In this study we have examined energetic neutral atom (ENA) images from the Medium Energy Neutral Atom (MEENA) and High Energy Neutral Atom (HENA) imagers on the Imager for Magnetopause-to-Auroral Global Exploration (IMAGE) observatory. In the Earth’s magnetosphere, energetic ions undergo charge exchange with the extended neutral atmosphere to create ENAs. IMAGE has three imagers which detect these ENAs for different energy ranges. The MEENA imager detects ENAs with 0.5-4 keV per nucleon, while the HENA imager detects ENAs with 10-150 keV per nucleon. Two different methods are used to obtain the ion temperature from these imagers. For the 12 August 2000 storm, the ion temperatures obtained using the two different methods and instruments were both consistent with in situ geosynchronous MPA measurements at the same magnetospheric location. However, on the other side of the magnetosphere, where no in situ measurements were available, the ion temperatures determined with the two methods were substantially different.

More recently, a superposed epoch analysis of ENA-based ion temperature images for 39 storms from 2000-2002 has demonstrated that regions of high plasma density, i.e. neutral flux, do not necessarily coincide with regions of high ion temperature [Zaniewski et al., 2006]. Similar trends are evident in 11 years of storm-synchronized MPA geosynchronous ion density and temperature measurements [Drozdov et al., 2005]. However, the MLT locations of the peak in ion density and cold ion population during storm main phase are quite different (see figures below). Thus, there appear to be significant differences in these global “views” of the magnetospheric ion populations. Comparison of the analysis methods for individual storms might identify the origin of the discrepancies.

**Comparison of the HENA detected ion equatorial temperature (red diamonds with error bars) with the ion temperature inferred from geosynchronous MPA measurements (solid line) and HENA observations (black solid circles with 0.2 keV error bars) at 12:00 UT, 12:30 UT and 13:00 UT during the 12 August 2000 storm.**

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**Introduction**

In this study we have examined energetic neutral atom (ENA) images from the Medium Energy Neutral Atom (MEENA) and High Energy Neutral Atom (HENA) imagers on the Imager for Magnetopause-to-Auroral Global Exploration (IMAGE) observatory. In the Earth’s magnetosphere, energetic ions undergo charge exchange with the extended neutral atmosphere to create ENAs. IMAGE has three imagers which detect these ENAs for different energy ranges. The MEENA imager detects ENAs with 0.5-4 keV per nucleon, while the HENA imager detects ENAs with 10-150 keV per nucleon. Two different methods are used to obtain the ion temperature from these imagers. For the 12 August 2000 storm, the ion temperatures obtained using the two different methods and instruments were both consistent with in situ geosynchronous MPA measurements at the same magnetospheric location. However, on the other side of the magnetosphere, where no in situ measurements were available, the ion temperatures determined with the two methods were substantially different.

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**Two Methods of Calculating Ion Temperature**

### HENA

The ion temperature, $T_i$, is obtained from ENA images by solving the charge exchange differential equation for a Maxwellian distribution of temperature, $T_m$, given by

$$\frac{dE}{dx} = C(E,T_m) \int_{E}^{\infty} \frac{E^2}{2T_m} \exp \left( \frac{-E}{T_m} \right) dE$$

where $C(E,T) = \sigma(E,T) n_0$ is the charge exchange cross section between neutrals and ions of energy $E$ and the integral over $E$ accounts for reduction of neutral flux due to additional collisions or ionization along the path from point $x$ to the instrument located at $x_0$. Outside of the plasmapause, the magnetosphere is optically thin so that neutral flux is given by

$$J(E) = J_0(E) \exp \left( -\alpha x \right)$$

where $J(E)$ is the equatorial ion flux extracted from ENA images and $J_0(E)$ is the source term for a Maxwellian ion distribution of temperature $T(E)$.

We assume that the ion distribution is a Maxwellian with temperature $T(E)$.

$$f(x,T(E)) = \frac{m T(E)}{2\pi k T(E)}^{3/2} \exp \left( -\frac{m x^2}{2k T(E)} \right)$$

where $x$ is the position on the equatorial plane, $T(E)$ is the kinetic energy of the trapped ions, and $k$ is the Boltzmann constant. The ion temperature of the ring current $T(E)$ in the equatorial plane is related to the ion differential flux $J(E)$, the observed quantity, through the relationship

$$f(x,E) = \frac{\int_{E}^{\infty} f(x,T) dT}{J(E)}$$

where $m$ is the mass of ion and $E$ is the energy of ion. The integration of $f(x,E)$ over pitch angle on the equatorial plane is the equatorial ion flux $J(E)$ of the ring current which is extracted from ENA images. Thus, the ion temperature of the ring current can be obtained from the linear fits of the observations at different energy ranges for a location using the following relationship

$$T(E) = \frac{\int_{E}^{\infty} J(E) dE}{\int_{E}^{\infty} J(E) dE}$$

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**MEENA**

The high-energy portion of the neutral atom energy spectrum, $F(E)$, generated via charge exchange collisions for a Maxwellian ion distribution of temperature $T$, is given by

$$F(E) = \frac{2m}{\pi k T} E^2 \exp \left( -\frac{m E}{k T} \right)$$

where $C(E,T) = \sigma(E,T) n_0$ is the charge exchange cross section between neutrals and ions of energy $E$ and the integral over $E$ accounts for reduction of neutral flux due to additional collisions or ionization along the path from point $x$ to the instrument located at $x_0$. Outside of the plasmapause, the magnetosphere is optically thin so that neutral flux is given by

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**Comparison of MEENA and HENA Ion Temperature Maps**

The averaged ion density and perpendicular temperature from MPA data as a function of storm epoch time, where the zero epoch occurs at minimum storm $Dst$. The averaged ion density and perpendicular temperature from MPA data as a function of storm epoch time, where the zero epoch occurs at minimum storm $Dst$. The averaged ion density and perpendicular temperature from MPA data as a function of storm epoch time, where the zero epoch occurs at minimum storm $Dst$. The averaged ion density and perpendicular temperature from MPA data as a function of storm epoch time, where the zero epoch occurs at minimum storm $Dst$.