# Suspended Particulate Matter dynamics in the surface waters of the Gironde plume

Sorin Constantin[a], David Doxaran[a], Anna Derkacheva[a], Stefani Novoa[a], Héloïse Lavigne[b], Quinten Vanhellemont[b]

[a] Laboratoire d'Océanographie de Villefranche UMR7093 CNRS/UPMC (France) (*sorin@obs-vlfr.fr*), [b] Royal Belgian Institute for Natural Sciences (Belgium)

## Introduction

**Introduction**

The Gironde Estuary, one of the largest in Europe, represents an important source of sediments for the outer coastal area, namely the continental shelf of the Bay of Biscaye. The massive solid discharge (estimated at around 2.3 million tons per year) helps the formation of an extensive Suspended Sediment Matter (SPM) plume at the estuary mouth. The dynamics of this plume are influenced by multiple factors, such as the rivers (Garonne and Dordogne) discharge rate, tidal currents and wind stress. In-situ measurements are an important source of information for monitoring the SPM evolution in specific locations, but, apart from the significant costs implied, it cannot give an overall synoptic view over the entire area. Remote sensing data is one alternative that can complement the in-situ sampling efforts. Multiple types on satellite information need to be considered, covering a diverse range in terms of spatial, temporal and spectral resolutions.

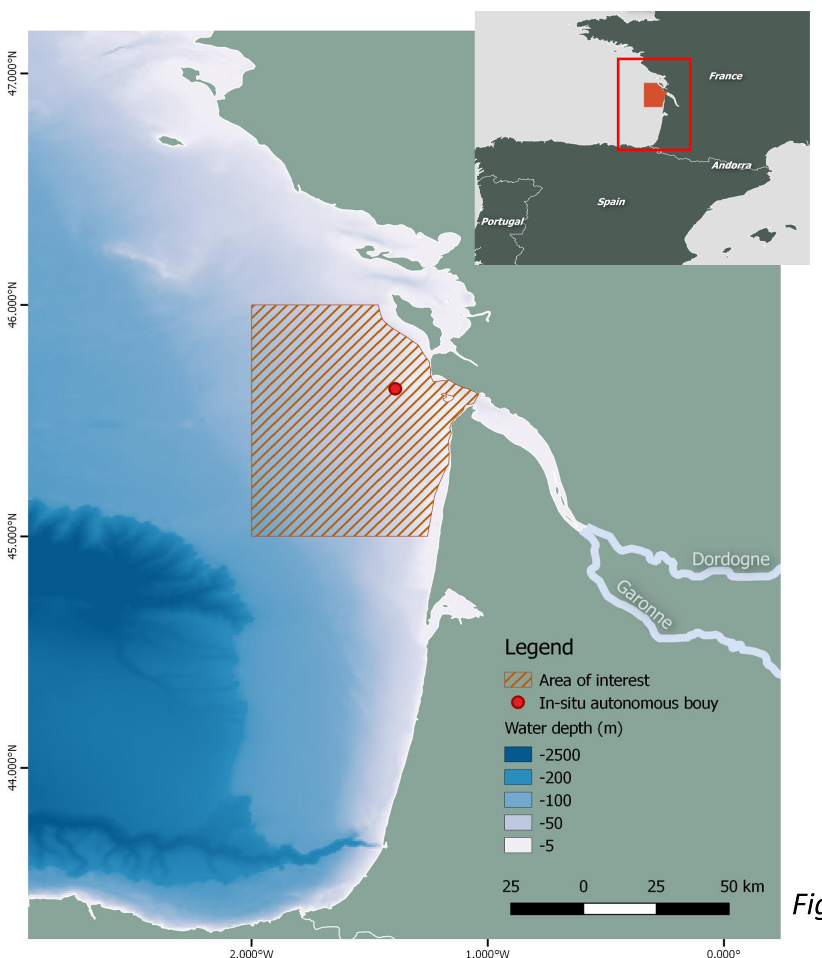


*Figure 1 – Area of interest location*

**Objectives**

The main objectives of this study are:

- To analyze Gironde SPM plume dynamics in correlation with various forcing factors
- To test the capability of different satellite sensors to capture such dynamics and compare with in-situ capabilities

## Data & Methods

- 3 years of MODIS Aqua & Terra data (605 usable images) - processed using SeaDAS
- Multiple SEVIRI-MSG products - processed using in-house developed algorithms
- 4 months of continuous (every 15 min) autonomous in-situ turbidity measurements

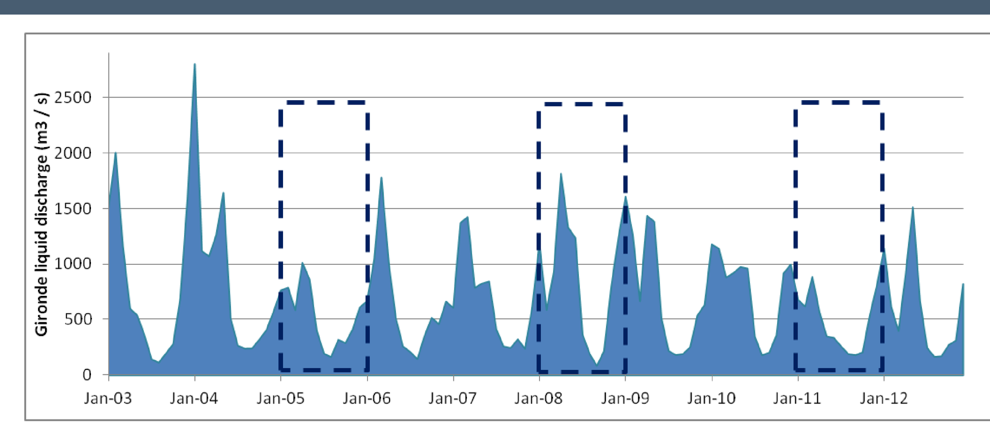


*Figure 2 - Selected years (2005, 2008 and 2011) for MODIS –based analysis and Gironde river discharge rates*

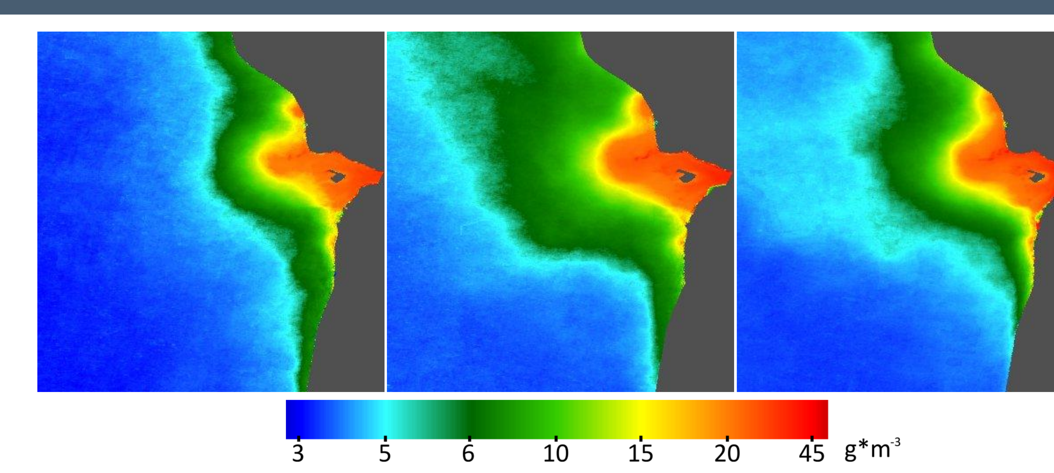


*Figure 3 – Annual SPM averages estimated using MODIS data*

## Results & Discussion

### SPM plume dynamics determined by river discharge rates

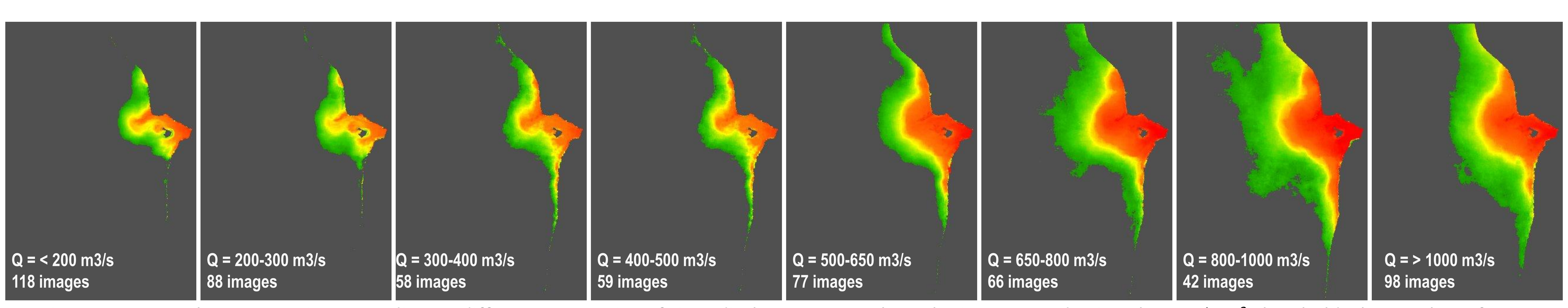


*Figure 4 – SPM plume extension according to different categories of river discharge rates; plume limit computed using the 8 g * m⁻³ threshold; the number of MODIS images used to compute each category average is displayed on the figures*

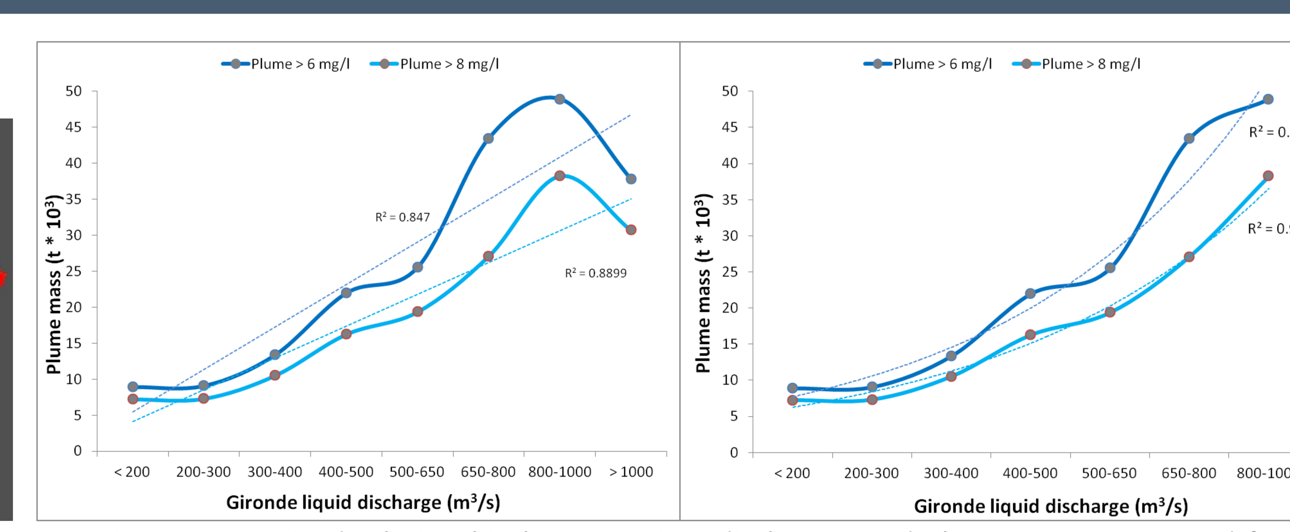


*Figure 5 – Derived relationship between river discharge and plume mass, computed for the surface 1 m of water column (based on the assumption that SPM distribution is homogenous in this thin layer)*

### SPM plume dynamics determined by tide ranges, tide water level and river discharge rates

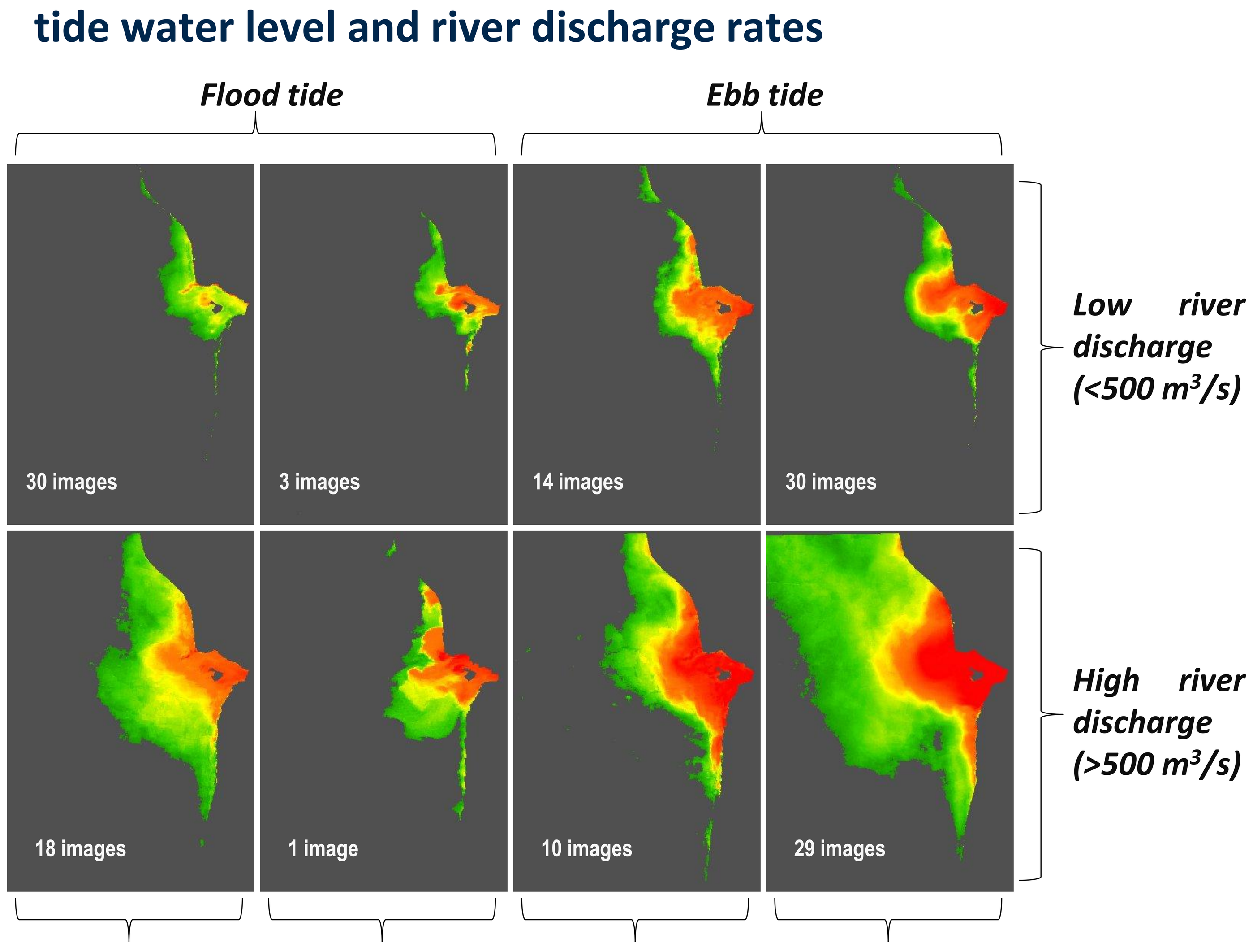


*Figure 6 – Average maps of SPM distribution according to multiple environmental conditions; during ebb tide moments, with high river discharge rates and high tidal range, the extension of the SPM plume is maximum; plume limit computed using the 8 g * m⁻³ threshold; the number of MODIS images used to compute each category average is displayed on the figures*

### Daily SPM dynamics analysis based on in-situ data and geostationary remote sensing observations

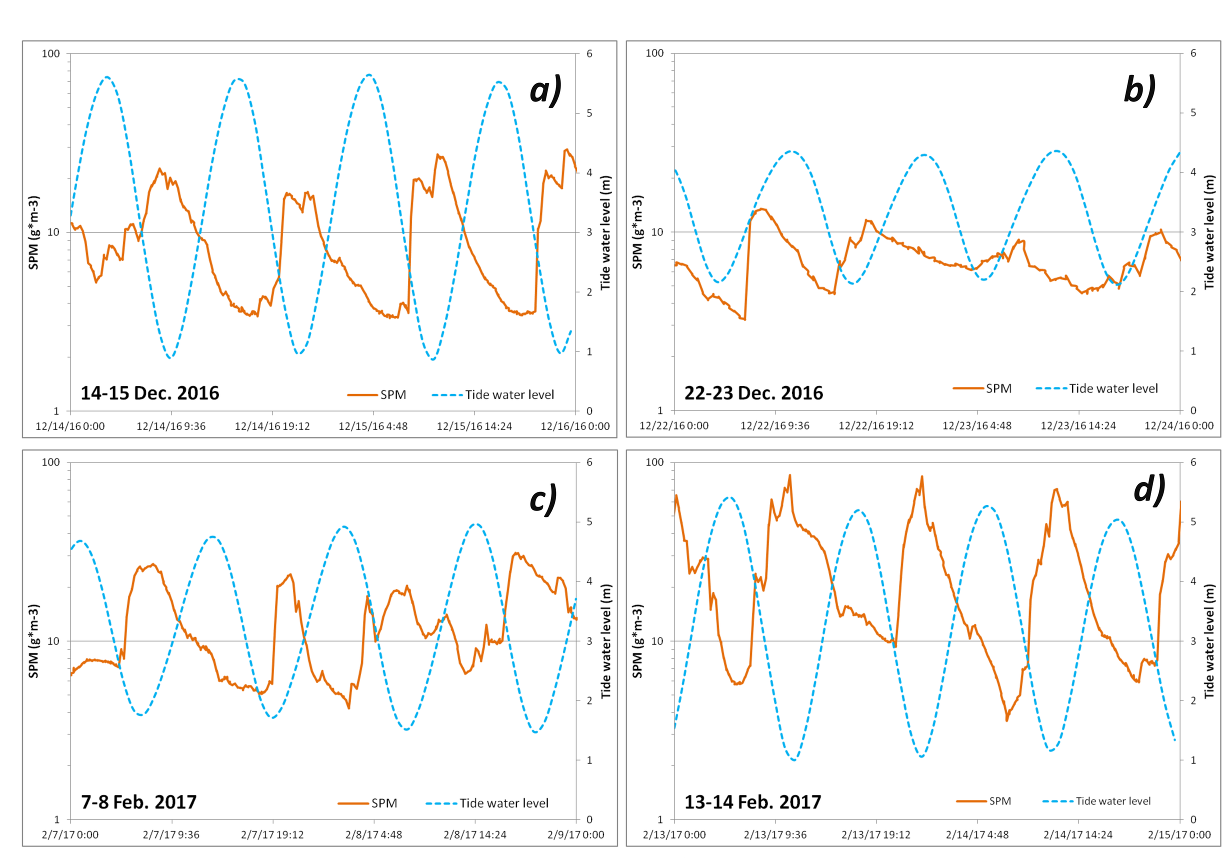


*Figure 7 – In-situ determinations of SPM variations plotted against tide water level fluctuations, for different scenarios:*

*a) High tidal range and low river discharge; patterns of sediment sinking is well visible during the minimum water levels (ebb), due to the water currents intensity decrease*

*b) Low tidal range and low river discharge; SPM variations are less dependant on the usual governing factors*

*c) Medium tidal range and high river discharge; although the sediment supply inside the estuary is higher then in case a), the SPM variations are similar, due to the fact that tides play a more important role in such dynamics*

*d) High tidal range and high river discharge; maximum values of SPM are reached during such periods (up to 80 – 90 g * m⁻³, in this case)*

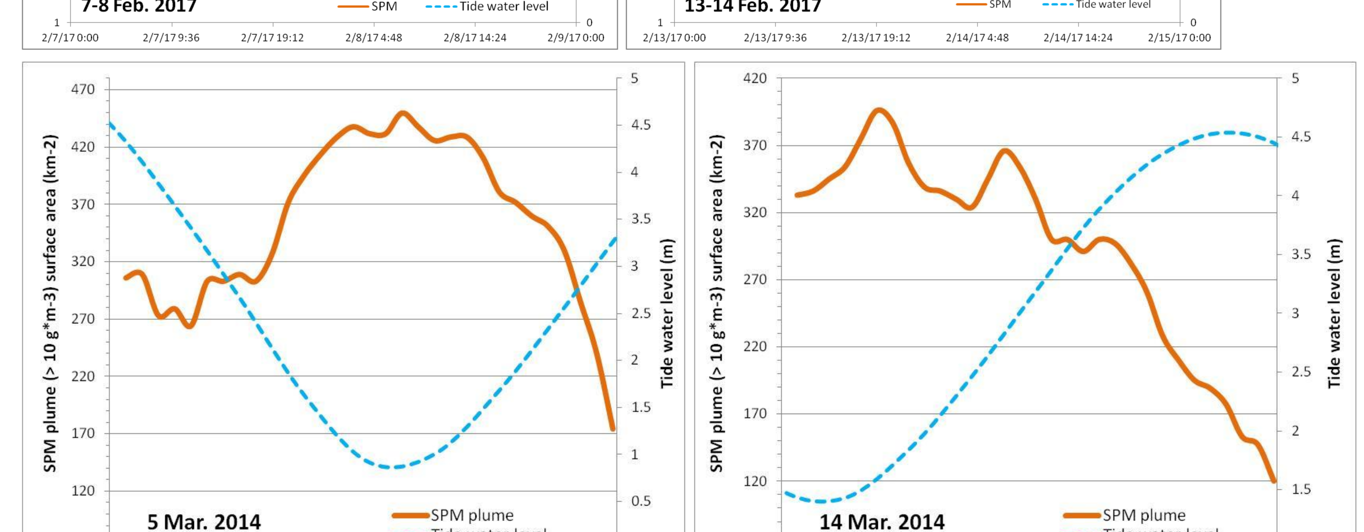


*Figure 8 – SPM dynamics observed using the SEVIRI sensor; the capabilities offered by these datasets make geostationary satellites a most valuable tool for analysis of the coastal areas; same patterns can be observed as using the in-situ measurements; nonetheless, the sensitivity of the sensor makes it more useful during conditions of high SPM concentrations*

## Conclusions

Satellite information can be successfully used to monitor, at different time scales, the coastal areas, even when the observed phenomena has a significant temporal and spatial dynamic. MODIS archive was intensively used for such studies and the new and upcoming similar sensors, with improved capabilities (such as Sentinel-3), opens new opportunities for future applications. Geostationary satellites, even though less used up to this point for marine applications, can provide most valuable information at frequencies comparable to in-situ autonomous stations. Future technical improvements (in terms of spatial, spectral and radiometric resolution of the delivered products) could make geostationary data more adapted to ocean colour studies. The above results show that current available remote sensing products can be successfully used to study river plumes and other similar areas, if proper data is selected and if its limitations and advantages are properly addressed.

## Acknowledgements

This work was funded by the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no. 606797 (HIGHROC project, www.highroc.eu).

In-situ data collected with the help of L'Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER) and the Port de Bordeaux. Participation to IOCS 2017 kindly supported through a scholarship by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT ) and The International Ocean-Colour Coordinating Group (IOCCG).