Comments from Public Consultation on ECV Requirements 13/01 – 13/03 2020 for:

# Lakes

## ECV Product: Lake Ice Cover (LIC)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | **Lake Ice Cover (LIC)** | | | | |
| **Definition** | Area of lake covered by ice | | | | |
| **Unit** | km2 | | | | |
| **Note** |   Based on lake-wide satellite observations. In situ observations of ice cover can be temporally and spatially consistent, and therefore be useful for climate monitoring, but capture variations and trends in ice cover that are spatially limited (i.e. not lake-wide but rather representative of some limited area observable from lake shore).    Lake-wide ice phenology can be derived from LIC (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) (Duguay et al., 2015).    For lakes that do not form a complete ice cover every year or in some years (e.g. Laurentian Great Lakes), maximum ice cover extent (timestamped with date) is also a useful climate indicator that can be derived; similarly minimum ice extent can be derived for High Arctic lakes that do not completely lose their ice cover in summer. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | m |  | G | 50 | Smaller water bodies as well as due to increased availability of synthetic aperture radar (SAR) and optical data at resolutions ≤ 50 m (e.g. Wang et al., 2018) |
| B | 10 | Small water bodies (lakes, ponds) can be observed |
| T | 1000 | Medium to large sized water bodies as demonstrated through ESA Lakes\_cci |
| **Vertical Resolution** |  |  | G | n/a |  |
| B | n/a |  |
| T | n/a |  |
| **Temporal Resolution** | day |  | G | 1 | Detection of interannual variability and decadal shifts in ice cover and for improving ice, weather forecasting and climate models |
| B | < 1 | Allows daily observations under variable cloud cover from optical satellite data |
| T | 3-7 | Useful for contrasting extreme ice years, numerical weather forecasting, and assessing lake models used as parameterization schemes in climate models |
| **Timeliness** | day | From observation day | G | 1 | In support of ice forecasting systems (e.g. NOAA’s Great Lakes Coastal Forecasting System (GLCFS)) |
| B |  |  |
| T | 365 | To support annual climate reporting |
| **Required Measurement Uncertainty** | % |  | G | 1 |  |
| B |  |  |
| T | 10 |  |
| **Stability** | % | Per decade | G | 0.1 |  |
| B |  |  |
| T | 1 |  |
| **Standards and References** |   ATBD and URD of ESA Lakes\_cci    Duguay, C.R., M. Bernier, Y. Gauthier, and A. Kouraev, 2015. Remote sensing of lake and river ice. In *Remote Sensing of the Cryosphere*, Edited by M. Tedesco. Wiley-Blackwell (Oxford, UK), pp. 273-306.  Wang, J., C.R. Duguay, and D.A. Clausi, V. Pinard, and S.E.L. Howell, 2018. Semi-automated classification of lake ice cover using dual polarization RADARSAT-2 imagery. *Remote Sensing*, 10(11), 1727; <https://doi.org/10.3390/rs10111727>. | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** | Yes | Yes (based on goals) | Transportation (shipping, ice roads) and food security (northern communities via ice roads) | | |
| **Extremes[3]** | Yes | Yes | Detection of extreme (cold, warm) ice years in relation to large-scale atmospheric teleconnection patterns (e.g. AO, NAO, PDO, ENSO) | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

NO COMMENT

## ECV Product: Lake ice thickness (LIT)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | **Lake ice thickness (LIT)** | | | | |
| **Definition** | Thickness of ice on a lake | | | | |
| **Unit** | cm | | | | |
| **Note** |   LIT measurements are largely based on in situ observational networks. Satellite-based retrieval algorithms are under development (research stage), not operational yet.    On-ice snow depth measurements are also useful for both climate monitoring as well as for assessing and improving lake models. | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | m | Point-scale for in situ measurements | G | 50 | From synthetic aperture radar (SAR) |
| B |  |  |
| T | 1000-10000 | From radar altimetry and passive microwave data (Kang et al., 2014) |
| **Vertical Resolution** | cm |  | G | 1-10 | Lower number from in situ measurements, higher number from satellite observations |
| B |  |  |
| T | 3-15 | Lower number from in situ measurements, higher number from satellite observations |
| **Temporal Resolution** | day |  | G | 1 | From satellite observations |
| B |  |  |
| T | 365 | Annual summary of in situ measurements from yearbooks |
| **Timeliness** | day |  | G | 1 | Using satellite telecommunication systems for in situ measurements; also daily from satellites for numerical models such as NOAA’s Great Lakes Coastal Forecasting System (GLCFS) |
| B |  |  |
| T | 365 | To support annual climate reporting |
| **Required Measurement Uncertainty** | cm |  | G | 5 |  |
| B |  |  |
| T | 15 |  |
| **Stability** | cm | Per decade | G | 1 |  |
| B |  |  |
| T | 10 |  |
| **Standards and References** | -   National standards  -   Kang, K.-K., C. R. Duguay, J. Lemmetyinen, and Y. Gel, 2014. Estimation of ice thickness on large northern lakes from AMSR-E brightness temperature measurements. *Remote Sensing of Environment*, 150: 1-19, <http://dx.doi.org/10.1016/j.rse.2014.04.016>. | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** | Yes | Yes (based on goals) | Transportation (shipping and ice roads) and food security (northern communities via ice roads) | | |
| **Extremes[3]** | Yes | Yes | Impact of cold/warm and low/high snow winters on ice growth and in relation to large-scale atmospheric teleconnection patterns (e.g. AO, NAO, PDO, ENSO) | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Zeli Tan | Email: tanzeli1982@gmail.com |
| Does Lake Ice Thickness proposed here also include lake snow? If so, is it possible to provide Lake Snow Thickness separately because snow and ice have large differences in physical properties, such as albedo and density. | |

## ECV Product: Lake Water Leaving Reflectance

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | **Lake Water Leaving Reflectance** | | | | |
| **Definition** | Water-leaving reflectance in discrete wavebands of electromagnetic radiation from near-UV through visible to near infrared and up to shortwave infrared, fully normalized for viewing and solar incident angles. | | | | |
| **Unit** | Dimensionless | | | | |
| **Note** |  | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | m |  | G | 100 | Smaller water bodies included with resolution < 300m, as demonstrated through Copernicus Global Land Service. |
| B | 10 | Rivers and small water bodies can be observed |
| T | 1000 | Medium to large sized water bodies (up to 50% of global inland water surface area), as demonstrated through ESA Lakes\_cci |
| **Vertical Resolution** | m |  | G | 1 | Identify thermal, density or bio-optical stratification |
| B | n/a | Identification of vertical stratification from above-water radiometry (requires hyperspectral sensors) |
| T | n/a | Water column is assumed well-mixed in the layer extending from the surface to the first optical depth, where 90% of reflected light interacts |
| **Temporal Resolution** | day | At equator | G | 1 | Decade-scale shifts in biological components become detectable in individual water bodies |
| B | <1 | Allows daily observations under variable cloud cover |
| T | 3-30 | Decade-scale shifts in biological components become detectable within global lake biomes |
| **Timeliness** | day | From observation day | G | 30 | Satellite observations supplied with reliable meteorological ancillary data |
| B | 1 | Episodic events can be detected in near real-time |
| T | 365 | Annual extension of existing data records based on measurements supplied with reliable meteorological records |
| **Required Measurement Uncertainty** | % | At peak reflectance amplitude | G | 10 | Expected to allow derived water column properties to be estimated within 0.1 mg m-3 chlorophyll-a  and 1 g m-3 suspended matter  or 1 NTU. See ESA Lakes\_cci URD. Impact of observation uncertainty will vary with lake type (shape of reflectance spectrum). |
| B |  |  |
| T | 30 | A threshold cannot be clearly defined for all optical water types and lake morphologies. A larger number of observations (large lakes) may compensate for increased per-observation uncertainty. |
| **Stability** | % | per decade | G | 0.1 | For in situ fiducial reference observations |
| B |  |  |
| T | 1 | Equates to 0.0001/decade for LWLR, 0.1 mg m-3 per decade for chlorophyll-a and 0.1 g m-3 for suspended matter or turbidity |
| **Standards and References** | ATBD and URD of ESA Lakes\_cci | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** | Yes |  | Through derived optical-biochemical water column properties such as phytoplankton biomass (by proxy of chlorophyll-a pigment concentration), turbidity or transparency and dissolved organic carbon. | | |
| **Extremes[3]** | Yes |  | Through derived optical-biochemical water column properties such as phytoplankton biomass (by proxy of chlorophyll-a pigment concentration), turbidity or transparency and dissolved organic carbon. | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

NO COMMENT

## ECV Product: Lake surface water temperature (LSWT)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | **Lake surface water temperature (LSWT)** | | | | |
| **Definition** | Temperature of the lake surface. | | | | |
| **Unit** | ºC | | | | |
| **Note** |  | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** |  |  | G |  | In situ observation by a point measurement on gauge |
| B |  |  |
| T | 1km2 | Using satellite technics |
| **Vertical Resolution** | - |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** | day |  | G | 1 |  |
| B |  |  |
| T | 360 | Annual  summary in the form of yearbook |
| **Timeliness** | month |  | G | 1 |  |
| B |  |  |
| T | 12 | For  yearbooks |
| **Required Measurement Uncertainty** | ºC |  | G | 0,1 |  |
| B |  |  |
| T |  |  |
| **Stability** | ºC/decade |  | G | 0,1 |  |
| B |  |  |
| T |  |  |
| **Standards and References** | Technical Regulations, volume III,Hydrology, 2006 edition, WMO-No.49 | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** | No |  |  | | |
| **Extremes[3]** | Yes |  | Long term annual water temperature variations  for big lakes may reflect climate extremes and their aspects. | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Chris Merchant | Email: c.j.merchant@reading.ac.uk |
| \*\* Definition:  "Temperature of the lake surface" -- suggest "Temperature of near-surface lake water", since defining the actual surface limits the measurement to radiometric techniques only (i.e., suggests only the skin temperature). Temperatures measured at near-surface depths should not be excluded.  Note:  Suggest add "The depth to which the temperature applies should be explicit"  \*\* Horizontal resolution:  Disagree that a point measurement makes sense as a goal (which means that more detailed information about a lake is not desirable), since a point measurements raises significant representativity questions. For comparison, in SST and similar ECV tables, no-one states an in situ point measurement as a resolution goal. This should be framed as the scale below which knowledge of LSWT distribution would not benefit increased understanding and given lake heterogeneity, especially nearshore and around inflows, I would have imagined something in the range of 10 m to 30 m would be appropriate as a goal, even if not yet achievable.  thank you for considering these comments  Chris  Well-calibrated LSWT at 100 m would be a breakthrough, I think. People are trying to use LandSat etc because it is potentially useful, but quantitative work is limited a bit by the calibration problems.  On the other hand, is 1 km really a threshold for usefulness of data for lake climatology? There have been many papers in recent years using data on the 5 km scale to uncover useful new science.  Vertical resolution is not applicable, so long as the near-surface depth is specified.  \*\* Temporal resolution:  Surely a goal is sub-daily, since the diurnal cycle may be relevant to many processes in some lakes. Perhaps 3 hourly is good. In situ systems often give more temporal resolution than this at a point, but I don't know how much extra benefit to understanding diurnal processes is gained (for profiles it is great, but this is surface).  Suggest move 1 day to being a breakthrough, since it is clearly desirable and not yet achieved by satellite systems (mainly because of cloud cover limitations).  As for threshold, 360 suggests an annual average, which is surely not helpful for many strongly seasonal lakes. The Copernicus land service provides a 10-day LSWT product, and possibly that indicates the threshold temporal resolution?  \*\* Timeliness:  Again the Copernicus land service 10-day LSWT service has a timeliness of 3 days (after the ten days), which is therefore presumably of use to their users. In that context a goal of 1 month says that 3 days timeliness is useless to anyone and would undermine them, so I think that should be avoided (and also I don't think 3 days timeliness is useless for monitoring thermal anomalies compared to climatological cycles).  I agree that the threshold is annual timeliness for annual climate reviews. the breakthrough should be inbetween threshold and goal, but I have no rationale for a number. Could plump for seasonal scale (3 months), but I don't really know.  \*\* Required measurement uncertainty"  0.1 K is a challenging goal, but why not, it would enable accurate determination of stratified periods, etc.  Recent papers on lake climatology have successfully drawn conclusions from data that have uncertainty ~0.6 K, so perhaps sets the threshold level? Again, no real rationale for "breakthrough" except that (say) 0.3 K would be significantly better than any satellite products currently available.  \*\* Stability  The suggest for goal is reasonable to me, given rates of change in lakes. This seems like something where the useful range is rather narrow: given observed rates of change, stability less good than 0.25 K/decade would compromise interpretation significantly. So is that the threshold? Again, I have no rationale for "breakthrough" except it should be between. | |

## ECV Product: Lake Water Extent (LWE)

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| --- | --- | --- | --- | --- | --- |
| **Name** | **Lake Water Extent (LWE)** | | | | |
| **Definition** | Areal extent of the surface of a lake. | | | | |
| **Unit** | Km2 | | | | |
| **Note** | LWE is only measurable using satellite imagery. For shallow lakes the LWE variable is more relevant than the Lake Water Level to detect climate change signal (Mason et al., 1994) | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | m |  | G | 10 | Using sentinel-2 missions. Allows to determine small extent variations |
| B |  |  |
| T | 30 | Using landsat (5,7,8) missions. Still relevant for shallow lakes with high extent potential variations |
| **Vertical Resolution** |  |  | G |  |  |
| B |  |  |
| T |  |  |
| **Temporal Resolution** | day |  | G | 5 | Looks reasonable for climate change studies. Consistent with possibilities offered by satellite technologies (sentinel-2 constellation can provide in the best case images every 5 days). Will allow detecting LWE changes linked to extreme events. |
| B |  |  |
| T | 30 | For long term evolution of lake extent changes monthly basis is still acceptable and usable. |
| **Timeliness** | day |  | G | 5 | To be consistent with temporal resolution and possibilities offered by satellite technologies (sentinel-2 constellation can provide in the best case images every 5 days) |
| B |  |  |
| T | 365 | Climate scale |
| **Required Measurement Uncertainty** | % |  | G | 5 | For LWE, the uncertainty relatively to the total surface makes sense. |
| B |  |  |
| T |  |  |
| **Stability** | %/decade |  | G | 5 |  |
| B |  |  |
| T |  |  |
| **Standards and References** | Algorithm Theoretical Basis Document (ATBD) of LWE (Lake Water Extent) calculation under ESA’s CCI (Climate change Initiative) program.  Mason I.M., Guzkowska M.A.J., Rapley C.G., and Street-Perrot F.A., (1994).the response of lake levels and areas to climate change, *Climate Change* 27, 161-197. | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** | No |  |  | | |
| **Extremes[3]** | Yes |  | Occurrence of extreme events can be observed in long term time series of lake water extent changes. | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Annett Bartsch | Email: Annett.Bartsch@polarresearch.at |
| The goal horizontal resolution is insufficent for Permafrost monitoring purposes. An optimal spatial resolution would be 0.5 meter and temporal resolution 1 day.  See NRC (2014) and further references for description of ponds and their importance in permafrost regions/Climate change monitoring are listed below.  National Research Council (2014). Opportunities to Use Remote Sensing in Understanding Permafrost and Related Ecological Characteristics: Report of a Workshop. Washington, DC: The National Academies Press. https://doi.org/10.17226/18711  Muster, S et al. (2017): PeRL: a circum-Arctic Permafrost Region Pond and Lake database. Earth System Science Data, 9(1), 317-348, https://doi.org/10.5194/essd-9-317-2017  Liljedahl et al. (2016):  Pan-Arctic ice-wedge degradation in warming permafrost and its influence on tundra hydrology. Nature Geoscience  https://www.nature.com/articles/ngeo2674 | |

### Comment 2

|  |  |
| --- | --- |
| Author: Andrew Ferrone | Email: pr.wmo.luxembourg@gmail.com |
| Luxembourg considers that Lake water extent is also relevant as adaptation indicator because the evolution of the extent of a lake may need adaptive measures if the lake is used as a drinking water reservoir, used for transport, used for irrigation (food supply),… | |

### Comment 3

|  |  |
| --- | --- |
| Author: ECMWF | Email: ecresgcosreqs@gmail.com |
| Lake water extent at global resolution of 1km (or better) and monthly frequency is important to partition surface energy fluxes. A static global lake cover (and lake depth) is an important first step. Processing of surface water bodies extend shall be interconsistent with land-use-land-cover.  Choulga, M., Kourzeneva, E., Balsamo, G., Boussetta, S., and Wedi, N.: Upgraded global mapping information for earth system modelling: an application to surface water depth at the ECMWF, Hydrol. Earth Syst. Sci., 23, 4051–4076, https://doi.org/10.5194/hess-23-4051-2019, 2019.  Pekel, J.-F., Cottam, A., Gorelick, N., and Belward, A. S.: High-resolution mapping of global surface water and its long-term changes, Nature, 540, 418–422, https://doi.org/10.1038/nature20584, 2016. | |

## ECV Product: Lake Water Level

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | **Lake Water Level** | | | | |
| **Definition** | Lake Water Level (LWL) | | | | |
| **Unit** | Elevation of the free surface of a lake relative to a specified vertical datum | | | | |
| **Note** | cm | | | | |
| **Requirements** | | | | | |
| **Item needed** | **Unit** | **Metric** | **[1]** | **Value** | **Derivation and References and Standards** |
| **Horizontal Resolution** | - |  | G |  | In situ observation by a point measurement on gauge |
| B |  |  |
| T |  |  |
| **Vertical Resolution** |  |  | G |  | In situ observation by a point measurement on gauge |
| B |  |  |
| T |  |  |
| **Temporal Resolution** | day |  | G | 1 |  |
| B |  |  |
| T | 365 | Annual  summary in the form of yearbook |
| **Timeliness** | day |  | G | 1 | In some case it can be interesting to have near real time lake level changes (in case of extreme events) |
| B |  |  |
| T | 365 | For yearbooks |
| **Required Measurement Uncertainty** | cm |  | G | 5 |  |
| B |  |  |
| T | 10 | Allows to use the considered characteristic in global and regional climate models |
| **Stability** | Cm/decade |  | G | 1 |  |
| B |  |  |
| T | 10 | Allows to use the considered characteristic in global and regional climate models |
| **Standards and References** | Technical Regulations, volume III,Hydrology, 2006 edition, WMO-No.49  Guide to Hydrological Practices, sixth edition,2008, WMO-No.168 | | | | |
| **Adaptation and Extremes** | | | | | |
|  | Relevant? (Yes/No) | Sugg. Req. sufficient? (Yes/No) | Explanation | | |
| **Adaptation[2]** | No |  |  | | |
| **Extremes[3]** | Yes |  | Long term water level variations for big lakes may reflect climate extremes and their aspects. | | |

[1]Goal (G); Breakthrough (B)(not mandatory, more as one possible); Threshold (T), for definitions see [Guidelines](http://tiny.cc/ecv-review)

[2] Is the ECV Product directly relevant to support Climate Adaptation?

[3] Can the ECV Product be used to monitor climate extremes or aspects of extremes?

### Comment 1

|  |  |
| --- | --- |
| Author: Andrew Ferrone | Email: pr.wmo.luxembourg@gmail.com |
| Luxembourg considers that Lake water extent is also relevant as adaptation indicator because the evolution of the extent of a lake may need adaptive measures if the lake is used as a drinking water reservoir, used for transport, used for irrigation (food supply),… | |