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Interactive Comment

Interactive comment on "On the measurement of solute concentrations in 2-D flow tank experiments" *by* M. Konz et al.

M. Konz et al.

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We would like to thank the referee for his efforts and the valuable comments. A detailed author comment will follow after the open discussion is closed. For now, we will focus on the main points raised by the referee. We fully agree with the referee on the comment of methodology comparison, especially the suggested comparison of light transmission and light reflection methods. According to the referee the problem of 3D effects would be less severe using the transmission method. We theoretically agree with this comment, however in our experiments 3D effects were not observed. The problem of 3D effects was visually tested by comparing the position of the salt-dye front at a distinct time step at the front window and at the back window of the tank. The inlet and outlet openings are placed in the center of the side edges, and the tank

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Interactive Discussion

Discussion Paper

is filled with homogeneous porous media what prevents 3D effects. Further, the referee argues that a uniform lightning could be achieved more easily applying the light through method. We agree, but since we derive the parameters of the intensity vs. concentration curve for each observation point separately a uniform illumination is not mandatory for our image analysis approach. The only prerequisite is that there are no fluctuations in lightning from one picture to the other. To summarize this it is essential to have a temporally uniform illumination, whereas the spatially non-uniform illumination is considered by the image analysis approach. We fully agree with the referee on the reduction of flare effects using the transmission method. However, the light transmission method is beyond the scope of this work. The focus of this paper is twofold. Firstly, to compare the optical method with the resistivity method and, secondly, to assess the limitations of the optical approach. To realize this, the resistivity measurement devices have to be placed on the back wall of the tank, which prevents the application of the light transmission technique. Almost all studies involving flow tank experiments to study solute transport with or without density effects apply the light-on technique (Schincariol et al., 1993, Schwartz and Swartz, 1998, Wildenschild and Jensen, 1999, Simmons et al., 2002, Rahman et al., 2005, McNeil et al., 2006, Goswami and Clement, 2007) and thus, in this study, we want to focus on this technology and demonstrate the applicability and limitations of this method. The comparison of light through vs. light–on technology is planned for the near future. Such a study requires a completely new experimental setup and cannot be conducted with the flow tank presented in this paper. The referee comments that both methods are not new. However, to our knowledge, breakthrough curves have not been derived so far from images for flow tank studies. This, combined with the required analysis procedure presented in the paper is a new contribution. Although, the resistivity method is a common technique in column or tank studies to analyze concentrations, to our knowledge, there is no technique available that enables the measurement of salt concentrations in the range of 100 g/l in situ within the porous media. This is also new in the presented paper.

We do not understand the comment on the resolution of the observation point. The sta-

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tistical analysis clearly demonstrates the decline of precision with increasing resolution. Therefore, we consider the conclusion that the resolution is crucial for the precision of the measurement as valid. There is no or at least little discussion on this in most of the studies found in the peer literature. Based on the statistical analysis the adequate resolution is a compromise between the precision of the measurement (lower resolution) and the ability to derive detailed information from the images (higher resolution). We agree with the referee that the right resolution corresponds to the REV. However, this has to be determined for grain size used in the experiment. Thus, the statistical analysis is necessary and that is why we consider it as an important finding that the resolution of the observation point needs to be determined specifically for each experiment. The referee asks whether the difference between the both methods in figure 15 could be due to flare effects although the mask was applied? From supplementary experiments (see section 3.5) we found that the observation holes around the observation point might influence the measurement and flare effects are possible although the mask is applied. Therefore, we present the concentrations derived from the image analysis method in boundaries and do not show the measured concentrations itself. The upper boundary contains the error related to flare effects and it is pretty close to the concentrations measured with the resistivity method. As the RMC concentrations are within the boundaries of the optical method at point P2 we conclude that both methods yield comparable concentrations. From the experimental setup we know that the concentration should be 100 g/l at P2 (this is also confirmed by the numerical simulation of the experiment). The resistivity method reproduces the 100 g/l. Therefore, we consider the electrical method as more precise. The drawback is that the measurement radius is not known and therefore it is not useful to compare these measurements with numerical simulations in order to benchmark numerical codes. We do not understand the argument that at point P3 the mass underneath the curves should be equal. Since the measurement areas significantly differ between both approaches we would not expect the mass to be equal underneath the curves. For the revision of the paper we will try to rephrase chapter 5 in order to make it clearer. We highly appreciate an open discussion with the referee and with further readers of the manuscript.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 4175, 2007.