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Shape, size, velocity and field-aligned currents of dayside plasma injections: a multi-altitude study

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On 20 February 2005, Cluster in the outer magnetosphere and Double Star-2 (TC-2) at mid-altitude are situated in the vicinity of the northern cusp/mantle, with Cluster moving sunward and TC-2 anti-sunward. Their magnetic footprints come very close together at about 15:28 UT, just over the common field-of-view of SuperDARN radars. Thanks to this conjunction, we determine the drift velocity, the transverse sizes, perpendicular and parallel to this drift, and the shape of three magnetic flux tubes of magnetosheath plasma injection. The drift velocity determined from the Cluster four-spacecraft timing analysis is almost purely antisunward. The transverse sizes are defined from the Cluster-TC-2 separation perpendicular to the magnetic field, and from the time spent by a Cluster spacecraft in one structure; they are comprised between 0.6 and 2 RE in agreement with previous studies. Finally, using a comparison of the eigenvectors deduced from a variance analysis of the magnetic perturbation at the four Cluster and at TC-2, we show that the upstream side of the injection flux tubes is magnetically well defined, with even a concave shape for the third one giving a bean-like shape, whereas the downstream side is far more turbulent. We also realise the first quantitative comparison of field-aligned currents at Cluster calculated with the curlometer technique and with the single-spacecraft method, assuming infinite parallel current sheets and taking into account the drift velocity of the plasma injection flux tubes. The results agree nicely, confirming the validity of both methods. Finally, we compare the field-aligned current distribution of the three injection flux tubes at the altitudes of Cluster and TC-2. Both profiles are fairly similar, with mainly a pair of opposite field-aligned currents, in agreement with the Southwood (1987) model. In terms of intensity, the field-aligned currents at Cluster are two to three times less intense than at TC-2 for the two first flux tubes, in agreement with magnetic field line convergence. For the third flux tube, the intensity is equal, which is explained by the fact that TC-2 crosses the tube on its edge. Finally, the analysis of the ion and electron moments at Cluster shows that the field-aligned currents result from a small difference between upward ions and electrons fluxes.