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Swarm-E (e-POP) Observations of Atomic N+ and Molecular Ions in Topside Ion Up-flows and Down-flows: Occurrence Characteristics and Impact on Magnetosphere-Plasmasphere-Thermosphere Coupling

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Atomic nitrogen (N+), molecular nitrogen (N2+), and nitric oxide (NO+) ions are minor ion species in the topside ionosphere. They are generally difficult to resolve unambiguously from adjacent major or overlapping ion species (e.g. O+, O_2+) and often not sampled at all in ion composition measurements. Using the first five years of Swarm-E (e-POP) data (from 2013 to 2018), we present a statistical study of N+ and molecular ion up-flows and down-flows in the high-latitude topside ionosphere (300-1500 km altitude), specifically their occurrence distributions and morphological characteristics. Our study reveals the presence of enhanced N+ and molecular N2+ and NO+ densities in both ion up-flows and down-flows during both storm and quiet (non-storm) times, at times at N+ densities of up to 10-50% of the plasma density, and at an averaged occurrence frequency of $\sim$10%. The occurrence of the most intense events peaks in the pre-midnight sector, and that of the low-intensity events in the pre-noon sector. We discuss the interpretation of these results in terms of (a) the sources of the enhanced densities, (b) the rates of ion acceleration and dissociative recombination in the F-region and topside ionosphere, (c) the scarcity of observed low and high-energy molecular ions at higher altitudes, and (d) heavy ion composition and redistribution in the plasmasphere and the different regions of the magnetosphere.