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Hall-MHD simulations of the magnetosphere-northward solar wind interface : the Kelvin-Helmholtz instability as an entry mechanism for the solar wind through mixing and reconnections

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The transfer of matter from the solar-wind to the Earth's magnetosphere during southward solar wind is mostly well understood but the processes governing the same phenomenon during northward solar wind remains to be fully apprehended. Numerous numerical studies have investigated the topic with many interesting results but most of these were considering two-dimensional situations with simplified magnetic configuration and often neglecting the inhomogeneities for the sake of clarity. Given the typical parameters at the magnetosphere-solar wind interface, the situation must be considered in the frame of Hall-MHD, due to the fact that the current layers widths and the gradient lengths can be in the order of the ion inertial length. As a consequence of Hall-MHD creating a third vector component from two planar ones, and also because magnetic perturbations can affect the field configuration at a distance in all directions and not only locally, three-dimensional treatment is necessary. In this spirit three-dimensional simulations of a configuration approaching the conditions leading to the development of Kelvin-Helmholtz instabilities at the flank of the magnetosphere during northward oriented solar-wind are performed as means to study the entry of solar-wind matter into Earth's magnetic field. In the scope of assessing the effect of the Hall-term in the physical processes, the simulations are also performed in the MHD frame. Furthermore the influence of the density and velocity jump through the shear layer on the rate of mass entering the magnetosphere is explored. Indeed, depending on the exact values of the physical quantities, the Kelvin-Helmholtz instability may have to compete with secondary instabilities and the non-linear phase may exhibit vortex merging and large-scale structures reorganisation, creating very different mixing layers, or generate different reconnection sites, locally and at a distance. These different configurations may have discernible signatures that can be identified by spacecraft diagnostics.