Risk assessments for pesticides and other plant protection products (PPPs) often use models to estimate the exposure of different population groups. These range from conservative, deterministic calculations to more complex simulation approaches. In a recent EU project (Browse) new models were developed including exposure scenarios for bystanders, residents, operators and workers. These were implemented alongside a software interface and included probability distributions to capture the variation of possible exposures within the modelled subpopulations. The software interface was designed to allow users to input either fixed (e.g. conservative) values, for various parameters, or to specify predefined probability distributions for those inputs. Some default choices are available based on internationally agreed defaults for risk assessments. The software can also be run using a batch mode and the outputs can be presented and exported in different ways to facilitate their use in subsequent studies. The probabilistic models for resident and bystander exposure are described. Orchard and arable cropping scenarios are included, for both long-term and short-term exposures. Mathematical details are presented alongside practical information for using the associated software interface for probabilistic analyses. Example outputs are shown and sources of simulation error are quantified.

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1. Introduction

Risk assessments are designed to ensure that plant protection products (PPPs) are used in a way that does not harm human health and therefore meet Regulation (EC) No 1107/2009. Guidance on how to carry out these assessments was provided by the European Food Safety Authority (EFSA, 2014), with the aim of improving harmonisation between authorities. Assessments should take account of realistic scenarios and include exposure to members of the general population, as well as spray operators and workers. The terms bystanders and residents are used for individuals located in an area of PPP use, whose presence is unrelated to work with PPP. Bystanders may be exposed during a short period of time whereas residents may be located close to the source for a longer time period (EFSA, 2014). Unlike workers...
The project Browse (Bystanders, residents, operators and worker’s exposure), supported by the EU 7th Framework Programme, developed a series of mathematical models to estimate exposure in multiple populations, considering various routes of exposure and scenarios (www.browseproject.eu). The aim was to design a flexible and comprehensive software tool that can also account for uncertainty and variability in input parameters. To achieve this, and for the system to be useful to decision-makers, it was essential to produce a fast model that can be run many thousands of times for user-specified conditions.

For bystanders and residents, the models build on the existing BREAM model (Butler Ellis and Miller, 2010; Kennedy, Ellis, & Miller, 2012). The new features included were: Inclusion of vapour exposure, updated bystander deposition measurements, improved modelling of decay as a function of distance, separate emulation of the spray drift component for a wider range of scenarios and nozzle types and new models for orchard spray scenarios. Existing models are generally designed to be conservative through the selection of particular input values. Conservative default parameter values are also available within the Browse models, particularly in cases where data are lacking or where standard defaults have been agreed for risk assessment. However, there is more flexibility allowing the user to input alternative values or input distributions. Browse models can therefore be adapted for first tier screening assessments or higher tier assessments. An overview of the structure of the new bystander and resident models is provided by Butler Ellis, van de Zande, van den Berg, and et al (2016a in prep).

The statistical and probabilistic aspects of these models are addressed here. With such diverse scenarios to model, and the flexibility required, it was not appropriate for the Browse project to develop a single modelling strategy. Different scenarios and model components required different approaches, depending on the types of data available. For example, the orchard scenarios were modelled empirically using measurements whereas the arable scenarios included process-based simulation models.

The remainder of the paper is structured as follows. In Section 2 the modelling approaches are described, starting with details that are common to all scenarios followed by details of individual arable model scenarios and orchard scenarios. Example model results are presented in Section 3. Finally, the results and potential improvements are discussed in Section 4.

2. Methods and data

2.1. General simulation approach for bystanders and residents

In the software each modelled scenario comes with default input settings, which can be changed as required. In any given run, some of the inputs may be fixed while others are assigned probability distributions. The Browse model includes some