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Lessons learned developing hyper-resolution hydrologic simulations of the Continental US

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Our team has developed a hyper-resolution (1km2) integrated hydrologic model of the continental US (CONUS). We use the hydrologic model ParFlow-CLM which simulates three-dimensional groundwater flow with fully integrated overland flow and coupled land surface processes. ParFlow is designed for efficient parallel simulation, and previous work has demonstrated good scaling performance across thousands of processors. Still, simulating variably saturated flow and nonlinear groundwater surface water interactions in complex, heterogeneous domains remains a computational challenge. The CONUS model has roughly 32 million grid cells, topography ranging from sea level to thousands of meters, semi-arid to humid climates and subsurface hydrologic properties that cover multiple orders of magnitude. To build a model of this scale that is both physically relevant and computationally feasible our development team combines expertise in hydrology, GIS, computational mathematics and scientific computing. Here we present the key advances and hurdles that occurred in the development of the existing domain including, solver improvements, software development, data handling and model initialization practices. Additionally, we highlight ongoing developments as we expand our simulation domain, increase spatial resolution and couple with additional simulation platforms.