**NEARSHORE SCALAR TRANSPORT MODEL WITH VIRTUAL REALITY ENVIRONMENT**

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ABSTRACT

The importance of public awareness in disaster preparation has been emphasized in recent studies (Burningham et al., 2008; Sermet and Demir, 2019). Advances in virtual reality (VR) technology and graphical processor units (GPU) enables simulation of real-world physics and simultaneous visualization within affordable costs. Owing to VR’s high immersiveness, it has been utilized in various fields such as medical sciences, fire dynamics and even disaster experience on the purpose of education and training (Cha et al., 2012; Pottle, 2019). VR-based numerical simulation with various scenarios can provide real-time training on water-related disasters (e.g., storm surge, tsunami, and flood) and invisible risks such as pollutants while ensuring human safety.

This study aims to develop a scalar transport model governed by shallow flows using a VR environment. We added an advection-diffusion equation within the governing equations of Celeris Base (Tavakkol and Lynett, 2020), a Boussinesq-type wave simulation software using an immersive simulation environment. To maintain a consistency of numerical scheme, advection and diffusion terms are discretized based on the finite volume and finite difference methods, respectively. The Harten-Lax-van Leer (HLL) Riemann solver (Harten et al., 1983), which was used to calculate the numerical flux at cell interface, was adopted to the advection term of scalar transport system as well as hydrodynamic system. Since the HLL scheme can cause numerical diffusion for additional transport system, we modified the HLL solver by introducing an anti-diffusion function. Wavemaker for generating random directionally spread waves (Suanda and Feddersen, 2016) and breaking model (Kennedy et al., 2000) considering momentum dissipation and mixing effects due to wave breaking are implemented to realistically simulate nearshore hydrodynamics and corresponding scalar transport. Several numerical tests were performed to verify the performance of the model. The results confirmed the numerical diffusion significantly decreased according to the modification of the HLL scheme, so there was a good agreement between the numerical and analytical solutions. We also tried to reproduce complex nearshore hydrodynamics and the resulting scalar transport. The Imperial Beach pollutant transport and dilution experiment (Hally-Rosendahl et al., 2015) was chosen. The experiment observed a dye transport driven by wind- and wave-driven currents at Imperial Beach, California. Despite the limitation of fully reproducing the exact irregular wave conditions, the simulated and observed dye transport along the shoreline were well matched. The developed model is expected to be employed not only for real-time prediction based on the numerical simulation, but also for disaster prevention education based on immersive VR experience.



Figure 1 – Comparison of dye transport between the observation (Rosendahl et al., 2015) and the numerical results

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