Response to Comments by Anonymous Referee #1:

General comments:

The manuscript presents a global dataset, LI-CCR, of daily lake ice coverage (LIC), annual ice status, lake ice phenology (LIP), and the probability of complete ice-cover occurrence (PCIO) for 32,800 lakes across cold-climate regions from 2002 to 2024. Given that lake ice is recognized as an Essential Climate Variable (ECV), this long-term, high-frequency dataset improves the representation of small and medium-sized lakes. The manuscript is generally well organized and clearly written. I only have a few minor comments related to the discussion of uncertainties and the potential future applications of the dataset.

Response:

We thank the reviewer for the positive assessment of our manuscript and for the constructive suggestions regarding the uncertainties and potential applications of the LI-CCR dataset. In response, we have made three main revisions.

First, we added lake-size-stratified analyses in Sects. 4.1.1–4.1.3 to assess (i) improvements in data availability achieved by the cloud-gap-filled workflow, (ii) consistency of LIC classifications under clear-sky conditions and at cloudy pixels after reconstruction, and (iii) the accuracy of the derived LIP.

Second, we expanded Sect. 5.1 to discuss uncertainties associated with wind-driven ice formation, breakup, redistribution, together with limitations in satellite detection during freeze-up and breakup periods.

Third, we added a new subsection (Sect. 5.3) outlining potential applications of LI-CCR in climate-change assessments, the evaluation of lake-ice and lake-thermodynamic models, and studies of lake–atmosphere carbon and energy exchanges.

Finally, we double checked the entire manuscript and corrected additional inconsistencies in units, abbreviations, terminology, grammar, and wording. Detailed responses and the corresponding manuscript revisions are provided below.

Specific comment 1:

The validation section could further illustrate how lake size influences the performance and uncertainty of different observation methods. For example, methods such as passive remote sensing may show larger uncertainties for small lakes, as noted in the Introduction.

Response:

We thank the reviewer for this constructive suggestion. We agree that lake size affects the performance and uncertainty. However, passive-microwave monitoring is generally limited to large lakes, precluding a robust assessment of lake-size effects across a broad range of lake sizes. We therefore investigated how the lake size influences cloud-gap-filled performance (Sect. 4.1.1), accuracy of lake ice cover results for clear-sky and cloudy conditions (Sect. 4.1.2), and the consistency of lake ice phenology estimates (Sect. 4.1.3).

For the cloud-gap-filled performance, the final proportion of unremoved pixels decreased with increasing lake size, from 34.3 % for lakes of < 10 km² to 17.5 % for lakes > 100 km². Thus, larger lakes provide more valid spatial information for gap filling.

In the external comparison with Sentinel-3 LIE-NH, the overall accuracy of the lake ice cover for the lakes of <10 km², 10–100 km², and ≥100 km² was 98.1 %, 97.9 %, and 98.7 % under clear-sky conditions, and 96.6 %, 96.4 %, and 97.8 % under cloudy conditions, respectively. Thus, ice/water classification accuracy was not influenced by the lake size.

For the lake ice phenology, we added comparisons with the MODIS-based GLIP dataset, the latter covering more than 25,000 matched lakes. The results of small and medium-sized lakes did not show systematically weaker consistency than large lakes. For example, the freeze-up end (FUE) R^2 values were 0.77, 0.77, and 0.79 for small, medium, and large lakes, respectively, while the corresponding the break-up end (BUE) R^2 values were 0.93, 0.95, and 0.96. The consistency was broadly comparable among lake-size classes, although BUE was consistently more concordant than FUE.

These results clarify that lake size primarily influences the observability and gap-filling capacity within LI-CCR, but does not produce a systematic decline in the LIC accuracy or LIP consistency.

Specific comment 2:

The discussion could mention potential biases related to wind speed, which may influence ice formation and/or breakup processes and remote-sensing detection during transitional periods.

Response:

Thank you for this insightful comment. We agree that wind forcing can affect both the physical evolution of lake ice and its satellite-based detection, particularly during freeze-up and break-up.

We have expanded Section 5.1 to explain that stronger wind forcing can fracture, transport, and redistribute thin or weak ice during these transitional periods, causing ice convergence and pile-up near shorelines while exposing open water elsewhere. Such rapidly changing and spatially heterogeneous conditions can alter the actual ice distribution and bias MODIS-derived LIC estimates and threshold-based phenology. This discussion is supported by previous observations from Nam Co, Lake Khovsgol, and Lake Peipsi (Gou et al., 2015; Zhang et al., 2021; Reinart and Pärn, 2006).

References cited in this response:

Gou, P., Ye, Q., and Wei, Q.: Lake ice change at the Nam Co Lake on the Tibetan Plateau during 2000-2013 and influencing factors, Progress in Geography, 34, 1241-1249, 10.18306/dlkxjz.2015.10.004, 2015.

Reinart, A. and Pärn, O.: Ice conditions of a large shallow lake (Lake Peipsi) determined by observations, an ice model, and satellite images, Proceedings of the Estonian Academy of Sciences. Biology. Ecology, 55, 243-261, 10.3176/biol.ecol.2006.3.05, 2006.

Zhang, J., He, P., Hu, X., and Liu, Z.: Dynamic Lake Ice Movement on Lake Khovsgol, Mongolia, Revealed by Time Series Displacements from Pixel Offset with Sentinel-2 Optical Images, Remote Sensing, 13, 4979, 10.3390/rs13244979, 2021.

Specific comment 3:

It would be helpful to further expand the discussion on potential future applications of this dataset, such as its use in climate studies, lake modeling, and lake-atmosphere interaction research.

Response:

We thank the reviewer for this careful and constructive suggestion. We agree that the potential applications of LI-CCR were not sufficiently discussed in the original manuscript, and we have therefore added a new subsection, 5.3 Potential future applications of the LI-CCR dataset which discusses LI-CCR as an observational tool for two complementary research areas: (i) lake–atmosphere exchanges of carbon and energy; and (ii) evaluation of lake-ice and lake-thermodynamic processes in land-surface, regional climate, and Earth system models. We have also clarified that LI-CCR provides daily ice coverage and phenological information and should be combined with complementary data on lake properties and meteorological forcing. Relevant references have been added to support these applications.

References cited in this response:

Denfeld, B. A., Baulch, H. M., del Giorgio, P. A., Hampton, S. E., and Karlsson, J.: A synthesis of carbon dioxide and methane dynamics during the ice-covered period of northern lakes, Limnology and Oceanography Letters, 3, 117-131, https://doi.org/10.1002/lol2.10079, 2018.

Huang, W., Zhang, Z., Li, Z., Lepparanta, M., Arvola, L., Song, S., Huotari, J., and Lin, Z.: Under-Ice Dissolved Oxygen and Metabolism Dynamics in a Shallow Lake: The Critical Role of Ice and Snow, Water Resources Research, 57, e2020WR027990, https://doi.org/10.1029/2020WR027990, 2021.

Pietikainen, J.-P., Markkanen, T., Sieck, K., Jacob, D., Korhonen, J., Raisanen, P., Gao, Y., Ahola, J., Korhonen, H., Laaksonen, A., and Kaurola, J.: The regional climate model REMO (v2015) coupled with the 1-D freshwater lake model FLake (v1): Fenno-Scandinavian climate and lakes, Geoscientific Model Development, 11, 1321-1342, https://doi.org/10.5194/gmd-11-1321-2018, 2018.

Subin, Z. M., Riley, W. J., and Mironov, D.: An improved lake model for climate simulations: Model structure, evaluation, and sensitivity analyses in CESM1, Journal of Advances in Modeling Earth Systems, 4, M02001, https://doi.org/10.1029/2011MS000072, 2012.

Technical correction 1:

Line 26: The link of dataset might contain an extra space that should be removed.

Response:

Thank you for identifying this typographical issue. We have removed the extra space from the dataset DOI link.

Technical correction 2:

Line 83: It might be helpful to specify the area range of the 32,800 lakes (e.g., >2 km2).

Response:

Thank you for this helpful suggestion. We have revised the text to clarify that the LI-CCR includes lakes with surface areas greater than 2 km^2.

Technical correction 3:

Line 310: "PICO" should be corrected to "PCIO".

Response:

Thank you for identifying this typographical error. We have corrected "PICO" to "PCIO" in the manuscript.

Technical correction 4:

Eq. (3): "Nremove" should be corrected to "Nremoved".

Response:

Thank you for identifying this typographical error. We have corrected N_{remove} to $N_{removed}$ in Eq. (3).

Technical correction 5:

Fig. 6 caption: A ":" is missing after "Figure 6".

Response:

Thank you for identifying this formatting error. We have added the missing colon after "Figure 6" in the figure caption.

We sincerely thank the reviewer for the careful and constructive comments. We believe that these revisions have improved the clarity, rigor, and overall presentation of the manuscript.