→ 6th ESA ADVANCED TRAINING COURSE
ON LAND REMOTE SENSING

# Floods & Lakes Monitoring

## Practical


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**With the collaboration of Robin FAIVRE**


D4P1a

Wenesday 16 of September 2015

**Challenging…**

**Diversity of :**

- **Size**
- **Landscapes**
- **Dynamics**
- **Scale of analysis**

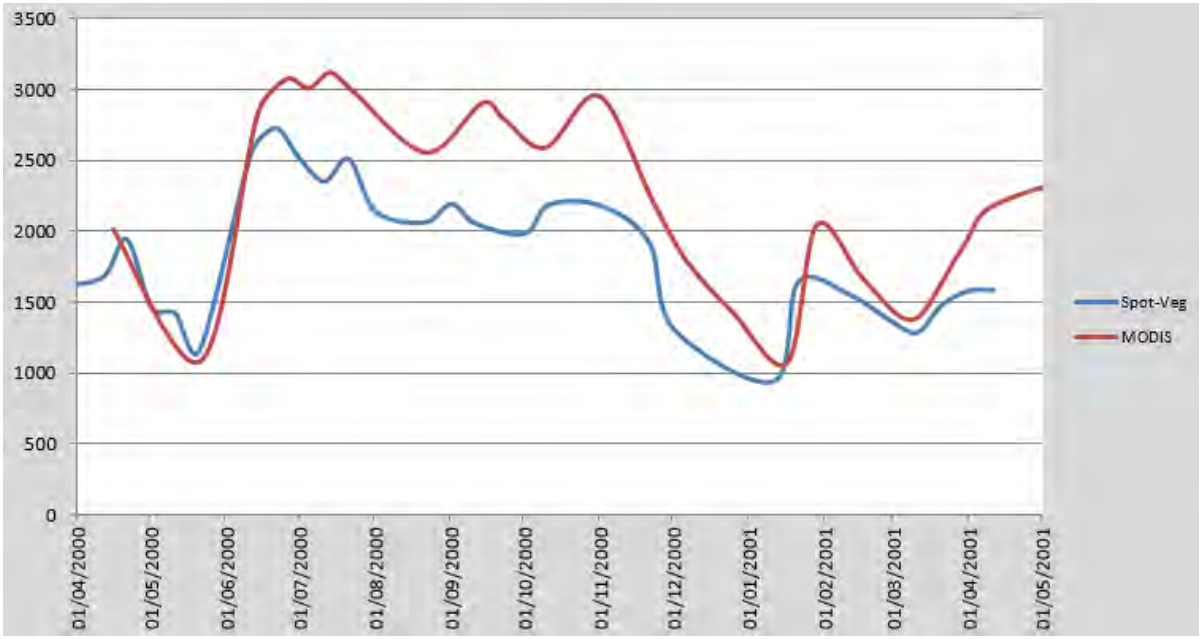
**Lot of approaches both in optical and Sar domain**

## Water bodies

- Unique target by complex target
- Water bodies as observed at a T time
- EO Ressources (all !!!)
  - SAR MR/HR/THR
  - Optical MR/HR/ THR
- Tools
  - Thresholding and screen validation
  - Auto processing (Otsu /VSM / change detection, snake..)
- Analyze of the accuracy depending of data's types and resolution

# EO data Resolution and detected surfaces

Large influence of resolution on detected target's observed size




Passager Vegetation/ Modis :1KM / 250m
60-70 % of common water

Worse when comparing ASAR GMM and MODIS: 36 to 56 % of common water

# Aims of Flood mapping and monitoring training course

**Thematic goals:**

- Flood extent
- Flood monitoring exploiting EO time series
- Flood analysis

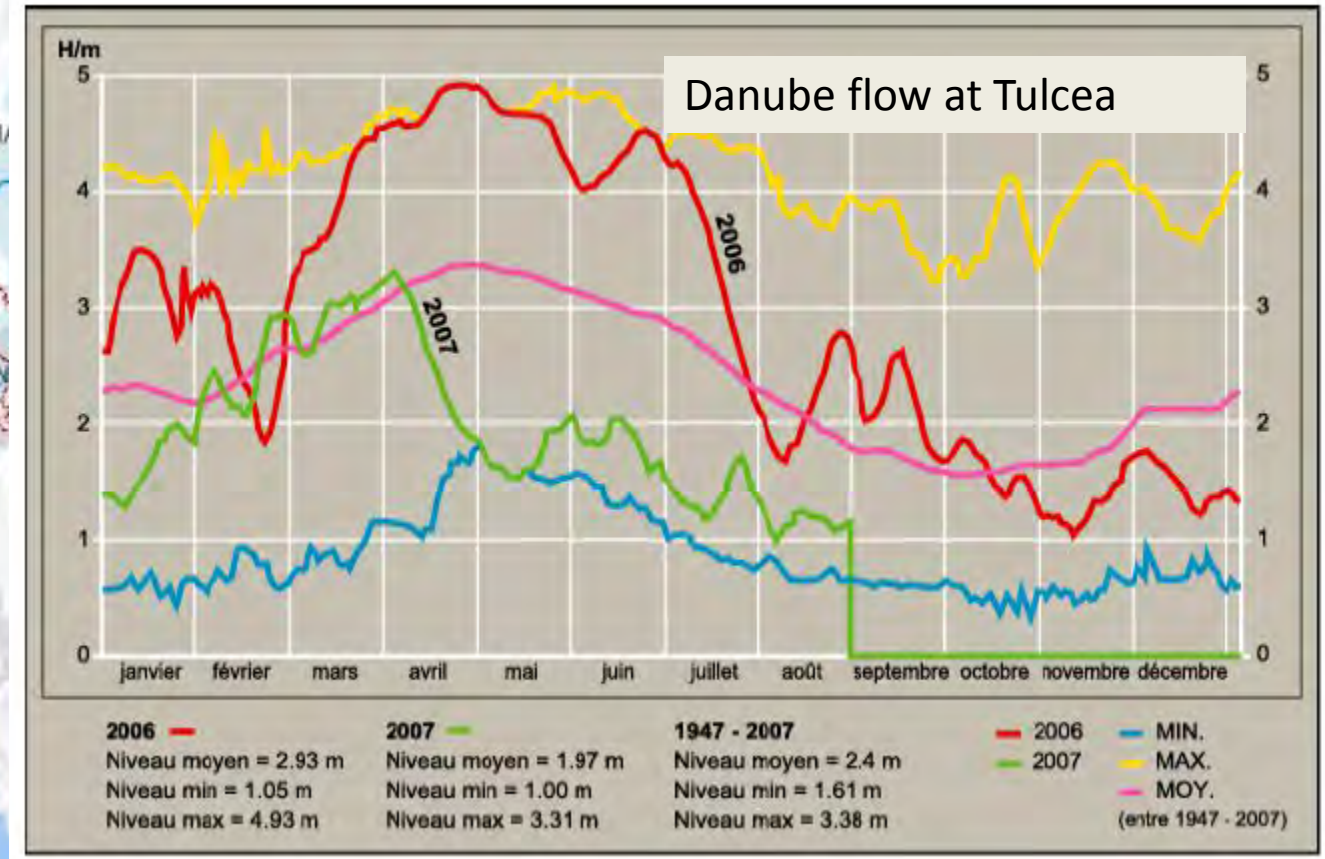
**Synergy assessment between**

- Medium resolution SAR and medium optical image
- Medium resolution and high optical image
- Approach of time series

**Prepare the exploitation**

- Sentinel1
- Sentinel2
- HJ1 A&B
- Cosmo Skymed

# Example- the 2006 Danube flood event



# Example- the 2006 Danube flood event

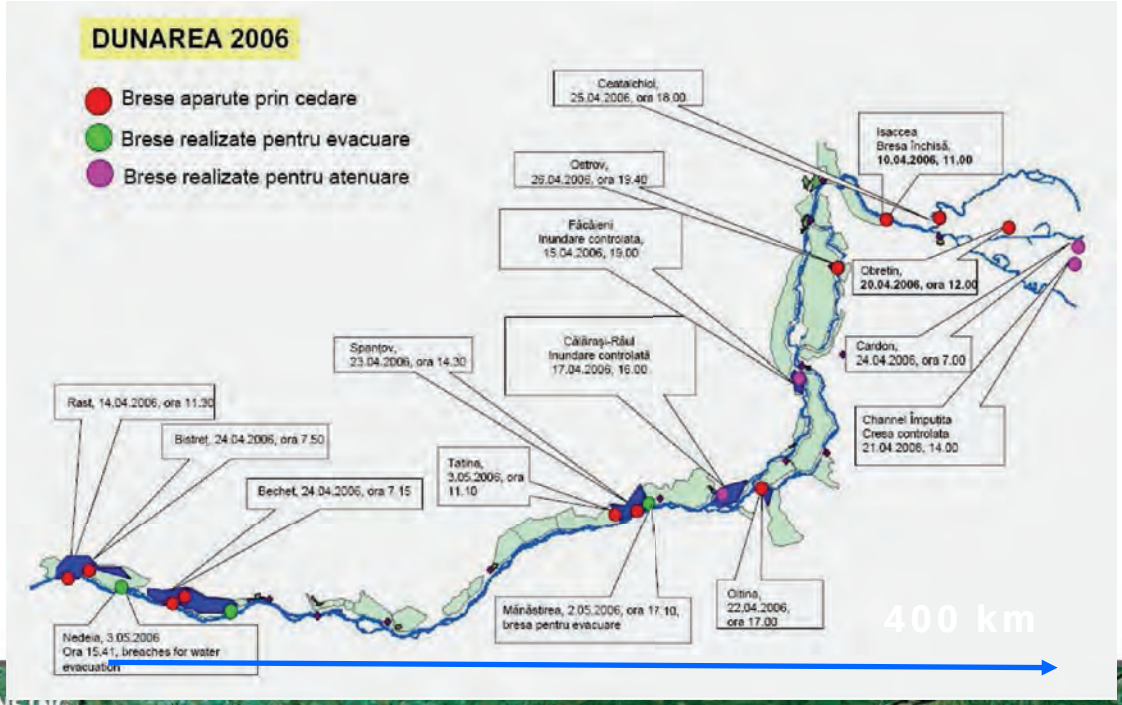
**Major floods began in Roumania since the 14 of April 2006 and water stayed in some place for more than 6 months**

**Main dike breaks :**

- **Rast : 14 April 11h30 (local time)**
- **Bistret - Nedeia 24 April 2006 à 7h50 LT;**
- **Bechet - Dabuleni, 24 April .2006, 7h15 LT;**
- **Dabuleni - Corabia, 27 April 2006, 11:00 LT.**

**Voluntary break of levees in order to allow the flow escape:**

- **Nedeia, 3 May 2006**
- **Orlea - Corabia, 9 May**

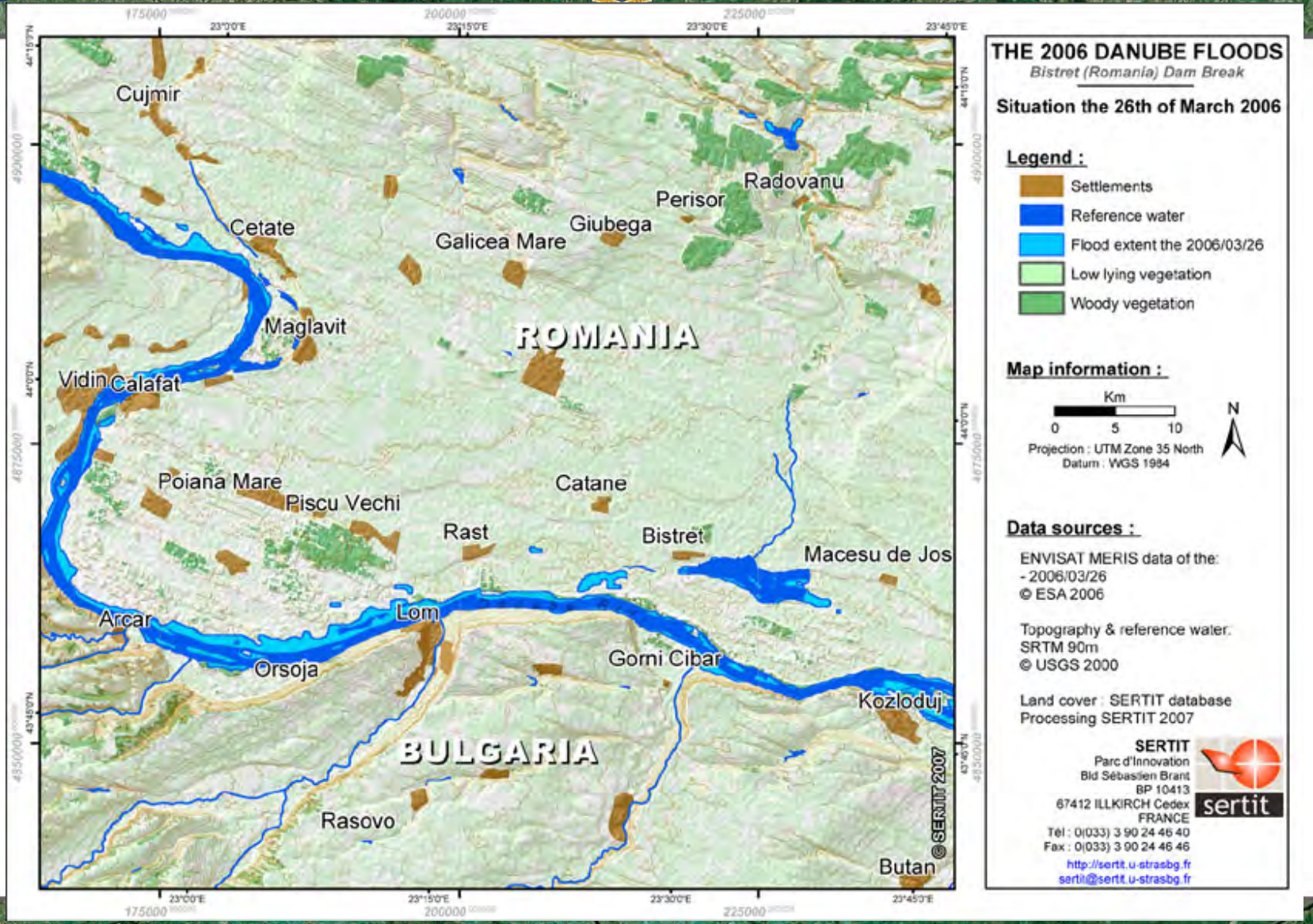



**Input from Corina Alecu & Anisoara Irimescu, Meteo Roumanie**

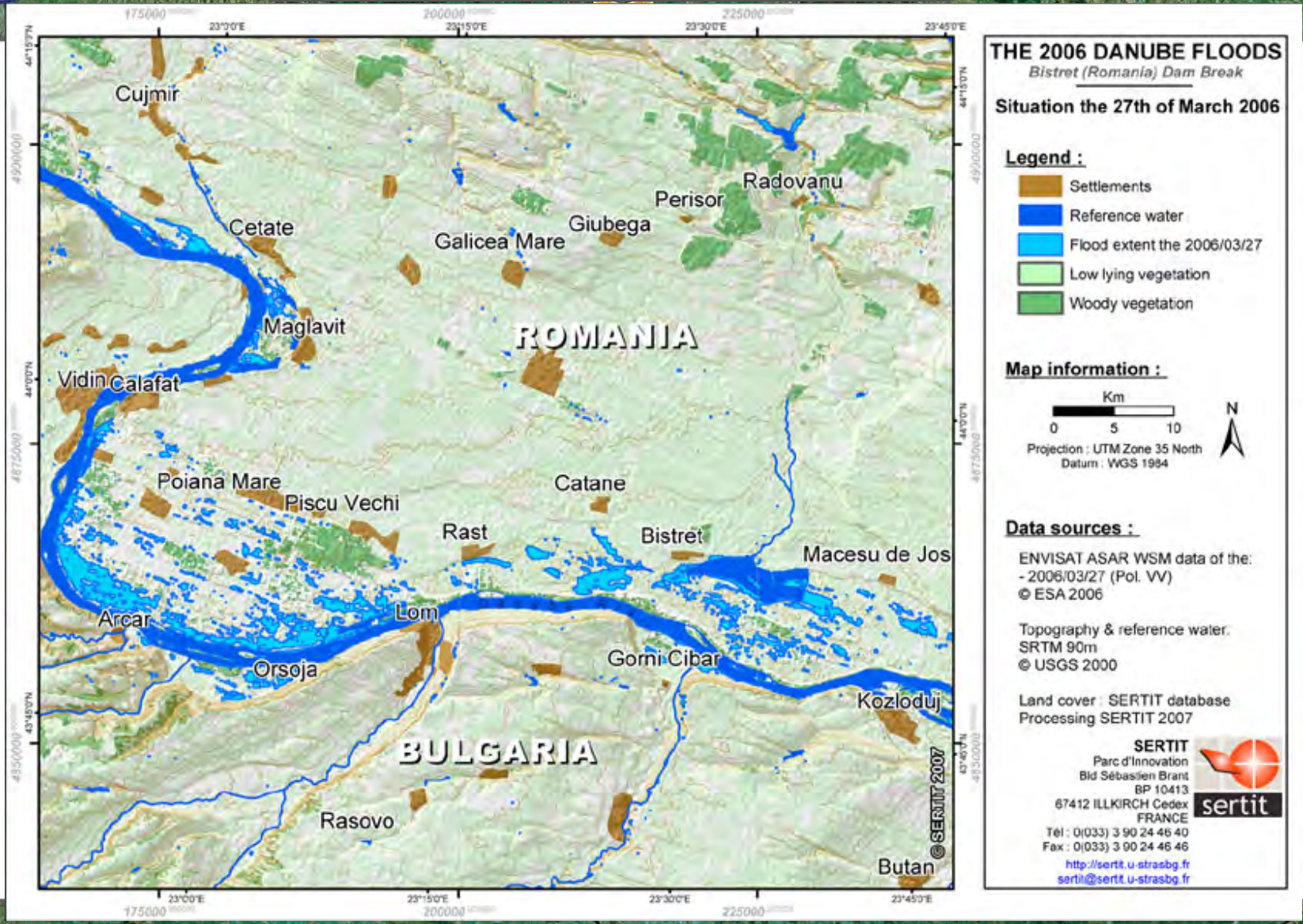
# Damages of the 2006 Danube flood event

| | Duration | People | Damage [million €] | Cause | Annuality |
|---|---|---|---|---|---|
| 1. Upper Danube (DE, AT, CZ) | 28.3. - 17.4. | 5 dead, 4,000 displaced (mostly in CZ) | ~ 110 | Snowmelt/rain | Lower Morava and Dye about 100 years event |
| 2. Middle Danube (SK, HU) | 28.3. - 28.4. | 3 dead, 6,000 displaced | ~ 30 | Snowmelt and rain and locally dike breaks | About 100 years event for the lower reaches of Bodrog and Tisza and the Danube |
| 3. Middle Danube (CS, HR) | 4.4. - 28.4. | 2 dead, 3,000 displaced | ~ 60 | Concurrent high discharges of the Danube, Tisza and Sava | At least 100 years event |
| 4. Lower Danube (CS, HR) | 7.4. - 15.6. | 14,000 displaced | ~ 400 | Water from middle Danube, Several dike breaks and controlled flooding | About 100 years event |

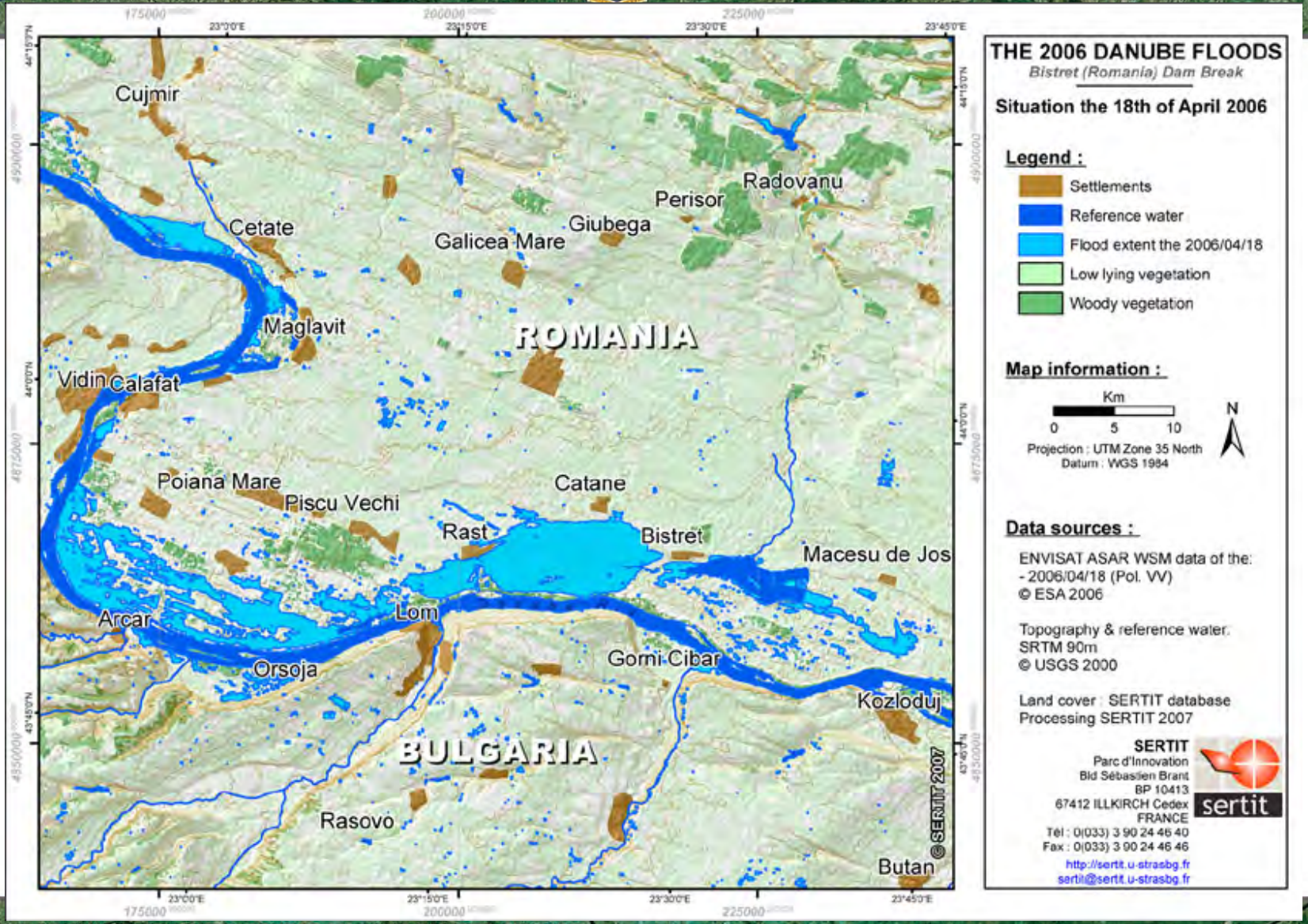
# Flood products



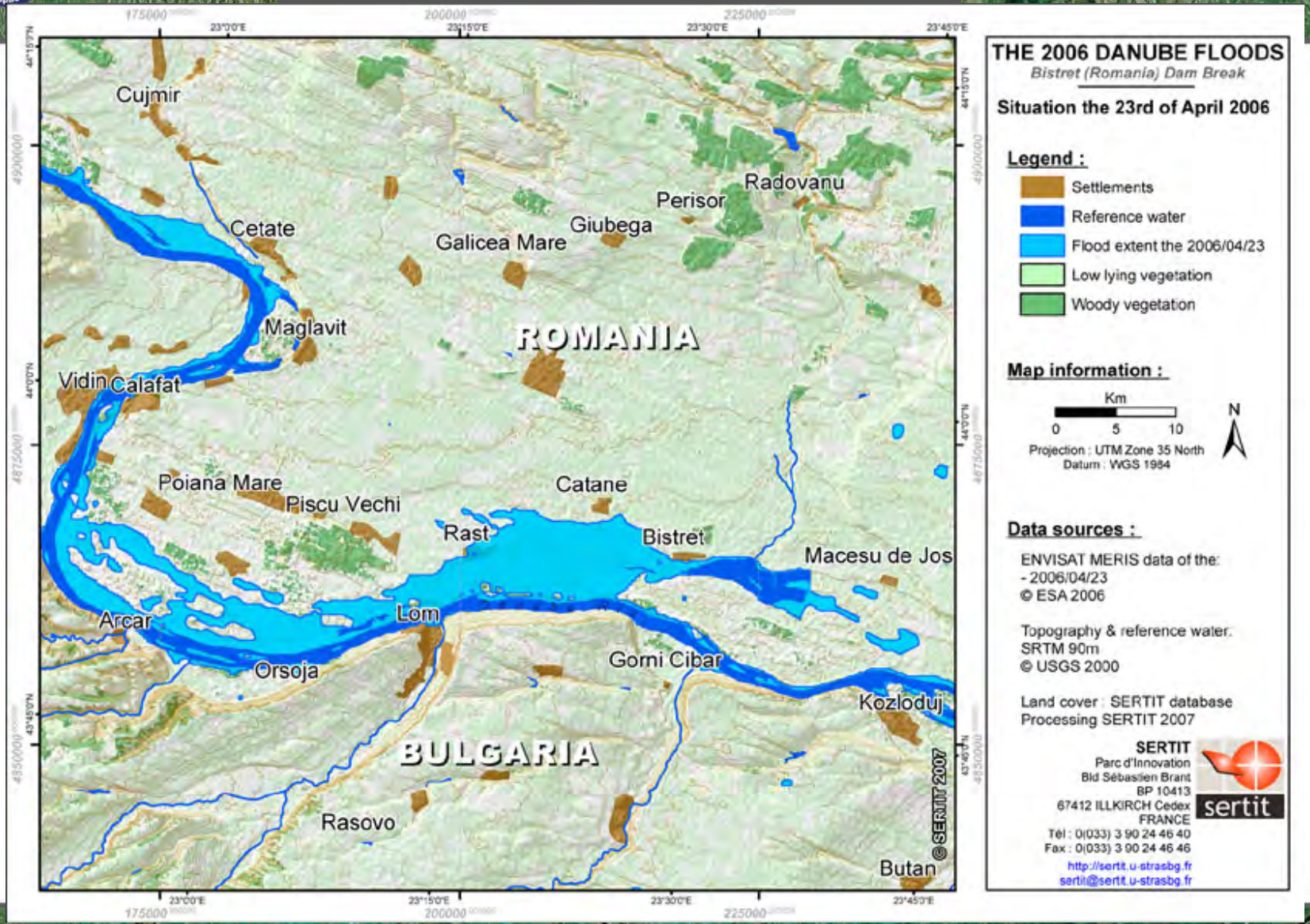
# Flood products



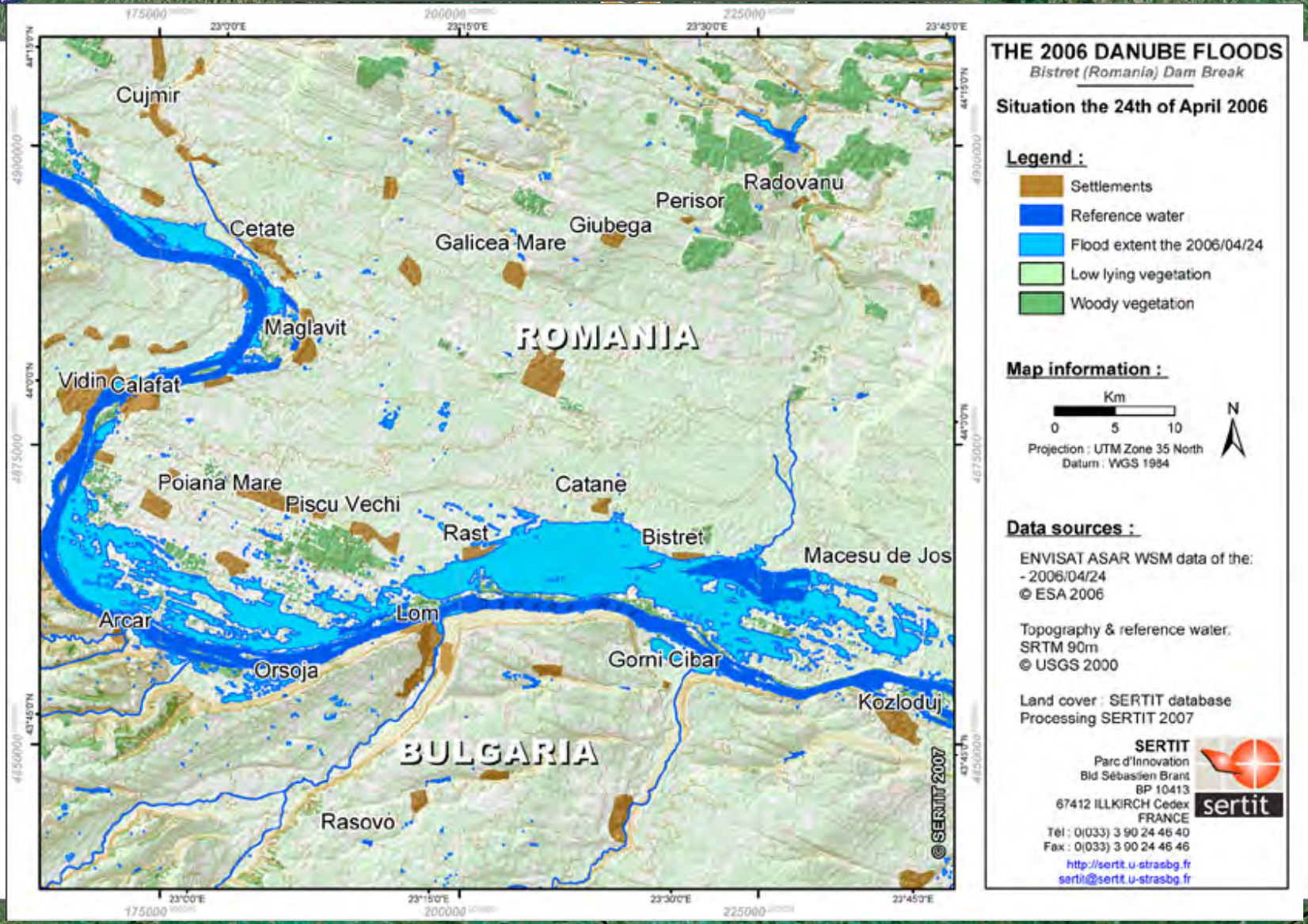
# Flood products



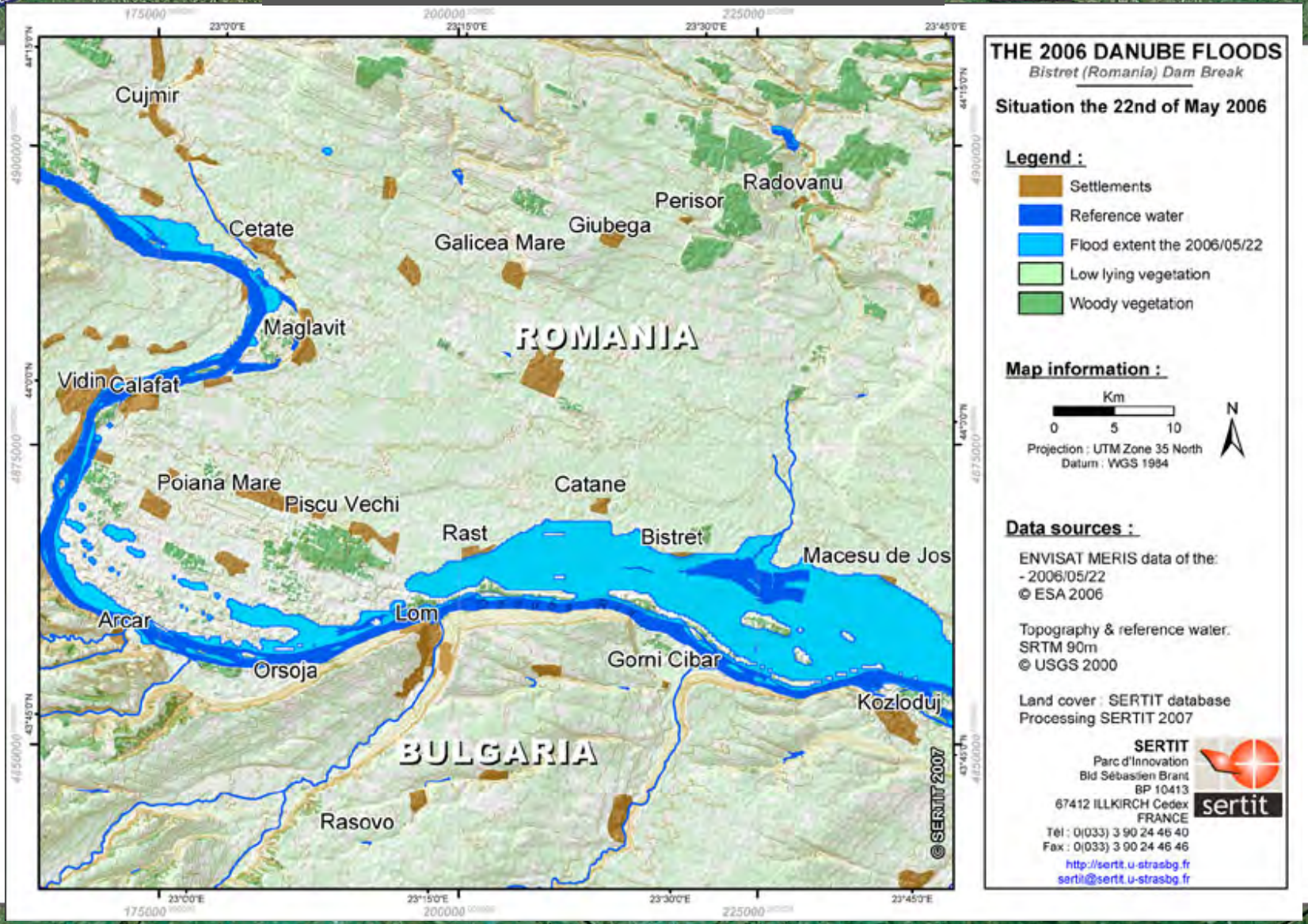
# Flood products



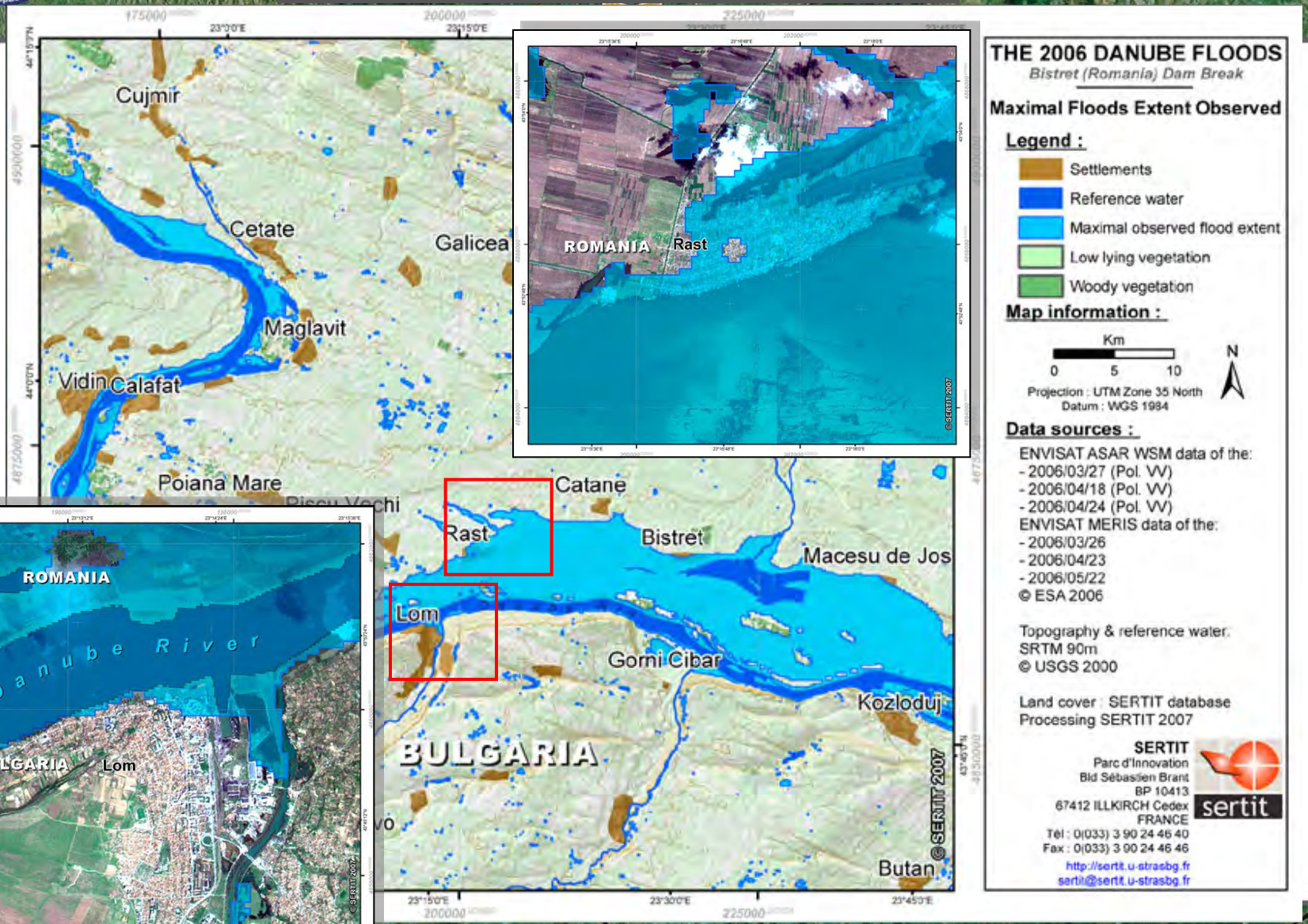
# Flood products



# Flood products



# Flood products



# Aims of Flood mapping and monitoring training course

Image Procesing part:

Image Visualisation and Manipulation

Flood water extraction

- Optical and Radar
- Mono-date and Multidate

Thresholding

Change detection

# Short term goal of flood mapping and monitoring training

## Preparing exploitation of the Sentinel series

Sentinel 1 : SAR

Sentinel 2 : Optical

# Short term goal of flood mapping and monitoring T.C.
# Preparing the exploitation Sentinel series

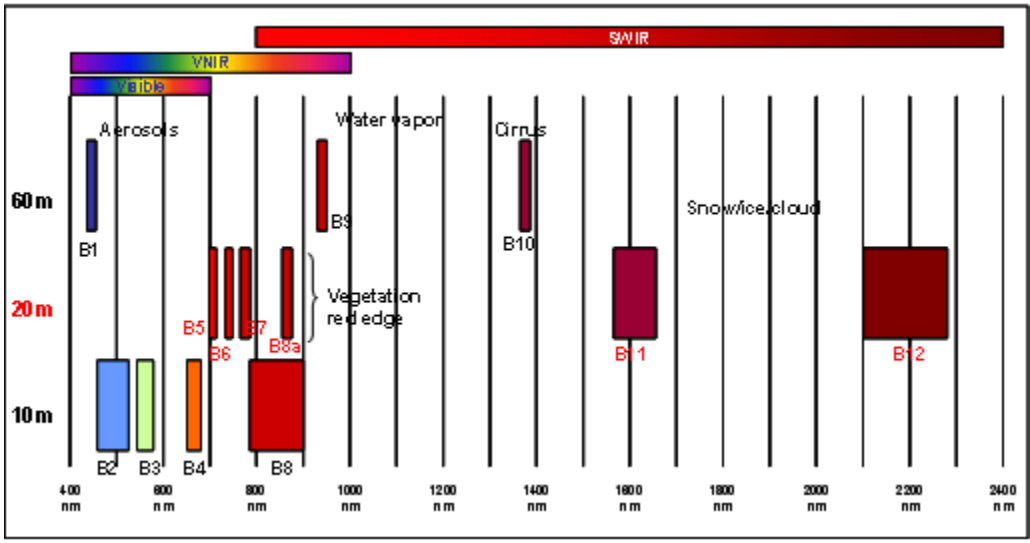
**Sentinel 2**

**Resolution same as SPOT5 (10m)**

**Presence of a SWIR band**

**Large swath (MERIS)**

**Revisiting time**



# Sentinel 2 like: Applicable to others optical sensors

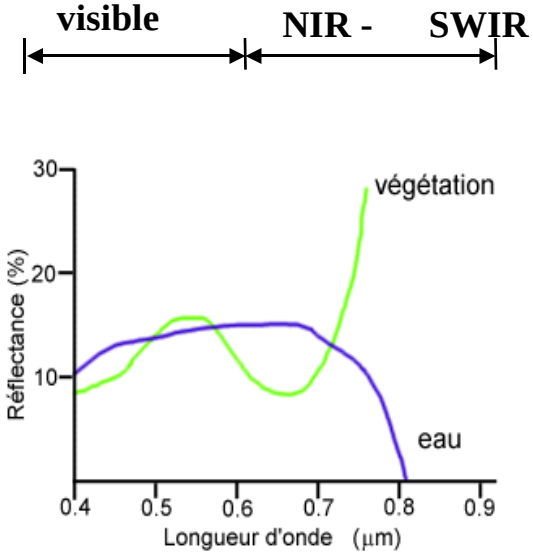

**SWIR**

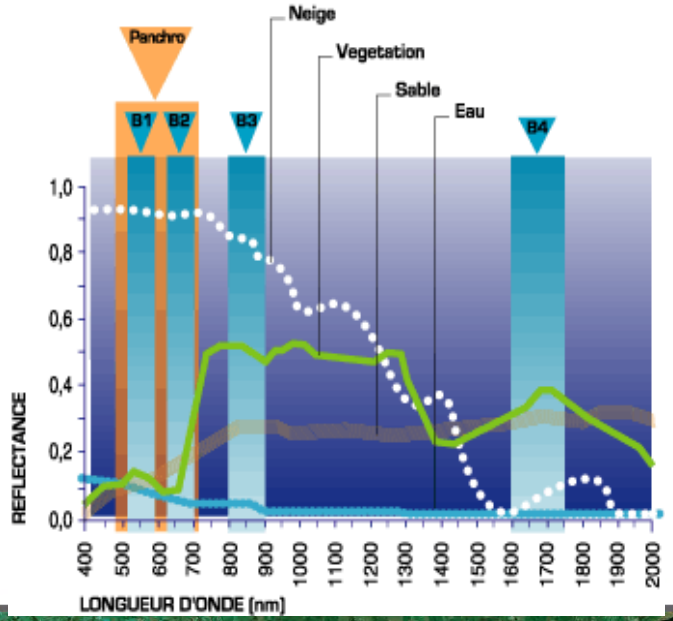
# Water extraction

## Flood mapping based on thresholding of raw channel

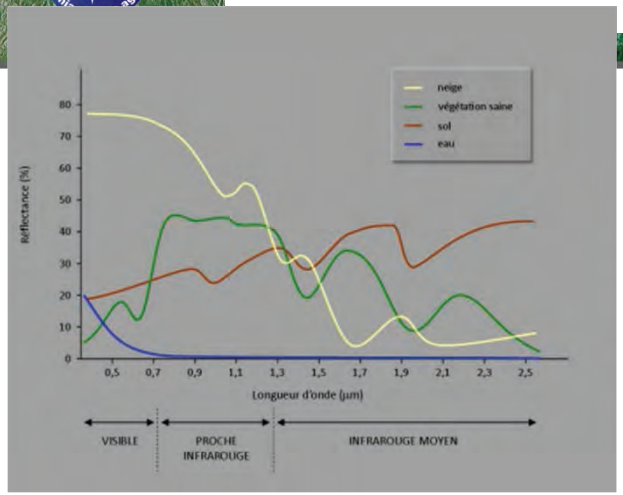
### Fundamentals: Spectral signature of water

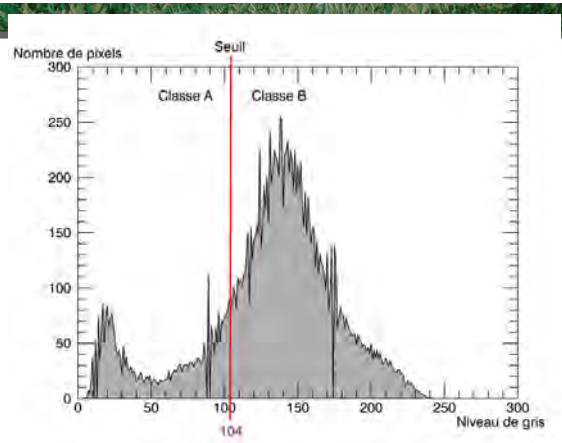
### NIR and SWIR are absorbed

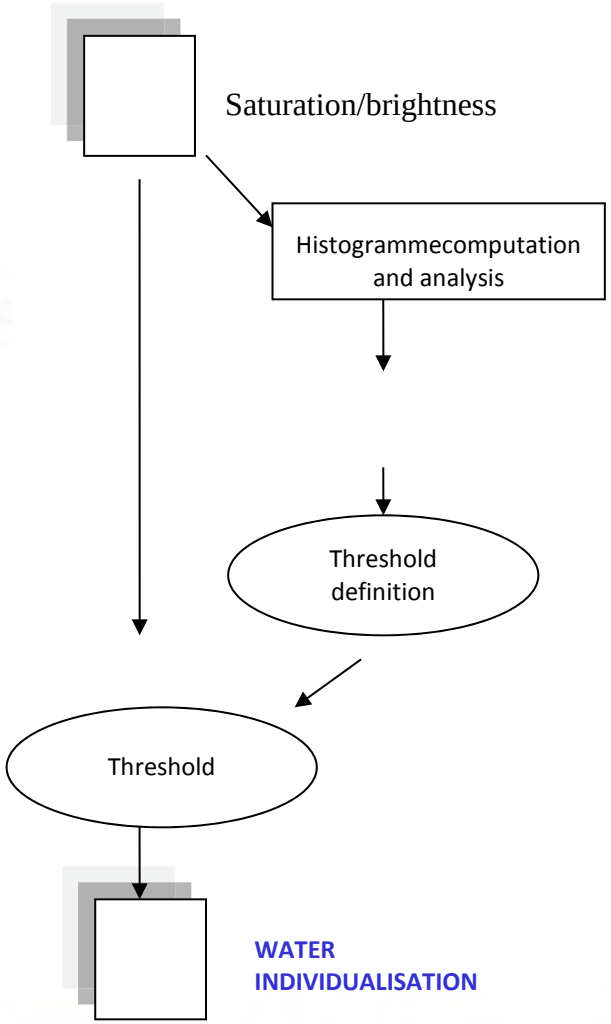


# Flood mapping based on thresholding of raw channel and /or indice




**Fundamentals: : water areas can be very bright if containing suspended materials**

**Extraction of water bodies from:**

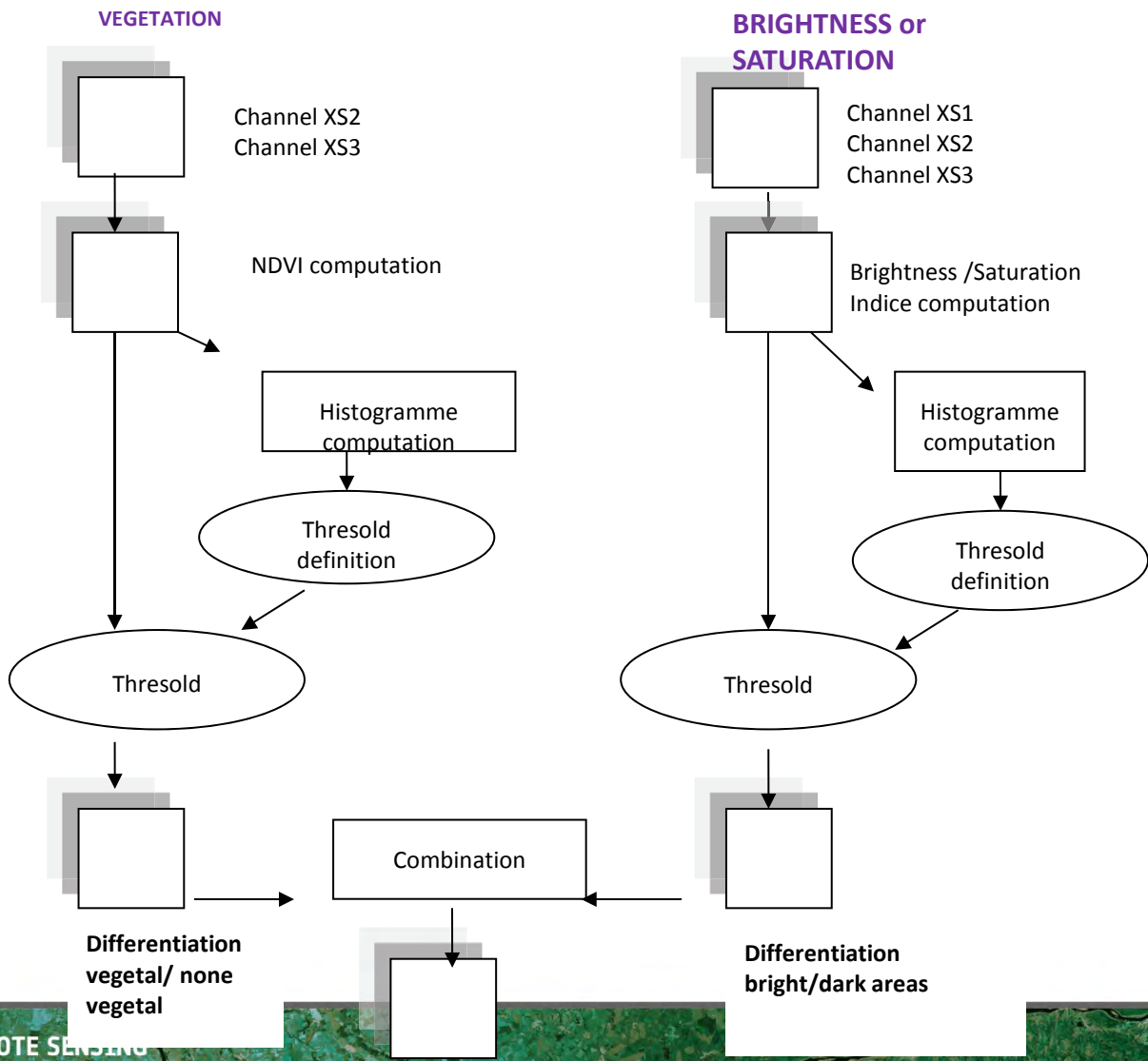
- **Brightness Standard or Tasseled Cap**
- **First component of a PCA,**
- **Saturation indices of a HIS transformation**

# Flood mapping based on optical data : combination of indices

**Fundamentals: water areas can be very bright if containing suspended materials**

**Extraction of water bodies from:**

- **Brightness Standard or Tasseled Cap**
- **First component of a PCA,**
- **Saturation indices of a HIS transformation**



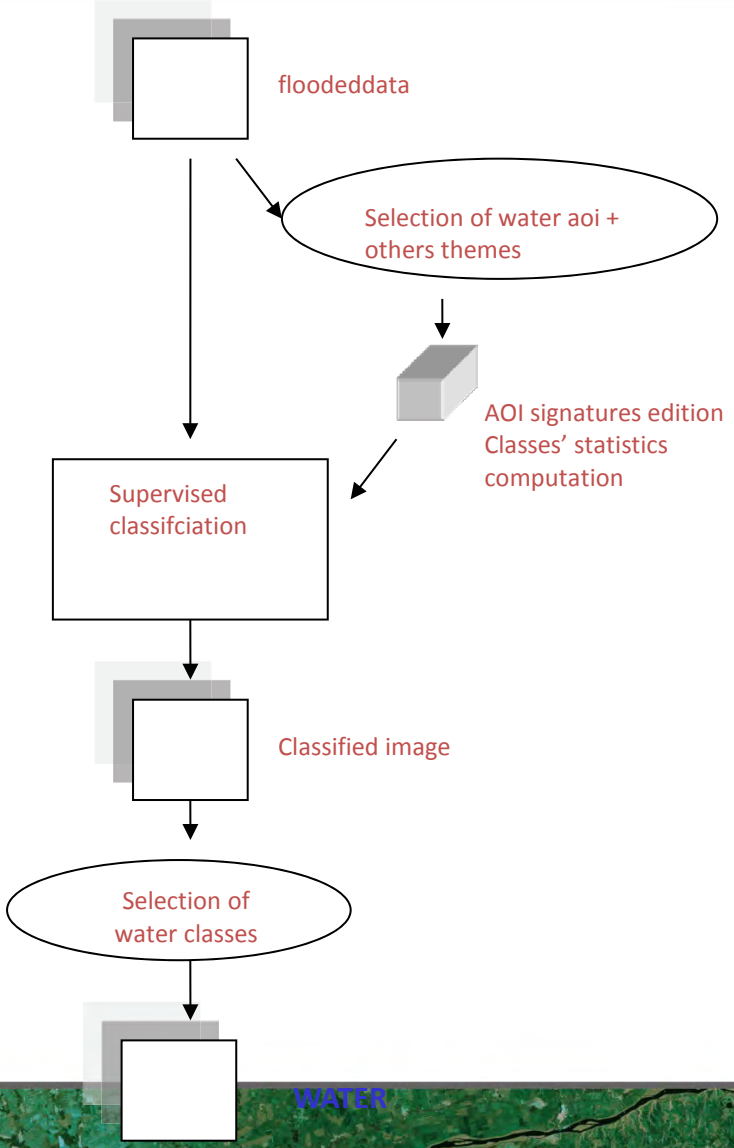
# Flood mapping based on classification

**Classification can be performed on:**

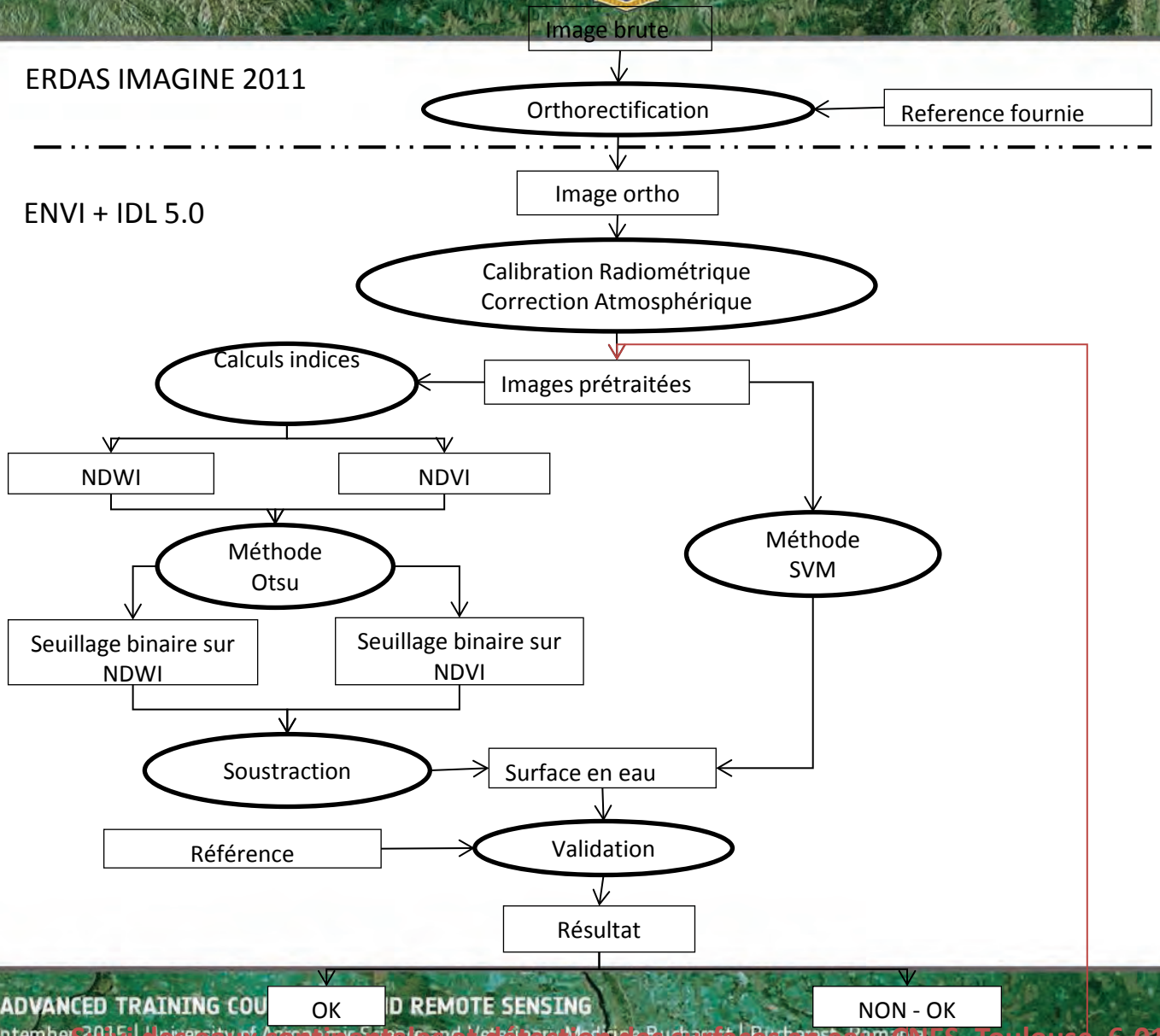
- **Raw flooded data**
- **Combination of indices**

**Methods of classification**

- **Supervised**
- **None supervised**
- **Oriented object methods**
- **SVM**



# Example of processing chaine



# Example of processing chaine

Données entrées ortho

↓

Choix de l'Orfeo Tool Box

↓

Ecriture des lignes de commandes pour : tests des algorithmes – Statistiques – Génération de l'image

↓

Sélection des échantillons sur l'image

↓

Tests des différents algorithmes avec différents paramètres

↓

Sélection du meilleur algorithme avec les meilleurs paramètres + validation / référence

↓

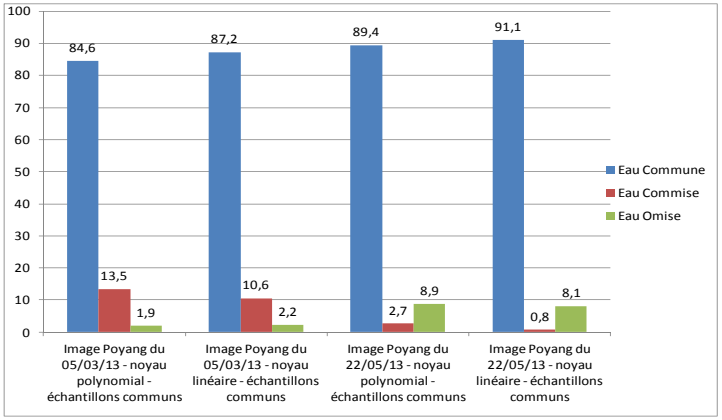
Sélection du classifieur SVM

↓

Tests des paramètres des SVM sur les images du Poyang

↓

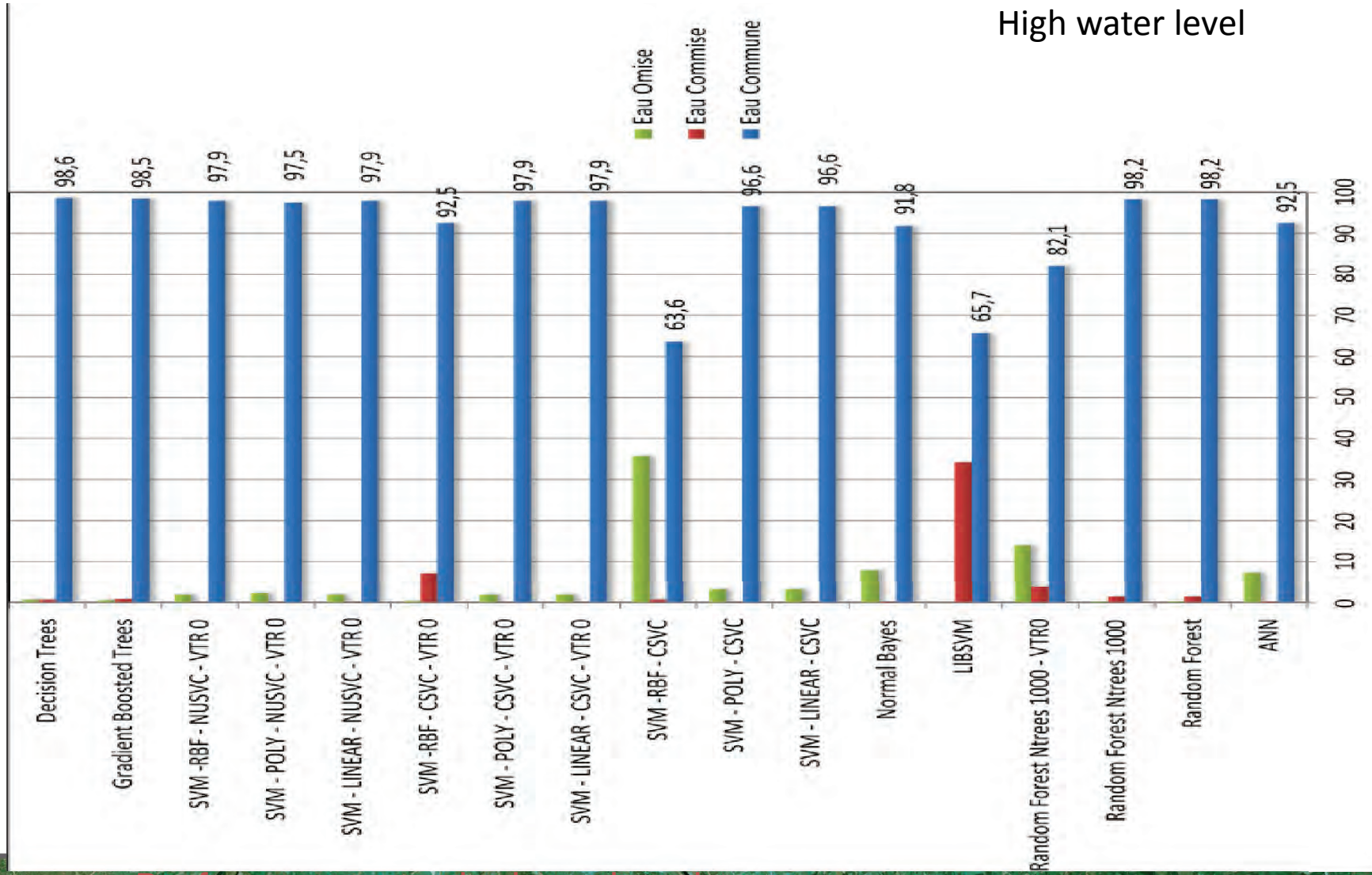
Tests de la robustesse des paramètres sélectionnés



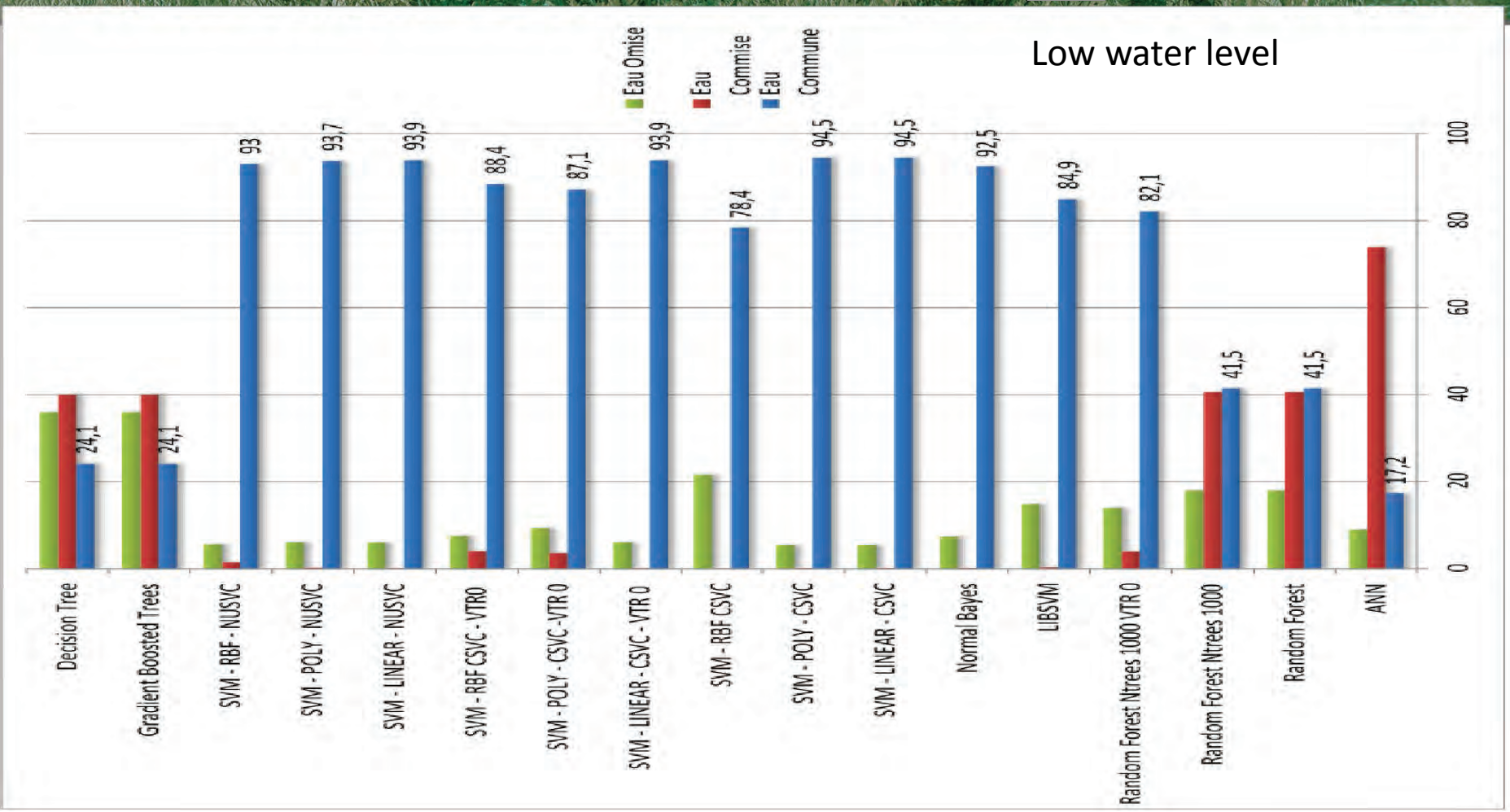

Noyaux linéaires et polynomiaux SVM
05-03-2013
22_05-2013
échantillons communs,

# Flood mapping based on classification from test areas

High water level

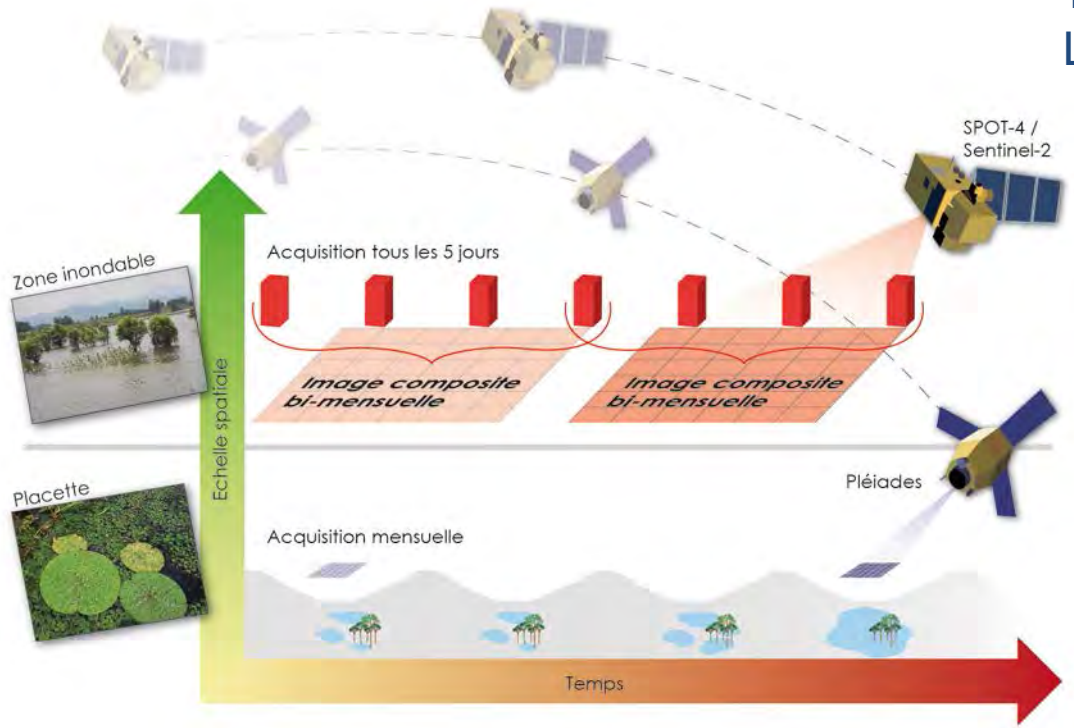


# Flood mapping based on classification from test areas




Performance analysis: a jungle

# Multi source & multiscale optical and SAR




SPOT4/ HJ/Deimos and Pleiades HR
TerraSAR, Wide ScanSAR to Staring Spot Light

VHR SAR or Optical imagery allow to validate the HR derived flood extent

# Objectives of training course

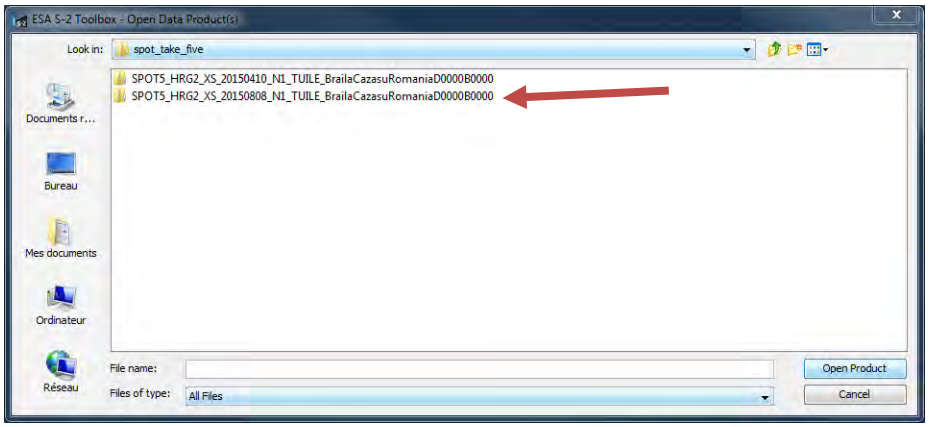
- Open SPOT-5 images in ESA S-2 Toolbox
- Edit different RGB views
- Interpretation of the surface's spectral behaviour based on the reference image
- Identify the spectral signature of permanent water bodies
- Creation of an image subset
- Extraction of permanent water bodies
- Identify the spectral signature of flooded areas
- Extraction of flooded areas

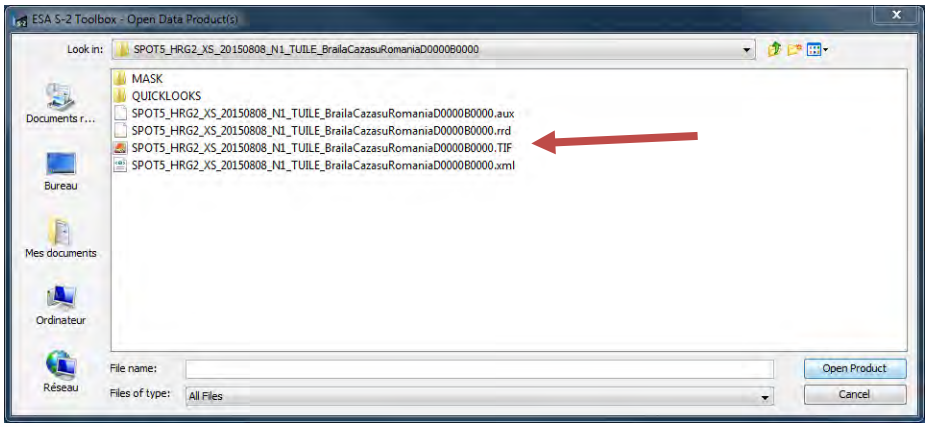
# SPOT 5 image opening in ESA S-2 Toolbox

- Open the ESA S-2 Toolbox software 


- Open the SPOT-5 image directory by clicking the folder icon 

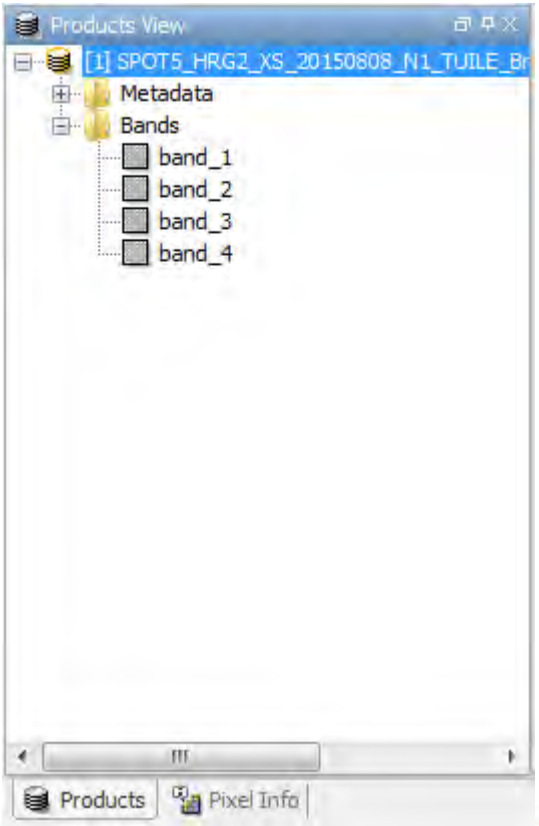
- Then open the **SPOT5_HRG2_XS_20150808** folder and select the .TIF image file



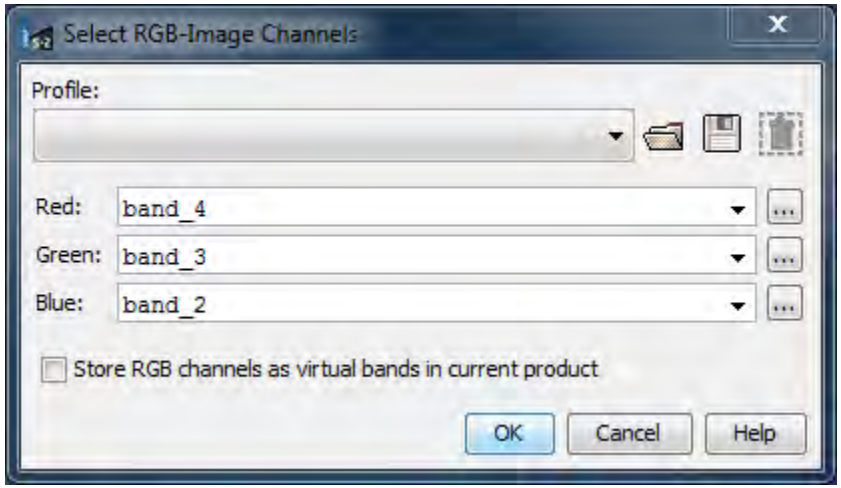
# SPOT 5 image opening in ESA S-2 Toolbox

- Unfold the list of bands

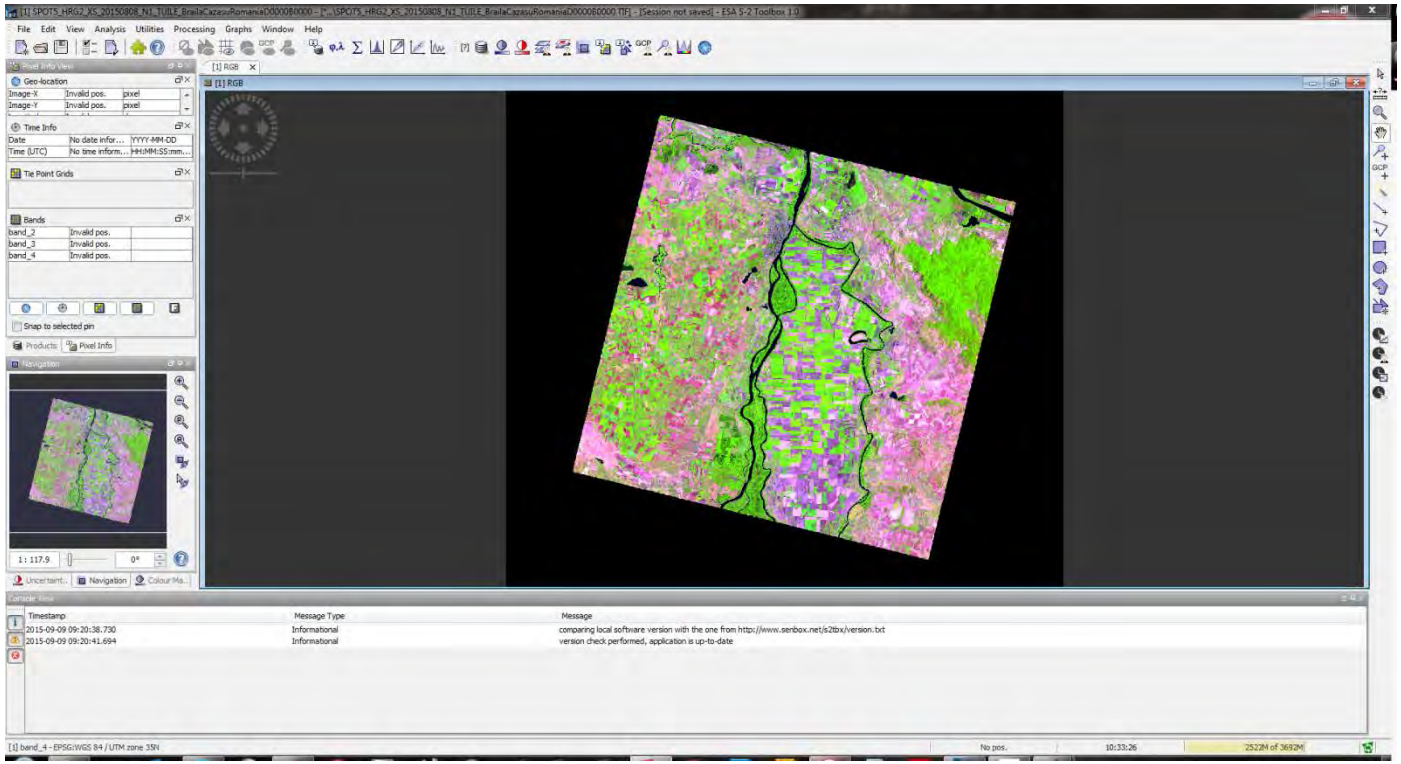
# False color composition with SPOT 5 MS channels

View > Open RGB Image View



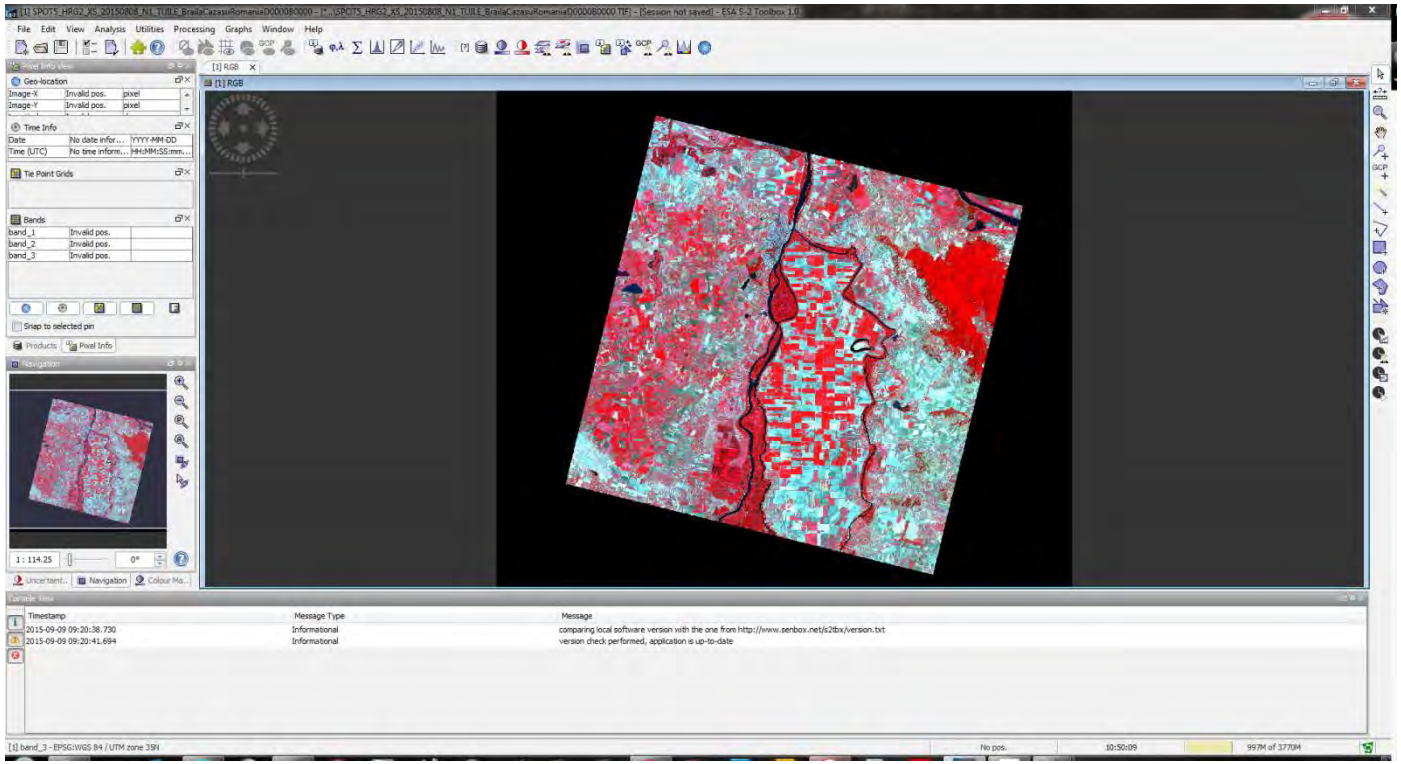
# False color composition with SPOT-5 MS channels

Bands : 4-3-2



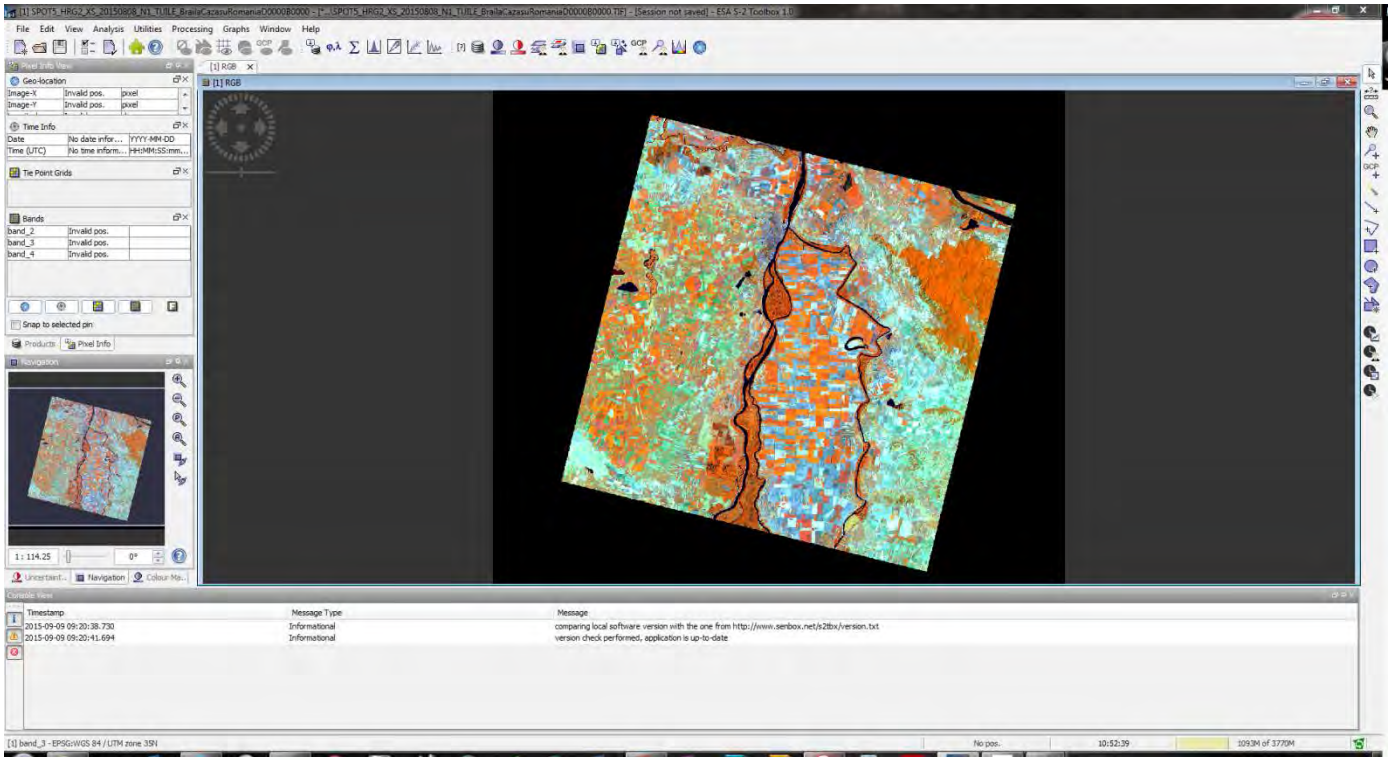
# False color composition with SPOT-5 MS channels

Bands : 3-2-1



# False color composition with SPOT-5 MS channels

Bands : 3-4-2



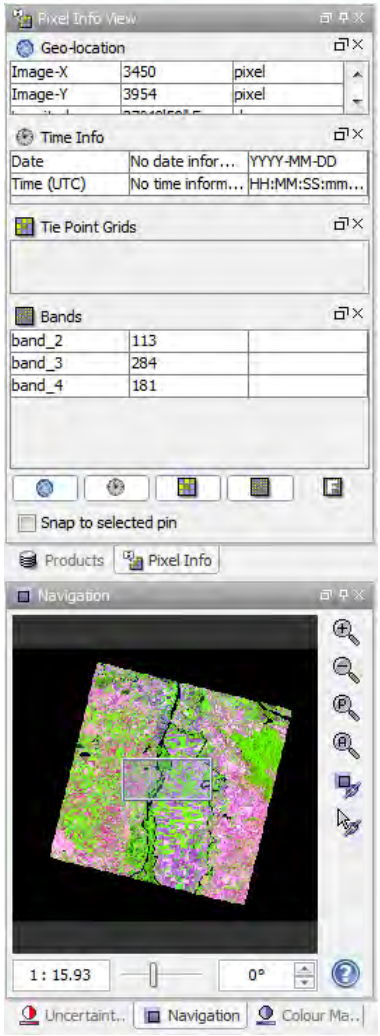
# Image interpretation and spectral behaviour

- Can you identify different kind of land surfaces ?

- Using the Pixel Info tab, can you detail the general spectral behaviour of green vegetation, bare soils, urban areas and water bodies ?

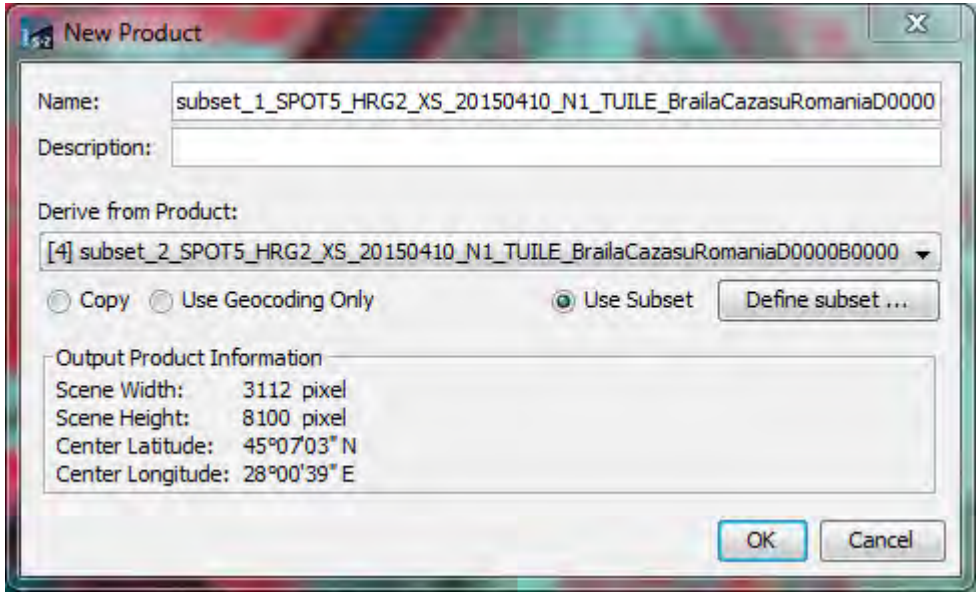
- What is the most sensible SPOT-5 channel to the green vegetation ? Why ?

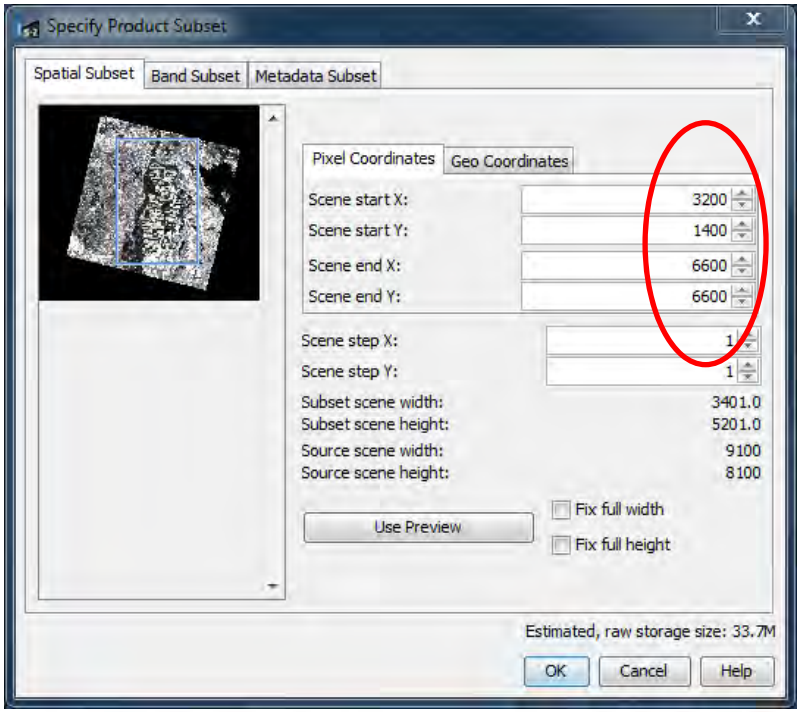
- How to separate a single kind of surface, such as water ?



# Creation of an image subset

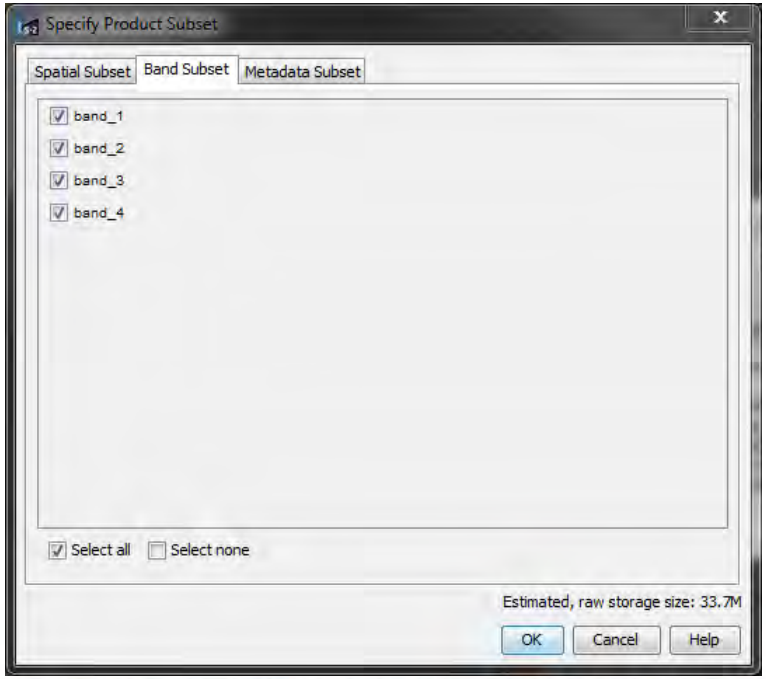
- File > New Product
- Click Define subset and set the pixel coordinates as follow :

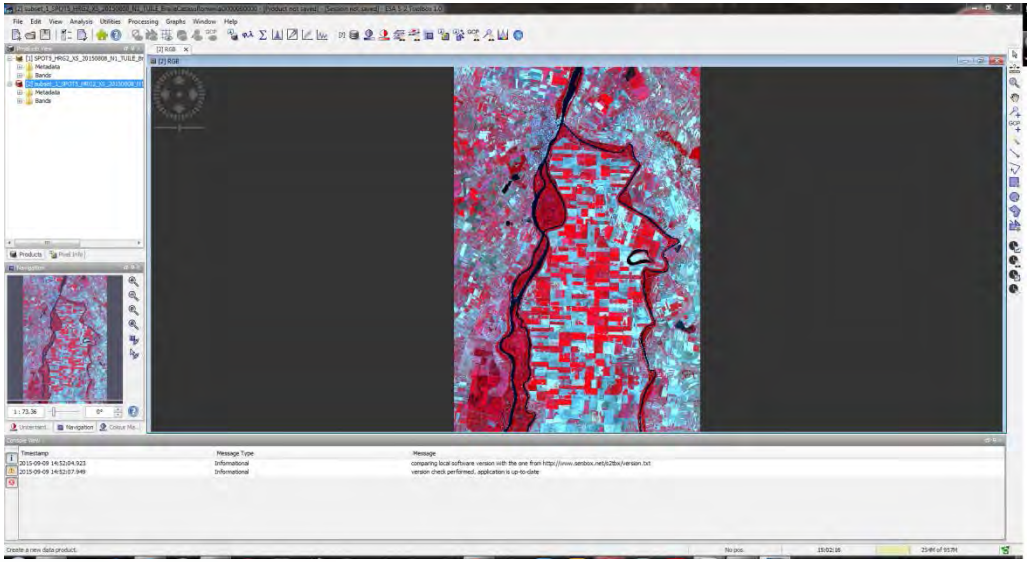


# Creation of an image subset

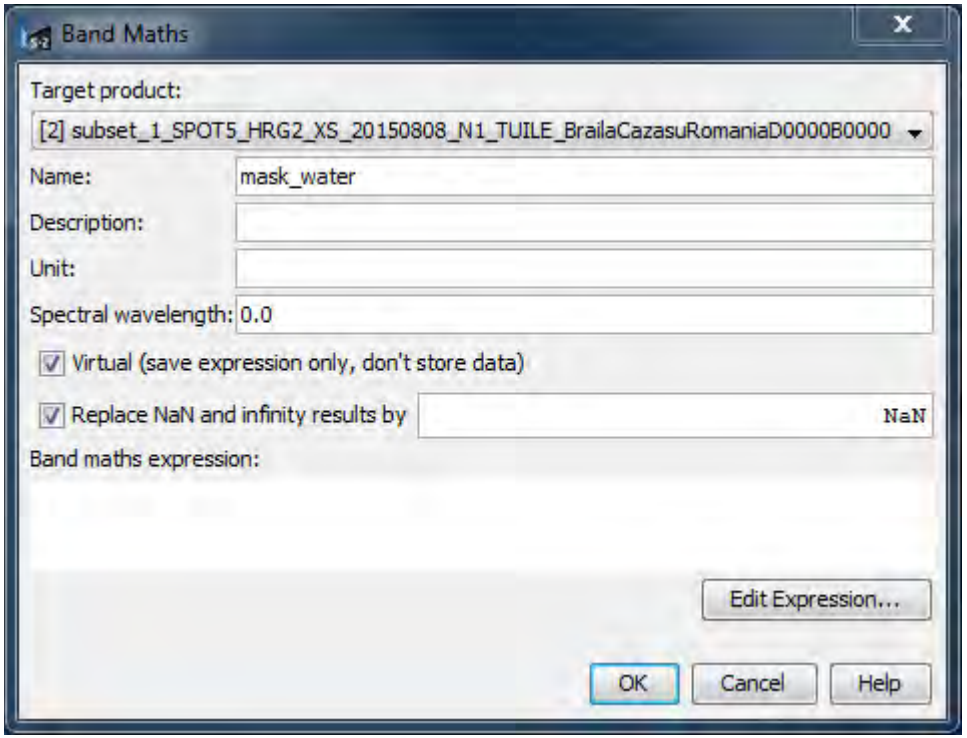
- Ensure that all bands are selected in the Band Subset tab
- Click OK (two times)
- The new subset appears in Products View list, then display a RGB view (3-2-1)



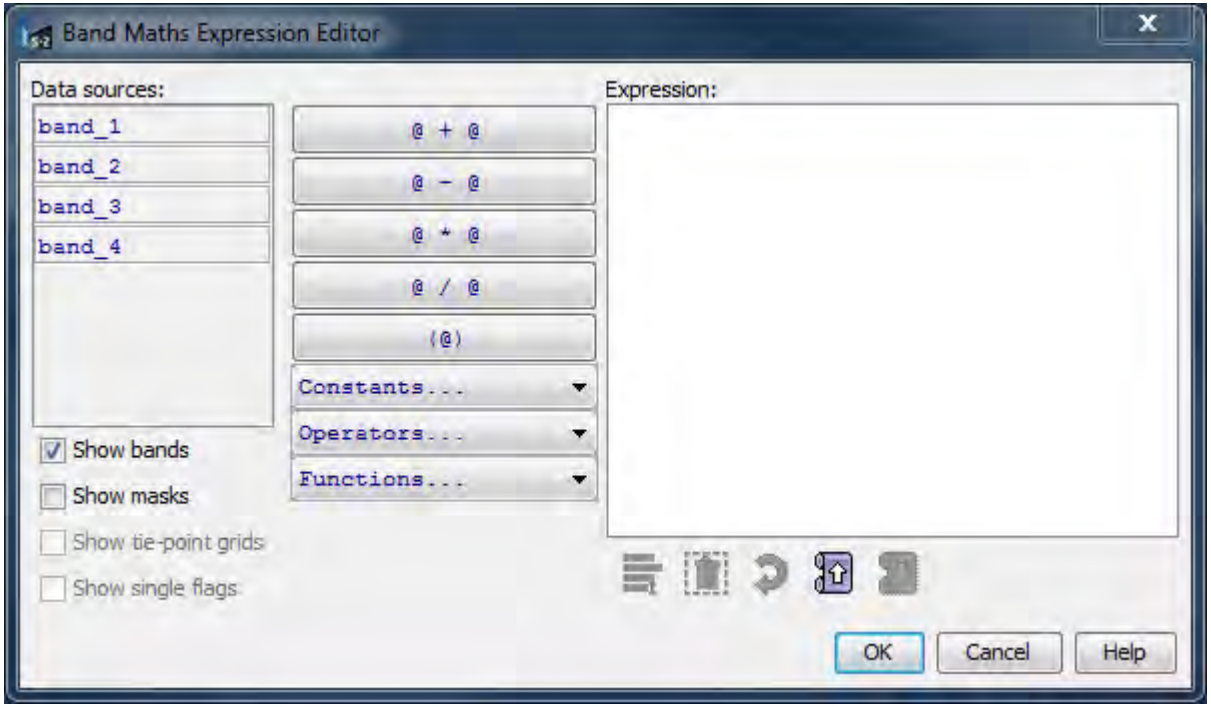
# Extraction of permanent water bodies

- Go to Utilities> Create Band from Math Expression



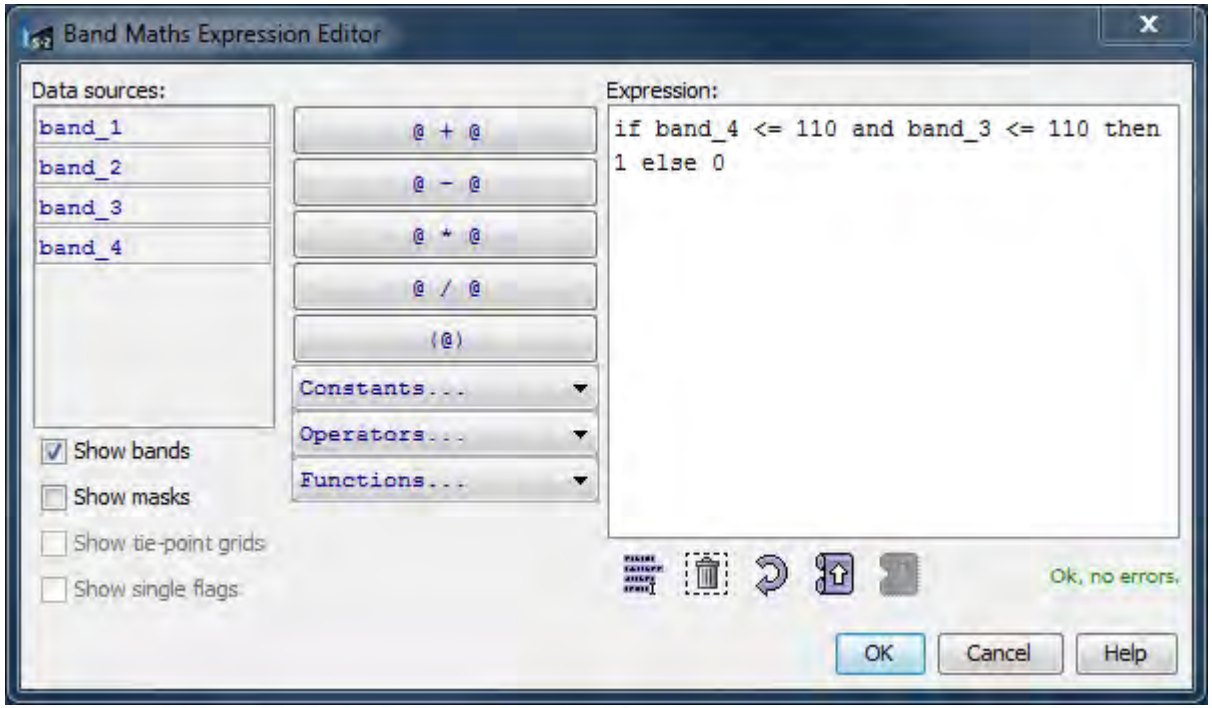
# Extraction of permanent water bodies

- Click on Edit Expression

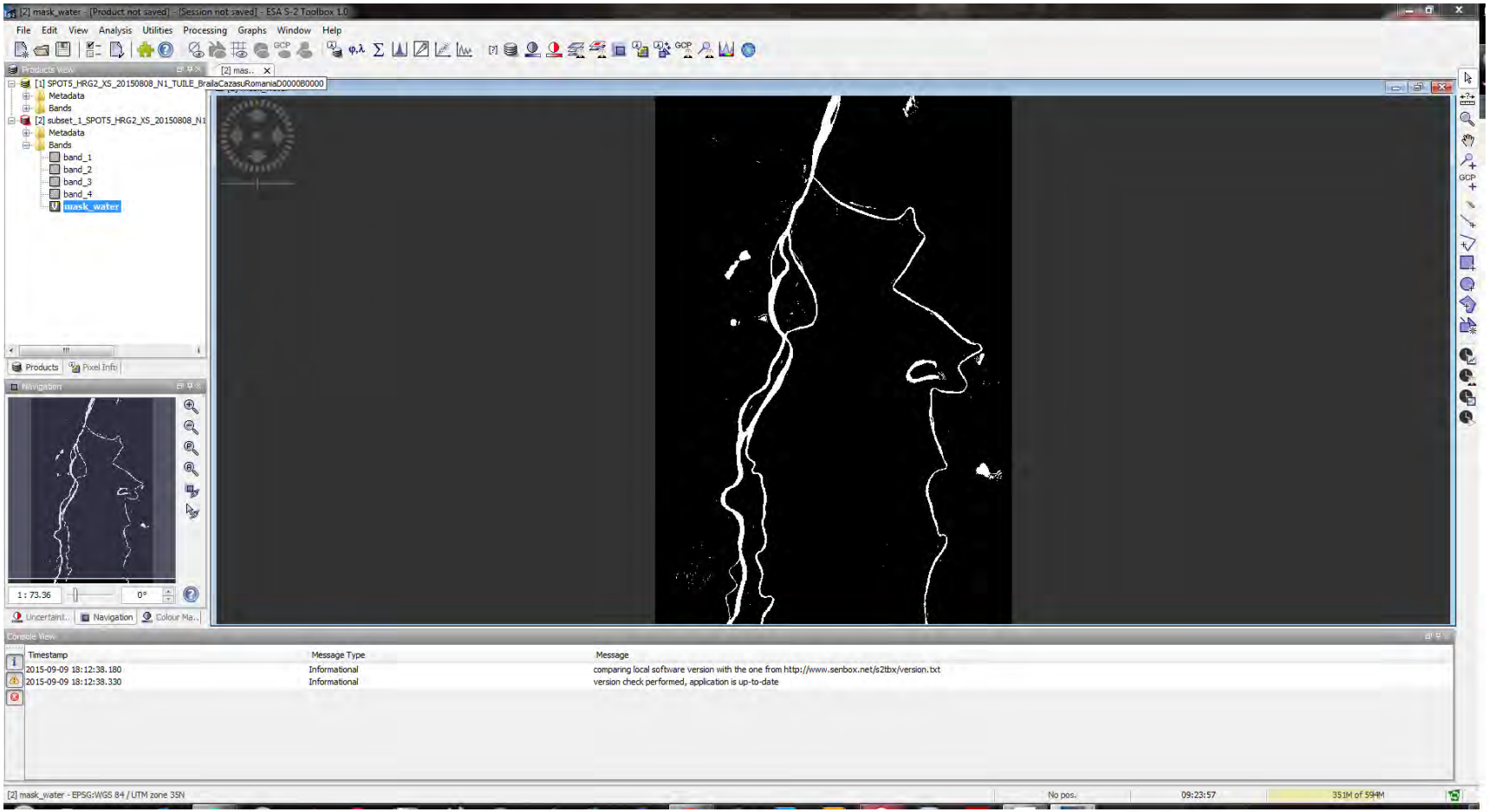


# Extraction of permanent water bodies

- Create a conditional expression on SPOT-5 spectral bands in order to generate a binary mask. Surfaces corresponding to water have to be coded by a 1, and to non-water by a 0.

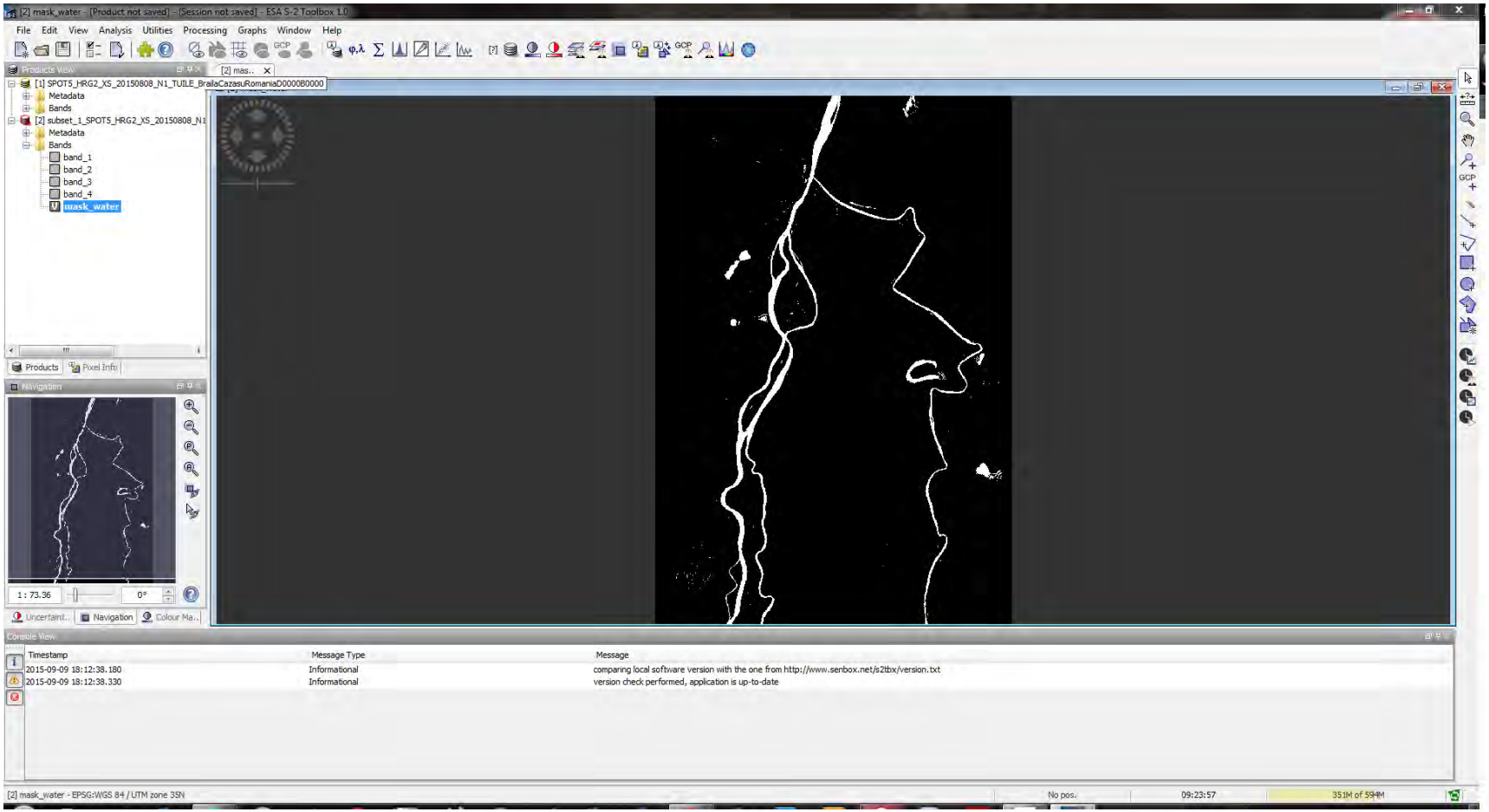


# Extraction of permanent water bodies



# Extraction of permanent water bodies

! Right clic on new band to « convert to band »



# Extraction of permanent water bodies

- Right click on the subset product in the list and choose Save Product AS …

- Choose a target directory, a name and save the subset file (which includes the binary mask

# Extraction of flooded areas

- Then open a New Product and choose the **SPOT5_HRG2_XS_20150410** folder and select the .TIF image file

- Create an image subset following the previous pixel coordinates

- Open several RGB views (4-3-2, 3-2-1, 3-4-2)

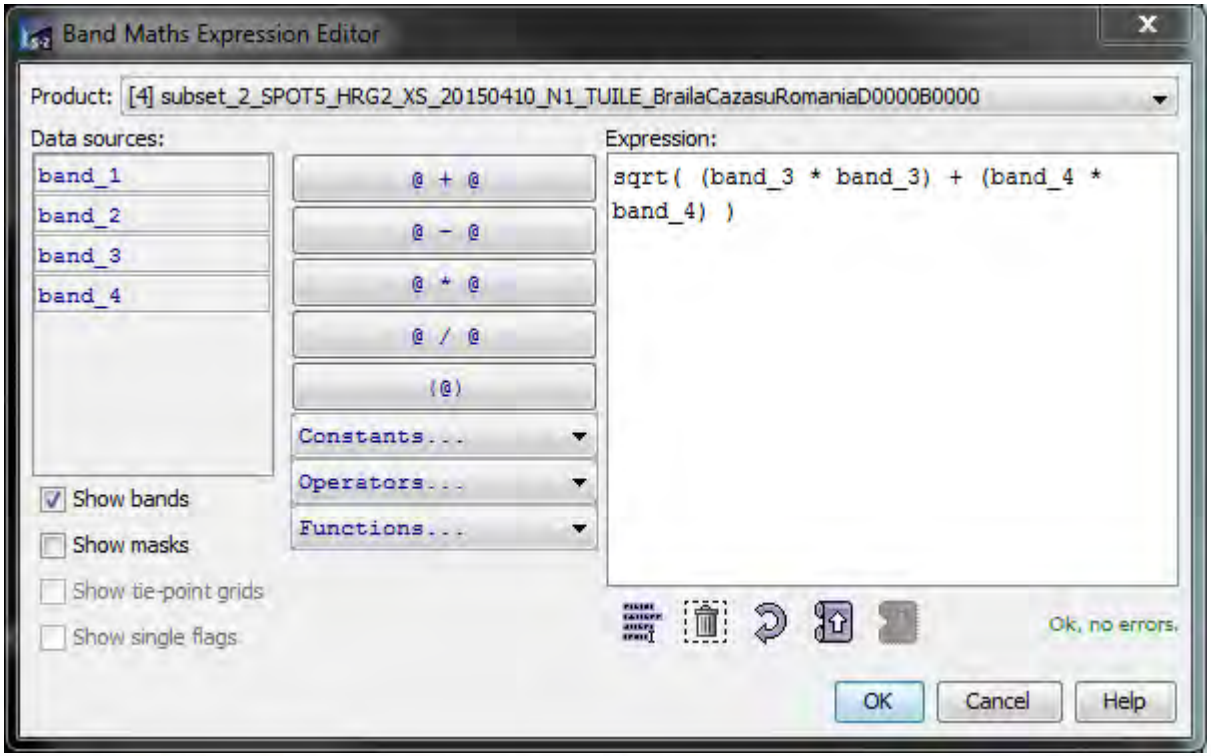
- Can you identify different the flooded areas ?

- Check the spectral behaviour of these surfaces, based on the four SPOT-5 channels

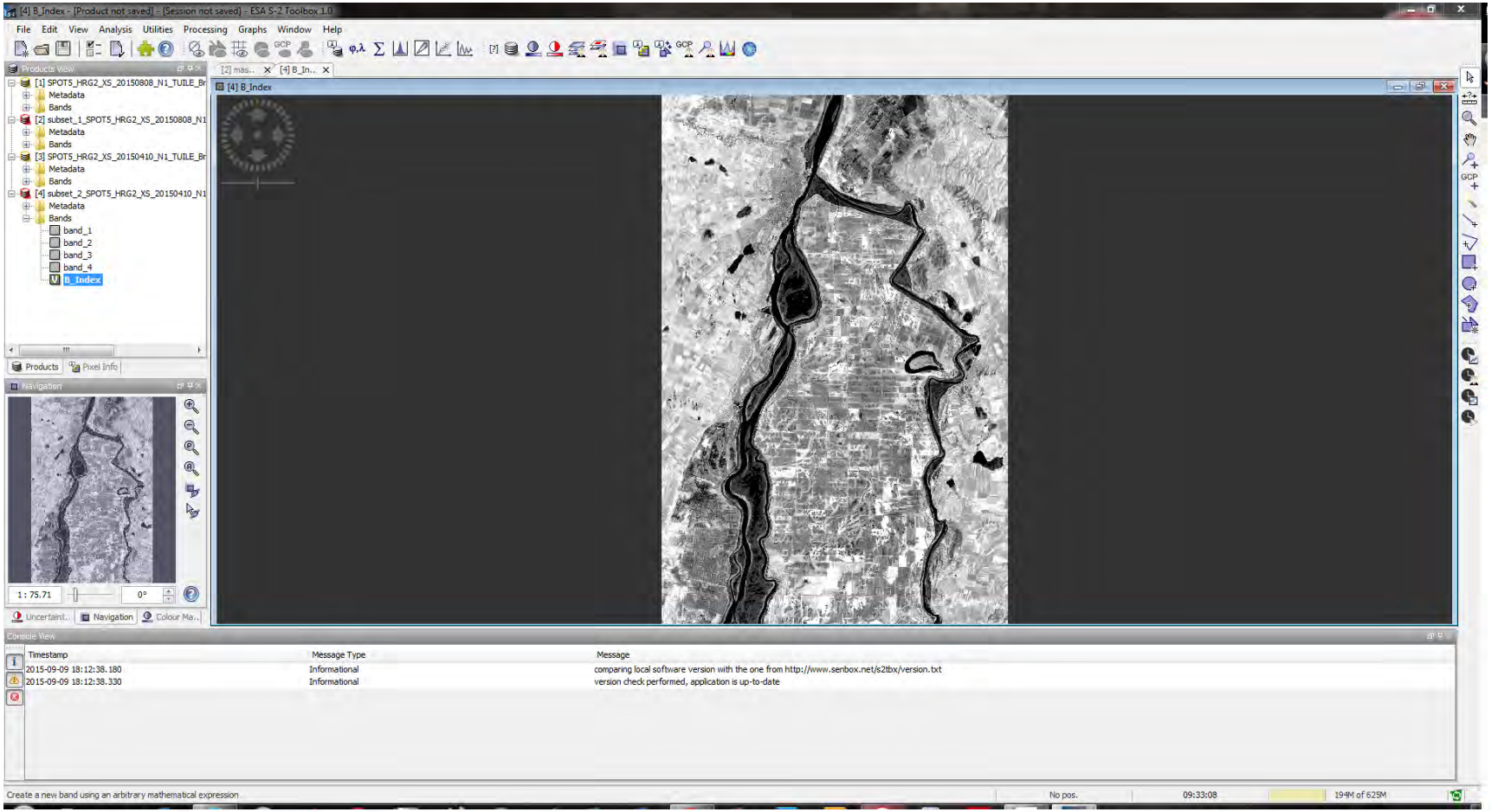
- **Create a binary mask of the flooded areas, but a little bit complex !**

# Extraction of flooded areas

- First, compute a bighting index as follow. It allows to better discriminate water, flooded and wet areas. Name it B_Index

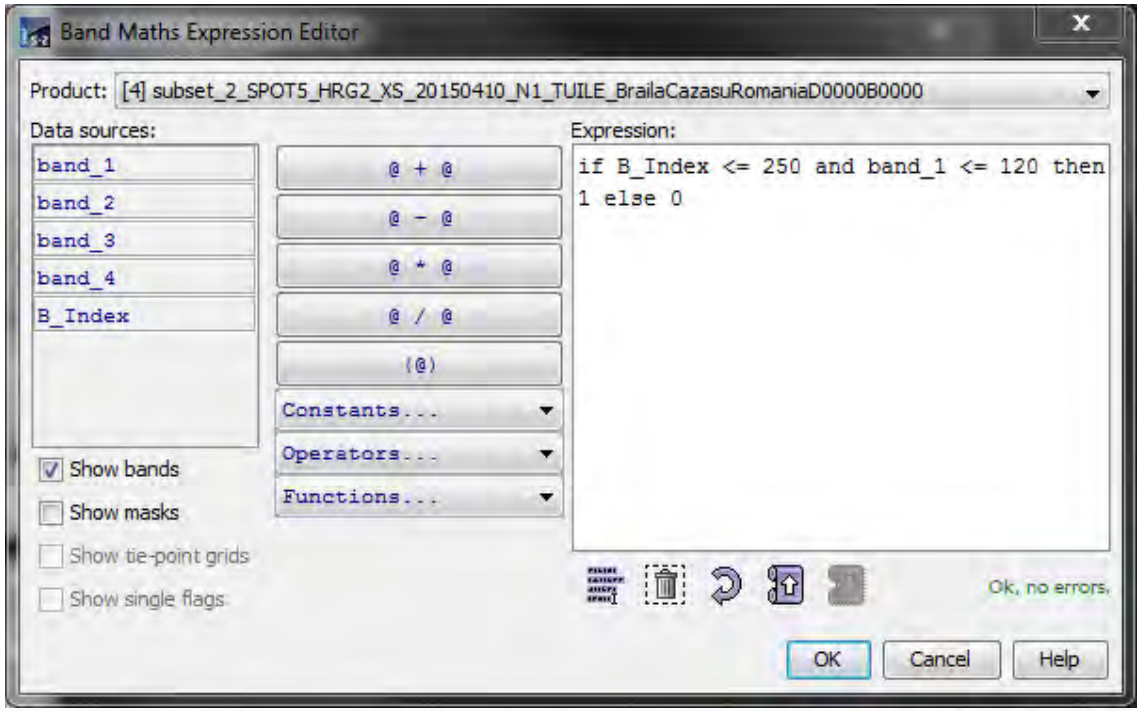


# Extraction of flooded areas

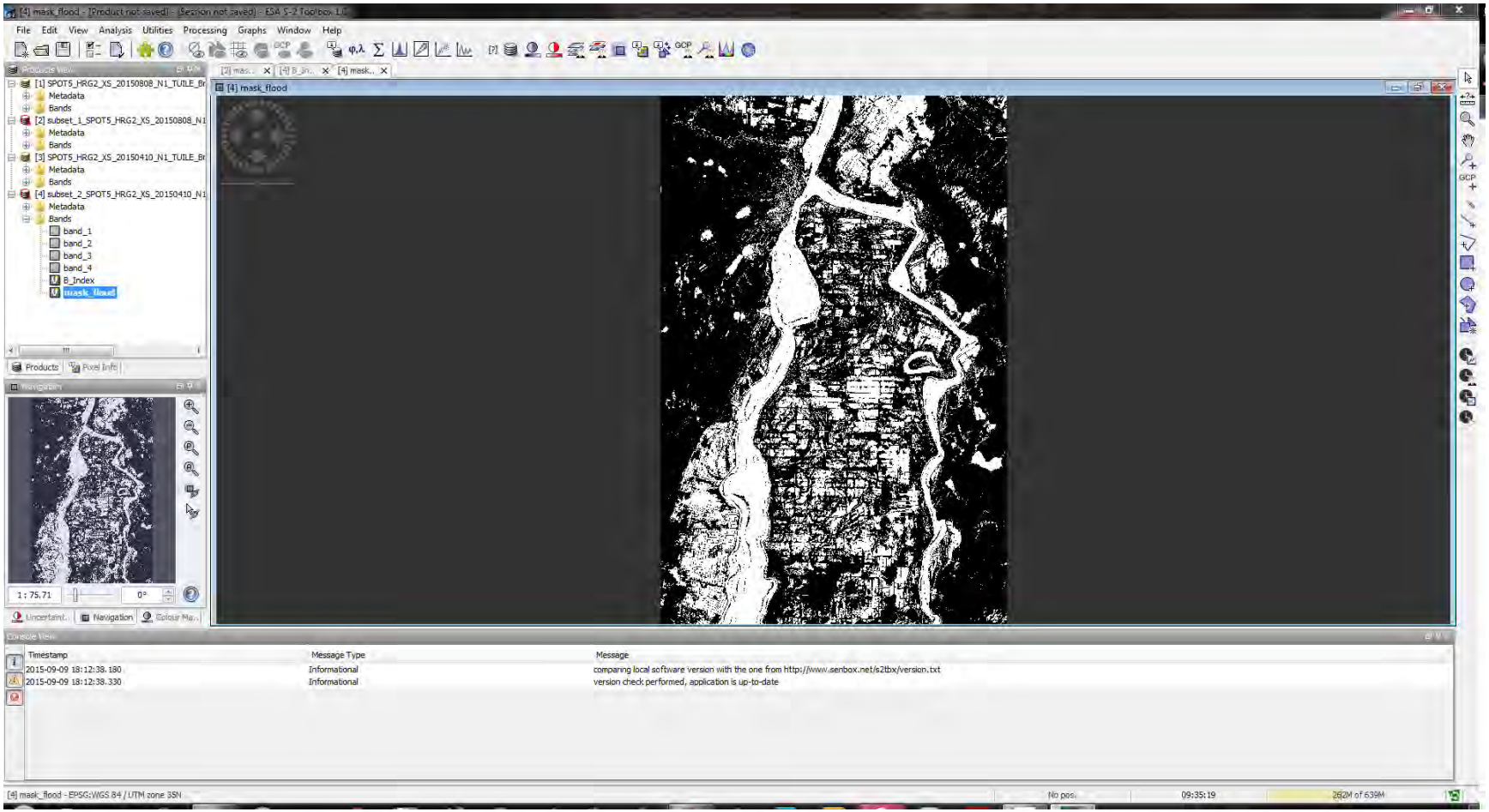


# Extraction of flooded areas

- Then, use this index to define a threshold, and find a second threshold to apply on the first band (it allows to discriminate bare soil and most of urban areas). Name it mask_flood.



# Extraction of flooded areas



# Extraction of flooded areas

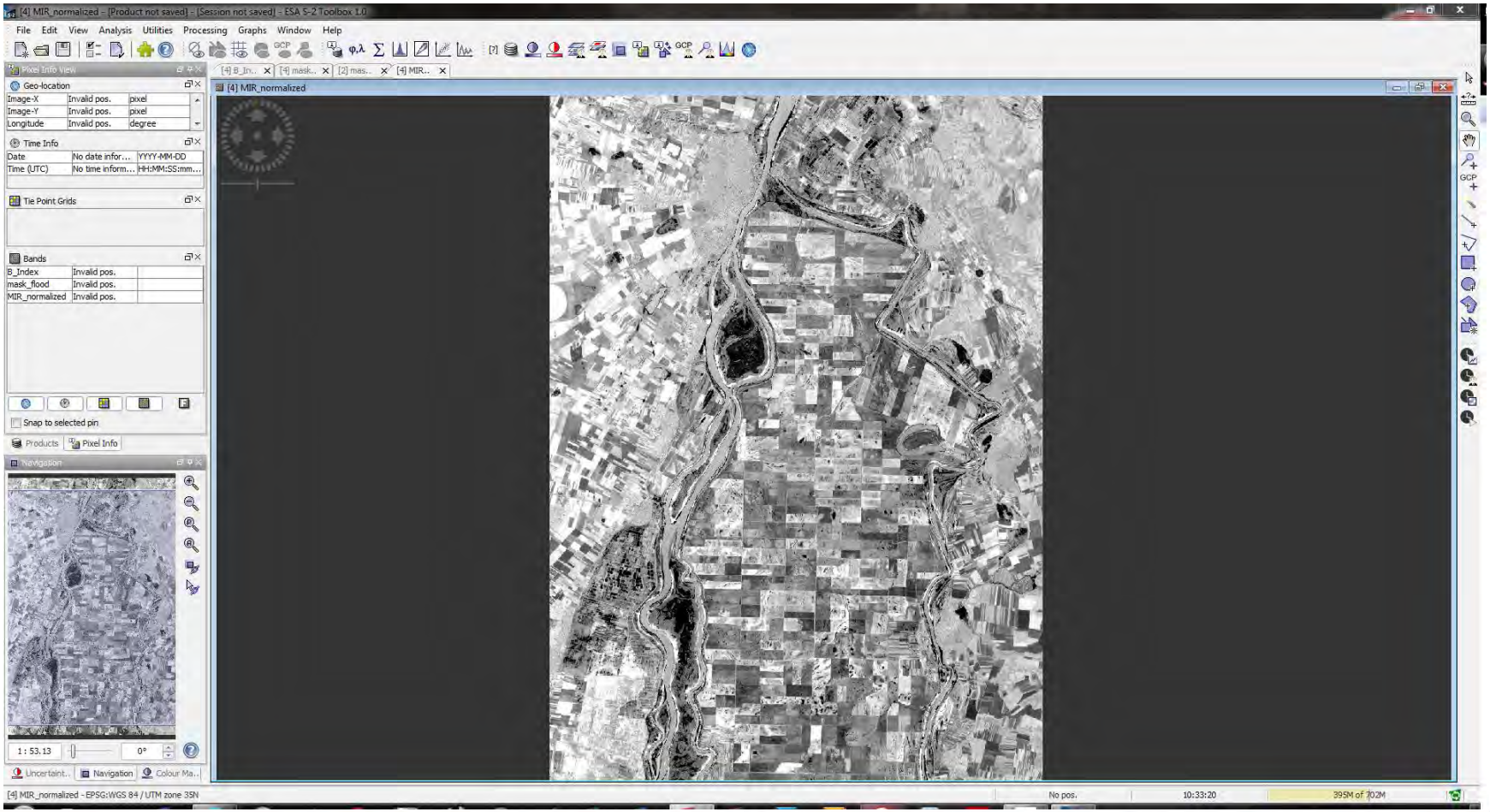
- Save the second subset with related computed bands (index & mask)

- Some issues : extraction of few urban areas or shaded pixels (relief, cloud, etc)

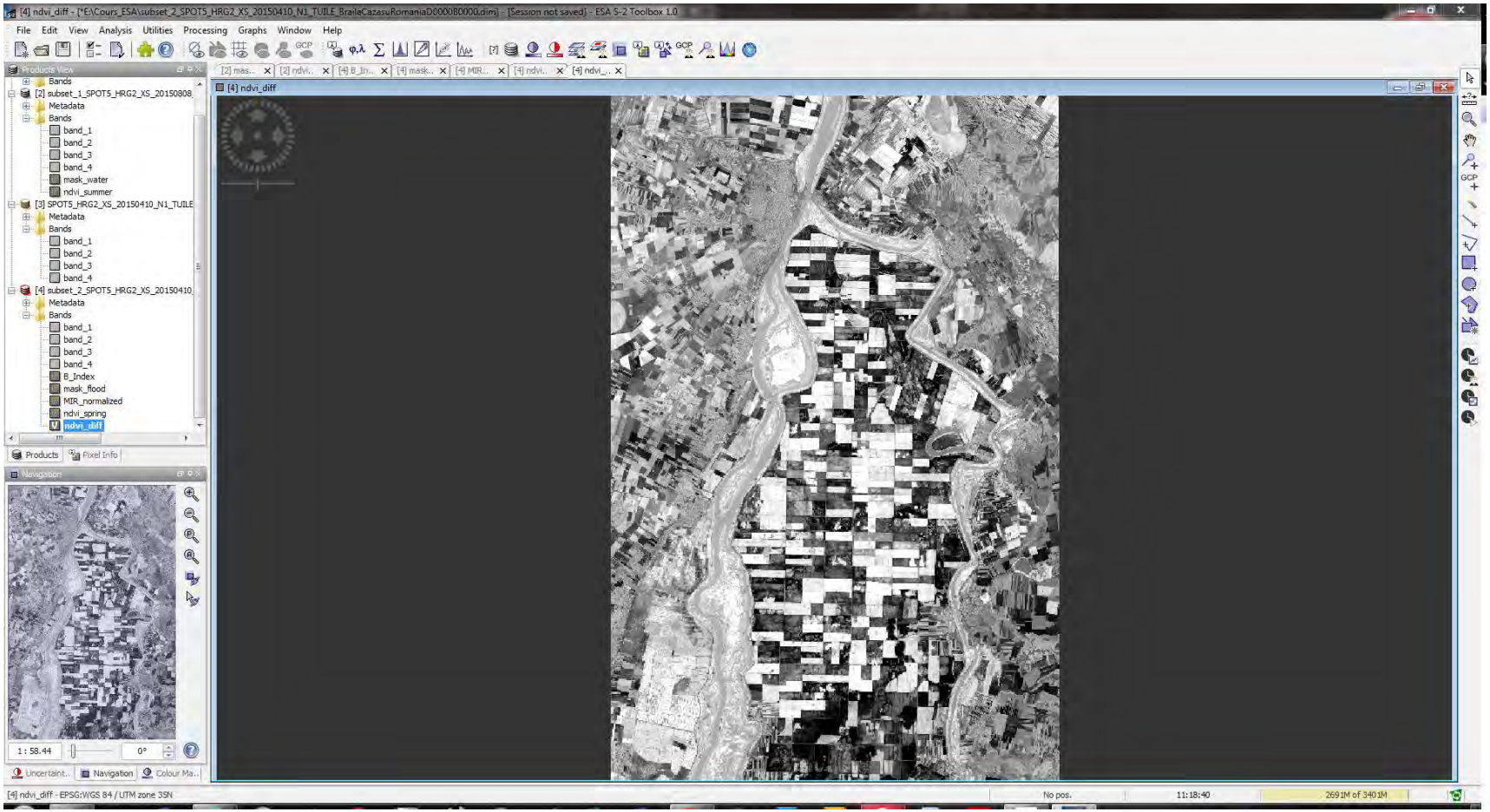
- Can be avoid by subtracting urban areas using a land cover classification

- Use of a DEM for eliminating high lands

# MIR normalized ??



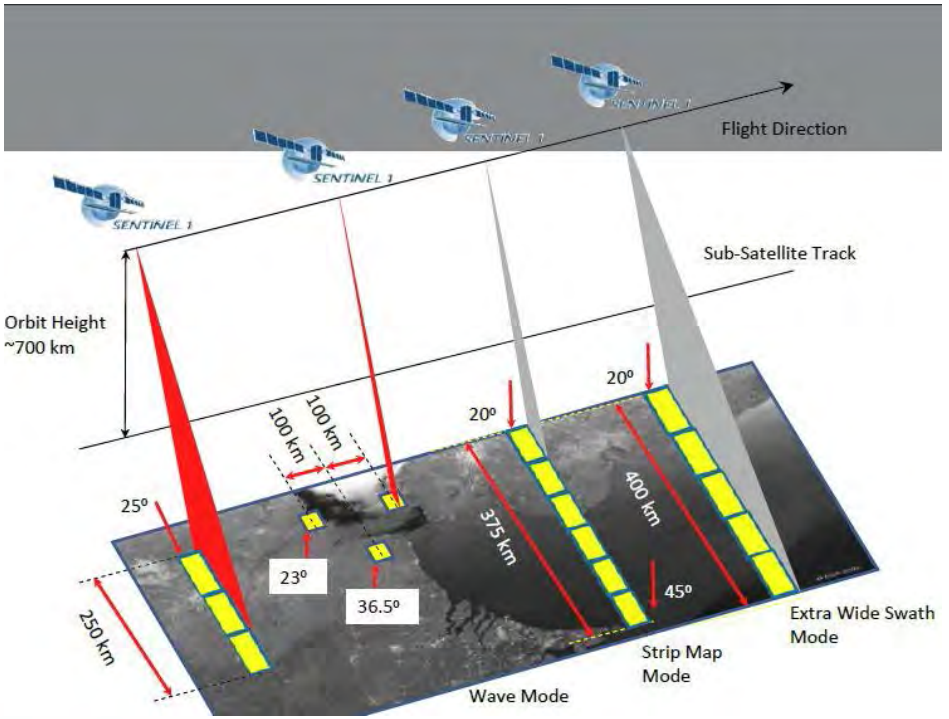
# NDVI difference ??



# Sentinel 1 Constellation

- Sentinel 1 A : 03-April 2014
- Operational since beginning of October

- Sentinel 1 B, 2016



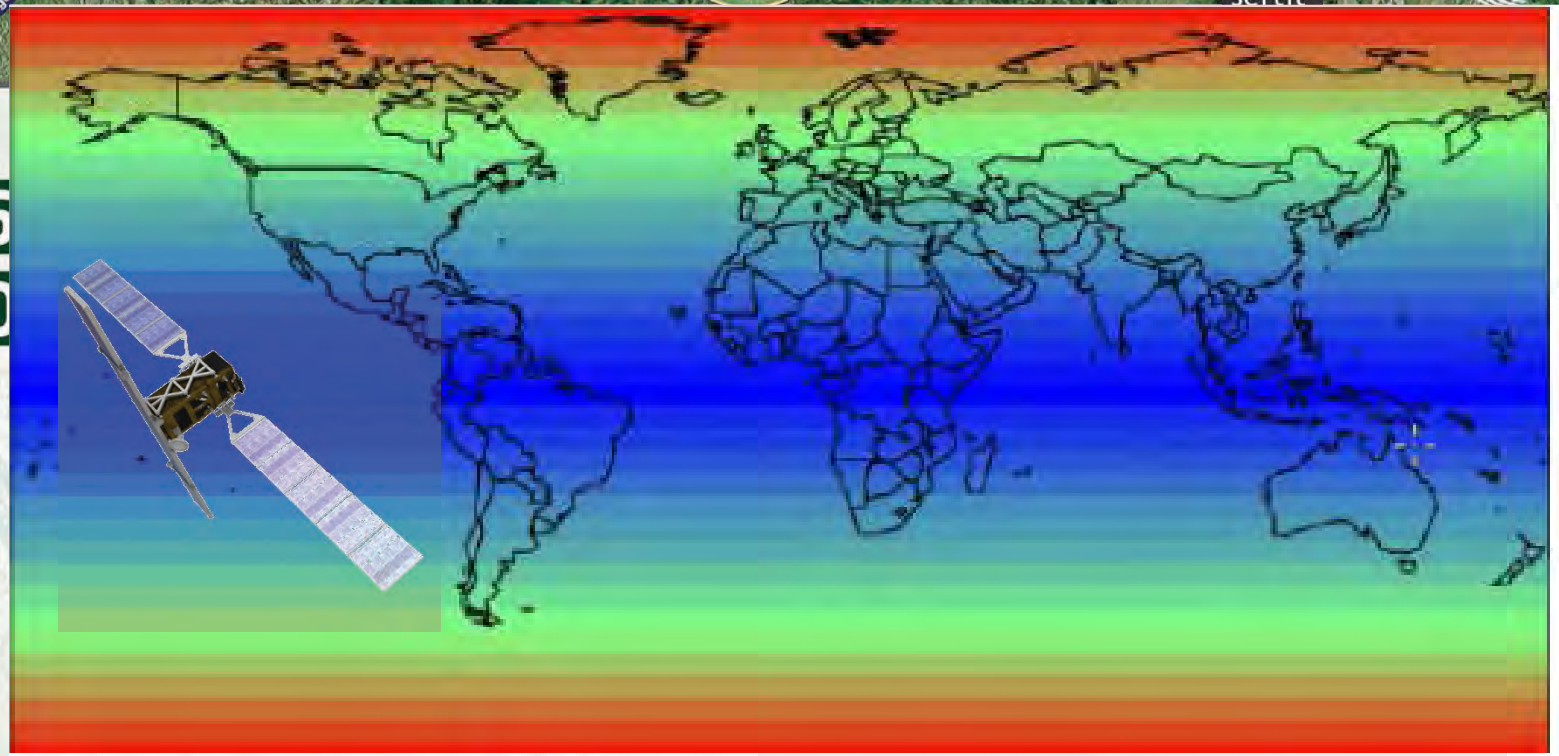

**Resolution same as actual VHR strip map**

**Band and Pol same as ENVISAT (C band)**

**Large swath**

**Revisiting time 5 days**

# First Sentinel1 over Poyang Lake

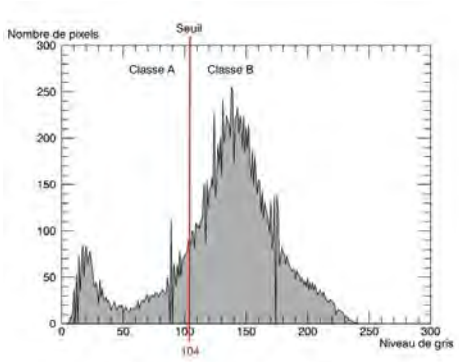


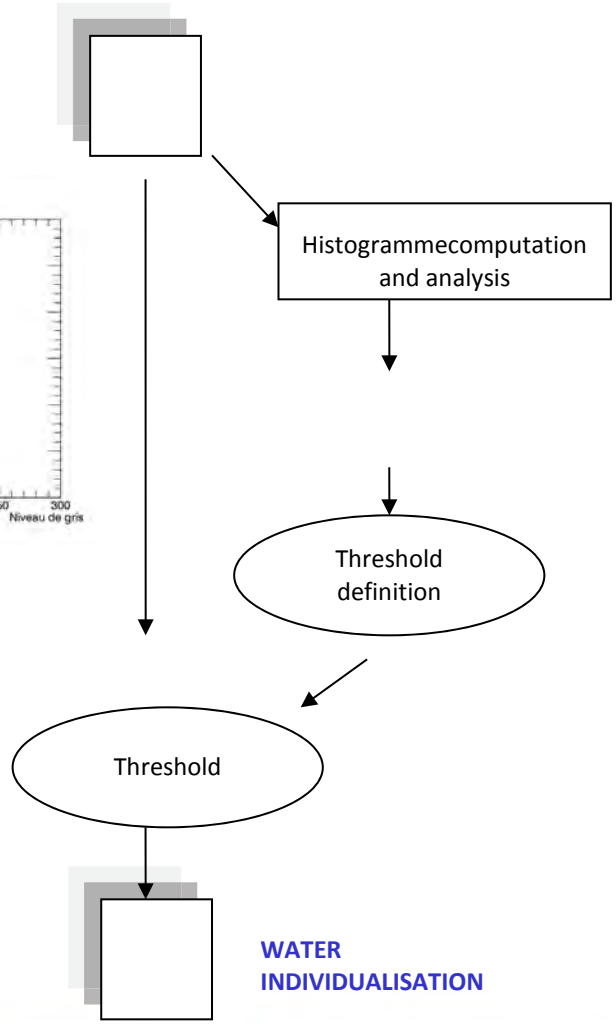

- ✓ Two satellites in a 12 day orbit
- ✓ Repeat frequency: 6 days (important for coherence)
- ✓ Revisit frequency: (asc/desc & overlap): 3 days at the equator, <1 day at high latitudes (Europe ~ 2 days)

YESOU H., HUBER Cl., POTIN P. & DESNOS YL., May 2014

# SAR Flood mapping based on SAR data

- **Water extraction by thresholding performed on:**
  - **Amplitude data (mediane fenetre glissante)**
  - **Coherence**
  - **Polarimetry approach (Shannon Entropy)**




- **Methods of classification**
  - **Supervised**
  - **None supervised**
  - **Oriented object methods**
  - **SVM**
  - **Snake detection**

→ 6th ESA ADVANCED TRAINING COURSE
ON LAND REMOTE SENSING

# Floods & Lakes Monitoring


**Dr Hervé YESOU**


D4P1a

Wenesday 16 of September 2015