## Response on RC1

We thank the reviewer for these helpful comments and suggestions. We have addressed the comments and will implement the proposed changes in the manuscript. Please, see below our detailed response. Major Comments were responded to in paragraphs, and Line Comments were responded to point by point.

Our response is highlighted in blue. We will provide a track-change version together with the revised paper.

## Summary

The article provides an overview of a new satellite that allows for detection of sea ice leads at a spatial resolution not possible with any other satellite. This is novel and interesting, however, the results as presented appear to over-emphasize the accuracy and precision of the results given the limited extent of the analysis.

**Response:** Thanks for your time and constructive comments on our manuscript. We have addressed the limitations of this study in Conclusion section:

"Nevertheless, limited by the imaging time and cloudy conditions over the Arctic region, only individual case studies based on TIS data were carried out."

## Major Comments

The comparisons against other moderate resolution products are incomplete. The focus of the analysis presented is on narrow leads that go undetected at moderate resolution (1km). The equally important but overlooked analysis would be the moderate (1km) resolutions results interpolated into higher resolution (30m). When detecting the same lead, how often do moderate resolution results over estimate (or under estimate) the lead area relative to the higher resolution detections. The claim that high resolution results detect more lead area because it can detect narrower leads is incomplete without establishing that moderate resolution lead detections do not have a bias in lead area. Because, visual inspection of the results suggest that moderate resolution lead detections have a bias in terms of over-representing lead area for leads that are wide enough to be detected. It may be true that more leads can be detected by a 30 m resolution imager, but the total lead area detected at 30 m resolution may not necessarily be higher overall if the 30 m lead detections do not have the same bias towards over-representing lead area for larger leads.

**Response:** In fact, we did not intentionally interpolate the MOIDS-derived leads to 30 m. The sea ice lead area derived from MODIS IST in Table 6 was calculated from at its original resolution of 1 km, while the area derived from the TIS was calculated at a resolution of 30 m.

We tried to understand that the argument raised by the reviewer, which might be briefly summarized “more leads detected by TIS does not mean that more lead areas obtained compared to the MODIS data”. This might be true. However, interpolation of the coarse-resolution (1000 m) to a high-resolution (30 m) probably can induce more problems on uncertainty of the brightness temperature data than the detection results using the original data. This is beyond scope of the presented study. Some previous studies applied interpolation methods to obtain high-resolution lead detection, and then estimated heat fluxes over them. For example, Qu et al. (2019) used cubic convolution interpolation to resample the Landsat-8 TIRS imagery from the resolution of 100 m to 30 m. Their results showed that the high-resolution TIRS data gave a slightly smaller lead area but a larger lead length compared to the MODIS data, which resulted in small leads accounting for more than a quarter of total heat flux. Applying a convolutional neural network, Yin et al. (2021) obtained the super-resolution MODIS data at 100 m resolution and more reliable heat flux estimations than those at original 1 km resolution and interpolation-based high resolution. But as we explained above, interpolation of the remote sensing data from coarse resolution to high resolution can induce some uncertainties, particularly for this study that TIS data has a resolution of 30 times better than the MODIS data.

Although we cannot assess the extent to which moderate-resolution detection under or over estimates results compared to high resolution, the statistical results shows that the lead area derived by the TIS at high resolution is larger than the moderate-resolution result by the MODIS IST. Thus, the leads that were unobserved at moderate resolution contribute more to the detection result in the cases of this study.

The justification for using a 3 channel approach is a little weak. There is mention of how there is ozone absorption in band 1, but the authors appear to be correlating ozone absorption with the air temperature near the surface rather than the air temperature in the ozone layer in the upper atmosphere. Also, the analysis of how the 11 and 12 micron channels (bands 2 and 3) compare in their sensitivity to ice vs water clouds is lacking; again the thermal contribution of water vapor and ice would tend to be much higher in the atmosphere than 2m.

**Response:** The SDGSAT-1 TIS has three infrared bands, all of which play an important role in surface temperature retrieval. Apart from the B2 and B3 bands, the B1 band is also a valid infrared channel for temperature measurement that can provide additional thermal information for use with B2 and B3 in the triple split window algorithm (Liu et al., 2021). The detection accuracy of the B1 band is slightly lower than the B2 and B3 bands, but still within a satisfactory level. We agree that for robustness purposes, it would be better to use the infrared band with the best detection performance (e.g., the B2 band). However, as the first study to apply the SDGSAT-1 TIS for lead detection, it is necessary to demonstrate the application of a combination of the three bands in addition to individual bands in this study.

With respect for the ozone data used in the Discussion section, we aimed to analyze the sensitivity of the B1 band to ozone solution, which were pointed out by previous studies (Wan and Li, 1997). Our results show that although ozone affects the absolute temperature of the B1 band, it does not diminish the thermal contrast, i.e., it does not affect the performance of lead detection.

It is true that the sensitivity of the B2 and B3 bands to ice and water clouds has not been analyzed in this study, because the low cloud cover in the selected TIS data makes such a comparison unnecessary.

Indeed, the correlation analyze between temperature characteristics and total cloud cover and total column water vapour (based on ERA5 product) has been carried out, but no correlation was found. It may be that the spatial resolutions (30 m for TIS vs 0.25 degree for ERA5) differ so much, or as mentioned earlier the TIS data selected are relatively clear, that it is difficult to detect correlations.

## Line Comments

Line 9: Use “sea ice” rather than “sea ice cover”.

**Response:** Done as it is suggested.

Line 9: Use “between” rather than “from” because the heat exchange can go in either direction.

**Response:** Done as it is suggested.

Line 15: The I-band on VIIRS has an IR resolution of 375m at 11 microns. So I would say that the resolution is an order of magnitude improvement rather than 2 orders of magnitude; hundreds of meters rather than kilometers.

**Response:** Thanks for pointing it out. We modified the sentence to “the spatial resolution of leads by infrared remote sensing increases from the scale of hundreds to tens of meters” in the revised version.

Line 16: It does not seem appropriate to attribute 4 significant digits to the results; the results may be 96% accurate, but the precision of the 0.01% is not likely.

**Response:** Thanks for your comment. After further consideration, we decided to use three significant digits, such as 96.3%. The corresponding tables and descriptions have been revised in the revised version.

Line 35-36: There are examples of the heat flux occurring in either direction (see above comment about line 9)

**Response:** Done as it is suggested.

Line 54: This overlooks the importance of clouds, cloud shadows, and the thermal contrast as ice ages.

**Response:** We agree with you that it is important to discriminate leads from clouds and cloud shadows and different ages of ice. The sentence has been modified:

"For sea ice lead detection based on thermal infrared data, the key lies in deriving thermal contrasts, namely, the temperature anomaly between sea ice and open water, and to distinguish leads from thermal contrasts caused by ice ages and clouds" in the revised version.

Line 76: This 1993 paper is too old – it references AVHRR – which does not describe the detection capabilities of modern satellite imagers.

**Response:** Yes, it is true that AVHRR was used in (Key et al., 1993). However, we cited it here because it suggested the effect of sensor resolution on lead statistics and therefore highlighted the importance of observing leads in a fine scale. We have replaced it with another literature, but also old. Since the effect of sensor resolution on lead statistics is well known, there has been relatively little research in recent years.

The corresponding sentence has been modified as: "Key et al. (1994) assessed the effect of sensor resolution on lead width statistics. They suggested that the mean lead width 'grows' as the pixel size builds up in gradually degraded images."

Line 78: Clarify what is meant by "resolve". Satellite imager can "detect" sub-resolution thermal emissions – if the thermal contrast is larger enough. Does this line mean just mean that it hard to attribute a width to sub-resolution features?

**Response:** We agree that for leads with widths less than pixel resolution, it is indeed possible to be represented as "mixed pixels" in thermal images. The sentence was deleted.

Line 92: The word "parallel" can be removed, it does not add any descriptive value.

**Response:** Done as it is suggested.

Line 111, Table 1: Is the expected noise still on the order of 0.2K at the cold end of the temperature range?

**Response:** The onboard blackbody is the primary calibration source for SDGSAT-1 TIS, and usually controlled at a constant low temperature. In the prelaunch test (Hu et al., 2022), the blackbody temperature varies from 240 K to 300 K. The NEdT at 300 K for the three TIS bands is 0.034 K, 0.047 K and 0.076 K respectively, which satisfy the pre-flight requirements (<0.2 K). Noise rises mainly with increasing temperature. Thus, although no NEdT was recorded at the cold end, the NEdT at nominal blackbody background temperature of 300 K is essentially representative of the performance of the TIS. The corresponding reference is：

Hu, Z., Zhu, M., Wang, Q., Su, X., and Chen, F.: SDGSAT-1 TIS Prelaunch Radiometric Calibration and Performance, Remote Sensing, 14, 4543, 10.3390/rs14184543, 2022.

Line 131: What is level-4 data?

**Response:** The SDGSAT-1 data products include different Level-1, Level-2 and Level-4 data products. Level-1 product is a standard product based on the Level-0 product, after data processing such as relative radiometric correction, band registration, HDR fusion, etc. Level-2 product is based on the Level-1 product after geometric correction. Level-4 product is based on the Level-1 product after ortho-rectification using ground control points and Digital Elevation Model (DEM) and output with standardized format. Currently, only Level-4 product is available to users. We have added corresponding reference in the revised version:

International Research Center of Big Data for Sustainable Development Goals (CBAS): SDGSAT-1 Data Users Handbook (Draft), 2022. http://60.245.209.56/preview/20221125/c84c0b5d89984cd384ffa05dbb163d14.pdf

Line 135: The first sentence is hard to understand. Could it be rephrased as “is a two satellite constellation” rather than “is formed by two satellites”?

**Response:** The sentence is modified as “Sentinel-2 (S2) is a constellation of two satellites, S2A and S2B”.

Line 139: Do you just mean that 560 nm is close to green on the visible spectrum? Why is that important? Is this saying that leads appear to be green in color?

**Response:** We visually compared S2 visible images (bands 2, 3 and 4) and found good discrimination between leads and surrounding sea ice from green band images. This may be because the green band primarily reflecting the differences between leads and sea ice rather than the differences between different types of sea ice, due to the generally low top-of-atmosphere (TOA) reflectance of sea ice in the green band (König et al., 2019). Therefore, it is appropriate to use the S2 green band images as the reference for validation. However, it does not mean that sea ice leads appear to be green in color.

Analogous situation can be found in the reflectance histogram of the three S2 bands (see Figure R1), i. e., the reflectance of the green curve is lower than the other two. For each histogram curve, the highest peak represents the surrounding sea ice, while the gentle slope and the lower peak represent the lead with seawater and thin ice. We noted that both peaks in the green band are more prominent, producing a good discrimination between sea ice and leads. It is easier to select a threshold at the valley between the two peaks (after obtaining the normalized image).

König, M., Hieronymi, M., and Oppelt, N.: Application of sentinel-2 MSI in Arctic research: Evaluating the performance of atmospheric correction approaches over Arctic sea ice, Frontiers in Earth Science, 7, 22, 10.3389/feart.2019.00022, 2019.

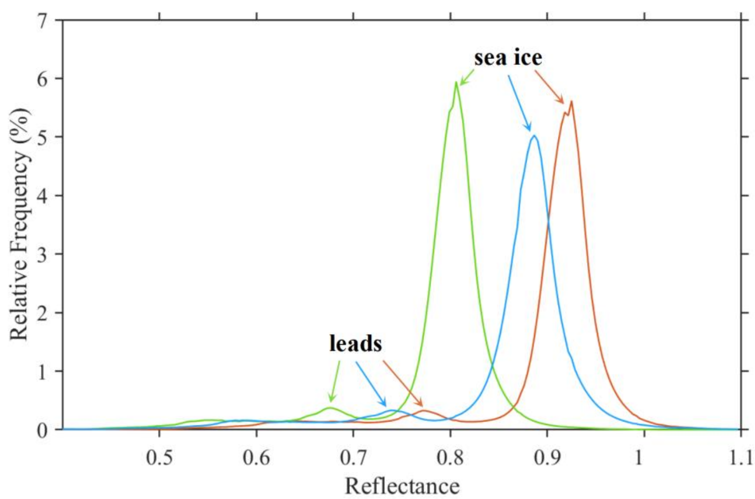



Figure R1 Histogram of reflectance in S2 band 2 (red line), band 3 (green line) and band 4 (blue line).

Line 150 & 151: Remove “The” in front of “MODIS”.

**Response:** Done.

Line 152: Why are level 3 products used instead of level 2 (or level 1)?

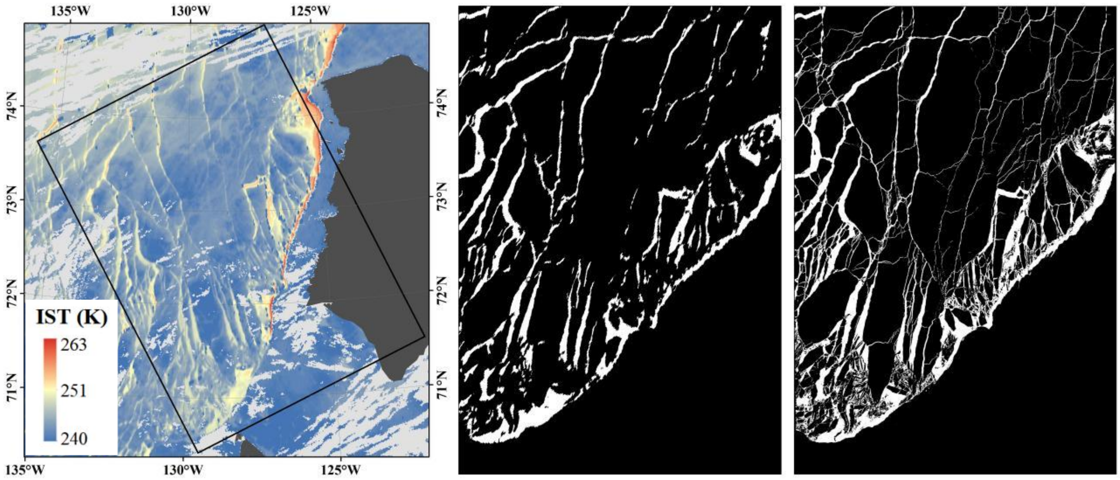
**Response:** Thanks for your valuable comment. We have conducted the comparison experiment for level-2 MOD29 and SDGSASAT-1 TIS data. Corresponding MOD03 geographic products were also used, as the data information listed in Table R1.

Leads were detected from the MOD29 data by the same method described in the original manuscript. The statistics of the lead area based on different data are listed in Table R2. Overall, the area estimated from the TIS data is larger than that estimated from MODIS IST, with the total area exceeding the latter by a third. The second comparison (on April 28) shows more reasonable result. These experiments will be presented in the revised version (if the editor decides the manuscript can be revised). Correspondingly, the correlation experiment in section 5.1 will be modified.

We would like to re-emphasize that while moderate resolution sensors over-represent the width of leads, this study showed that the narrow leads overlooked at moderate resolution are more important and contribute more to the overall lead area.

Table R1 Information of MODIS products used in this study

<table>
<tr><th colspan="2"></th><th>MOD29</th><th>MOD03</th></tr>
<tr><td rowspan="3">Date and time (UTC)</td><td>2022-03-23</td><td>10:30<br>12:05</td><td>10:30<br>12:05</td></tr>
<tr><td>2022-04-03</td><td>05:10</td><td>05:10</td></tr>
<tr><td>2022-04-28</td><td>05:05</td><td>05:05</td></tr>
<tr><td colspan="2">Spatial resolution</td><td>1 km</td><td>1 km</td></tr>
</table>




(a) (b) (c)

Figure R2 Comparisons between lead detection based on MOD29 and SDGSAT-1 TIS data in the Beaufort Sea on April 3, 2022. (a) Level-2 MODIS IST products, where the clouds are off-white, the land is dark gray, and the overlaid black border denotes a coverage for (b), (c). (b) Leads at 1 km resolution derived by MODIS IST product. (c) Leads at 30 m resolution derived from the combined result of SDGSAT-1 TIS B1, B2 and B3 bands.

Table R2 Statistics of the lead area estimated from the MODIS IST data (level 2) and the SDGSAT-1 TIS data.

| | | **Sea ice lead area (km$^2$)** | | | **Additional lead area by the TIS than by Hoffman et al. (2022b) (km$^2$)** |
|---|---|---|---|---|---|
| | | MODIS IST | SDGSAT-1 TIS | TIS/MODIS | |
| **1** | Beaufort Sea on April 3 | 14,283 | 15,362 | 1.08 | 5,679 |
| **2** | Beaufort Sea on April 28 | 4,238 | 10,500 | 2.48 | 4,590 |
| **3** | Laptev Sea on March 23 | 4,021 | 4,519 | 1.12 | 1,462 |
| **4** | Laptev Sea on March 23 | 3,886 | 3,936 | 1.01 | 2,415 |
| | **Total** | **26,427** | **34,318** | **1.30** | **14,145** |

Line 158: While it is true that MODIS-Terra crosses the equator in the morning, this does not have any correlation with what time of day the satellite will provide coverage in the Arctic. And again, level 1 or 2 products will provide a better time-match than averaged level-3 products.

**Response:** Thanks for your comment. MODIS-Terra based products can be matched to SDGSAT-1 well, with an average time difference of 1 hour. Therefore, we mainly used the MOD29 IST data. We have taken your advice and conducted the comparison experiment for level-2 MOD29 and SDGSASAT-1 TIS data. Please refer to the previous response for the comparison.

Line 160-164: What is the importance of the near-surface air temperature? If there is ozone, water vapor, or ice crystal absorption, those phenomena would be occurring much higher in the atmosphere.

**Response:** Thanks for your comment. We agree with you that the absorption effect of atmospheric components would be significant for temperature dataset without atmospheric effects removal. However, we focused the discussion on the temperature characteristics of leads. There is a physical dependence between the evolution of the leads (or sea ice) and the near surface air temperature.

On the one hand, as leads would refreeze quickly at low air temperature (e.g., in the winter), changes in air temperature are important to leads. On the other hand, leads allow for strong heat exchange between the ocean and under atmosphere. Opening leads may potentially change air temperature (Lüpkes et al., 2008). Furthermore, near-surface temperatures and IST are often correlated (such as a spatial correlation shown in Fig. 12 (a) and (b)). Please refer to the corresponding literature:

Nielsen-Englyst, P., Høyer, J. L., Madsen, K. S., Tonboe, R., Dybkjær, G., and Alerskans, E.: In situ observed relationships between snow and ice surface skin temperatures and 2 m air temperatures in the Arctic, The Cryosphere, 13, 1005-1024, 2019.

Line 170-174: Without objecting to the accuracy of this section, I don't know that it is necessary for this paper.

**Response:** Please refer to the previous response.

Figure 2: The chart shows 1 path going to Step 1 and 1 path going straight to Step 2. By what logic can Step 1 be bypassed?

**Response:** Step1 is not bypassed by Step2. After Step1, Step2 uses two input data. One of them is the original BT data (which was also the input to Step1); the other is the potential leads output from Step1.

We have amended the corresponding descriptions in the revised version: "the first step of our lead detection is applying a binary segmentation to extract potential leads from the BTA data. In the second step, the potential leads are used together with BT data in a designed filter to obtain the consequent leads".

Line 228: On example is presented, is this representative of what other cases look like?

**Response:** There are prevalently different effects when selecting three different thresholds of 1.2, 1.5 and 2.7 K base on the TIS data used in this study. We have recognized that the result is not representative of other seasons and seas since the TIS data are limited. However, the case shown here is quite representative with both clear large and narrow leads, as well as wealth of temperature variations. Based on this typical example, we aimed to show each step result of the proposed detection method. In the Result section of the manuscript, we have presented few individual cases of the lead detection from the Beaufort Sea in April 2022, and also included a complex scenario from the Laptev Sea in March 2022, all of which demonstrated good applicability.

Line 229: False-positive detections could be clouds, cloud shadows, or cloud edges; not just sea ice.

**Response:** Thanks for pointing it out. We modified the sentence as "false-positive detections (i.e., sea ice or others classified as leads), e.g., the white pixels marked by the orange square in Fig. 5 (a)"

Line 232: "Multiple tests" needs further explanation.

**Response:** We tested the BTA threshold segmentation when the BTA threshold was varied from 1.2 K to 2.7 K in steps of 0.1 K and visually compared their segmentation effects. The corresponding sentences are modified:

"Multiple threshold segmentation was tested when the BTA threshold was varied from 1.2 K to 2.7 K in 0.1 K steps. After visual comparison, using 1.8 K threshold resulted in a significantly different segmentation effect from the previous step, with minimal differences from the next step.".

Figure 7: Do not slit the figure across 2 pages. And, in (a), what do the numbers 1,2,3 mean?

**Response:** Thanks for pointing it out. We will improve these figures in the revised manuscript. We have explained the meaning of the numbers 1,2,3 in Figure 7's caption: "These thresholds are 1: mean plus standard deviation (std) of BT before segmentation, 2: iterative threshold, and 3: Otsu's threshold."

Line 247: Hard to follow.

**Response:** The sentence is revised as: "False positive detections can be attributed to imperfectly removed clouds, cloud edges, or sea ice of different thicknesses. These interferences cause gradient variations in the BT values measured by the TIS sensor yielding high BTA values."

Line 248: Which temperature gradient are you talking about? Ice surface temperature, retrieved brightness temperature, surface air temperature?

**Response:** We meant the gradient of the TIS brightness temperature. The sentence is modified in the revised version. Please refer to the revised statement in the previous response.

Line 253: The false positives are likely clouds or cloud artifacts.

**Response:** We agree that false positives are likely clouds or artifacts. In general, clouds have low temperature but high BTA values in the edges. We were careful to mention this in the revised version. Please refer to the revised statement in the previous response.

Line 256: Does "in view 1" mean Figure 7, Panel 1?

**Response:** Yes. Both "View 1" and "View 2" are taken from the left-hand panel in Figure 7. Their corresponding BTA images are shown in the first row on the right parallel panels, and the BT images are shown in the last row. The corresponding sentence is amended "in the second row of right parallel panels, the absolute values of the BT of those reliable leads in the first column (in view 1) are all greater than those of the false-positive detections in the second column (in view 2) by at least 2 K."

Line 257: Is this true for just this case, is it also true for other times of day or times of year when the ice and clouds may tend to have different temperatures?

**Response:** The distinguishability between leads and false-positive detections (i.e., false positives generally have lower BT values than highly reliable leads, despite having high BTA values) was found in all the 11 TIS data used in this study. Since the SDGSAT-1 data over the Arctic are still ongoing collected, we have not studied cases in other seasons, but this will be our future research focus.

Line 258: When you say "remaining", where do you mean, Figure 7 (a)?

**Response:** We have recognized that this can been misleading and have revised it to "The BT histogram for those potential leads is shown in Fig. 7 (a)".

Line 279: "co-located" is more commonly used than "collocated".

**Response:** Done as it is suggested.

Line 281: Is this just saying that leads are darker than ice in the visible spectrum? I think it is already well understood that water is visually darker than ice.

**Response:** Thanks for pointing it out. We will simplify the sentence in the revised manuscript: "For the matched visible images, leads are darker than ice surface".

Line 285: So this is not a binary mask, it could have 3 outcomes: lead, non-lead, ambiguous?

**Response:** Yes, the normalized brightness can be interpreted as three cases:

1) A pixel with normalized brightness between 0 and 0.07 must be a lead;

2) a pixel between 0.07 and 0.7 is an ambiguous case;

3) a pixel between 0.7 and 1 must be sea ice.

However, in order to compare with binary lead detection, the second ambiguous case was subsumed into the "possible lead" and "possible sea ice". That is, both the first and second cases are "possible lead"; both the second and third cases are "possible sea ice". As what we mentioned in the original manuscript: "a pixel with a normalized brightness below 0.7 could be a lead, while a pixel with a normalized brightness above 0.07 could be sea ice."

Figure 8: Why is the B1 brightness temperature (blue) so much colder than B2 & B3 (yellow)?

**Response:** The B1 band is centered at 9.3 µm (8.0-10.5 µm). Comparing to the B2 and B3 bands, its radiation is attenuated by ozone. The previous studies (Wan and Li, 1997; Prabhakara and Dalu, 1976) also demonstrated that the 9.3 µm channel has colder brightness temperature. This is exactly the reason we decided to investigate the influence of ozone on the lead detection by the TIS B1 band and the correlation between ozone solution and the three TIS bands. Thus, we would like to remain the corresponding content in sub-sections 2.5 and 5.1.

Table 3: How can you have a binary comparison when you are excluding brightness values between 0.007-0.7 (see not on Line 285)?

**Response:** In this study, a pixel with a normalized brightness below 0.7 could be a lead (< 0.7), while a pixel with a normalized brightness above 0.07 could be sea ice (> 0.07). We did not exclude the overlapping interval between these two cases (0.07 - 0.7), but set the interval as an ambiguous case, as shown in Figure R3.

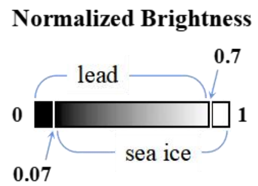



Figure R3 Diagram of a binary cases (sea ice and lead) for the normalized brightness.

Table 5: How do these numbers change if the temperature threshold is changed?

**Response:** Thank you for your question. The method proposed in this study used two thresholds. One of the two is the BTA threshold of 1.8 K. The other is the BT threshold selected by an iterative method based on the previous segmentation result (potential leads). The BT threshold is not fixed and generally varies with the temperature characteristics of the potential leads. Thus, the statistics of the lead detection for the TIS three bands shown in the Table 5 of the manuscript are less dependent on the temperature threshold. In contrast, the BTA threshold is often a fixed constant. For example, Hoffman et al. (2019) identified a threshold of 1.5 K; Qu et al. (2021) took 1.2 K, 1.5 K and 2 K as thresholds for different types of leads, corresponding to large to small uncertainty levels.

Line 360: Plead define strip noise.

**Response:** Strip noise is a sharp fluctuation in DN values that occurs when imaging a homogeneous surface due to different noise bias given by each detector. This results in a strip of noise in the scanning direction of the TIS sensor. We have mentioned this in sub-section 2.2: “The B1 band shows less strip noise (i.e., signal fluctuations along the sensor scan caused by detector noise) than the other two bands.”.

Table 6: Do not split table across two pages. Also, the ratio is 3 cases are on the order of 1, but Case 2 is more than 5 times higher. It is hard to generalize a relationship with such a big outlier yet a small sample size.

**Response:** Thanks for your valuable comment. In the added comparison experiment using the level-2 MODIS IST product, Case 2 yields a ratio of 2.48 (see the Table R2), which is more reasonable than before. The different statistics between Case 2 from others may be due to significant changes in leads in the late spring (near the melting season).

For a more general comparison, we have collected another lead dataset based on MODIS data (Hoffman et al., 2022b) and conducted a comparison. The result was listed in the last column of Table 6 in the original manuscript. More details in this comparison are presented in the following Table R3. Please note the difference between the two "All lead areas" and the "Additional lead area". The latter is not a direct subtraction between the first two datasets, but rather the redundant area after a mask processing (as we have mentioned in the original manuscript). Here, the result of Case 2 is reasonable, in which the additional lead area detected by the TIS than by Hoffman are 4,590 km$^2$.

Table R3 Statistics of the lead area estimated from the lead dataset of Hoffman et al. (2022b), referred to as Hoffman in the following, and the SDGSAT-1 TIS data.

| | | **All lead area (km$^2$)** | | **Additional lead area by the TIS than by Hoffman (km$^2$)** |
|---|---|---|---|---|
| | | Hoffman | SDGSAT-1 TIS | |
| **1** | Beaufort Sea on April 3 | 34,170 | 15,362 | 5,679 |
| **2** | Beaufort Sea on April 28 | 20,287 | 10,500 | 4,590 |
| **3** | Laptev Sea on March 23 | 14,566 | 4,519 | 1,462 |
| **4** | Laptev Sea on March 23 | 4,109 | 3,936 | 2,415 |
| | **Total** | **73,132** | **34,318** | **14,145** |

Line 441: Do you mean 30 m instead of 30 km?

**Response:** The number is right. We extracted the BT and BTA data only for the lead pixels and allocated them to the geographic grids at 30 km, i.e., one tenth of the TIS swath width, so that we can easily compare the temperature characteristics with the coarse-resolution datasets (ERA5 air temperature data and OMI/Aura product in a regular grid of 0.25 degrees).

Figure 12: Why is the 2m air temperature shown? If Ozone is contributing to the brightness temperature retrieval, that thermal contribution would be coming from much higher in the atmosphere.

**Response:** Same as our previous response, the reason we used near-surface temperatures is to investigate the correlation between leads and air temperatures. There were some studies exploring the relationships (Qu et al., 2021; Qu et al., 2019; Nielsen-Englyst et al., 2019; Yin et al., 2021). We were not suggesting that near-surface temperatures are related to ozone.

Nielsen-Englyst, P., Høyer, J. L., Madsen, K. S., Tonboe, R., Dybkjær, G., and Alerskans, E.: In situ observed relationships between snow and ice surface skin temperatures and 2 m air temperatures in the Arctic, The Cryosphere, 13, 1005-1024, 2019.