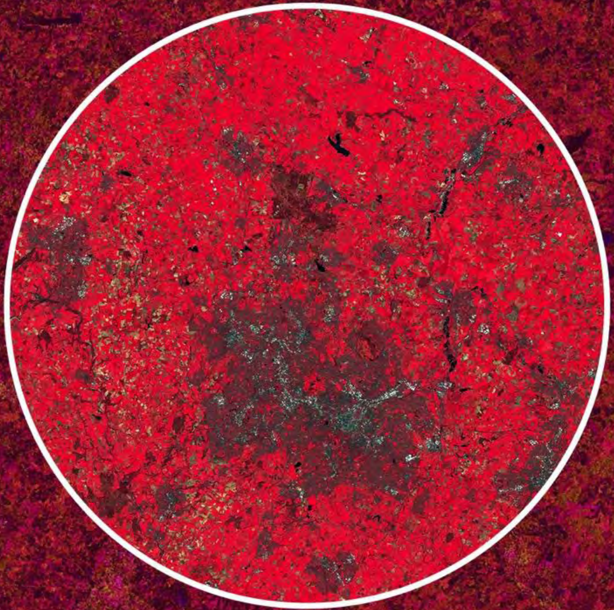
→ 8th ADVANCED TRAINING COURSE ON LAND REMOTE SENSING

10–14 September 2018
University of Leicester | United Kingdom

Flood Mapping



Dr Hervé YESOU

14/09/2018

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL
UNIVERSITY OF LEICESTER
esa
iCUBE
sertit

SERTIT

Technological and services platform of ICube lab from Strasbourg University
Valorisation and technological transfert in space techniques and E.O. applications

Activities
- Image processing
- Remote Sensing
- GIS
- -Expertise
- -Training

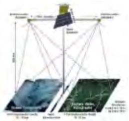
Applications
- Land management and urban planning
- Natural resources monitoring
- Environmental survey
- Epidemiology
- *Natural disaster and risk management*


Western
Europe
Paris
Strasbourg
Munich
Toulouse
Roma

Water bodies and Flood mapping and monitoring based on EO data

ESA Programmes
- AO and CAT1 ERS/ Radarsat SOAR
- EOMD Plain flood project
- Water an Fire project
- GMES- ESA GSE projects (Riskeos, Respond)
- DRAGON ESA MOST

CNES projects
- SPOT2 to SPOT5 preparatory and validation programmes
- Pactes
- Pléiades / Orfeo thematic programme
- Post Pléiades: SWIR /VHR trade off and synergy
- SWOT SDT



Others projects
- CSK ASI
- TerraSAR AOs

International Charter Space and Major Disasters
Former GMES SAFER and EMS Copernicus
more than 200 actions of flood rapid mapping

http://sertit.u-strasbg.fr

Presentation outline

Context

Why flood mapping and monitoring
Flood in the landscape

SAR

Short cut of SAR Physical basis for Water bodies mapping
Backscattering in function of:
- Acquisition parameter
- Surface roughness
- Atmospheric/meteorological conditions

SAR sensors for water bodies and/or flood mapping
- Past mission
- On going missions
- Future missions

Optical

Short cut of Optical Physical basis for Water bodies mapping
Water bodies spectral signatures
Contribution of SWIR channels
Errors in water bodies mapping

Optical sensors for water bodies and/or flood mapping
Sentinel2 and S2 like sensors
VHR sensors

Concluding remarks

Why it is relevant to map and monitor flood events?

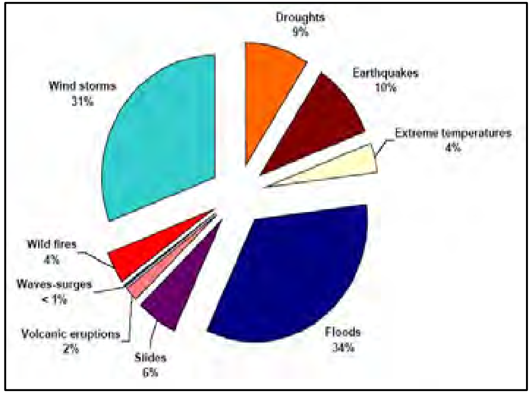
Floods: 34% world natural hazards between 1974-2003

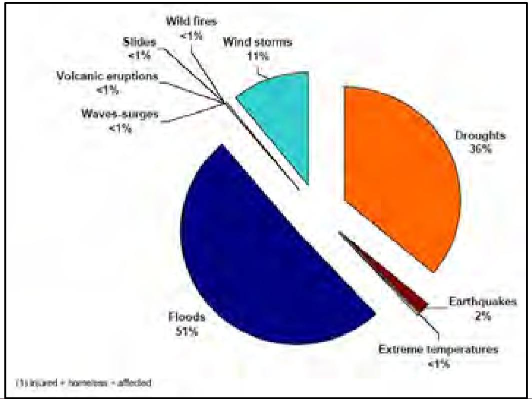
Half of affected people related to flood events

Near 200 millions of affected people each year (more than half of affected people by a natural hazards)

More than 170 000 deceases from 1980 to 2000

Average: 4700 persons /year (2006-2015)





Source:EM-DAT - International Disaster Database

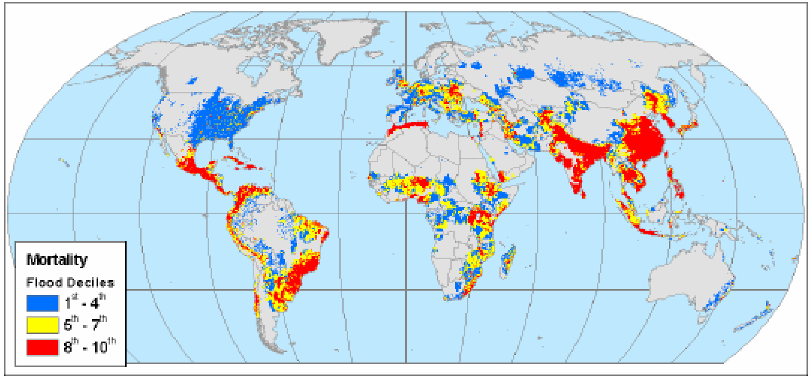
Why it is relevant to map and monitor flood events?

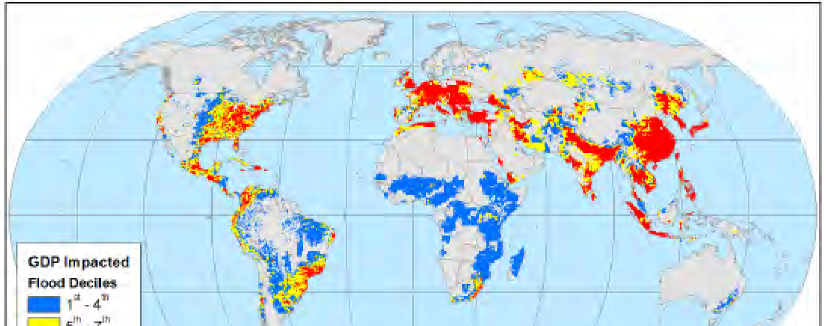
Floods: worldwide

Important mortality in Asia, Central-South America, Eastern Africa

Important economic losses in Europe, Northern America as well as Asia

Most dramatic are not the most costly ones (Nargis: 140 000 , none insurance prime, whereas 2008 spring floods in US and Germany 1,1billion $ each





Global Distribution of Flood Risk
(Source: Columbia University, UNDP, CRED)

Why it is relevant to map and monitor flood events?

Closer period

2016: (Nino Year) China, one flood affected 60 million (134 million affected in 2010, 105 million in 2007 and 68 million in 2011).

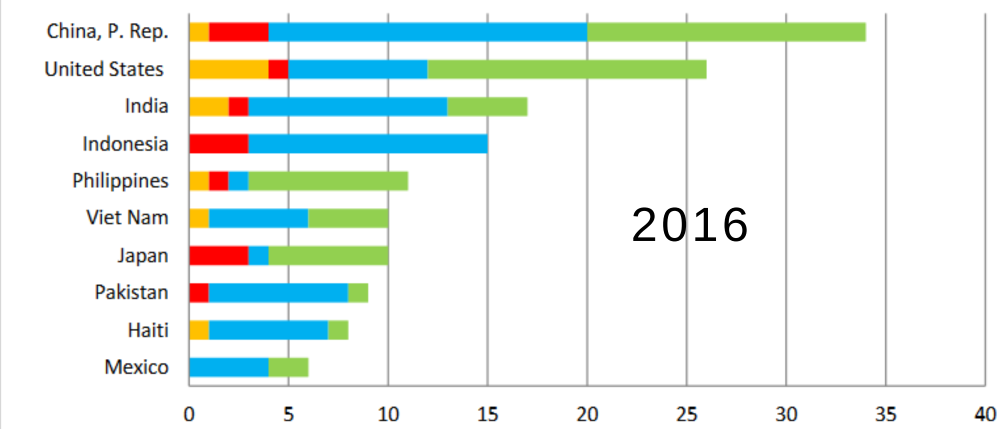
- 200 000 homes damages
- > 5 Billion $ of damages

2018:

Kerala (India) flood event in summer 2018, near 500 casualties, 1 million of displaced people, 3 B US$

With climate change it would become worse worldwide

Fitting floods is one of the most important environmental challenge



	Mexico	Haiti	Pakistan	Japan	Viet Nam	Philippines	Indonesia	India	United States	China, P. Rep.
Climatological		1			1	1		2	4	1
Geophysical			1	3		1	3	1	1	3
Hydrological	4	6	7	1	5	1	12	10	7	16
Meteorological	2	1	1	6	4	8		4	14	14

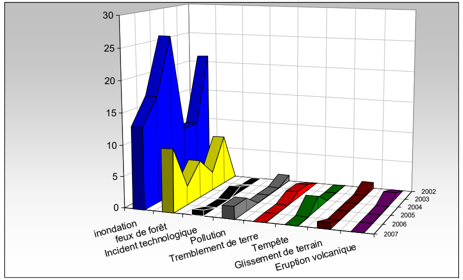
Figure 5 – Top 10 countries by number of reported events in 2016

Source:EM-DAT - International Disaster Database

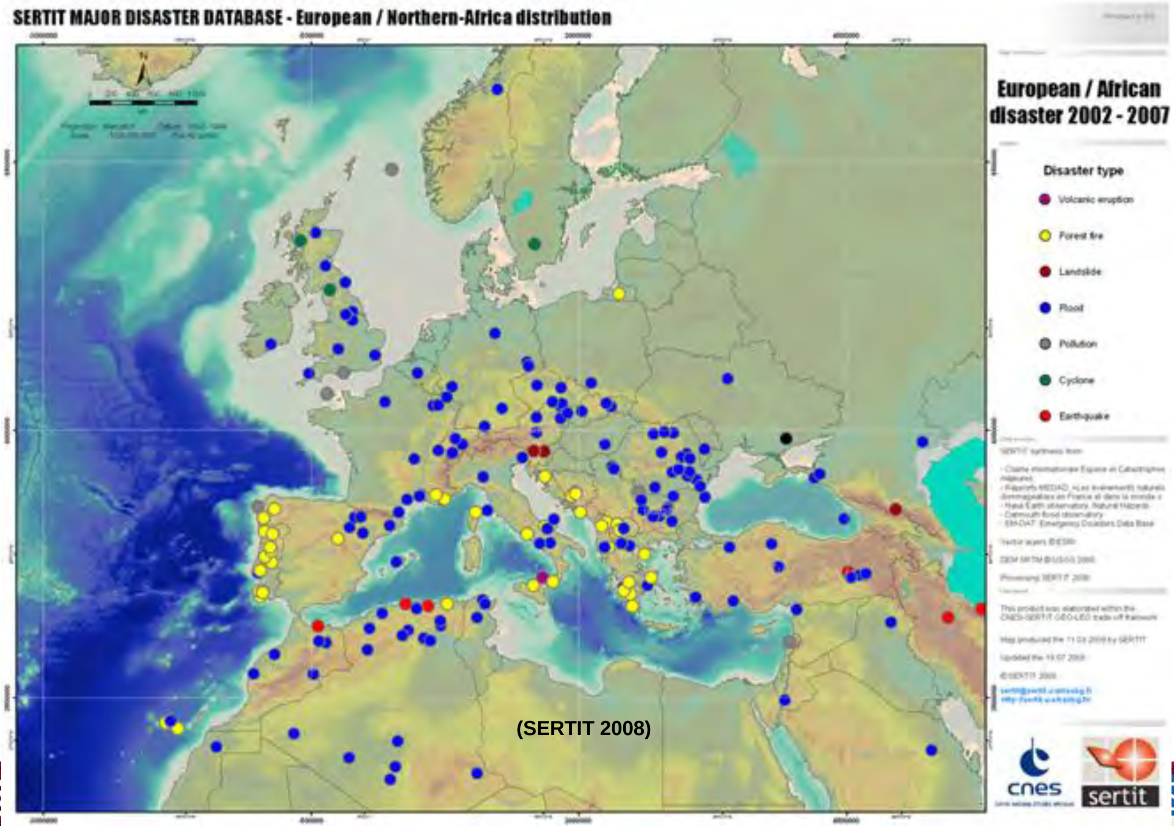
Why it is relevant to map and monitor flood events?

- Floods: Europe

- Central Europe
- British Islands
- South France

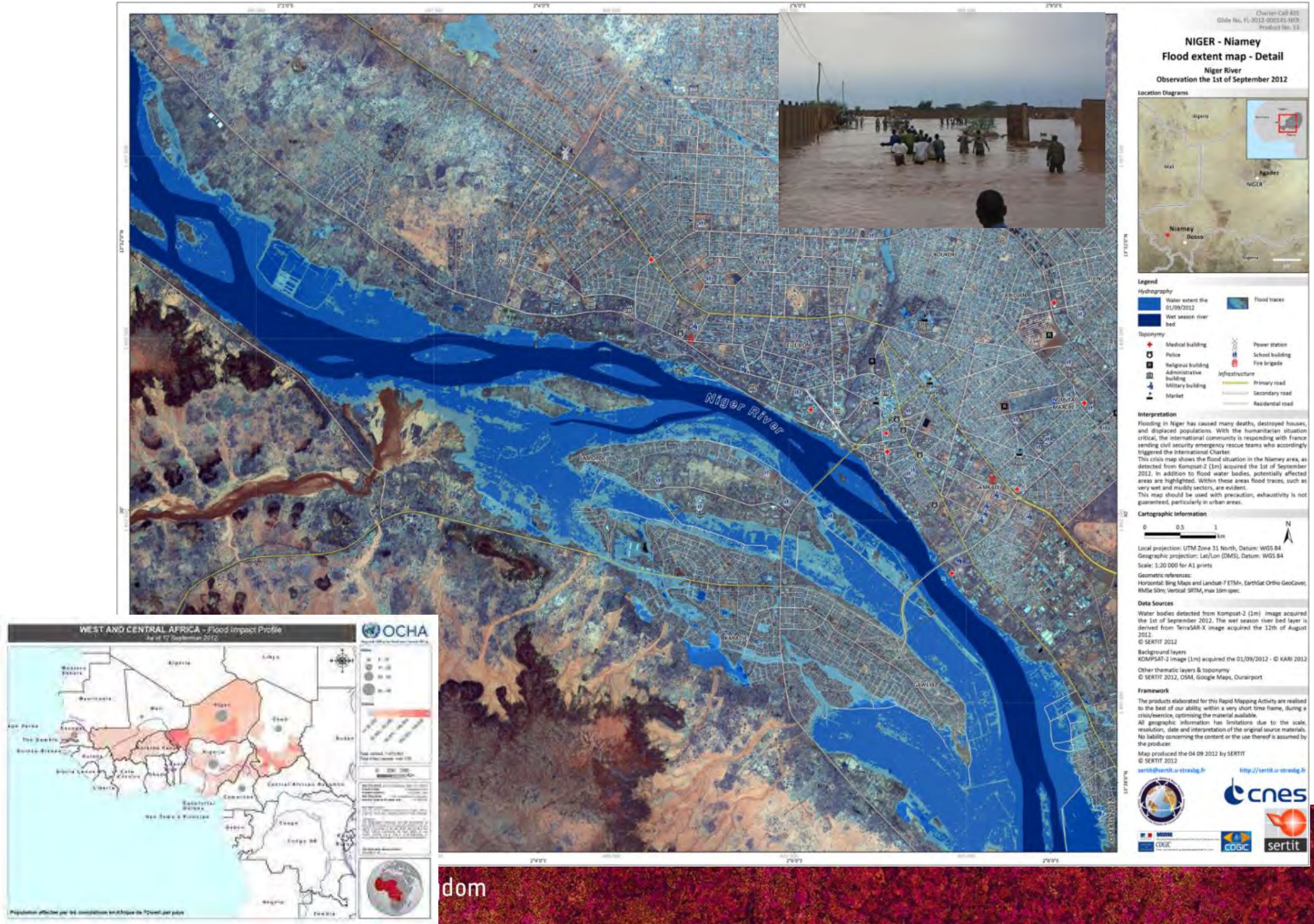


(Europe 2002-2007: SERTIT 2008)



(SERTIT 2008)

Set up risk memory Niamey, Niger, September 2012



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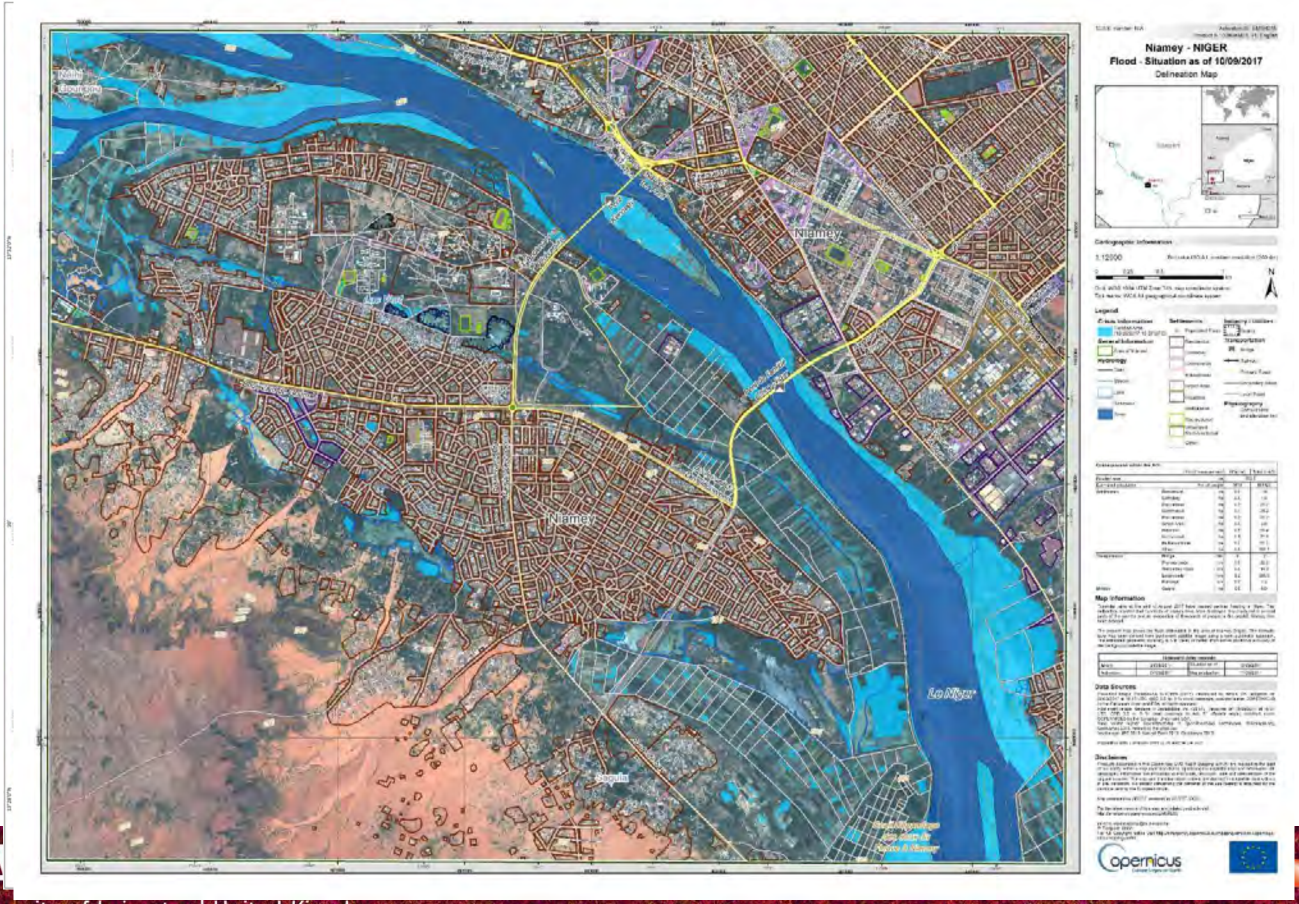


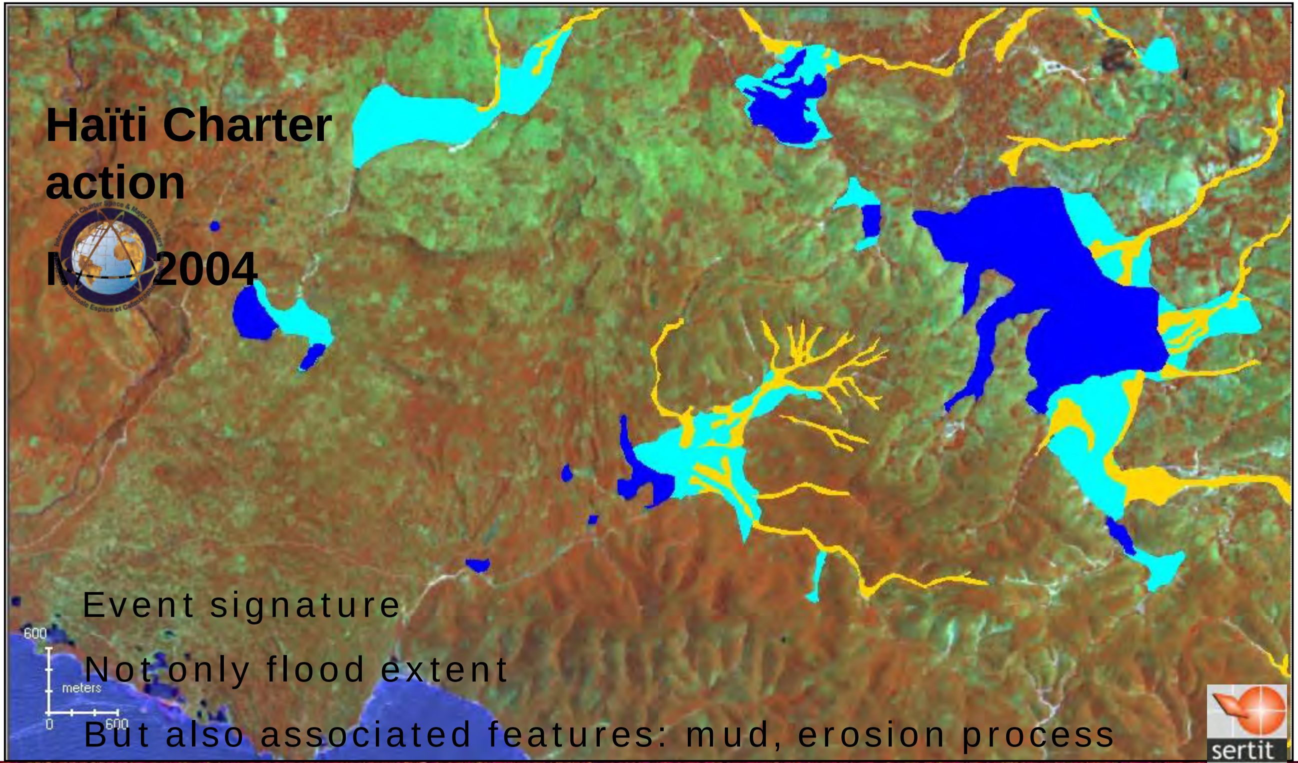
What are we are looking for: Flood events definition

Hydrological

Disaster Group	Disaster Subgroup	Disaster Main Type	Disaster Sub-Type
Natural Disaster	Hydrological	Flood	Coastal flood
			Riverine flood
			Flash flood
			Ice jam flood
		Landslide	Avalanche (snow, debris, mudflow, rockfall)
		Wave action	Rogue wave
			Seiche

EM-DAT
The International Disaster Database
Centre for Research on the Epidemiology of Disasters - CRED

Flood patterns recognition: events' **signatures**



Haïti Charter action

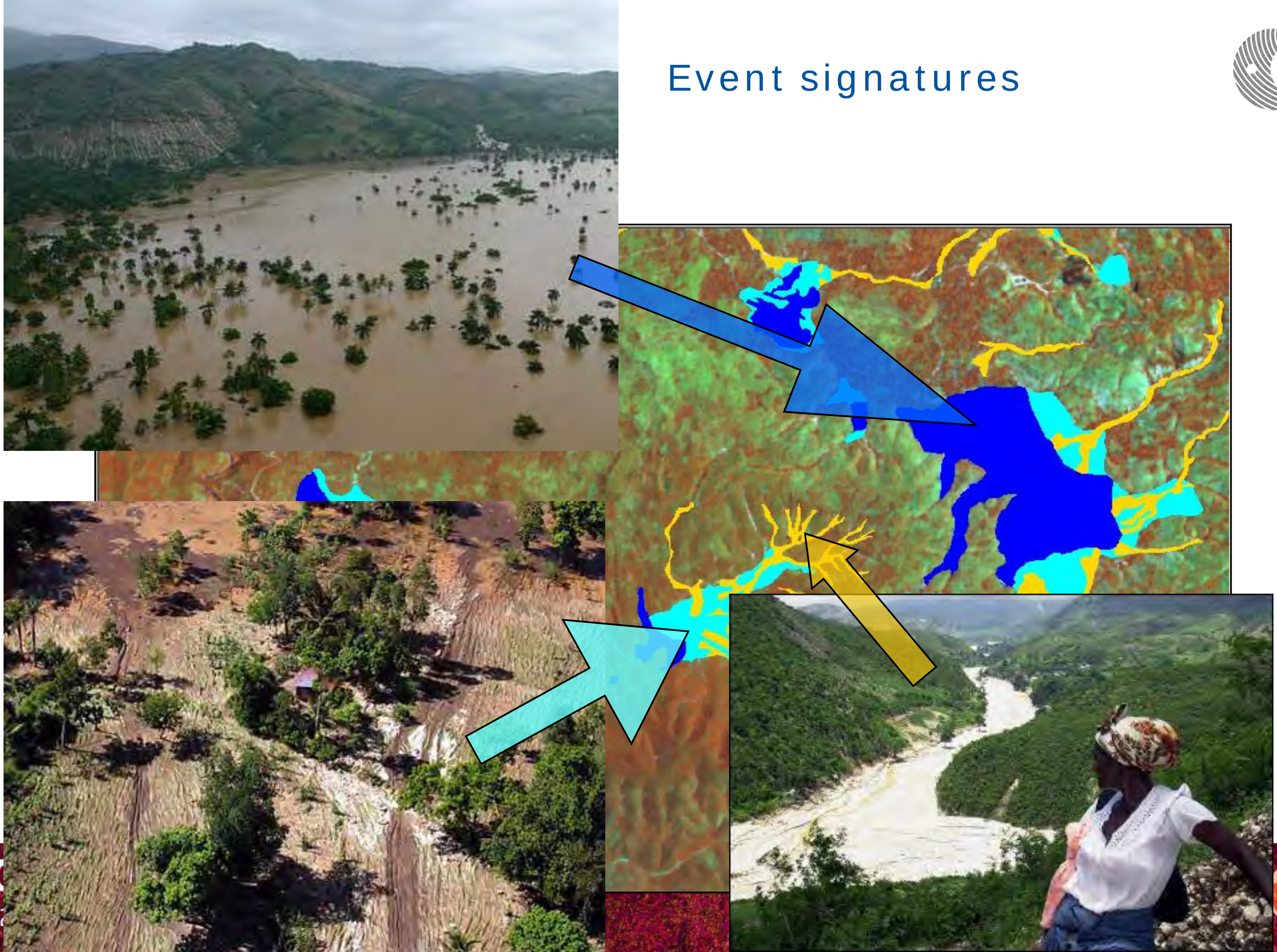
M[illegible] 2004

Event signature

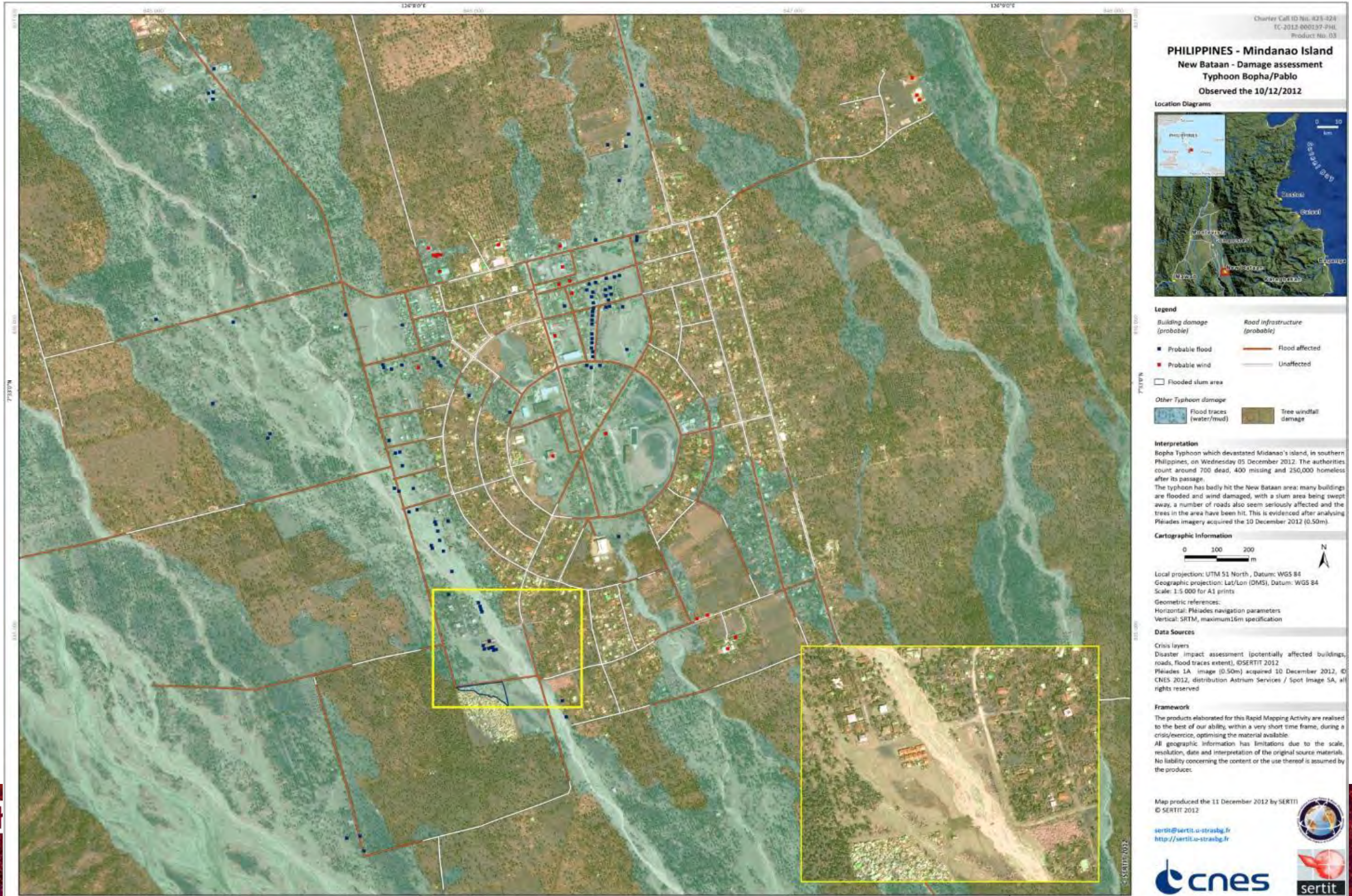
Not only flood extent

But also associated features: mud, erosion process etc …

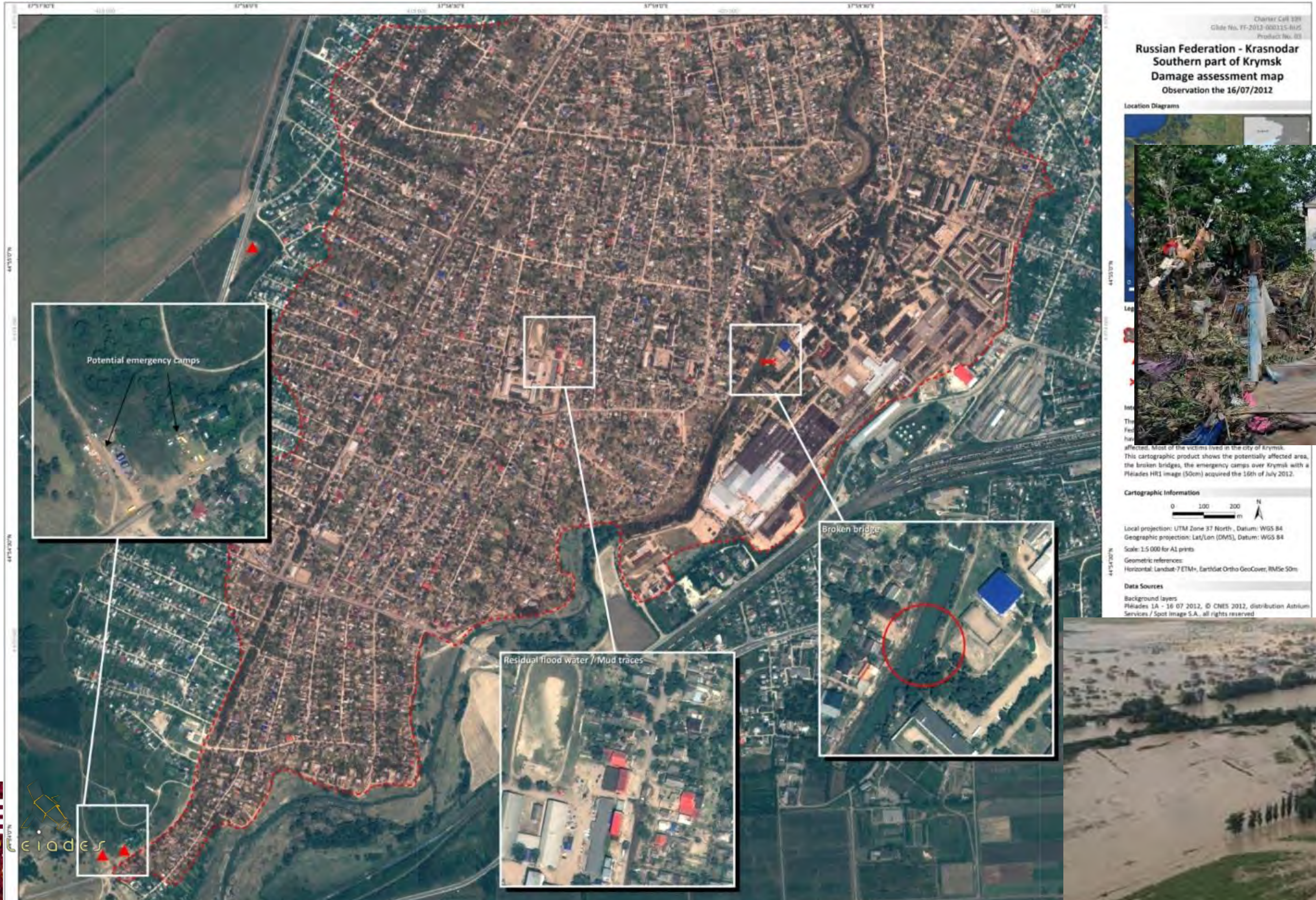
Event signatures



Flood patterns recognition



Flood patterns recognition: flash flood, dam rupture: Krymsh- Russia 2012



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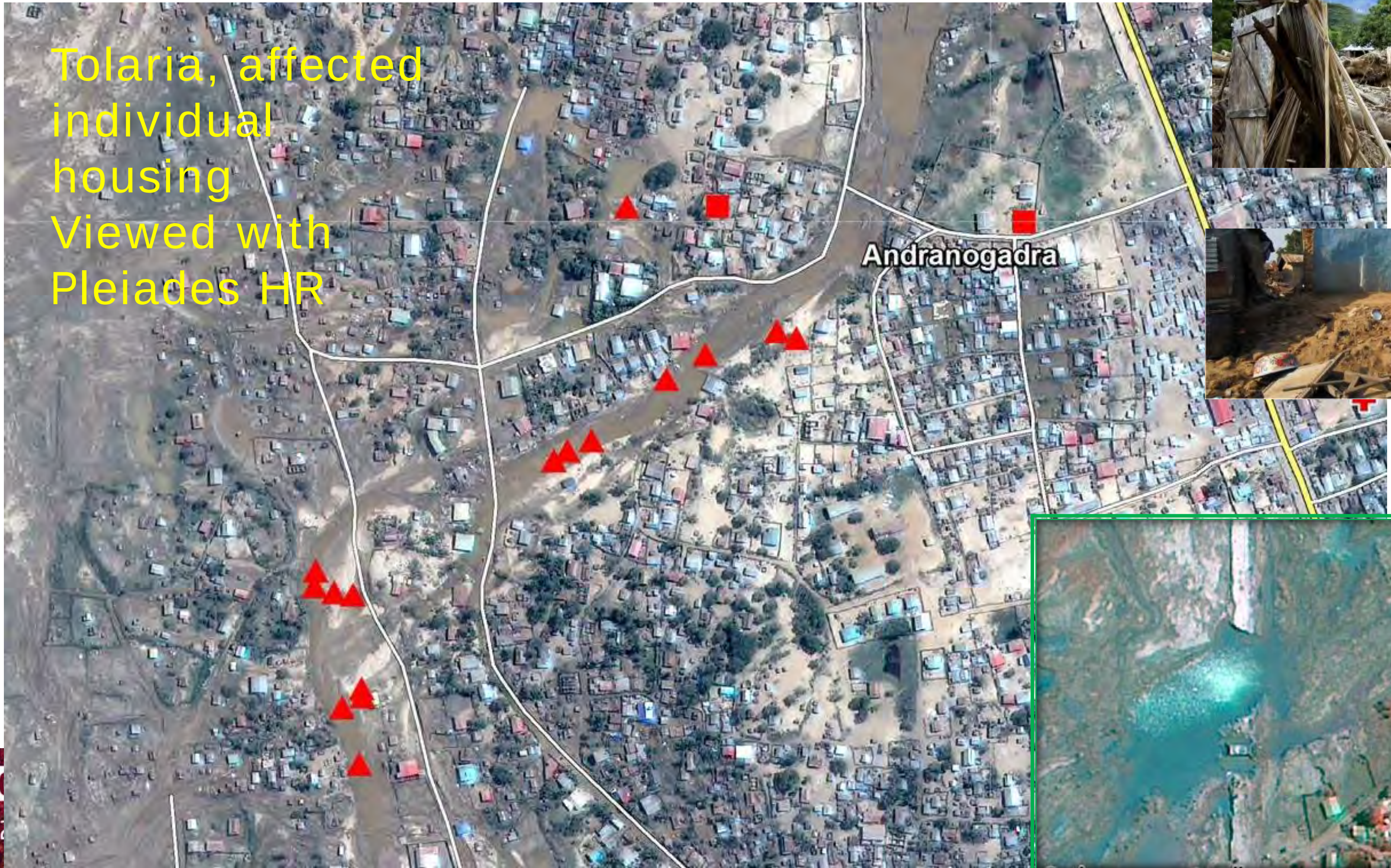
Flood patterns recognition: heavy Rain
Haruna Cyclone, Madagascar, 02-2013

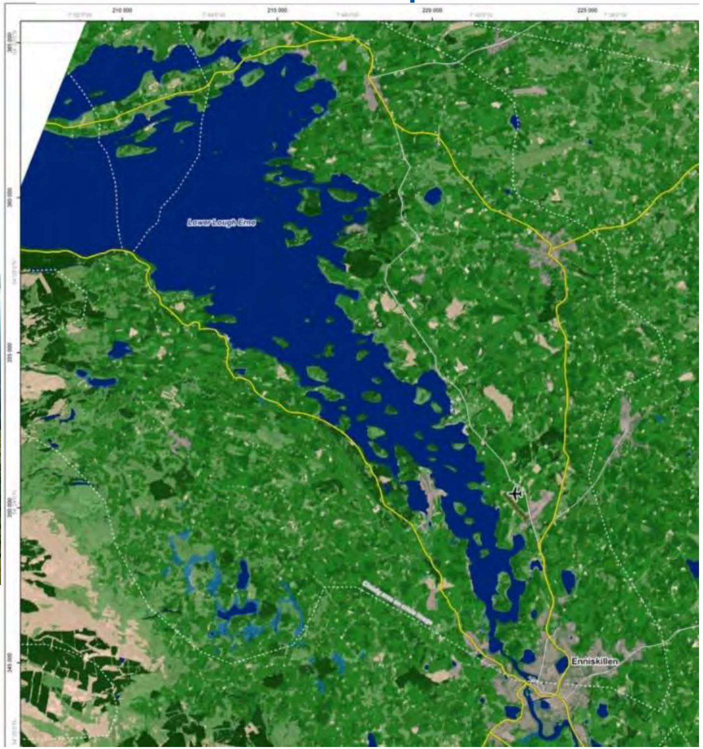
Tolaria, affected individual housing
Viewed with Pleiades HR

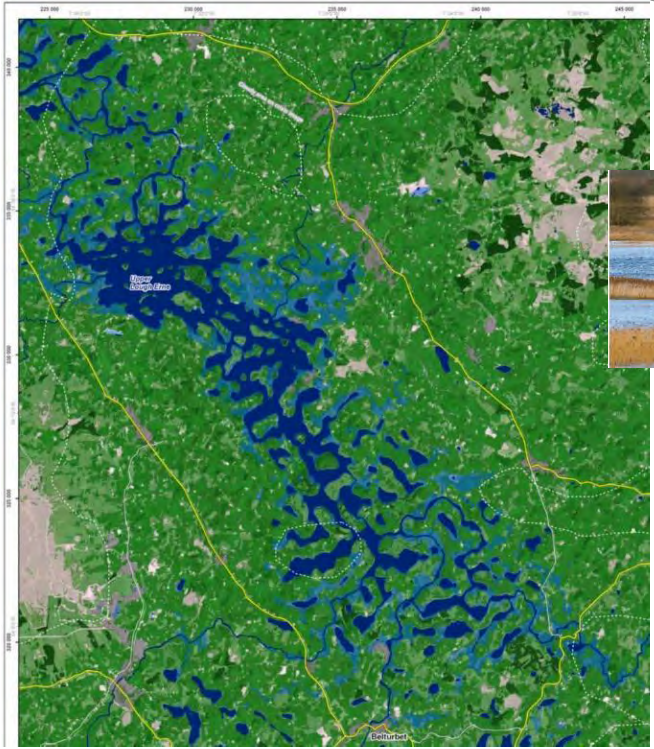


Flood patterns recognition: heavy Rain
Haruna Cyclone, Madagascar, 02-2013

Water trapped in depression

Flood patterns recognition





Ireland SAFER 027, 2010: Water within bogs

Flood patterns recognition

Water within inter dune depression

Angola Charter action, May 2009

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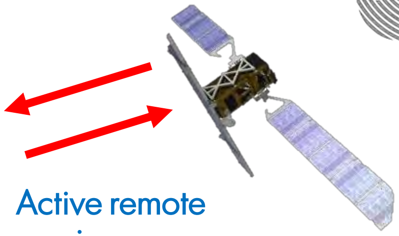
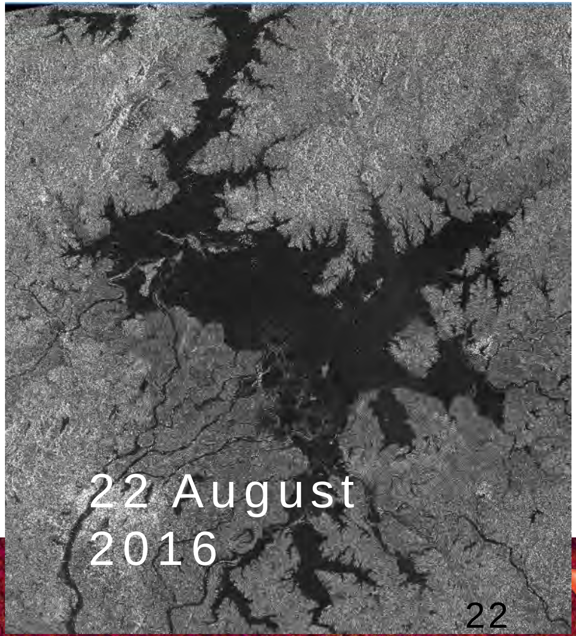
SAR for flood mapping



Cloudy , rainy weather
Sunny weather
⇒ Sentinel 1
⇒ Radarsat
⇒ TSX & CSK
⇒ Gaofeng 3



Wavelenghts pertinent for water surface mapping/monitoring

Mapping+ reconnaissanc e intelligence

Hydrology + land cover/use

Flood under vegetation Biomas

Biomas DEM under forest

Bandes	Ka	K	Ku	X	C	S	L	P
Fréquence (GHz)	40-26.5	26.5-18	18-12.5	12.5-8	8-4	4-2	2-1	1-0.3
Longueur d'onde (cm)	0.75-1.1	1.1-1.67	1.67-2.4	2.4-3.75	3.75-7.5	7.5-15	15-30	30-100
Polarisation	HH, VV, HV, VH							

Images acquired in X, C, S, L Bands are potentially suitable for water bodies mapping

Why SAR is a performing tool for water bodies and flood mapping ?

Near all weather capability

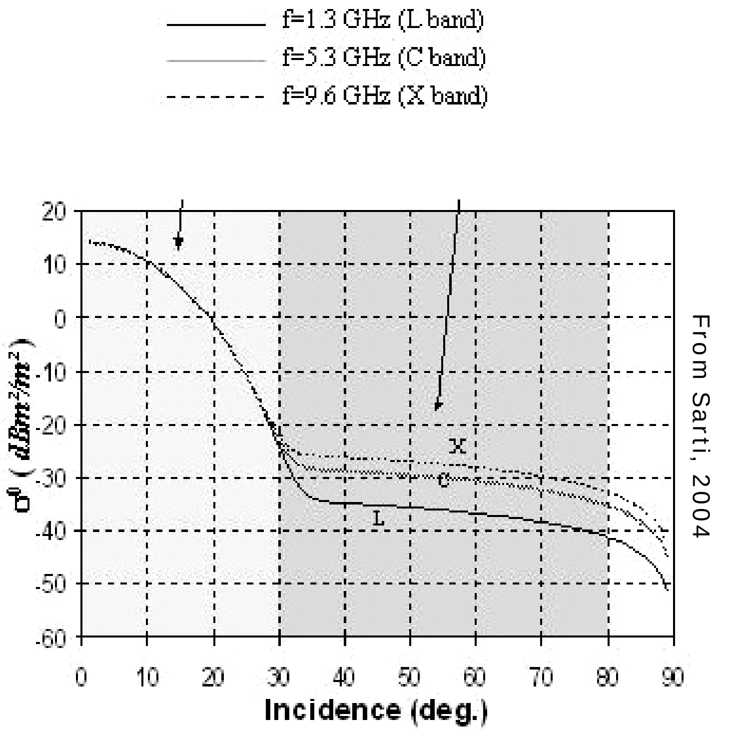
Day & night capabilities

Relative large swath

Relative good revisit

On SAR data water surfaces have low values of BS

But local weather (wind/rain) effect altering the signal

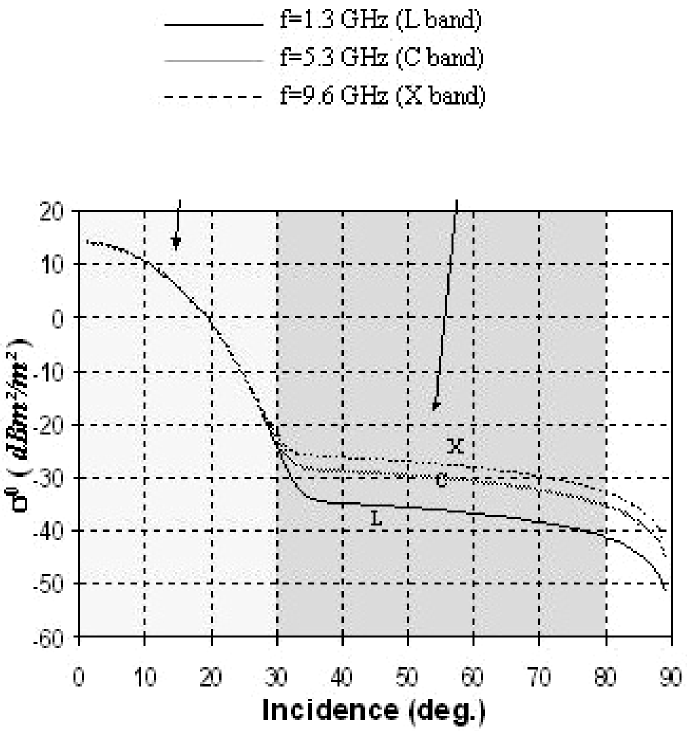


semi-empirical function of backscatter coefficient σ^0 as a function of incidence (for a mean sea), for 3 different radar bands

Why SAR is a performing tool for water bodies and flood mapping ?

Therefore sensibility more or less important depending of the wavelength to:

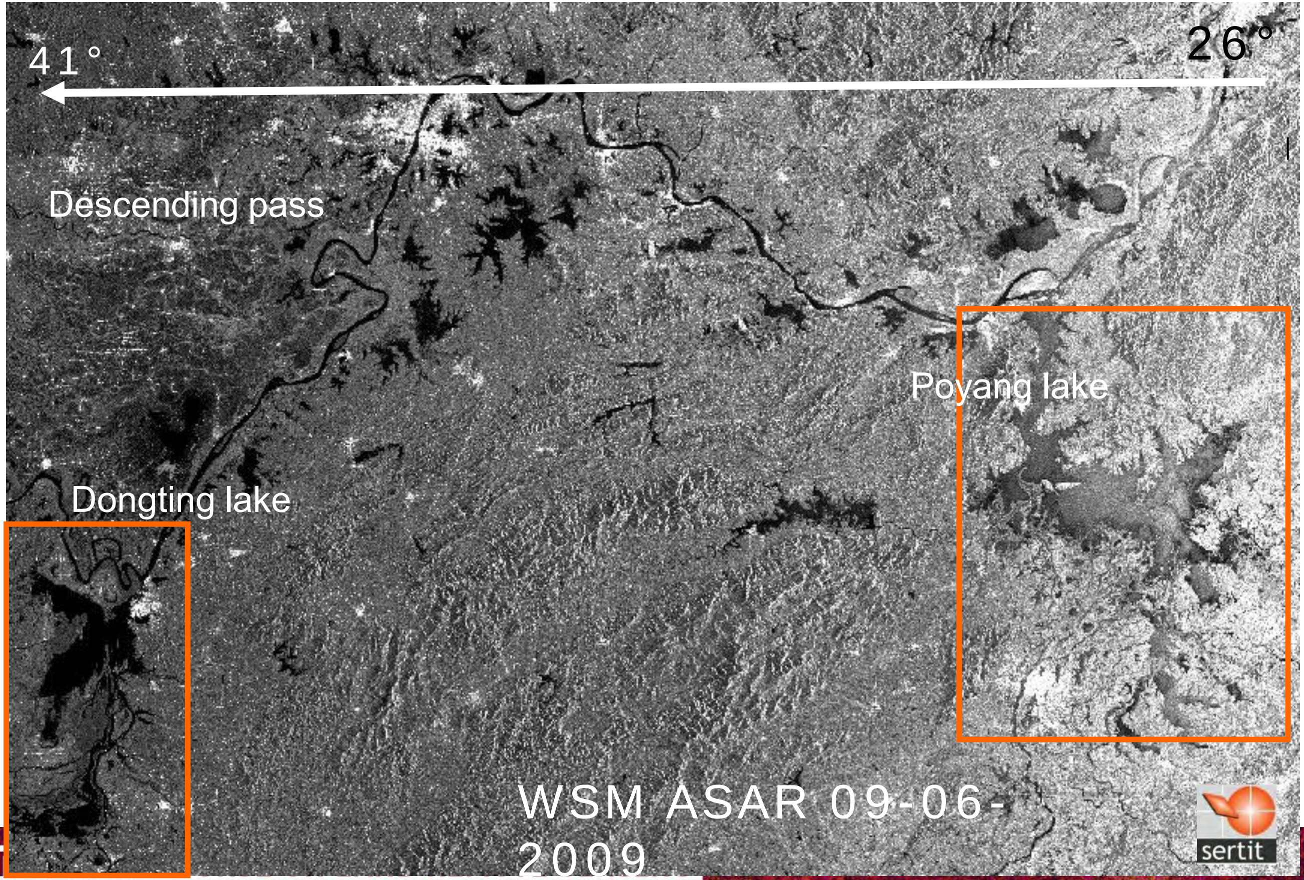
- Acquisition parameters (incidence angle
- Wind locally can alter the surface roughness
- Rain locally can alter the signal path



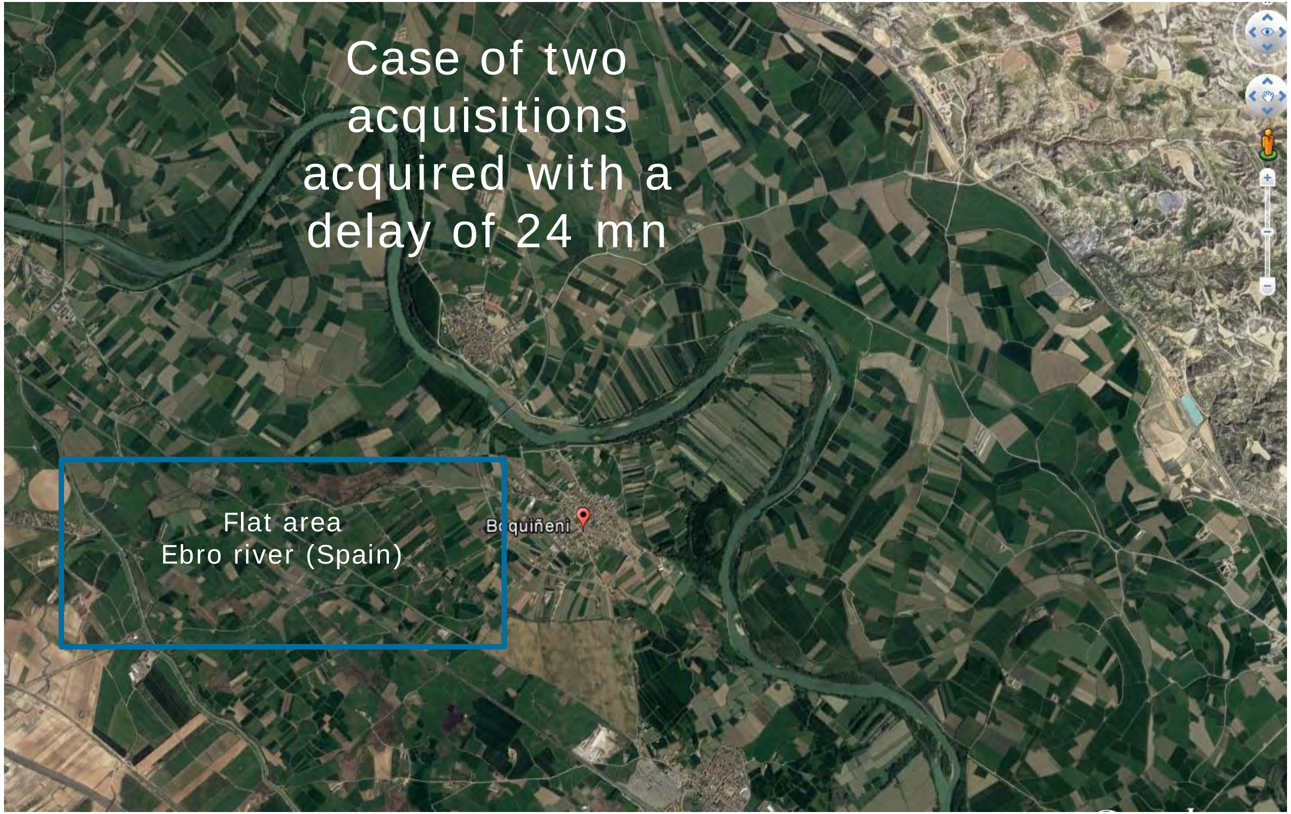
semi-empirical function of backscatter coefficient σ^0 as a function of incidence (for a mean sea), for 3 different radar bands

From Sarti, 2004

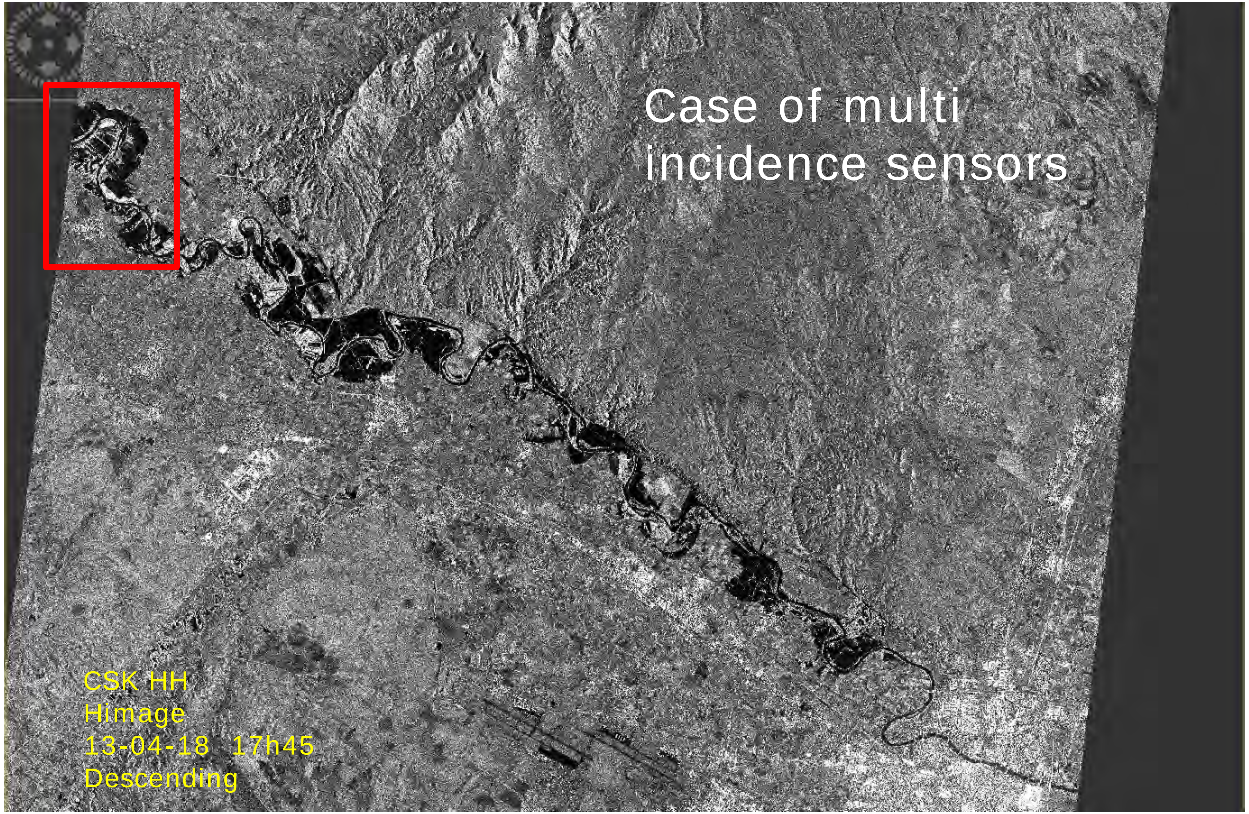
Water backscattering in function of incidence angle



Water backscattering in function of incidence angle



Water backscattering in function of incidence angle



Water backscattering in function of incidence angle

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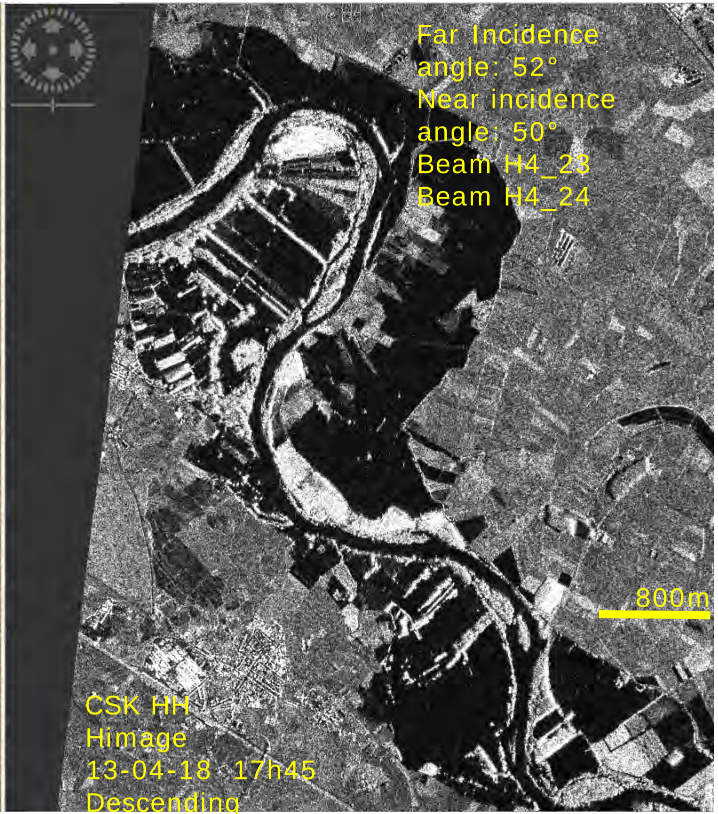
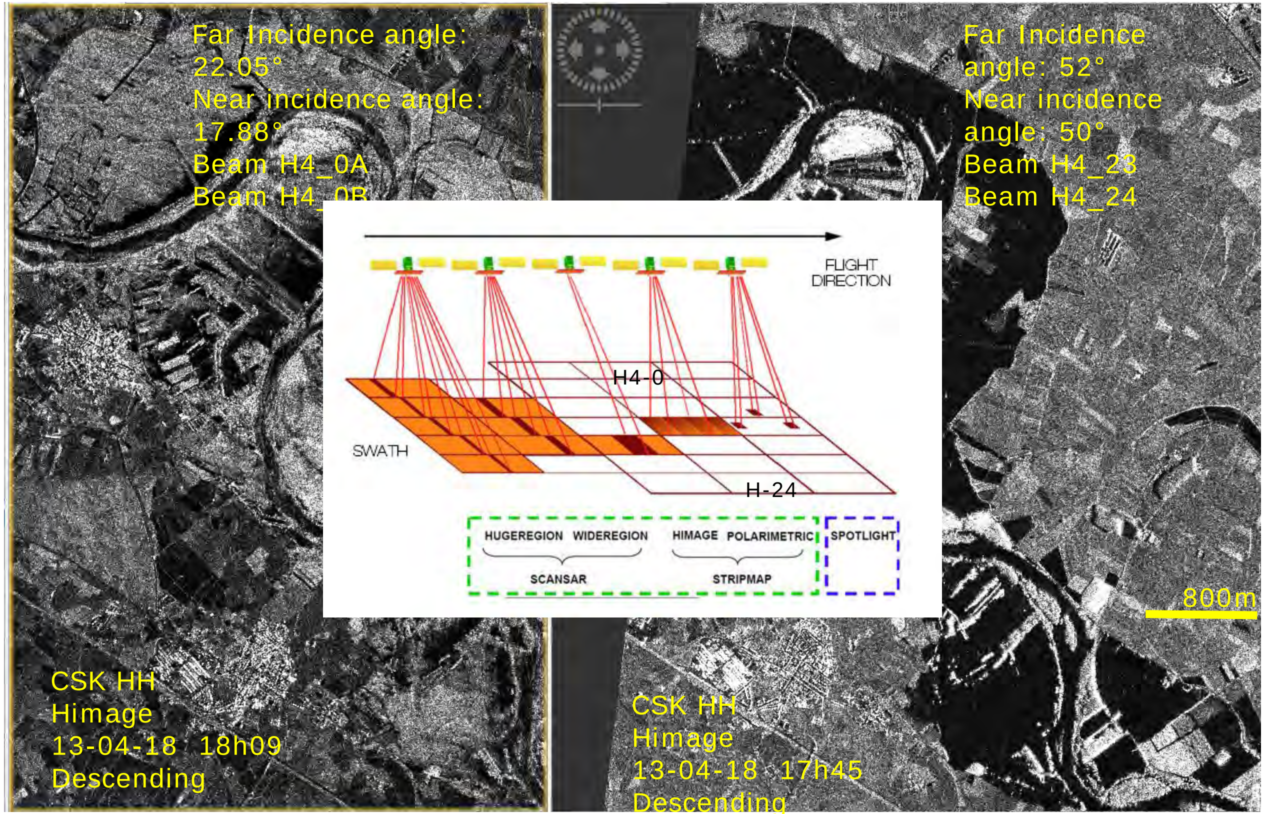
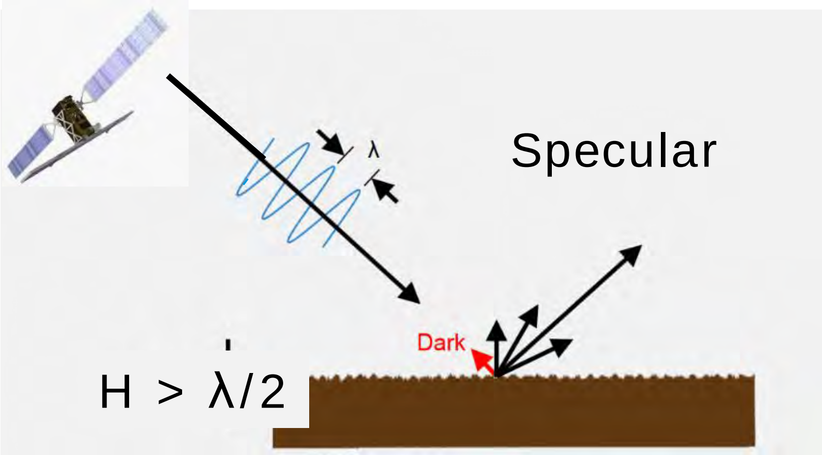


Water backscattering in function of incidence angle



Water backscattering in function of surface roughness



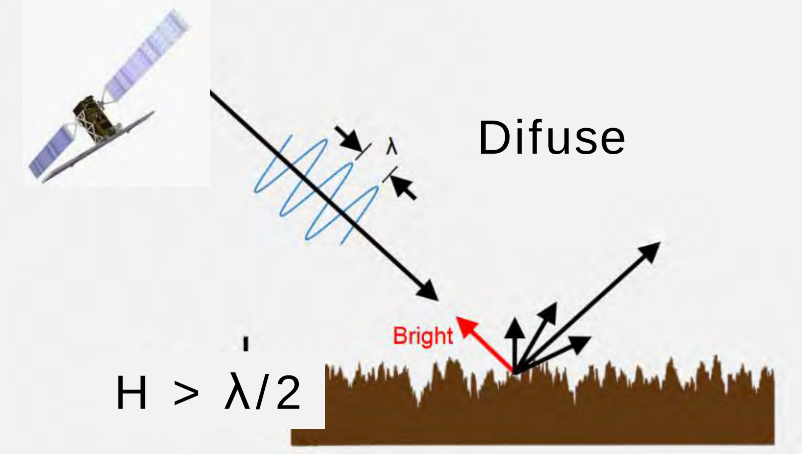
λ varies from
K 1cm
X 3cm
C 5.6cm
S 10cm
L 23cm
P 70cm

HJ-C
ALOS PALSAR

Case for bare soils
Rayleigh criterions

VH being less sensitive than VV

Adapted from Sang-Ho Yun, NASA JPL



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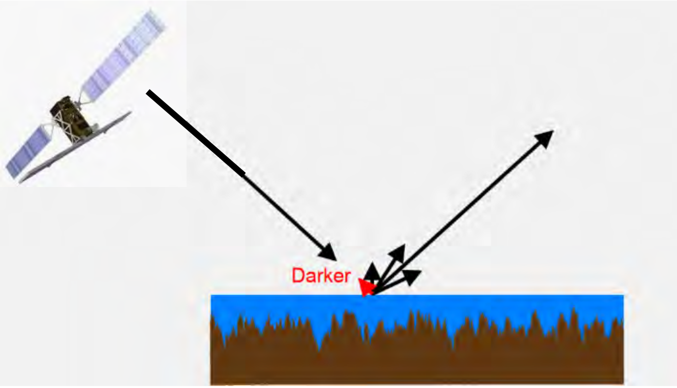
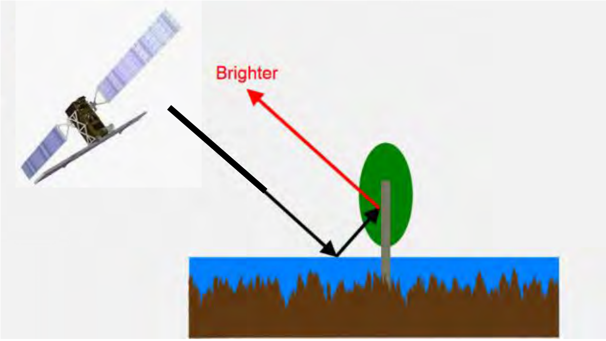
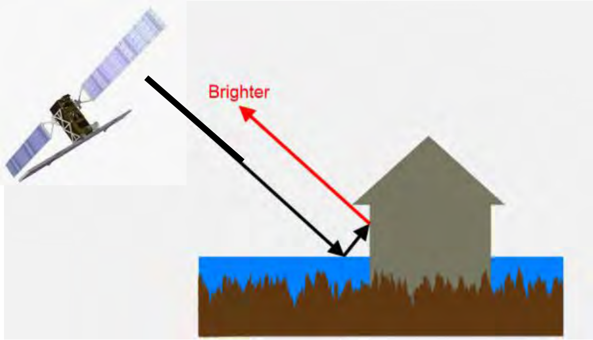


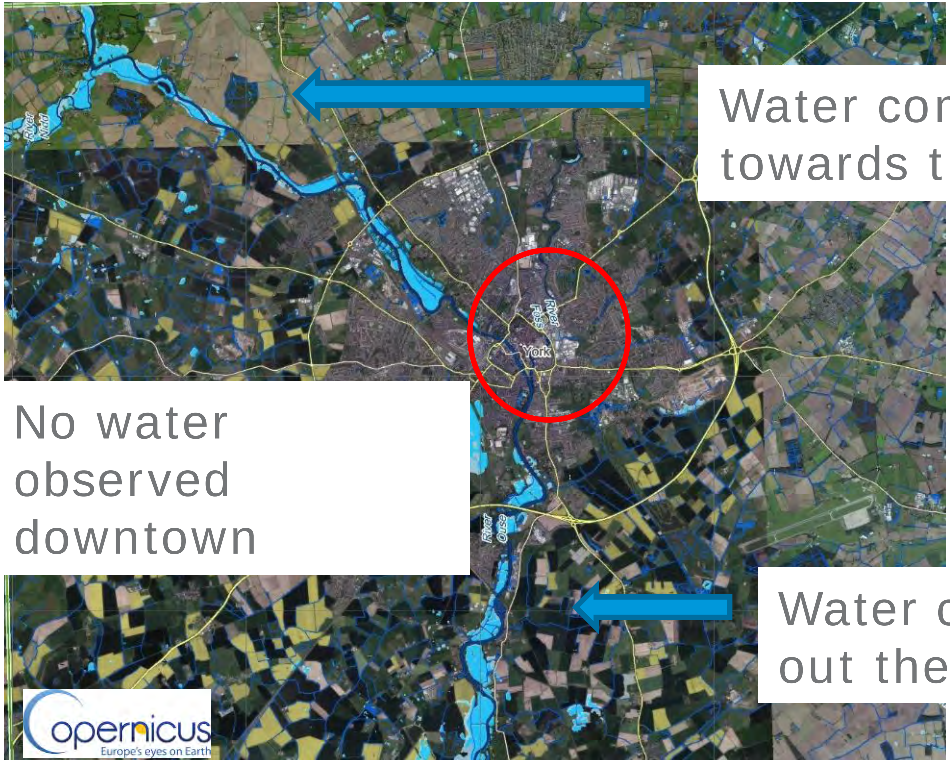
Case of water surface in various environments





Adapted from Sang-Ho Yun, NASA JPL

Water backscattering within urban landscape



Water coming towards the city

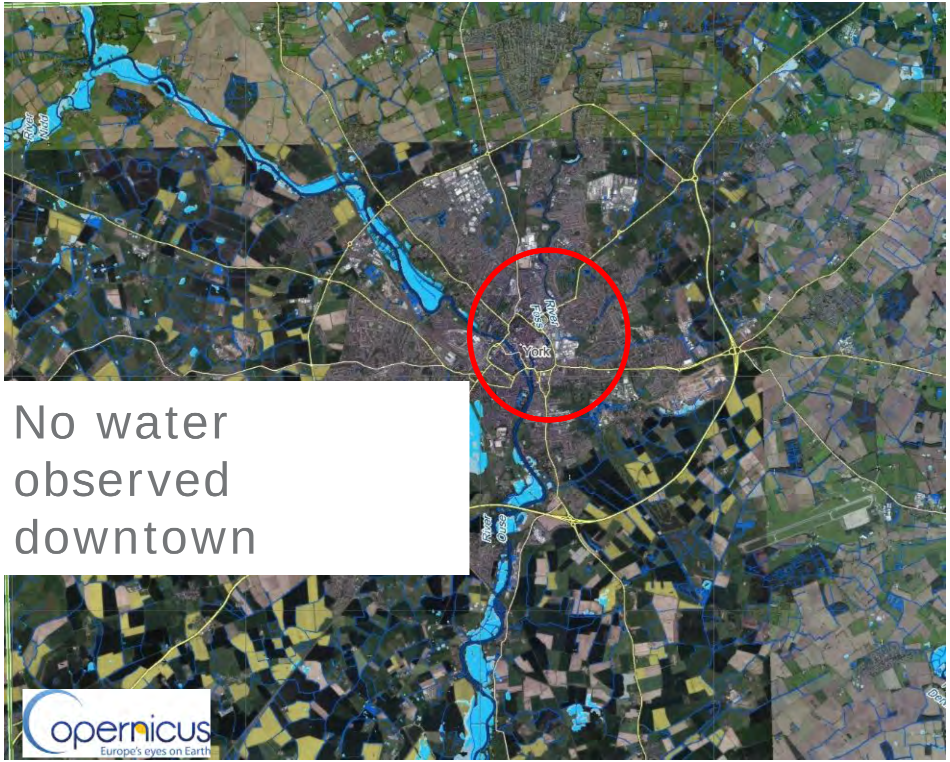
No water observed downtown

Water coming out the city

December 2016 Flood in York, England, based on Radarsat 2 imagery:

Illustration of SAR limitation in Urban area

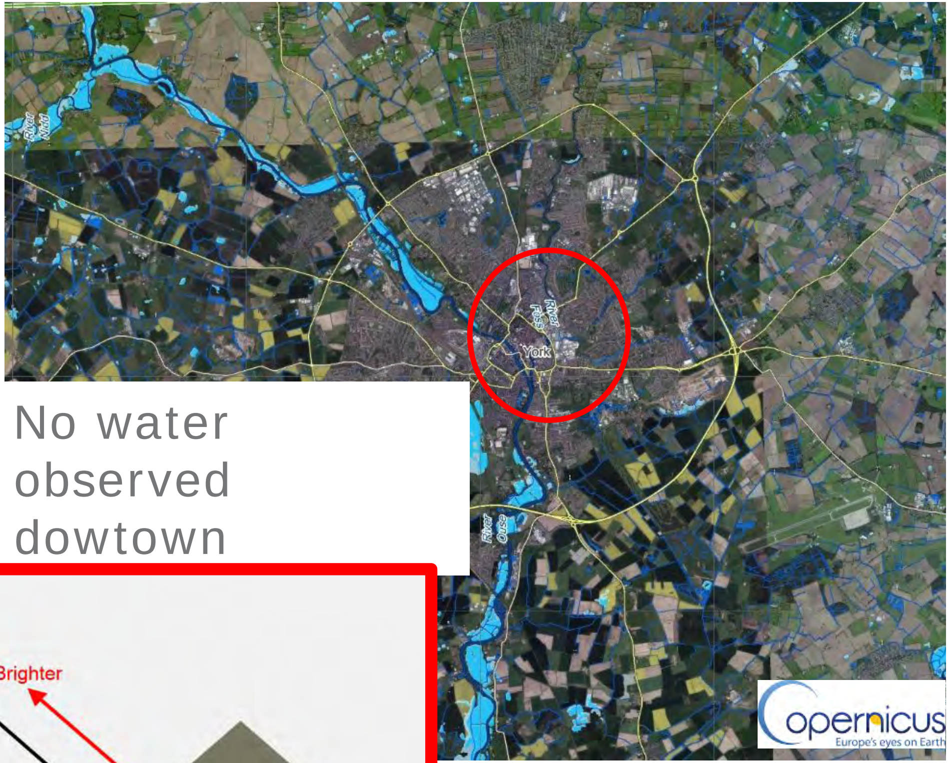
Water backscattering within urban landscape



English Prime Minister visiting the affected York downtown

December 2016 Flood in York, England, based on Radarsat 2 imagery:

Water backscattering within urban landscape



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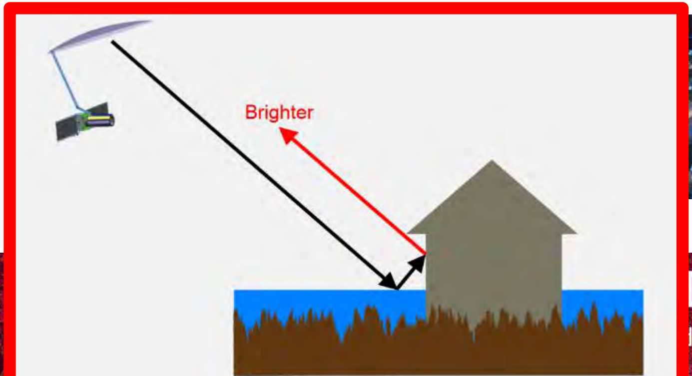

English Prime Minister visiting the affected York downtown

D REMOTE SENSING

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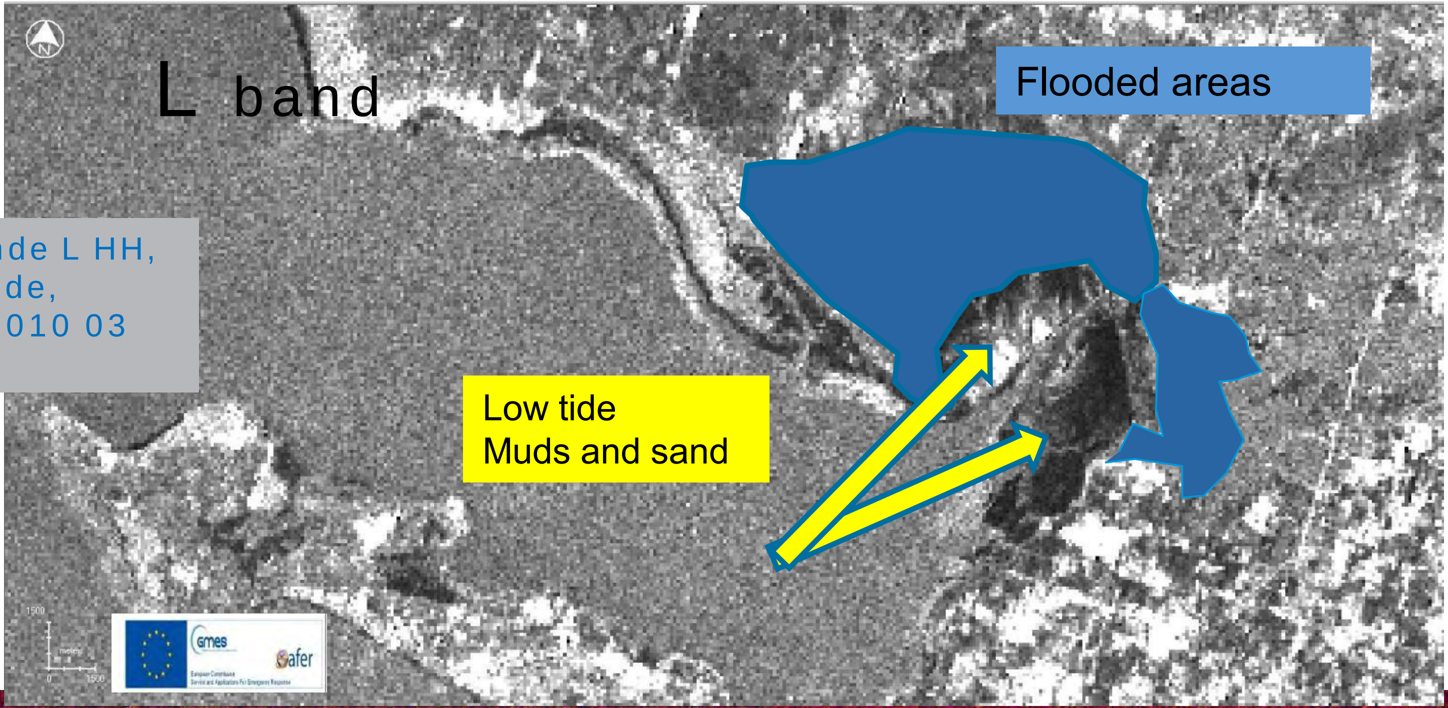
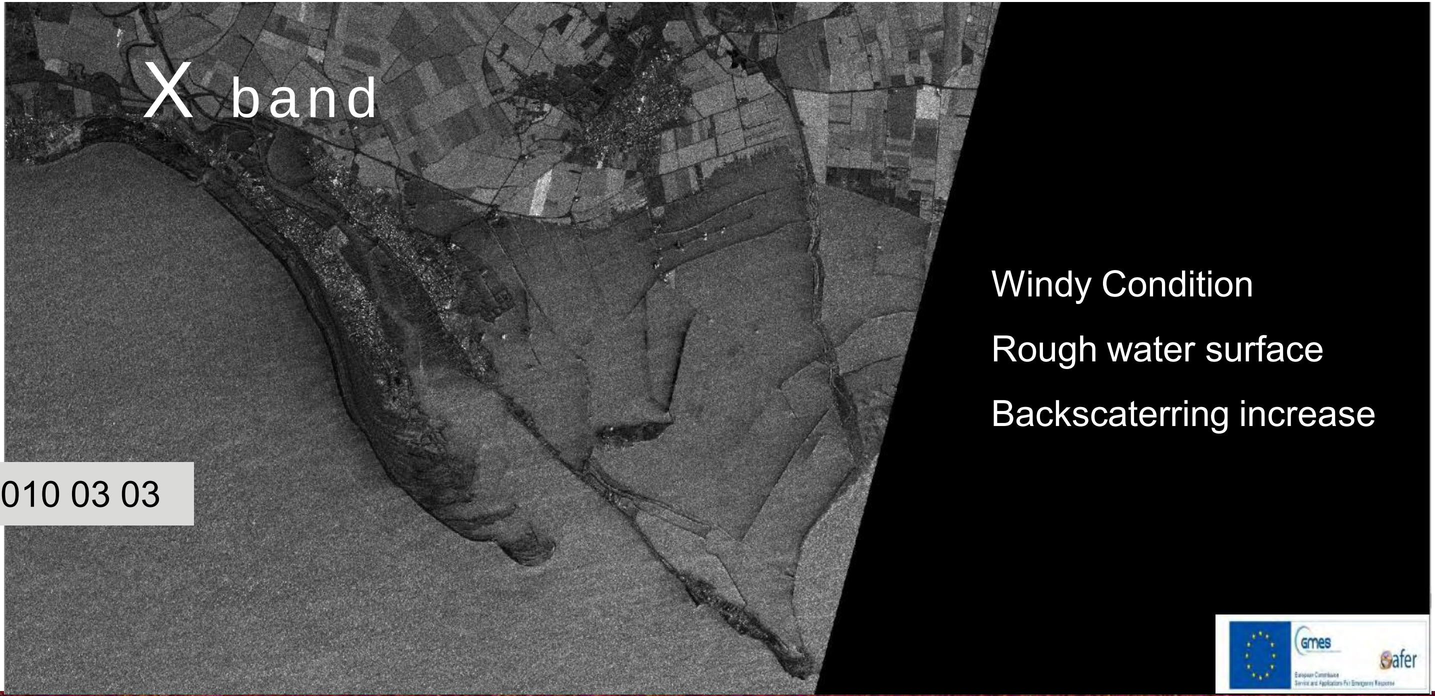
Water backscattering in function of water surface roughness



PALSAR bande L HH, ScanSAr mode, 10h56 the 2010 03 01

Water backscattering in function of water surface roughness

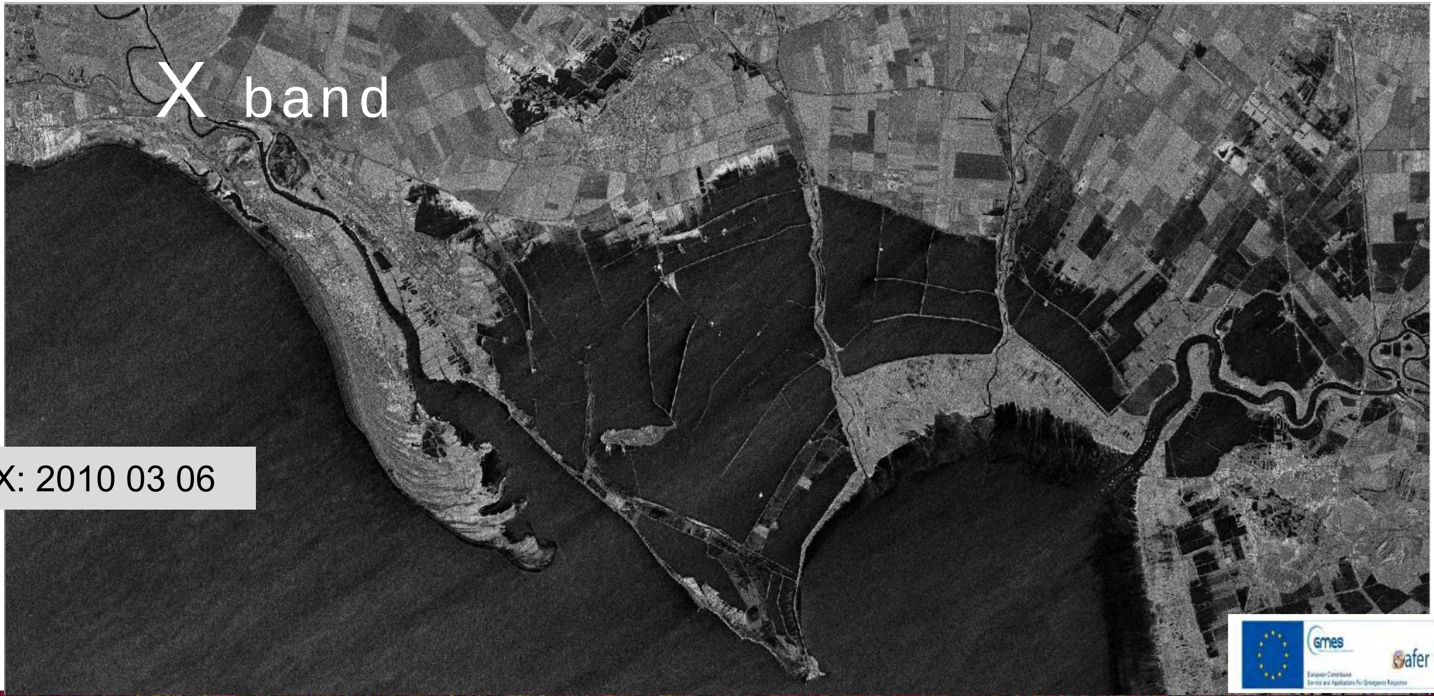


TerraSAR X: 2010 03 03

Water backscattering in function of water surface roughness

ASAR ENVISAT
APP HH HV,
10h18 the 2010 03 04

Water backscattering in function of water surface roughness



TerraSAR X: 2010 03 06

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Water recognition in function of meteo conditions

SAR: All weather system: Yes but !!!!

Distortions in the SAR observational data come from various factors.

Absorption by the atmosphere (oxygen, water vapor, and so on.)

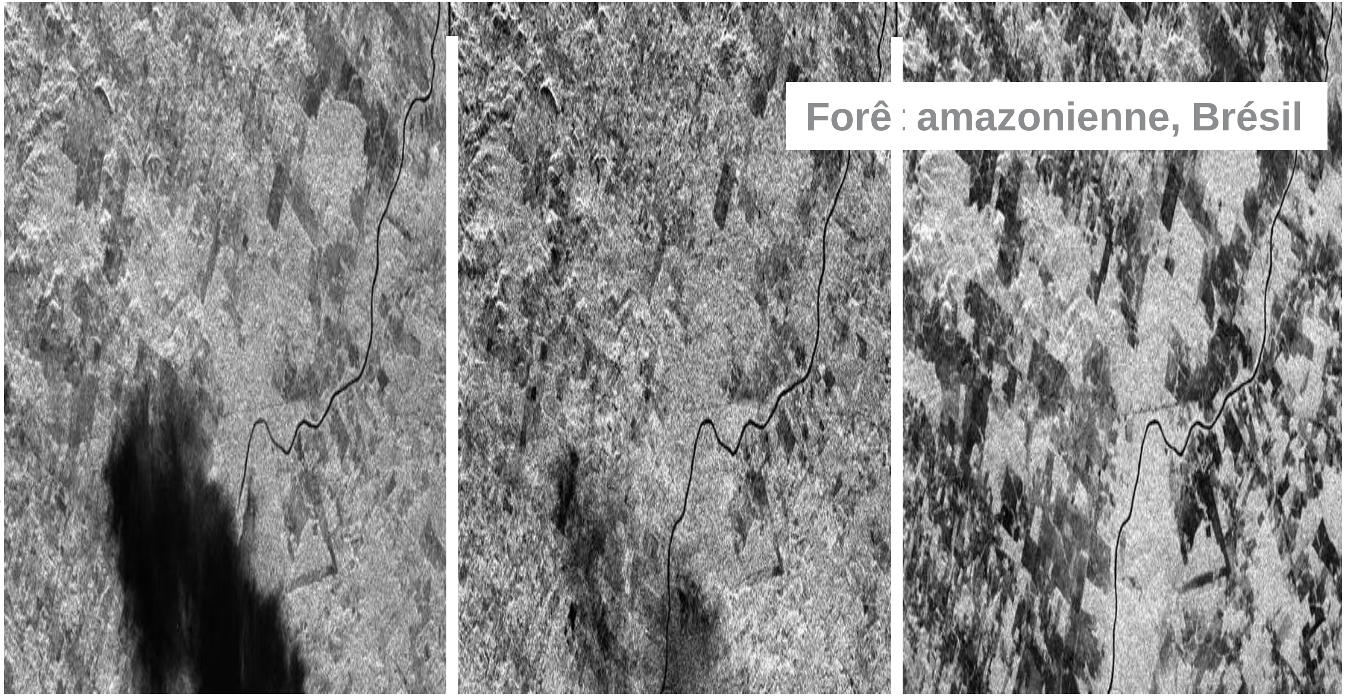
Scattering by the weather particle (Rain, snow, fog, and hail, etc.)

Faraday Rotation (FR) (Phenomenon of polarization rotation)

Observation Frequency	Example of SAR	Meteorological Particle	FR
X-Band	TerraSAR-X (9.65 GHz)	**Important**	**Negligible**
C-Band	RADARSAT-2 (5.405GHz)	↕	↕
L-Band	PALSAR (1.27GHz)	**Negligible**	**Important**

Water recognition in function of meteo conditions

Signal attenuation by clouds and rain for smaller wavelengths

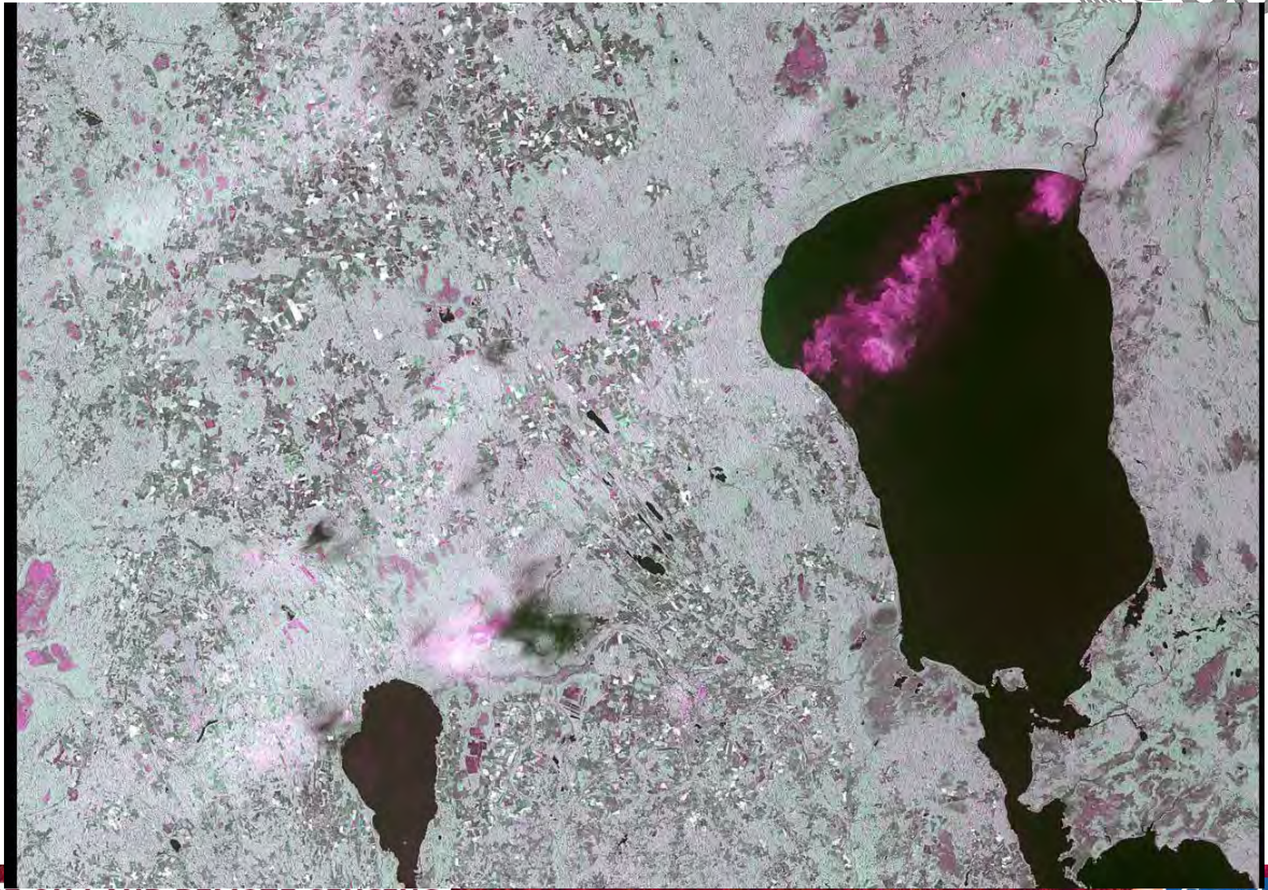


Bande X (3 cm) **Bande C (5.6 cm)** **Bande L (25 cm)**

Signal attenuation by rain (XSAR, MALI, 1994) – clouds and its shadow

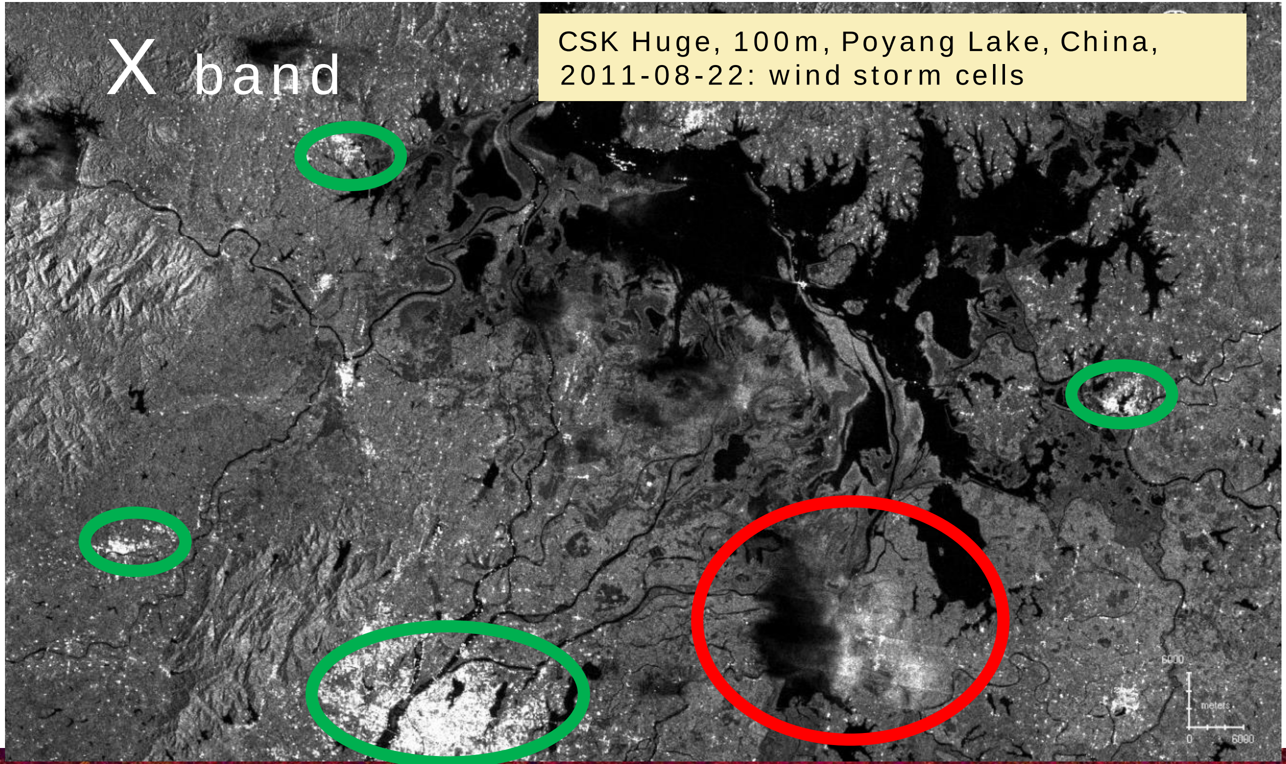
Water recognition in function of meteo conditions

Sentinel1
C Band
Rain (clouds (?) effects



Sentinel1)

Water recognition in function of meteo conditions



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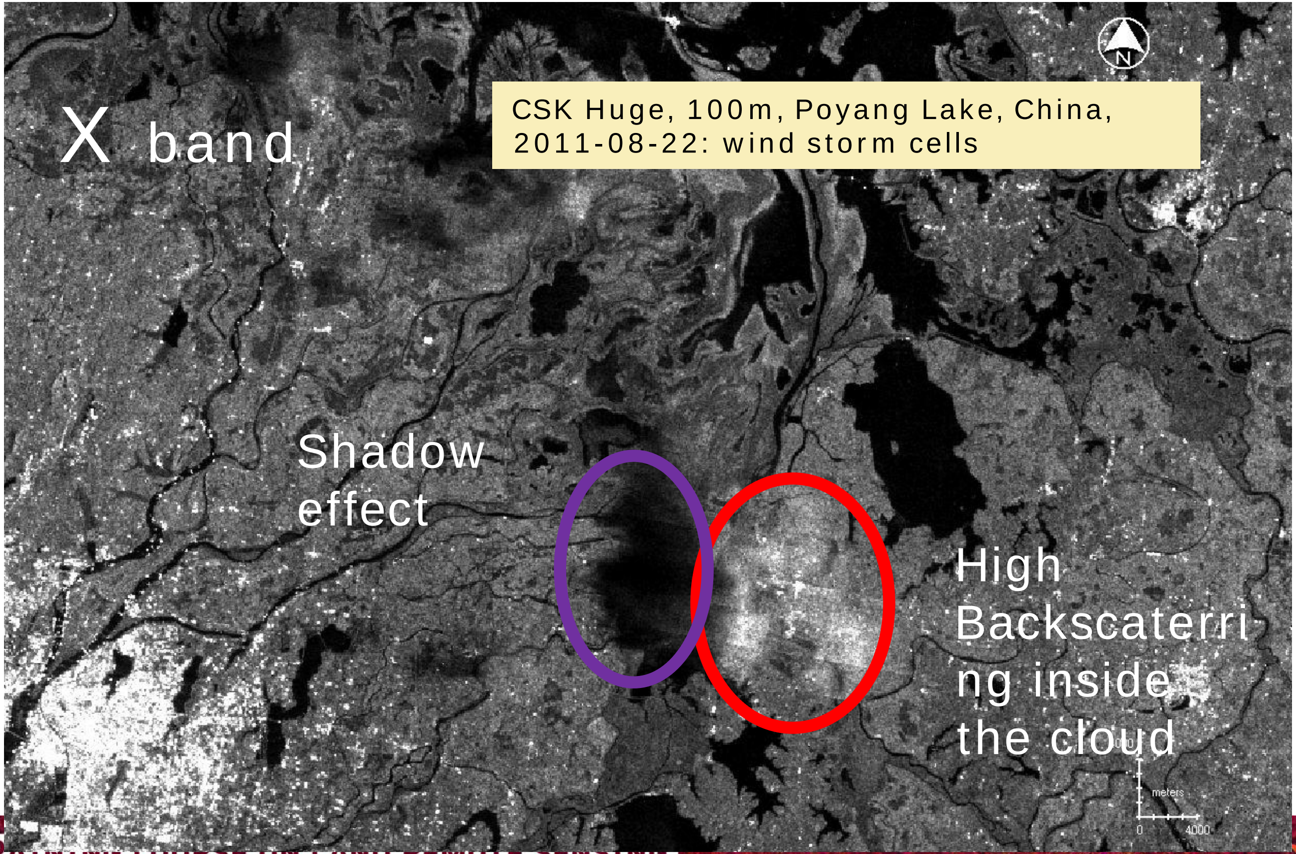

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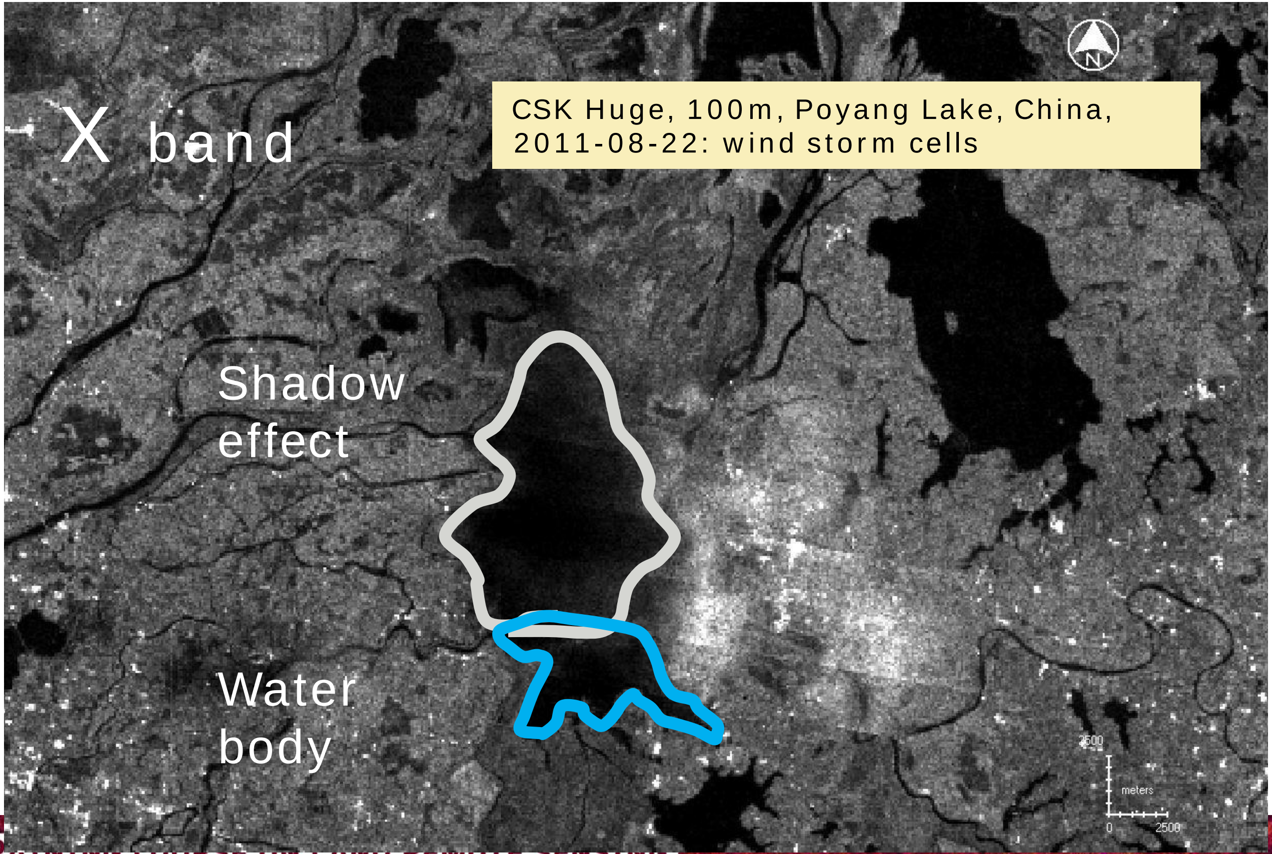
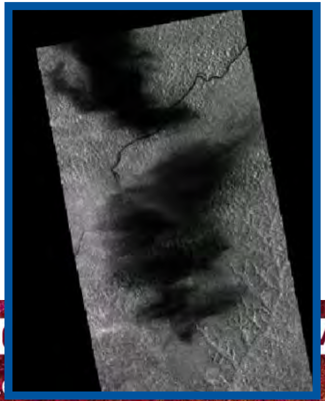
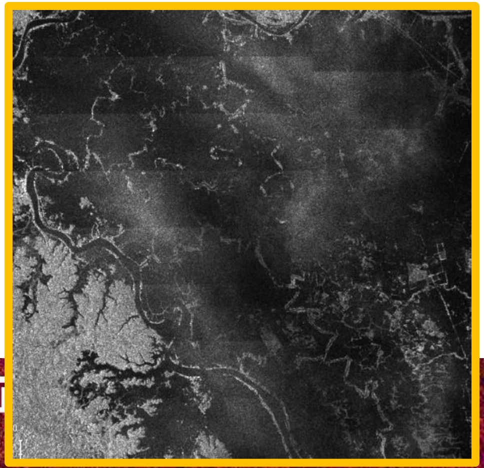


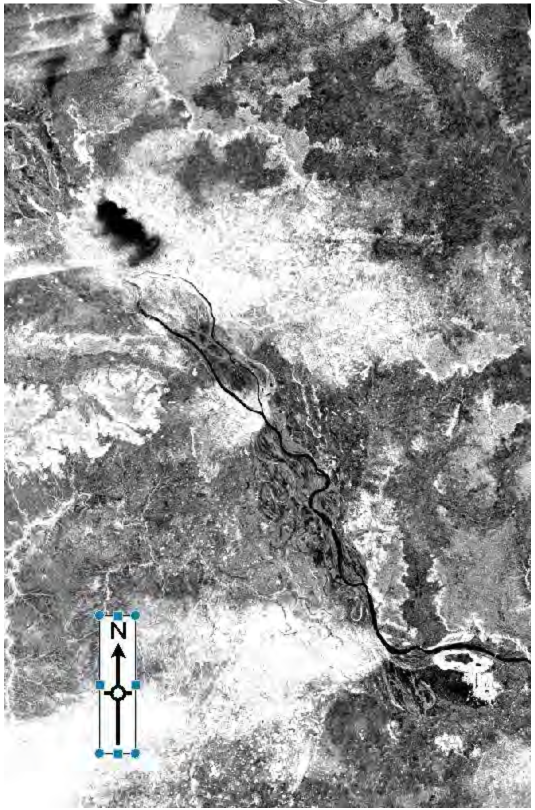
Water recognition in function of meteo conditions
Wavelength dependencies

C band:
1 image ASAR ENVISAT en bande C, over +200 analyzed
1 Sentinel1 case reported on the Web

X Band
•1 image CSK Huge, over 15 analyzed (China)...
•1 TerraSAR X Stripmap, over 5 analysed (Ivory coast
•1 TerraSAR X ScanSAR, over 3 analysed (Niger : attenuation and huge backscaterring
1 CSK, over 2 CSK (Myanmar)







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Backscattering in function of:
- Acquisition parameter
- Surface roughness
- Atmospheric/meteorological conditions

SAR sensors for water bodies and/or flood mapping
- Past mission
- On going missions
- Future missions

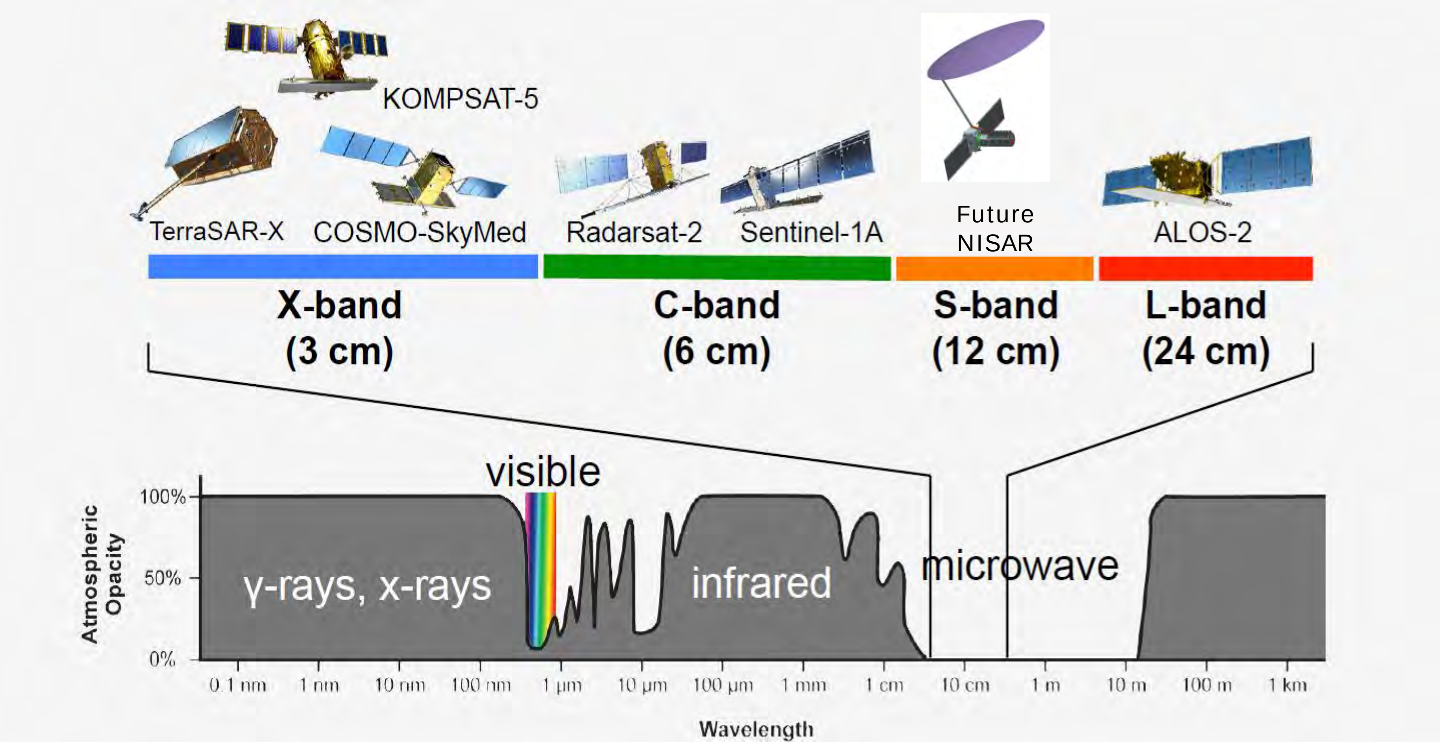
Optical

Short cut of Optical Physical basis for Water bodies mapping
Water bodies spectral signatures
Contribution of SWIR channels
Errors in water bodies mapping

Optical sensors for water bodies and/or flood mapping
Sentinel2 and S2 like sensors
VHR sensors

Concluding remarks

Wavelengths pertinent for water surface mapping/monitoring



Former missions: precursors and rich archives

1978 : First civilian SAR, SEASAT (USA).; 108 days

1981 : SIR A Mission, on board on US Shuttle , band L

1984 : SIR-B, Mission, on board on the US Shuttle, Band L, 5 - 13 October 1984

1991 : ERS-1 , ESA , launch 17 of July 1991 , ended in March 2000

1992 : J-ERS , Japan

1994 : SIRC X SAR, two shuttle’s missions (10 days: 9/20-04-1994 and 30-09 - 11-10-1994)
Bande L, C et X

1995 : ERS-2 , in tandem with ERS1 , ended in September 2011 (16 years of operation)

1995 : RADARSAT 1, Canadian Space Agency

2000 : Mission SRTM, topographic mission on the shuttle , 11-22 February 2000

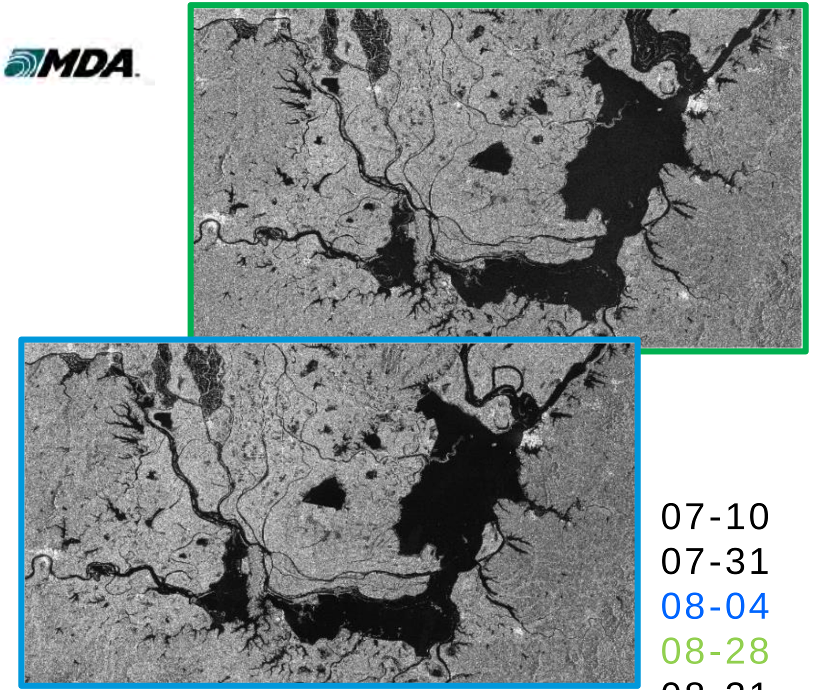
2002 : Envisat, European Space Agency ended 12 of May 2012

2006 : PALSAR's L-band SAR, on ALOS mission (ended in 2011)

Importance of the Archive: Flood memory

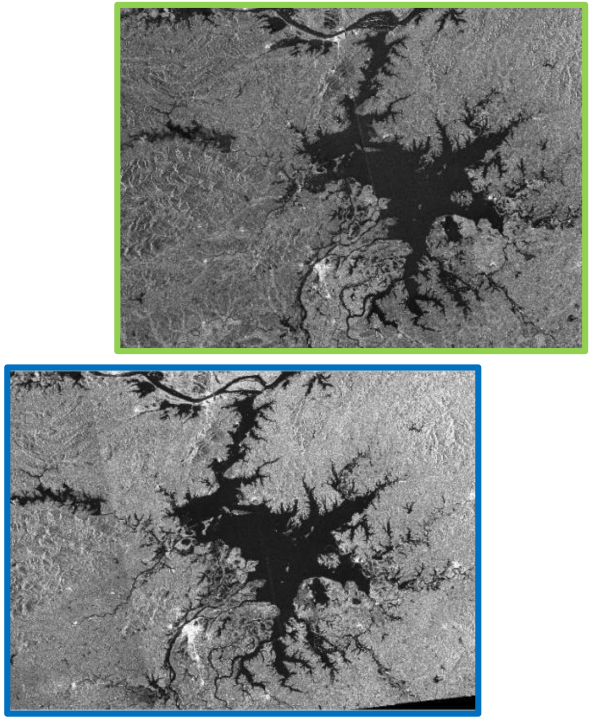
Radarsat over 1998 Yangtze historical flood

MDA



07-10
07-31
08-04
08-28
08-31

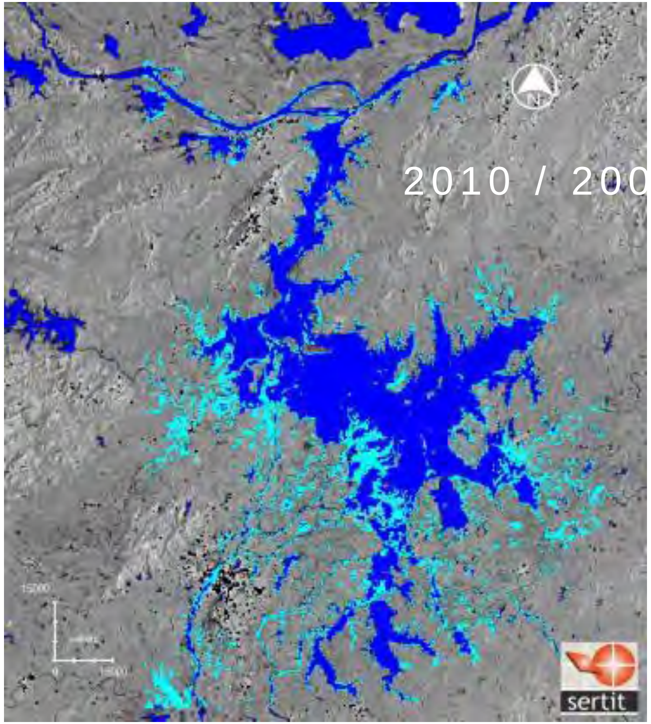
Dongting 1998: SCN, SCW, SGF

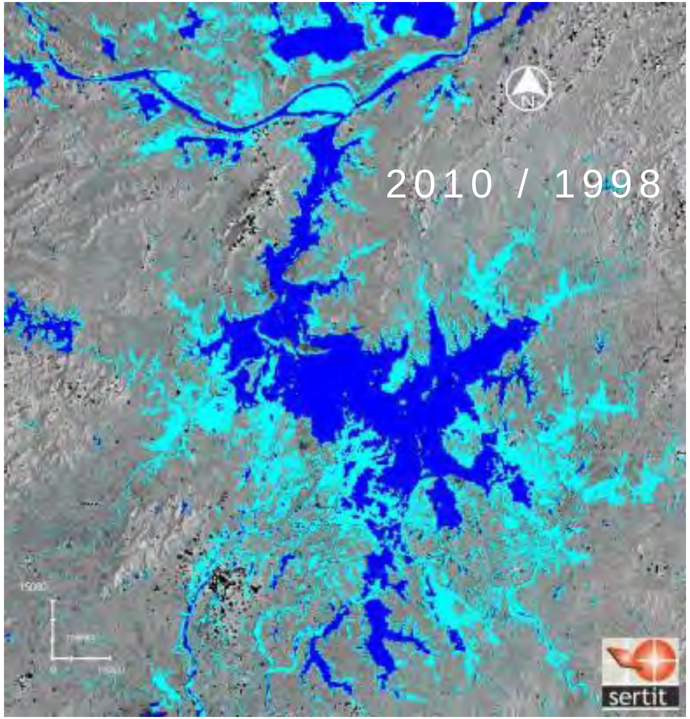


07-22
07-25
07-31
08-04
08-07
08-14
08-17
08-31

Poyang 1998: SGF, SCW,

Analysis of Poyang lake Summer 2010 flood
2010 versus 2002 and 1998





2010 flood event is an important one in Poyang last decade history
2010 extent (3354 km²) no far to the 2002 extent (3392 km²)
2010 much smaller in term of extent than 1998 (4116 km2)

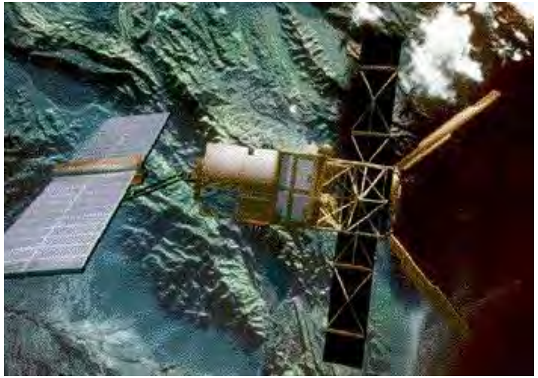
ERS 1 - 2

ERS 1 launch, 1991,17 of July
ERS 2 in 1995, 21 of April

C Band, VV

Cycle: 35 days
Cycle: 3 days

Cycle: 265 days, Geoid & bathymetry



Operational mode	Band	Center frequency	Polarization	Incidence angle	Spatial resolution	Swath width
SAR Imaging mode	C-band	5.3 GHz	LV (linear vertical)	23º at mid-swath	10-30 m	100 km
SAR Wave	C-band	5.3 GHz	LV	23º ±0.5º	30 m	5 km x 5 km
AMI-SCAT (wind)	C-band	5.3 GHz	LV	Fore/aft: 25º-29º Mid: 18º-47º	50 km	500 km

ERS 1 – 2: precursors systems

ERS SAR data have been wordily exploited for flood mapping

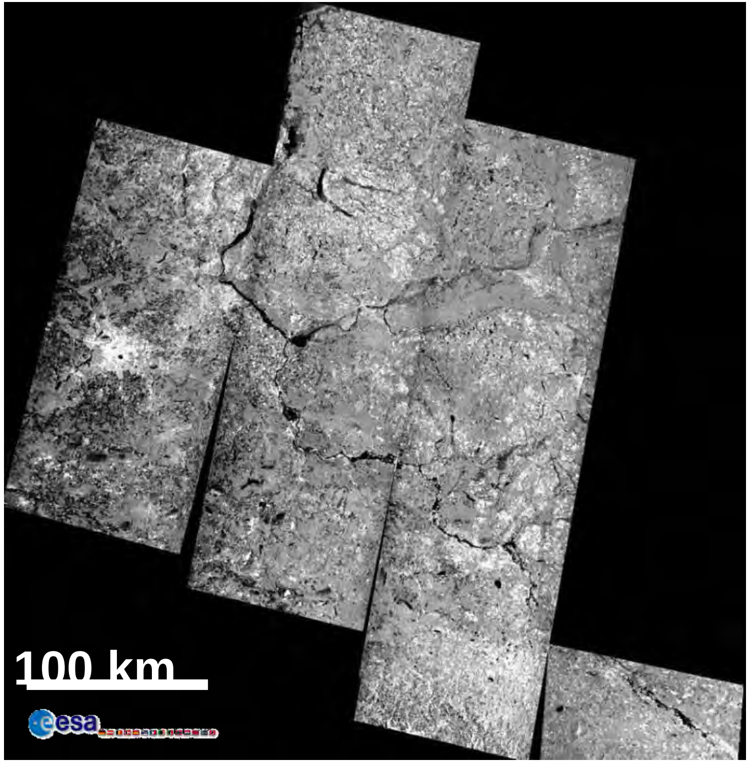
(cf numerous papers on ESA conferences)

- Thames flood 1992
- Camargue flood in 1993
- Meuse flood 1993-1994
- Aude flood 1996
- Oder flood in 1997
- Chinese flood in 1998

and many more…

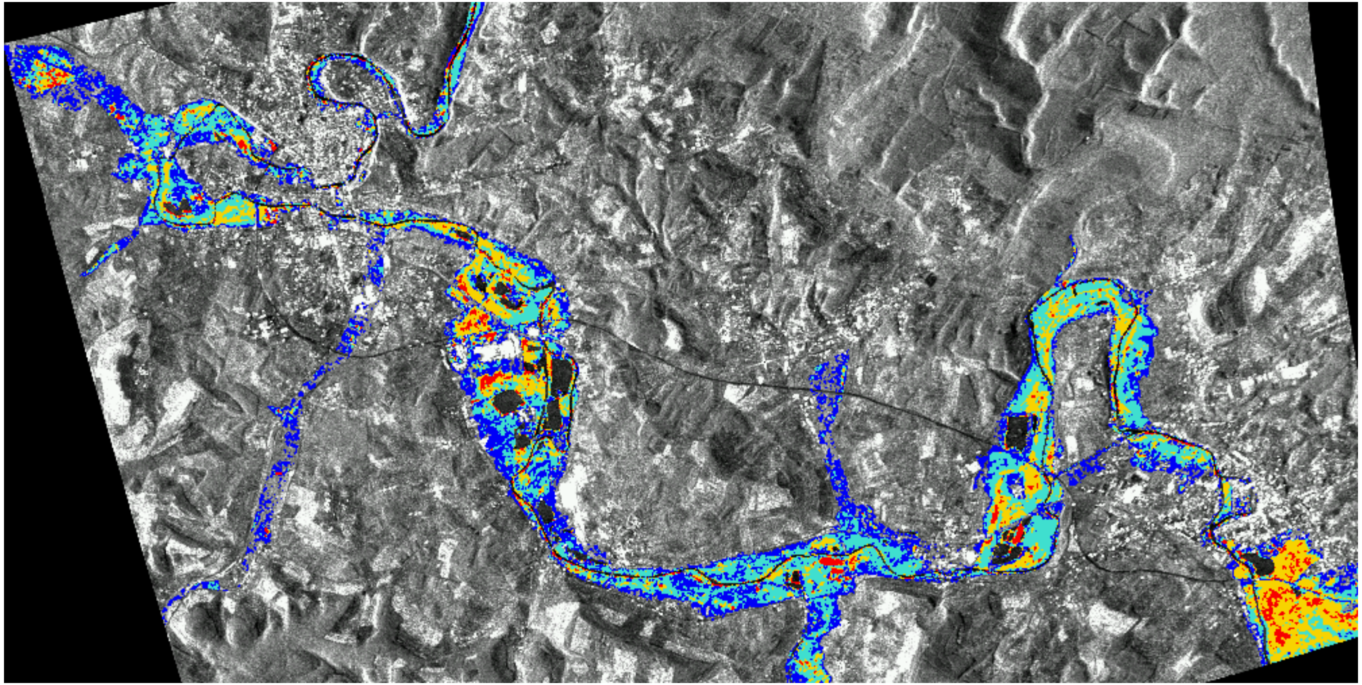
=> Polish floods, 19-05-2010

Exploiting mostly the Amplitude



ERS Mosaïque over the Oder river :
Acquired 30-07 to 9-08-97

Flood mapping based on ERS 1 - 2



ERS: experimental 3 days mode from winter 93 to spring 94
Map of water permanency during the Meuse flood draw off in spring 1994
(Yésou et Chastanet, 2000)

Flood mapping based on ERS 1 - 2 INSAR

Few examples of Coherence exploitation

Aude 96 flood event

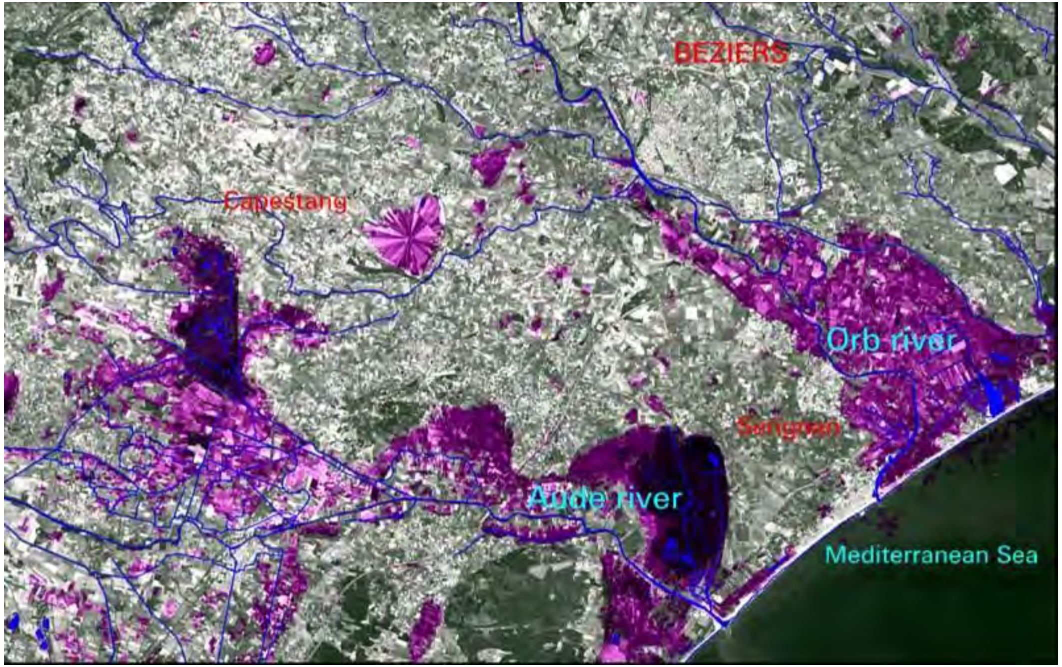
ERS-2: 7 8 1995
ERS-2: 29 01 1996
ERS-1: 28 01 1996

Acquisition near the maximum of the flood

2 consecutives images

Exploitation of the phase information: lost of coherence on water surface

(Marinelli et al., 97 ; Nico et al., 2000 ; Sarti, 2004)



(© CEMAGREF 1996 , © ESA, 1996)

On going SAR Missions

2007 : June launches constellation Cosmo Skymed constellation , Terra SAR X
December: Radarsat 2

2012 : launch of RISAT (ISRO) , operational mode in 2015

2014 : Launch ALOS 2, bande L

2014-2016: Launches of Sentinel 1A and 1B (Constellation Copernicus)

2016 : Gaofeng 3, C band (Quad Pol)

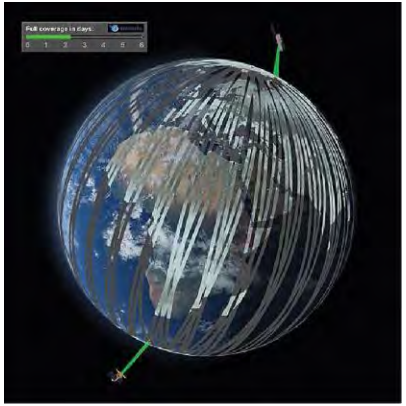
SENTINEL 1

The Sentinel-1 series : part of the GMES programme
Sentinel1A, 2014 Sentinel1B, 2016

Priority : ensure continuity for C-band data
Improvement of SAR signal (30% better than ENVISAT)

Multi mode

- Strip map: 80 km swath , 5m
- Interferometric Wide swath mode IW, 250km, 20 m
- Extra wide EW Swath , 400 km , 25x100 m
- Wave mode, WV, low data rate, 5x20m
- Swath 250 km

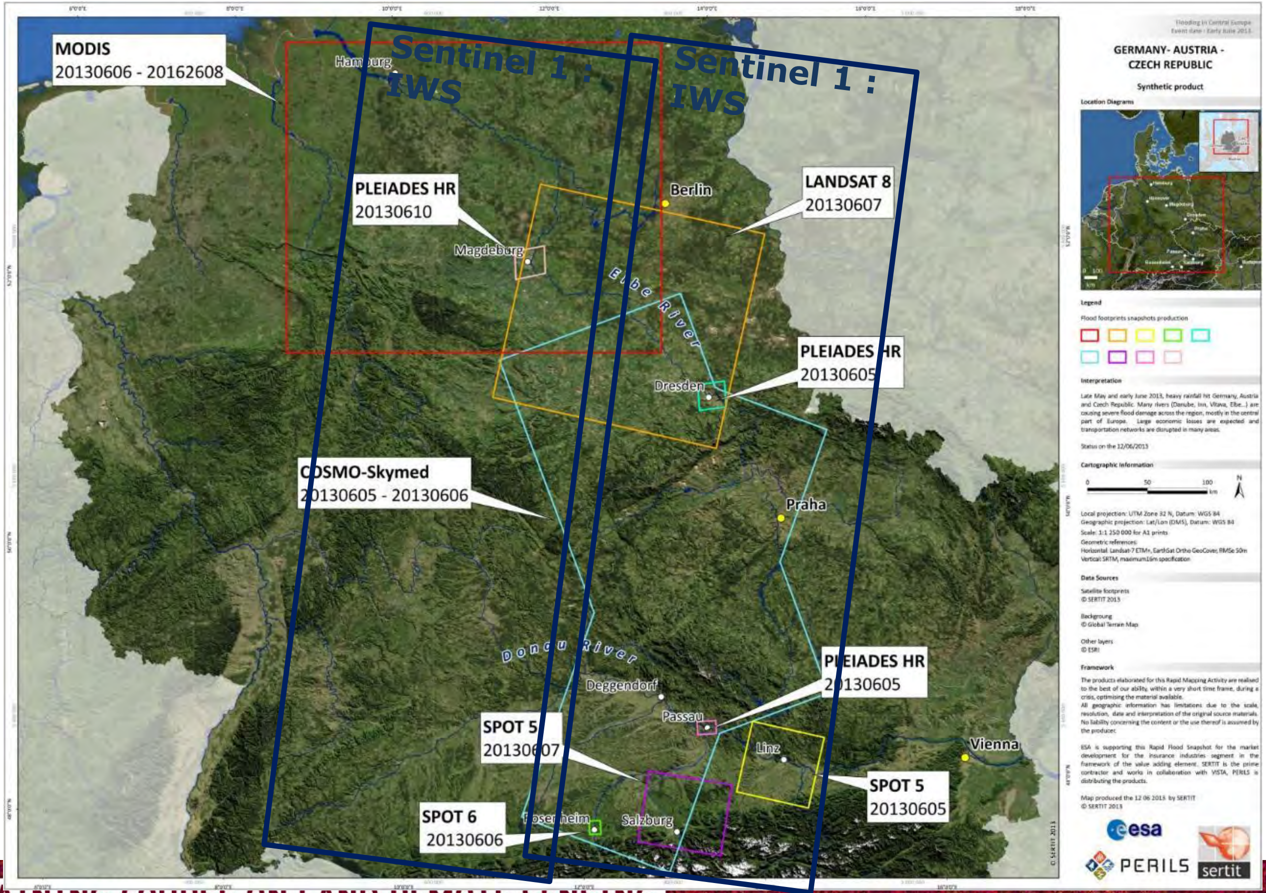


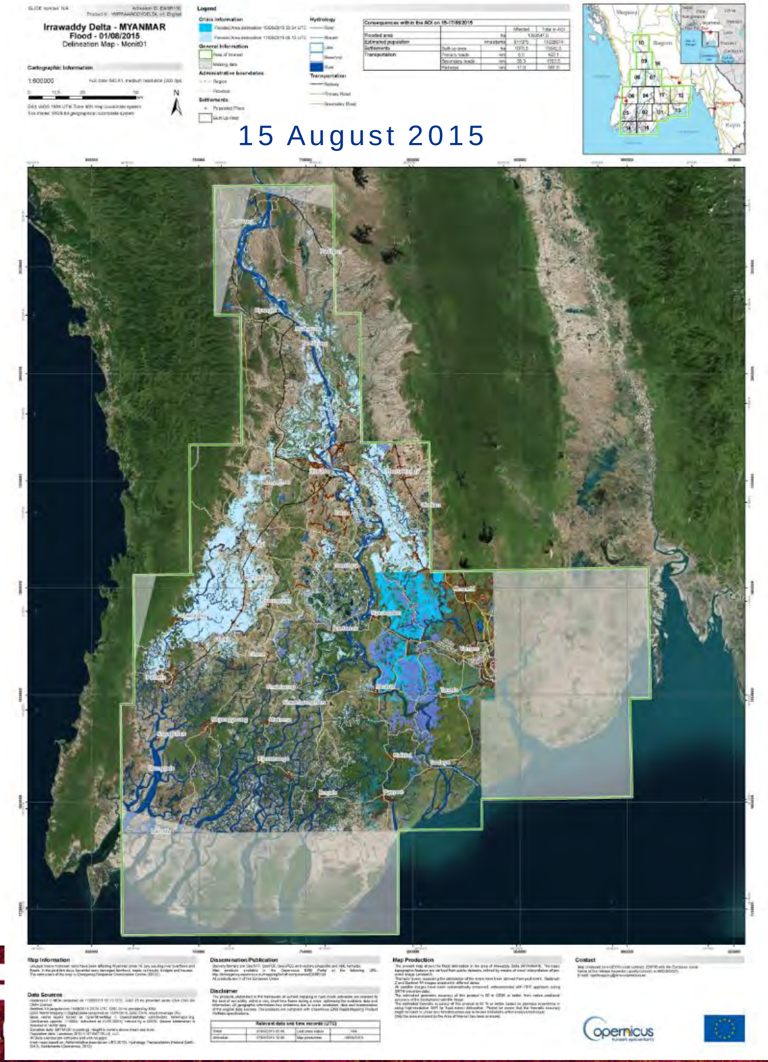
Polarisation modes:

- VV or HH in wave mode
- Selectable dual pol for all other mode HH+HV; VV+VH

- => follow on until 2030...

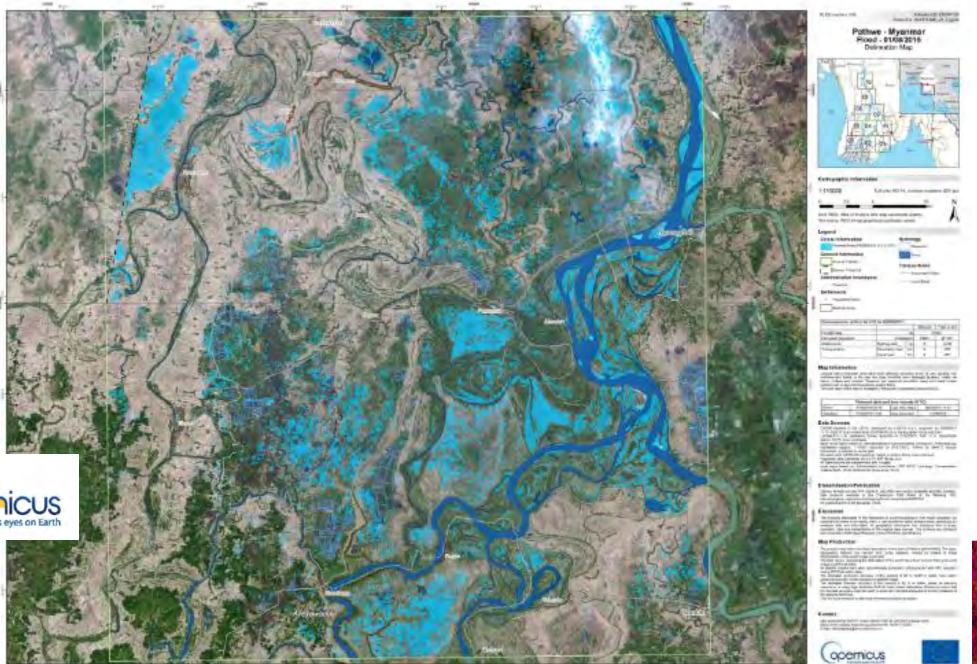
Sentinel 1 improvement in term of swath : standard mode

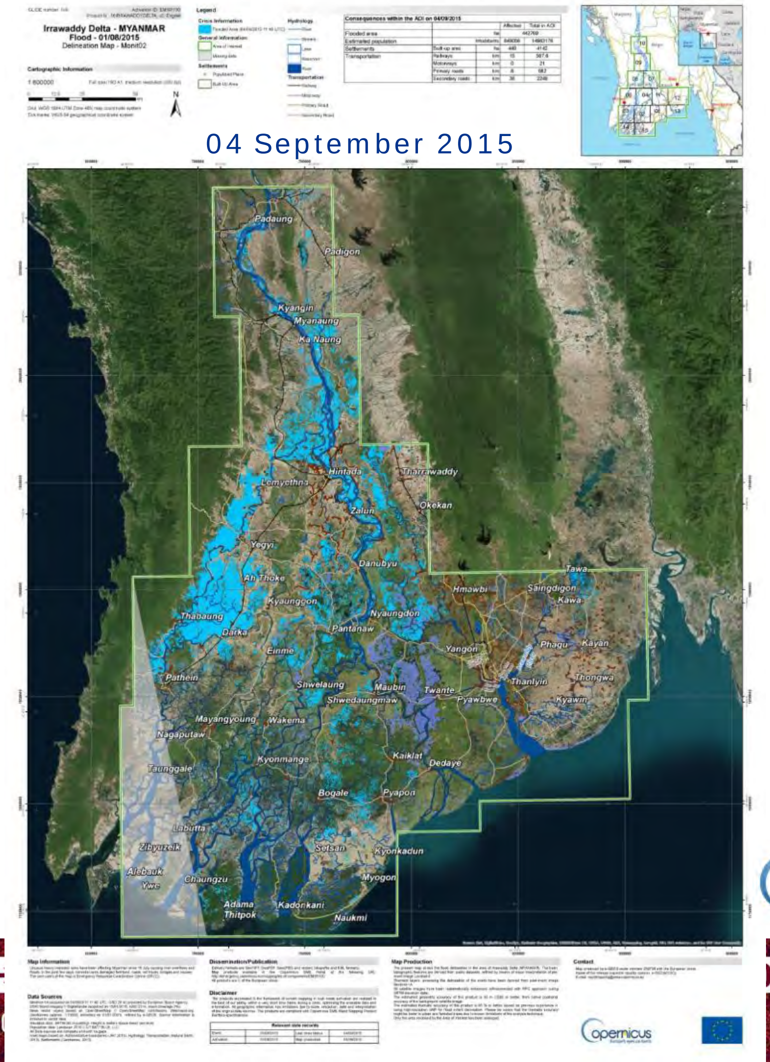




Sentinel1: revisit and large swath

Myanmar
Heavy monsoon rain caused river overflow and flooding in August 2015

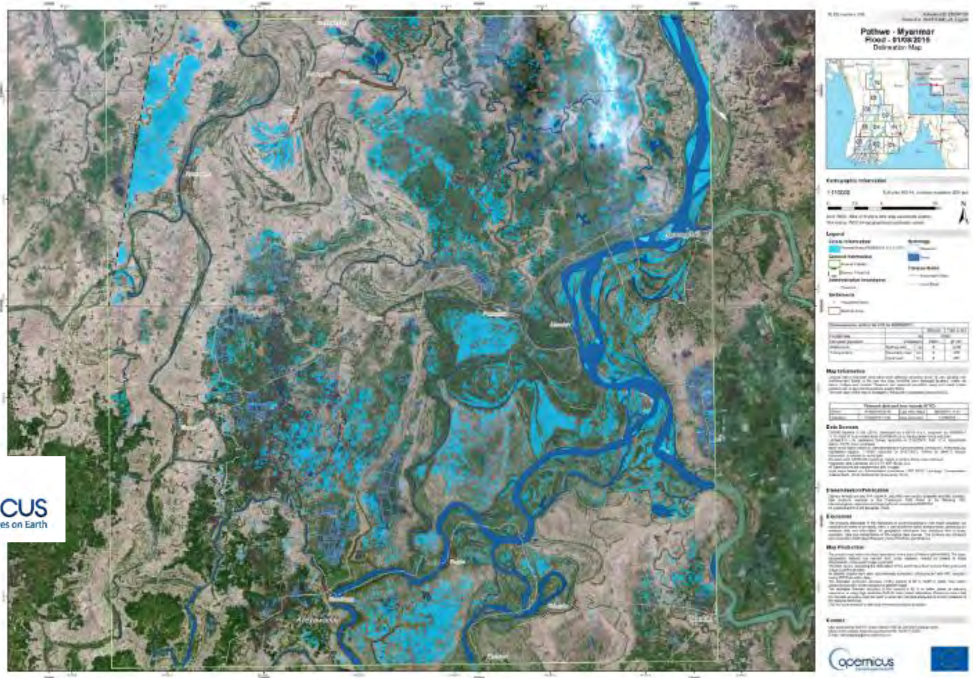




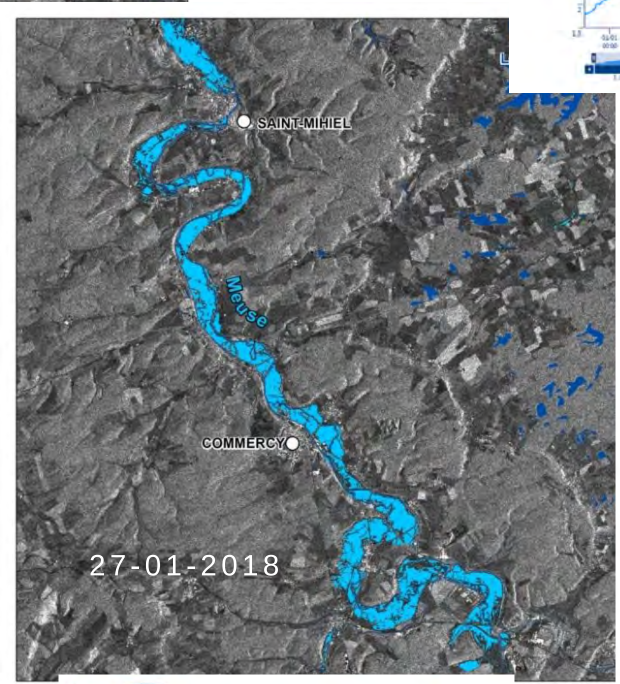
04 September 2015

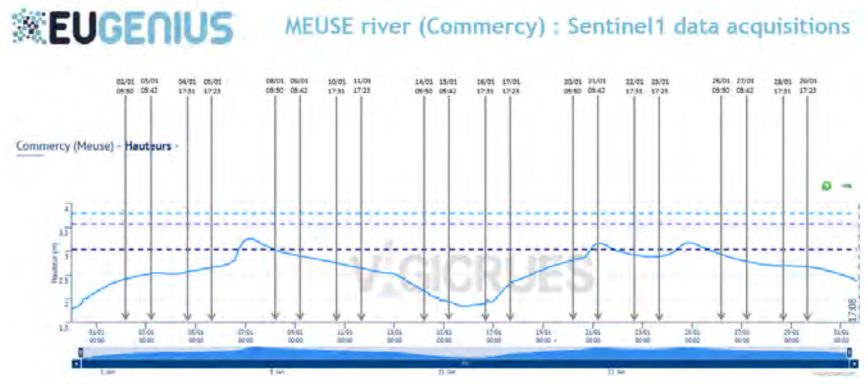
Sentinel1: revisit and large swath

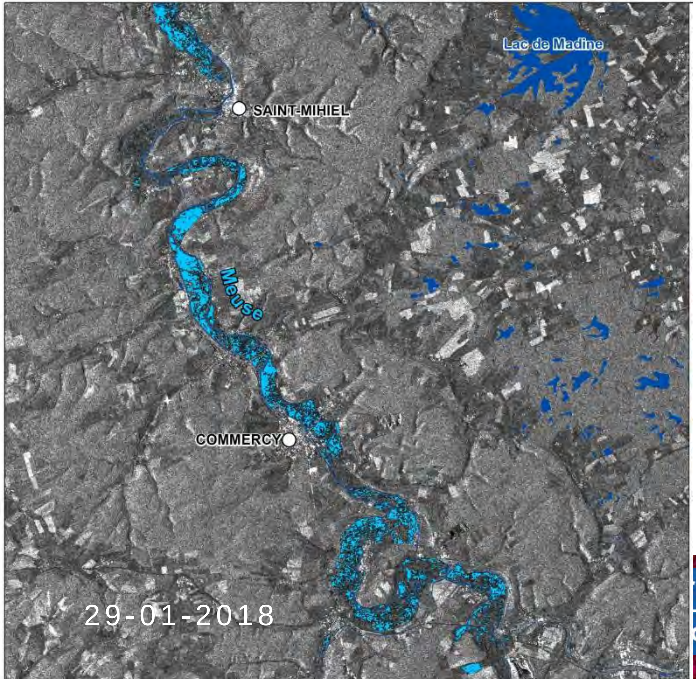
Myanmar
Heavy monsoon rain caused river overflow and flooding in August 2015



Sentinel1 :Flood Events of January 2018 in the Grand Est region (France)







sentinel-1

On Going VHR and polarimetric SAR:

X Band: VHR SAR: TerraSAR, CosmoSkymed

C Band: RadarSAT II: VHR and Full Pol

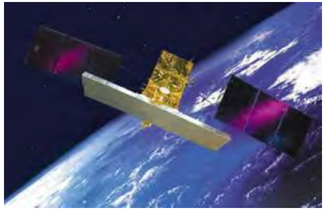
GAOFENG 3: VHR and Full Pol

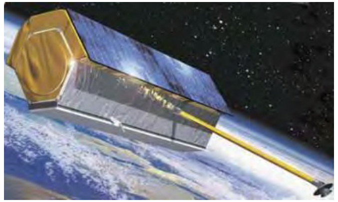
L Band : PALSAR II bi & Full Pol, large swath ScanSAR mode

See Pr. Pottier presentations

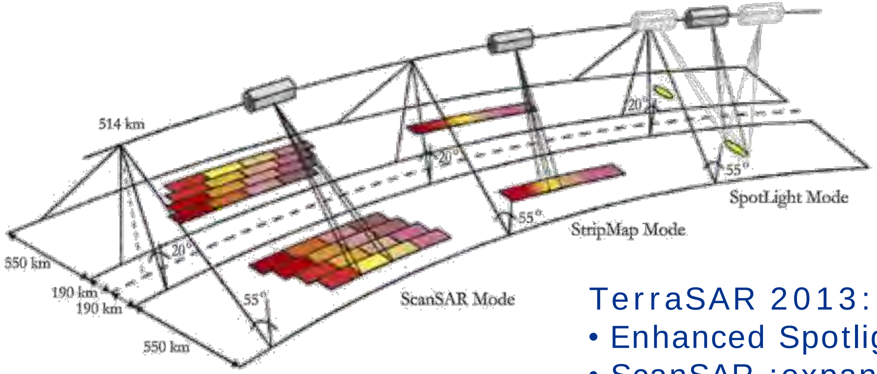
X band VHR satellites

- Cosmo-Skymed: Italian, Launch: 08-06-07 , Constellation of 4 Dual civilian-military
- Terra SAR: German, Launch: 15-06-07





Multi mode, Spotlight, Stripmap, ScanSar
Pol capabilities

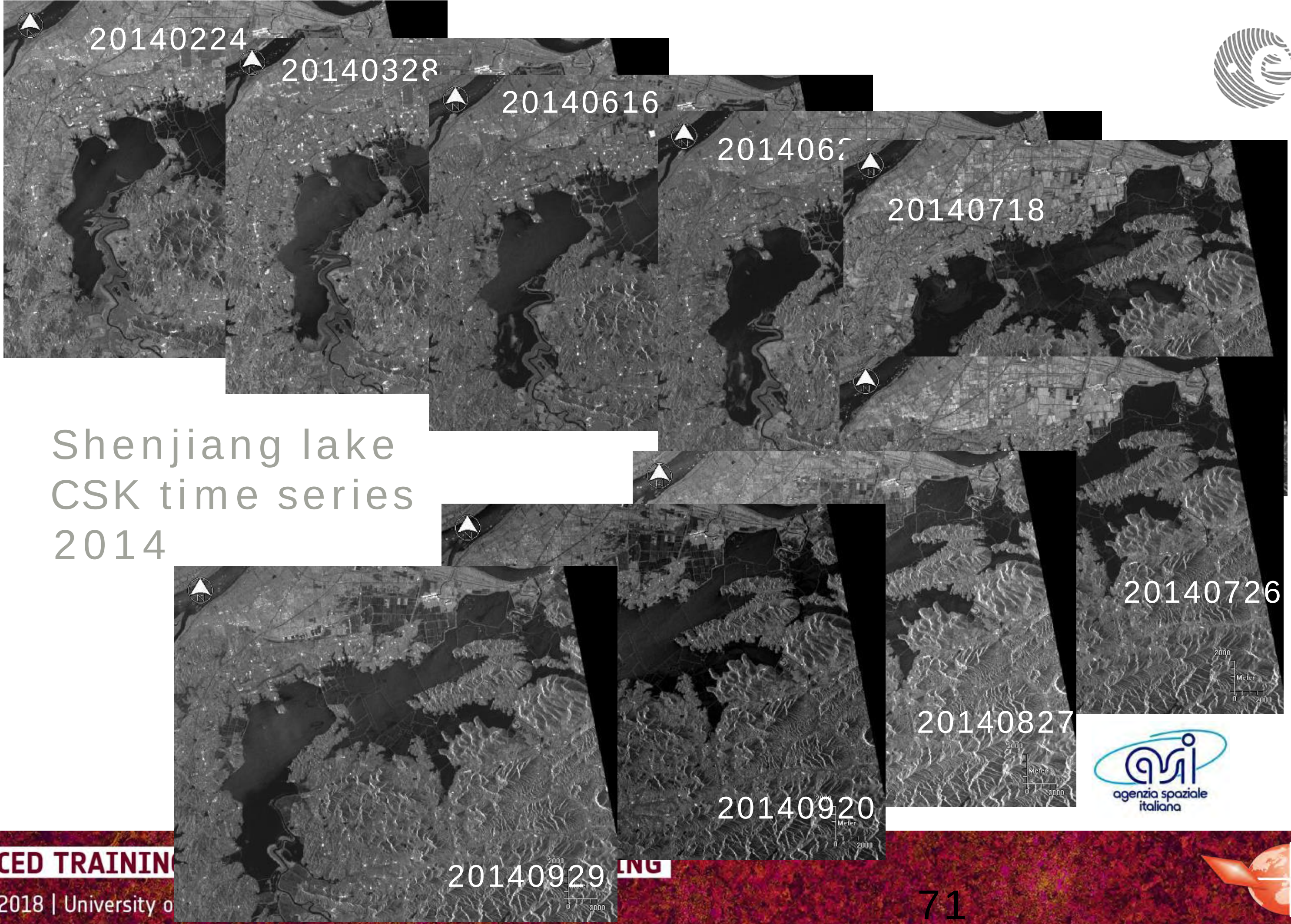


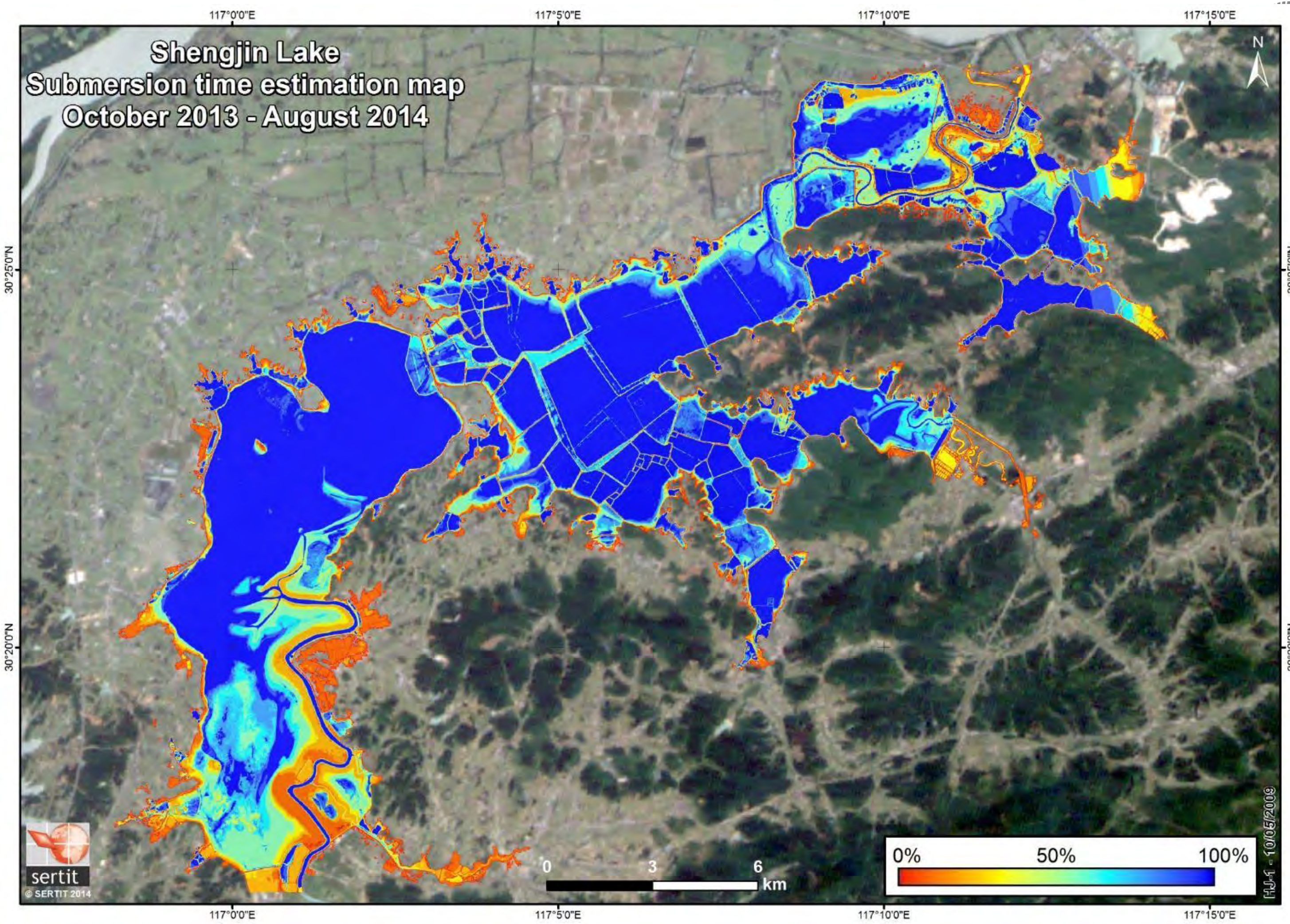
TerraSAR 2013: New operational Imaging Modes

- Enhanced Spotlight Mode (Starring Spotlight).
- ScanSAR :expanded swath width (200 instead of 100km).

The VHR and polarimetric SAR: TerraSAR, CSK

Shenjiang lake CSK time series 2014

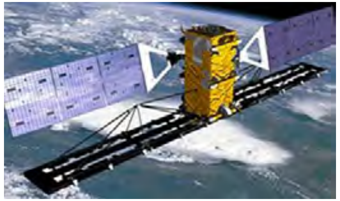


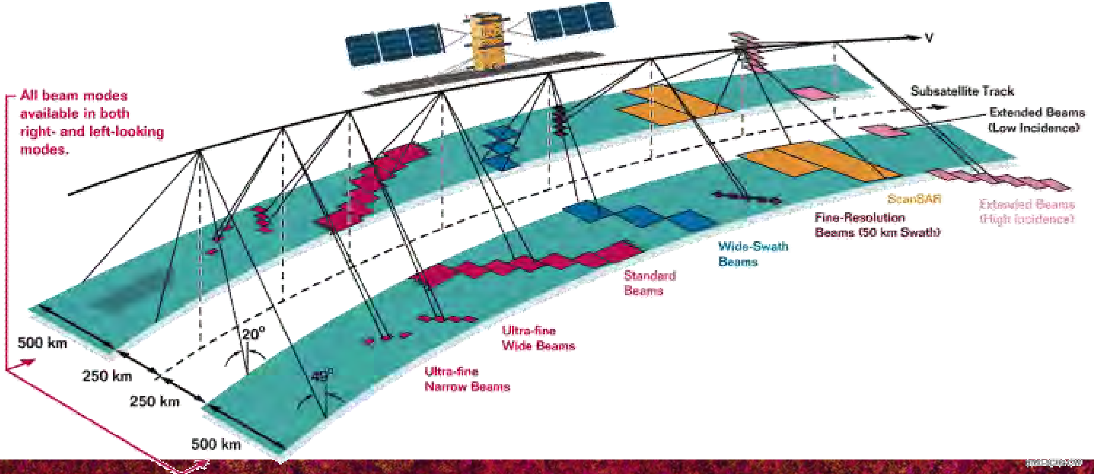

Shengjin Lake
Submersion time estimation map
October 2013 - August 2014
117°0'0"E
117°5'0"E
117°10'0"E
117°15'0"E
30°25'0"N
30°20'0"N
N
0
3
6
km
0%
50%
100%
HJ-1 - 10/05/2009
sertit
© SERTIT 2014

The VHR and polarimetric SAR: Radarsat

C band : Radarsat II: Canadian, left right looking Launch: 14-12-07 C

- High resol mode, 3m band
- Full polarimetric mode (scientific)





Exploitation of VHR SAR: Radarsat II
Polarimetric approach

Exploitation of the polarimetric information based on the entropy (valuable technics in natural/Agricultural landscape)

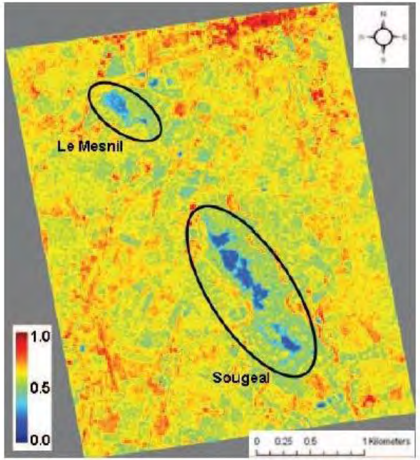


Figure 3- *The normalized Shannon Entropy (SE) image.*

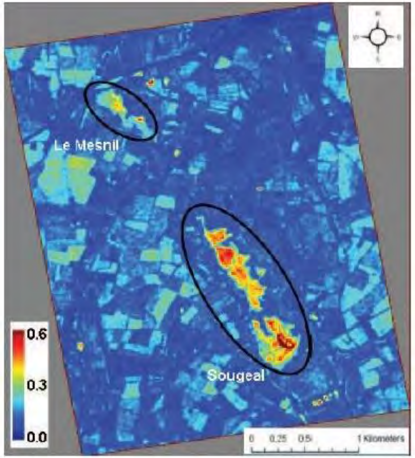


Figure 4- *Temporal coefficient of variation of the SE parameter*

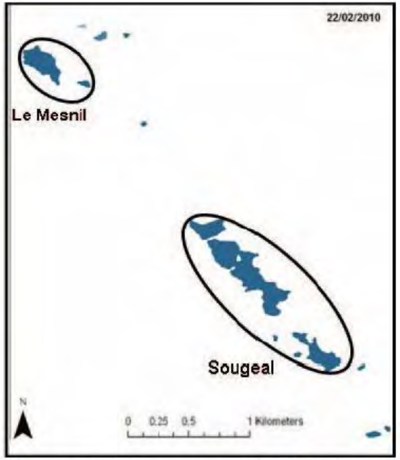


Figure 5-*The segmented SE image with the open water in blue*

From Maréchal, Pottier et al., Igarss 2011; Pottier et al., Igarss Munich 2012

Advanced Land Observing Satellite (ALOS II) PALSAR

L Band

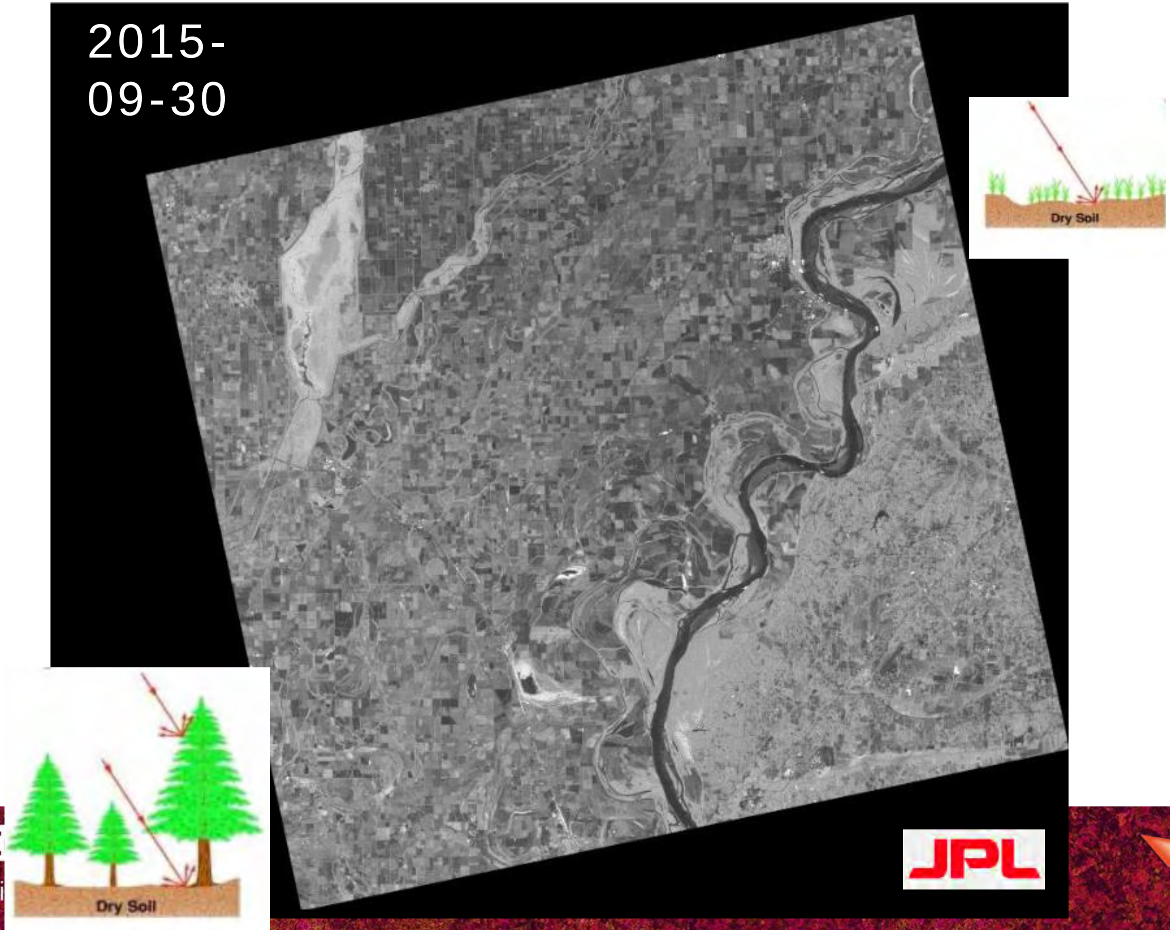
Phased Array type L-band
Synthetic Aperture Radar (PALSAR)

Left/right looking

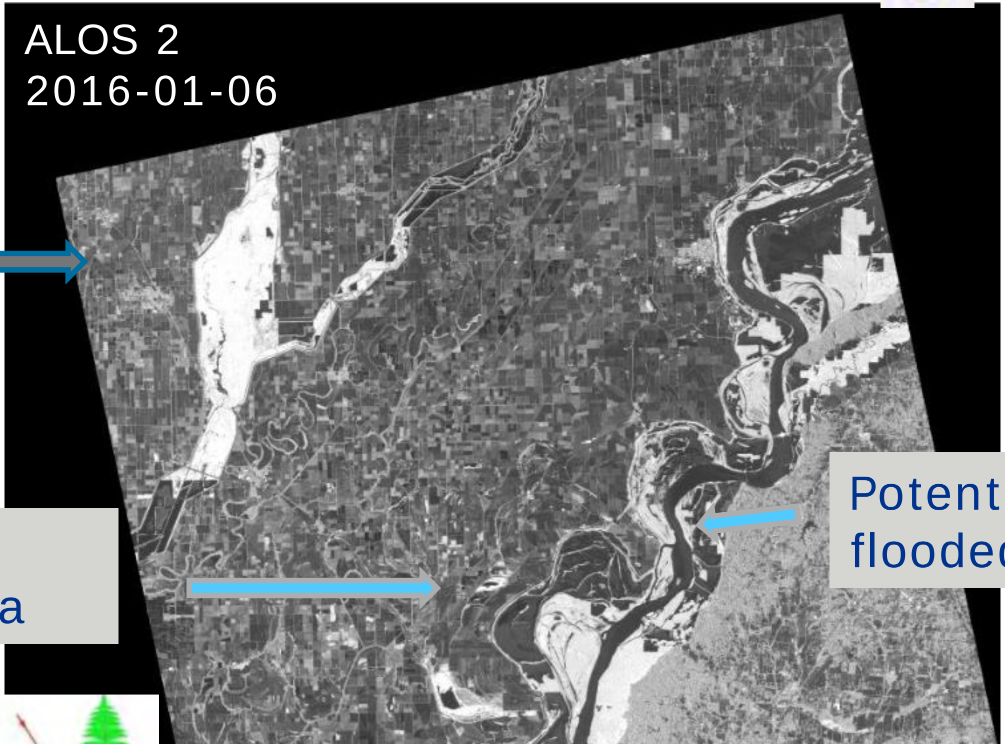
WS to ultra fine (490 to 25km => 60 m to 1m)

24 May 2014

Advanced Land Observing Satellite (ALOS II) PALSAR



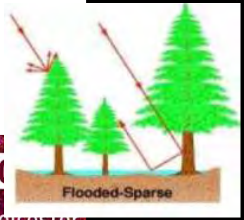
Advanced Land Observing Satellite (ALOS II) PALSAR

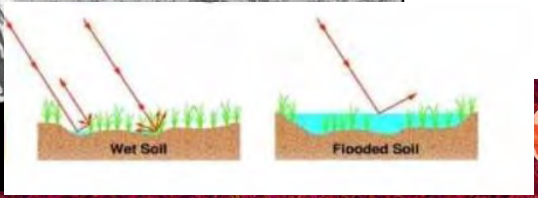


Flooded area under or with tall vegetation

Potentially flooded area

Potentially flooded area





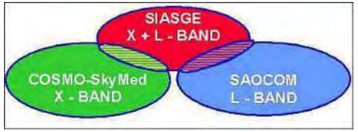
Coming SAR missions

Nov. 2018 : Radarsat Constellation Mission (RCM) , C Band, Singl, Dual, Hybrid Pol,
Revisit 4 days

2018-2019 SIASGE Italian-Argentine System of Satellites for Emergency management

October 2018-2019 : SAOCOM de la Conae, L band (Singl, Dual Twin Pol, revisit 4 days) two satellites A & B

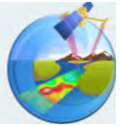
2018- 2019 : COSMO SkyMed Second Generation ,
(X band Sing/Dual/Quad Pol)



2021 : BIOMASS P band, not suitable for flood/lake mapping too coarse resolution (May some interest for DEM under forest)

2021 : NISAR , Indo American mission, bande L et S

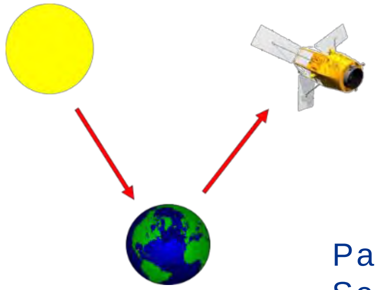
2021 : SWOT Altimetry Mission,



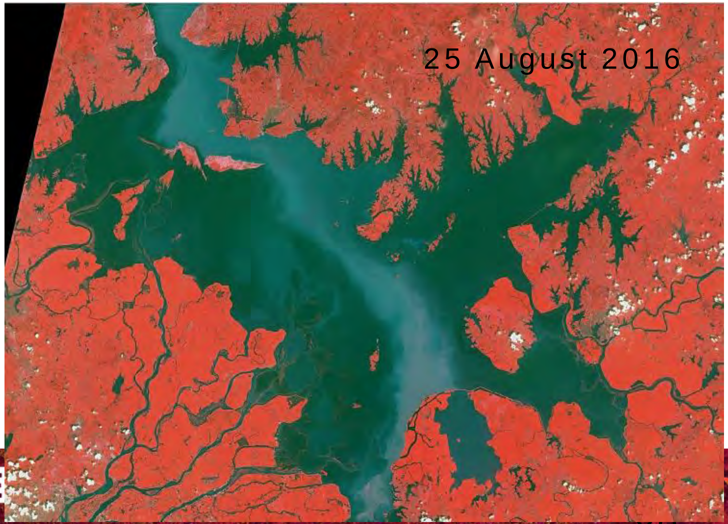
Presentation outline

Context	Why flood mapping and monitoring Flood in the landscape
SAR	Short cut of SAR Physical basis for Water bodies mapping Backscattering in function of: • Acquisition parameter • Surface roughness • Atmospheric/meteorological conditions SAR sensors for water bodies and/or flood mapping • Past mission • On going missions • Future missions
Optical	Short cut of Optical Physical basis for Water bodies mapping Water bodies spectral signatures Contribution of SWIR channels Errors in water bodies mapping Optical sensors for water bodies and/or flood mapping Sentinel2 and S2 like sensors VHR sensors
	Concluding remarks

Clear sky
Sunny weather
⇒ Sentinel 2
⇒ SPOT 6-7
⇒ Pléiades HR
⇒ ….



Pasive Remote Sensing
Optical sensors

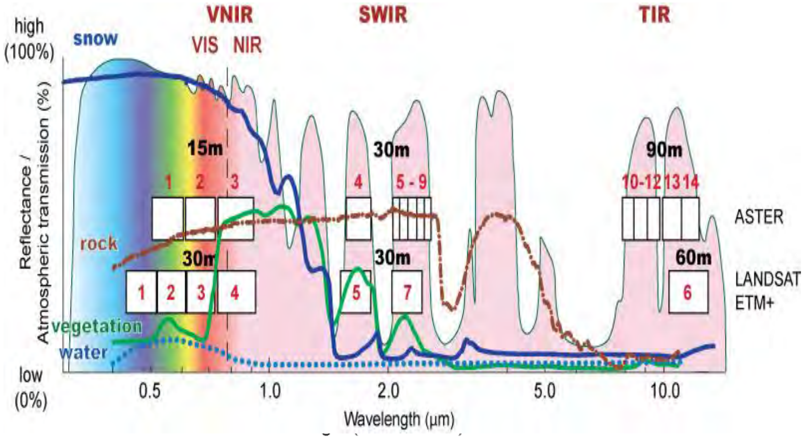


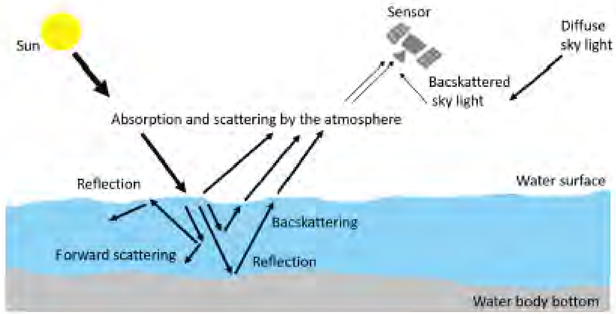
Short cut of Physical basis for Water bodies mapping

Water absorbs the longer wavelengths of visible and NIR and SWIR domains
Reflects the shorter wavelengths of the visible domain (blue, green)

⇒ More precisely water color depends on:

- Depth (ground influence sand/rocks)
- Materials in suspension
- Vegetation or algae





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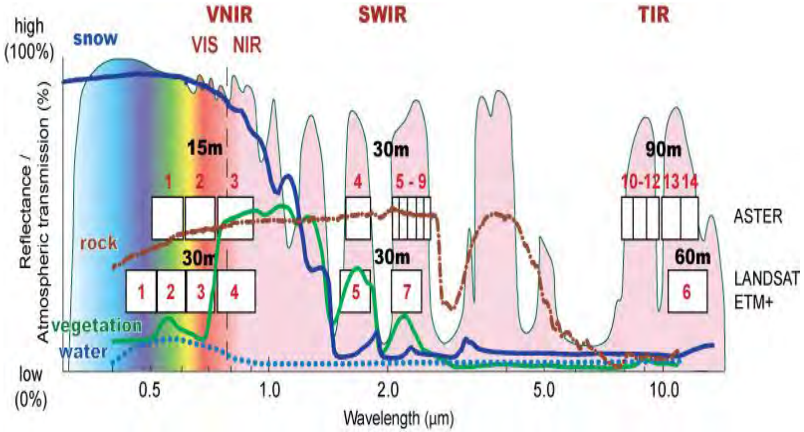

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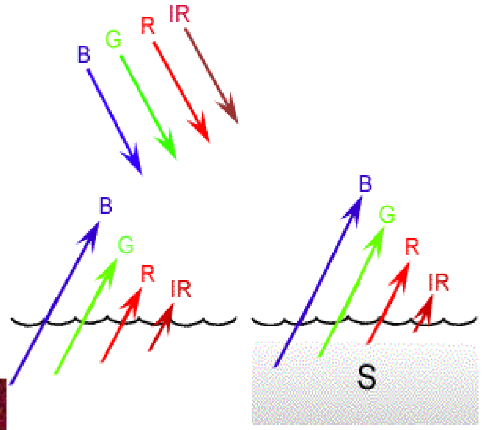
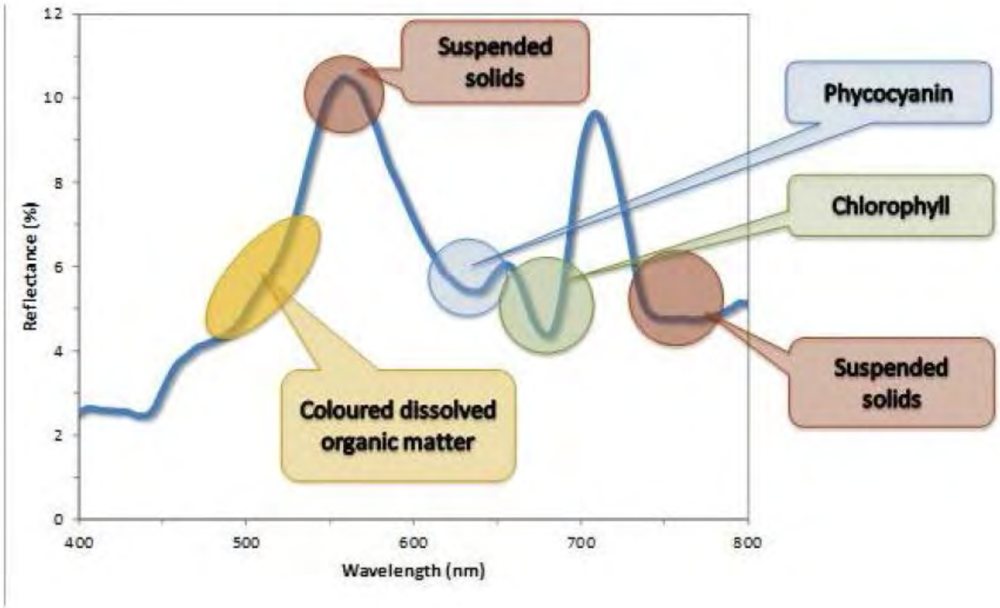
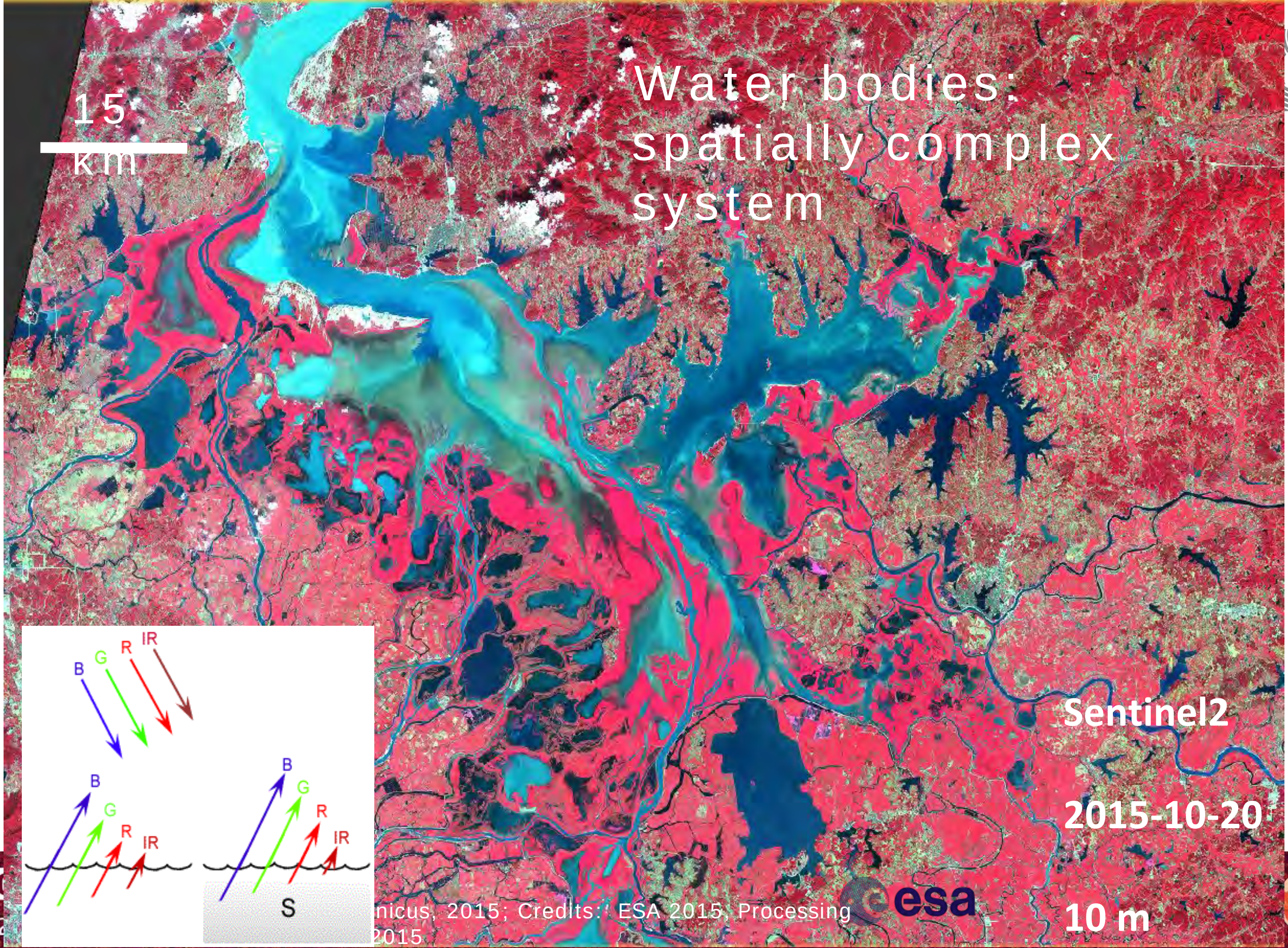


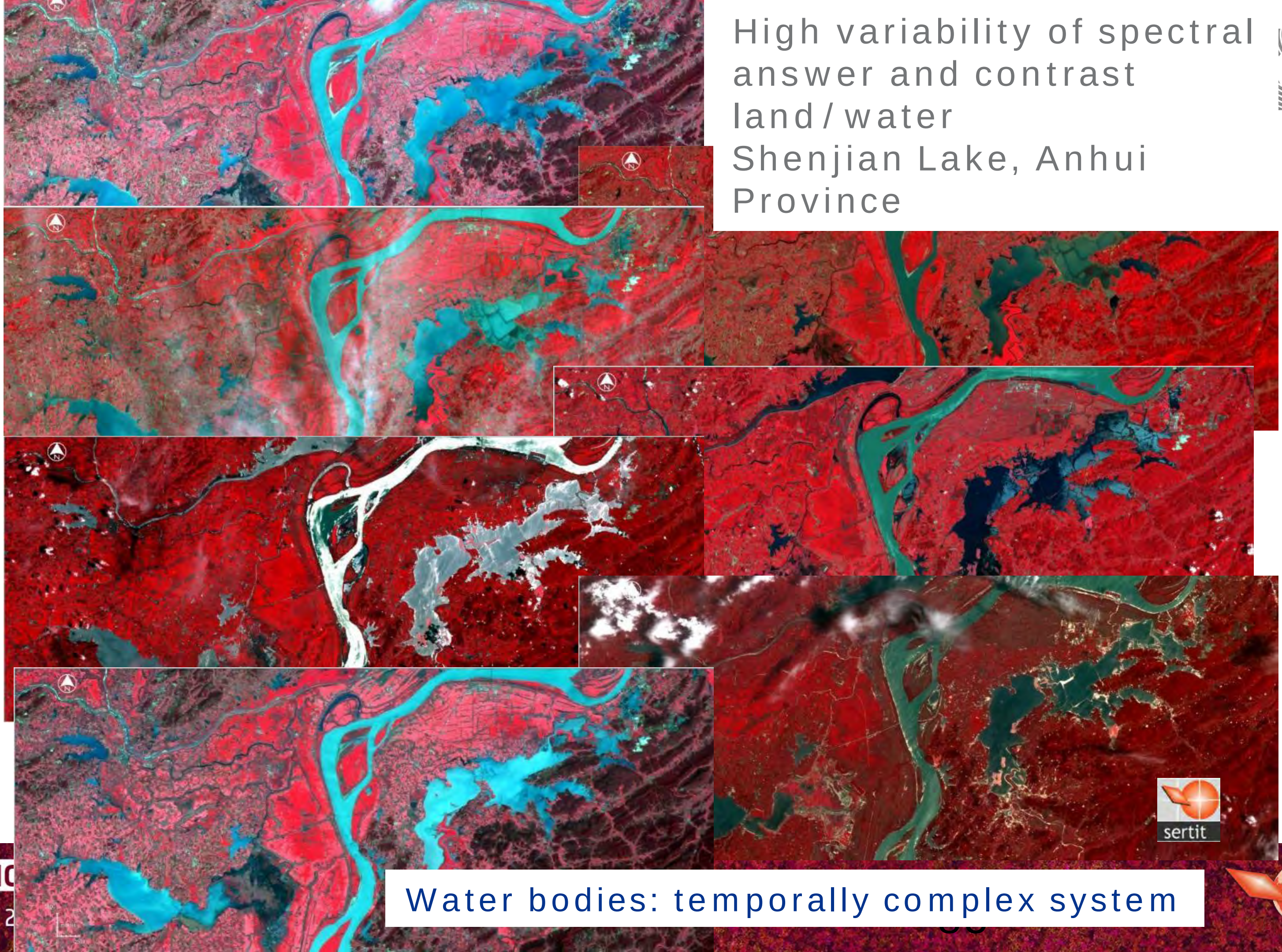
Short cut of Physical basis for Water bodies mapping
Realation between water quality / color and water content



Water bodies: spatially complex system

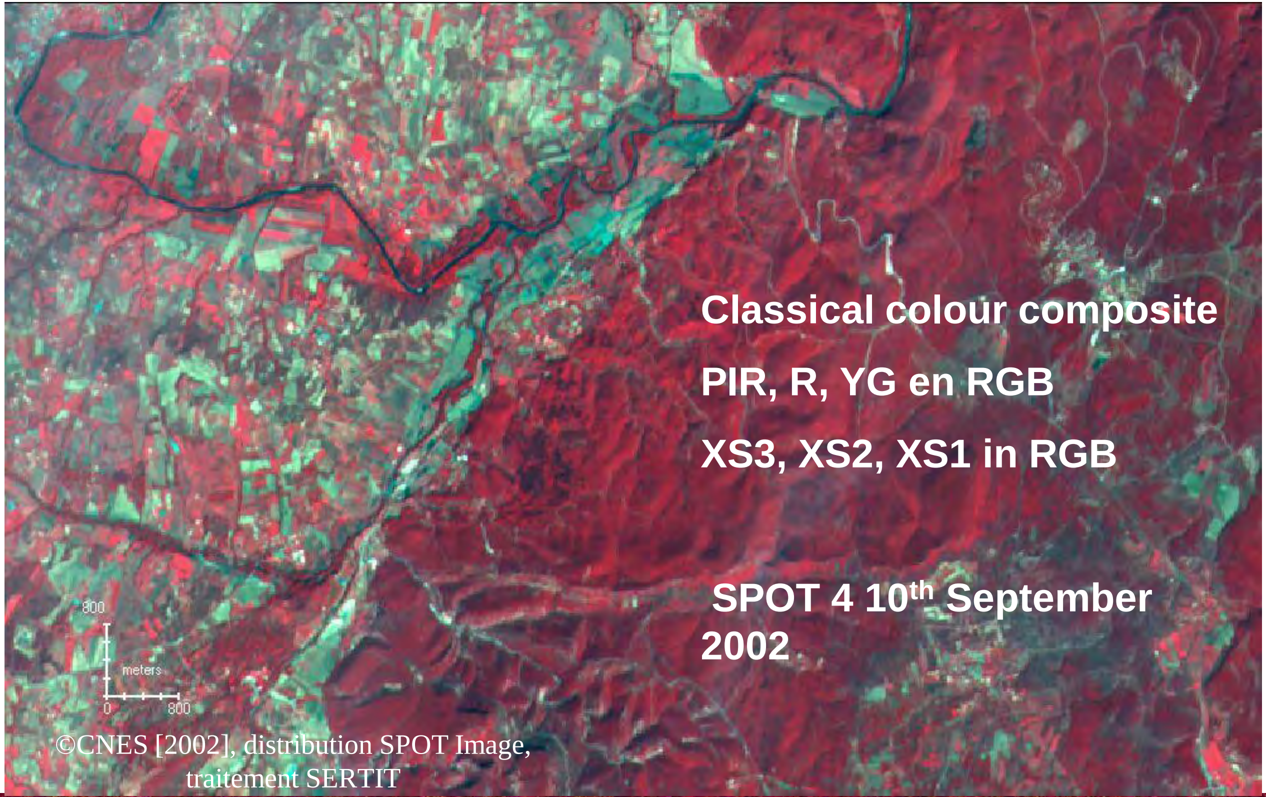


High variability of spectral answer and contrast land / water
Shenjian Lake, Anhui Province

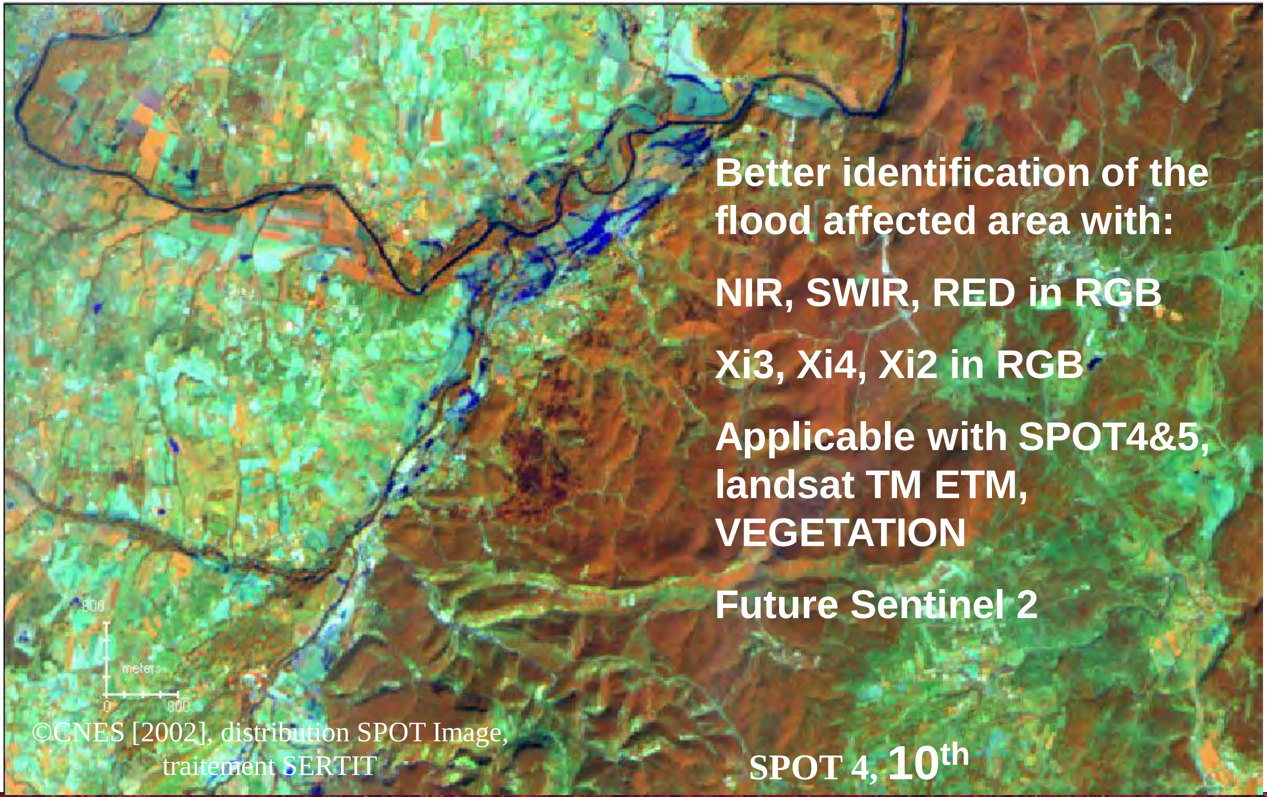


Water bodies: temporally complex system

Optical Flood mapping : channel selection



Optical Flood mapping :
Contribution of the SWIR channel



©CNES [2002], distribution SPOT Image, traitement SERTIT

Better identification of the flood affected area with:

NIR, SWIR, RED in RGB

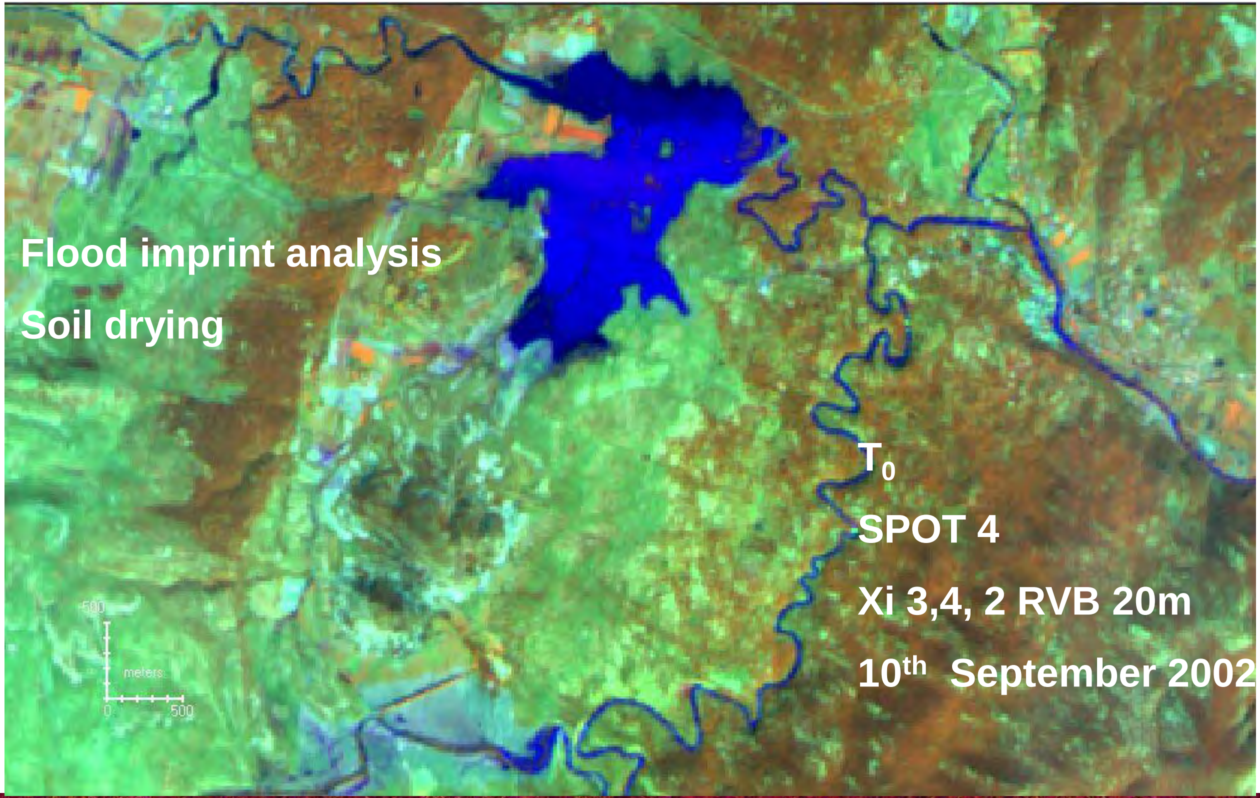
Xi3, Xi4, Xi2 in RGB

Applicable with SPOT4&5, landsat TM ETM, VEGETATION

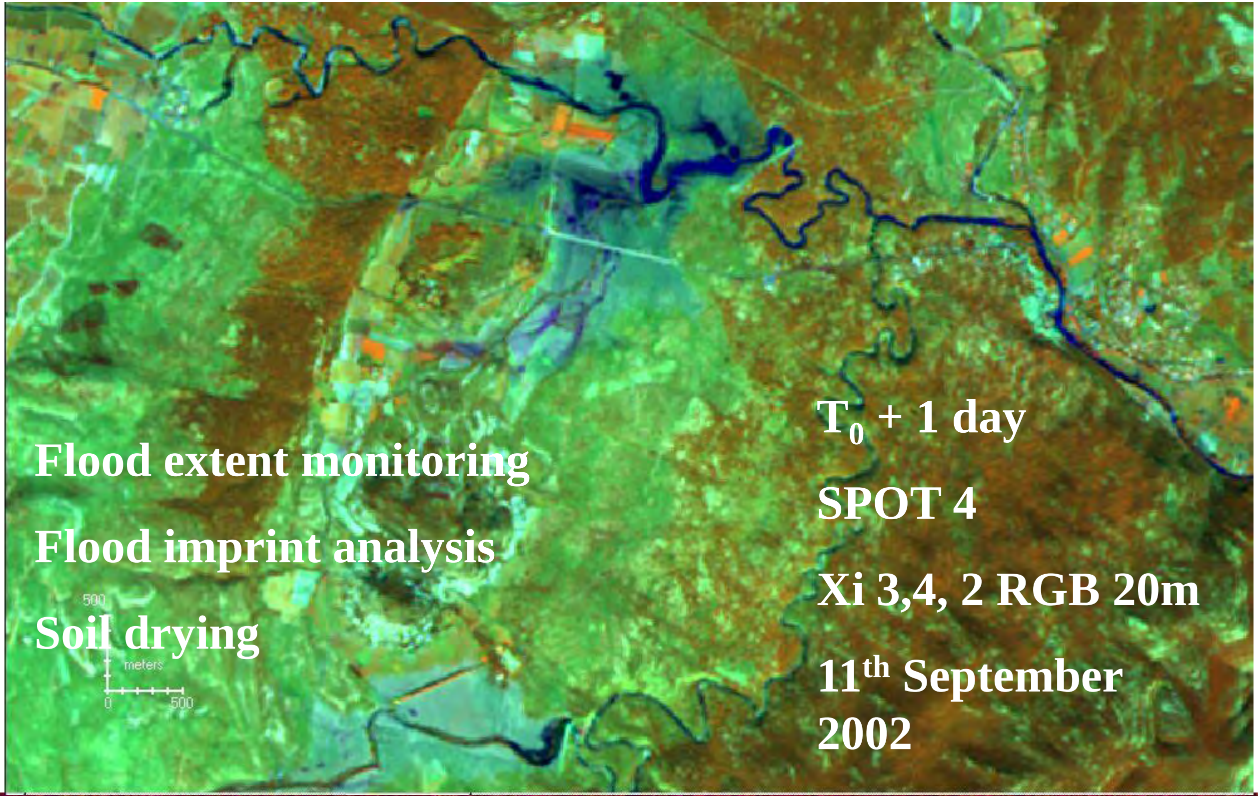
Future Sentinel 2

SPOT 4, 10th September 2002

Optical Flood mapping :
Contribution of the SWIR channel



Contribution of the SWIR channel for flood imprint mapping

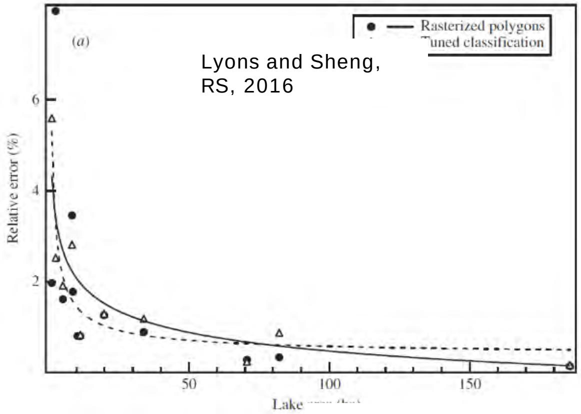


Water related indices exploiting VIS, NIR and SWIR channels

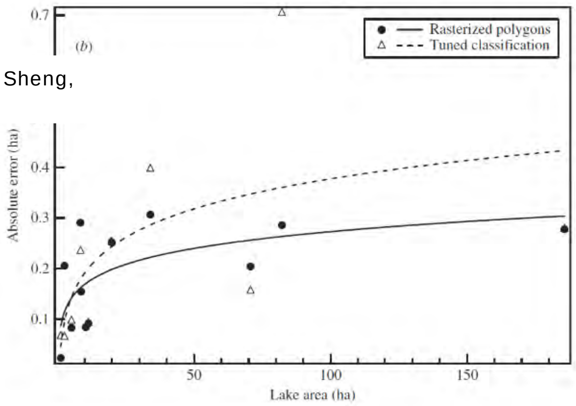
Index	Equation	Remark
Normalized Difference Water Index	NDWI = (Green − NIR)/(Green + NIR)	Water has positive value
Normalized Difference Moisture Index	NDMI = (NIR − MIR)/(NIR + MIR)	Water has positive value
Modified Normalized Difference Water Index	MNDWI = (Green − MIR)/(Green + MIR)	Water has positive value
Water Ratio Index	WRI = (Green + Red)/(NIR + MIR)	Value of water body is greater than 1
Normalized Difference Vegetation Index	NDVI = (NIR − Red)/(NIR + Red)	Water has negative value
Automated Water Extraction Index	AWEI = 4 × (Green-MIR) − (0.25 × NIR + 2.75 × SWIR)	Water has positive value

Errors and sources of errors in water surfaces mapping

	Sensors properties	Lakes Characteristics	Data processing
Spatial	Spatial resolution	Size and Shape Size of the transition zones between dry and flooded areas.. Ice..	Spatial sampling
Radiometric	Radiometric resolution Spectral coverage (bands)	Spectral response of water/land, floating or submerged vegetation	Radiometric sampling Sensitivity of the descriptors
Temporal	Temporal resolution Acquisition date	Seasonal water surfaces fluctuations Periodic/recurrent inundations	Co registration Nb exploitable images



Lyons and Sheng, RS, 2016

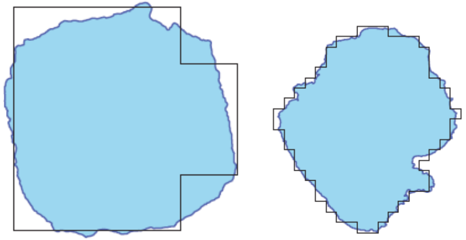


Lyons and Sheng, RS, 2016

Errors distribution in function of water bodies size

Errors and sources of errors in water surfaces mapping

Definition of limits of flooded areas



Shape / sensor resolution

Floating vegetation

Presence of vegetation/alga bloom
Presence of Ice

Potential limitation on water surface recognition water flooded vegetation and floating vegetation

La Coste pound, Saint-Julien, Côtes-d'Armor, FR, 04-2016

Azolla filiculoides

Presentation outline

Context

Why flood mapping and monitoring
Flood in the landscape

SAR

Short cut of SAR Physical basis for Water bodies mapping
Backscattering in function of:

- Acquisition parameter
- Surface roughness
- Atmospheric/meteorological conditions

SAR sensors for water bodies and/or flood mapping

- Past mission
- On going missions
- Future missions

Optical

Short cut of Optical Physical basis for Water bodies mapping
Water bodies spectral signatures
Contribution of SWIR channels
Errors in water bodies mapping

Optical sensors for water bodies and/or flood mapping
Sentinel2 and S2 like sensors
VHR sensors

Concluding remarks

Sentinel 2

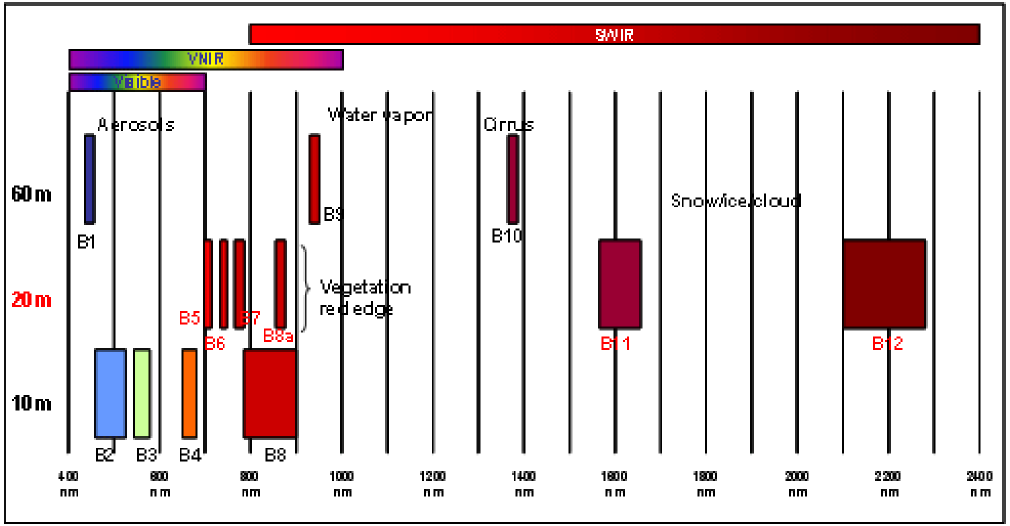
Highest Resolution same as SPOT5 (10m)

Presence of two SWIR bands (heritage of landsat)

Large swath (MERIS heritage)

Revisiting time 10 – 5 days

Free access

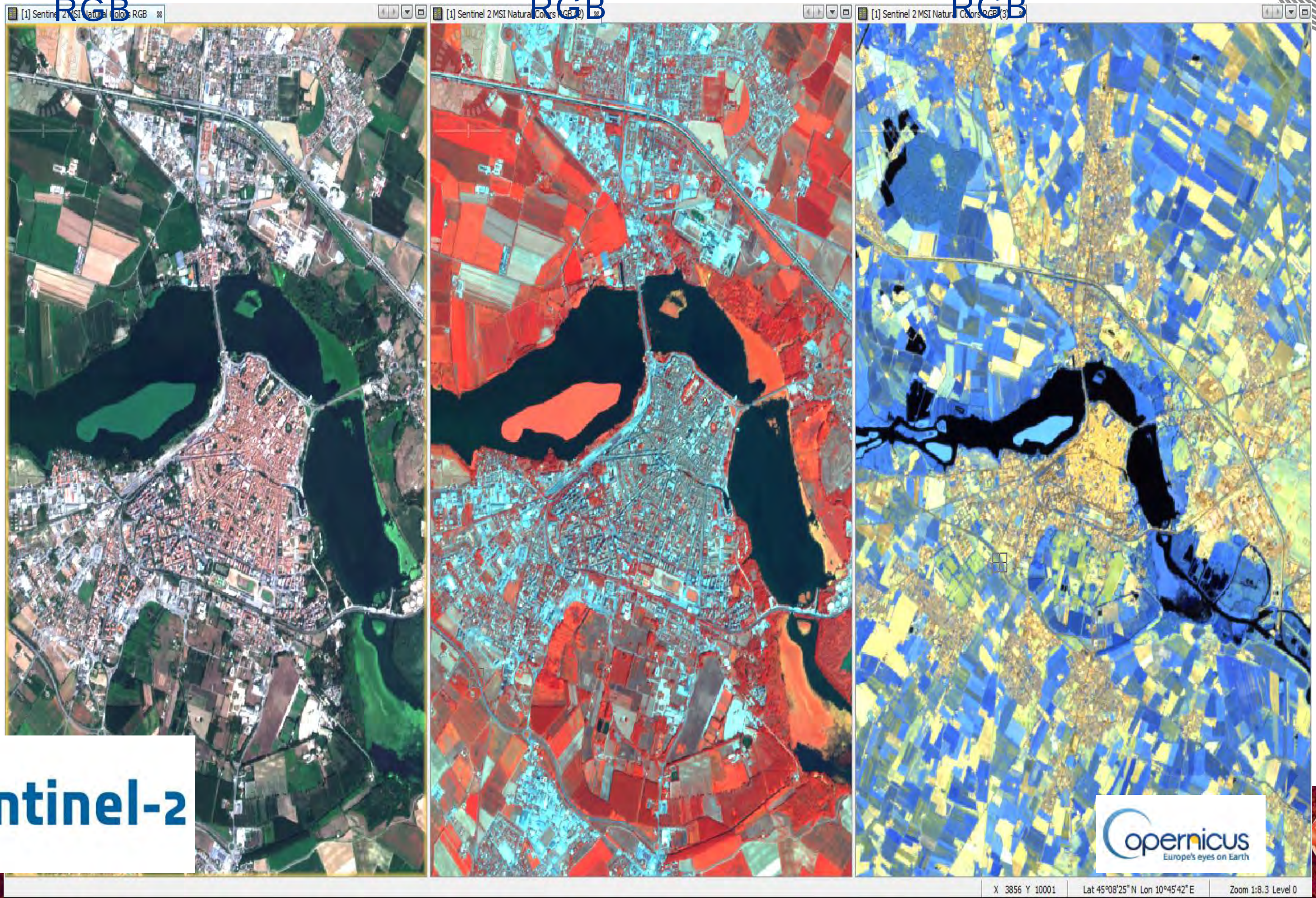


Sentinel-2A : on 23 June 2015
Sentinel-2B : on 7 march 2017

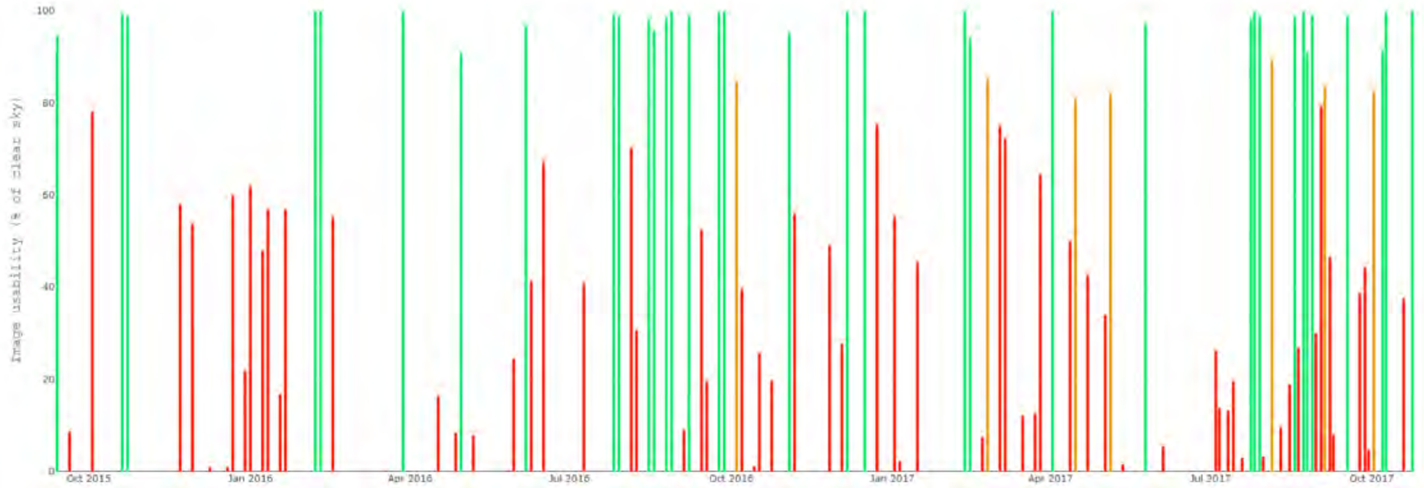
Natural CC
B4, B3, B2
RGB

False CC
B8, B4, B3
RGB

False CC
B12, B11, B8A
RGB

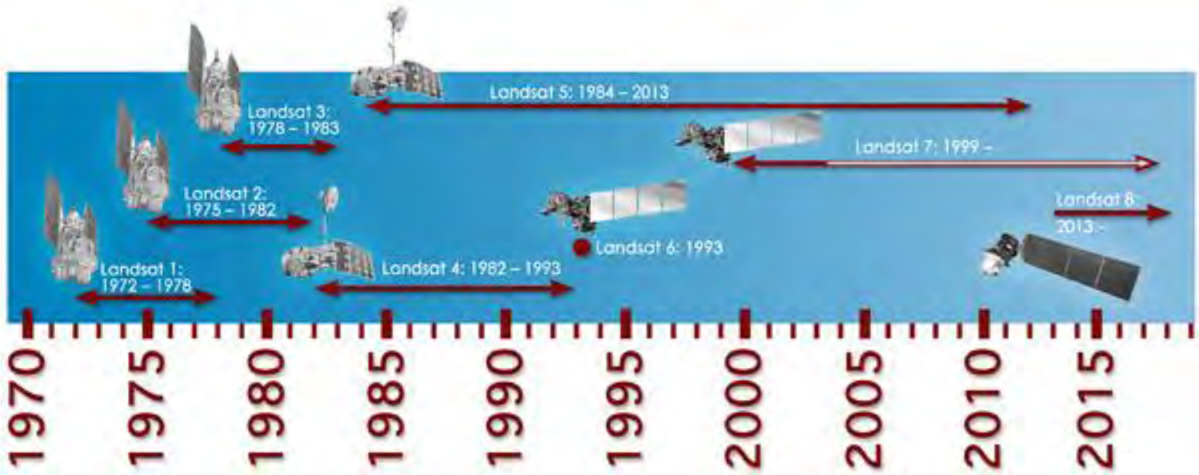


Sentinel2 revisit: images acquired over Poyang Lake (PR China)



155 images S2 acquired since October 2015 (at the 11-11-2017)
Increase of acquisitions since the rump up phase of Sentinel 2B

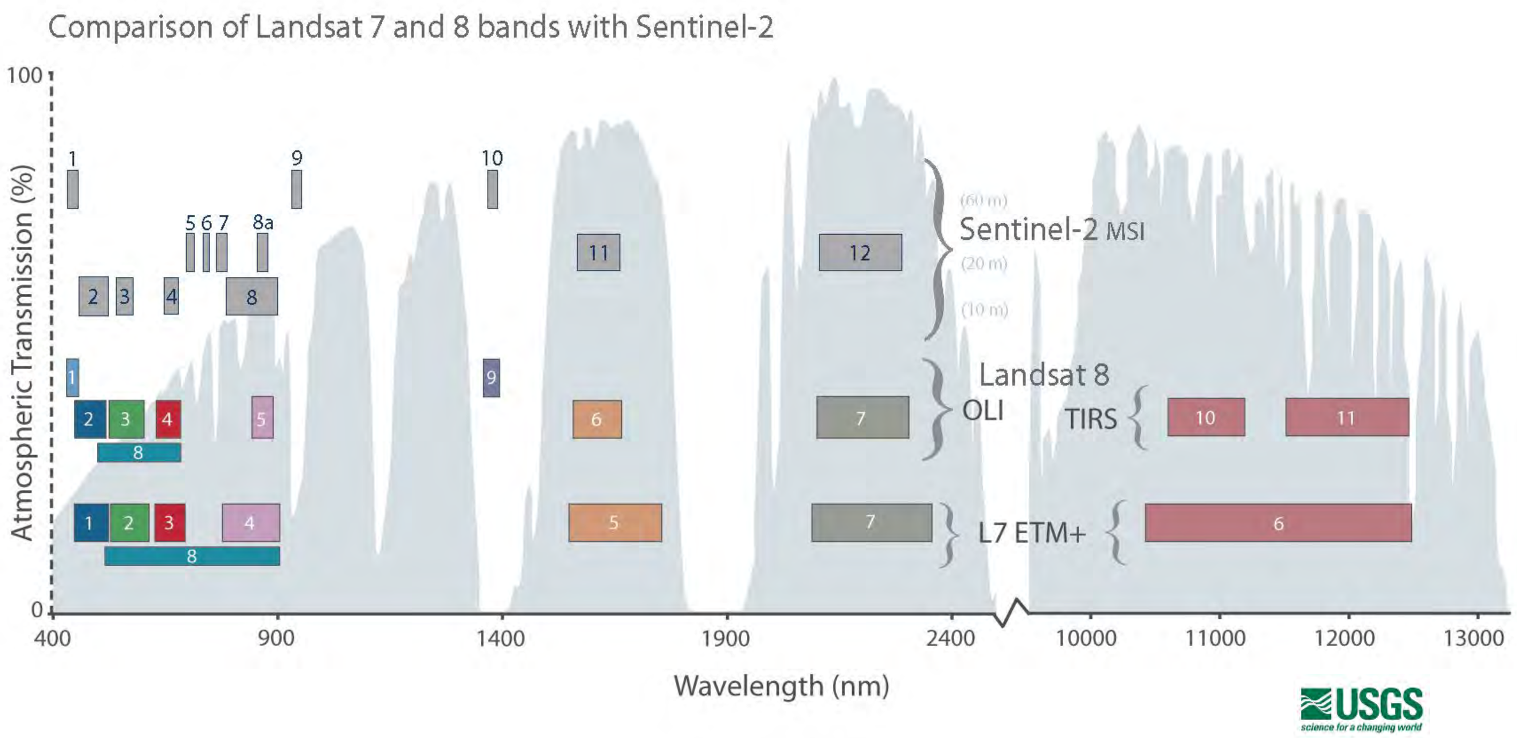
Landsat Family



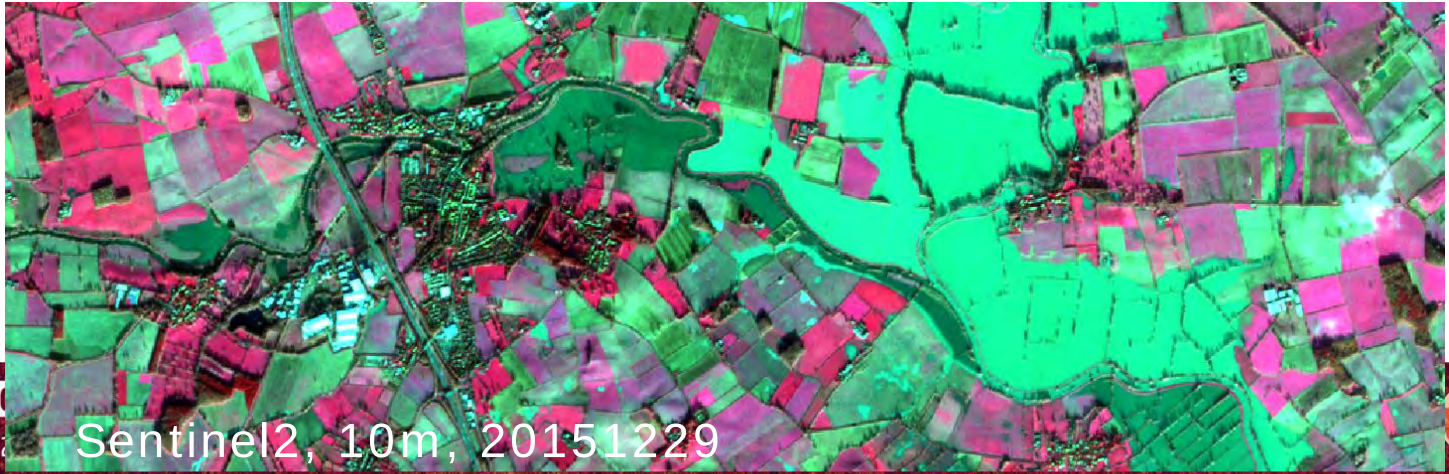
Systematic acquisition
16 days revisit
Huge archive

Since Landsat 4-5 . SWIR band
30 m

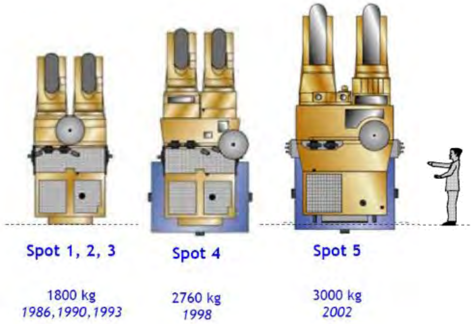
Comparison Sentinel2 and Landsat family: spectral



Comparison Sentinel2 and Landsat family: spatial



SPOT 1-5



SPOT1-3 3XS + 1 PAN
20m -10 m

SPOT4-5 4XS + PAN
20 m + 10m (red band)
10 m + 2,5m

Green: 0.53-0.60 µm
Red: 0.61-0,68 µm
NIR: 0.78-0,89 µm
SWIR: 1.58-1,75 µm

PAN: 0.48-0,71 µm

Swath 60 km

- SPOT 1: 22 February 1986 / 17 November 2003
- SPOT 2: 22 January 1990 / July 2009
- SPOT 3: 26 September 1993 / November 1996
- SPOT4: 26 March 1998 /
- SPOT5: 4 May 2002 /31 March 2015

- => Very rich archive, no so well known and exploited

SPOT 6-7

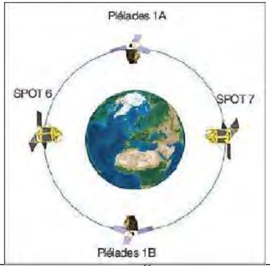
Following of SPOT 5
with improved spatial resolution 1,5-6m at nadir
2 satellites in constellation with Pleaides

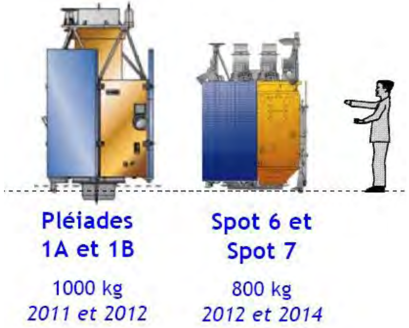
Launch September 2012 and June 2014

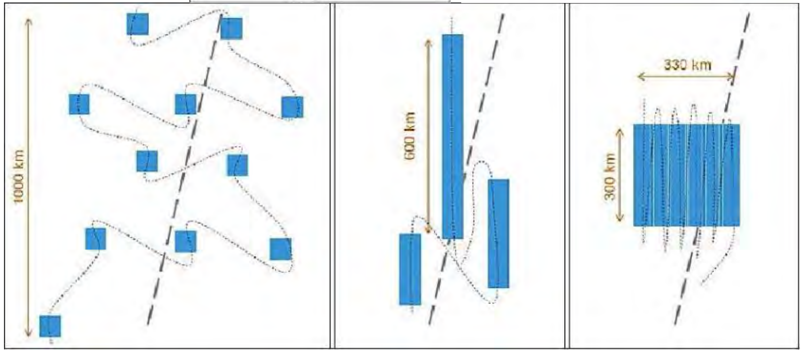
4 bands + Pan
Blue: 0.45-0.52 µm
Green: 0.53-0.60 µm
Red: 0.76-0,69 µm
NIR: 0.76-0,89 µm
PAN: 0.45-0,75 µm

Swath 60 km (agil)

=> Daily coverage capacity







SPOT 6-7

Flood in Bridgewater, England,
11 January 2014

SPOT IMAGE

AIRBUS DEFENCE & SPACE

Sertit iCUBE

PLEIADES

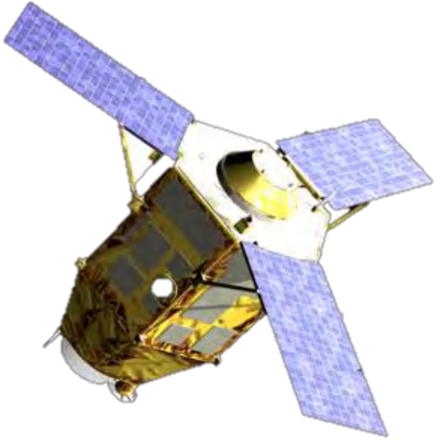
2 satellites in constellation
Launch December 2011 and 2012

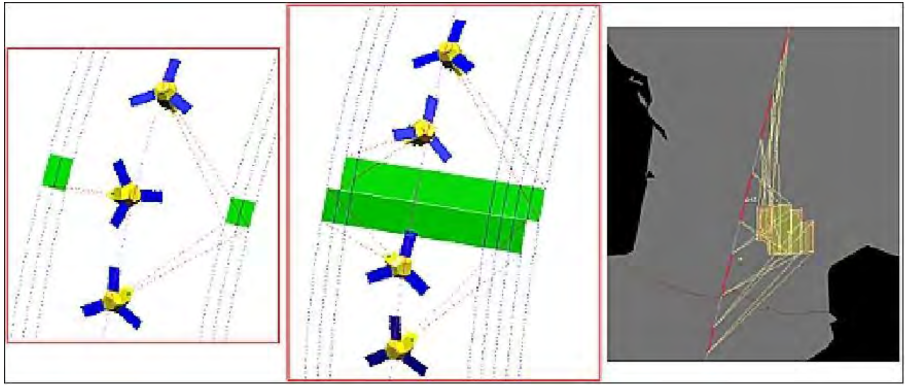
0,70 cm in PAN
2,8 in XS

4 bands + Pan
Blue: 0.43-0.55 µm
Green: 0.50-0.62 µm
Red: 0.59-0,71 µm
NIR: 0.70-0,94 µm
PAN: 0.47-0,83 µm

Swath 20 km (agility)

=> Daily coverage capacity





Optical VHR and flood mapping: very fine description of the flood field

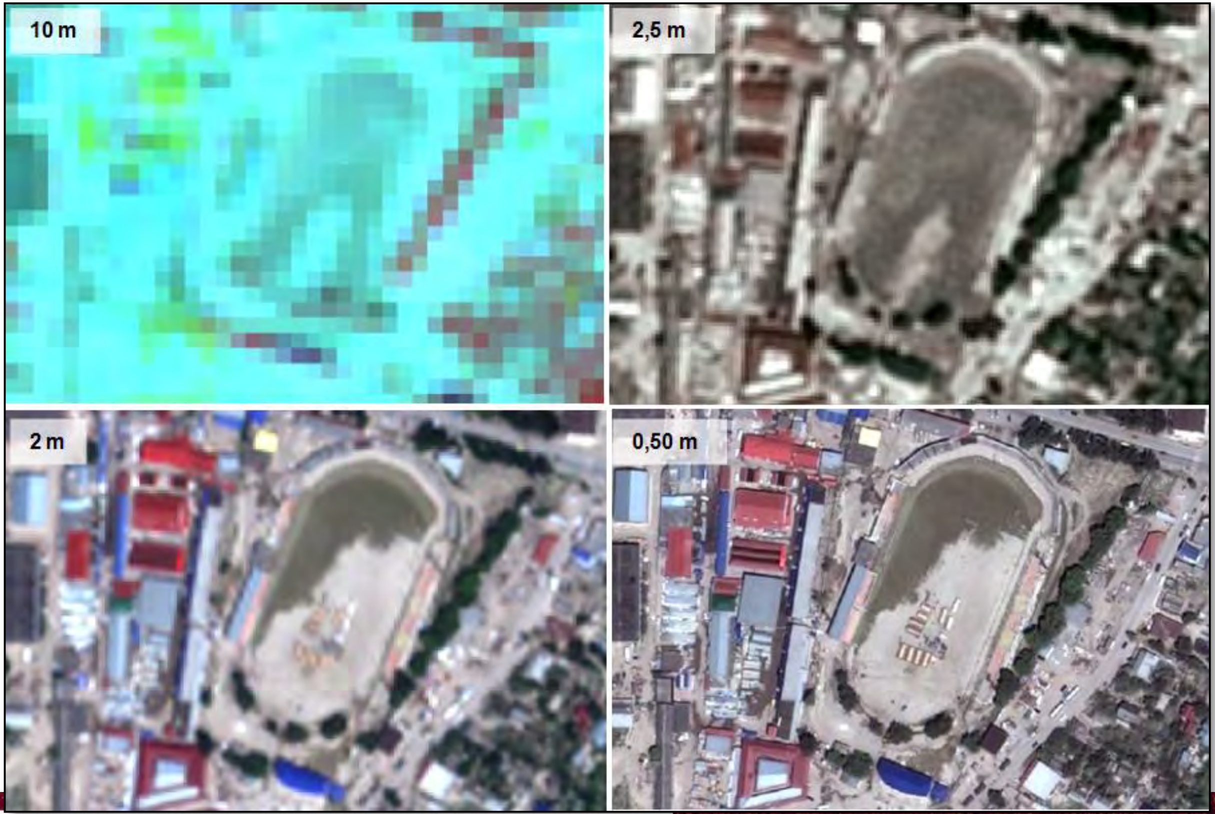
Mud traces recognition: within cities

Image pré-crise (Google)

Image post-crise (Pléiades)

Krymsk , Rusia,
july 2012

Flood traces detection: Influence of spatial resolution



VHR & Flood mapping: Mud traces recognition: within cities

VHR & flood mapping: Impact on agricultural parcels

Optical VHR : parcelling and flood

- Extraction of narrow water bodies
- Identification of mud deposit
- Impact on river pathway
- Impact on agricultural field

Reference image, IGN BD topo

Hautes-Pyrénées: flash flood of Gave de Pau (June 2013)

22 of June 2013

Optical VHR and flood mapping: very fine description of the flood impact on hydraulic elements

Optical VHR : Dike break

Agly 2013 flood event

Based on Pleiades HR

Pre event image

Post event image acquired on the 9 March 2013

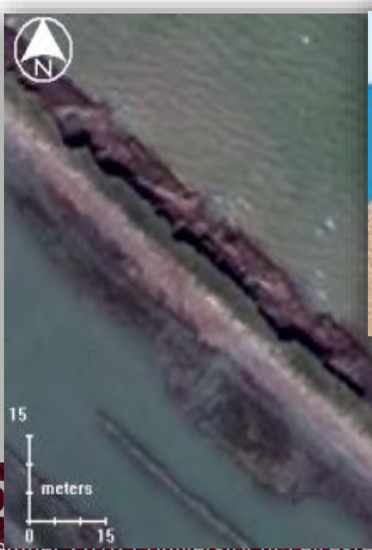
Damaged infrastructure: Bridge

Image pre crisis (Google)

Image post-crisis (Pléiades)

Optical VHR : Dike over flooded and partially erased

Xynthia 2010 – Western coast of France



Optical VHR : Dike over flooded and partially erased

Digue fortement impactée avec trace de laisse de surverse

Digue dégradée Erosion par surverse

Incertitude. Forte probabilité de surverse

Digue sans dégâts apparents

Brèche de vidange ouverte après le 1er mars 2010

Xynthia 2010

Western coast of France

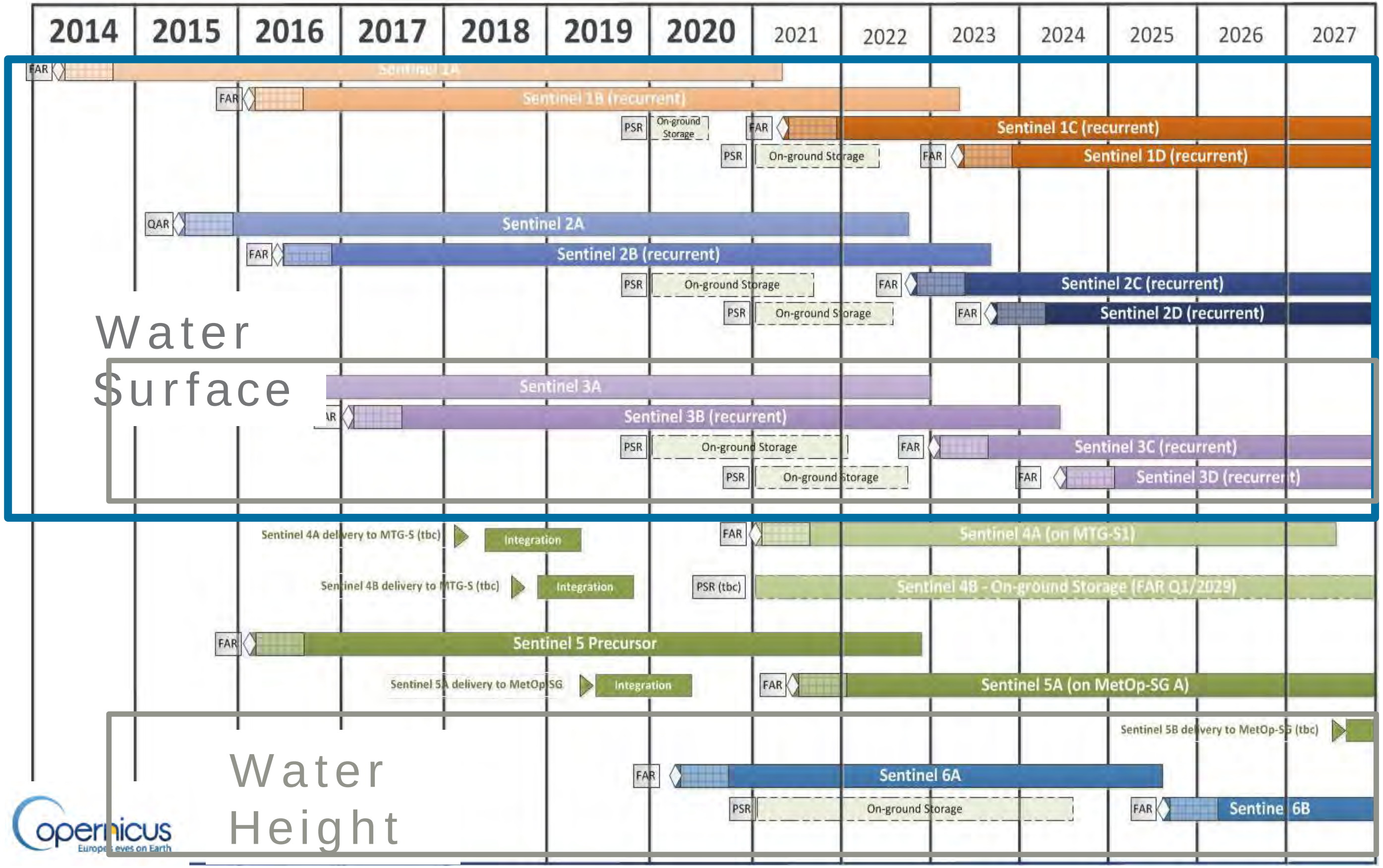
Conclusion

- Flood is a major threat
- EO data can help to understand, describe and monitoring/modelize these events
- Both passive (Optical HR) than active sensors (SAR/INSAR) are pertinent
- DO NOT oppose the systems but exploit the synergism (revisit, resolution, spectral information)
- DO NOT oppose the different resolution (synergy in term of spatial coverage, tool for validation)
- Not so "simple" task/work..

  => acquisition parameter's, scene characteristics, wavelength, meteo

  => different landscape, different signatures /traces of the event
- Resource is guarantee for the next 15-20 years (Sentinel 1/2/3)

Copernicus missions (ESA) exploitable for hydrology



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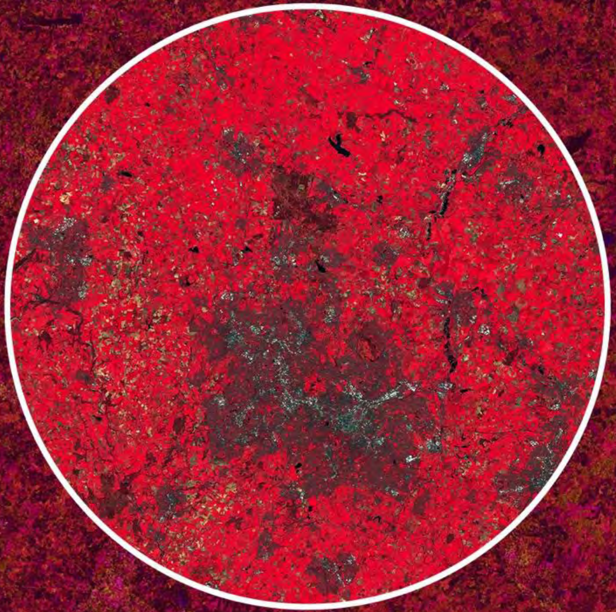
University of Leicester | United Kingdom



Flood Mapping

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14/09/2018

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iCUBE

sertit