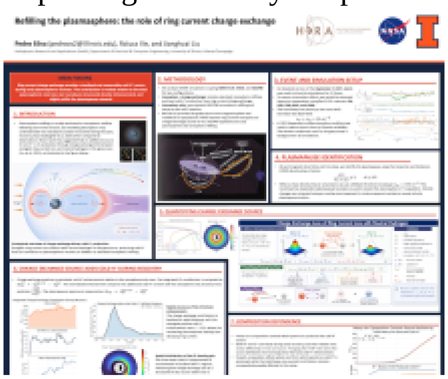
Pedro
Silva
University of Illinois Urbana-Champaign
Raluca Ilie, University of Illinois Urbana-Champaign
Jianghuai Liu, University of Illinois Urbana-Champaign
Oral and Poster
The terrestrial plasmasphere, a crucial reservoir of cold plasma within Earth's magnetosphere, exhibits complex density variations in response to geomagnetic activity. While depleted magnetic flux tubes are traditionally thought to refill exclusively via ionospheric outflow, current global models consistently underestimate these refilling rates by an order of magnitude compared to observations. To reconcile this persistent discrepancy, this study introduces and quantifies a novel supplementary refilling mechanism: the in-situ generation of cold H+ ions through charge exchange reactions between energetic ring current ions and exospheric neutral hydrogen. For the first time, we employ a sophisticated coupling between the multi-fluid MHD BATS-R-US model and the drift-kinetic HEIDI model. By explicitly incorporating heavy ion species (O+ and N+), this integrated approach allows us to derive and track a separate phase-space distribution function for the newly generated cold H+ population. Our analysis demonstrates that plasma sheet composition and localized exospheric density structures significantly influence the efficacy of this charge exchange source. We show that this top-down injection of cold plasma profoundly alters the spatial distribution of plasmaspheric density. Ultimately, incorporating this previously underestimated ring current source provides a critical pathway to resolving the refilling rate anomaly, carrying significant implications for advancing our understanding of magnetosphere-ionosphere coupling and improving the fidelity of space weather predictions.

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