We present results of real-time 3D global magnetohydrodynamic simulations of the solar wind interaction with the Earth's magnetosphere using time-varying data from the NASA Advanced Composition Explorer (ACE) satellite during a few large magnetic storm events of the previous and current solar cycles, namely 06 April 2000, 20 November 2003 and 05 April 2010 storms. We introduce a numerical magnetic storm index and compare the geo-effectiveness of these events in terms of this storm index which is a measure for the resulting global perturbation of the Earth's magnetic field. Steady simulations show that the upstream solar wind plasma parameters enter the low-beta switch-on regime for some time intervals during a magnetic storm causing a complex dimpled bow shock structure. We also investigate the trace of such bow shock structures during time-dependent simulations of the events. We utilize a 3D, implicit, parallel, unstructured grid, compressible finite volume ideal MHD solver with an anisotropic grid adaptation technique for our simulations. This solver is implemented inside COOLFluiD, which is an object-oriented multi-physics framework into which we plan to implement different space weather models and couple them with the abovementioned global magnetohydrodynamic model in the future.