Dear Margreth Keiler,

Thank you for taking the time to solve the communication and technical submission issues, as well as carefully reading the manuscript again, in order to proceed with the review process of our manuscript. Hereby, we would like to provide our point-by-point reply to the comments of Referee #1. As you know, Referee #2 recommended to accept the manuscript as is, and had no further comments.

Original Referee #1 comments are marked by 'RC#1', our responses by 'Authors', and corresponding changes to the manuscript by 'Change' (line numbers refer to the track-changes file). All text changes are visible in the track-changes version of the manuscript.

Kind regards,

Sigrid J. Bakke, Niko Wanders, Karin van der Wiel and Lena M. Tallaksen

Response to comments by Referee #1 (RC#1)

1.01 RC#1 Introduction - The Flannigan et al. (2009) does not find that boreal regions store 30% of the world's soil carbon pool. Within that paper, they are citing someone else's work "...but store an estimated 30% of the world's soil C pool (Gorham, 1991)." Is this still the estimate?

Authors Thank you for this notice; we have replaced the percentage from Gorham (1991) with information based on an updated estimate of the boreal carbon stock from Bradshaw and Warkentin (2015) in our revised manuscript.

Change Line 21-23

"In the boreal region, which *have the largest carbon stock of all major global forest biomes*, fires are the major stand-renewing agent and play a major role in carbon storage and emissions (*Bradshaw and Warkentin, 2015;* Flannigan et al., 2009)."

1.02 RC#1 Section 2 - The authors must consider that the spatial resolution of burned area data, which is nominally 250 m, means that it will miss small fires. Active fire products, at 1 km or 375 m, are capable of detecting fires 1/10 the size the pixel resolution [see Patricia Oliva and Wilfrid Schroeder, "Assessment of VIIRS 375 m active fire detection product for direct burned area mapping", Remote Sensing of Environment, vol. 160 (2015), pp. 144–155; Tianran Zhang et al. "Approaches for synergistically exploiting VIIRS I-and M-Band data in regional active fire detection and FRP assessment: A demonstration with respect to agricultural residue burning in Eastern China", Remote Sensing of

Environment, vol. 198 (2017), pp.407–424.] So excluding active fire products excluded smaller fires.

Authors Thank you for suggesting these two papers that emphasise active fire products' capability of detecting smaller fires as compared to burned area products. We agree that there is a lack of small fires in the burned area product used in the paper. In the manuscript, we acknowledge that the burned area data lack small fires in the abstract (line 14-15), introduction (line 57-59) and discussion (Sect 4.3).

The benefits and drawbacks of different data sets used for fire occurrences are discussed in Sect. 4.3. Here, the reasons for not selecting active fire products are provided (line 632-635). Based on your comment, we have added a remark about the capability of active fire products to detect small fires in Sect. 4.3 in the revised manuscript.

Change Line 629-632

"*Active fire products are capable of detecting smaller fires compared to standard burned area products (Wooster et al., 2021; Oliva and Schroeder, 2015). Whereas small fire detection is improved in many regions by using active fire products, detection errors (i.e. false fires) are a problem in some regions and seasons (Wooster et al., 2021; Zhang et al., 2018).*"

1.03 RC#1 Aggregating 250 m to 0.25° is also potentially averaging out smaller fires. This should be noted in the discussion of uncertainty, especially given that the official on-the-ground fire occurrence dataset registers all fires regardless of size.

Authors The burned areas are summed in the aggregation from 250m pixels to 0.25° grid cells. Consequently, fire occurrence for a given grid cell at a given month is set to one or true for all grid cells with at least one underlying pixel with burned area >0. This reduces the number of fires in cases where more than one underlying pixel had burned area >0 *regardless of the size* of the detected fires (burned areas). The same reduction happens when we transform the point based national record to a gridded data set of Norwegian fire occurrences (ref. line 184-187). Thus, the difference between the satellite based and on the ground based fire occurrence data set is mainly stemming from the inability of the satellite product to detect small fires, and not the spatial aggregation. We argue for our choice of the *gridded* burned area data in Sect 2.1.1 (line 163-165): the gridded data set matches the spatial scale of the state of the art climate models and it reduces the risk of spatial dependency between fire occurrences (i.e. same fire occurring in two or more cells). The problem of detecting small fires in the burned area product as compared to the national record is discussed in Sect 4.3.

Change No change in manuscript.

1.04 RC#1 Section 2.1.1 – How many fires are included in Figure 2? This is should be reported in the text and ideally broken down by country.

Authors We edited the text in Sect 2.1.1 to include the number of fire occurrences in the revised manuscript.

Change Line 174

"There is an extreme imbalance between the two classes (fire and no-fire) in the target variable, with only *1439 of the 444030 data points (*0.3%*)* classified as fire."

1.05 RC#1 Figure 3 – What is the spatial resolution of Figure 3? 0.25°? Were the the Norweigan fire occurrence data aggregated to 0.25°? Or was a 0.25° grid overlaid on the Norweigan dataset? Explaining this a bit more explains why there is so much fire in Figure 3B and basically no fire in Figure 3A.

Authors The spatial resolution of Fig. 3 is 0.25°. We now provide this information in the figure caption in the revised manuscript.

The transformation of the point-based national record of historical wildfires in Norway to the 0.25° resolution is described in Section 2.1.2 (line 184-187). The reason for the large differences between Fig. 3a and Fig. 3b is mainly the lack of small fires in the satellite-based fire occurrence data, as mentioned in Sect. 4.3 (line 613-616). We have added this information in Sect 2.1.2 in the revised manuscript.

Change Figure caption of Fig. 3 (page 8) and line 192

"… spatial distribution over Norway (map; *0.25° resolution*), and the…"

"There are substantial differences between the two datasets*, mainly arising from the lack of small fires in the satellite-based fire occurrence dataset*."

1.06 RC#1 Section 4.5 – What exactly is the value-added for a data-driven model to predict fire danger probability for actionable management of wildfires? In Figure 8, the months of May, June, July have more detail in the Model Prediction for high fire danger than FWI, but a very similar pattern. Additionally, explain to the reader how this developed could be used for fire season management if using near-real-time data and/or near term climate model outputs. This is not obvious in this section.

Authors The value added (as discussed in Sect. 4.5) include improved trust (and knowledge about the uncertainties) in the fire danger maps, insight into which environmental indices one should consider when improving process-based models, and the transferability of this method to other regions. For example, high agreement between the two approaches gives improved trust in the fire danger for the given region and month. The similarities between the model prediction and FWI varies over time. As you mention, they are similar in May-July 2018, whereas in April, August and September 2018 they are more diverse (Fig. 8). Figure 9 summarises the similarities/differences between the approaches for the full test set.

As for your second comment (starting with “Additionally..”), we assume you refer to our comment that we regard data-driven models as valuable contributions to fire forecasting (line 701-702). Here, we refer to data-driven models in general, and not our model specifically, which was not developed for forecasting.

Change — No change in manuscript.

1.07 RC#1 — Data availability - The authors need to better describe how to access the Norwegian wildfire record at https://www.brannstatistikk.no/. Mention that the site is in Norwegian. How would someone request the data from here? Do you have to be a resident of Norway or a citizen of Norway to request and/or access the data? Is the data allowed to be shared or posted publicly? This is an important data set for the findings of this analysis but how someone would replicate this study by accessing this data is unclear.

Authors — We agree it is valuable to make the information about data access as clear as possible, and we have added information based on your suggestions in the revised manuscript.

Change — Line 754-755

“Note that the DSB webpage is in Norwegian. Data are freely available, and in case of any questions regarding the data, please use the contact information provided by the webpage.”

1.08 RC#1 — References - The following reference is now out of date and the brokered links do not appear anymore at https://climate.esa.int/en/projects/fire/key-documents/:

Pettinari, M., Lizundia-Loiola, J., and Chuvieco, E.: Algorithm Theoretical Basis Document: CDR Fire Burned Area (brokered from CCI Fire Burned Area), available at: http://datastore.copernicus-climate.eu/documents/satellite-fire-burned-area/D1.6.2-v1.0_ATBD_CDR_BA-FireCCI_MODIS_v5.1cds_PRODUCTS_v1.0.1.pdf, 2019.

Authors — We use the same reference as the Copernicus Data Store (CDS), from which we downloaded the burned area product (https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-fire-burned-area?tab=doc). This document builds on other documents available at ESA’s webpage. Because we used data from CDS, we find it more appropriate to use the connected CDS reference. The link we provide in the reference is working, and the reference is to our knowledge not out of date (it is still used by CDS).

Change — No change in manuscript.