

HICO Data User's Proposal

Monitoring highly turbid waters using HICO: La Plata and Le Gironde estuaries

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Abstract

La Plata is a shallow (<20 m) and large-scale estuary which drains the second largest basin in South America. Very high values of total suspended matter (TSM) have been reported in this region, with mean values ranging from 100 to 300 mg l⁻¹ and extreme concentrations up to 400 mg l⁻¹. The Gironde Estuary, located in southwest France, is one of the largest estuaries of the European Atlantic coast. It presents a well developed turbidity maximum and mean TSM concentrations vary from 150 to approximately 3000 mg l⁻¹ in surface waters of the estuary. Recently the project team started the SeaSWIR project (BELSPO, 2012-2013). In this project in situ measurements have been collected and analyzed including water reflectance, IOPs and constituent concentrations in the Scheldt, Gironde and La Plata rivers. The focus of the SeaSWIR project is to look into the variability of the water reflectance in the SWIR by performing in situ measurements, simulations, image analysis and providing a theoretical basis. As a continuation of this project, a systematic sampling has been started and in situ measurements of radiometry and in-water constituents being sampling (monthly sampling) in La Plata estuary, while in the Gironde estuary, as part of the SOGIR long-term observation program, physical, biogeochemical and optical properties are monthly monitored in four fixed locations covering the whole estuary from its mouth to its upstream limit. HICO could significantly help in the interpretation of SeaSWIR results and following work because of its high spatial and spectral resolution. It will provide insight into the spatial variability of the suspended sediment within one MODIS pixels and will provide additional information on the spectral variability of the signal in the VNIR spectral region.

Statement of work/Project description

The main goal of the present project is to derive total suspended matter (TSM) concentration maps in two highly turbid estuaries (La Plata and Gironde) from HICO images with high spatial resolution. Standard and alternative atmospheric correction algorithms will be tested using simultaneous field radiometric measurements and HICO images.

Work plan for La Plata and Gironde study sites:

- Field measurements will be collected and special effort will be made to match with HICO acquisition date and time.
- HICO water leaving reflectances will be compared with in situ derived water reflectance. And different atmospheric correction algorithms will be tested.
- A comparison will be done of different existing general and regional algorithms which have been used to map the concentrations of total suspended matter in the Rio de la Plata and Le Gironde using ocean color remote sensing data.
- The best performing algorithm will be applied to MODIS and HICO and results will be compared taking into account the different image acquisition times.
- Analysis of MODIS intra-pixel variability will be assessed.

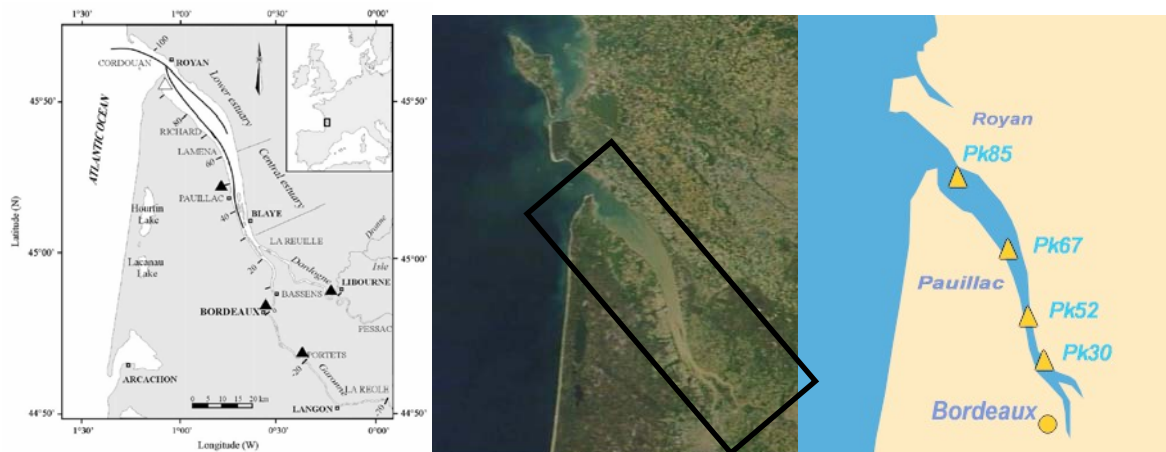
Most of the existing TSM algorithms need first the accurate retrieval of water-leaving reflectance which depends on the good performance of atmospheric corrections. Highly turbid waters, such as the La Plata and Gironde estuaries, represent a challenge to cloud masking and atmospheric correction algorithms which usually rely on the assumption of zero water leaving reflectance in the NIR or SWIR part of the spectrum (black pixel assumption). Previous work in La Plata (Dogliotti et al. 2011b) showed that the standard NIR atmospheric correction completely fails in retrieving water reflectance mainly due to sensor saturation. The standard SWIR approach (which calculates the aerosol model in a pixel-by-pixel basis) clearly showed better results, but still some over-estimation

of aerosol reflectance in the most turbid part of the estuary, leading to an underestimation of water reflectance indicating that the black pixel assumption in the 1,240 nm SWIR band also fails in these extremely turbid waters. Finally, it was shown that the atmospheric correction can be improved in the most turbid region of the estuary using a spatially constant aerosol model determined from clear waters using MODIS-Aqua SWIR bands. To overcome the problems with the atmospheric correction in these turbid waters, an alternative Turbidity/TSM algorithm has been proposed (Dogliotti et al. 2011a). This algorithm is based on the difference between two bands in the NIR and SWIR and the one-band algorithm developed by Nechad et al. (2009, 2010). The use of a Rayleigh-corrected band difference algorithm avoids the challenging task of performing the aerosol correction in highly turbid waters, like La Plata. The model was calibrated using data from the Southern North Sea and tested using MODIS-Aqua Rayleigh-corrected reflectance in La Plata River showing a good performance. In turn, a very large bio-optical database exists for the Gironde estuary (Doxaran et al. 2002a, 2002b, 2006, 2009). An algorithm has been developed for this area to quantify TSM within surface waters from ocean color satellite data (Doxaran *et al.*, 2002a, 2003) and a validation of remote sensing data and the long-term field measurements was carried out in the Gironde (Doxaran et al. 2003). More recently, MODIS satellite data were proved to be operational to quantify TSM concentrations in turbid sediment-dominated surface waters (Doxaran et al. 2009). In the Gironde estuary, TSM concentrations were retrieved with uncertainties of 22 and 18% from MODIS Aqua and MODIS Terra data, respectively, when applying the algorithm developed by Doxaran et al. (2002a). Calibrated top-of-atmosphere and surface reflectance HICO images are requested for research purpose only over the La Plata and Gironde regions where in situ measurements will be performed.

Río de La Plata (Argentina) – Palermo Fishermen Club Pier (-34.34° S /-58.24° W)



Le Gironde (France) – Area: 45°45' - 44°50' N / 1° 30' W - 0°



Biographical sketch and available facilities

The Institute of Astronomy and Space Physics (IAFE) is a research institute that belongs to the National Research Council for Science and Technology and the University of Buenos Aires (UBA), Argentina. IAFE's Marine Remote Sensing (MARS) team comprises a multi-disciplinary group of scientists with expertise in remote-sensing, physics and biology. Its activities involve the processing and analysis of satellite observations from sensors onboard of satellites which sense electromagnetic energy in the visible and near infrared (SeaWiFS, MODIS, MERIS, Landsat-TM/ETM), thermal infrared (NOAA/AVHRR, MODIS) and microwaves (ERS-SAR, ENVISAT-ASAR) part of the spectrum. The main research activities of the group focus on the characterization of different oceanic and coastal environments of the Argentine Sea using remotely sensed data, including the analysis of spatio-temporal variability of satellite-derived products and the development of methodologies for the identification of thermal fronts and analysis of their spatio-temporal variability. Also MARS team has been working on the validation of satellite-derived products using field data (radiometric and bio-optical data) and the development of bio-optical algorithms in order to improve the retrieval of optically active components of the water column (like chlorophyll and total suspended matter concentration) in the Argentinean Continental shelf and shelf-break regions. MARS is actively involved as part of the Scientific Team of the Argentine-Brazilian future ocean colour satellite SABIA/MAR mission and is planning to install an AERONET-OC site, which has a CIMEL instrument with a 1020 nm band, in the La Plata river for the validation activities related to SABIA/MAR sensor and for other current and future ocean colour sensors like MODIS, MERIS, OLCI, VIIRS, etc.

The Marine Optics and Remote Sensing Lab (OMT Group) is an interdisciplinary group studying the interaction of solar energy with the ocean. One of the specific activity concerns the study of solid fluxes (suspended sediments, particulate organic carbon) in coastal waters directly influenced by river inputs. The speciality of our Lab is to characterize the inherent and apparent optical properties of waters in relation with the concentration, composition and size distribution of particles in suspension in the water. Based on field measurements, laboratory experiments and theoretical simulations we develop relationships and algorithms to retrieve the concentration of suspended solids in coastal waters from field optical measurements recorded onboard research vessels and by autonomous bio-optical floats and from ocean colour satellite data (SPOT, Landsat, MERIS and MODIS). The Lab owns a wide set of optical sensors to measure in the field and/or in laboratory the inherent and apparent optical properties of coastal waters.

Existing collaboration with MUMM (Management Unit of the North Sea Mathematical Models) and VITO (Flemish Institute for Technological Research) will contribute to the success of this proposal. MUMM's REMSEM (Remote Sensing and Ecosystem Modelling) team has been working since 1997 on developing, improving and validating products such as Total Suspended Matter and Chlorophyll a concentration from sensors such as SeaWiFS, MODIS and MERIS, and atmospheric correction algorithms, especially for turbid waters. VITO/TAP (Remote Sensing Department) has more than 8 years of expertise in the atmospheric correction above water including the correction of adjacency effects, water quality retrieval algorithms for inland and coastal waters and bottom effects.

Available facilities

In situ measurements will be made at La Plata and Le Gironde with special attention for a sound and robust protocol.

Río de La Plata

Monthly sampling from the Palermo Fishermen Club Pier will be made. The water reflectance will be measured above water with an ASD FieldSpec FR spectrometer provided by the Argentine Space Agency – CONAE. The ASD spectrometer measures the reflected light in the Visible/Near Infrared (VNIR, 350- 1050 nm) and the Short-Wave Infrared (SWIR, 900 – 2500 nm) portion of the spectrum. Turbidity will be measured with a portable HACH 2100P ISO turbidimeter (IAFE). The instrument records turbidity between 0 and 1000 FNU, with a resolution of 0.01 FNU. Upon availability of funding total suspended matter and chlorophyll-*a* concentrations will be determined at the Limnology Laboratory at the University of Buenos Aires. These measurements are part of the activities planned within the framework of the existing cooperation agreement between IAFE (Ana Dogliotti) and CONAE.

Le Gironde:

The measured biogeochemical variables at four fixed locations include the concentrations of total suspended matter, particulate organic carbon, dissolved organic carbon and chlorophyll-*a*. The measured optical properties include the hyperspectral seawater reflectance and water turbidity. These monthly sampling are part of the SOGIR long-term observation program: <http://archimer.ifremer.fr/doc/00062/17292/14805.pdf>. The University Bordeaux 1 (UMR-EPOC laboratory) is responsible of this program. David Doxaran (LOV) has access to this dataset and has the opportunity to participate to the field campaigns for measuring additional bio-optical parameters. In addition, the estuary is equipped since 2005 with autonomous field platform measuring continuously (every 15 minutes) the water temperature and salinity of surface waters together with the water turbidity: <http://www.magest.u-bordeaux1.fr/>. David Doxaran (LOV) has access to the archive and real-time data as part of a collaboration with the University Bordeaux 1 (UMR-EPOC laboratory).

Output and deliverables

The output of the project will be atmospherically corrected HICO imagery and TSM maps for the La Plata and Le Gironde estuaries, a comparison of HICO water reflectance with field water reflectance and a comparison of HICO derived TSM maps with TSM maps derived from MODIS.

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