Pesticide Behaviour in Soils, Water and Air 2017

Development of a model to estimate airborne concentrations of pesticides downwind of treated fields

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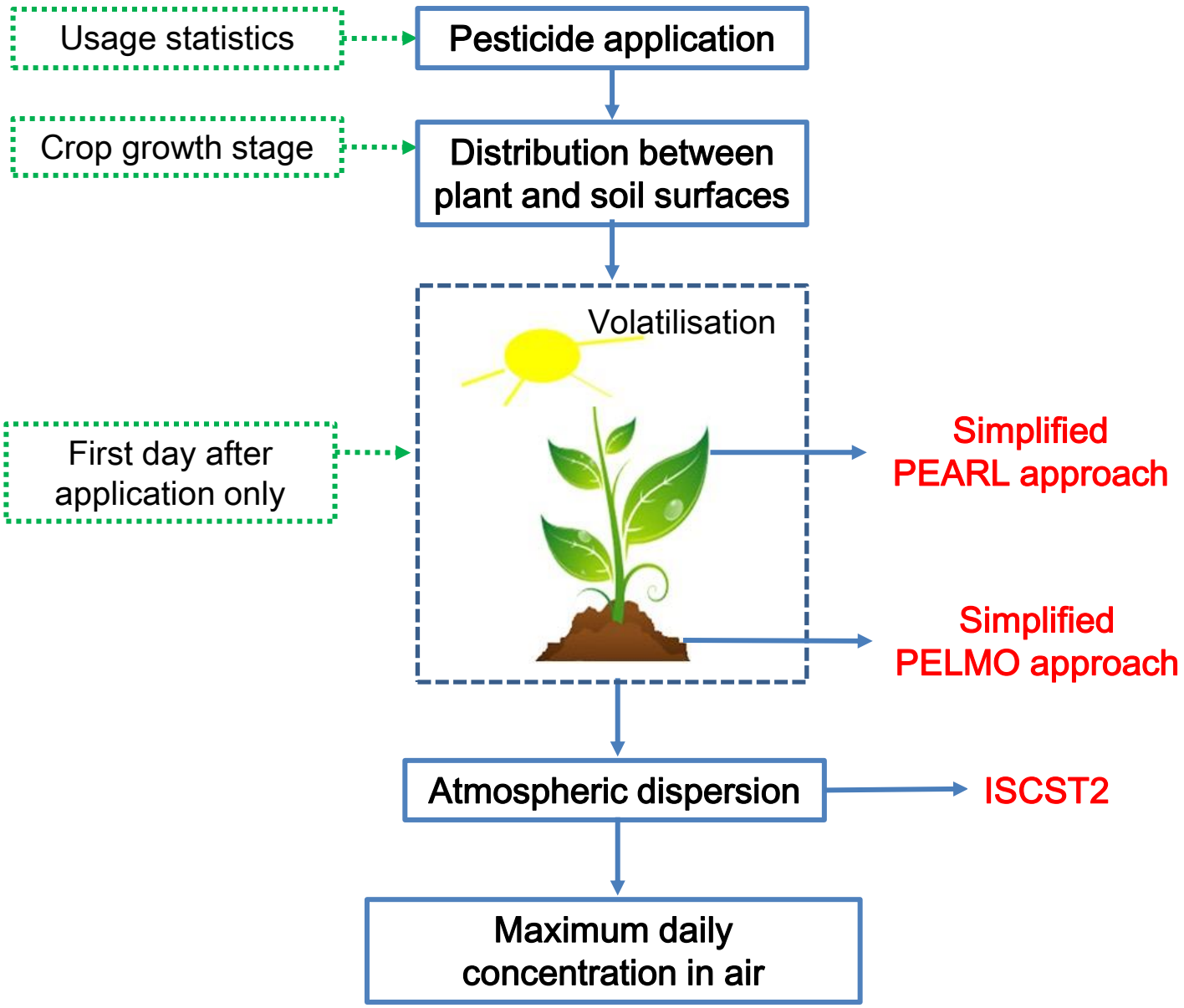
Introduction

- Pesticide can be emitted to the atmosphere via **volatilisation** for periods up to several weeks after application.
- Whereas spray drift decreases rapidly with distance from the treated area, vapour drift can occur over **longer distances**.
- It is important to **quantify concentrations in air** and how these vary both with crop type and over time.

Requirement for model

- Most epidemiological studies that investigate pesticide-related health issues have no quantification of exposure.
- Existing regulatory models that predict residential exposure are inflexible for calculating concentration in air for a range of distances downwind of treated fields.
- We lack a model to simulate emission and dispersion in air for very large quantities of usage data.

Model development



Emission to air (1)

Amount applied, fraction of pesticide on leaves

Volatilisation

Air temperature (T), thickness of air boundary layer, diffusion coefficient into air$_{(T)}$

Physicochemical properties of pesticide:

i. Molecular weight

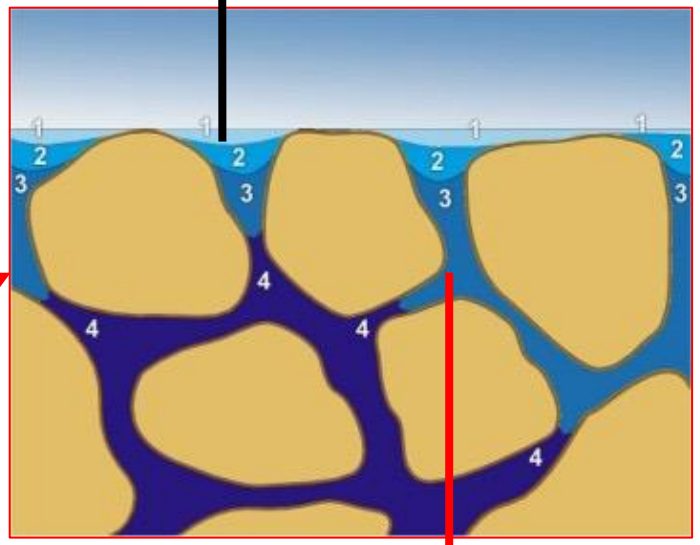
ii. Vapour pressure$_{(T)}$

Emission to air (2)

Amount applied, fraction of pesticide on soil

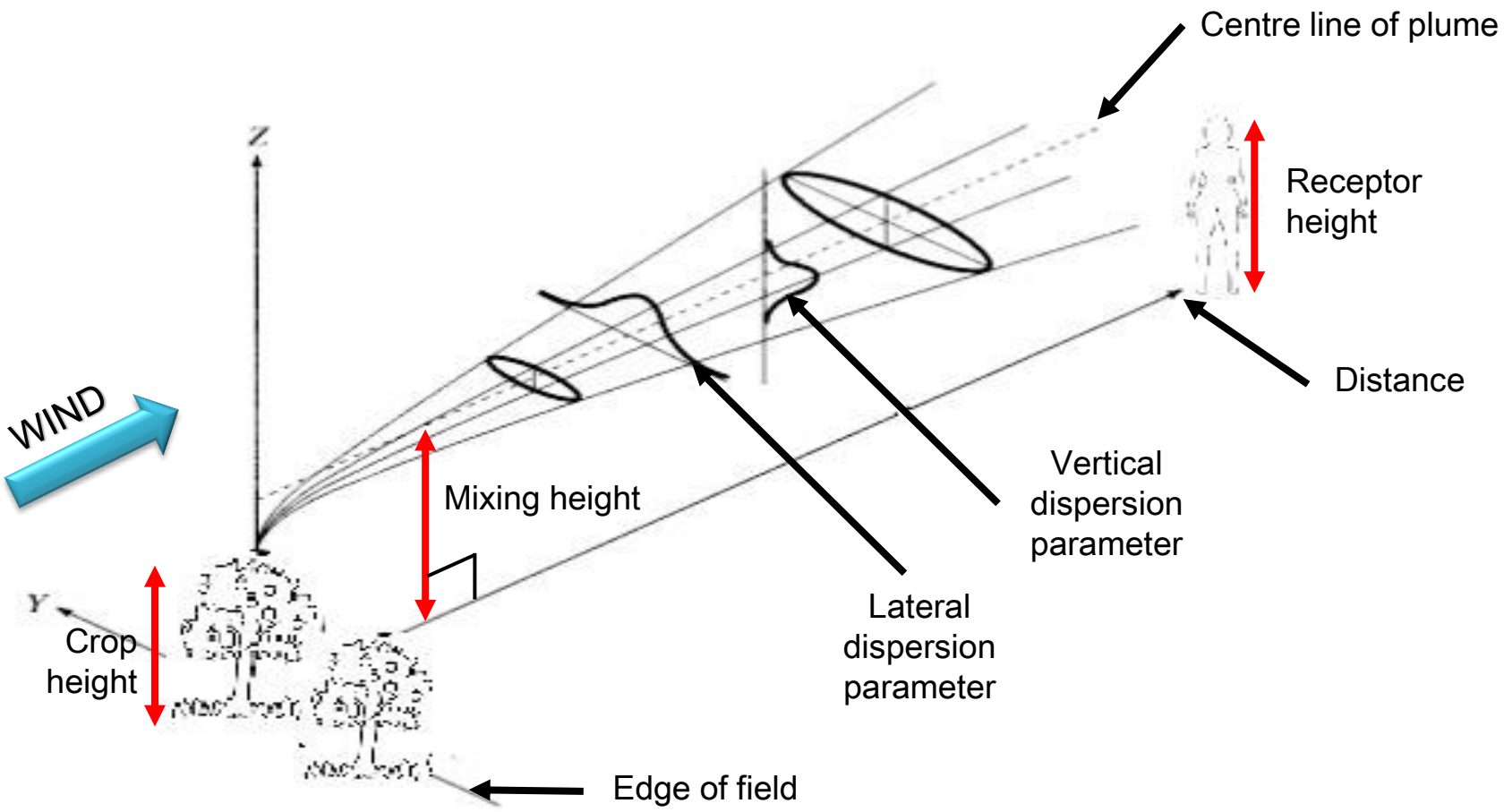
Volatilisation

Non-dimensional Henry's law constant, Air temperature (T), air boundary layer, diffusion coefficient into air$_{(T)}$



Organic carbon partition coefficient (K_{OC}), fraction of organic carbon, dry soil bulk density, soil water content

Atmospheric dispersion



Model application

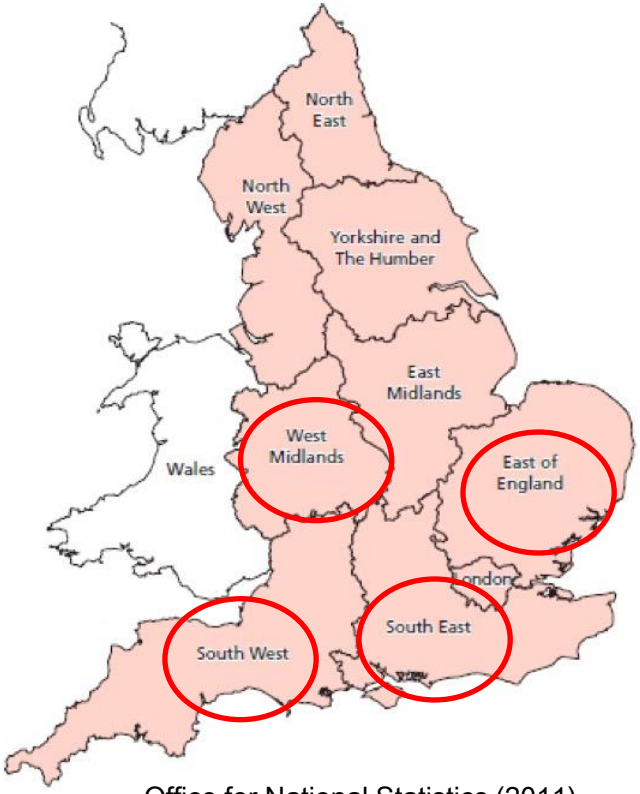
Model application

Based on Fera's pesticide usage survey, the model is applied to investigate:

i. changes in pesticide usage;

ii. changes in airborne concentration; and

iii. major drivers of these changes over time.



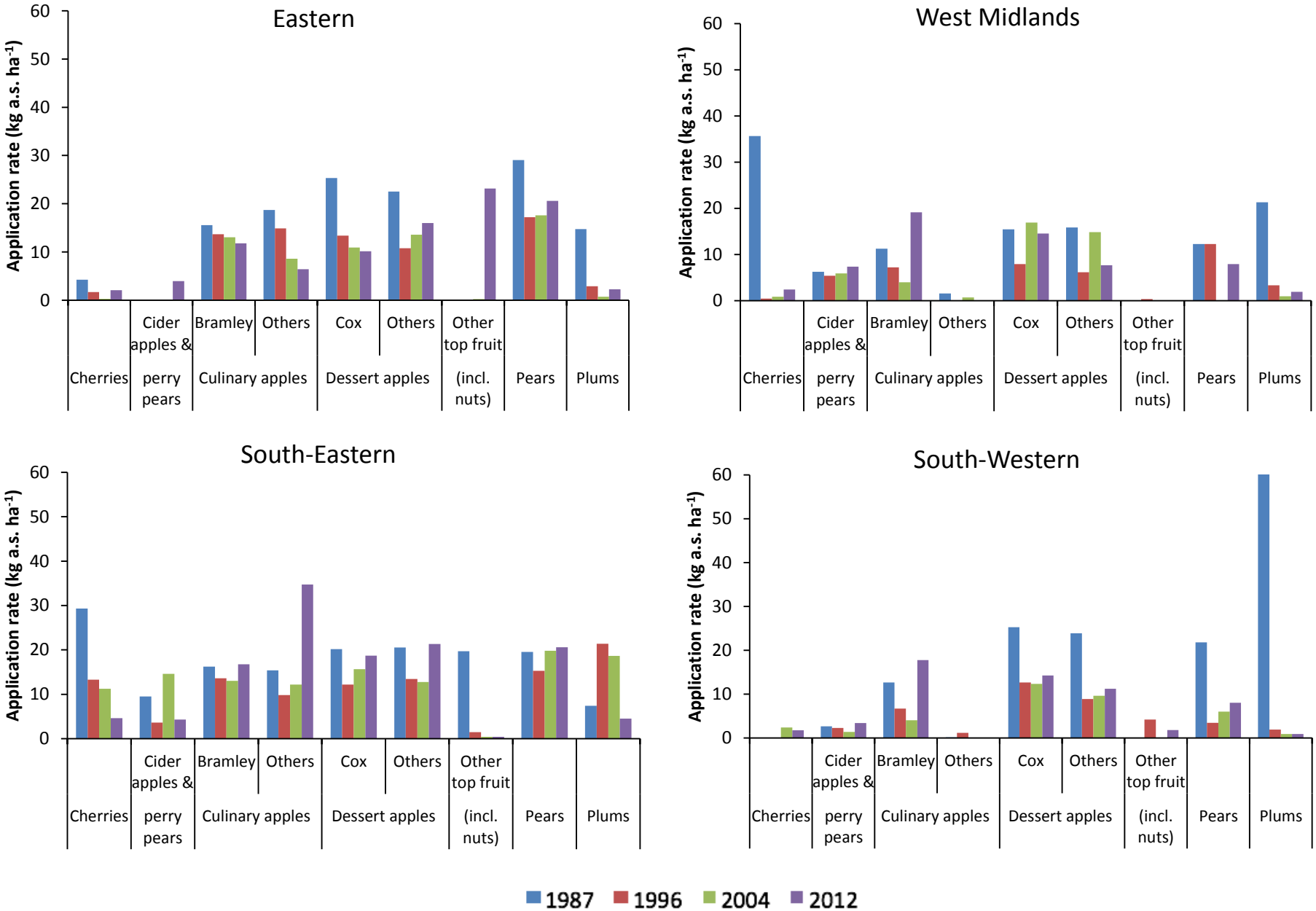
Office for National Statistics (2011)

Year	Crop type	Month of application	Active substance
1987, 1996, 2004 & 2012	9 types of orchard crops	Jan - Dec	132 compounds

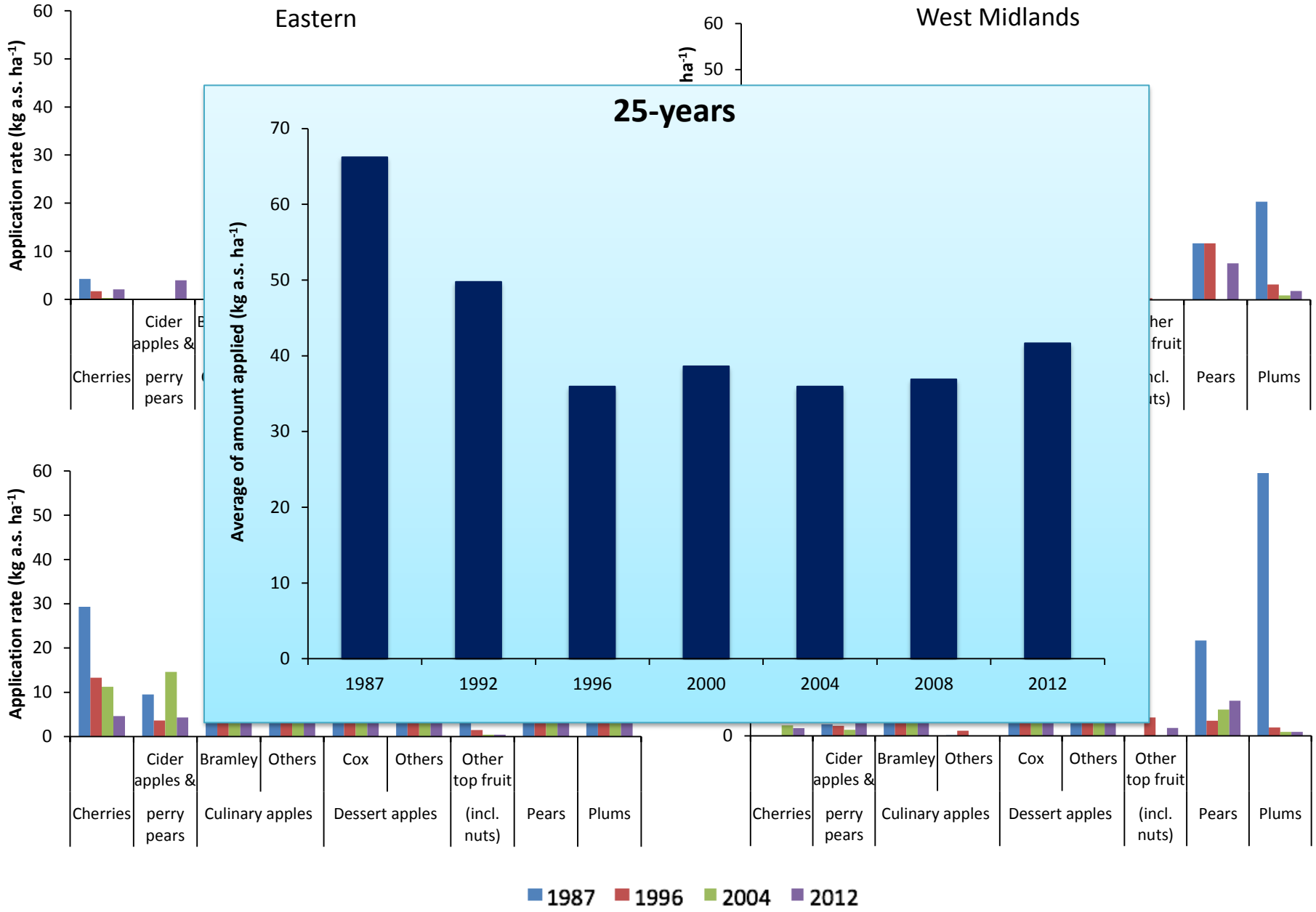
15,000 simulations

Result Analysis

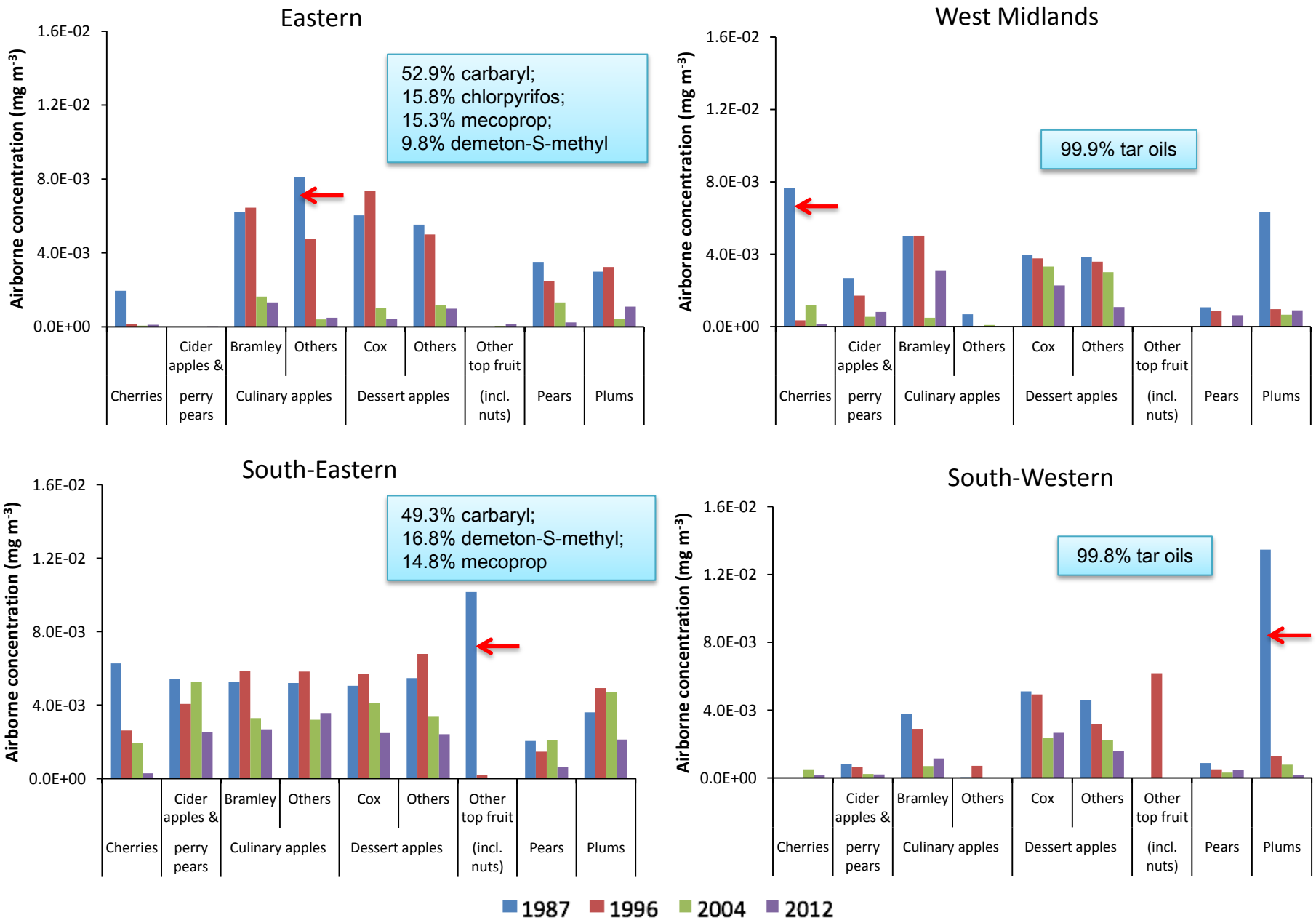
Pesticide usage



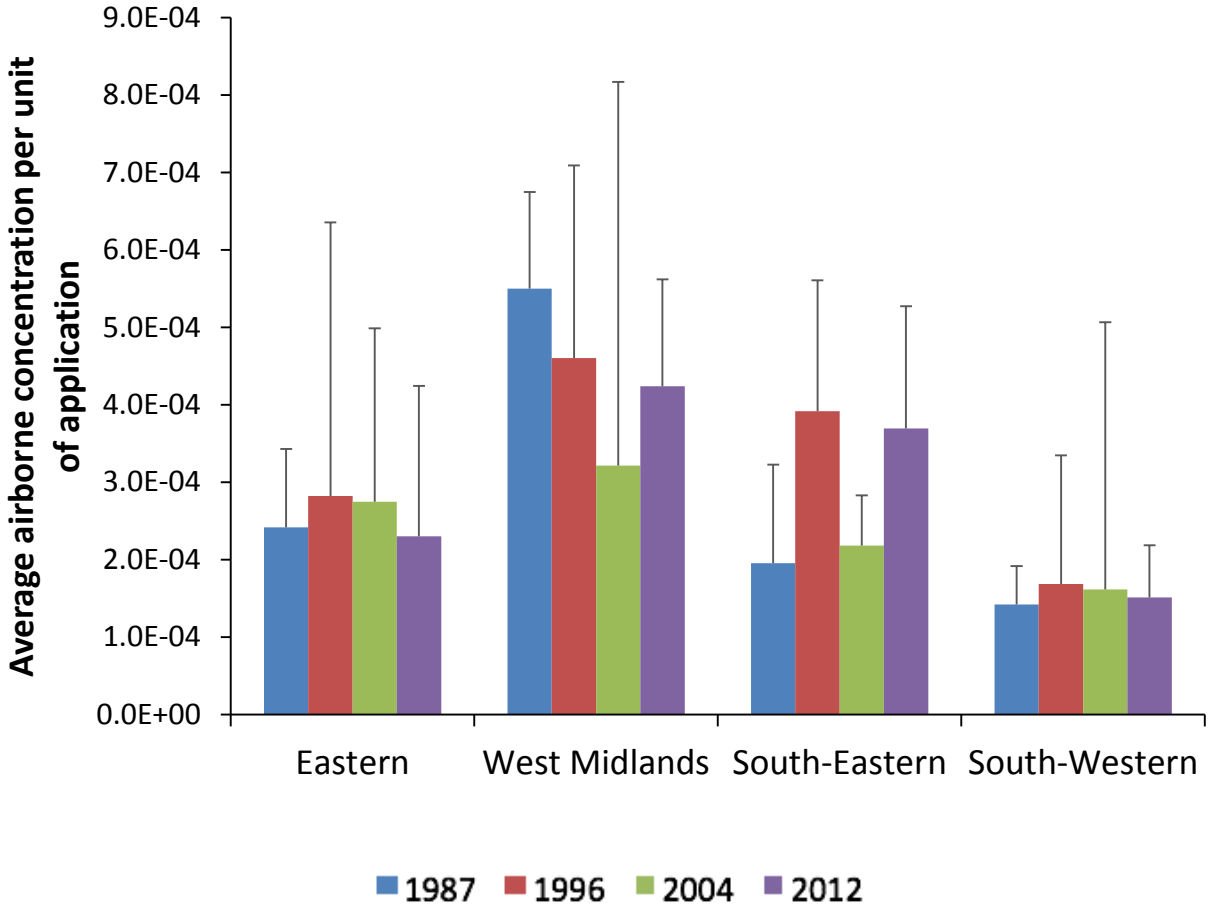
Pesticide usage



Airborne concentration at 100 m



Airborne concentration per unit of application



Pesticide properties (1987-2012)

Year	Total number of substances applied	Proportion of substances with VP >1.0x10^{-5} Pa* [threshold for plants (%)]	Proportion of substances with VP >1.0x10^{-4} Pa* [threshold for soil (%)]	Proportion of substances applied that are no longer in use (%)
1987	91	71%	36%	41%
1996	82	73%	34%	34%
2004	60	58%	28%	27%
2012	53	51%	23%	2%

*Vapour pressure at 20°C proposed by FOCUS AIR WG below which volatilisation is expected to be relatively insignificant

Conclusion

- Total **pesticide usage** decreased largely from 1987 to 1996 and relatively stable thereafter with application rate ↘ & number of treatment ↗.
- Predicted **airborne concentration** decreased largely from 1996 to 2004 due to the cessation of use of very volatile substances.
- The model has the potential to **quantify** human exposure to pesticides.
- Model **validation** is needed when field data become available.