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Interactive comment

Interactive comment on "Inverse modeling of turbidity currents using artificial neural network: verification for field application" *by* Hajime Naruse and Kento Nakao

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Reply to Reviewer1

Thank you very much for your thoughtful comments. Our replies to your comments are as follows. We will revise the manuscript to incorporate all of these discussions.

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Discussion paper

Comment 1: necessity of two layer model

Thank you for your important comment. As mentioned in section 5.4, in a turbid current flowing over hundreds of kilometers, the upper layer of the current is predicted to be continuously diluted while the lower layer remains highly concentrated, thus maintaining the current over long distances. Existing one-layer shallow water equation models are insufficient to reproduce such phenomena. The forward model of this study is not an exception.

However, the focus of this study is on rapidly decelerating sedimentary turbidity currents. Normally graded turbidites are considered to be deposited from such decaying flows. In this study, the distribution of turbidites is assumed to be limited to about several tens km at most, and the separation of the lower and upper layers that occurs in sustained turbidity currents after flowing tens of kilometers does not need to be considered when calculating such relatively small-scale turbidity currents. In fact, Kostic and Parker (2006), on which the forward model of this study is based, has been verified to reproduce turbidity currents at experimental and small natural scales (e.g., Fildani et al., 2006). This suggests that the inverse model in this study is well suited to analyze a single bed of turbidites that generally exhibit normal grading in strata.

It is expected that turbidity currents maintained over long distances do not leave turbidites and create a bypassing zone. Otherwise, the concentration in the lower layers of turbidity currents decrease, and therefore the currents stop within a relatively short distance. Thus, a two-layer model of turbidity currents is not always necessary for inversion of bed-scale turbidites. However, modeling of continuos sustained turbidity currents is necessary for inverse analysis of the development of submarine fans and channel-levee systems in a larger scale. This is an interesting research topic in the future. We will fully describe this aspect in the Introduction and Section 2 of our revised manuscript.

Comment 2: the reason why the inverse model reconstructs initial conditions

As you pointed out, our objective of the inverse analysis is the local conditions of a turbidity current (velocity, concentration, etc.) that resulted in a turbidite. That is why we used inverse analysis to estimate the initial conditions of the flow. This is because, as shown in Figure 9, we can obtain the state of the turbidity current at any location and time by calculating the time evolution of the forward model from the initial conditions. On the other hand, if we conduct inverse analysis to reconstruct all the values of the local flow conditions at a certain location, we have to estimate an almost infinite number of parameters because the flow velocity and concentration at the point of interest keep changing with time. If we consider all the hydraulic conditions at any given time as independent parameters, the number of values to be obtained in the inverse analysis will be the same as the number of time steps in the forward model. To avoid this situation, we decided to reconstruct the initial conditions at the onset of the flow. In this way, we can obtain the behavior of the flow with a relatively small number of parameters. This approach has already been tried successfully by Lesshafft et al. (2011), and Falcini et al. (2009) also reconstructed flow conditions of turbidity currents by obtaining boundary conditions of the model. Thus, the approach we adopted here is a standard procedure in this research field.

This is an essential point for the inverse model in this study, but we acknowledge that it has not been fully explained yet in the current text. In the revised manuscript, we will explain these points in the sections of Introduction, Forward model, Inverse model, and Discussion. We will also add a new figure in the revised paper to illustrate our strategy as described above. In that figure, the reconstructed results of the temporal changes of velocity and concentration at several locations with the original data to exhibit that our method can estimate the flow conditions at a particular location.

Comment 3: length of slope

In this study, the length of the slope located upstream was not changed. The slope from the point of flow occurrence to the bottom works as a hypothetical generator of turbidity currents. The hydraulic conditions on the slope do not necessarily have to be realistic because the role of the slope is to allow the sediment cloud to acquire the structure of a turbidity current and the flow conditions on the slope are not subjects to be estimated. If the length of the slope is changed, the flow initial conditions on the slope may vary. However, our aim is to obtain sufficiently realistic values of the velocity, concentration and thickness of the flow on the sedimentary basin. In other words, if the hydraulic conditions at the upstream end of the basin are the same, we do not need to worry about the differences in velocity and thickness of the flow on the slope caused by differences in slope length. To clarify that the slope length is not significant in this study, we will conduct new numerical experiments to show the effect of the slope length on the results of the inverse analysis in the revised manuscript.

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