

A fractional-order diffusion model to predict transgenic pollen dispersal

Emmanuel Hanert^{1,*}, Valentin Vallaëys², Rebecca Tyson³, David Lane⁴ and Eric Deleersnijder²

¹*Université catholique de Louvain, Earth and Life Institute (ELI), Belgium.*

²*Université catholique de Louvain, Institute of Mechanics, Materials and Civil Engineering (IMMC), Belgium.*

³*University of British Columbia Okanagan, Canada.*

⁴*Blue Comet Agro Inc., Canada.*

*Corresponding author: <mailto:emmanuel.hanert@uclouvain.be>

Abstract. A number of recent studies suggest that pollinating insects such as bees follow a Lévy random walk in their search for food. Such a strategy has been shown to be more efficient than classical Brownian motion when resources are scarce. However, the models that are currently used to predict the dispersal of pollen by insect pollinators still rely on the Brownian motion assumption and hence likely underestimate the probability of long-range dispersal. In this work, we propose a mechanistic model for pollen dispersal that is based on bee movement through space. The assumption that bees follow a Lévy random walk leads to a model with a fractional-order diffusion term. By numerically solving the model equations, we show that the tails of the stationary pollen distribution decay more slowly than with a classical diffusion model and hence spread over a larger area. The isolation distances required to keep outcrossing below a certain threshold are thus substantially increased. Our results therefore suggest that classical models based on the Brownian motion assumption might seriously underestimate the risk associated with GM pollen outcrossing in conventional crops.

Keywords: bee-mediated pollen dispersal, genetically modified crops, isolation distances, truncated Lévy flights, anomalous diffusion