



# PolSARPro & Land Retrievals

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培训时间: 2019年11月18日-23日 主办方: 重庆大学

# **Land cover classification from PolSAR data with PolSARPro**

# Outlines

**I. Introduction**

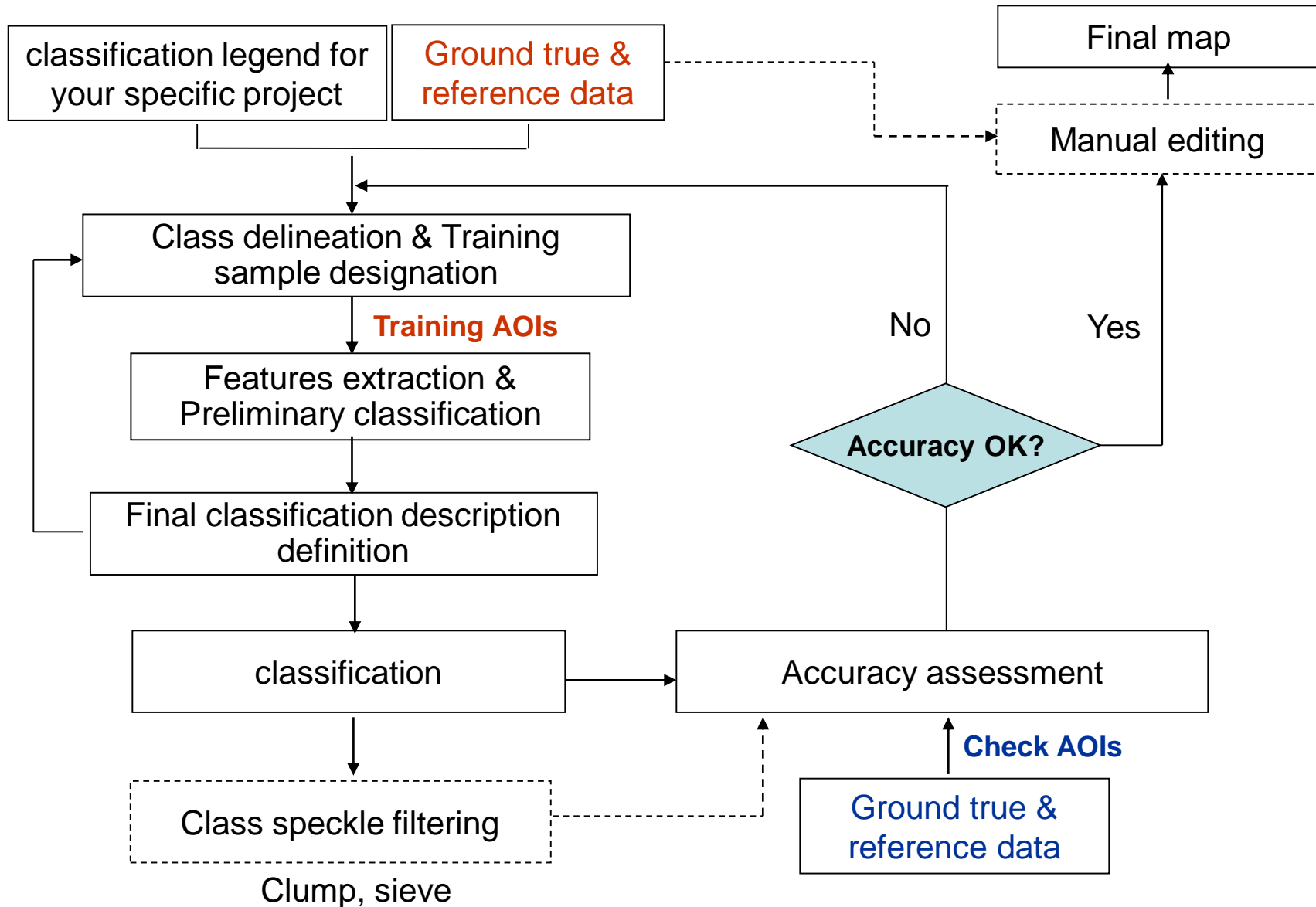
**II. GF-3 PolSAR dataset**

**III. Practical**

# I. Introduction



## 1.1 General technique framework for remote sensing image classification



## 1.2 Classification system and legend defining

### Classification system

- It is an abstract representation of the situation in the field using well defined diagnostic criteria
- One define it as: “The ordering or arrangement of objects into groups or sets on the basis of their relationships”

### A classification system is

- **scale independent:** the classes should be applicable at any scale or level of detail;
- **source independent:** independent of the means used to collect information, whether it be through satellite imagery, aerial photography, field survey or using a combination of sources.

### Remote sensing classification legend

- It is the application of a classification system in a specific area using a defined mapping scale and specific data set

### Classification legend is

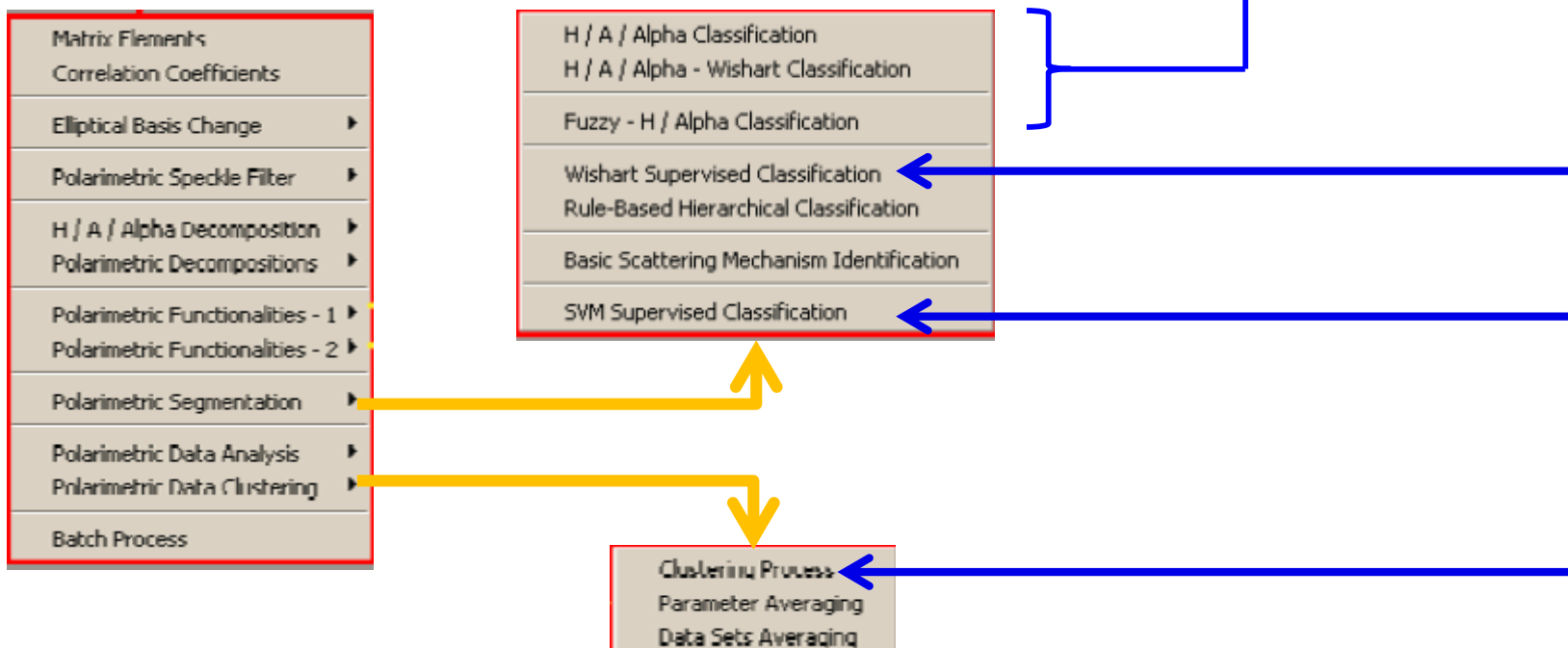
- **Scale and cartographic representation dependent;**
- **Data and mapping methodology dependent.**

## 1.3 Classification method introduction through PolSARPro

Pixel based  $\leftrightarrow$  Object based

Unsupervised  $\leftrightarrow$  Supervised

- Currently only pixel based classifier
- Object based is not available

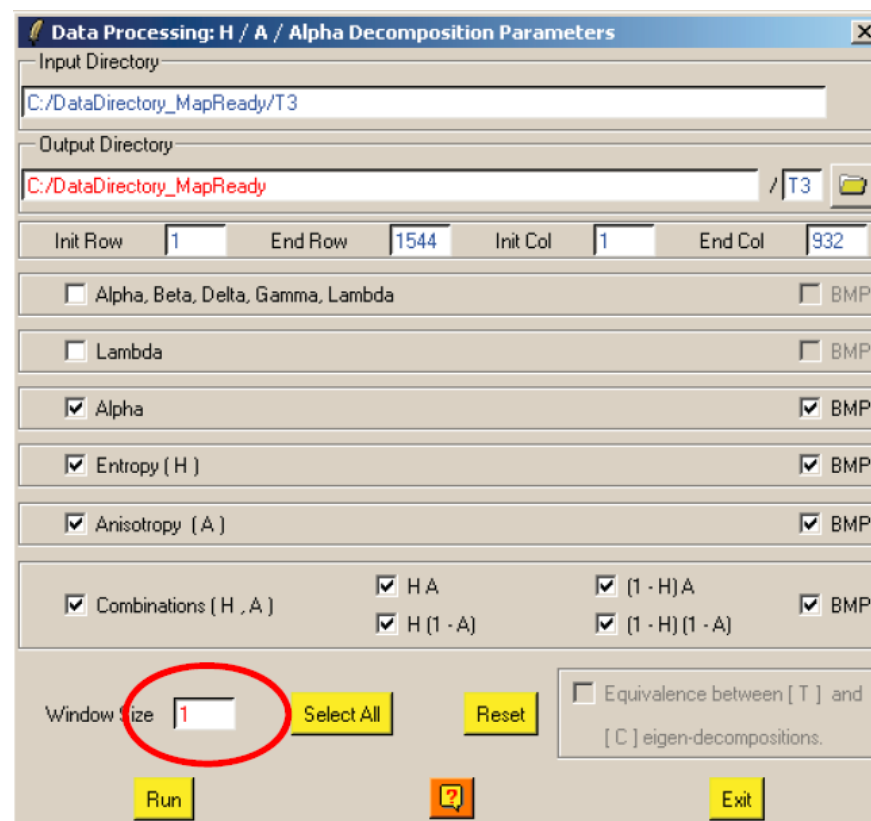
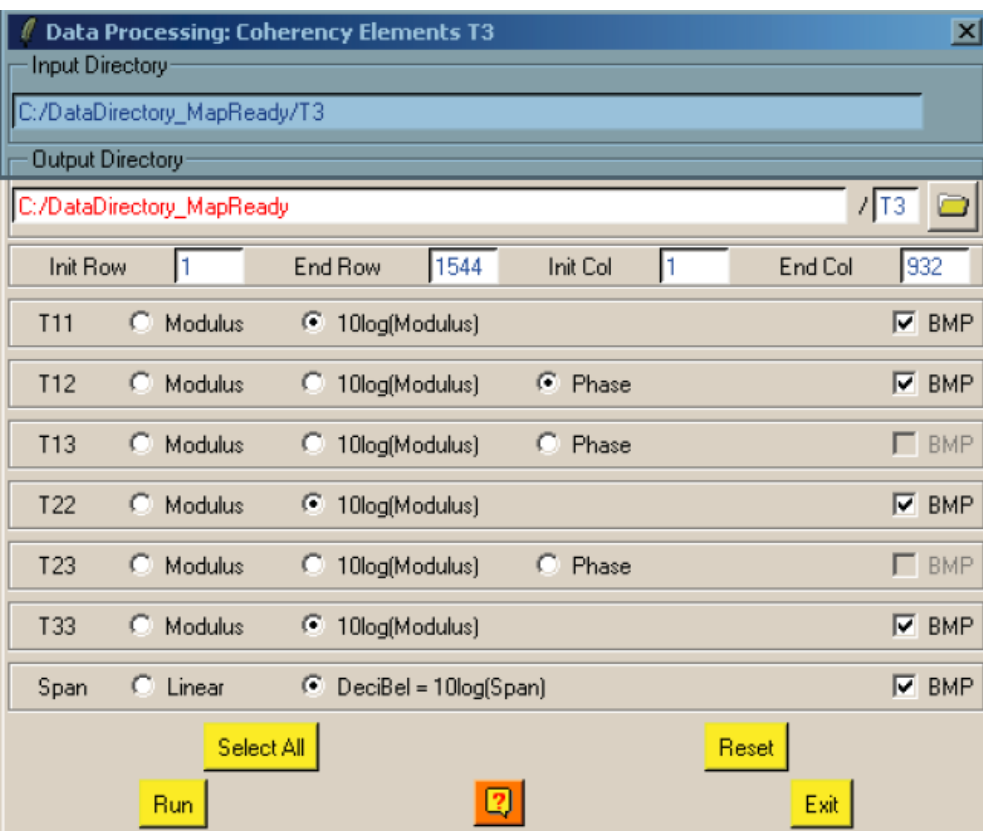


## 1.4 Feature selection and transformation

Features available in PolSARPro:

(1) Matrix elements, eg. [T3]

(2) Polarimetric decomposition features  
eg. H/A/Alpha decomposition



All the elements can be used as features

## 1.4 Feature selection and transformation

Features available in PolSARPro:

(2) Polarimetric decomposition features and many others provided by PolSARPro:

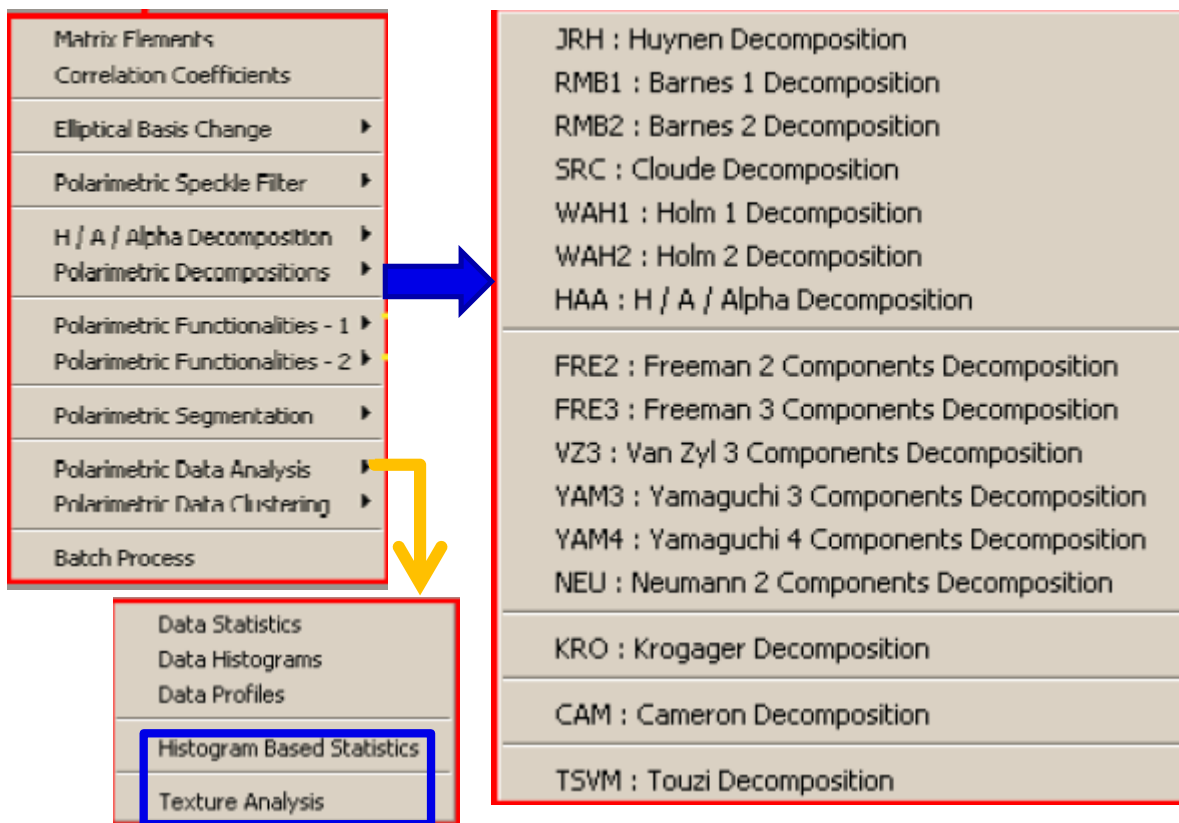
**But it does not mean the more the better for classification:**

**Dimension disaster problem:**

- With fixed training samples, accuracy increases with dim to one maximum acc., then decreases
- The key reason is there are correlations between features, and more feature needs more training samples to solve the classification model.

**PolSARPro solution:**

- SVM supervised classification, lets you to choose features.





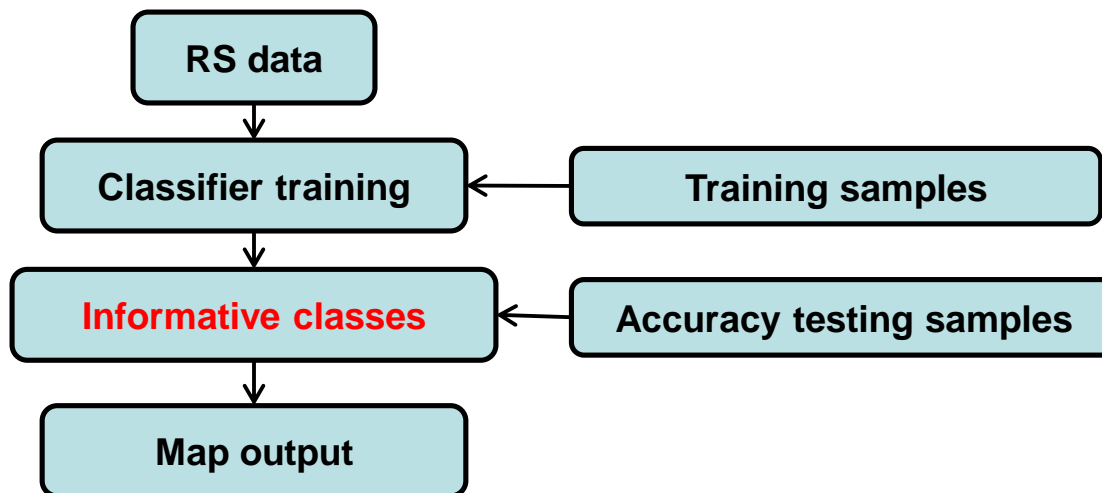
## 1.5 Classifier training and testing

- “spectral classes “ and “informative classes”
  - Spectral classes
    - Classes can be spectrally separated, optical remote sensing
    - Classes can be separated by polarimetric mechanism or PolSAR data itself
  - Informative classes: useful for real applications

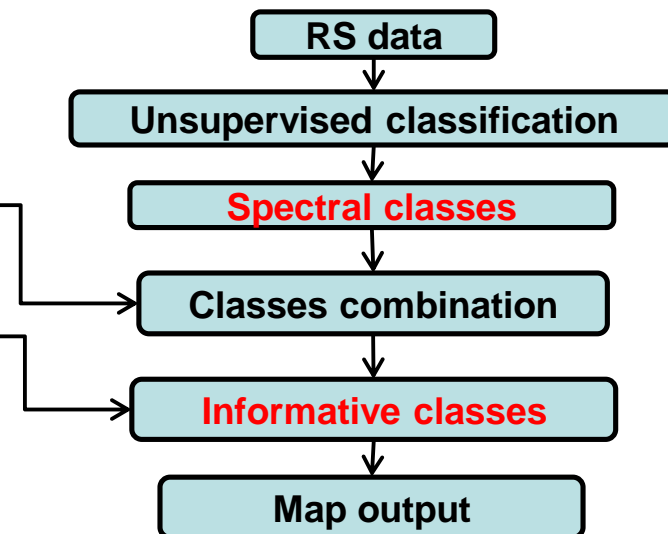
But,

- Without training it is harder to get informative classes

Supervised classification



Un-supervised classification



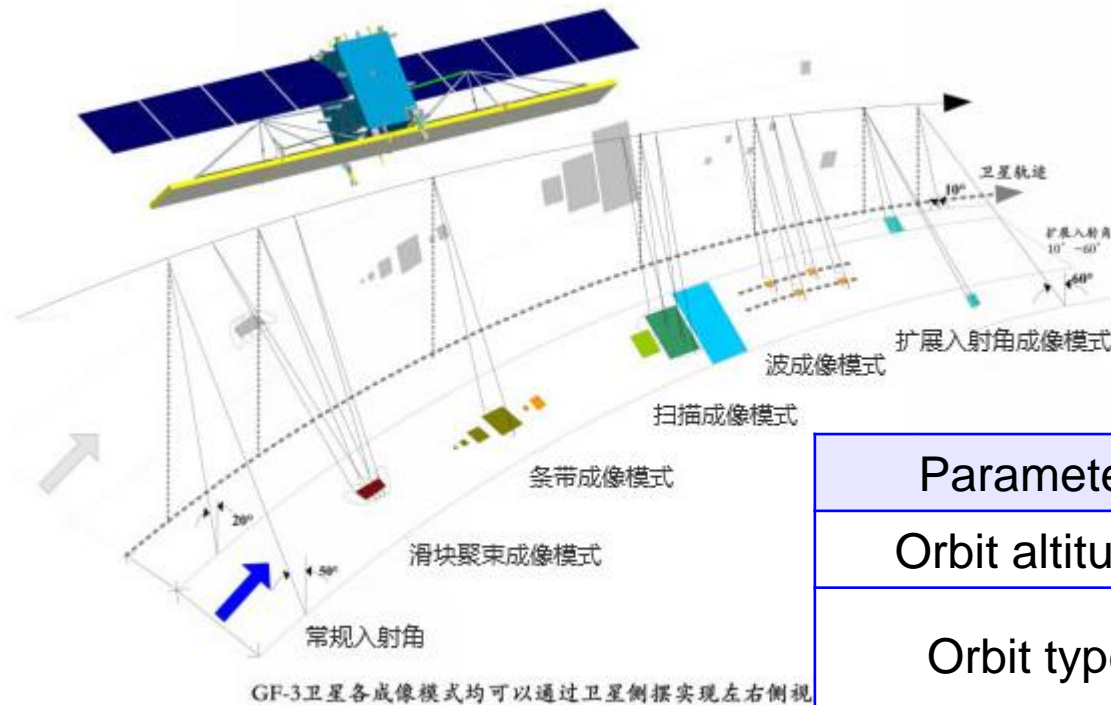
# II. GF-3 PoISAR dataset



## 2.1 The Specifications of GF-3 Satellite

Advantages:

- ❖ High spatial resolution (1 m)
- ❖ Multi imaging mode (12 types)
- ❖ Universal application (Ocean, Disaster reduction, Meteorology)



Parameter	Specification
Orbit altitude	755 km
Orbit type	Sun synchronization repeating orbit
Revisit cycle	29 days
Band	C
Incidence angle	10° ~ 60°

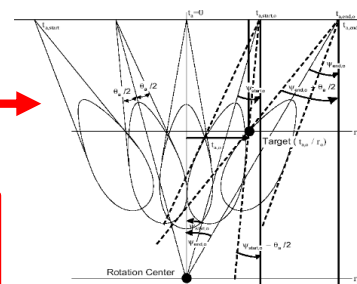
# II. GF-3 PoSAR dataset



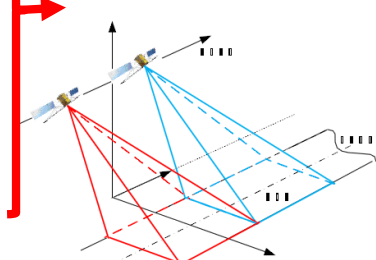
## 2.1 The Specifications of GF-3 Satellite

NO.	Mode	Incidence angle	Resolution (m)	Width (Km)	Polarization
1	SL	20-50	1	10	Single
2	UFS	20-50	3	30	Single
3	FSI	19-50	5	50	Dual
4	FSII	19-50	10	100	Dual
5	SS	17-50	25	130	Dual
6	<b>QPSI</b>	<b>20-41</b>	<b>8</b>	<b>30</b>	<b>Full</b>
7	QPSII	20-41	25	40	Full
8	NSC	17-50	50	300	Dual
9	WSC	17-50	100	500	Dual
10	GLO	17-53	500	130	Dual
11	WAV	20-41	10	5	Full
12	EXT	10-60	25	80	Dual

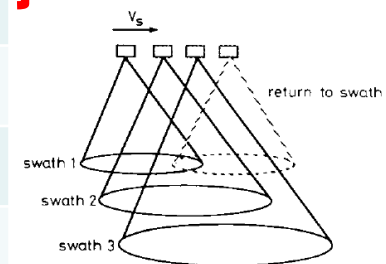
Spotlight



Stripmap



ScanSAR

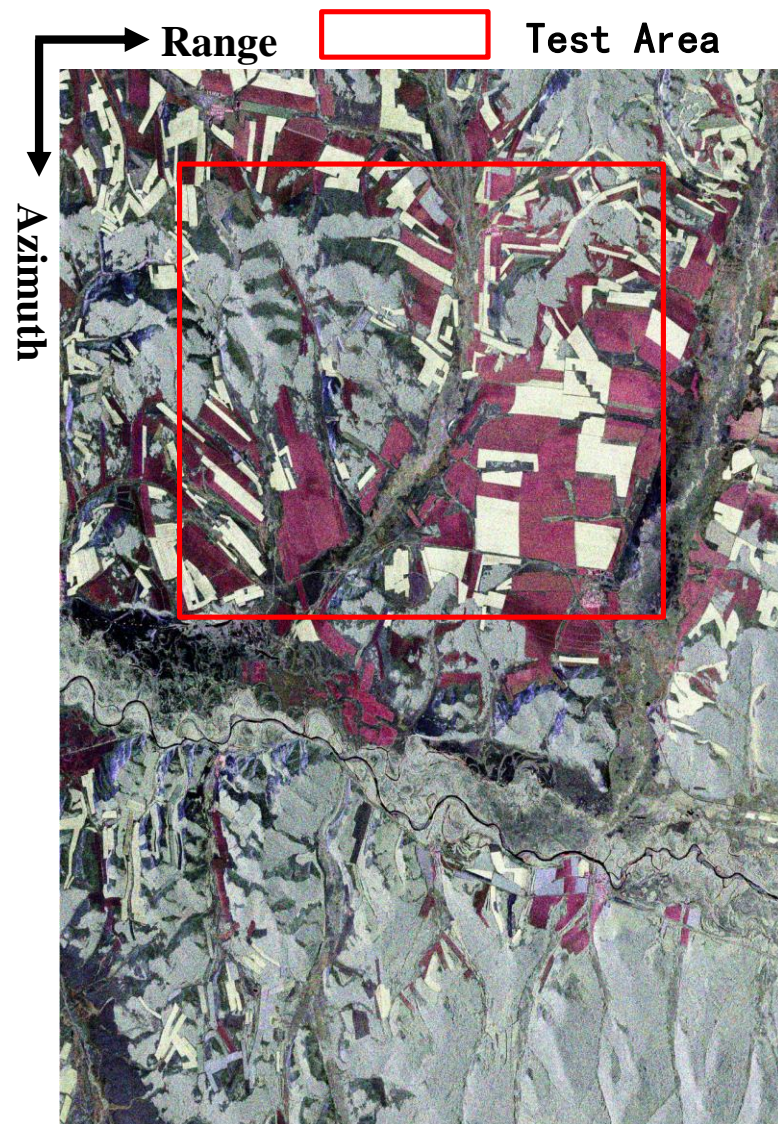


# II. GF-3 PolSAR dataset



## 2.2 Practical Data of GF-3

- GF-3 PolSAR Data
  - Observation Mode:  
**QPSI (Quad Polarization Strip I)**
  - Observation Date:  
**Aug. 03. 2017.**
  - Pixel Spacing(azimuthxrange):  
**5.01 m × 4.50 m.**
  - Center incidence angle:  
**48.8°**

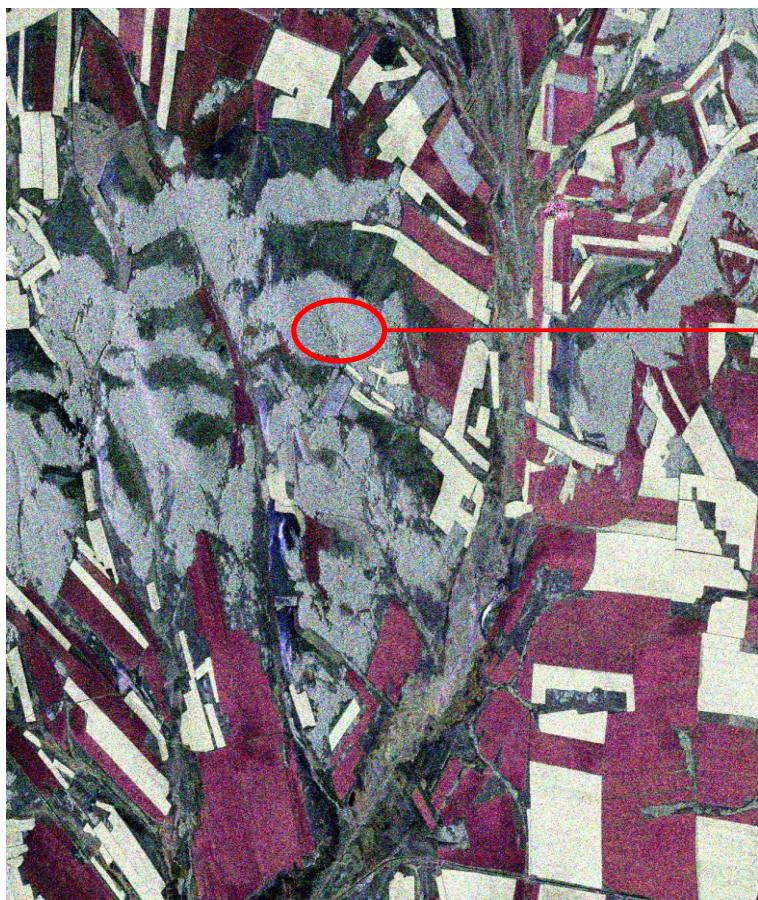


Calibrated and Multi-look ( 2 × 2 )  
processed Result (Pauli RGB)

## II. GF-3 PolSAR dataset



### 2.3 GF-3 PolSAR PauliRGB and the key landcover types



**Forest**



**Subset Test Area**

## II. GF-3 PolSAR dataset



### 2.3 GF-3 PolSAR PauliRGB and the key landcover types



Wheat



Subset Test Area

## II. GF-3 PoISAR dataset



### 2.3 GF-3 PoISAR PauliRGB and the key landcover types



Cole

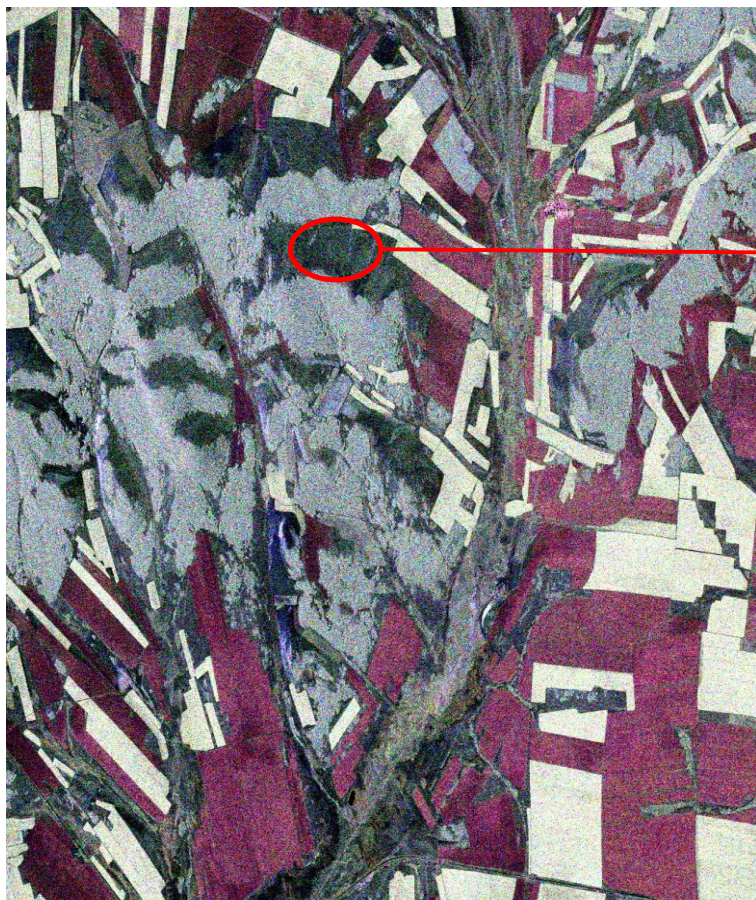


Subset Test Area

## II. GF-3 PolSAR dataset



### 2.3 GF-3 PolSAR PauliRGB and the key landcover types



Subset Test Area

Grass





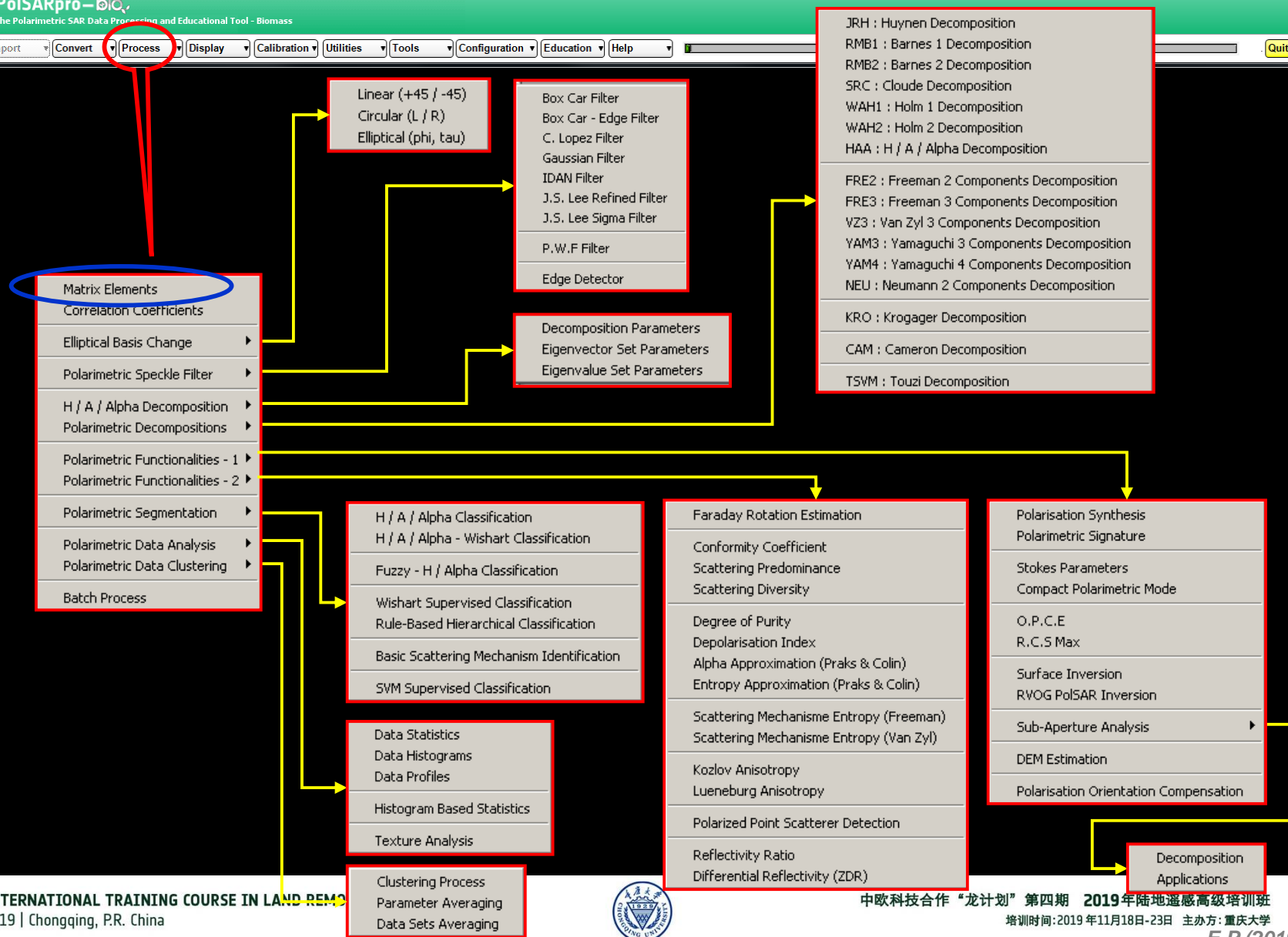
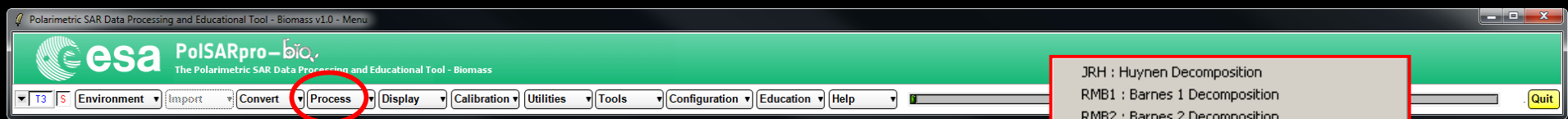
# III. Practical

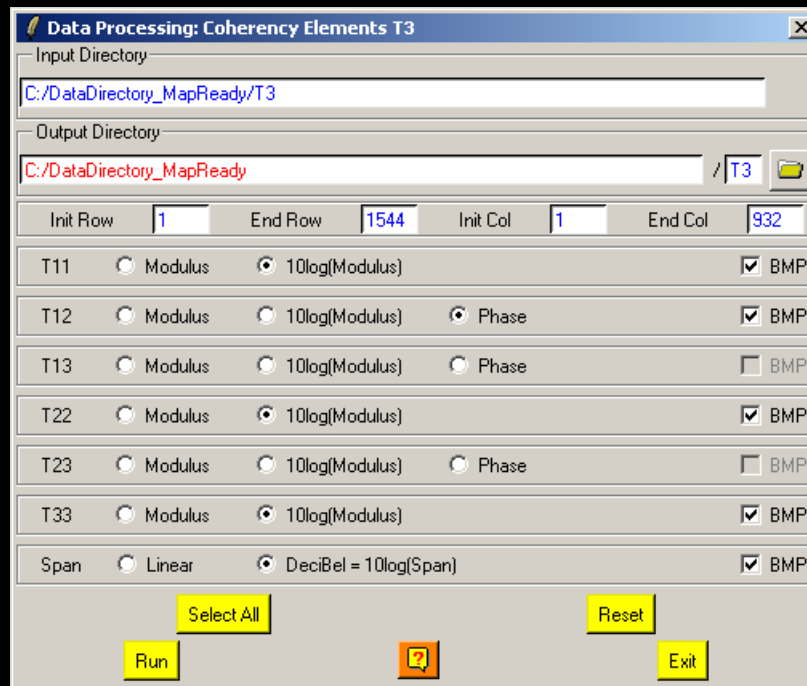
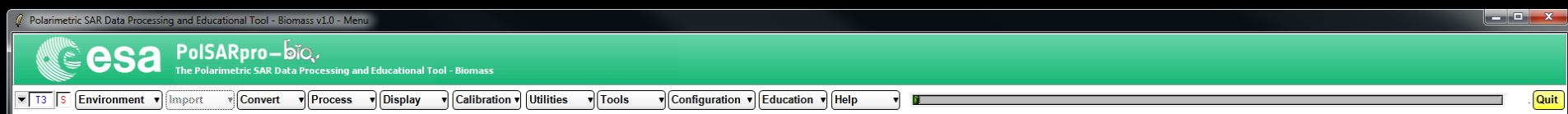


- [T3] elements
- Decomposition parameters
- H/A/alpha classification
- H/A/alpha WISHART classification
- SVM supervised classification



# PoISARpro - Bio SOFTWARE





**DATADIR**

**T3**

config.txt  
[T3x3] Elements

Txy\_mod.bin  
Txy\_db.bin  
Txy pha.bin  
Txy\_mod.bmp  
Txy\_db.bmp  
Txy pha.bmp

**Do it Yourself:**  
Select some elements, set the parameters and view the corresponding BMP files (select BMP).

# DECOMPOSITION PARAMETERS



**Do it Yourself:**  
Select some elements, set the parameters (**Nwin = 1**) and view the corresponding BMP files (**select BMP**).

**Data Processing: H / A / Alpha Decomposition Parameters**

Input Directory: D:/SAN\_FRANCISCO\_ALOS\_SNAP/T3

Output Directory: D:/SAN\_FRANCISCO\_ALOS\_SNAP / T3

Init Row: 1    End Row: 3010    Init Col: 1    End Col: 2269

<input checked="" type="checkbox"/> Alpha, Beta, Delta, Gamma, Lambda	<input checked="" type="checkbox"/> BMP
<input checked="" type="checkbox"/> Lambda	<input checked="" type="checkbox"/> BMP
<input checked="" type="checkbox"/> Alpha	<input checked="" type="checkbox"/> BMP
<input checked="" type="checkbox"/> Entropy [ H ]	<input checked="" type="checkbox"/> BMP
<input checked="" type="checkbox"/> Anisotropy [ A ]	<input checked="" type="checkbox"/> BMP
<input checked="" type="checkbox"/> Combinations [ H , A ]	<input checked="" type="checkbox"/> H A <input checked="" type="checkbox"/> (1 - H) A <input checked="" type="checkbox"/> H (1 - A) <input checked="" type="checkbox"/> (1 - H) (1 - A) <input checked="" type="checkbox"/> BMP

Window Size Row: 1    Window Size Col: 1    **Select All**    **Reset**

Equivalence between [ T ] and [ C ] eigen-decompositions.

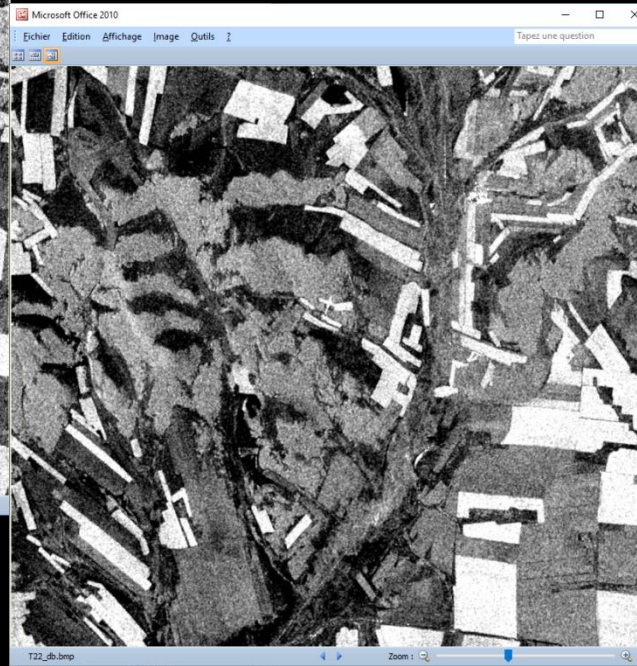
**Run**    **Exit**



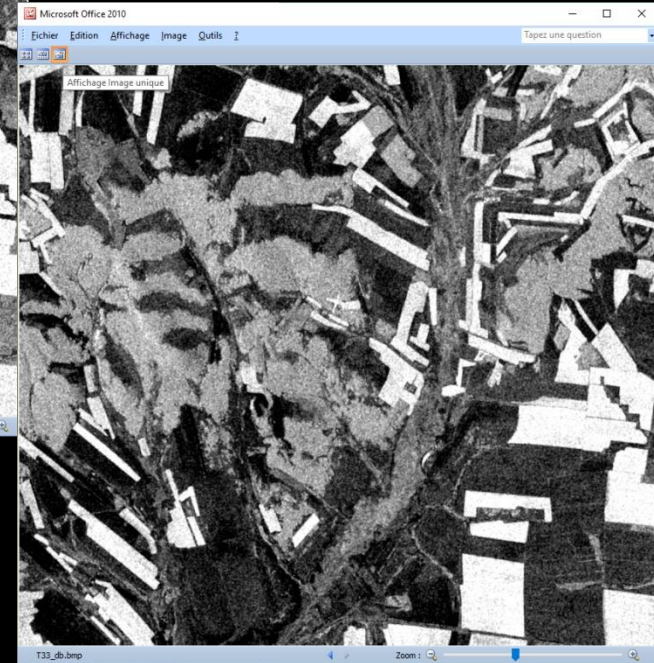
## T11\_dB



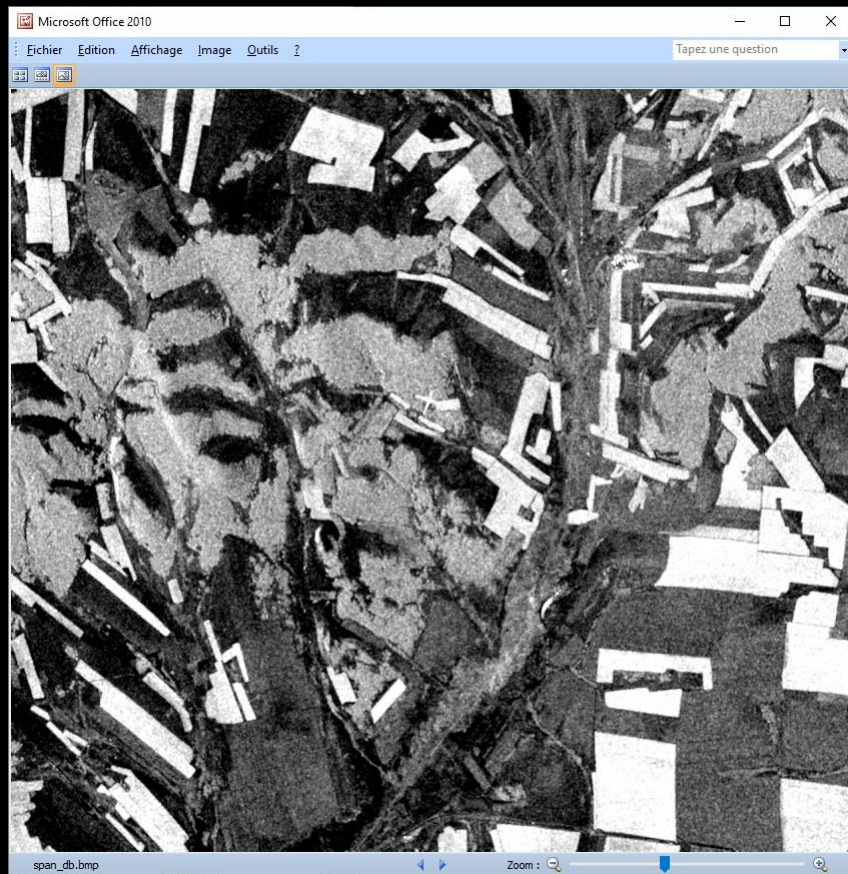
## T22\_dB



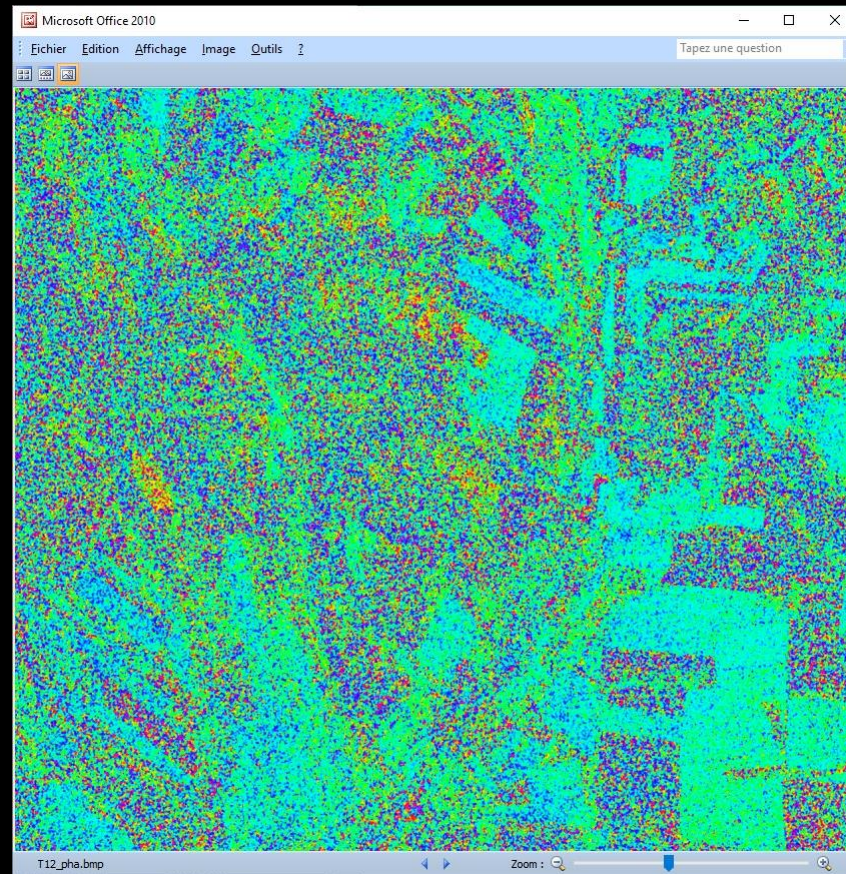
## T33\_dB



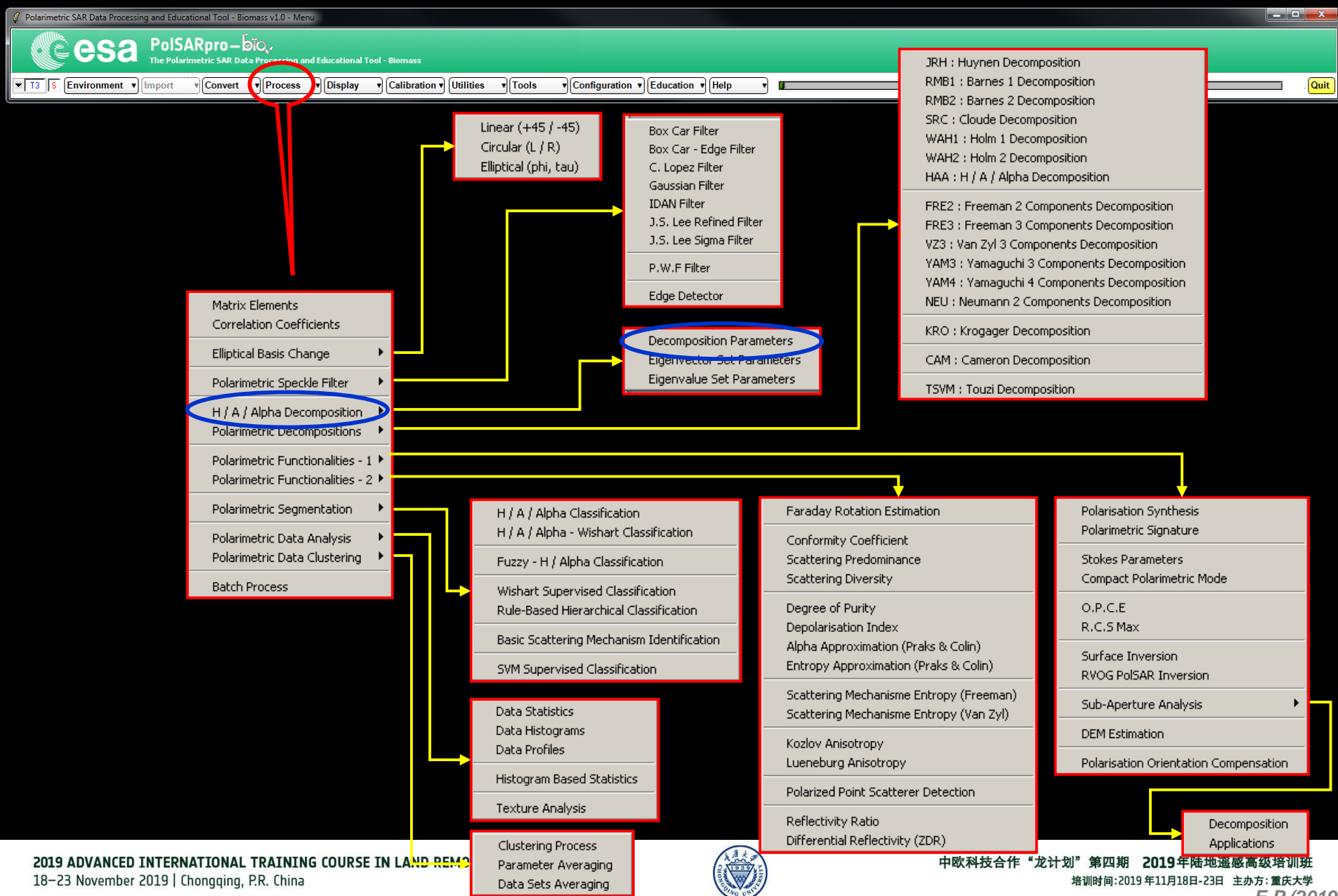
## span\_dB



## T12 pha



# PoISARpro - Bio SOFTWARE



# DECOMPOSITION PARAMETERS



**Do it Yourself:**  
Select some elements, set the parameters (**Nwin = 3**) and view the corresponding BMP files.

**Data Processing: H / A / Alpha Decomposition Parameters**

Input Directory:

Output Directory:  /

Init Row:  End Row:  Init Col:  End Col:

<input checked="" type="checkbox"/> Alpha, Beta, Delta, Gamma, Lambda	<input checked="" type="checkbox"/> BMP		
<input checked="" type="checkbox"/> Lambda	<input checked="" type="checkbox"/> BMP		
<input checked="" type="checkbox"/> Alpha	<input checked="" type="checkbox"/> BMP		
<input checked="" type="checkbox"/> Entropy ( H )	<input checked="" type="checkbox"/> BMP		
<input checked="" type="checkbox"/> Anisotropy ( A )	<input checked="" type="checkbox"/> BMP		
<input checked="" type="checkbox"/> Combinations ( H , A )	<input checked="" type="checkbox"/> H A	<input checked="" type="checkbox"/> ( 1 - H ) A	<input checked="" type="checkbox"/> BMP
	<input checked="" type="checkbox"/> H ( 1 - A )	<input checked="" type="checkbox"/> ( 1 - H ) ( 1 - A )	

Window Size Row:  Window Size Col:

Equivalence between [ T ] and [ C ] eigen-decompositions.

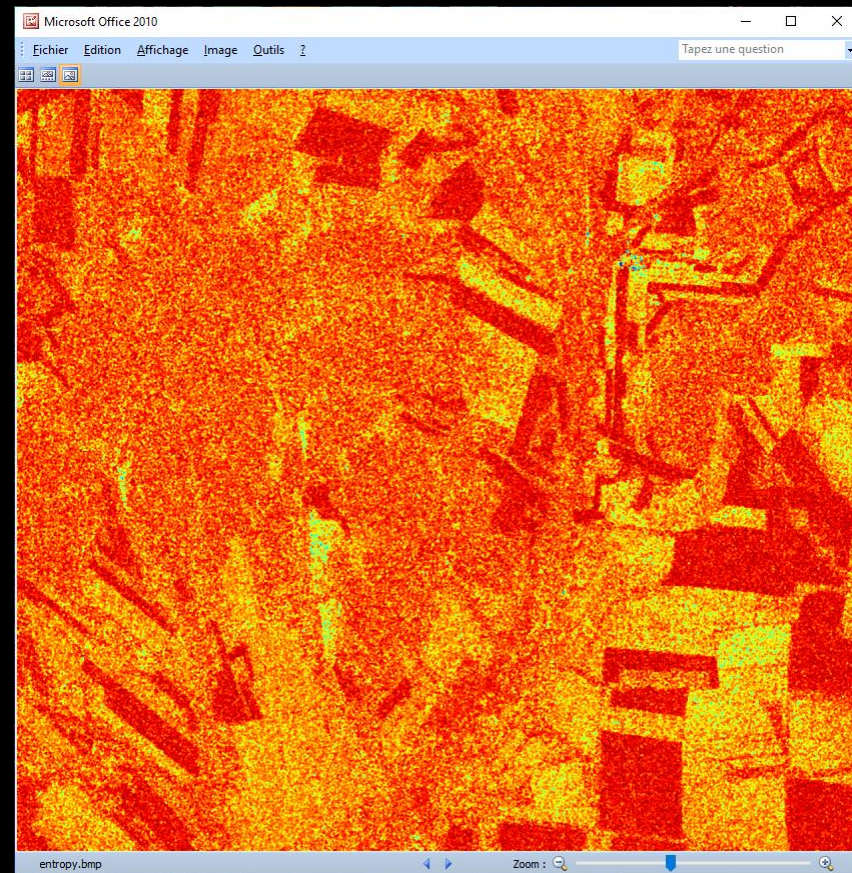




## Lambda



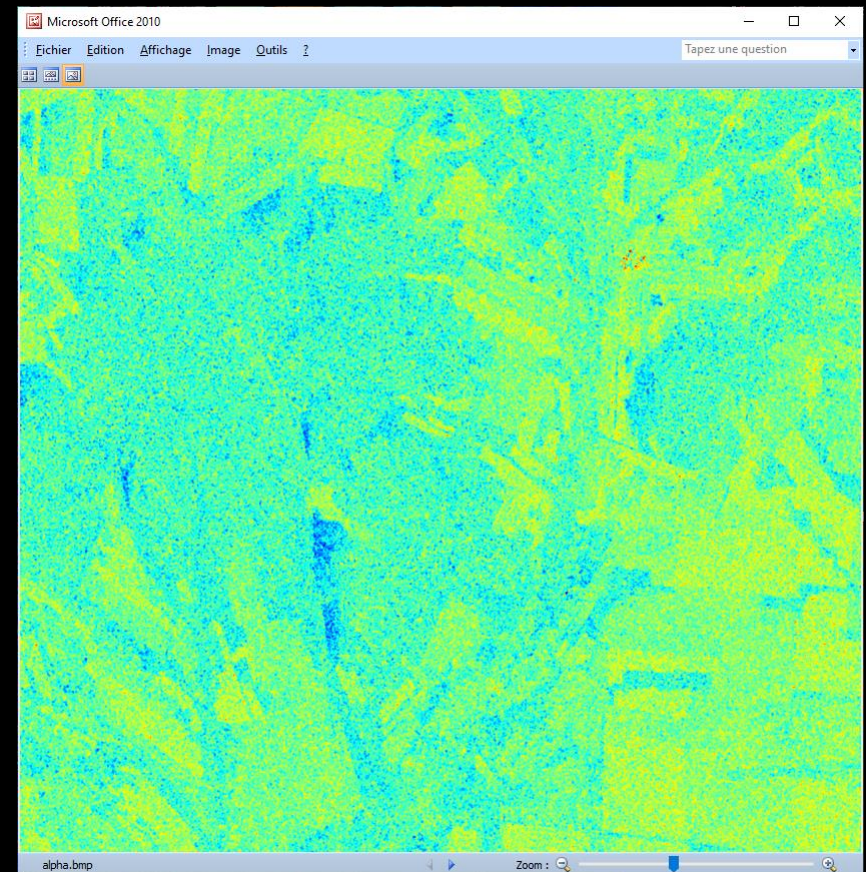
## Entropy



## Lambda



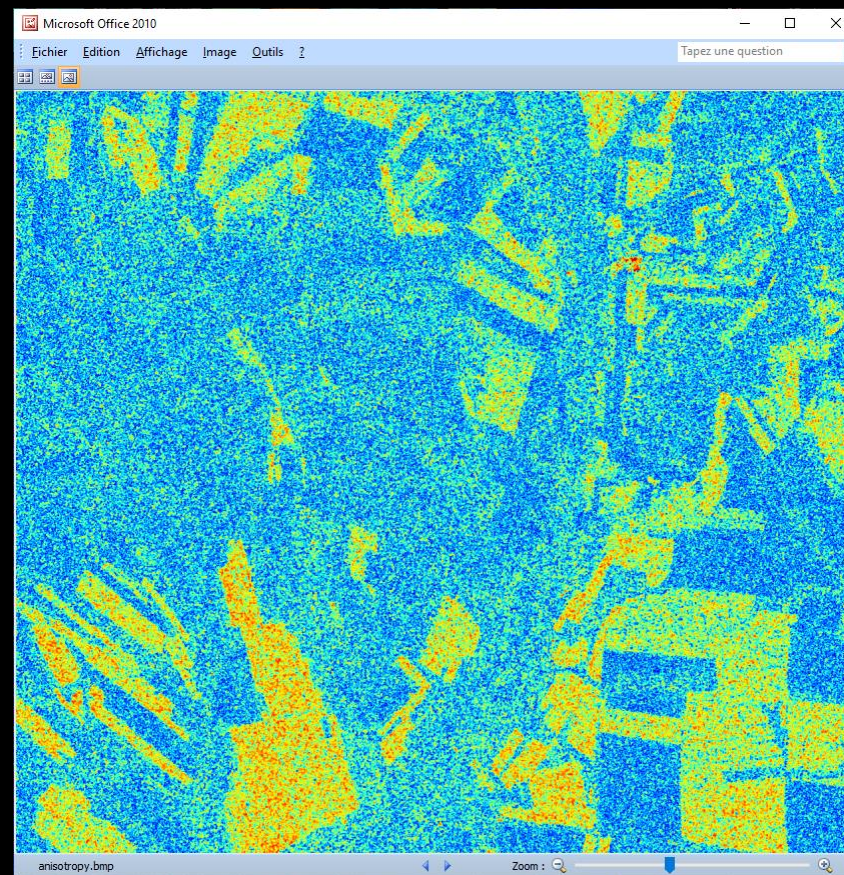
## Alpha



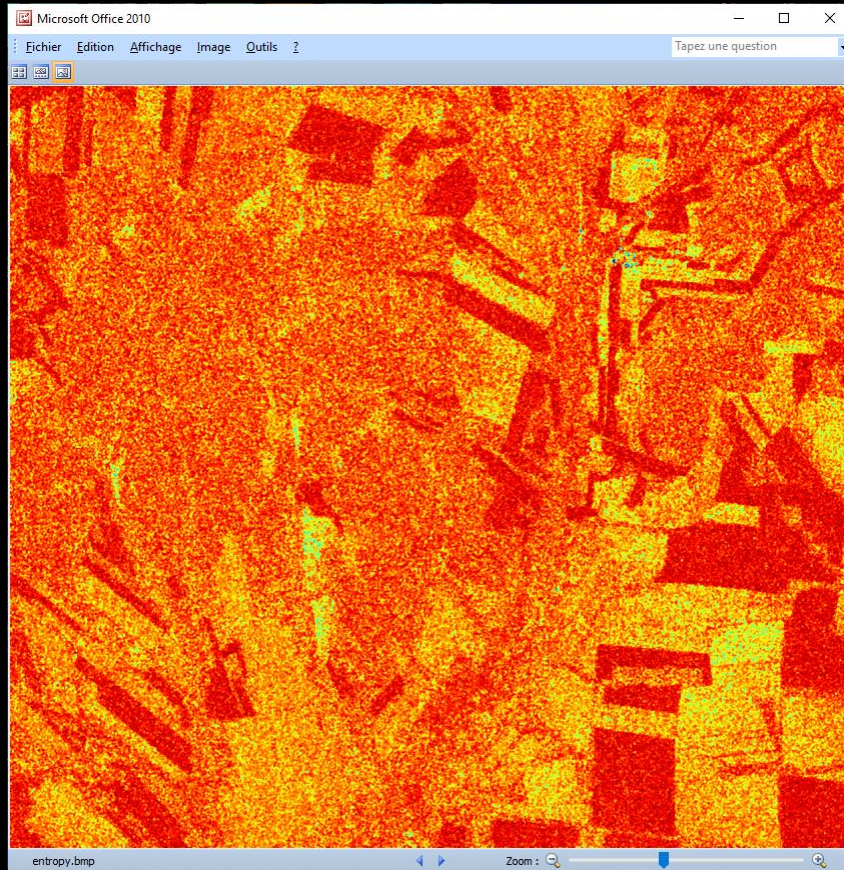
## Lambda



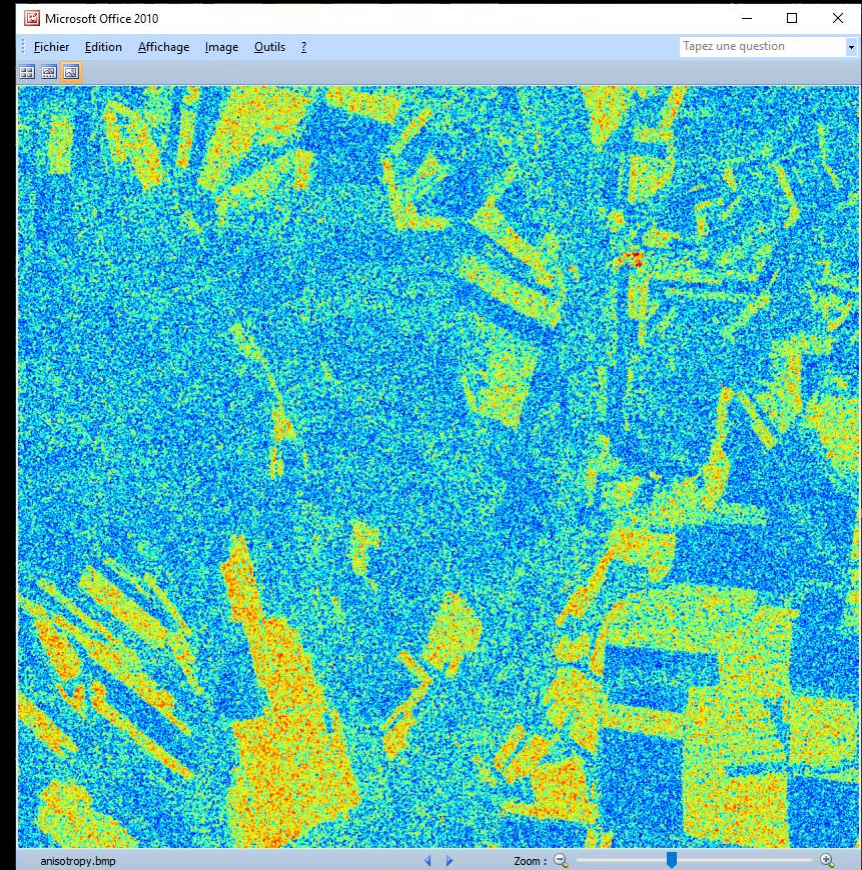
## Anisotropy



## Entropy

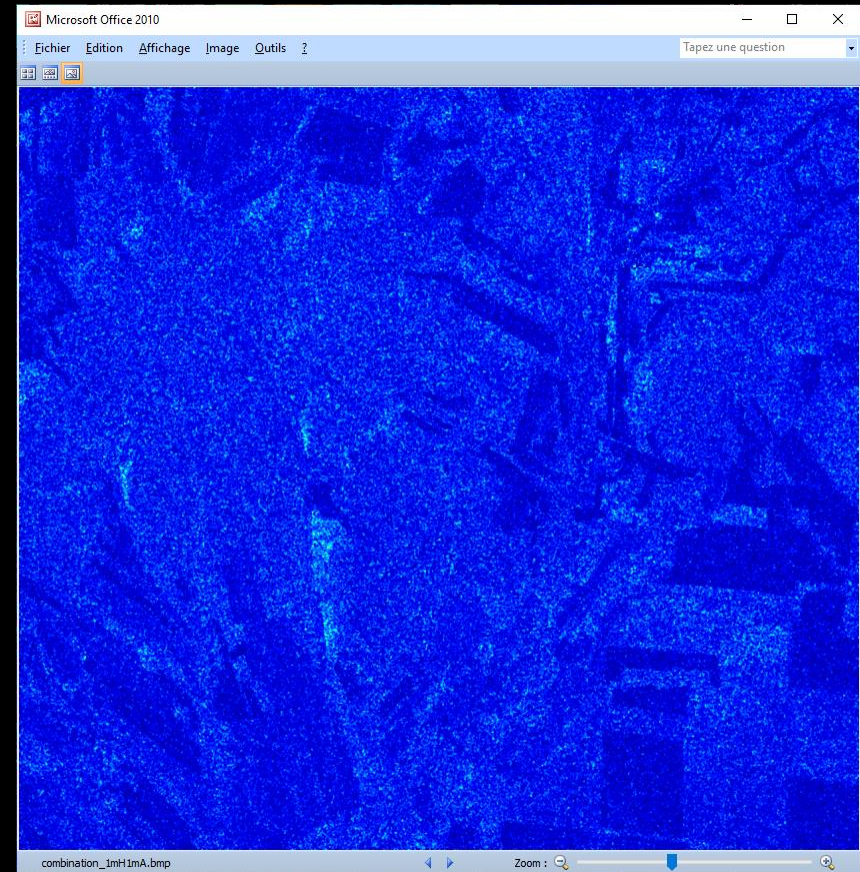
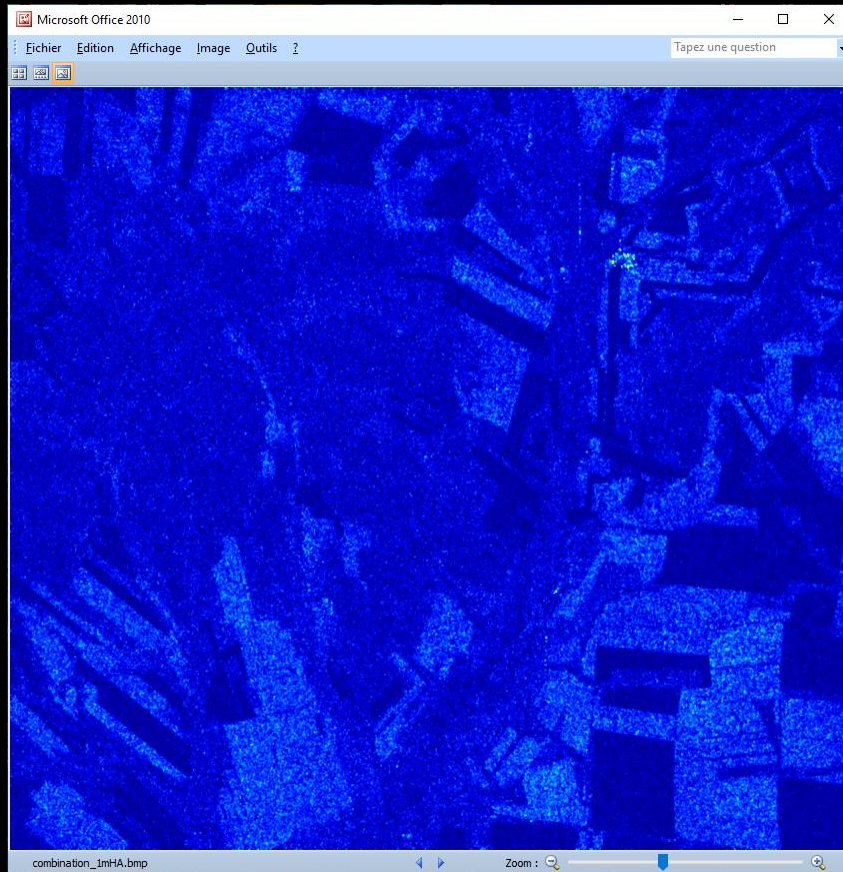


## Anisotropy



(1-H) A

(1-H) (1-A)



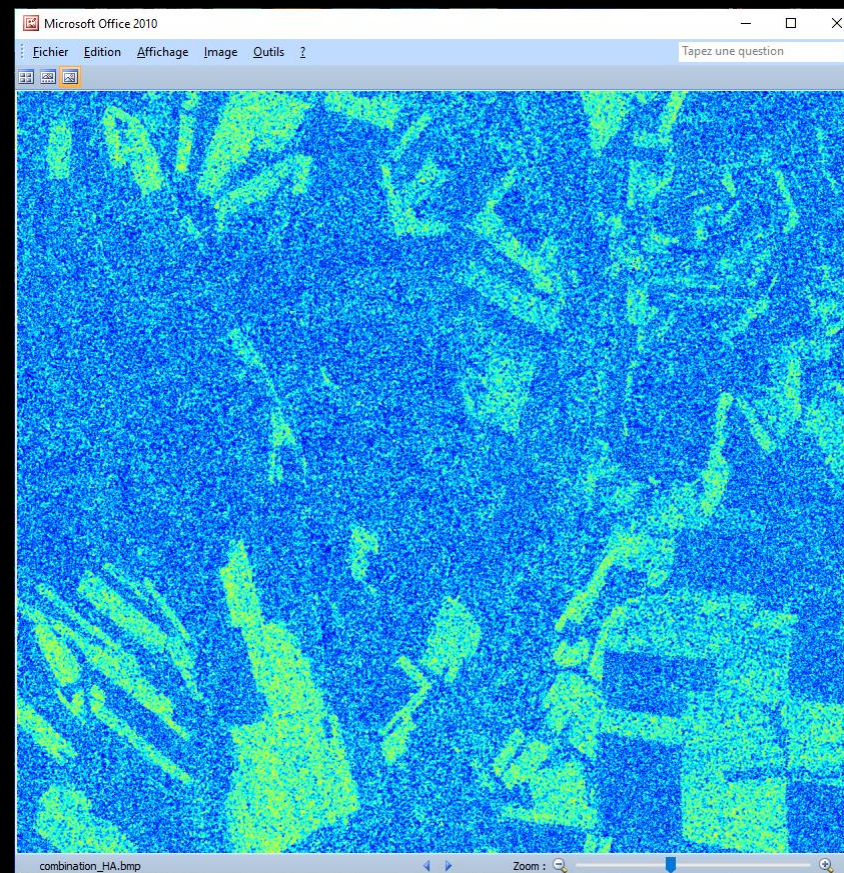
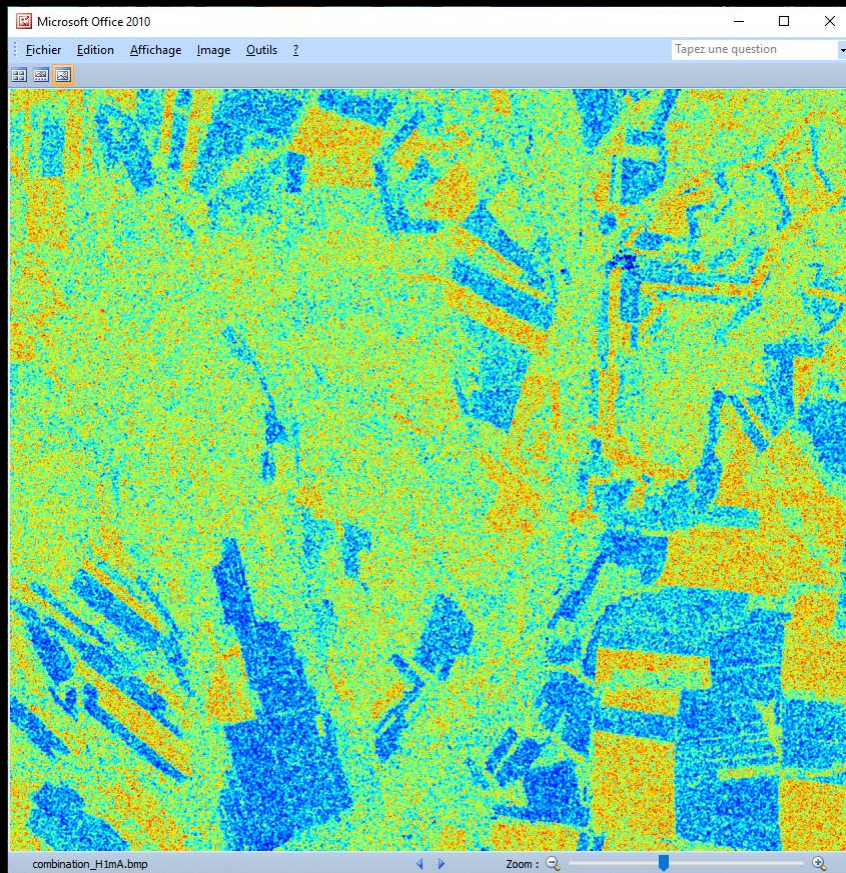
low to medium entropy



low entropy and low anisotropy

## H (1-A)

## HA

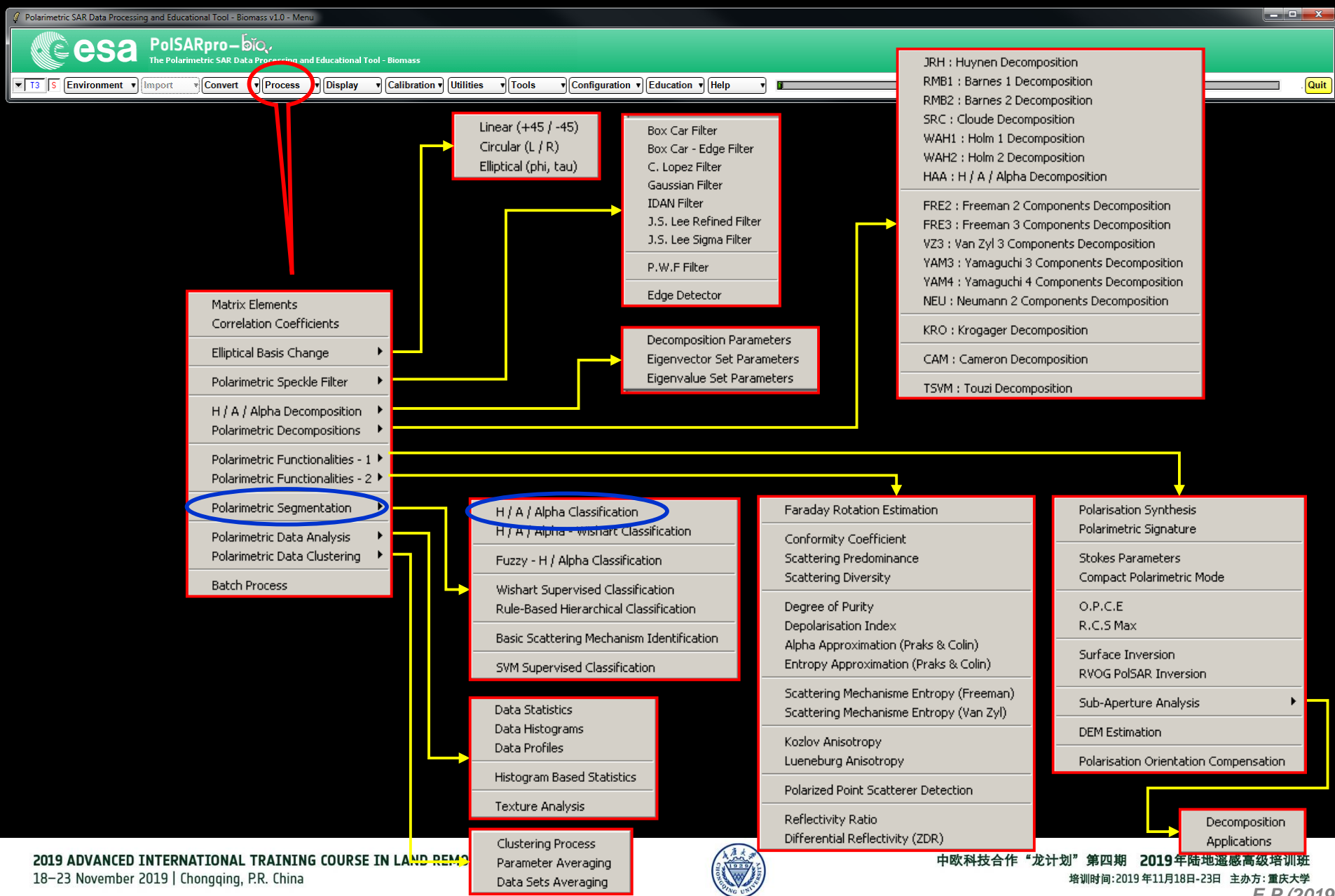


high entropy and  
low anisotropy

high entropy and  
high anisotropy



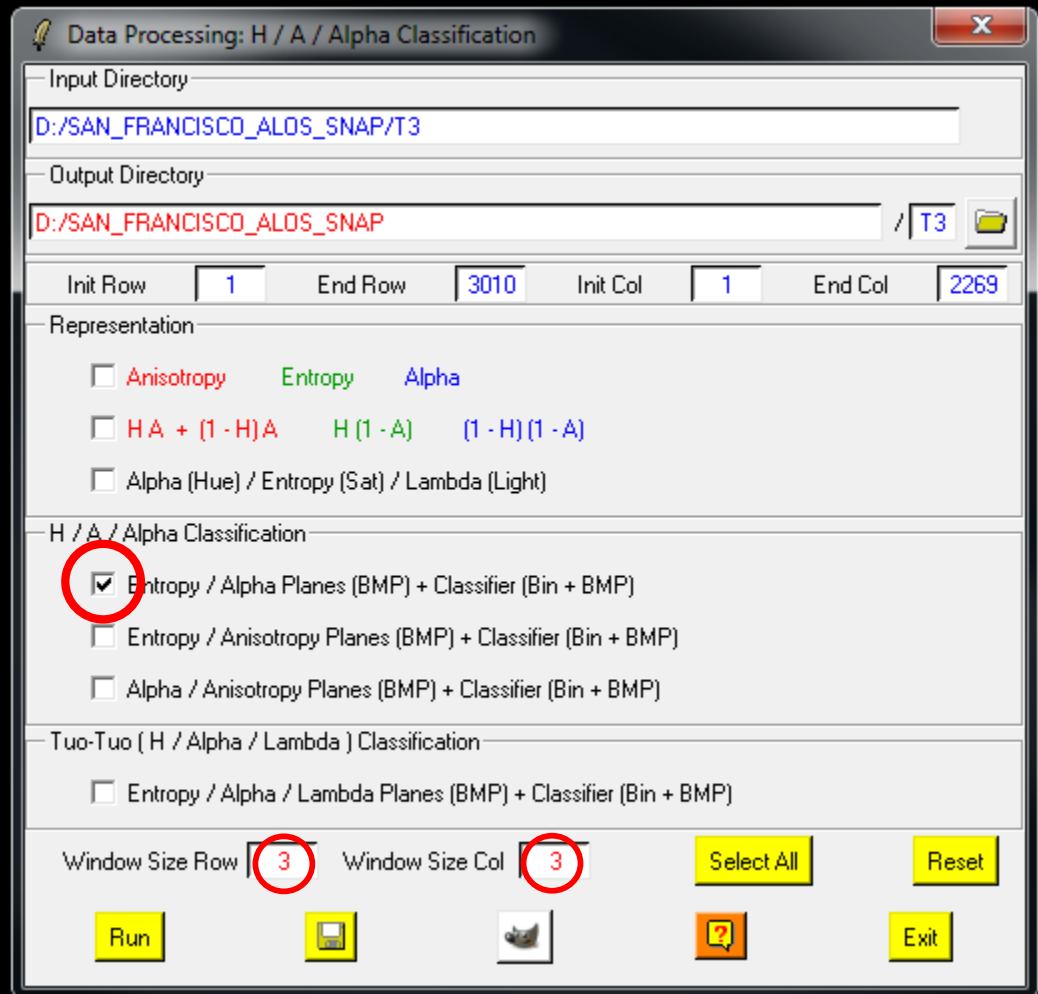
# PoISARpro - Bio SOFTWARE



# H / A / alpha CLASSIFICATION

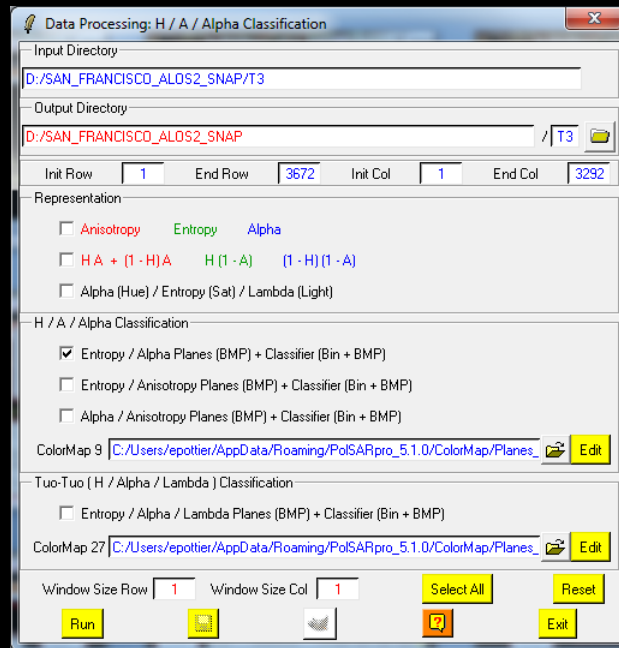


**Do it Yourself:**  
Select some elements, set the parameters (**Nwin = 3**) and view the corresponding BMP files.





# H / A / alpha CLASSIFICATION



**Do it Yourself:**  
Select some elements, set the parameters (**Nwin = 1**) and view the corresponding **BMP** files.

## DATADIR

config.txt

[T3x3] Elements



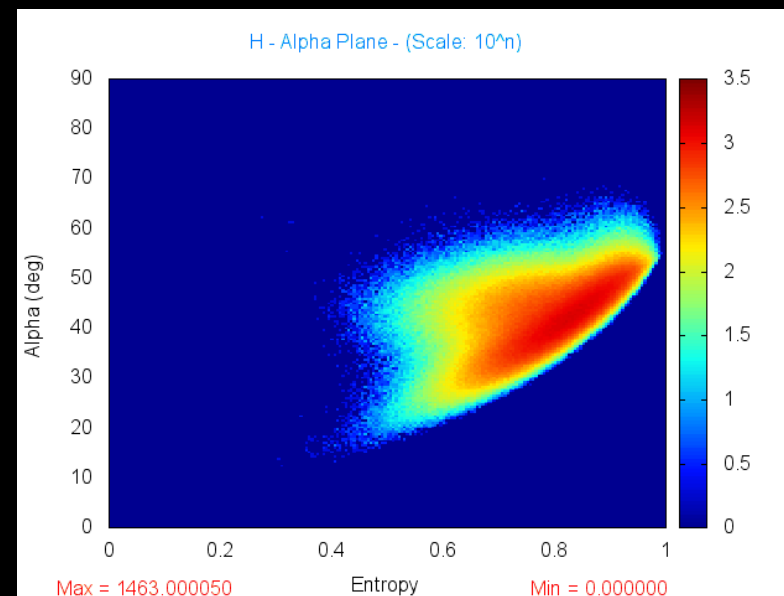
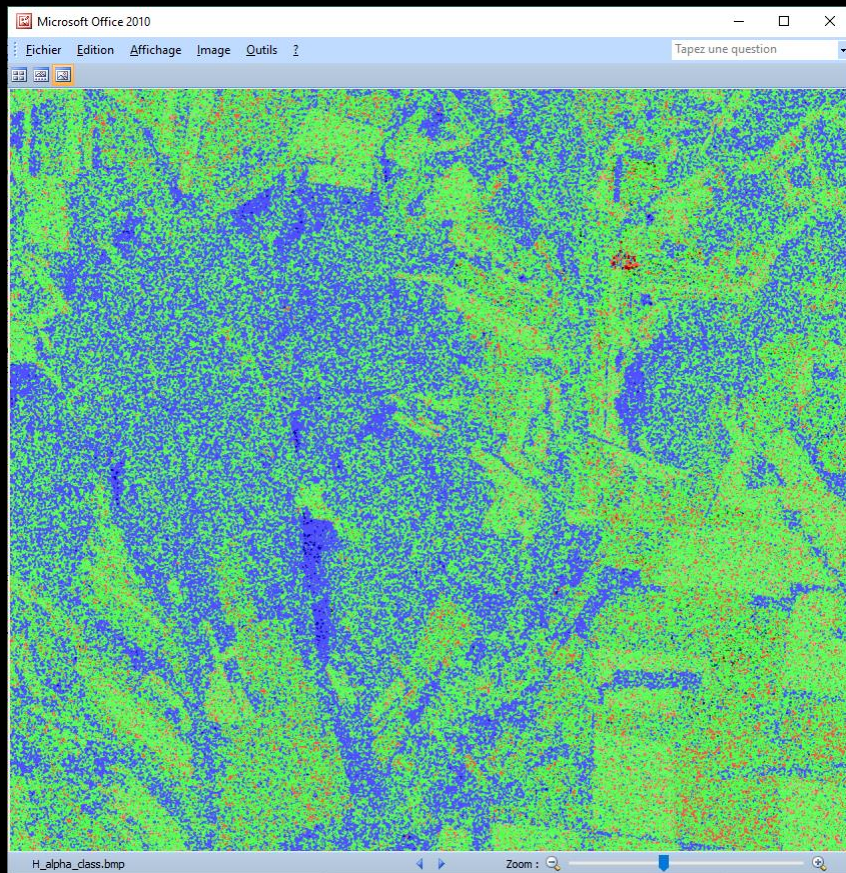
entropy.bin, anisotropy.bin, alpha.bin  
combination\_HA.bin, combination\_1mHA.bin,  
combination\_H1mA.bin, combination\_1mH1mA.bin  
H\_A\_class.bin, H\_Alpha\_class.bin, A\_Alpha\_class.bin



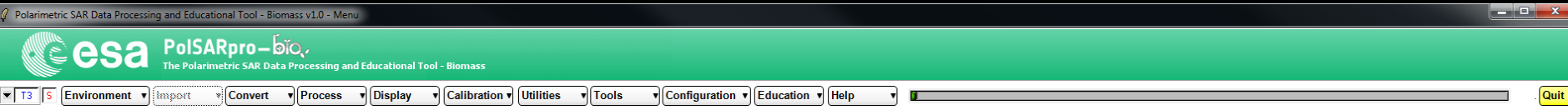
entropy.bmp, anisotropy.bmp, alpha.bmp  
combination\_HA.bmp, combination\_1mHA.bmp,  
combination\_H1mA.bmp, combination\_1mH1mA.bmp  
H\_A\_class.bmp, H\_Alpha\_class.bmp, A\_Alpha\_class.bmp  
H\_A\_occurrence.bmp, H\_Alpha\_occurrence.bmp,  
A\_Alpha\_occurrence.bmp, H\_A\_segmented.bmp,  
H\_Alpha\_segmented.bmp, A\_Alpha\_segmented.bmp  
HAlphaLambda\_RGB.bmp, HAlpha\_RGB.bmp  
HACombinations\_RGB.bmp



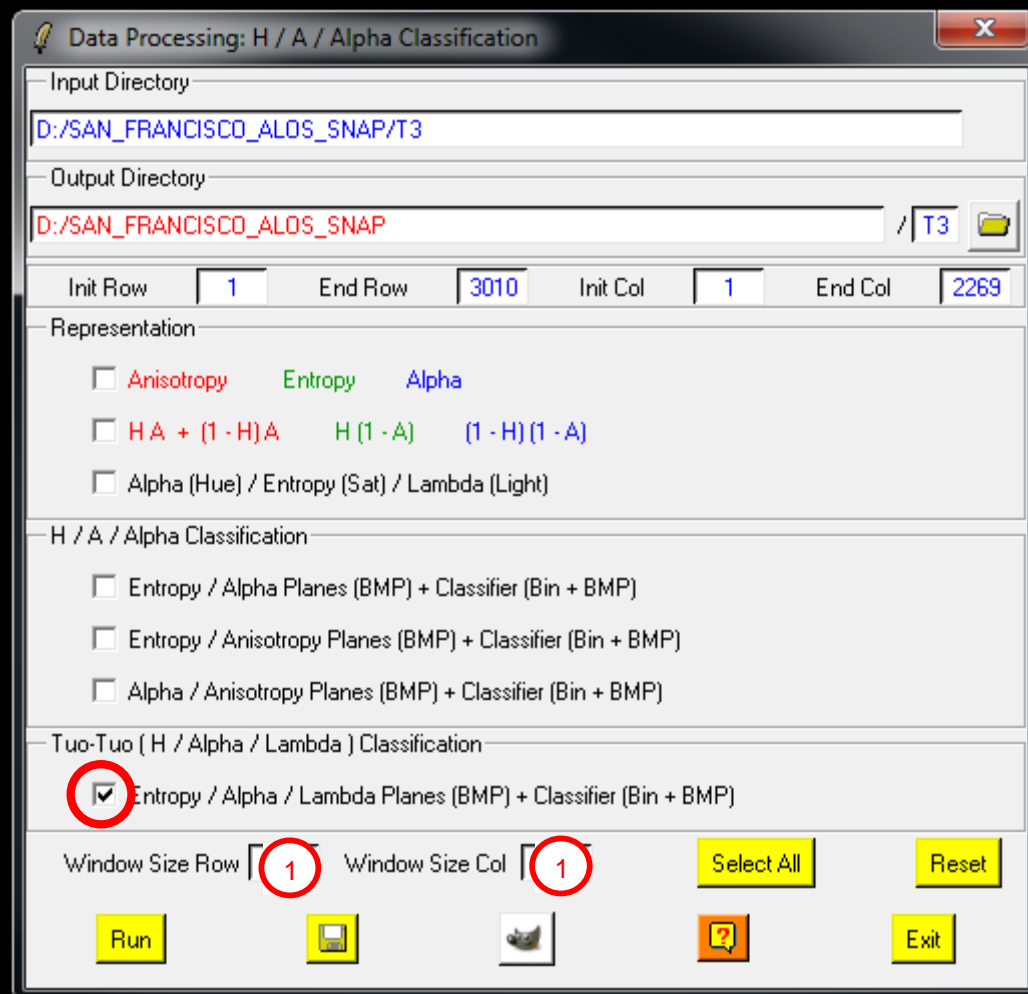
# H / A / alpha CLASSIFICATION



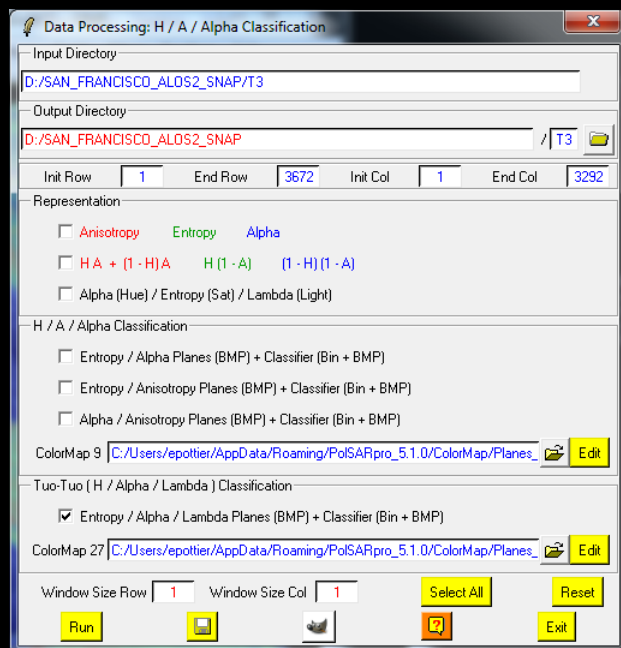
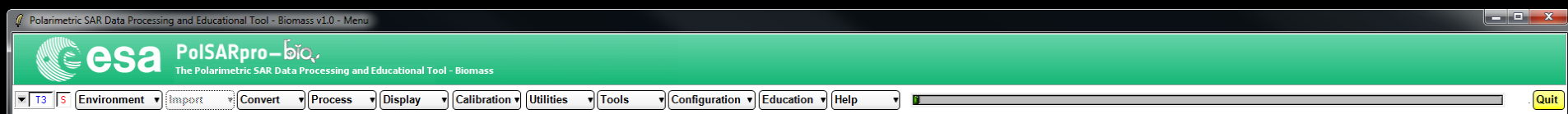
# H / alpha / Lambda CLASSIFICATION



**Do it Yourself:**  
Select some elements, set the parameters (**Nwin = 1**) and view the corresponding BMP files.



# H / alpha / Lambda CLASSIFICATION



## DATADIR

config.txt

[T3x3] Elements



H\_alpha\_lambda\_class1(2,3).bin,  
H\_alpha\_lambda\_occurrence\_class1(2,3).bin,  
H\_alpha\_lambda\_segmented\_class1(2,3).bin,  
H\_alpha\_lambda\_class.bin,

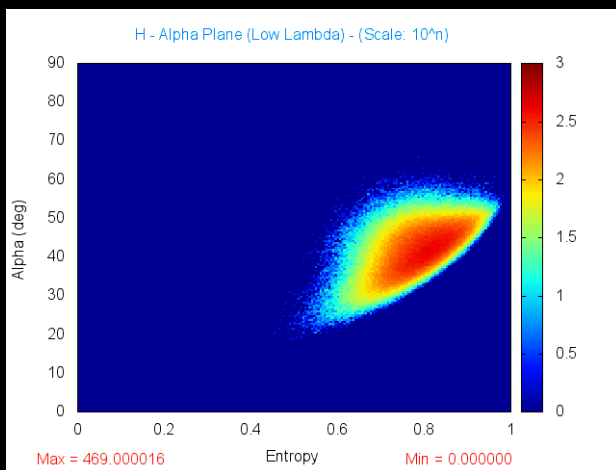
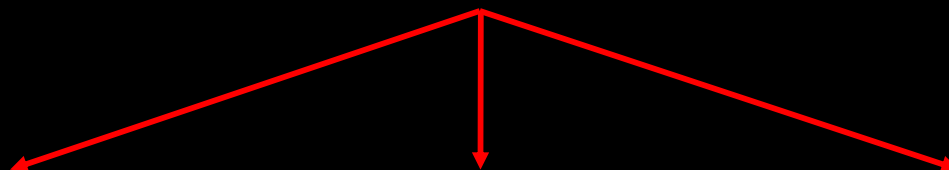
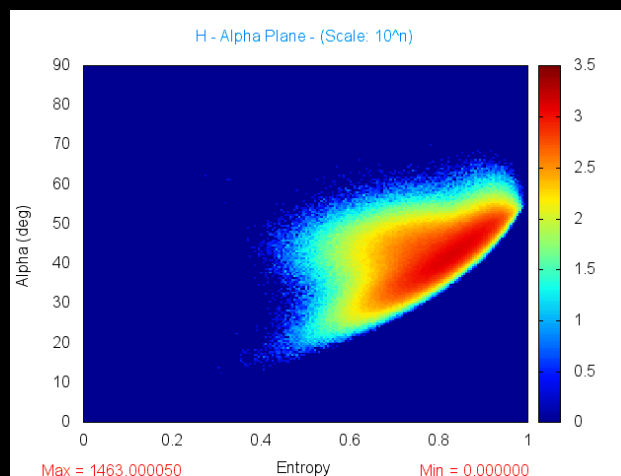


H\_alpha\_lambda\_class1(2,3).bmp,  
H\_alpha\_lambda\_occurrence\_class1(2,3).bmp,  
H\_alpha\_lambda\_segmented\_class1(2,3).bmp,  
H\_alpha\_lambda\_class.bmp,

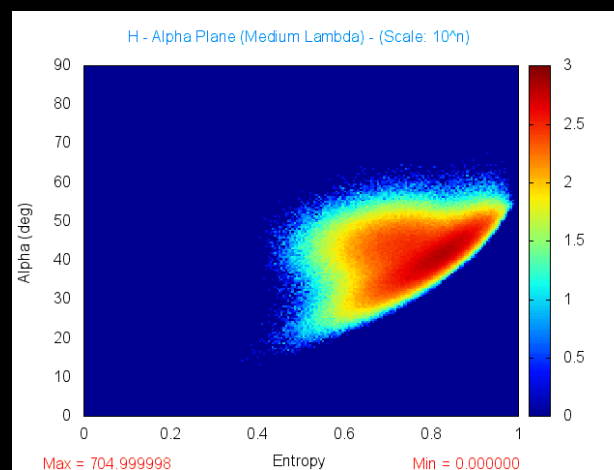
**Do it Yourself:**  
Select some elements, set the parameters (**Nwin = 3**) and view the corresponding BMP files.



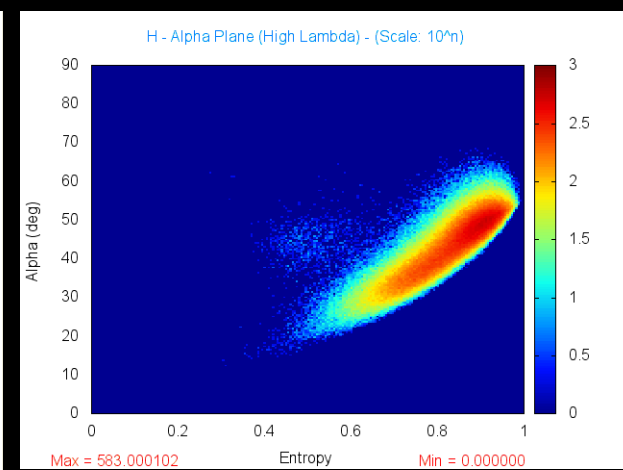
# H / alpha / Lambda CLASSIFICATION



Low  $\lambda$



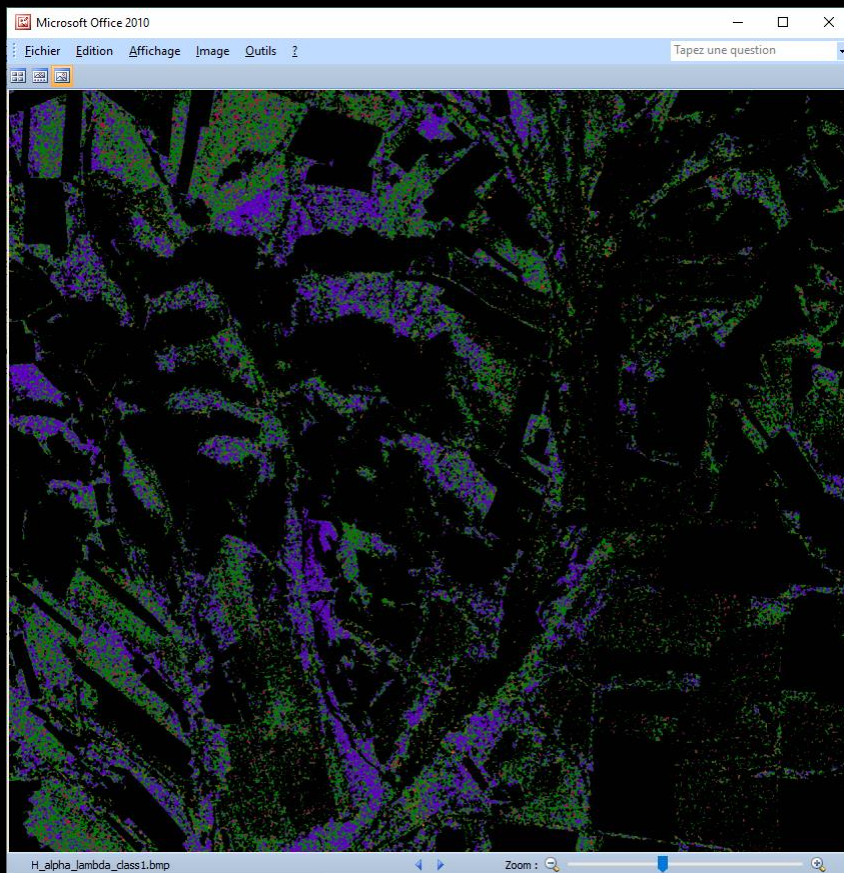
Medium  $\lambda$



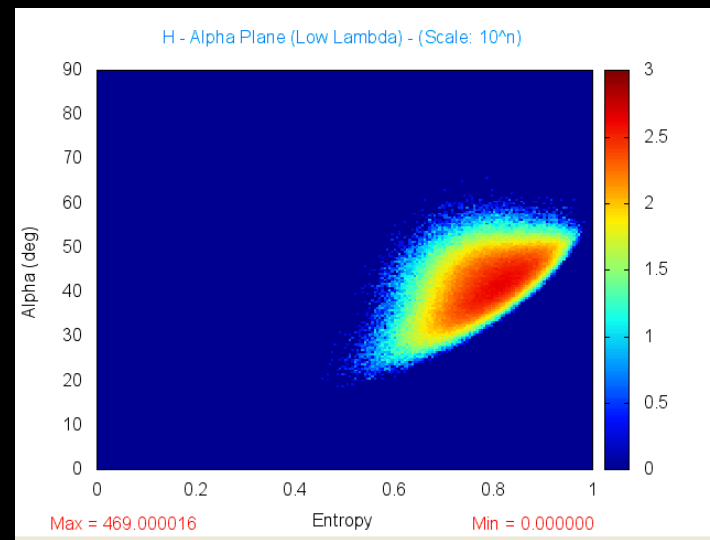
High  $\lambda$



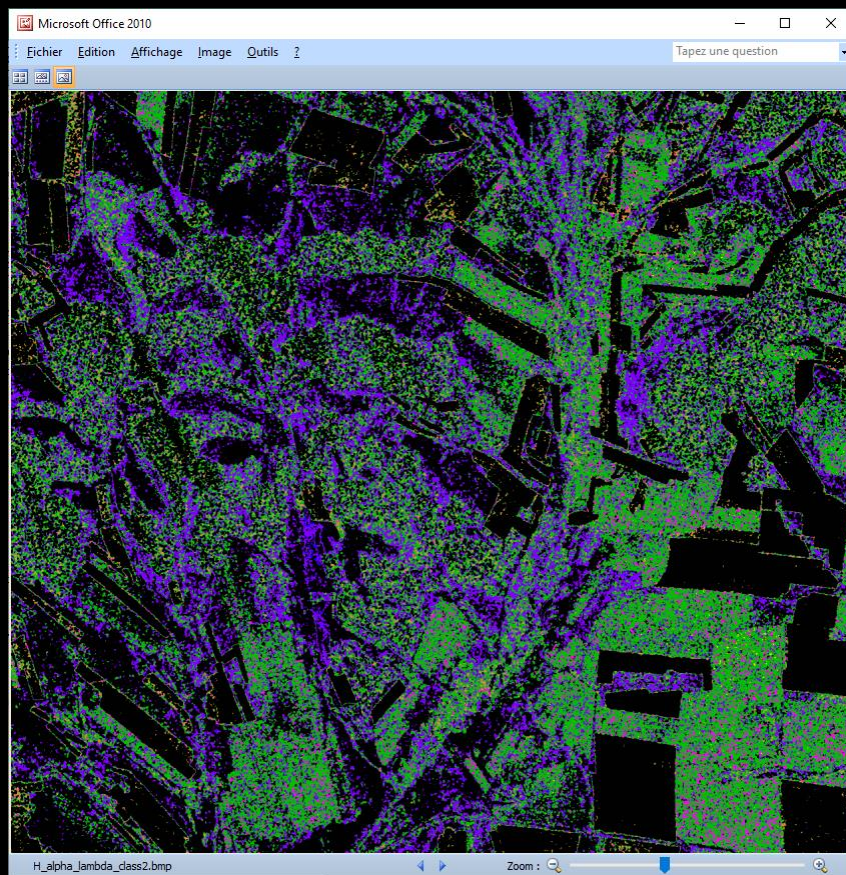
# H / alpha / Lambda CLASSIFICATION



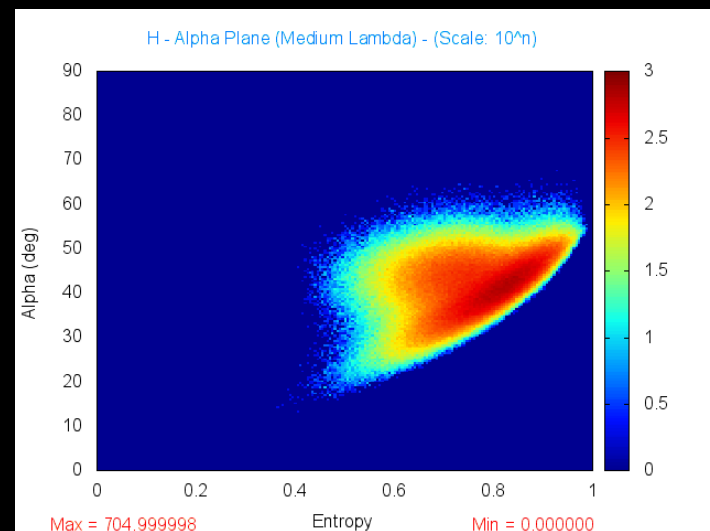
Low  $\lambda$



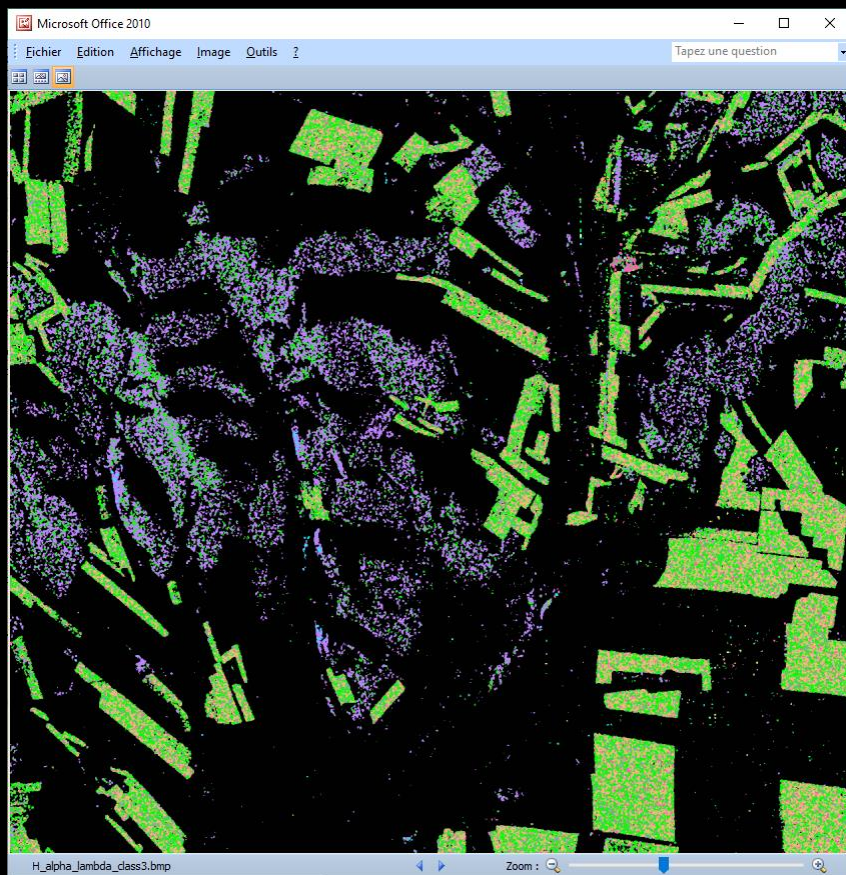
# H / alpha / Lambda CLASSIFICATION



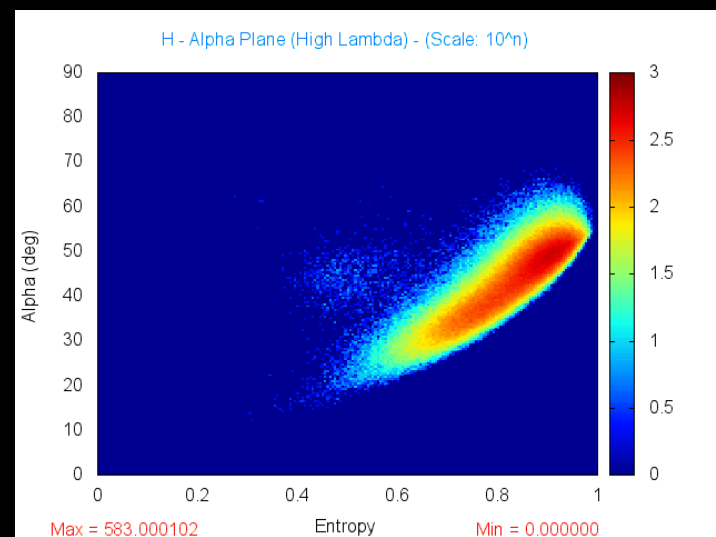
Medium  $\lambda$



# H / alpha / Lambda CLASSIFICATION

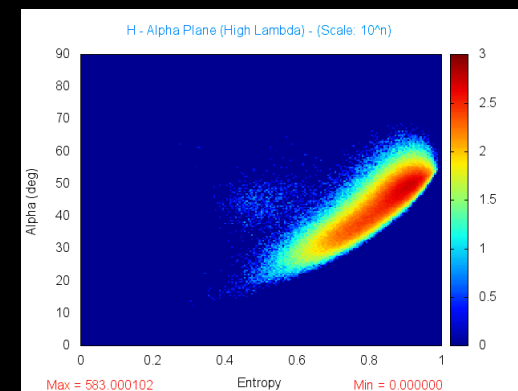
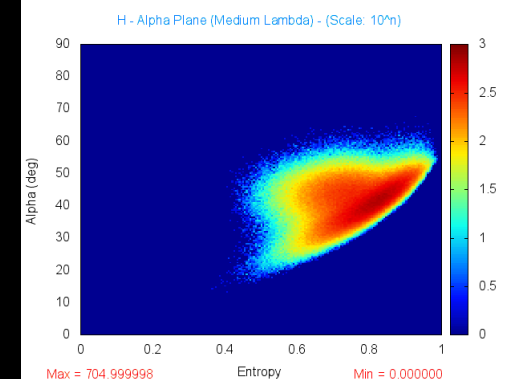
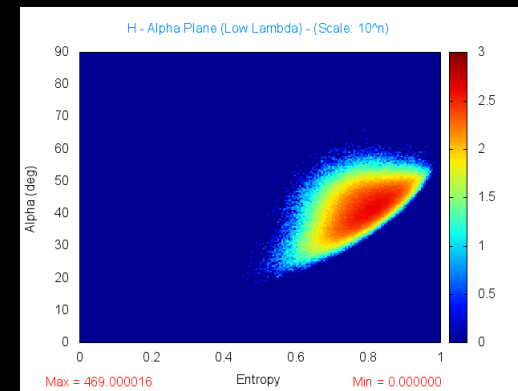
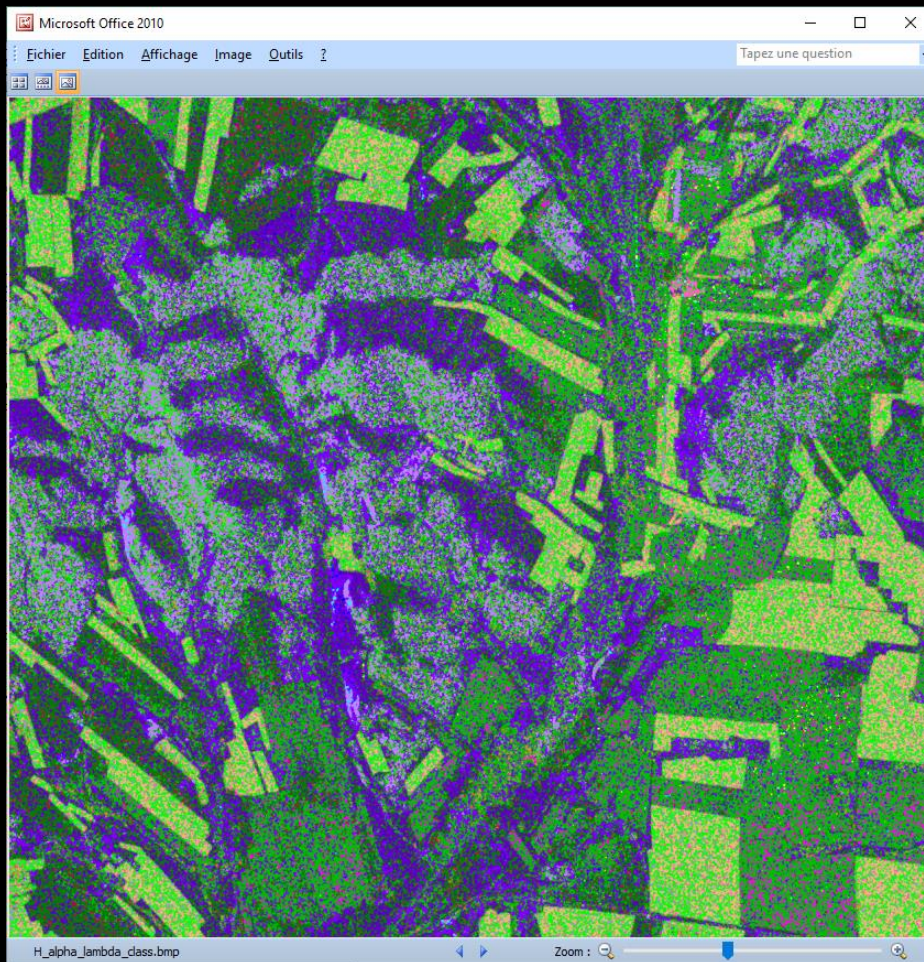


High  $\lambda$

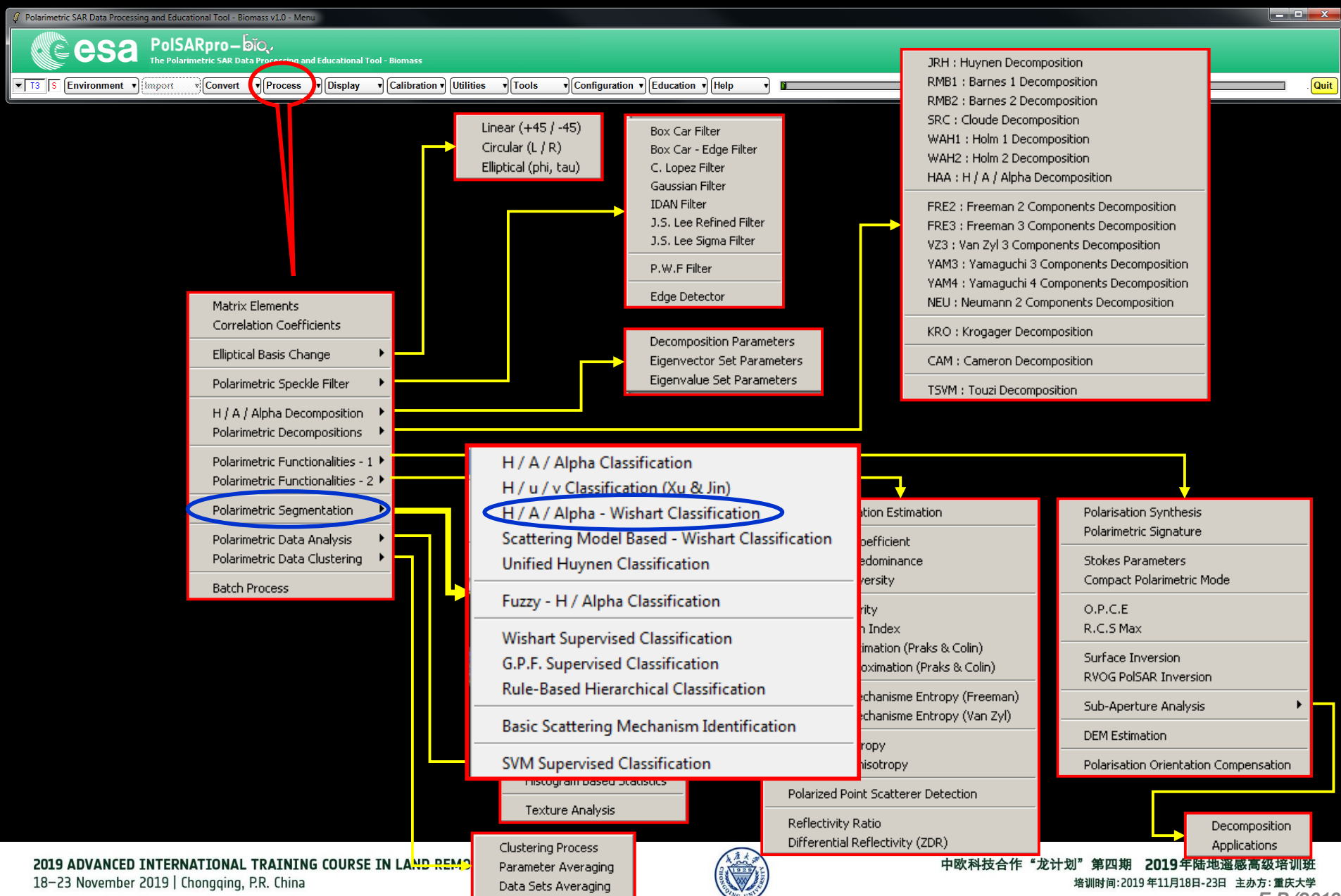




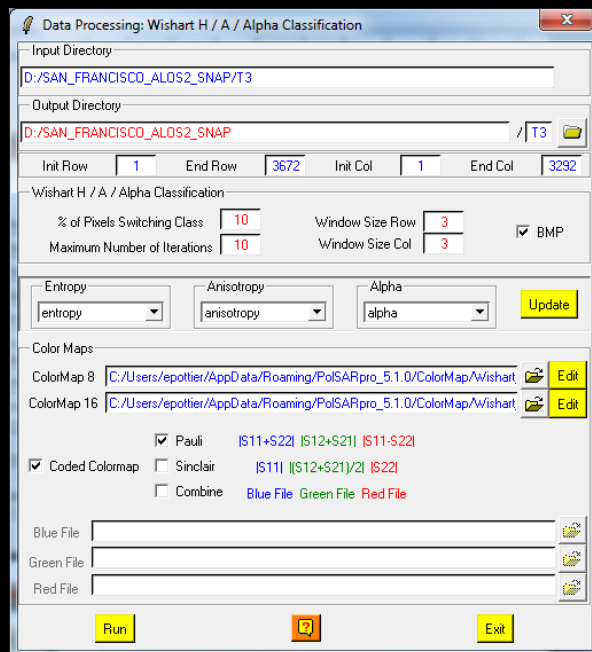
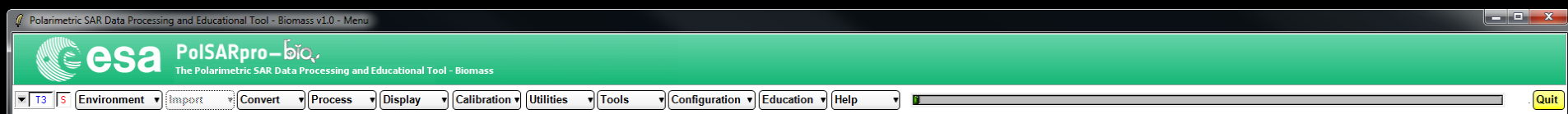
# H / alpha / Lambda CLASSIFICATION



# PoISARpro - Bio SOFTWARE







## DATADIR

config.txt

[T3x3] Elements

Wishart\_H\_alpha\_class\_X.bin

Wishart\_H\_A\_alpha\_class\_X.bin

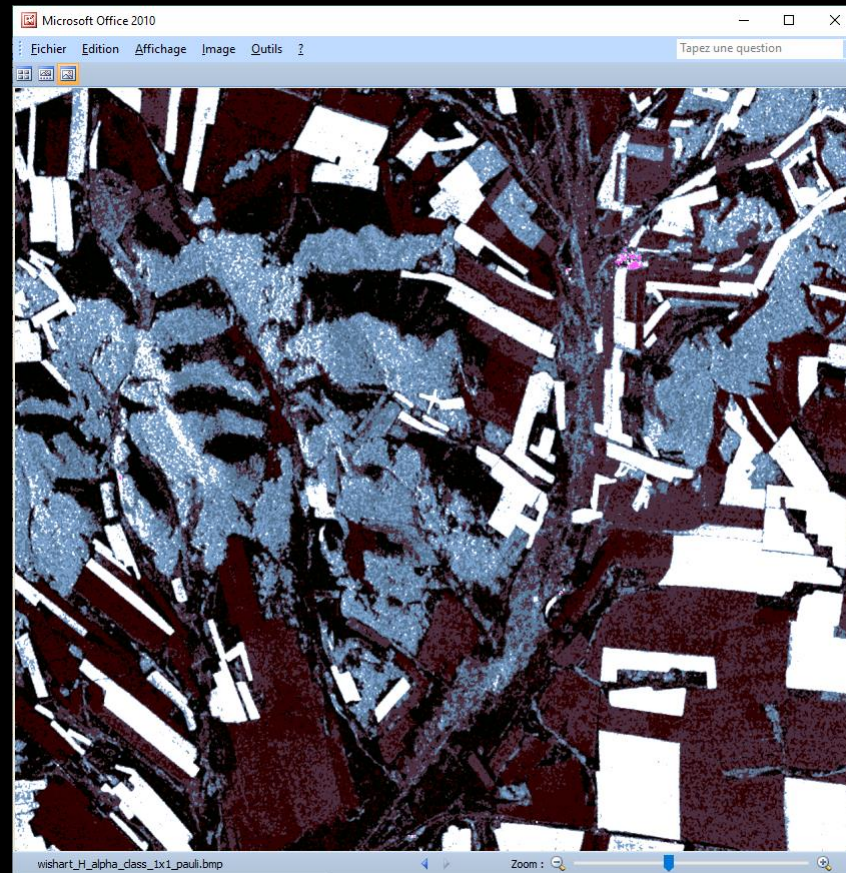
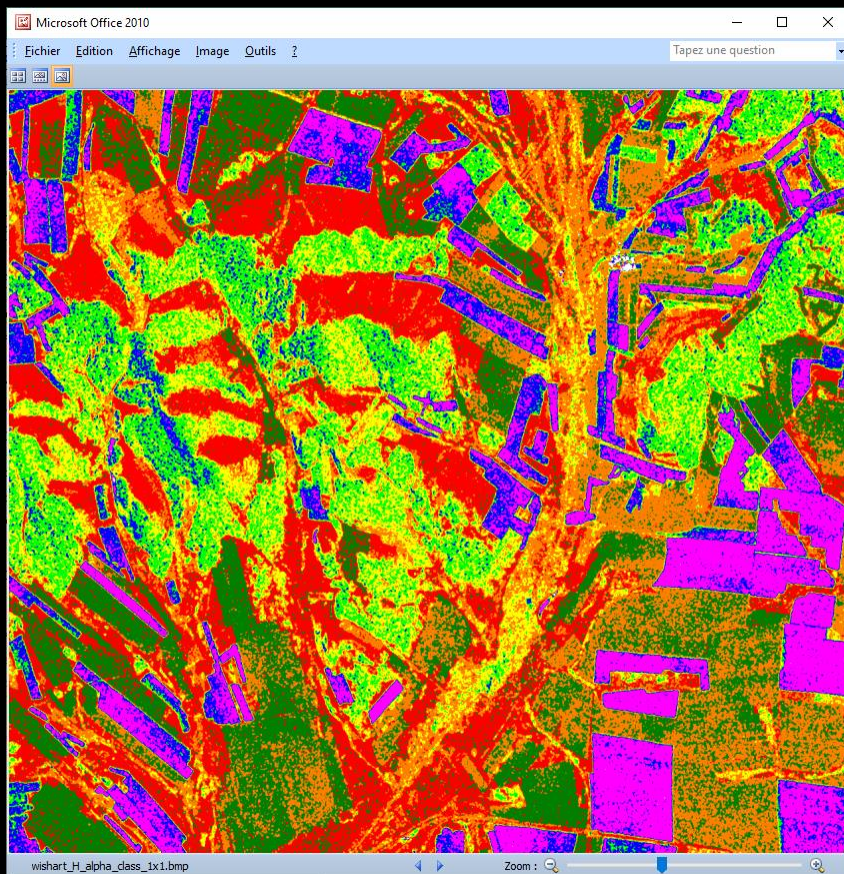
Wishart\_H\_alpha\_class\_X.bmp

Wishart\_H\_A\_alpha\_class\_X.bmp

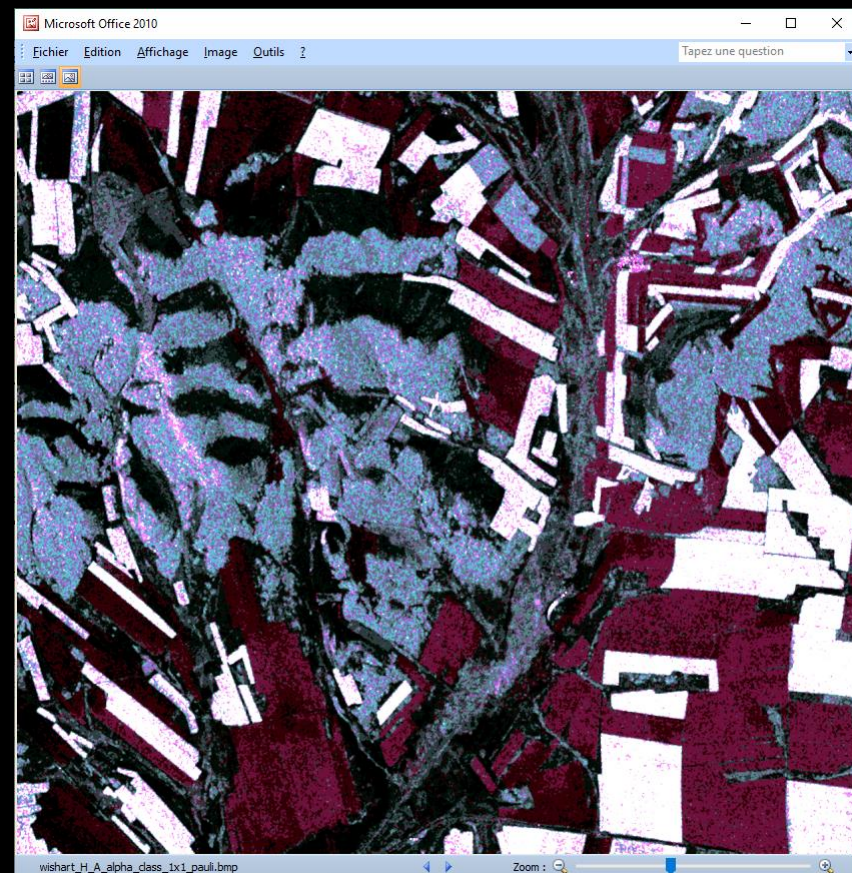
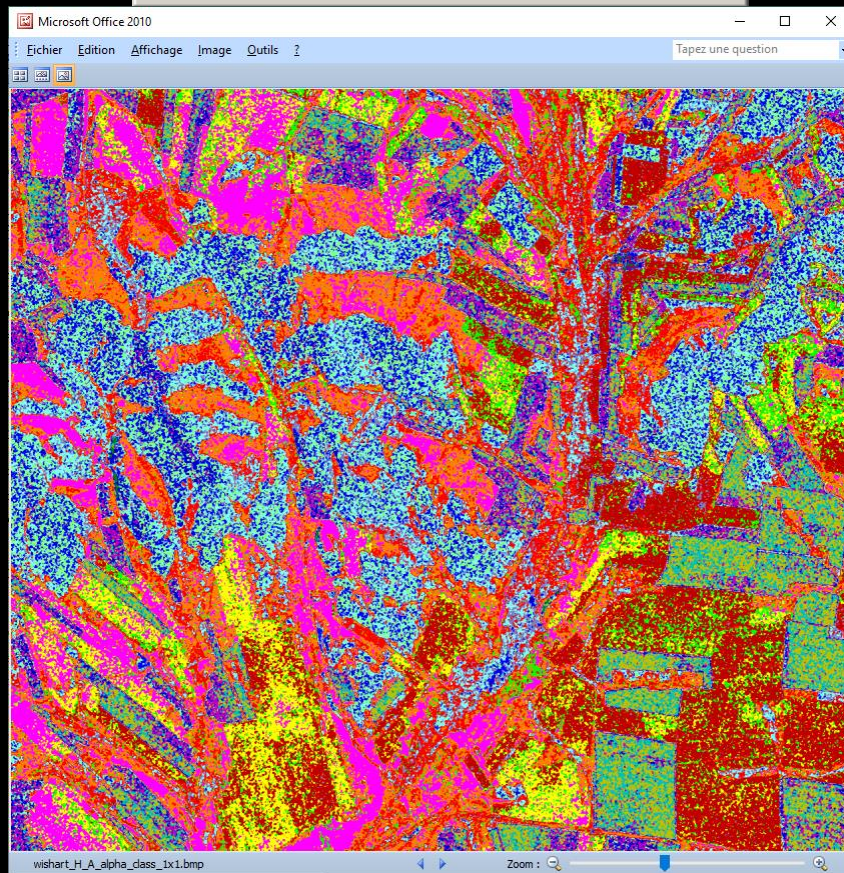
X = window size

### Do it Yourself:

Set the parameters, run and view the corresponding BMP files.



# WISHART - H/A/alpha CLASSIFICATION



GF-3 PolSAR Raw Data

Import and Calibration

Multi-Look

T3 Matrix

Speckle Filter

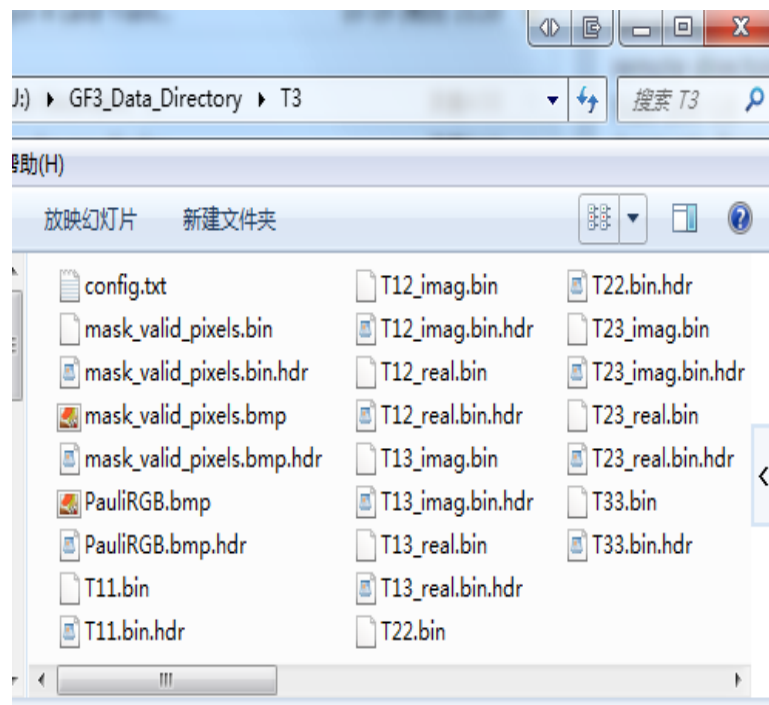
Features Extraction

SVM classifier

Classification Result

We started this practical session from T3 matrix that has been calibrated and multi-look processed.

Sample Data



- GF-3 QPSI Quad-Pol
- Range pixel spacing: 9.0 m
- Azimuth pixel spacing: 10.0 m

## Step-1: Define classification system & classification legend

### Classification system:

### Legend:



GB/T 21010—2017  
代替 GB/T 21010—2007

ICS 07.040  
A 76

中华人民共和国国家标准

土地利用现状分类

Current land use classification

1. 耕地(crop land)
  - 1.1 水田(paddy)
  - 1.2 水浇地(irrigated) ↔ 1. Wheat
  - 1.2 旱地(dry) → 2. Cole
2. 园地(garden)
3. 林地(forest)
  - 3.1 乔木林地(arbor) → 3. Forest
  - 3.2 竹林地(bamboo)
- ...
4. 草地(grass land) → 4. Grass
  - 4.1 天然牧草地(natural grass land)
- ...
5. 商服用地(commercial)
- 6.
- ...
12. 其他土地(others)



# Step-2: Speckle Filter



- Matrix Elements
- Correlation Coefficients
- Elliptical Basis Change
- Polarimetric Speckle Filter**
- H / A / Alpha Decomposition
- Polarimetric Decompositions
- Polarimetric Functionalities - 1
- Polarimetric Functionalities - 2
- Polarimetric Segmentation
- Polarimetric Data Analysis
- Polarimetric Data Clustering
- Batch Process

- An-Yang Filter
- Box Car Filter**
- Box Car - Edge Filter
- Gaussian Filter
- IDAN Filter
- Lee Refined Filter
- Lee Sigma Filter
- Lopez Filter
- Mean-Shift Filter
- Non Local Means Filter
- Scattering Model Based Filter
- P. W. F Filter
- SIRV Model Estimation
- Skou-Skriver Restoration

Speckle Filter

Input Directory: J:/GF3\_Data\_Directory/T3

Output Directory: J:/GF3\_Data\_Directory\_BOX / T3

Init Row: 1, End Row: 1892, Init Col: 1, End Col: 1373

BOXCAR Speckle Filter

[S2] >> [T3]    [S2] >> [C3]    [S2] >> [T4]    [S2] >> [C4]

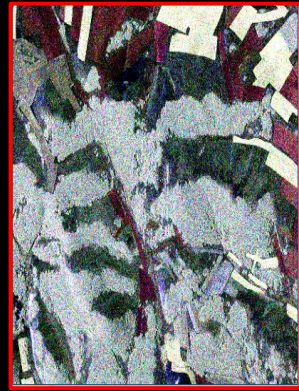
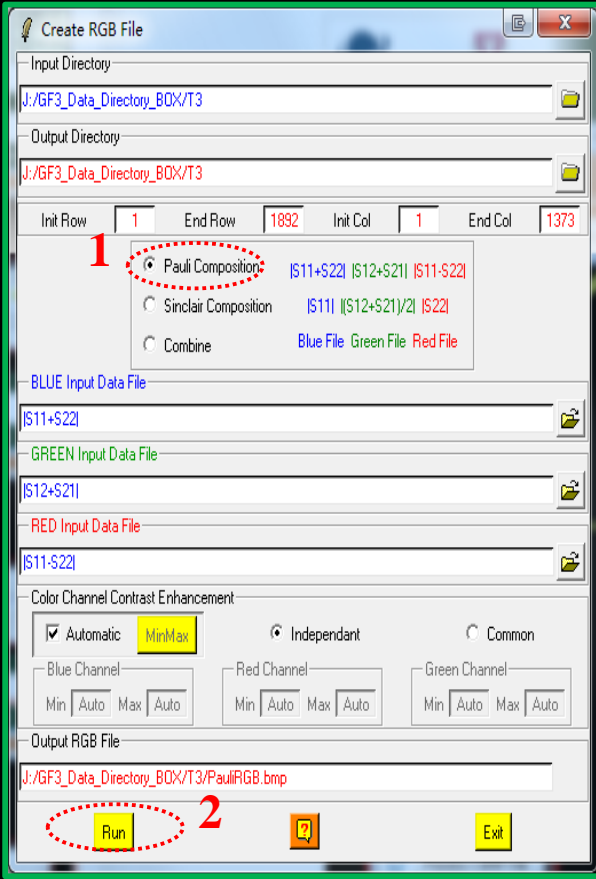
Number of Looks: 1   Window Size Row: 3   Window Size Col: 3

System Noise Filtering ( HV / VH )

Run   ?   Exit



# Step-2: Speckle Filter



**PauliRGB Before Filter**



**PauliRGB After Filter**



# Step-3: Features Extraction

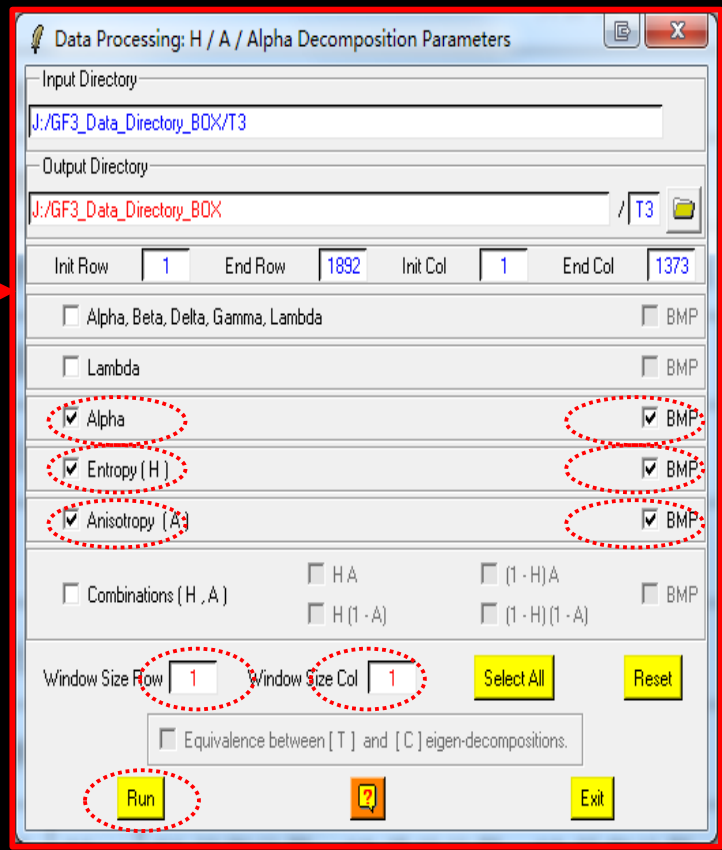


- Matrix Elements
- Correlation Coefficients
- Elliptical Basis Change
- Polarimetric Speckle Filter
- H / A / Alpha Decomposition**
- Polarimetric Decompositions
- Polarimetric Functionalities - 1
- Polarimetric Functionalities - 2
- Polarimetric Segmentation
- Polarimetric Data Analysis
- Polarimetric Data Clustering
- Batch Process

- Decomposition Parameters**
- Eigenvector Set Parameters
- Eigenvalue Set Parameters
- Diversity Index

**Polarization features:**

- entropy.bin
- anisotropy.bin
- alpha.bin



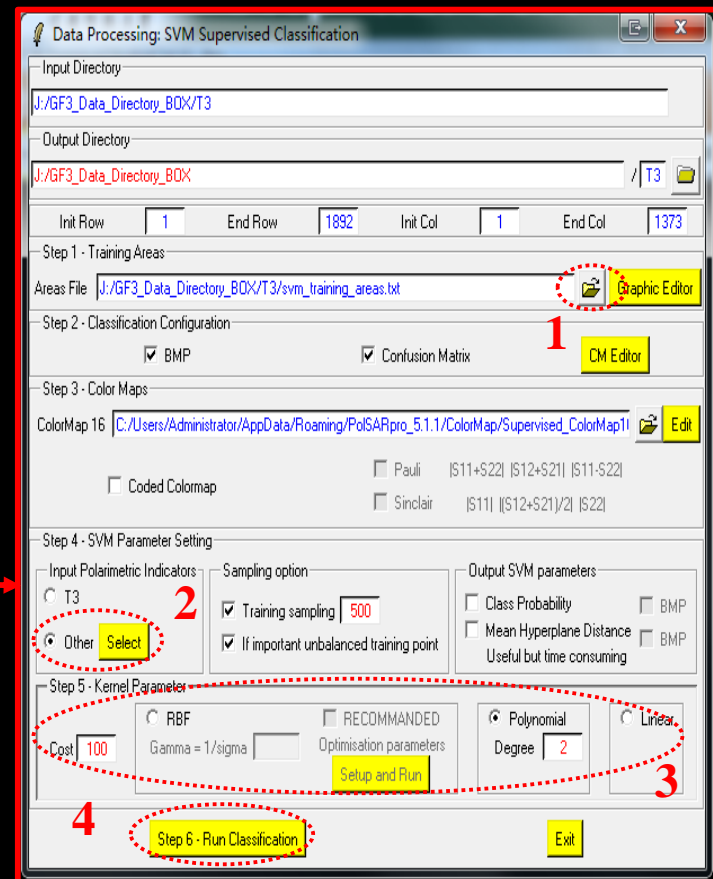
# Step-4: SVM classifier



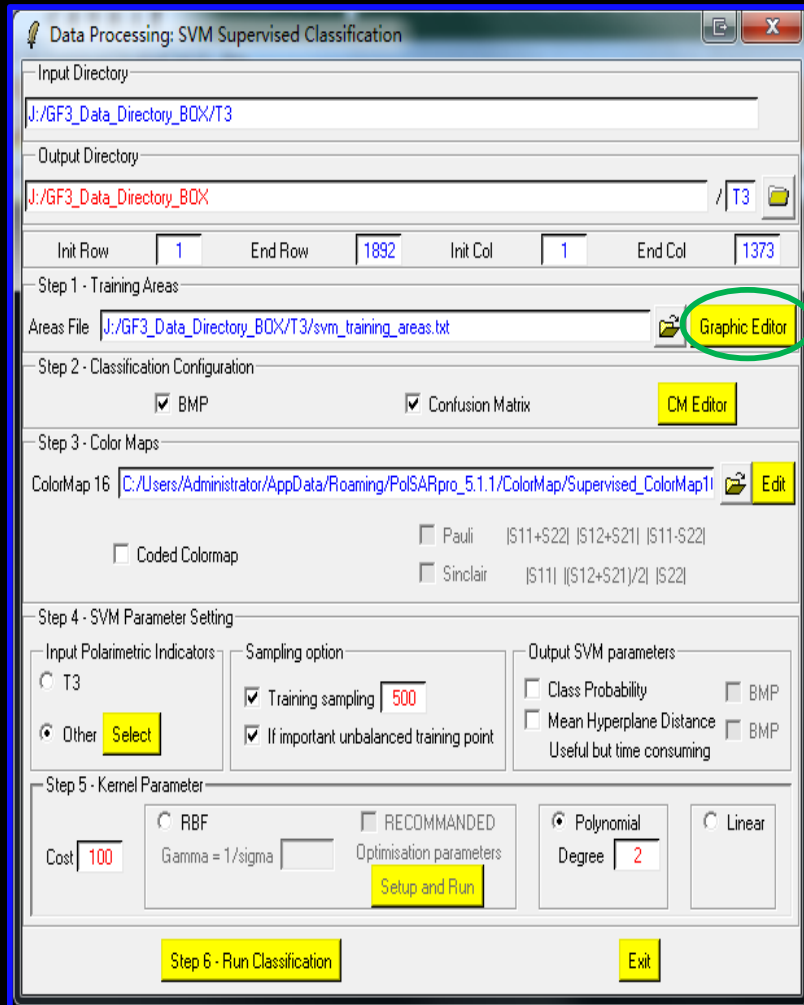
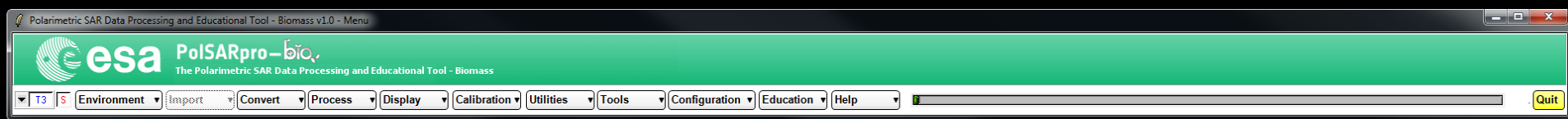
- Matrix Elements
- Correlation Coefficients
- Elliptical Basis Change ▶
- Polarimetric Speckle Filter ▶
- H / A / Alpha Decomposition ▶
- Polarimetric Decompositions ▶
- Polarimetric Functionalities - 1 ▶
- Polarimetric Functionalities - 2 ▶
- Polarimetric Segmentation**
- Polarimetric Data Analysis ▶
- Polarimetric Data Clustering ▶
- Batch Process

- H / A / Alpha Classification
- H / u / v Classification (Xu @ Jin)
- H / A / Alpha - Wishart Classification
- Scattering Model Based - Wishart Classification
- Unified Huynen Classification
- Fuzzy - H / Alpha Classification
- Wishart Supervised Classification
- G.P.F. Supervised Classification
- Rule-Based Hierarchical Classification
- Basic Scattering Mechanism Identification
- SVM Supervised Classification**

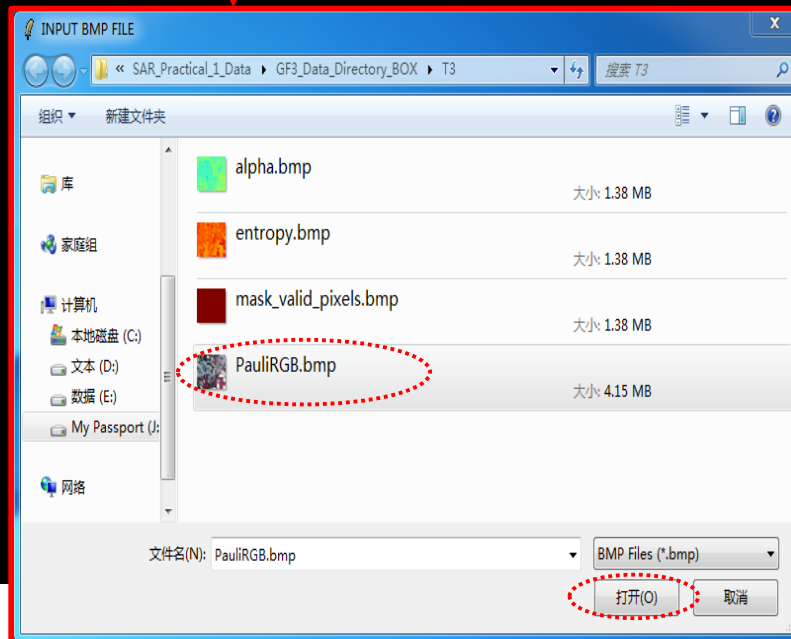
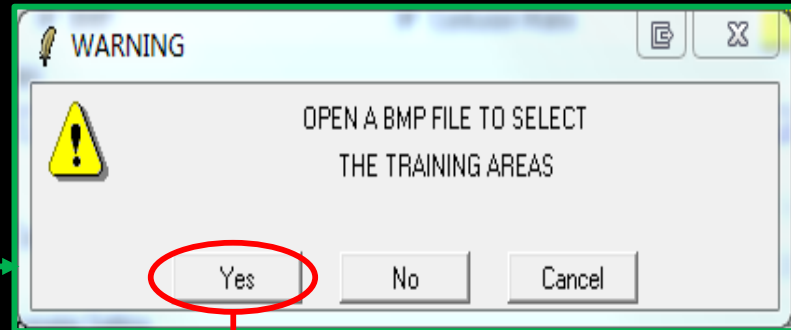
1. Select the training sample data.
2. Select the classification features
3. Select the Kernel function
4. Run Classification



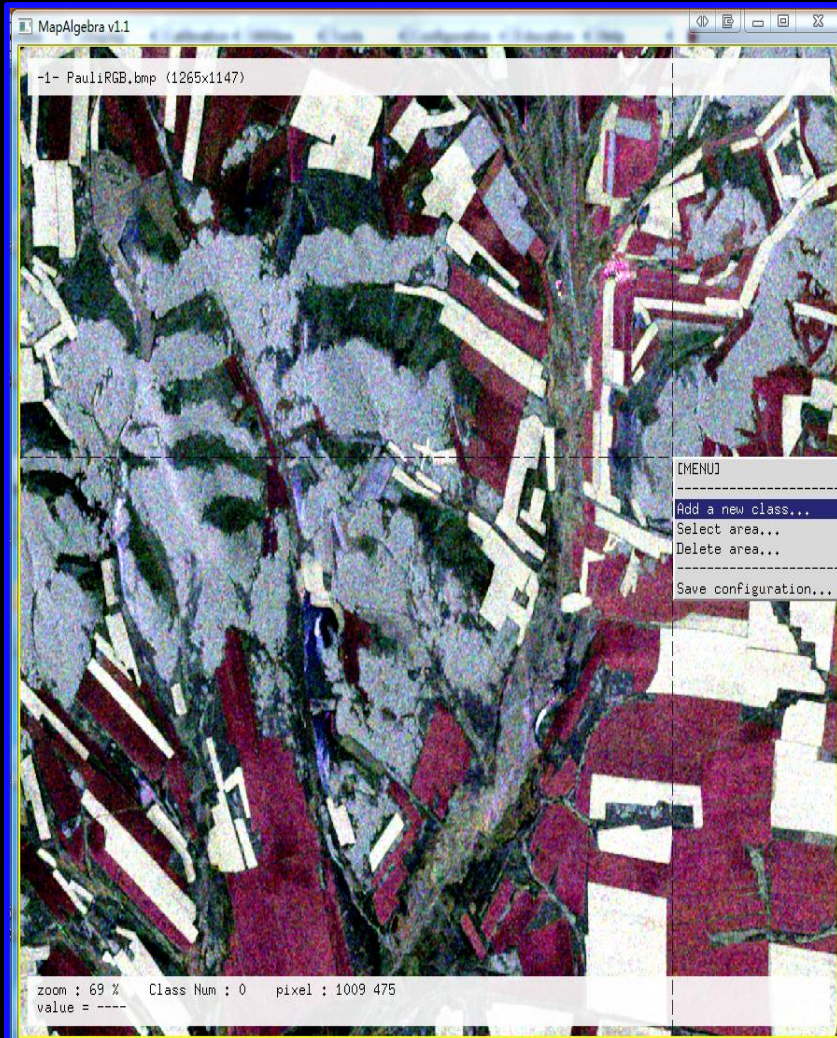
# Step-4: SVM classifier



1. Select the training sample data.



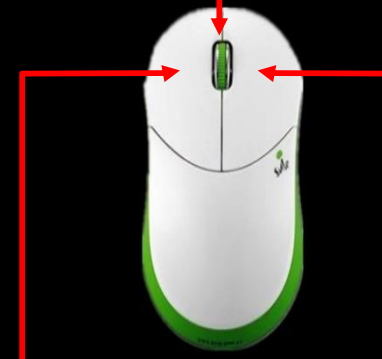
# Step-4: SVM classifier



## 1. Select the training sample data.

Basic operation:

➤ Zoom button



➤ Select button

➤ Open the menu



# Step-4: SVM classifier



## 1. Select the training sample data.

### Basic operation:

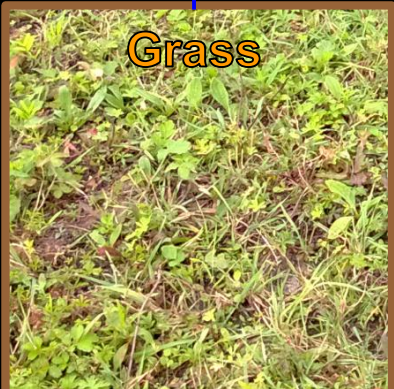
1. Add a new class 1.
2. Select first area for class1
  - ① Click 'Select area', draw a polygon
  - ② Click 'Select area', stop drawing;
  - ③ Click 'Delete area'.
3. Select second area for class1;
4. ....
5. Add a new class 2.
6. Select first area for class2; Select second area for class2;....
7. ....
8. Save configuration

# Step-4: SVM classifier



## 1. Select the training sample data.

Do it yourself.  
Prepare the training sample data





# Step-4: SVM classifier



**Data Processing: SVM Supervised Classification**

Input Directory: J:/GF3\_Data\_Directory\_BOX/T3

Output Directory: J:/GF3\_Data\_Directory\_BOX / T3

Init Row: 1, End Row: 1892, Init Col: 1, End Col: 1373

Step 1 - Training Areas  
Areas File: J:/GF3\_Data\_Directory\_BOX/T3/svm\_training\_areas.txt **Graphic Editor**

Step 2 - Classification Configuration  
 BMP  Confusion Matrix **CM Editor**

Step 3 - Color Maps  
ColorMap 16: C:/Users/Administrator/AppData/Roaming/PolSARpro\_5.1.1/ColorMap/Supervised\_ColorMap1 **Edit**

Step 4 - SVM Parameter Setting

Input Polarimetric Indicators:  T3  Other **Select**

Sampling option:  
 Training sampling: 500  
 If important unbalanced training point

Output SVM parameters:  
 Class Probability  BMP  
 Mean Hyperplane Distance  BMP  
Useful but time consuming

Step 5 - Kernel Parameter  
Cost: 100, Gamma = 1/sigma, RECOMMENDED, Optimisation parameters, **Setup and Run**

Polynomial Degree: 2, Linear

Step 6 - Run Classification **Exit**

## 2. Select the classification features

**Select Polarimetric Indicators**

Add or remove polarimetric indicator (No complex file !)

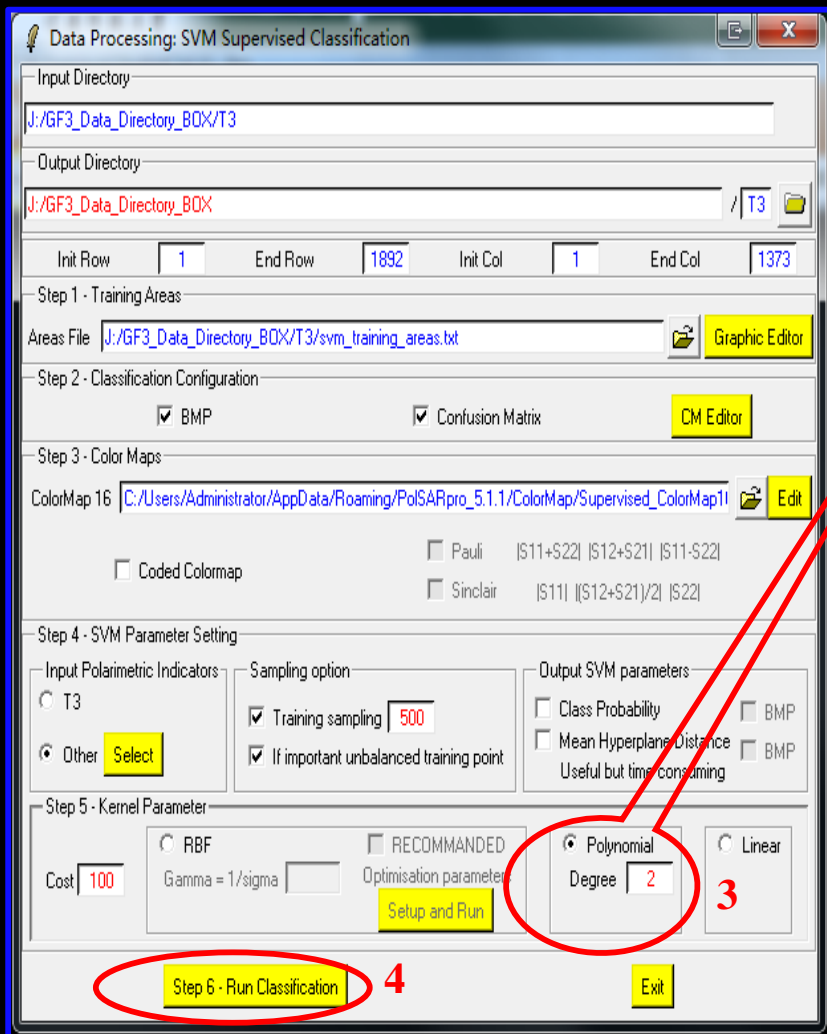
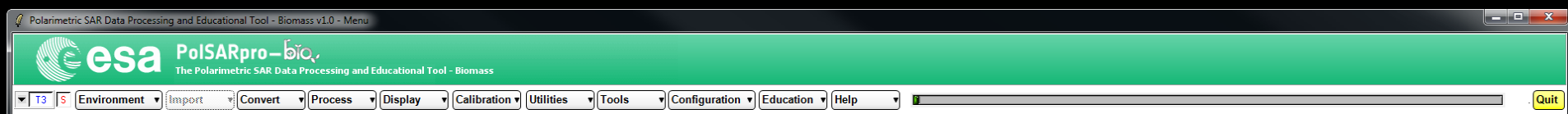
alpha.bin  
anisotropy.bin  
entropy.bin  
mask\_valid\_pixels.bin  
T11.bin  
T12\_imag.bin  
T12\_real.bin  
T13\_imag.bin  
T13\_real.bin  
T22.bin

alpha.bin  
anisotropy.bin  
entropy.bin

**Exit and Save**



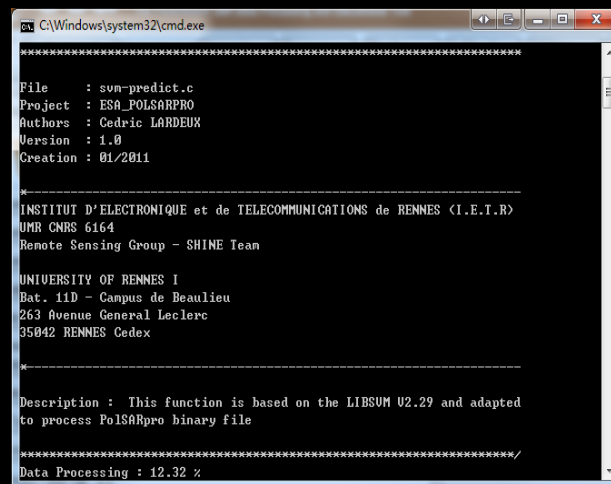
# Step-4: SVM classifier



## 3. Select the Kernel function

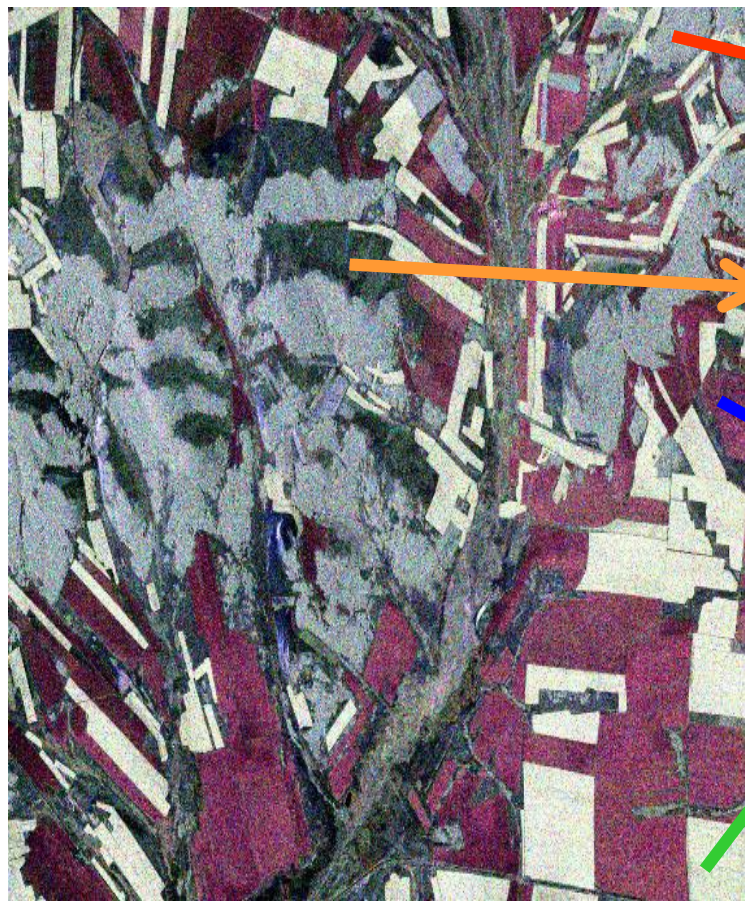
- We choose polynomial kernel function
- Degree:2

## 4. Run Classification



## II. GF-3 PoSAR dataset

Classification result vs. GF-3 PoSAR Pauli-RGB image

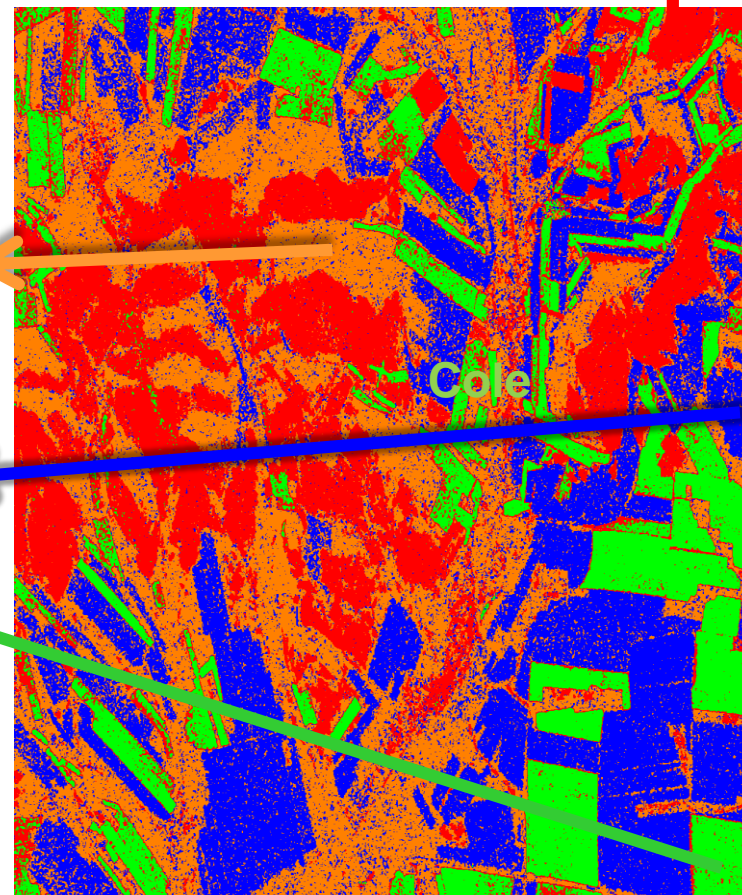


Forest

Grass

Wheat

Cole



Cole

Thanks