ASSESSING THE SPATIAL AND TEMPORAL DYNAMICS OF SUSPENDED PARTICLES IN THE RHÔNE RIVER PLUME BASED ON HIGH RESOLUTION OCEAN COLOUR SATELLITE DATA

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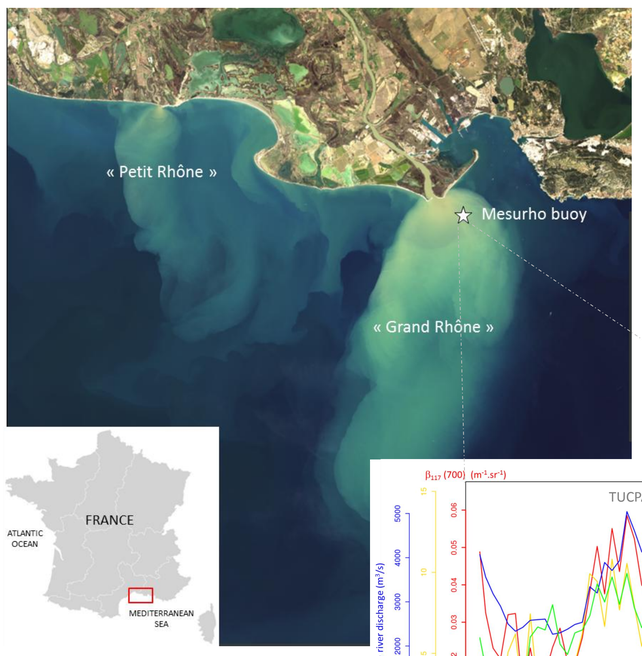
River plumes are associated to complex and highly dynamic physical and chemical processes, making them difficult to study based on scarce field observations. However, the recent capabilities improvement of **ocean colour satellite sensors** have made of them an efficient way to assess and monitor river plume dynamics. The prime objectives of this study are to i) test and compare the capabilities in terms of **spectral**, **spatial** and **temporal resolution** of three complementary satellite sensors **L8/OLI, AQUA/TERRA/MODIS** and **MSG-3/ SEVIRI**, for the mapping of **suspended particulate matter (SPM)** in the **moderately turbid waters of the Rhône River plume**, and ii) describe the **dynamics** of SPM in the Rhône River plume using these **high spatial and temporal data**.

STUDY AREA : RHONE RIVER PLUME AND DATASET:



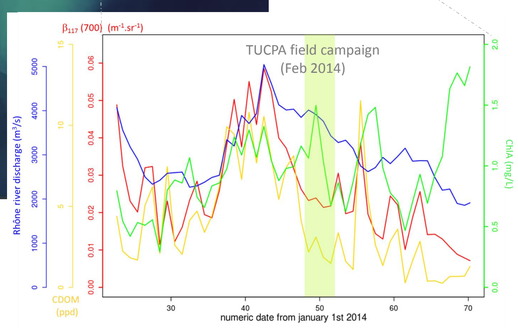


Figure 1. (left) RGB OLI/Landsat-8 image of the Rhône river plume (23/02/2014 - LC81960302014054). (right) Wetlabs ECO-BB2FL probe measurements and Rhône river discharge from 22 of January to 11 of March 2014

In-situ dataset:

Campaign	dates	Measured Parameters	Statut
TUCPA	17 to 20/02/2014	Trios Rrs; SPM; Chl a, Turbidity	Used
Rhône river Campaigns	2010, 2011, 2015	Trios Rrs; SPM; Chl a Turbidity	To be added
Mesurho Buoy BB2FL probe	22/01 to 11/03/2014	Bbp; Chl a fluorescence; CDOM fluorescence	To be calibrated

Remote sensing dataset:

Sensors	OLI/ Landsat-8	MODIS/ AQUA & TERRA	SEVIRI/ MSG-3
Spectral bands for [SPM] inversion	560 nm 655 nm 864 nm	555 nm 645 nm 859 nm	635 nm
Spatial Resolution	30 m	1km; 500 m; 250m	3x5 km (~43°N)
Temporal resolution	16 days	1 day (each)	15 min
Atm correction	SWIR [1]	MUMM [2]	NIR [3]

[1] Vanhellemont et al., 2014; [2] Ruddick et al. 2000; [3] Wang and shi, 2009

Rrs vs SPM RELATIONSHIP:

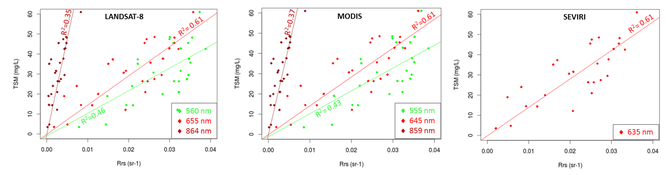


Figure 2. Test of satellite sensor Green, red and NIR spectral bands for inversion of Rrs in SPM concentration

Best relationship => linear relation using sensor red bands:

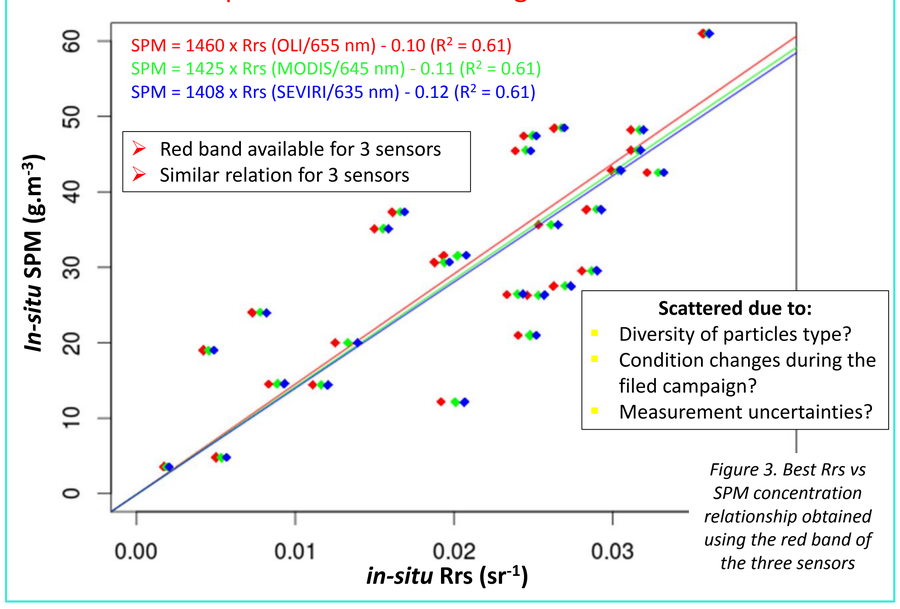
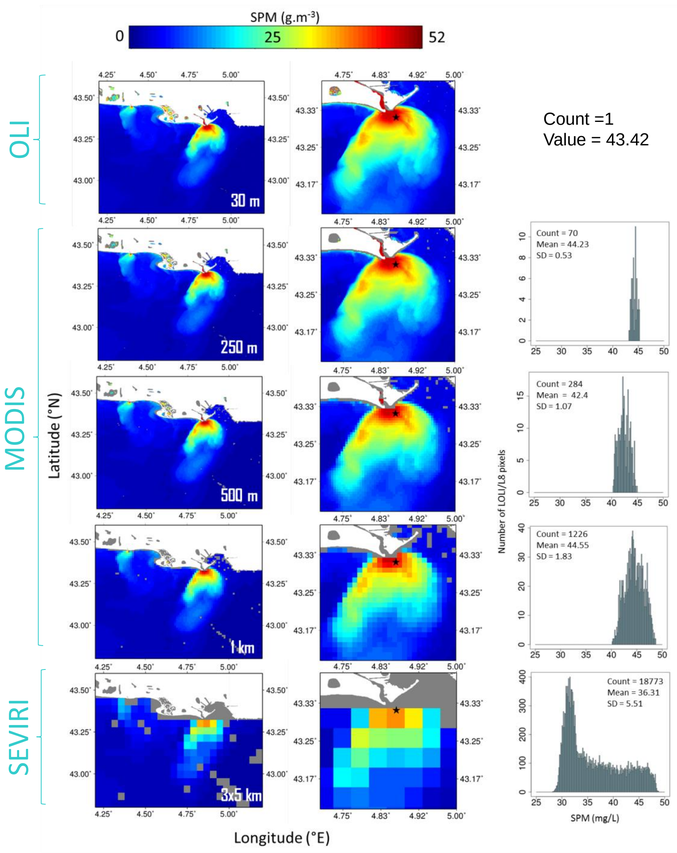


Figure 3. Best Rrs vs SPM concentration relationship obtained using the red band of the three sensors

IMPACT OF SPATIAL RESOLUTION:



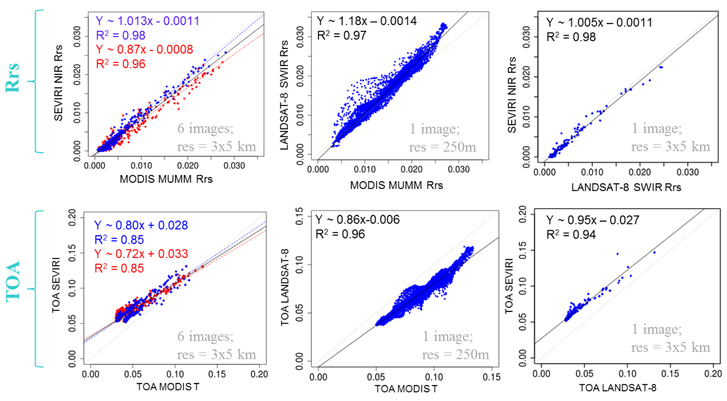
- **Well reproduce plume shape and small scale features (front contours, inhomogeneities, etc…)**
- Gaussian distribution of OLI pixels into coarser pixels
- Close mean values ranging from 42 to 44 g.m-3
- **~5 g.m-3 of variability in 1 km square in river mouth**

- **Globally reproduce plume shape**
- Small scale features are lost and replaced by coarse pixel boundaries.
- Large distribution of OLI pixel SPM values [30-50]g.m^{-3} into SEVIRI pixel.
- **Two parts distribution:**
  - high SPM concentration of the river mouth
  - lower SPM concentration at greater distances

= > **Lower mean value (36 g.m^{-3})**

Figure 4. (left) OLI image (30m of spatial resolution) degraded in in coarser grid corresponding to MODIS 250 m, 500 m and 1 km and SEVIRI 3x5 km spatial resolution. (right) Distribution of OLI pixels (30m) into one lower resolution pixel (indicated with black stars on left panel)

COMPARISON BETWEEN SENSORS:



- Not yet well understood
- Differences due to differences in calibration, sensibility, thickness of crossing atmosphere, viewing angles, etc…?

- **Differences between sensors < 20%**

Figure 7. Comparison between water-leaving Rrs (top) and top of atmosphere reflectance(TOA) obtained with the 3 sensors.

COMPARISON WITH IN-SITU DATA:

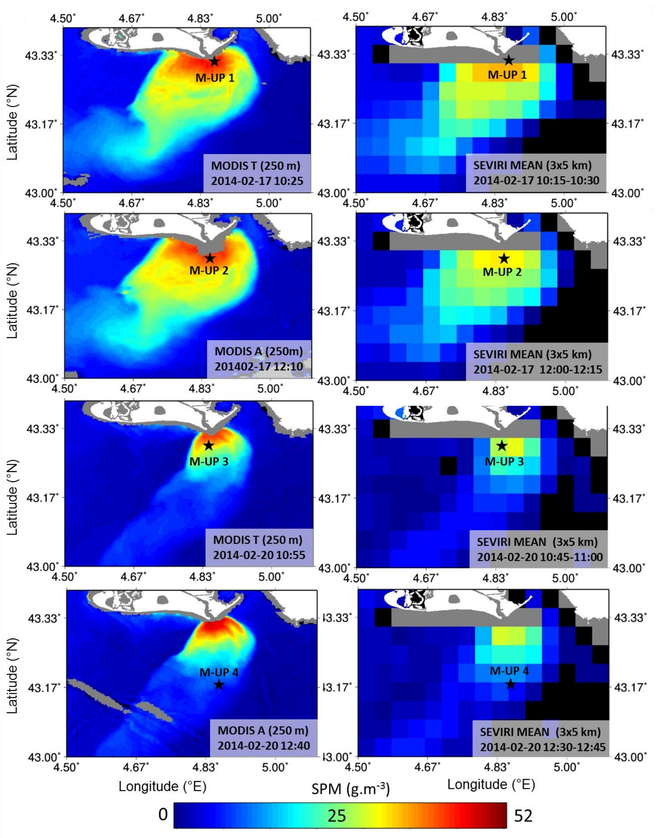


Figure 5. MODIS (left) and SEVIRI (right) images acquired during match-up with TUCPA station. Locations of TUCPA station are indicated with black stars

- MODIS Rrs/SPM concentration well consistent with in-situ SPM
- SEVIRI Rrs/SPM underestimate SPM concentration of ~20%

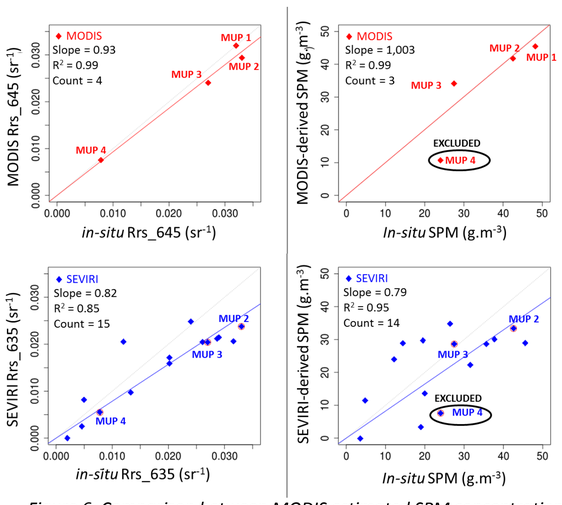
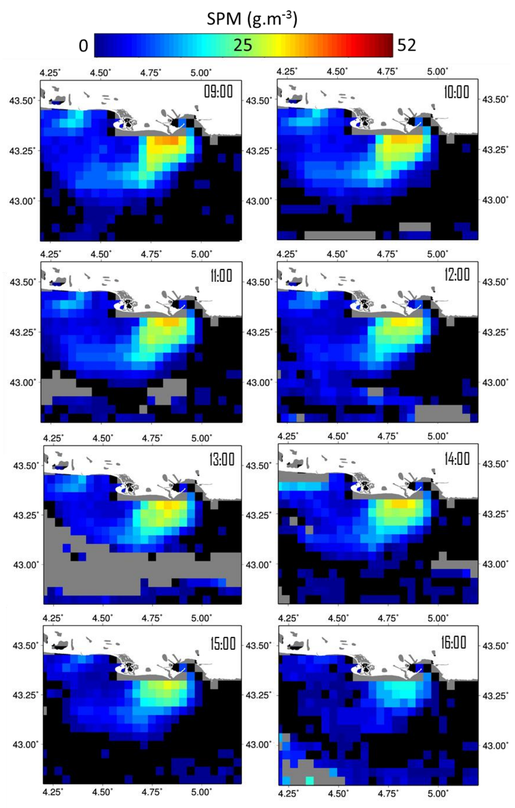


Figure 6. Comparison between MODIS estimated SPM concentration (top, red points) and SEVIRI estimated SPM concentration (bottom, blue points) with in-situ measured SPM concentration

MUP 4:
Turbidity ~ 5 NTU
In-situ [SPM] = 24 g.m^{-3}
Sensors [SPM] ~ 6-10 g.m^{-3}

=> Error in in-situ SPM concentration measurement

DYNAMIC OF THE RHONE RIVER PLUME:



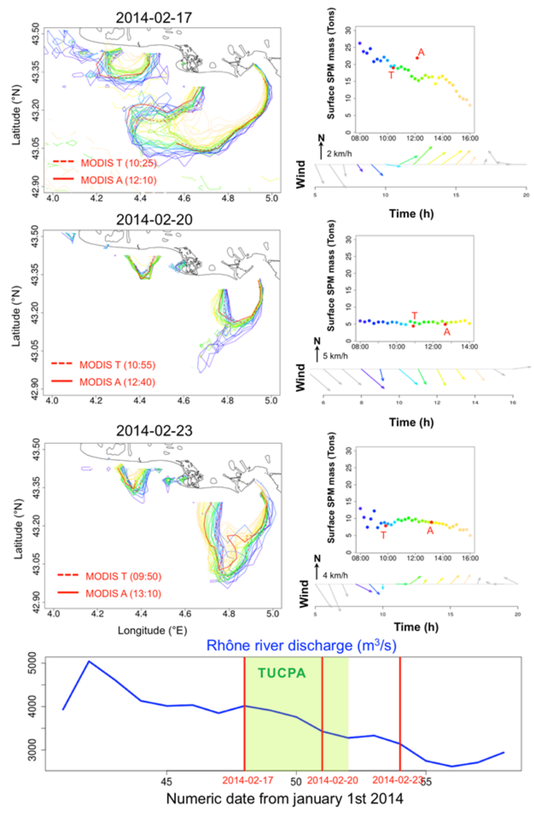


Figure 8. Rhône river plume shape and SPM concentration evolution as seen by SEVIRI during the 17 of February 2014 .

Figure 9. (top left) Plume contour at 10g.m-3 obtained with SEVIRI (from blue to orange lines) and MODIS A and T (red lines) for the 3 clear sky day of the TUCPA campaign.(top right) Evolution of the SPM mass during the day, and wind speed and direction (arrows). (bottom) Rhône river discharge during the studied period.

- Non negligible daily variations in plume shape and SPM concentration
- Plume extent and SPM concentration seem to diminish with the end of the day (?).

- Large variation of plume shape and extent during a week.
- Under NW wind => thin plume pushed offshore.
- Under offshore wind => Larger plume folded down toward the coast.

- **OLI and MODIS well reproduce the SPM concentration and plume shape at all scales** but their temporal resolution (1 day, 16 days) is limited to study short-term event.

- SEVIRI globally reproduce the plume shape but small scale features are lost and it tends to slightly underestimate the SPM concentration. However, its high temporal resolution (15min) makes of it a **powerful tool for the study of the daily and weekly dynamics of the Rhône River plume.**