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Understanding atmospheric particle escape from distant tail measurements

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The evolution of the Earth's atmosphere cannot be understood without an assessment of the amount of atmospheric escape to space. While the current neutral escape from the Earth's atmosphere is considered negligible (at least for the heavier species), the ion escape is more difficult to evaluate because of the diversity of escape mechanisms and the complexity of ion escape routes, and the possible recirculation of the plasma. Tracking the heavy ions is therefore of paramount importance.

It is difficult to assess the total ion escape rate based on measurements in near-Earth space, in particular because the net escape rate is the difference between the upward ion flux and the downward flux of recirculated plasma. Both the upward and downward contributions are characterized by a strong spatial and time variability and a dependence on solar and geomagnetic conditions.

It was recently proposed to measure the net outflow rate from a vantage point in the deep tail (ESA F1 FATE mission proposal). It is reasonable to assume that the return flow from beyond $\sim$200 RE is negligible, so that an evaluation of the net escape rate becomes more straightforward. A contribution that would be missed are ions that are transformed into escaping energetic neutral atoms through charge exchange. Ions that are lost through magnetopause shadowing will be dragged along with the magnetosheath flow and can still be detected in the magnetosheath adjacent to the tail magnetopause, except if they are too energetic. Using simulations based on a simplified model, we examine whether it is possible to disentangle the contributions from the different atmospheric escape processes from their combined signatures in the deep tail.