Exploring the capabilities of Landsat8-OLI and Sentinel2-MSI satellite data to remotely sense the size distribution and composition of suspended particles in river plumes.

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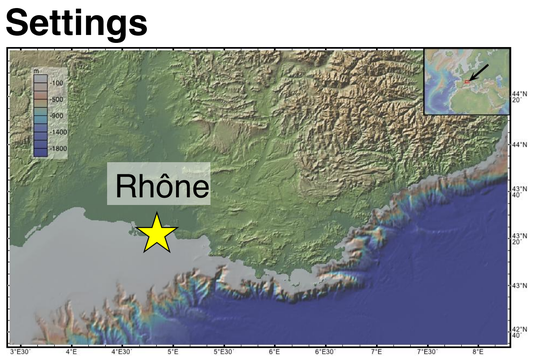
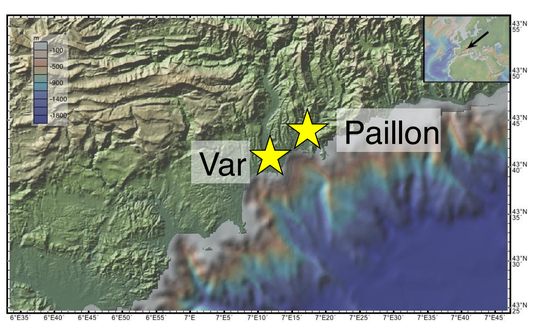
1 Objectives and methods

Ocean colour science have recently benefited from high spatial resolution satellite data from OLI-L8, MSI-S2, allowing the monitoring of fine coastal processes.
We present results from three river plumes draining geologically contrasted watersheds in NW Mediterranean Sea: the Rhône, Var and Paillon.
We conducted field measurements of turbidity (FNU), remote-sensing reflectance (Rrs, sr^{-1}), inherent optical properties (IOPs), and particle size distribution (PSD) that we compared to high resolution (L8, S2) satellite data.

The aim of this study is :
1 – To establish regional relationship between IOPs and Rrs.
3 – To explain the differences observed in IOPs for the three rivers with PSD
4 – To implement algorithms such as QAA in order to retrieve IOPs and PSD from satellite data and especially high resolution data from OLI-L8 and MSI-S2.

2 Settings





Our study mainly focuses on three different river plumes located in Southern France (c.f. figure 1). These rivers drain contrasted watershed in terms of areas, geological units, and elevation.

Rhône :
Watershed area : 95 590 km^2 Length : 784 km Elevation : from 4498 to 0 m
Yearly averaged discharge: 554 m^3/s Pluvial regime

Var :
WA : 2 819 km^2 L : 113 km E : from 1790 to 0 m
YA discharge : 50 m^3/s Nivo-pluvial regime

Paillon :
WA : 95 km^2 L : 36 km E : from 1300 to 0 m
YA discharge : Unknown Nivo-pluvial regime

Figure 1. Geographical locations of the three river plumes of the Rhône, Var, and Paillon in Southern France.

3 Spectral signatures of three river plumes

3.1 Suspended Particulate Matter (SPM) concentration calculation from Rrs

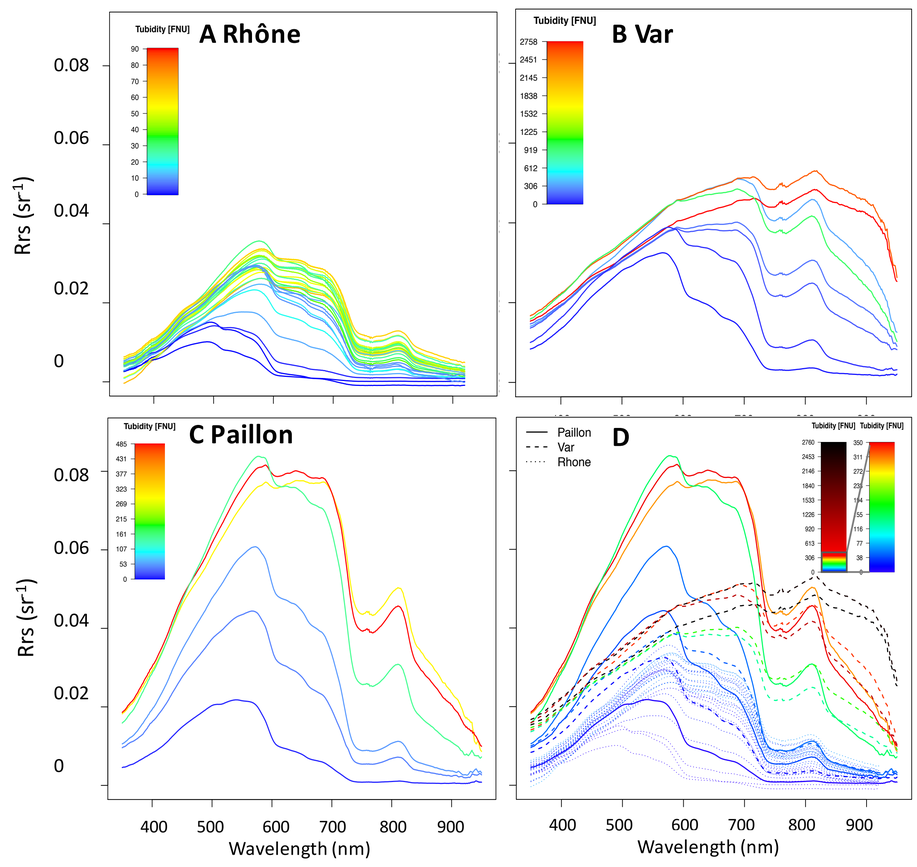


Figure 2. Hyperspectral in situ Rrs measured on the three river plumes. Paillon plume displays very high reflectences in visible spectrum region (for a, b, c, color scale is relative to local maximum while for d it is merged in a common scale).

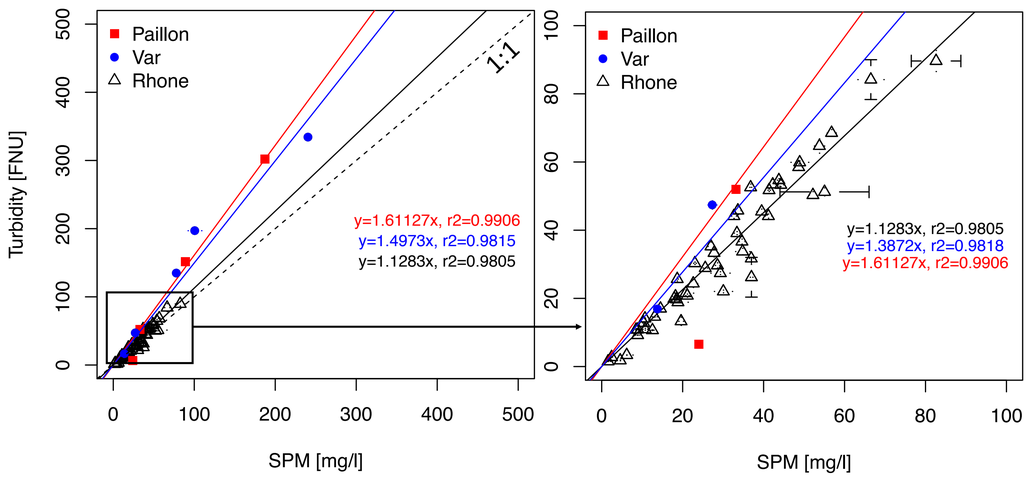


Figure 3. Turbidity vs SPM for Rhone, Var and Paillon river plumes. Robust linear relationships can be established for each river, nevertheless higher slopes for Paillon and Var river demonstrate higher lateral scattering coefficients for these rivers particles.

$SPM = A^{\rho} \cdot \rho_w/(1-\rho_w/C^{\rho})$ *(Nechad et al., 2010)*

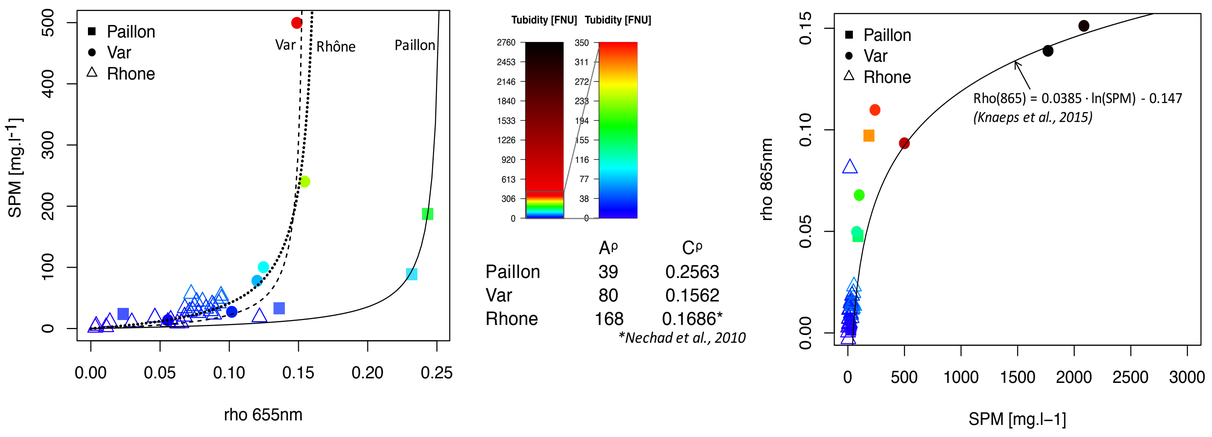
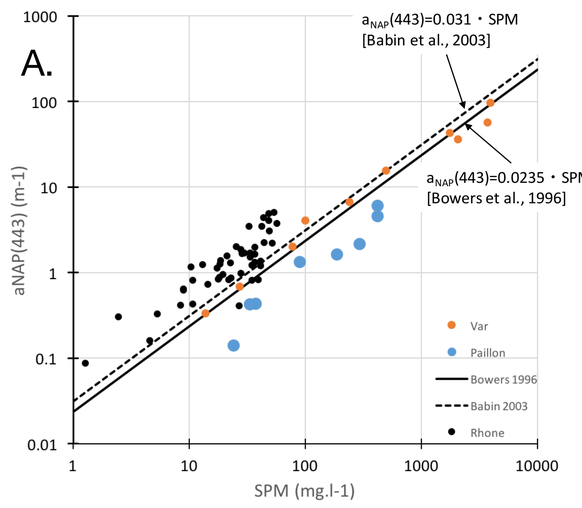
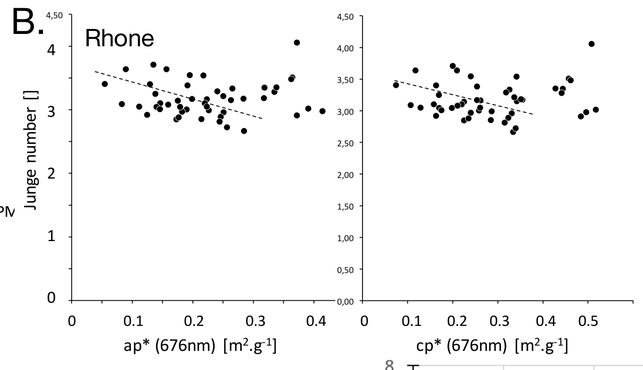


Figure 4. Saturation of water reflectance rho (rho = π • Rrs) with SPM (left) is higher for Paillon than Var and Rhone. Following Nechad et al., 2010, it provides informations concerning a_p and b_{bp}. On the contrary, 865 nm reflectances still display sensitive variations with SPM, which follows Knaps et al.,2015 empirical relationship (right) and that can be used to derive SPM.

3.2 Inherent optical properties (IOP) and PSD





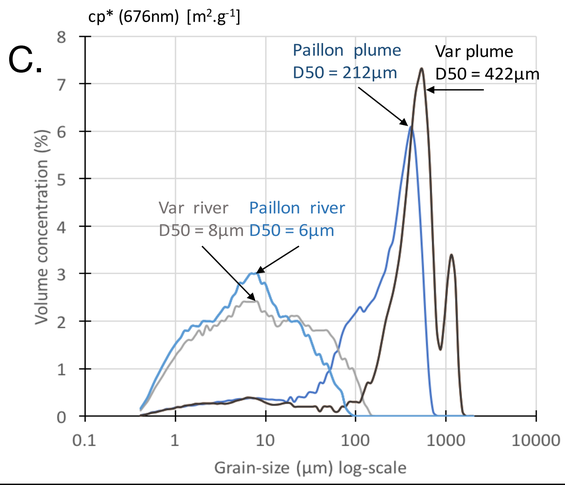


Figure 5. Relationship of absorption coefficients of Non-Algal Particles (aNAP) at 443 nm with SPM demonstrate that Rhône particules have slightly higher absorptions than Var and Paillon, but all remain comparable to published values (A.) Specific absorptions ap and attenuations cp* of Rhône particles are correlated with PSD (represented by Junge number) and contain PSD informations (B.) PSD from river to plume are clearly affected by floculation effect that might change water reflectances pattern in the plumes (C.).*

4 Deriving particles properties from high resolution satellite data

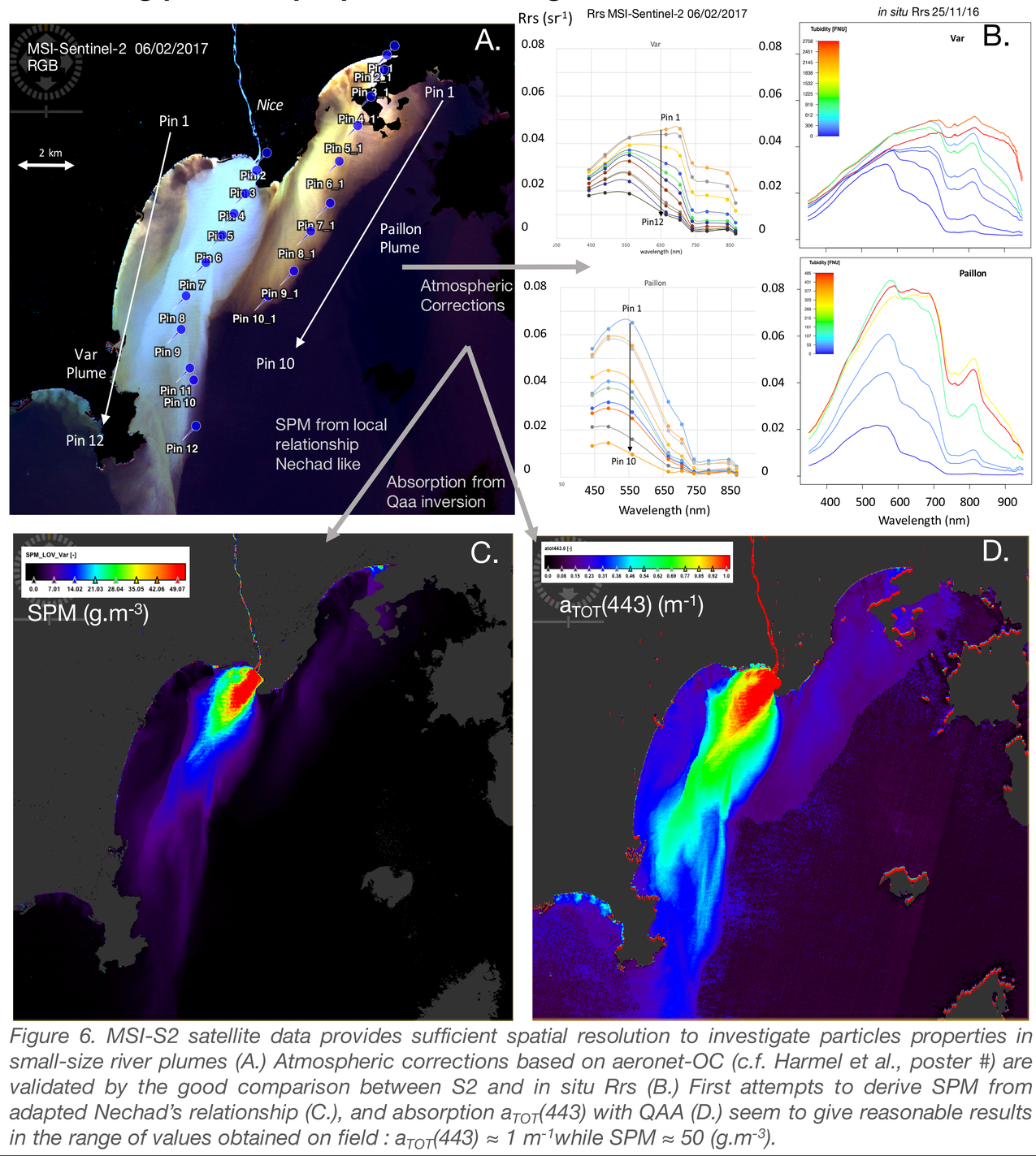


Figure 6. MSI-S2 satellite data provides sufficient spatial resolution to investigate particles properties in small-size river plumes (A.) Atmospheric corrections based on aeronet-OC (c.f. Harmel et al., poster #) are validated by the good comparison between S2 and in situ Rrs (B.) First attempts to derive SPM from adapted Nechad's relationship (C.), and absorption $a_{TOT}(443)$ with QAA (D.) seem to give reasonable results in the range of values obtained on field : $a_{TOT}(443) \approx 1\ m^{-1}$ while SPM ≈ 50 ($g.m^{-3}$).

5 Conclusion

At this stage of the study, results demonstrate that river plume particles display sensitively different IOPs and PSD, which will later be correlated to water reflectances by modelling.
1 – To explain the very different patterns of the three river plumes Rrs and their saturation, we suspect the combined effect of finer median and flocs size in Paillon plume than in Var plume (D50 of 212µm against 422µm), and higher content in smectite (clays) and carbonates that might significantly impact the optical properties of particles (mass-specific back-scattering coefficient) in the Paillon.
2 – *in situ* Rrs compare very well with MSI-S2 data when applying atmospheric corrections developed at LOV, which shows the ability of L8 and S2 to document river plumes of limited areas.
Further work:
1 – modelling of Rrs with Hydrolight from measured IOPs will be attempted to reproduce Rrs in plumes.
2 – implemented version of QAA incorporating all L8 and S2 spectral bands and IOPs measured on field will be tested on all L8 and S2 available.

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