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A statistical study of energetic ions (H+, He+, and O+) in the inner magnetosphere using the Arase satellite observations

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We perform a statistical study of energetic ions (H+, He+, and O+) in the inner magnetosphere depending on geomagnetic conditions using the Arase satellite observations from March 2017 to December 2021. We used a combined dataset for ions (LEPi and MEPi) onboard the Arase satellite with a combined energy range of 0.01-187 keV. In order to examine the spatial distributions of energetic ions depending on geomagnetic conditions, the energy fluxes for all species were sorted by the magnetic local time (MLT), L∗shell, energy, and three Kp steps (quiet: Kp<1, intermediate: Kp=1-3, disturbed: Kp>3). Overall, all ion species showed similar spatial distributions. Taking a close look at the resultant L∗-energy and L∗-MLT spectra, we can find four distinct H+ populations within different energy ranges: (1) plasmaspheric H+ (E <30 eV) at L <5, (2) warm plasma cloak at energies of several tens eV - several keV, (3) the ring current population (E = 1 keV – several tens of keV) with nose structures, (4) high-energy ring current particles (E >30 keV) with symmetric distributions in MLT, and these populations exhibited different behaviors as Kp increases. At E=0.05-1 keV, other heavy ions (He+ and O+) show higher energy fluxes near the earth region (L∗˜2) and the energy flux has the tendency that keeps decreasing as L∗increases. On the other hand, H+ exhibits significant energy flux variations inside and outside the plasmasphere, and a higher energy flux of H+ appears outside the plasmasphere. Ion nose structures appeared at energies of ˜several keV in the noon and dusk sectors. These structures showed inner boundaries at different L∗locations for different ion species (L∗˜4 for H+, L∗˜2 for He+ and O+). The difference in L∗is due to a longer charge exchange lifetime for heavy ions as compared to that for H+. We discuss the underlying physical dynamics and the possible origins of the different populations and compare the observational results with a model calculation using simple electric and magnetic fields.