Implementation of the interacting particle filter with complex dynamic crop models using the Discrete Event System Specification

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Dynamic crop models predict several state variables at a daily time step and thus provide useful information for optimizing agricultural techniques. These models can be used to assess the risks of air and water pollution in crop fields, but several studies showed that their prediction errors were often large due to uncertainties in parameters, initial state values, and equations. Measurements of output variables are more and more commonly available, with increases in detection and transmission capability. Potentially, such measurements could lead to a large improvement in model predictions. Satellite systems give information about plant biomass, leaf area, or leaf chlorophyll content. Tensiometers can be used to give information about soil moisture. Several different methods are available for giving information about plant nitrogen status. In each case, the measurements can be compared to model predictions, and the model can be adjusted in the light of those measurements. Monte Carlo sequential methods, like the interacting particle filter can be used to update the state variable values predicted by nonlinear dynamic models from a set of measurements and thus reduce the prediction errors. The state variables are updated sequentially *i.e* each time an observation is available. An interesting feature of these Bayesian methods is that they do not require a linearization of the original nonlinear model. It was recently shown that the implementation of the interacting particle filter can reduce the root mean squared error of a dynamic crop model by up to 50%, but that the filter performance was highly sensitive to the assumptions made about the probability distribution of the model errors and about the state transition equations. In view of these results, an attractive approach would be to apply the interacting particle filter to several model variants and to identify the best one. However, the development of a large number of model variants is not straightforward when the model is complex and includes numerous modules. In this work, we show how the Discrete Event System Specification (DEVS) can be used to develop a large number of variants of a dynamic crop model, to apply the interacting particle filter to each one, and to compare the results. DEVS is a modular and hierarchical formalism for modelling and analyzing discrete event systems. We show here how this formalism can be used to update complex dynamic crop models with in-season measurements using two freely available softwares, namely the Virtual Laboratory Environment and R.

Key-words: Discrete Event System Specification, Dynamic crop model, Importance sampling, Interacting particle filter, Model selection.