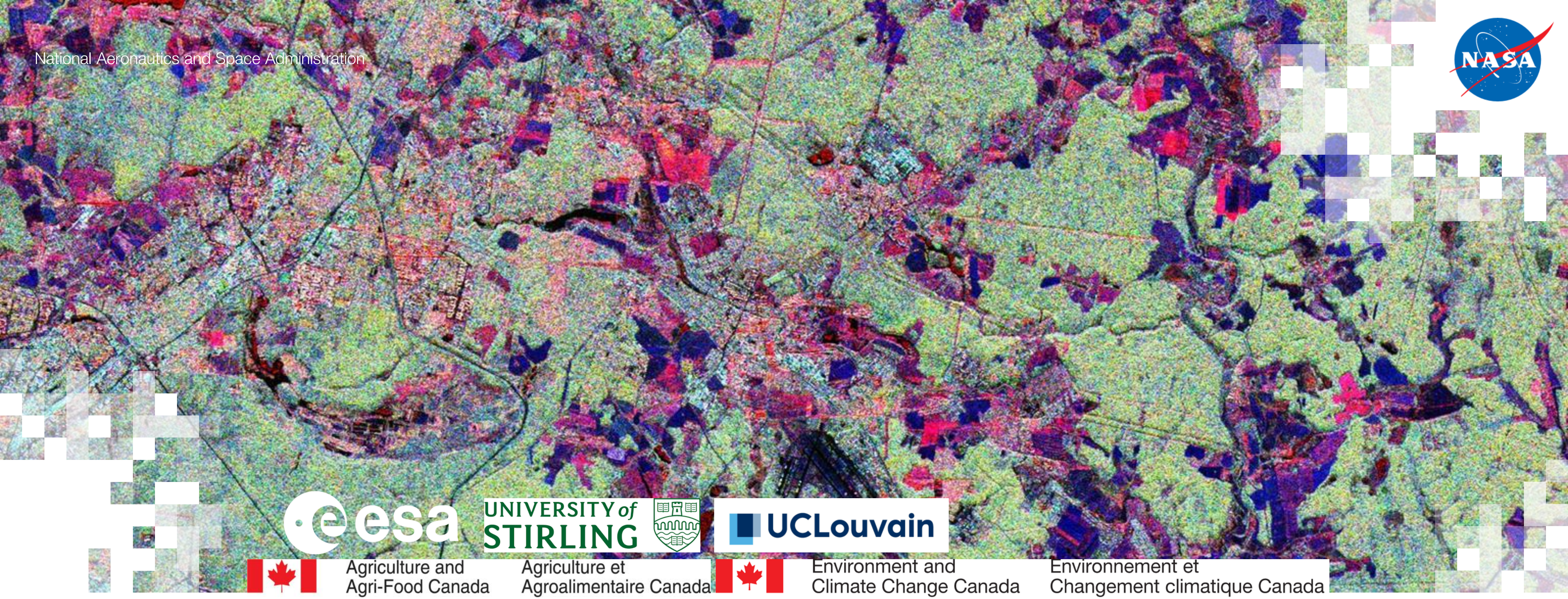
National Aeronautics and Space Administration



Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

Environment and Climate Change Canada / Environnement et Changement climatique Canada

Mapping Crops and their Biophysical Characteristics with Polarimetric Synthetic Aperture Radar and Optical Remote Sensing

Part 2: Polarimetry Practical – SAR Polarimetry with Sentinel-1, RCM, & SAOCOM Imagery for Agriculture

19 April 2022

Training Outline

April 12, 2022

SAR Polarimetry for Agriculture (Theory and Practice)

April 19, 2022

Polarimetry Practical Part 2: SAR Polarimetry with Sentinel-1, RCM, & SAOCOM Imagery for Agriculture

April 26, 2022

Sen4Stat Open-Source Toolbox (Theory and Practical)

May 1, 2022

Crop-Specific Time Series Analysis for Growth Monitoring

Homework and Certificate

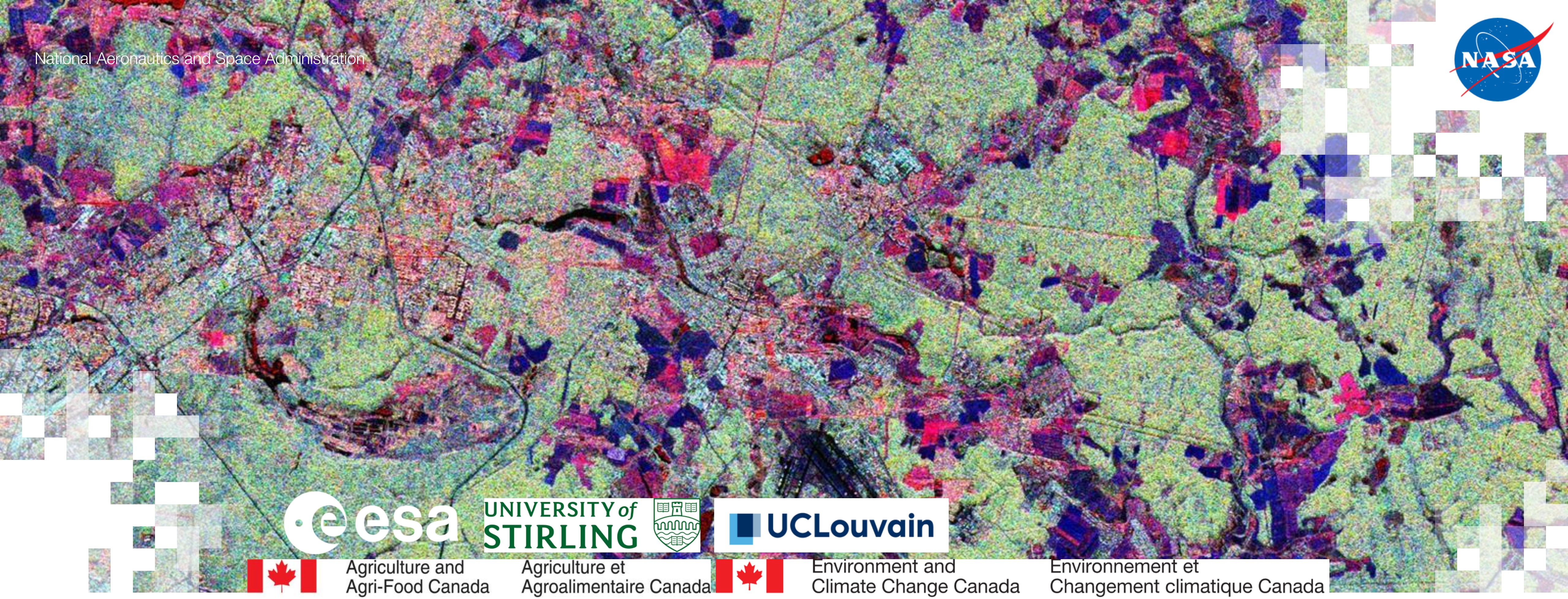
- Homework Assignment:
  - Answers must be submitted via Google Form
  - Due Date: May 17, 2022
- A certificate of completion will be awarded to those who:
  - Attend all live webinars
  - Complete the homework assignment by the deadline (access from website)
  - You will receive a certificate approximately two months after the completion of the course from: marines.martins@ssaihq.com

Training Objectives

By the end of this training attendees will be able to:

- Explain the theory behind SAR Polarimetry, especially as related to crop characteristics
- Generate polarimetric parameters using open-source imagery/software and perform a time series analysis of crop growth
- Identify how Sen4Stat can support National Statistical Offices in the uptake of satellite Earth observations for agricultural statistics
- Perform a time series analysis of crop types using Sentinel-2 derived LAI index

National Aeronautics and Space Administration



Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

Environment and Climate Change Canada / Environnement et Changement climatique Canada

Polarimetry Practical: SAR Polarimetry with Sentinel-1

Laura Dingle Robertson, Heather McNairn, Sarah Banks, Xianfeng Jiao

19 April 2022

Polarimetry with Sentinel-1 Single Look Complex (SLC) Data

- Polarimetry allows for the use of phase and creates "richer" information than just intensity alone.
- Sentinel-1 dual-pol (VV, VH) SLC data can be stored in a 2x2 covariance matrix [C2].
  - uses the full available signal bandwidth, and
  - phase is preserved and each pixel consists of both a real and imaginary component
- Using the 2x2 covariance matrix [C2] we can derive scattering parameters that are similar to fully polarimetric or compact polarimetric parameters.

‘Pseudo’ Polarimetric Parameters

Stokes parameters (S_0, S_1, S_2, S_3)	A set of values that describe the partial polarization state of an electromagnetic wave	$S_0 = \|E_H\|^2 + \|E_V\|^2$ $S_1 = \|E_H\|^2 - \|E_V\|^2$ $S_2 = 2\|E_H\|\|E_V\| \cos \emptyset_{HV}$ $S_3 = 2\|E_H\|\|E_V\| \sin \emptyset_{HV}$
Orientation angle (ψ)	The orientation of the linear polarization with the strongest backscatter	$\psi = \frac{1}{2}\tan^{-1}\frac{S_2}{S_1}$
Ellipticity angle (χ)	The ellipticity of the scattered wave	$\chi = \frac{1}{2}\tan^{-1}\frac{S_3}{\sqrt{S_1^2 + S_2^2}}$
Degree of linear polarization (DoLP)	The degree of linear polarization components in the polarized scattering	$DoLP = \frac{\sqrt{S_1^2 + S_2^2}}{\sqrt{S_1^2 + S_2^2 + S_3^2}}$
Linear polarization ratio (LPR)	The ratio of VH and VV intensities	$LPR = \frac{S_0 - S_1}{S_0 + S_1}$
Span (I)	Total intensity (VH+VV), expressed in power	
Eigenvalues (l_1)	Eigenvalues of the coherency matrix	$l_1 = \frac{1}{2}(S_0 + mS_0)$
Eigenvalues (l_2)	Eigenvalues of the coherency matrix	$l_2 = \frac{1}{2}(S_0 - mS_0)$
Entropy (H)	The degree of randomness of scattering	See Cloude, et al. 2012 https://www.researchgate.net/publication/260622729_Compact_Decomposition_Theory
Alpha ($\bar{\alpha}$)	The dominant scattering mechanism (in degrees)	See Cloude, et al. 2012 https://www.researchgate.net/publication/260622729_Compact_Decomposition_Theory
Normalized Shannon Entropy (SE)	The sum of total backscatter power and the Barakat degree of polarization, normalized to between 0 and 1	See Réfrégier and Morio 2006 https://www.researchgate.net/publication/6692148_Shannon_entropy_of_partially_polarized_and_partially_coherent_light_with_Gaussian_fluctuations

Stokes Parameters

- Describes the scattering from a partially polarized electromagnetic (EM) field.
- Contains all the polarimetric information to describe scattering from a target.

$$S_0 = |E_H|^2 + |E_V|^2$$
$$S_1 = |E_H|^2 - |E_V|^2$$
$$S_2 = 2|E_H||E_V| \cos \emptyset_{HV}$$
$$S_3 = 2|E_H||E_V| \sin \emptyset_{HV}$$

where $|E|$ is the amplitude of the intensity and ϕ_{HV} is the phase difference between H and V. All four stokes parameters are real numbers.

- first Stokes vector parameter (S_0) indicates the total intensity of the radar backscatter (polarized and unpolarized), which is the sum of the powers of the two orthogonally-polarized received waves.
- other three parameters (S_1, S_2, and S_3) describe the properties of the polarized portion of the EM field.

Degree of Linear Polarization (DoLP)

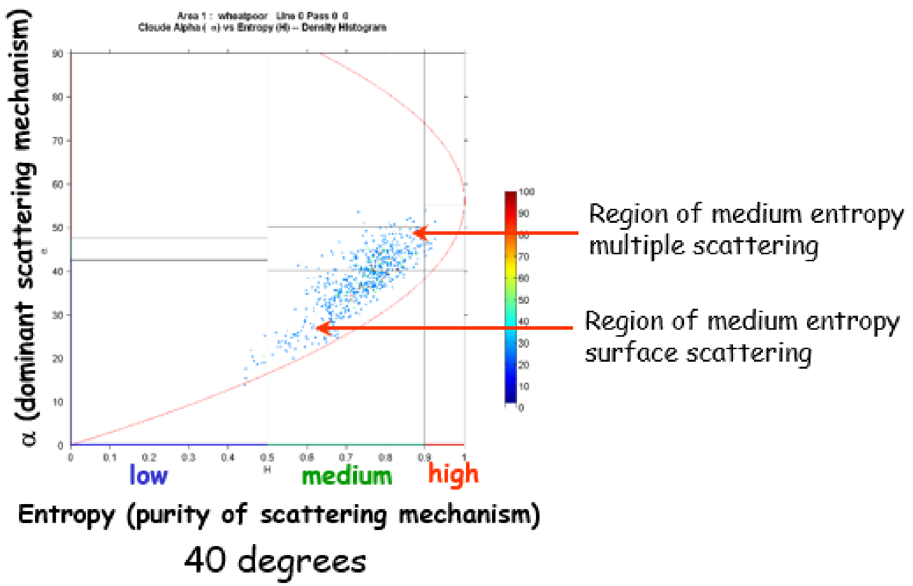
- The wave incident upon the target arrives completely polarized.
- If the target is composed of elements with varying orientations (e.g., leaves, stalks, flowers, etc.) the waves scattered by these individual elements will vary in phase and polarization.
- DoLP measures the percentage of the polarized energy, which is linearly polarized.
- DoLP is low where scattering is dominated by circularly polarized waves and approaches one when scattered waves are linearly polarized (regardless of orientation angle).
- This is based on Stokes and is measured as:

$$DoLP = \frac{\sqrt{S_1^2 + S_2^2}}{\sqrt{S_1^2 + S_2^2 + S_3^2}}$$

Entropy / Alpha

- Cloude et al. (2012), Cloude(2007) developed a dual-polarized version of the fully polarimetric H/a/alpha decomposition method, which only includes entropy & alpha.
- Extends the idea of alpha as an indicator of the dominant scattering type (e.g., multiple/volume scatterer, single bounce/surface scatterer, and double bounce scatterer), in general:
  - single scatterers will have lower alpha and alpha will increase as biomass increases (indicating a change from dominant surface scattering to multiple and double bounce scattering).
  - keep in mind that how a wave scatters also depends on the incidence angle; both alpha and entropy will change with changing incidence angle.

Wheat



Entropy

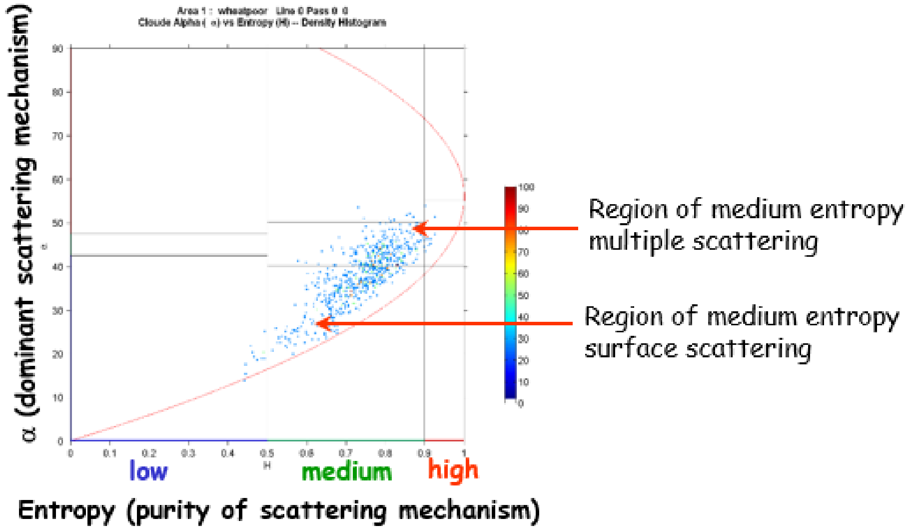
Incidence Angle	Low Biomass	Higher Biomass
25	0.40	0.51
36	0.63	0.69
40	0.74	0.76
45	0.80	0.80

Courtesy: H. McNairn

Entropy / Alpha

- Extends idea of entropy from fully polarimetric decomposition as a measure of the complexity and/or uniformity of the target.
  - On a bare, smooth field the polarization of the scattered wave will be predictable from location to location; alpha will indicate a dominance of single bounce scattering and entropy will remain low.
  - As vegetation cover increases, the polarization of the scattered wave becomes less predictable, and entropy will increase.

Wheat



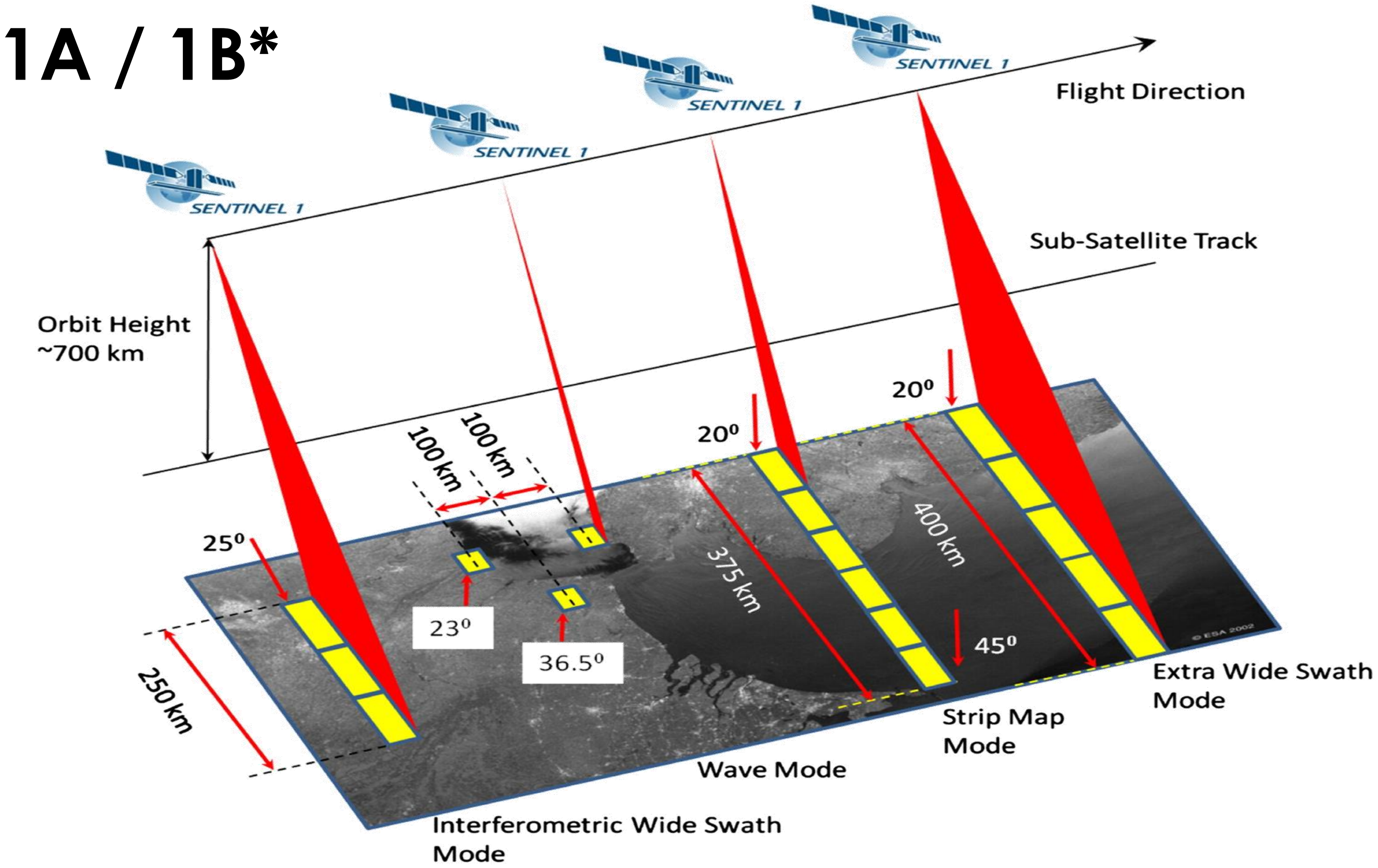
40 degrees

Entropy

Incidence Angle	Low Biomass	Higher Biomass
25	0.40	0.51
36	0.63	0.69
40	0.74	0.76
45	0.80	0.80

Courtesy: H. McNairn

Sentinel-1A / 1B*



Overview of the Sentinel-1 scanning modes – Revisit time: 6 days

*Sentinel 1B malfunctioned in December 2021 and has not been acquiring imagery since that date. ESA is working diligently to try and fix the issue. Sentinel 1A continues to collect imagery. See https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario/acquisition-segments for acquisition plans.
Thales Alenia Space is prime contractor for Sentinel-1C and its twin Sentinel-1 D. Airbus Defence and Space is responsible for both radars. **Expected launch of Sentinel 1C is 2023** (as of April 2022).

Image Source: https://sentinel.esa.int/web/sentinel/missions/sentinel-1/instrument-payload

Sentinel-1 Image Modes and Products

Acq. Mode	Product Type	Resolution Class	Resolution Rng x Azi [m]	Pixel Spacing Rng x Azi [m]	Num Looks Rng x Azi
SM	SLC		1.7x4.3 to 3.6x4.9	1.5x3.6 to 3.1x4.1	1x1
	GRD	FR	9x9	3.5x3.5	2x2
		HR	23x23	10x10	6x6
		MR	84x84	40x40	22x22
IW	SLC		2.7x22 to 3.5x22	2.3x14.1	1x1
	GRD	HR	20x22	10x10	5x1
		MR	88x87	40x40	22x5
EW	SLC		7.9x43 to 15x43	5.9x19.9	1x1
	GRD	HR	50x50	25x25	3x1
		MR	93x87	40x40	6x2
WV	SLC		2.0x4.8 3.1x4.8	1.7x4.1 2.7x4.1	1x1
	GRD	MR	52x51	25x25	13x13

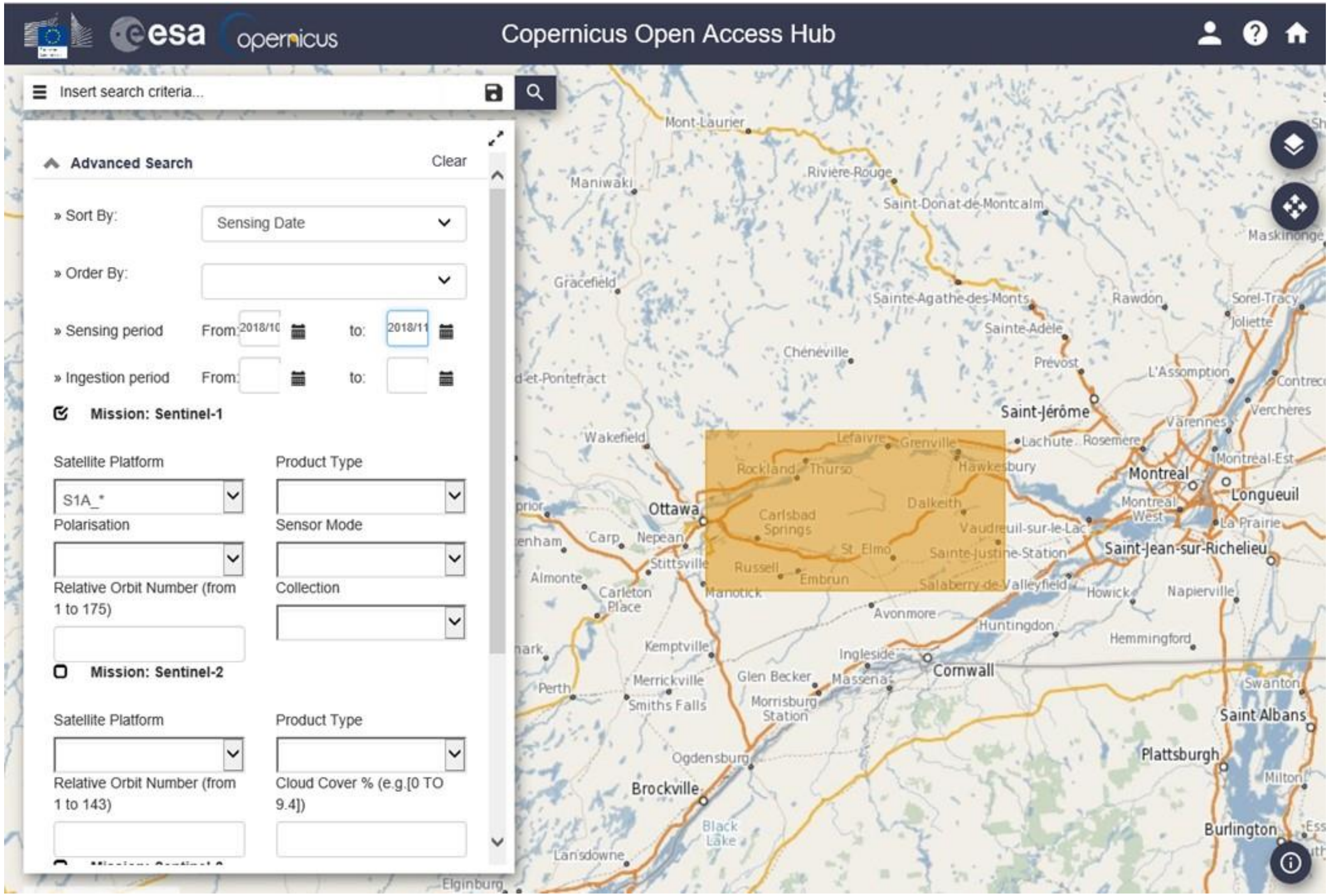
Sentinel-1 imaging modes

Product types

- **SLC – Single Look Complex: Slant range Single Look Complex product**
- GRD – Ground Range Detected: Ground range multi-looked that can be in one of three resolutions: Full Resolution (FR), High Resolution (HR), and Medium Resolution (MR)

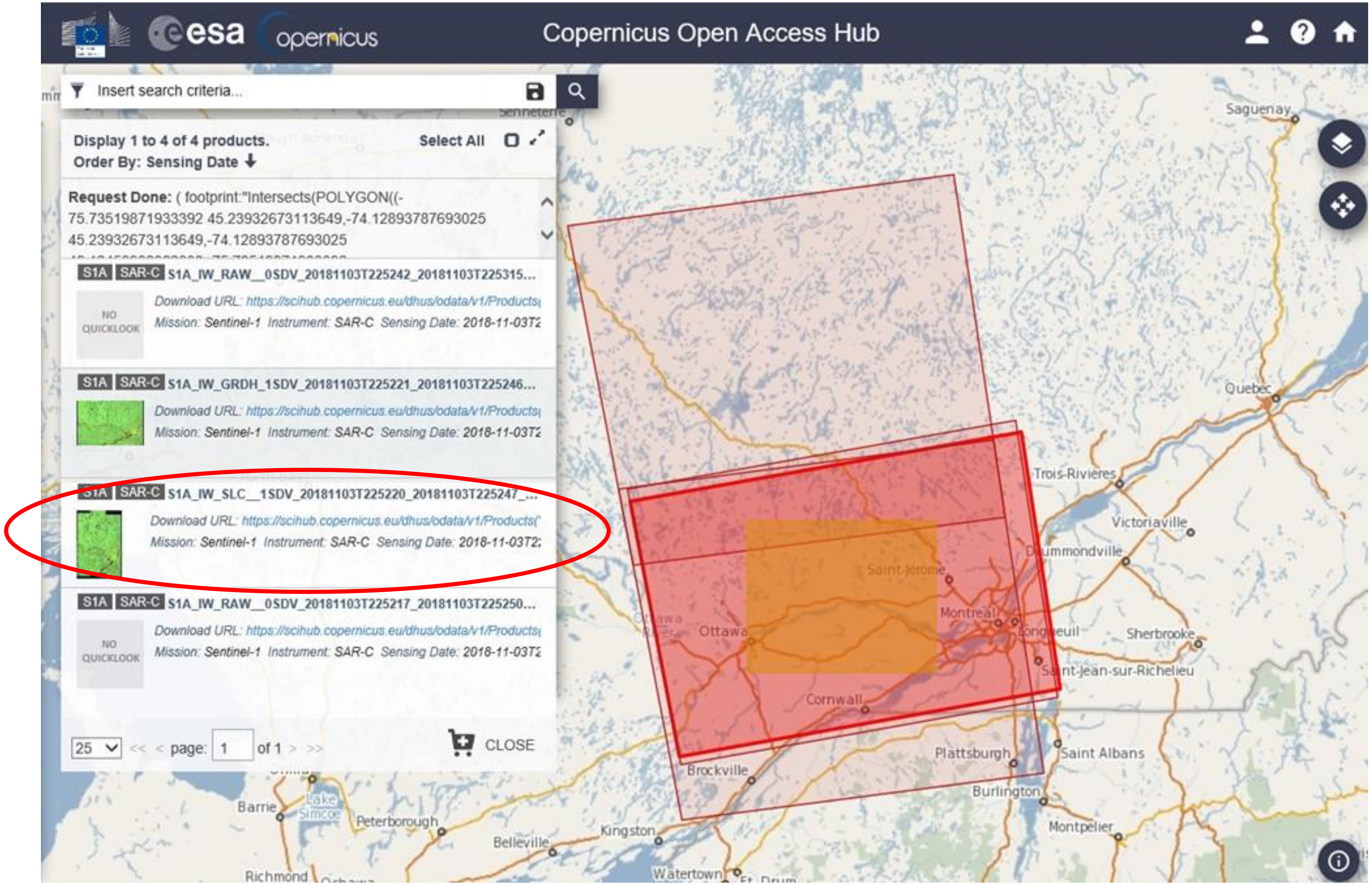
Image Source: https://earth.esa.int/web/sentinel/technical-guides/sentinel-1-sar/products-algorithms/level-1-algorithms/products

Sentinel-1 Data Access



https://scihub.copernicus.eu/dhus/#/home

Sentinel-1 Data Access



Alaska Satellite Facility Data Portal

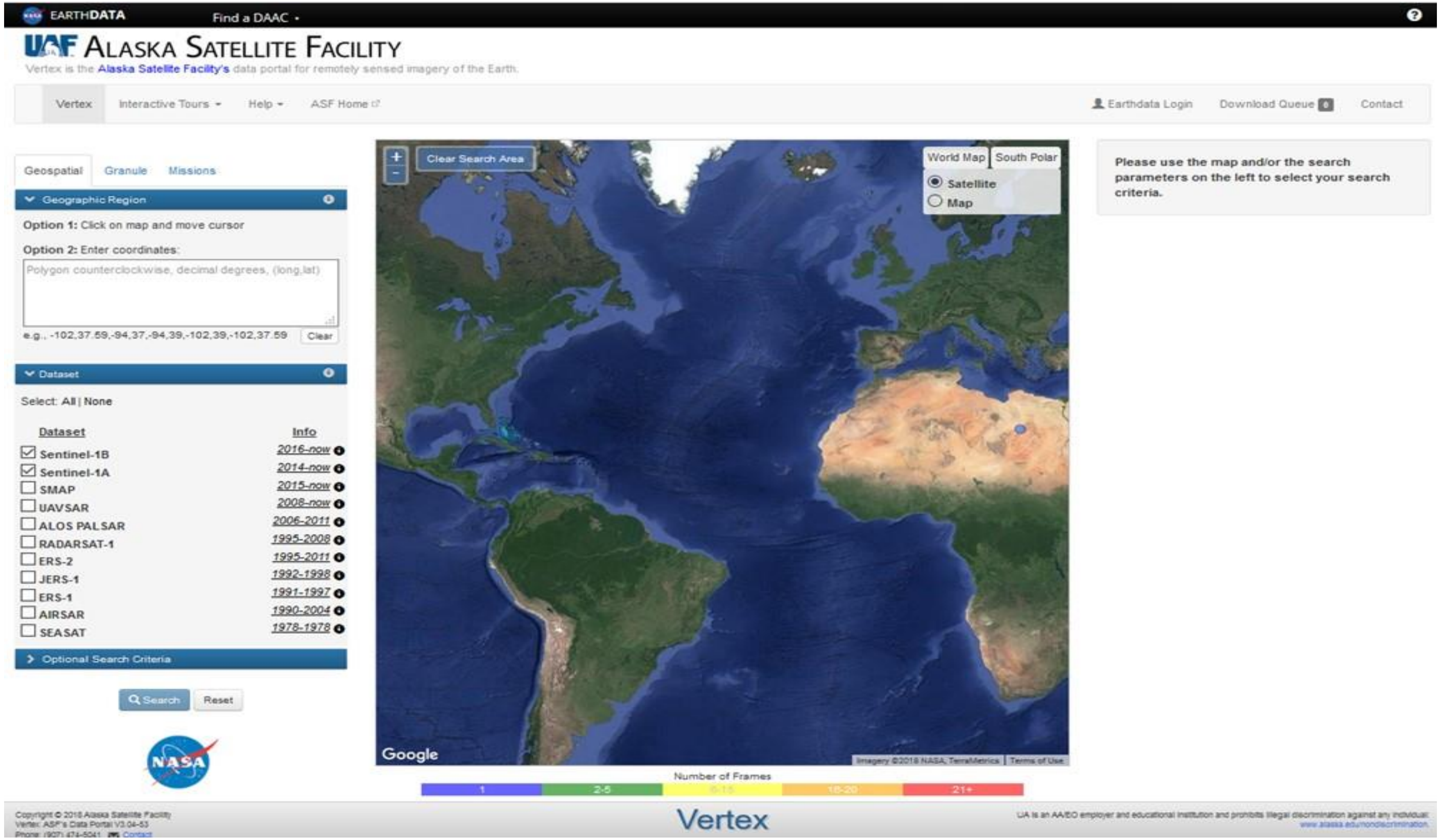
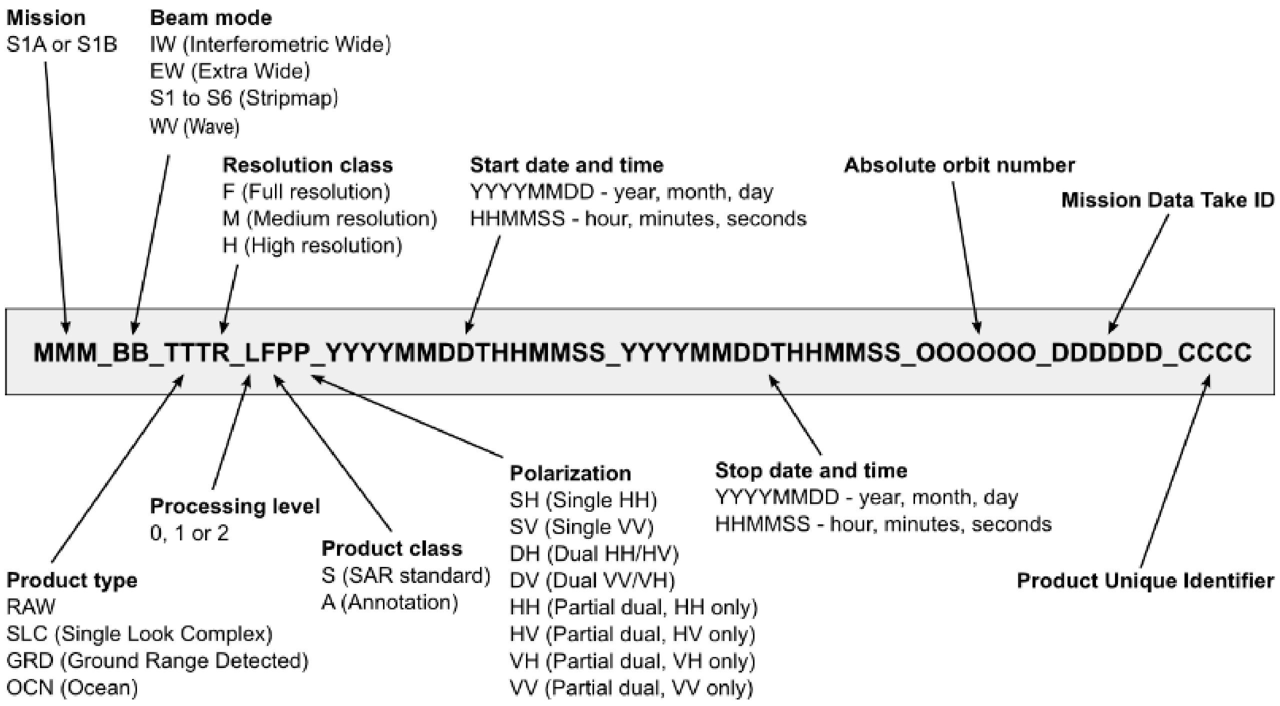


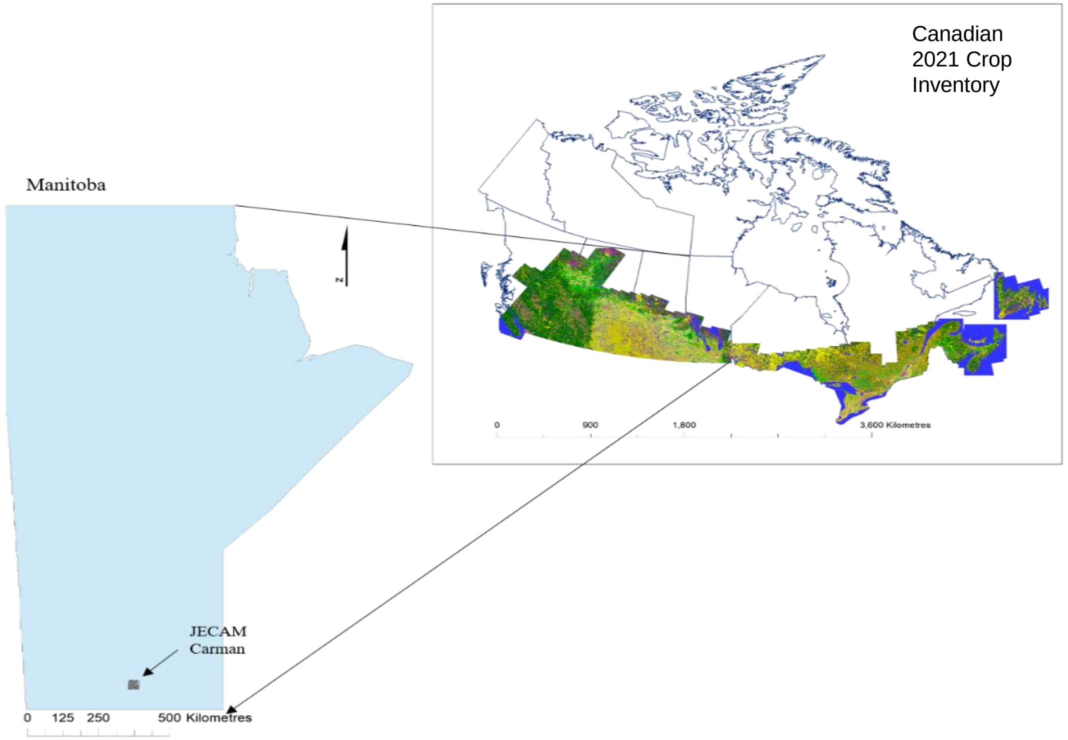
Image Source: https://vertex.daac.asf.alaska.edu/

Area of Interest

- July 9, 2020, image

S1B_IW_SLC__1SDV_20200709T002321_20200709T002348_022387_02A7D6_65BE





Sentinel-1SLC Image

Apply Orbit file

S1 TOPS Split

Radiometric Calibration (complex output)

S1 TOPS Deburst

S1 TOPS Merge

Polarimetric Speckle Filter

Terrain correction

Export C2 matrix to PolSARpro format & GeoTIFF/BigTIFF

Import C2 matrix to PolSARpro

Process : Extract parameters:
Matrix elements: C11, C22 and span
Stokes Parameters:
Stokes Components (S0, S1, S2, S3)
Orientation Angle
Ellipticity Angle
Eigenvalues l_1, l_2
Degree of Linear Polarization
Linear Polarization Ratio
H / Alpha Decomposition
Alpha
Entropy
Shannon Entropy

Convert PolSAR Output to Geotiff

SNAP

PolSARpro

Python

Generating C2 Matrix with SNAP

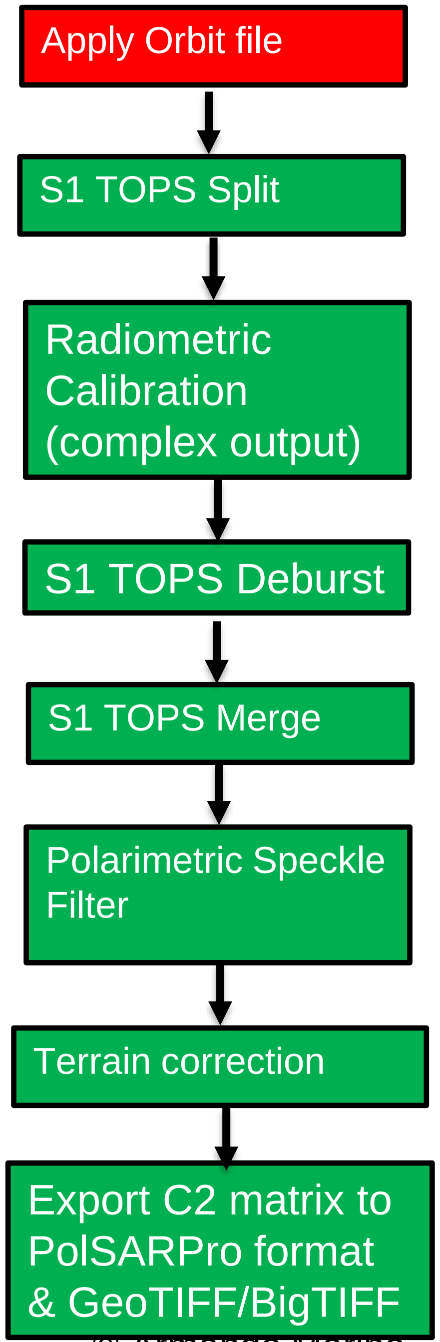
- Must use Single Look Complex (SLC) Sentinel-1

$$\mathbf{C}_2 = \begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix} = \begin{bmatrix} \langle |S_{VV}|^2 \rangle & \langle S_{VV} S_{VH}^* \rangle \\ \langle S_{VH} S_{VV}^* \rangle & \langle |S_{VH}|^2 \rangle \end{bmatrix}$$

- First step to create pseudo polarimetric parameters is generating **[C2]** 2x2 Covariance Matrix using ESA's SNAP
- Issues with generating S1 polarimetric parameters include the processing time and memory requirements
- Each interferometric wide swath consists of:
  - Three sub-swaths (IW1, IW2, and IW3) in the range direction.
    - Each sub-swath has 9 bursts in the azimuth direction

Apply Orbit File

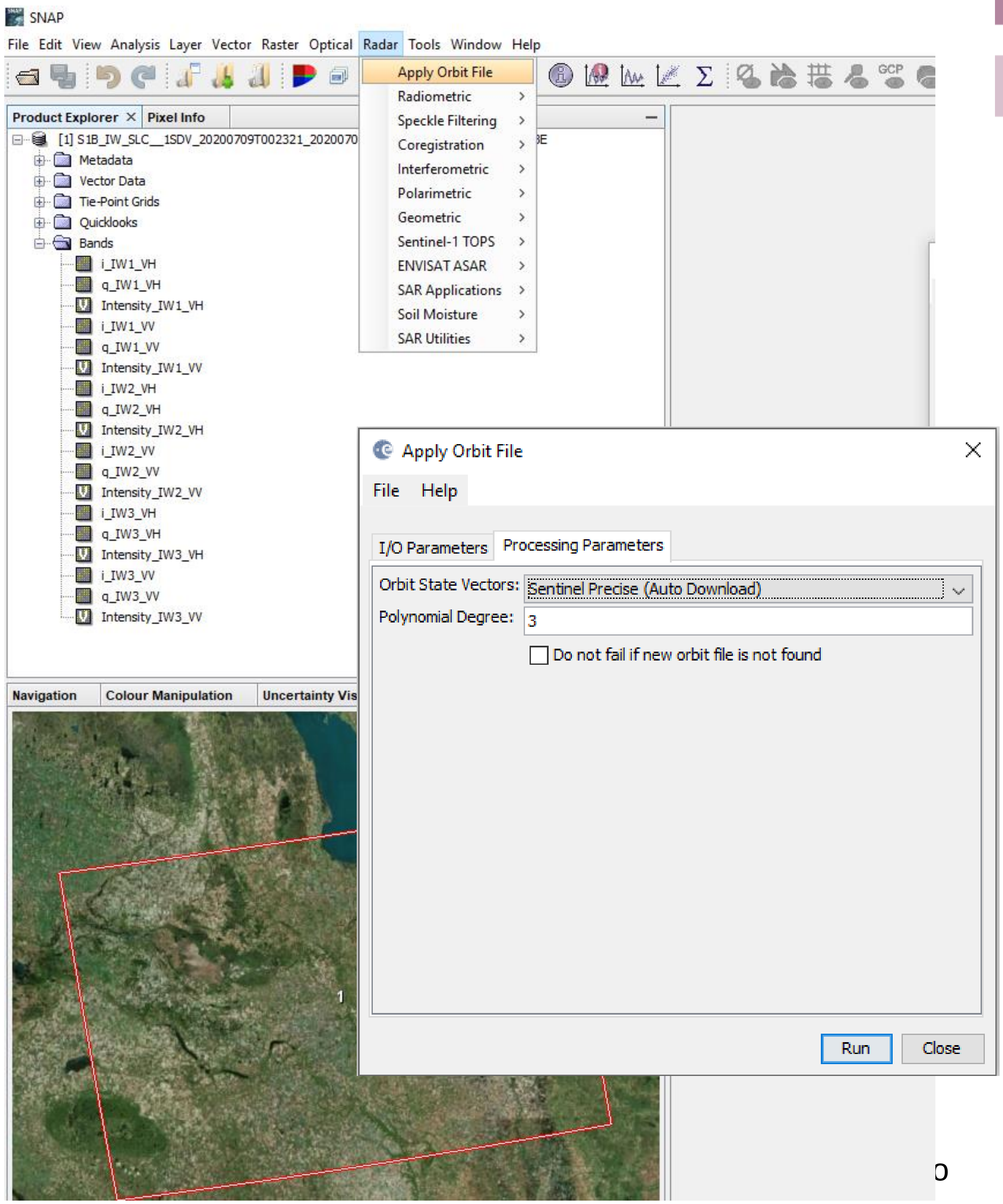
- Satellite positions are recorded by a Global Navigation Satellite System (GNSS).
- To assure a fast delivery of Sentinel-1 products, orbit information generated by an on-board navigation solution is stored within the Sentinel-1 Level-1 products.
- The orbit positions are later refined by the Copernicus Precise Orbit Determination (POD) Service.
- Precise orbit files have less than 5 cm accuracy and are delivered within 20 days after data acquisitions.
- The accuracy of restituted orbit files is less than 10 cm. The files are available 3 hours after data acquisitions.



Apply Orbit File

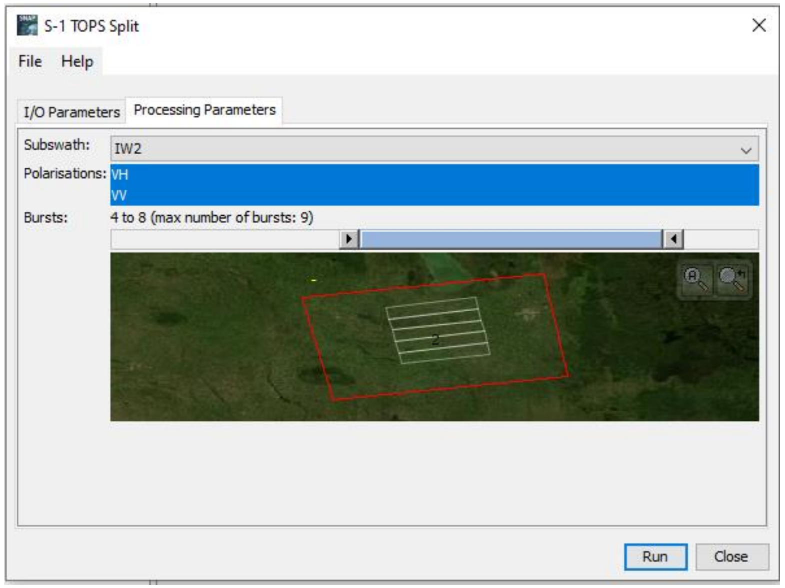
Go to Radar Menu → Apply Orbit File

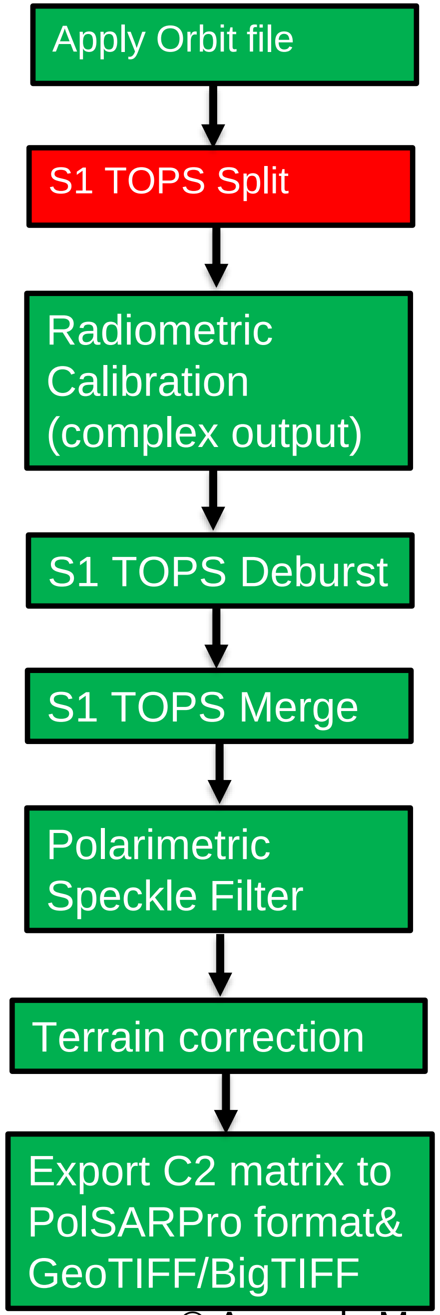
- I/O Parameters tab: source → Sentinel 1 SLC image + Target product
- Processing Parameters tab:
  - Orbit State Vectors: Sentinel Precise (Auto Download).
  - Polynomial Degree: 3
  - Click Run and Close window when completed



S1 TOPS Split

- TOPSAR Split operator splits each sub swath into selected bursts
- Limits the amount of data to process, reducing processing time and memory requirements

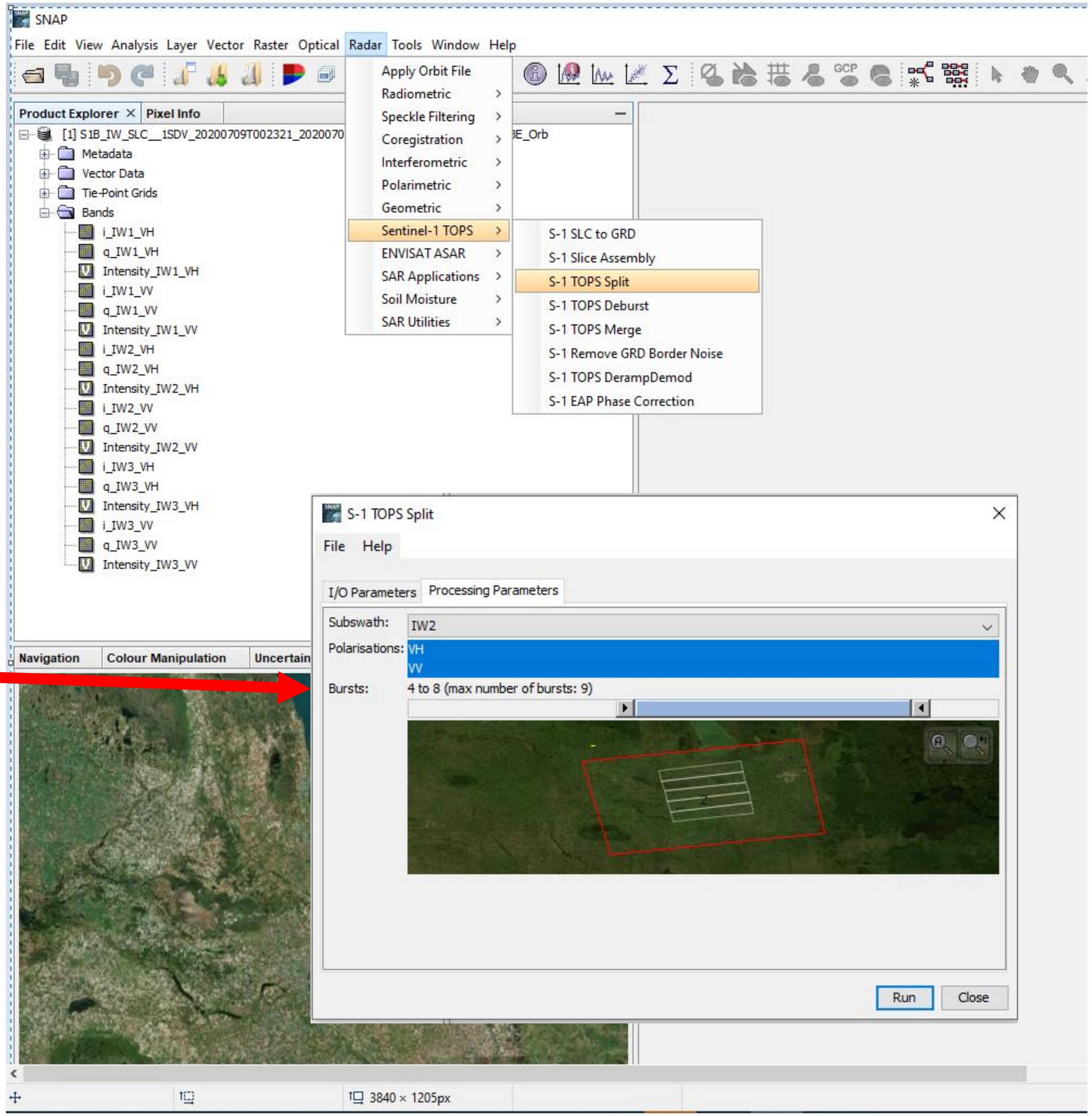




S1 TOPS Split

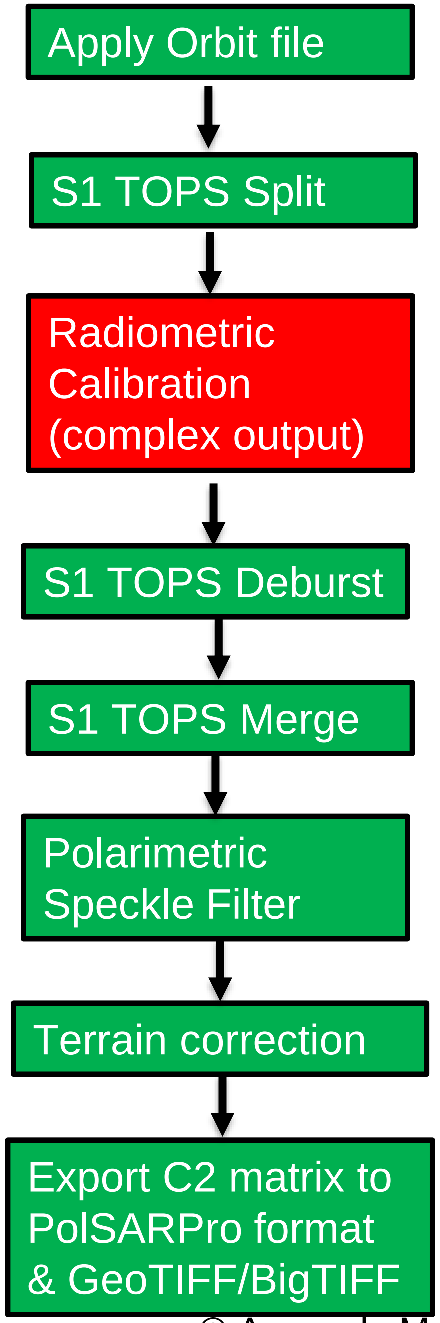
Go to Radar Menu → Sentinel-1 TOPS → S-1 TOPS Split:

- I/O Parameters tab: source → Orbit corrected S1 SLC image + Target product
- Processing Parameters tab:
  - Subswath: choose either IW1, IW2 or IW3
  - Polarisations: Highlight one or both
  - Bursts: Reduce the bursts to those that fall over the top of your area of interest; choose the arrow on either side of the slide bar and move inward
  - Click Run and Close window when completed



Radiometric Conversion

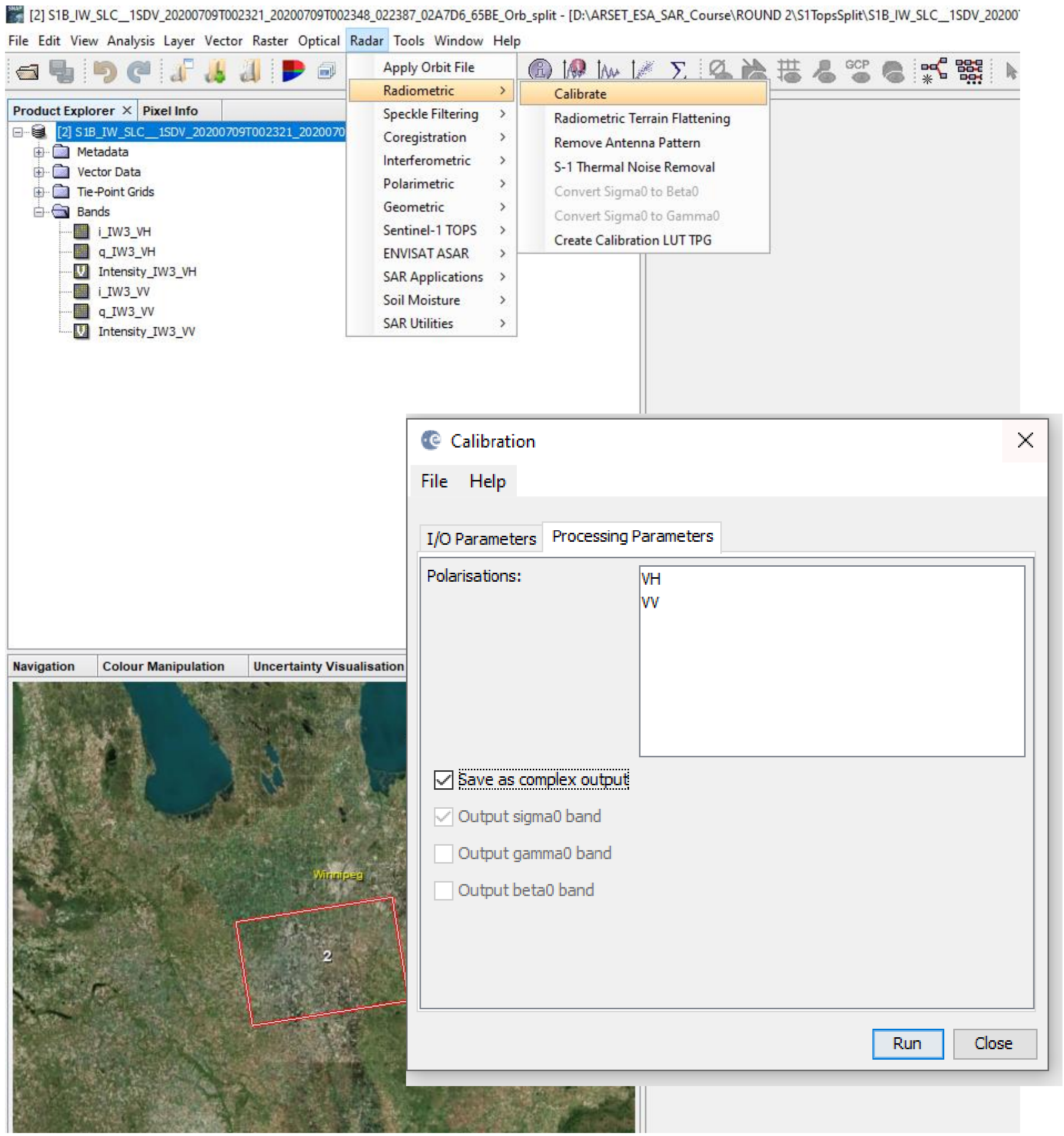
- SAR SLC products are complex and must be converted to real (intensity) and imaginary (phase) channels.
- The conversion is mission-specific and for polarimetric processing the data must be complex.
- SNAP will automatically determine what kind of input product you have and what conversion needs to be applied based on the product's metadata.



Radiometric Conversion

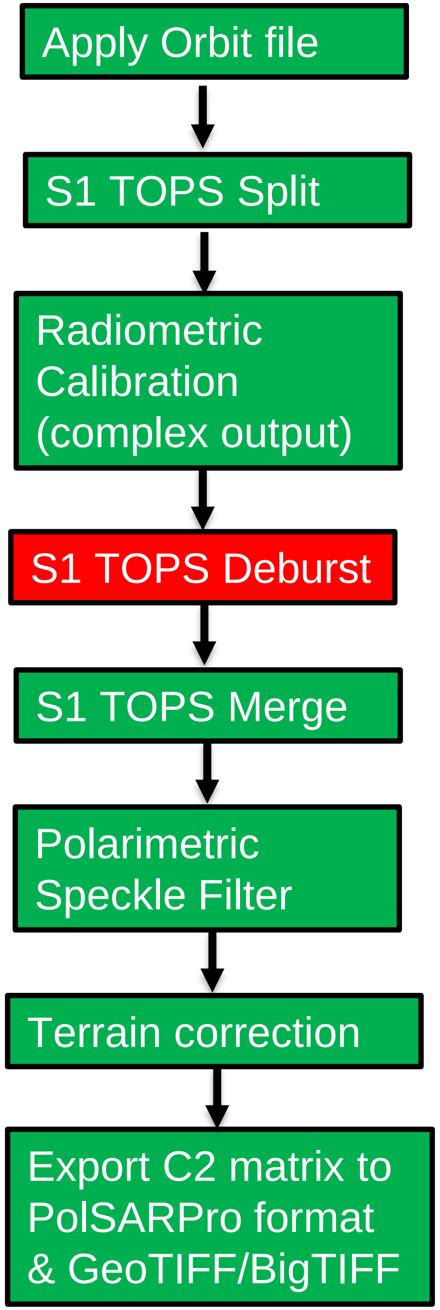
Go to Radar Menu → Radiometric → Calibrate:

- I/O Parameters tab: source → S1 Tops Split & Orbit Corrected Image + Target product
- Select "Save as complex output"
- Processing Parameters tab:
- Click Run and Close window when completed



S1 TOPS Deburst

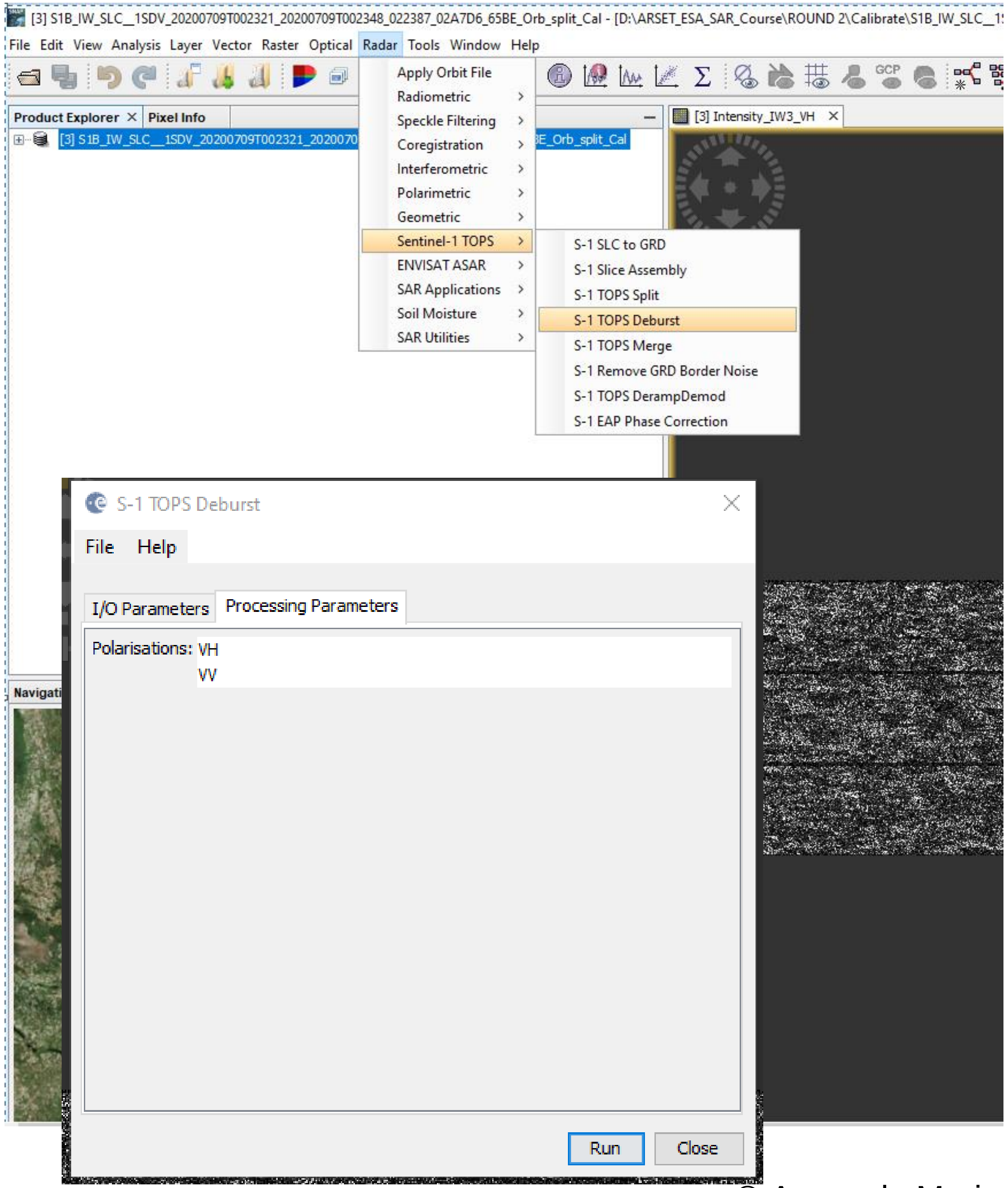
The images for all selected bursts from the previous results in the selected sub-swaths are resampled to a common pixel spacing grid in range and azimuth while preserving the phase information. All bursts are merged.



S1 TOPS Deburst

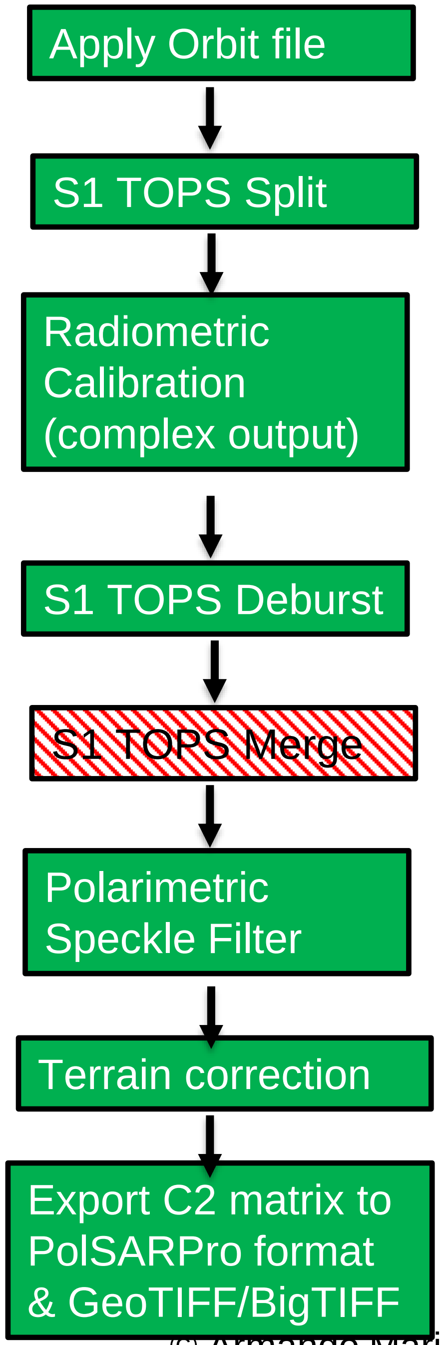
Go to Radar Menu → Sentinel-1 TOPS → S-1 TOPS Deburst:

- I/O Parameters tab: source → Orbit, TOPS Split, Calibrated S1 SLC image + Target product
- Processing Parameters tab:
  - Polarisations: VH, VV
  - Click Run and Close window when completed



S1 TOPS Merge

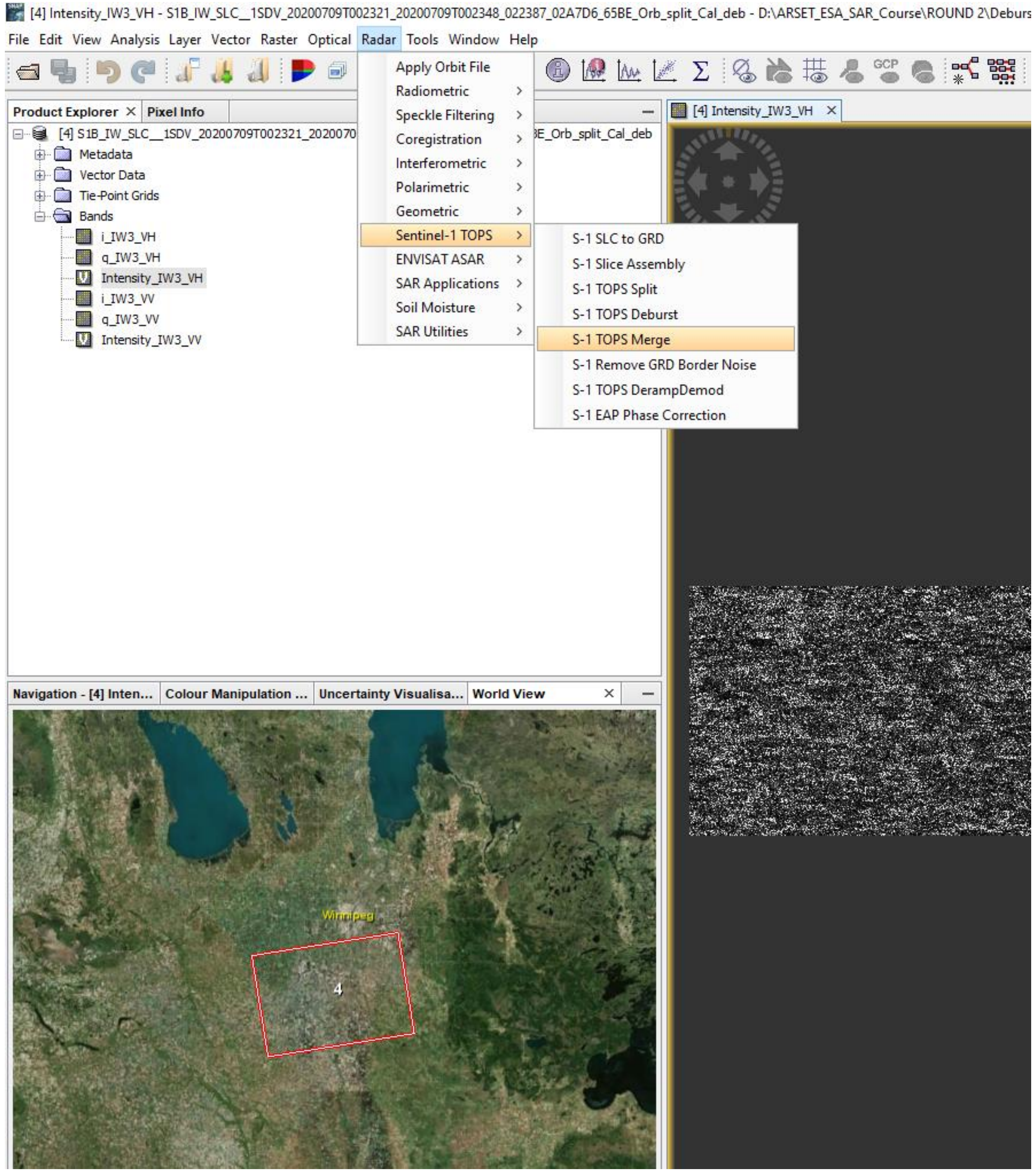
If you have processed multiple sub swaths of one image (e.g., 1 to 3), the S1 TOPS Merge operator merges the merged bursts, as sub-swaths products into one complete product



S1 TOPS Merge

Go to Radar Menu → Sentinel-1 TOPS → S-1 TOPS Merge:

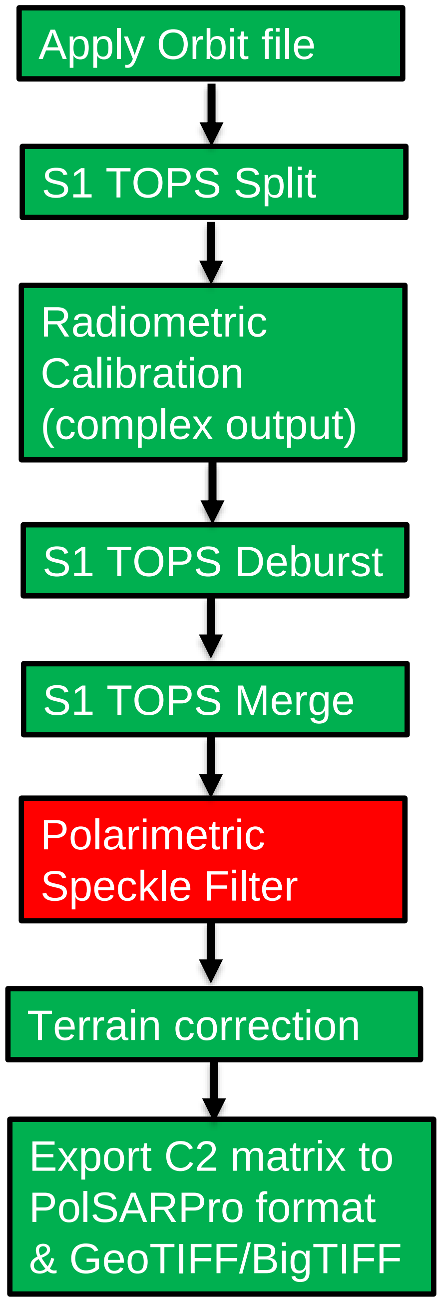
- I/O Parameters tab: source → Orbit, TOPS Split, Calibrated & TOPS Deburst S1 SLC images + Target product
- Processing Parameters tab:
  - Polarisations: VH, VV
  - Click Run and Close window when completed



Polarimetric Speckle Filter

For polarimetric parameters, the filter chosen must ensure that there is a preservation of phase and polarimetric information while suppressing the noise. There are 4 polarimetric speckle filters available in SNAP. The choice of filter type and size should be related to the AOI and what the final data will be used for.

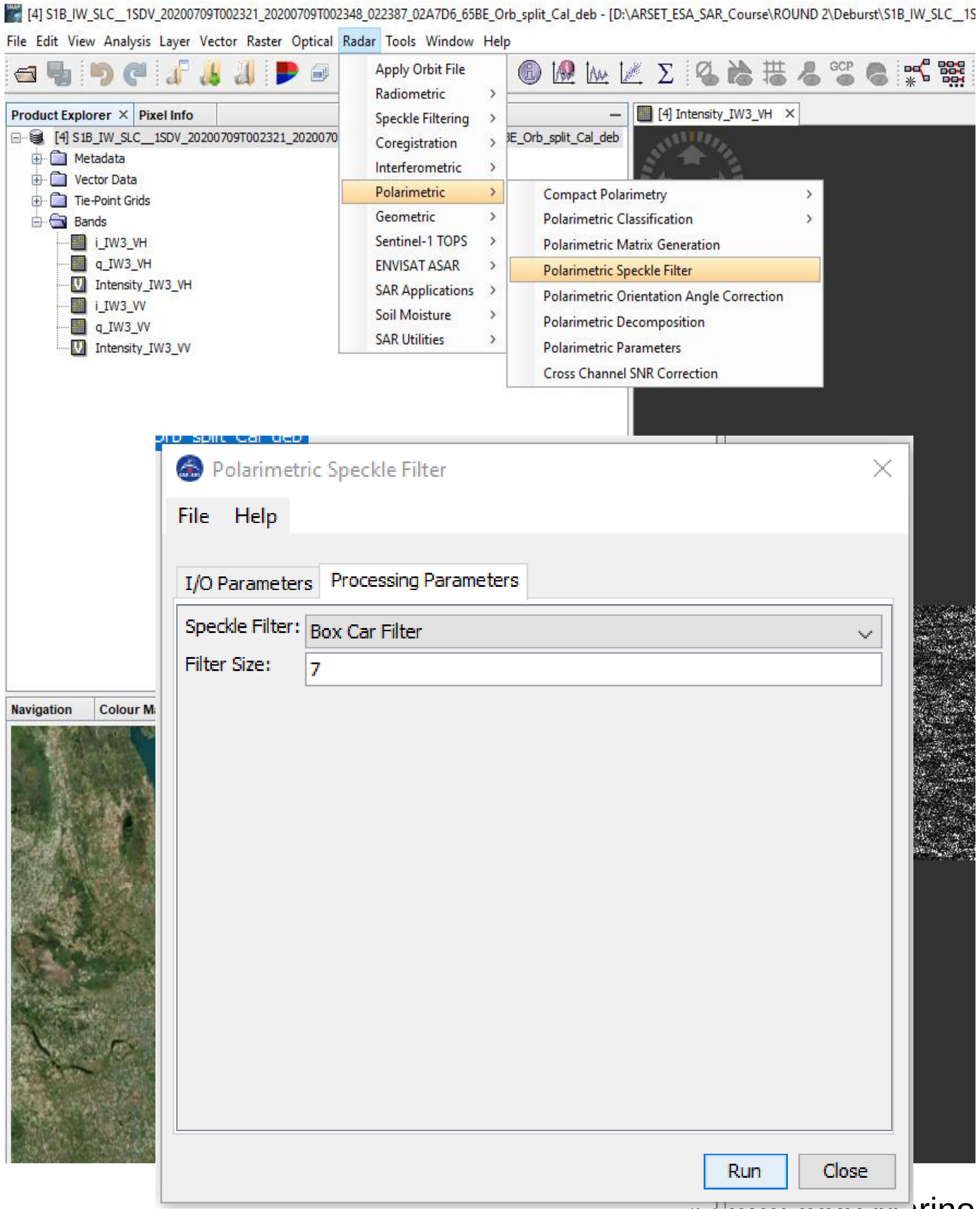
The output of the Polarimetric Speckle Filter is C2 matrix



Polarimetric Speckle Filter

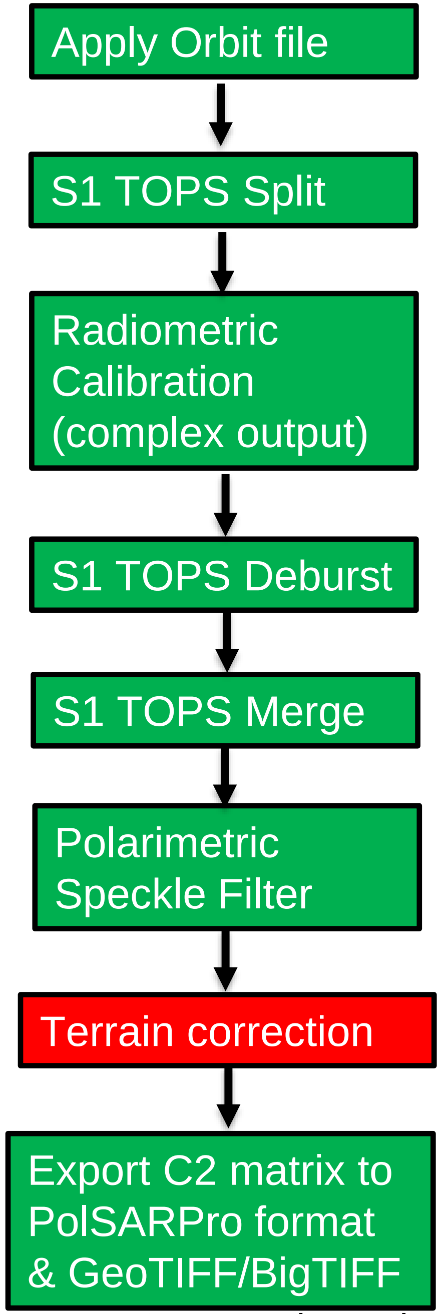
Go to Radar Menu → Polarimetric → Polarimetric Speckle Filter :

- I/O Parameters tab: source → Orbit, TOPS Split, Calibrated & TOPS Deburst (and Merged if using more than one sub swath) S1 SLC images + Target product
- Processing Parameters tab:
  - Speckle Filter: Choose one of four speckle filter types
  - Filter Size: Select filter size
  - Click Run and Close window when completed



C2 Matrix is Generated – Terrain Correction

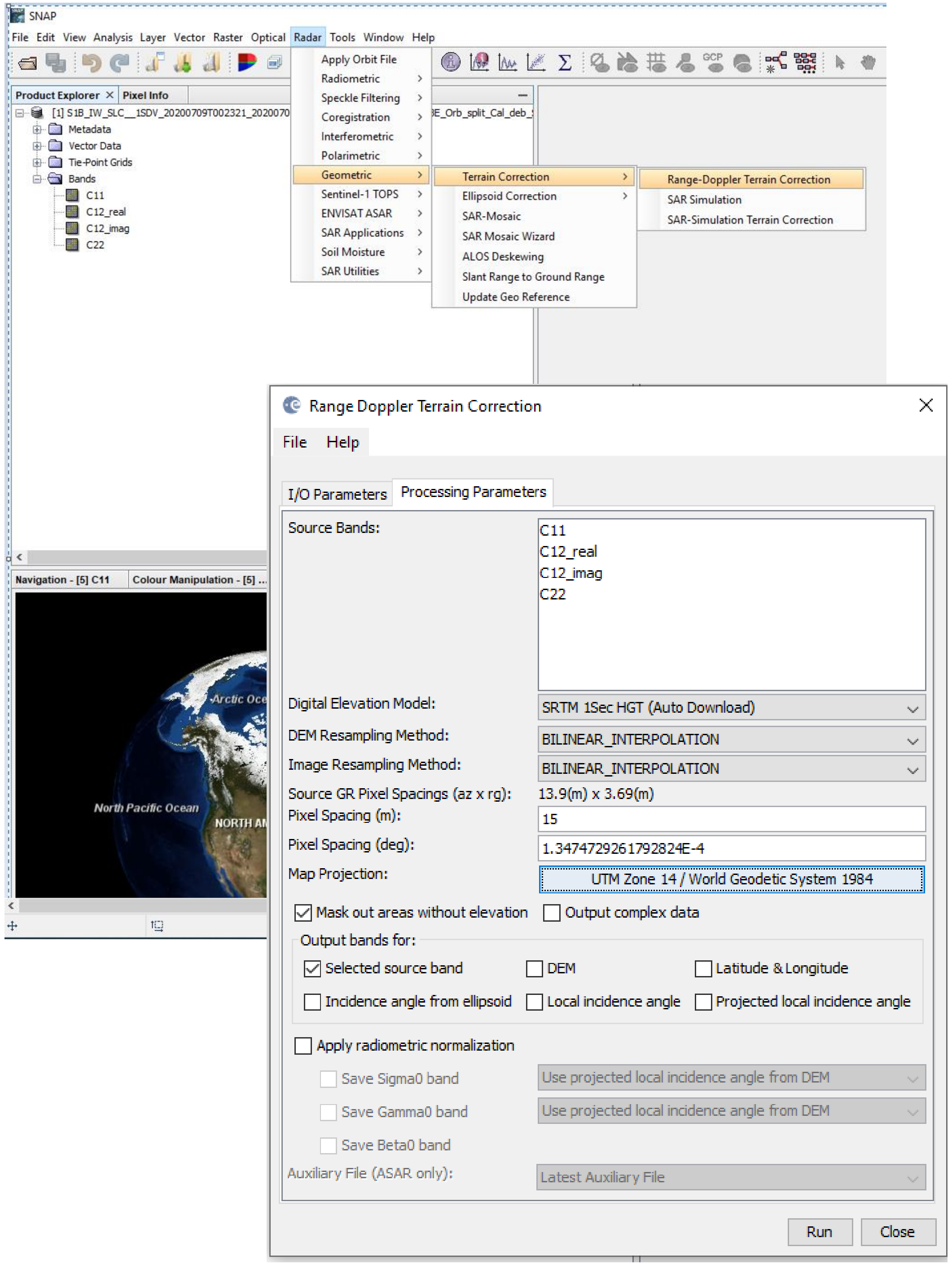
- Terrain correction, with the use of Digital Elevation Model (DEM) data, corrects topographical distortions like foreshortening, layover, or shadowing.
- The Range-Doppler approach is one way to perform geometric correction. The method needs information about the topography (normally provided by a DEM) as well as orbit satellite information to correct the topographic distortions and derive a precise geolocation for each pixel of the image.



C2 Matrix is Generated – Terrain Correction

Go to Radar Menu → Radar → Geometric → Terrain Correction → Range Doppler Terrain Correction:

- I/O Parameters tab: source → C2 Matrix + Target product
- Processing Parameters tab:
  - Digital Elevation Model: SRTM 1SEC HGT (or appropriate for your area)
  - Most parameters will be set as per your AOI
  - Click Run and Close window when completed

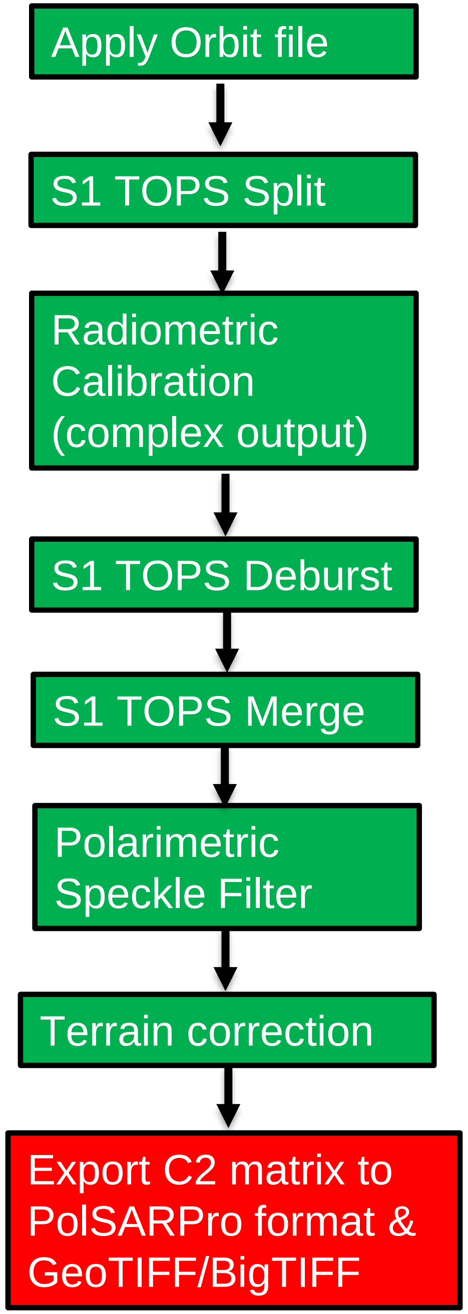


Export C2 Matrix from SNAP to PolSAR Pro Format & GeoTIFF/BigTIFF

PolSARpro format has all bands of data in .bin and .hdr pairs. A 'config.txt' file and a 'metadata.xml' file are under the output folder.

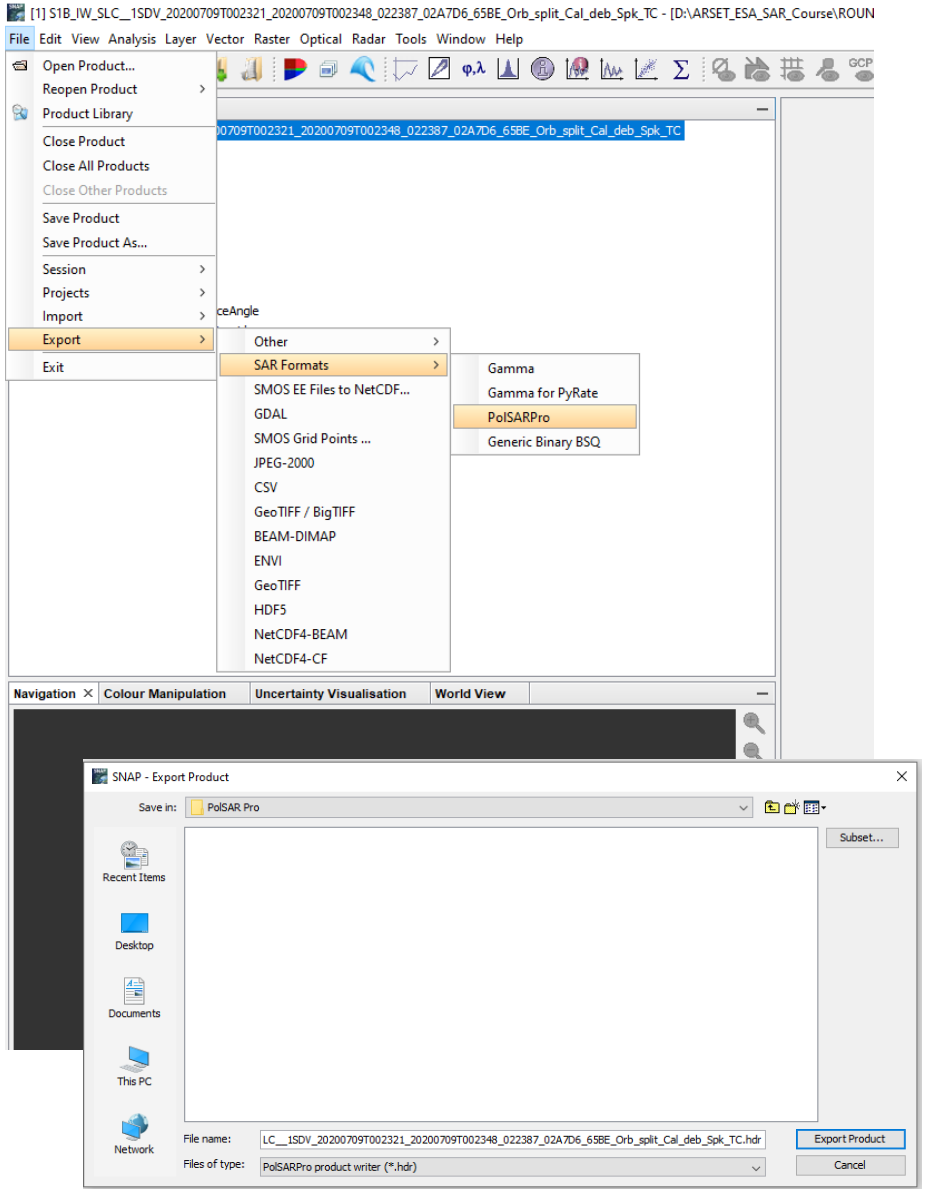
› ROUND 2 › PolSARPro › S1B_IW_SLC__1SDV_20200709T002321_20200709T002348_022387_02A7D6_65BE_Orb_split_Cal_deb_Spk

Name	Date modified	Type	Size
C11.bin	2/18/2022 9:15 AM	BIN File	832,661 KB
C11.bin.hdr	2/18/2022 9:14 AM	HDR File	1 KB
C12_imag.bin	2/18/2022 9:15 AM	BIN File	832,661 KB
C12_imag.bin.hdr	2/18/2022 9:14 AM	HDR File	1 KB
C12_real.bin	2/18/2022 9:15 AM	BIN File	832,661 KB
C12_real.bin.hdr	2/18/2022 9:14 AM	HDR File	1 KB
C22.bin	2/18/2022 9:15 AM	BIN File	832,661 KB
C22.bin.hdr	2/18/2022 9:14 AM	HDR File	1 KB
config.txt	2/18/2022 9:14 AM	Text Document	1 KB
metadata.xml	2/18/2022 9:14 AM	XML Document	66 KB



Export C2 Matrix from SNAP to PolSAR Pro Format & GeoTIFF/BigTIFF

PLUS!! File → Export → GeoTIFF/BigTIFF to be used as "Master Tif" during the Python generation of the Tif's from the PolSARpro output



ESA PolSAR Pro v6.0.3

- Long term research software for fully polarimetric data analysis
- Free and open for download
- [PolSARpro v6.0 (Biomass Edition) | Institut d'Électronique et des Techniques du numéRique - UMR CNRS 6164 (univ-rennes1.fr)]

POLSARPRO V6.0.3
(BIOMASS EDITION)

WIN64 INSTALLATION
PROCEDURE

1 - PRE - INSTALLATION

PolSARpro v6.0.3 (Biomass Edition) Software requires the installation of the following packages (*if not already installed on the machine*) :

Tcl (*Tool Command Language*) - **Tk** (*ToolKit*) enable the execution of powerful **GUIs** (*Graphical User Interface*). **Tcl-Tk** binary distribution and installers for Windows platform are available for download from :

https://www.magicsplat.com/tcl-installer/index.html

Gimp (*GNU Image Manipulation Program*) is a free and open-source graphics editor. The current stable release of **Gimp** for Windows platform is available for download from :

https://www.gimp.org/downloads/

ImageMagick is a free and open-source software suite for converting / creating / editing image files. The current stable release of **ImageMagick** for Windows platform is available for download from :

https://www.imagemagick.org/script/download.php#windows

SNAP (*Sentinel Application Platform*) reunites all Sentinel Toolboxes in order to offer the most complex platform for this mission. The current stable release of SNAP for Windows platform is available for download from :

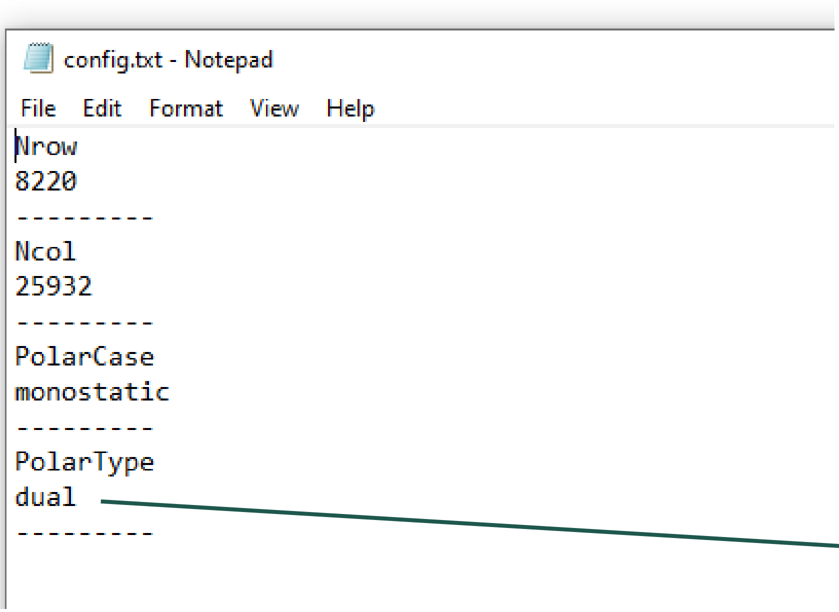
http://step.esa.int/main/download/

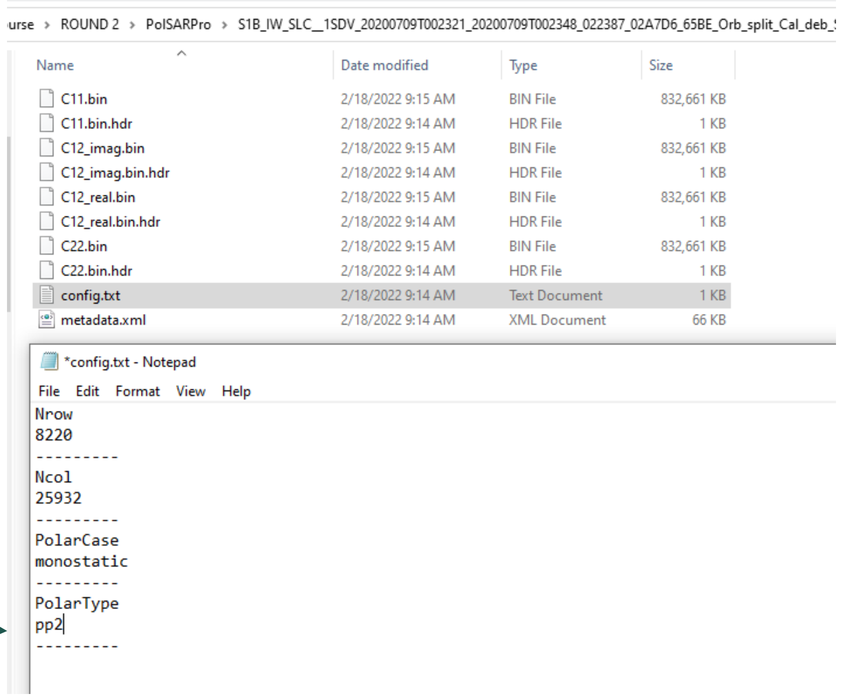
Google Earth is a computer program that renders a 3D representation of Earth based on satellite imagery. The current stable release of **Google Earth** for Windows platform is available for download from :

https://www.google.com/earth/download/gep/agree.html

Calculate SAR Polarimetric Parameters Using PolSARpro: Import Data

- Create a “C2” folder and copy all files exported from SNAP to this folder.
  - The C2 folder name will enable PolSARPro to recognize the dataset
- Modify the config.txt file. Change the ‘PolarType’ to ‘pp2’.
  - This term allows PolSAR Pro to identify that this data is represented as a 2 x 2 matrix

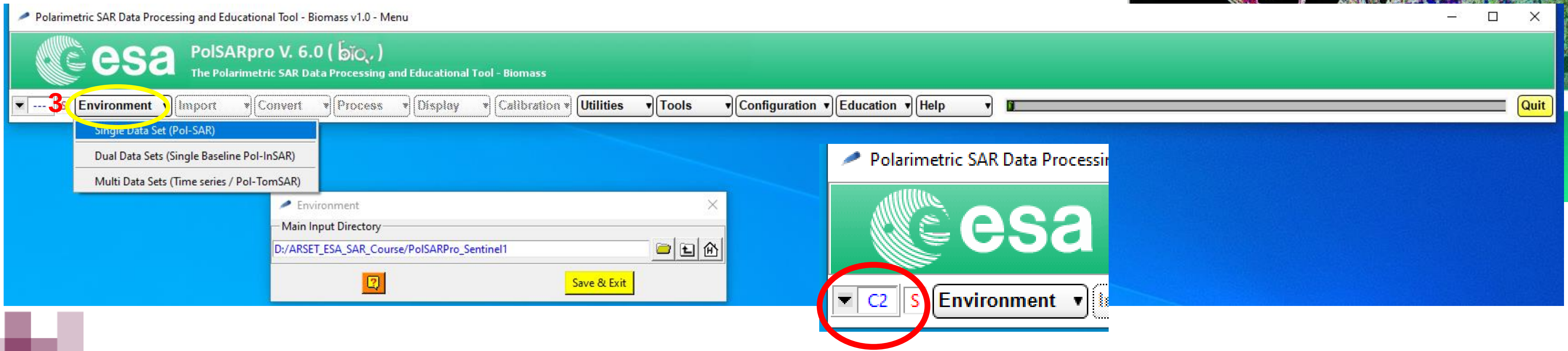




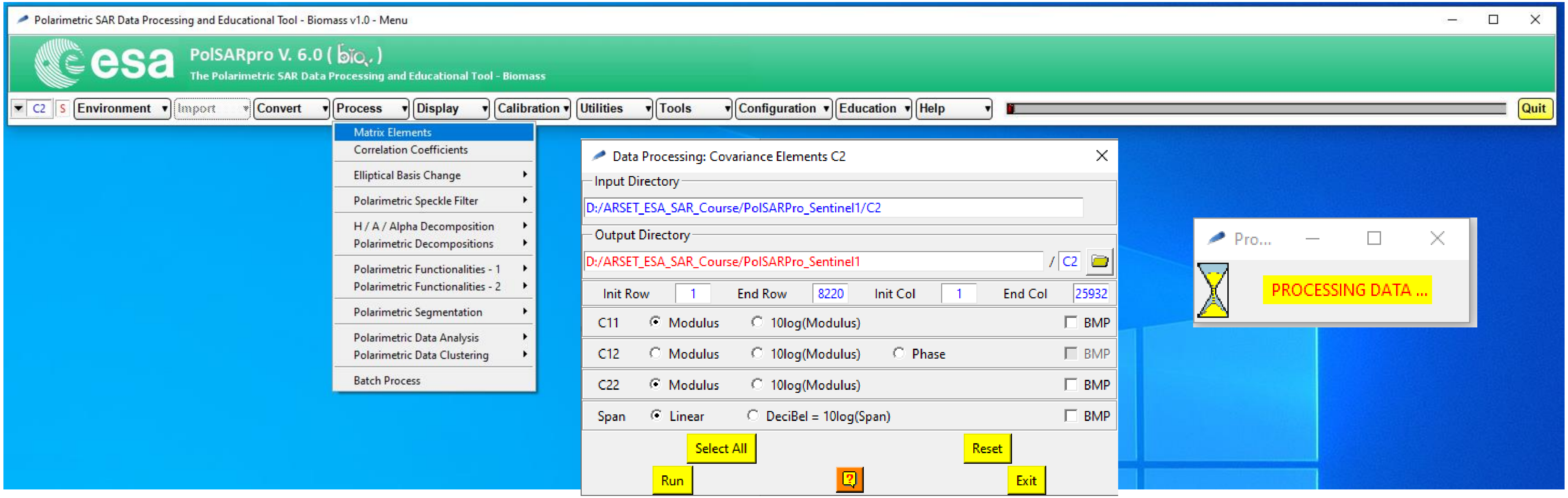
Setting an Environment in PolSAR Pro

Start your PolSAR Pro edition on your desktop

1. Click on PolSAR Pro Biomass on the initial tool bar and then select "Enter" on the pop up.
2. The main PolSAR Pro Biomass tool bar opens.
3. First set the "Environment", which is the folder holding your main data set contained in the C2 folder



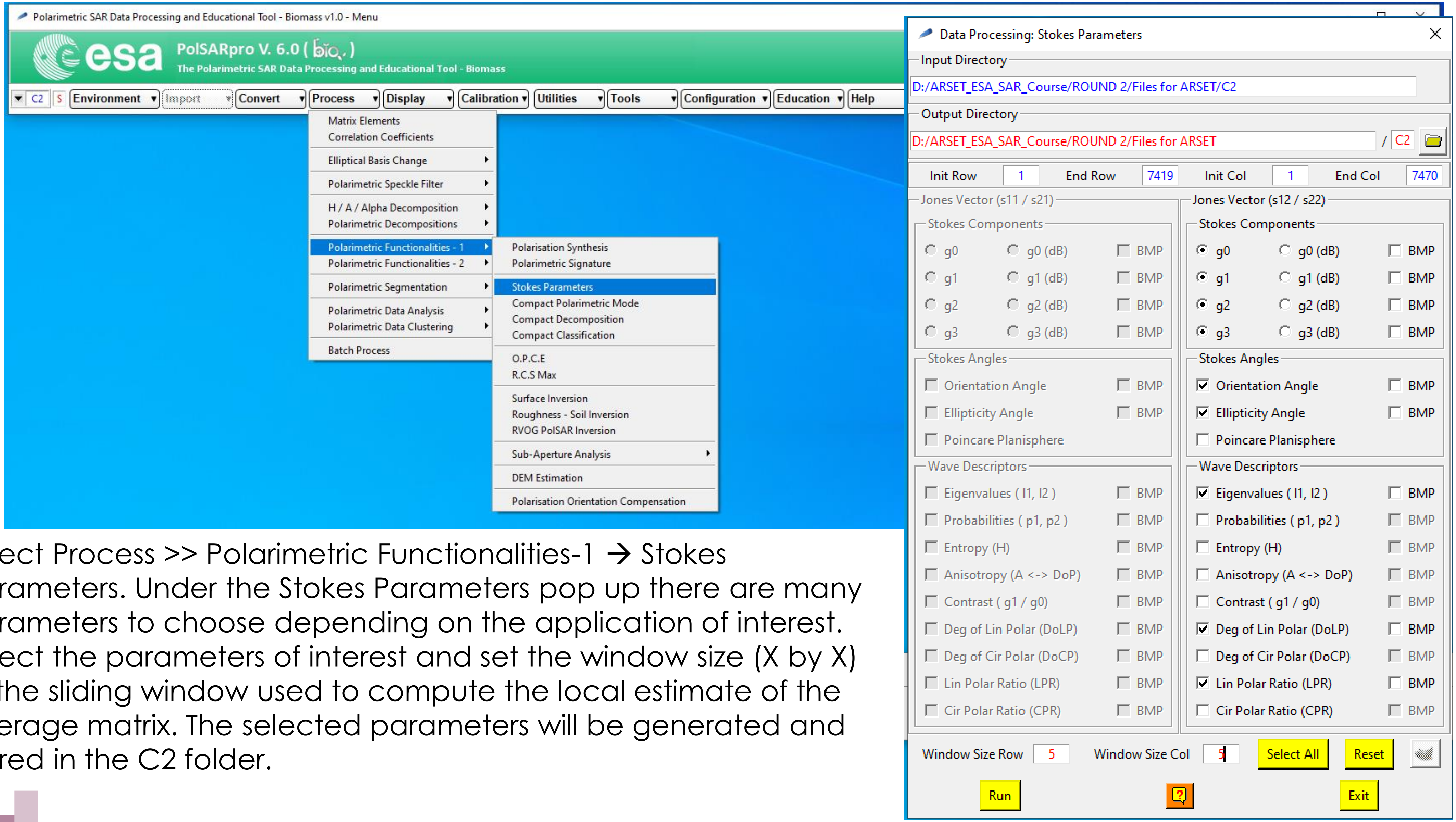
Generate the C2 Matrix Elements



Select Process – Matrix Elements and in the popup select C11 Modulus, C22 Modulus, and Span linear. The selected parameters will be generated and stored in the C2 folder. You can create an "output" folder to store items.

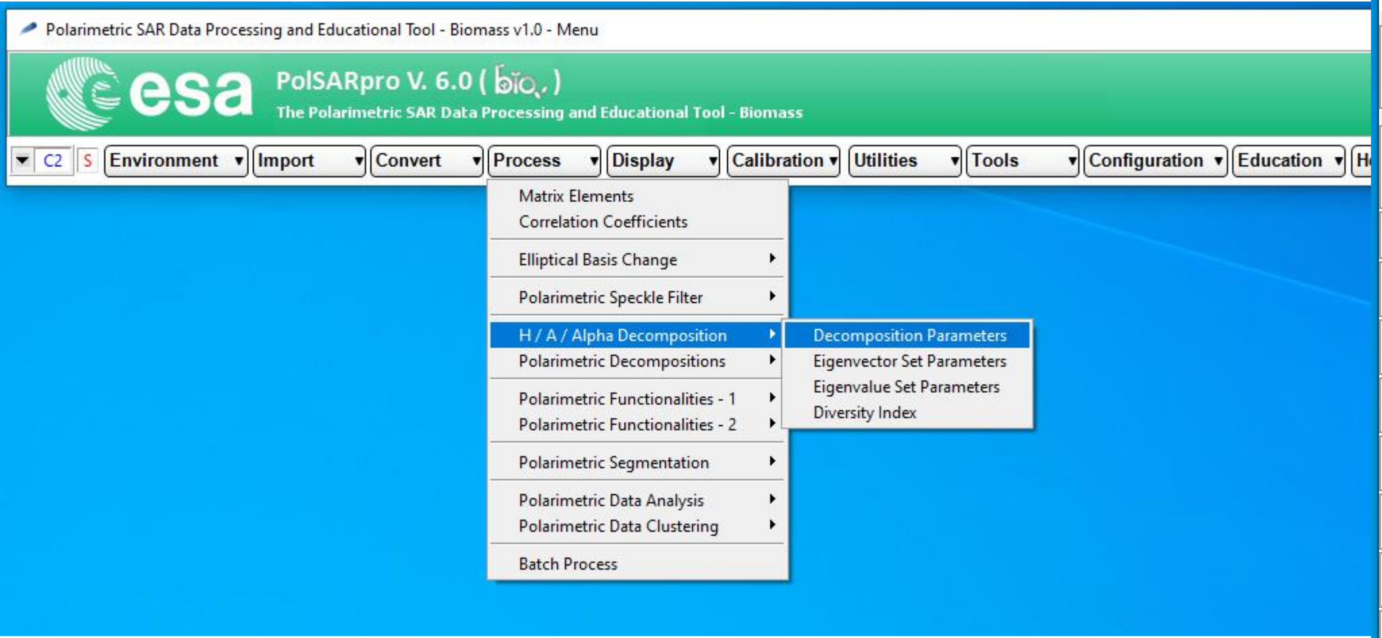
- Modulus – is the linear representation of the considered **[C2]** element amplitude.
- Span – A quantity giving the total power (intensity) received.
  - In terms of the scattering matrix, the total power equal to the sum of all the matrix elements.

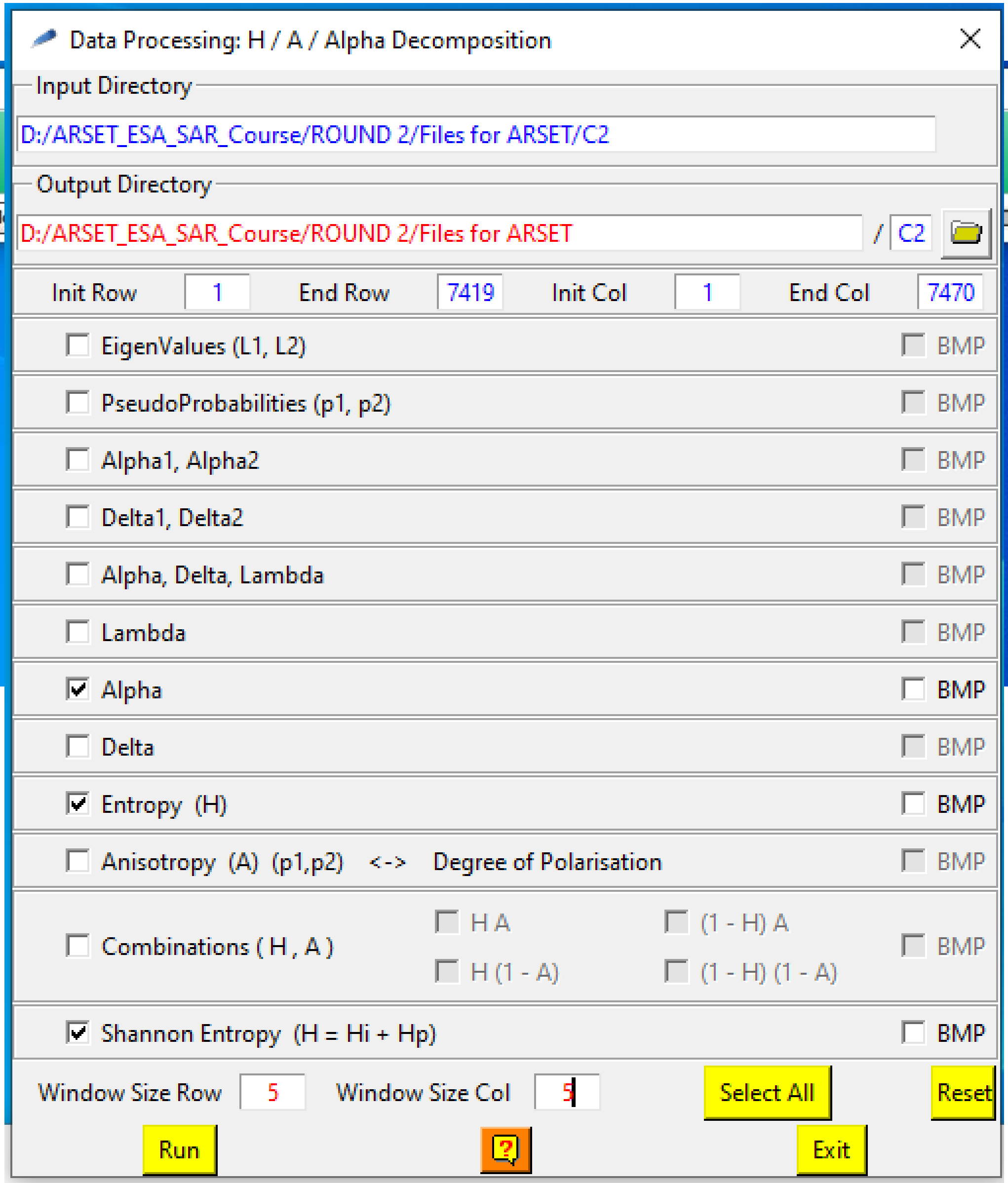
Stokes Parameter Generation



Select Process >> Polarimetric Functionalities-1 → Stokes parameters. Under the Stokes Parameters pop up there are many parameters to choose depending on the application of interest. Select the parameters of interest and set the window size (X by X) of the sliding window used to compute the local estimate of the average matrix. The selected parameters will be generated and stored in the C2 folder.

Entropy/Alpha Decomposition Parameters Generation





Select Process → H/A/Alpha decomposition → Decomposition Parameters. Select the parameters of interest and set window size. In this case we select, Alpha, Entropy, and Shannon Entropy. The selected parameters will be generated and stored in the C2 folder.

Converting PolSAR Pro Output to GeoTIFF using Python

Script: Convert_PolSARpro_Output_to_Tif_20220207.py

Python: 3.6 or greater; **must have GDAL**

Files required:

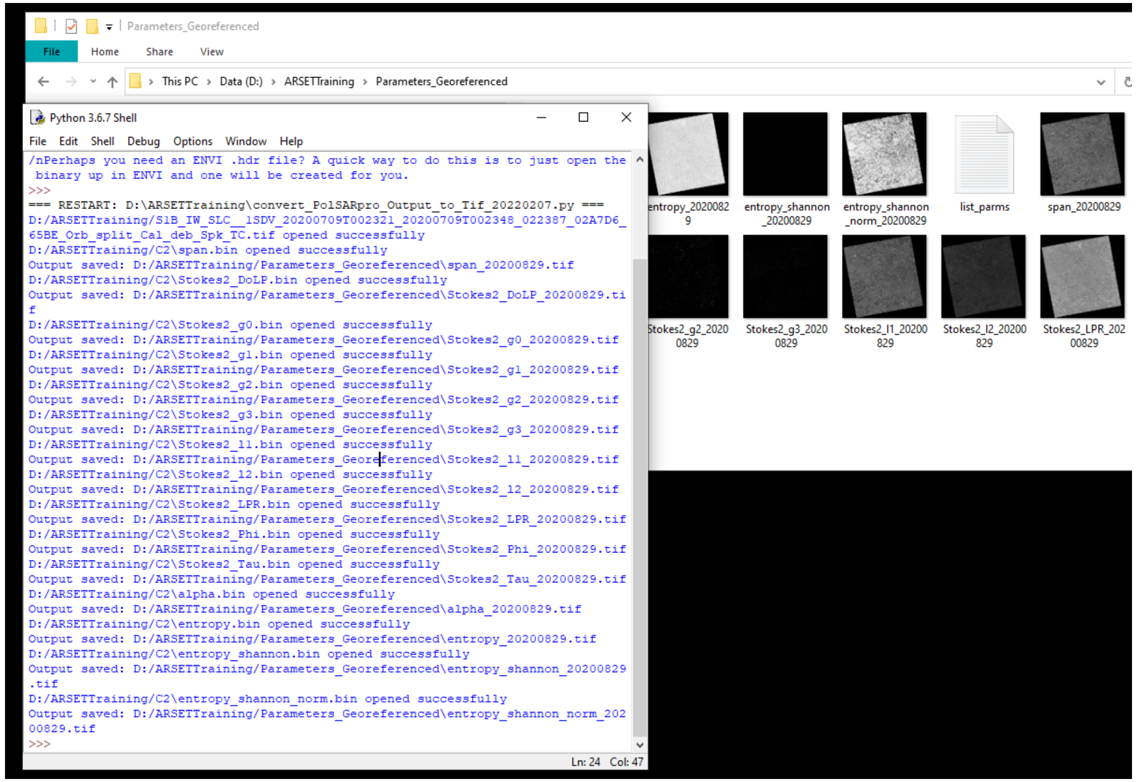
- PolSAR Pro Output (C2 folder)
- MasterTIF: From Exporting the _TC file to GeoTIFF/BigTIFF from final SNAP step; contains the georeferencing information
- List_Parms.txt: Contains a list of the parameters in C2 folder to convert to TIF

Parameters to change are located at the bottom of the script:

Inpath = r'D:/ARSETTraining/C2‘ – location of C2 folder

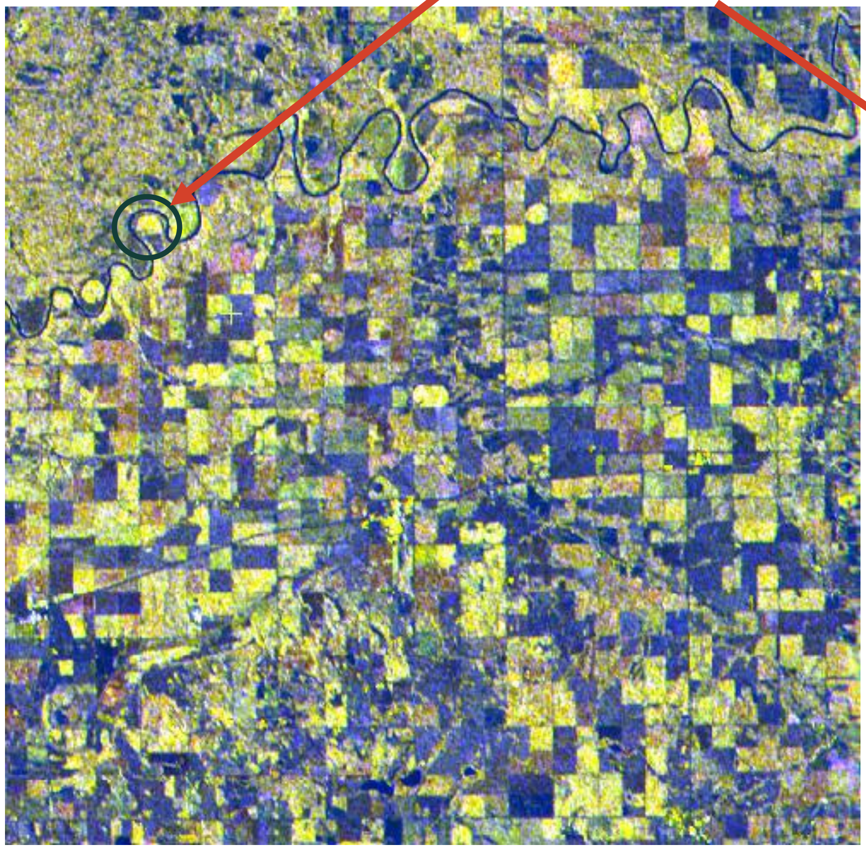
Outpath = r'D:/ARSETTraining/Parameters_Georeferenced‘ – location where output should go; “List_Parms.txt” should be located here

Masterfile = r"D:/ARSETTraining/S1B_IW_SLC__1SDV_20200709T002321_20200709T002348_022387_02A7D6_65BE_Orb_split_Cal_deb_Spk_TC.tif“ – location of Master file for georeferencing



Stokes Parameters

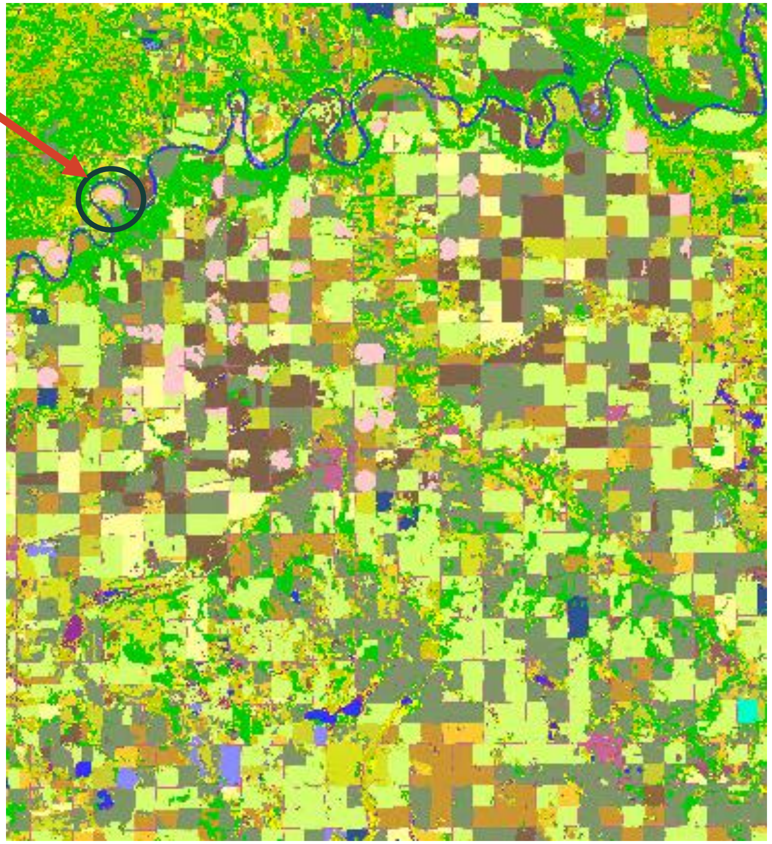
- First Stokes vector parameter ($S_{0, RED}$) indicates the total intensity of the radar backscatter (polarized and unpolarized), which is the sum of the powers of the two orthogonally-polarized received waves.
- other three parameters (S_{1Green}, S_{2Blue}, and S_3) describe the properties of the polarized portion of the EM field.



S0 July 9th, 2020, Sentinel 1 Stokes RGB Image Carman, Manitoba

S1

S2



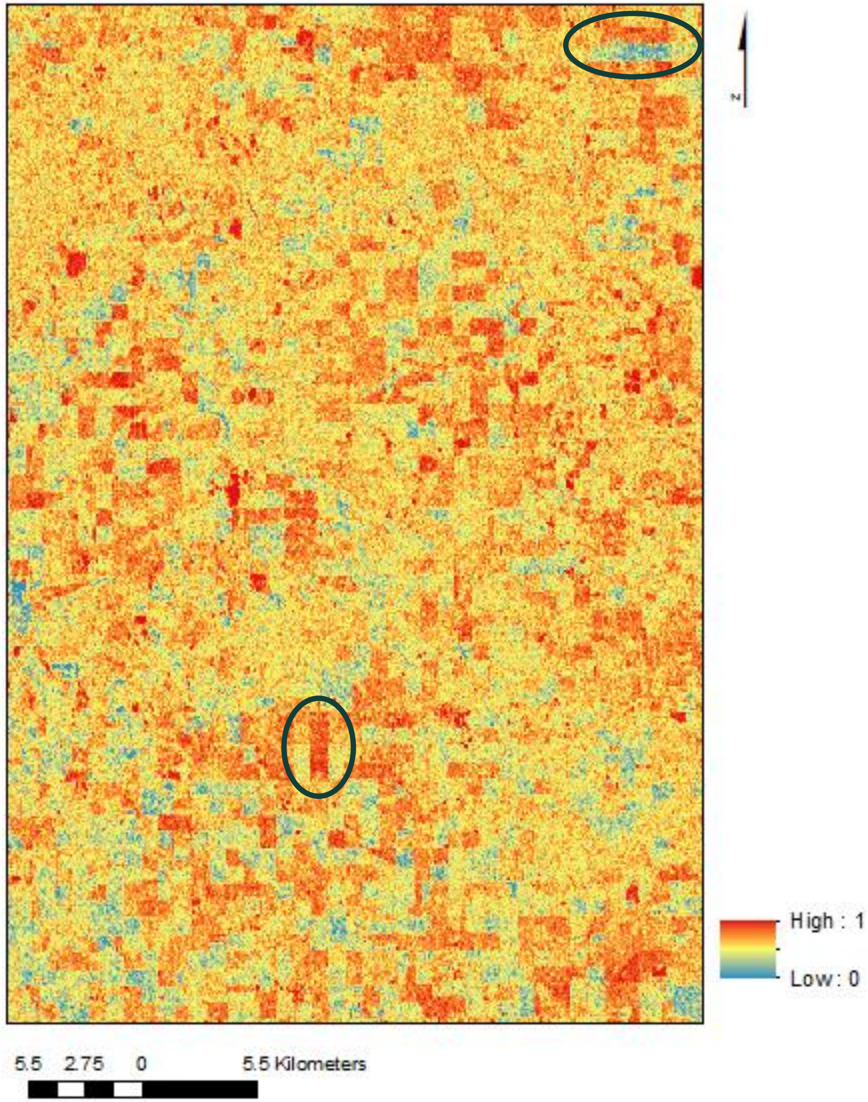
2020 AAFC Annual Crop Inventory Carman, Manitoba

Degree of Linear Polarization

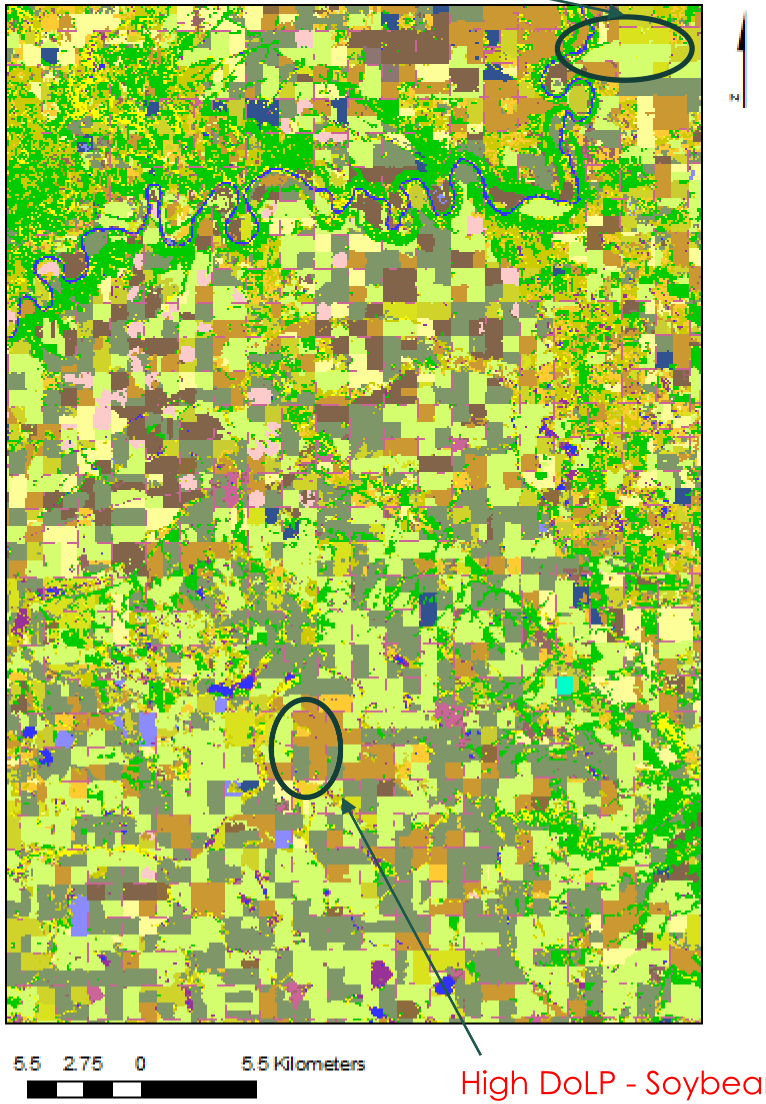
- High values of degree of linear polarization represent that the waves being scattered are linearly polarized.

Soybean
~BBCH 60-62
Early flowering

Canola
~BBCH 65-70
Late flowering



Low DoLP - Canola



High DoLP - Soybeans

July 9th, 2020, Sentinel 1 Image
Carman, Manitoba

Entropy / Alpha

The incidence angle for this burst/subswath range was approximately 36.1 ° – 41.8°. Alpha ranges from 0 to 65.5° with Entropy values ranging from 0 to 0.99 with most of the values greater than 0.60. These are similar to what has been found for examples in the past using airborne SAR:

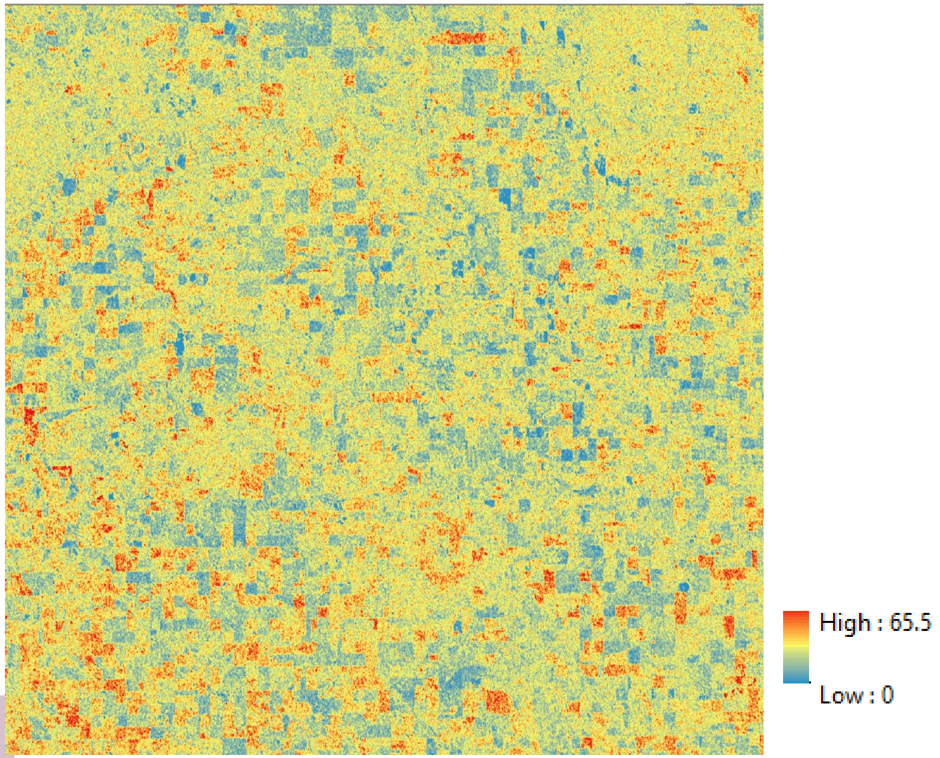
Wheat Entropy Examples

Incidence Angle	Low Biomass	Higher Biomass
25	0.40	0.51
36	0.63	0.69
40	0.74	0.76
45	0.80	0.80

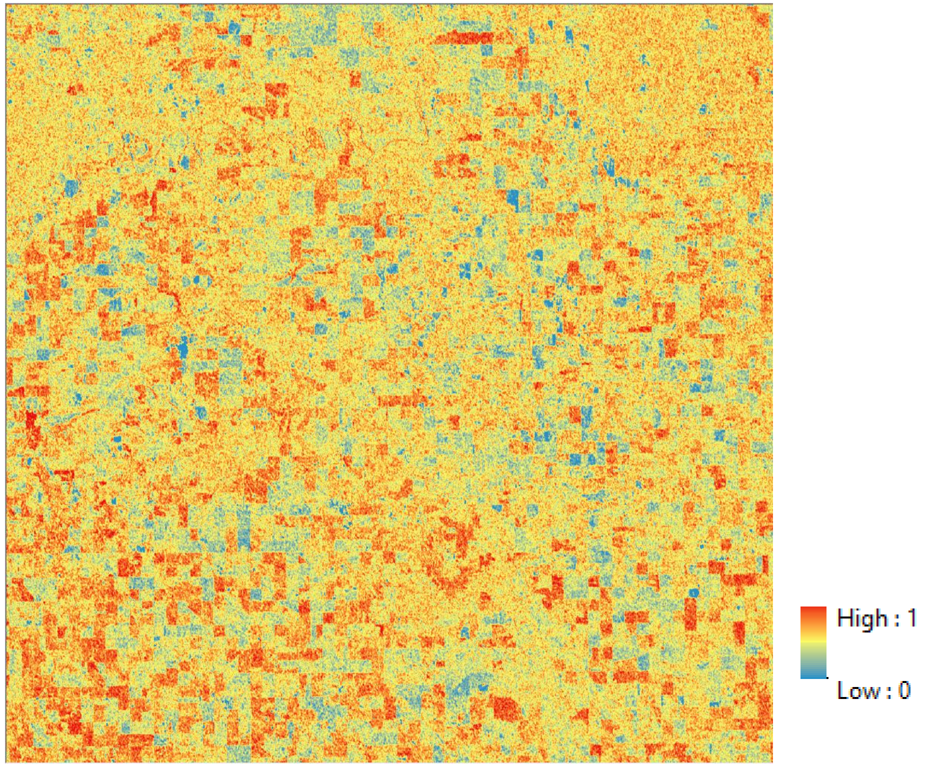
Canola Entropy Example

Incidence Angle	Low Biomass	Higher Biomass
25	0.79	0.71
36	0.84	0.75
40	0.88	0.78
45	0.91	0.77

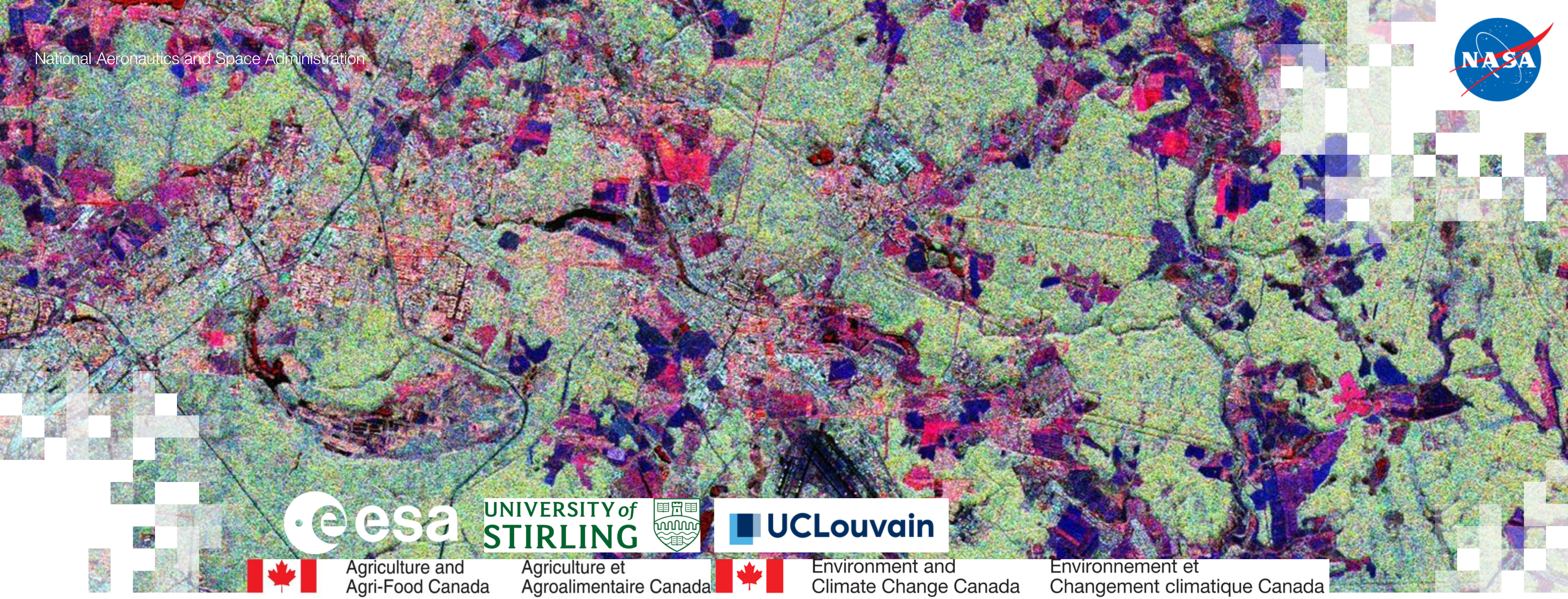
Alpha



Entropy



July 9th, 2020, Sentinel 1 Image – Carman, Manitoba

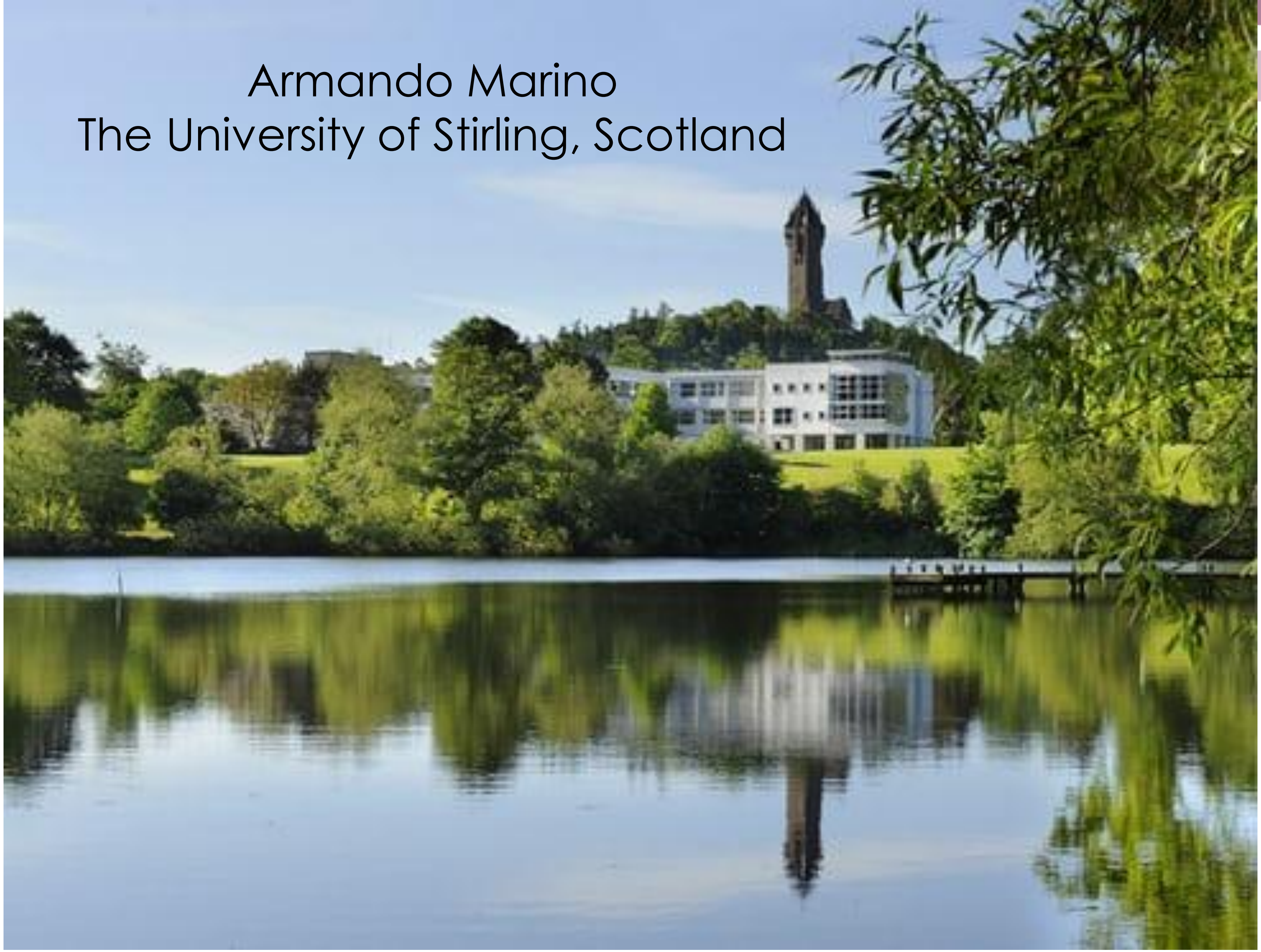


SAR Polarimetry with Sentinel-1, RCM, & SAOCOM Imagery for Agriculture

Armando Marino, PhD, University of Stirling

19 April 2022

Introduction



Learning outcomes:

By the end of this practical you will learn how to:

✓ Run python code for processing PolSAR data

✓ Open a binary file in Python

✓ Visualize the images

✓ Perform filtering

✓ Manipulate the elements of the Covariance/Coherency matrix

✓ Derive the elements of the Cloude-Pottier Decomposition

✓ Produce a time series of polarimetric observables

Python

"Python is a programming language that lets you work quickly and integrate systems more effectively."
https://www.python.org/

You can find many tutorials or books on the web, the one I used is the following:
https://docs.python.org/3/tutorial/

Downloading/Installing: Anaconda

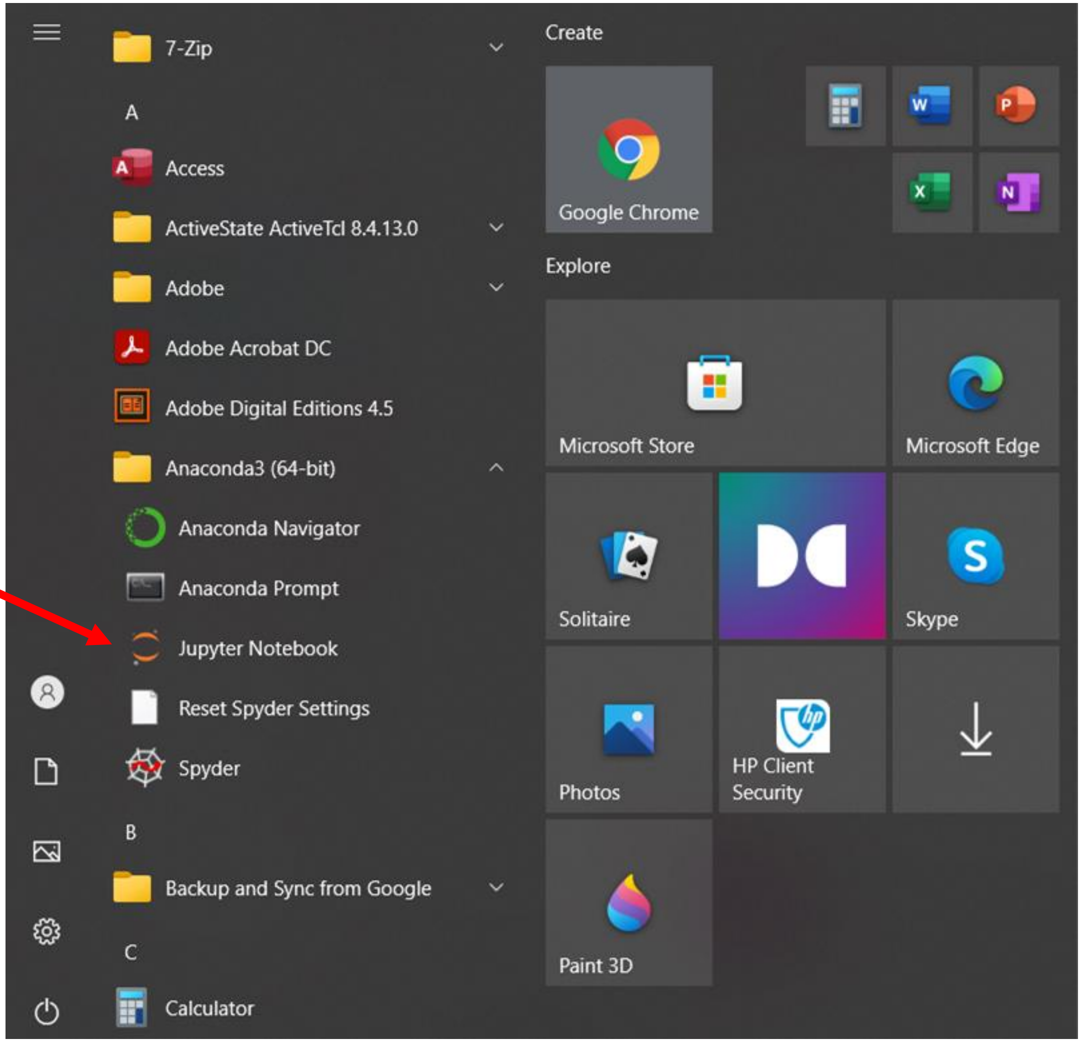
My suggestion is to use the *Anaconda installer*, because it comes with most of the common libraries: https://www.anaconda.com/products/individual?modal=nucleus

If you do not want to use Anaconda, please make sure you get the 3.x version (3.6+ will be fine), but NOT 2.7, since some functions changed!

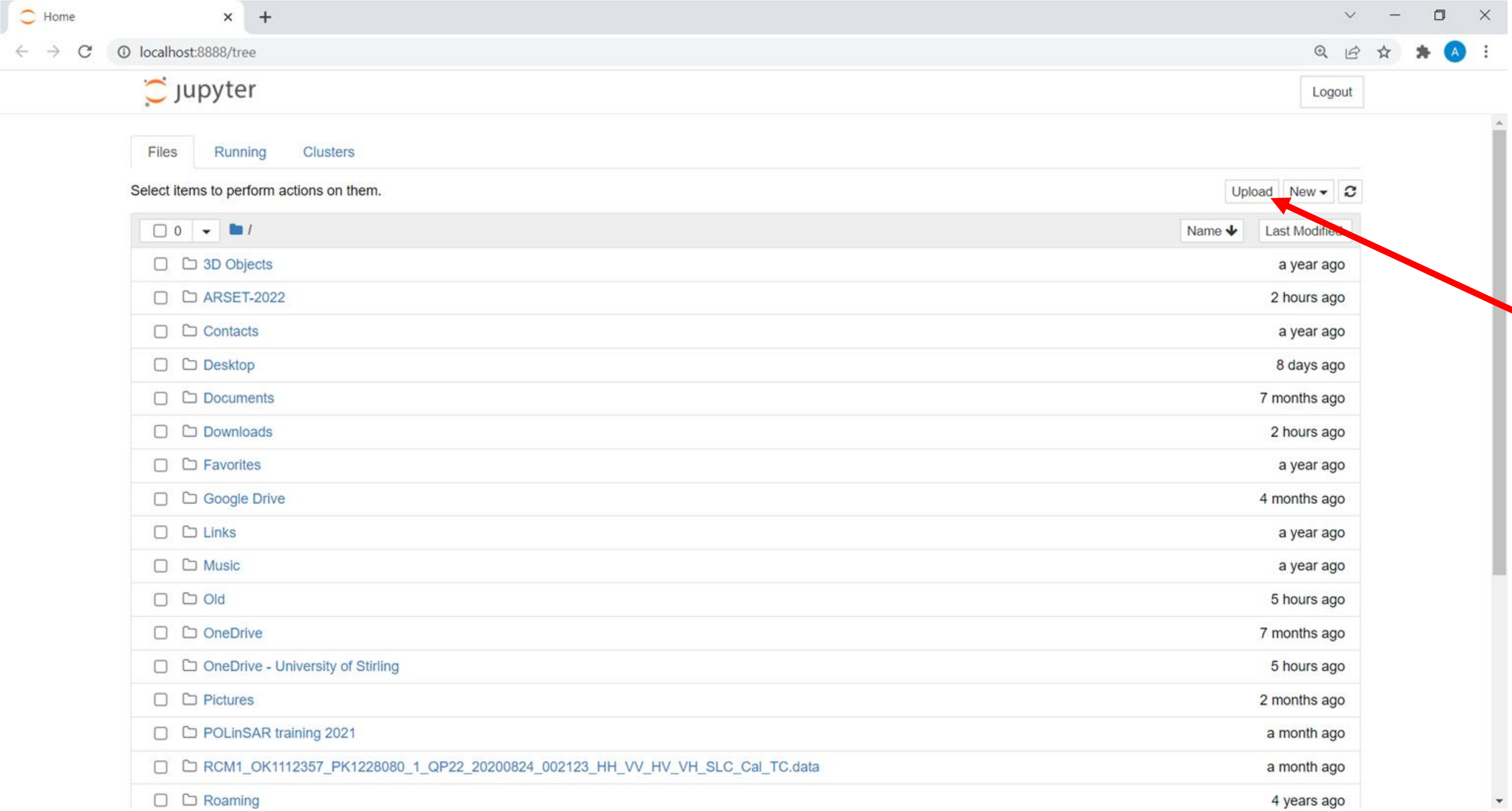
The 2.7 version will NOT run with the code I am sharing!

Jupyter Notebook

Anaconda will install Jupyter Notebook and you should see its icon.



Jupyter Notebook

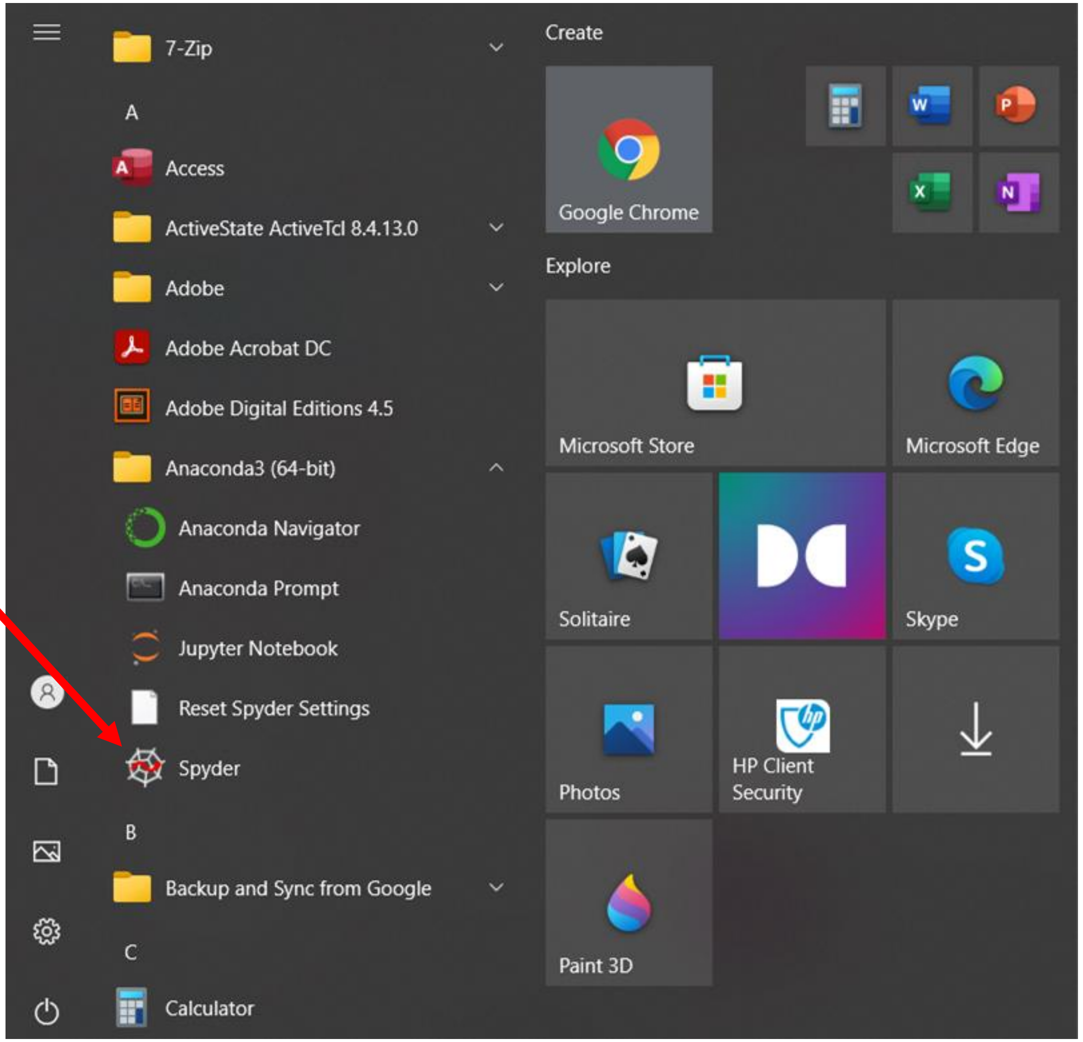


Jupyter opens in a web browser, and you can upload scripts using the **Upload** button.

Spyder

Anaconda will install the Python editor **Spyder** and you should see the icon below:

Spyder is a handy editor, and you may want to use it when you are scripting **operational/automatic processing stacks.**

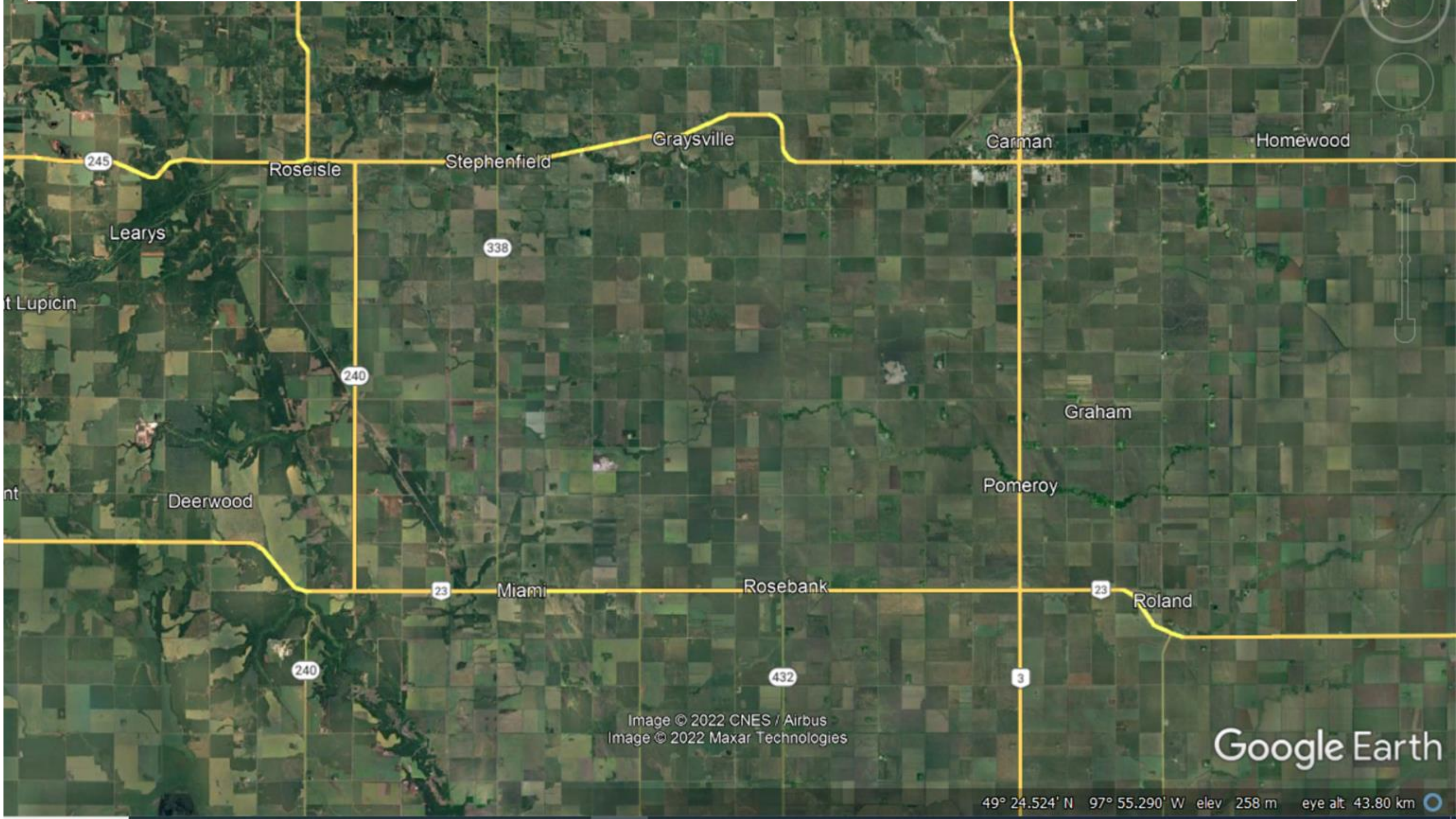


Data: RCM; Location: Carman, Manitoba, Canada

The **crops** are: forage, canola, flaxseed, sunflower, soybeans, corn, barley, spring wheat, winter wheat, rye, oat, canary seed, potato and field pea.

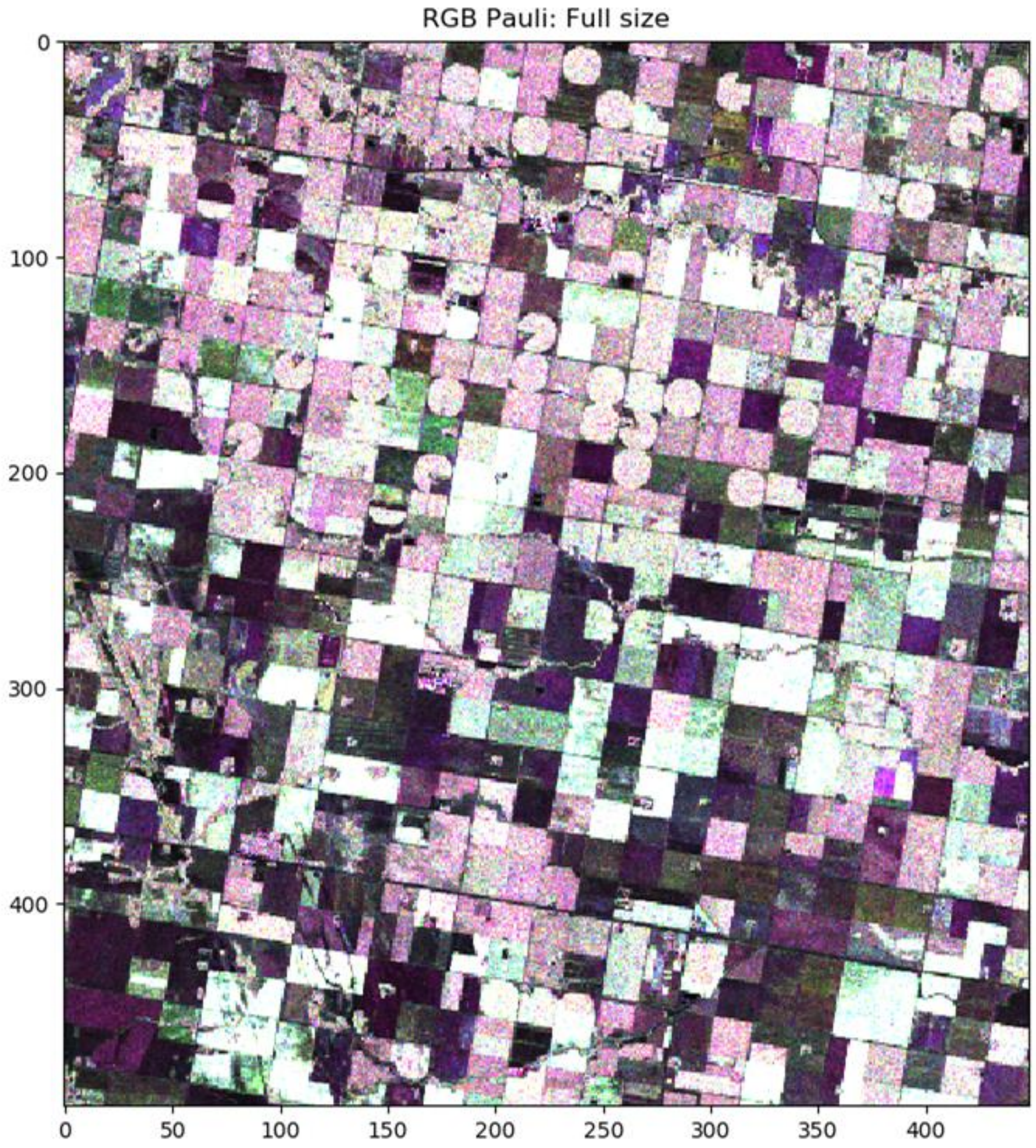
Info on crops can be found at the link provided by Agriculture and Agri-Food Canada, Gov. Canada.

https://open.canada.ca/data/en/dataset/ba2645d5-4458-414d-b196-6303ac06c1c9



Data: RCM; Location: Carman, Manitoba, Canada

Pauli RGB for 24th August 2020.
Carman, Manitoba, Canada.
Multi-looked 7x14, not geocoded.

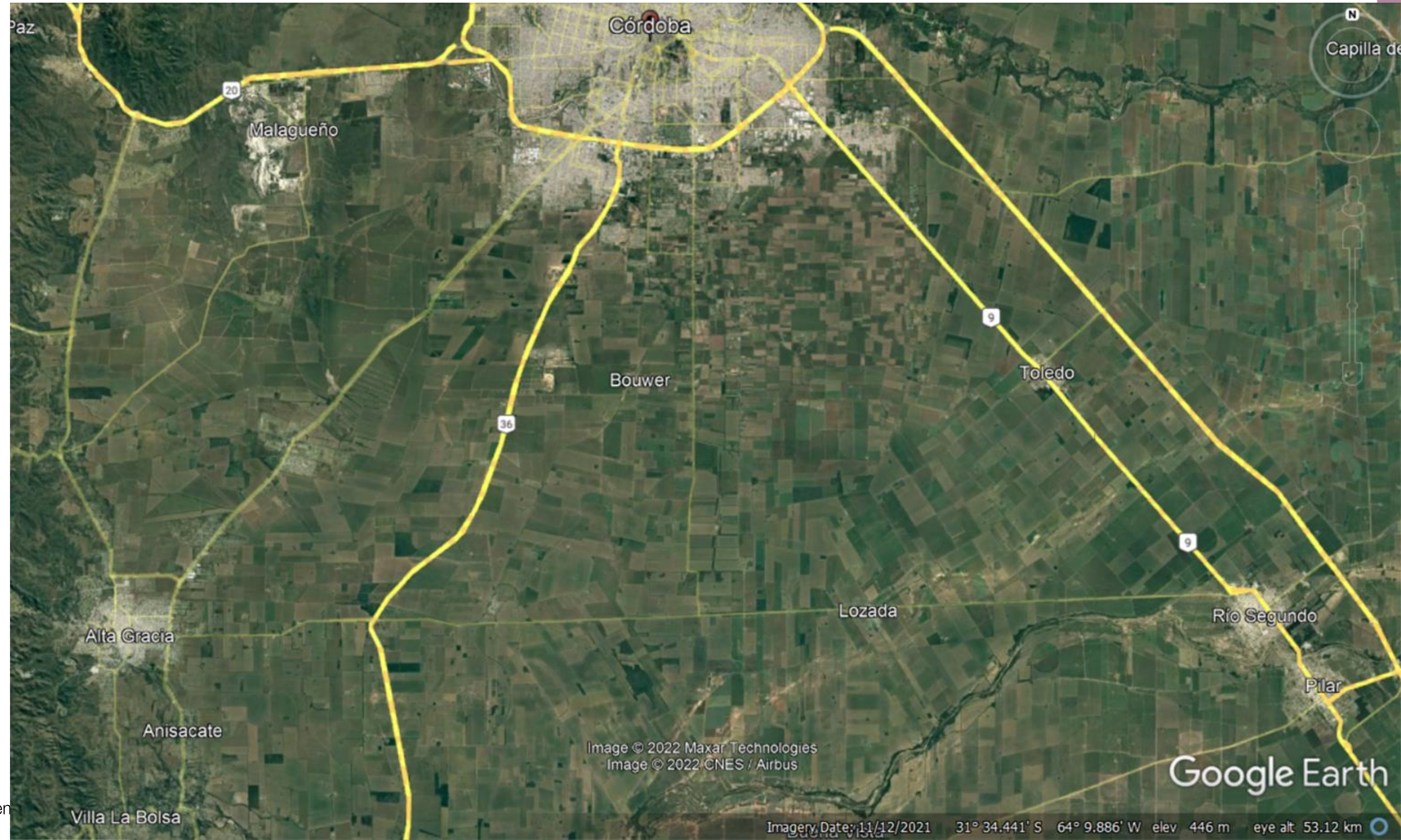


Data: SAOCOM; Location: Cordoba, Argentina

The **crops** are mostly corn and soybean.

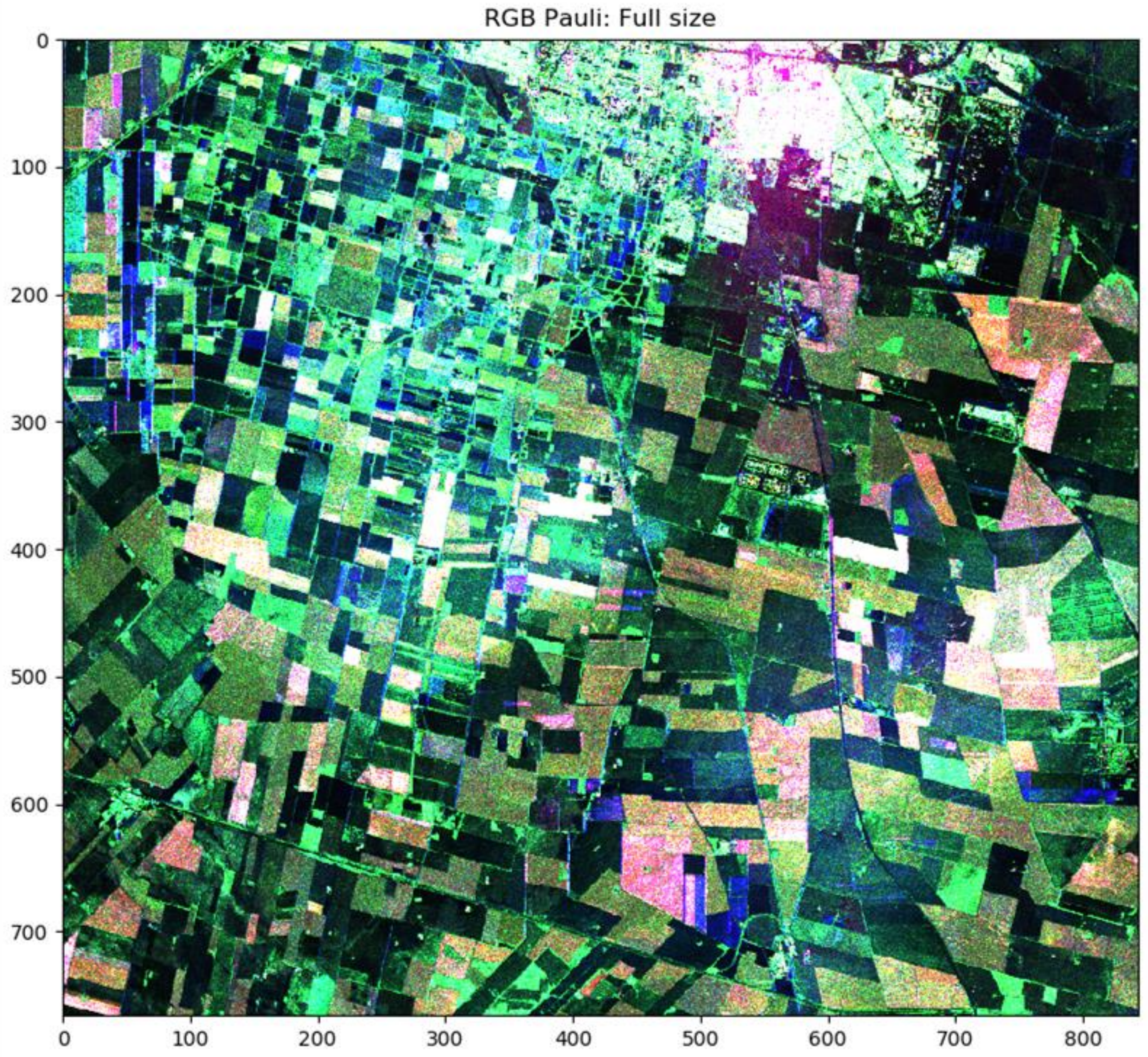
SAOCOM (Argentine Space Agency)

These data can be used for training purposes only.



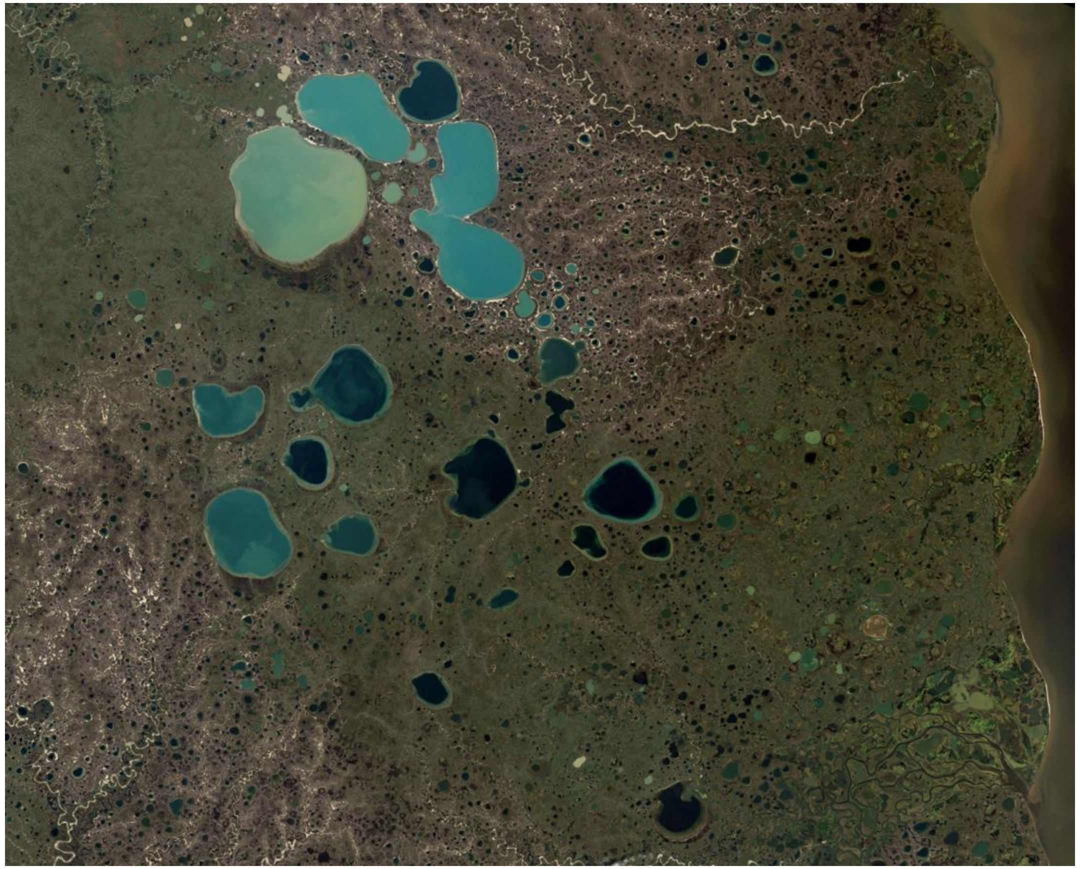
Data: SAOCOM; Location: Cordoba, Argentina

Pauli RGB for 11th March 2020. Cordoba, Argentina. Multi-looked 5x8, not geocoded.



Questions?

- Please enter your questions in the Q&A box. We will answer them in the order they were received.
- We will post the Q&A to the training website following the conclusion of the webinar.



https://earthobservatory.nasa.gov/images/6034/pothole-lakes-in-siberia

Contacts

- Trainers:
  - Laura Dingle-Robertson: laura.dingle-robertson@AGR.GC.CA
  - Armando Marino: armando.marino@stir.ac.uk
- Training Webpage:
  - https://appliedsciences.nasa.gov/join-mission/training/english/arset-mapping-crops-and-their-biophysical-characteristics
- ARSET Website:
  - https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset
- Twitter: @NASAARSET

Thank You!