In this newsletter

After a short Project progress and next works, we highlight the generation of the Lake Ice Cover (LIC) product V1.0. LIC refers to the extent (or area) of a lake covered by ice. According to GCOS (2016), LIC ECV product requirements are: daily frequency, 300-m spatial resolution, 10% measurement uncertainty, and stability of 1% per decade. At the end a short description of the CRDP V1.0 is given.

Project status

The first year of the project ended in February. The annual review took place in a virtual room in early April. There were more than 25 participants from their home during one day and a half. This meeting was successful and the team had the opportunity to show all the work performed during this first year. It was also a good introduction for the new ESA Technical Officer, Dr. Clément Albergel, to take over this project. The major deliverables after one year is the CRDP (Climate Research Data Product). It was still under progress at the time of the Annual Review meeting. The CRDP will content 30 years of measurements over 250 lakes. The CRDP will be available by the end of May.

The next steps is the use of the CRDP by the 5 use cases of the project and also the end the WP6 dedicated to the new methodologies for Lake Water Extent.

Product highlight: Lake Ice Cover

*Claude Duguay (H2O Geomatics and University of Waterloo)*

LIC is highly sensitive to changes in weather and climate. Lake-wide ice phenology can be derived from LIC, including freeze onset to complete freeze over (CFO) dates during the freeze-up period, melt onset to water clear of ice (WCI) dates during the break-up period, and ice cover duration derived from number of days between CFO and WCI dates over an ice year. For lakes that do not form a complete ice cover every year or in some years (e.g. Laurentian Great Lakes of North America), maximum ice cover extent (timestamped with date) is also a useful climate indicator that can be determined. Similarly, minimum ice cover extent (timestamped with date) can be derived for High Arctic lakes that do not completely lose their ice cover in summer. Knowledge of the presence/absence or fractional coverage/concentration of ice cover on large lakes on a ca. weekly basis is also useful for improving numerical weather forecasting (e.g., lake-effect snowfall, thermal moderation effect) in cold regions.
For Climate Research Data Package (CDRP) V1.0, the LIC product is generated on a daily basis using MODIS data acquired from multiple Terra and Aqua satellite overpasses on each day as to maximize the number of cloud-free observations. The product, which covers a 20-year period (2000-2019), is first produced on a ca. 250-m grid (internal product) and then merged with the other lake thematic products on a common 1/120th degree grid. The primary input data source is the MODIS Terra/Aqua Atmospherically Corrected Surface Reflectance 5-Min L2 Swath (MOD09/MYD09), Collection 6 product. MODIS surface reflectance and brightness temperature bands are used in a threshold-based algorithm for feature retrieval (i.e. water, ice, or cloud classes). The surface reflectance bands are available at 250 m and 500 m resolutions. Brightness temperature bands are available in 1 km resolution. Geolocation is provided at 1 km resolution and is interpolated to 250 m. The second data source for LIC product generation is the maximum water extent observed in ESA CCI Land Cover (v4.0) at 150-m resolution. MOD09/MYD09 data from 17 lakes located in different regions of the Northern Hemisphere were selected for algorithm development and validation (Figure 1).

Figure 1 Geographical distribution of 17 lakes used for lake ice cover algorithm development and validation.
Figure 2 shows an example of LIC products generated for low (winter 2011-2012) and high (winter 2013-2014) ice years. Validation of the LIC product and comparison with lake ice retrievals provided by NASA’s MODIS Terra/Aqua Snow Cover products (MOD10/MYD10) have been performed via computation of confusion matrices built on independent statistical validation. Results show that the retrieval algorithm implemented for Lakes CCI outperforms NASA’s Snowmap algorithm, attaining an overall accuracy (FU and BU periods combined) of 95.54% compared to 87.09%. Retrieval accuracies have been found to be more consistent between classes and also ice periods for the Lakes CCI LIC algorithm (BU: 14% and FU: 22% higher accuracy than NASA’s Snowmap algorithm), in addition to better capturing the spatial distribution of cloud cover compared to the MODIS Snow Cover (MYD10/MOD10) products. Individual class accuracies are all above 90% (errors less than 10%) for LIC CDRP V1.0 (ice: 91.71%, water: 98.85%, cloud: 95.63%) which meet uncertainty requirements of 10% set by GCOS. Further assessment of the LIC product and its comparison with other products is planned leading to CDRP V2.0 by the broader user/modelling community.
Given the importance of ice cover in lake-atmosphere interactions, the LIC ECV will be of interest to users who wish to: 1) examine short-term trends and interannual variability in ice cover globally (ca. 20 years); 2) investigate the impact of changing ice cover conditions on other variables covered in Lakes CCI, such as Lake Surface Water Temperature (LSWT); 3) conduct data assimilation experiments using state-of-the-art numerical weather prediction systems to demonstrate the impact of better consideration of LIC on, for example, improving predictions of lake-effect snowfall; and 4) evaluate lake models (e.g. FLake model) used as lake parameterization schemes in numerical weather prediction and climate models. Finally, from a socio-economic perspective, the LIC variable may also serve to examine the impact of changing ice conditions on winter transportation (shipping, ice roads) and food security (access to resources by northern communities via ice roads).

**CRDP V1.0**

Main Data characteristics:

- **Spatial coverage:** 168 lakes spread over the world
- **Spatial resolution:** Grid 1/120 degree
- **Temporal resolution:** Daily. 1 file per day containing all parameters
- **Temporal coverage:** From 1992 up to 2019.

---

**Temporal coverage for each Lakes CCI parameter**

- **Location of the 250 lakes of the CRDP V1.0**