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Discussions

Interactive comment on "Landsat NIR band and ELM-FATES sensitivity to forest disturbances and regrowth in the Central Amazon" *by* Robinson I. Negrón-Juárez et al.

Anonymous Referee #2

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GENERAL COMMENTS

The paper titled 'Landsat NIR band and ELM-FATES sensitivity to forest disturbances and regrowth in the Central Amazon' examines the use of Landsat satellite data as a tool for quantifying post-disturbance tropical forest recovery following clear-cut logging, burning, and windthrow events in the Central Amazon. The study also compares modeled post-disturbance recovery to the satellite observations, using ELM-FATES (a dynamic global vegetation model), to evaluate whether the model accurately represents differences in forest recovery pathways.

The main claims are as follows:

1. The near infrared (NIR) band provides a useful metric for mapping disturbance events and quantifying the temporal dynamics of post-disturbance recovery.

2. Changes in the NIR band reflect tropical forest succession dynamics following a disturbance event, demonstrated by a decrease in the NIR band that corresponds to the timing of tree loss, a rapid increase in the NIR as tree growth occurs during recovery, followed by a linear decline in NIR back to pre-disturbance conditions over the course of several decades.

3. Clear-cut logging and windthrow events simulated using the version of ELM-FATES in this analysis reproduces Landsat-derived post-disturbance recovery dynamics.

This study offers two valuable contributions:

1. It provides a methodological contribution for identifying how remote sensing data can be used to evaluate demography model performance.

2. It offers an evaluation of ELM-FATES simulated disturbance dynamics and post-disturbance recovery processes following three important disturbance processes.

The study yields interesting results and a useful discussion around the capacity to remotely sense and model tropical forest regrowth following disturbances. The inclusion of spectral leaf reflectance as model output using radiative transfer schemes for direct comparison with remotely sensed data is a welcome idea. I do, however, have several major concerns about the methods and the presentation and interpretation of results, described in detail below. In general, the manuscript would benefit from reorganization and a tighter framing of the narrative. Several paragraphs could be cut down, with unnecessary detail removed, while some descriptions and background information would benefit from greater specificity and detail.

SPECIFIC COMMENTS

- Why use only raw bands? I recognize the importance of understanding band behavior, but as Referee # 1 mentioned, it would be incredibly useful to also look at vegetation

indices (e.g. NDVI, NIRv, EVI) and/or spectrally unmixed bands (e.g. photosynthetic vegetation, non-photosynthetic vegetation, and bare soil) to compare more direct metrics of productivity. Given the amount of non-photosynthetic information in a 30x30 m pixel (e.g. bare soil, branches, etc.), direct comparison of the NIR band to model output like LAI is tricky. NIRv (or EVI, NDVI) is an approach for estimating GPP that will offer a more direct comparison with model output. See: - Badgley, G., Field, C.B. and Berry, J.A., 2017. Canopy near-infrared reflectance and terrestrial photosynthesis. Science advances, 3(3), p.e1602244.

- Why run 20 independent simulations with single PFTs, but no runs with multiple PFTs? It seems highly relevant to look at changes in modeled composition / successional changes to see whether the model qualitatively gets those dynamics right.

L57-58: A quick Google Scholar search reveals several studies using Landsat time-series to map and analyze forest disturbance and recovery dynamics. See, for example:

o Huang, C., Goward, S.N., Masek, J.G., Thomas, N., Zhu, Z. and Vogelmann, J.E., 2010. An automated approach for reconstructing recent forest disturbance history using dense Landsat time series stacks. Remote Sensing of Environment, 114(1), pp.183-198.

o Schroeder, T.A., Wulder, M.A., Healey, S.P. and Moisen, G.G., 2011. Mapping wildfire and clearcut harvest disturbances in boreal forests with Landsat time series data. Remote Sensing of Environment, 115(6), pp.1421-1433.

o Hansen, M.C., Krylov, A., Tyukavina, A., Potapov, P.V., Turubanova, S., Zutta, B., Ifo, S., Margono, B., Stolle, F. and Moore, R., 2016. Humid tropical forest disturbance alerts using Landsat data. Environmental Research Letters, 11(3), p.034008.

o Sen, S., Zipper, C.E., Wynne, R.H. and Donovan, P.F., 2012. Identifying revegetated mines as disturbance/recovery trajectories using an interannual Landsat chronose-

quence. Photogrammetric Engineering & Remote Sensing, 78(3), pp.223-235.

L84-85: The manuscript would benefit from a more detailed description of the 'range of successional regrowth pathways.' For example, describe what is meant by pathway (recovery of lost/disturbed vegetation to pre-disturbance vegetation), and how pathways could potentially differ (timing, species composition, forest structure, etc.). This will also help clarify how (i) and (ii) differ in L88-89.

L146-163 & L178-191: Much of the information in each of these paragraphs can be tightened.

L188-189: Move L211-213 here so that the different boxes within each site are more clearly linked to the edge effects question. Clarify the distance to edge for each clear cut A1, A2, A3, and burned A1 and A2.

L212-213: clear-cut should read, "selected three areas", while burned site should read, "two areas".

L250-251: It's really too bad that burned area recovery could not be simulated. It would be nice to at least see some discussion of the differences in remotely sensed recovery pathways at all three sites, and how burned area simulations might be expected to differ or not given existing fire models in related DGVMs (e.g. ED), or what aspects of recovery differed at the burn site that should be evaluated in future data-model comparisons.

L316-318: Too much detail for the Results section. Move to Discussion.

L319-320: But L5/L7 data do not reveal anything about species composition. This sentence is misleading.

L480: What is the biophysical motivation/basis for this? Please include a very brief explanation of the relationship.

Clarification requested

L102-103: Provide slightly more descriptive, albeit brief definitions of clear-cut and burned areas. As an example, are clear-cut areas stand-level clearance events where every stem/tree is removed? Is soil compacted by heavy machinery? For burned areas, what is the severity of the fire? Is this typical of fire events in the region? Do all stems/trees burn or is it primarily a brush fire? In addition, please include the complete extent of each disturbance.

L104: Define 'upland' in terms of meters/elevation. Are upland forests characteristic of the region or are lowland (see 50-105 m asl in L136)?

L105: Define 'same geographic region.'

L105: Provide more detail/background information on site characteristics either in the main body of the manuscript or in Supplementary Material. For example, how were the minimal differences in climatic, edaphic, and floristic characteristics determined? What data were used? Provide quantitative comparisons. Additional information on things like AGB, basal area, stem density, etc. will allow the reader to evaluate how similar or different these sites are from one another and how representative they are of the broader landscape.

L134-142: Describe this information for each site separately (e.g. soil characteristics, species diversity/composition, topographic characteristics, mean canopy height, stem density, background mortality rates, etc.).

L113: Why 3x3 windows? Provide an explanation and perhaps compare results using a range of window sizes to evaluate the robustness of results.

L157: Provide very brief explanation of why "especially in tropical forests".

L170-172: Were all Landsat scenes truly cloud free / 0% cloud cover? This seems unlikely. If not, please provide a brief description of what was done to [cloud] mask the data.

L194-196: Show the real data and gap filled data (in Supplementary Material?).

L198 & L341: I am confused about the use of L7 data. Please clarify in the description of the L5 and L7 data precisely when one or both are used.

L205: Briefly explain why these years were selected, e.g. refer to Fig. 3 (d-f).

L220-221: What field observations? What comparisons were made? How was this assessed? Please provide more detail.

L245-250: Aren't there data for the actual sites where analyses were conducted? If so, please provide actual values of mortality, etc. for each site to directly compare the model simulations to the site disturbances.

L294-296: This logic is unclear to me.

L357-361: Are 0.15 and 0.13 mixed up? 0.15 > 0.13. For clarity, it would be useful to compare the relative change in percent reflectance across sites.

o L361: should this read 0.15% yr-1?

o Figs 4-6: These seem to indicate that exactly the same control / old growth values reflectance values were used for each site, although Fig. 1 and earlier descriptions indicate that different control plots were used at each site, which would presumably have different values. Please clarify as this will influence results.

L388-L389: I don't understand how the rate of change can be higher but take longer? Were the starting biomass values different across sites?

L415-417: State this earlier, perhaps on the previous page?

Figure 7: This figure, particularly the AGB panel, seems to imply that the model simulations have not achieved equilibrium after 50 years. Why were simulations cut off at 50 years? How might this impact your results?

L533: Should this read "higher peaks of post-disturbance stem. . ." instead of "initial stem. . ."?

Species composition

The changes in species composition at each site is mentioned several times (see L129, L131, L488-490, L492-509). However, it is unclear whether the literature cited to support the differences in pioneer species at each site, and the general changes in composition overlaps directly with the sites included in this study/evaluated using Landsat data.

L488-490: Reword this sentence. This conclusion is overstated based on the data and results reported in the manuscript. Without showing the data on trends in species composition at these sites, this cannot be stated with this much certainty.

o Similarly, L492-509 & L525-528 are all speculation unless you are able to provide the data for these sites. Please clarify that these are speculations or report site-specific data.

Given that changes in species composition provides an important model benchmark, it is unclear why only single PFT simulations were conducted. The manuscript would greatly benefit from additional simulations that include a combination of (at least) early and late successional PFTs.

Timing of disturbances and data availability

L120-132: The different dates associated with each disturbance (1982 – clear-cut, 1984 – burned area, 1987 – windthrow) should be addressed explicitly. Clarify whether analyses (e.g. changes in NIR) are quantified based on recovery since disturbance date or recovery since start of data availability. For example, in Fig. 5 the x-axis title states, "Years since 1984", which is the start date of L5 data, but 2 years after the clear-cut disturbance.

L311-312: Yet you don't have Landsat data immediately following every single disturbance event. Please clarify wording.

- Similarly, if the burned area was used as pastureland until 1987, wouldn't the post-

disturbance recovery start data be 1987 instead of 1984 for the burned area site (see L130-131)?

o Fig. 3 highlights the lack of Landsat 5 data for the 1982 clear-cut and 1984 burned area disturbance dates. Given that the L5 launch date was in 1984, there is nothing that can be done about the lack of data prior to 1984. However, I recommend extending the x-axis on Fig. 3 (d-f) back to 1982 to avoid misrepresentation of the data coverage. Including a vertical line at the year of each disturbance in these plots would further clarify this.

L131: Instead of "some" years, could this read 2 or 3 years?

L309: Replace "with" with something like "immediately after" or "within X years of. . ."

L122: The authors mention in situ data collection on forest structure and species composition since 2011 at the windthrow site. 2011 is well after this forest has recovered. How are these data relevant to this analysis? It is unclear whether they are used directly in analyses in this manuscript. Please clarify.

TECHNICAL CORRECTIONS

L30-32: This statement does not seem fully supported by the results given that observations and model output yielded opposites rate of recovery for clear-cut and windthrow disturbances. What does 'appropriate fidelity' refer to here?

L51: Replace horizontal resolution with spatial resolution

L70: The use of Vegetation Demographic Models (VDMs) as an acronym is unfamiliar. Perhaps replace with Dynamic Vegetation Models (DVMs) or Dynamic Global Vegetation Models (DGVMs).

L120: Include GPS coordinates for the windthrow site, similar to the burned area and clear-cut sites.

L147: . . .and Landsat 7 ETM+?

L154: Add ‘bands’ so that it reads, “L5 bands are derived using. . .”

L159-160: remove “has”, “promptly”, and “have” so this sentence reads, “We used LEDAPS since a long time series of data is available with high spectral performance. . .”

L168: Insert “dry season” before “months present less cloud cover”?

L173: Mention that all sites are in a single Landsat scene and include the path and row, as is done in the Figure 1 legend.

L178: replace “several boxes” with “n = X boxes.”

L179-181: Confusing, reword sentence.

L187: include year – “. . .containing the highest level of SWIR1 in year XXX. . .”

L193: The numbers 27 and 12 don’t seem to make sense given the 1984 start of data acquisition to ∼2019.

L202: Insert “in the Manaus region” before “affected by windthrows are dominated. . .”

L213: Insert “Time series of. . .” before “L5 bands were.”

L297: Insert “modeled” after “we averaged.”

L298: Replace “influence the” with “are more comparable to 30 m. . .”

L301-303: Confusing sentence, reword.

L314: Replace “behavior” with “response.”

L330: Clarify at the start of this sentence whether you are referring to all three disturbance types.

L332-333 / Figure 3: Include NIR band values in Fig 3 (d-f) for control plots for direct comparison to emphasize “return to pre-disturbance values”.

L338: Replace “become” with “became.”

Figure 1: Show inset with all three site locations in the Manaus region together to illustrate their spatial proximity (i.e. a close up of the yellow box in Fig. 1a).

Table 2: Replace “Bolt” with “Bold.”

Table 3: Swap the “NIR” and “Model average of forest structure” columns.

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