Preliminary assessment of the performance of Hyperion in coastal waters. Cal/Val activities in Moreton Bay, Queensland, Australia

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***Abstract* – Moreton Bay is the Australian EO1-Hyperion coastal site used for Cal/Val activities. Moreton Bay shows spatial gradients in optical depth, bathymetry, and substrate composition. The turbid and humic river inputs, as well as the open ocean flushing, determine the water quality of the bay. Recently lyngbya toxic algae blooms have become a serious environmental and health concern. The field campaigns, carried out to coincide with Hyperion overpasses, focussed on the retrieval of Inherent Optical Properties (IOP's), Apparent Optical Properties (AOP's), substrate reflectance spectra and water quality parameters. Spectra from a 12th Jan. 2001 Hyperion image show very close agreement to in situ upwelling radiance spectra.**

INTRODUCTION

Moreton Bay (Fig. 1) serves as a multi-use resource for a large population in the greater Brisbane urban area. Research groups from the University of Queensland and CSIRO cooperate in the areas of biophysical remote sensing [1]. These groups carry out cal/val activities of airborne and satellite sensors capable of sensing the spatial and temporal variations of such dynamic environments. Moreton Bay is currently part of cal/val activities for the Hyperion and MERIS missions.

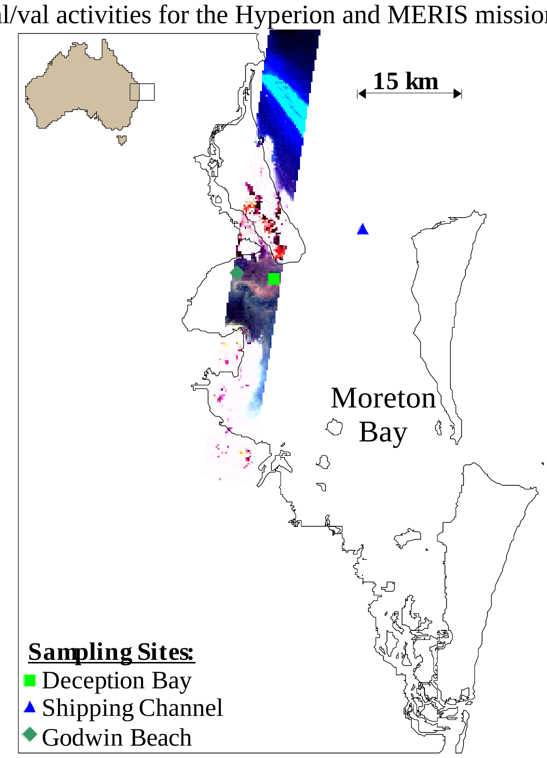

Fig.1 Moreton Bay, Australia. Locations of the sampling sites and of the Hyperion imagery.

METHODS

A water sampling and spectrometry protocol was developed to facilitate intercomparison of field sampling for airborne and satellite sensor overpasses. During each Hyperion overpass a limited set of spectroradiometric measurements *and in situ* sampling was carried out by the UQ focussing on the Northern portion of the bay, where the Lyngbya blooms occur [3]. An extensive joint field campaign was carried out in February 2001 (see table I) to parameterise a full bio-optical model for Moreton Bay [2] for both optically deep and shallow waters. With this model it is possible to simulate any range of concentrations occurring during a Hyperion overpass (provided the specific inherent optical properties do not vary significantly). A concurrent 30-band CASI acquisition will provide spatial variation of the optical water quality variables and a Hyperion comparable spectral response in the visible range.

RESULTS & DISCUSSION

Hyperion exploratory data analysis

We carried out a one day exploratory data analysis of the Hyperion data (as we received the Hyperion data on the 11th April 2001). In Fig. 2 the in situ upwelling radiance spectrum (Lu) is compared to the Hyperion upwelling radiance extracted from the imagery (after applying a dark

TABLE I
FIELD CAMPAIGN – MEASURED AND ESTIMATED PARAMETERS

Instrument	Measured parameters	Estimated Parameters	
ASD	E_d/L_u	R(0-), R(z), K_d, K_u	UQ- BRG
RAMSES MCC	E_d air		UQ- BRG
RAMSES MCC & MRC	E_d/L_u	R(0-), R(z), K_d, K_u	CLW
Unispec	L_u	R(0-), R(z), K_u	CLW
Licor	E_d	R(0-), R(z), K_d,	CLW
HydroScat 6	b_b 145°	b_b	CLW / EOC
PSICAM	$A_{tot}(\lambda)$, $a_{detr}(\lambda)$, $a_{CDOM}(\lambda)$	$a_{phy}(\lambda)$	CLW
Turbidity-meter	b_b 90°	NTU	QLD EPA
Secchi Depth			CLW /UQ/EPA
CTD	Temp, Salinity		QLD EPA
Water samples	Chl a, TSS		UQ-MB
HPLC			UW

CLW: CSIRO Land &Water; UQ- BRG: University of Queensland Biophysical Remote Sensing Group; UQ- MB: University of Queensland, Marine Botany; QLD EPA: Queensland Environmental Protection Agency; EOC: CSIRO Earth Observation Center; UW: University of Wollongong

pixel pseudo-atmospheric correction). There is good agreement between the two spectra, and the satellite sensor was able to measure all the features measurable in the field.
Fig 3 presents Hyperion upwelling radiance spectra extracted from the imagery of Deception Bay. The high variability of the bay (Fig. 4) is clearly illustrated within the end-members of the clear Ocean and turbid River spectra.

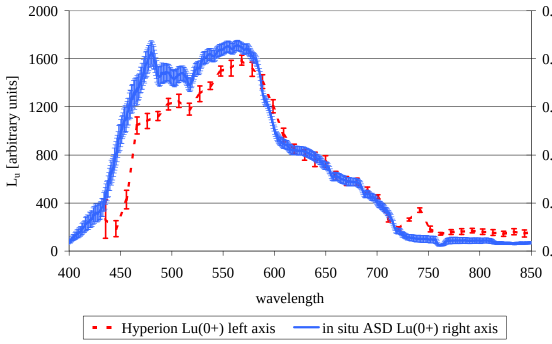

Fig. 2. Comparison of upwelling radiance spectra measured *in situ* and extracted from the Hyperion imagery of Deception Bay, 12 Jan 2001.

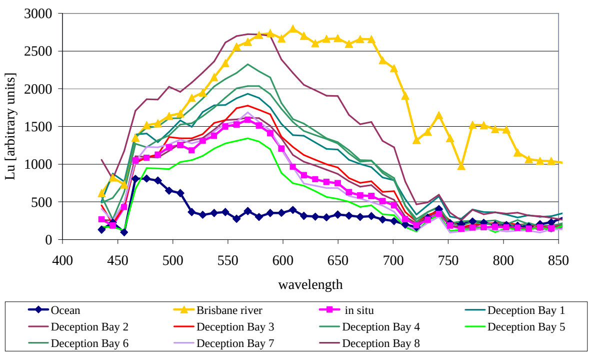

Fig. 3. Deception Bay spectra from Hyperion 12 Jan 2001.

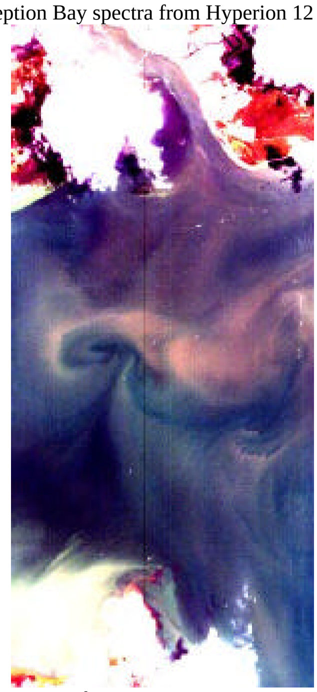

Fig. 4. Hyperion imagery of Deception Bay, 12 Jan 2001. Channels 30 (649.6 nm), 19 (537.5 nm) and 12 (466.1 nm) displayed as RGB

These preliminary results show good promise for imaging spectrometry from space become a worthwhile tool for detection and monitoring of water quality in coastal systems.

Inherent Optical Properties analysis

The February 2001 intensive field campaign focused on one the following three sites (table II) representing an ocean water site (Shipping Channel), a mixed water site (Deception Bay) and a close to shore shallow site with riverine influences (Godwin Beach) within the Hyperion cal/val site.

The subsurface reflectance spectra of the three sites (Fig 5) show significant differences in spectral shape and relative height of the measured reflectance. A qualitative analysis of these spectra is based on the absorption and backscattering spectra of the three sites (see Fig. 6 and 7). The Shipping Channel site reflectance has the highest value at low wavelengths up to 550 nm. Figs. 6 and 7 show this site having the lowest spectral absorption and backscattering values. The relatively higher reflectance below 550 nm is due to the combination of pure water scattering and particulate scattering and lower absorption by coloured dissolved organic matter (CDOM) and particulate organic material. This is confirmed by the lower reflectance beyond 550 nm where pure water absorption has a key role (Fig. 6). The Deception Bay reflectance shows a similar shape to the Shipping Channel spectrum, except for a wavelength shift of about 100 nm to longer wavelengths. The backscattering was much higher at Deception Bay than at the Shipping Channel, while a higher amount of absorption by CDOM and /or particulate matter occurred in the shorter wavelengths. The Deception Bay reflectance shows a local peak at 575 nm.

The Godwin Beach spectrum is similar to the Deception Bay spectrum up till 550 nm. From 600 to 850 nm the Godwin Beach spectrum typical of either algae rich waters or waters with bottom visibility and a notable seagrass cover. As this spectrum was measured 40 cm above the substrate the spectrum is markedly influenced by the seagrasses.

Figure 8 shows a time series of reflectance measurements (similar to Godwin Beach in Fig 5.) at Godwin Beach, the Seagrass site, where Lyngbya was also present [3]. All these spectra are similar from 350 to 500 nm, and beyond 650 nm. From the literature it is well known ([4] & [5]) that blue-green algae may exhibit absorption features due to the presence of cyanophycoerythrin (CPE) and cyanophycocyanin (CPC), with in vivo absorption features at 565 and

TABLE II
FIELD CAMPAIGN SITES DESCRIPTION

Site name	Depth (m)	Secchi depth	Water type	Substrate type
Deception Bay	8	2.90	Mixed water	Sand with benthic micro-algae
Shipping Channel	27	5.25	Ocean water	Sand
Godwin Beach	1.2	bottom visibility	Shallow water/ riverine influence	Seagrasses, macro-algae. Lyngbya in water column and on seagrasses

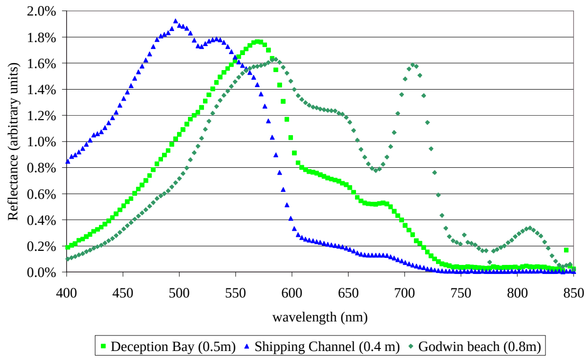

Fig. 5. Reflectance spectra (RAMSES MRC & MCC) at the three sites. 14 Feb 2001

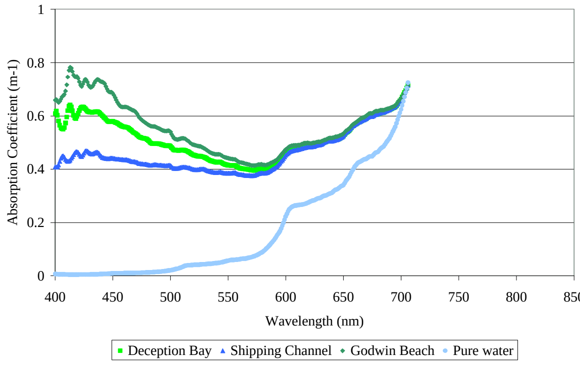

Fig. 6. Total absorption (PSICAM) three sites, compared to the pure water absorption spectrum on 14th Feb 2001

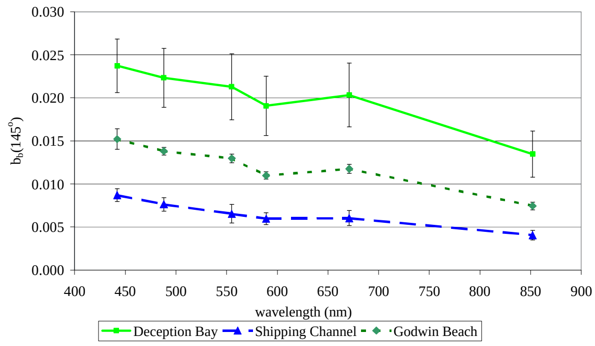

Fig. 7. Backscattering spectra (HydroScat6) at the three sites. 14 Feb 2001

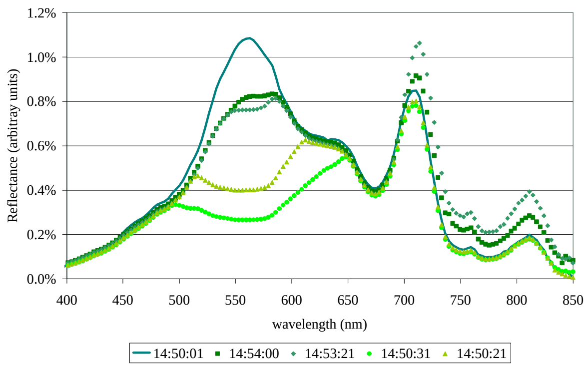

Fig. 8. Reflectance spectra (RAMSES MRC & MCC) at a depth of 80 cm, 40 cm above the substrate at Godwin Beach on 14 Feb 2001. Note the effects of pigment absorption between 500 and 650 nm.

624 nm resp.. These spectra show an absorption induced reflectance trough centered at 565 nm with variable intensity and width of the Gaussian shaped absorption feature. Our explanation is that tufts of Lyngbya floated past under the upwelling radiance sensor. Concurrent video images confirmed the occurrence of this phenomenon.

The preliminary results of the IOP's analysis indicate that the selected site for Hyperion cal/val activities is well-chosen as it highlights the necessity of using imaging spectrometry as opposed to using a sensor with a limited number of spectral bands. In fact, capturing the variable width of the absorption feature due to CPE in the Godwin Beach reflectance spectra is only possible with a full coverage of bands not in excess of approximately 10 to 12 nm.

Future Research

Parameterization of a bio-optical model based on 'in situ' measurements will simulate the performance of Hyperion. These simulations will be used to develop Hyperion water quality algorithms. We will apply these water quality parameters algorithms to assess the sensor capabilities.

Acknowledgment

None of these results would have been possible without the impressive contributions of the University of Queensland Marine Botany and Biophysical Remote Research groups. In particular we would like to thank Stuart Phinn, Chris Roelfsema, Peter Scarth, Josh Rapp and the Centre of Marine Studies at UQ for the use/assistance of the "mv Seawanderer II" and Moreton Bay Research Station. The Hyperion data were collected by NASA and processed by TRW for the evaluation of the experimental sensors on the New Millennium EO-1 mission. Data were provided to CSIRO through its membership of the EO-1 Science Validation Team (SVT). The special efforts of TRW to facilitate access to the data are gratefully acknowledged.

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