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The Spatial Distribution of Upstream Ion Events Measured by ACE, Wind, and STEREO Near the Earth's Bow Shock

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Abrupt enhancements in the intensities of ions in the energy range of a few 10s of keV to 100s of keV upstream of the Earth's Bow Shock – upstream ion events – are characterized by short durations ($\sim$1-2 hours), steeply falling spectra, large ($>$100:1) field-aligned sunward anisotropies, and positive correlations with the solar wind speed and geomagnetic indices. Despite the wealth of information available, however, it is still not clear whether these ions are accelerated at the bow shock or somewhere inside the Earth's magnetosphere. Furthermore, such events are also often observed simultaneously at two or more spacecraft, indicating that a large source region perhaps covering the entire size of the bow shock fills large spatial structures in the upstream region. In this paper we use simultaneous measurements of $>$40 keV upstream ions observed at ACE, Wind, and STEREO-A between 2007, day 1 through 2007, day 181 to calculate the occurrence probability of upstream events as a function of lateral and radial separation between L1 and STEREO-A. During the end of this $\sim$6-month period, Wind (or ACE) and STEREO-A were separated by $\sim$1750 R_E in the radial direction and laterally in Y_{GSE} by $\sim$3800 R_E. Despite this large separation, STEREO-A continued to observe upstream events right up until the end of our survey period. More surprisingly, we found that the occurrence probability for measuring simultaneous upstream events at Wind or ACE at L1 and STEREO-A was $\sim$20-30%, i.e., far greater than that ex-

pected from accidental coincidences. We discuss the implications of these results for the size of the source region, the conditions under which upstream events occur, and the size and nature of the spatial structures in which these ions populate and propagate in the upstream region.