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Monitoring of mechanical stability of arboreal individuals by GNSS low-cost sensors

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Climate-induced stresses, more than in the past, exposes trees to hazards possibly compromising their stability, with serious risk for people, structures and infrastructures.
In order to prevent trees falling phenomena, a constant improvement of the knowledge of relations between trees and meteorological events (trees-wind in particular) is crucial. Any new technology that can support the research and the monitoring in this direction has hence to be investigated, tested and eventually adopted if able to give a support.
The case study reported here refers to an experimental analysis carried out on an individual of Italian stone pine (Pinus pinea L.) vegetating in the CNR-RM 1 Research Area of Montelibretti (Italy).
The boundary conditions have been studied with the help of different survey instruments, including an anemometer, in order to define as accurately as possible the relation between the gusts of wind and the pattern of movement of the trees.
The experimentation has been carried out through the use of a single frequency GNSS receiver; its autonomy and low cost make it, indeed, very competitive compared to other instruments that can be used for similar purposes.
The data were collected over approximately two months at 1 second rate, and they were processed both by RTKLIB and VADASE software, in order to preliminary investigate on the average data quality, considering the non optimal installation of the GNSS antenna partially surrounded by pine canopy, and then to analyse positions and velocity time series and vibration frequencies during the wind storms.
A sonic anemometer was installed very close to the pine tree (within 20 meters), in order to independently record the impacting wind fields (velocity, direction) and to enable correlation analysis between them and the tree response.
The aim of this analysis is to define a new stability index on the basis of the kinematic behaviour of the tree, and to identify a specific alarm threshold to be used for timely safety intervention.
The medium-term objective of the proposed methodology is to demonstrate the feasibility to realize a low-cost GNSS-based device (possibly complemented with other sensors as MEMS accelerometers), enabling the installation of a network to monitor permanently and in real time the mechanical responses of different tree species, on different soil types, to wind storms. The collected data will allow a larger comprehension of the trees-wind relations and the definition of new indexes that will support the studies related to tree stability. This infrastructure will be clearly beneficial from a social, economic and environmental point of view.