



Validation and use of a model for the calculation of trace element accumulation in soils

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Introduction

- Trace elements (TEs) contained in agrichemicals can accumulate in soils and pose risks to soil quality, plant growth and animal and human health through plant uptake into food chains.
- Understanding likely rates of accumulation can inform application rates that will not lead to the exceedance of soil guideline values.
- We have developed a mass-balance model to calculate TE accumulation rates under agricultural production.

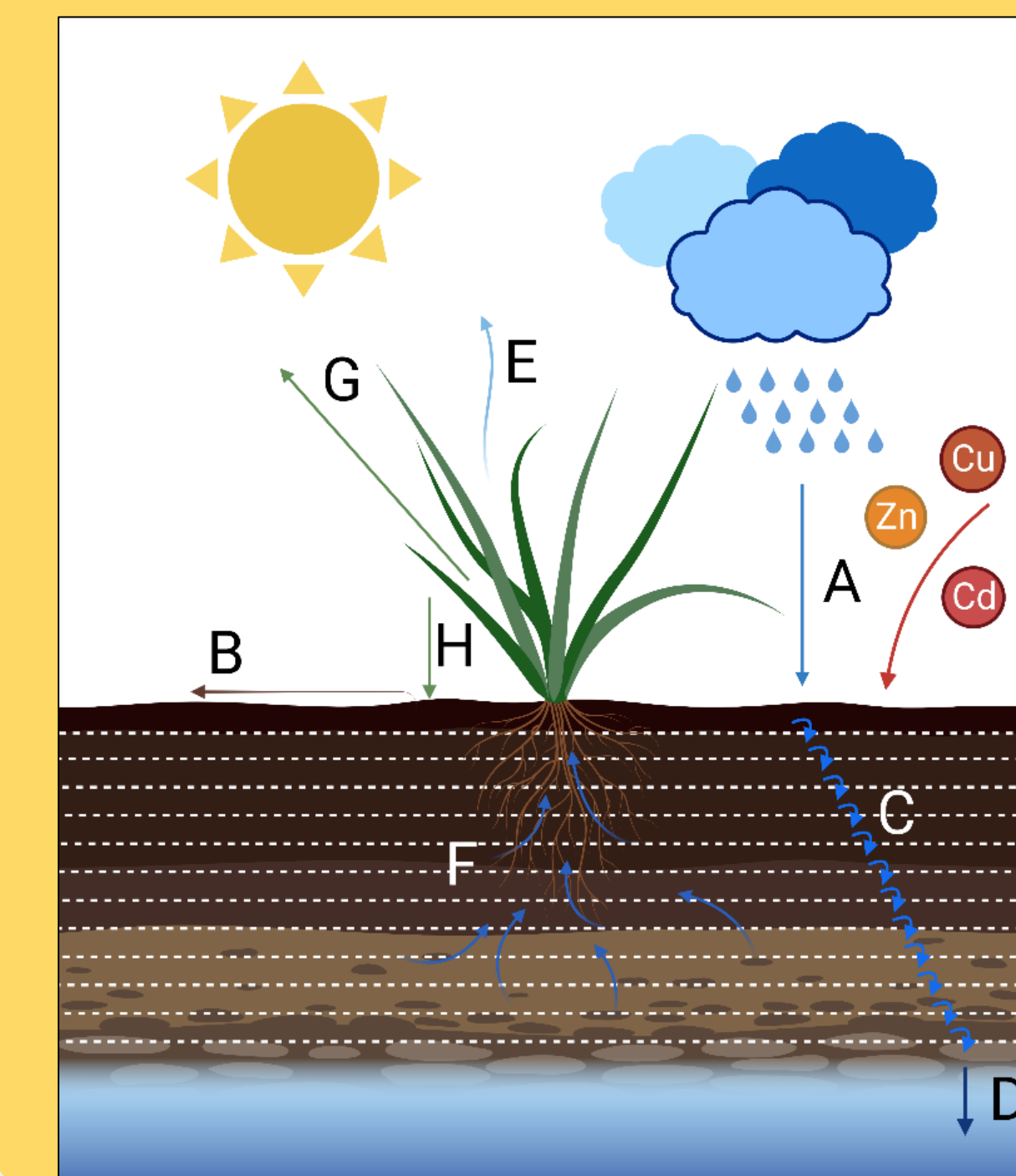
Modelling approach

Our model was founded on the mass-balance equation:

$$\sum_d M_{Y,d} = \sum_d M_{0,d} + \sum_y M_{y,\bullet}^+ - \sum_y (M_y^{(P)} + M_y^{(L)} + M_y^{(R)})$$

Where $M_{Y,d}$ = TE mass (g) in year $y = 1, \dots, Y$ in soil layer $d = 1, \dots, D$ with $d = 1$ corresponding to the topmost layer; $M_{0,d}$ = mass of background TE in soil; $M_{y,\bullet}^+$ = TE mass added to soil in year y ; $M_y^{(P)}$ = TE mass taken up by plants in year y ; $M_y^{(L)}$ = TE mass leached in year y ; and $M_y^{(R)}$ = TE mass lost in soil erosion in year y .

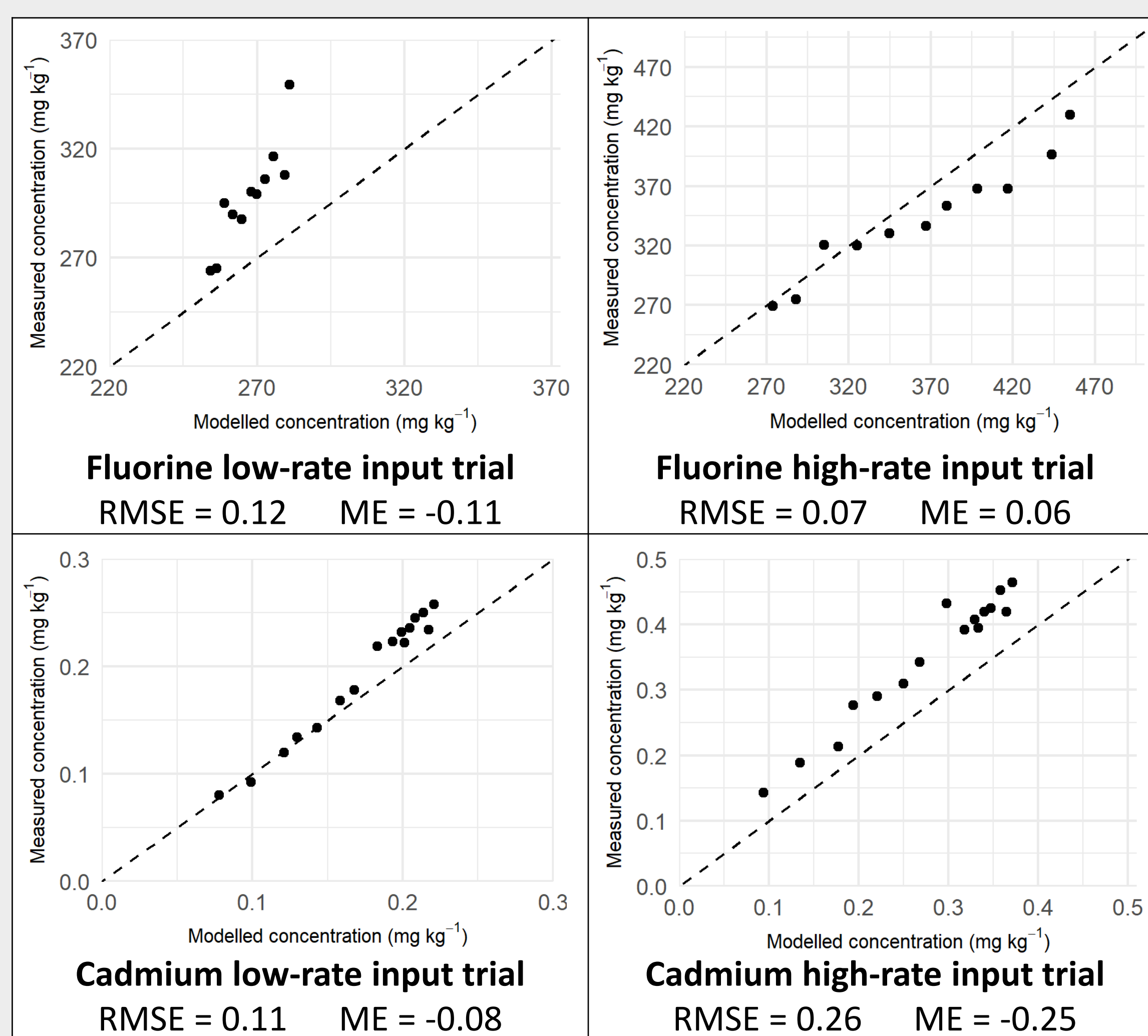
The following soil-plant processes were modelled numerically:



- A: Input of water and TEs;
- B: Soil erosion;
- C: Water percolation and TE mobilisation;
- D: Leaching;
- E: Evapotranspiration;
- F: Plant uptake;
- G: Biomass removal;
- H: Biomass reincorporation to soil

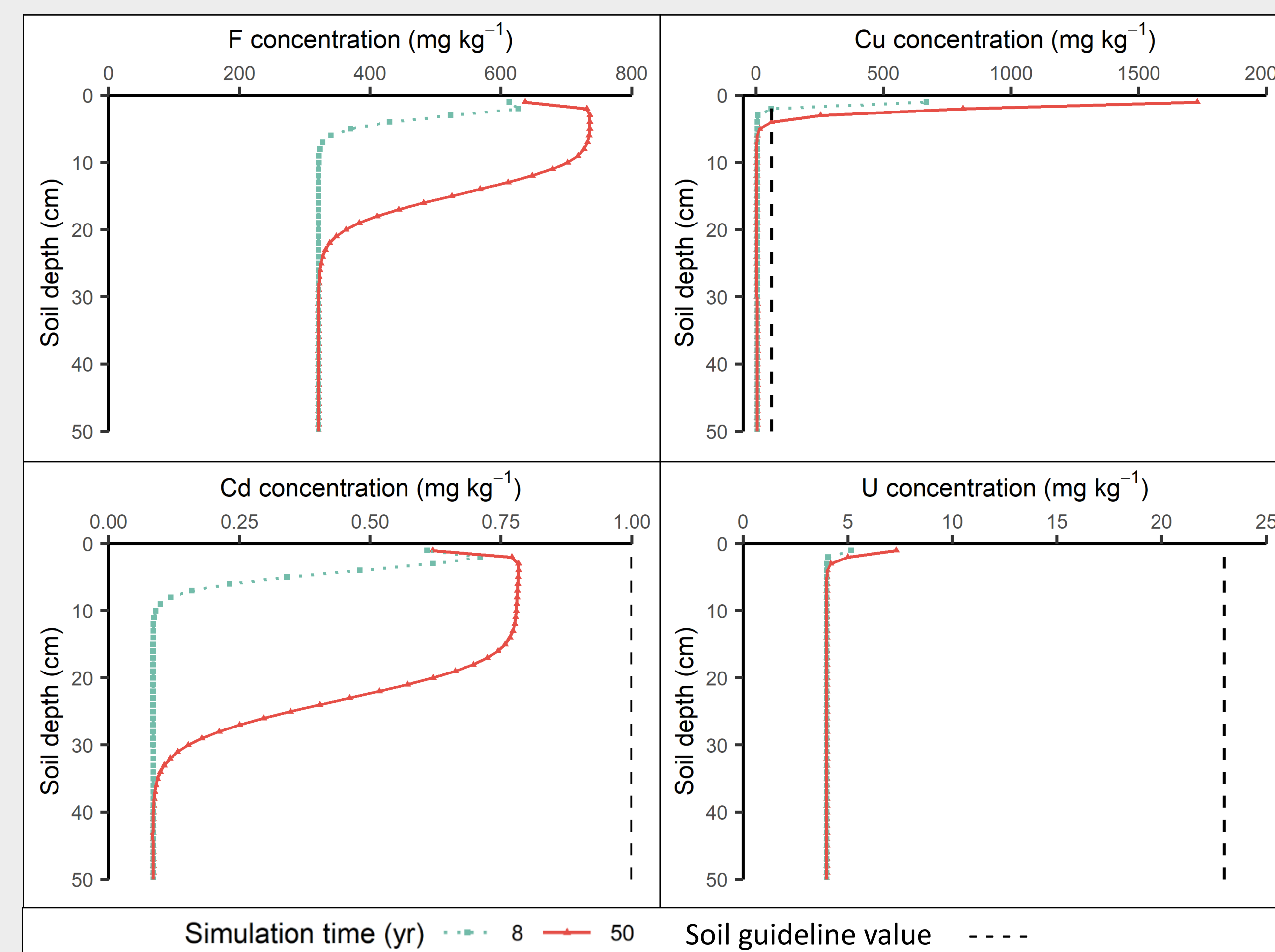
Model validation

Done using data from the Winchmore fertiliser trials – a 70 year long research trial from New Zealand with known TE inputs and soil concentrations over the life of the trial.



A case study: Oil palm plantation soils

Oil palm is an intensive crop with high rates of agrichemical inputs. Some oil palm plantation soils in Indonesia are accumulating TEs at rates that may be unsustainable. We modelled the soils of a smallholder plantation into the future to determine likely TE concentrations after 8 and 50 years.



The TEs modelled included fluorine (F), cadmium (Cd) and uranium (U) — common contaminants in NPK fertiliser used in oil palm production — and copper (Cu) — a commonly used fungicide spray. After 8 years, topsoil concentrations of F and Cu become phytotoxic.

Conclusions

- The model developed is a useful tool to determine the sustainability of inputs into agricultural soils.
- Oil palm production in Indonesia will likely become challenged by phytotoxic concentrations of F and Cu in soils.

Acknowledgements

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Citation

Thompson-Morrison et al. (2023). Development and use of a mass-balance model to calculate the likely effects of agrichemicals on trace element accumulation in soils supporting palm oil production. [In press].

