We thank the reviewer for their thoughtful and detailed comments that definitely helped us clarify the manuscript and avoid misinterpretations.

*General comment: The paper presents a study on the quality of the statistical calibration of hydraulic and transport soil properties using an infiltration experiment. In the experiment, tracer-contaminated water is injected into a laboratory column filled with a homogeneous soil in a given period. Influences of different experimental factors on the calibration results were studied.*

*In general, this paper deals with an interesting issue. I find some merits in the both methodology and results. As the authors describe, the soil parameters that influence water flow and contaminant transport in unsaturated zones are not generally known a priori and have to be estimated by fitting model responses to observed data. The authors realized this issue and pointed out the limitations of their work. Overall, this paper has a good potential to be published in the journal. English is also very easy to read in the manuscript. Authors have done much work and give us an exciting paper theoretical and experimental study results.*

We thank the reviewer for his/her positive overall appraisal of our work.

*However, there are some issues, listed below, that need to be addressed before it is ready for publication.*

***Revised comment:***

*1. From the abstract, we want to know what you have done in your manuscript, but I can not know which parameters you have calibrated in your abstract. Please describe them in the abstract.*

The abstract will rewritten as follows.

The quality of the statistical calibration of hydraulic and transport soil properties is studied for infiltration experiments in which, over a given period, tracer-contaminated water is injected into an hypothetical column filled with a homogeneous soil. The saturated hydraulic conductivity, the saturated and residual water contents, the Mualem-van Genuchten shape parameters and the longitudinal dispersivity are estimated in a Bayesian framework using the Markov Chain Monte Carlo (MCMC) sampler. The impact on the quality of the estimated parameters of the kind of measurement sets (water content and/or pressure inside the column, solute concentration at the outlet and cumulative outflow) and that of the injection duration of the solute is investigated by analyzing the calibrated model parameters and their confidence intervals for different scenarios. The results show that the injection period has a significant effect on the quality of the estimation, in particular, on the posterior uncertainty range of the parameters. All hydraulic and transport parameters of the investigated soil can be well estimated from the experiment using only the outlet concentration and cumulative outflow, which are measured non-intrusively. An improvement of the identifiability of the hydraulic parameters is observed when the pressure data from measurements taken inside the column are also considered in the inversion.

*2. In the introduction section, please describe the development on soil parameters in more detail, and please highlight the innovation of this manuscript.*

A significant number of references will be added and the introduction will be changed as follows:

The soil parameters that influence water flow and contaminant transport in unsaturated zones are not generally known a priori and have to be estimated by fitting model responses to observed data. The unsaturated soil hydraulic parameters can be (more or less accurately) estimated from dynamic flow experiments (e.g., Hopmans et al., 2002; Vrugt et al., 2003a; Durner and Iden, 2011; Younes et al., 2013). Several authors have investigated different types of transient experiments and boundary conditions suited for a reliable estimation of soil hydraulic properties (e.g. van Dam et al., 1994; Simunek and van Genuchten, 1997; Inoue et al, 1998; Durner et al, 1999). Soil hydraulic properties are often estimated using inversion of one-step (Kool et al., 1985; van Dam et al., 1992) or multistep (Eching et al., 1994; van Dam et al., 1994) outflow experiments or controlled infiltration experiments (Hudson et al., 1996).

Kool et al. (1985) and Kool and Parker (1988) suggested that the transient experiments should cover a wide range in water contents to obtain a reliable estimation of the parameters. Van Dam et al. (1994) have shown that more reliable parameter estimates are obtained by increasing the pneumatic pressure in several steps instead of a single step. The multistep outflow experiments are the most popular laboratory methods (e.g., Eching and Hopmans, 1993; Eching et al., 1994; van Dam et al., 1994; Hopmans et al., 2002). However, their application is limited by expensive measurement equipment (Nasta et al., 2011).

Infiltration experiments have been investigated by Mishra and Parker (1989) to study the reliability of hydraulic and transport estimated parameters for a soil column of 200 cm using measurements of water content, concentration and water pressure inside the column. They showed that the simultaneous estimation of hydraulic and transport properties yields to smaller estimation errors for model parameters than the sequential inversion of hydraulic properties from the water content and/or pressure head followed by the inversion of transport properties from concentration data (Mishra and Parker, 1989).

Inoue et al. (2000) performed infiltration experiments using a soil column of 30 cm. Pressure head and solute concentration were measured at different locations. A constant infiltration rate was applied to the soil surface and a balance was used to measure the cumulative outflow. They showed that both hydraulic and transport parameters can be assessed by the combination of flow and transport experiments.

Furthermore, infiltration experiments were often conducted in lysimeters for pesticide leaching studies. Indeed, lysimeter experiments are generally used to assess the leaching risks of pesticides using soil columns of around 1.2 m depth which is the standard scale for these types of experiments (Mertens et al, 2009; Kahl et al., 2015). Before performing the column leaching experiment, several infiltration-outflow experiments are often realized to estimate the soil hydraulic parameters (Kahl et al., 2015; Dusek et al, 2015).

The key objective of this study is to evaluate the reliability of different experimental protocols for estimating hydraulic and transport parameters and their associated uncertainties for column experiments. We consider the flow and the transport of an inert solute injected into a hypothetical column filled with a homogeneous sandy clay loam soil. We assume that flow can be modelled by the Richards' equation (RE) and that the solute transport can be simulated by the classical advection-dispersion model. Furthermore, the Mualem and van Genuchten (MvG) models (Mualem 1976, van Genuchten 1980) are chosen to describe the retention curve and to relate the hydraulic conductivity of the unsaturated soil to the water content. The estimation of the flow and transport parameters through flow-transport model inversion is investigated for two injection periods of the solute and different data measurement scenarios.

Inverse modelling is often performed using local search algorithms such as the Levenberg-Marquardt algorithm (Marquardt, 1963). Besides, the degree of uncertainty in the estimated parameters, expressed by their confidence intervals, is often calculated using a first-order approximation of the model near its minimum (Carrera and Neuman, 1986, Kool and parker, 1988). However, as stated by Vrugt and Bouten (2002), parameter interdependence and model nonlinearity occurring in hydrologic models violate the use of this first approximation to obtain accurate confidence intervals of each parameter. Therefore, in this work, the estimation of hydraulic and transport parameters is performed in a Bayesian framework using the Markov Chain Monte Carlo (MCMC) sampler (Vrugt and Bouten, 2002; Vrugt et al., 2008). Unlike classical parameter optimization algorithms, the MCMC approach provides parameter joint probability distributions, which are useful to assess the quality of the estimation. The MCMC samples can be used to summarize parameter uncertainties and to perform predictive uncertainty (Ades and Lu, 2003).

Hypothetical infiltration experiments are considered for a column of 120 cm depth, initially under hydrostatic conditions, free of solute and filled with a homogeneous sandy clay loam soil. Continuous flow and solute injection are performed during a time period $T_{inj}$ at the top of the column and with a zero pressure head at the bottom. The unknown parameters for the water flow are the hydraulic parameters: $k_s$ [$LT^{-1}$], the saturated hydraulic conductivity; $\theta_s$ [$L^3L^{-3}$], the saturated water content; $\theta_r$ [$L^3L^{-3}$], the residual water content; and $\alpha$ [$L^{-1}$] and $n$ [−], the MvG shape parameters. The only unknown parameter of the tracer transport is the longitudinal dispersivity, $a_L$ [$L$].

Several scenarios corresponding to different sets of measurements are investigated to address the following questions:

1) Can we obtain an appropriate estimation of all flow and transport parameters from tracer-infiltration experiments, even though a limited range in water content is covered (only moderately dry conditions are used)?
2) What is the optimal set of measurements for the estimation of all the parameters? Can we use only non-intrusive measurements (cumulative outflow and concentration breakthrough curve) or are intrusive measurements such as the measurements pressure heads and/or water contents inside the column unavoidable?
3) Similar to multistep outflow experiments, is there an optimal design for the tracer injection?

*3. In the results and discussion section, please analyze in more detail.*

We will provide some more explanations, especially concerning the injection duration. The explanations will be:

The improvement of the parameter estimation in this last scenario compared to the previous one can be explained by the fact that the injection of water and solute contaminant is stopped once the concentration reaches the column outlet. Hence, the injected volume (0.015x3000 = 45cm$^3$/cm$^2$) is slightly less than the pore volume (120x0.43=51 cm$^3$/cm$^2$). Thus, when the injection is stopped, the column is not fully saturated and the outlet flux strongly reduces (see the asymptotic behavior of the cumulative outflow when the injection is stopped). As a consequence, the concentration profile increases smoothly (see Fig. 6) until reaching its maximum value in contrast to the sharp front observed for $T_{inj} = 5000\,\min$ in the scenario 6 (see Fig. 5). As a consequence, the breakthrough curve obtained with $T_{inj} = 3000\,\min$ is more affected by the hydraulic parameters than the breakthrough curve obtained with $T_{inj} = 5000\,\min$. This explains why a better estimation of the parameters is observed for the last scenario compared to the scenario 6.

*4. In the conclusions section, please describe the further work needs to be done*

Possible extensions of this work are:

These results are of course related to the models and experimental conditions we used. This work will be extended to different types of soils, water retention and/or relative permeability functions to evaluate the interest of coupling flow and transport for parameter identification. This work can also be extended to reactive solutes.