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Établissement public du ministère chargé du développement durable

Remote sensing data with high repetitivity : a contribution to coastal and estuarine processes knowledge



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*GIP Loire Estuaire, **I-Sea, *** IUML, Université de Nantes, **** GEO-Transfert



i-Sea



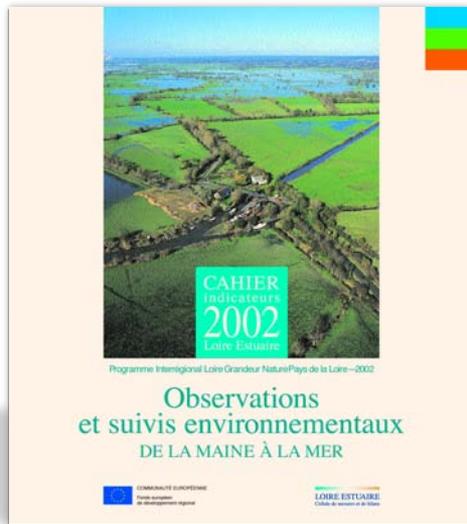
GE-Transfert





Sources : GIP Loire Estuaire Lidar 2008, Litto3D® © IGN Paris 2010, BD ALTI® - © IGN Paris 2004

0 10km



= environmental monitoring center

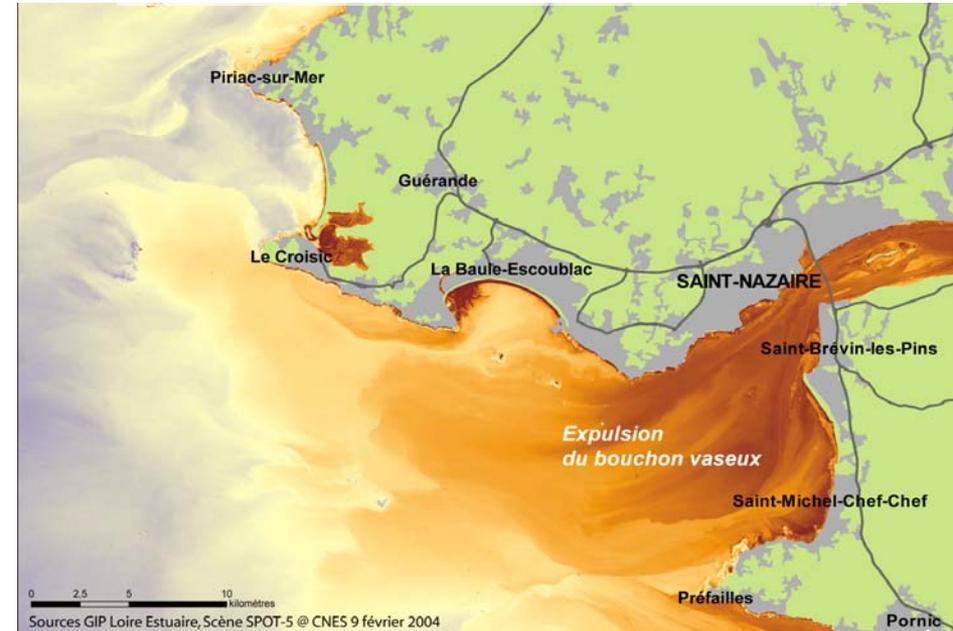
Marine floods dynamics



As Papillon
Estuaire de La Loire
Le Pellerin - Faimboug
Vers vers l'aval / Aval 1
Cher Mars 2010, 3 jours
après la Tempête Xynthia
St Etienne de Montlic
16 h 22 min
3 mars 2010
Perspective
Cliquez
Info, 7804_AP1209.jpg
GIP
Loire
Estuaire

- Biodiversity
- Agricultural practices

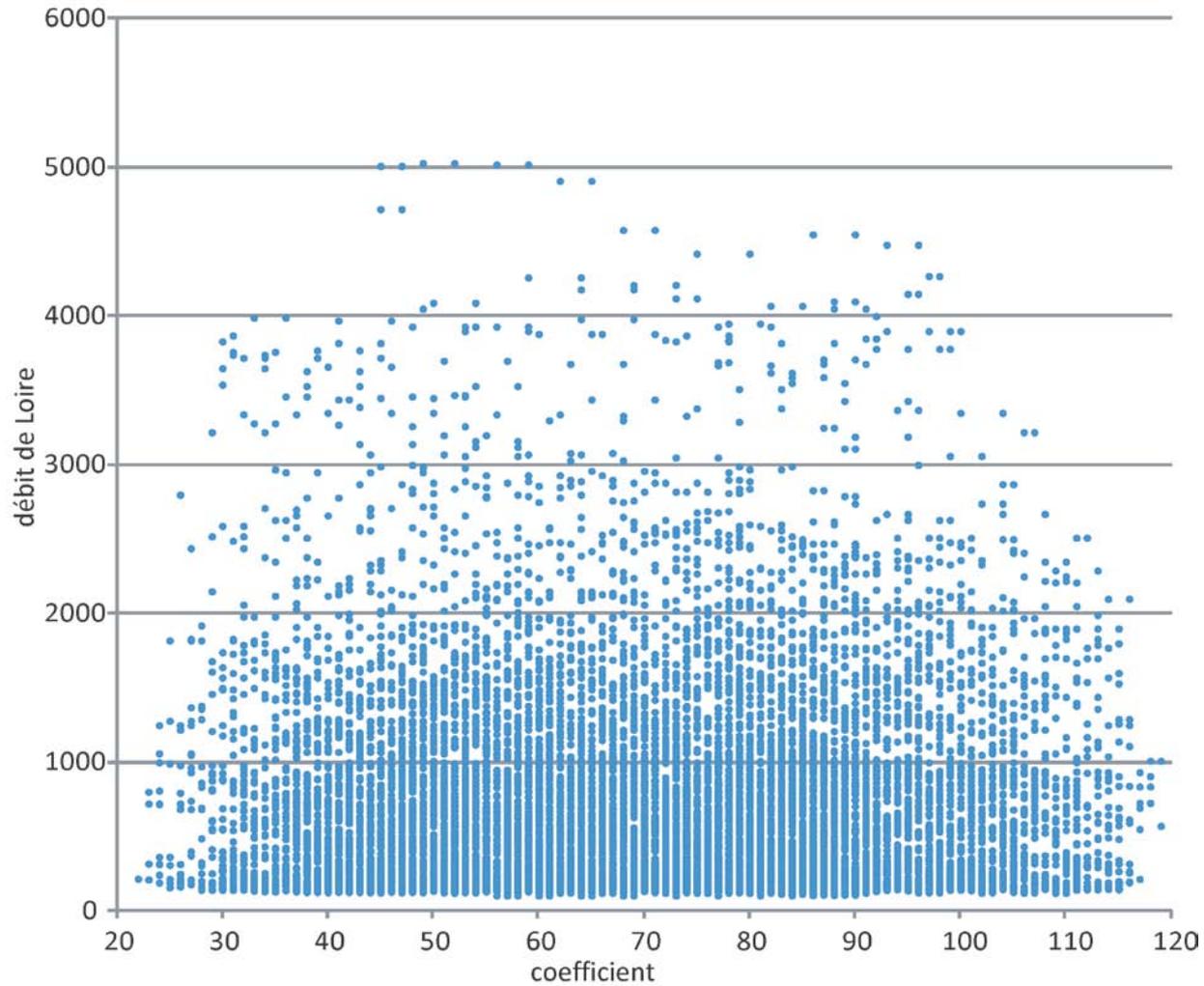
MTZ dynamics



- Biodiversity
- Industry & urban
- Navigation
- Fishing

+ Climate Variability and Change

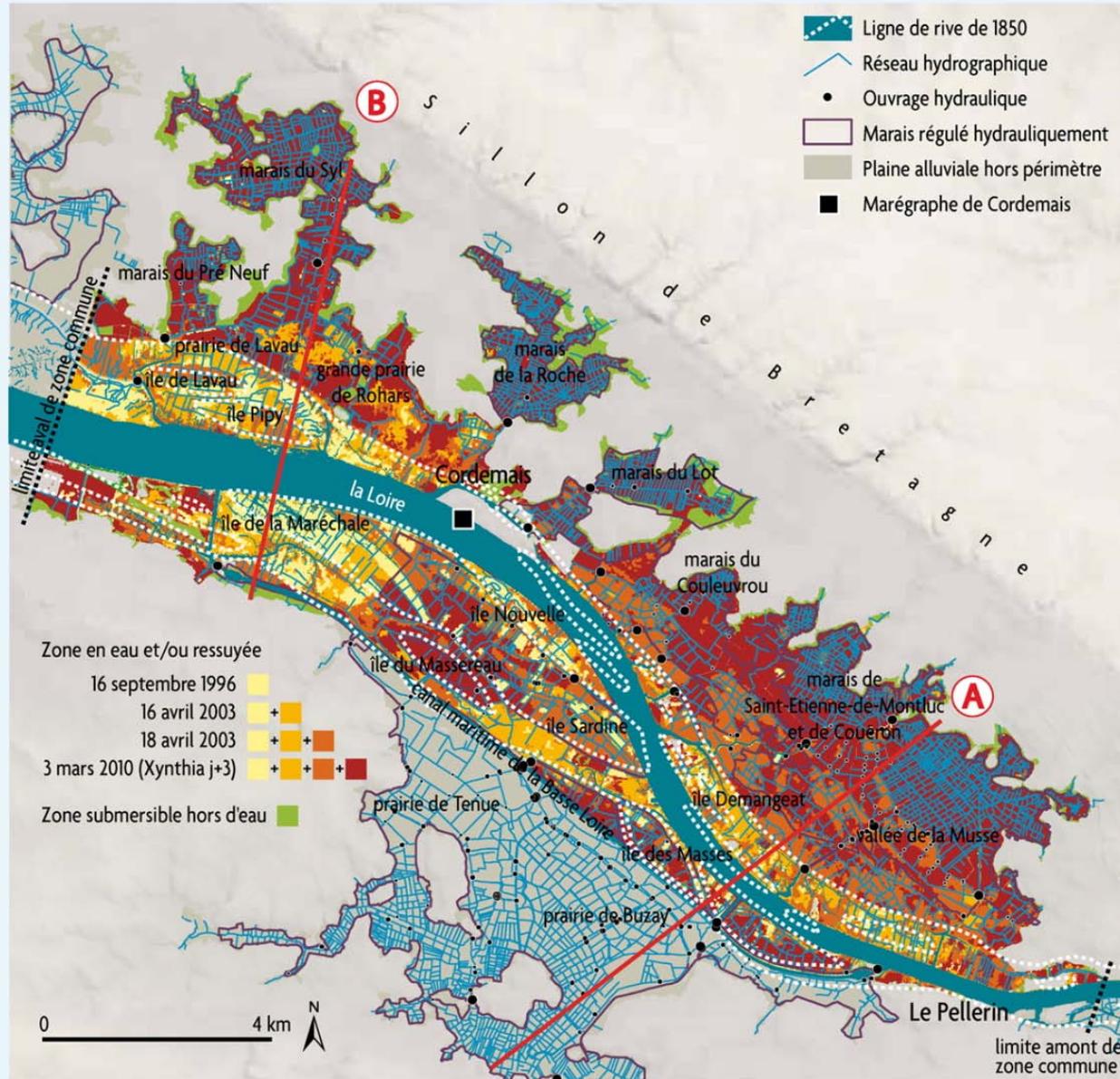
*Hydrological
Situations
1996 to 2013*



Sources : banque Hydro, NSNP, GIPLE

Marine floods dynamics

Cartographie des zones en eau au cours de 4 débordements

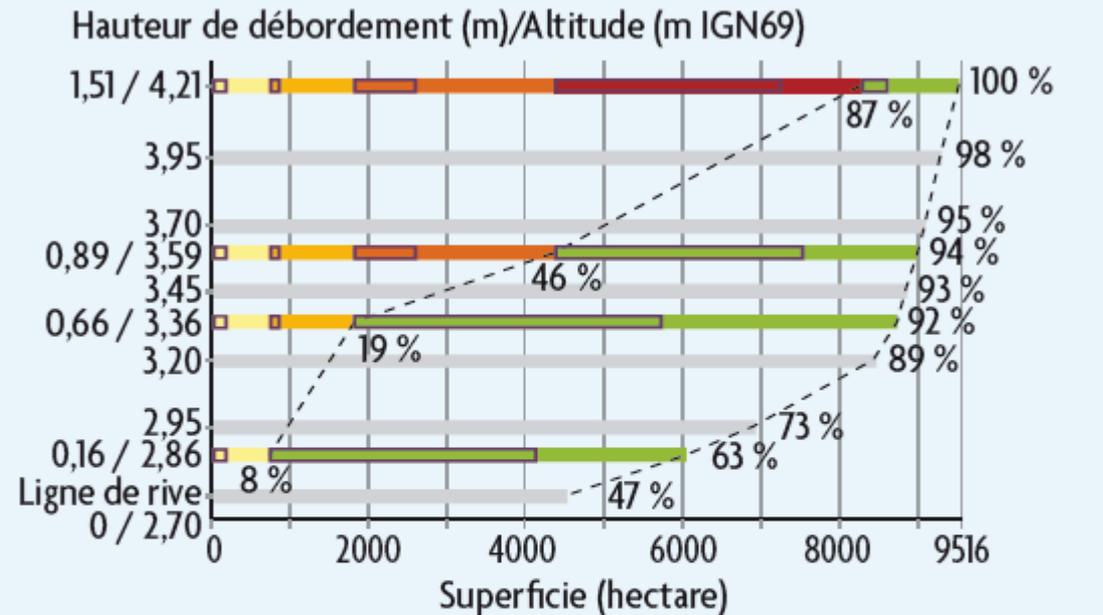


SPOT2/Landsat 7/ IRS/aerial photography

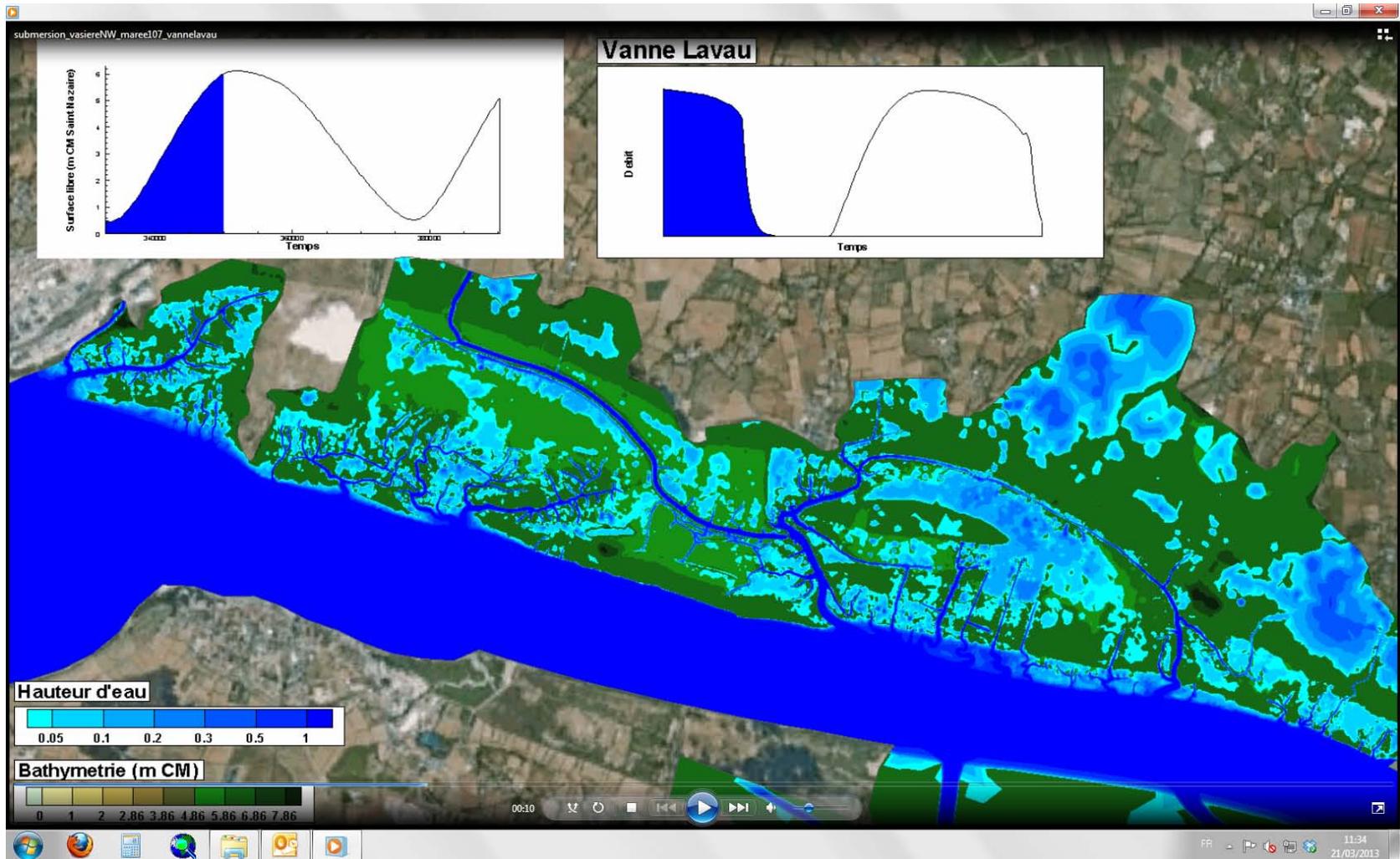


Sources : Litto3D®IGN /BD TOPO®IGN/GIP Loire Estuaire

Proportion des surfaces submersibles et submergées au cours de 4 débordements



Sources : Litto3D®IGN/BD TOPO®IGN/Images SPOT2, Landsat 7, IRS/GIP Loire Estuaire



A limit : *a posteriori* acquisition

- no initial state of flood plain
- no simultaneous field data
- events too spaced apart in time

> No distinction of water supplies

Hydrological and meteorological conditions

date	Heure	Coeff marée (-)	Position dans cycle semi-diurne	Position cycle VE/ME	Débit (m3/s)	Vagues Hs (m)
21/02/13	9:57	37	Mi-marée	Mortes Eaux, (Vives Eaux 7 j avant)	2080	1.1
28/03/13	9:54	102	Basse mer	Pic de Vives Eaux	1400	0.6
17/04/13	10:52	46	2h après PM	Mortes Eaux (VE 5-7 j avant)	2410	1.5
06/06/13	10:48	67	1h30 après BM	Coeff moyens, (Vives Eaux 7 j avant)	1540	NA

in situ data streaming :

- tide height (NSNP)
- river flow (Banque Hydro)
- atmospheric pressure (Infoclimat)
- sea-state (Candhis – CEREMA)
- water depth (4 stations Altus : 6 Mars à Juin 2013) IFREMER

Niveaux d'eau atteints à la pleine mer précédente

date	Heure	Niveau d'eau Cordemais (m CM)	Altus Rohars (-)	Altus Lavau (-)	Altus Pipy SE (-)	Altus Pipy NE (-)	débordement
21/02/13	9:57	NC	NC	NC	NC	NC	?
28/03/13	9:54	6.57	3.3	1.9	0.28	0.2	OUI
17/04/13	10:52	4.98	1.81	0.6	0.002	<0	NON
06/06/13	10:48	5.45	NC	NC	NC	NC	NON



Data processing

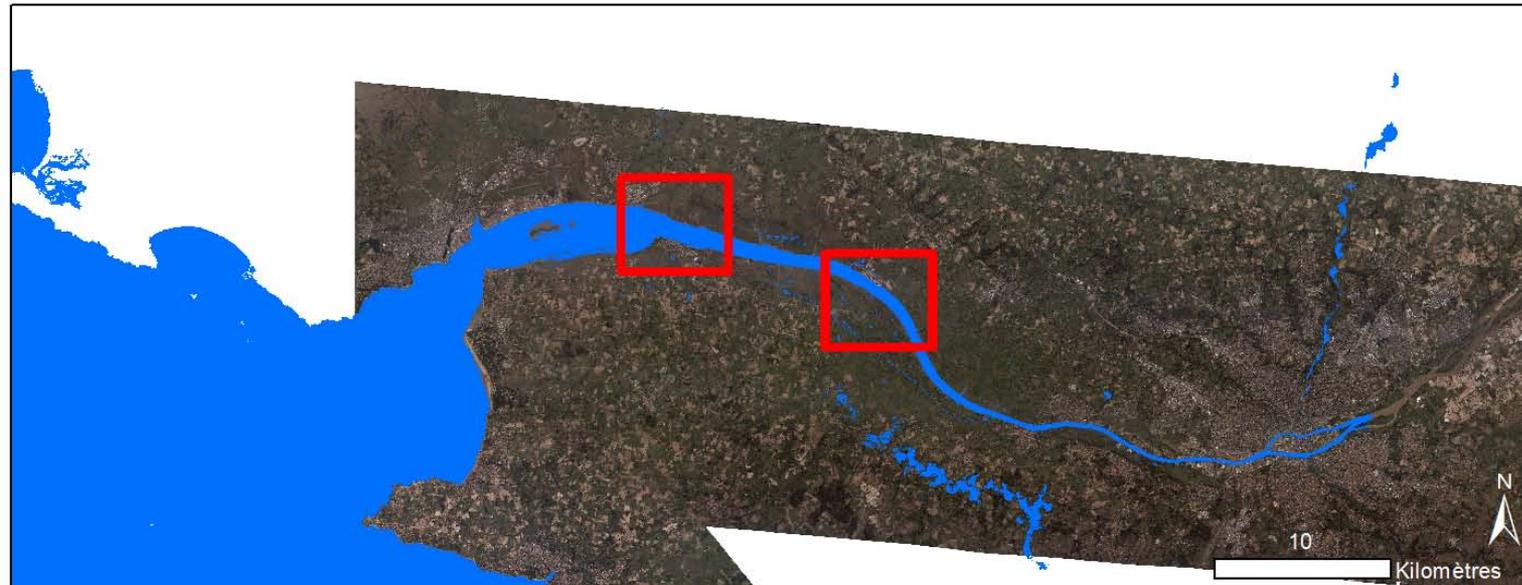
Mask of clouds, projected shadows, tracks of plane

Extraction of flood plain

Indices

- NDWI (Difference Water Index: $V-PIR/V+PIR$) : indice de présence d'eau libre
- MNDWI (normalized Difference Water Index: $V-MIR/V+MIR$) : indice de présence d'eau libre
- NDVI : indice de végétation
- IRI : indice d'humidité

MNDWI Février 2013

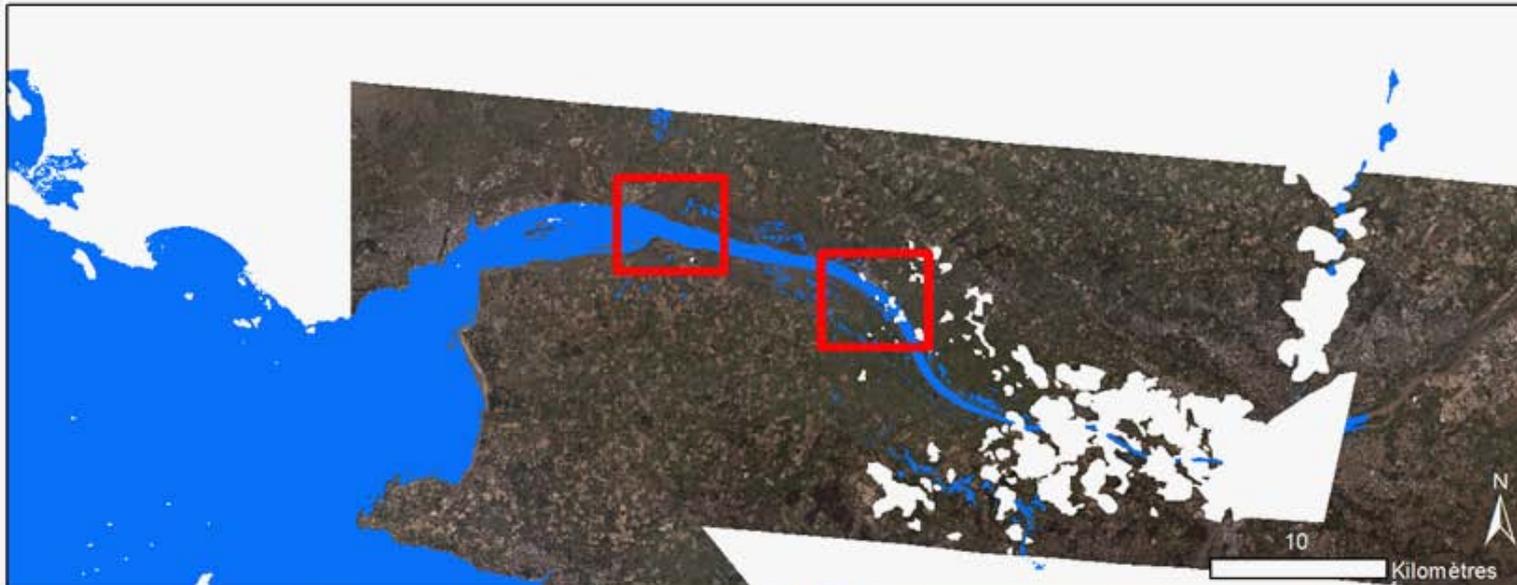


- MNDWI
- nuages, avions, bateaux

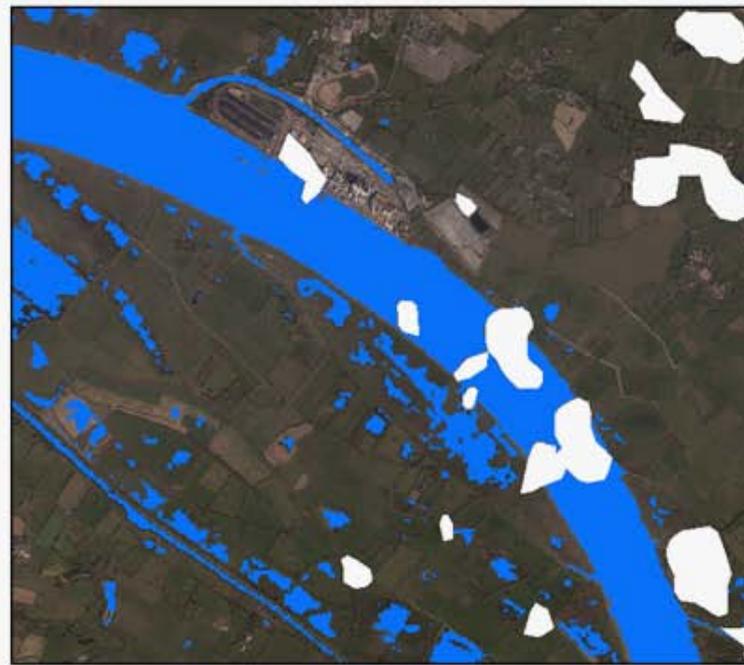


Réalisation : i-Sea 2014
Sources : GIPLE, Spot 4 take 5
Système de coordonnées :
RGF - Lambert 93

MNDWI Mars 2013



- MNDWI
- nuages, avions, bateaux



Réalisation : i-Sea 2014
Sources : GIPLE, Spot 4 take 5
Système de coordonnées :
RGF - Lambert 93



MNDWI Avril 2013



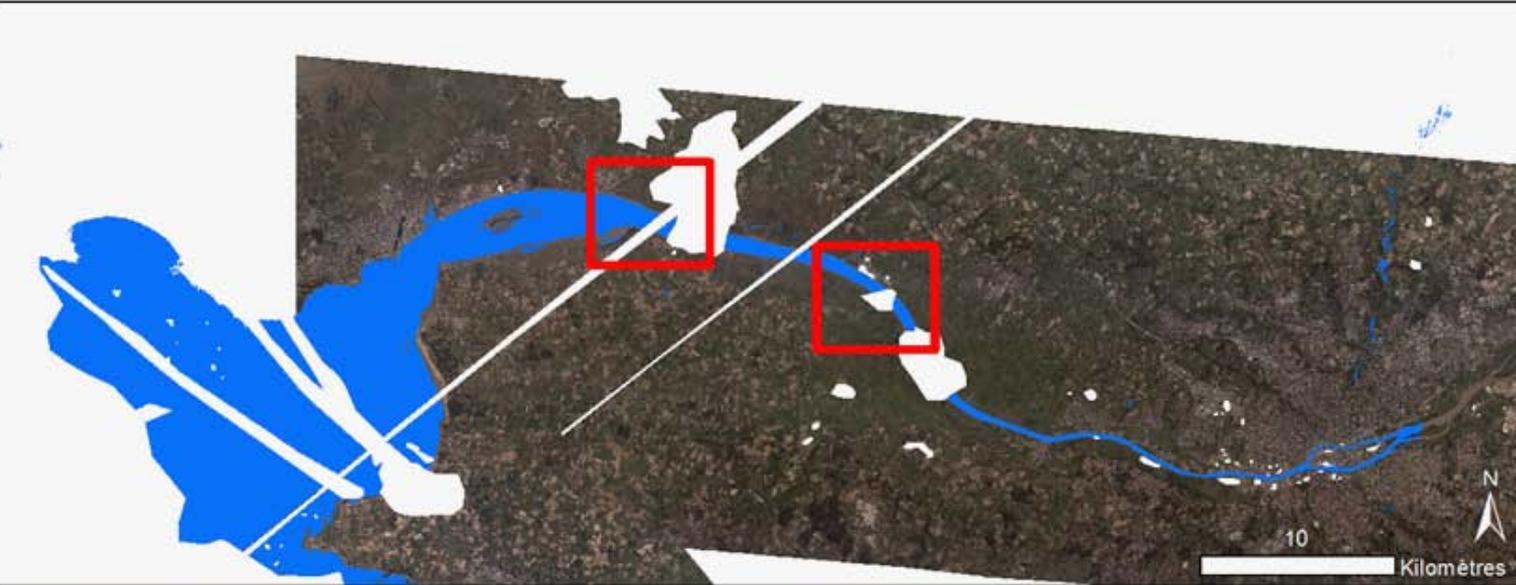
- MNDWI
- nuages, avions, bateaux



Réalisation : i-Sea 2014
Sources : GIPLE, Spot 4 take 5
Système de coordonnées :
RGF - Lambert 93



MNDWI Juin 2013



- MNDWI
- nuages, avions, bateaux

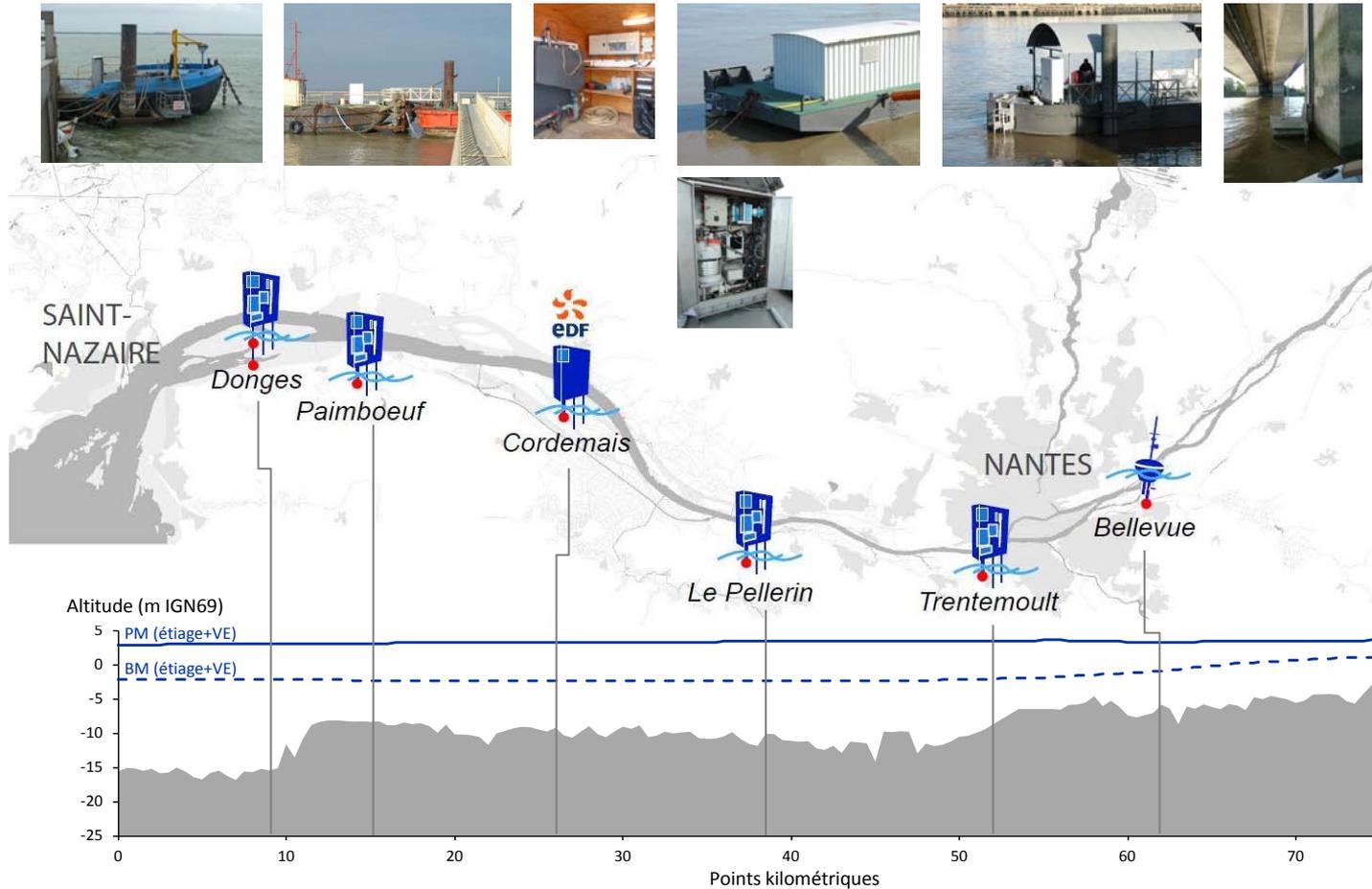


Réalisation : i-Sea 2014
Sources : GIPLE, Spot 4 take 5
Système de coordonnées :
RGF - Lambert 93

- one marine flood
- no tidal cycle (=3 successive scenes)
- cross check with vegetation (map & indices)
- effect of the duration of flood (66 cm vs 71 cm overflowing) to calcul

MTZ dynamics

SYVEL (SYstème de Veille dans l'Estuaire de la Loire)



Sources : DREAL Pays de la Loire, EDF, GPMNSN, GIP Loire Estuaire

Parameters

- conductivity (salinity)
- Turbidity (MTZ)
- Dissolved oxygen
- Temperature

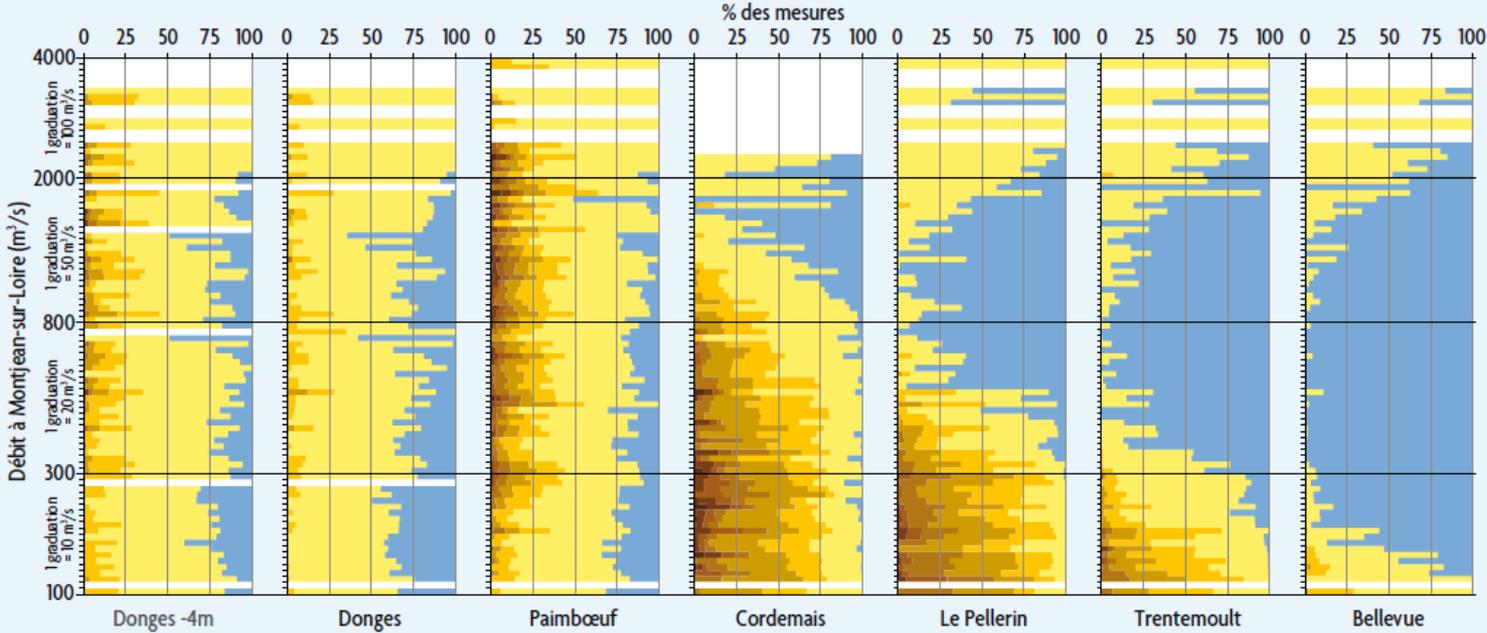
Frequency of acquisition

10 to 15 minutes
3000 mesures a day

SYVEL (SYstème de Veille dans l'Estuaire de la Loire)

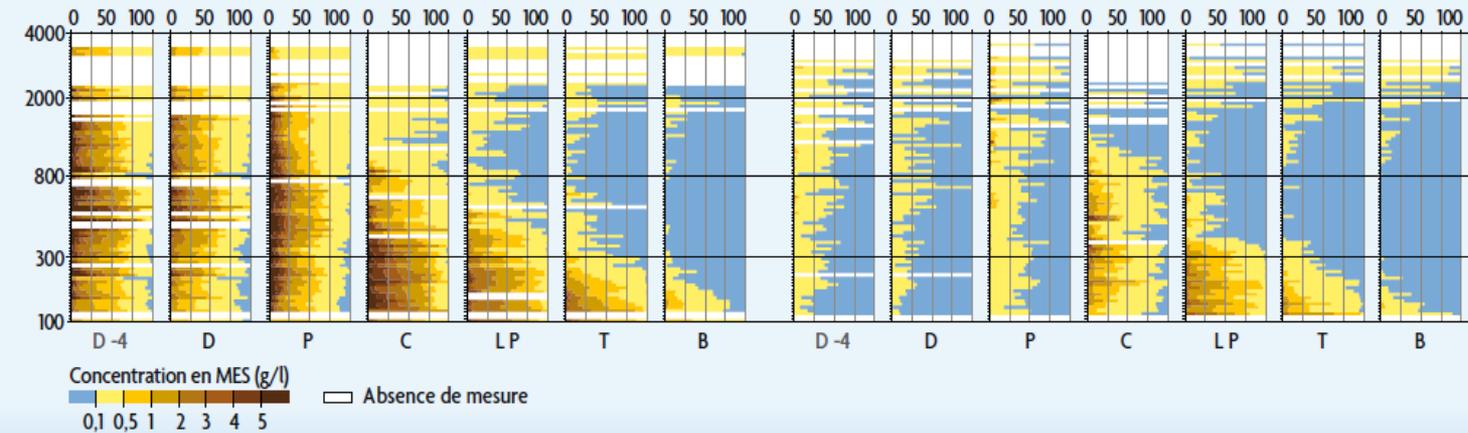
Pourcentage de mesures par gamme de concentration pour différentes classes de débit de 2007 à 2013

Marées moyennes (65 ≤ coeff. ≤ 75)

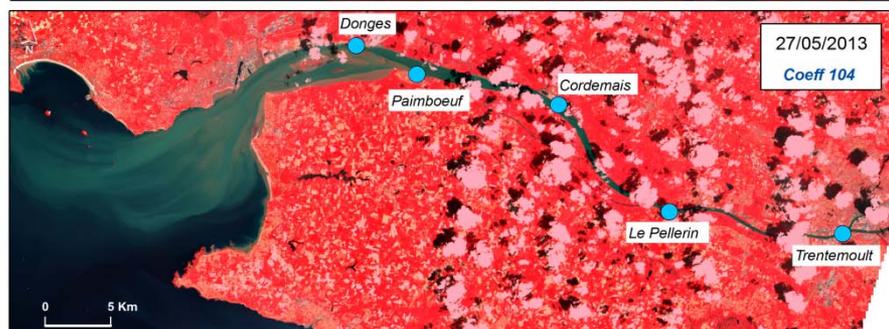
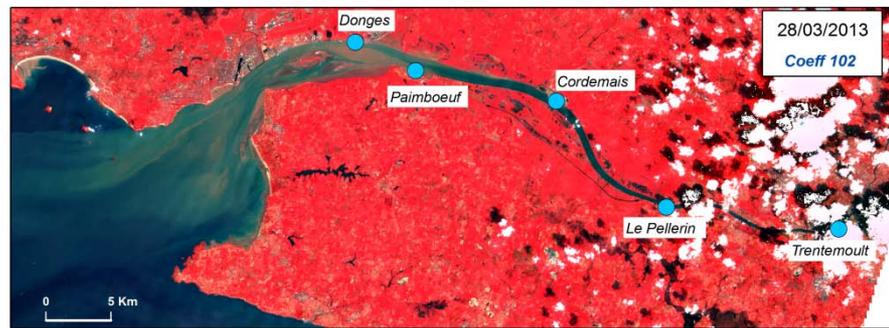
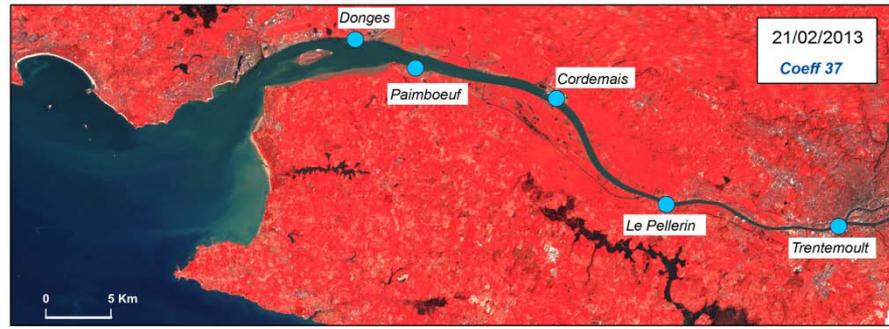
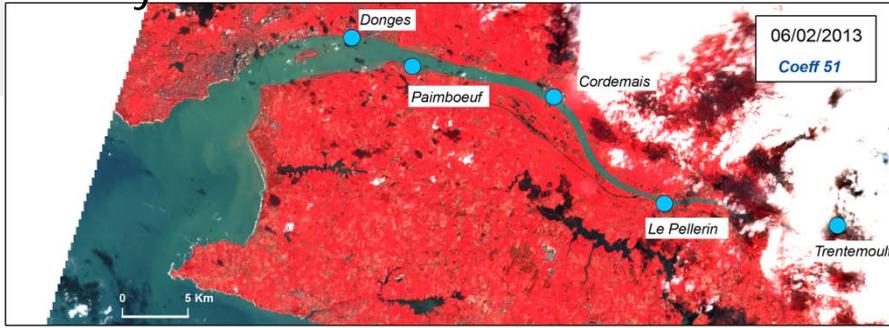


Vives eaux moyennes (90 ≤ coeff. ≤ 100)

Mortes eaux moyennes (40 ≤ coeff. ≤ 50)



High SPM value in spring tide



4 images selected according to hydrological conditions :

1. Neap tide, **outflow = 3200 m³ s⁻¹**

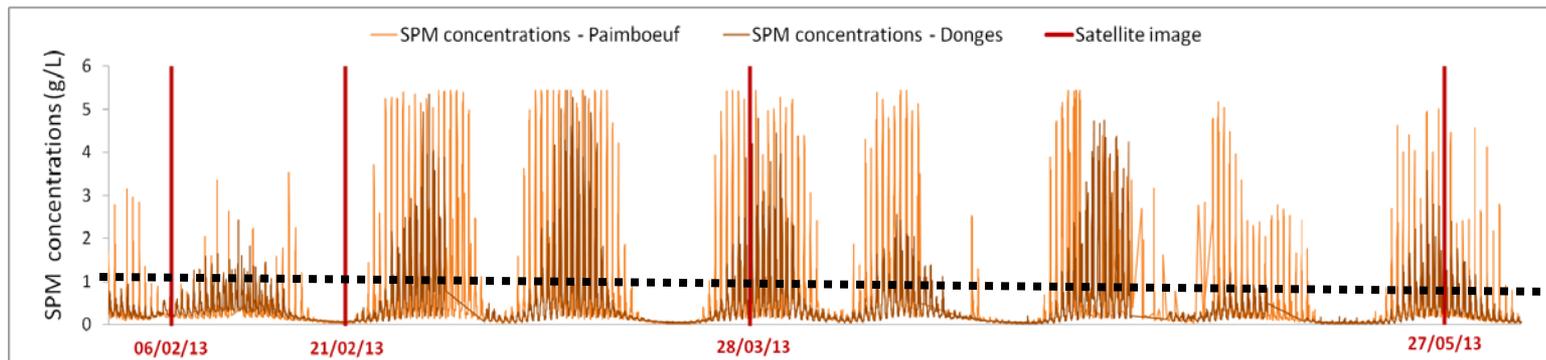
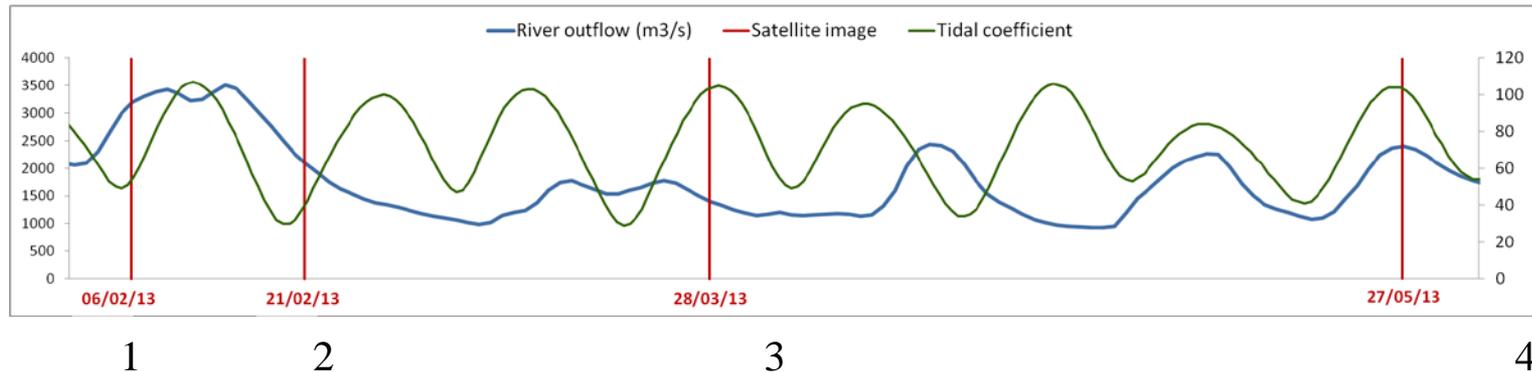
2. Neap tide, **outflow = 2800 m³ s⁻¹**

3. Spring tide, **outflow = 1400 m³ s⁻¹**

4. Spring tide, **outflow = 2400 m³ s⁻¹**

4 images selected according to hydrological conditions

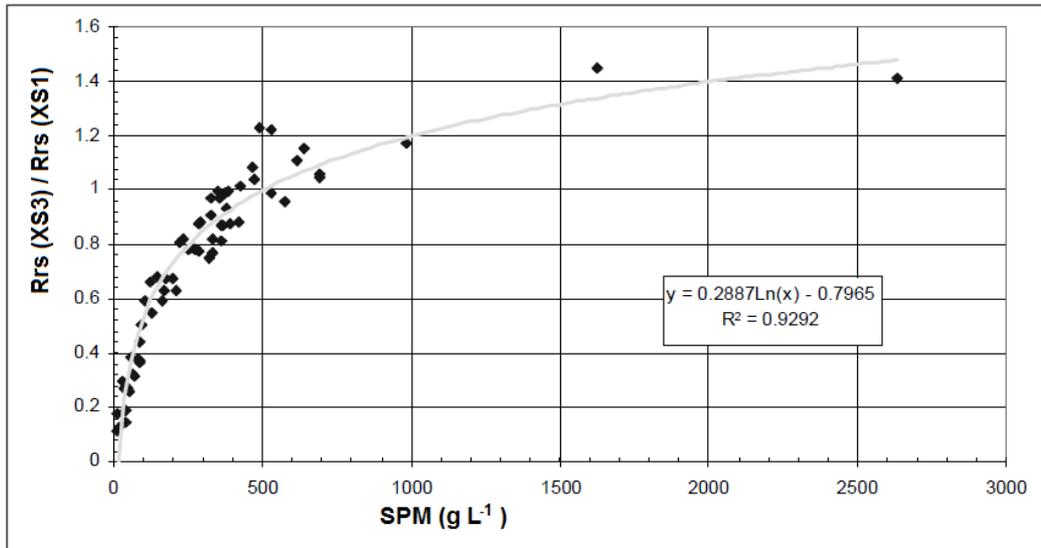
Image number	Date	Hydrological condition	Tidal coefficient	River outflow (m ³ /s)
1	06/02/2013	Neap tide	51	3200
2	21/02/2013	Neap tide	37	2080
3	28/03/2013	Spring tide	102	1400
4	27/05/2013	Spring tide	104	2400



High SPM value in spring tide

Method : inversion of SPM concentration from SPOT4 data

- NIR/VIS band ratio algorithm for SPOT
(Doxaran *et al.*, 2003; Froidefond, 2004)



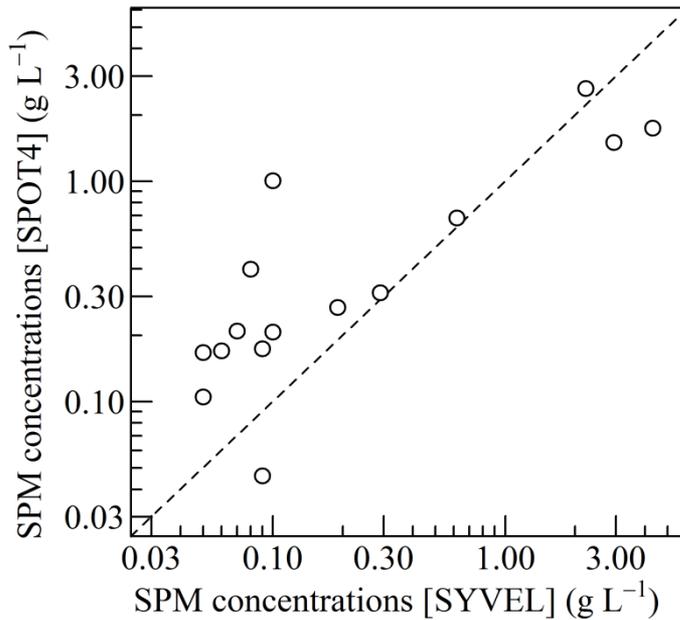
Rrs(XS3)/Rrs(XS1) band ratio versus SPM concentration

Froidefond J.M. 2004. Opération 2. Acquisition et traitement d'images satellites : le panache de la Loire pendant la crue de janvier 2004. Programme Interrégional Loire Grandeur Nature. Loire Estuaire. Cellule de Mesures et de Bilans. 45p.

Doxaran, D., Froidefond, J. M., & Castaing, P. (2003). Remote-sensing reflectance of turbid sediment-dominated waters. Reduction of sediment type variations and changing illumination conditions effects by use of reflectance ratios. *Applied Optics*, 42(15), 2623-2634.

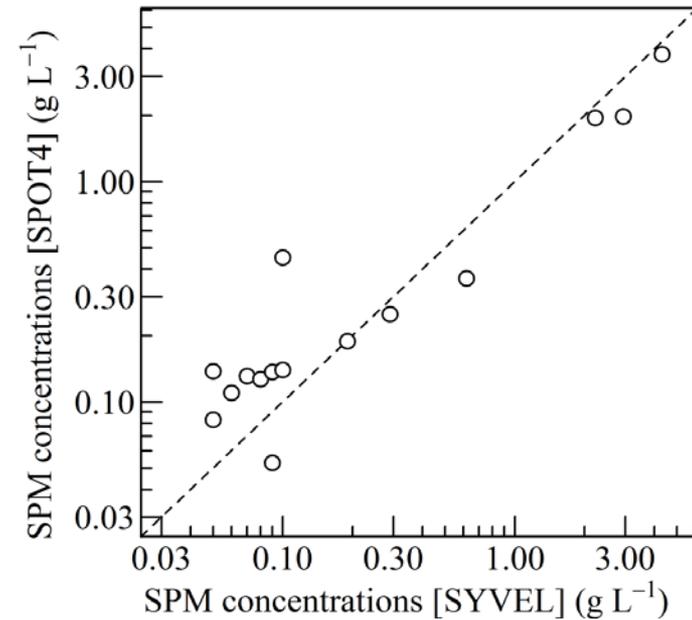
Comparison of in-situ vs satellite-derived SPM concentration

15 concomittant SYVEL and SPOT4 data points :



Nearest satellite pixel

$R^2 = 0.65$; slope = 0.5

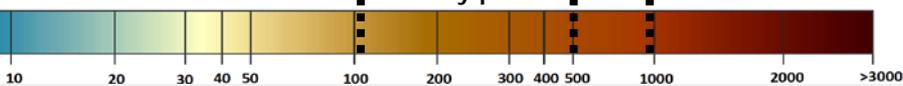


Average of 5 satellite pixels
(excluding the nearest pixel)

$R^2 = 0.97$; slope = 0.8

SPM concentrations (mg/L)

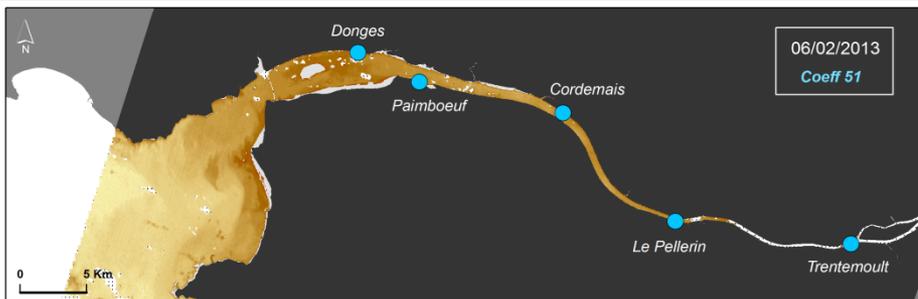
Turbidity plume MTZ MTZ str. s.



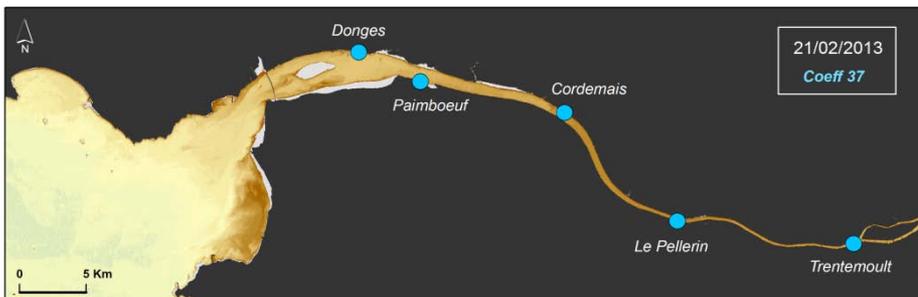
4 images selected according to hydrological conditions

Agitation on shallow depths

1. Neap tide, **outflow = 3200 m³ s⁻¹**

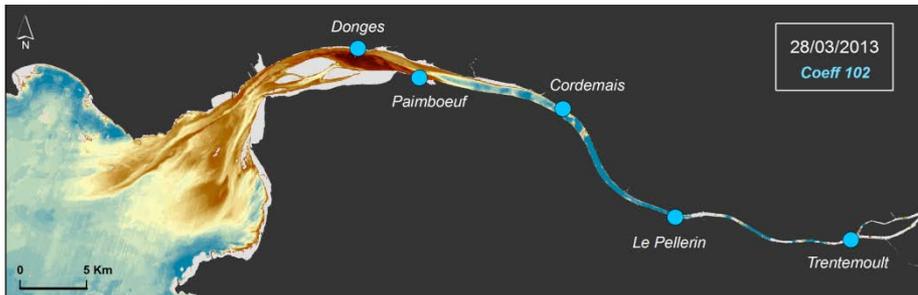


2. Neap tide, **outflow = 2800 m³ s⁻¹**

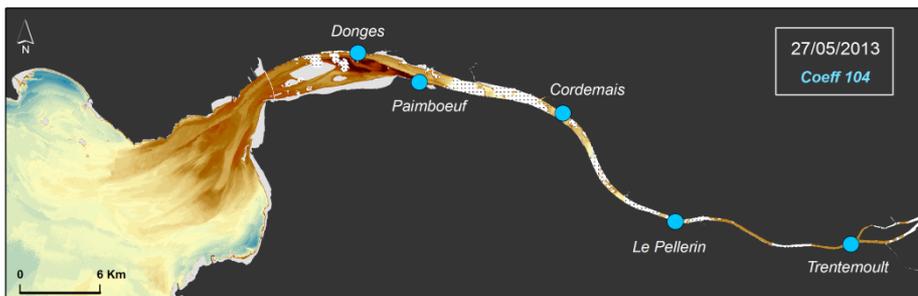


Form of turbidity plume

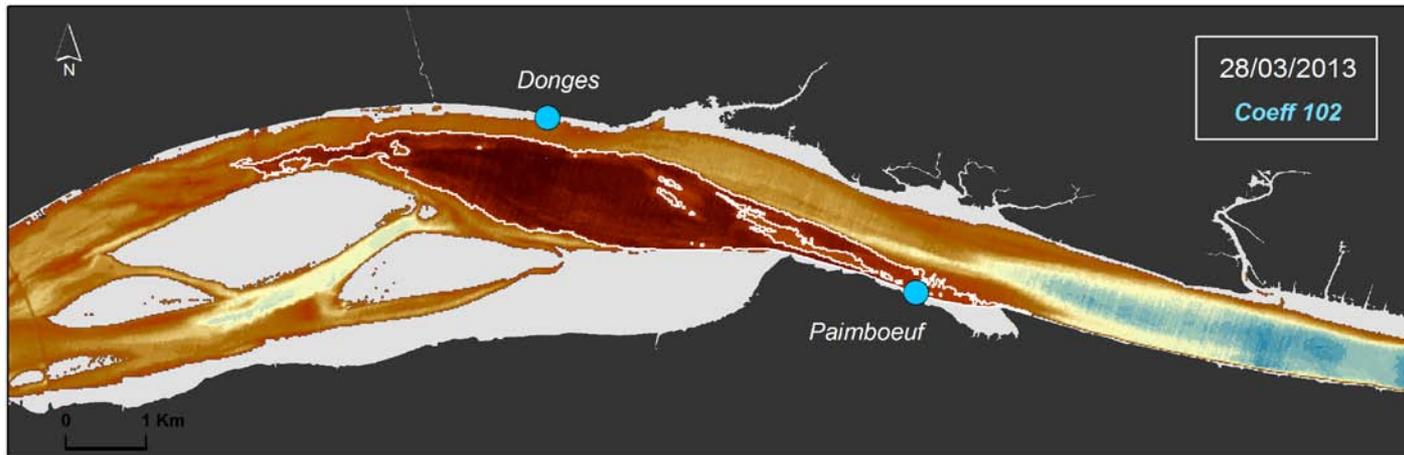
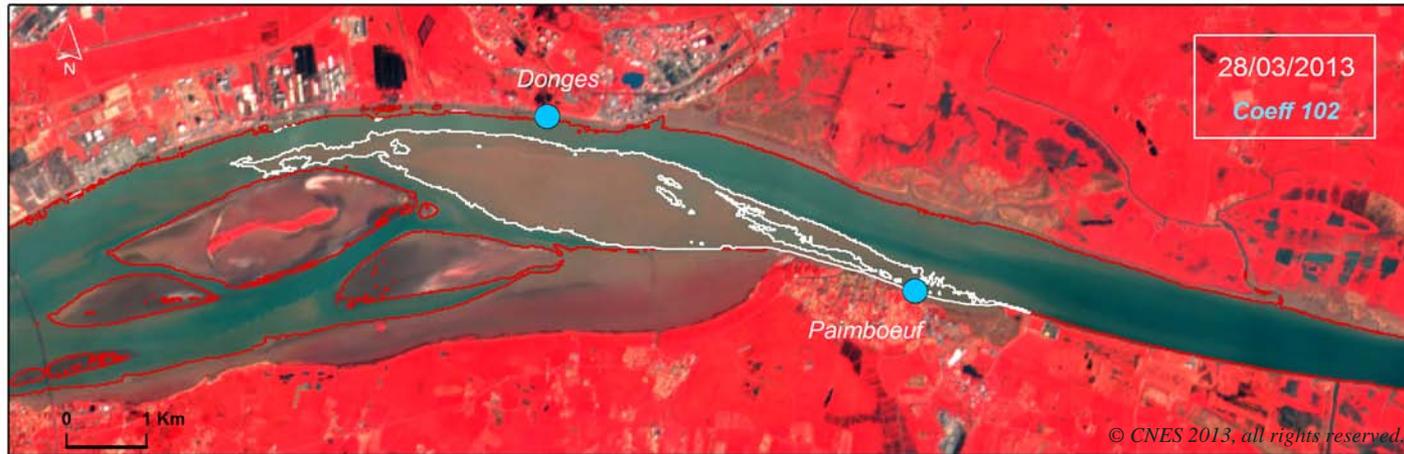
3. Spring tide, **outflow = 1400 m³ s⁻¹**



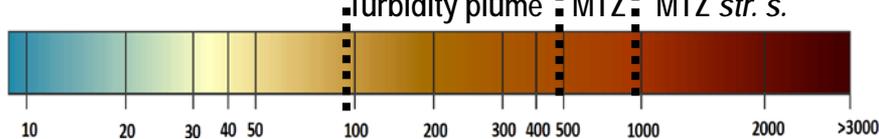
4. Spring tide, **outflow = 2400 m³ s⁻¹**



Highest turbid areas on shallow depths...



SPM concentrations (mg/L)



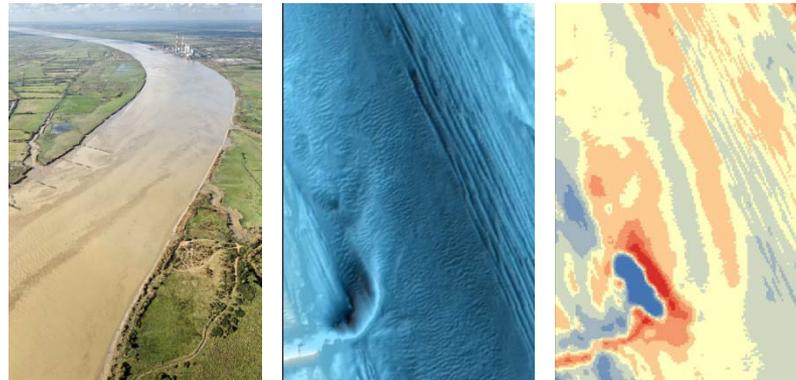
Turbidity plume ■ MTZ ■ MTZ str. s.

● SYVEL stations □ Mud banks

- good corelation between in-situ vs satellite-derived SPM concentration
- turbidity Plume on 2 scenes
- effects of shallow depths to determine

- expand our knowledge of marine floods dynamics
- adjustments of algorithms (MTZ)
- a contribution to inter-estuaries comparison

Merci de votre attention



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