HICO Data User's Proposal
HICO for Optical Active Constituents Retrieval applied to Amazon floodplain Lakes

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Abstract

The Solimões-Amazonas floodplain has a singular ecological, biogeochemical and socioeconomic behavior inside the Amazon biome. However, floodplain systems are poorly known and studied, specially the optical components aspects. This proposal focuses on the study of optical properties of the lake Lago Grande Curuai (LGC), which is a part of the Amazon River floodplain. A dataset of Inherent and Apparent Optical Properties have been constructed from *in situ* measurements and will be used in an inverse modeling approach to retrieve Optical Active Components (OAC) concentrations from airborne and orbital remote sensing. Then, HICO hyperespectral sensor represents an excellent choice because its radiometric and spectral specifications have potential for retrieving OAC from optically complex waters. HICO images will be

used, coupled with in situ data, as an alternative to assess our analytical inverse model approach. A comparison with airborne data is also proposed.

Statement of work

This research is part of a PhD thesis developed to assess the application of HICO images, integrated with *in situ* measurements for estimating Total Suspended Solids (TSS) and Chlorophyll-a (Chl) concentrations in highly turbid waters of Amazon River floodplain lakes. In situ measurements of inherent optical properties (absorption, scattering and attenuation coefficients) and apparent (upward radiance, downward irradiance (E_d), remote sensing reflectance (R_{rs}) and diffuse attenuation coefficient (K_d)) are being collected in field campaigns. A specific set of measurements will be carried out concurrently to an airborne mission equipped with the hyperspectral SpecTir. This mission is planned to be held in August 2013, and the dataset will be used on the development and test of Inverse Models for TSS and Chl-a estimation. Our proposal is to take advantage of the field mission effort to acquire HICO images, in order to assess their suitability as input to the Inverse Models.

Project description

Background

The Remote Sensing of Inland Water Group (RSIWG) from the National Institute for Space Research (INPE), in the last two decades has contributed to the understanding of ecological, biogeochemical and socioeconomic factors affect aquatic systems. This effort is mainly focused on the Solimões-Amazonas floodplain lakes, which is a landscape baring extreme natural oscillation on river stage, known as "flood pulse", (Junk 1989). This flood pulse is the largest ecological force acting in the floodplain ecosystem requiring specific adaptations of the biota (Adis and Junk, 2002; Simone et al., 2003; Parolin 2010; Piedade 1997; Arraut 2008).

However, Amazon floodplain systems are poorly known and studied, when compared to terrestrial Amazon ecosystems. Estimates made by Sippel et al. (1992) estimated more than 10 000 lakes with an area larger than one hectare (1 ha), in which less than 1% have been adequately studied. Particularly, studies that aim to characterize and estimate OAC concentrations and optical properties are even scarcer due to the dependence on *in situ* data, remotely sensed data and also well established analytical models.

The knowledge built by RSIWG (Novo et al., 2004; Barbosa, 2005; Novo et al., 2006; Rudorff et al., 2007; Barbosa et al., 2009; Rudorff et al. 2009; Lobo et al., 2009 , Lobo et al., 2011) shows that the use of *in situ* data collected under controlled conditions coupled with remote sensing data, allows the retrieval of OAC and their thermal properties (Alcantara et al. , 2011), but it is necessary to move forward the use of analytical inversion methods to achieve more robust algorithms.

Some experimental Hyperspectral systems provided valuable insights into the potential of such images to the study of continental aquatic systems (Rudorff et al., 2007; Rudorff et al., 2009; Lobo et al., 2009) in tropical and subtropical regions. However, some of these systems, such as Hyperion / Earth Observing One (EO-1) and the Compact High Resolution Imaging Spectrometer (CHRIS / PROBA) ESA were not suitable for the study of natural and anthropogenic impacts on the Amazon floodplain. The main reasons were :

1) Very narrow swath, covering only partially water bodies area;
2) Unsuitable signal / noise ratio (SNR) for the low levels of radiation registered on water bodies

Therefore, we believed that the HICO sensor, which was designed for applications in coastal areas may be suitable for Amazon regions. Table (1) shows HICO's potentialities for Amazon floodplains studies in the range of 400-900 nm. Despite its restrictive spatial resolution when compared to Hyperion and CHRIS / PROBA, HICO's signal to noise ratio and spectral range are more appropriate when applied to low signal water bodies. In relation to MERIS sensor, HICO's spatial resolution and the number of available bands are also encouraging.

Table 1 – Sensors Comparison

Characteristics	MERIS	Hyperion	CHRIS/PROBA	HICO
Spatial Resolution at nadir (m)	260 x 300	30	18	90
Spectral Resolution (nm)	390-1040	400-2500	410-1050	400-900
Swath (km)	1150	7,6	13.5	42
Number of Bands	15	220	63	87
SNR	> 218	< 190	< 250	> 200

Project Goals

The main objective of this proposal is to evaluate the application of HICO images to retrieve and map optically active constituents (OAC) in optically complex waters lakes (Case 2), from Amazon River floodplain. Semi-analytical models, based on *concurrent in situ* measurements (IOP and AOP) and HICO image will be used to retrieve OAC concentrations. A comparative analysis between the retrieves from the HICO and those obtained from the SpecTir will be also carried out.

Study site

The Lago Grande de Curuai (LGC) floodplain (01º50'S to 02º15'S and 55º00'W to 55º55'W), located along the Amazon River near Óbidos city (Brazil) 900 km upstream from the Atlantic Ocean (Fig. 1), is a complex system of about 30 shallow, interconnected lakes linked to the Amazon River by several channels including open water, flooded savannas and floating grasses. This study site represents the central region of the Amazon floodplain and has been subject of study for over 15 years by our

research group. This region also has suffered from anthropogenic processes that might have interfered in the local ecosystem (Renó et al, 2011) and affected light availability in the aquatic environment.

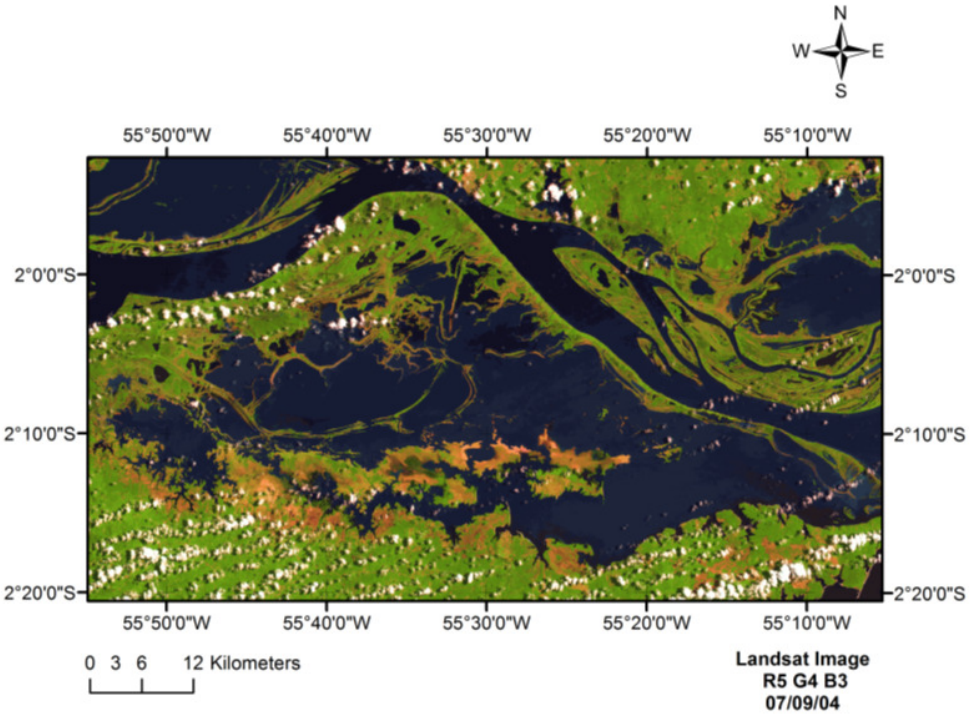


Figura 1 –Lago Grande Curuai Study Area

Schedule and Plans

As part of a Phd thesis from the student Lino Carvalho, three field campaigns were performed on 10/2012, 02/2013 and 03/2013 at 30 sampling stations distributed along the lake. The following data were acquired: profiles of absorption and attenuation coefficients (AC-S WetLabs), backscattering coefficients (Hydroscat 6p), measurements of upward radiance and downward irradiance (Ramses trios), dissolved oxygen, turbidity, pH, concentrations of chlorophyll-a, organic and inorganic colored dissolved organic matter (CDOM) and organic and inorganic suspended matter (TSS). A new field campaign, which includes a flight with a SpecTir airborne sensor, is scheduled for the period from 08/10/2013 to 08/15/2013. Considering the operational constraints, all field measurements follow the standard NASA protocol (Muller et. Al., 2000).

Biographical sketch and available facilities

Cláudio Clemente Faria Barbosa will lead this study in collaboration with Dr. Evlyn Novo, Dr. Lênio Soares Galvão, Dr. Enner Alcantara and his PhD student Lino Sander Augusto Sander de Carvalho. Dr, Claudio Barbosa is a researcher of the National Institute for Space Research (INPE) and has specialized in the use of remote sensing application to inland waters. During the development of his doctoral thesis, Dr. Claudio studied the water dynamics in the Curuai floodplain / Amazon River system. Dr.

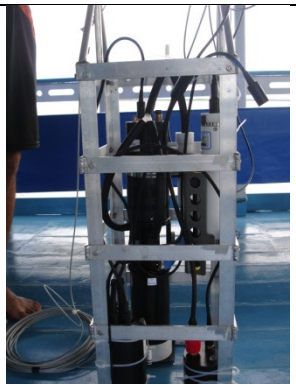
Cláudio is also a professor at INPE's Remote Sensing Graduate Course as well as a Master and PhD advisor.

The remote sensing group of inland waters of INPE has developed studies on remote sensing applications for monitoring the floodplain of the Amazonian rivers and reservoirs focusing on: building a spectral library and limnological characterization of Amazonian waters, in spatial dynamic of distribution of suspended sediment and chlorophyll and evaluation of trophic status of lakes in lowland Amazon. (Alcantara et al 2011, Affonso, et al, 2011, Barbosa et al 2010, Lobo et al 2009, Alcantara et al, 2008, Novo et al 2006).

More recently the group has focused on measurements of apparent and inherent optical properties of Amazonian waters and hydroelectric reservoirs to support studies of carbon balance and the impact of sugar cane on water bodies. As part of this effort, the group acquired a series of equipment (listed below), and also hired Dr. Curtis Mobley to a two week course on Optical Oceanography and HydroLight. Also Lino Carvalho was selected to enroll on the Calibration and Validation for Ocean Color Remote Sensing, from the Maine University - USA, which will contribute to upgrade the group skills on field measurements and data processing.

Available facilities

The group has recently acquired the following equipments: a hyperspectral radiometer to measure radiance and irradiance (RAMSES - Trios), field spectrophotometers to measure attenuation and absorption coefficients (ACS-Wetlabs), equipment for measuring the backscatter coefficient (Hydroscat - HOBILabs), particle size meter (LISST - Sequoia) and fluorometers field (Turner Designs).



(a)

(b)

Figura 2 - Equipments Acquired - (a) AC-S Sketch (b) Ship View

Output and deliverables

1) A comparative analysis between the results obtained from the HICO data and results obtained from the Spectir airborne sensor for mapping total suspended sediments and chlorophyll in amazon floodplain lakes.

2) Yearly participation in HICO Data Team Meetings to present our ongoing results.

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