Assessing the efficacy of pesticide placement strategies with a novel approach to fate modelling

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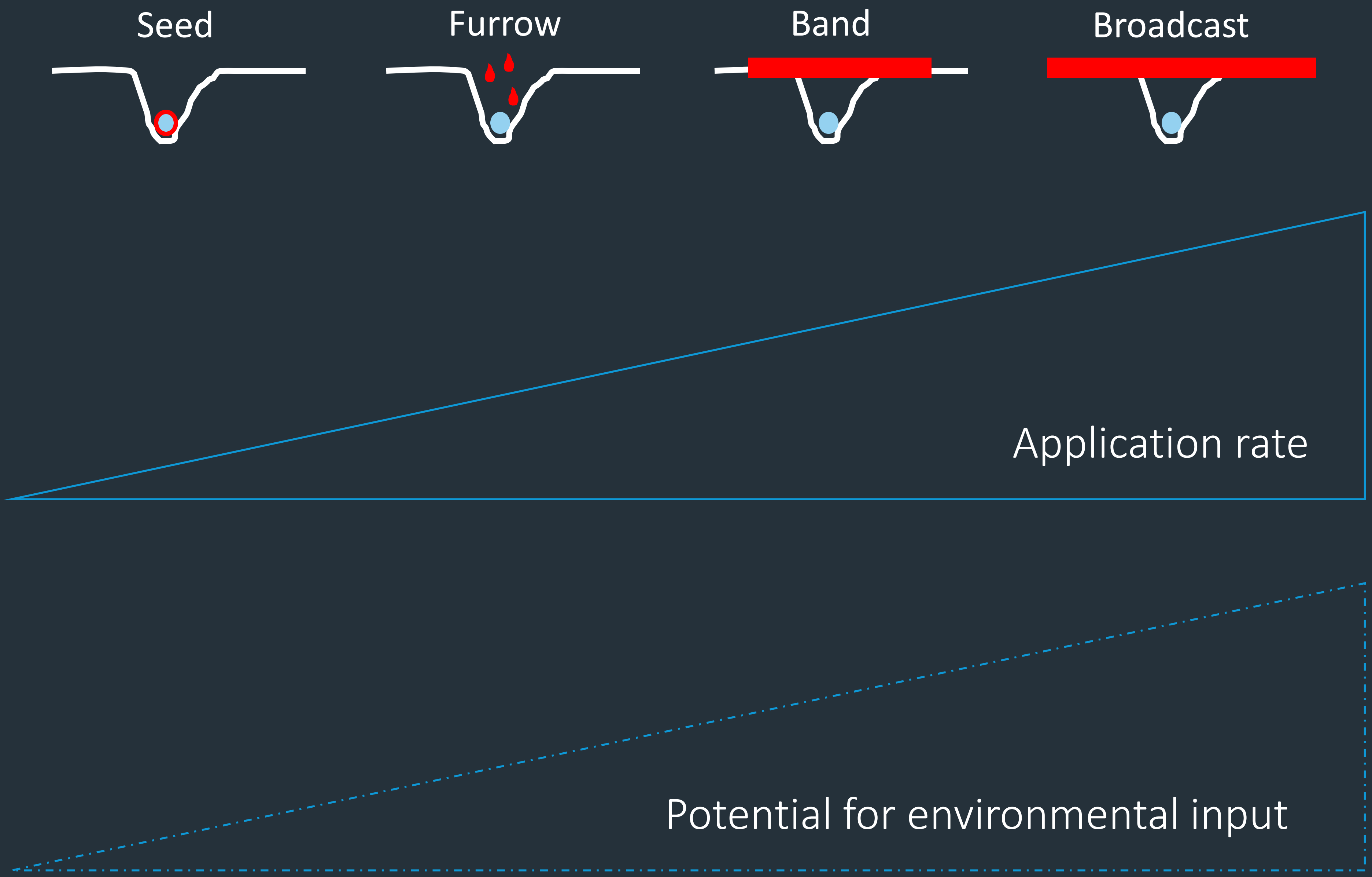
Background


Seed
Furrow
Band
Broadcast
Application rate
Potential for environmental input

Problem formulation

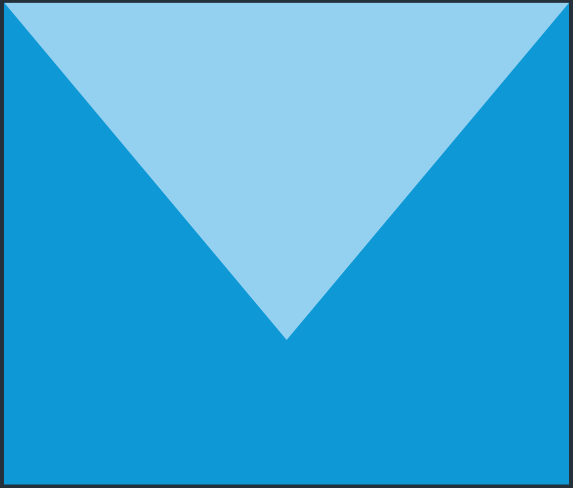
- Models for pesticide fate in soil are primarily 1-D
  - Limiting to assess strategies for pesticide placement in soil (seed treatment, furrow or band applications etc.)
- Existing 2-D models are parameter/computation intensive and often have simplified representations of the crop root system
  - Limiting to integrate efficacy testing against root damaging pests

Aim

- To develop a 2-D model of pesticide fate in the soil profile
    - Spatially-explicit description of crop roots
    - Spatially-explicit pesticide placement
    - Parameterised with readily-available information
    - Run times sufficiently short to allow multiple model iterations

Main difference from other 2-D fate models

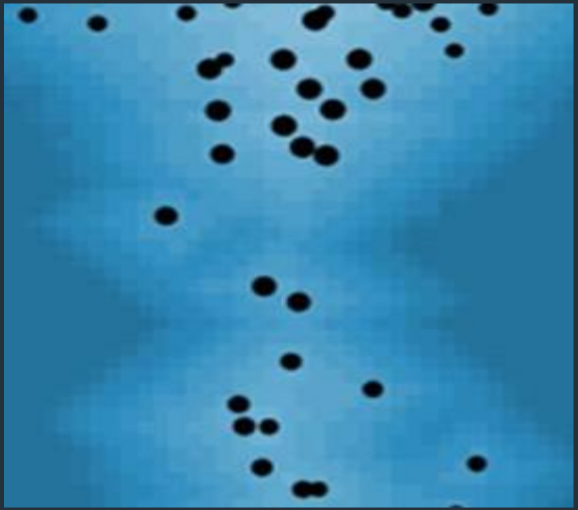
Other 2-D models



Root distribution with total biomass

Water extraction from root distribution zone according to water pressure

2-DROPS



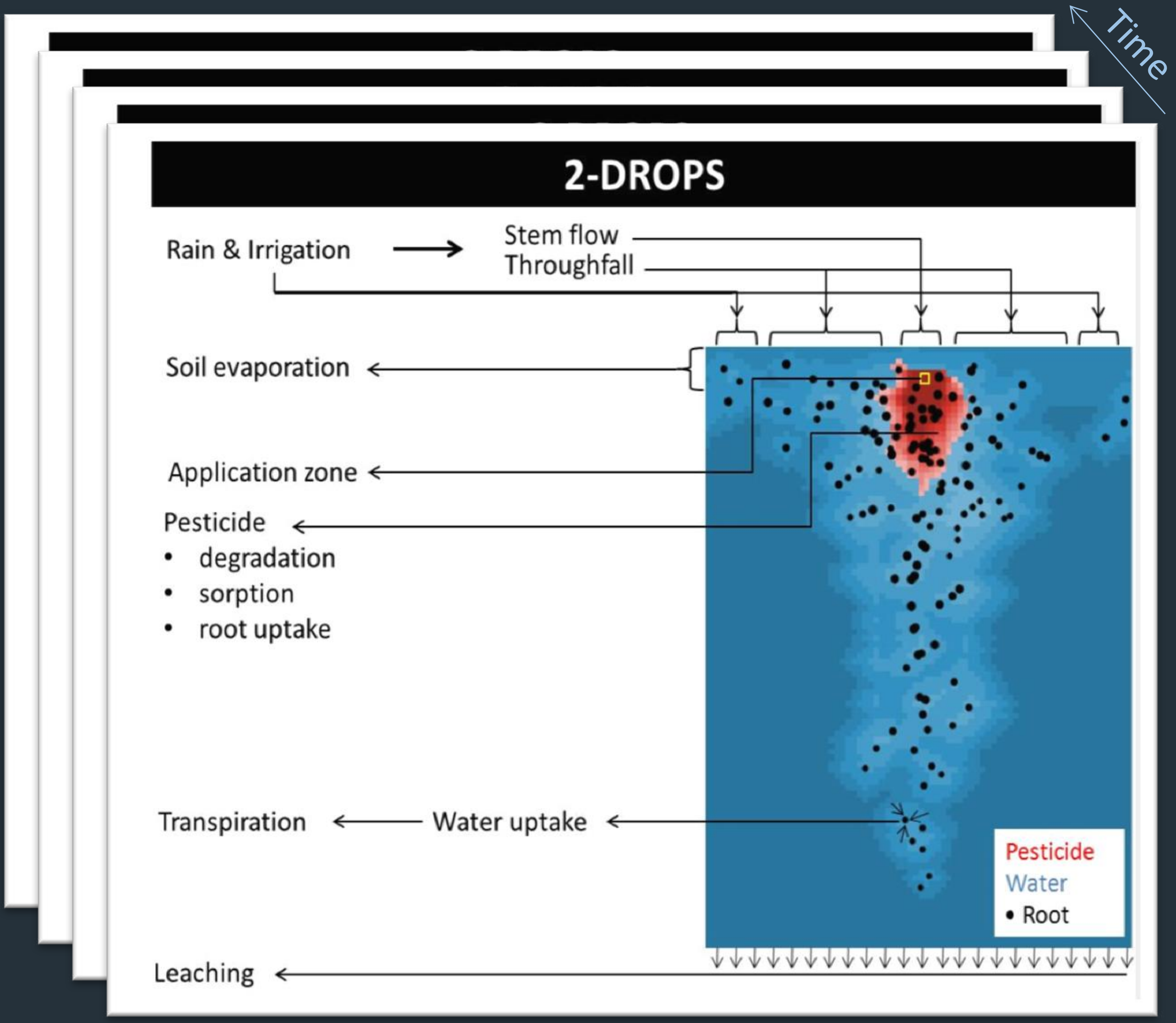
Root segment with individual biomass

Water extraction from individual root segments

2-DROPS 2-Dimensional ROots and Pesticide Simulation

Programmed in NetLogo 5.05

- Flexible and spatially-explicit
- Allows linkage to other agent-based models



2-DROPS

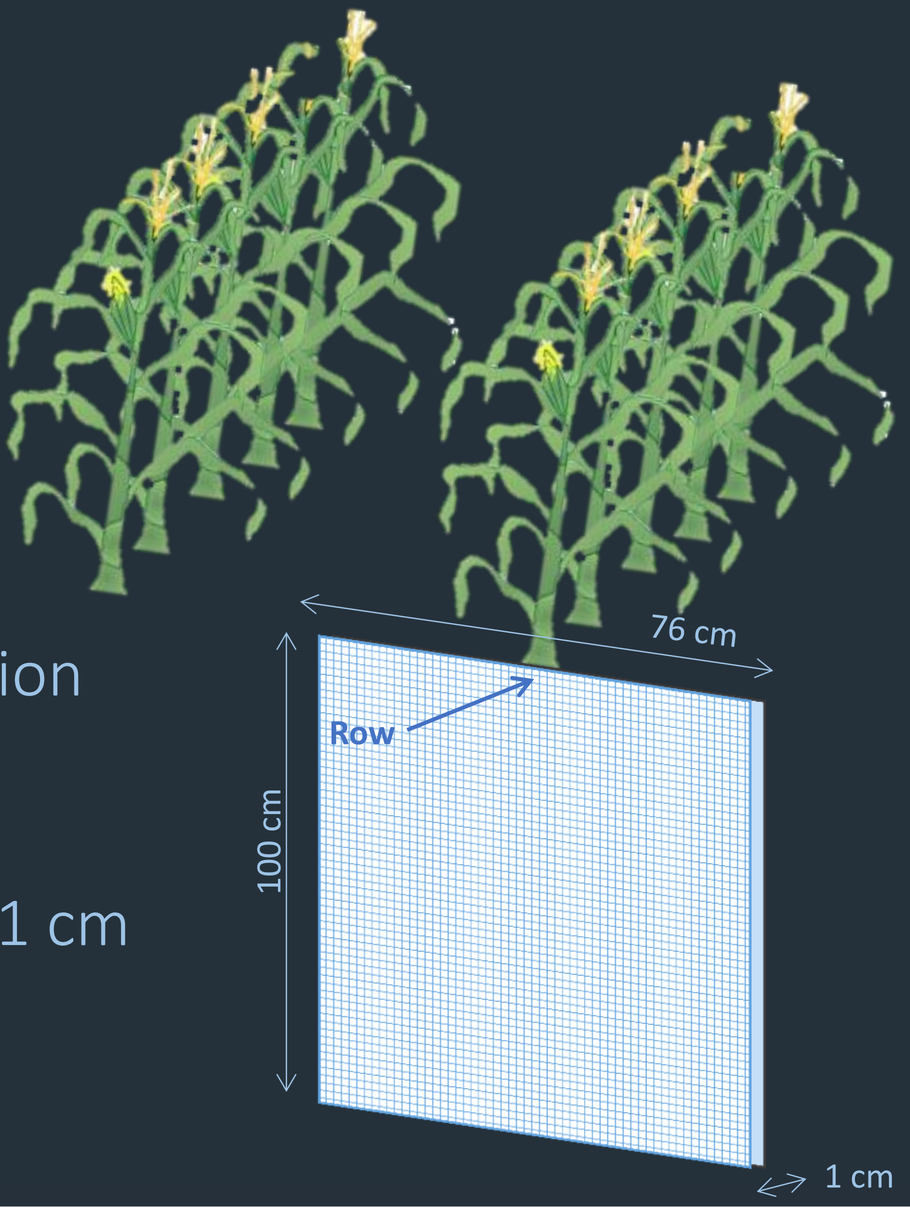
Temporal and spatial resolution

- Model runs and outputs with a
- daily time step

- Fixed grid cells of 1 * 1 * 1 cm

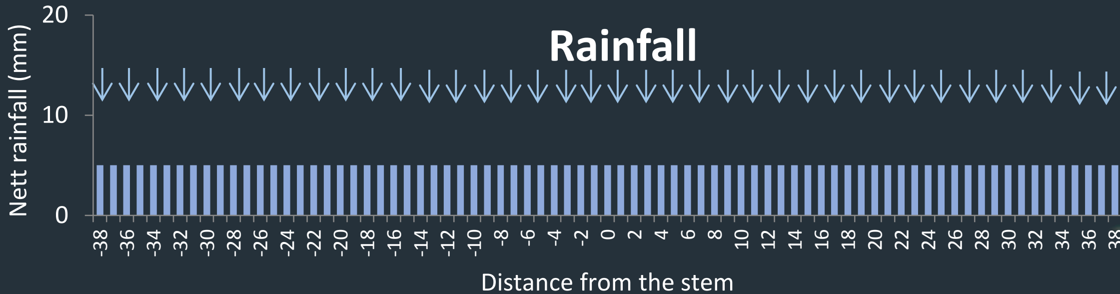
- Simulation space is a cross section through one plant row

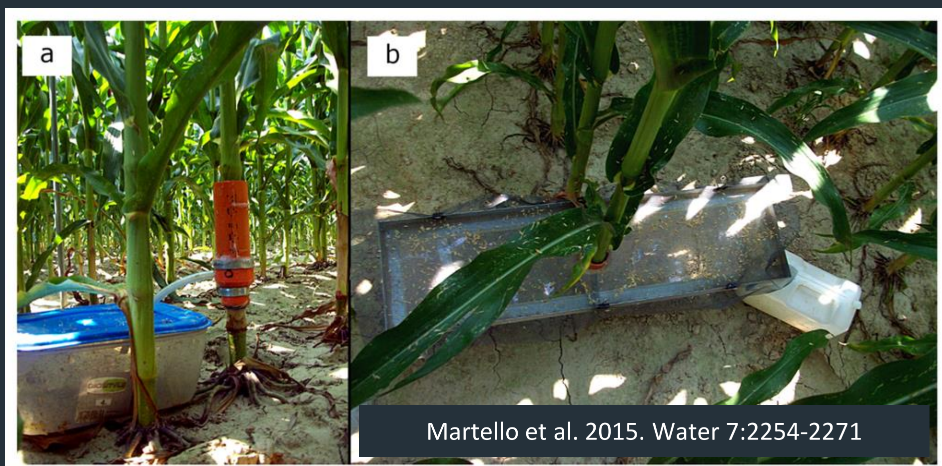
- For maize example: 76 * 100 * 1 cm

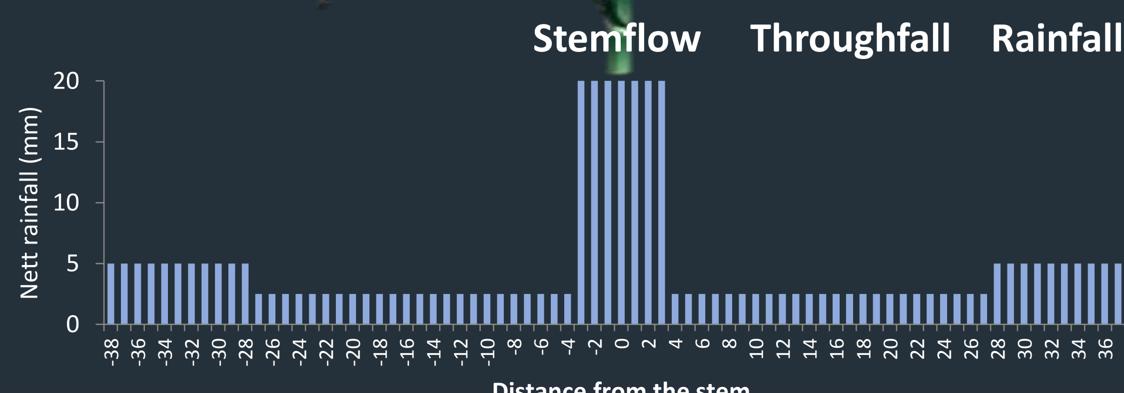


2-DROPS

Canopy interception

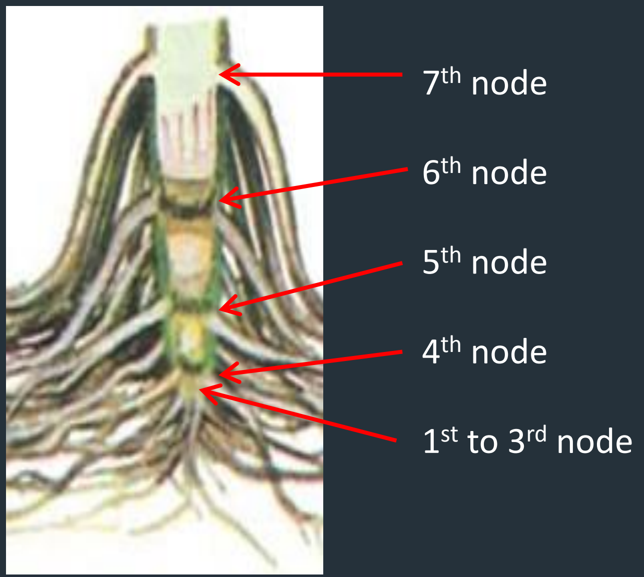


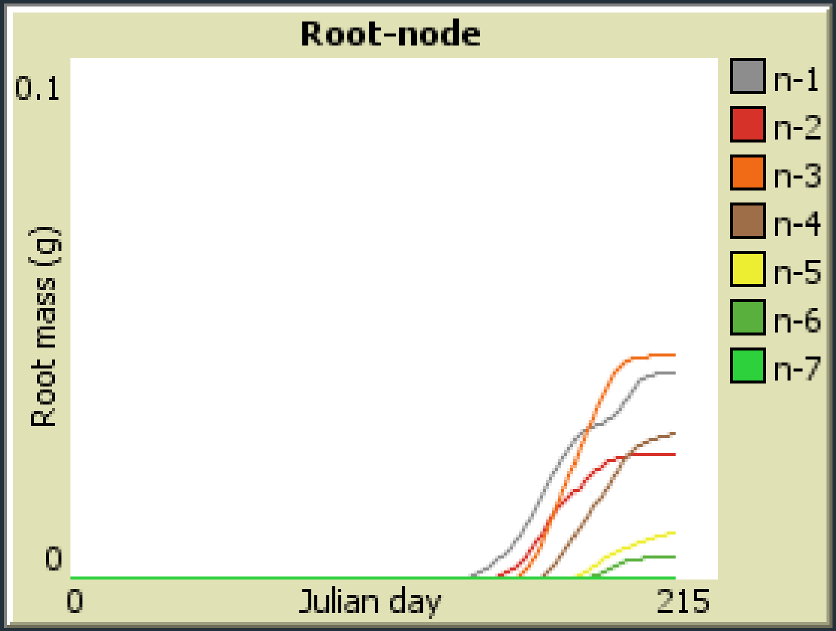




2-DROPS

- Temperature-dependent germination
- Stochastic appearance of roots within defined root development
- For maize example: root mass grouped according to affiliation to node 1 to 7

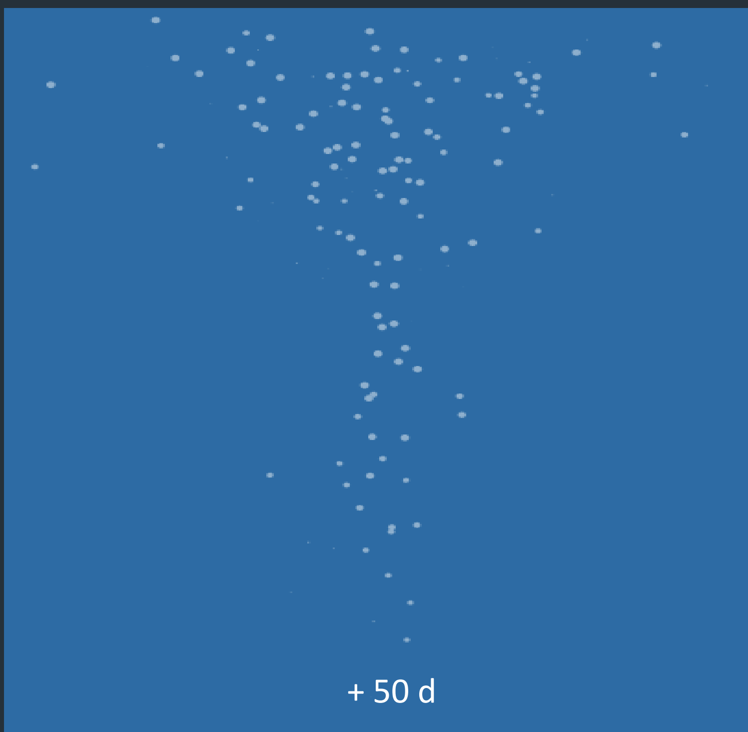


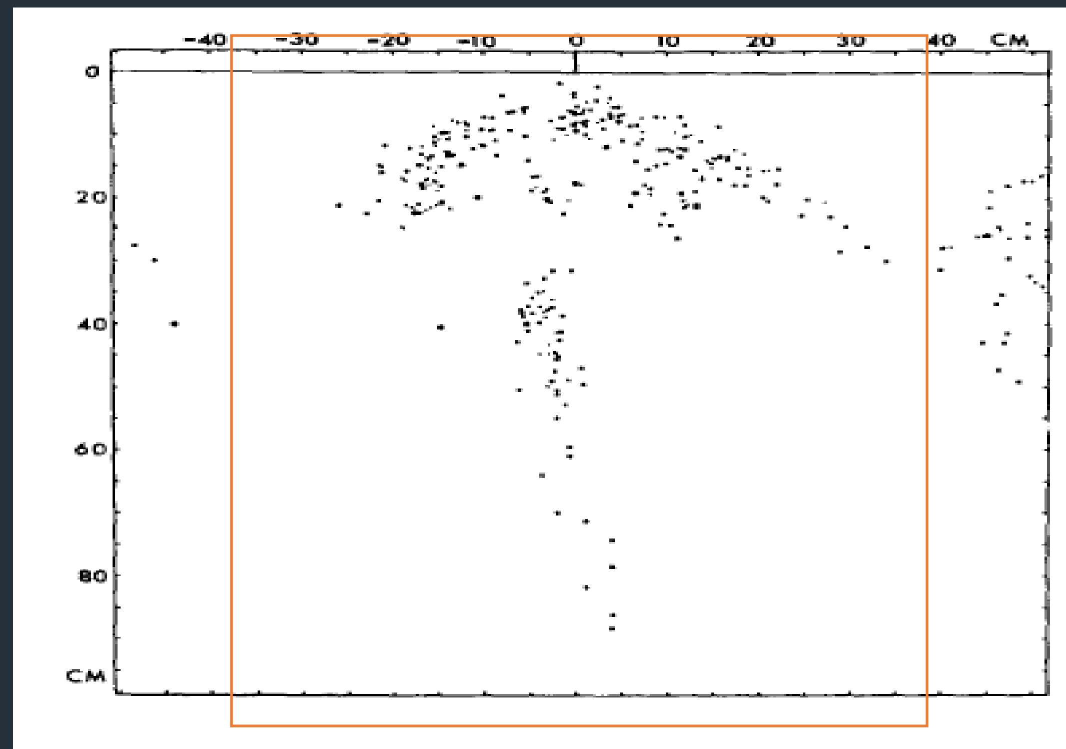


2-DROPS

Root growth

Spatial comparison to more detailed 3D model

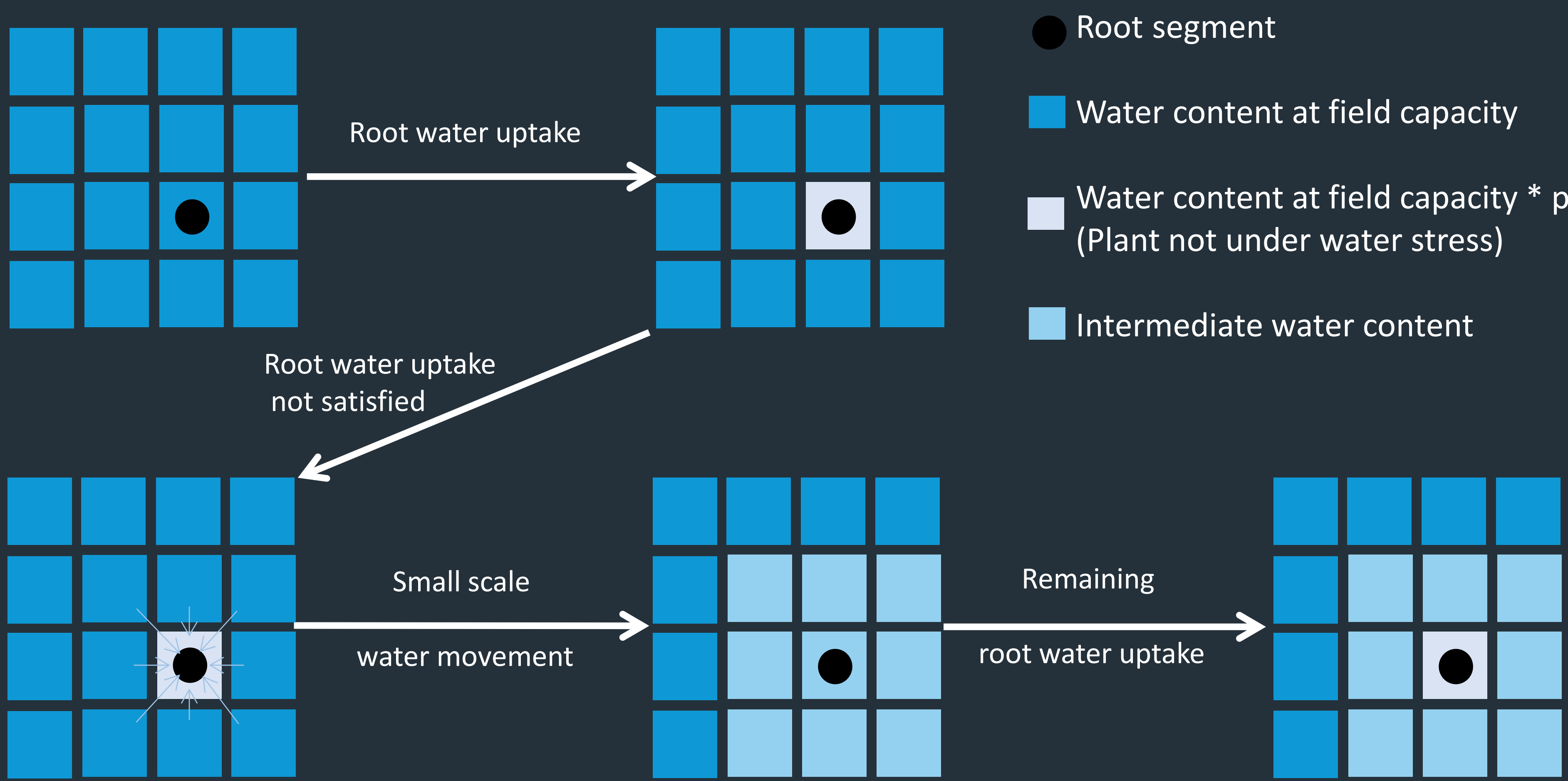




Pagés et al. (1998): Cross section of a corn root after 50 days

2-DROPS

Sequence for water uptake by roots



2-DROPS

Water transport in the soil profile

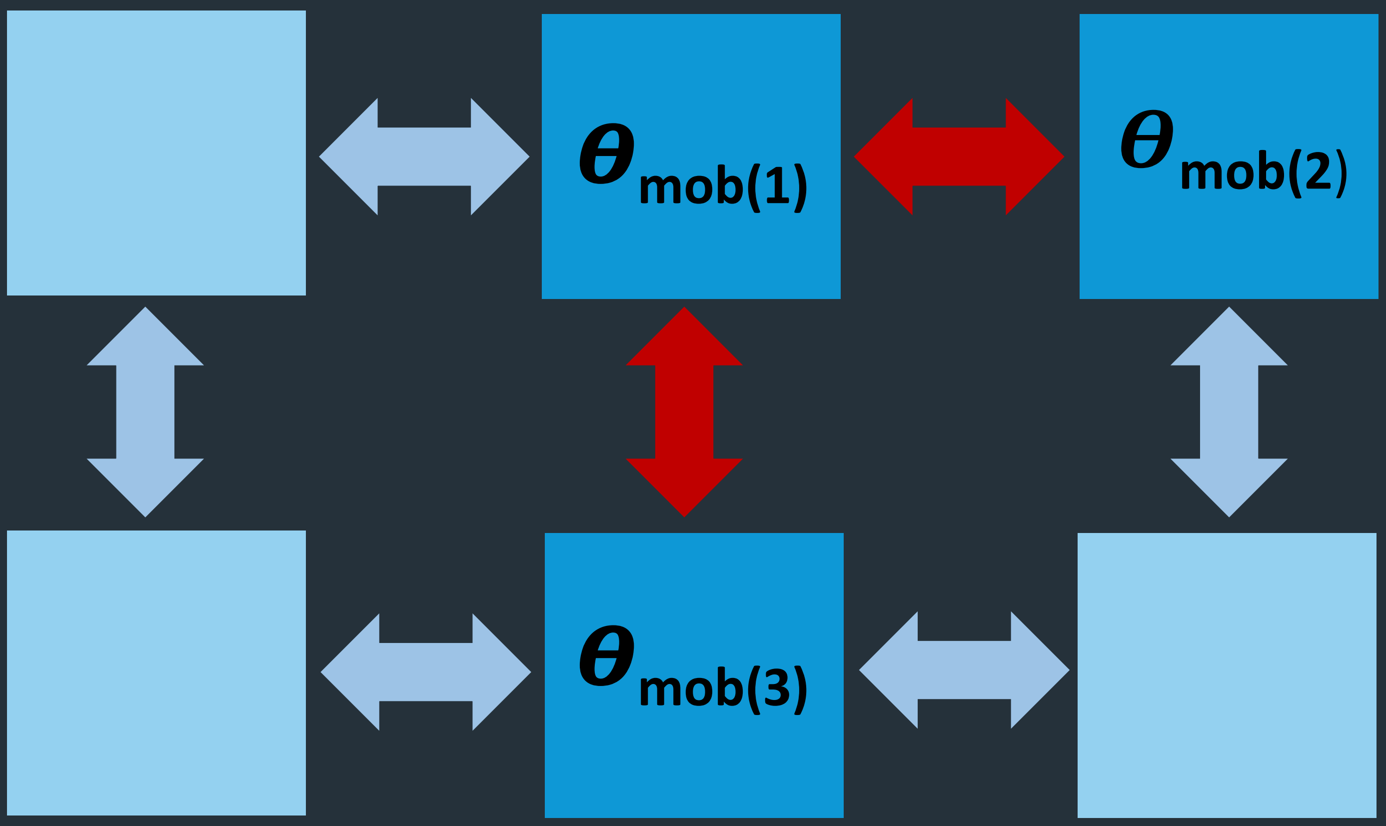
- Capacity approach
- Water can move upwards in the profile, but water leaching out of the profile base is lost
- Iterative redistribution in vertical and horizontal planes
  - User defined maximum hydraulic gradients (***MHG***)
  - Water moves when the difference in mobile water content between adjacent cells exceeds the (*V* or *H*) ***MHG***
  - Water moves until the ***MHG*** is reached

2-DROPS

Water transport in the soil profile

Horizontal hydraulic gradient = $\boldsymbol{\theta}_{mob(1)}/\boldsymbol{\theta}_{mob(2)}$

Vertical hydraulic gradient = $\boldsymbol{\theta}_{mob(1)}/\boldsymbol{\theta}_{mob(3)}$



2-DROPS

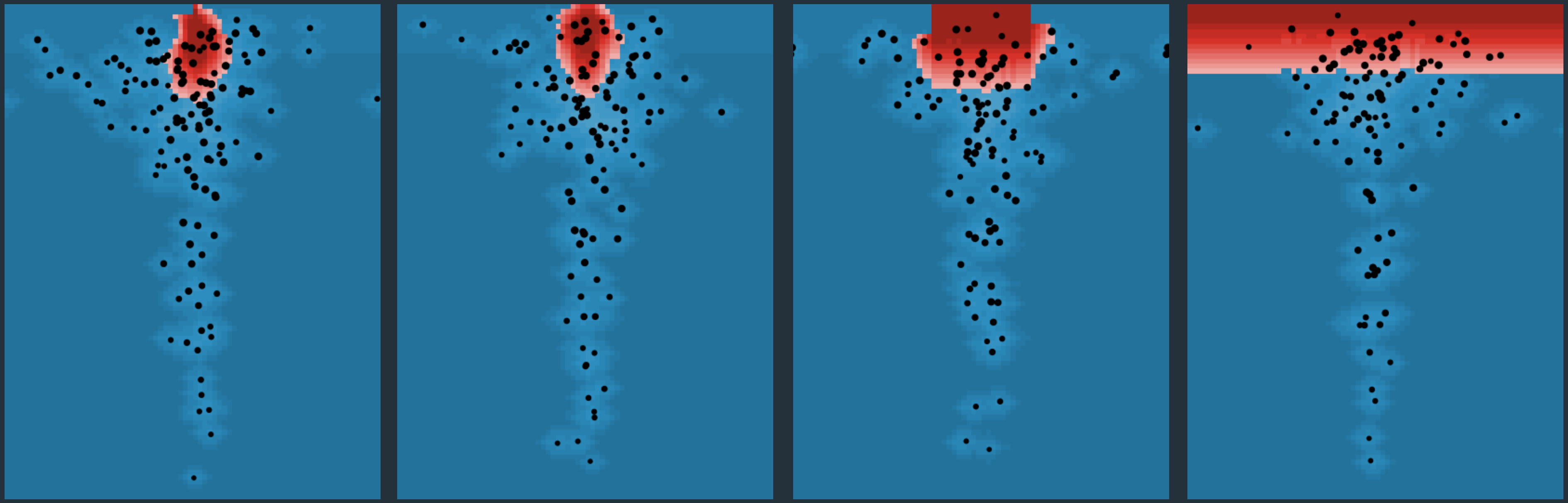
Pesticide processes

- First-order degradation
  - Varies with soil temperature and soil moisture content in 2-dimensions
- Linear, instantaneous sorption
  - Calculated for each grid cell (because adjacent cells may have different moisture content)
- Uptake by roots with mobile soil water

2-DROPS

Clothianidin

60 days post-application

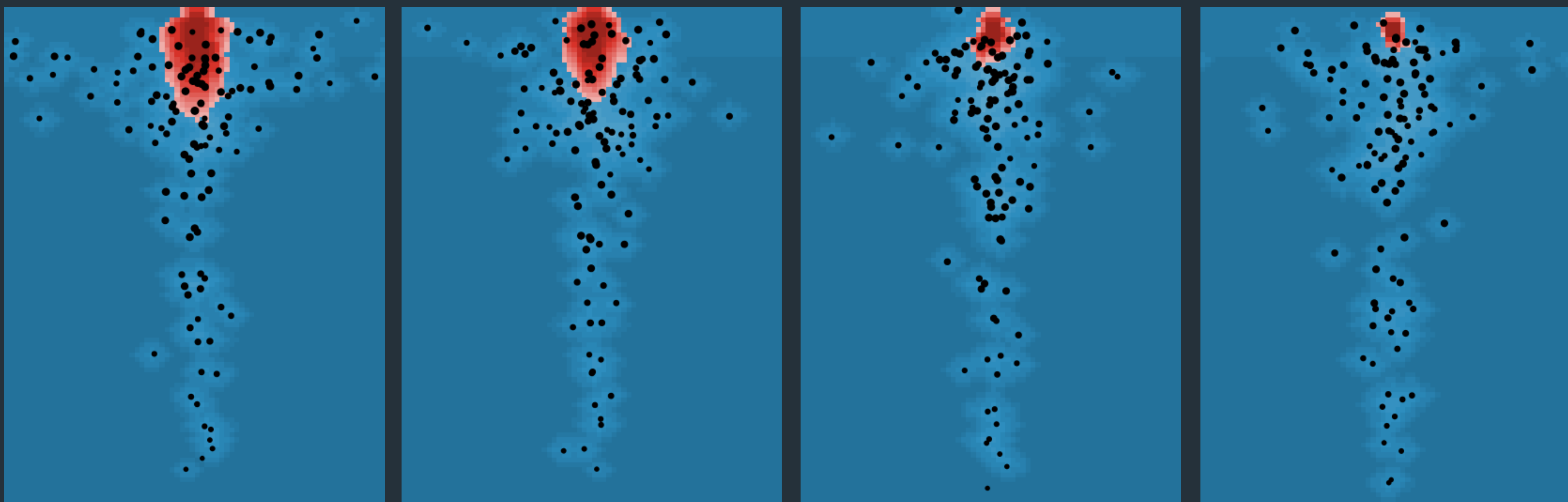


Seed | Furrow | Band | Broadcast

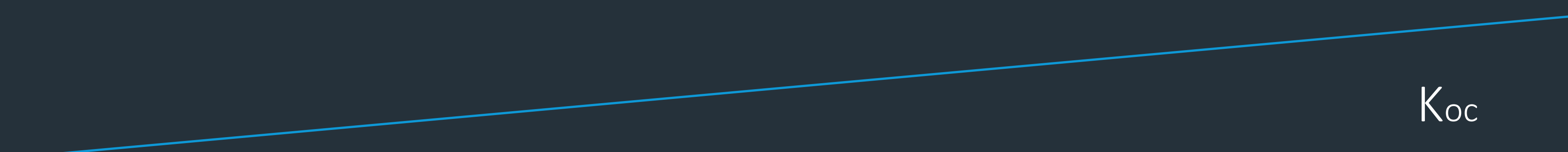
2-DROPS

Four pesticides

60 days post furrow application



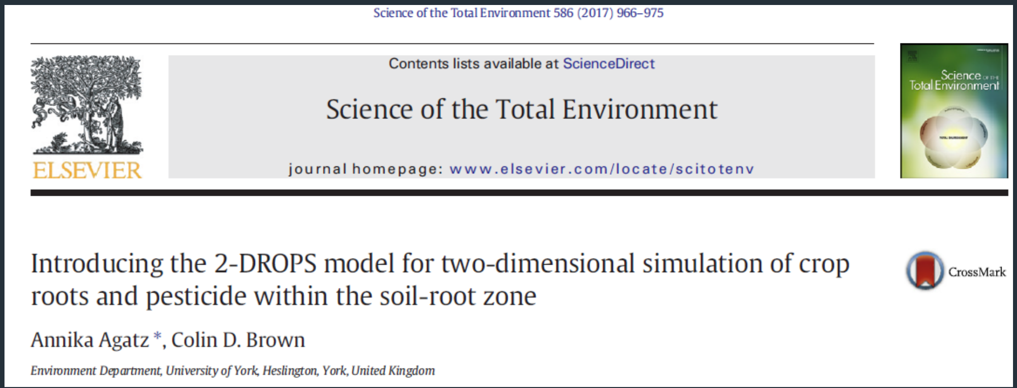
Thiamethoxam Clothianidin Chlorpyrifos Tefluthrin



2-DROPS

Summary

- Prototype model ready for evaluation
- Adds to existing tools through spatially-explicit simulation of crop roots
- Has applications in developing and testing pesticide placement strategies
- Potential to link to IBM's for crop pests in soil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journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

Introducing the 2-DROPS model for two-dimensional simulation of crop roots and pesticide within the soil-root zone

CrossMark

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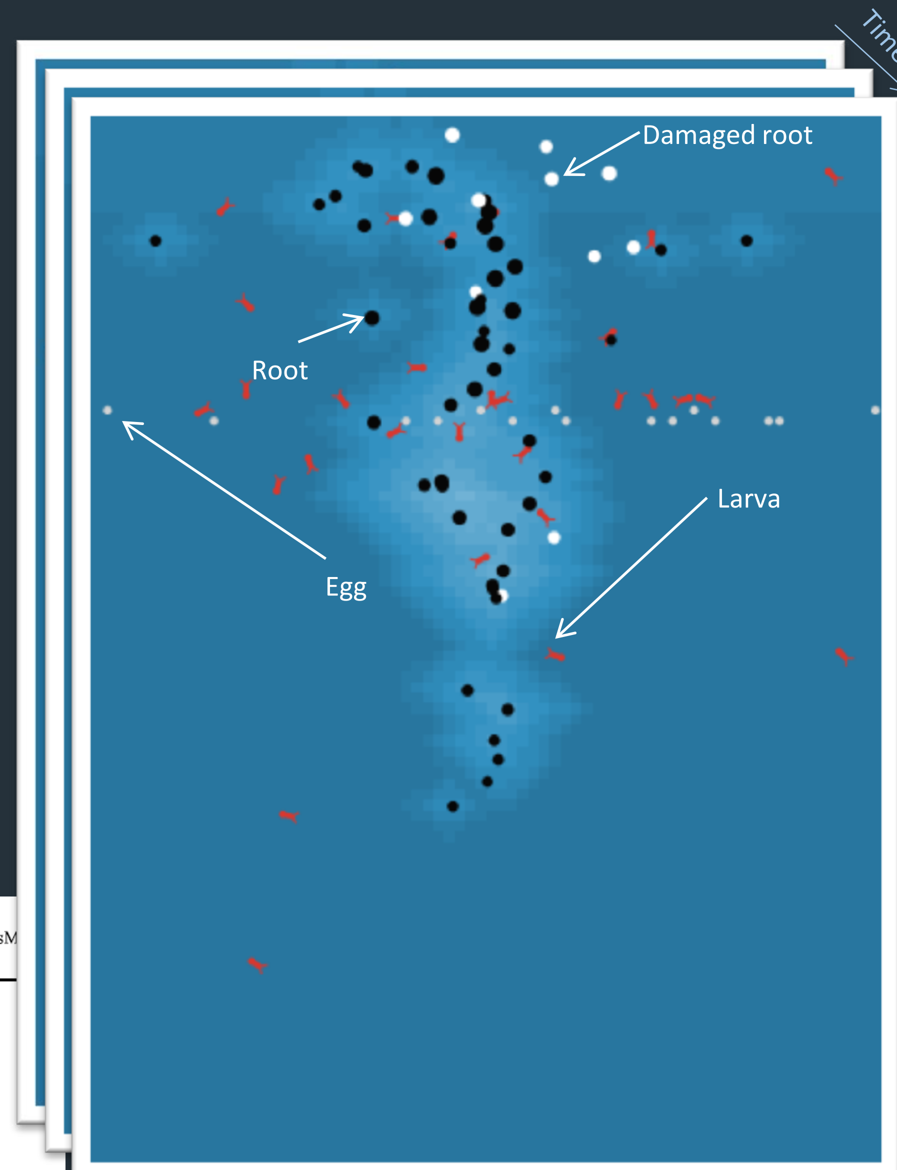
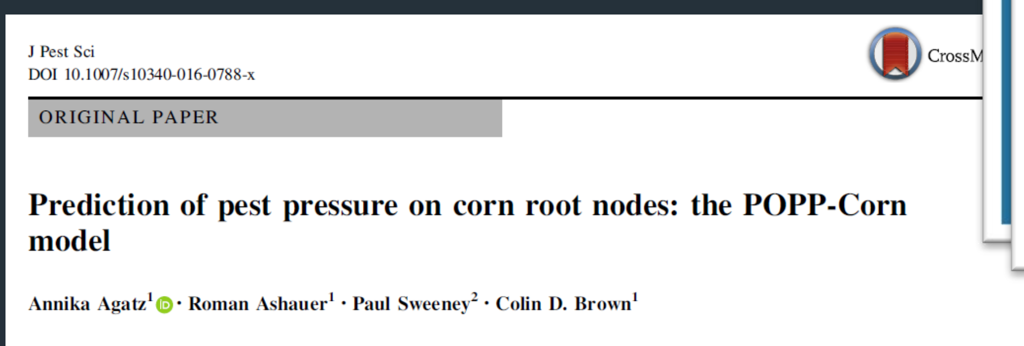
IBM’s for crop pests in soil

- Aim to develop a 2-D model of pest development and pest movement in soil profile
  - Spatially-explicit description of crop roots (identical to 2-DROPS)
  - Spatially- and temporally-explicit pest appearance
  - Parameterised with readily-available information
  - Predictions for crop root damage are directly comparable with observations made in the field

POPP-Corn

Prediction Of Pest Pressure on Corn root nodes




J Pest Sci
DOI 10.1007/s10340-016-0788-x

ORIGINAL PAPER

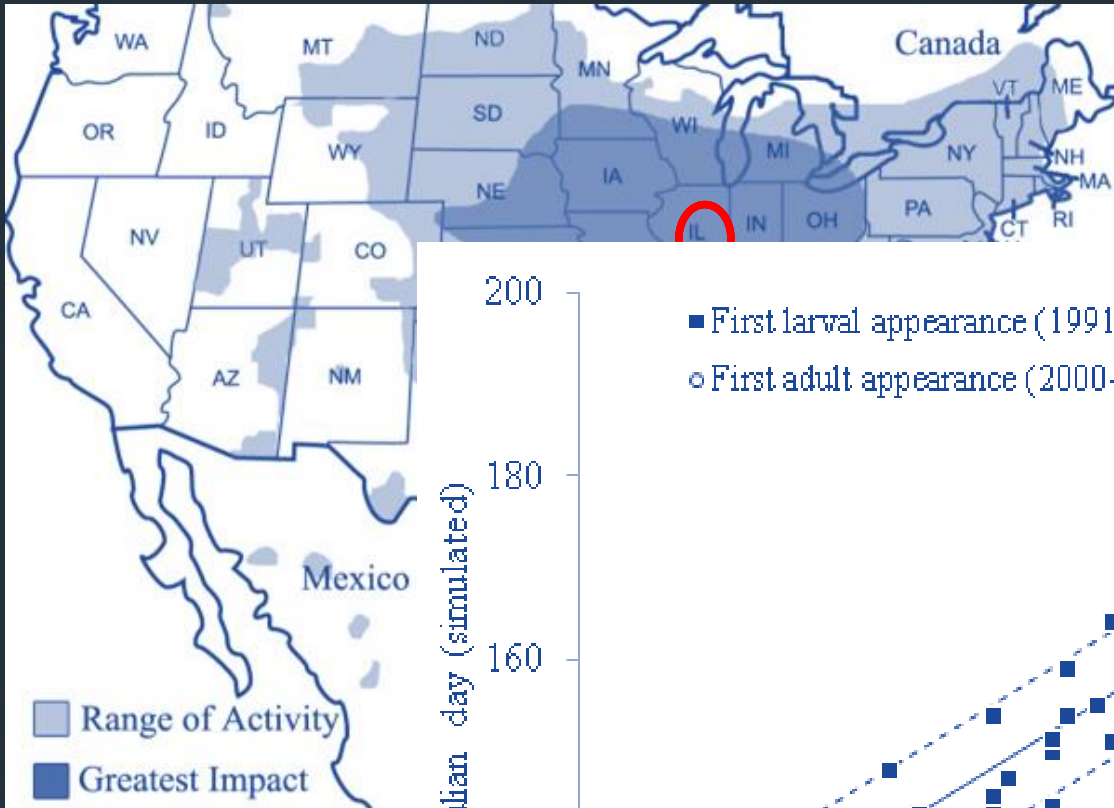
Prediction of pest pressure on corn root nodes: the POPP-Corn model

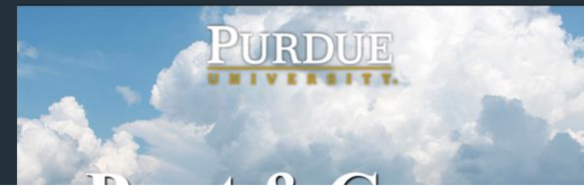
Annika Agatz[1] · Roman Ashauer[1] · Paul Sweeney[2] · Colin D. Brown[1]

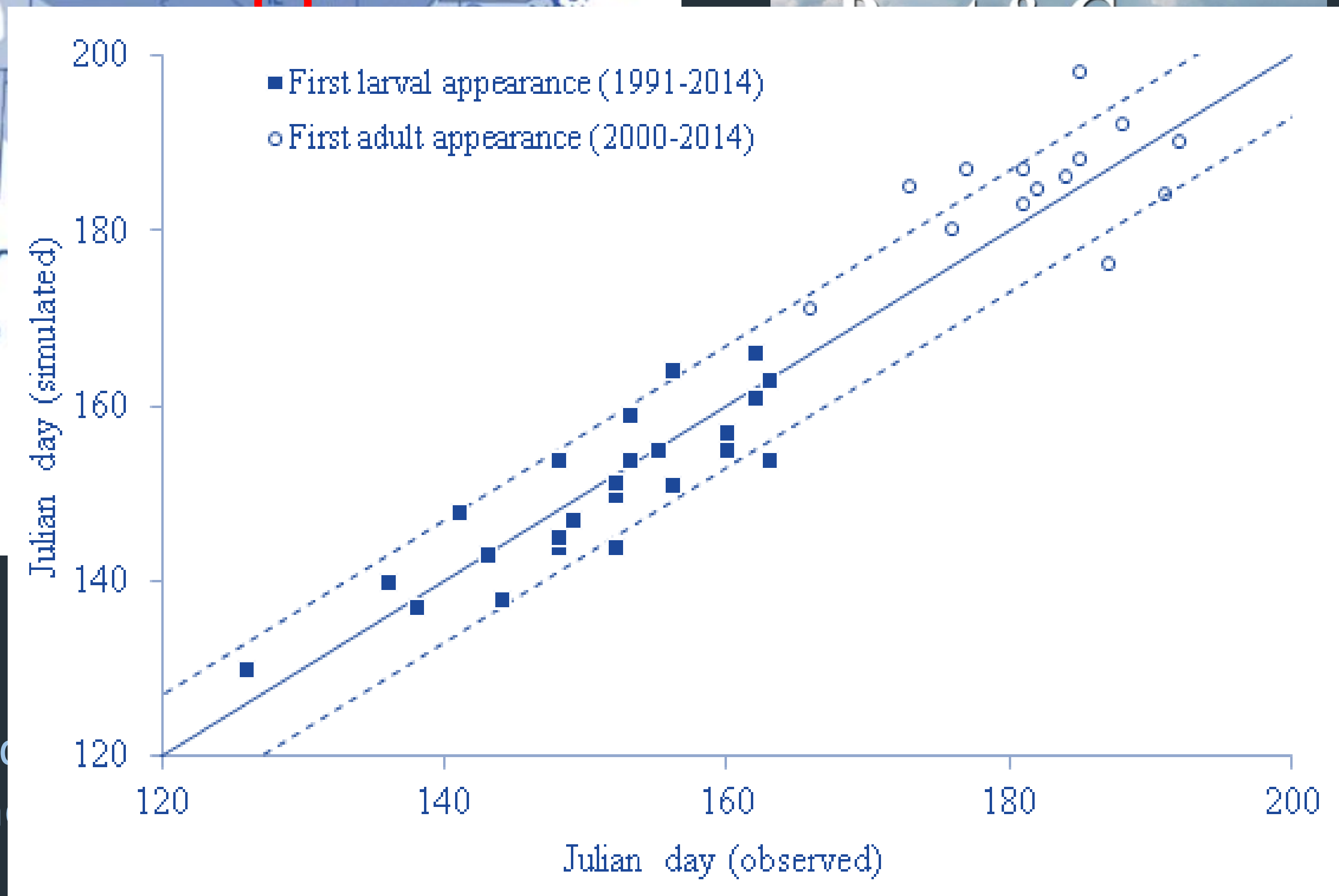
syngenta Innovate UK Technology Strategy Board BBSRC bioscience for the future

POPP-Corn

Validation



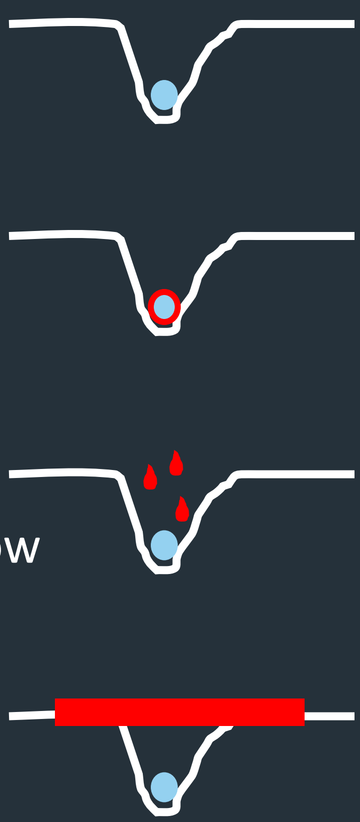




- Weather data
- First larva found
- First adult found

Example runs

Clothianidin



		1.91 NIS	
Seed	0.60 mg/seed	1.43 NIS	-25%
Furrow	0.30 mg/m row	1.77 NIS	-7.5%
	0.60 mg/m row	1.48 NIS	-23%
	1.20 mg/m row	1.47 NIS	-23%
Band	5 cm 0.60 mg/m row	1.56 NIS	-18%
	10 cm 0.60 mg/m row	1.57 NIS	-18%
	20 cm 0.60 mg/m row	1.93 NIS	0%

NIS = Node Injury Scale; value from 0 to 3

Potential applications

- Comparing field efficacy of new and existing products
  → Increase success of new actives
- Strategies for product enhancement
  → Evidenced product optimization
- Any combination of crop and soil-based pest possible

Thanks!