INT. J. REMOTE SENSING, 10–20 APRIL, 2004,
VOL. 25, NO. 7–8, 1501–1505

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Validation of SeaWiFS-derived chlorophyll for the Rio de la Plata Estuary and adjacent waters

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Abstract. The South Atlantic Ocean near the Río de la Plata Estuary is a highly dynamic region that encompasses four different water bodies: the Río de la Plata, the continental shelf and the Brazil and Malvinas currents. Bio-optical measurements obtained during 6–11 November 1999 provided the initial field data for validating Sea viewing Wide Field of view Sensor (SeaWiFS)-derived chlorophyll imagery for this region. The turbid waters of the Río de la Plata Estuary showed the highest variability and complexity in water optical properties, while the offshore waters of the Brazil Current had the lowest. In most cases, the estimates of chlorophyll using the SeaWiFS algorithm were higher than *in situ* measured values.

1. Introduction

Reliable remote sensing estimates of chlorophyll-*a* (chl-*a*) in coastal waters continues to be a challenge even for second-generation ocean colour sensors (IOCCG 2000). Unlike open ocean waters, where phytoplankton pigments and their degradation products dominate ocean colour (Case 1), coastal waters are usually characterized by the presence of one or more optically competitive compounds (Case 2) (Bukata *et al.* 1995). The South Atlantic Ocean near the Río de la Plata Estuary is a highly dynamic and complex region (Framiñan and Brown 1996, Guerrero *et al.* 1997) that encompasses both Case 1 and Case 2 water types. The presence of four different water bodies in this area—the Río de la Plata, the continental shelf and the Brazil and Malvinas currents—presents an ideal scenario for validating the Sea viewing Wide Field of view Sensor (SeaWiFS) chl-*a*

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An updated version of a paper originally presented at *Oceans from Space 'Venice 2000' Symposium*, Venice, Italy, 9–13 October 2000.

International Journal of Remote Sensing
ISSN 0143-1161 print/ISSN 1366-5901 online © 2004 Taylor & Francis Ltd
http://www.tandf.co.uk/journals
DOI: 10.1080/01431160310001592517

algorithm. For this purpose, oceanographic stations were occupied along an inshore–offshore section to measure the variability of chl-*a* and the diffuse attenuation coefficient in this region.

2. Field measurements

Twenty-five stations were sampled from 6–11 November 1999 for near-surface chl-*a* and water optical properties for the Río de la Plata, the continental shelf and the Brazil and Malvinas waters. The *R/V Capitán Canepa*, operated by the Argentinian Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), was used for field sampling. Profiles of temperature, conductivity and fluorescence were obtained using a SEA-BIRD SBE911-plus conductivity, temperature, depth and a SeaPoint fluorometer. Surface water samples were collected at each station for chl-*a* determinations. The water samples were filtered using Whatman GF/C glass fibre filters and stored in liquid nitrogen until further analysis by spectrofluorometry (Yentsch and Menzel 1963). Profiles of downwelling photosynthetically active radiation (PAR) irradiance (E_{dPAR}) were made using a Licor LI 1400 radiometer. These measurements were used to calculate the diffuse attenuation coefficient (K_{dPAR}) (Kirk 1994). The mean K_{dPAR} value for the water column was used.

3. Satellite sensor data

Daily SeaWiFS data coincident with the oceanographic cruise were acquired by the Argentinean Comisión Nacional de Actividades Espaciales (CONAE) and processed at the Bio-optical Oceanography Laboratory of the University of Puerto Rico to Level 2 products using SeaDAS 4.0 software. The OC2v2 chlorophyll algorithm with default atmospheric correction and pixel flags was used. Masked pixels near the river mouth included both cloud and turbidity flags. Selected SeaWiFS chl-*a* images (figure 1) were used for comparisons with field measurements of near-surface chl-*a* values. SeaWiFS data from 8 to 9 November could not be used due to extensive cloud cover.

4. Results

The oceanographic stations occupied along the section encompass four distinctive water bodies, each having its own signature regarding temperature and salinity (table 1). Río de la Plata estuarine waters, with surface salinities between 0 and 30 ps, exhibit the highest chl-*a* values (up to $5.04\,\mathrm{mg\,m^{-3}}$). Subtropical or Brazil waters have the highest salinities above 34.7 and lowest chl-*a* values ranging from 0.39 to $0.63\,\mathrm{mg\,m^{-3}}$. Continental shelf and Malvinas waters are characterized by intermediate values of both salinity and chl-*a*. However, upper continental shelf waters can be highly influenced by the Río de la Plata. Attenuation coefficients (K_{dPAR}) ranged from $2.07\,\mathrm{m^{-1}}$ for the turbid waters of the river plume to $0.17\,\mathrm{m^{-1}}$ for the warmer waters of the Brazil Current. The corresponding depths of the euphotic zone for these stations were 2.26 m and 26.31 m, respectively (figure 2). SeaWiFS over-estimated chl-*a* (up to six times) at stations near the turbidity front and in the Río de la Plata Estuary waters (figure 3). Better estimates (within 65%) were found in continental shelf waters, where chl-*a* values ranged from 0.7 to $1.8\,\mathrm{mg\,m^{-3}}$. For the Case 1 Brazil and Malvinas waters (Stations193–200), with chl-*a* values ranging from 0.39 to $1.49\,\mathrm{mg\,m^{-3}}$, SeaWiFS estimates agreed to within 10% of the measured values.

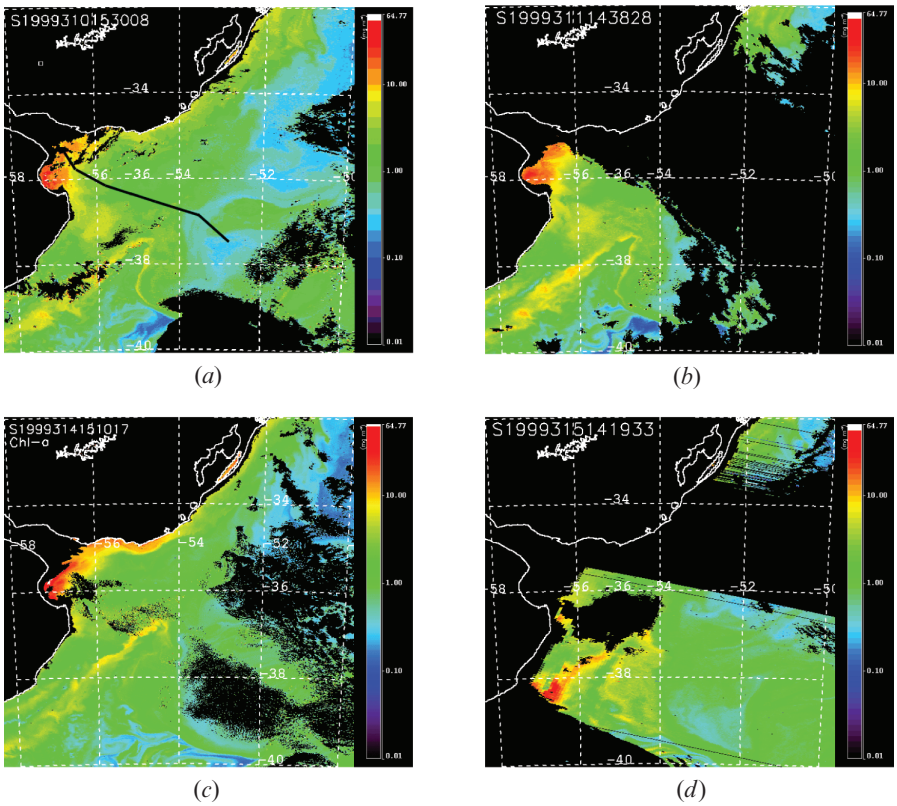

Figure 1. Derived-chlorophyll SeaWiFS images for (*a*) 6, (*b*) 7, (*c*) 10 and (*d*) 11 November, 1999. Clouds, land areas and the Río de la Plata turbidity front are masked in black. The black line shows the sampled section along the cruise tract.

Table 1. Temperature, salinity and chlorophyll signatures of the four water bodies sampled during 6–11 November 1999.

Water body	Temperature (°C)	Practical salinity (ps)	Mean chlorophyll ($mg\,m^{-3}$)	Stations
Río de la Plata Estuary	16–18	0–30	2.98	175–187
Continental Shelf	10–15	29–33.6	1.15	188–192
Brazil Current	15–17	34.7–35.7	0.52	193–198
Malvinas Current	6.4–10	33.75–33.85	1.46	199–200

5. Conclusions

The presence of four distinctive water bodies with complex oceanographic and bio-optical properties makes the Río de la Plata estuarine system an ideal site for testing and validating present and future bio-optical algorithms. The OC2v2 SeaWiFS chl-*a* algorithm significantly over-estimated near-surface chl-*a* in the Río de la Plata Estuary but provided adequate estimates (within 10%) in the subtropical waters of the Brazil Current. Reliable chl-*a* estimates in these optically complex waters will require the use of more advanced Case 2 water algorithms from ocean colour sensors.

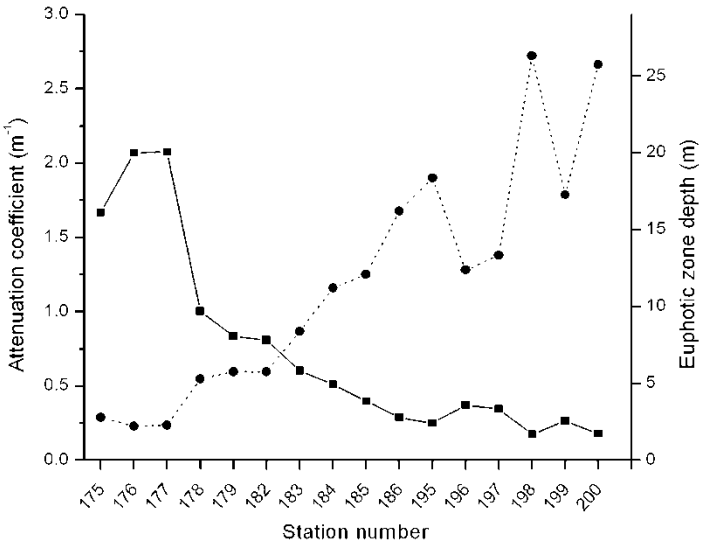

Figure 2. Diffuse attenuation coefficients (squares) and the corresponding depth of the euphotic zone (circles) along the sampled inshore–offshore section.

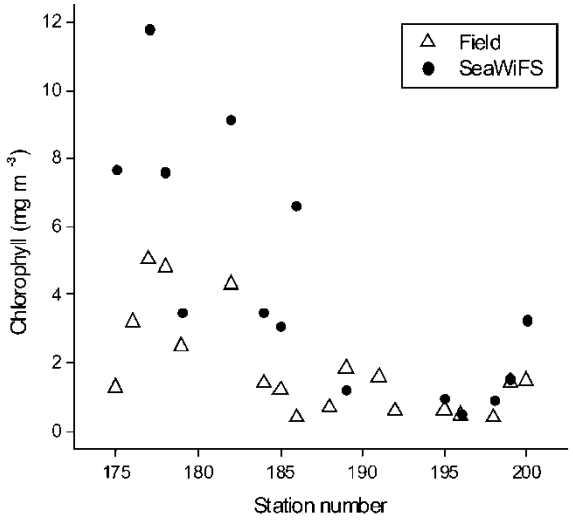

Figure 3. Comparison between SeaWiFS-derived and field measured chl-*a* for each station.

Acknowledgments

We appreciate the collaboration of Jorge Milovich of CONAE for providing the SeaWiFS data used in this study, the help of the captain and crew of the *R/V Capitán Canepa*, and ship time support from INIDEP. We thank Marcos Sastre for assistance with SeaWiFS image processing. This work was partially supported by NASA grant NAG13-54 and Fundación ANTORCHAS grant 13817-5.

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