



Floods & Lakes Monitoring

SAR Practical

ESA-MOST Dragon 4 Cooperation

ADVANCED LAND REMOTE SENSING INTERNATIONAL TRAINING COURSE

“龙计划4”高级陆地遥感国际培训班

Dr Hervé YESOU

D2S -P2

Tuesday 25 of November 2017

20-25 November 2017 | Yunnan Normal University
Kunming, Yunnan Province, P.R. China

2017年11月20日—11月25日
云南师范大学, 中国, 昆明

Flood mapping and monitoring

Challenging...

Diversity of :

- Size
- Landscapes
- Dynamics
- Scale of analysis

Lot of approaches both in optical and Sar domain

Detecting water surfaces

Water bodies

- Unique target by complex target
- Water bodies as observed at a T time
- EO Ressources (all !!!)
 - SAR 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

Aims of Flood mapping and monitoring training course

Thematic goals:

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

- Approach of time series

Prepare the exploitation

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

Aims of Flood mapping and monitoring training course

Image Processing 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

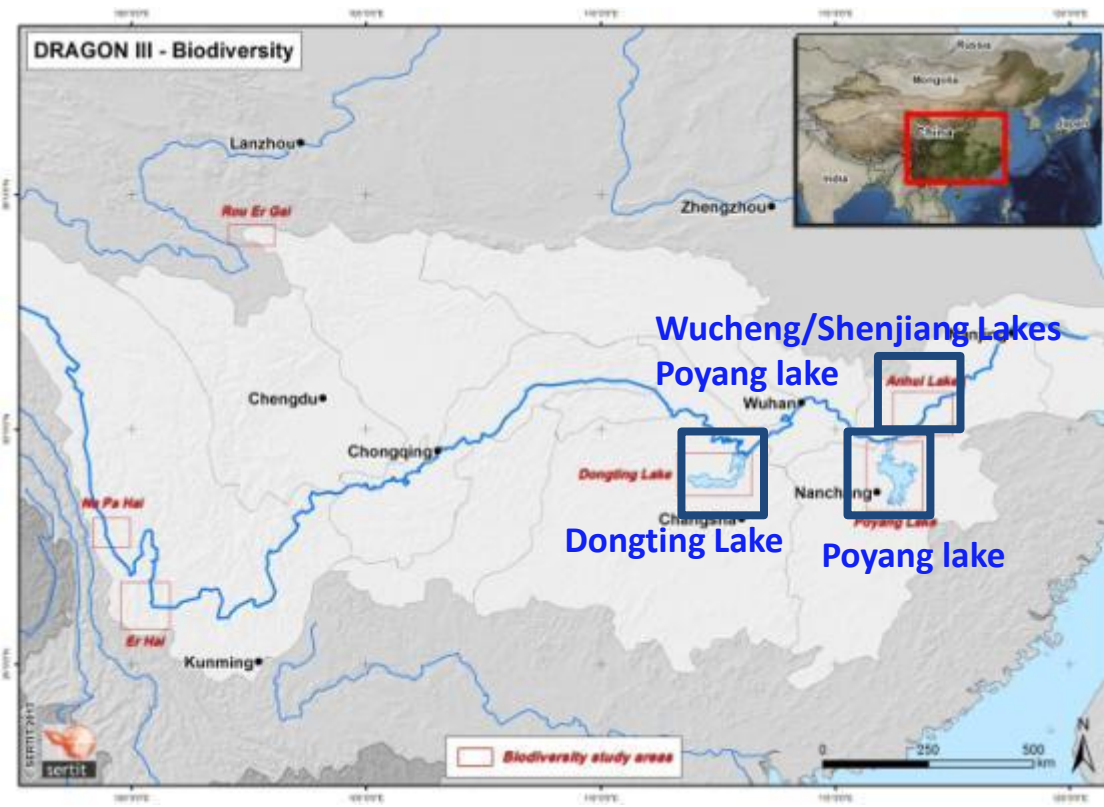
Exploitation of the Sentinel series



Sentinel 1 : SAR



Context: Yangtze river's monsoons & lakes monitoring

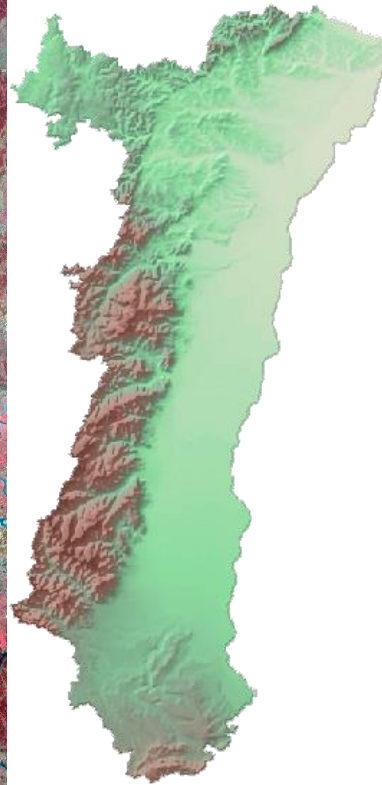
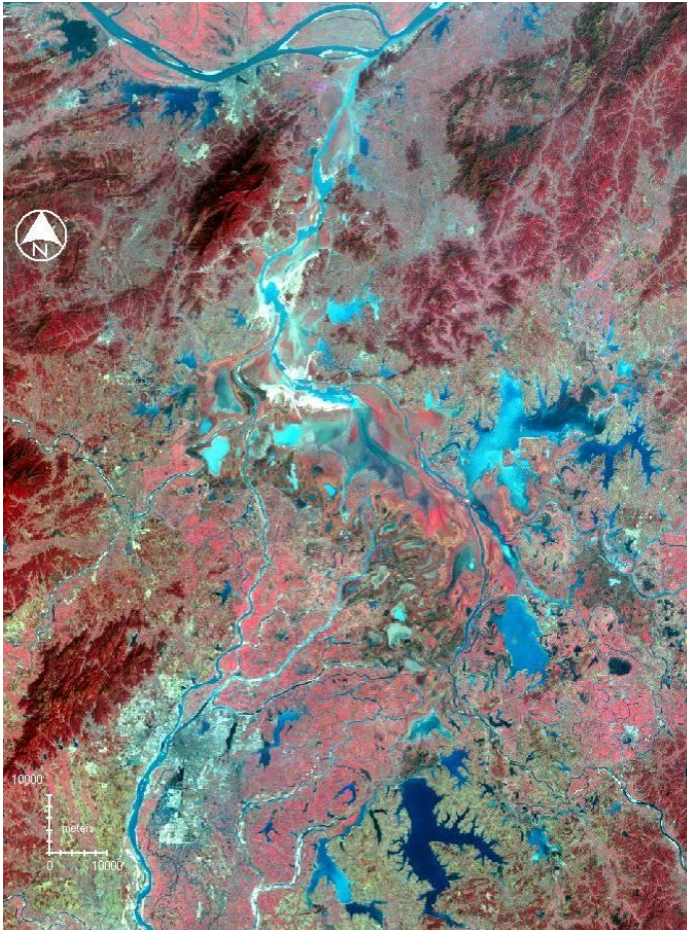


- 6000 Lakes, pond, reservoirs
- 25% freshwater of SE Asia
- 1 ha to 3500 km²
- Large flooded lakes: 30-40 % of area, 2 majors and 4 small ones
- Water services:
 - 330 000 000 inhabitants
 - Public health
 - Biodiversity stakes
- Within climate change and water management (3GD)



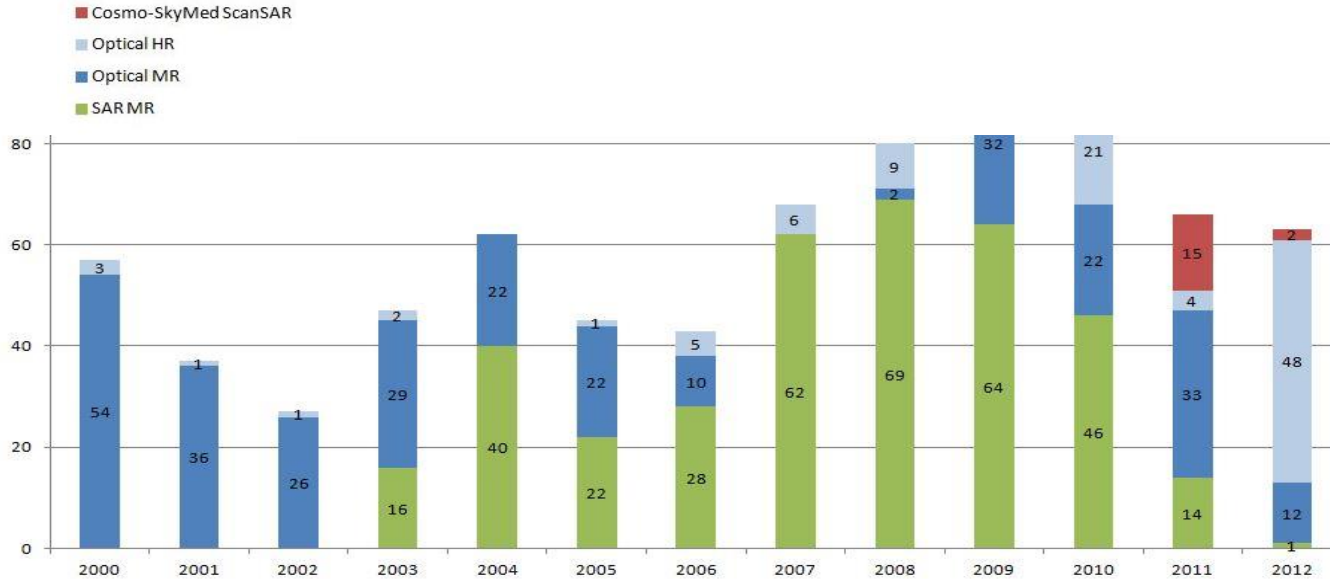
Test sites: Poyang Lake (PR China), Alsatian Flood Plain (Fr)

Poyang lake, Monsoon lake 15 years of monitoring



Monitoring water bodies based on EO a resource

Request to a secured resource allowing to monitoring large areas with a short revisiting time (10 days)

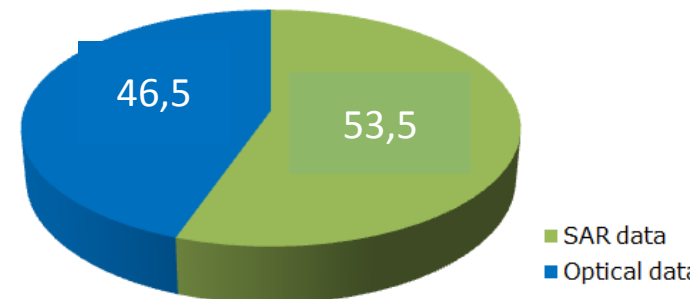


Near Half SAR and optic: 2000-2012

=>ENVISAT, Beijing1 and HJ thanks to DRAGON

=> + opportunistic approach to insure revisit, AO JAXA, DEIMOS, TakeFive, AO CSK ASI

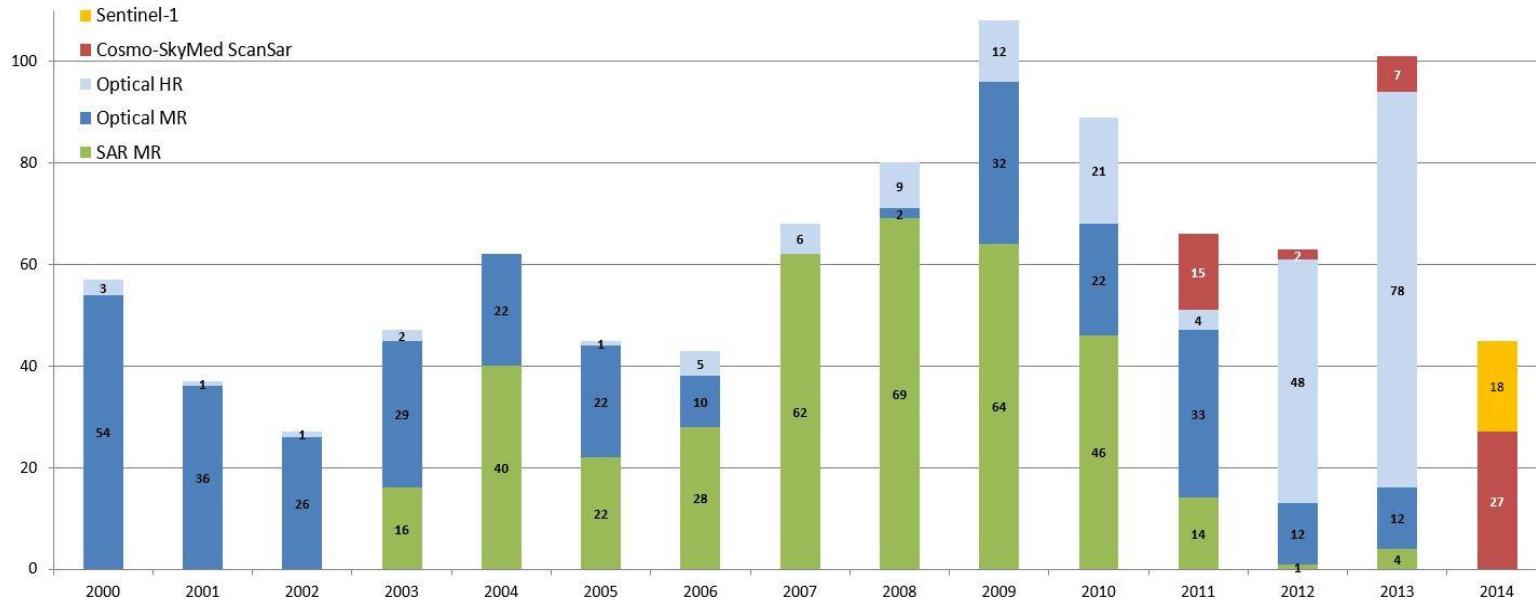
=> Open EO database, MODIS, Landsat





Monitoring water bodies based on EO resource 2012-2014 ...

Request to a secured resource allowing to monitoring large areas with a short revisiting time (10 days)



Moving from MR to HR

⇒ **SPOT 4 TakeFive, HJ1A, preparing Sentinel 2 venue**

⇒ **Archive TerraSAR, New modes TerraSAR TandemX**

⇒ **Cosmo Skymed from ASI (supporting Envisat Gap)**

SENTINEL 1

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



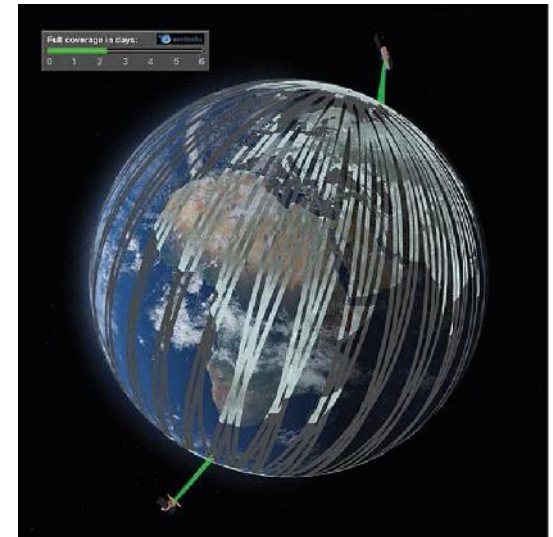
Priority : ensure continuity for C-band data
Improvement of SAR signal (30% better than ENVISAT)

Multi mode

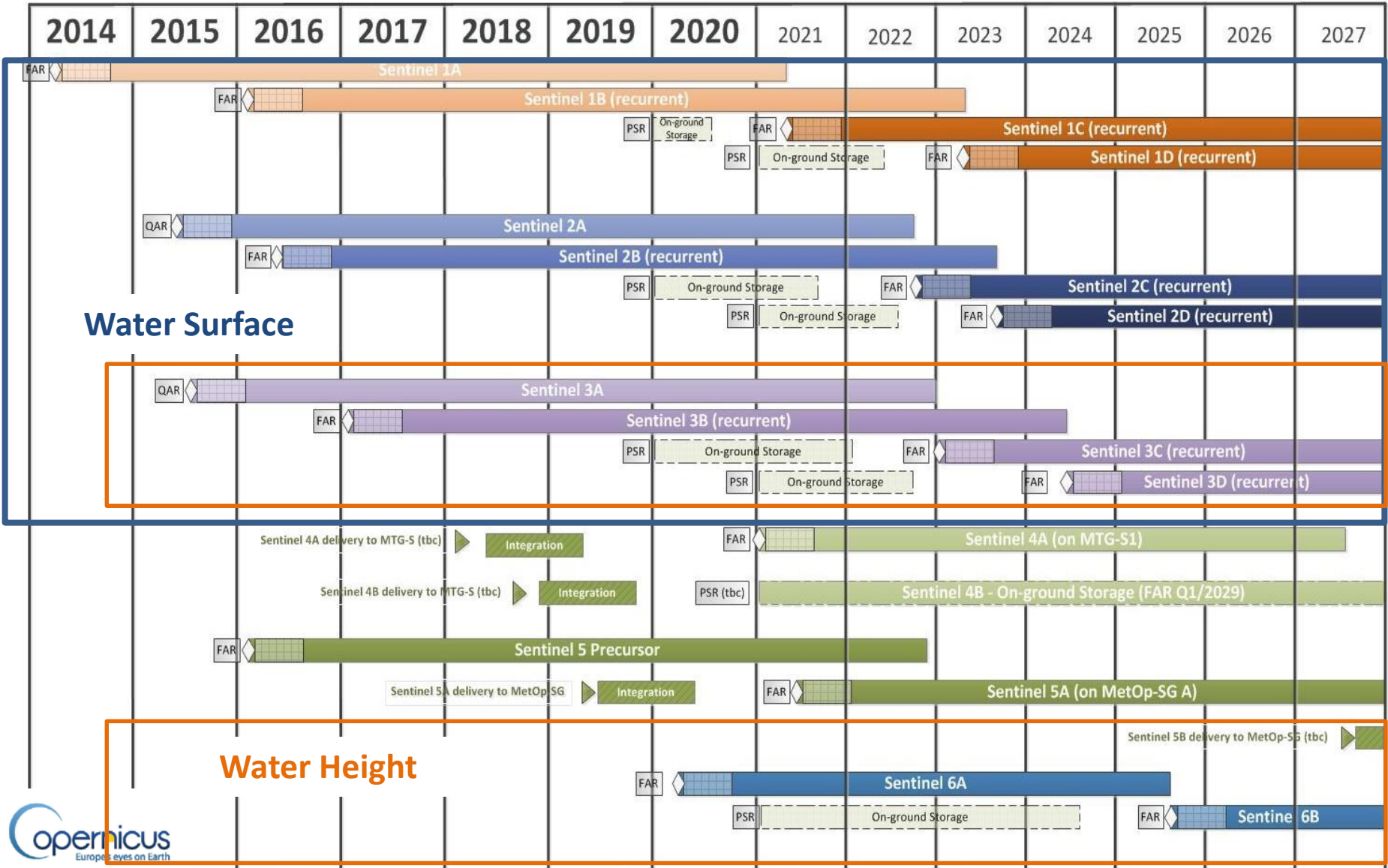
- Strip map: 80 km swath , 5m
- Interferometric Wide swath mode IW, 250km, 20 m
- Extra wide EW Swath , 400 km , 25x100 m
- Wave mode, WV, low data rate, 5x20m
- Swath 250 km

Polarisation modes:

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



Copernicus missions (ESA) exploitable for hydrology



SENTINEL 1

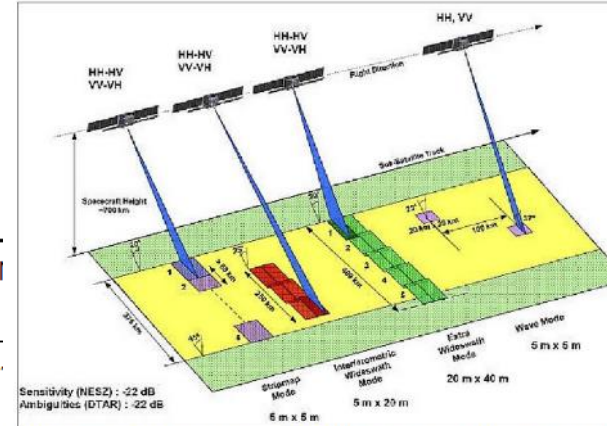
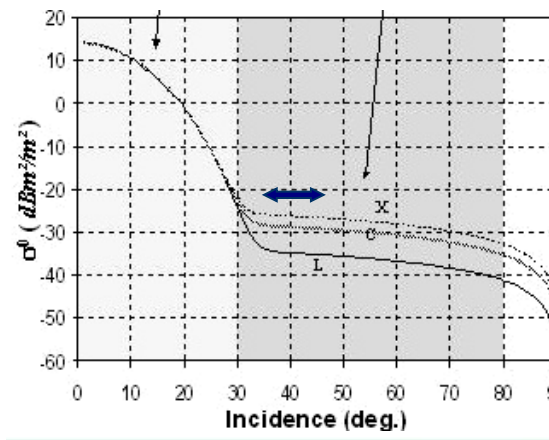


Figure 129: Overview of the Sentinel-1 C-SAR instrument observation scheme and operational support (image credit: ESA)

Acquisition mode	Product type	Resolution class	Resolution (range x azi) (m)	Pixel spacing (range x azi) (m)	No of looks (range x azi)	EI
SM (Stripmap Mode)	SLC	-	1.7 x 4.3 to 3.6 x 4.9	1.5 x 3.6 to 3.1 x 4.1	1 x 1	-
	GRD	FR	9 x 9	4 x 4	2 x 2	3.9
		HR	23 x 23	10 x 10	6 x 6	34.4
	MR	84 x 84	40 x 40	22 x 22	464.7	
IW (Interferometric Wide Swath)	SLC	-	2.7 x 22 to 3.5 x 22	2.3 x 17.4 to 3 x 17.4	1	1
	GRD	HR	20 x 22	10 x 10	5 x 1	4.9
		MR	88 x 89	40 x 40	22 x 5	105.7
EW (Extra Wide Swath)	SLC	-	7.9 x 42 to 14.4 x 43	5.9 x 34.7 to 12.5 x 34.7	1 x 1	1
	GRD	HR	50 x 50	25 x 25	3 x 1	3
		MR	93 x 87	40 x 40	6 x 2	12
WV (Water Vapor)	SLC	-	2.0 x 4.8 and 3.1 x 4.8	1.7 x 4.1 and 2.7 x 4.1	1 x 1	1
	GRD	MR	52 x 51	25 x 25	13 x 13	139.7



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Sentinel 1: High temporal revisit T0 , +5, +7



2014092

20140926



20141003



20141008



20141011



20141020



20141108



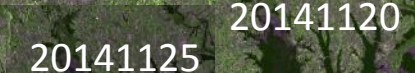
20141101



20141113



20141120



20141125



20141202



20141207

ADVANCED L

20-25 November



20141214



20141219



20141226

示培训班

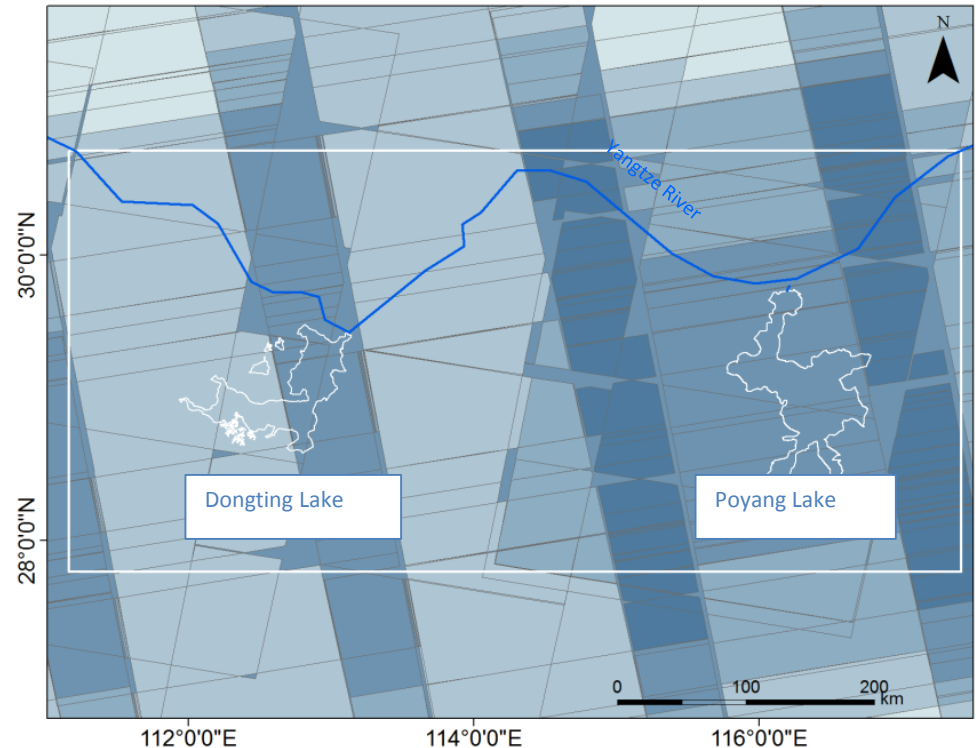
中国, 昆明

Sentinel 1 data availability

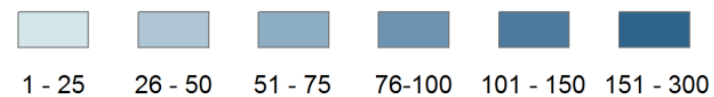
(acquisitions from beginning until 14.06.2017)

Case of the Yangtze monsoon lakes

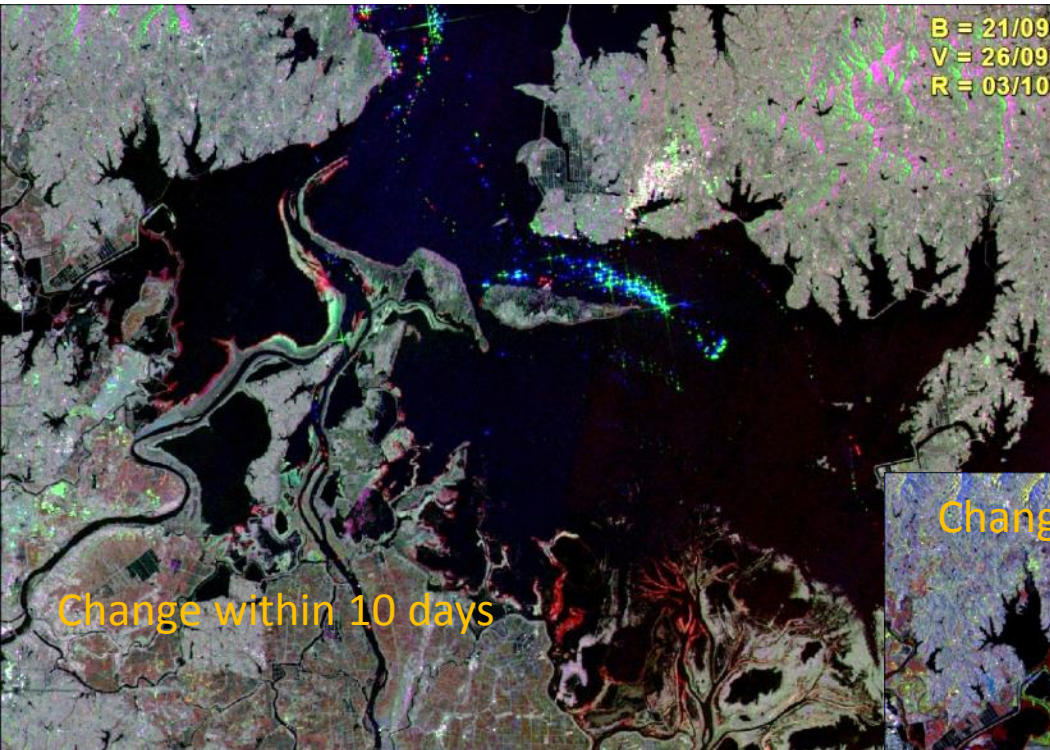
Sentinel-1A/B SAR-C, GRD, 818 Scenes, 1.2 TB data volume



Number of scenes

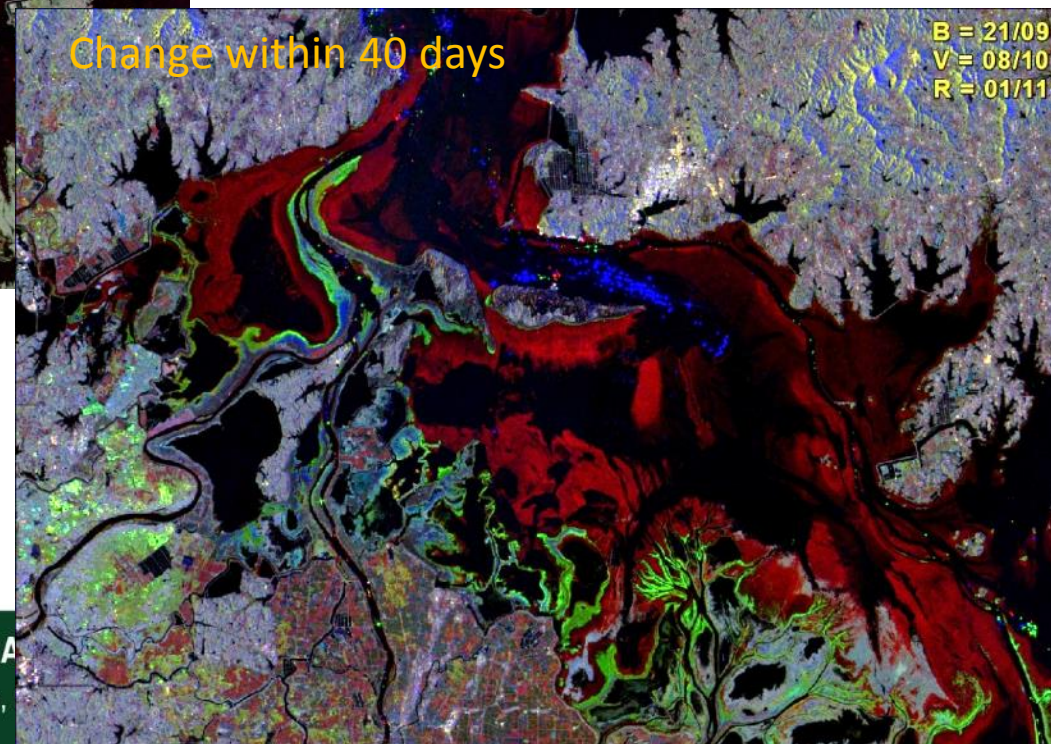


Courtesy of Juliane Huth DLR



Interest of High temporal revisit for monitoring hydrological behaviors

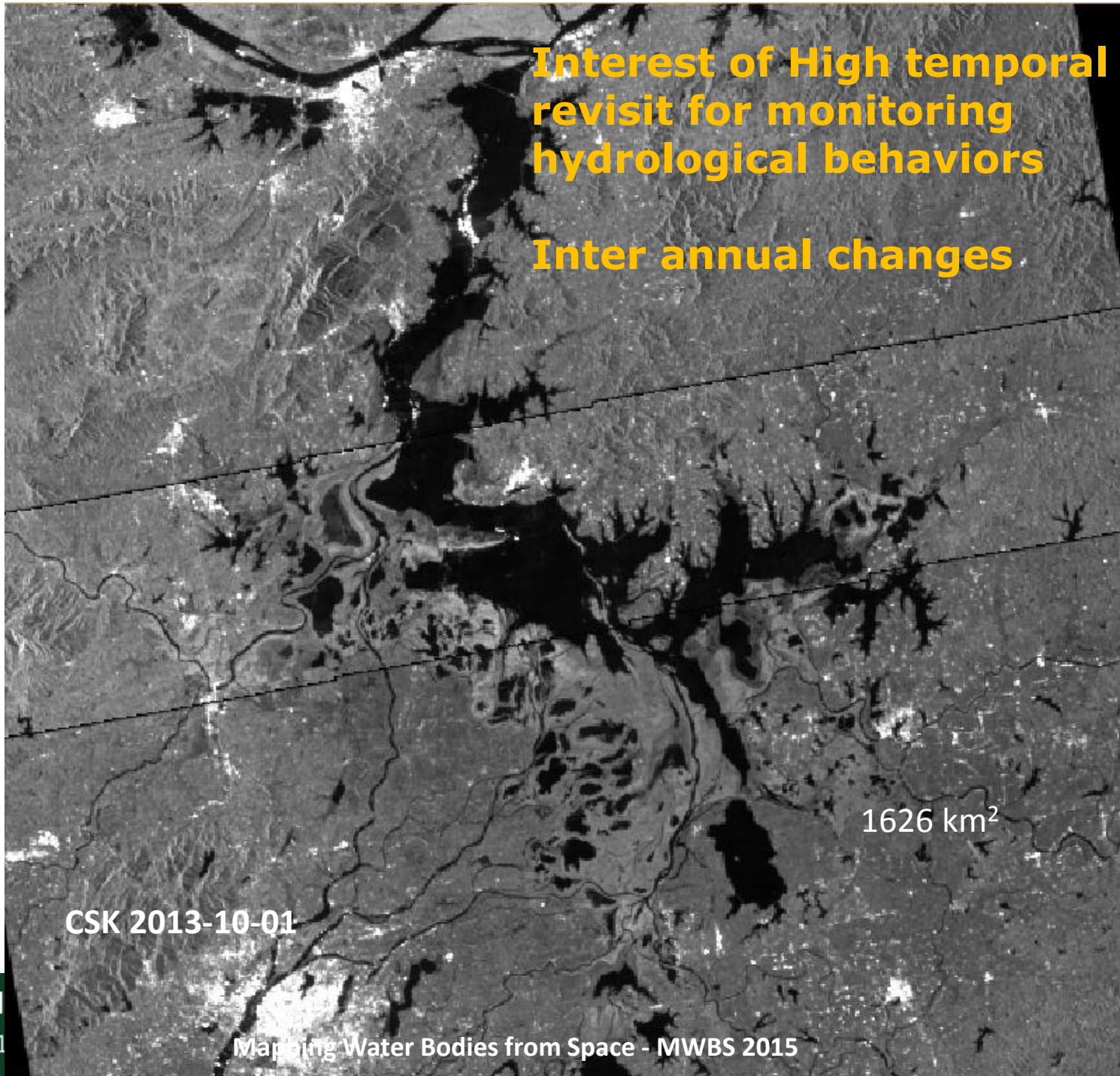
Intra annual changes



Copernicus
Europe's eyes on Earth

**Interest of High temporal
revisit for monitoring
hydrological behaviors**

Inter annual changes



CSK 2013-10-01

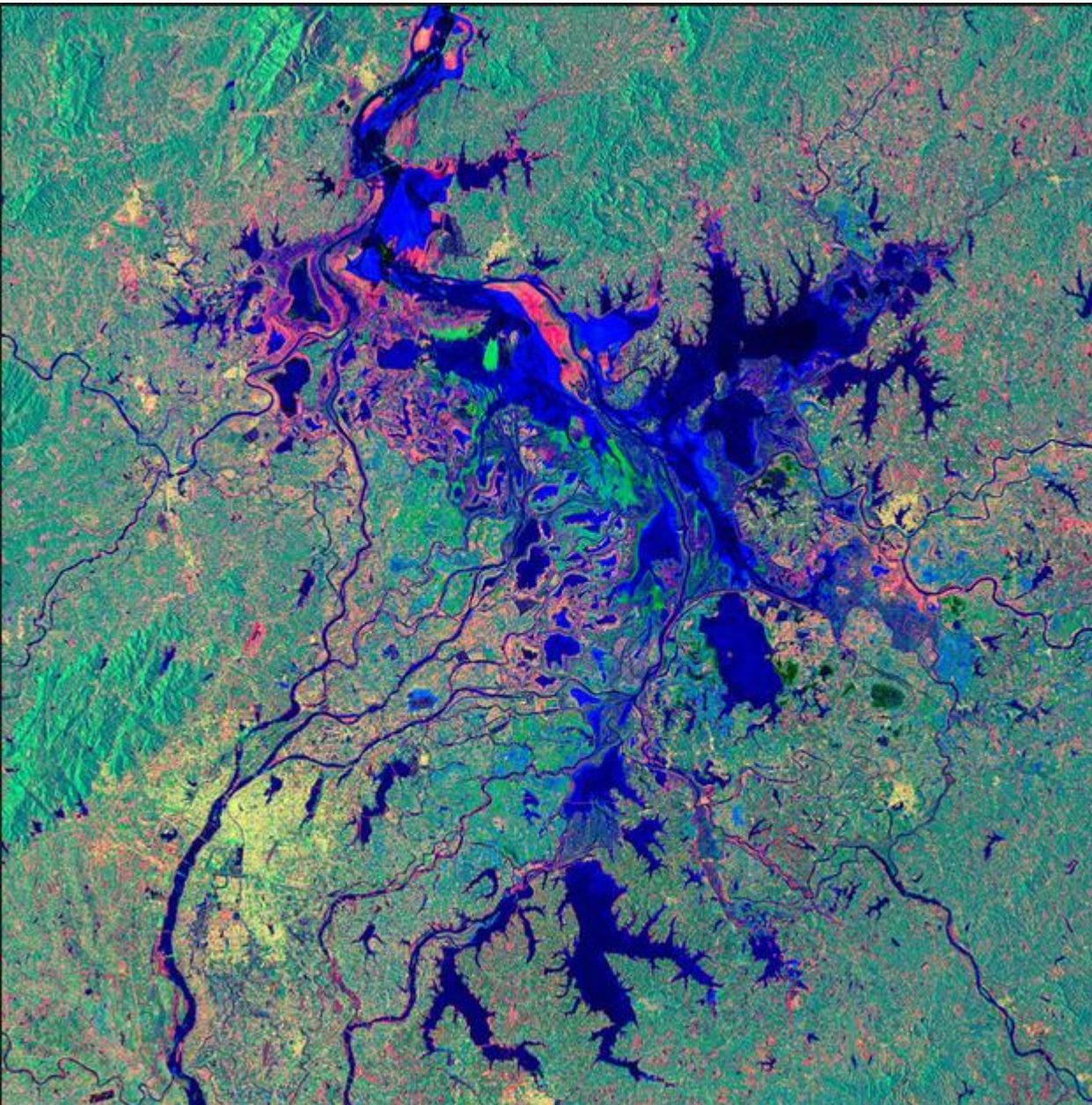
1626 km²

**Interest of High temporal
revisit for monitoring
hydrological behaviors**

Inter annual changes

2718 km²

Sentinel 1 2014-10-03



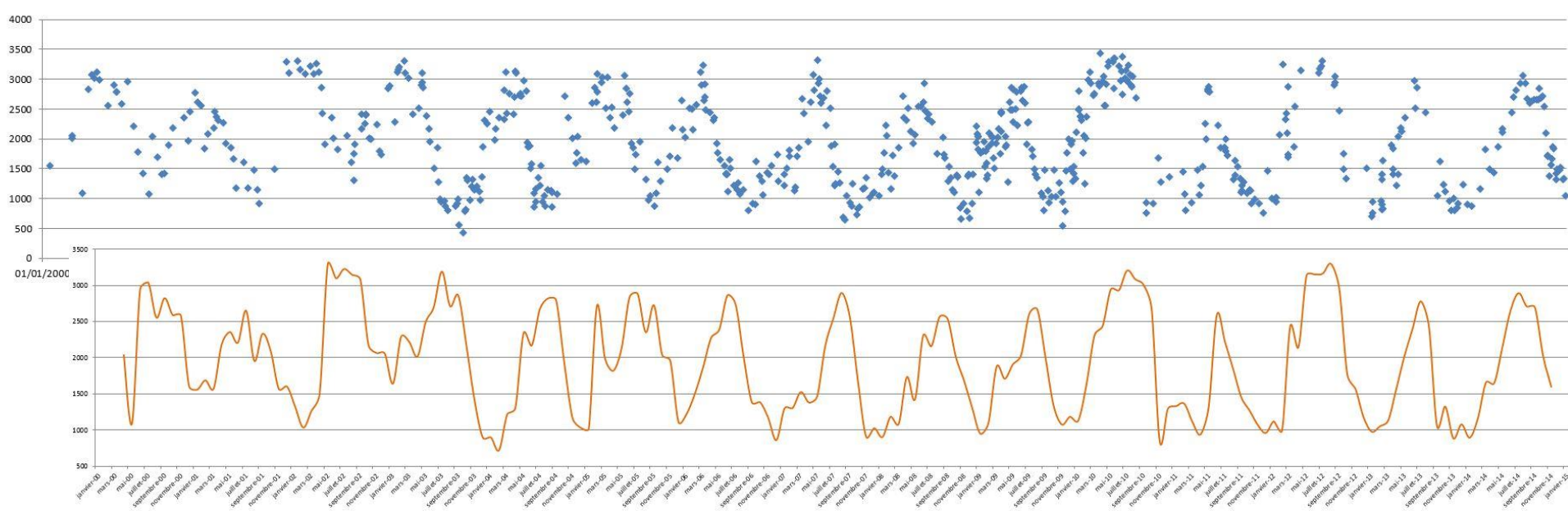
Sentinel1

Interest of High temporal revisit for monitoring hydrological behaviors

Intra annual changes based on coherence analysis

**Courtesy
M. Foumelis**

Ends: Water surfaces monitoring



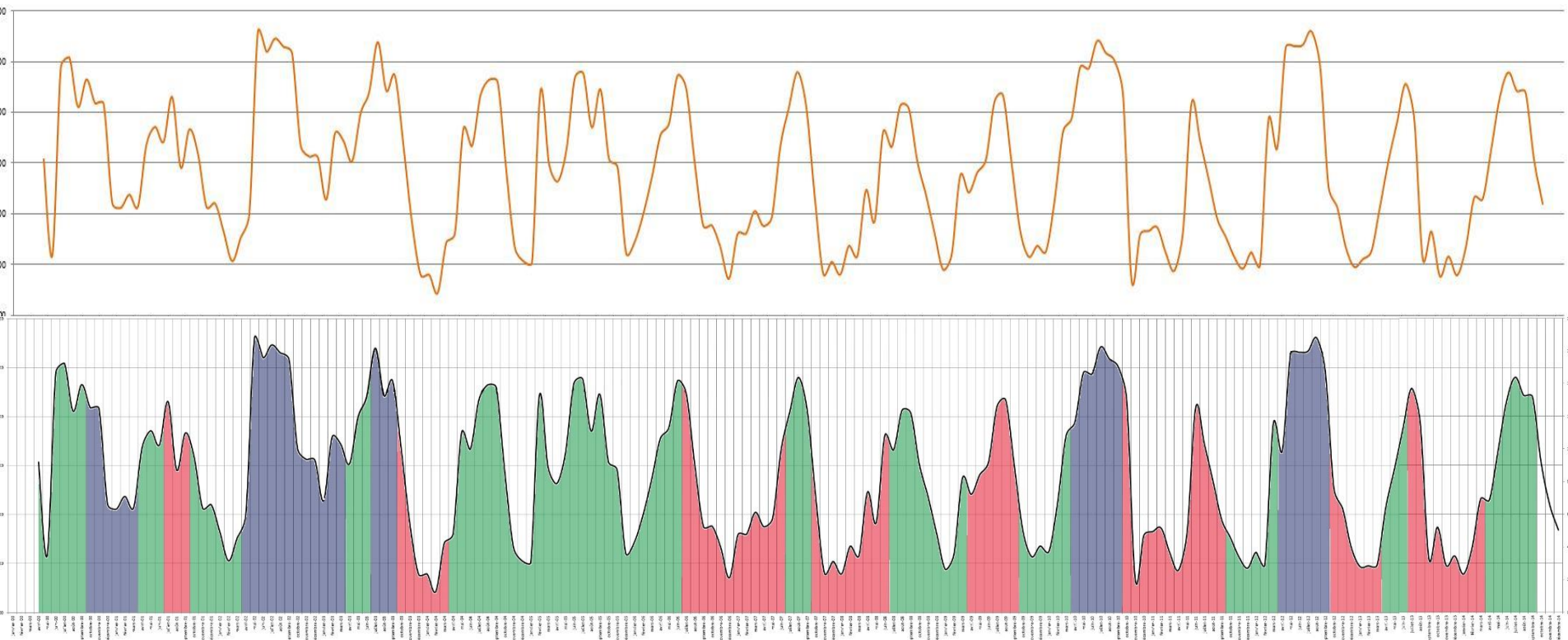
Analysis of temporal variations of water surfaces from 2000 to 2014. Our core information is 15 years of surface extents with a high frequency scoring (10 days in average)





Water surfaces monitoring

Both in spatial and temporal domains



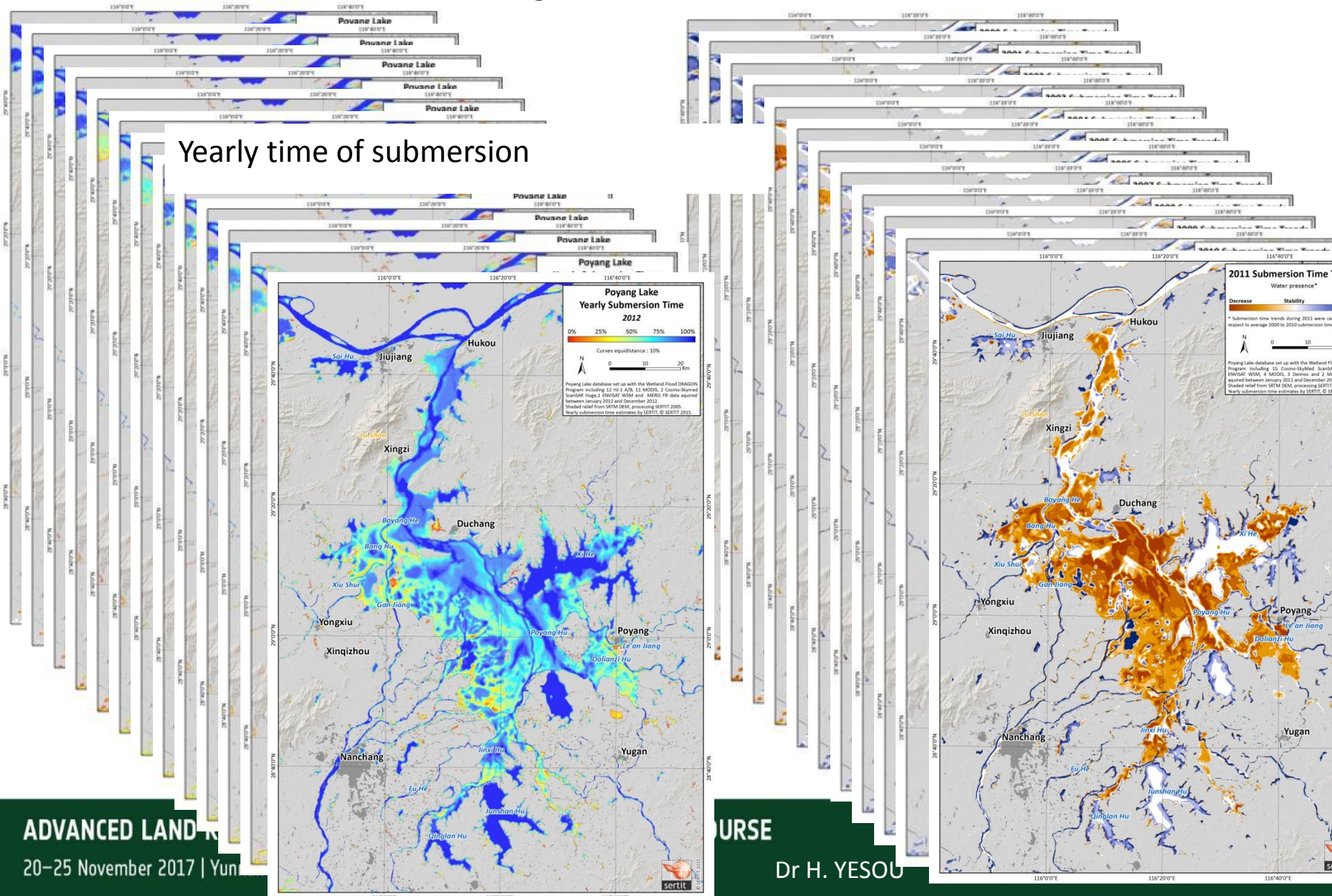
Analysis of temporal variations of water surfaces from 2000 to 2014
Normal hydrological year, wetness and dryer successions

=> Trends analysis in conjunction with meteo parameters ...



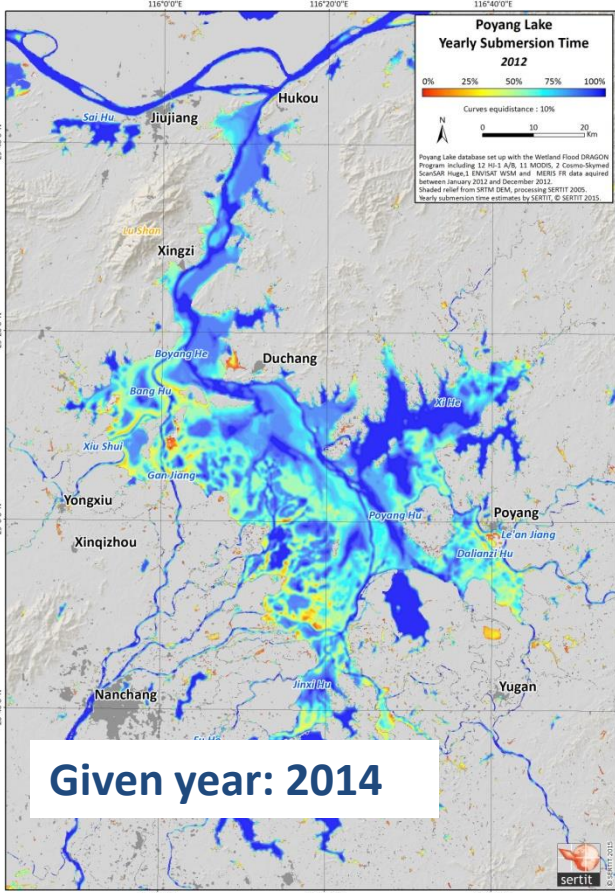
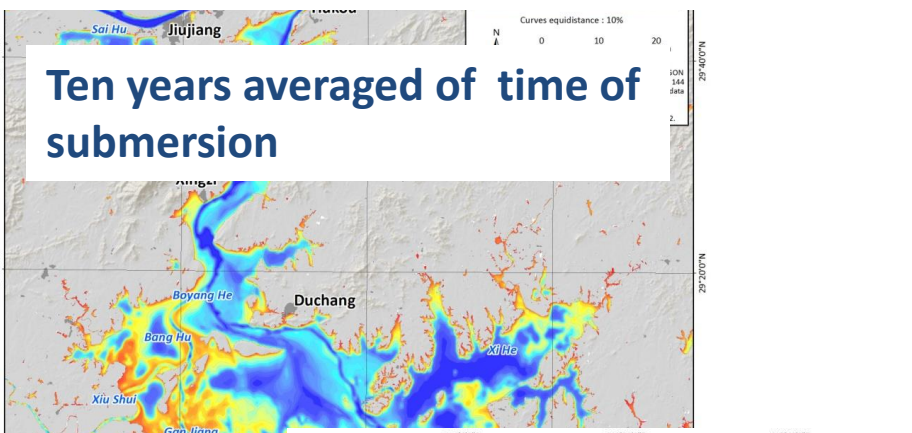
Water extent monitoring: Submersion time, occurrence maps

Yearly time of submersion

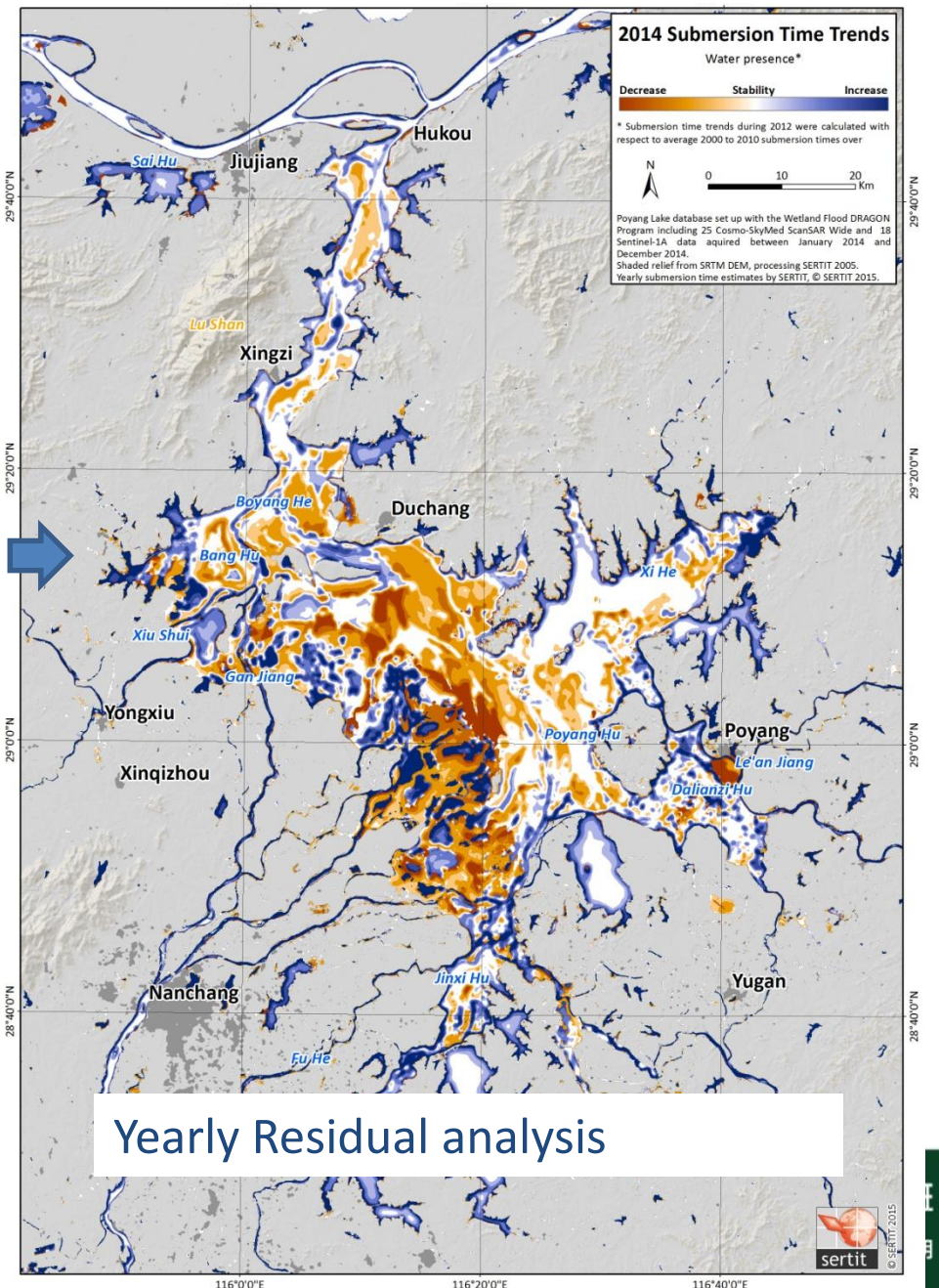


Water extent monitoring: Submersion time: residual analysis

Ten years averaged of time of submersion

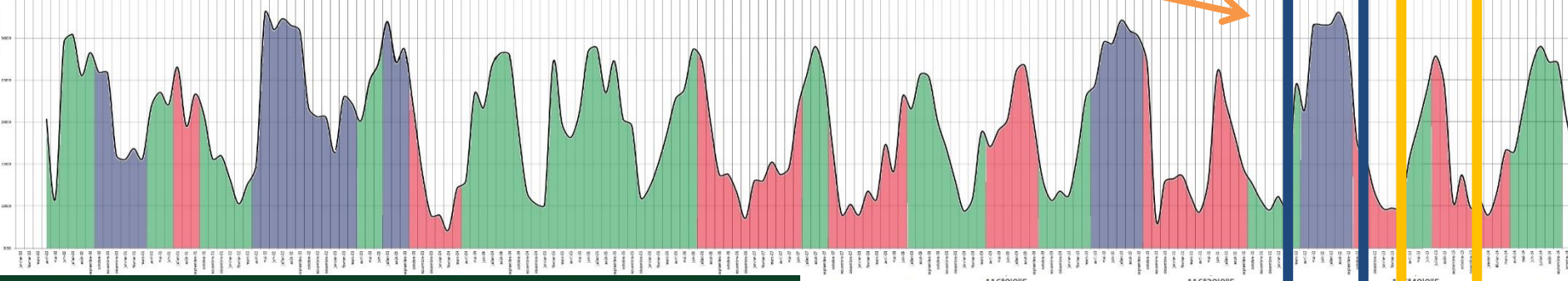
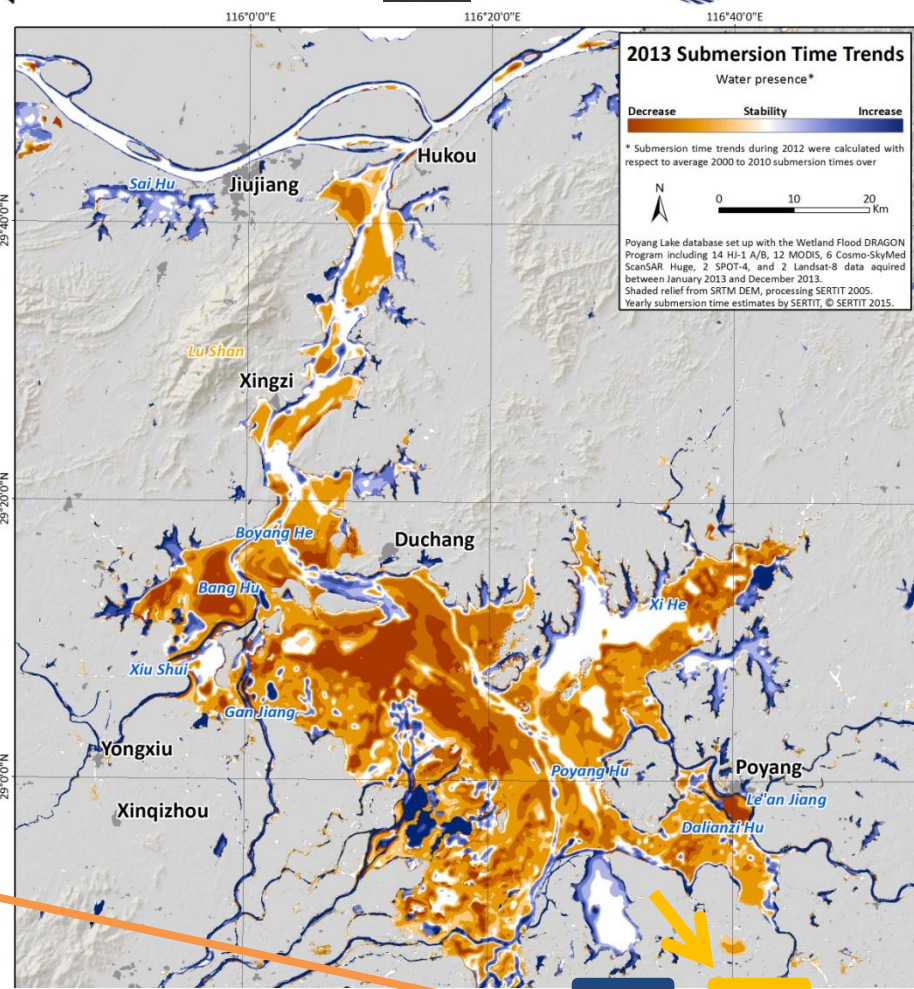
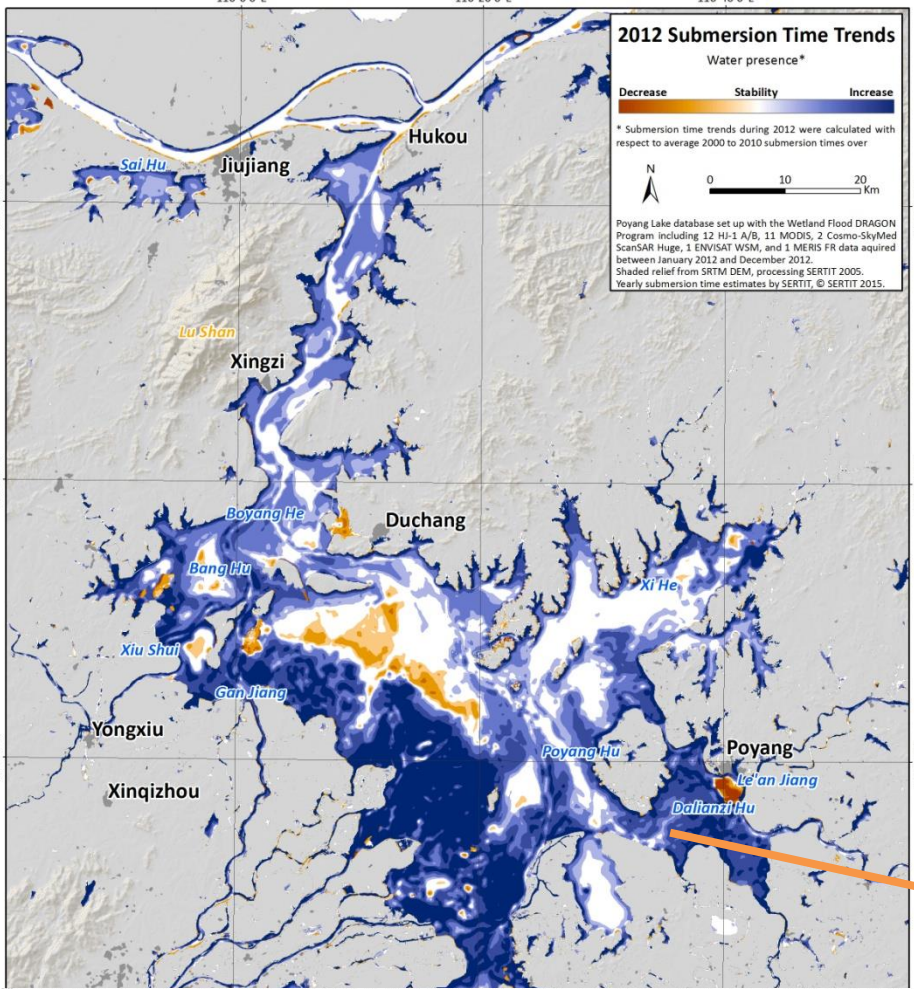


Given year: 2014



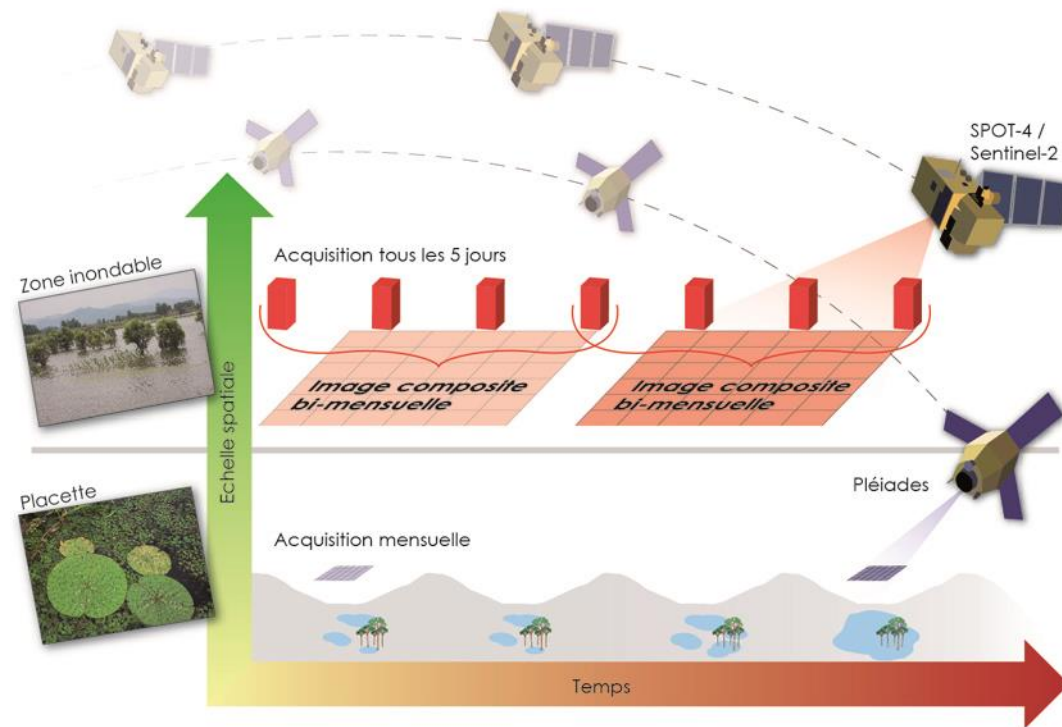
Yearly Residual analysis

Water extent monitoring: Submersion time: residual analysis



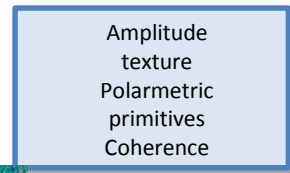
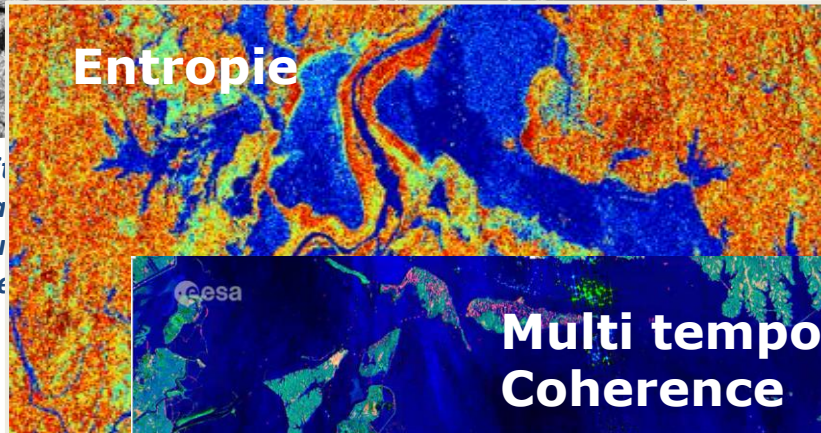
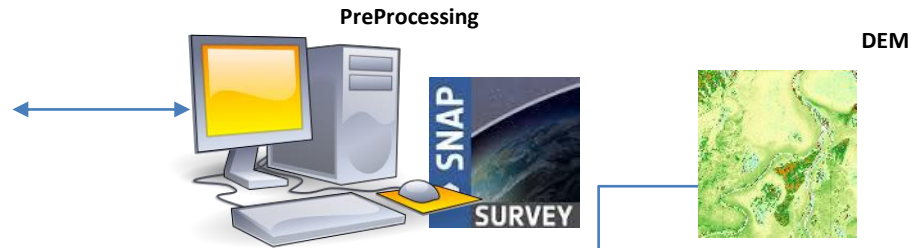
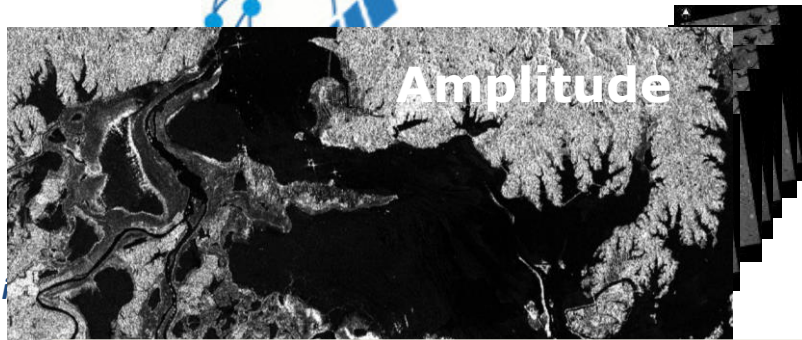
Multi source & multiscale optical and SAR

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

Schematic processing flow for Sentinel1 Sar data

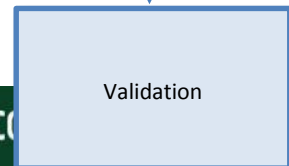
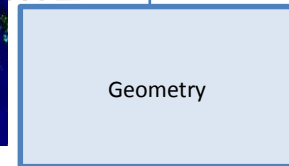
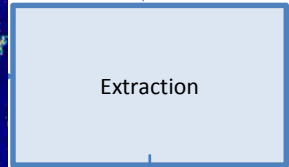
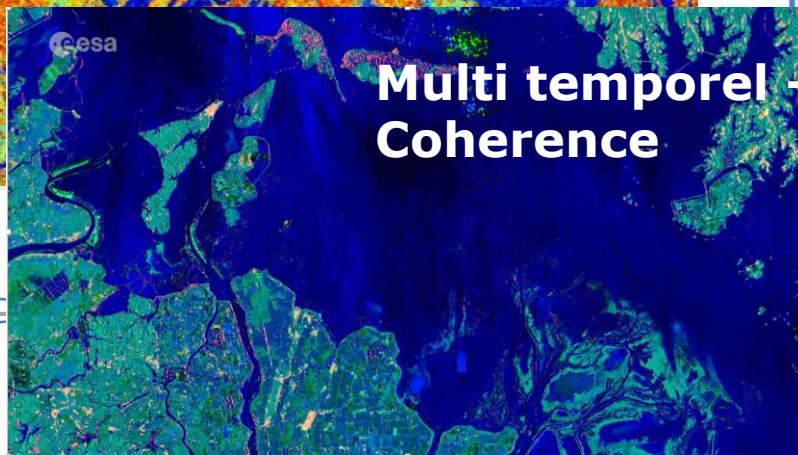


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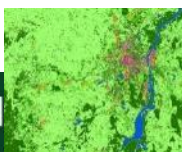
Methods

Geometry

Validation



Database

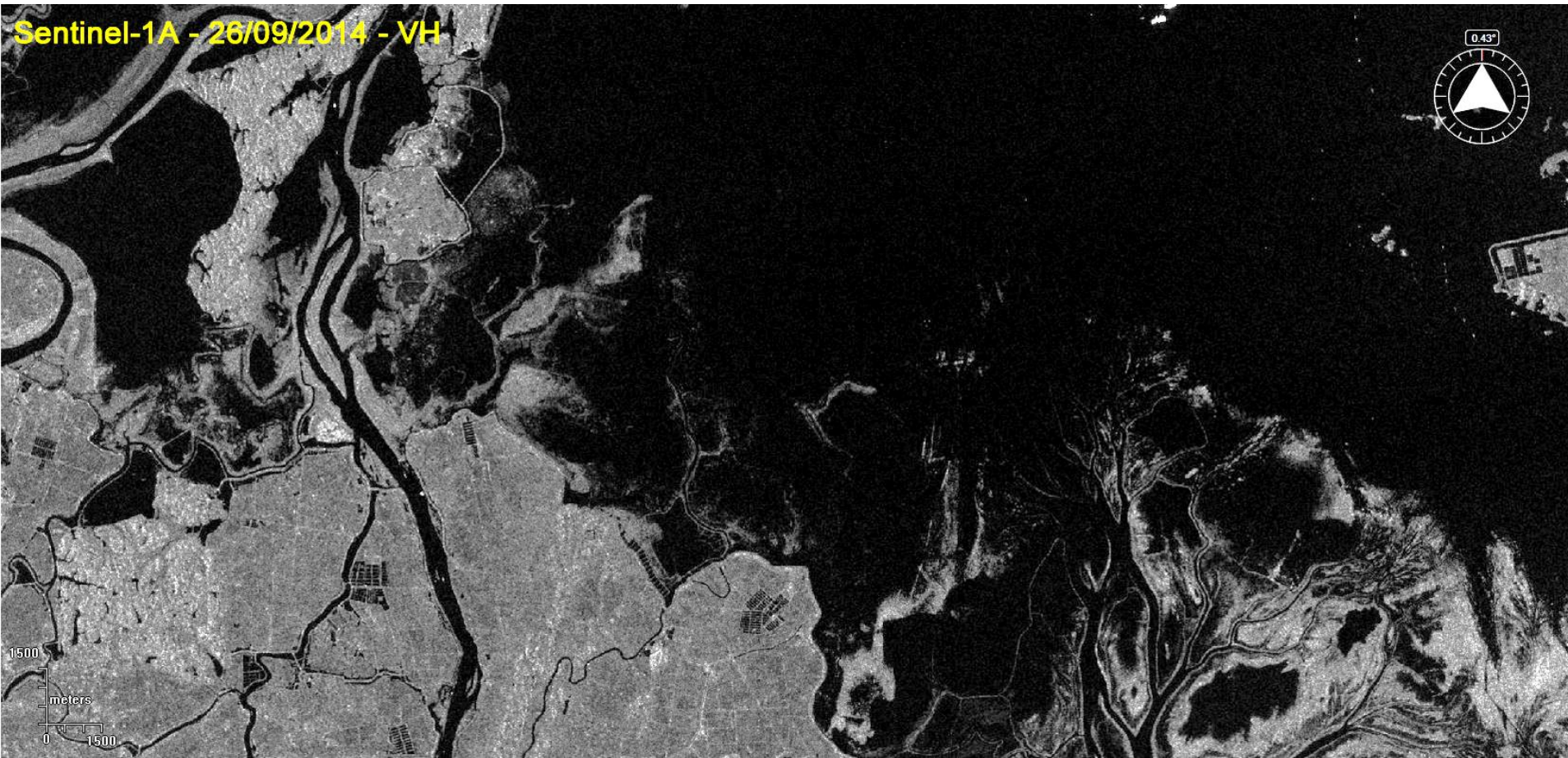


Objectives of training course

- Open SPOT-5 images in ESA SNAP 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

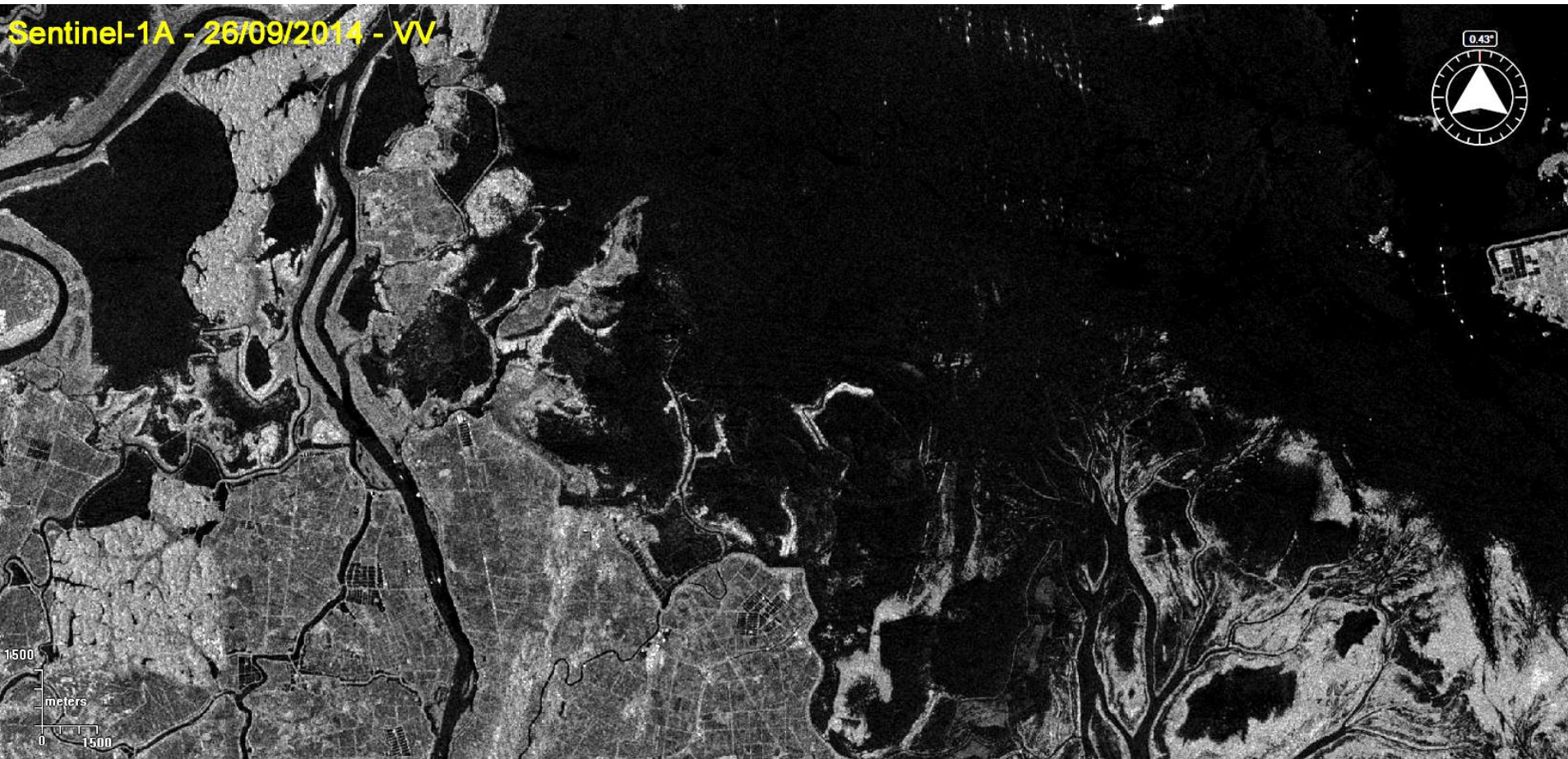


Recognition of water surface water flooded vegetation and floating vegetation



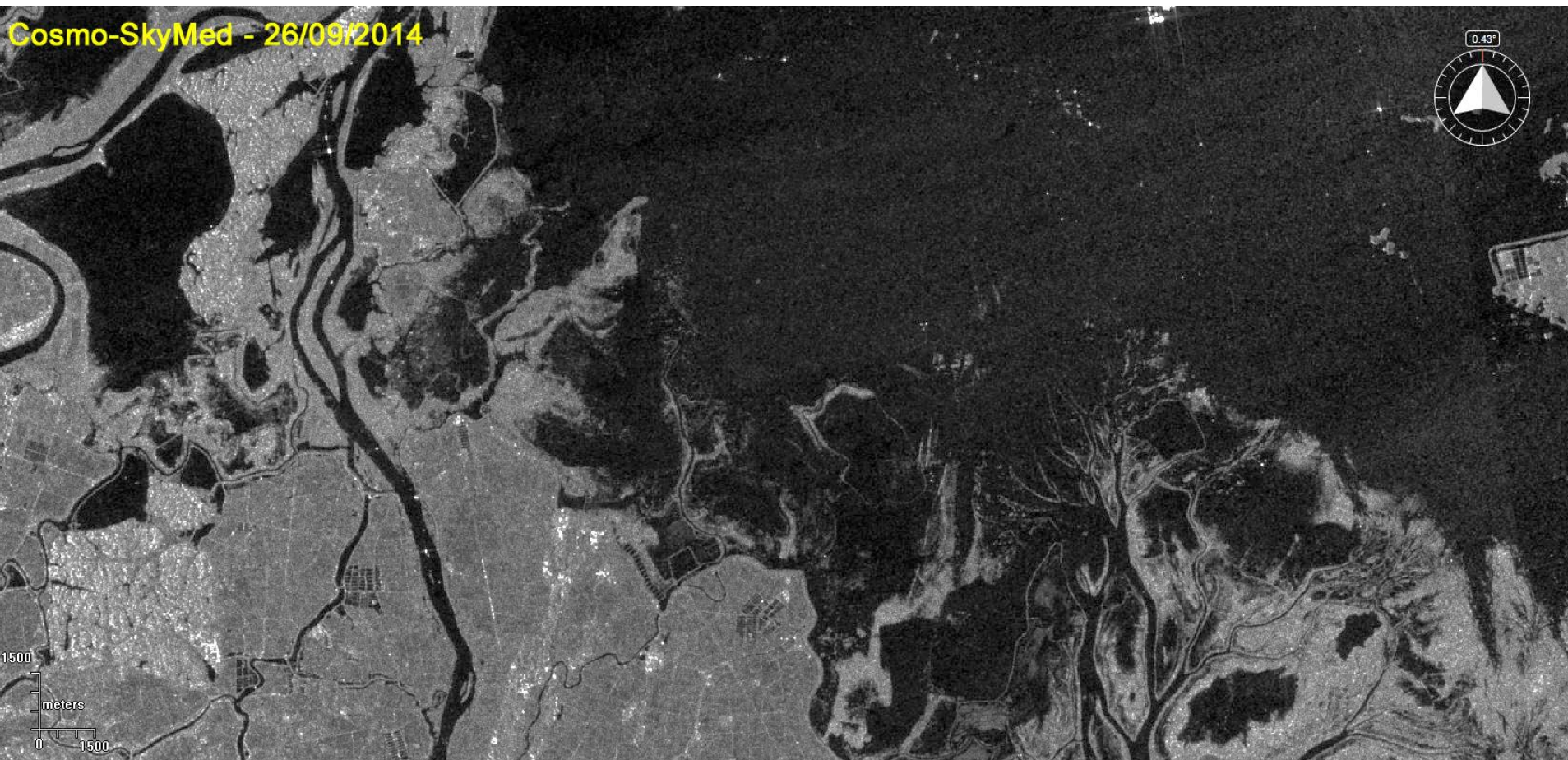
Recognition of water surface water flooded vegetation and floating vegetation

Sentinel1 VV less apparent water than on VH



Recognition of water surface water flooded vegetation and floating vegetation

Sentinel1 band C VV = CSK band X HH



Recognition of water surface water flooded vegetation and floating vegetation



Nymphoides Pelatum



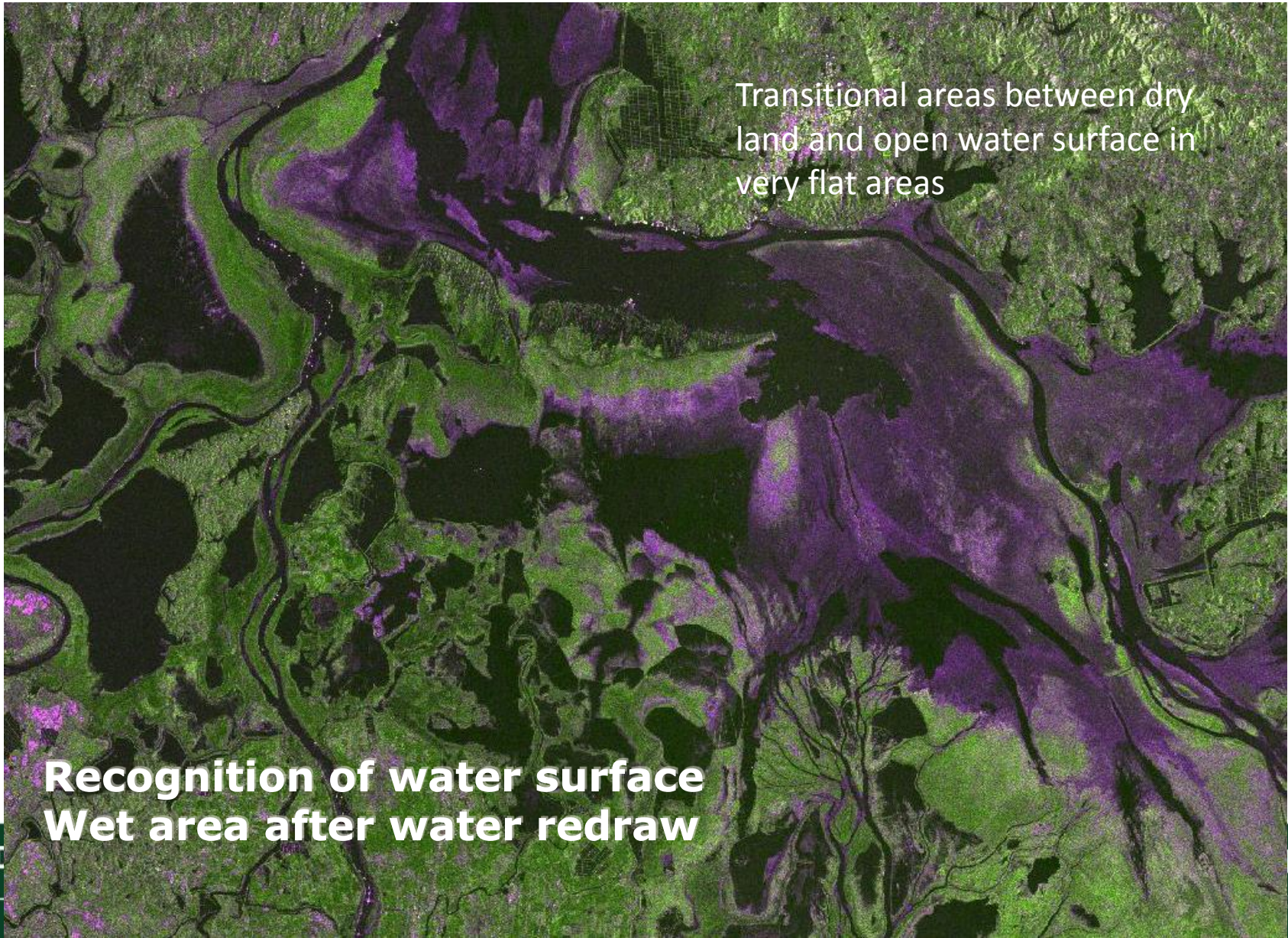
Recognition of water surface water flooded vegetation and floating vegetation



Jacynth

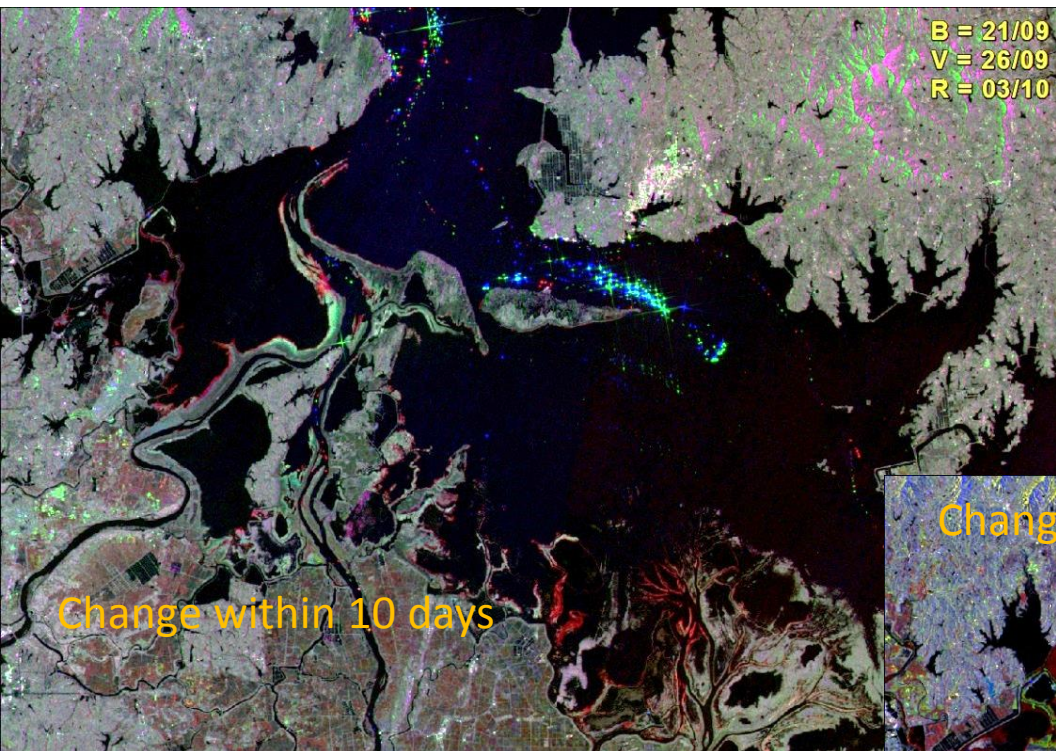
Recognition of water surface Wet area after water redraw





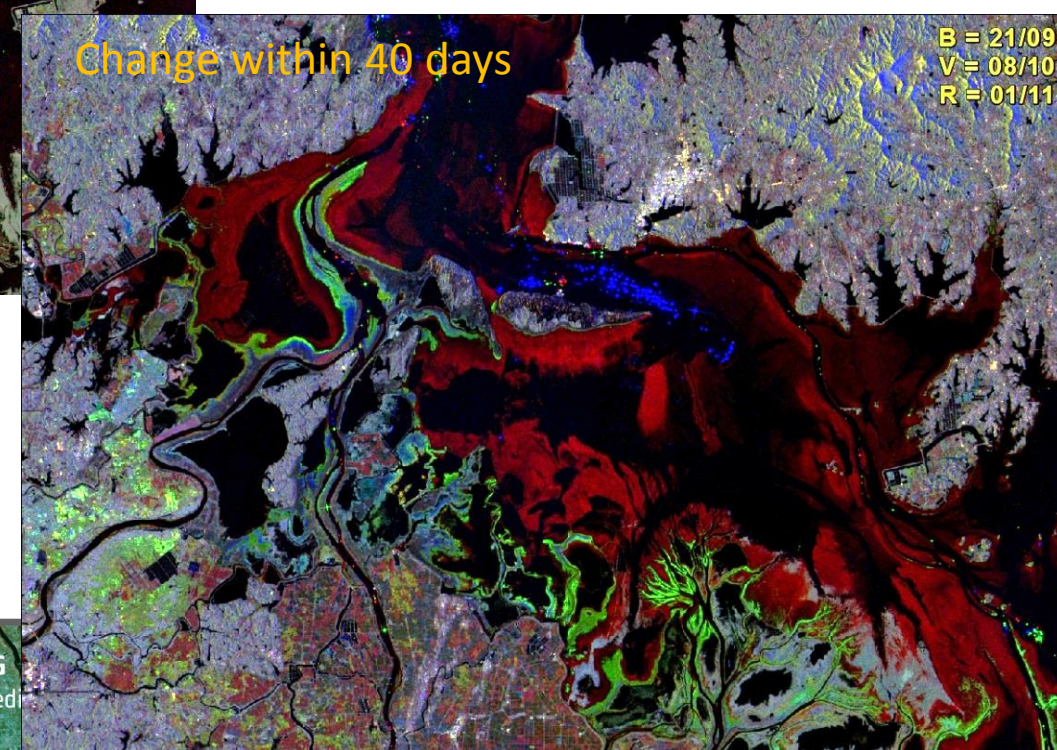
Transitional areas between dry land and open water surface in very flat areas

Recognition of water surface
Wet area after water redraw

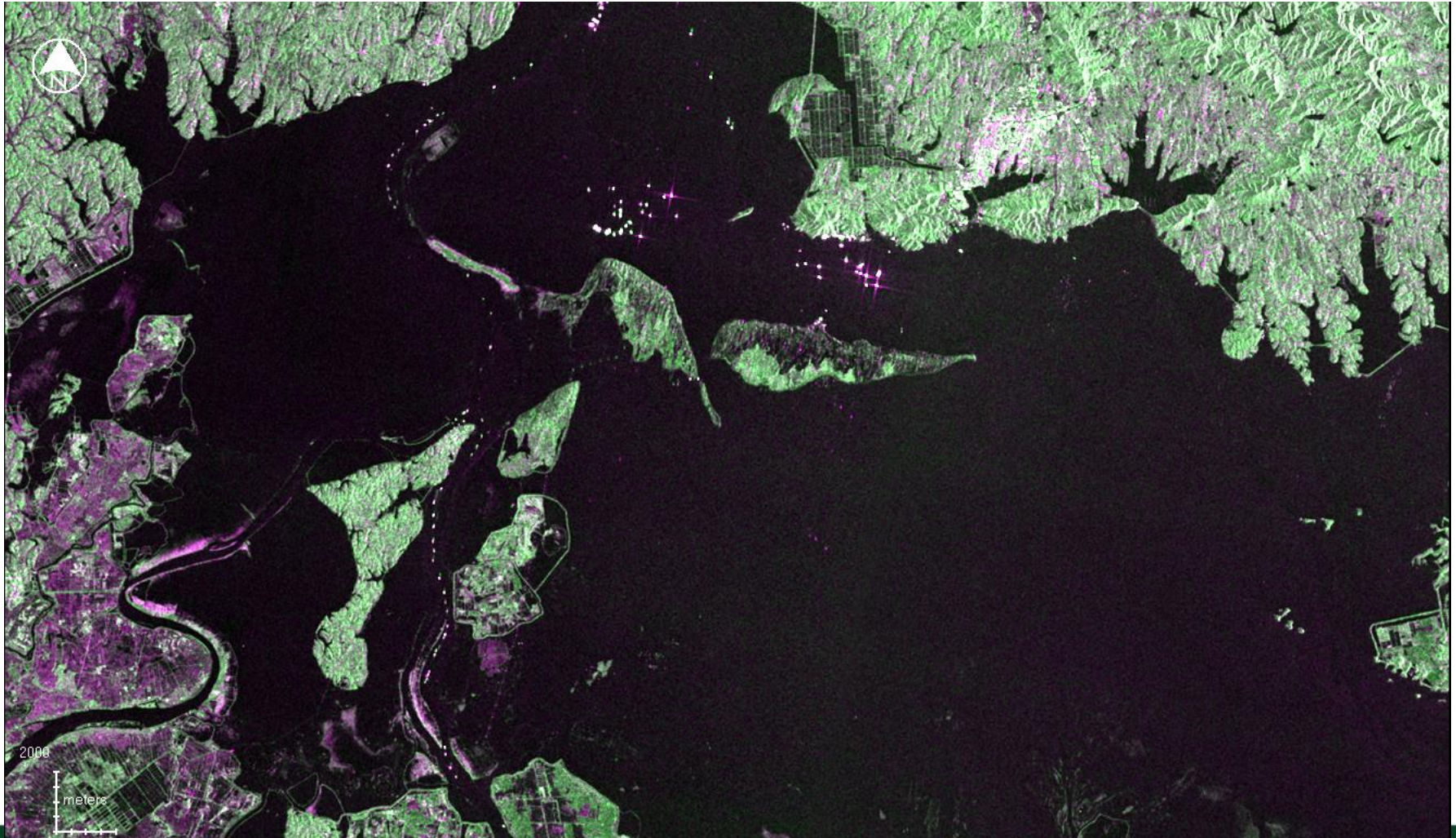


Interest of High temporal revisit for monitoring hydrological behaviors

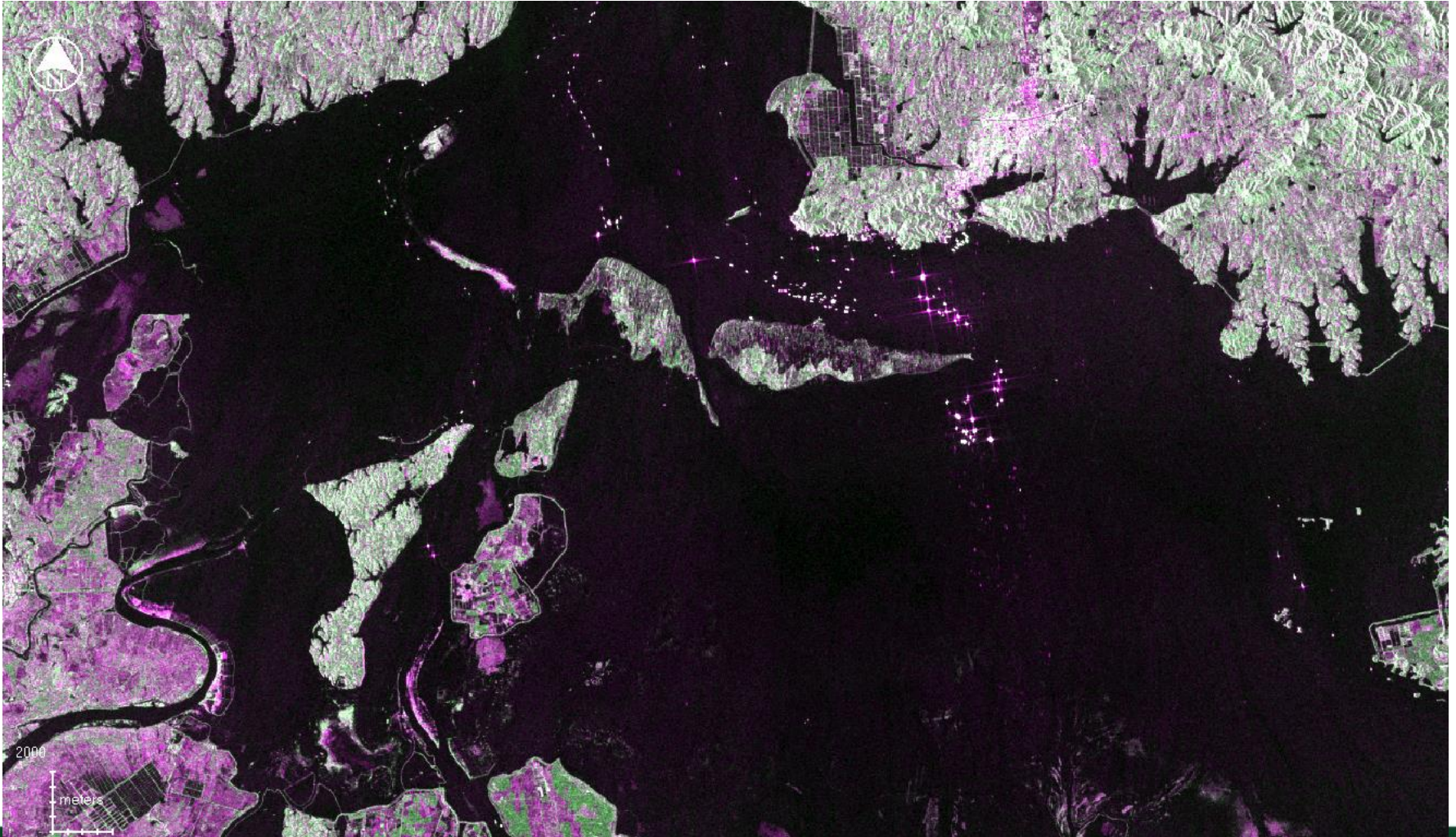
Intra annual changes



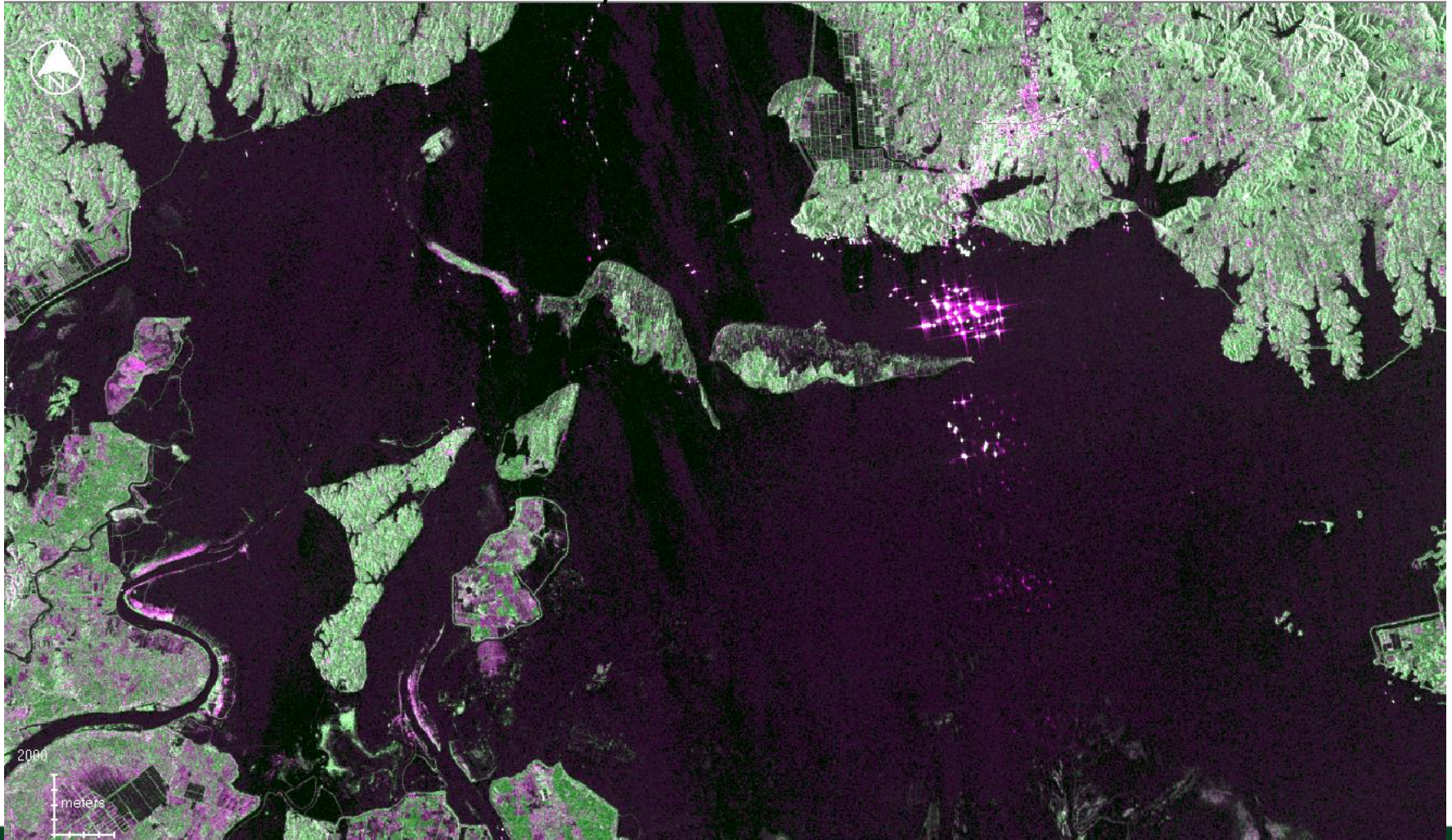
12 of June 2015



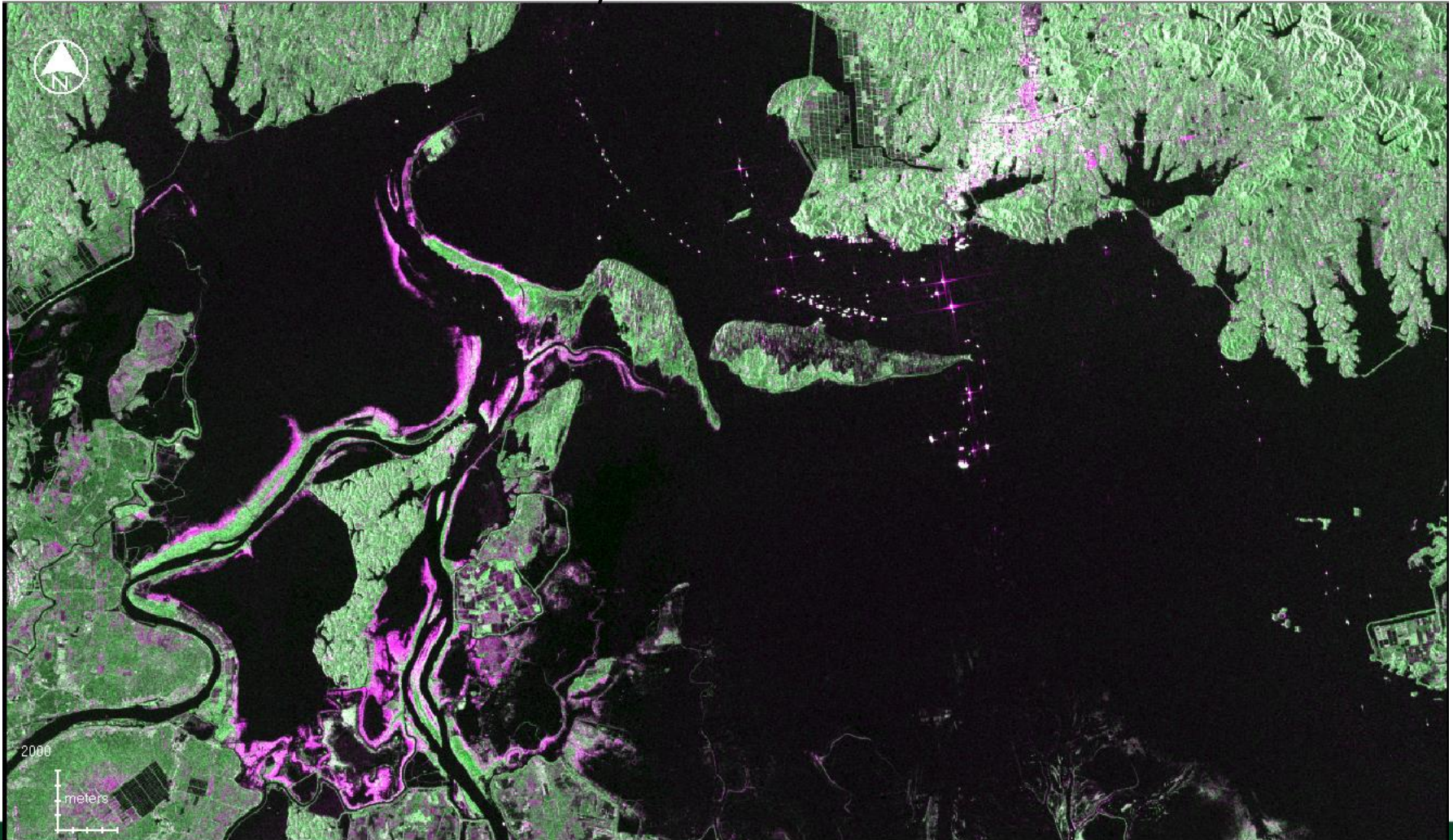
29 of June 2015



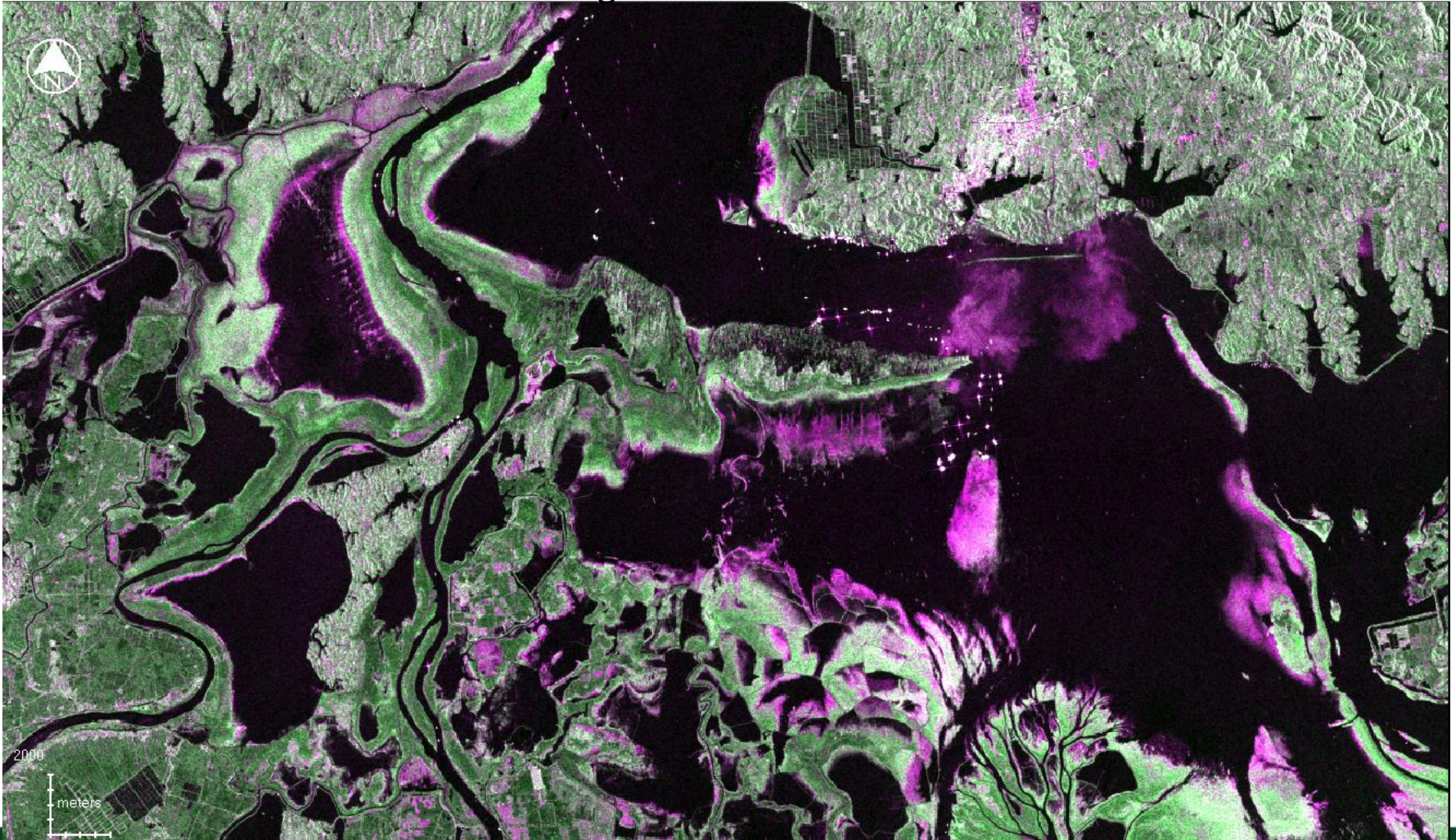
11 of July 2015



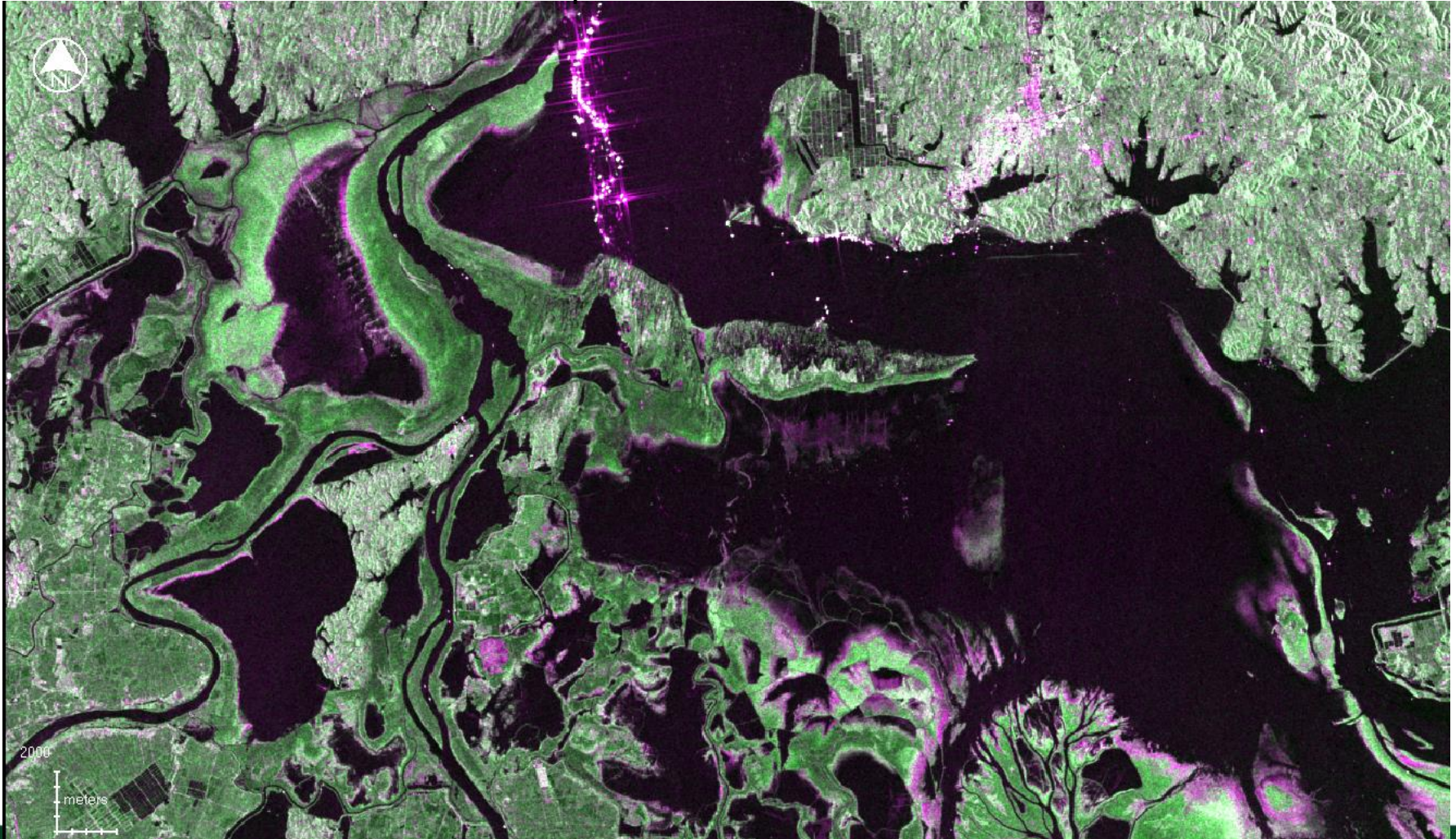
23 of July 2015


































28 of August 2015



9 of September 2015










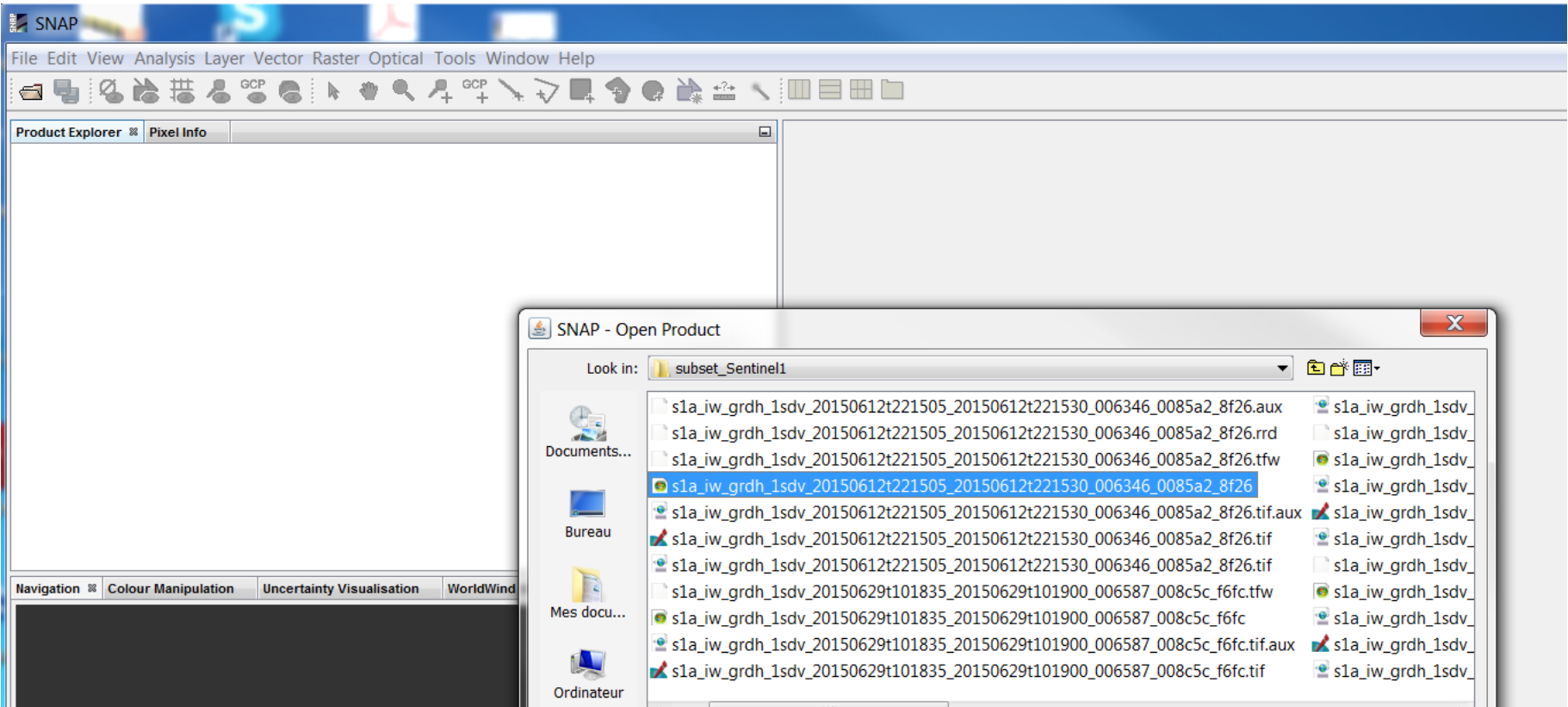
Available SAR Sentinel1 data

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 s1a_iw_grdh_1sdv_20150828t101838_20150828t101903_007462_00a492_b9a2.tfw	Fichier TFW	1 Ko
 s1a_iw_grdh_1sdv_20150909t101838_20150909t101903_007637_00a962_ddda.tfw	Fichier TFW	1 Ko
 s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26	Fichier TIF	118 504 Ko
 s1a_iw_grdh_1sdv_20150629t101835_20150629t101900_006587_008c5c_f6fc	Fichier TIF	118 193 Ko
 s1a_iw_grdh_1sdv_20150711t101835_20150711t101900_006762_009129_c8a1	Fichier TIF	118 586 Ko
 s1a_iw_grdh_1sdv_20150723t101836_20150723t101901_006937_00962c_0fe5	Fichier TIF	118 891 Ko
 s1a_iw_grdh_1sdv_20150816t101837_20150816t101902_007287_009fd6_c32e	Fichier TIF	119 176 Ko
 s1a_iw_grdh_1sdv_20150828t101838_20150828t101903_007462_00a492_b9a2	Fichier TIF	119 522 Ko
 s1a_iw_grdh_1sdv_20150909t101838_20150909t101903_007637_00a962_ddda	Fichier TIF	119 260 Ko

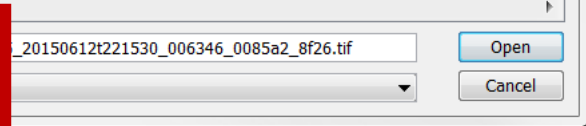
Available SAR Sentinel1 data

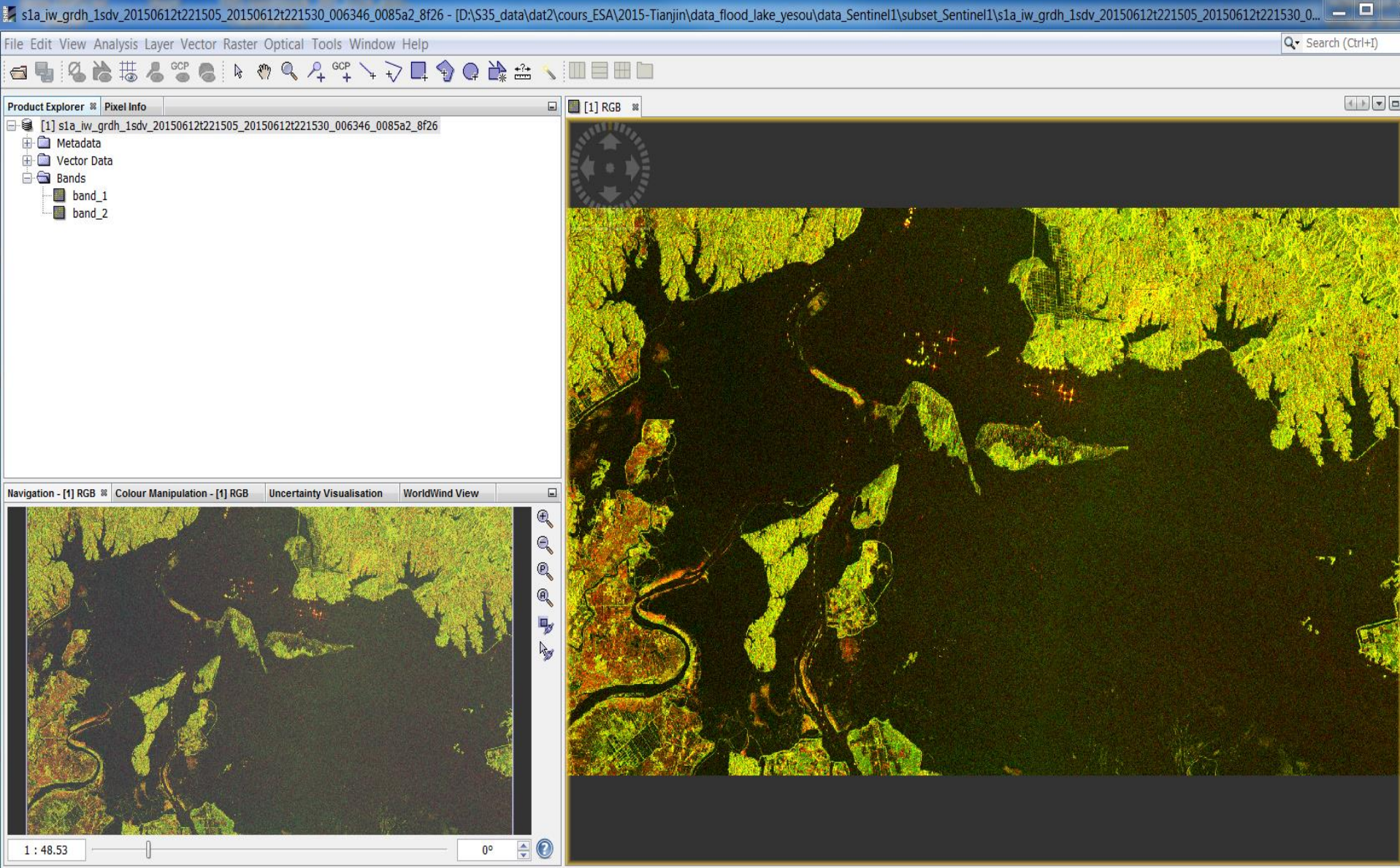
6 Subset of Sentinel1 images acquired in 2015

 s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26	Fichier TIF	118 504 Ko
 s1a_iw_grdh_1sdv_20150629t101835_20150629t101900_006587_008c5c_f6fc	Fichier TIF	118 193 Ko
 s1a_iw_grdh_1sdv_20150711t101835_20150711t101900_006762_009129_c8a1	Fichier TIF	118 586 Ko
 s1a_iw_grdh_1sdv_20150723t101836_20150723t101901_006937_00962c_0fe5	Fichier TIF	118 891 Ko
 s1a_iw_grdh_1sdv_20150816t101837_20150816t101902_007287_009fd6_c32e	Fichier TIF	119 176 Ko
 s1a_iw_grdh_1sdv_20150828t101838_20150828t101903_007462_00a492_b9a2	Fichier TIF	119 522 Ko
 s1a_iw_grdh_1sdv_20150909t101838_20150909t101903_007637_00a962_ddda	Fichier TIF	119 260 Ko

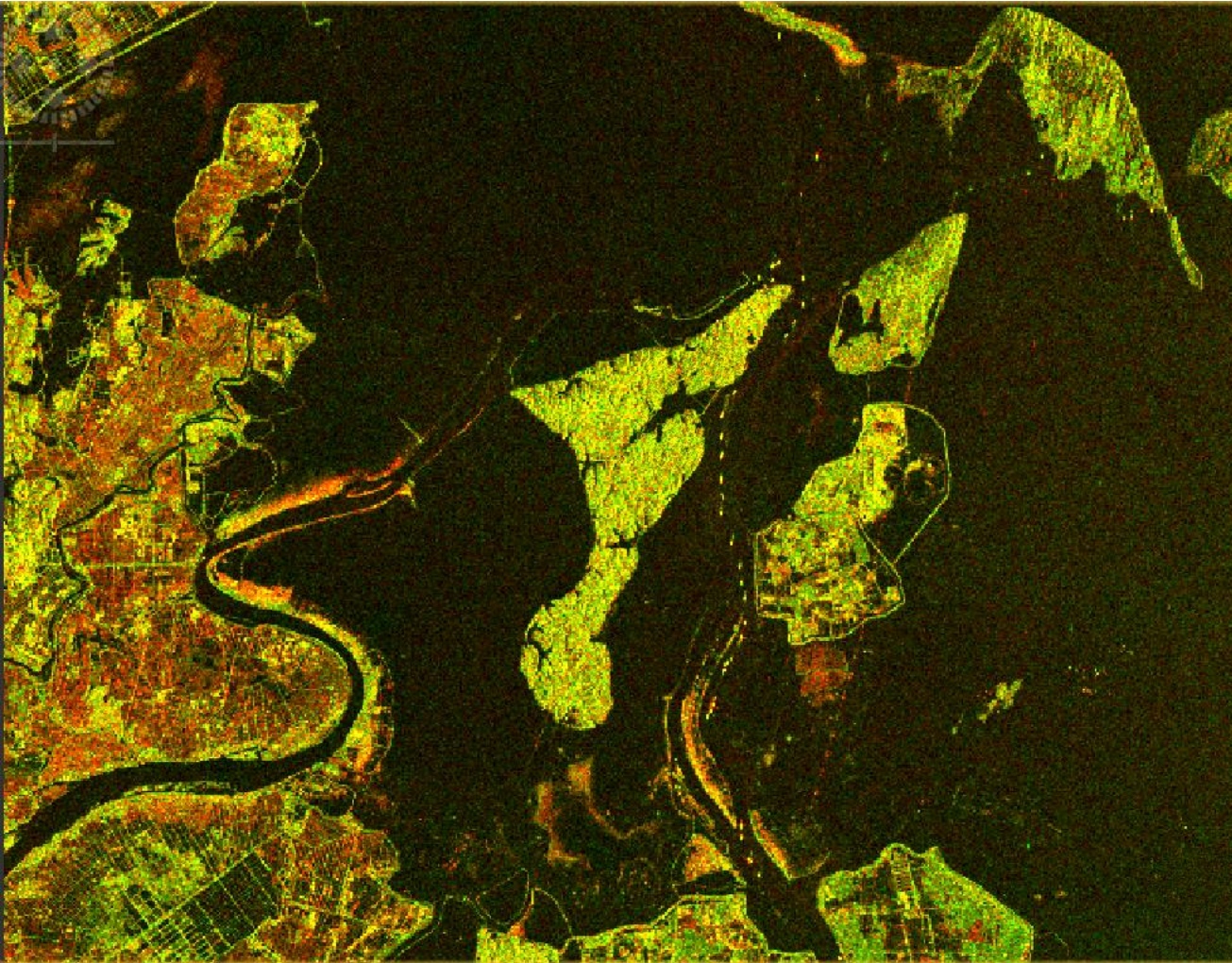


- s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26.aux
- s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26.rrd
- s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26.tfw
- s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26.tif**
- s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26.tif.aux
- s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26.tif
- s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26.tif
- s1a_iw_grdh_1sdv_20150629t101835_20150629t101900_006587_008c5c_f6fc.tfw
- s1a_iw_grdh_1sdv_20150629t101835_20150629t101900_006587_008c5c_f6fc
- s1a_iw_grdh_1sdv_20150629t101835_20150629t101900_006587_008c5c_f6fc.tif.aux





12 of June 2015

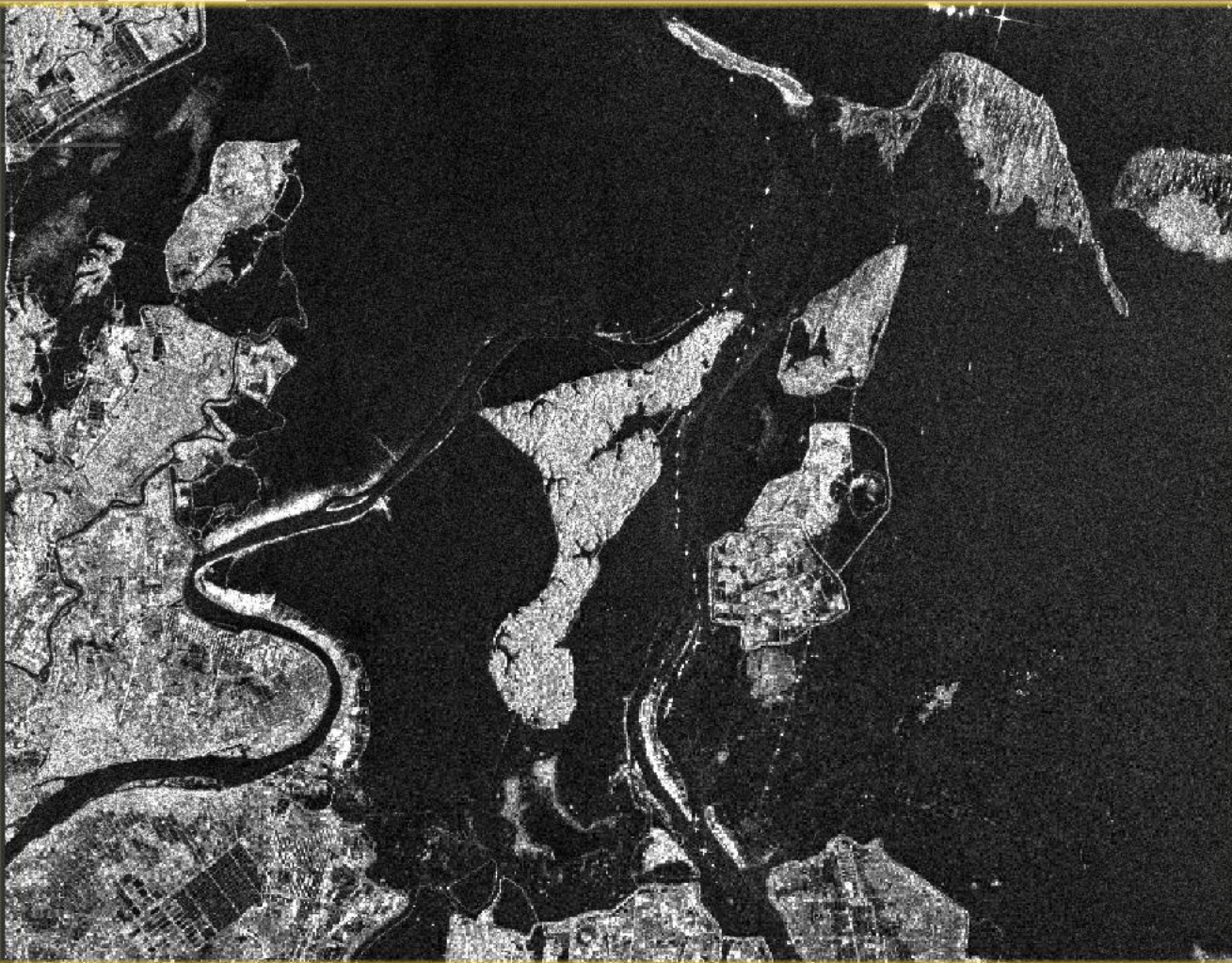


Water
Dykes
Wuchen island
Paddy fields
Sandy hills

Boats

...

12 of June 2015: VV

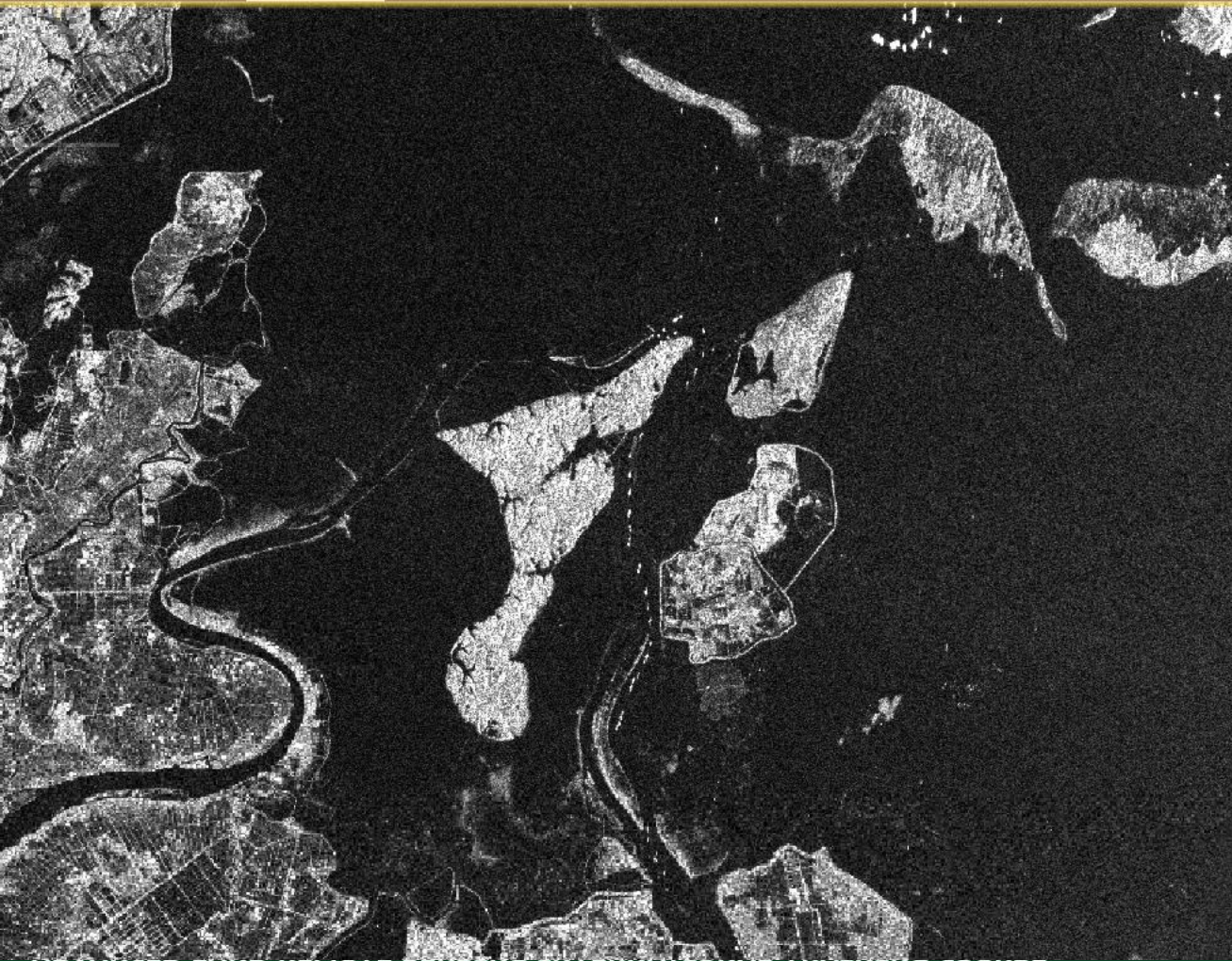


Water
Dykes
Wuchen island
Paddy fields
Sandy hills

Boats

...

12 of June 2015: VH



Water
Dykes
Wuchen island
Paddy fields

Boats

...

SNAP - Open Product

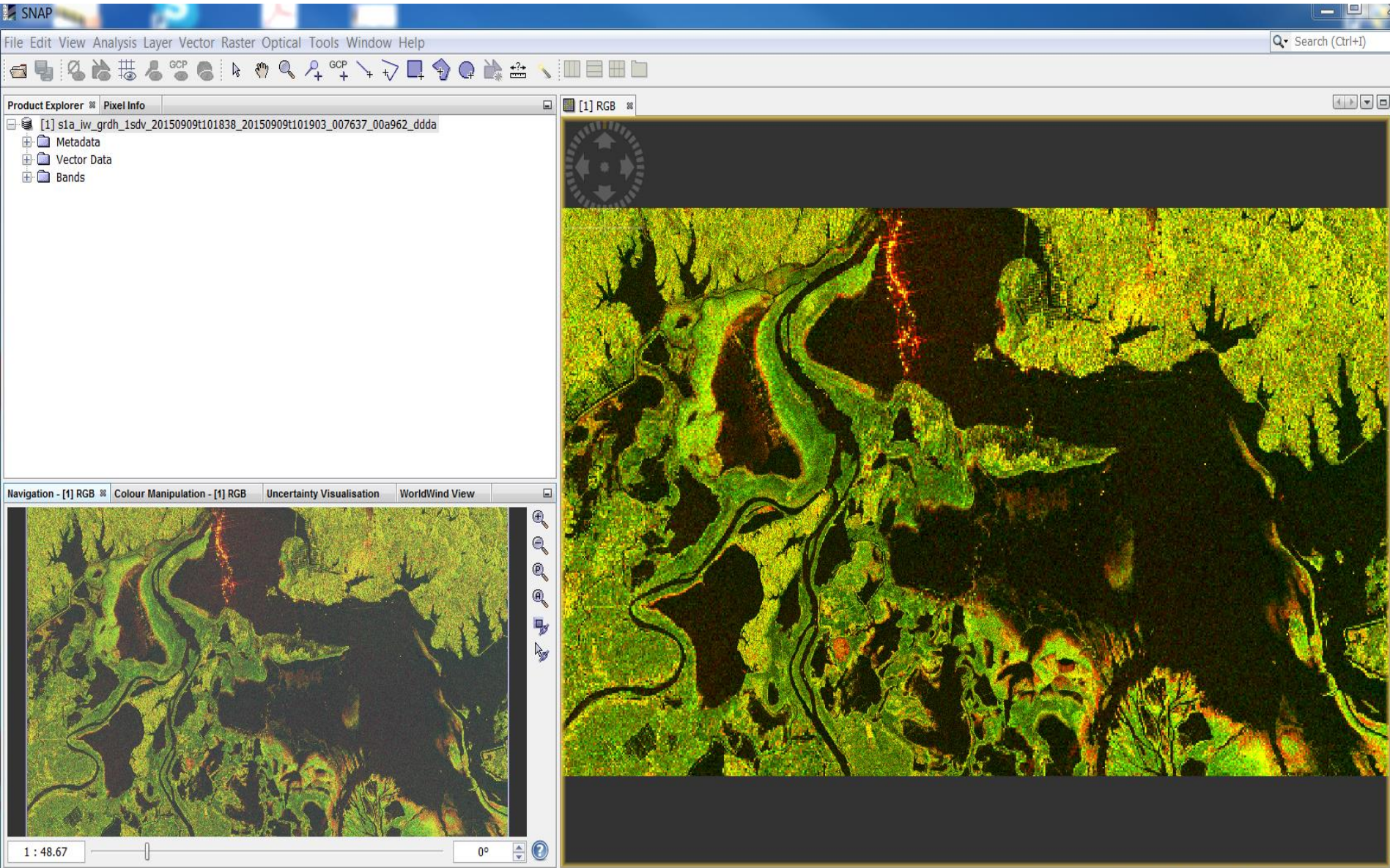
Look in: subset_Sentinel1

7_009fd6_c32e.tfw	s1a_iw_grdh_1sdv_20150909t101838_20150909t101903_007637_00a962_ddd.rrd
7_009fd6_c32e	s1a_iw_grdh_1sdv_20150909t101838_20150909t101903_007637_00a962_ddd.tfw
7_009fd6_c32e.tif.aux	s1a_iw_grdh_1sdv_20150909t101838_20150909t101903_007637_00a962_ddd
7_009fd6_c32e.tif	s1a_iw_grdh_1sdv_20150909t101838_20150909t101903_007637_00a962_ddd.tif.aux
7_009fd6_c32e.tif	s1a_iw_grdh_1sdv_20150909t101838_20150909t101903_007637_00a962_ddd.tif
2_00a492_b9a2.tfw	s1a_iw_grdh_1sdv_20150909t101838_20150909t101903_007637_00a962_ddd.tif
2_00a492_b9a2	s1a_iw_grdh_1sdv_20150909t101838_20150909t101903_007637_00a962_ddd.tif
2_00a492_b9a2.tif.aux	
2_00a492_b9a2.tif	
2_00a492_b9a2.tif	
7_00a962_ddd.aux	

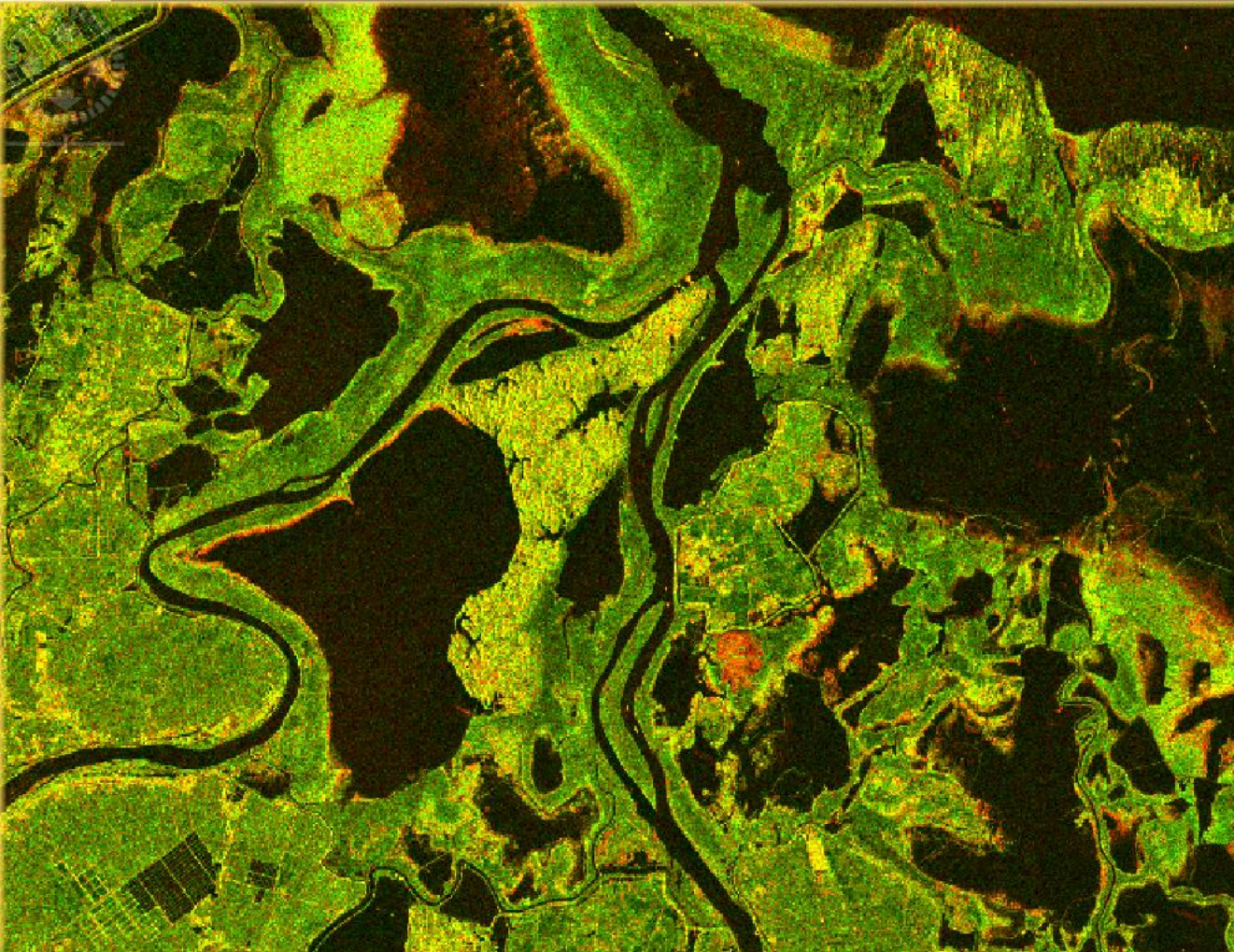
File name:

Files of type: All Files

Open Cancel



09 of Septembr 2015

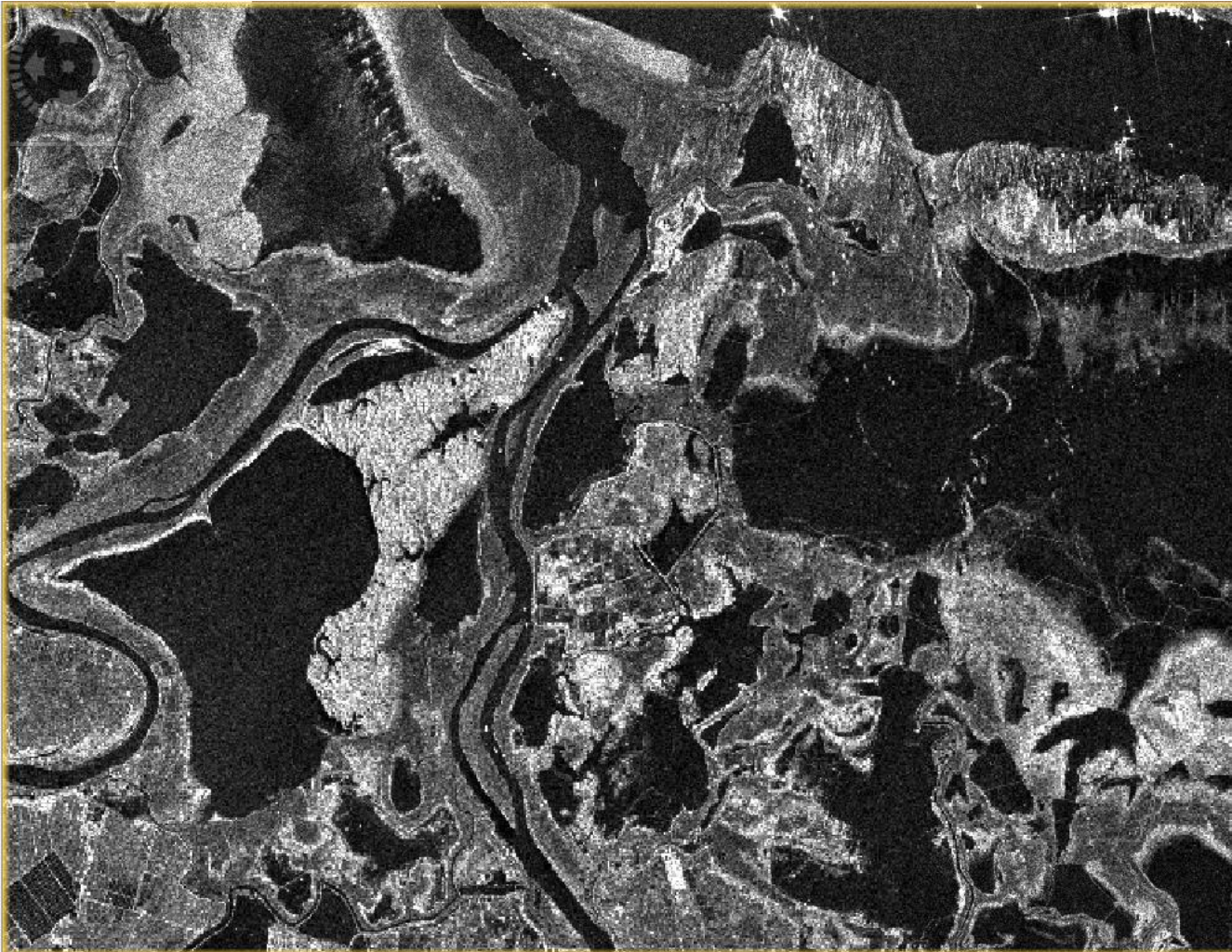


Water
Dykes
Wuchen island
Paddy fields
Sandy hills

Boats
Fish nets

...

09 of September 2015 VV

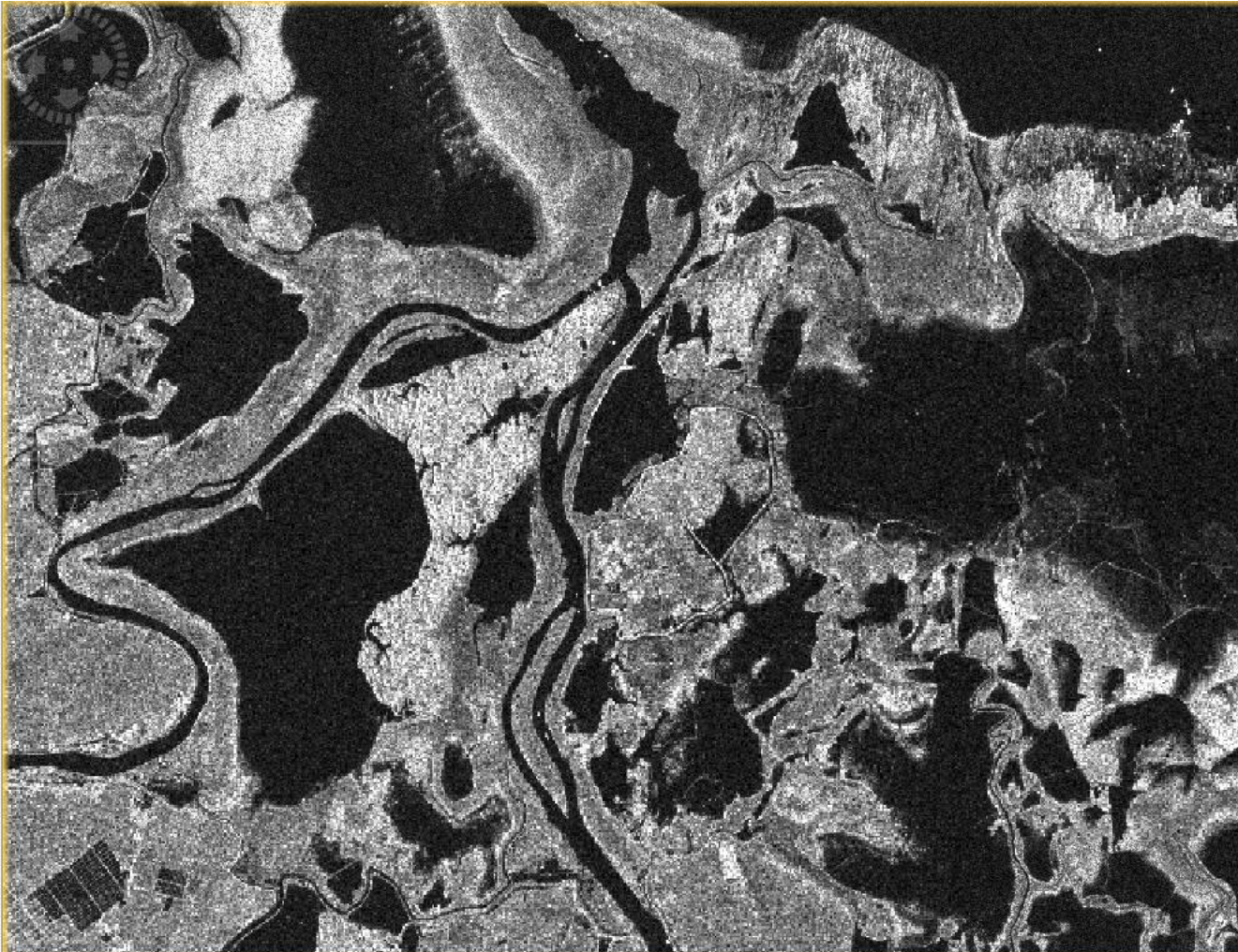


Water
Dykes
Wuchen island
Paddy fields
Sandy hills

Boats
Fish nets

...

09 of September 2015 VH



Water
Dykes
Wuchen island
Paddy fields
Sandy hills

Boats
Fish nets

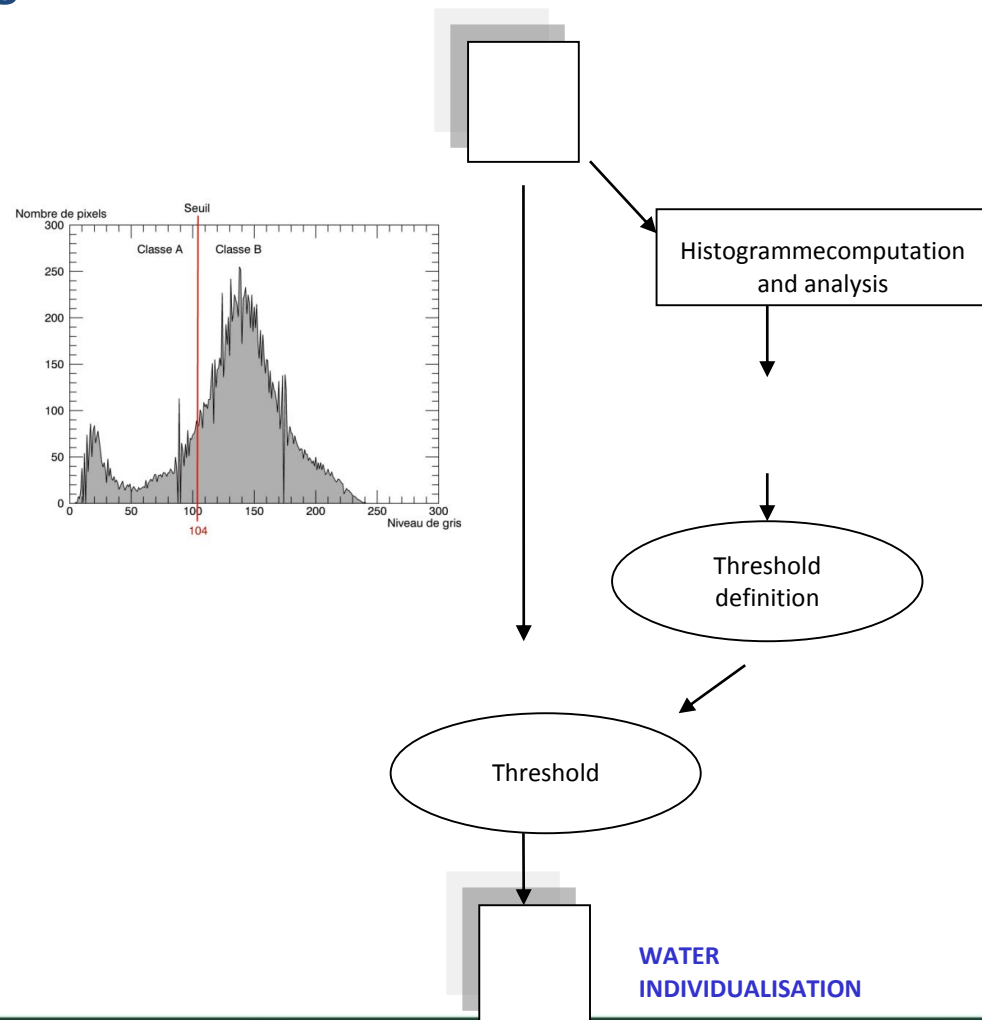
...

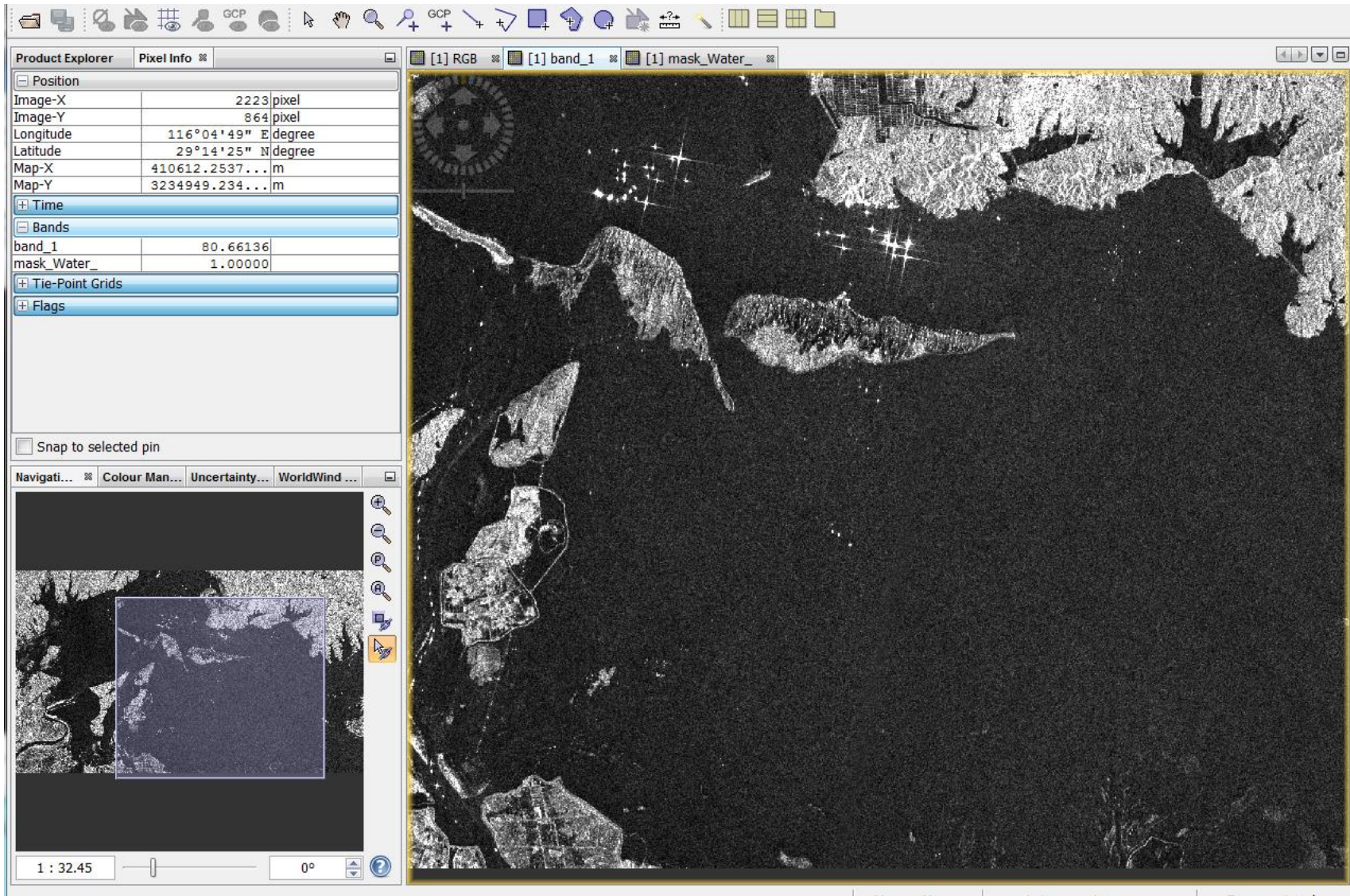
- Water extraction by thresholding performed on:

- Amplitude data (mediane fenetre glissante)
- Coherence
- Polarimetry approach (Shannon Entropy)

- Methods of classification

- Supervised
- None supervised
- Oriented object methods
- SVM
- Snake detection





s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26 - [D:\S35_data\dat2\cours_ESA\2015-Tianjin\data_flood_lake_yesou\data_Sentinel1\subset_Senti...

File Edit View Analysis Layer Vector Raster Optical Tools Window Help

Search (Ctrl+F)

Product Explorer Pixel Info [1] RGB [1] band_1

- [1] s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26
 - Metadata
 - Vector Data
 - Bands
 - band_1
 - band_2

Band Maths

Target product:
[1] s1a_iw_grdh_1sdv_20150612t221505_20150612t221530_006346_0085a2_8f26

Name: new_band_2

Description:

Unit:

Spectral wavelength: 0.0

Virtual (save expression only, don't store data)

Replace NaN and infinity results by NaN

Generate associated uncertainty band

Band maths expression:

Load... Save... Edit Expression...

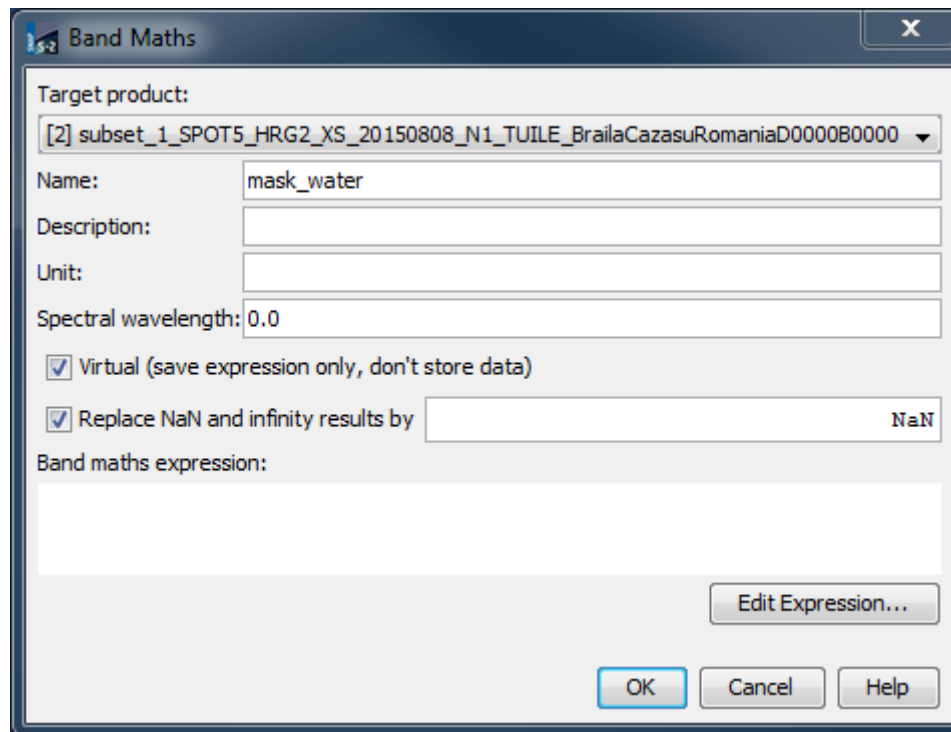
OK Cancel Help

1 : 32.45 0°

X -- Y -- Lat -- Lon -- Zoom -- Level --

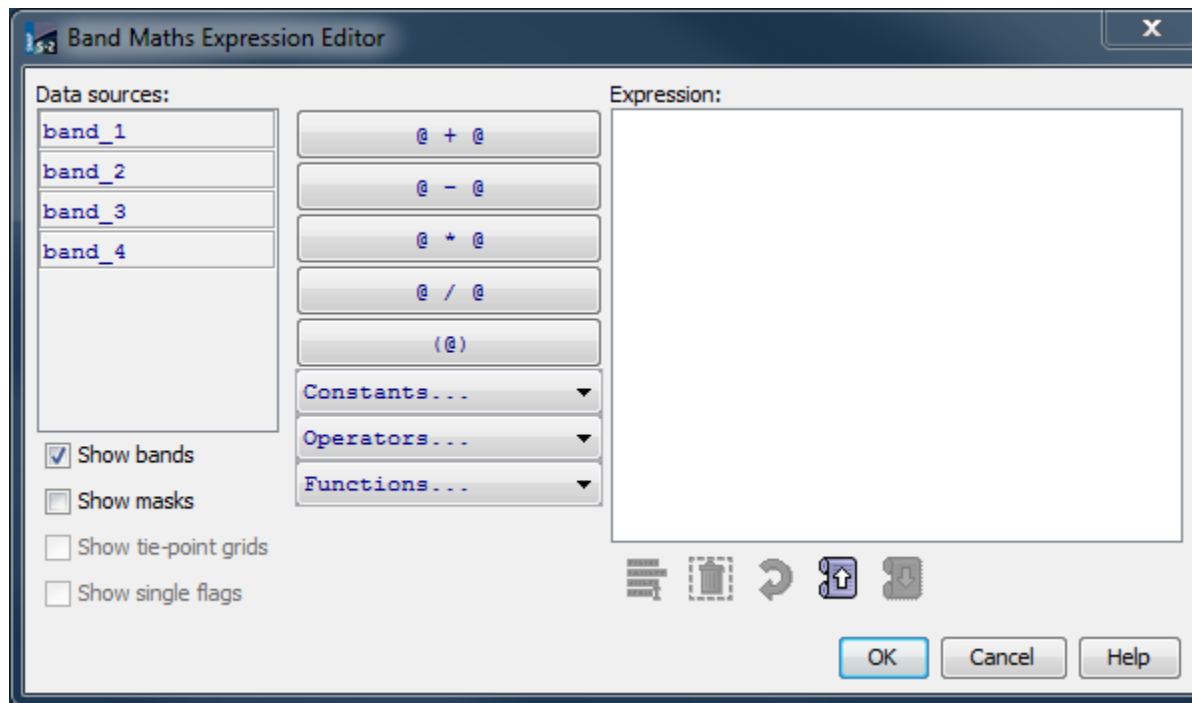
Extraction of permanent water bodies

- Go to Utilities> Create Band from Math Expression



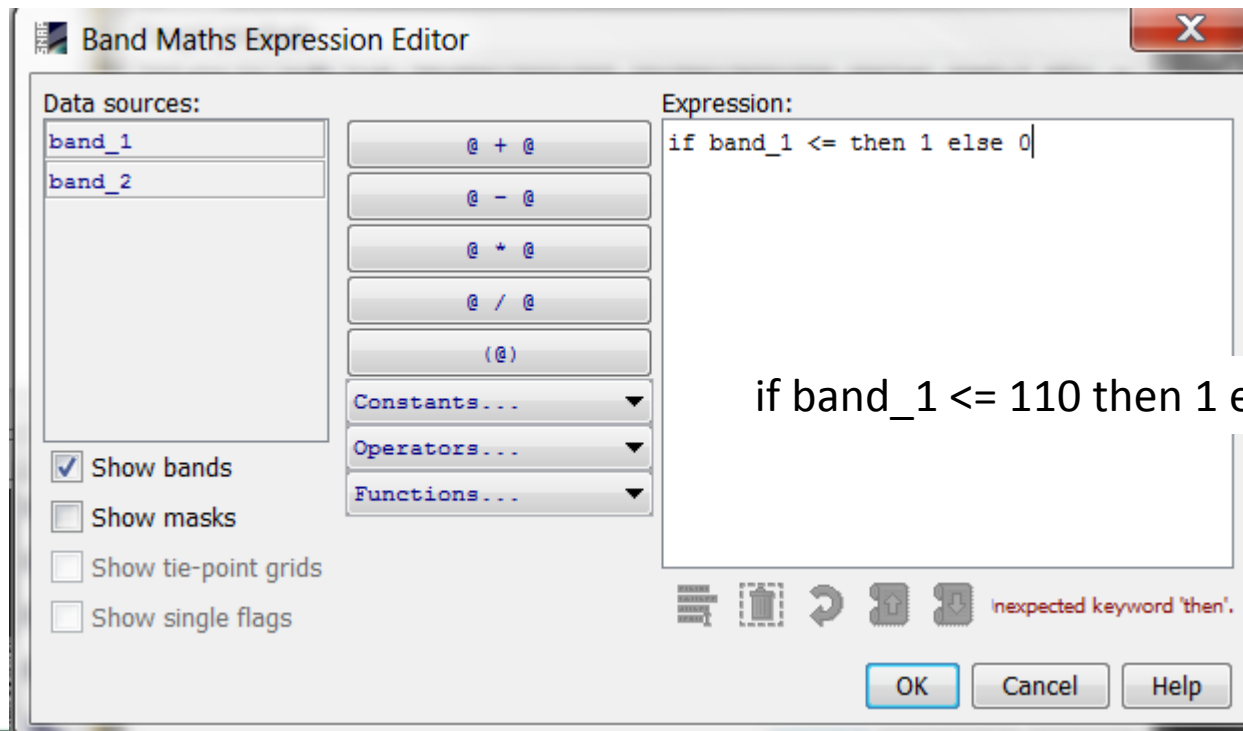
Extraction of permanent water bodies

- Click on Edit Expression



Extraction of permanent water bodies

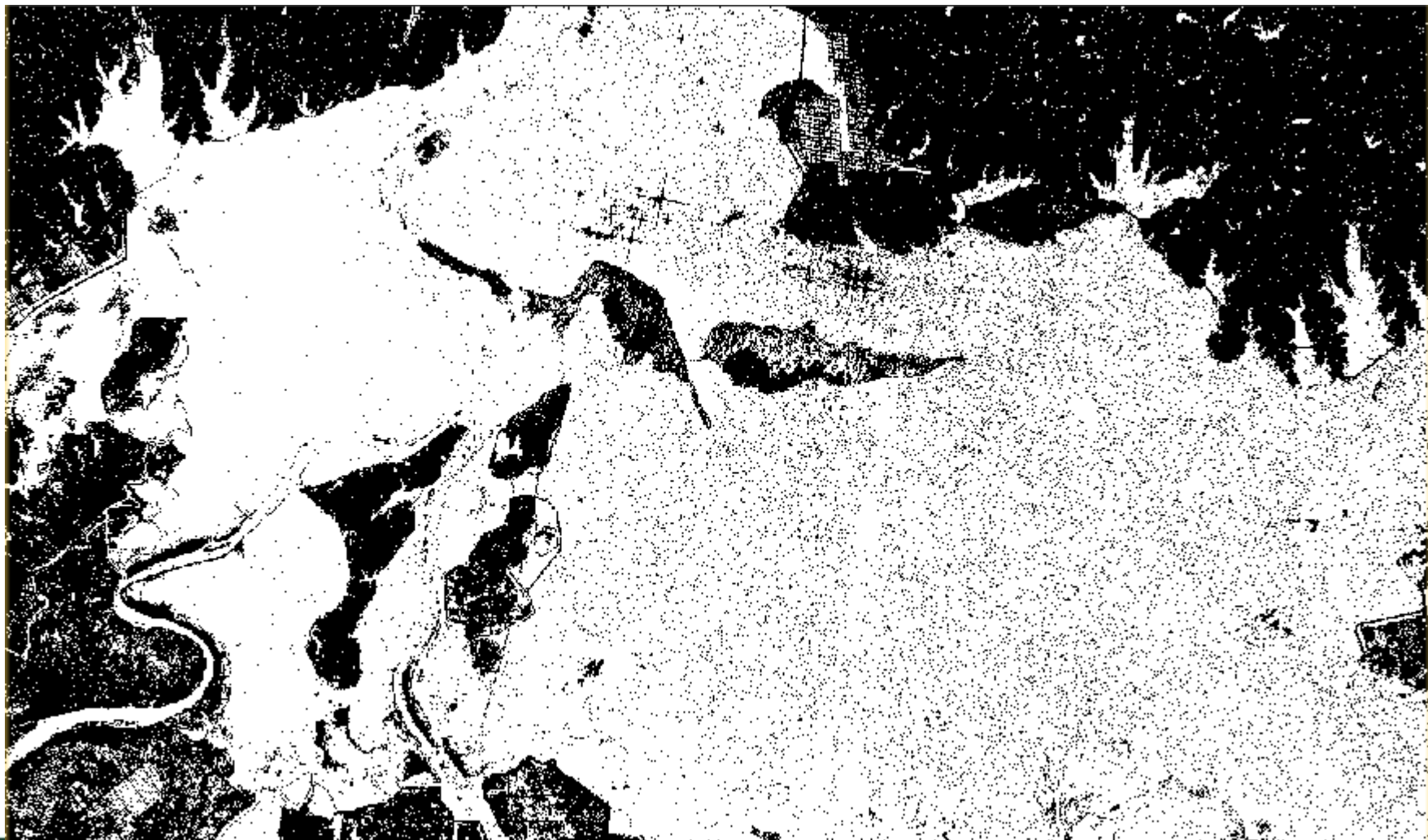
- Create a conditional expression on Sentinel bands in order to generate a binary mask. Surfaces corresponding to water have to be coded by a 1, and to non-water by a 0.

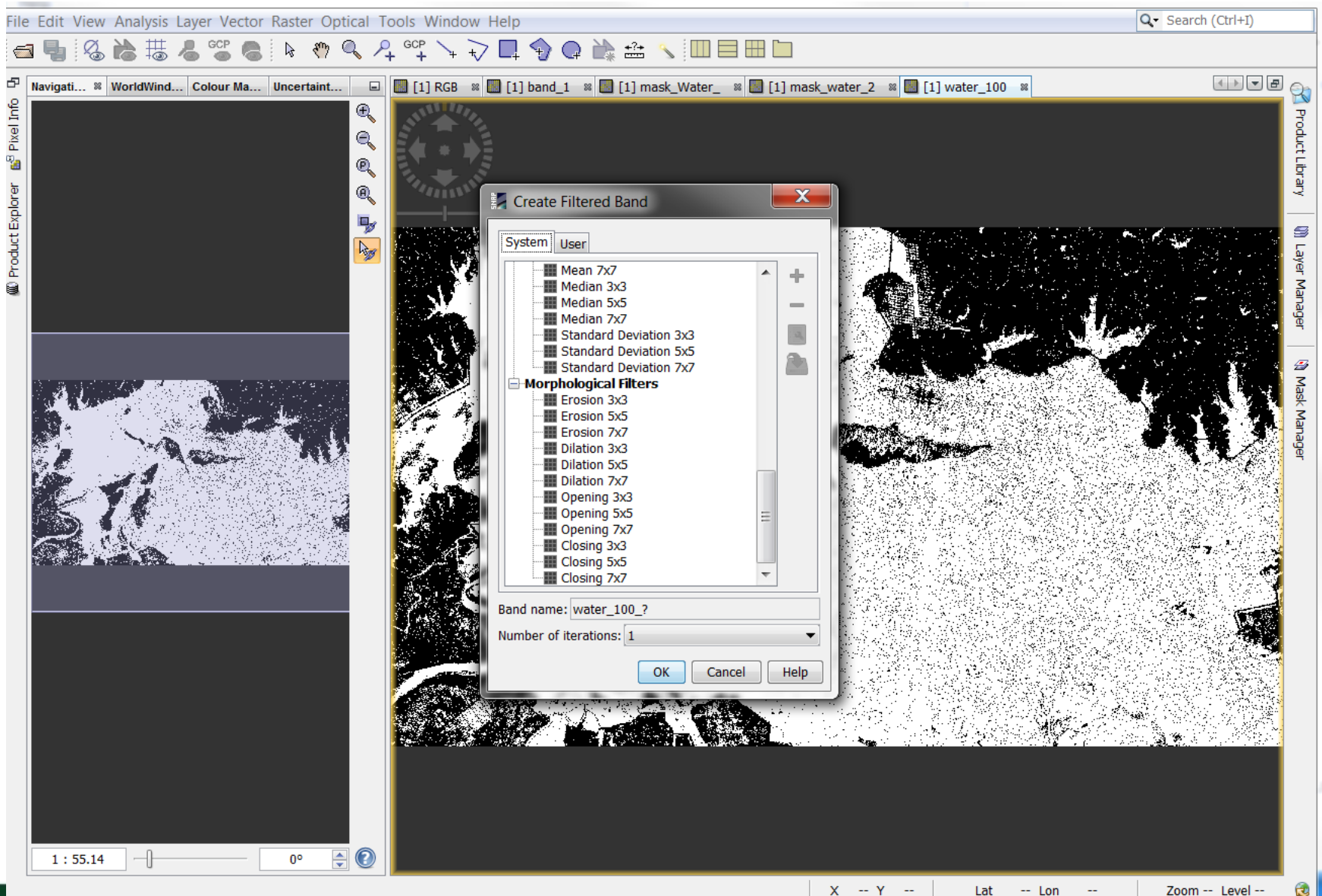




Threshold
85





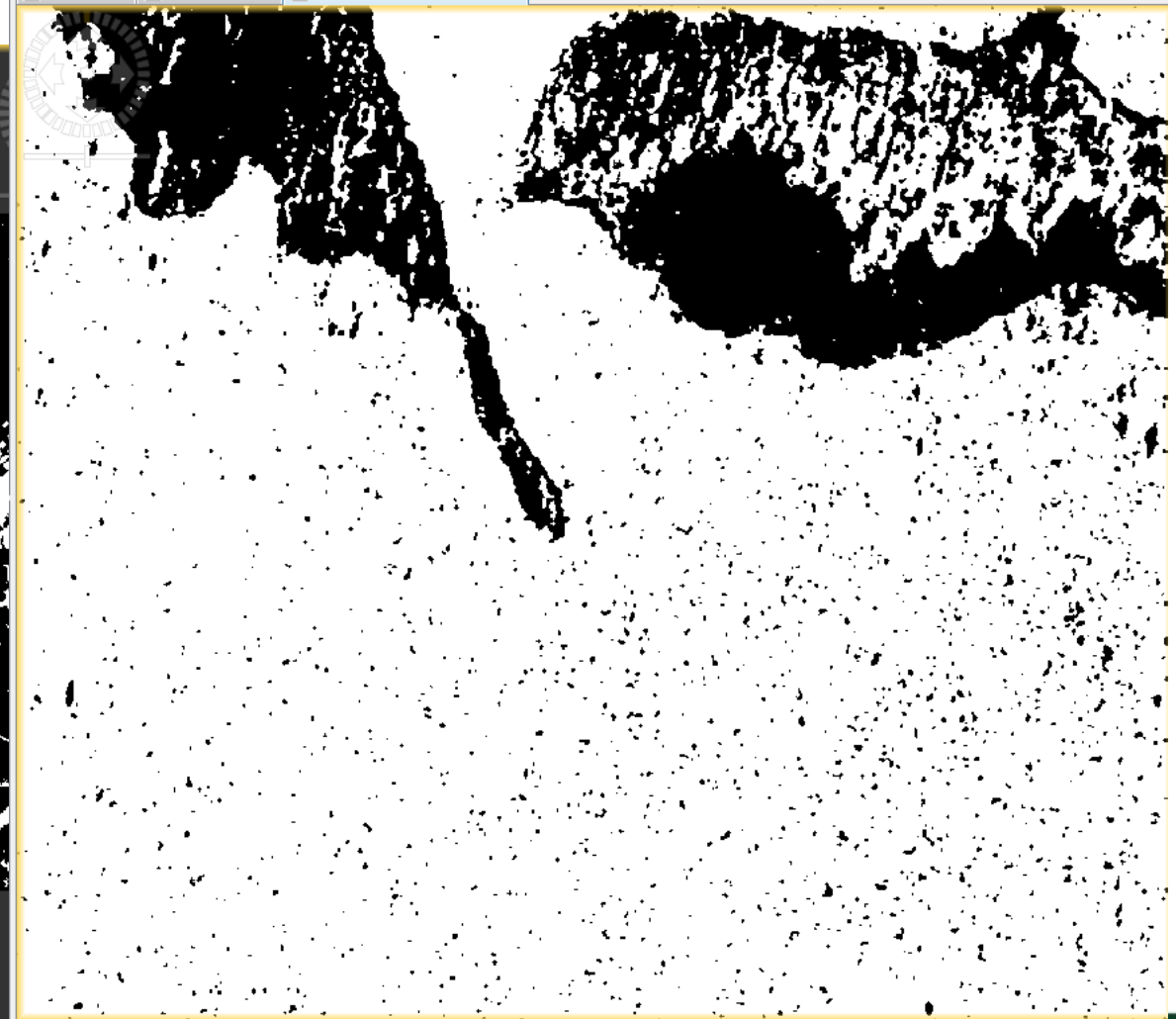


Median 3*3

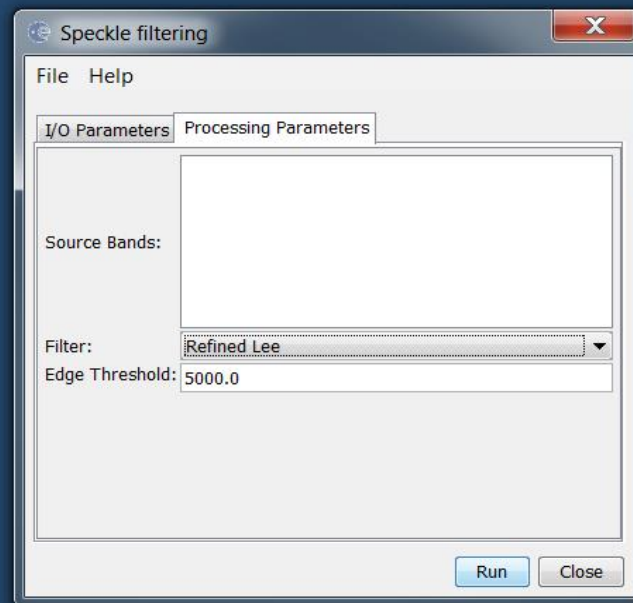


Median 3*3

**Best approach
Speckle filtering and
majority threshold**



Replay the exercise after applying a speckle filter (lee or gamma, with a 5*5 window)





Floods & Lakes Monitoring

SAR Practical

ESA-MOST Dragon 4 Cooperation

ADVANCED LAND REMOTE SENSING INTERNATIONAL TRAINING COURSE

“龙计划4”高级陆地遥感国际培训班

Dr Hervé YESOU

D2S -P2

Tuesday 25 of November 2017

20-25 November 2017 | Yunnan Normal University
Kunming, Yunnan Province, P.R. China

2017年11月20日—11月25日
云南师范大学, 中国, 昆明