Volcanic change of the distribution of Io's neutral oxygen cloud observed by Hisaki

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Io has a thin atmosphere created by volcanism and sublimation from the surface frost. Io's atmospheric oxygen atoms are heated by atmospheric sputtering, and escape from Io's gravity, forming a neutral oxygen cloud around Io's orbit. The neutral cloud is important as a source of the Io plasma torus. Previous studies derived the distribution and density of the equilibrium neutral oxygen cloud, and showed changes in Io's volcanism can lead to increase densities of both neutral clouds and Io plasma torus. Koga et al (2018) showed the distribution of Io's neutral oxygen cloud from Hisaki observation data during a volcanically quiet period (November and December in 2014). The equilibrium neutral oxygen cloud consists of a dense region distributed around Io (the "banana cloud") and a longitudinally uniform, diffuse region distributed along Io's orbit. However, the evolution of the distribution of neutral clouds was not understood. In this study, we analyzed the Hisaki satellite observations of the spatial distribution of OI 130.4 nm emissions around Io's orbit during a volcanic event in 2015.
The radial distribution shows the oxygen cloud spread outward during the volcanically active period. The outer edge of the OI emission was 7 R_J (Jupiter radii) before the volcanic activity, but it spread to around 8-8.6 R_J during the volcanically active period. We also estimated the oxygen number density outward Io's orbit represented as $n(r)=n_0(r/r_0)^{\gamma}$, where r is radial distnace from Jupiter, r_0 is 5.9 R_J (orbit of Io), n_0 is a number density at 5.9 R_J, γ is a power law slope of the profile. The number density at Io's orbit (where north-south thickness is 1.2 R_J) increased to 88±9 cm^{-3} during the active period that is more than twice as large as the number density during the quiet period (40 cm^{-3}). The power law slope outward Io's orbit during the active period (γ=-5.5±1.3) is similar to that during the quiet period (γ=-5.3). The azimuthal distribution shows the neutral oxygen cloud during the active period also consists of the banana cloud and diffuse region distributed along Io's orbit, but both of the regions enlarge. The observation results show the main escape process of neutrals from Io's graivity remains atmospheric sputtering, but the escape rate of them significantly increased during a volcanically active period. One of the possible mechanisms to increase the escape rate is that the sublimation frost area increases and the density of sublimation driven atmosphere also increases. Another mechanism is that plumes increase the height of the exobase, and the area of atmospheric sputtering increases.

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