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The evolution and non-fickian flow of local stagnant zones in hierarchically nested groundwater flow system under different rainfall infiltration intensity

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Groundwater plays an active role in certain geologic processes that has been recognized in numerous subdisciplines for a long time. According to Toth (1963, 2009), gravity-driven regional groundwater flow is induced by elevation differences in the water table and its pattern is self-organized into hierarchical sets of local, intermediate and regional flow systems. Convergence of two flow systems results in a stagnant zone called hydraulic trap which is under the discharge area, and diverge of two flow systems results in a stagnant zone called quasi-stagnant zone which is under the water divide. These stagnant zones have been found to be critical to accumulation of transported mineral matter. Based on analytical and numerical solutions, some researchers reported that the local stagnant point or zone that are located under the local counter directional flow system. There is a question that whether hydraulic trap and quasi-stagnant zone is separate or integrate, and whether they are located under the discharge area or water divide or counter directional flow systems.

In this study, two-dimensional numerical cross-sectional model is used to investigate the effect of climate change on local stagnant zones and whether the hydraulic trap and quasi-stagnant zone is separate or integrate. Considering the climate change of basin and the change of rainfall infiltration intensity, a flux upper boundary is used to simulate the rainfall recharge. Then a synthetic homogeneous sandbox with three potential sinks is used to validate the evolution of the hierarchical nested groundwater flow systems considering different rainfall infiltration intensity. Salt tracer test is used to investigate the effect of stagnant zones on solute transport.

According to numerical results, we concluded that the hydraulic traps and quasi-stagnant are possible to be separate only for simple local systems and the two local stagnant zones are located on two sides of the counter directional flow system. When nested flow systems occur, such as local-intermediate, local-intermediate-local, local-regional, the local hydraulic traps and quasi-stagnant zones are always integrated under the local counter directional flow systems. Laboratory results show that when the rainfall infiltration intensity reduce, the groundwater flow pattern will change and the penetration depth and scope of counter directional local flow system will decrease. The corresponding local stagnant zone will slowly be closing to the discharge area of that counter directional local flow system. Salt tracer tests show that there are obvious non-fickian

phenomenon in the local stagnant zones in hierarchically nested flow systems even in the homogeneous aquifer.