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On the biomechanics of seedling anchorage

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We propose a minimal model for the response of vegetation to pullout constraints at early development stage. We try to capture both the average mechanical properties of the root system and the stochastic component of the uprooting process of seedlings. We identify a minimal set of relevant physical components in the purpose of quantifying the uprooting process: length of the root fibres, elastic response of the fibres and adhesion between the roots and the soil matrix.

We present for validation a dataset extracted from Edmaier et al. (under revision), accounting for 98 uprooting experiments using Avena sativa L. seedlings (common oat), growing in non-cohesive sediment under controlled conditions. The corresponding root system has a very simple architecture, with three root fibres of different lengths. The response of the system to the constraint is however complex: the stress-strain signal presents sudden jumps followed by partial elastic recoveries. The analysis of the jumps and partial recoveries gives an insight into the resilience of the system. The anchorage of less mature seedlings rapidly collapses after the peak force has been reached, while more mature seedlings usually recover from partial failures. We explore this crossover with our validation dataset.

The type of seedlings we study has been used in flume experiments investigating the feedbacks between the vegetation and the river morphodynamics (see for example Perona et al. (2012)). An understanding of the characteristics of the uprooting curve (maximal uprooting force and total uprooting work) of such vegetation reveals the ability of seedlings to withstand environmental constraints in terms of duration or intensity (see Edmaier et al., under revision), and is therefore helpful for planning future experiments.

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