This research applied image fusion of Landsat OLI and GOCI images using ESTARFM, then extracted linear structure on the lake ice surface of the high spatial temporal fusion images and monitored the changes in surface morphology in Chagan Lake. Through the correlation analysis with meteorological factors, it showed that the surface morphology is closed related to wind direction, snowfall, and air temperature. This paper provided a good idea for monitoring lake ice surface morphology. However, there are still some improvement should be made and some mistakes need to be corrected in the manuscript.

Reply to comment: Thank you for your comments concerning our manuscript entitled "The Capability of high spatial-temporal remote sensing imagery for monitoring surface morphology of lake ice in Chagan Lake of Northeast China" (tc-2022-175). Those comments are all valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our work. We have carefully gone through the comments and made corrections accordingly, marked as red in the manuscript.

1、 Line 11-14, "The surface morphology of lake ice undergoes remarkable changes under the combined influence of thermal and mechanical forces, which has been rarely observed by remote sensing. A large-scale linear structure has repeatedly appeared on satellite images of Chagan Lake in recent years." The first sentence said the surface morphology has been rarely observed by remote sensing, the second sentence said that a large-scale linear structure has repeatedly appeared on satellite images of Chagan Lake in recent years. So, why it was rarely observed before and appeared recently? Is it because of the remote sensing image with course resolution or there are few surface morphology before?

Reply to comment: Thank you for your question, the sentence is not appropriate herein, and we modified it, as follows (Line 12-13).

The surface morphology of lake ice remarkably changes under the combined influence of thermal and mechanical forces. However, research on the surface morphology of lake ice and its interaction with climate is limited.

Then we come to your question. A large-scale linear structure has repeatedly appeared

on satellite images of Chagan Lake in recent years. We checked the quick images of three sensors of Landsat since 1986, including TM, ETM+, and OLI (Figure 1). A similar linear structure had been found on the Landsat quick images during 18 of those 35 cold seasons.

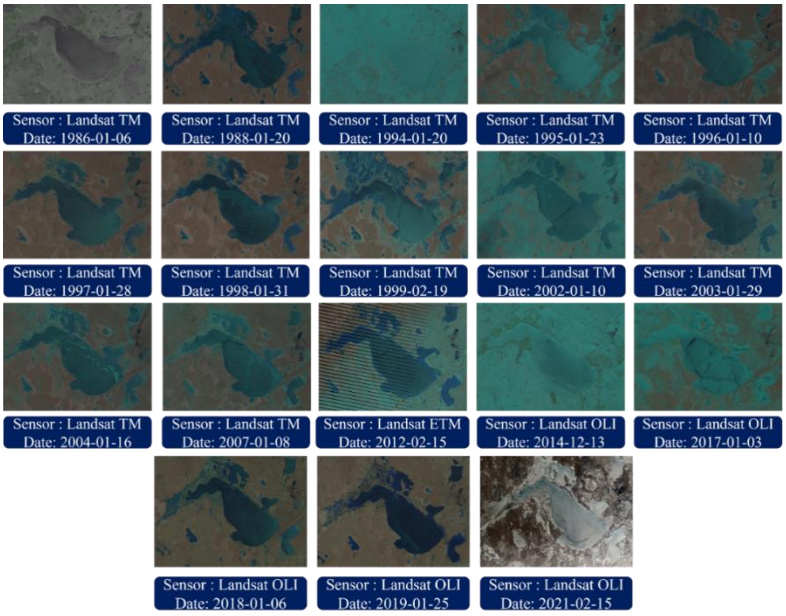

Figure 1. The quick images of Landsat with similar cracks. We checked three sensors of Landsat for 35 cold seasons since 1986, including TM, ETM+, and OLI.

So, why it was rarely observed before and appeared recently? The lake area of Chagan is only 372 km^2, and the small lake hasn't received wide attention. Scarce work has been carried out for frozen lakes in Northeast China. Moreover, the image quality limited the remote sensing monitoring. Figure 2 presents the satellite images of Landsat OLI 8 with the best quality for each year. The existence of snow cover and cloud cover makes it difficult to extract the length and angle of linear structure. Only the images during 2018-2019 provide suitable materials for further exploration.

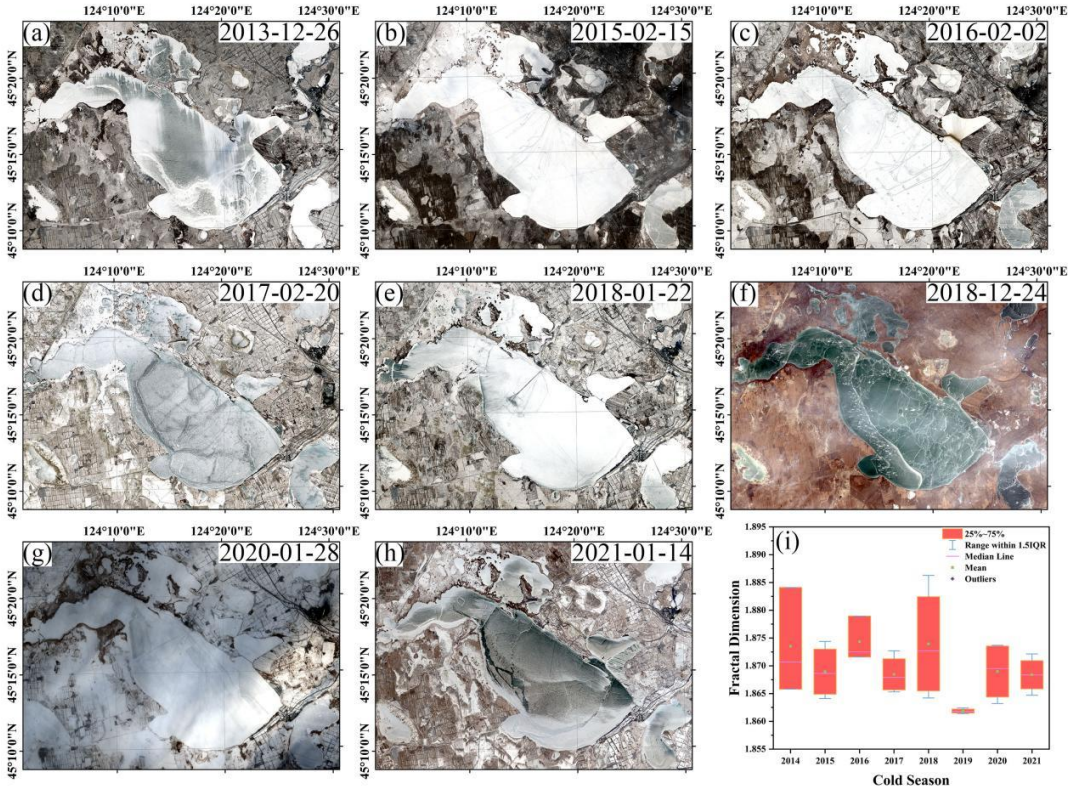

Figure 2. The satellite images of the frozen Chagan Lake with the best quality for the cold seasons from 2013 to 2020.

2、 Line14, "We prosed a method to extract linear structure on the lake ice surface." According to the manuscript, the extraction method of linear structure on the lake ice surface is not proposed in this paper, but your work before.

Reply to comment: Thank you for your careful question. We re-write this sentence in the abstract as follows (Line 16-18).

We merged the Landsat and GOCI images using an enhanced spatial and temporal adaptive reflectance fusion model (ESTARFM), and extracted the lengths and angles of the linear structure. We monitored the hourly changes in the surface morphology during the cold season from 2018 to 2019.

3、 Line 51-54, these sentences do not fit in here. You said, "multi-sensor, multitemporal and multi-spatial resolution remote sensing image data have been successfully applied to monitoring the lake ice" in end of last paragraph. Then the

common fusion methods should be described. While the high spatial-temporal resolution fusion such as Landsat and MODIS fusion is just one of these fusion methods.

Reply to comment: Thank you for the professional question. The logic is not reasonable herein, and we modified as below (Line 50-51):

Although multi-source remote sensing is available to monitor lake ice processes, single-sensor remote sensing data cannot simultaneously achieve accurate remote sensing monitoring and high frequency.

4、 Line 134， Why are the reflectance images of Landsat band 2 and GOCI band 3 chosen to be fused? Why not the Pan band of OLI with 15m resolution?

Reply to comment: This is a good question and giver us insight into our work. we chose the two bands considering the spectral feature of the water body. Table 1 compares the band information of Landsat and GOCI. From it, we can find that the band range of band 3 of GOCI (480-500 nm) overlaps with that of band 2 of Landsat 8 OLI (450-515 nm). The water body had relatively strong reflectance in the blue band (400-480 nm), and the blue band images clearly display the linear structure. The table and the corresponding content have been added to the new version of the manuscript.

Table 1 The comparison of band information between GOCI and Landsat. The selected bands for merging Landsat and GOCI are marked with red.

Band	GOCI		Landsat 8 OLI	
	Band centre (nm)	Bandwidth (nm)	Band centre (nm)	Bandwidth (nm)
Band 1	402-422	20	433-453	20
Band 2	433-453	20	450-515	65
Band 3	480-500	20	525-600	75
Band 4	545-565	20	630-680	50
Band 5	650-670	20	845-885	40
Band 6	675-685	10	1560-1660	100
Band 7	735-755	20	2100-2300	200
Band 8	845-885	40	500-680	180

5、 Line 138, “estarfm” should be capitalized.

Reply to comment: Thank you for your suggestion, we have modified the corresponding content in the text (Line 148).

6、 There are some problems in formula 1

(1) There are two “n” in the formula, k=m,n and i=1 to n

(2) L is “Landsat OLI”, but not “MODIS ”

(3) How to calculate the *Wi* and the *Vi*, and what is the convert coeffects?

(4) I think the formula is STARFM but not the ESTARFM

Response: Thank you for your professional question. After our confirmation that Equation 1 is the formula of STARFM model, we have modified it to the formula of ESTARFM model in the text with detailed explanation of the formula.

Reply to comment: We feel very sorry for the errors, and we updated the expressions in the new version of the manuscript (Line 149-163).

The ESTARFM, in which two pairs of Landsat and GOCI images were used to generate spatial-temporal fusion data, was proposed by Zhu et al. (2010) based on the STARFM. Firstly, the coarse GOCI data were projected and resampled to a fine Landsat image at two known times tm and tn. Secondly, similar neighborhood pixels were searched with a moving window by setting spectral differences. Thirdly, we calculated the normalized weight of each similar pixel by considering the spatial, spectral, and temporal differences. Then, the coarse GOCI values were transferred to fine Landsat data using the pixel-based conversion coefficients in the linear regression. Finally, the coarse GOCI data at the same time were used to calculate the fine fusion data at the predicted time (t_p), expressed as follows (Liu et al., 2021; Bai et al., 2017; Zhu et al., 2010):

$$L_b\left(x_{w/2}, y_{w/2}, t_p\right) = T_m \times L_{bm}\left(x_{w/2}, y_{w/2}, t_p\right) + T_n \times L_{bn}\left(x_{w/2}, y_{w/2}, t_p\right) \quad (1)$$

where L_b ($x_{w/2}$, $y_{w/2}$, t_p) is the final predicted fine-resolution reflectance at the prediction time t_p; w represents the size of the moving window, and the corresponding center is ($x_{w/2}$, $y_{w/2}$); L_{bk} ($x_{w/2}$, $y_{w/2}$, t_p) is the fine-resolution reflectance at t_k (k = m or n) at the base date; Tk is the time weight, calculated from the magnitude of the detected change

in the reflectance of the coarse spatial resolution image between t_m and t_n and the prediction moment t_p;

$$T_k = \frac{1/\left|\sum_{j=1}^{w}\sum_{i=1}^{w} C\left(x_j, y_i, t_k\right) - \sum_{j=1}^{w}\sum_{i=1}^{w} C\left(x_j, y_i, t_p\right)\right|}{\sum_{k=m,n}\left(1/\left|\sum_{j=1}^{w}\sum_{i=1}^{w} C\left(x_j, y_i, t_k\right) - \sum_{j=1}^{w}\sum_{i=1}^{w} C\left(x_j, y_i, t_p\right)\right|\right)}, (k = m, n) \quad (2)$$

where $C(x_j, y_i, t_k)$ and $C(x_j, y_i, t_k)$ denote the image element values of similar image elements (x_i, y_j) within the moving window of the coarse spatial resolution image at the reference moment t_k and prediction moment t_p, respectively.

7、 Line 172, "The high R2 between actual and predicted images was 0.935 on November 28, 2018, which proved that the fusion images are consistent with the remote sensing data." I think there is no Landsat OLI image on November 28, 2018, how can you do that?

Reply to comment: We are sorry for the mistake and thank you for the mistake. The correct date is November 22, 2018, and we have modified it (Line 183-184).

Line 176, "Estarfm" shoud be capitalized.

Reply to comment: Thank you for your suggestion, we have modified the corresponding content in the text (Line 185).

Line 191, figure 9 should be figure6.

Reply to comment: Thank you for your careful check, we delete the Figure 9.(Line 198).

10、 Line 214, "However, the ice ball was frozen beneath the ice surface, and the surface was relatively smooth." Is it said the ice ball of 2022? It should be clear in the manuscript.

Reply to comment: Thank you for your suggestion, and we delete the related contents of ice ball (Line 217-221).

11、 Line 257, same as the second comment.

Reply to comment: Thank you for the helpful suggestion, we updated as you suggest as below (Line 302-303).

We calculated the lengths and the angles of the linear structure on the fusion images in the freeze-up and break-up processes during the cold season from 2018 to 2019.

12、 Line 275, "From Figure 9, the occurrence of ice ball needs to meet the strict requirements of climate conditions together during the frozen process:" It seems that the conditions for the occurrence of ice ball are summarized in Figure 9. However, line 281 is "During the past decade, only the cold season of 2020 and 2021 could meet all three conditions". Here, the logic is not clear.

Reply to comment: Thank you for the professional suggestion. and we delete the related contents of the ice ball. This paragraph has been deleted。