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Three-dimensional Hybrid-Vlasov Simulations of Geomagnetic Storms

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Vlasiator (<https://www2.helsinki.fi/en/researchgroups/vlasiator>) is a high-performance kinetic code that is now conducting the first ever 3D hybrid-Vlasov simulations of the global magnetospheric system. In recent months, the driving conditions of these simulations have been scaled up to emulate intense space weather events. Specifically, we have investigated the impact of a pressure pulse with southward-oriented B_z on the Earth's magnetosphere. Our simulations reproduce many known effects, for example the expansion of the auroral oval, compression of the magnetopause, the development of field-aligned currents, and enhanced particle precipitation near the open/closed field line boundary. We compare our data with spacecraft observations of real events that exhibit similar parameters to those imposed in the simulation. Our analysis shows that the hybrid-Vlasov approach captures many of the important aspects of the magnetospheric response to an incoming pressure pulse. With sufficient validation of our simulations by comparison with moderate storms, we aim to show that Vlasiator can be used as a tool to study even the most extreme events and their potential impacts on Earth's critical infrastructure.