Mechanistic approach towards the analysis of tree mortality in Belgian forests impacted by extreme weather events

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Tree mortality is a key driver of forest dynamics, and it is expected to become more common in the future as a result of climate change. Episodes of tree mortality associated with drought and heat stress have been reported in forests over the last decades and are expected to increase under ongoing climate change. Forests are the main–contributors to the terrestrial carbon sink which can mitigate atmospheric CO_2 rise and reduce global warming. However, tree mortality reduces this carbon sink and may even turn it to a source. Tree mortality at the ecosystem level remains challenging to quantify since long-term, tree-individual, reliable observations are uncertain. For this reason, here we adapted a satellite-model approach to work on regional forests and upscale the results to the global forest.

In Belgium, 30% of the territory of Wallonia is covered by a forest which is the highest among all the three regions. The consecutive recent extreme events, especially the droughts and heat waves of 2018, 2019, and 2020, caused water stress and bark beetle attack. According to the 35 years (1985-2020) land use land cover change extracted by LANDSAT 5,7 and 8 satellite, there is no significant change in forest land in Wallonia, Belgium. Meanwhile, in the current years 2021-2022, there is a decrease in forest land with intensive forest management due to tree mortality. On the other hand, in Wallonia, the forest is distributed insignificant plots of broadleaf deciduous, coniferous, and mixed forests. However, we found that after the consecutive drought events and water stress with the Norway spruce, other tree species are also in vulnerable states. For example: In a mixed forest when bark beetle or Scolytidae attacked the spruce tree it is more attracted to the other trees and in this consequence tree species like – birch and oak are now also in premature death or deteriorating tree health.

In this study, we are using a high spatial resolution 25 cm drone image to find out pixel-based tree mortality by using artificial intelligence (deep learning) and machine learning techniques. In addition, the high-resolution tree mortality extracted data have been used in the CARAIB dynamic vegetation model to analyze the impact of extreme events on forest trees during the recent past and the future (until 2070). In conclusion, with this study, we better constrain our model regarding tree species mortality aspects, towards an improved prediction of tree species' vulnerability under the future extreme weather events.