climate change initiative

→ LAKES NEWSLETTER

October 2019

In this newsletter

During the second quarter of the Lakes_cci project our teams have started to tackle some of the challenges involved in producing what will become the largest and longest consistent time-series of the Lakes Essential Climate Variables (ECVs). This included a preparatory phase of screening input data sets, revising algorithms and collecting validation data sets, for which collaborations with research teams around the world have been set up (more are welcome!).

In this newsletter, we share results from a user requirements analysis that has guided this process, and we take a closer look at one of the thematic Lakes ECVs: Lake Water-Leaving Reflectance, also known as water colour.

Preparing for the first Lakes ECV climate data record

Claudia Giardino (CNR), Chris Merchant (U Reading) and Stefan Simis (PML)

The first climate data record will be a collection of the current state-of-the-art in satellite processing systems for each thematic ECV, applied to 250 globally distributed waterbodies and provided on a mutually compatible spatio-temporal grid. While the data production teams are preparing to produce this data set over the coming months we engaged in a user consultation and requirements assessment process, held through scientific conferences and an online survey. The survey included questions on data accessibility and format, requirements on spatial and temporal aggregation, and usage scenarios. We were pleased to see that the responses covered a wide field of users, self-identifying as working in the fields of Limnology (78%) and Ecology (55%), followed by Hydrology (38%) and Climatology (32%) as opposed to only 3,8% in Remote Sensing and thus representing a wide group of truly scientific end-users. The survey response indicated that the Lakes_cci products will be mainly used for “Understanding causes of environmental changes” (76%), and for the “Assessment of trends in geostatistics” (70%), followed by “Lake management” (55%) or “Ecological modelling” (51%) fields (Figure 1).

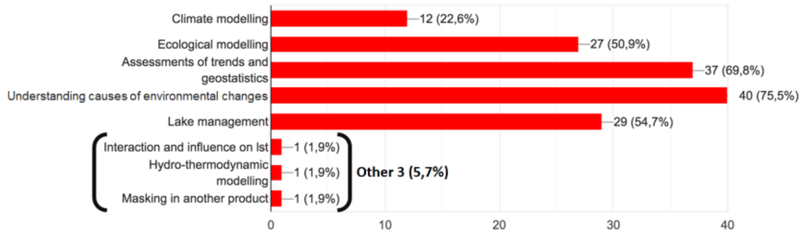

Figure 1 Answers to survey question: how would you use Lakes_cci products?

The majority of respondents also indicated that 'ease of use' and 'length of record' were the dominant factors that would encourage their use of the dataset, followed by the availability of 'uncertainty information' and 'particular lakes in the data set' as shown in Figure 2.

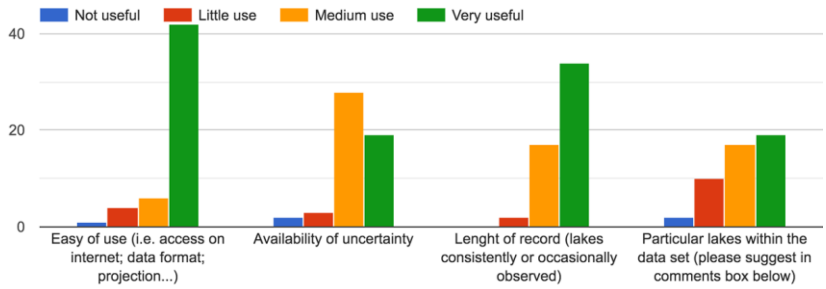

Figure 2 Answers to survey question 'What factors would encourage you to use Lakes_cci products?'

The responses from the wider user consultation were combined with further requirements from literature research as well as the data requirements for five use case studies which will be carried out using the first release of the Lakes climate data record. The User Requirements Document details these findings and will soon be available from the Lakes_cci website. Although the initial round of user requirements analysis is complete, engagement with the user community does not end here. For example, the Lakes_cci team will be present during a special session of the 6th Workshop on Parameterization of Lakes in Numerical Weather Prediction and Climate Modelling (Lake2019), 22-24 October, 2019 at Météo-France (Toulouse).

Product highlight: Lake Water-Leaving Reflectance

Stefan Simis and Xiaohan Liu (PML)

In each of the first round of newsletters we highlight the state-of-the-art in one of the Lakes thematic ECVs, which include Lake Water Level and Lake Water Extent, Lake Water-Leaving Reflectance, Lake Ice Cover and Lake Surface Water Temperature. In this newsletter we highlight the Lake-Water-leaving Reflectance (LWLR), also referred to as water colour, and the biogeochemical products we can subsequently derive from it.

The terms 'water colour', 'water-leaving reflectance' and 'ocean colour' are all used to describe the quantity of sunlight reaching a remote detector after interaction with the water column. This quantity is only part of what the detector sees, since sunlight also interacts with the atmosphere and the water surface, which requires correcting. Once the water 'reflectance' has been obtained it contains information about light absorption and scattering processes in the water column, such as absorption by pigments that harvest light energy for photosynthesis, scattering by mineral and organic particles, and absorption by coloured dissolved substances. This information is used to monitor waterbody health and functioning and to assess long term trends including the effects of climate change on water quality.

The first ocean-colour sensor to contribute to an uninterrupted observation record of water colour was SeaWIFS, launched on the GeoEye OrbView-2 satellite in 1997. Several other ocean colour sensors have continued the legacy of SeaWIFS but it was not until the launch of the Medium Resolution Imaging Spectrometer (MERIS) on Envisat in 2002 that advances in technology included several optical channels to better separate the effects of atmosphere and land on water colour. This capability is essential for observing the reflectance of lakes, and it remains a prominent research question for the Lakes_cci project to determine the value of preceding sensors for lakes of varying size and shape. Using recent satellite sensors (MERIS and the Ocean and Land Colour Instrument (OLCI) on Sentinel-3), the team producing the Lakes_cci data set has already produced time series spanning more than 10 years for more than 1000 lakes globally. This is done using the *Calimnos* satellite processing chain, a set of software tools initially developed in the UK GloboLakes project to efficiently produce time-series of data for individual lakes. Under Lakes_cci, *Calimnos* will be extended to use data from earlier satellites such as MODIS, VIIRS and ultimately SeaWIFS.

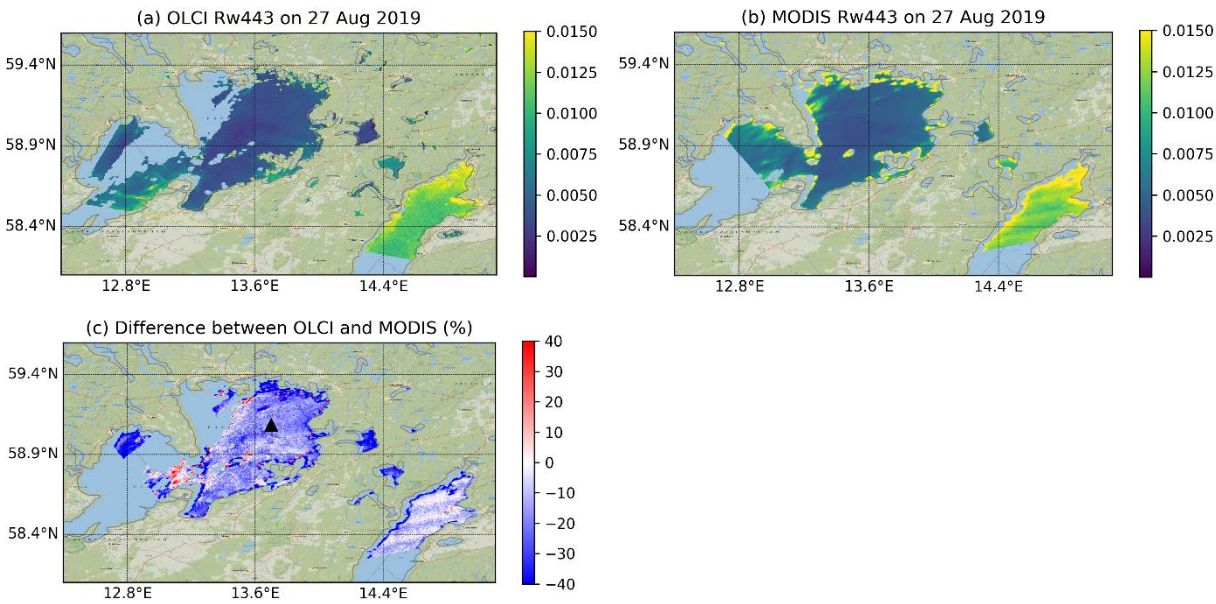

Figure 3 Inter-sensor bias of normalized water-leaving reflectance at 443 nm for OLCI (a) and MODIS (b), and the percentage difference between the two sensors (c). The black triangle in panel c indicates the site selected for time-series comparison in Lake Vänern.

Combining data from multiple satellite sensors requires any bias between them to be removed. To illustrate the effects of inter-sensor bias, Figure 3 shows a comparison of normalized water-leaving reflectance at 443 nm (blue light) between OLCI and MODIS sensors observed on the same day in the same region (27th Aug 2019) of lakes Vänern and Vättern in Sweden. The general patterns of the reflectance are similar between the two sensors, while OLCI shows relatively lower values near land, suggesting that reflectance from MODIS suffers more from the 'land-adjacency' effect.

The inter-sensor bias needs to be derived from data over a diverse set of lakes and a long time period, to determine an appropriate correction. For illustration, a time-series for a single point in the centre of Lake Vänern shows that a consistent time-series could be expected after removal of inter-sensor bias, since both sensors show similar trends over time (Figure 4).

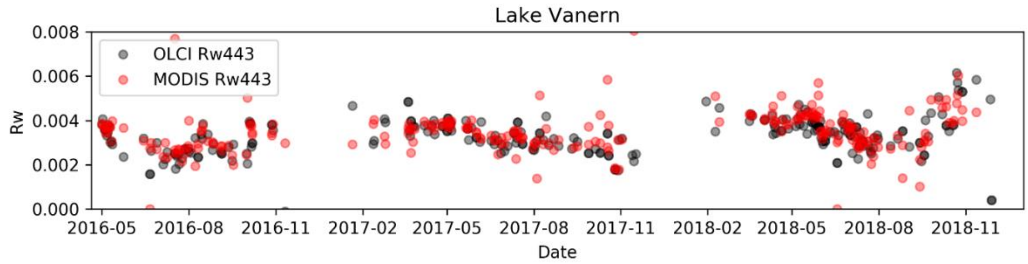

Figure 4 Time-series comparison of the inter-sensor bias of the normalized water-leaving reflectance at 443 nm between OLCI and MODIS. The black triangle in Figure 3c indicates the site selected for the comparison in Lake Vänern.

The bias correction is also dependent on the optical waveband. Whereas the spatial patterns for the blue band at 443 nm showed high similarity in the scene from 27th August 2019, larger horizontal differences show in the red band at 665 nm band, and they appear to differ between lakes. Nevertheless, the differences are not so apparent when we look at the time-series of Lake Vänern (Figure 6. Therefore, the inter-sensor bias needs to be corrected for individual wavebands between sensors and ideally we can define conditions for which a particular sensor has particularly high product uncertainty so that such observations can be removed.

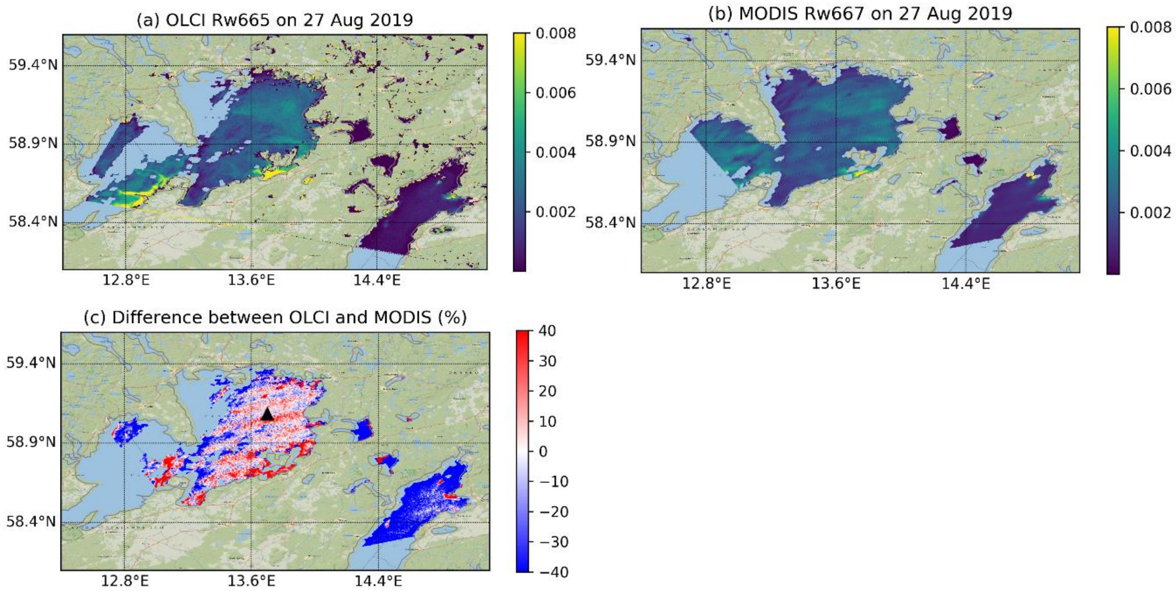

Figure 5 same as figure 3, but for normalized water-leaving reflectance at a waveband around 665 nm.

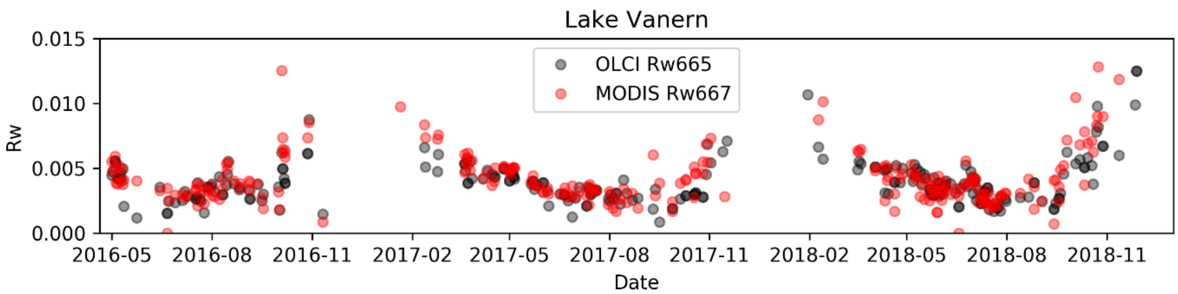

Figure 6 same as figure 4, but for normalized water-leaving reflectance at a waveband around 665 nm.

The next step in interpreting the reflectance signal is the retrieval of biogeochemical proxies such as chlorophyll-*a* concentration or turbidity. *Calimnos* is designed to analyse each pixel in terms of its similarity to known *optical water types*. Each water type has been given a specific set of algorithms to derive substance concentrations, and these are optimised for given combinations of satellite sensor and pre-processing such as the atmospheric and sensor bias corrections. Algorithm results from each water type with high similarity to the pixel in question are then blended together. This dynamic algorithm selection approach allows the processor to be applied to waterbodies for which no prior knowledge exists, which is essential when creating a large global data set. However, the tuning of each algorithm does depend on having sufficient and widely representative data sets of in situ concentration estimates, which is often lacking. Most of the available in situ data are from the period when the MERIS sensor was active (2002-2012). Other observation periods will therefore be benchmarked to this period. The Lakes_cci project is very keen to interact with research groups who consistently collect in situ data in lakes that can be observed with remote sensors.

In our next newsletter we will take a closer look at the generation of Lake Ice Cover products.