

## HICO Data User's Progress Report 2014

### “Assessment and application of HICO data for the study and monitoring of lakes”

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## Project summary

The use of satellite observations for monitoring change in the status of lakes has progressed significantly in recent years but the complexity in the optical properties of these water bodies and the continentality of the overlying atmosphere still presents notable challenges for the accurate retrieval of in-water biogeochemical constituents. In addition, strong land adjacency effects also diminish the accuracy of satellite observations over lakes. Consequently, algorithms for chlorophyll a (Chla) retrieval developed for ocean and coastal waters have limited applicability to turbid lakes. The recently-funded €3.5M GloboLakes project ([www.globolakes.ac.uk](http://www.globolakes.ac.uk)), involving a consortium of six UK universities and research institutes including the University of Stirling (USTIR), Plymouth Marine Laboratory (PML), and the Centre for Ecology & Hydrology (CEH), is developing an operational satellite-based observatory for more than 1000 lakes globally. The GloboLakes project provides a unique opportunity to assess HICO as a potential tool for the study and monitoring of lakes. In addition, we propose to validate a range of atmospheric and in-water biogeochemical algorithms using HICO data products.

## Summary of progress

“Assessment and application of HICO data for the study and monitoring of lakes” was approved on the 27th of June 2013, while the request for a new target (HUN\_LakeBalaton) was accepted on the 17th of July 2013. Since the latter date HICO has acquired nine images over Lake Balaton.

Table 1. HICO imagery of the target HUN\_LakeBalaton acquired in 2013, 2014.

Date	Orbit direction	Sky conditions
2013-08-19	Ascending	clear
2013-08-31	Ascending	clear
2013-09-04	Ascending	partly cloudy
2013-10-31	Ascending	clear
2013-11-04	Descending	cloudy
2013-11-05	Descending	cloudy
2013-11-08	Descending	partly cloudy
2014-03-01	Ascending	clear
2014-03-08	Descending	clear

Table 2. HICO imagery of the target Lake\_Taihu acquired in 2013, 2014.

Date	Orbit direction	Sky conditions
2013-01-08	Descending	clear
2013-01-09	Descending	partly cloudy
2013-01-12	Descending	partly cloudy
2013-03-23	Descending	cloudy
2013-06-13	Ascending	cloudy
2013-07-06	Ascending	cloudy
2013-07-18	Descending	clear
2013-07-22	Descending	partly cloudy
2013-09-08	Descending	cloudy

2013-09-12	Descending	partly cloudy
2013-10-20	Ascending	partly cloudy
2013-11-04	Ascending	clear
2013-11-12	Descending	cloudy
2013-11-16	Descending	clear
2013-11-20	Descending	clear
2014-03-01	Descending	cloudy
2014-03-16	Descending	clear
2014-03-20	Descending	cloudy

We undertook research cruises on 7 lakes between May and September during the 2013 Globolakes sampling campaigns. Among them the HICO target Lake Balaton and the hypertrophic lake, adjacent to Lake Balaton, Kis Balaton (also captured in some of the HICO overpasses) were sampled for two weeks in August (12-16/08/2013).

In total, 158 optics casts were made using the AC-S/BB3 instrument suite and 35 water samples were collected from these two lakes for analysis of in-water constituent concentrations (e.g. Chla, TSM, CDOM) (Table 2).

Table 3. The Globolakes campaigns carried out in 2013 in Lake Balaton and Kis Balaton. The symbol (|) represents sampling days in week 1, 2, 3 or 4 of every month from May to September.

		Stations	Samples	Casts	May	June	July	August	September
Hungarian lakes	Balaton	11	33	150				■	
	Kis Balaton	2	2	8					

In-situ measurements of water leaving reflectance were produced by the HyperSAS sensor on the same days (Fig. 1).



Fig.1: Radiometers used for the in-situ measurements in Lake Balaton.

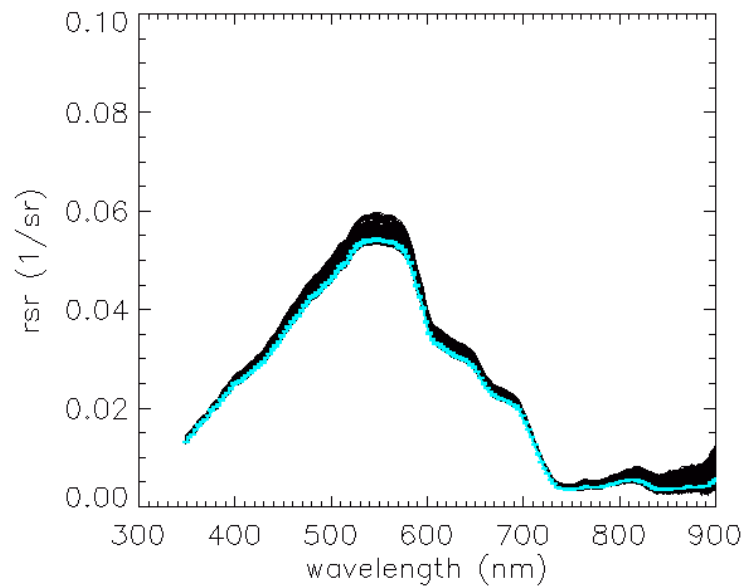


Fig.2: Example of in-situ above water reflectance spectra from a station at the north part of Lake Balaton (15/08/13). The HyperSAS data were processed by Plymouth Marine Laboratory.

During the August field work in Lake Balaton and Kis Balaton several data of bio-optical properties were collected:

- Spectral attenuation, absorption and scattering (Wetlabs AC-9, AC-S);
- Spectral backscattering (2 x Wetlabs ECOBB3);
- Subsurface irradiance reflectance and above water-leaving reflectances (Satlantic HyperOCRs and HyperSAS);
- Temperature, depth and salinity (SeaBird CTD);

Moreover, surface water samples were collected for the analysis of a wide range of parameters:

- Absorption coefficients for total particulate ( $a_p$ ), phytoplankton ( $a_{ph}$ ), non-algal particles ( $a_{NAP}$ ) and CDOM ( $a_{CDOM}$ ) (Cary 100 dual beam spectrophotometers with an integrating-sphere attachment)
- Spectrophotometric chlorophyll
- HPLC chlorophyll and accessory pigments (2 HPLC systems)
- Total (TSM), inorganic (PIM) and organic (POM) particulate matter
- Phytoplankton cell counts (microscopy and flow cytometry)

Data were collected at 13 stations with highly varied biogeochemical characteristics (e.g. chlorophyll  $a$  in Balaton ranged from 4.32 to 55.25 mg/m<sup>3</sup>).

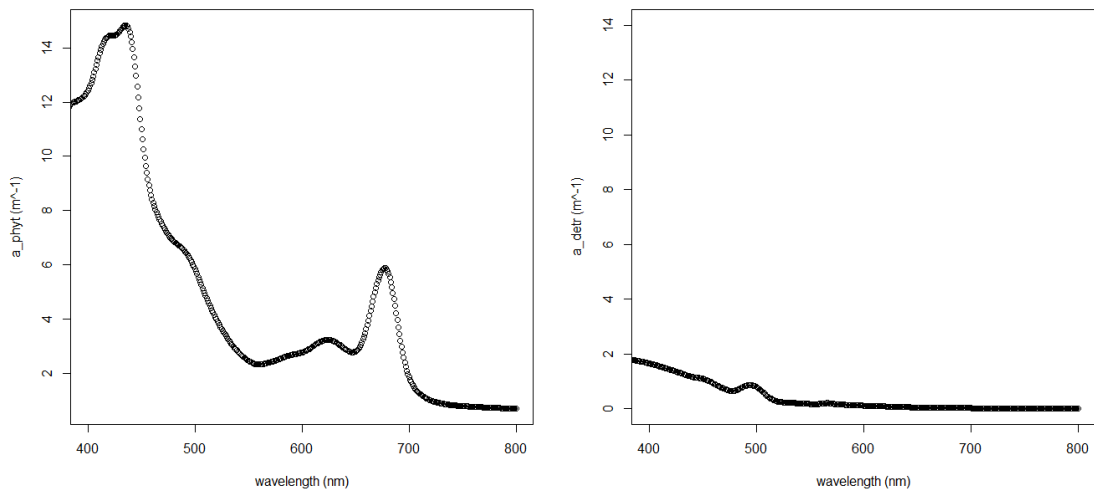


Fig.3: Example of phytoplankton (left) and detritus (right) absorption spectra from Kis Balaton (16/08/2013). The method described in Tassan & Ferrari (1995).

Additional water samples were collected from Balaton Limnological Research Institute of the Hungarian Academy of Sciences in 2013 for analysis of in-water constituent concentrations (Chla, TSM, CDOM). These campaigns were carried out in order to coincide with scheduled HICO overpasses.

In parallel to the field campaigns we have undertaken the establishment of a database of lakes in-situ biogeochemical, inherent and apparent optical properties (LIMNADES, [www.globolakes.ac.uk/limnades](http://www.globolakes.ac.uk/limnades)) for algorithm development and validation. LIMNADES was conceived as part of the GloboLakes project to provide a mechanism for partners to contribute and share bio-optical datasets with the project and each other. However, LIMNADES has received an enthusiastic response from the international community and grown rapidly to now encompass data from over 100 lakes in several countries located across 5 continents. This is coupled with increasing request to access the database we now host. Some of these data (e.g. from Lake Taihu, already a HICO target) could be used for the objectives of “Assessment and application of HICO data for the study and monitoring of lakes”.

In summary, in these nine months since access to HICO data was approved we focused our efforts in building up a HICO (HUN\_LakeBalaton, Lake\_Taihu\_CHN) match-up database by means of dedicated field campaigns and use of LIMNADES database. This is a critical step for the achievement of our principal objectives:

- To exploit HICO data products over lakes around the world using in-situ matchups from field campaigns, routine monitoring programmes and instrumented moorings
- To develop and validate water constituent retrieval algorithms from HICO data specifically for lakes and explore the algorithm requirements for future remote sensing water colour missions

## **2013 list of conference talks with reference to HICO Data User's proposal: "Assessment and application of HICO data for the study and monitoring of lakes"**

E Spyarakos, P. D. Hunter, A. Tyler, S. Groom, G. Dall'Olmo, S.Tilstone,,V. Martinez Vicente, C.M. Merchant, S. MacCallum, M. Cutler, J. Rowan, T., Dawson, E. Politi, S.C. Maberley & L. Carvalho, J.A. Elliot ,S. Thackery, S., C.A. Miller & E.M. Scott: A Global Observatory Of Lake Responses To Environmental Change. First International Conference on Remote Sensing and Geoinformation of Environment, Pafos, 08-10 April 2013.

P. D. Hunter, A.Tyler, E. Spyarakos, S. Groom, G. Dall'Olmo, S.Tilstone,,V. Martinez Vicente, C.M. Merchant, S. MacCallum, M. Cutler, J. Rowan, T., Dawson, E. Politi, S.C. Maberley & L. Carvalho, J.A. Elliot ,S. Thackery, S., C.A. Miller & E.M. Scott: A Global Observatory Of Lake Responses To Environmental Change. GEO European Projects workshop, Barcelona, 15-16 April 2013.

Hunter (2013) Remote sensing of lake biogeochemical properties – some perspectives from the GloboLakes project. The Colour of Water Workshop. Uppsala, June 2013.

A.Tyler, P. D. Hunter, , E. Spyarakos, S. Groom, G. Dall'Olmo, S.Tilstone,,V. Martinez Vicente, C.M. Merchant, S. MacCallum, M. Cutler, J. Rowan, T., Dawson, E. Politi, S.C. Maberley & L. Carvalho, J.A. Elliot ,S. Thackery, S., C.A. Miller & E.M. Scott: A Global Observatory Of Lake Responses To Environmental Change. Overview and update. The Colour of Water Workshop. Uppsala, June 2013.

A.Tyler, P. D. Hunter, , E. Spyarakos, S. Groom, G. Dall'Olmo, S.Tilstone,,V. Martinez Vicente, C.M. Merchant, S. MacCallum, M. Cutler, J. Rowan, T., Dawson, E. Politi, S.C. Maberley & L. Carvalho, J.A. Elliot ,S. Thackery, S., C.A. Miller & E.M. Scott: A Global Observatory Of Lake Responses To Environmental Change. Overview and update. SIL XXXII Congress, Budapest, 04-09 August 2013.

A.Tyler, P. D. Hunter, , E. Spyarakos, S. Groom, G. Dall'Olmo, S.Tilstone,,V. Martinez Vicente, C.M. Merchant, S. MacCallum, M. Cutler, J. Rowan, T., Dawson, E. Politi, S.C. Maberley & L. Carvalho, J.A. Elliot ,S. Thackery, S., C.A. Miller & E.M. Scott: A Global Observatory Of Lake Responses To Environmental Change. Overview and update. European Space Agency Living Planet Symposium, Edinburgh, 09-13 September 2013.

P. D. Hunter, A.Tyler, E. Spyarakos, S. Groom, G. Dall'Olmo, S.Tilstone,,V. Martinez Vicente, C.M. Merchant, S. MacCallum, M. Cutler, J. Rowan, T., Dawson, E. Politi, S.C. Maberley & L. Carvalho, J.A. Elliot ,S. Thackery, S., C.A. Miller & E.M. Scott: A Global Observatory Of Lake Responses To Environmental Change. INFORM Kick-off Meeting, Mol, 23-24 January 2014.

## **2014 planning**

- To continue collecting in-situ data of chlorophyll a, phycocyanin, SPM and cdom over the "HUN\_LakeBalaton" target weekly/biweekly till the end of December (carried out by Balaton Limnological Research Institute of the Hungarian Academy of Sciences) and ask for coinciding HICO data collection
- We have also scheduled daily sampling campaigns in Balaton including among other: in-situ radiometry (HyperSaS, TriOS RAMSES, WISP, ASD) and IOP measurements (ACS, TriOS OSCAR) for the period 10th-27th July this year. We have identified a week (14/07-18/07) when we consider crucial to explore HICO data. During this week we have planned an APEX flight over Balaton. The APEX instrument is developed by a Swiss-Belgian consortium on behalf of ESA as a simulator and a calibration and validation device for spaceborne imagers. APEX records hyperspectral data in approximately 300 bands in the wavelength range between 380 and 2500 nm. We are considering Landsat 8 images for this period (overpass 16/07/2014). APEX flights and (partially) the field campaign in July 2014 will be funded by the FP7-SPACE-2013-1 project INFORM (Improved monitoring and

forecasting of ecological status of European INland waters by combining Future earth ObseRvation data and Models)

- Request a new target (Lake Geneva, 46.433 N, 6.55 E). A field campaign has been scheduled for 02-06/06/2014.
- Develop and validate water constituent retrieval algorithms from HICO data specifically for lakes.
- Expand the objectives of “Assessment and application of HICO data for the study and monitoring of lakes” to include the development, testing and validation of algorithms for retrieval of the different main phytoplankton functional types, primary production from a hyperspectral spaceborne sensor such as HICO.

### **References**

Tassan, S., and G.M. Ferrari. 1995. An alternative approach to absorption measurements of aquatic particles retained on filters. *Limnol. Oceanogr.* 40: 1358-1368.