EDGAR: Energy Deposition in the Geomagnetic Cusp Alfvén Resonator

I. KEY POINTS
- Models of energy deposition within the ionospheric Alfvén resonator (IAR) have so far not explicitly considered conditions in the geomagnetic cusp.
- EDGAR represents the first attempt to use intra-cusp conditions, as observed by EISCAT and the CAPER-2 sounding rocket, as inputs to an energy deposition model.

II. MOTIVATION
Vernikovskaya et al. (2018) (hereafter V18) have presented a model for electromagnetic energy deposition (ED) within the IAR via Alfvén waves (Sec. III). The ionospheric density and temperature profiles assumed by these authors are based on empirical/statistical models that do not specifically consider the conditions (i.e., enhanced temperatures and densities) that occur within the geomagnetic cusp.

As perhaps the most active site of Alfvén waves over altitudes below ~4000 km, the geomagnetic cusp is a primary site of electromagnetic ED. Thus the EDGAR project seeks to answer the following questions:
(i) What are the predicted rates of electromagnetic ED within the overlapping daytime MR/cusp region when modeled using typical cusp density and temperature profiles as well as electric fields?
(ii) How do these cusp-specific estimates of the rates of electromagnetic ED compare with the theoretical estimates of V18?

These questions will be answered using observations (Sec. III) made on January 4, 2019 by UiO all-sky cameras at the Kjell Henriksen Observatory (KHO) in Longyearbyen, the Cusp Alfvén and Plasma Electrodynamics Rocket-2 (CAPER-2) sounding rocket (Fig. 1a) and the EISCAT Svalbard Incoherent Scatter Radar (ESR) (Fig. 2). A subset of these observations will be used as inputs for the V18 ED model (Sec. III).

II. OBSERVATIONS
The CAPER-2 rocket traveled through red auroral arcs (Fig. 1a) caused by a prolonged, negative (approx. -5 nT) component of the interplanetary magnetic field. During the CAPER-2 flight (Fig. 1b), the ESR 42-meter dish made complete observations of the electron density (Fig. 2a) and electron and ion temperature (Figs. 2b and 2c). The enhanced densities and temperatures that are typical of the cusp begin near 09:30 UT and continue to the end of the period shown in Fig. 2.

Observations made by CAPER-2 instrumentation, which are still being processed, include particle measurements and both electric and magnetic field measurements.

FIG. 1: ASC OBSERVATIONS DURING CAPER-2 FLIGHT
(a) UiO/KHO all-sky camera @ 09:39 UT, Jan 4, 2019
(b) CAPER-2 Trajectory

FIG. 2: ESR OBSERVATIONS DURING CAPER-2 FLIGHT
(c) Electron density % change
(d) Pedersen conductivity % change
(e) Temperature % change
(f) Overhead flight track

III. WAVE-MODIFIED CONDUCTIVITIES, V18 ED MODEL

The V18 electromagnetic ED model is based on the following expressions for the Pedersen conductivity $\sigma_P$ and the parallel conductivity $\sigma_T$:

$$\sigma_P = c_0 \sum \left( p \omega_0^2 + q \omega_0^2 \right)$$
$$\sigma_T = \sigma_P + \frac{1}{\left( \frac{\omega}{\omega_0} \right)^2}$$

The expression for each conductivity explicitly depends on wave frequency $\omega$, which to our knowledge appears in these expressions for the first time in the V18 model. The dependence arises because of the retention of the time derivative in Poynting’s theorem. Fig. 3 illustrates (based on empirical models, not CAPER-2 or ESR data!) how these conductivities may change with wave frequency.

IV. SUMMARY
When CAPER-2 data become available, we will use (i) ESR measurements of electron and ion temperature as well as electron density over altitudes between 100 and 400 km, and (ii) CAPER-2 measurements of electric fields as well as electron density and temperature above 400 km as inputs to the V18 model for electromagnetic ED. These results, which will be based on in situ measurements of geomagnetic cusp properties, will be compared with results based on empirical models for ionospheric densities.

REFERENCES
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