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 esa

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING

Lakes - Floods monitoring practical

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With contributions of SERTIT Rapid Mapping team

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4th of July 2013, D4P1a



1–5 July 2013 | Harokopio University | Athens, Greece
19/06/2013

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Aims of flood mapping and monitoring training course

- Thematic goals:
 - Flood monitoring exploiting EO data
 - Flood analysis
- Synergy assessment between
 - Medium resolution SAR and medium optical image
 - Optical medium and high resolution image
 - Approach of time series

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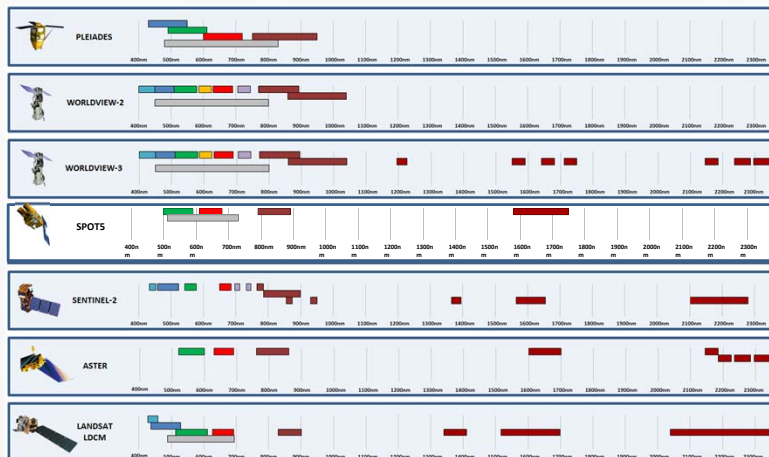
Aims of Flood mapping and monitoring training course

- IP part:
- Image Visualisation and Manipulation
- Flood water extraction
 - Optical and Radar
 - Mono-date and Multidate
- Thresholding
- Change detection
- Flood event characterization



Spectral basis for flood mapping

Applicable to others SAR or optical sensors



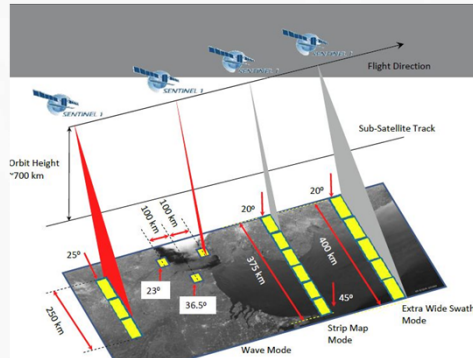


Short term goal of flood mapping and monitoring T.C. Preparing exploitation of the Sentinel series



Sentinel 1

- Resolution same as actual VHR strip map
- Band and Pol same as ENVISAT (C band)
- Large swath
- Revisiting time



(From Yi Desnos presentation, Lanzhou, 09-2010)

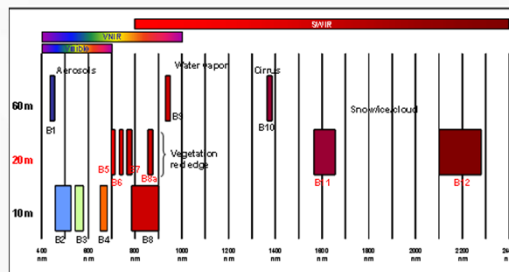


Short term goal of flood mapping and monitoring T.C. Preparing the exploitation Sentinel series



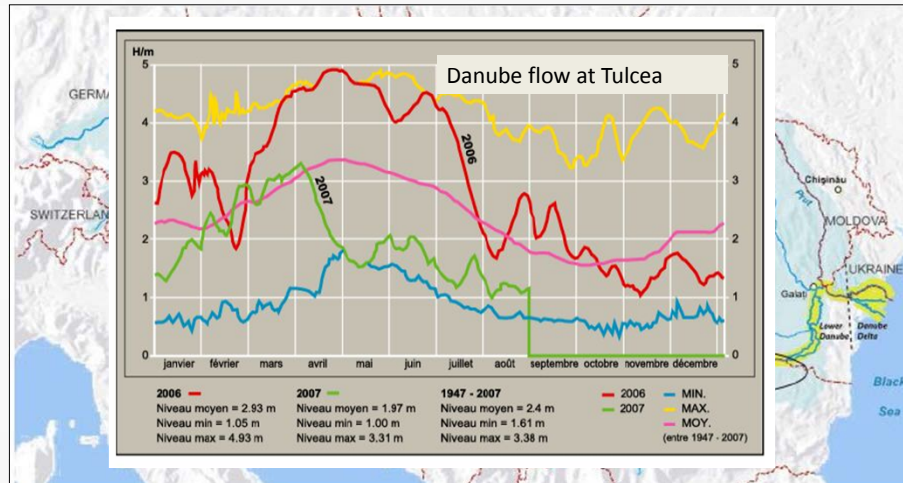
Sentinel 2

- Resolution same as SPOT5 (10m)
- Presence of a SWIR band
- Large swath (MERIS)
- Revisiting time





Case study - the 2006 Danube flood event



Case study - 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

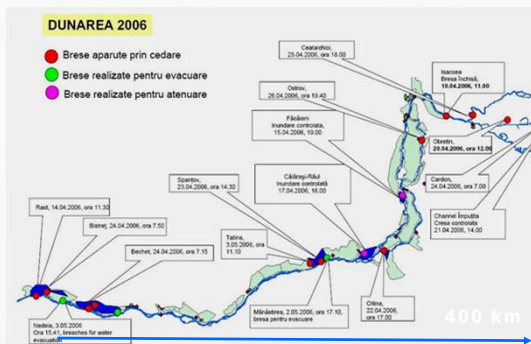
Main dike breaks :

- 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



**EO data covering 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

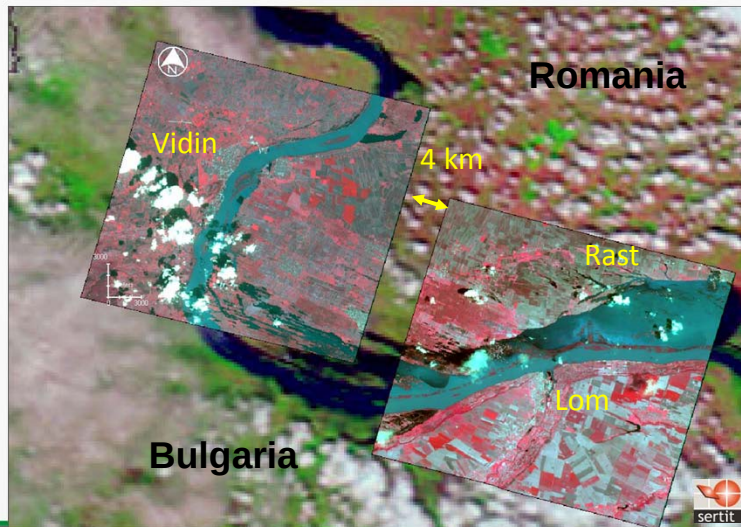
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**Single event monitoring exploiting HR data****The Spring 2006 Danube flood case**

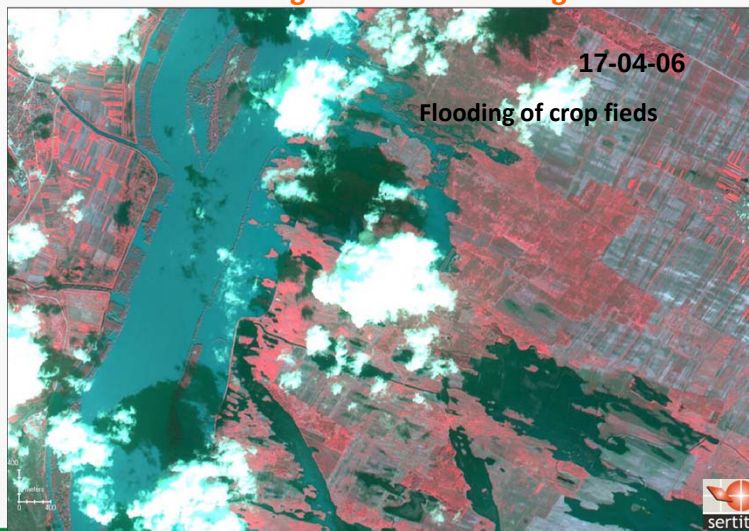
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Single event monitoring

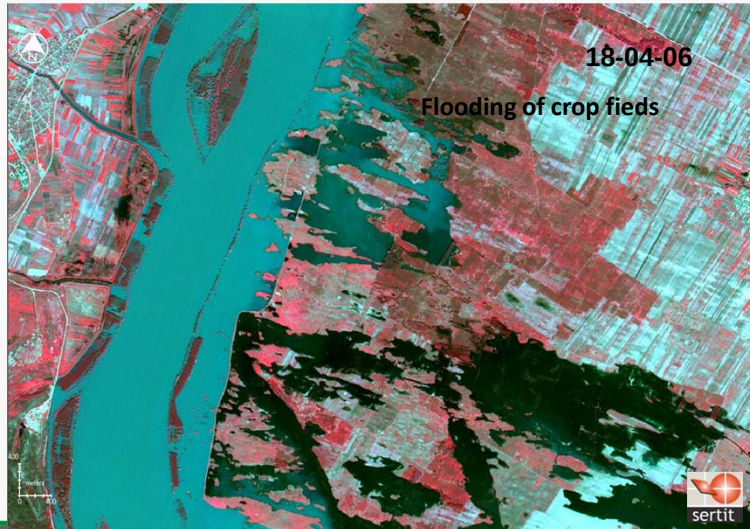


Single event monitoring





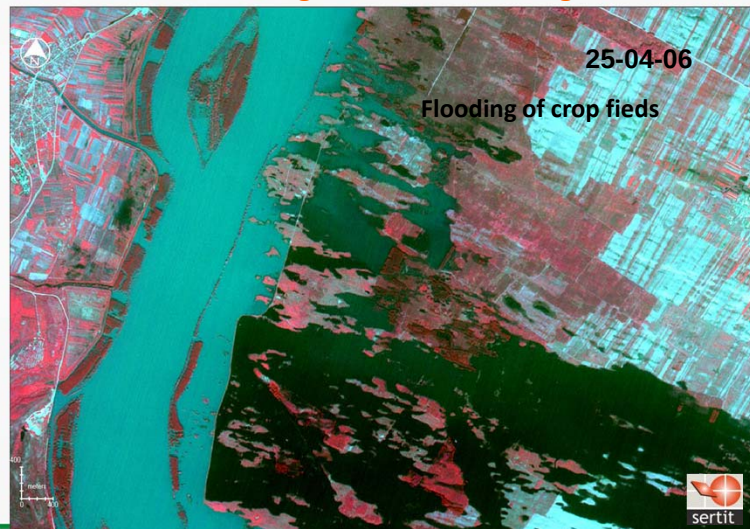
Single event monitoring



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Single event monitoring



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Case study - the 2006 Danube flood event

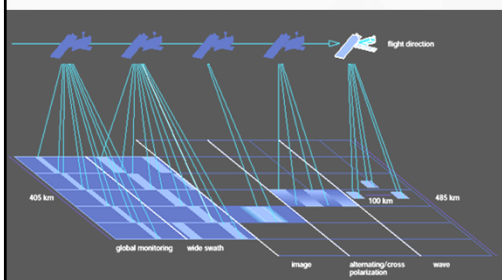
- **Medium resolution optical data: MERIS FR level 1 (300m)**
 - 26 March 2006
 - 23 April 2006
 - 22 May 2006
- **Medium resolution ASAR data: WSM VV Pol (75 m pixel spacing)**
 - 27 March 2006
 - 18 & 24 April 2006
- **HR SPOT Image**
 - 17, 23 and 6 of April 2006
- **HR and VHR optical data: Formosat-2 XS and merged PXS (8 and 2 m)**
 - 17 & 25 April 2006
- **Reference data**
 - SPOT 11 August 2004
 - Landsat 7 ETM image
 - SRTM DEM



ENVISAT ASAR

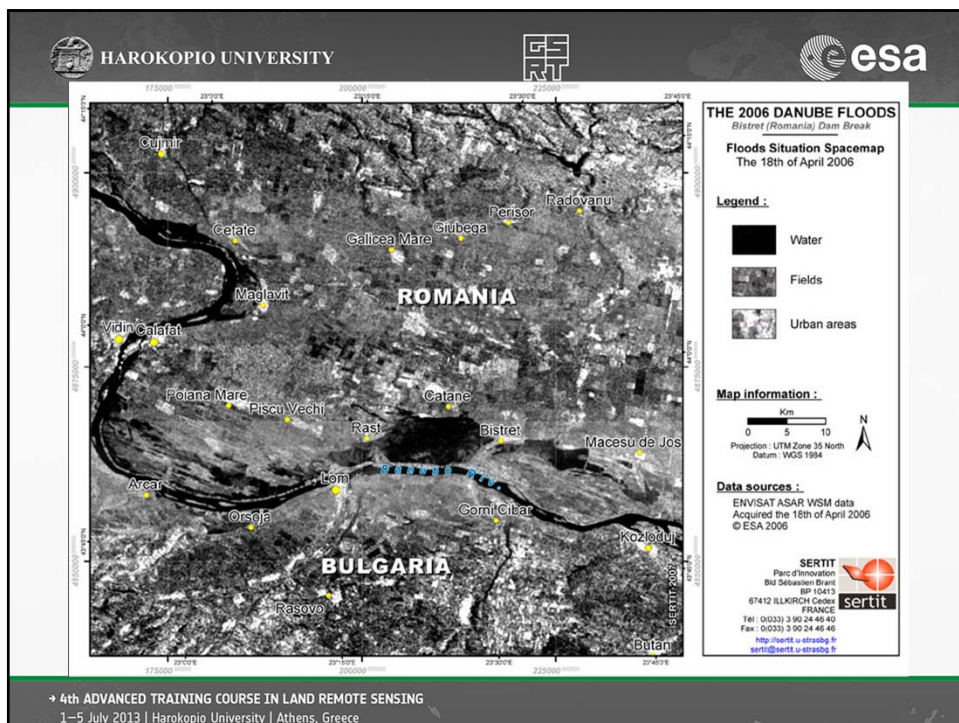
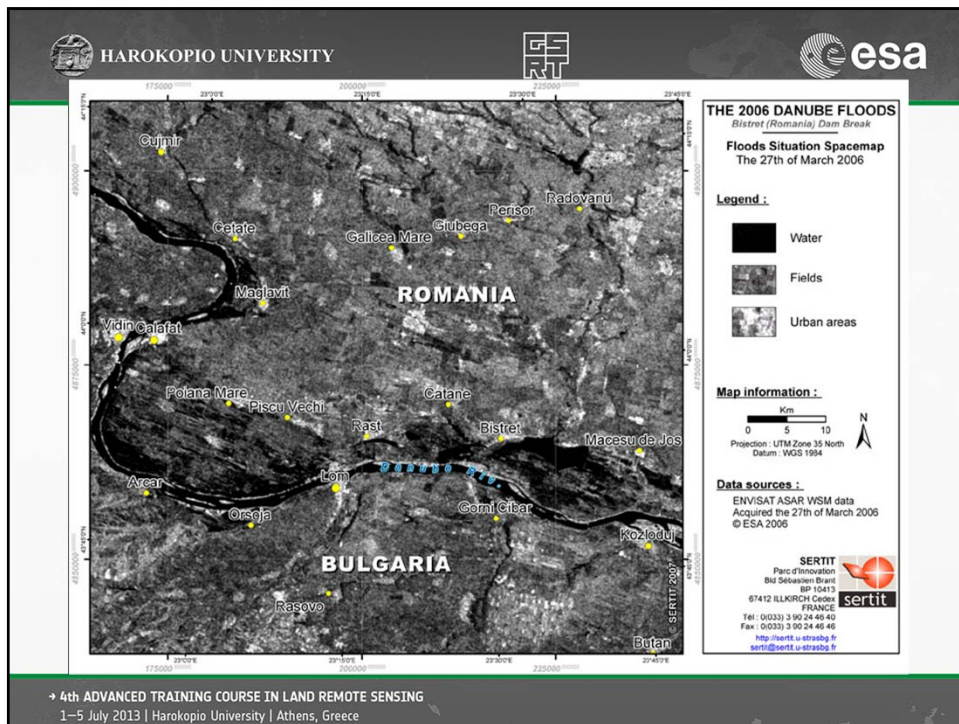


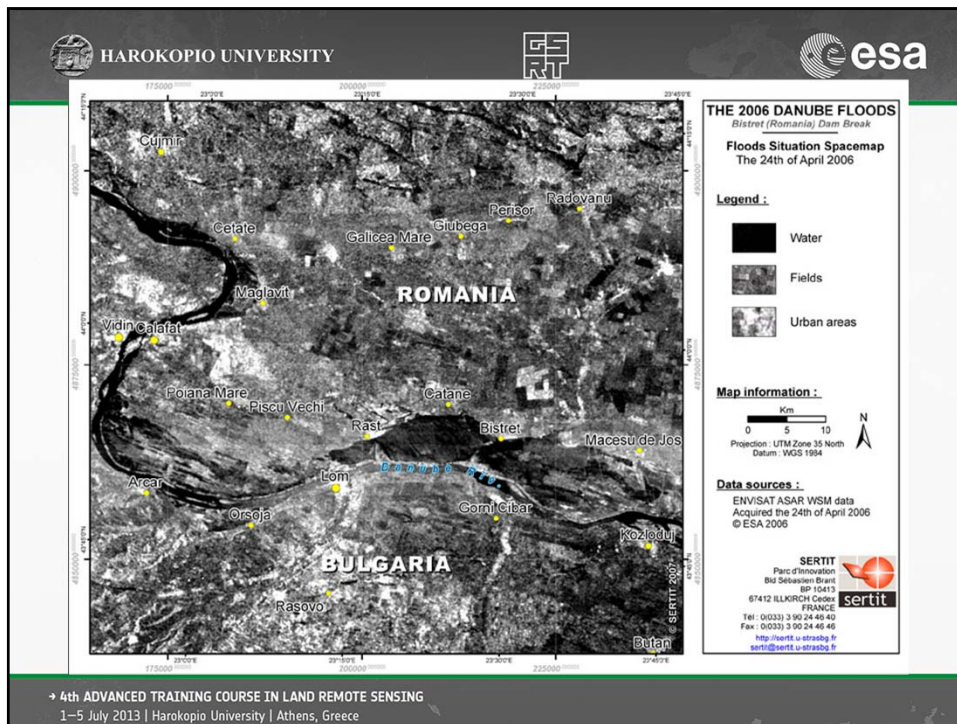
- ♦ C Band, HH, VV, HV 20° - 49° incidence
- ♦ Range of viewing (beam positions)
- ♦ 37 different and mutually exclusive operating modes in high, medium (Wide Swath Mode),



Wide swath coverage; 405 km swath with 150 m or 1 km resolution.

- ♦ Resolution, 30 m to 1 km
- ♦ Data transfer : potential coupling with Artemis





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Medium resolution sensor : MERIS

ESA ENVISAT satellite

15 spectral bands,

**Programmable in width and position,
in the visible and near infrared.**

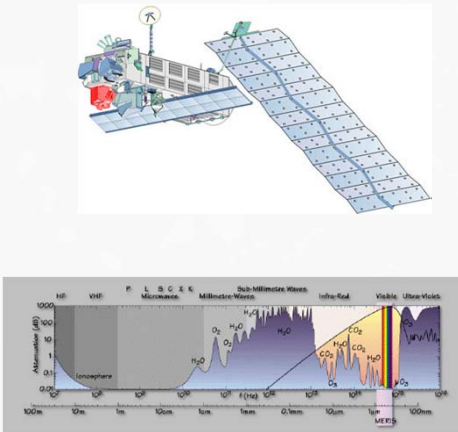
Swath width :1150 km

Coverage of the Earth in 3 days.

2 resolutions: 1.2 km and 250 m

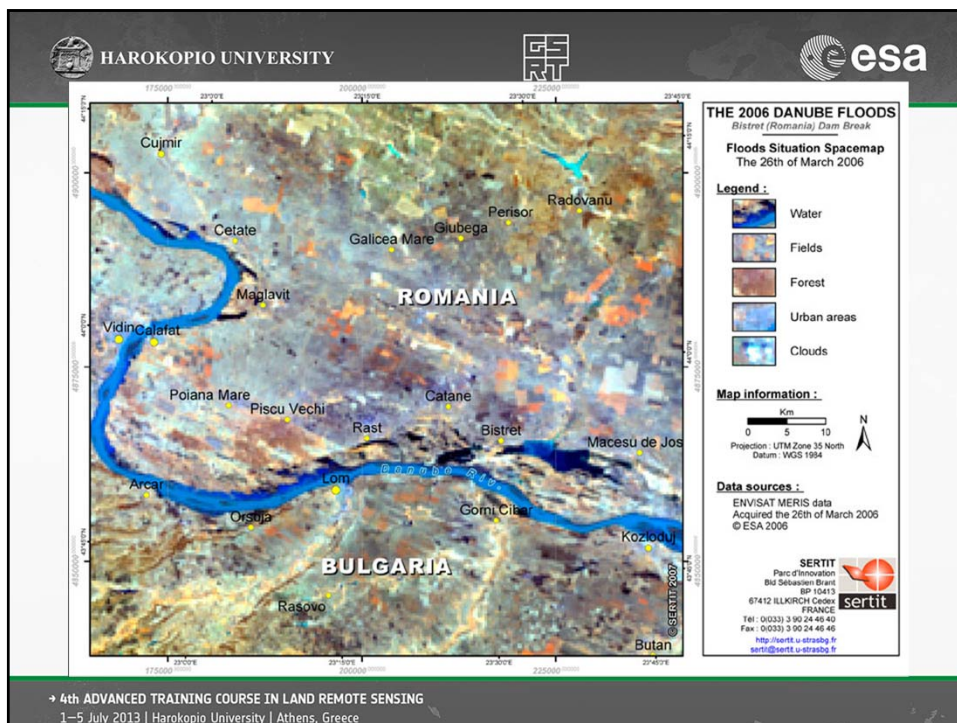
Full resolution products

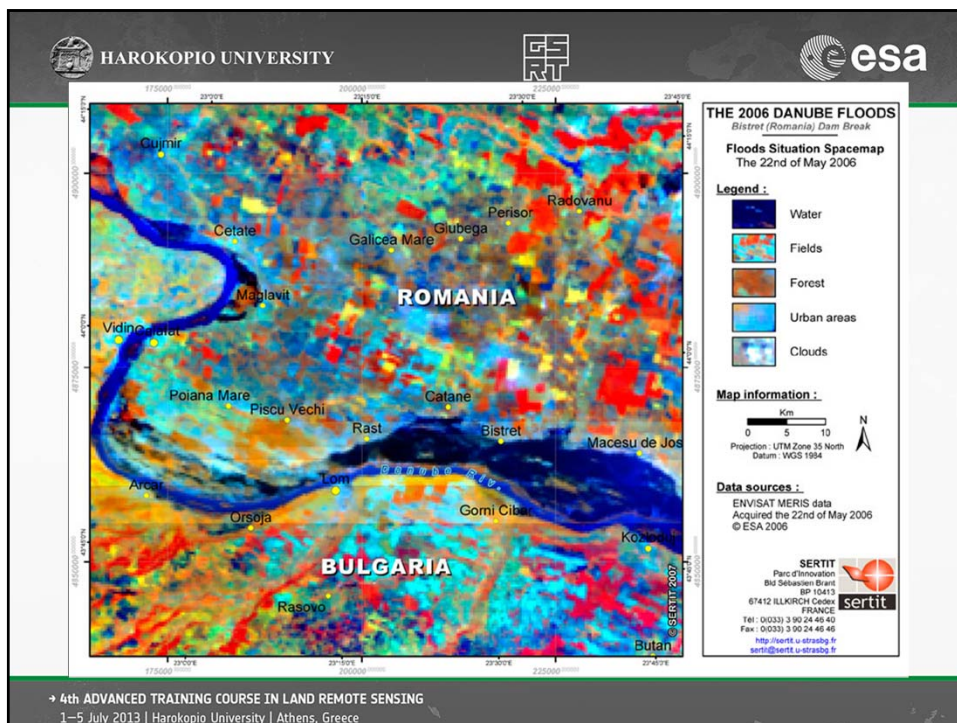
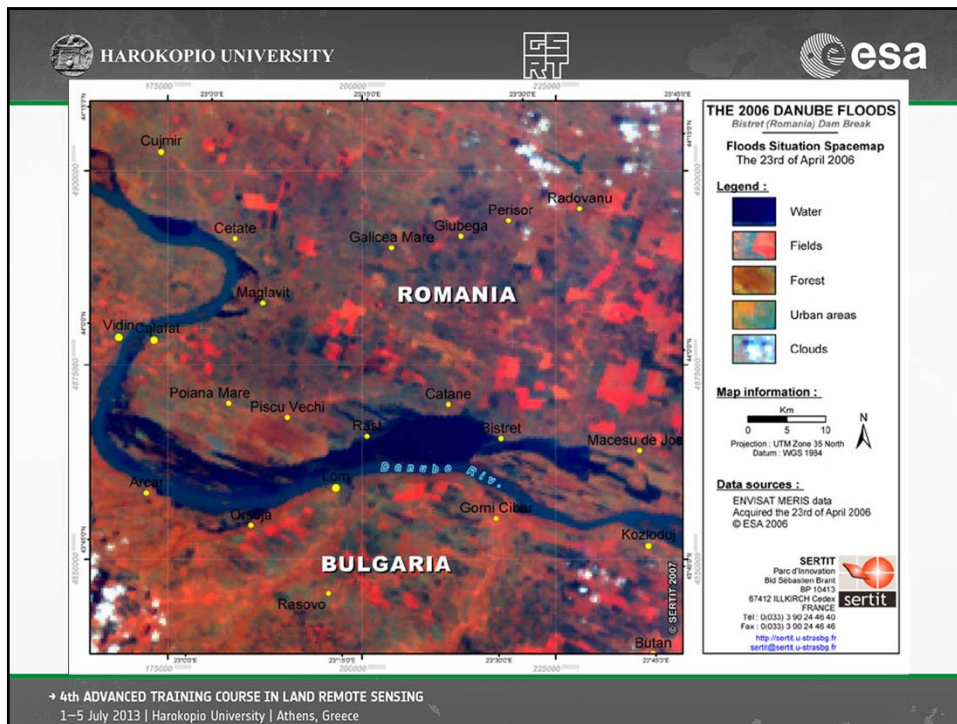
- 582 km × 650 km
- 300 km × 334 km



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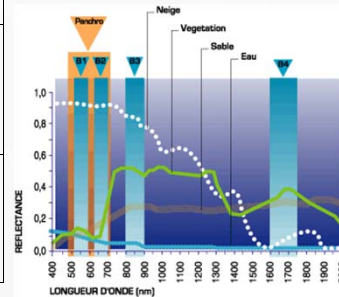
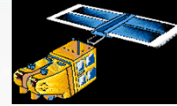
 HAROKOPIO UNIVERSITY  					Medium resolution sensor : MERIS
V I S I B L E	Band	Band centre	Bandwidth (nm)	Primary Use	
	1	412.5	10	Yellow substance and detrital pigments	
	2	442.5	10	Chlorophyll absorption maximum	
	3	490	10	Chlorophyll and other pigments	
	4	510	10	Suspended sediment, red tides	
	5	560	10	Chlorophyll absorption minimum	
	6	620	10	Suspended sediment	
	7	665	10	Chlorophyll absorption and fluo. reference	
	8	681.25	7.5	Chlorophyll fluorescence peak	
	9	708.75	10	Fluo. Reference, atmospheric corrections	
I N F R A R E D	10	753.75	7.5	Vegetation, cloud	
	11	760.625	3.75	Oxygen absorption R-branch	
	12	778.75	15	Atmosphere corrections	
	13	865	20	Vegetation, water vapour reference	
	14	885	10	Atmosphere corrections	
	15	900	10	Water vapour, land	







Capteurs	Spectre électromagnétique	Taille des pixels	Bandes spectrales
Spot 5	Panchromatique B1 : vert B2 : rouge B3 : proche infrarouge B4 : moyen infrarouge (MIR)	2,5 m ou 5 m 10 m 10 m 20 m	0.48 - 0.71 μm 0.50 - 0.59 μm 0.61 - 0.68 μm 0.78 - 0.89 μm 1.58 - 1.75 μm
Spot 4	Monospectral B1 : vert B2 : rouge B3 : proche infrarouge B4 : moyen infrarouge (MIR)	10 m 20 m 20 m 20 m 20 m	0.61 - 0.68 μm 0.50 - 0.59 μm 0.61 - 0.68 μm 0.78 - 0.89 μm 1.58 - 1.75 μm
Spot 1 Spot 2 Spot 3	Panchromatique B1 : vert B2 : rouge B3 : proche infrarouge	10 m 20 m 20 m 20 m	0.50 - 0.73 μm 0.50 - 0.59 μm 0.61 - 0.68 μm 0.78 - 0.89 μm

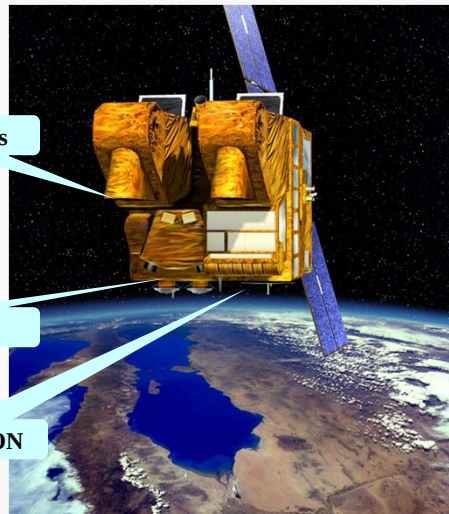


SPOT 5 satellite

HRG sensors

HRS sensor

VEGETATION



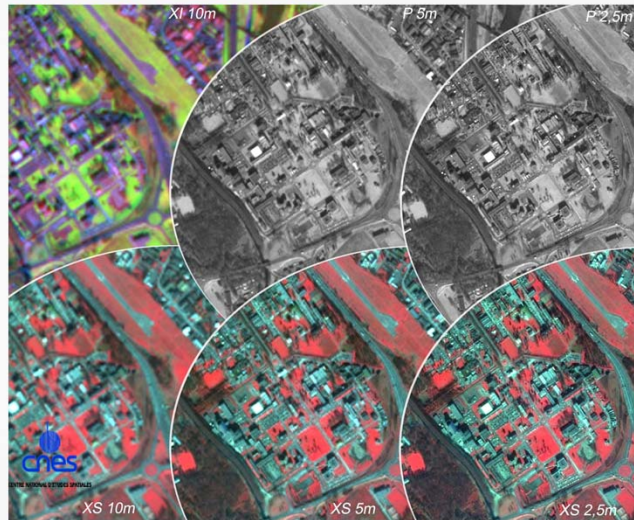
•Continuity of the SPOT service : functioning in conjunction with SPOT 2, SPOT 4

•Improvement of the spatial resolution

•Improvement of the accuracy

•Launched 4 of May 2002

•Data available since end of Spring 2002

**SPOT 5 Products**

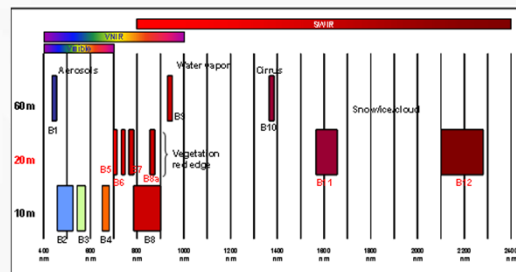
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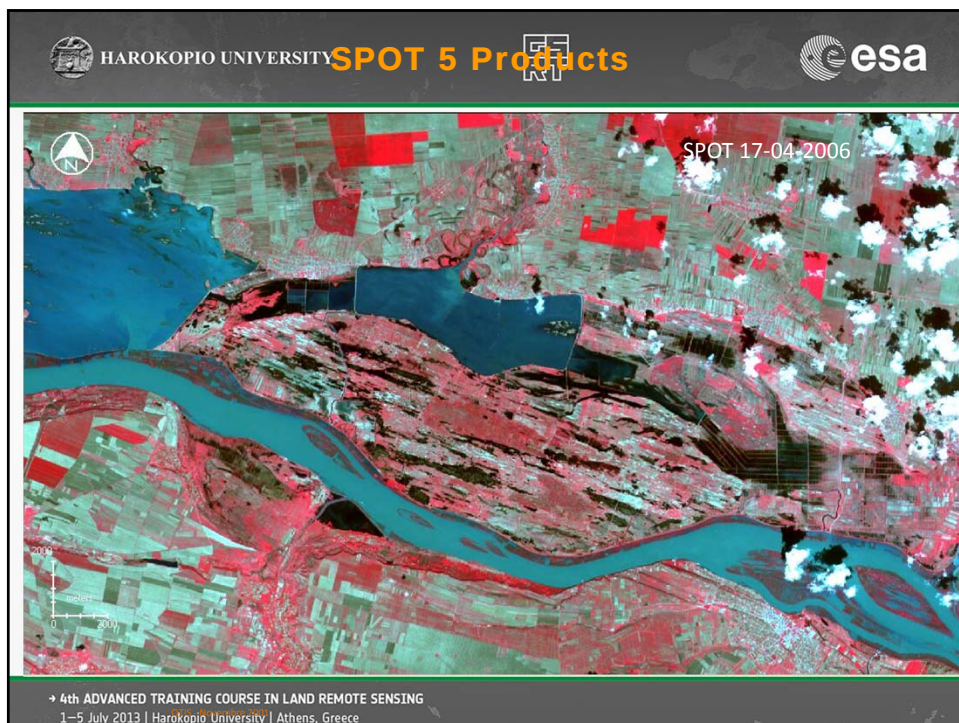
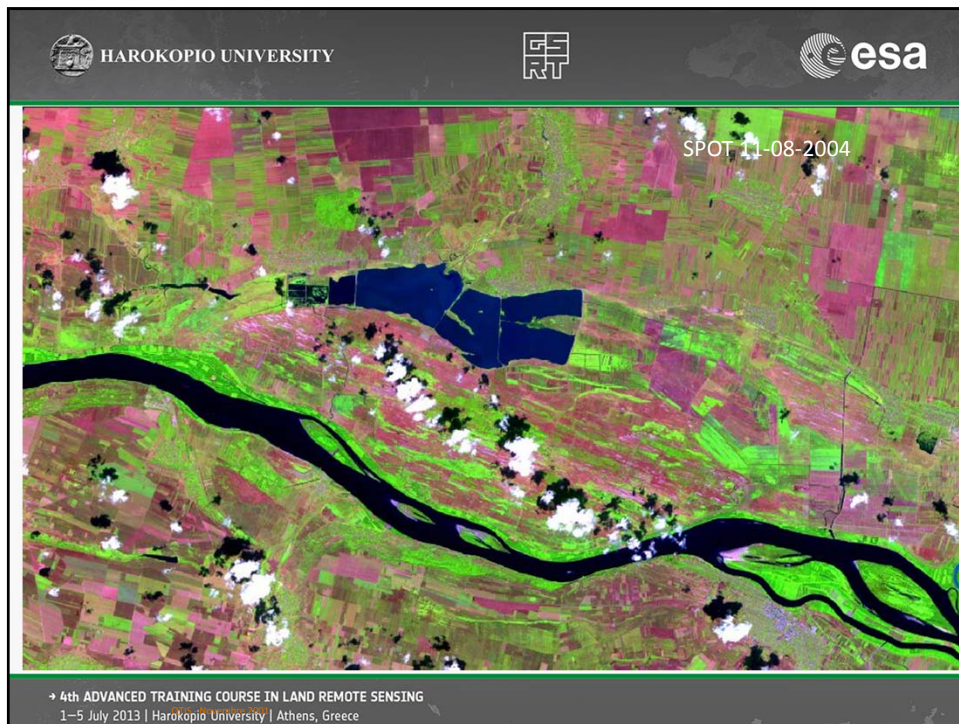
**Mid term goal of flood mapping and monitoring T.C.
Preparing the Sentinel series**

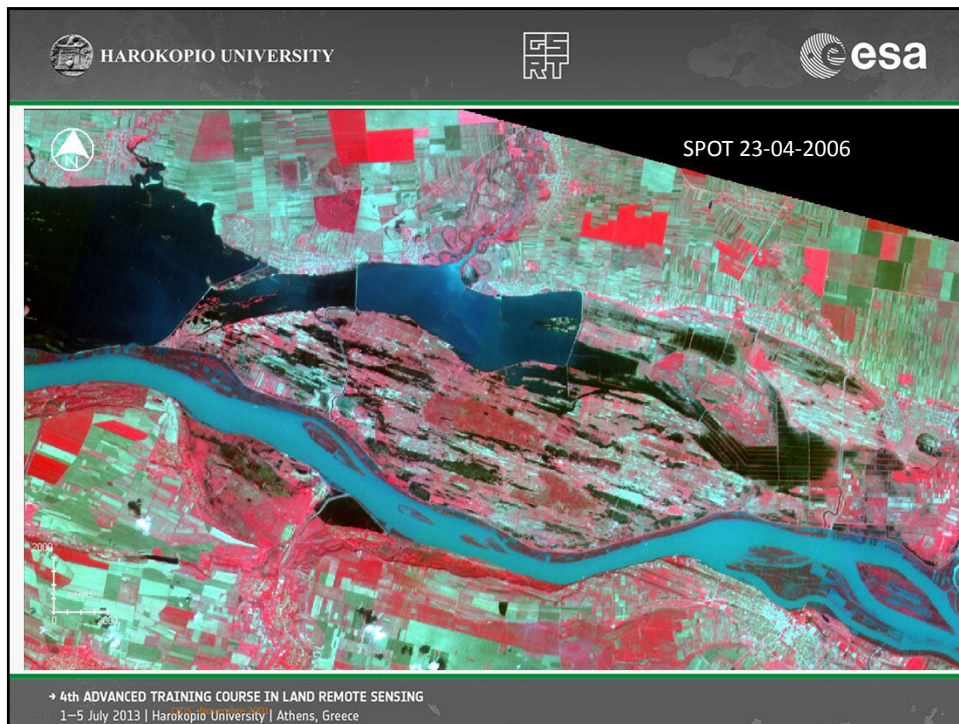
**Sentinel 2**

- Resolution same as SPOT5 (10m in Vis PIR)
- Presence of a SWIR bands



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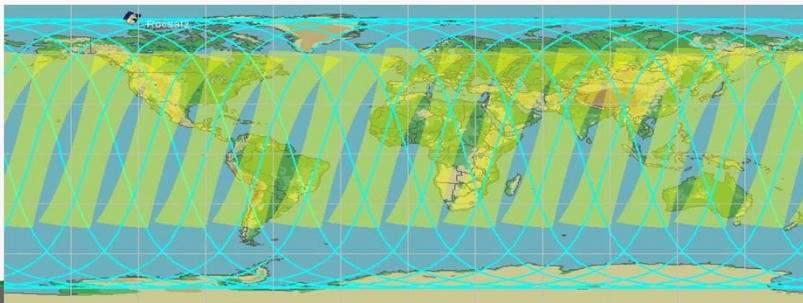






Formosat-2 satellite

- FORMOSAT-2 – a particular orbit
 - 891 km: sun-synchronous & geo-synchronous
 - Exactly 14 orbits/day
 - Daily revisit of accessible areas,
 - with the same incidence angle
 - GSD & swath pre-determined
 - 9:30 am Local Time at descending node



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Formosat satellite

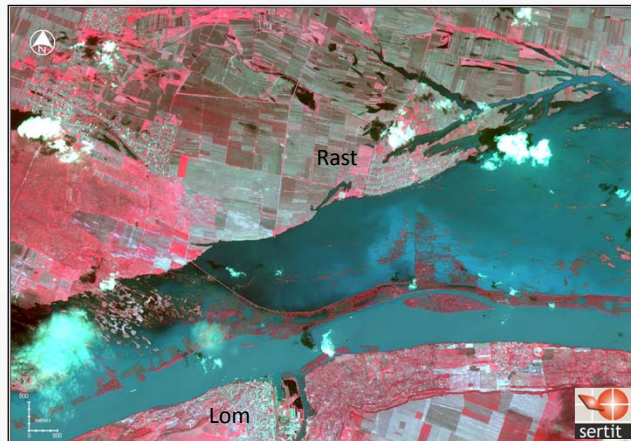
- FORMOSAT-2 imaging capabilities
 - 2-m pan / 8-m colour
 - Swath width @ NADIR: 24 km
 - 4 spectral bands (B,G,R,PIR – delivered R,G,B,PIR)
 - On board memory: 40 Gbit
 - High agility: stereo along the track and fast roll access
 - 8 minutes imaging per orbit – can't cover the full orbit



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Formosat-2 multispectral data

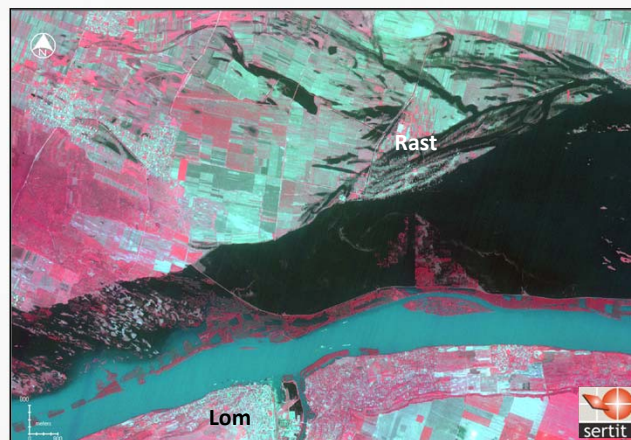


17-04-2006

8 m



Formosat-2 multispectral data

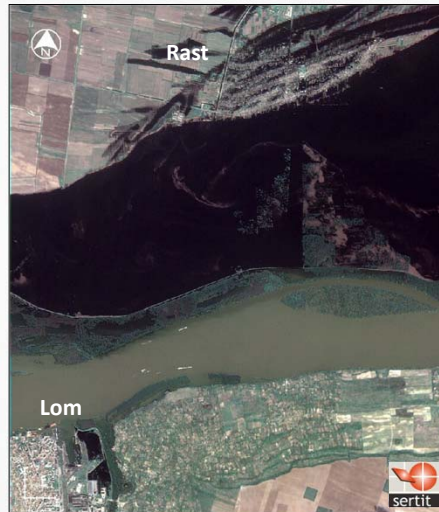


25-04-2006

8 m



Formosat-2 Merged PXS data



25-04-2006

2 m



Image analysis

First step: Taking image in hands

- Work on band combination (Meris)
 - Work on lut (breakpoints)
 - Zoom in / out
 - Superpose images
- => **Very important step, manipulate image gives the opportunity to learn the images in terms on landscape units**



MERIS FR Data

- Try different band combinations
- Compare the dates (overlay / swipe / geo-link / blend)
 - Have a look at the different landuse classes
 - Urban
 - Water, different turbidity (lakes, rivers)
 - Grasslands
 - Forestry
 - Bare soil
 - Cropland



MERIS FR Data

- What do you think of them?
 - Can you find composites to highlight landuse themes?
- Natural colours
 - 8-5-4 in RGB

Swap channel 4 with channel 1 → more atmospheric effects

Analyse water colours in terms of turbidity (speed) / depth
- False colour composites
 - 14-9-3 in RVB
 - 12-8-3 in RVB
 - 8-12-2 in RVB



ASAR WSM Data

- **Gamma filtered images**
 - **Apply it only to the ASAR image acquired the 24-04-06**
- **Compare with ASAR WSM unfiltered data and filtered data (overlay / swipe / geo-link / blend)**
 - **Have a look on the different landuse classes:**
 - **Urban**
 - **Water, variations of backscattering (wind effect)**
 - **Grasslands**
 - **Forestry**
 - **Bare soil**
 - **Cropland**



SPOT Data

- **Try band combinations (321, 432, 342)**
- **Compare Channel 1 versus 2, 2 versus 3, 3 versus 4**
- **Compare the different dates (overlay / swipe / geo-link / blend)**
- **Have a look on the different landuse classes**
 - **Urban structures**
 - **Water**
 - **Grasslands**
 - **Forestry**
 - **Bare soil**
 - **Cropland**
- **Analyse water colours in terms of turbidity (speed) / depth**



Formosat-2 Data

- **Try band combinations**
- **Compare the two dates (overlay / swipe / geo-link / blend)**
 - **Have a look on the different landuse classes**
 - **Urban and harbour structures (warehouse and cranes)**
 - **Water, different turbidity**
 - **Grasslands**
 - **Forestry**
 - **Bare soil**
 - **Cropland**



Flood products

- **Water extent at each date**
- **Dynamic of flooding**
- **Damage assessment (Formosat PXS)**



Water extraction

- ENVISAT MERIS FR
- Single band
- Double threshold :NDVI mean + Band 15 (PIR)
- ENVISAT ASAR WSM
- Threshold
- SPOT
- Single band (PIR = channel 1)
- Classification approach
- Double threshold: indices (HIS transform) and channels for more advanced trainees
- Change detection for the more advanced
- For each: validation by PIAO (visualization and screen digitalization)

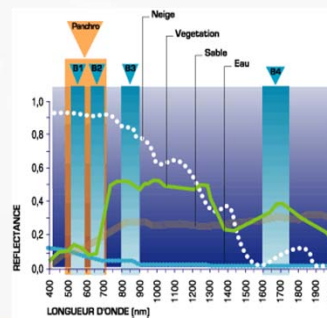
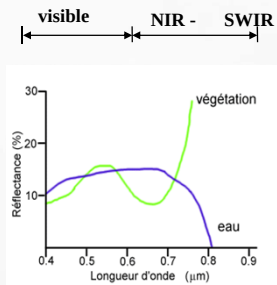


Water extraction

Flood mapping based on thresholding of raw channel

Fundamentals: Spectral signature of water

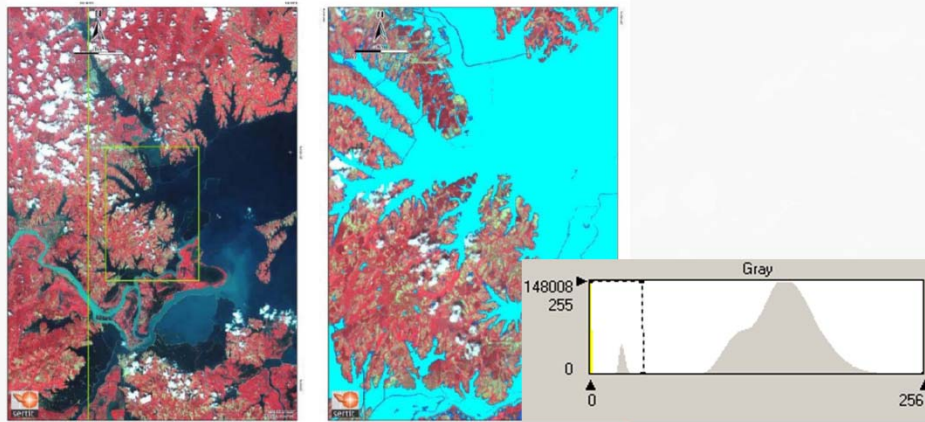
NIR and SWIR are absorbed





Water extraction

Water extraction based on monotemporal approach
(thresholding)

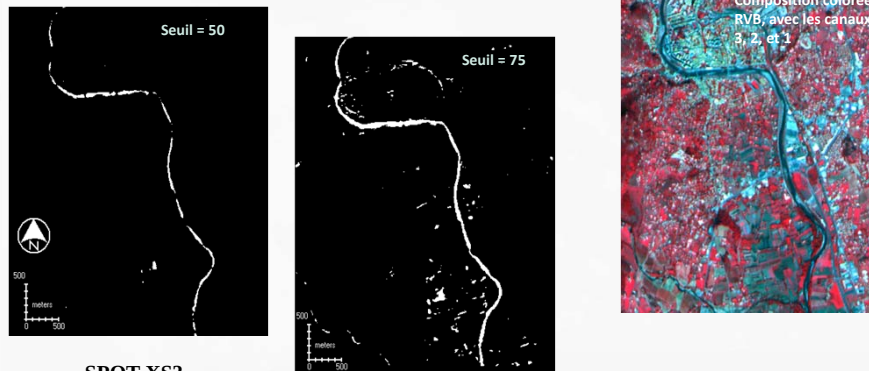


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Water extraction

Neighbourhood influence on threshold definition



SPOT XS3

Threshold = 50

SPOT XS3

Threshold = 75

Extraction of water : urban neighbourhood

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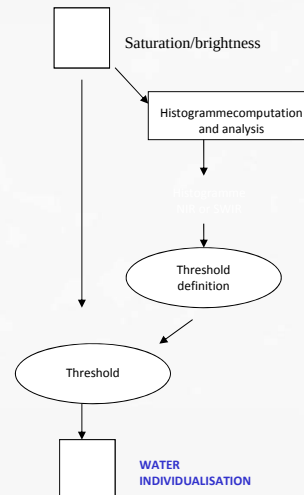
Water extraction

Flood mapping based on thresholding of 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**

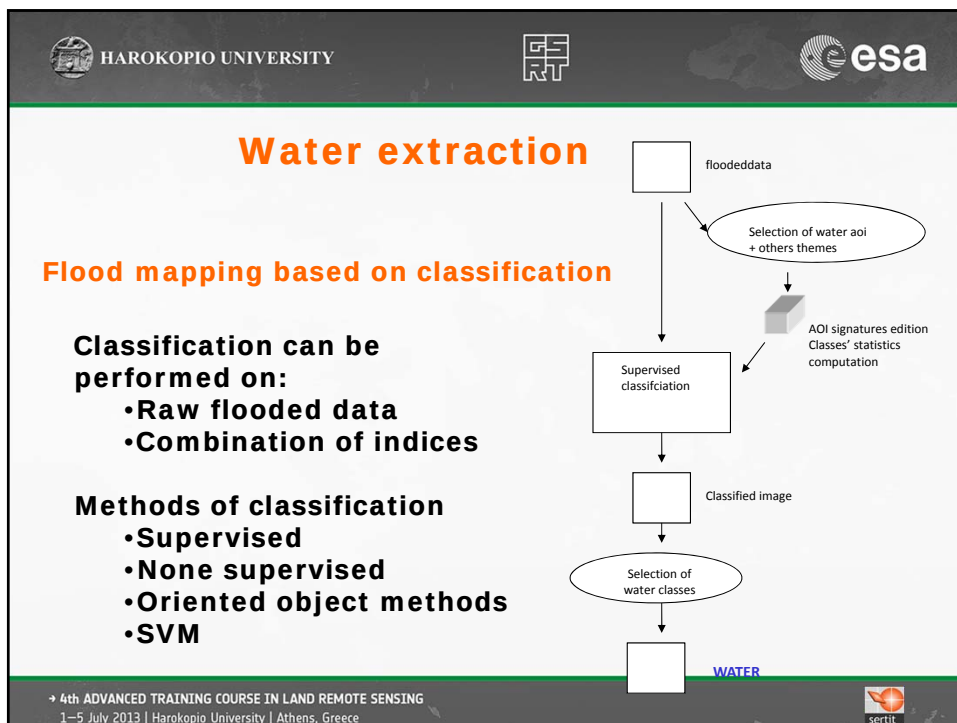
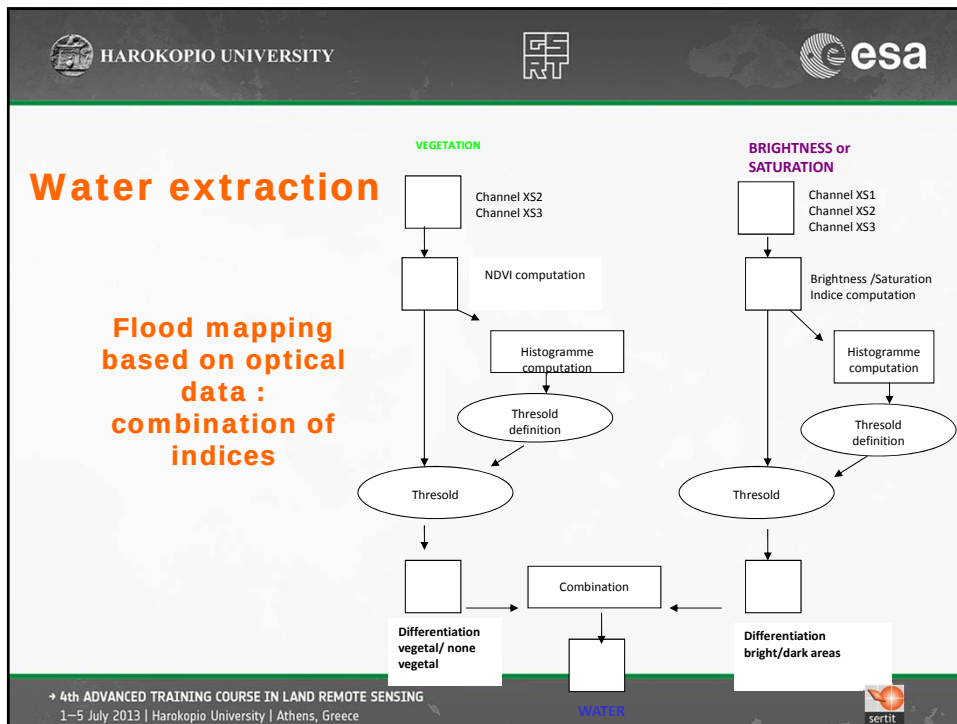


Water extraction

Flood mapping based on optical data : combination of indices

When flooded area extraction is carried on single channel/indice such as brightness, saturation, there is some possible confusion between very bright water areas and some very chlorophyll zones

Combination of normalized vegetation and of brightness or saturation indices allow to extract only flooded area



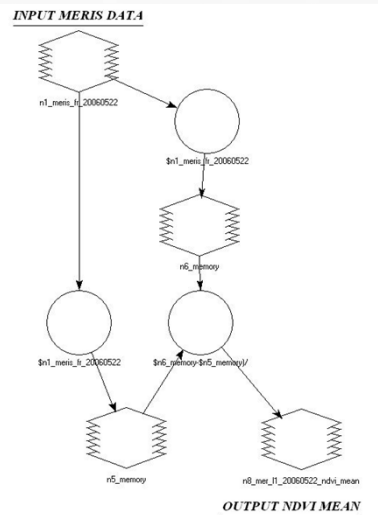


Your work on the Danube data set

- **Meris FR**
 - Double Threshold : NDVI and C15
 - Two steps : first compute the NDVI
 - Threshold step
- **SPOT images**
 - Single band (NIR on SPOT 3 , SWIR on SPOT 4)
 - Classification approach via quick alarm
 - Double threshold:
 - indices (HIS transform) and channels
 - Change detection
 - Reference/crisis
 - Crisis/crisis



Water extraction



calculation of $NDVI_{mean}$

$$NDVI_{mean} = \frac{\frac{1}{n_{pir}} \sum_{i=10}^{15} DN - \frac{1}{n_{red}} \sum_{i=6}^9 DN}{\frac{1}{n_{pir}} \sum_{i=10}^{15} DN + \frac{1}{n_{red}} \sum_{i=6}^9 DN}$$

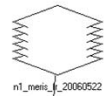
With :

- i = band number
- DN = reflectance value
- n_{pir} = number of near infrared bands
- n_{red} = number of red bands



Water extraction

INPUT MERIS DATA



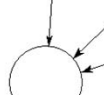
n1_meris_20060522

INPUT MERIS NDVI MEAN



n2_meris_20060522_ndvi_mean

MERIS - double threshold



EITHER 1 IF



Threshold MERIS Band 15



Threshold NDVI mean

n3_water_layer_meris_2006_05_22_raw

Output Water Layer

Data	Band 15	NDVI _{Mean}
2006/03/26	19	-0.250
2006/04/23	22	-0.025
2006/05/22	22	0.100

Apply it to the MERIS
image acquired the 23-
04-06



Water extraction

MERIS - correction and validation

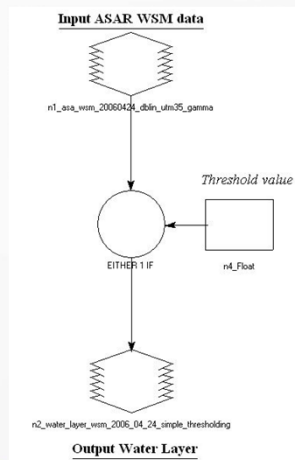
- Compare the thresholded water extraction image with the original image
- Exploiting the recode tool
 - correct and validate the water extent layer



Water extraction

ASAR WSM Data

- Simple approach: single threshold



Data	Threshold value
2006/03/27	1010000000
2006/04/18	1013000000
2006/04/24	1010000000

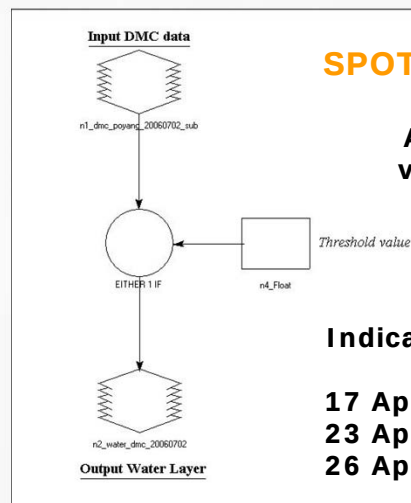
Apply it to the ASAR
filtered image acquired
the 24-04-06



Water extraction

SPOT : simple threshold

Analyse exploiting the cursor
values of water in band 3 or 4
(NIR or SWIR)

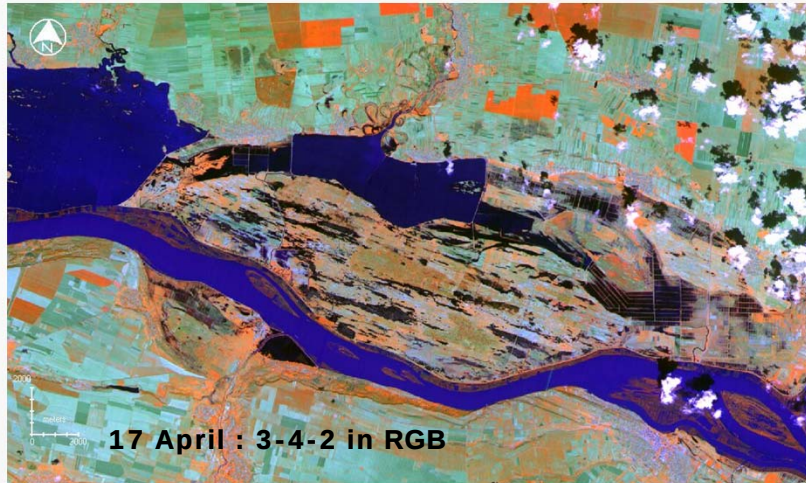


Indicative threshold values:

17 April : 26-30 DN (band 4)
23 April : 50 (band 3)
26 April : ca 45 (see flooded forest)



Water extraction on SPOT : simple threshold



Water extraction on SPOT : simple threshold




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Water extraction on SPOT : simple threshold

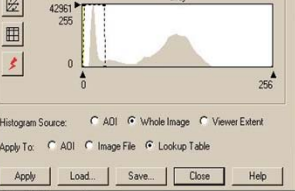
Viewer #1 : cns_xs4_2006_04_17_utm_35_ext.img (Layer_4)



Indicative threshold values:

17 April : 30 DN

Breakpoint Editor For cns_xs4_2006_04_17_utm_35...



Histogram Source: ☐ ADI ☒ Whole Image ☐ Viewer Extent

Apply To: ☐ ADI ☐ Image File ☒ Lookup Table

Buttons: Apply Load Save Close Help

Viewer #1 : cns_xs4_2006_04_17_utm_35_ext.img

UTM / WGS 84

Band	FILE PIXEL	LUT VALUE
1	114,000	
2	58,000	
3	23,000	
4	26,000	255,000

Buttons: 1,0000 File

Gray Lookup Table

Input	Output	X	Y
0	0	0	0
1	85	3	255
2	170	30	255
3	255	31	0
4	255	255	0
5	255		
6	255		
7	255		
8	255		
9	255		
10	255		
11	255		
12	255		
13	255		
14	255		
15	255		

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SPOT: water extraction via classification

ERDAS IMAGINE 9.1



224.36, 4853329.79 (UTM / WGS 84)

Classification

Signature Editor ...

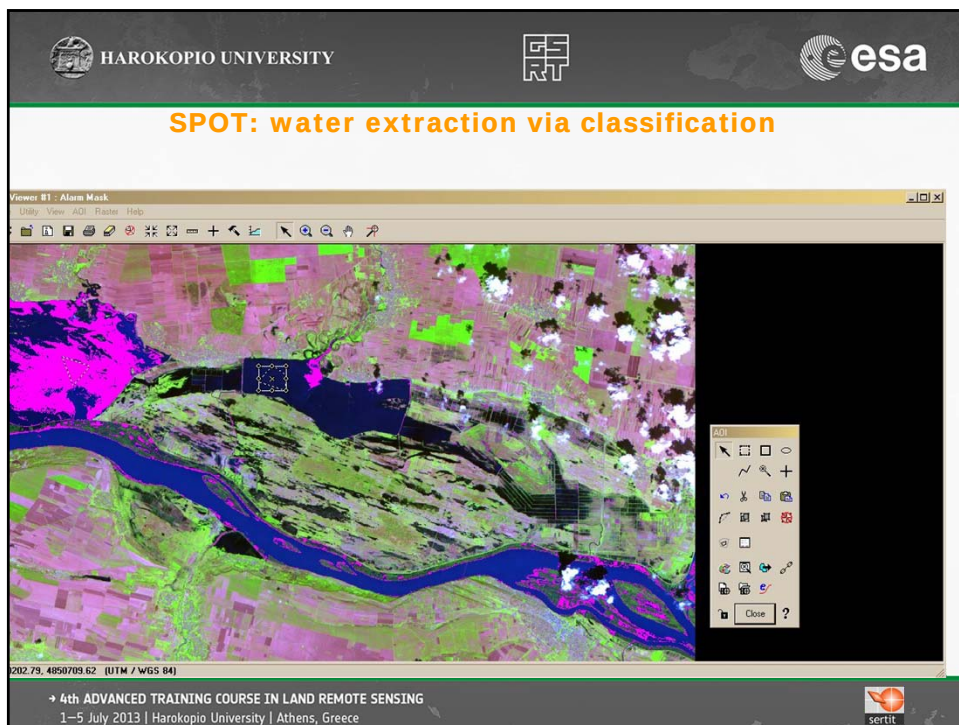
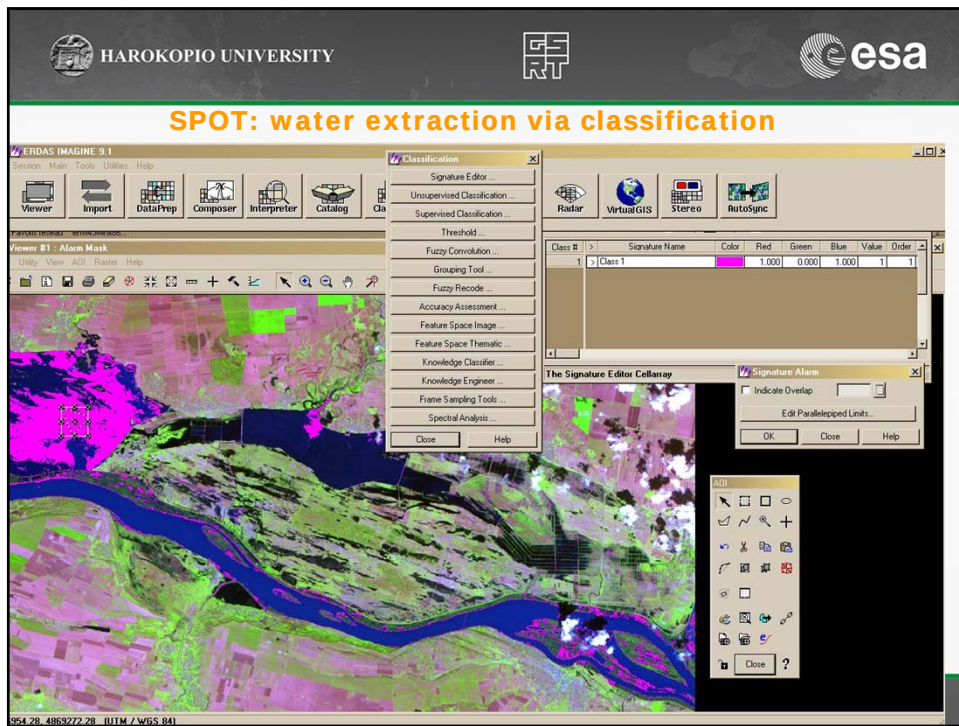
Unsupervised Classification ...

Supervised Classification ...

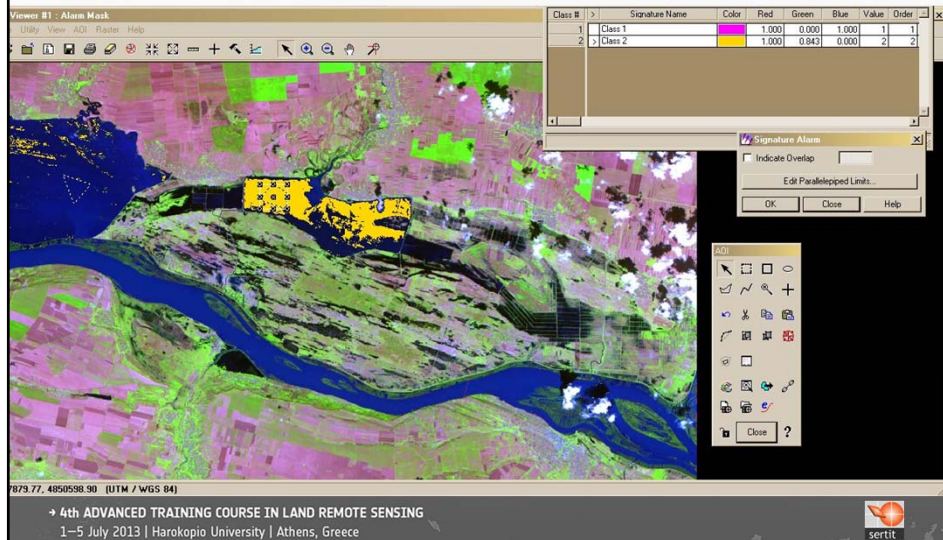
Threshold ...

Signature Editor (No File)

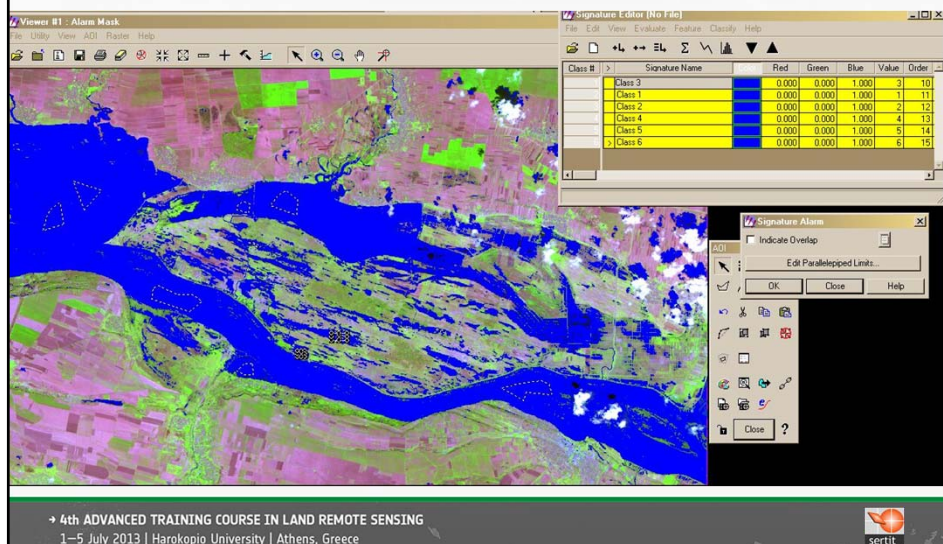
Class #	Signature Name	Color	Red	Green	Blue	Value	Order
1	Class 1	Blue	0.070	0.082	0.470	1	1



SPOT: water extraction via classification



SPOT: water extraction via classification



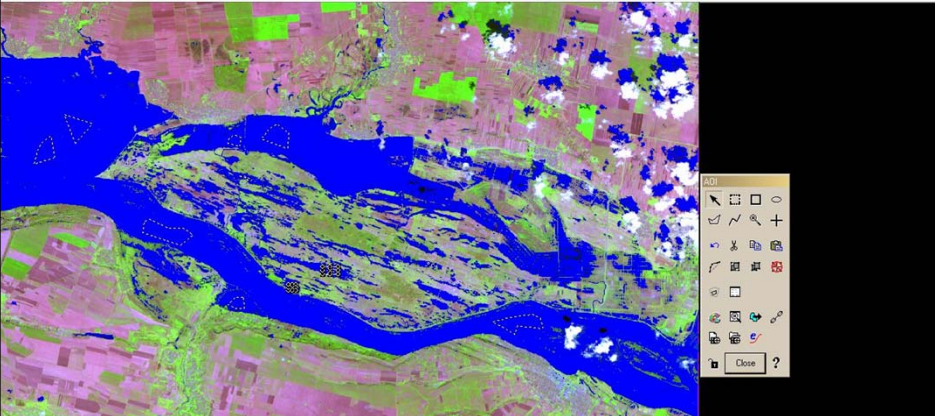

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SPOT: water extraction via classification

Clouds also integrated: need to correction



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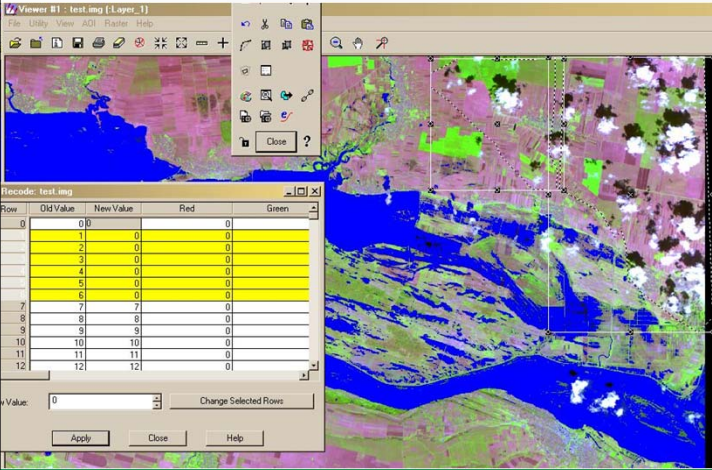

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SPOT1: water extraction via classification

Exploitation of AOI tools and recode (from raster on the viewer)



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Water extraction

SPOT : change detection

Can be applied to :

Reference versus crisis data

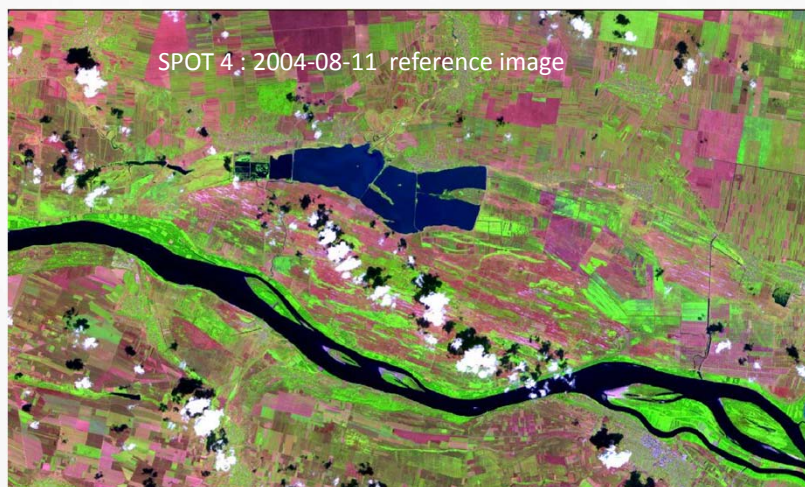
Different data from crisis set

As optional work

Can also be applied to the formosat crisis pair of images

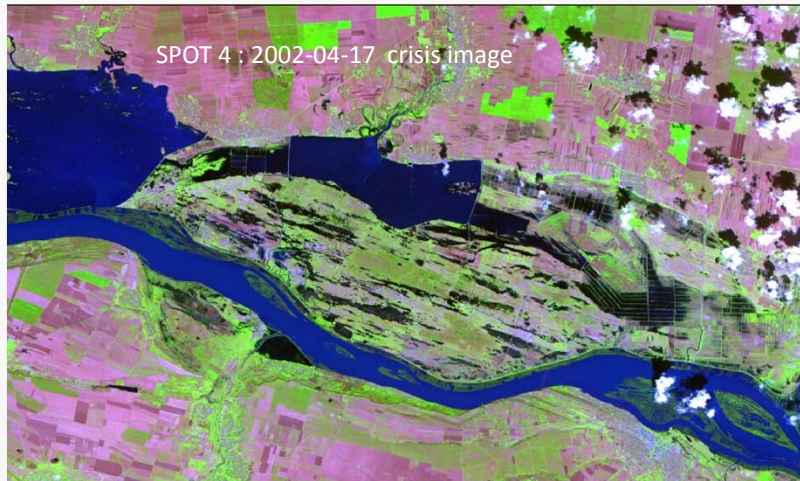


SPOT : change detection: reference / crisis





SPOT : change detection: reference / crisis



SPOT : change detection: reference / crisis



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SPOT : change detection: reference / crisis

Access to the Change detection module

SPOT 11-08-2004 SPOT 17 - 04 -06

Work on channel
4 (SWIR)
Value 2 & 10 %

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SPOT : change detection: reference / crisis

Change channel

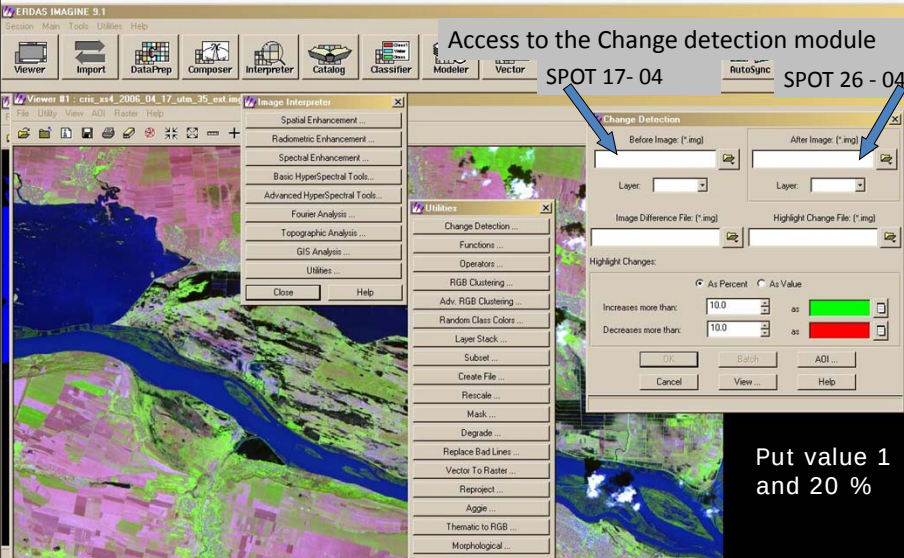
Two values: decrease/increase


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SPOT : change detection: crisis / crisis



Access to the Change detection module

SPOT 17- 04 SPOT 26 - 04

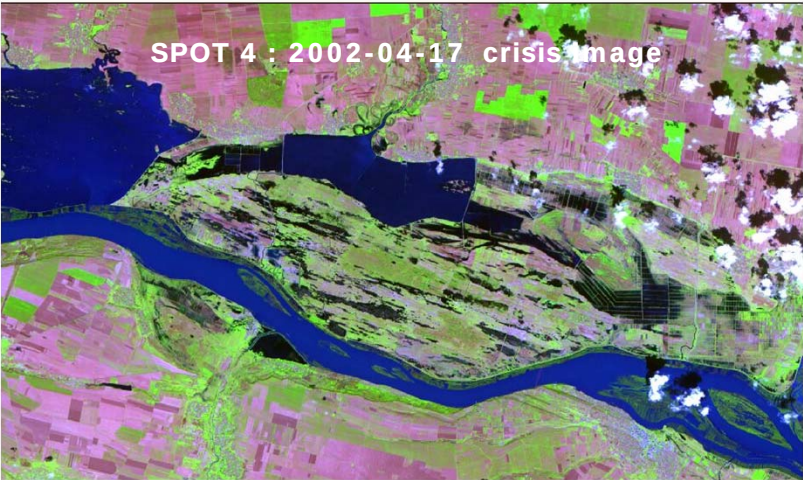
Put value 1 and 20 %


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SPOT : change detection: crisis / crisis



SPOT 4 : 2002-04-17 crisis image

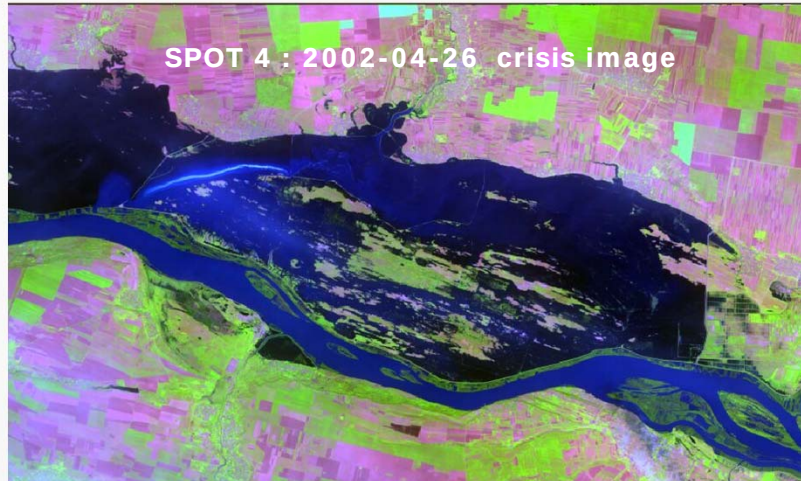
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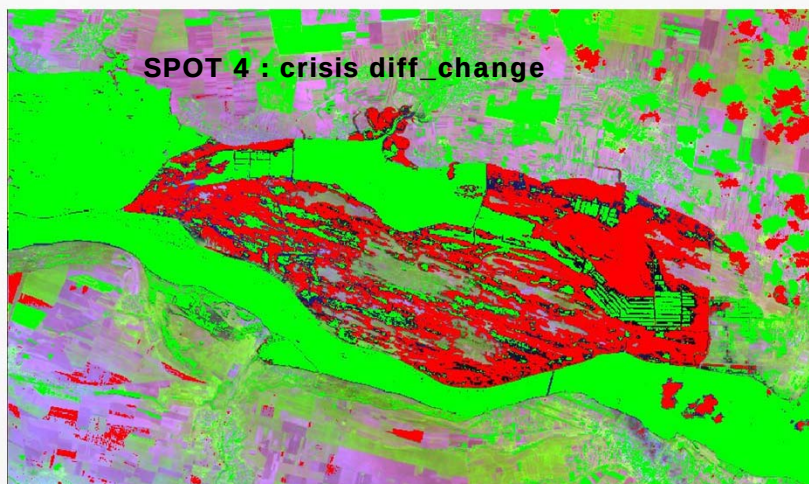




SPOT : change detection: crisis / crisis

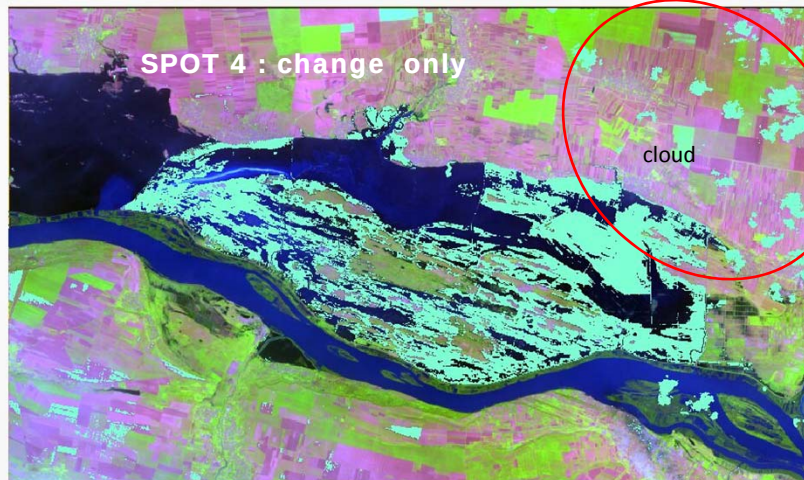


SPOT : change detection: crisis / crisis





SPOT : change detection: crisis / crisis



SPOT : change detection: crisis / crisis Correction exploiting the recode tool

Viewer #1: chang_cris_cris_2_1_20.img [Layer: 1]

File Utility View ADI Raster Help

Row	Old Value	New Value	Histogram	Class Names
0	0	0	0	Background
1	1	0	993290	Decreased
2	2	2	3.63466e+006	Some Decrease
3	3	3	89798	Unchanged
4	4	4	82184	Some Increase
5	5	5	2.42163e+006	Increased
6	6	6	0	
7	7	7	0	
8	8	8	0	
9	9	9	0	
10	10	10	0	
11	11	11	0	
12	12	12	0	

New Value: 1

Change Selected Rows

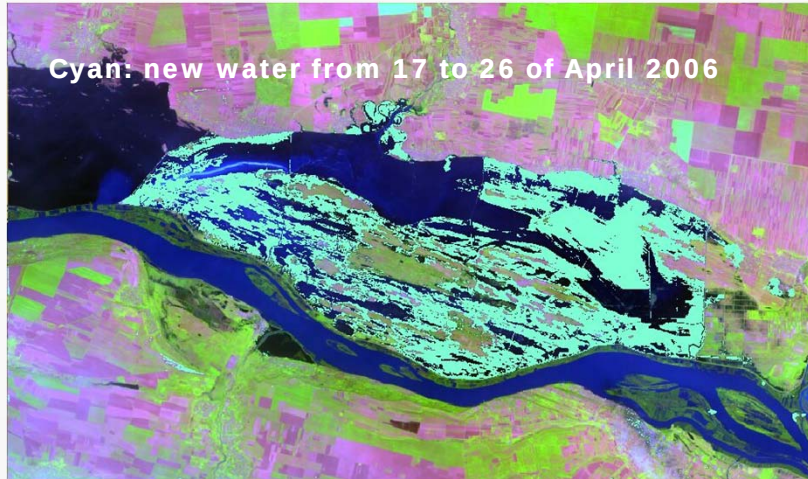
Apply Close Help

ADI

Close ?



SPOT : change detection: crisis / crisis



ASAR: correction and validation

- Compare thresholded water mask with:
 - original images
 - the closest MERIS image in time (in order to avoid confusion/ mis-classification in crop fields)
- Exploiting recode tool
 - correct and validate the water extent layer



Flood products

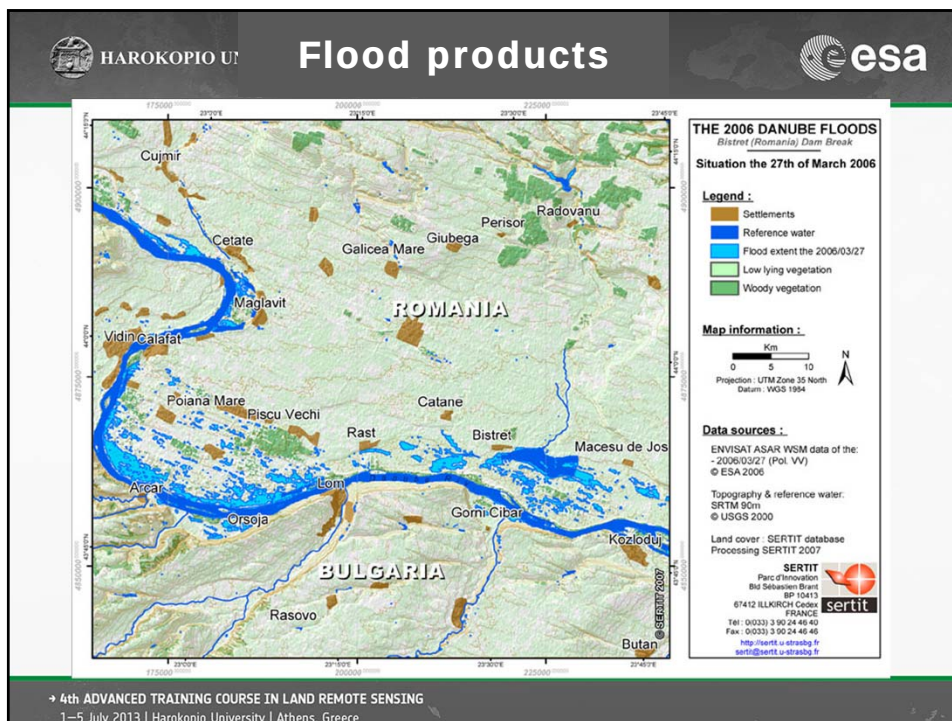
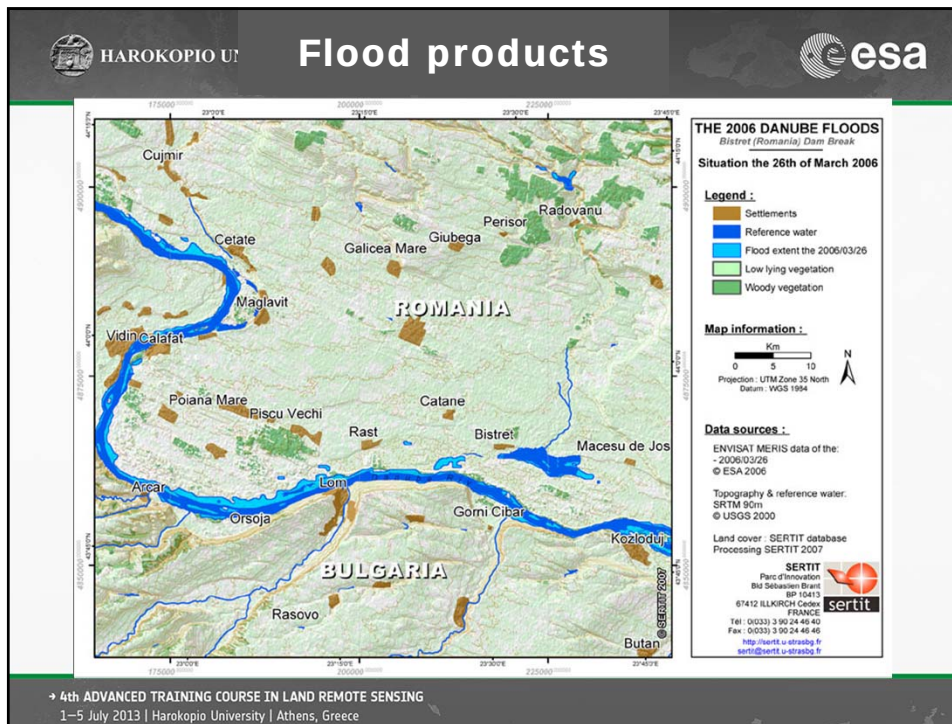
- **Water extent at each date**
- **Dynamic of flooding**
- **Damage assessment (Formosat PXS)**

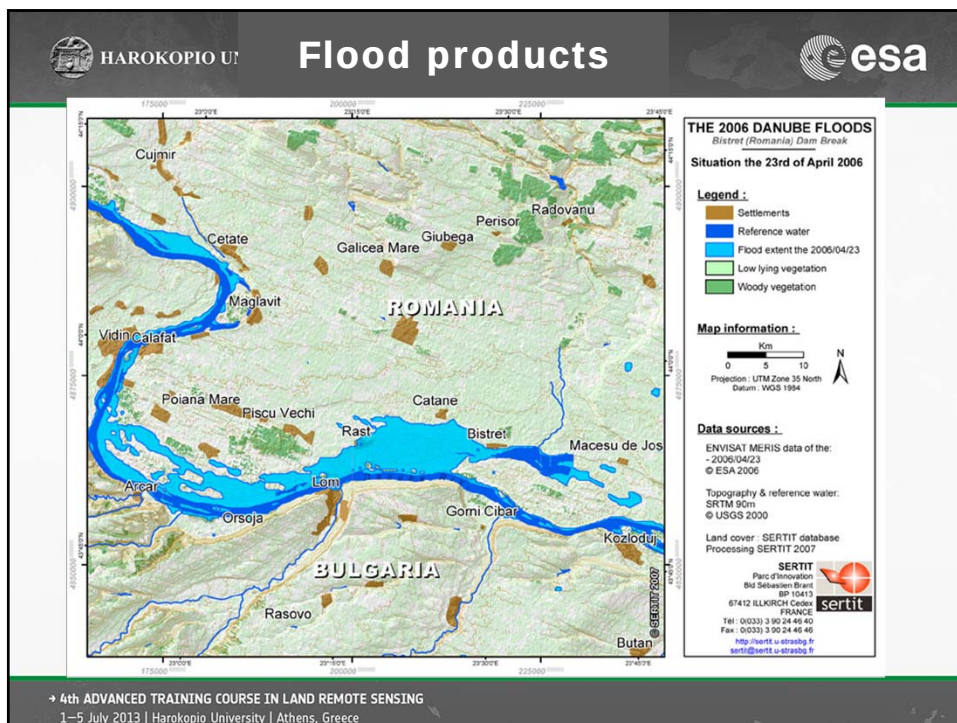
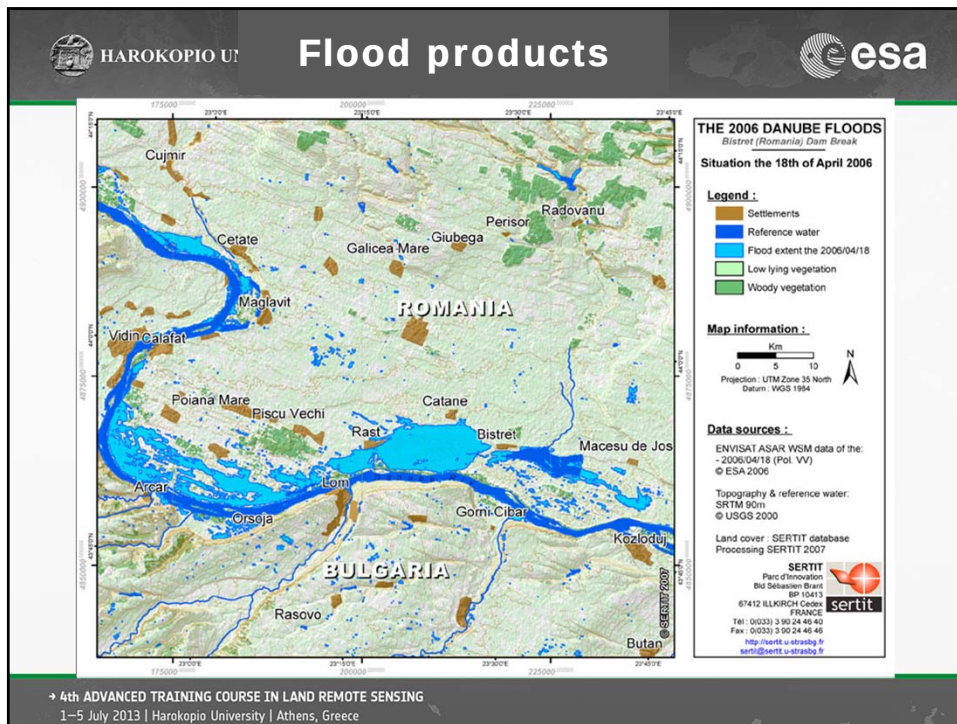


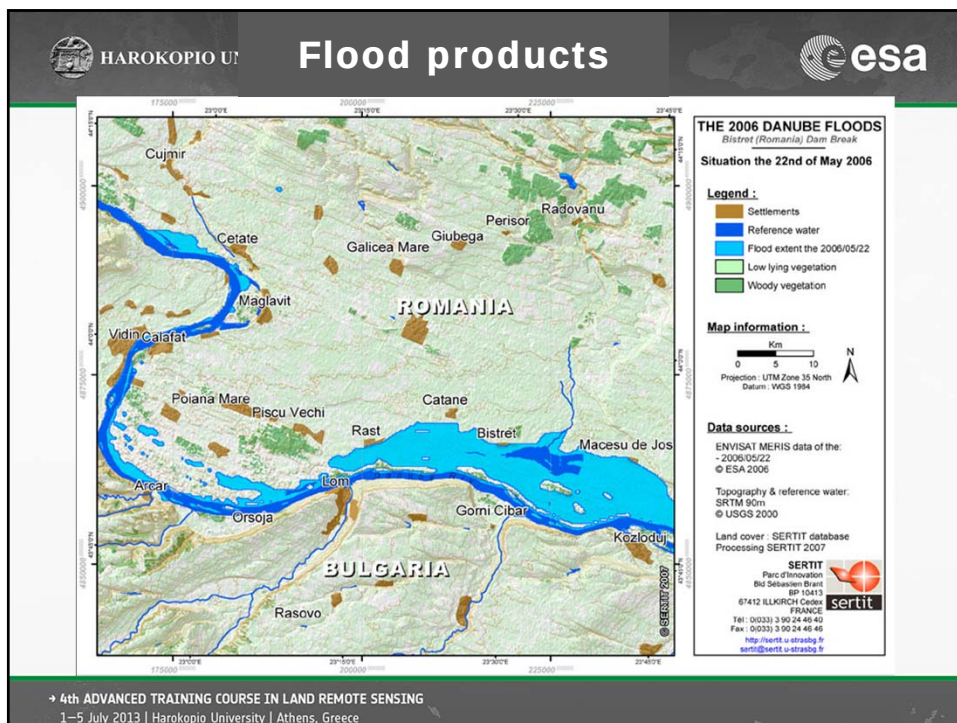
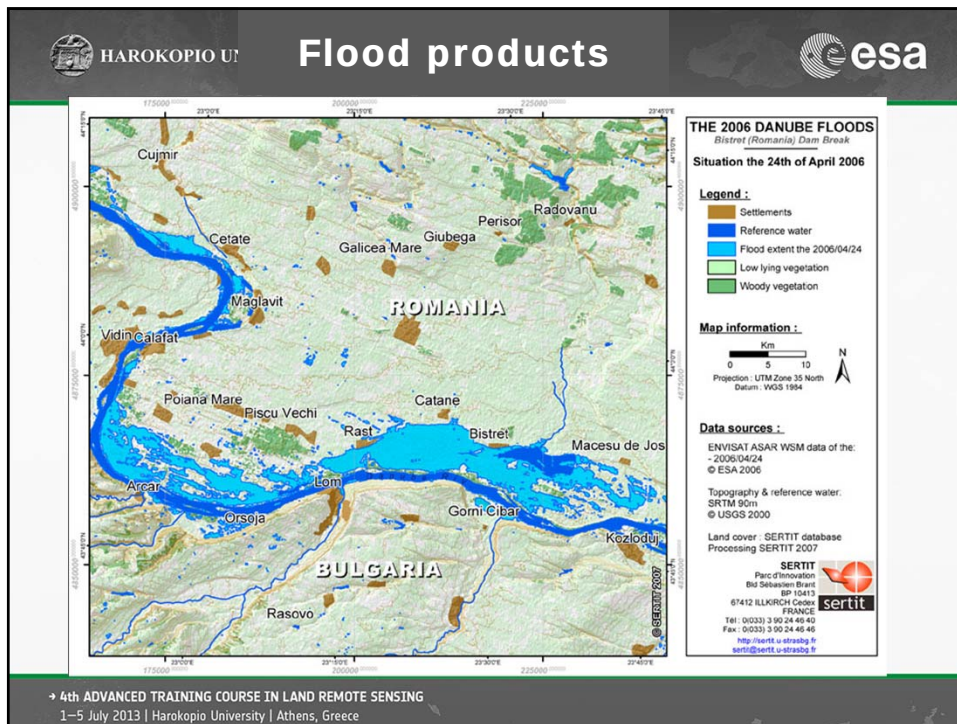
Flood products

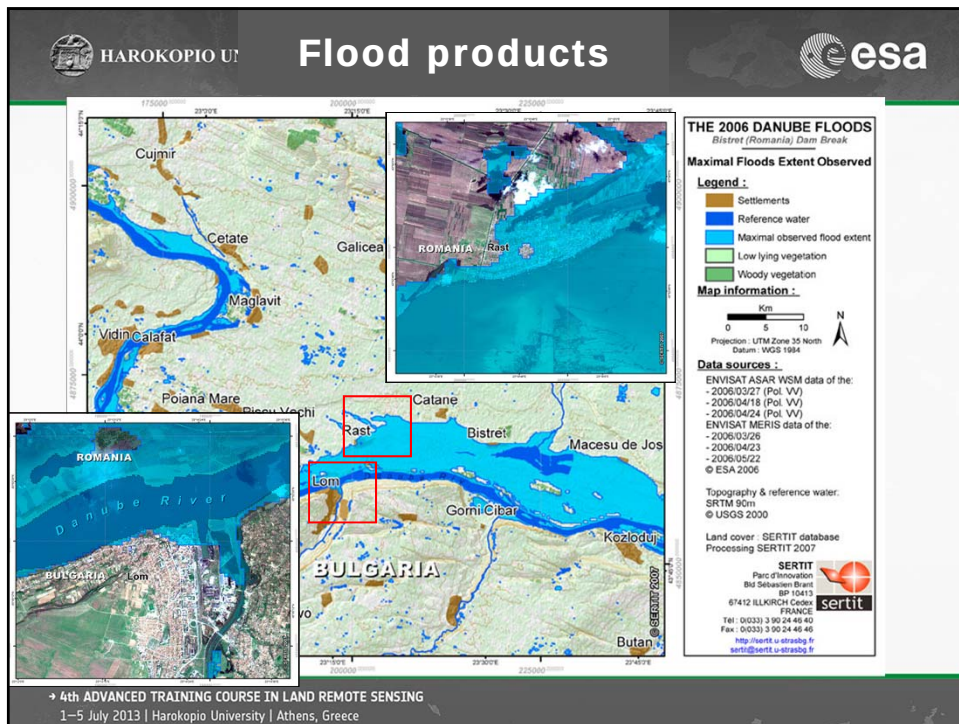
Water layer comparison

- **Medium resolution water layer comparison**
 - MERIS 26-03-2006 and WSM 27-03-2006
 - MERIS 23-04-2006 and WSM 24-04-2006
- **Compare Medium resolution water layers and HR/VHR Formosat images or SPOT image data**
 - WSM 18-04-2006 and Formosat 17-04-2006
 - MERIS 23-04-2006 and Formosat 25-04-2006
 - WSM 24-04-2006 and Formosat 25-04-2006
- **Compare Formosat and SPOT images**
 - WSM 18-04-2006 and Formosat 17-04-2006
 - MERIS 23-04-2006 and Formosat 25-04-2006
 - WSM 24-04-2006 and Formosat 25-04-2006 → Conclusion
 - Are they coherent, complementary










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Flood Analysis

- **From flood dynamics...**



... to flood damage

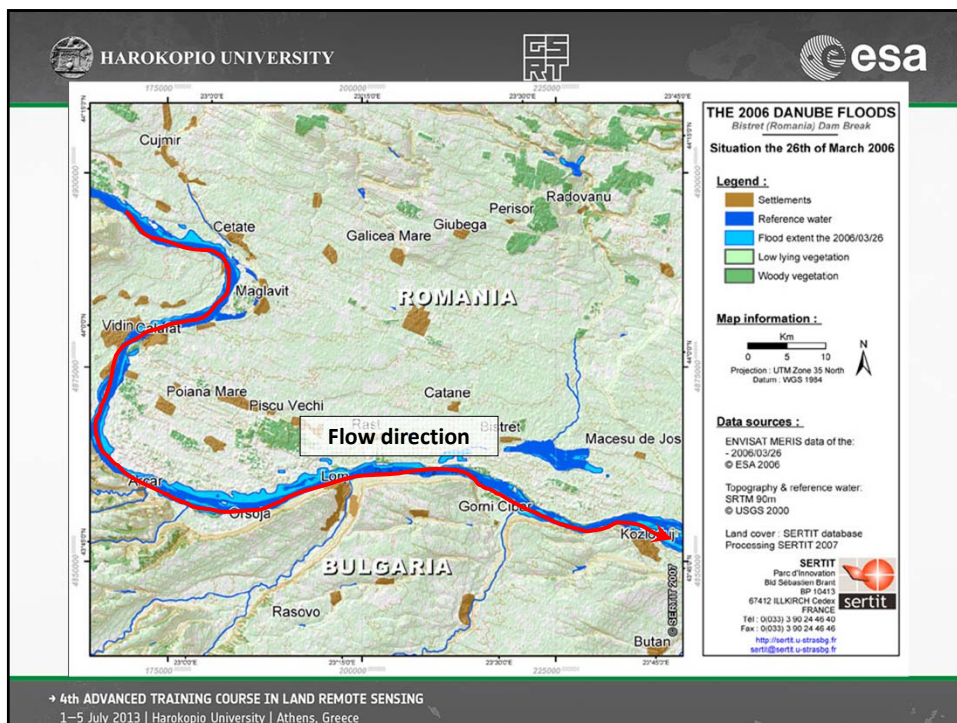
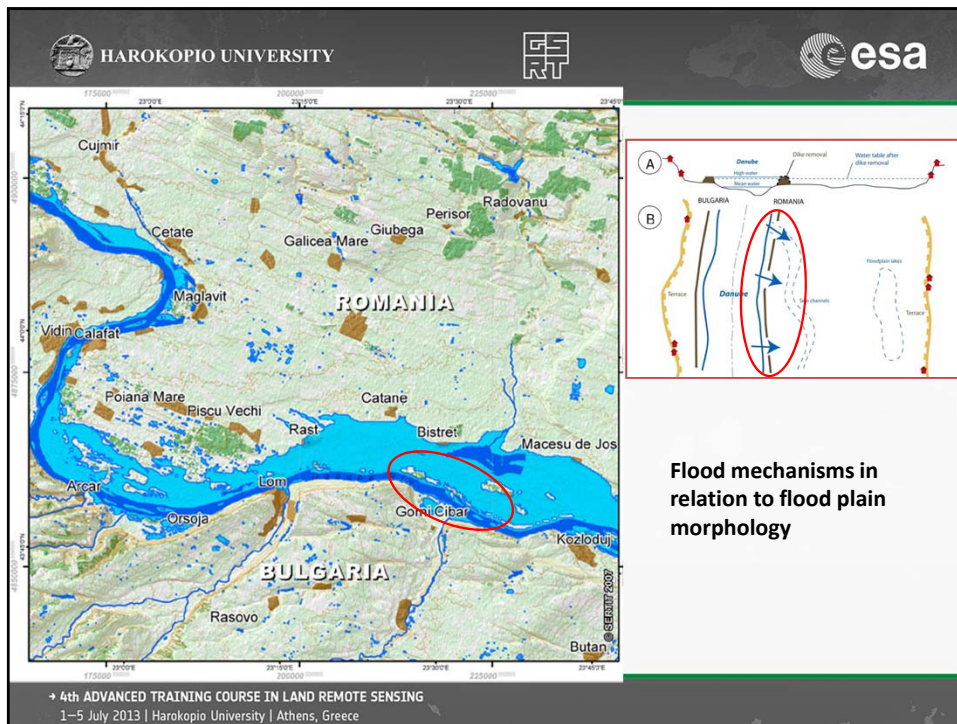


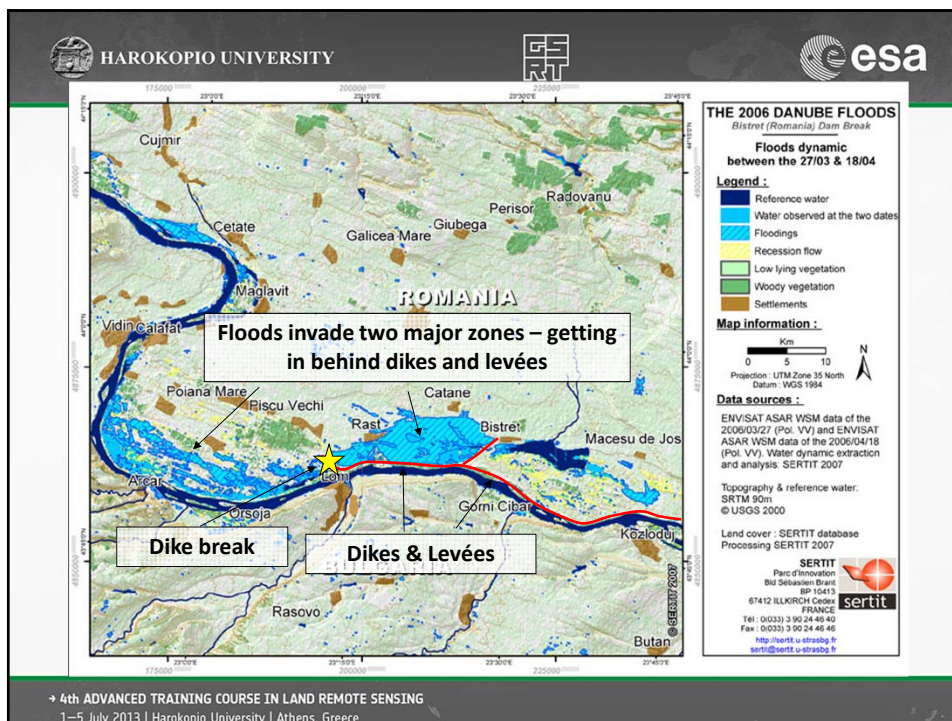
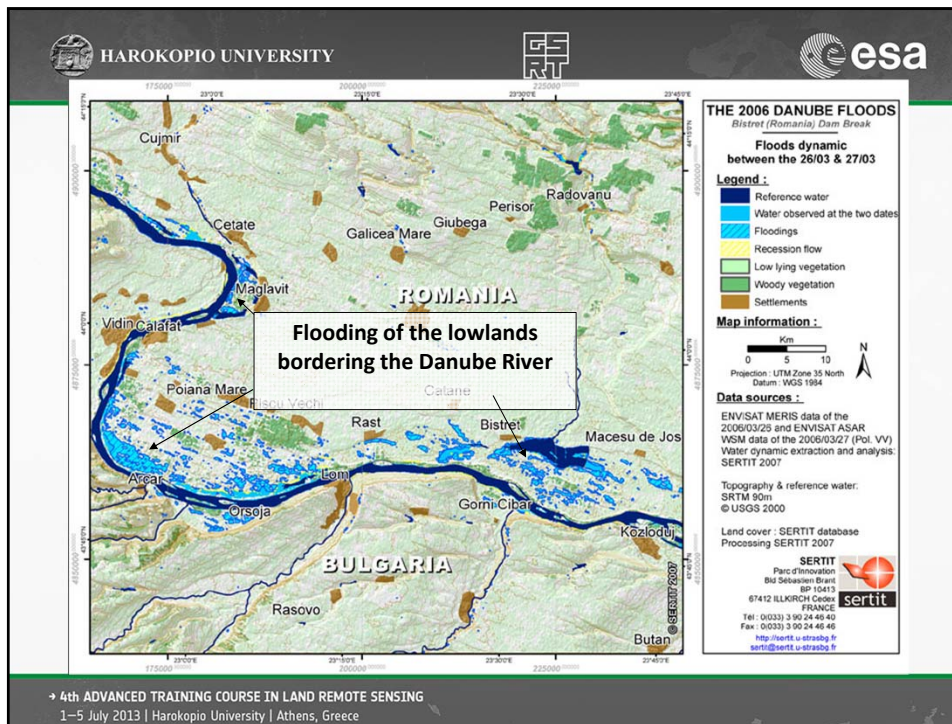


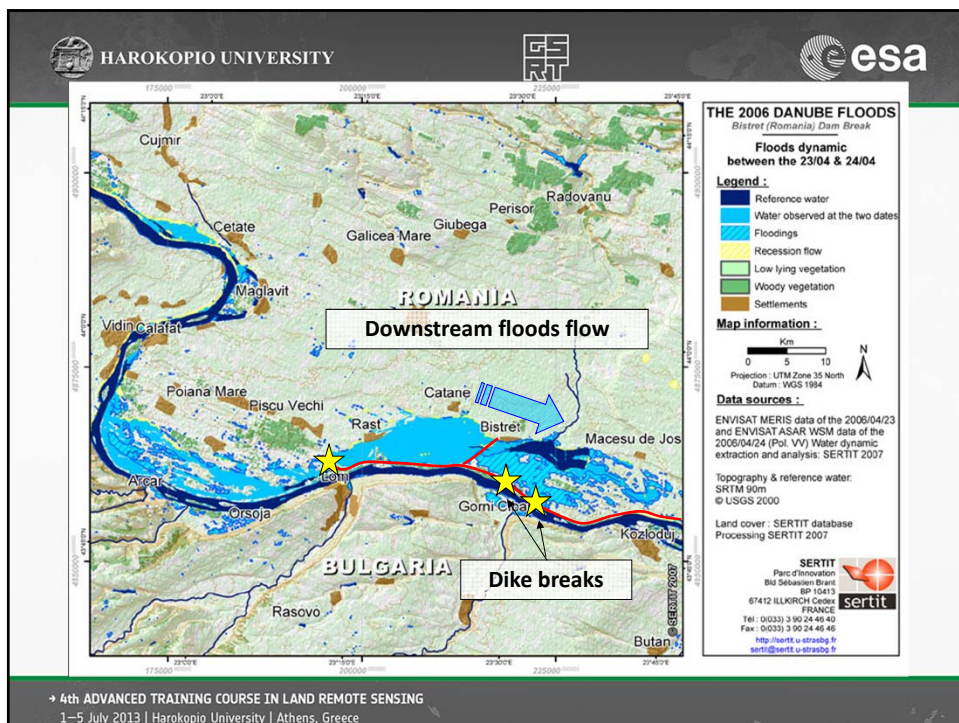
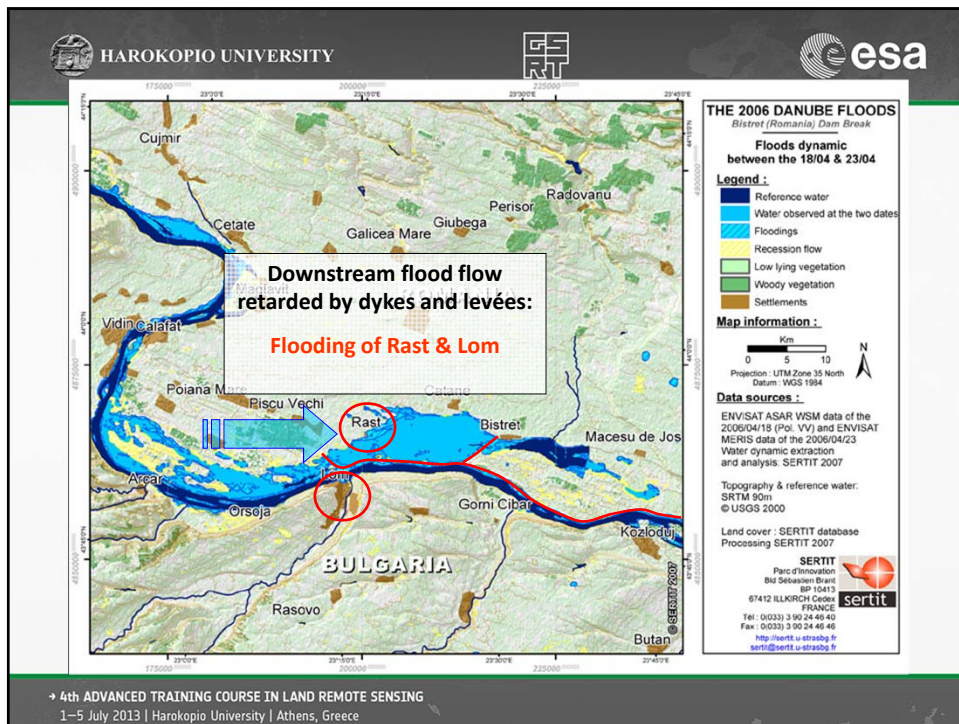


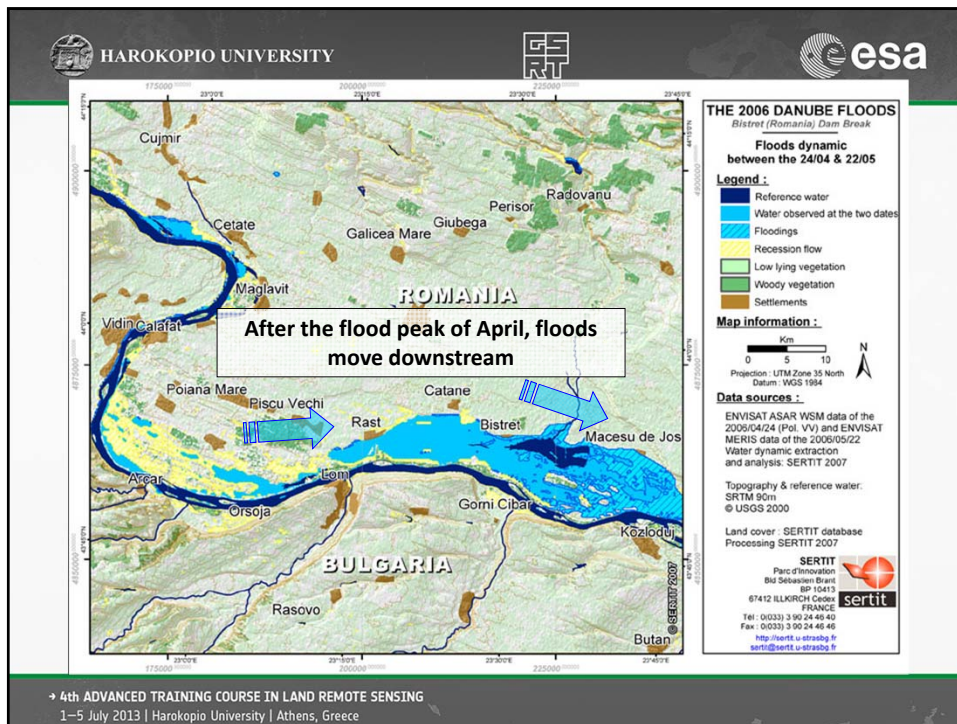


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esa

Flood Analysis:

examples of event summarising hydro-dynamical products

- **Compute:**
 1. Maximum Flood extent
 2. Estimated Flood duration
- **Compare:**
 - Estimated flood duration with the flood progression layer (given)

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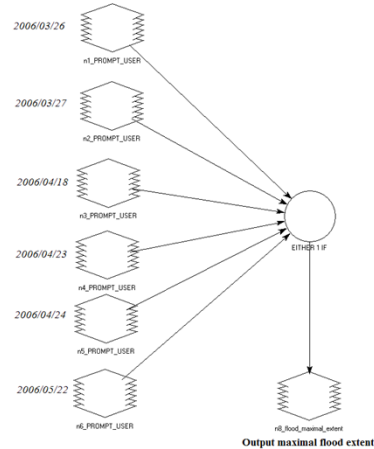


Flood analysis: maximal extent = Alea

Compute

- Flood maximal extent (see model)

Input water layers of the



Flood analysis



THE 2006 DANUBE FLOODS

Bistret (Romanian) Dam Break

Maximal Floods Extent Observed

Legend :

- Settlements
- Reference water
- Maximal observed flood extent
- Low lying vegetation
- Woody vegetation

Map information :

Projection : UTM Zone 35 North
Datum : WGS 1984

Data sources :

ENVISAT ASAR WSM data of the:
- 2006/03/27 (Pol. VV)
- 2006/04/18 (Pol. VV)
- 2006/04/24 (Pol. VV)
ENVISAT MERIS data of the:
- 2006/03/26
- 2006/04/23
- 2006/05/22
© ESA 2006

Topography & reference water:
SRTM 90m
© USGS 2000

Land cover : SERTIT database
Processing SERTIT 2007

SERTIT
Pôle d'Innovation
Bâtiment 1000
BP 10413
67412 ILLKIRCH Cedex
FRANCE
Tel : 0333 3 90 24 46 40
Fax : 0333 3 90 24 46 46
<http://sertit.u-strasbg.fr>
sertit@unistra.fr

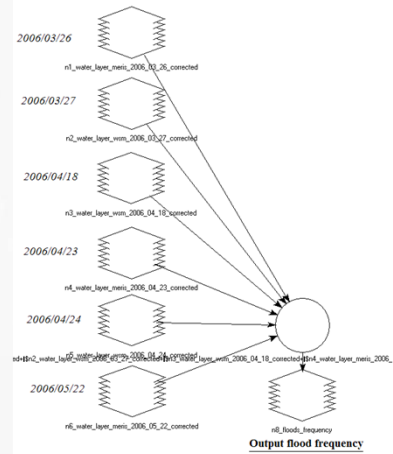


Flood analysis: Duration

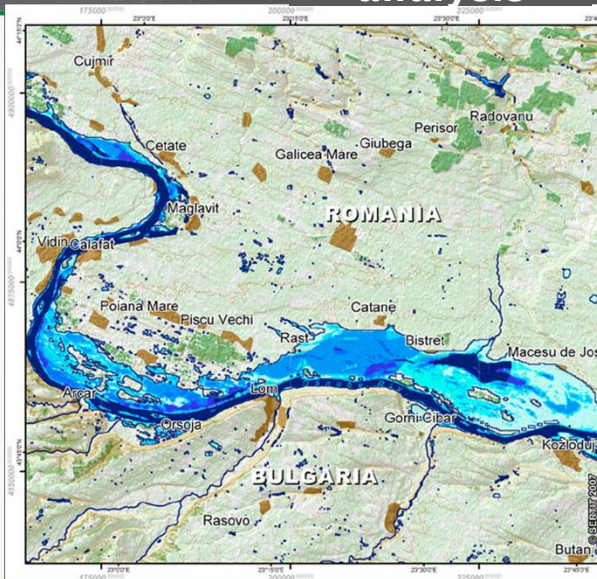
Compute

- Estimated flood duration (see model)

Input water layer of the



Flood analysis



THE 2006 DANUBE FLOODS

Bistret (Romania) Dam Break

Floods duration estimation

Legend:

- Reference water
- Water observed... in only 1 image
- ... in all images
- Settlements
- Low lying vegetation
- Woody vegetation

Map information:

Projection: UTM Zone 35 North
Datum: WGS 1984

Data sources:

Flood duration estimation estimated from ENVISAT MERIS and ASAR WSM data of the 26/03, 27/03, 18/04, 23/04, 24/04 and 22/05 of the year 2006

Processing SERTIT 2007

Land cover: SERTIT database

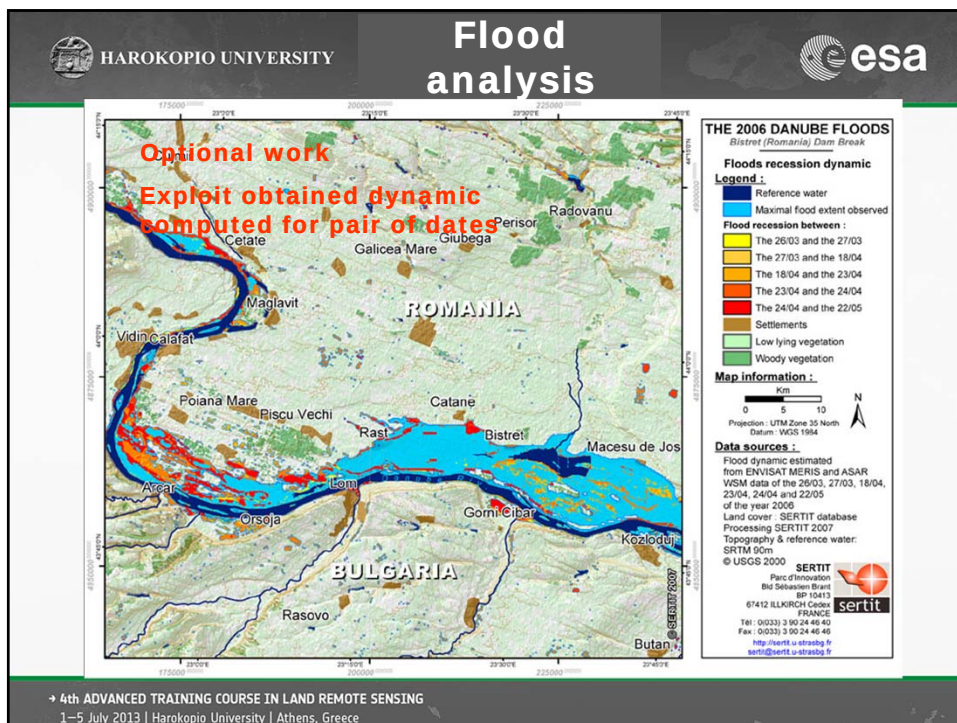
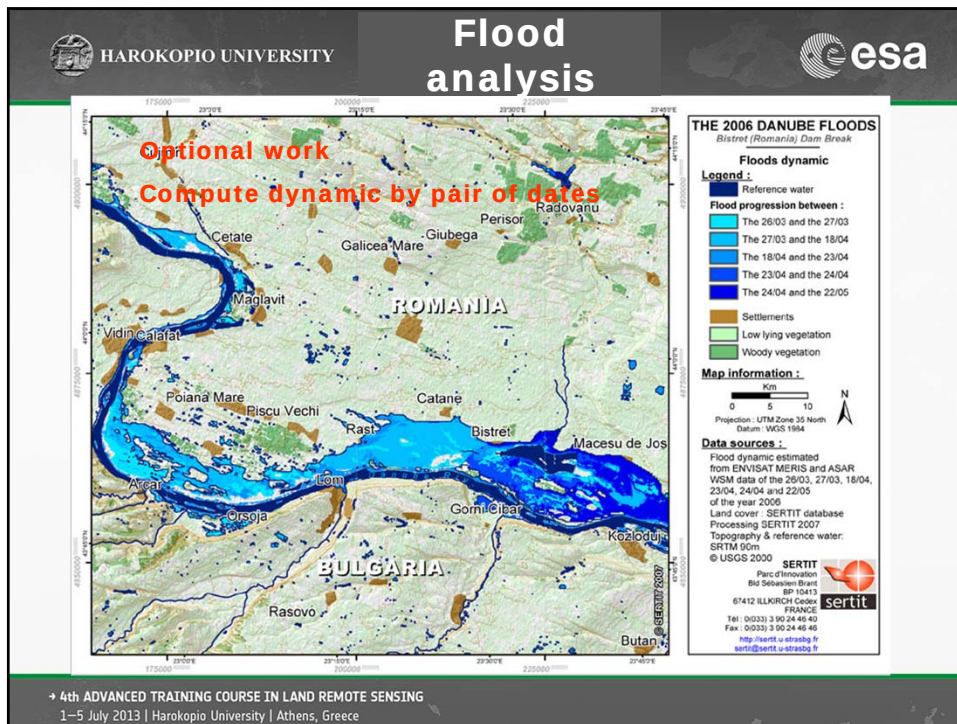
Processing SERTIT 2007

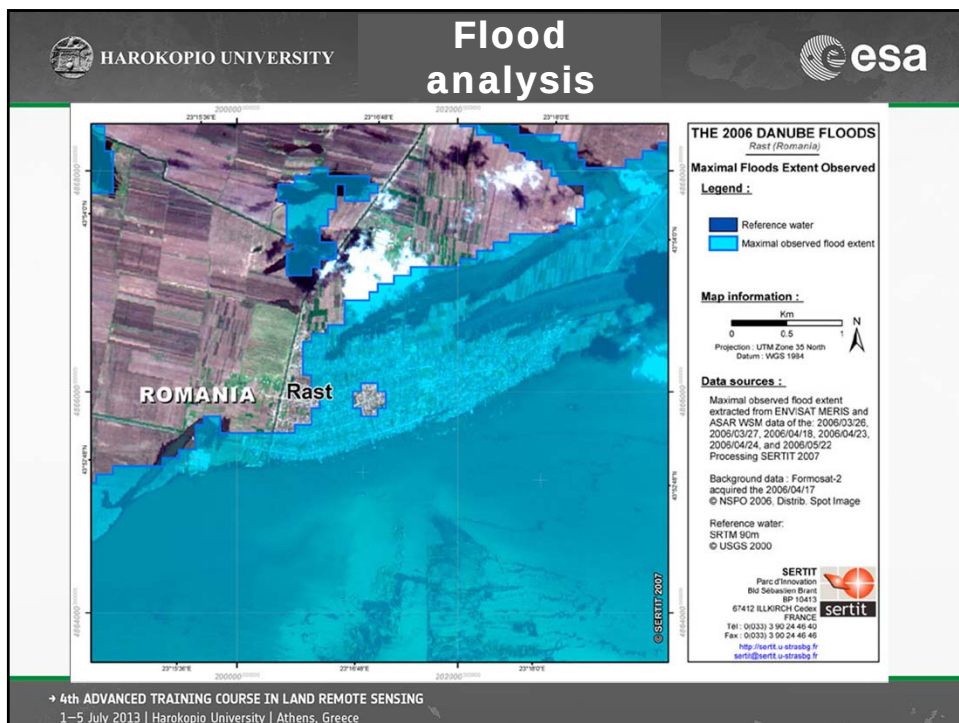
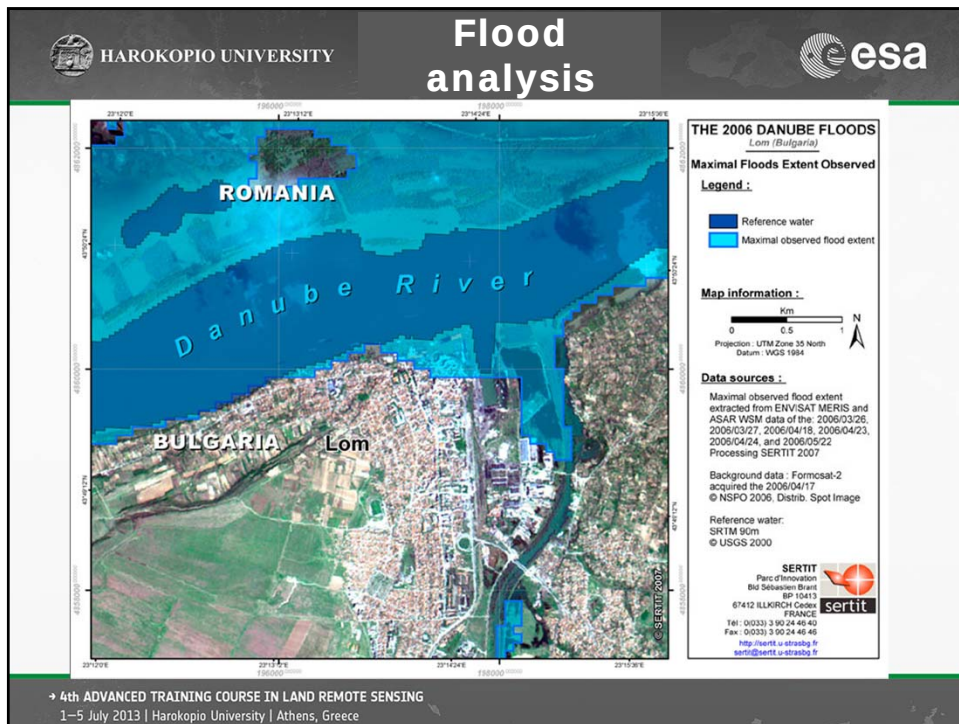
Topography and reference water:

SRTM 90m

© USGS 2000

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Lakes - Floods monitoring practical

Dr Yésou H.

With contributions of SERTIT Rapid Mapping team

SERTIT, Bv Sébastien Brant, BP10413, 67412 Illkirch, France

herve@sertit.u-strasbg.fr, <http://sertit.u-strasbg.fr>

4th of July 2013, D4P1a



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19/06/2013

