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Foreword

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The terrestrial magnetosphere is at once the protector of the Earth's atmosphere from energetic radiation from outer space and the "breeding ground" for a variety of space weather phenomena such as geomagnetic storms and substorms, which are the manifestations of the complex interaction between the Sun's electromagnetic and particle radiation and the Earth's upper atmosphere and magnetic field.

Ion outflows and other plasma processes in the high-latitude ionosphere are believed to influence the dynamics of the magnetosphere, and play an important role in the three-way interactions ("coupling") of the magnetosphere, ionosphere, and thermosphere (MIT). Previous satellite observations revealed the existence of energetic ions of ionospheric origin in the magnetosphere and the heating and acceleration of such ions in and above the topside auroral ionosphere.

The topside ionosphere is a critical but relatively underexplored transition region between the collision-dominated region below and the collision-less, transport-dominated region above. This topside region is closely coupled with the thermosphere via Joule heating and charge exchange reactions, which result in increases in neutral temperature and mass density and the production of fast or hot neutral atoms.

The topside auroral ionosphere is also closely coupled with the magnetosphere, being an integral part of the auroral system and intimately connected to the electric field, field-aligned currents, electron precipitation, and low-frequency plasma waves in the aurora. Strong field-aligned currents can drive plasma instabilities, which in turn generate plasma waves and lead to ion acceleration. Soft precipitating electrons produce enhanced ambipolar electric fields and enhanced ionization that result in field-aligned ion flow and ionospheric density structures. The latter can scatter radio waves and distort or disrupt their propagation.

The Enhanced Polar Outflow Probe (e-POP) was motivated by the important role of plasma processes in the topside ionosphere in MIT coupling, and the dearth of detailed, high-resolution observational knowledge of such processes. The e-POP science objectives

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are focused on the micro-scale characteristics of plasma outflow and related micro- and meso-scale plasma processes in the polar ionosphere, the associated neutral upwelling and escape in the upper atmosphere, and the effects of auroral currents on plasma outflow and those of plasma microstructures on radio propagation.

This special issue of Space Science Reviews documents the science objectives, instrument design, and capabilities of the e-POP mission. Specifically, the paper on mission overview (Yau and James) describes the top-level e-POP science drivers and mission implementation. The papers on the fast auroral imager (Cogger et al.), the fluxgate magnetometer (Wallis et al.), the imaging ion mass spectrometer (Yau et al.), the suprathermal electron imager (Knudsen et al.), the radio receiver (James et al.), and the coherent electromagnetic radio beacon (Siefring et al.) describe the design, implementation, data quality, and first results of these six e-POP instruments. It is hoped that the special issue will help researchers fully understand the e-POP mission results and advance their own research on MIT coupling using the mission data; e-POP mission data are openly available to the science community via the Canadian Space Science Data Portal, cssdp.ca.

The e-POP was implemented as a low-cost mission and as a part of the larger Canadian CASSIOPE multi-purpose small-satellite. The success of the mission to date attests to the dedication and hard work of the many individuals who have played important roles in the definition, design, and development of the mission and its instrument payload. These include members of the e-POP Science Team and the individual instrument development teams, as well as technical personnel at the Canadian Space Agency, MacDonald Dettwiler and Associates, and Magellan Aerospace. The efforts of all these individuals are greatly appreciated.

I am grateful to Editor Jim Burch and the editorial staff of Space Science Reviews for their efficient effort in producing this special issue.