Hybrid-Vlasov simulation of auroral proton precipitation in the cusps: Comparison of northward and southward interplanetary magnetic field driving

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We present the first hybrid-Vlasov simulations of proton precipitation in the polar cusps. We use two runs from the Vlasiator model to compare cusp proton precipitation fluxes during southward and northward interplanetary magnetic field (IMF) driving. The simulations reproduce well-known features of cusp precipitation, such as a reverse dispersion of precipitating proton energies, with proton energies increasing with increasing geomagnetic latitude under northward IMF driving, and a nonreversed dispersion under southward IMF driving. The cusp location is also found more poleward in the northward IMF simulation than in the southward IMF simulation. In addition, we find that the precipitation takes place in the form of successive bursts during southward IMF driving, those bursts being associated with the transit of flux transfer events in the vicinity of the cusp. In the northward IMF simulation, dual lobe reconnection takes place. As a consequence, in addition to the high-latitude precipitation footprint associated with the lobe reconnection from the same hemisphere, we observe lower-latitude precipitating protons which originate from the opposite hemisphere's lobe reconnection site. The proton velocity distribution functions along the newly closed dayside magnetic field lines exhibit multiple proton beams travelling parallel and antiparallel to the magnetic field direction, which is consistent with observations with the Cluster spacecraft. We suggest that precipitating protons originating from the opposite hemisphere's lobe reconnection site, albeit infrequent, could be observed in a situation of dual lobe reconnection.