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The effect of solar illumination on ionospheric outflow composition in the polar cap region

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We use measurements by the CODIF ion spectrometer aboard the Cluster spacecraft, to investigate the composition of upflowing ion beams detected in the magnetospheric lobes during periods of northward IMF. These ion beams consist of ionospheric ions originating from the local polar ionosphere and are accelerated upward by a quasi-static electric field. This field-aligned electric field effectively acts as an extension of the experiment, probing the plasma at the altitude just below the bottom of the acceleration region and accelerating the ions into the energy range accessible by the CODIF detector. In this way it becomes possible to analyze the composition of upflowing ionospheric ions just above the polar ionosphere where ions are usually too cold to be measured by ion detectors due to the spacecraft charging

We make a statistical analysis of the change in the composition of upflowing ions as a function of the solar zenith angle at the local ionosphere for a set of $\sim$70 events. We show that the composition undergoes a very distinct regime change around 100° solar zenith angle, which corresponds to the solar terminator at ionospheric altitude. While the H^+ density only shows weak variations with the solar zenith angle, the amount of O^+ ions sharply decreases around 100° solar zenith angle. This illustrates how the alteration of ionospheric properties by solar illumination can affect the ionospheric upflow composition, and particularly the amount of O^+ upflowing from the polar ionosphere.

With a very simple model we investigate the implications of these observations on the seasonal variation of the average composition of ionospheric plasma upflowing from the polar ionosphere. Considering both the northern and southern polar regions, we show that the proportion of the polar ionosphere which is sunlit (i.e. below 100° solar zenith angle) varies through the year. Therefore the O^+ dependency on solar illumination evidenced by Cluster suggests that ionospheric outflow will exhibit seasonal variations. Due to this seasonal effect, we may expect a higher amount of O^+ ions escaping the polar ionosphere during spring/autumn than during winter/summer.