# I. INTRODUCTION

Shallow water flows are found in many geophysical phenomena such as ocean currents, river flow, flow in channels, coastal flooding or tsunami wave propagation and runup. These shallow flows is usually can be represented by the nonlinear non-dispersive wave model called the Shallow Water Equations (SWE). The model is derived from 3 dimensional (3D) problem Navier-Stokes model by neglecting the vertical flow variation. Therefore the model is rather simple than other more advanced wave model such as Boussinesq type of Model (BTM) (see [1], [2]) or Non-Hydrostatic model ( [3], [4]). As a consequence of the simplification, the model is non-dispersive, and is only valid for shallow flows or long wave simulation, i.e. the wavelength is much larger than the water depth. To obtain an accurate and efficient numerical code, it also very important to choose a numerical scheme for the wave model. To solve the SWE, various numerical methods can be applied such as Finite Volume Method, Finite Element Method, Finite Difference Method (see [5], [7], [17]). In this paper, we use the Finite Volume method with momentum conservative staggered grid scheme. The method was proposed by Stelling Duinmeijer 2003 [8], and later was applied for other wave

models such as in Boussinesq Model ( [2], [9]) and Nonhydrostatic model ( [3]). Different than in the collocated grid, in the staggered grid, the control volume for the momentum and continuity equation are located in different grids, while in collocated grid, they are located in the same grid. According to Stelling and Duinmeijer (2003) [8], the staggered grid scheme has advantages compared to collocated grid, i.e. it is known for its robustness and straightforward method. For simulating large problem such as a big computation domain and high resolution computational grid, the computational cost should be very efficient to obtain extremely fast computation time. In general, there are two ways to reduce the computational time, i.e. the parallelization of the numerical implementation and also to choose which architecture to compute the numerical implementation, i.e. in the Central Processing Unit (CPU) or in Graphics Processing Unit (GPU). Parallel programming is a technique to allow a simultaneous execution of operation using more than one processing unit. This technique can make the execution time of program faster than the usual serial execution. The parallel programming architecture by using CPU can use the OpenMP and MPI (Sandra 2017, [12]), whereas in the GPU architecture are the OpenACC and CUDA. CUDA is a parallel programming architecture developed by technology company NVidia, that allows the programmer to do computation in big sizes by using a Graphics Processing Unit, that has more processing cores than the Central Processing Unit. GPU has thousands of processing cores, with many threads compared to the CPU. The usage of GPU for parallel programming makes the execution time faster and allows the creation of program with bigger computational load. The performance speedup of the parallel architecture will be measured by comparing the run time of parallel and serial respectively. In this paper, the SWE model is implemented numerically by using Finite Volume method in a staggered grid scheme, and is calculated in parallel programming by using CUDA architecture. The performance of implementation in CUDA will be compared with the execution by using CPU. The content of this paper is as follows. In the next section details of the Shallow Water

Equations and its implementation using staggered grid scheme are discussed. It is then followed by numerical implementation in a parallel programming using CUDA. The performance of theimplementationwillbepresentedinsection4.Weconclude the paper in section 5.