Mapping water bodies exploited multi-sensors and multi resolution optical and SAR data: gained experience from plain flood monitoring in Western Europe and Asia

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SERTIT, France, ASI, Italy, ESA-ESRIN

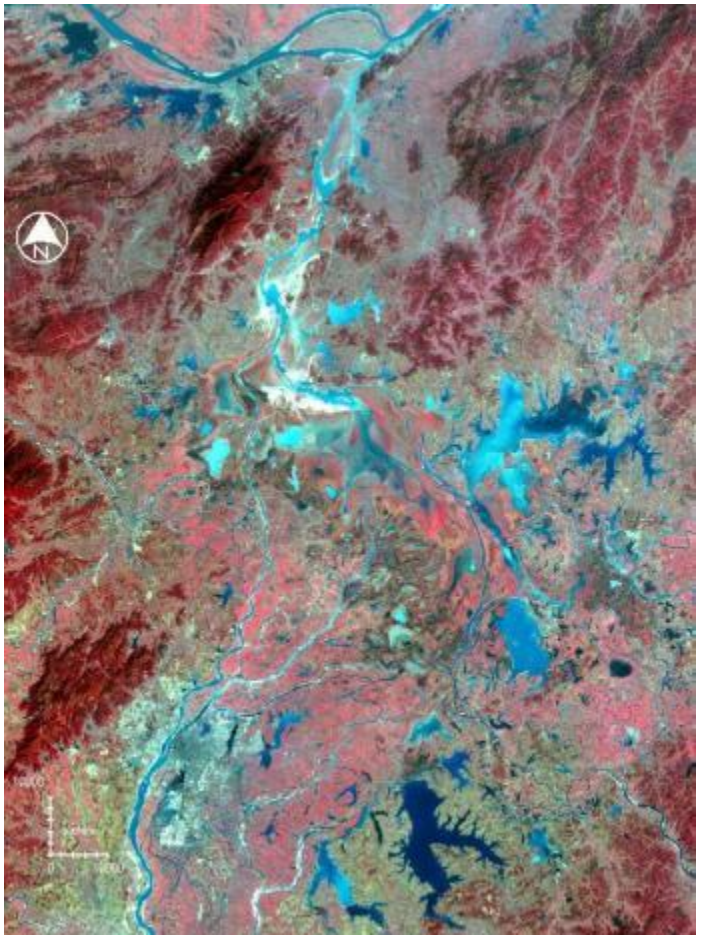
Mapping Water Bodies from Space - MWBS 2015
ESA ESRIN, 18-19 March 2015

Context: better understanding in of water bodies dynamic (water cycle and services)

- Test site Alsatian plain flood & Yangtze intermediate basin
- Dynamic of water bodies
- EO time series description/access
- Sentinel 1 versus Envisat ASAR
- Challenging problems, submerged /floating vegetation, mud banks
- Water bodies from time series
- Validation via multi resolution approach
- Indicators derived from times series
- Perspectives recommendations

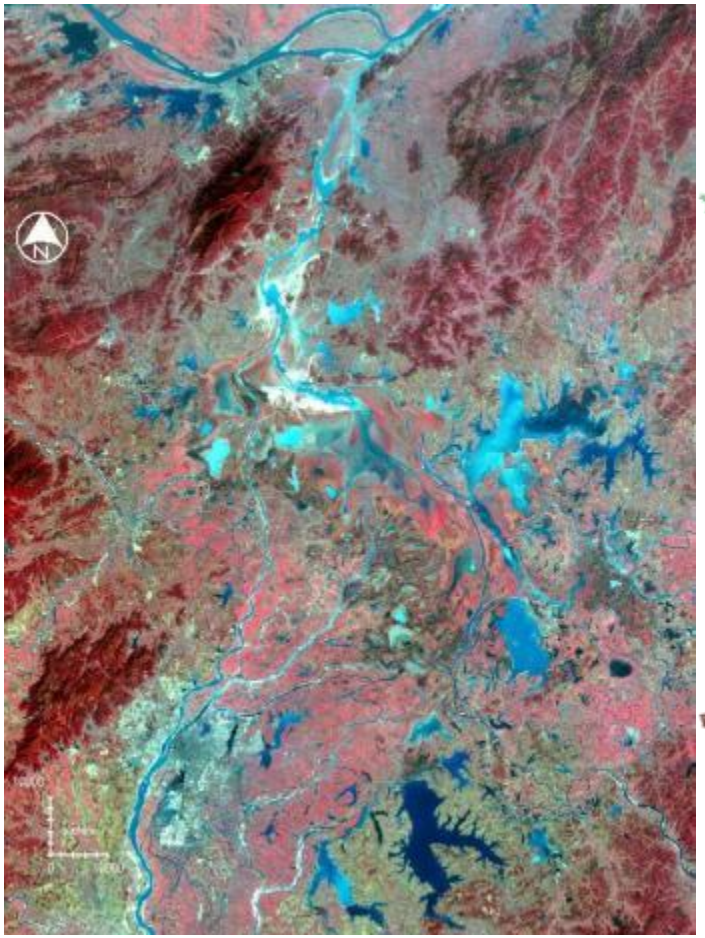
Test sites: Poyang Lake (PR China), Alsatian Flood Plain (Fr)

Poyang lake, Monsoon lake 15 years of monitoring



Test sites: Poyang Lake (PR China),

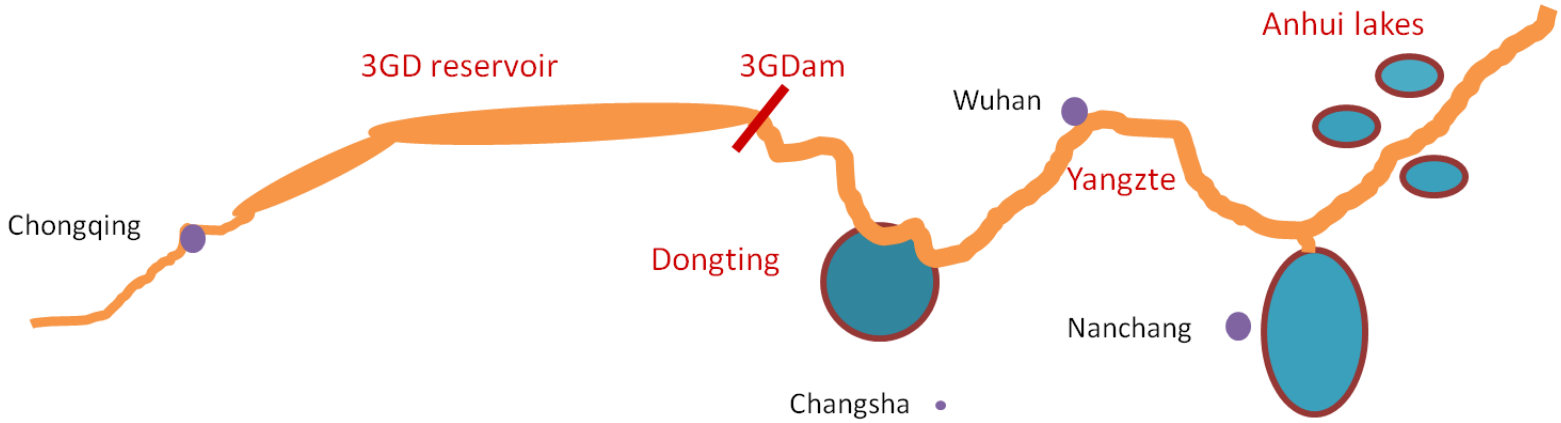
Poyang lake, Monsoon lake 15 years of mon



Alsatian Flood plain, less regularly monitor area, but lot of experiment, SPOT Take Five, Pleiades, CSK, Terra SAR ,

Poyang study context: Yangtze middle watershed

- Diversity of types of water bodies, narrow reservoir, large flat depression, etc ..
- water surface extent behaviors, depending of the season, size factor 5
- huge water height variations from 40 to 1 m depending of the water body



3 Gorges Reservoir (3G) reservoir : 1084 km² 2 to 2.5km width, 40m of annual water height variations

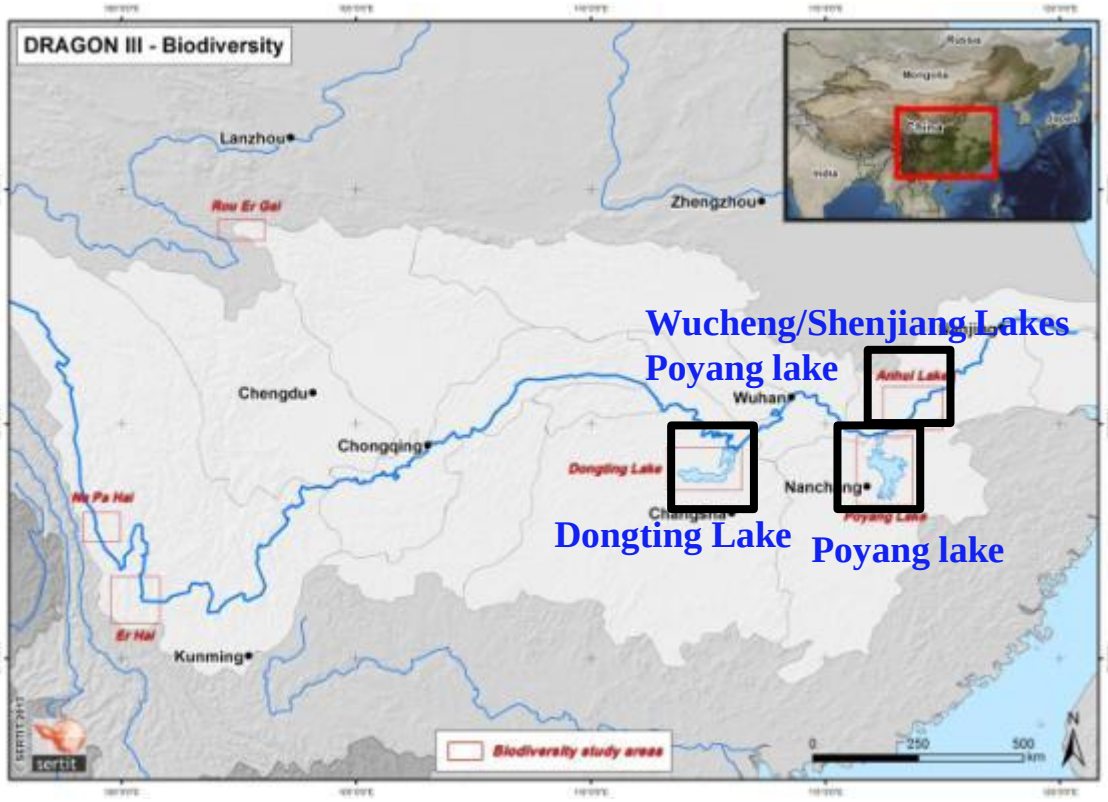
Yangtze river: 1-2 km , 9-12m of annual water height variations

Dongting Lake: 500-2500 km², 9-12m of annual water height variations

Poyang Lake: 700-3300 km², 9-12m of annual water height variations

Anhui lakes: >10-100 km² , 1-3 m of annual water height variations

Context: Yangtze river's monsoons lakes monitoring



- 6000 Lakes, pound, 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
- Whithin climate change and water management (3GD)







Acknowledgement

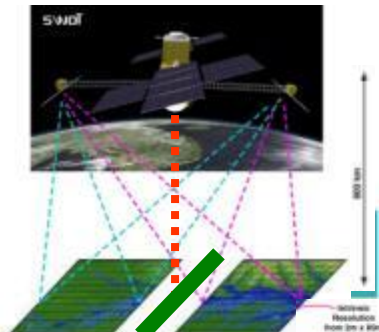
No product without raw material !!!!!!

Major pillars :

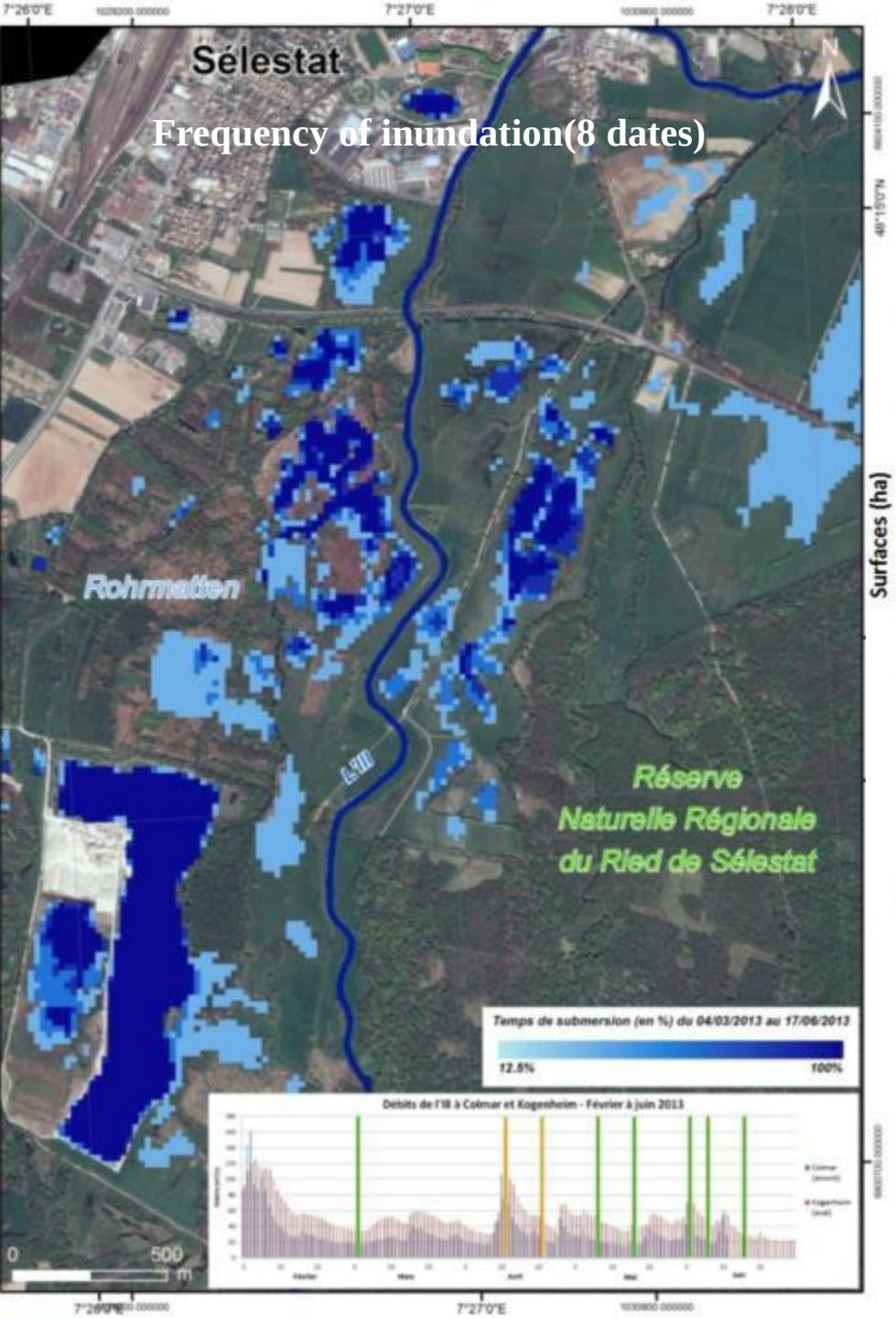
- ESA MOST DRAGON (2004-2016 and more !!)
- CNES télé-épidémiologie and SWOT (RTU + Take 5)

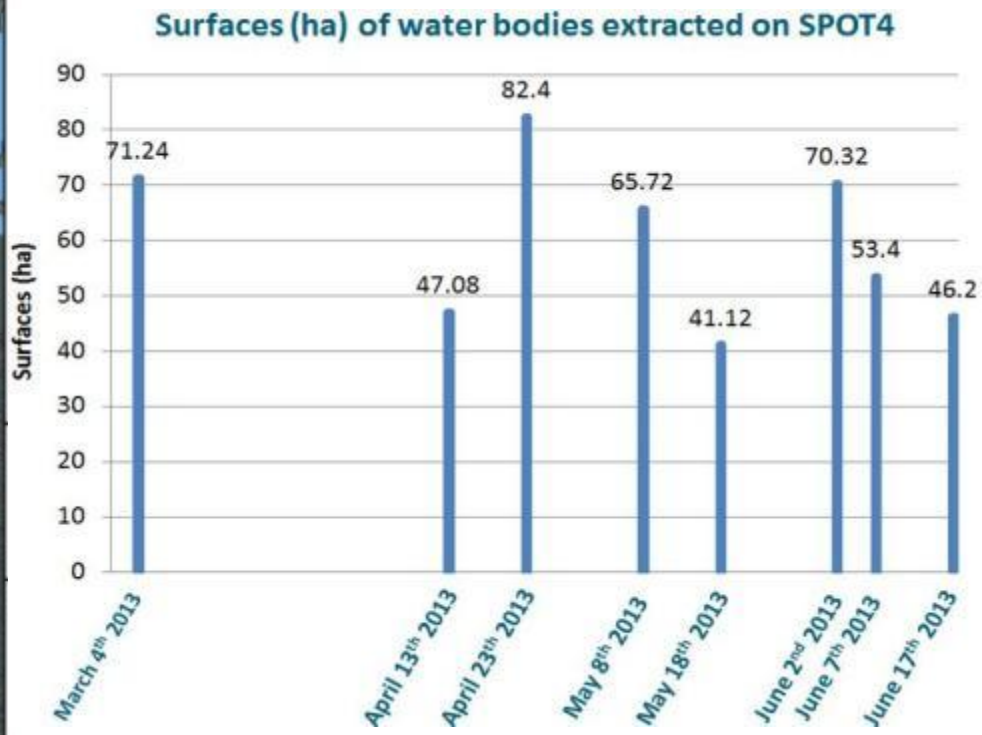
Others very valuable contributions:

- ASI for CSK time series 2010-2011, 2013-2015
- DLR for Tandem X and multimode data access
- Deimos
- etc

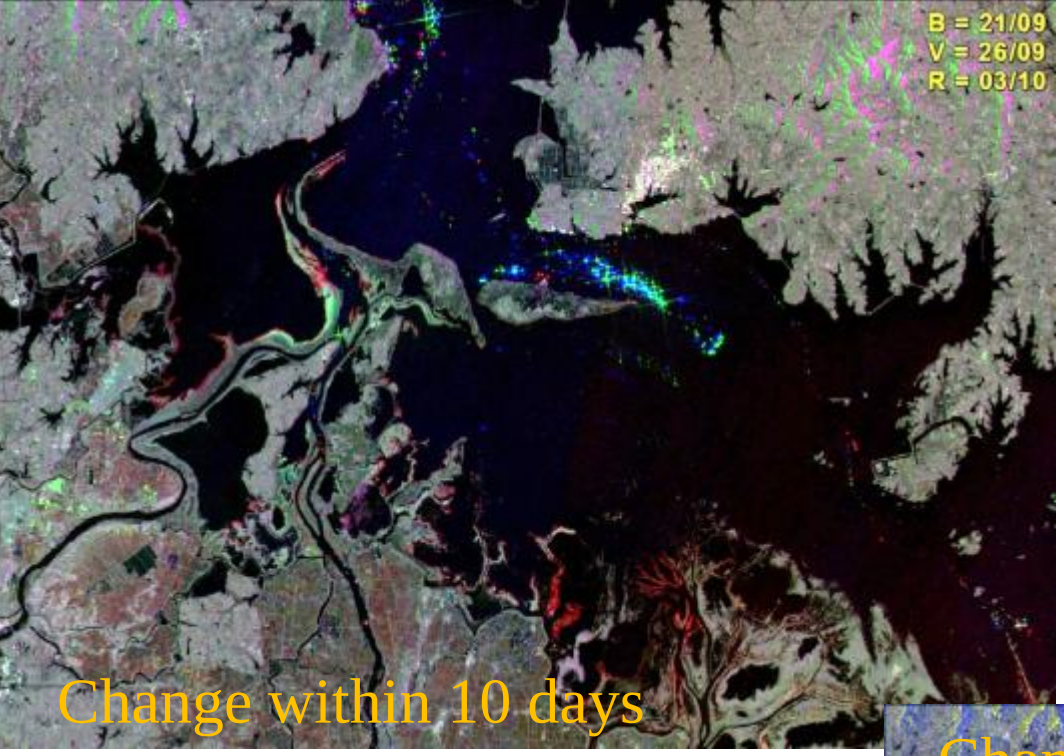


Water monitoring Alsatian Plain flood
TAKE5 SPOT4 exploitation





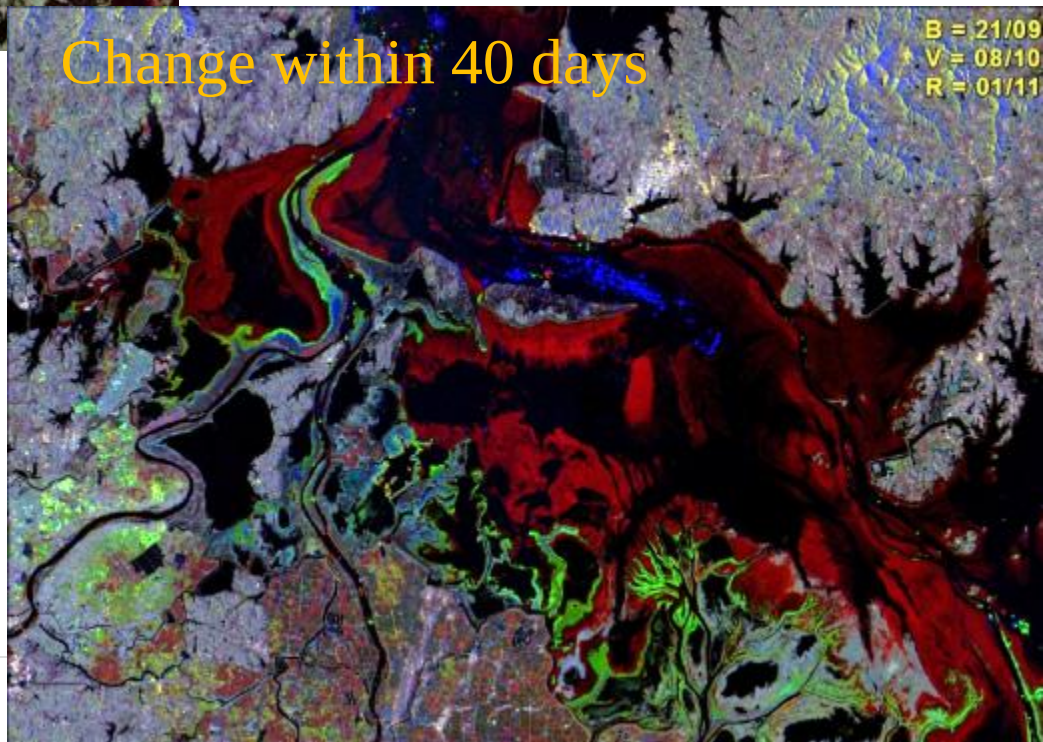
Possibility to follow very small wetlands complex presenting in fact an unexpected/unknown (?) dynamic.



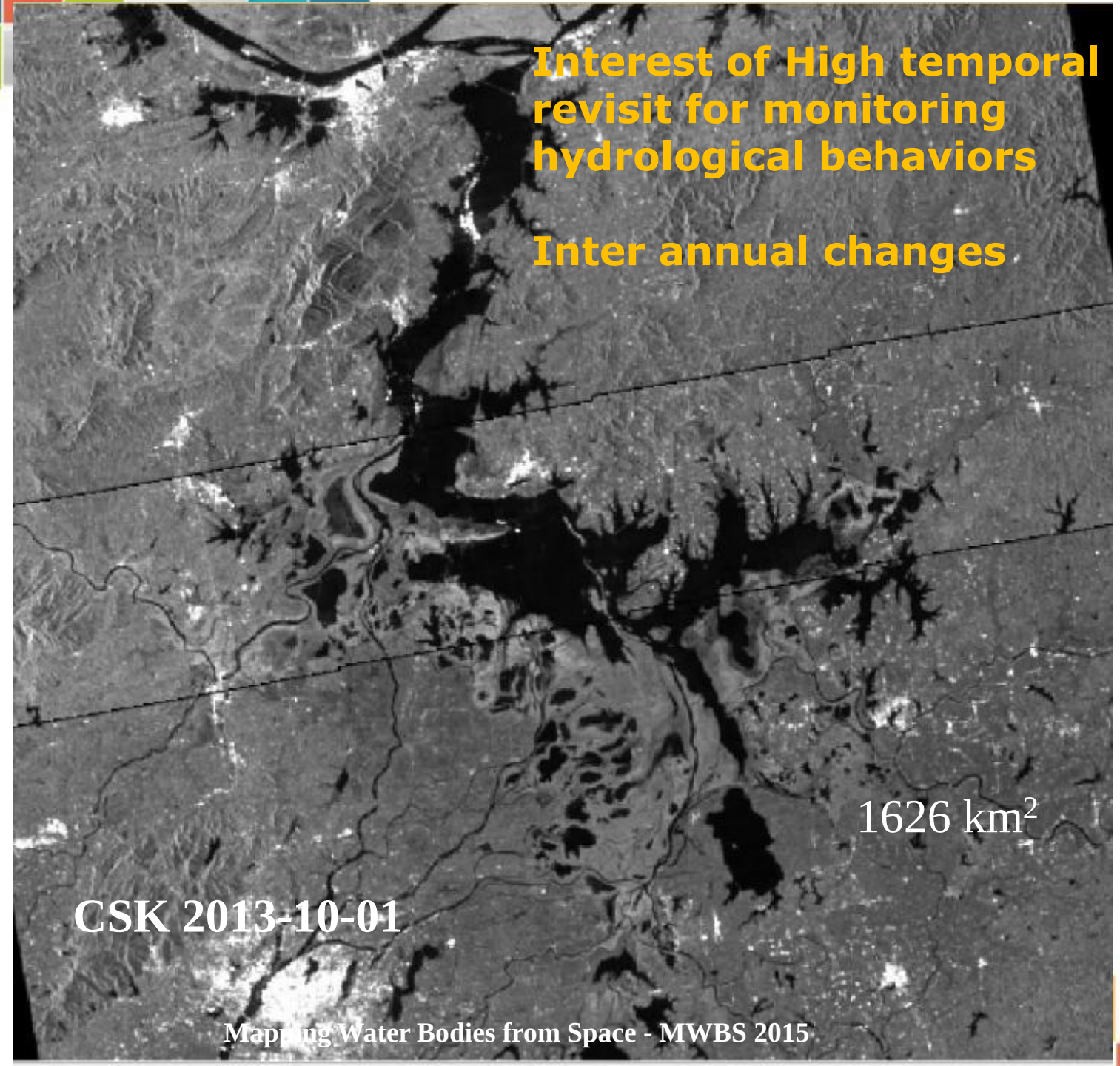
Change within 10 days

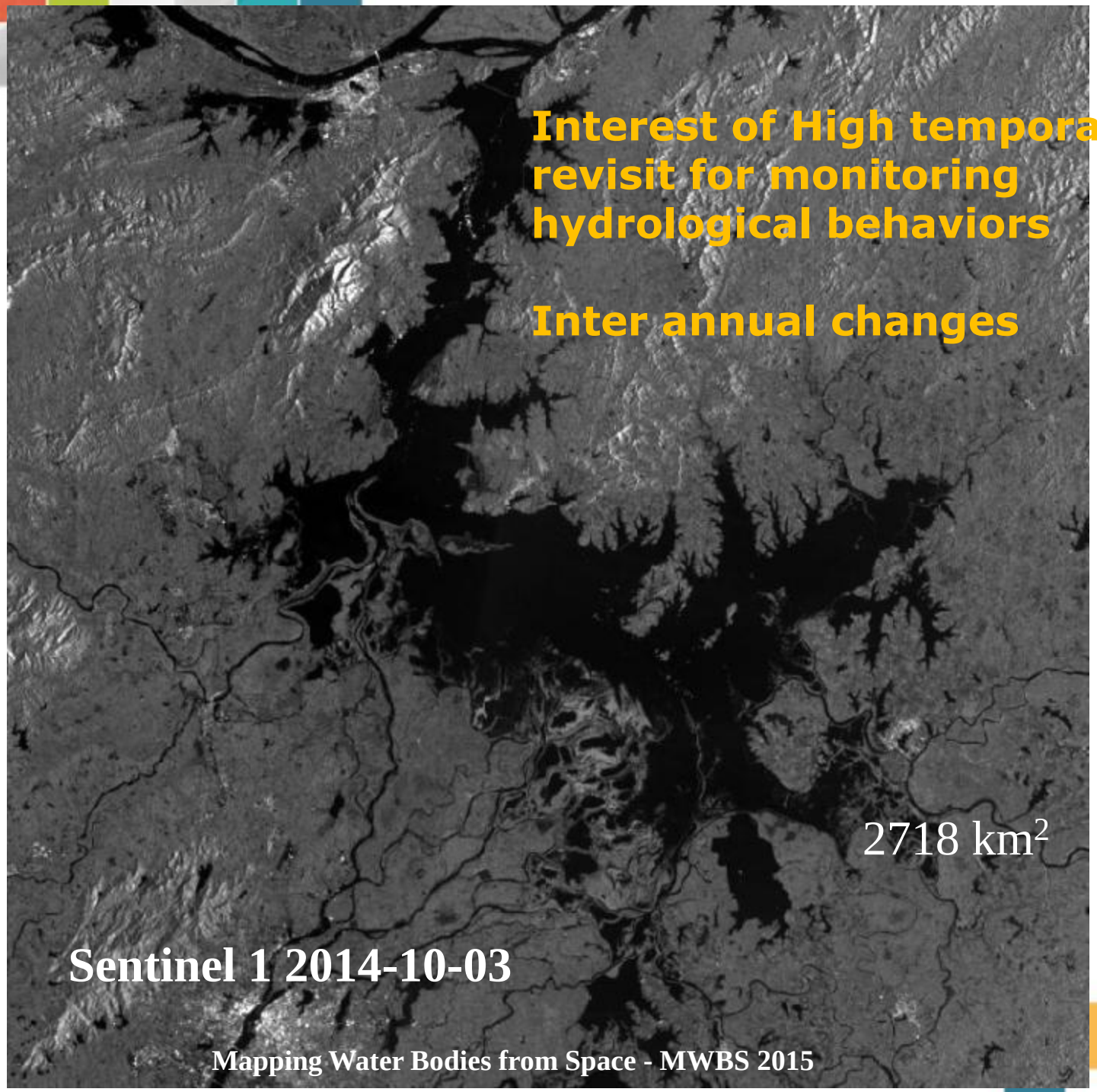
Interest of High temporal revisit for monitoring hydrological behaviors

Intra annual changes



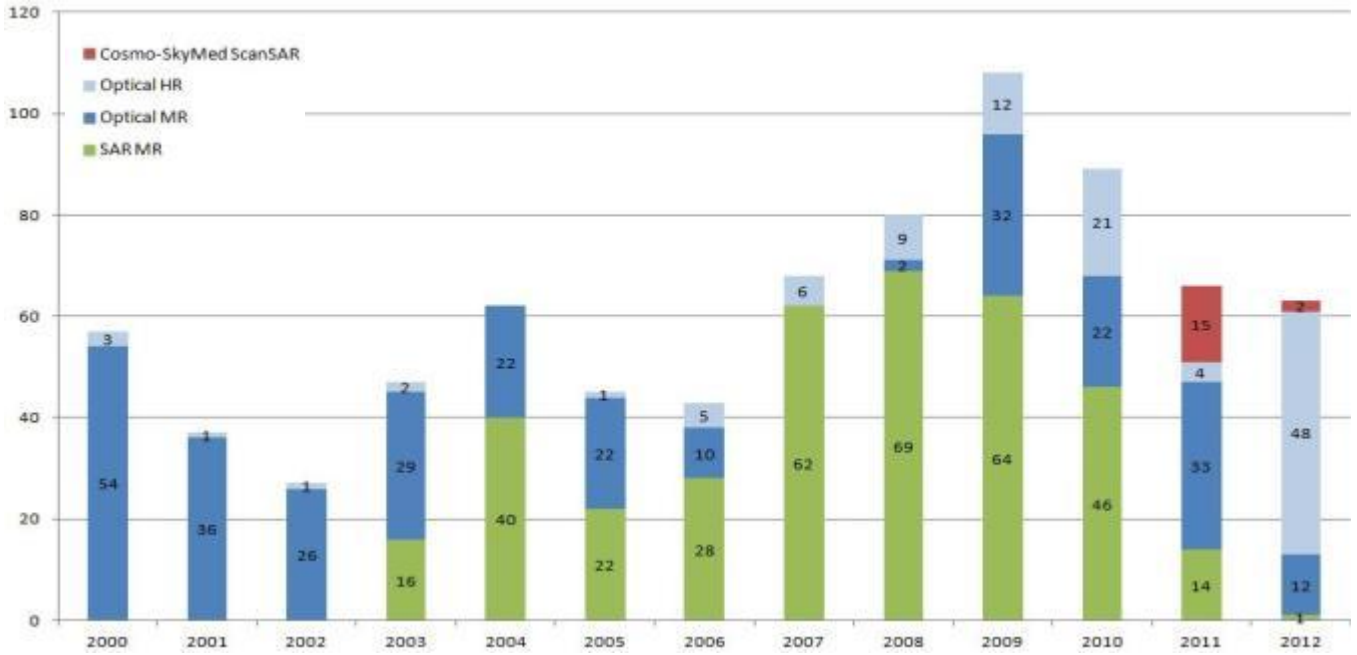
Change within 40 days


Interest of High temporal revisit for monitoring hydrological behaviors
Inter annual changes
1626 km²
CSK 2013-10-01


Interest of High temporal revisit for monitoring hydrological behaviors
Inter annual changes
2718 km²
Sentinel 1 2014-10-03

Monitoring water bodies based on EO resource 2000-2012

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

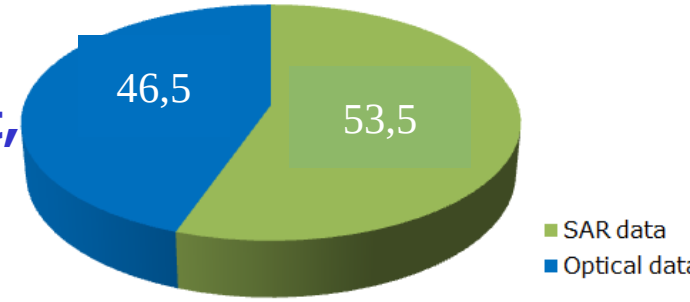


Near Half SAR and optic: 2000-2012

=>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 …

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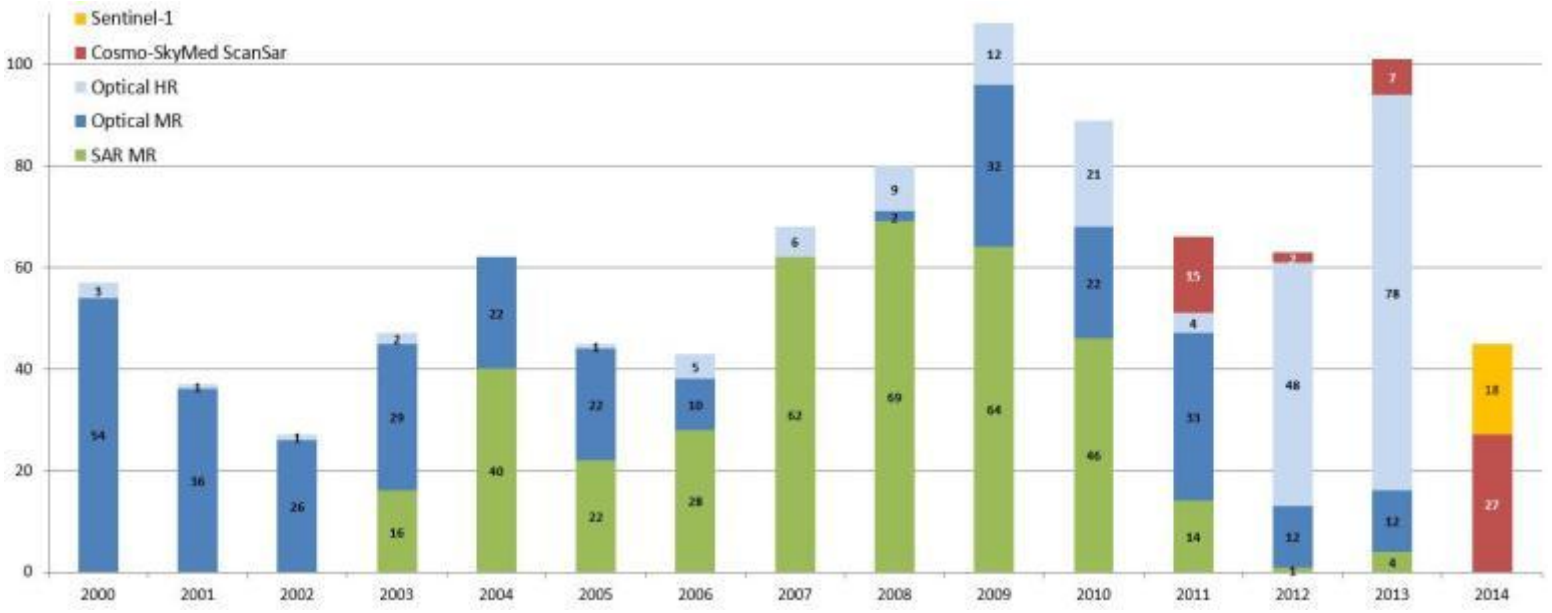
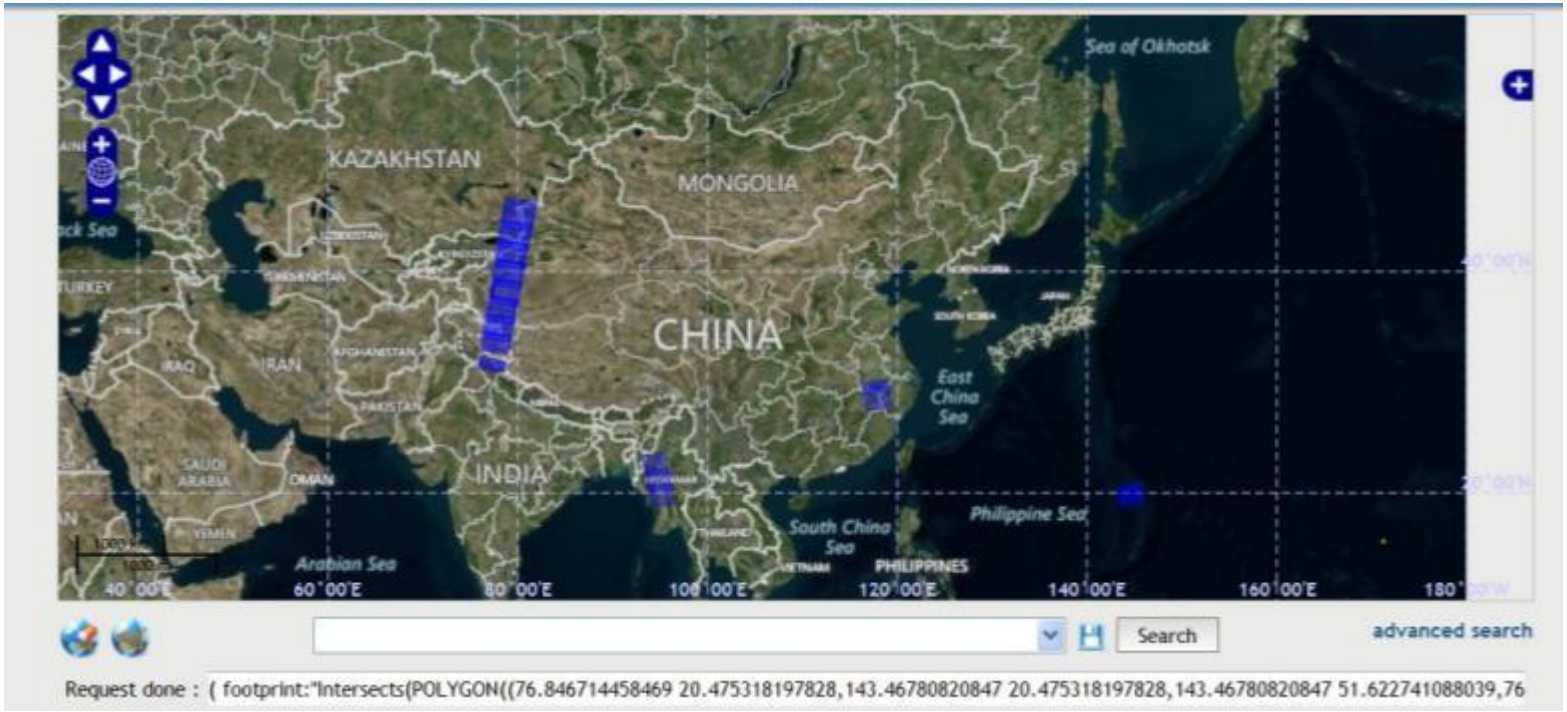


Moving from MR to HR
⇒, SPOT 4 TakeFive, HJ1A, preparing Sentinel 2 venue

⇒ Archive TerraSAR, New modes TerraSAR TandemX
⇒ Cosmo Skymed from ASI (supporting Envisat Gap)

⇒ Sentinel 1

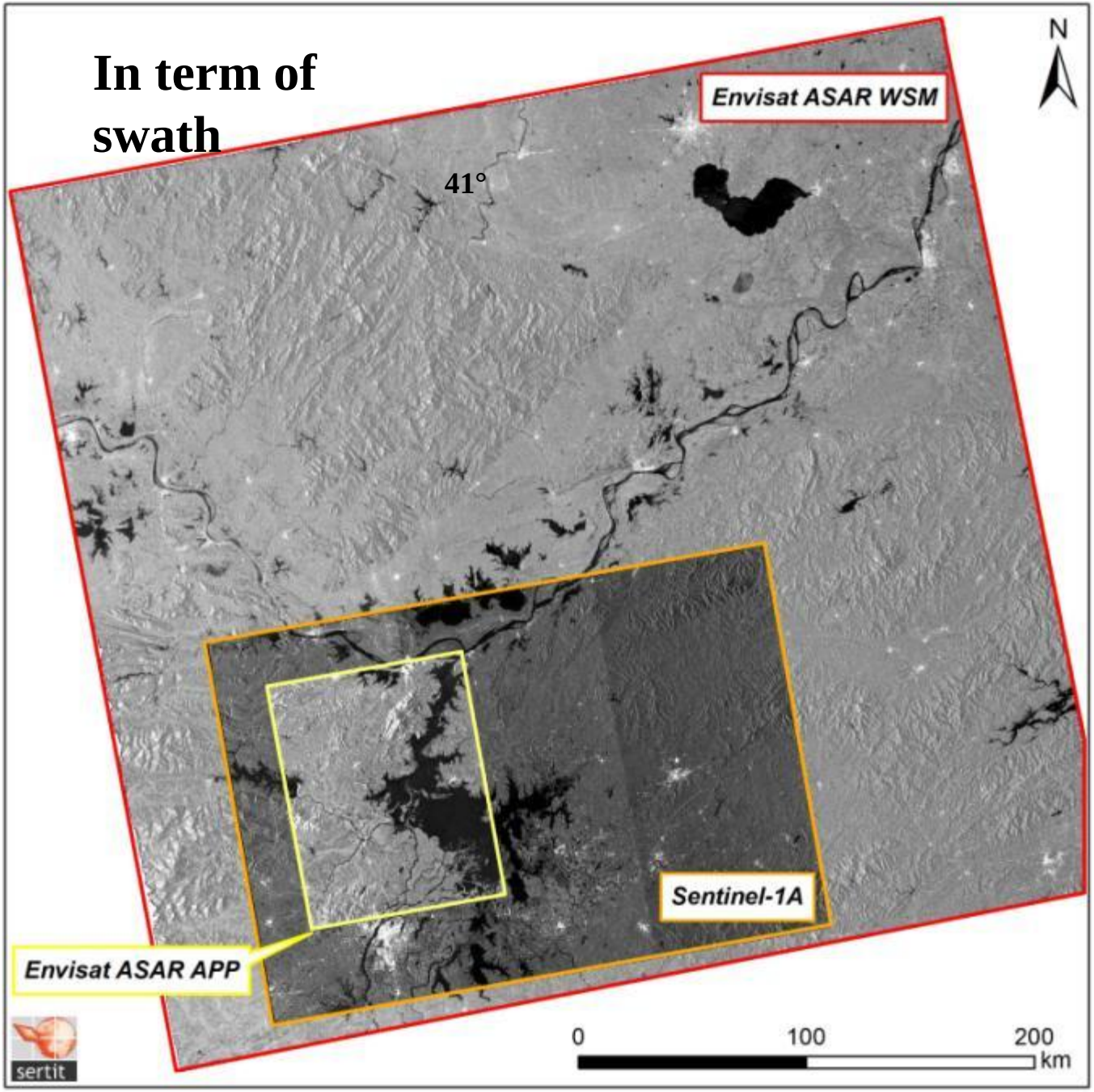
Integration of Sentinel 1 data within the monitoring scheme



Poyang lake is one of the rare site that is covered by systematic acquisition as viewed in the Sentinel Scientific Hub

Comparison Sentinel1 IWS With ENVISAT ASAR WSM and APP modes over Poyang Lake, PR China

In term of swath



ASAR WSM ENVISAT

400 km

26° - 41° ENL 10.5

Sentinel 1

250 km

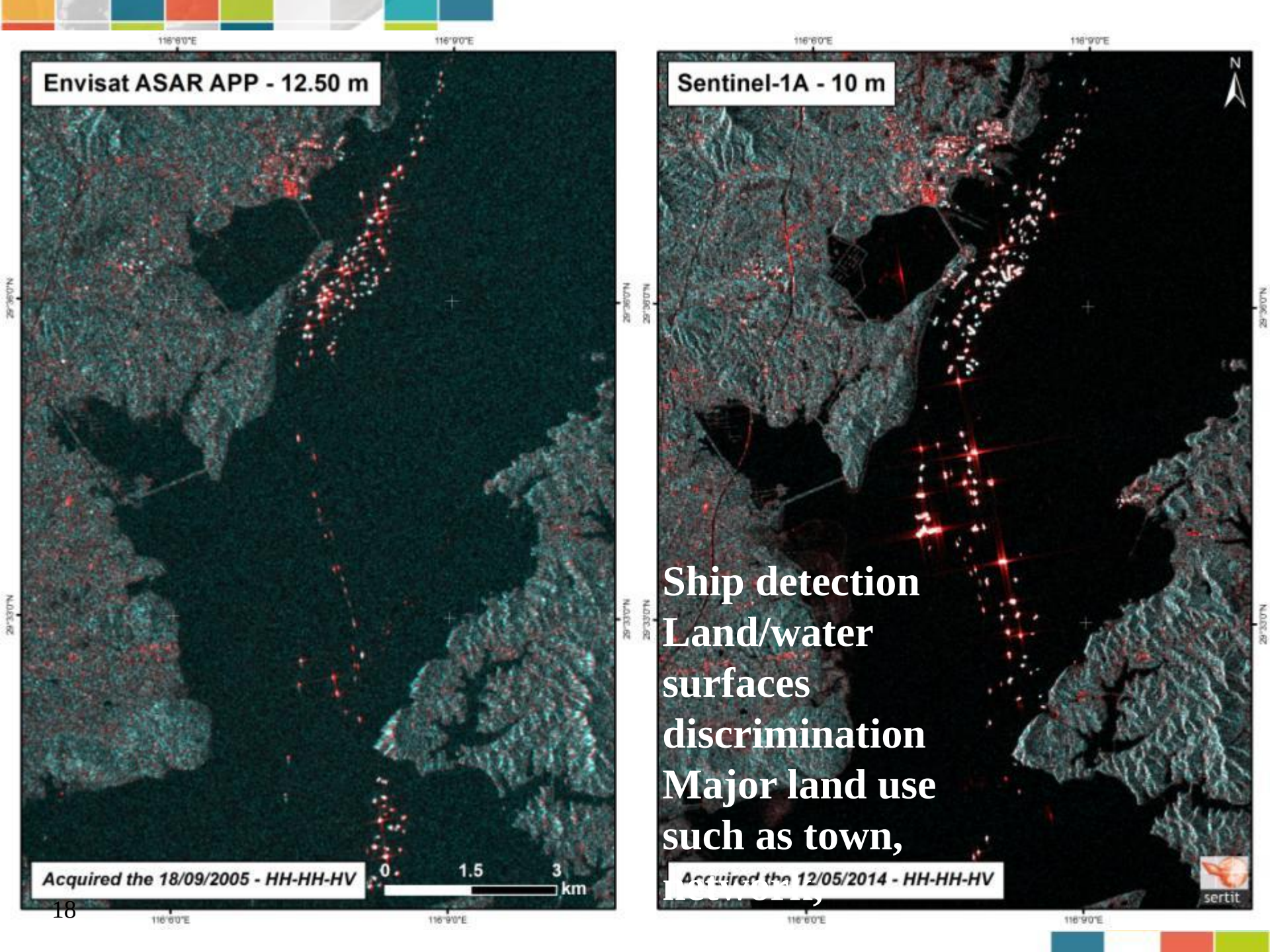
30° - 45 ENL: 4.9

ASAR APP S4 ENVISAT

88 km

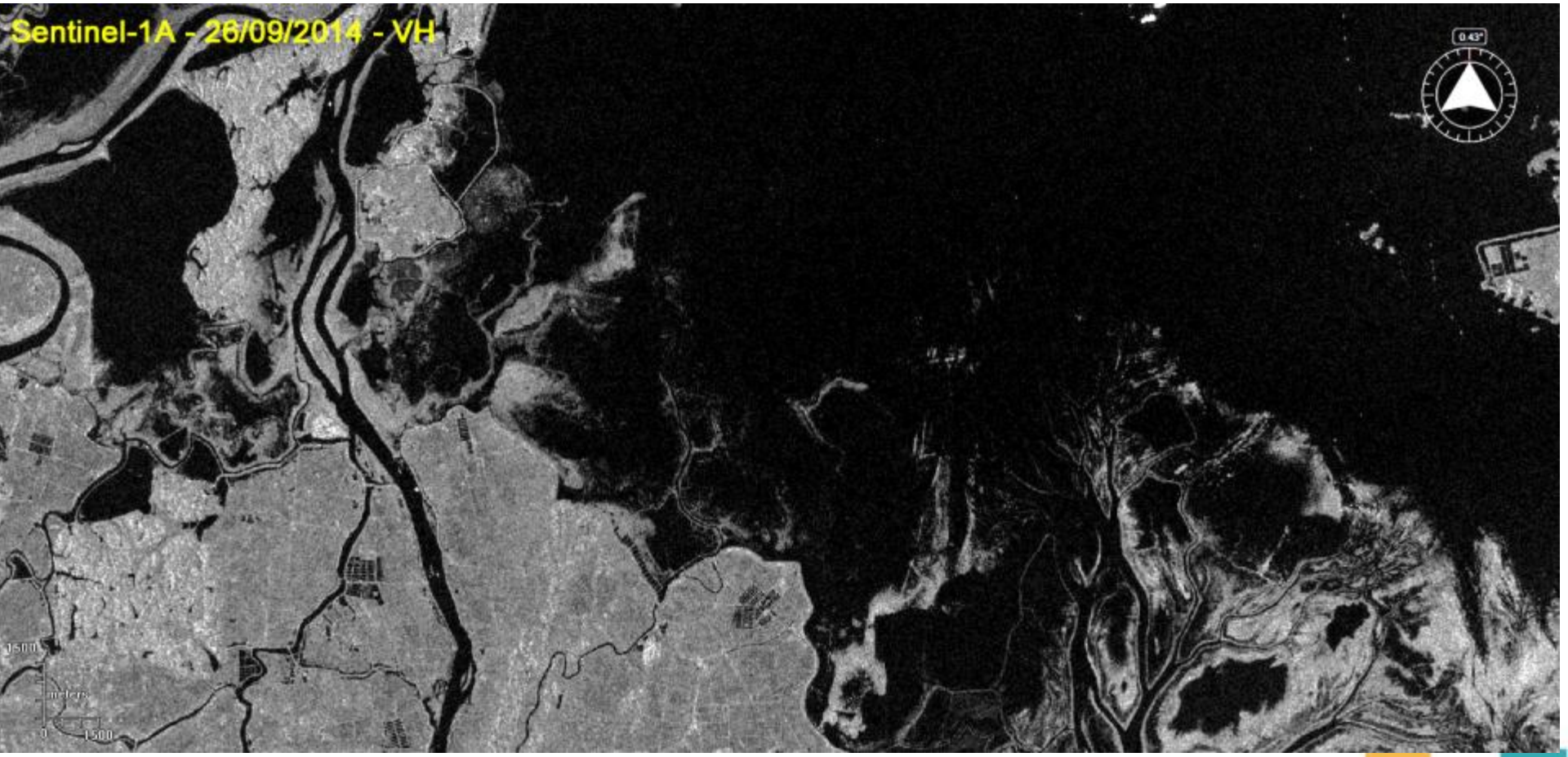
31-36° ENL 1.9


Envisat ASAR APP - 12.50 m
Land/water surfaces discrimination Major land use such as town, network, infrastructure, agricultural parceling
Acquired the 18/09/2005 - HH-HH-HV
0 2 4 km
Sentinel-1A - 10 m
Acquired the 12/05/2014 - HH-HH-HV
sertit



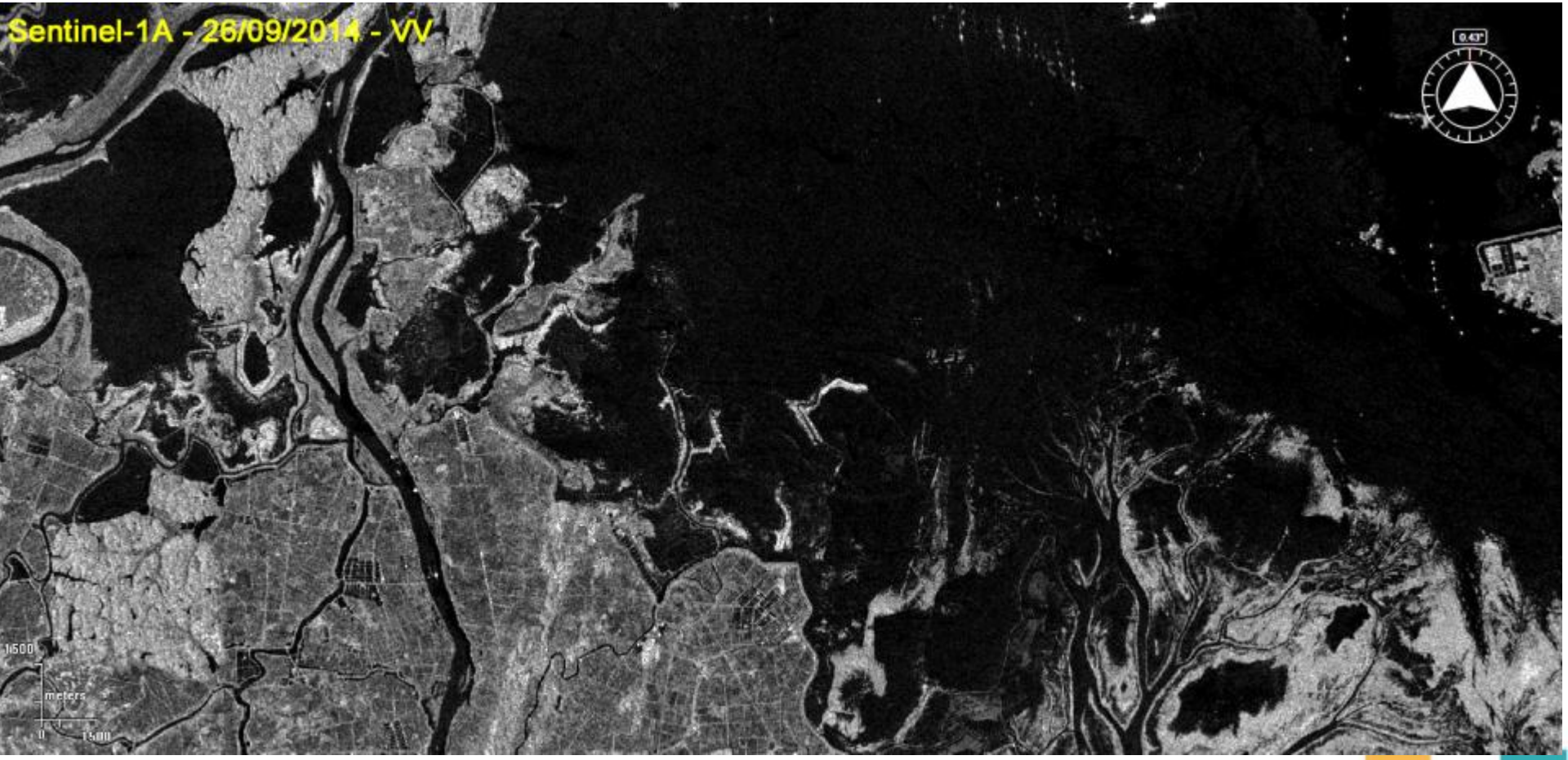
Ship detection
Land/water surfaces discrimination
Major land use such as town,

Recognition of water surface
water flooded vegetation and floating vegetation



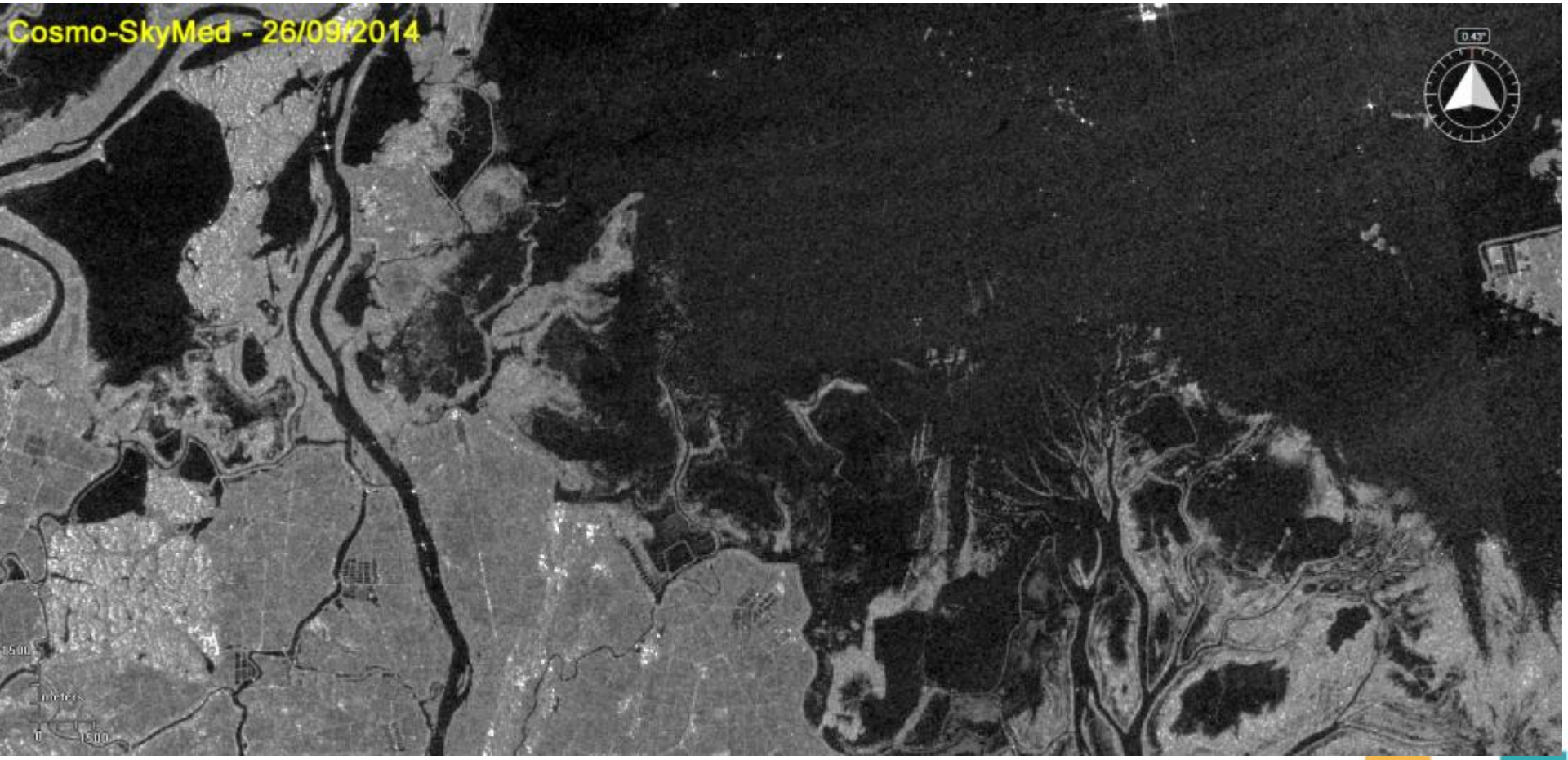
Recognition of water surface
water flooded vegetation and floating vegetation

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

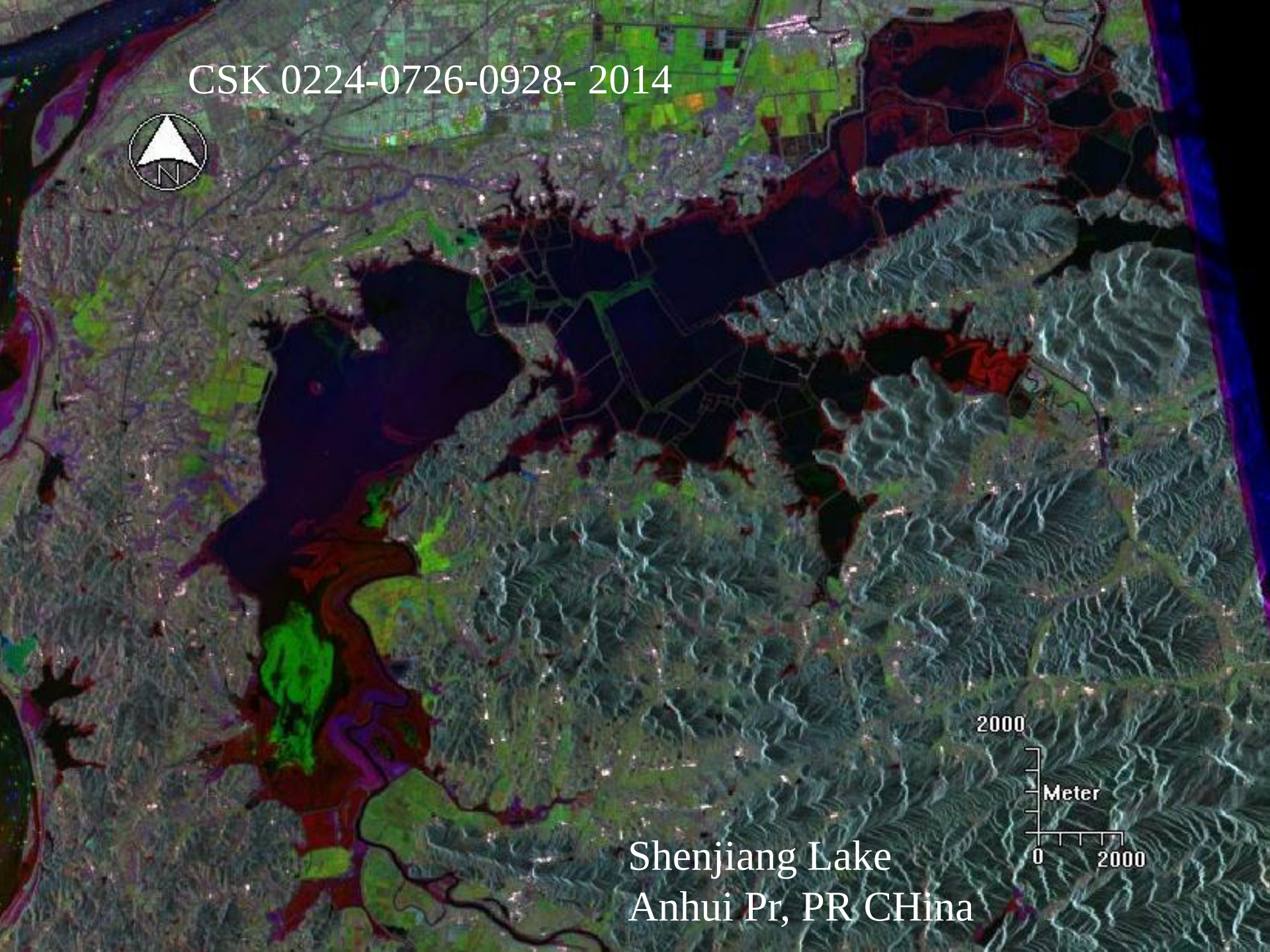


Recognition of water surface
water flooded vegetation and floating vegetation

Nymphoides Pelatum

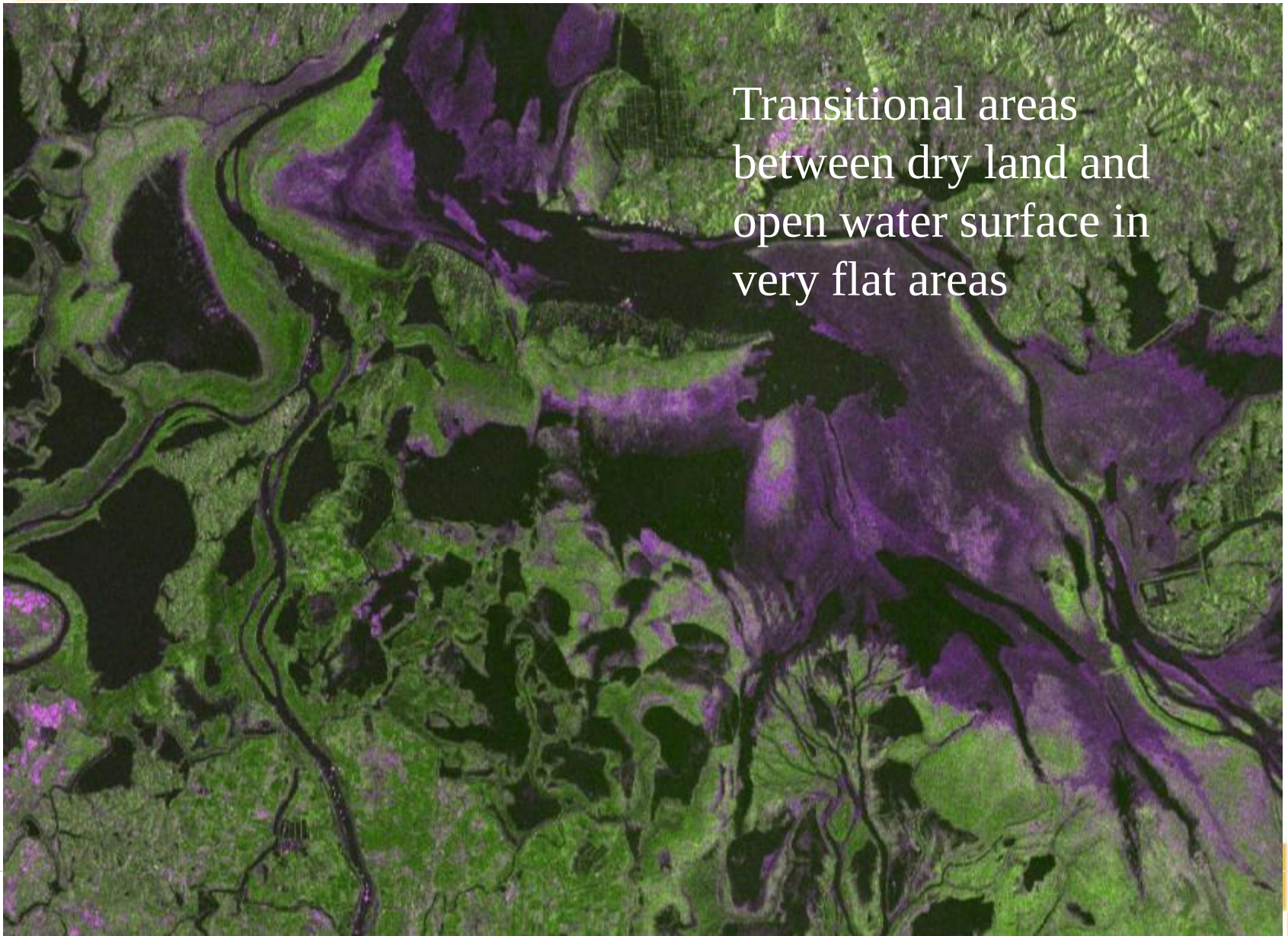
Recognition of water surface
water flooded vegetation and floating vegetation

Jacynth


CSK 0224-0726-0928- 2014
N
2000
Meter
0
2000
Shenjiang Lake
Anhui Pr, PR CHina

Recognition of water surface
Wet area after water redraw

Recognition of water surface
Wet area after water redraw

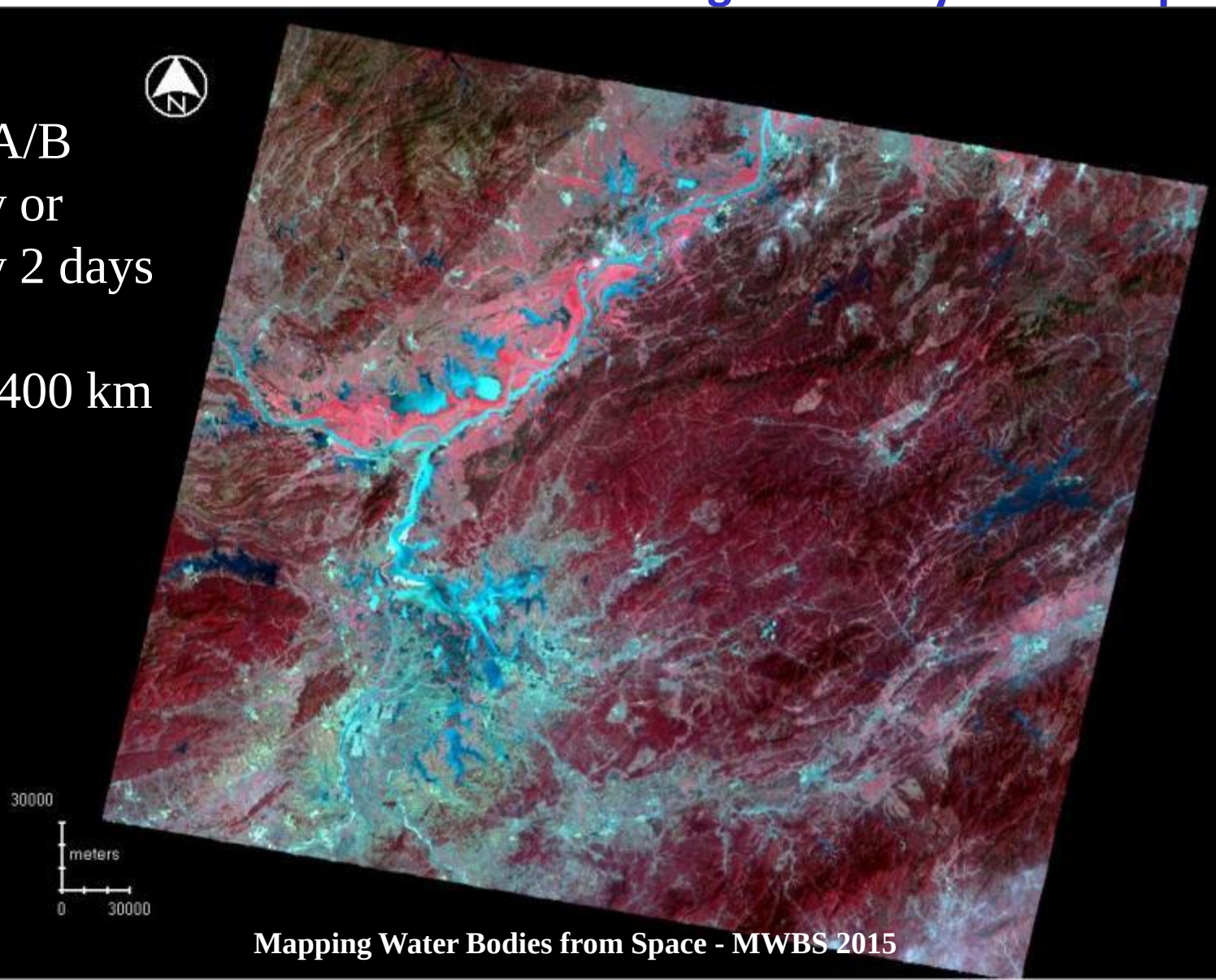


Water extraction from Sentinel 1, CSK, HJ1A Time series over Poyang Lake and Anhui lakes , PR China

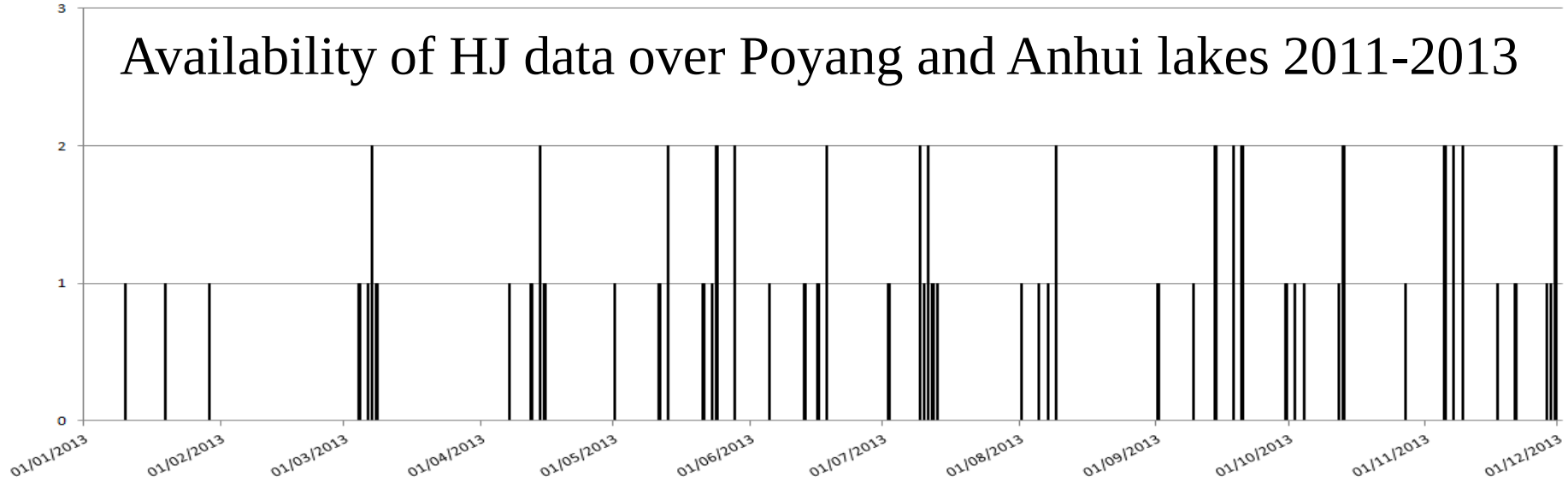
HR exploited dataset: HJ Chinese satellite
400 km swath: large diversity of lanscapes

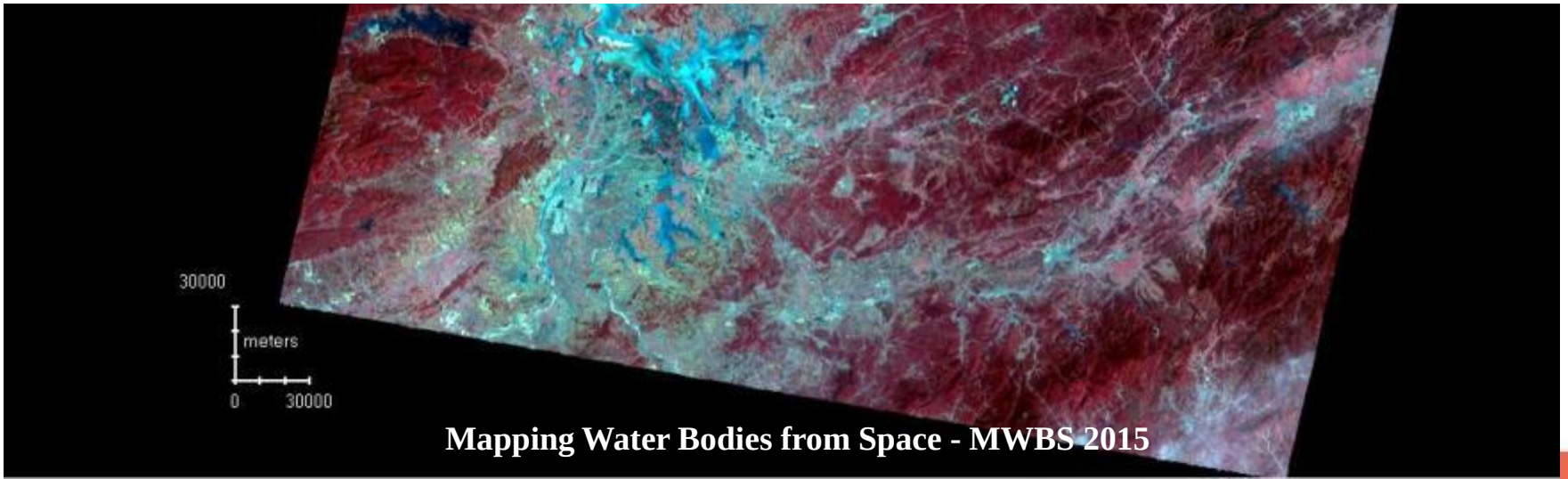
HJ1 A/B
Daily or
every 2 days

400*400 km
30m

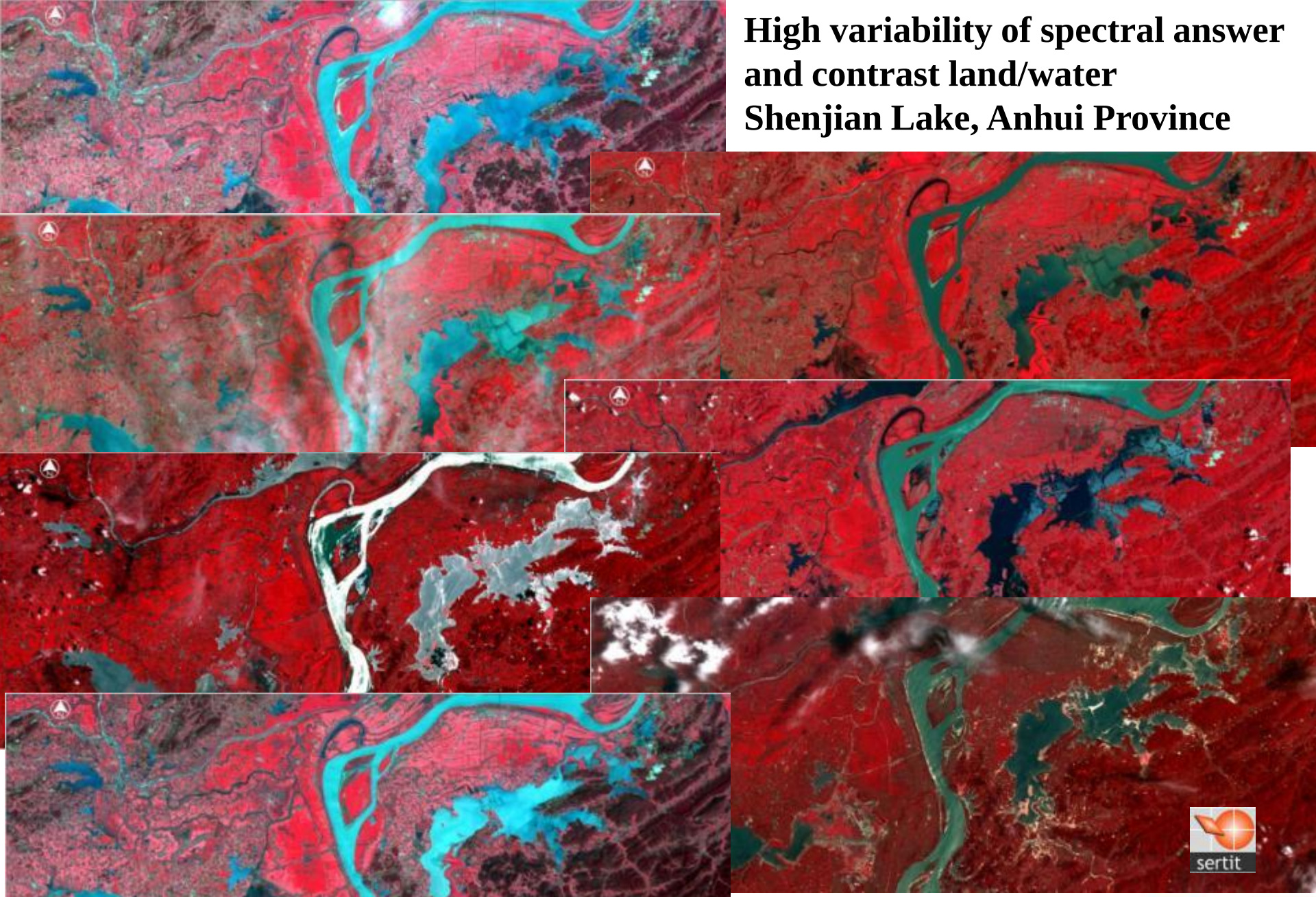


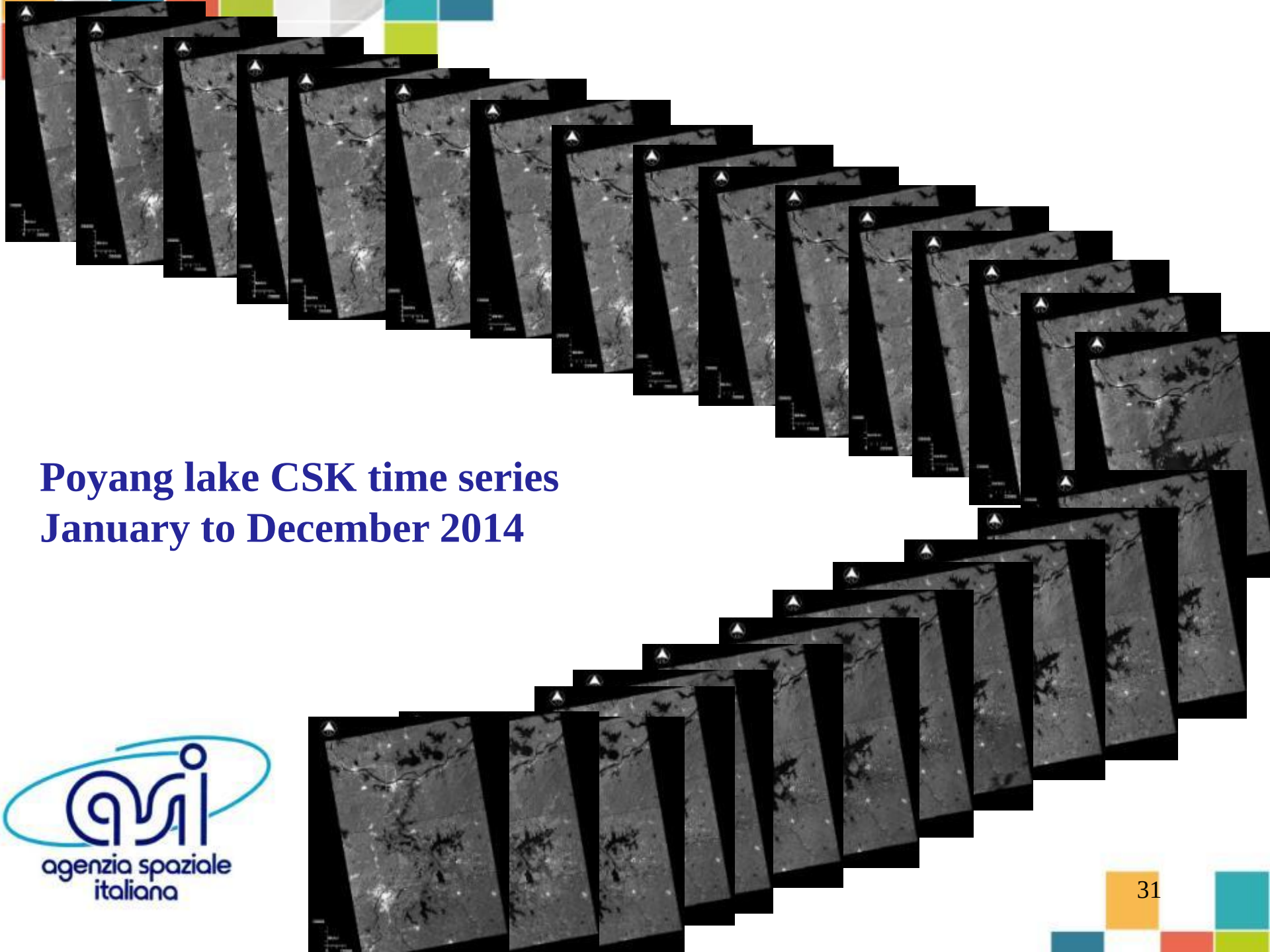
HR exploited dataset: HJ Chinese satellite 400 km swath: large diversity of lanscapes





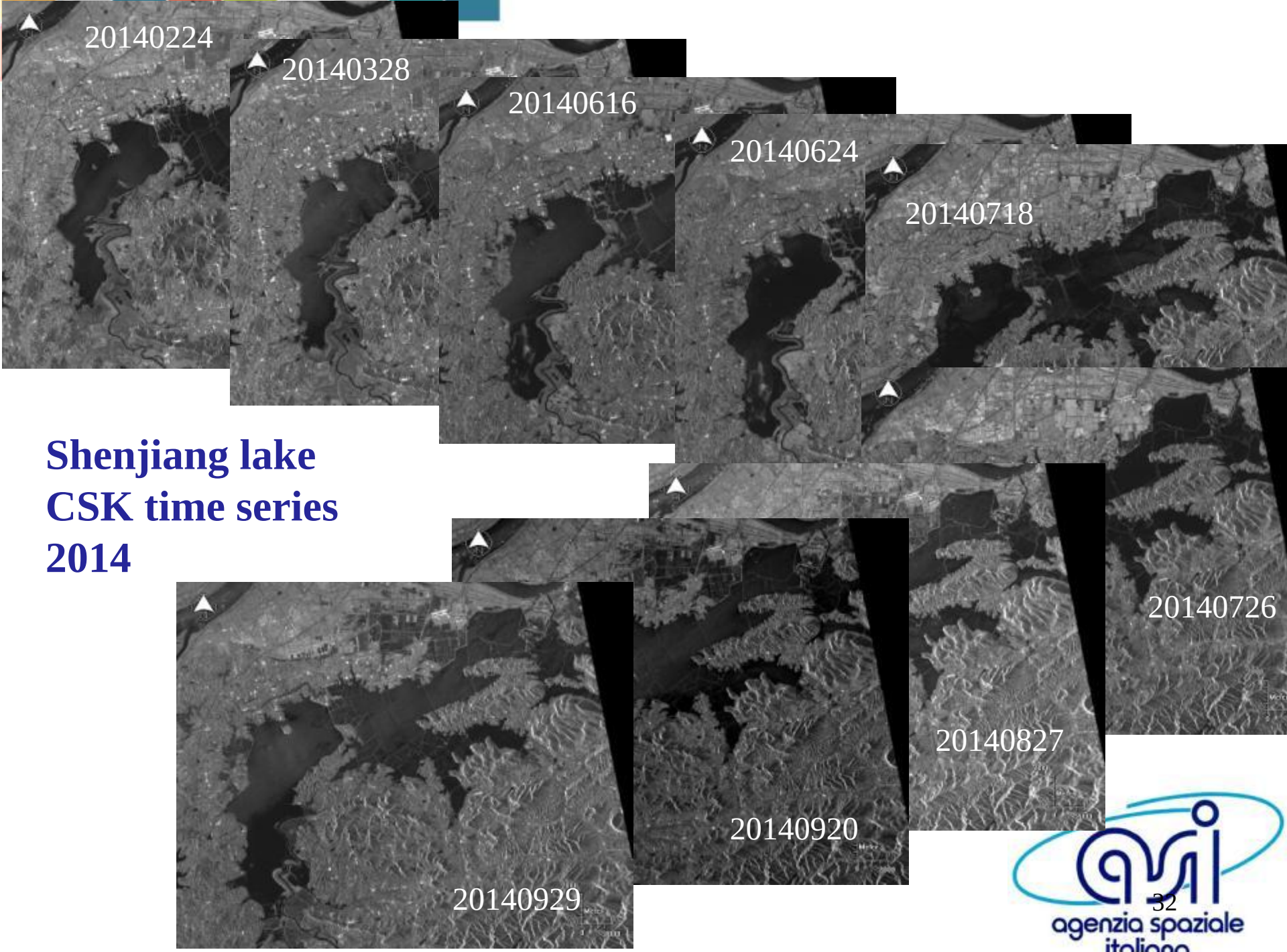
High variability of spectral answer and contrast land/water
Shenjian Lake, Anhui Province





Poyang lake CSK time series
January to December 2014

agenzia spaziale italiana



Shenjiang lake
CSK time series
2014

agenzia spaziale italiana

2014092

20140926

20141003

20141008

20141015

20141020

20141101

20141108

20141113

20141120

20141125

20141202

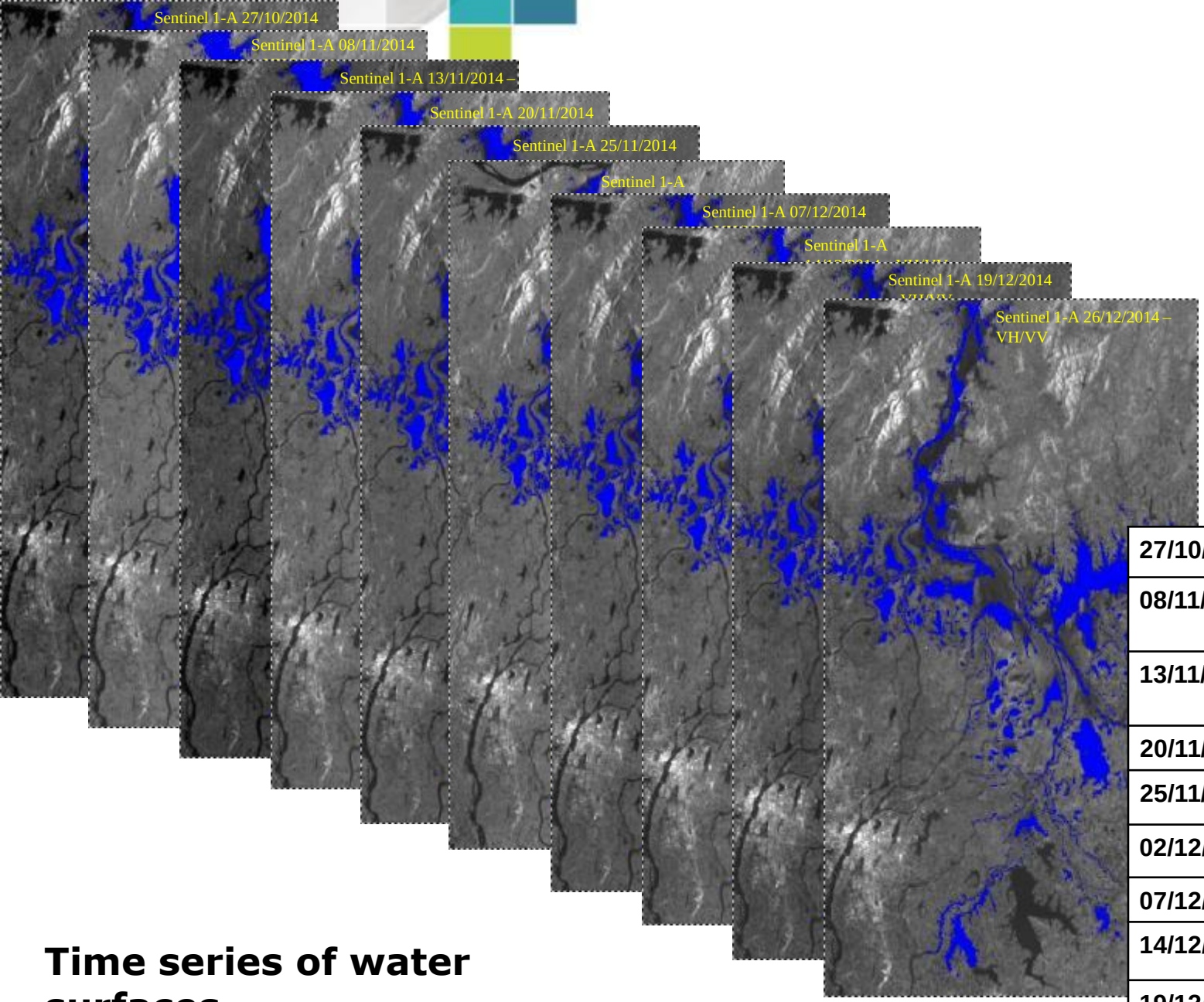
20141207

20141214

20141219

20141226

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

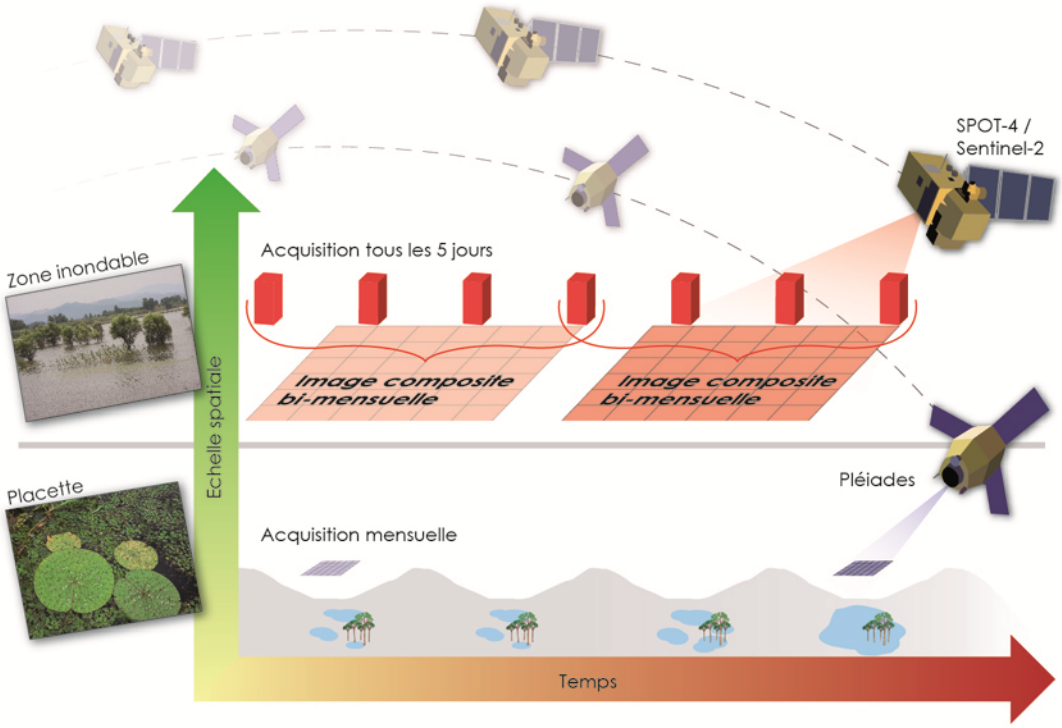


Time series of water surfaces
Example with Sentinel-1a

27/10/14	S -1A	1380 km²
08/11/14	S -1A	1871 km²
13/11/14	S -1A	1844 km²
20/11/14	S -1A	1417 km²
25/11/14	S -1A	1485 km²
02/12/14	S -1A	1475 km²
07/12/14	S -1A	1514 km²
14/12/14	S -1A	1324 km²
19/12/14	S -1A	1341 km²
26/12/14	S -1A	1048 km²

Validation approach
Multi source & multiscale optical and SAR

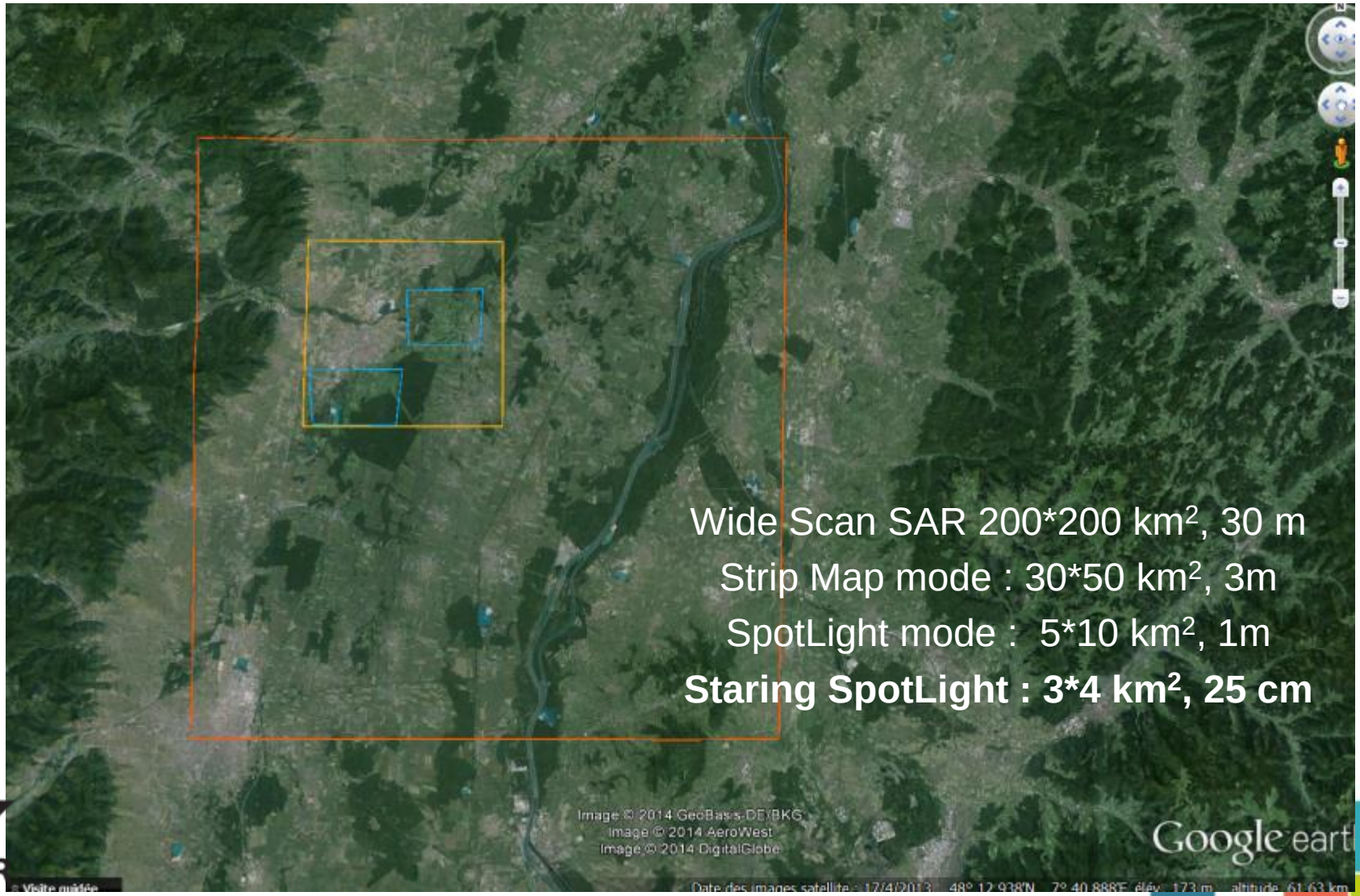
SPOT4/ HJ/Deimos and Pleiades HR
TerraSAR, Wide ScanSAR to Staring Spot Light



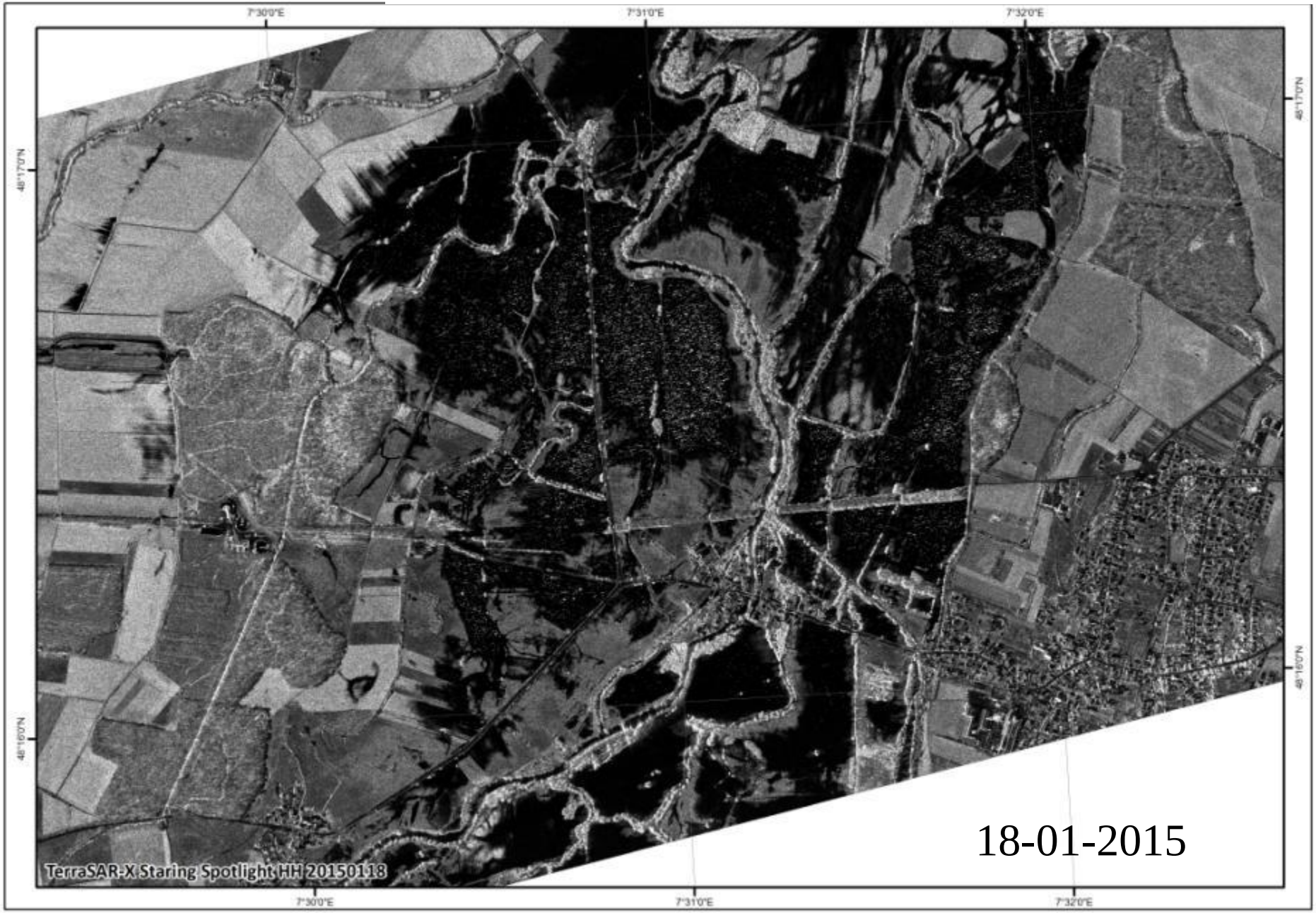
VHR SAR (CSK, Multi mode TerraSAR) or VHR Optical (Pleaides, Kompsat) imagery allow to validate the HR derived flood extent

Validation of water bodies delineation Based on HR/VHR multi resolution approach

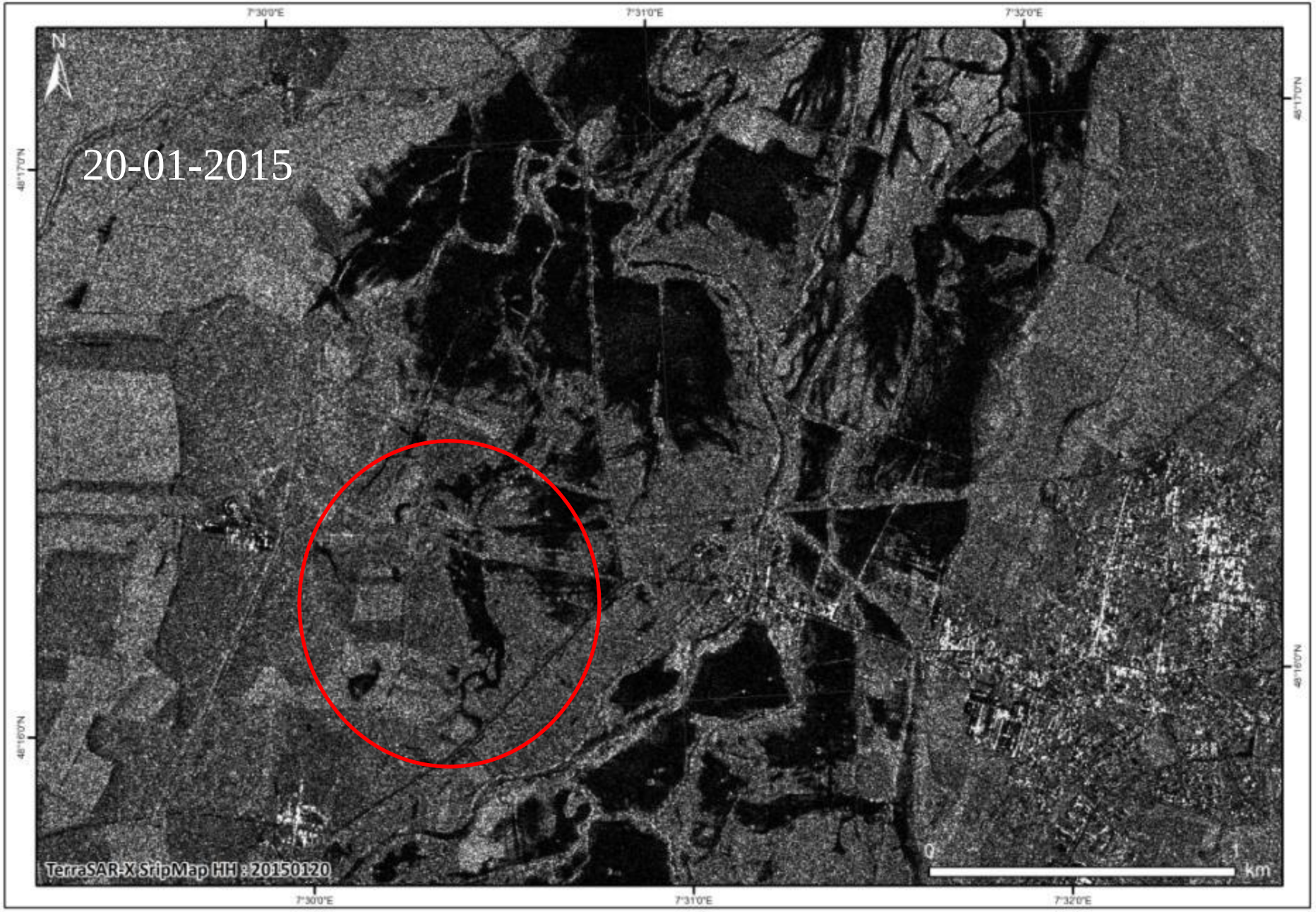
Stripmap (SM) / Spotlight standard (SL) / Staring Spotlight (ST)



New TerraSAR X Starring Spot Light images



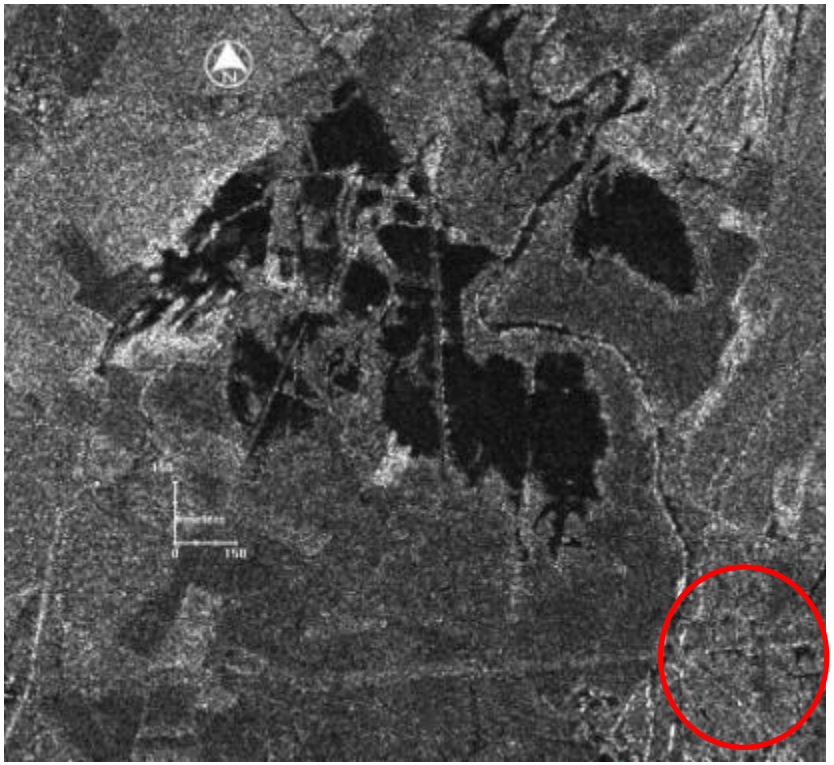
Classical TerraSAR X Strip map images



Multi resolution analysis for water extraction validation

Muttersoltz, Alsatian flood Plain

2015-03-03

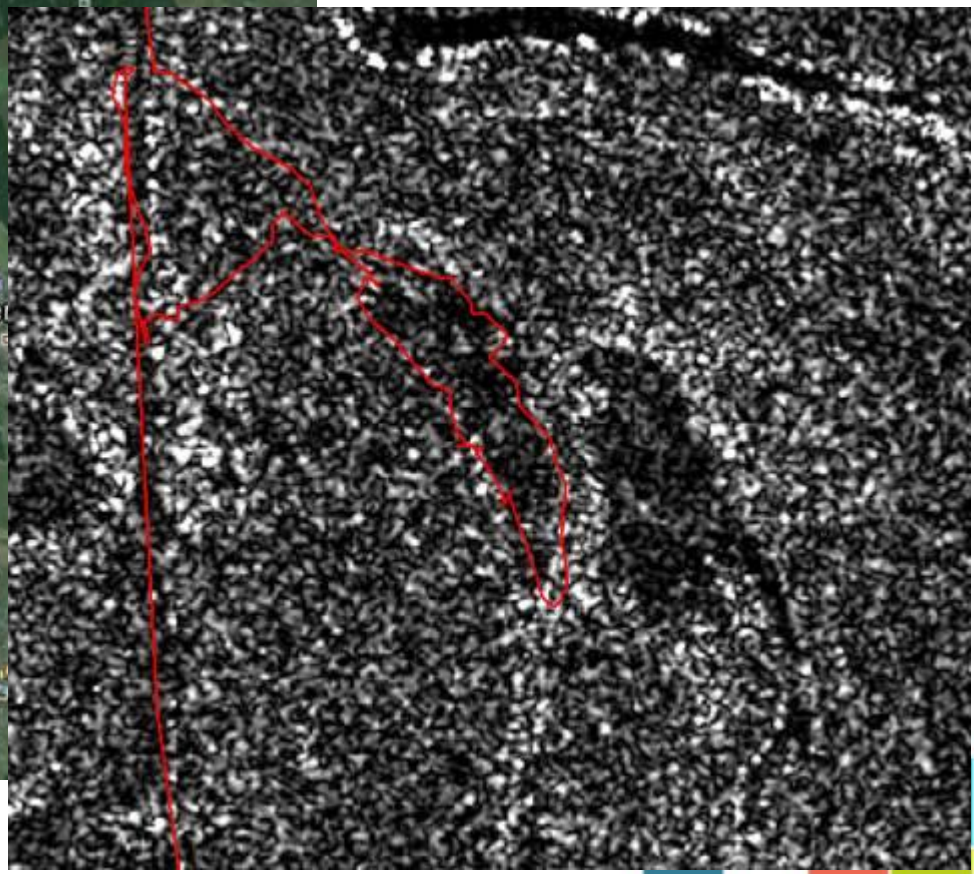


2015-03-05

Comparison TS Staring Spot Light and Strip map

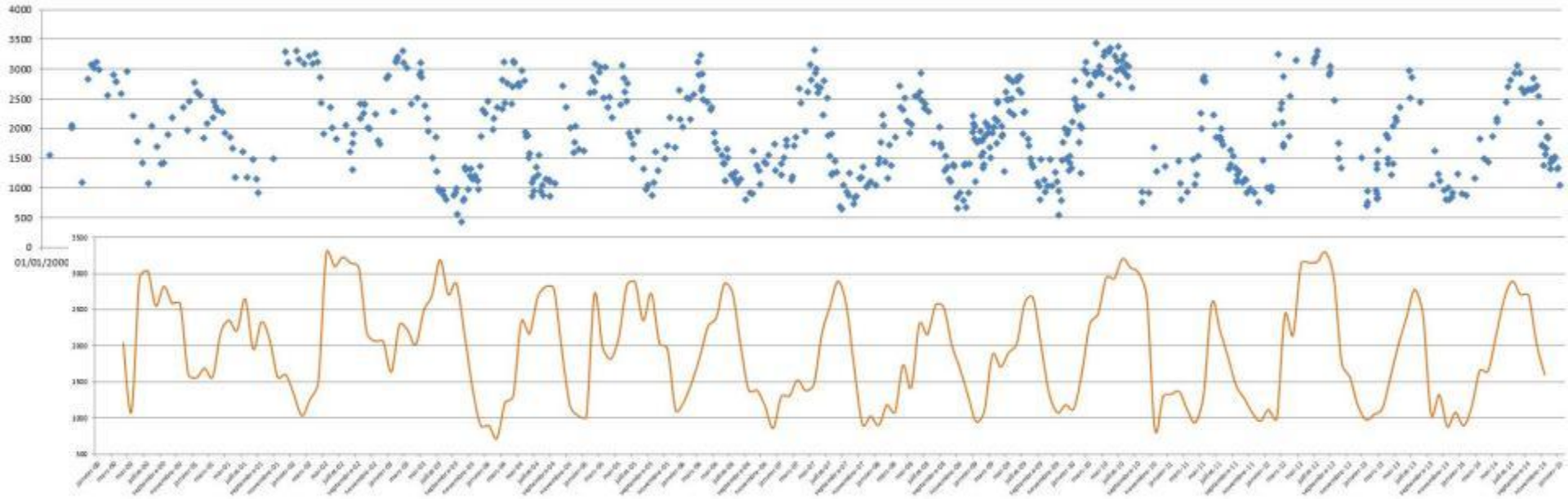
Temporal effect and resolution artefact


Sermersheim
Dambach-la-ville
Ebersheim
Scherwiller
Sélestat
© 2015 Google



12-02-2015

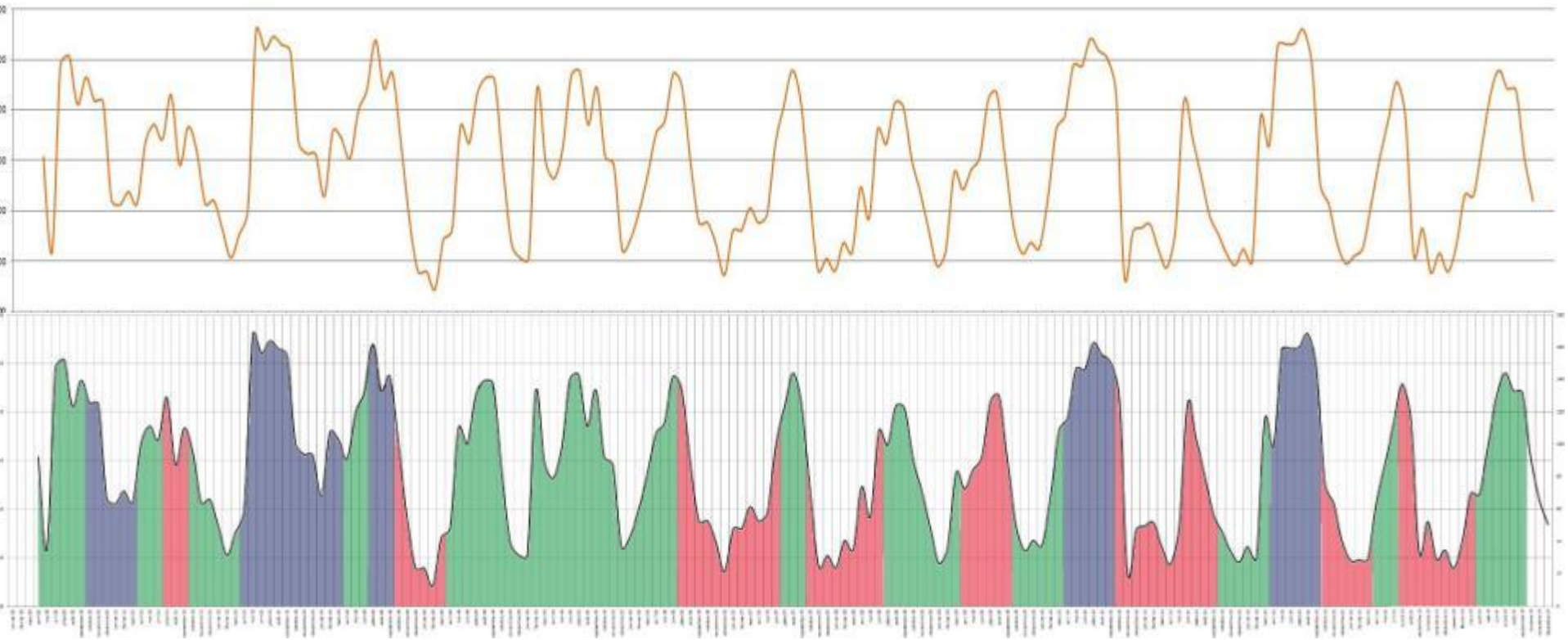
Ends: Water surfaces monitoring



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

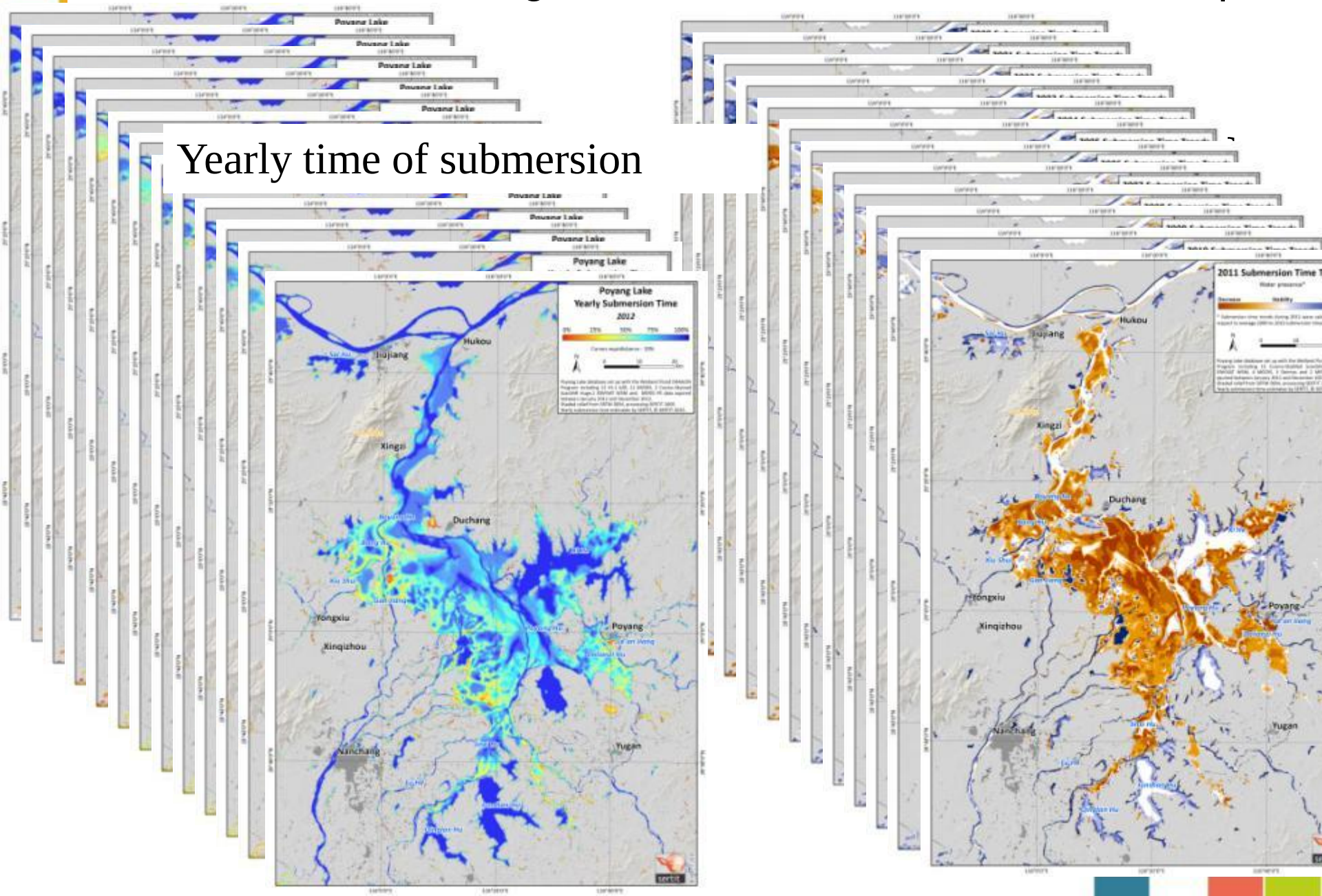


Analysis of temporal variations of water surfaces from 2000 to 2014
Normal hydrological year, wetness and dryer successions

=> Trends analysis in conjunction with meteo parameters …

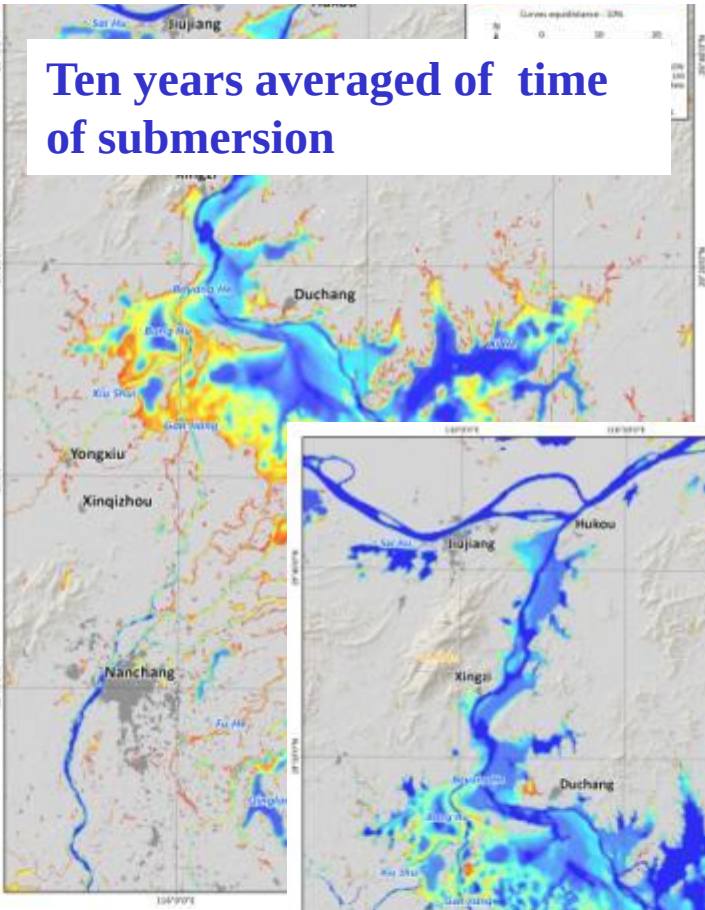
Water extent monitoring: Submersion time, occurrence maps

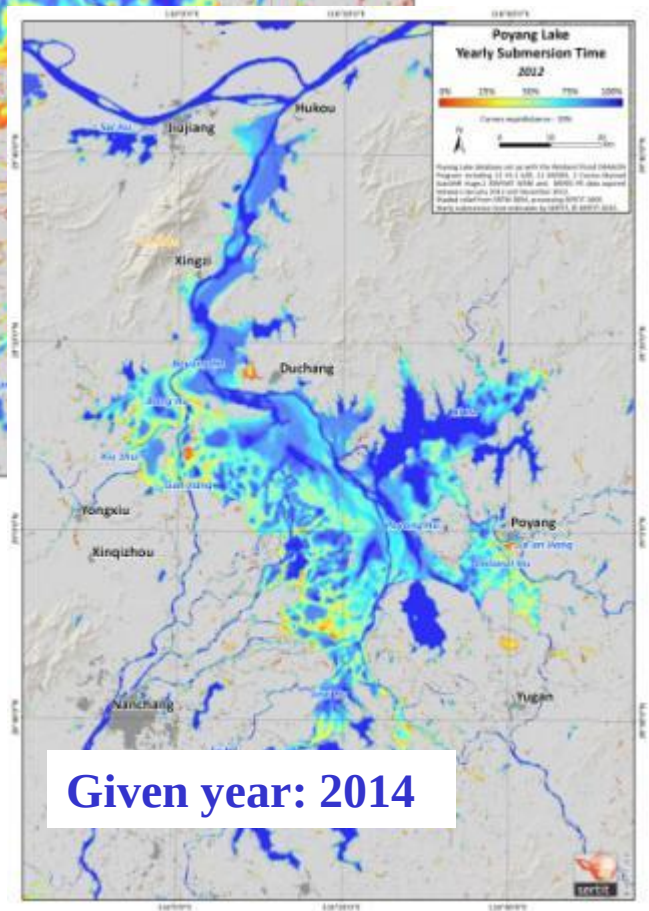
Yearly time of submersion



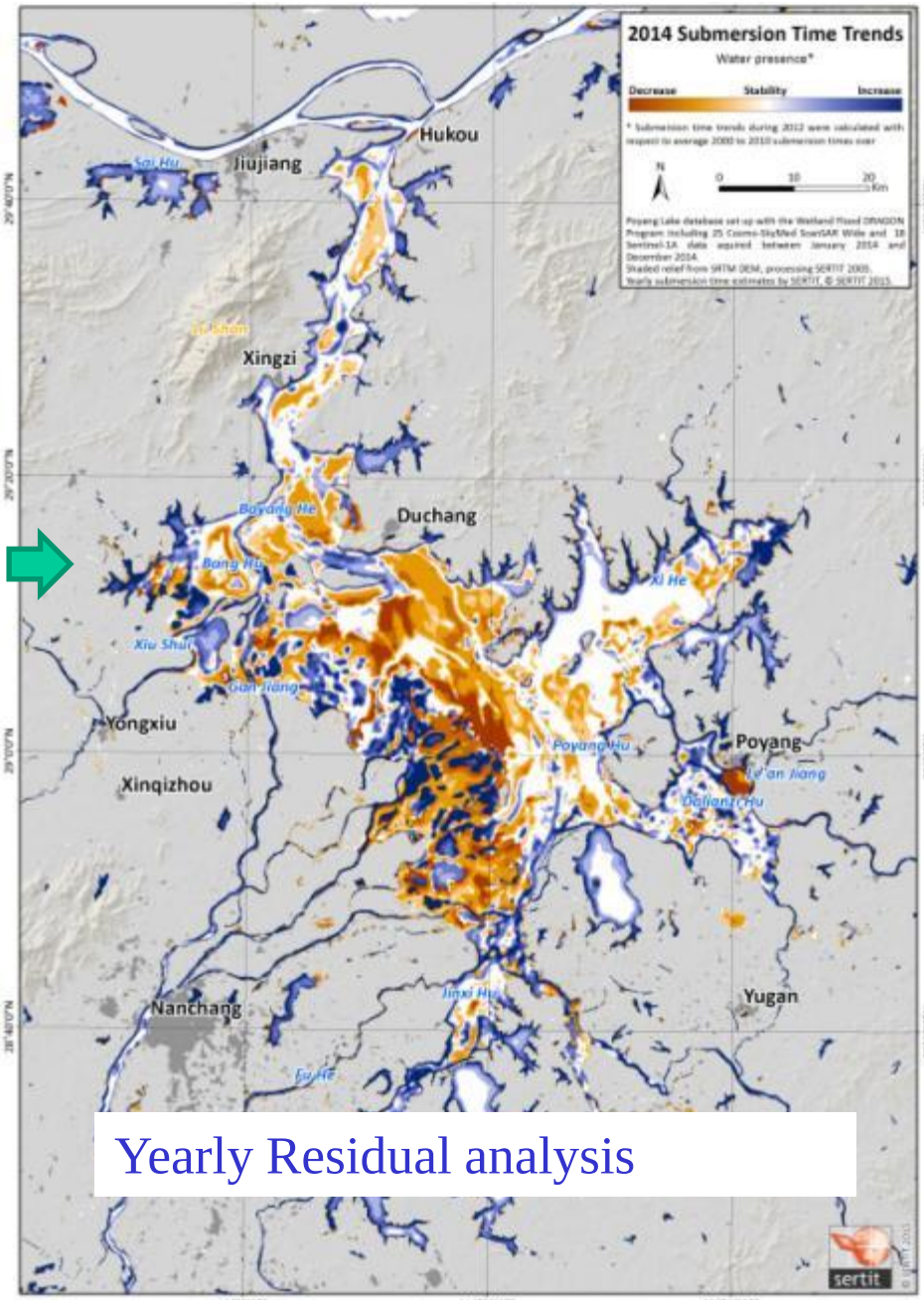
Water extent monitoring: Submersion time: residual analysis

Ten years averaged of time of submersion



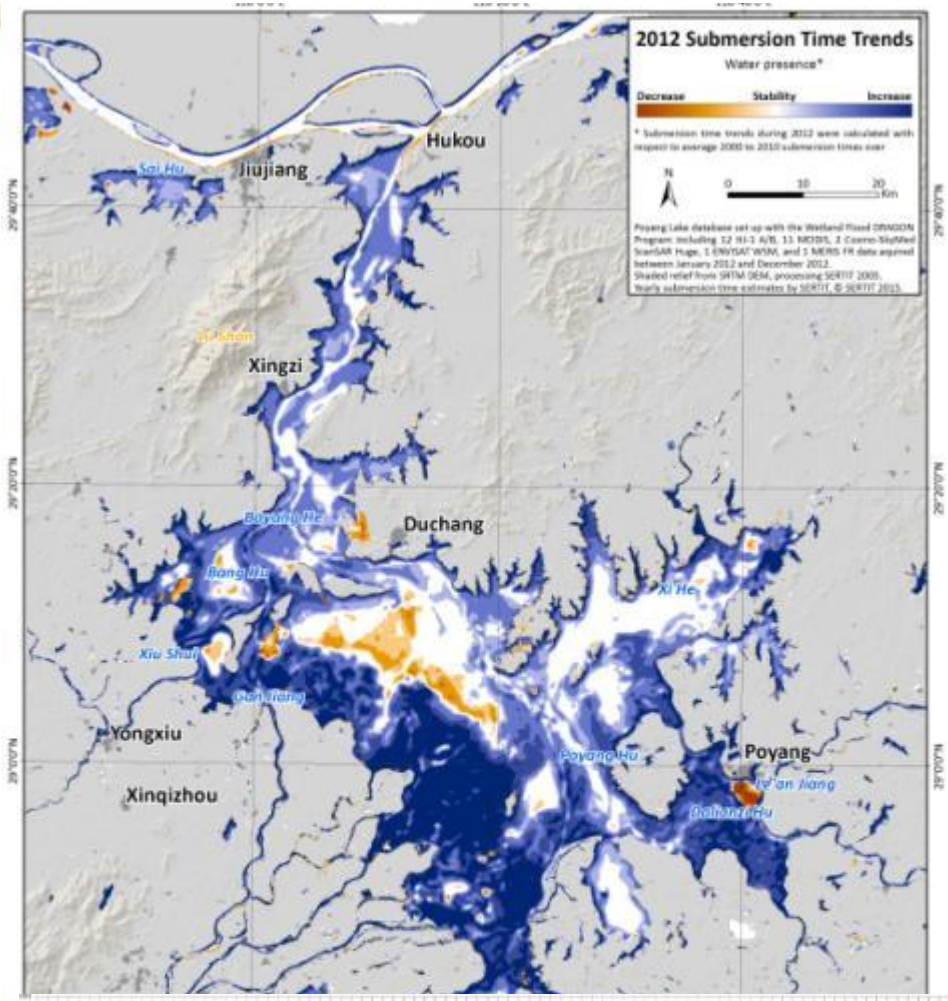


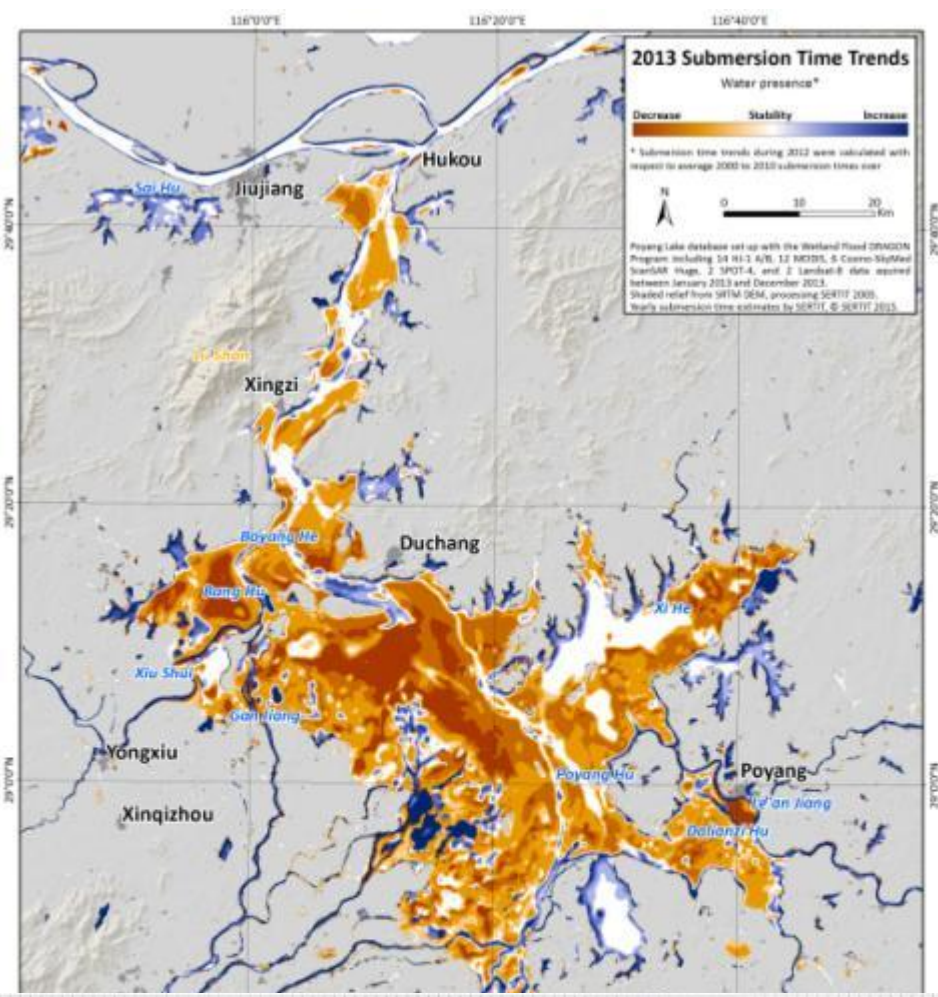
Given year: 2014

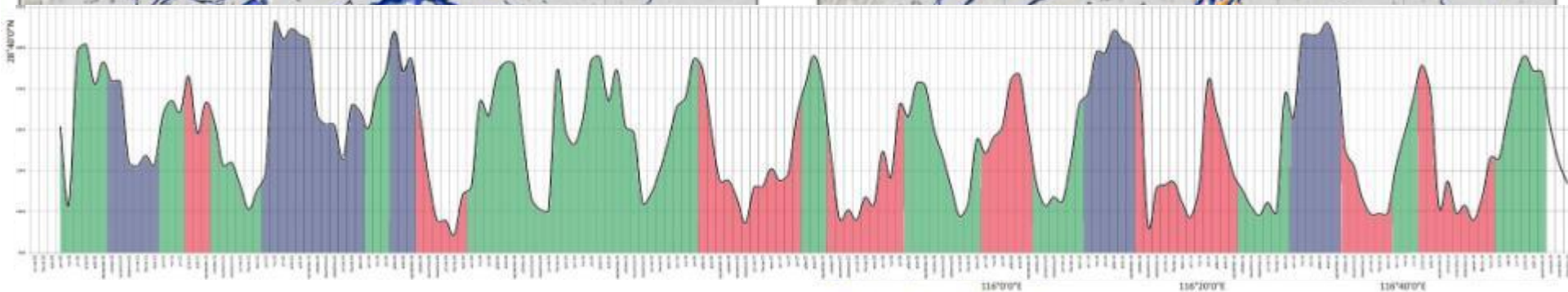


Yearly Residual analysis

Water extent monitoring: Submersion time: residual analysis







Complementarity SAR Optical HR

High complementary-synergy

Temporal:

- Long term few weeks/month with none exploitable Optical data
- Short term: increase the revisit, that interesting because evolution in less than 5 days (multiscale)

=> More accurate indicators (be careful with trends motions…)

Thematic:

- Optical :
  - Vegetation on optical: flooded, submerged floating vegetation
  - Water quality

⇒ Be careful with scale of analysis (Vegetation versus Modis, versus SPOT… 20% break each time…)..

⇒ Water bodies monitoring request regular and long term time series, continuity and consistency are key words

Perspectives and recommendations

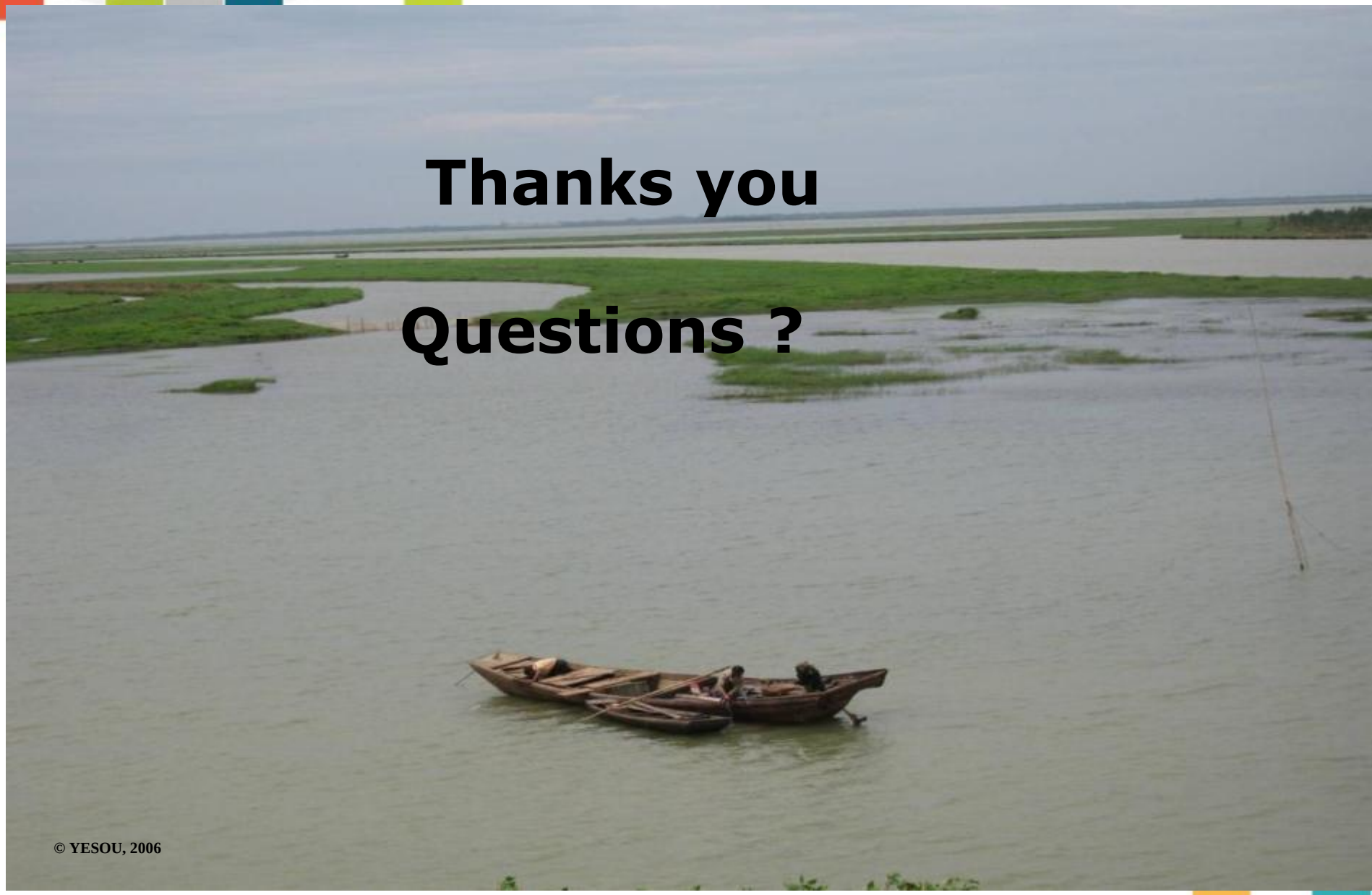
Sentinel1 : systematic VV/VH rather than HH/HV !!!!

More global coverage.. Poyang is covered by S1 but only one major sites over hundreds ,

Sentinel 2: the systematic will be really systematic all around the world .. And at which time

Pursuit of the synergy approach with Sentinel3 OCLI (and other L8, Proba 100m) ,

Integrate as much as possible others source of information , such as water height (Jason, Altika, coming S3 and Jason CS before SWOT 2020)


Thanks you
Questions ?
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L'ESPACE…

…AU SERVICE DE LA TERRE

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