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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Mapping Water Bodies from Space - MWBS 2015
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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 monitoring,

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

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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

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
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
- Within 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:
- 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.
Interest of High temporal revisit for monitoring hydrological behaviors

Intra annual changes
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

Sentinel 1 2014-10-03

2718 km²
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 ...

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
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

**Envisat ASAR WSM**
- 400 km
- 26° - 41° ENL 10.5

**Sentinel 1**
- 250 km
- 30° - 45 ENL: 4.9

**Envisat ASAR APP S4**
- 88 km
- 31-36° ENL 1.9
Land/water surfaces discrimination

Major land use such as town, network, infrastructure, agricultural parceling
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

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Recognition of water surface, water flooded vegetation and floating vegetation.
Recognition of water surface
Wet area after water redraw
Recognition of water surface
Wet area after water redraw

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

HJ1 A/B
Daily or every 2 days

400*400 km
30m
HR exploited dataset: HJ Chinese satellite
400 km swath: large diversity of landscapes

Availability of HJ data over Poyang and Anhui lakes 2011-2013

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High variability of spectral answer and contrast land/water Shenjian Lake, Anhui Province
Poyang lake CSK time series
January to December 2014
Shenjiang lake
CSK time series
2014
Sentinel 1: High temporal revisit T0, +5, +7
Time series of water surfaces
Example with Sentinel-1a
Validation approach
Multi source & multiscale optical and SAR

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

VHR SAR (CSK, Multimode TerraSAR) or VHR Optical (Pleides, 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)

Wide Scan SAR 200*200 km², 30 m
Strip Map mode : 30*50 km², 3m
SpotLight mode : 5*10 km², 1m
Staring SpotLight : 3*4 km², 25 cm
New TerraSAR X Starring Spot Light images

18-01-2015
Classical TerraSAR X Strip map images

20-01-2015
Multi resolution analysis for water extraction validation

Muttersoltz, Alsatian flood Plain

Comparison TS Staring Spot Light and Strip map

Temporal effect and resolution artefact
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)
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 ...

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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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