A fractional-order diffusion model to predict transgenic pollen dispersal

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A number of recent studies suggest that pollinating insects such as bees follow a Levy 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 Levy 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.

References:

- Vallaeys V., R. Tyson, D. Lane, E. Deleersnijder and E. Hanert (2017) A Lévy-flight diffusion model to predict transgenic pollen dispersal, *Journal of the Royal Society Interface* (accepted for publication).
- Hanert E. and C. Piret (2014) A Chebyshev pseudo-spectral method to solve the space-time tempered fractional diffusion equation, *SIAM Journal on Scientific Computing*, 36-4, A1797-A1812.
- Hanert E. (2012) Front dynamics in a two-species competition model driven by Lévy flights, *Journal of Theoretical Biology*, 300, 134-142.
- Tyson, R.C., J.B. Wilson and W.D. Lane (2011) A mechanistic model to predict transgenic seed contamination in bee-pollinated crops validated in an apple orchard. *Ecological Modelling* 222, 2084Ð2092.
- Hanert E., E. Schumacher and E. Deleersnijder (2011) Front dynamics in

fractional-order epidemics models, *Journal of Theoretical Biology*, 279, 9-16.

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