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Reply on RC2

Cornelius Senf and Rupert Seidl

Author comment on "Persistent impacts of the 2018 drought on forest disturbance regimes in Europe" by Cornelius Senf and Rupert Seidl, Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-120-AC2, 2021

Comment: Senf & Seidl contribute a very interesting assessment of post-drought forest disturbance impacts on European forests. Using a satellite based remote-sensing approach with 30 m x 30 m resolution (I guess with Landsat, not mentioned in the methods), they compute forest disturbance anomalies as the deviation of the 2018-2020 period from a 'long-term' average (1986-2015). They show that anomalies go up to >500%, and conclude that the 2018 drought had "unprecedented impacts on forest disturbance regimes in Europe". The paper is well written and conveys a clear message. Knowing also other works by the authors, I have upmost confidence in the scientific soundness of their analytical approach. My only comment on result reporting is that 'disturbance' is not defined anywhere in the text and it is not clear what a 500% increase actually means. Is this related to changes in forest canopy cover, changes in greenness or something else?

Response: We thank the reviewer for the positive and thorough review. We agree that a proper definition of disturbance was missing from the manuscript and we thus revised the main text and methods description to properly define disturbances as used in our study:

L. 31: "In Europe, drought is considered a major driver of forest disturbances (Senf et al., 2020), with forest disturbances here defined as any abrupt decline in the dominant forest canopy.".

L. 161: "We updated an existing pan-European forest disturbance map based on Landsat data, originally covering the time period 1986-2016 (Senf and Seidl, 2021a), until the year 2020. The map depicts any abrupt declines in the dominant forest canopy – regardless of its cause – that are detectable at a spatial grain of 30 m, including disturbances that only remove a part of the canopy within a pixel. It does, however, not detect any changes in sub-canopy tree layers".

A positive disturbance anomaly thus indicates a surplus in disturbed area (i.e., a higher disturbed forest area than recorded, on average, in the period 1986-2015). We explain this in detail in the methods section (L. 175ff); yet we revised the figure caption to make this point clearer to the reader (Fig. 1 and 3): "Anomalies are expressed in percent area change, that is +100% indicates a doubling of the disturbed forest area relative to the average disturbed forest area in the period 1986-2015.".

Comment: In my understanding, the conclusion is somewhat overstretching the data, though. Unprecedented impacts can only be defined if the historical level of disturbance is

known, which is not the case. The reference to other works (Schelhaas et al. 2003) is not enough to make such a strong statement and the temporal horizon of 170 years mentioned there cannot be taken as a benchmark for precedence. The authors are certainly aware of early reports of large-scale drought-induced forest disturbance in the 18th century ("the wormy drought", Gmelin, Johann Friedrich. 1787. Abhandlung Über Die Wurmtroknis. Leipzig: Verlag der Crusiussischen Buchhandlung) that devastated large forest tracts in the Harz region in central Germany. It is likely that other regions were also strongly affected, but we simply don't know.

Response: A valid point by the reviewer which we mostly agree with. We consequently revised the text to tone down our conclusions on the 'unprecedented impacts' of the current disturbance episode. However, we still highlight that the current disturbance episode is the largest one recorded in the past 35 years, and might be among the largest of the past 170 years, given that the largest pulse of disturbance in that period was reported for the year 2000 (i.e., based on Scheelhaas et al. 2003), and that our values for 2020 clearly exceed our records for 2000. We though agree that for any time before 1850 we simply do not know. The revised paragraph reads as following (L. 119): "The persistent increase in forest disturbances reported here will have long-lasting impacts on forest dynamics in Europe. In the past decades, wind was the most important natural disturbance agent on the continent (Schelhaas et al., 2003; Seidl et al., 2014; Senf and Seidl, 2021b). The single largest forest disturbance event reported in Europe since 1850 was the storm 'Lothar' in the winter of 1999/2000 (Gardiner et al., 2010). We here show that current forest disturbance levels exceeded this past maximum, with levels of forest disturbance being 1.42 times higher in 2020 than in the year 2000 (i.e., the year in which we record the impact of storm 'Lothar'). This indicates that the drought of 2018 might be responsible for one of the biggest pulses of disturbances in Europe in the past 170 years (Schelhaas et al., 2003), though we note that large-scale disturbances also occurred prior to modern records on forest disturbance (Gmelin, 1787).".

Comment: It would have been nice to see how disturbance anomalies relate to other important site factors, like altitude, exposition, soil depth, initial stand density, forest type etc. This would allow insights into climate vulnerabilities of European forests and provide useful information for forest management.

Response: While we certainly agree with the reviewer that a more in-depth analysis of disturbance drivers would be of interest, we believe this is beyond the scope of this letter. Moreover, data for many drivers of interest do simply not exist across Europe in sufficient spatial, temporal and thematic detail (e.g., stand density, soil depth, dominant species). We thus refrained from adding additional analysis on further drivers to the manuscript.