Title: Ensemble Alfvén Model for CHAMP Small-Scale Field-Aligned Currents
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Abstract: Intense, small-scale field-aligned currents (SSFACs) deduced from CHAllenging Minisatellite Payload (CHAMP) measurements of magnetic field fluctuations at 400 km altitude in Earth's ionosphere are correlated with cusp-region, thermospheric density anomalies and are thought to underlie anomaly formation in both empirical and theoretical studies. The analysis of SSFACs from magnetic time series in the CHAMP studies derives from a calculation of the curl of the magnetic field under two basic assumptions: (1) SSFACs are sheet currents and (2) the spatial derivative across the sheet current can be approximated as the Doppler derivative $\partial/\partial(\mathrm{vs}\ t)$ where vs is the satellite velocity normal to the sheet. Assumption (2) requires the time dependence of SSFACs to be sufficiently slow so that the variations in the measured magnetic time series may be considered spatial on the transit time of the satellite across them. We examine this assumption in the context of an Alfvén wave series expansion for SSFACs, first using the model to create an ensemble of SSFACs "events" with statistically similar properties for model and observed events. Time-integration of the CHAMP magnetic and FAC time series for the model SSFACs then provides the magnetic time series, as well as the electric field using the Alfvén wave conjecture. In contrast with an analysis of time series recorded on a single satellite, the Alfvén expansion disambiguates the spatial and temporal dependence of the magnetic variability and allows for comparison of SSFACs derived from the Doppler derivative versus the curl of the magnetic field. SSFACs derived from both the curl and Doppler derivative are compared with observational SSFACs reported by Rother et al. (2007). We have found that the ensemble Alfvén wave model is capable of simulating SSFACs with spectral characteristics similar to Rother et al., and that the model may be further used to calculate time series and spectral properties of electric and magnetic fields at all altitudes in the ionosphere thermosphere, along with altitude profiles of thermospheric heating rates consistent with CHAMP SSFACs.