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Pan-European mapping of windthrows

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Natural Forest disturbances represent a serious peril for maintaining healthy and productive forests. Studies indicate that their occurrence can lead to a reduction in primary productivity and partially offset carbon sinks or even alter the state of ecosystems to the point that forests became carbon sources instead of carbon sink. Such disturbances are accelerating globally, but their full impacts are not quantified because we lack adequate monitoring systems. This is particular true for windthrows which represent one of the major natural disturbances for European forests. Satellite remote sensing represents a valuable source of information to spatially assess the impact of windstorms at large scales. However, most remote sensing-based approaches focused on local scale events. Some pioneering studies have begun producing regional and national scale maps of various forest disturbance agents. However, the satellite-based explicit attribution of forest changes to windstorms remains challenging due to the complexity of disentangling their signature from other natural and human-induced effects. In addition, the scarcity of recorded wind-affected areas strongly hampers the development of detection and attribution models.

We present here a novel data-driven modelling approach to map windthrows occurred during the 2000-2017 period at European level. The classification method combines high-spatial resolution forest changes obtained from the Landsat archive, maximum wind speed derived from NCEP (National Centre for Environmental prediction) reanalysis climate data and plant biomechanics features retrieved from multiple satellites and national inventories. Possible contamination effects of fires and land management are quantified and ruled out based on the European Forest Fire System Information and regional silvicultural metrics, respectively. The integration of such information in Google Earth Engine platform enables us to identify at fine spatial resolution (30 meter) the forest losses attributable to tree overturning and stem breakage due to strong winds. We calibrate and validate our approach on existing country-level disturbance datasets and a new large sample of areas affected by windstorms (>40000 records) collected over a gradient of climate and environmental conditions through a unique collaborative effort of different European forestry research groups.

The generated Pan-European mapping of windthrows provides key spatially-explicit information to quantify the vulnerability of forest ecosystems and develop effective adaptation strategies. A comprehensive mapping of historical windthrows is particularly important in view of the expected rise of their impacts in the next decades following global warming. Furthermore, our results represent a useful benchmark to improve the representation of windthrows in land surface models, now widely applied as supporting tools for policy relevant scientific assessment of climate change and its impact on terrestrial ecosystems.