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**"Large live biomass carbon losses from droughts in the northern temperate ecosystems during 2016-2022" Li et al. Nature Communications, 2025**

For the fourth quarter, we highlight a major scientific breakthrough supported by this project, recently published in Nature Communications (Li et al., 2025b). Focusing on northern ecosystems (north of 30°N), which host about 41% of the world's forests and contribute 1.4–2.0 PgC annually to the global terrestrial carbon sink, our study reveals how their carbon balance has been increasingly threatened by compound drought–heatwave events and wildfires. To achieve this, detailed spatiotemporal maps of carbon stocks are essential, which is precisely one of the primary objectives of the RECCAP-2 project. Satellite observations, such as those from ESA's SMOS mission, are changing the way we monitor and understand the carbon cycle. Leveraging the L-band Vegetation Optical Depth (L-VOD) dataset developed by INRAE Bordeaux from SMOS (Wigneron et al., 2021), which uniquely enables annual and consistent monitoring of above-ground biomass carbon, we analyzed the spatiotemporal dynamics of regional live biomass carbon across the Northern Hemisphere from 2010 to 2022. After optimizing the L-VOD biomass monitoring method by correcting for vegetation moisture content, our analysis shows that frequent droughts and wildfires have turned live biomass carbon in this large from a net sink into a net source since 2016 (Li et al., 2025a).

Specifically, the analysis examined northern ecosystems, including boreal and temperate forests as well as tundra regions across Russia, Europe, and North America, during 2010–2022. It identified 2016 as the point when living biomass carbon stocks began to decline (Fig. 1c). Although northern ecosystems showed a net increase in living biomass carbon over the entire period, from 2016 to 2022 they lost an average of 0.20 PgC each year, roughly equivalent to the annual emissions of more than 160 million cars. Temperate biomes recorded the largest losses at 0.26 PgC per year, corresponding to a 4% annual reduction in carbon stored in living biomass, while boreal forests experienced a small net sink.

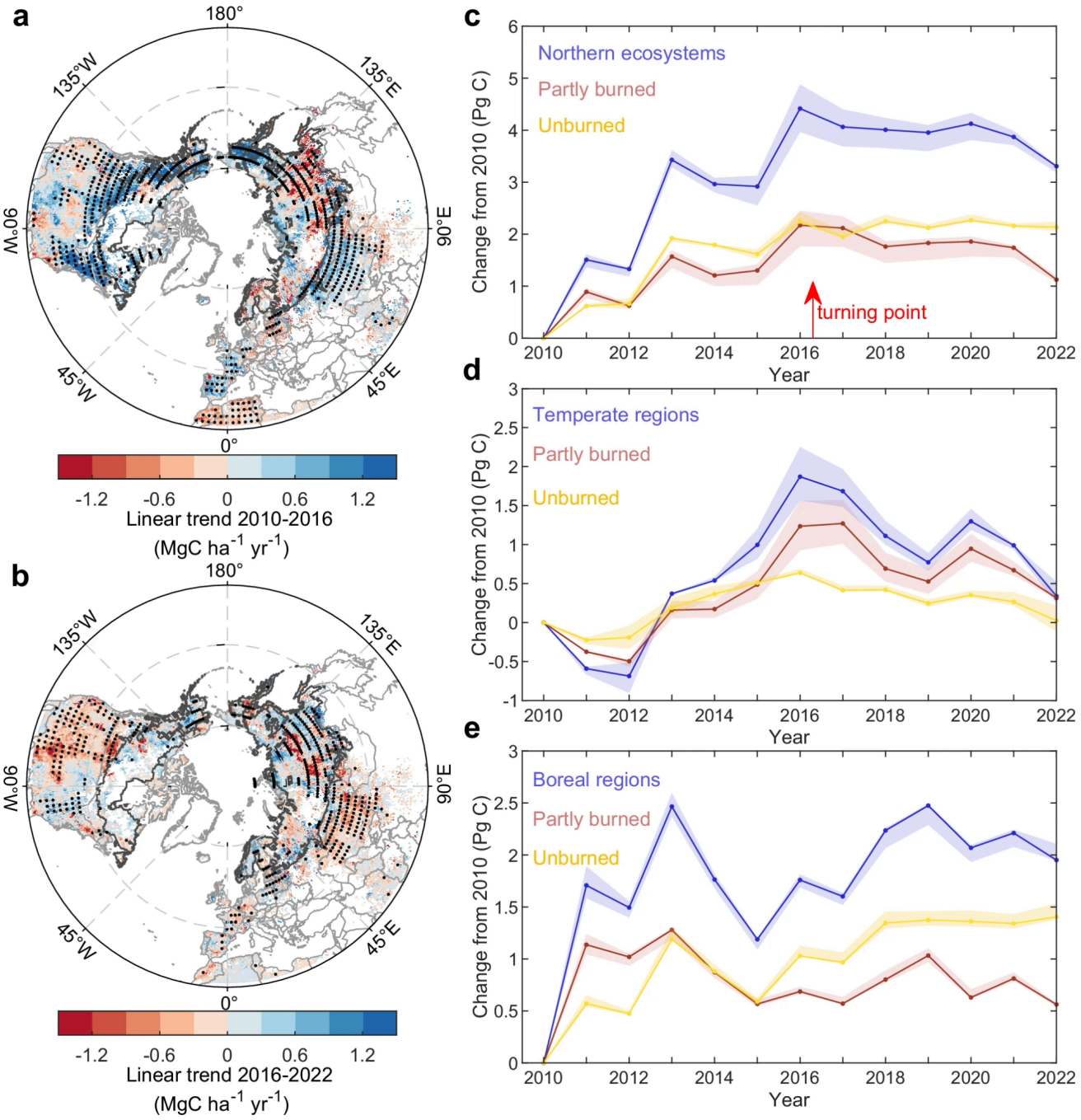


Fig. 1. Spatiotemporal dynamics of vegetation carbon stocks in the Northern Hemisphere. a) Pixel-wise trends during 2010–2016; b) Pixel-wise trends during 2016–2022; c–e) Interannual net changes in vegetation carbon stocks relative to 2010 for different ecosystems.

The analysis also revealed substantial year-to-year variability, mainly driven by extreme events. For example, 2022, the year most affected by drought, showed the sharpest decline in live biomass carbon stocks over the 2010-2022 period, with a net change of -0.67 PgC. Of this reduction, 37% (-0.25 PgC) occurred in Europe, which is qualitatively consistent with the widespread impacts of drought in the region observed during the summer of 2022, including reduced net carbon uptake by forests. Using interpretable machine learning models, the research team further quantified the relative importance and mechanisms of climate, anthropogenic, and soil factors in shaping vegetation carbon stocks across the Northern Hemisphere. The results showed that

variations in solar radiation were the key climatic driver for both temperate and boreal ecosystems, with temperate regions being more sensitive to soil drought, whereas boreal regions were mainly affected by wildfires, insect outbreaks, and atmospheric drought (VPD).

The study underscores the need for strengthened international collaboration to protect vulnerable live forest carbon pools under global warming and provides an important complement to previous findings highlighting the dominant role of non-living carbon pools in the terrestrial carbon sink (Bar-On et al., 2025). The study was also featured in a special report by the ESA: https://climate.esa.int/en/news-events/Forests-turn-from-carbon-sinks-to-emitters/

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