A review of "A Global Forest Burn Severity Dataset from Landsat Imagery" by He et al.

This manuscript attempts to develop a global forest burn severity (GFBS) database by combining Fire Atlas product, MODIS land cover data product, and the Landsat reflectance product. Results were validated over CONUS using the MODIS global burn severity dataset (MOSEV). Overall, the technical description seems technically sound and, in most cases, is well-written. The experiment is designed for global, thus the influence of the dataset will be important. The results are reasonable, some issues need further clarification.

Respond: We appreciate the reviewer's constructive comments on the manuscript to further improve the quality and the contribution of our work. Below are the authors' responses to all of the reviewer's questions and suggestions. The reviewer's comments are marked as **red**, while our responses are marked as **blue**.

General questions:

Q1: Need further validations across the world, because the current version includes no validations outside CONUS. At least should done for Australia and North Russia where server burns have been reported.

Respond: In the revised manuscript, we compared the performances of GFBS with CanLaBS data for forest fires over Canada from 2003 to 2015. The results show that GFBS agreed well in representing the distribution of forest fire severity to those of CanLaBS over Canada, which outperforms MOSEV.

From line 190 to line 194 in the revised manuscript:

"In addition to validation against in-situ data., we also compared the fire severity magnitudes of GFBS with the CanLaBS dataset available over Canada. CanLaBS provides burn severity information for burned areas identified from the Canada Landsat Disturbance product at the level of individual 30m resolution pixels. The dataset was derived from Landsat imagery and uses values of pre-fire to post-fire differences in dNBRs for nearly 60 million hectares of burned areas across Canada's forests from 1985 to 2015. [Guindon et al., 2017; Guindon et al., 2018]."

References:

Guindon, L., P. Villemaire, R. St-Amant, P.Y. Bernier, A. Beaudoin, F. Caron, M. Bonucelli and H. Dorion.: Canada Landsat Disturbance (CanLaD): a Canada-wide Landsat-based 30-m resolution product of fire and harvest detection and attribution since 1984. https://doi.org/10.23687/add1346b-f632-4eb9-a83d-a662b38655ad, 2017.

Guindon, L.; Bernier, P.Y.; Gauthier, S.; Stinson, G.; Villemaire, P.; Beaudoin, A.: Missing forest cover gains in boreal forests explained. Ecosphere, 9 (1), e02094. https://doi.org/10.1002/ecs2.2094, 2018.

From line 233 to line 259 in the revised manuscript:

3.2 Comparison between GFBS and CanLaBS over Canada

"In this section we describe the comparison of the fire severity maps of GFBS and MOSEV datasets to the ones from the CanLaBS dataset over Canada for an overlapped period from 2003 to 2015. Figure 6 shows the number and the trend of forest fires over Canada from 2003 to 2015, by CanLaBS data and GFBS products, while the vertical bar represents the number of forest fires recorded by both CanLaBS and GFBS each year. Due to the different sources and algorithms to map the burn area, the number of forest fires depicted by CanLaBS is larger than those by GFBS each year. Nevertheless, it is noted that GFBS agrees with CanLaBS in terms of the variations of forest fire activities, such as the intense forest fires in 2004 and 2015 and the relatively low number of forest fires in 2007 and 2008."

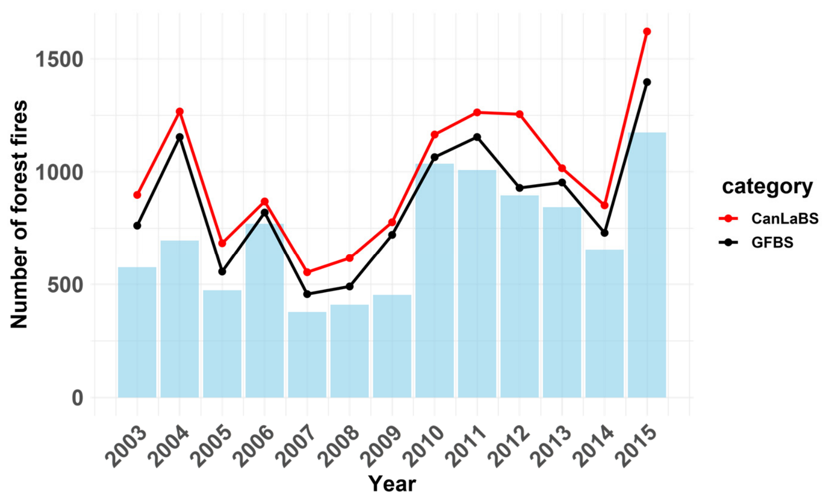
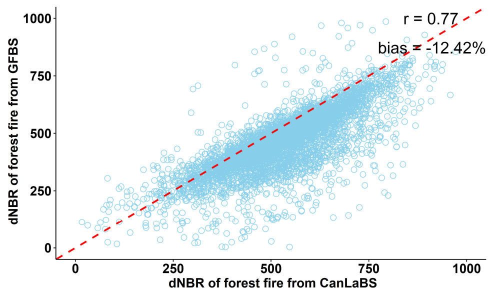


Figure 6. Number of forest fires by CanLaBS and GFBS dataset. Vertical bars show the number of overlapping forest fires.

"Figure 7 illustrate the scatterplots of dNBR of forest fires from CanLaBS against those from GFBS (panel a) and MOSEV (panel b), for the period 2003 to 2015. Consistent to the results shown in Figure 6, dNBR from GFBS shows strong correlation with the dNBR from CanLaBS with r being 0.77 and a slightly underestimation of the overall dNBR for forest fires (bias = -12.42%). On the other hand, dNBR from MOSEV exhibited low correlation with the dNBR from CanLaBS (r = 0.42) and slight overestimation (bias = 11.84 %). Figure 7 (c) displays the probability density function (PDF) plots of CanLaBS dNBR, GFBS dNBR and MOSEV dNBR. It is noted the close PDFs of GFBS dNBR and CanLaBS dNBR, though the mode of GFBS distribution is at slightly lower dNBR value relative to the CanLaBS distribution. On the other hand, the distribution of MOSEV dNBR significantly deviates from CanLaBS dNBR, having a lower peak and larger tails."



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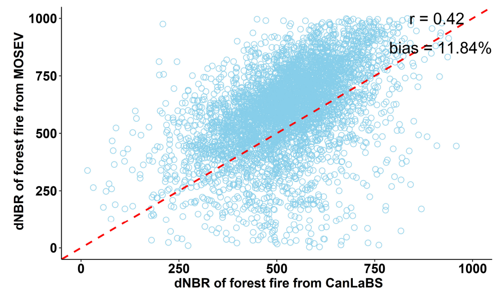

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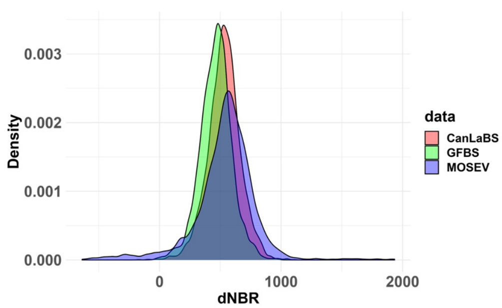


(c)

Figure 7. Scatterplots of dNBR from CanLaBS against those from (a) GFBS and (b) MOSEV; (c) density plot of dNBR from CanLaBS, GFBS and MOSEV, for forest fires from 2003 to 2015 over Canada.

"Figure 8 presents the boxplots of distributions of dNBR from CanLaBS, GFBS and MOSEV separate by year. Consistent to the previous results, GFBS compares well with CanLaBS in terms of the dNBR distribution of annual forest fires and as well as the variations of dNBR over time, even though it provides slightly lower dNBR values compared to CanLaBS. On the other hand, MOSEV compared poorly with CanLaBS annual dNBR distributions, exhibiting overall larger dNBR values and larger anomalies over time."

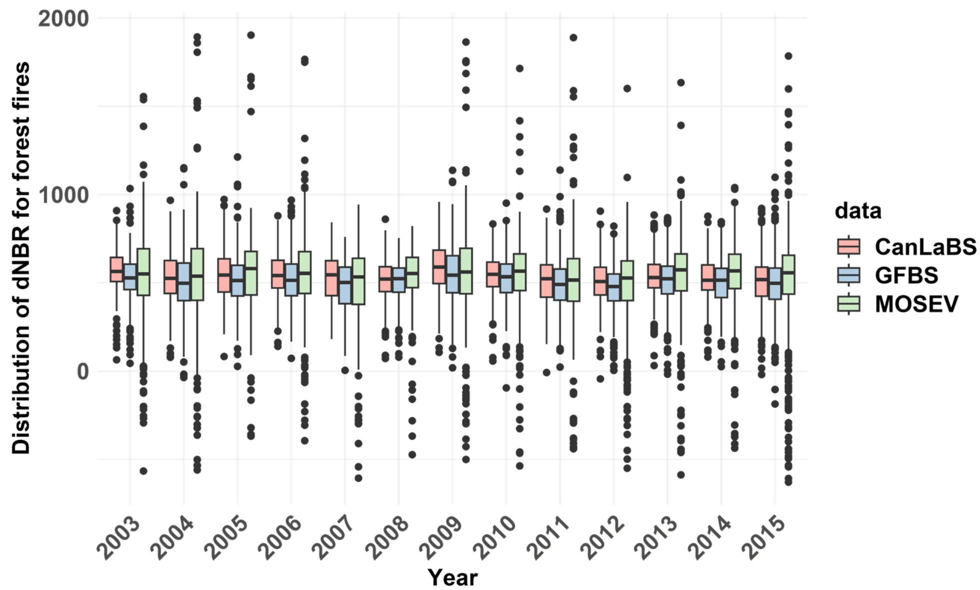


Figure 8. Boxplots of annual distributions of dNBR values from CanLaBS, GFBS and MOSEV for forest fires over Canada from 2003 to 2015.

Besides, in the revised manuscript, we validated the performances of GFBS and MOSEV over southeastern Australia using 112 field assessed burn severity category data for the wildfires in 2013. We demonstrated that GFBS could provide burn severity estimation with clearer discrepancy between high-severity class and moderate/low severity class, while such differences among burn severity class are not obvious in MOSEV. This was mainly due to the improved resolution of GFBS which enables it to better capture the localized variability of burn severity, which was ignored in MOSEV data.

From 157 to line 161 in the revised manuscript:

"To validate the GFBS database, we used the 112 ground-verified burn severity category data following the Fire Extent and Severity Mapping (FESM) scheme for the 2013 wildfires over southeastern Australia. The FESM severity classes include unburnt, low severity (burnt understory, unburnt canopy), moderate severity (partial canopy scorch), high severity (complete canopy scorch, partial canopy consumption), and extreme severity (full canopy consumption)."

From 173 to line 177 in the revised manuscript:

"Figure 2 (a) shows the locations of the 112 ground-verified burn severity sites for the 2013 wildfires over southeastern Australia. Figure 2 (b) shows the locations of CBI observations over CONUS for the period from 2003 to 2016. Of the 1,315 ground-surveyed CBI reports for forest fires during that time, most came from western states, such as Arizona, Colorado, and Oregon, where forest fires are more frequent and severe. Fewer CBI records are available in eastern states, such as Florida and Georgia."

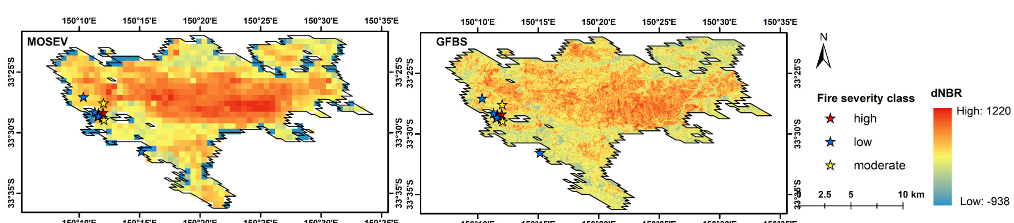
(a) (b)

Figure 2. Locations of (a) ground verification burn severity sites over southeastern Australia and (b) forest fire CBIs over CONUS.

From 260 to line 302 in the revised manuscript:

3.3. Validation against in situ fire severity category over southeastern Australia

"Using as the ground truth the in-situ burn severity categorizations from the 2013 wildfires over southeastern Australia, we evaluate the performance of GFBS and MOSEV datasets. Figure 9 (a), (b) and (c) display the spatial patterns of GFBS dNBR and MOSEV dNBR for wildfires that happened on October 15 2023, October 17 2023 and October 21 2023, respectively, in southeastern Australia, where relatively dense in situ burn severity categorization data are available. It is noted that GFBS dNBR shows similar spatial patterns to the MOSEV dNBR in the events on October 15 2023 and October 17 2023, both showing significant fire centers where high dNBR are found. For the October 21 2023 event, however, the dNBR map from MOSEV shows a larger high burn severity area than GFBS."



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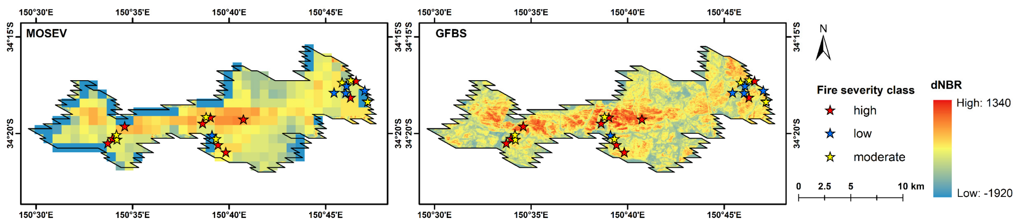

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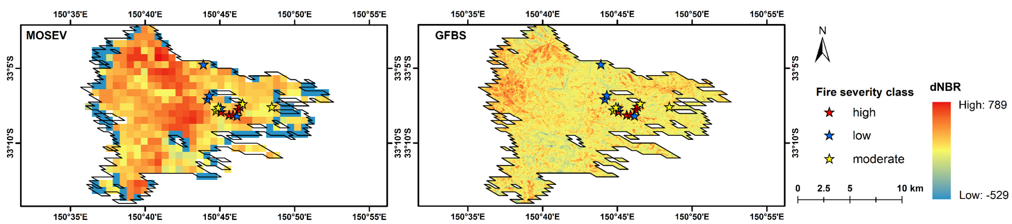

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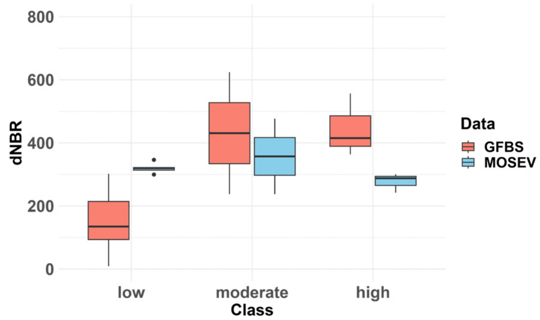
Figure 9. Spatial patterns of dNBR for wildfires on (a) October 15 2023, (b) October 17 2023 and (c) October 21 2023, in southeastern Australia, derived from the GFBS and MOSEV datasets.

"The boxplots in Figure 10 (a), (b) and (c) display the corresponding distributions of dNBR from GFBS and MOSEV at different observed severity classes in the events on October 15 2023, October 17 2023 and October 21 2023, respectively. The severity classes, e.g. low, moderate and high, are categorized from the field assessed sites in the corresponding fire events. For the event on October 15 2023, dNBR from GFBS shows significant difference between the moderate/high and low severity class, and no difference between high and moderate severity class. The dNBR from MOSEV, however, presents lower dNBR at high severity class than those at moderate and low severity class. For the event on October 17 2023, both GFBS and MOSEV show significant discrepancies on dNBR between high and moderate/low severity class. For the event on October 21 2023, GFBS could clearly differentiate among high, moderate and low severity classes in terms of dNBR values, while MOSEV presents the lowest dNBR values at the moderate severity class, while exhibits small differences in dNBR values between the low and high severity classes. Figure 10 (d) shows the overall performances of dNBR from GFBS and MOSEV for the different severity classes, combining all 112 ground verification sites. More significant differences are shown in the GFBS dNBR boxplots between high, moderate and low severity classes than those from MOSEV, indicating a better skill of GFBS to distinguish between forest fires of different severity levels."



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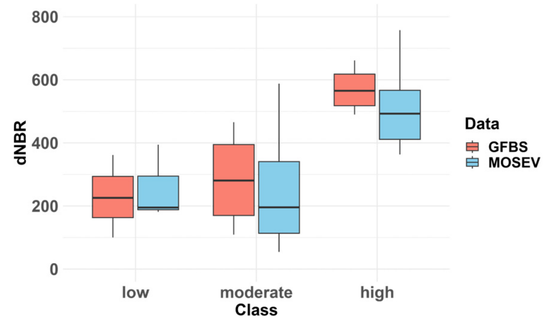

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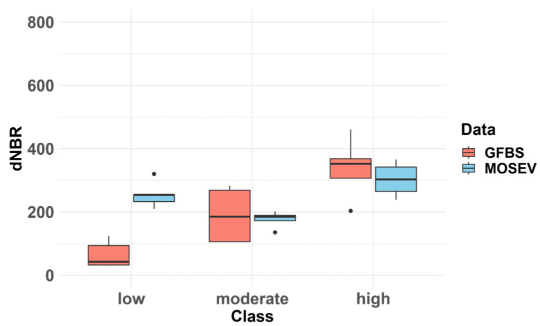

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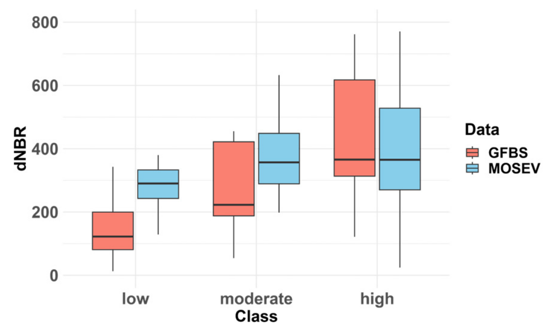
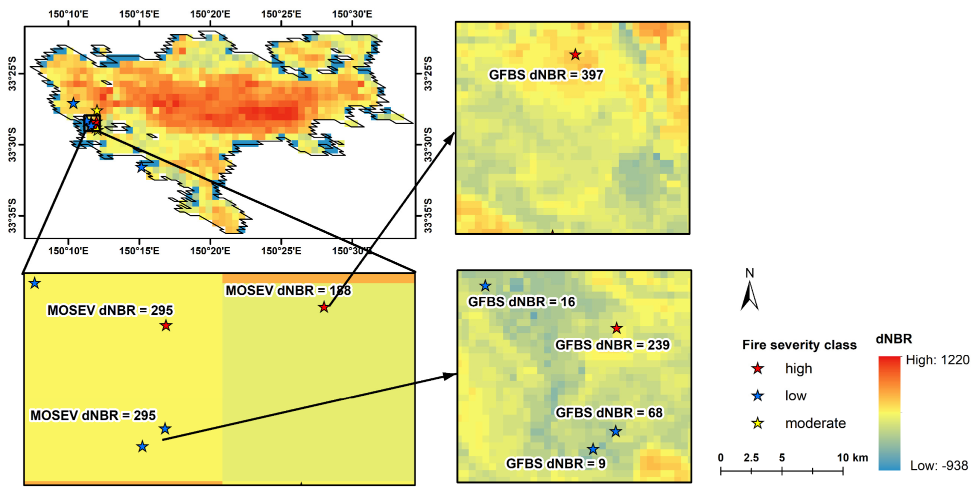


(d)

Figure 10. Boxplots of distributions of dNBR at different burn severity classes from the in situ data for (a) event on October 15 2023; (b) event on October 17 2023; (c) event on October 21 2023; and (d) combining all events with in situ data.

"As mentioned above, MOSEV gave relatively small dNBR values in the event on October 15 2023, where burn severity is classified from in situ measurement as high. Figure 11 (a) displays the location of the ground verification sites with the corresponding burn severity class and associated dNBR values from MOSEV and GFBS. It is noted that within one MOSEV grid cell (500 meter) four ground verification sites are located. The dNBR value from MOSEV is 295 for all four sites, while three of the sites are classified as low and only one site is classified as high severity. On the other hand, at GFBS resolution (30 meter), we can note significant spatial variation in dNBR, with GFBS dNBR being 239 for the site classified as high and 9, 16 and 68 for the sites classified as low severity. In a surrounding MOSEV pixel we note a site classified as high severity, but dNBR from MOSEV is 188 while dNBR from GFBS is 397. In the event on October 21 2023, we found that MOSEV gave relatively high dNBR values at ground verification sites that are classified as low severity. Figure 11 (b) shows the locations of ground verification sites with corresponding classified burn severity and associated dNBR values from MOSEV and GFBS. In the two adjacent MOSEV grids, the dNBR values from MOSEV are 287 and 327 respectively where both sites are classified as low severity. At GFBS resolution more significant changes between high and low dNBR are found within the same MOSEV grid, resulting in dNBR values of 30 and 32 for the ground verification sites classified as low severity. The results demonstrate the significance of GFBS high resolution data in representing the small-scale variations of dNBR and providing more granular and reliable dNBR estimations."



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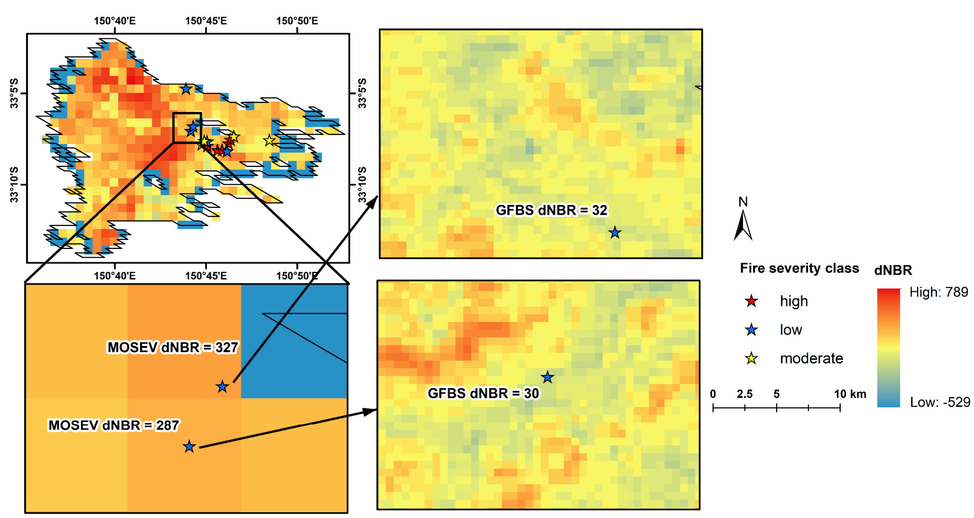


(b)

Figure 11. The location of ground verification sites with burn severity classes overlaid by dNBR values from GFBS and MOSEV for the fire event of (a) October 15 2023 and (b) October 21 2023.

Q2: What's the resolution of your data product is not clearly described in the abstract. It should be the strength of the developed GFBS database.

Respond: Thanks for your suggestions, we have addressed this in the revised abstract

From line 12 to line 14 in the revised manuscript:

"To improve quantification of the intensity and extent of forest fire damage, we have developed a 30-meter resolution Global Forest Burn Severity (GFBS) dataset of the degree of biomass consumed by fires from 2003 to 2016."

Q3: What's the spatial resolution of the CONUS-wide Composite Burn Index? If CBI plots are at 30m diameters, they should be more consistent with Landsat-derived burn servility.

Respond: Yes. The CBI plots for CONUS is with a 30-m diameter, which is described in https://burnseverity.cr.usgs.gov/products/cbi. How CBI is measured in also mentioned in the revised manuscript:

from line 161 to line 166:

"CBI was developed by Key and Benson (2006) to assess the aboveground effects of fire on vegetation and soil land use types (i.e., burn severity). It is determined through direct field observations after a fire when assessors visited various sites within the burned area to evaluate the effects of the fire on different components of the ecosystem, such as the degree of charring, percentage of foliage consumed, changes in ground cover, and mortality of plants. The CBI score for each site was calculated by averaging the scores of the different components. This overall score represents the burn severity at a specific site."

Q4: When describing correlation, suggest using r, not R2.
e.g. "… dNBR of GFBS was more strongly correlated with CBI (R2 = 0.4) than dNBR of MOSEV (R2 = 0.08) …"
Respond: Thanks for your suggestion. We have used r value to replace R^2 value in the revised manuscript, and also use r value in the figures.

For example, from line 22 to line 26:
"Using the CONUS-wide Composite Burn Index (CBI) as a ground truth, we showed that dNBR from GFBS was more strongly correlated with CBI (r = 0.63) than dNBR from MOSEV (r = 0.28). RdNBR from GFBS also exhibited better agreement with CBI (r = 0.56) than RdNBR from MOSEV (r = 0.20)."

Q5: Is the method used in this study limited to the combustion areas already discovered by MODIS at 250m scale? If that's the case, it may miss many visible combustions on the Landsat scale (30m).

Respond: Yes, you are correct. The fire polygon data we used to estimate forest burn severity is from the Fire Atlas product derived from the MODIS burn area product at 500 m resolution. fires with burn area smaller than 500 m might not be detected. By comparing GFBS with CanLaBS over Canada, we found that the number of forest fires in CanLaBS dataset is larger than those in GFBS. This is because CanLaBS retrieves burn area from Canada Landsat Disturbance product at 30 meter resolution. This difference in the spatial resolution of burn area causes some small forest fires unidentified in the GFBS dataset.

We have addressed this in the discussion section,

From line 484 to line 490:

"By comparing GFBS with CanLaBS, we found that the number of forest fires in CanLaBS dataset is larger than those in GFBS. This is because CanLaBS is based on the burn area map from Canada Landsat Disturbance product at 30 meter resolution, while GFBS is based on the burn area map from Global Fire Atlas which is derived from MODIS burn area product at 500 meter resolution. This difference in the spatial resolution of the burn area causes some small forest fires to be ignored in the GFBS dataset. Therefore, finer spatial resolution burn area product (10/30 meter) is promoted regionally and globally to better reveal the forest fire behavior, e.g. fire number, size and severity (Roy et al., 2019; Bar et al., 2020)."

References:

Bar, S., Parida, B.R. and Pandey, A.C. Landsat-8 and Sentinel-2 based Forest fire burn area mapping using machine learning algorithms on GEE cloud platform over Uttarakhand, Western Himalaya. Remote Sens Appl, 18, 100324, https://doi.org/10.1016/j.rsase.2020.100324, 2020.

Roy, D.P., Huang, H., Boschetti, L., Giglio, L., Yan, L., Zhang, H.H. and Li, Z. Landsat-8 and Sentinel-2 burned area mapping-A combined sensor multi-temporal change detection approach. Remote Sens Environ, 231, 111254, https://doi.org/10.1016/j.rse.2019.111254, 2019.

Figure 1: Why "Forest fire" in "I. Data input" was not linked to items in other sections?

Respond: We apologize for the mistake, the forest fire is firstly determined by overlaying the Fire Atlas polygon with land cover map, and then the corresponding start and end dates for the forest fires are used for dNBR calculation. We have designed the flowchart to make it more clear to describe the steps.

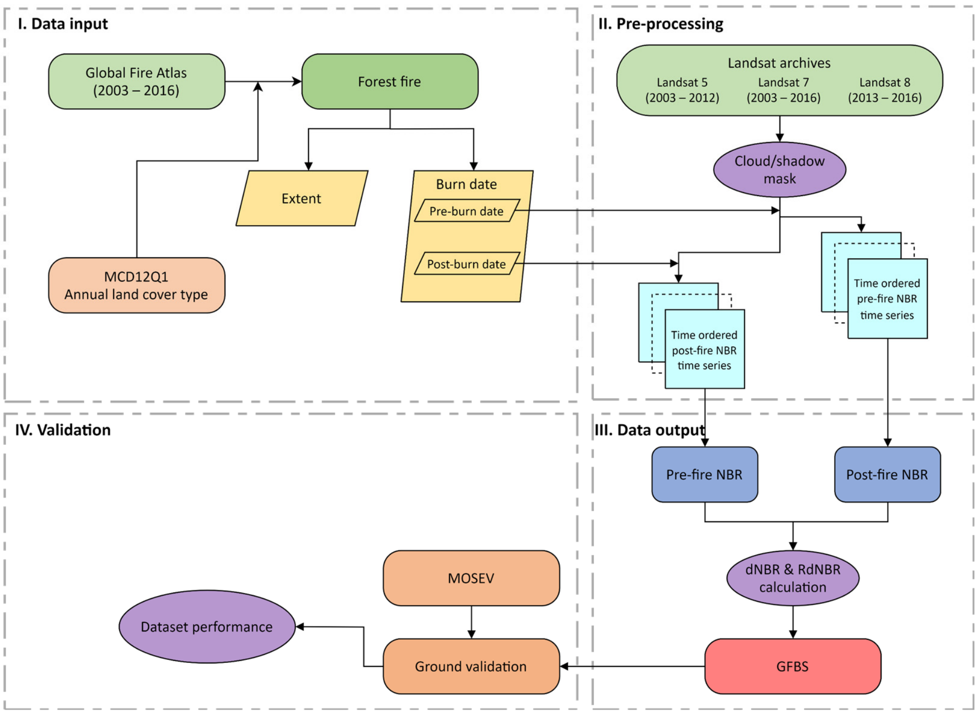


Figure 1. Methodology for building the GFBS database (2003–2016) and validation and comparison with the MOSEV benchmark.

Specific comments:

The definition of "burn severity" is not clear, e.g.,

L13: "... amounts of biomass"

L44: "... degree of biomass"

Respond: Thanks for pointing out this, the burn severity is derived for determining the degree of biomass consumption and the overall impact of fire on ecosystems, as mentioned in Keeley, 2009.

We have corrected this.

From line 12 to line 13 in the revised manuscript,

"To improve quantification of the intensity and extent of forest fire damage, we have developed a 30-meter resolution Global Forest Burn Severity (GFBS) dataset of the degree of biomass consumed by fires from 2003 to 2016."

L49: Did you solve this issue?

"... the use of inadequate sampling data to construct the plot level prediction models"

Respond: We are sorry, but we didn't find this statement in the original manuscript in line 49 and throughout the original submitted manuscript.

In line 49 in the original manuscript:

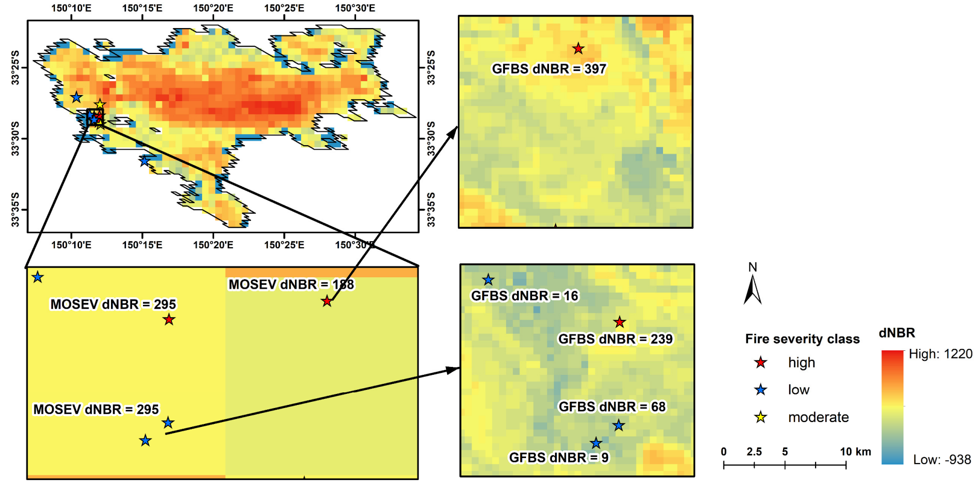
"Regionally, the Monitoring Trends in Burn Severity (MTBS) dataset, which includes burn severity assessments for the contiguous United States (CONUS) and provides information on fire perimeters and severity classes, uses satellite data—specifically, Landsat imagery (Eidenshink et al., 2007)."

L172: What's the reason for underestimation and overestimation?

Respond: The main reason for the differences in dNBR estimates between GFBS and MOSEV lays the gaps between the resolution of MOSEV (500 meter) and GFBS (30 meter). The coarse resolution of MOSEV impedes it to capture the localized variability of dNBR. In the revised paper, we have presented two cases as Figure 11 (a) and (b) to demonstrate that MOSEV tends to provide burn severity estimation with large uncertainty.

From line 285 to line 301 in the revised manuscript:

"As mentioned above, MOSEV gave relatively small dNBR values in the event on October 15 2023, where burn severity is classified from in situ measurement as high. Figure 11 (a) displays the location of the ground verification sites with the corresponding burn severity class and associated dNBR values from MOSEV and GFBS. It is noted that within one MOSEV grid cell (500 meter) four ground verification sites are located. The dNBR value from MOSEV is 295 for all four sites, while three of the sites are classified as low and only one site is classified as high severity. On the other hand, at GFBS resolution (30 meter), we can note significant spatial variation in dNBR, with GFBS dNBR being 239 for the site classified as high and 9, 16 and 68 for the sites classified as low severity. In a surrounding MOSEV pixel we note a site classified as high severity, but dNBR from MOSEV is 188 while dNBR from GFBS is 397. In the event on October 21 2023, we found that MOSEV gave relatively high dNBR values at ground verification sites that are classified as low severity. Figure 11 (b) shows the locations of ground verification sites with corresponding classified burn severity and associated dNBR values from MOSEV and GFBS. In the two adjacent MOSEV grids, the dNBR values from MOSEV are 287 and 327 respectively where both sites are classified as low severity. At GFBS resolution more significant changes between high and low dNBR are found within the same MOSEV grid, resulting in dNBR values of 30 and 32 for the ground verification sites classified as low severity. The results demonstrate the significance of GFBS high resolution data in representing the small-scale variations of dNBR and providing more granular and reliable dNBR estimations."



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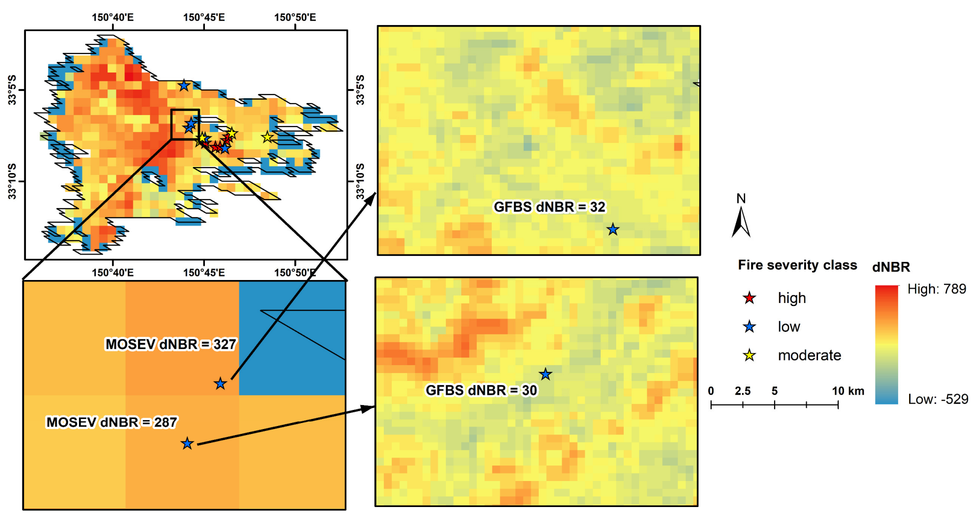

(b)

Figure 11. The location of ground verification sites with burn severity classes overlaid by dNBR values from GFBS and MOSEV for the fire event of (a) October 15 2023 and (b) October 21 2023.

And from line 435 to line 443 in the revised manuscript:

"As shown in Figure 11 (a), stemming from the coarse spatial resolution, MOSEV provides dNBR value of 295 for the site classified as high severity as well as for those classified as low severity, leading to an overestimation for low severity sites. With the improved spatial resolution, GFBS is able to capture more detailed localized variability of dNBR, providing more reasonable dNBR estimation for low severity sites (dNBR equal to 9, 16, 68). Similarly, in the event shown in Figure 11 (b), MOSEV provides dNBR estimations of 287 and 327 for the low severity sites, which is relatively too large. In GFBS, the relative lower dNBR of 30 and 32 is provided at the corresponding low severity sites.”

L263: “We based GFBS on Landsat (5, 7, and 8) images …” please rewrite to read.

Respond: We have corrected these kinds of writing errors in the revised manuscript.