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Properties of molecular ions in the ring current and their supply mechanism from the low-altitude ionosphere

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Molecular ions usually exist only in the low-altitude (< 300 km) ionosphere and cannot escape to space without a fast ion upflow/outflow to overcome a rapid loss due to dissociative recombination (e.g., Peterson et al., 1994). Thus, molecular ion escape from the terrestrial atmosphere to space can be used as a tracer of effective ion loss from the deep ionosphere. Reports on molecular ion observations in the ring current are limited to some event studies (e.g., Klecker et al., 1986) and their statistical properties are far from understood. Here we report observations by the Arase (ERG) satellite which enables definitive identification of molecular ions (O_2^+/NO^+/N_2^+) by frequent TOF (time-of-flight) mode observations (Seki et al., 2019) and a simultaneous observation by the EISCAT radar and Arase to investigate the mechanisms to cause the fast upward ion transport in the deep ionosphere (Takada et al., submitted, 2021).

Statistical properties of molecular ions in the ring current are investigated based on ion composition measurements (<180 keV/q) by MEPi and LEPi instruments onboard Arase. The investigated period from late March to December 2017 includes 11 geomagnetic storms with the minimum Dst index less than -40 nT. The molecular ions are observed in association with geomagnetic disturbances with Dst < -30 nT. During quiet times, molecular ions are not observed. The tendency is consistent with previous observations. The molecular ions are observed mainly in the region of L=3.5-6.6 and clearly identified at energies above ~14 keV with moleculartо O^+ ion energy density ratio of the order of 1 percent. Detection probability of molecular ions in the ring current becomes higher with increasing size of geomagnetic storms (minimum Dst index). Their detection probability also tends to be higher during substorms as well as during high-speed solar wind period. The observation probability of the molecular ions in the ring current is comparable or higher than that in the high-altitude auroral regions, suggesting the importance of the subauroral

zone. Existence of molecular ions even during small magnetic storms suggests that the fast ion outflow from the deep ionosphere occurs frequently during geomagnetically active periods. In order to understand the mechanism of the molecular ion supply to the magnetosphere, we will also briefly report on an event study of the ion upflow in the low-altitude (250-350 km) ionosphere observed by EISCAT during the storm main phase on September 8, 2017, when Arase observed molecular ions in the ring current.

References:

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