Reply to "Comment on 'Critical wind speed at which trees break' "

E. Virot,[1] A. Ponomarenko,[1,2] É. Dehandschoewercker,[1,2] D. Quéré,[1,2] and C. Clanet[1,2]
[1]*LadHyX, CNRS UMR 7646, École Polytechnique, 91128 Palaiseau, France*
[2]*PMMH, CNRS UMR 7636, ESPCI-Paris, 10 rue Vauquelin, 75005 Paris, France*

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In the preceding comment [A. Albrecht *et al.*, Phys. Rev. E **94**, 067001 (2016)], Albrecht *et al.* argue that important biomechanical ingredients are missing in our model about the wind speed at which trees break [Phys. Rev. E **93**, 023001 (2016)]. Here we wish to emphasize that our model is an idealization, which primarily aims at evidencing the dominant ingredients of the problem. Since it captures both observed trends and orders of magnitude, we believe that the essential parameters in tree breakage have been identified, a useful step to make further progress and more detailed descriptions.

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It is first useful to recall that our recent paper [1] mainly discusses how model rods (made of wood or carbon) break when they are bent or twisted. We performed series of experiments on such brittle rods and analyzed our results with scaling laws. Such laws are often very general, and we look at the possibility of extrapolating our findings to trees by using allometric scaling relationships, and considering the wind strength as the force able to bend trees. What Albrecht *et al.* mainly criticize in [2] is the possibility of performing such an extrapolation.

It is always an interesting question to wonder up (or down) to which point we can be (too) simple. Our extrapolation of rod rupture to tree breakage predicts a critical wind speed of rupture on the order of 40 m/s that weakly depends on the tree characteristics, in agreement with field observations, and helps to understand the universality of the phenomenon. Of course, the assumptions made for the sake of simplicity (elementary shape, homogeneity of the material, primitive fracture criterion) are debatable. Albrecht *et al.* argue that extending our model on brittle rods to trees is unsubstantiated owing to severe simplifications of the biomechanics of trees. We would like here to make it clear that our aim in [1] was to gain insights into the physical causes that rule tree breakage. As rightfully stated in [2], quantitative applications of our results in forests and urban tree management (such as depicted by popular science press) would obviously require a more detailed theory. However, the use of scaling laws often allows us to build straightforward first-order models, which is relevant to capture the essence of a physical situation and/or to account for clear trends—in our case, the critical wind strength at which major damage is observed in forests. Scaling laws deal with average quantities, and as such, they are both efficient (they point out main parameters and provide relevant orders of magnitude), and questionable (they suffer exceptions and they are not fully quantitative).

The scaling laws of tree allometry are typical of this duality, as is our model. On the one hand, our approach indeed captures both the observed trends and the magnitude of the critical wind speed, which strongly suggests that the main ingredients leading to tree breakage have been identified. On the other hand, a forest of trees involves many factors, many scales, and all kinds of fluctuations that are not (cannot be) contained in average laws. As usefully listed in [2], more detailed approaches should take into account, and treat as add-ons, factors such as fracture mode, humidity, trunk tapering, complex allometry, thigmomorphogenesis, wind gusts, or fatigue.

[1] E. Virot, A. Ponomarenko, É. Dehandschoewercker, D. Quéré, and C. Clanet, Critical wind speed at which trees break, Phys. Rev. E **93**, 023001 (2016).

[2] A. Albrecht *et al.*, Comment on "Critical wind speed at which trees break", Phys. Rev. E **94**, 067001 (2016).

