Geophysical Research Abstracts
Vol. 17, EGU2015-12691, 2015
EGU General Assembly 2015

Plant uprooting by flow as a fatigue mechanical process

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In river corridors, plant uprooting by flow mostly occurs as a delayed process where flow erosion first causes root exposure until residual anchoring balances hydrodynamic forces on the part of the plant that is exposed to the stream. Because a given plant exposure time to the action of the stream is needed before uprooting occurs (time-to-uprooting), this uprooting mechanism has been denominated Type II, in contrast to Type I, which mostly affect early stage seedlings and is rather instantaneous. In this work, we propose a stochastic framework that describes a (deterministic) mechanical fatigue process perturbed by a (stochastic) process noise, where collapse occurs after a given exposure time. We test the model using the experimental data of Edmaier (2014) and Edmaier et al. (submitted), who investigated vegetation uprooting by flow in the limit of low plant stem-to-sediment size ratio by inducing parallel riverbed erosion within an experimental flume. We first identify the proper timescale and lengthscale for rescaling the model. Then, we show that it describes well all the empirical cumulative distribution functions (cdf) of time-to-uprooting obtained under constant riverbed erosion rate and assuming additive gaussian process noise. By this mean, we explore the level of determinism and stochasticity affecting the time-to-uprooting for *Avena sativa* in relation to root anchoring and flow drag forces. We eventually ascribe the overall dynamics of the Type II uprooting mechanism to the memory of the plant-soil system that is stored by root anchoring, and discuss related implications thereof.

References

Edmaier, K., Uprooting mechansims of juvenile vegetation by flow erosion, Ph.D. thesis, EPFL, 2014.
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