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Numerical simulation of pesticide dispersal at the scale of rows and vineyards

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Abstract

Spray drift during pesticide applications is a major path for atmospheric contamination by agrochemical products, which has been shown to be a potential risk for human health. Spray drift should therefore be better understood in order to reduce their undesirable effects. As spray drift is controlled by canopy architecture and wind flow structures, modelling pesticide dispersal is a promising way to survey pesticide input to the atmosphere and evaluate resulting exposure levels for the bystanders. In this study pesticide dispersal over vineyards was studied combining numerical and experimental approaches. The experimental approach consisted in measuring wind velocity and monitoring spray application in a vineyard, in order to quantify the air flow generated by an air-assisted sprayer as well as vertical losses to the air and ground deposition. The numerical approach was used to model wind flow and pesticide dispersal over the vineyard. The atmospheric wind flow model ARPS was used in the large-eddy simulation (LES) mode to solve the transient air flow within and above the vineyard, while for pesticide dispersal a coupled Lagrangian-LES approach was used to track droplet trajectories. Our measurements show that the vertical losses of pesticides are well correlated with meteorological conditions such as temperature, wind speed and turbulence level. They also show that the spatial structure of pesticide losses at the plot scale is directly related to the characteristics of the spray jet. In the numerical approach the source of pesticide at the scale of the rows is considered as a moving air-assisted sprayer. The model predictions compare well with the measurements. At a larger scale the source is deduced from the spatial structure of pesticide losses at the vineyard-atmosphere interface. Several scenarios of vineyard configurations, differing by the orientation of the vine rows with respect to the dominant wind direction and the presence of a tree hedge, were studied numerically. The exposure level of the bystanders during the vine treatment is shown to depend strongly on the vineyard configuration. With this modelling strategy, we show that it is possible to simulate pesticide drift and predict human exposure levels at larger scales.