HICO Data User's Proposal

Evaluation of chlorophyll a retrieval algorithms in Tasmanian coastal waters with a view to the detection and monitoring of harmful algal blooms.

Principal Investigator

Name: James Bramich

Address: 109 Appleby Rd
Northdown, TAS 7307
Australia

Phone: +61 477 064164

Fax: n/a

e-mail: james_mb@utas.edu.au

Co-investigators:

- Dr. Andrew Fischer, University of Tasmania, Andy.Fischer@utas.edu.au
- Dr. Chris Bolch, University of Tasmania, Chris.Bolch@utas.edu.au

Project Summary:

In order to improve remote sensing of chlorophyll a (Chl-a) in Tasmanian coastal waters this project will evaluate several Chl-a retrieval algorithms that have shown promise in coastal waters elsewhere against in situ datasets obtained through several water quality monitoring initiatives. Remote Chl-a estimates obtained from a variety of algorithms will be correlated against the in-situ measurements and the performance of each algorithm evaluated. In addition to Chl-a retrieval accuracy, the influence of total suspended solids and the time difference between satellite image and in-situ data collection will be quantified in order to determine how these variables affect algorithm performance. The best performing Chl-a algorithms will be applied to the detection and monitoring of Alexandrium tamarense blooms on Tasmania's east coast. Satellite derived Chl-a data will be integrated the results of FRDC funded water sampling and other oceanographic observations in order to identify key indicators of bloom conditions. These outcomes can be combined to form a structured framework (Shen et al. 2012) for identifying high risk conditions for bloom outbreaks.

1. Project Description

The aims of this project are to identify the most effective algorithms for the remote retrieval of chlorophyll a in Tasmanian coastal waters. These algorithms will then be integrated into a structured framework for the detection and monitoring of harmful algal blooms on Tasmania's east coast.

Numerous promising algorithms have been developed for chlorophyll a retrieval in complex waters: fluorescence line height (FLH)(Gower et al. 1999), a neural network algorithm (Doerffer and Schiller 2007; Schiller and Doerffer 1999) and a variety of methods using two (Gitelson et al. 2008; Gurlin et al. 2011), three (Gilerson et al. 2010; Gitelson et al. 2008; Gons 1999; Gons et al. 2008; Gons et al. 2002) or four (Le et al. 2009) bands in the red and NIR regions of the spectrum. Red and NIR spectral bands are less sensitive to turbidity and CDOM, however these algorithms are not equally effective in all water bodies. The usefulness of FLH is reduced in turbid waters where available light is less and fluorescence can vary significantly between phytoplankton communities (Zimba and Gitelson 2006), Gons' three band model has been shown to overestimate Chl at concentrations below $10mgm^{-3}$ making it less useful in mesotrophic waters (Gitelson et al. 2008) while other three band models in the red/NIR spectrum have been shown to be variously superior (Gilerson et al. 2010; Gitelson et al. 2011) and inferior (Gurlin et al. 2011) to two band models. These discrepancies can be explained to some extent by the variation in the optical properties of the water bodies to which they have been applied. Chl-a specific absorption by phytoplankton is not constant and has been shown to vary according to algal type (Ahn et al. 1992), size (Ciotti and Bricaud 2006) and concentration (Bricaud et al. 1995). It is broadly acknowledged that these algorithms will need to be regionally validated and/or tuned before they can be reliably applied to new water bodies (Dierssen 2010; Gilerson et al. 2010; Gitelson et al. 2008; Schiller and Doerffer 1999).

HiCO imagery will be validated against in situ data collected in Storm Bay. It is also hoped that a new scene will be captured in Spring Bay on Tasmania's east

coast in order to validate the sensor performance with future water quality sampling in this bloom prone region. With the demise of the Envisat/MERIS platform it is hoped that the superior spatial and spectral resolution of the HiCO sensor will offer improved performance when compared with remote sensing using MODIS/Aqua imagery.

2. Biographical sketch and available facilities

James has a primary degree in computer systems engineering. Following a decade in the IT industry and several years in secondary education, James returned to study by completing a graduate diploma in applied science (marine environment) and has commenced this project as a PhD candidate at the University of Tasmania.

While this project represents James' entrance into the field of ocean colour remote sensing, he is backed by the strong supervisory team of Dr. Andrew Fischer and Dr. Chris Bolch, who each have many years of research experience in remote sensing (Dr. Fischer) and phycology (Dr. Bolch) respectively.

Supervisor profiles:

- https://www.amc.edu.au/marine-conservation-and-resource-sustainability/people/andrew-fischer
- https://www.amc.edu.au/research/people/christopher-js-bolch

3. Output and deliverables

It is expected that outputs of this project will be a doctoral thesis and several peer review publications detailing the validation of both chl-a retrieval algorithms and HiCO imagery in regions as yet undocumented. These findings will be made available to the HiCO user community and, pending funding, will be presented in person.

4. References

Ahn, Y.-H., Bricaud, A., & Morel, A. (1992). Light backscattering efficiency and related properties of some phytoplankters. *Deep Sea Research Part A. Oceanographic Research Papers, 39*, 1835-1855

Bricaud, A., Babin, M., Morel, A., & Claustre, H. (1995). Variability in the chlorophyll-specific absorption coefficients of natural phytoplankton: Analysis and parameterization. *Journal of geophysical Research, 100*, 13321-13313,13332

Ciotti, A.M., & Bricaud, A. (2006). Retrievals of a size parameter for phytoplankton and spectral light absorption by colored detrital matter from water-leaving radiances at SeaWiFS channels in a continental shelf region off Brazil. *Limnology and Oceanography: Methods, 4*, 237-253

Dierssen, H.M. (2010). Perspectives on empirical approaches for ocean color remote sensing of chlorophyll in a changing climate. *Proceedings of the National Academy of Sciences, 107*, 17073-17078

Doerffer, R., & Schiller, H. (2007). The MERIS Case 2 water algorithm. *International Journal of Remote Sensing, 28*, 517-535

Gilerson, A.A., Gitelson, A.A., Zhou, J., Gurlin, D., Moses, W., Ioannou, I., & Ahmed, S.A. (2010). Algorithms for remote estimation of chlorophyll-a in coastal and inland waters using red and near infrared bands. *Optics Express, 18*

Gitelson, A.A., Dall'Olmo, G., Moses, W., Rundquist, D.C., Barrow, T., Fisher, T.R., Gurlin, D., & Holz, J. (2008). A simple semi-analytical model for remote estimation of chlorophyll-a in turbid waters: Validation. *Remote Sensing of Environment, 112*, 3582-3593

Gitelson, A.A., Gao, B.C., Li, R.R., Berdnikov, S., & Saprygin, V. (2011). Estimation of chlorophyll-a concentration in productive turbid waters using a Hyperspectral Imager for the Coastal Ocean-the Azov Sea case study. *Environmental Research Letters, 6*

Gons, H.J. (1999). Optical teledetection of chlorophyll a in turbid inland waters. *Environmental Science & Technology, 33*, 1127-1132

Gons, H.J., Auer, M.T., & Effler, S.W. (2008). MERIS satellite chlorophyll mapping of oligotrophic and eutrophic waters in the Laurentian Great Lakes. *Remote Sensing of Environment, 112*, 4098-4106

Gons, H.J., Rijkeboer, M., & Ruddick, K.G. (2002). A chlorophyll-retrieval algorithm for satellite imagery (Medium Resolution Imaging Spectrometer) of inland and coastal waters. *Journal of Plankton Research, 24*, 947-951

Gower, J.F.R., Doerffer, R., & Borstad, G.A. (1999). Interpretation of the 685 nm peak in water-leaving radiance spectra in terms of fluorescence, absorption and scattering, and its observation by MERIS. *International Journal of Remote Sensing, 20*, 1771-1786

Gurlin, D., Gitelson, A.A., & Moses, W.J. (2011). Remote estimation of chl-a concentration in turbid productive waters - Return to a simple two-band NIR-red model? *Remote Sensing of Environment, 115*, 3479-3490

Le, C., Li, Y., Zha, Y., Sun, D., Huang, C., & Lu, H. (2009). A four-band semi-analytical model for estimating chlorophyll a in highly turbid lakes: the case of Taihu Lake, China. *Remote Sensing of Environment, 113*, 1175-1182

Schiller, H., & Doerffer, R. (1999). Neural network for emulation of an inverse model operational derivation of Case II water properties from MERIS data. *International Journal of Remote Sensing, 20*, 1735-1746

Shen, L., Xu, H., & Guo, X. (2012). Satellite remote sensing of harmful algal blooms (HABs) and a potential synthesized framework. *Sensors (Basel), 12*, 7778-7803

Zimba, P.V., & Gitelson, A. (2006). Remote estimation of chlorophyll concentration in hyper-eutrophic aquatic systems: Model tuning and accuracy optimization. *Aquaculture, 256*, 272-286