

Supplementary Information for ”Ionospheric signatures of Bursty Bulk Flows in the 6D Vlasiator simulations”

Abiyot Workayehu¹, Palmroth Palmroth^{1,2}, Maxime Grandin²,

Liisa Juusola², Markku Alho¹, Ivan Zaitsev¹, Venla Koikkalainen¹,

Konstantinos Horaites³, Yann Pfau-Kempf⁴, Urs Ganse¹,

Markus Battarbee¹, and Jonas Suni¹

¹Department of Physics, University of Helsinki, Helsinki, Finland

²Finnish Meteorological Institute, Helsinki, Finland

³Cooperative Institute for Research in Environmental Sciences University of Colorado, Boulder Boulder, CO, USA

⁴CSC – IT Center for Science, Espoo, Finland

Correspondence: Abiyot Workayehu, abiyot.workayehu@helsinki.fi

Supplementary Animation Movies (Files uploaded separately)

1. Captions for Movies S1 and S2

Introduction

This supporting information provides two animation movies, referred to as Movie S1 and Movie S2, from the Vlasiator simulations. Movie S1 shows the magnetic conjugacy between the dynamics occurring in the near-Earth magnetotail and its effect on the Field-Aligned Currents (FACs) at the ionosphere altitude. Movie S2 shows the temporal evolution of the earthward fast flows and the magnitude of pressure gradient in the magnetotail, and the ionospheric signatures of those fast flows. For more detail discussions related to these animation movies, please refer to Sections 3.2 and 3.3 of the main paper.

Movie S1. Magnetic conjugacy of the plasma flow vorticity $\Omega_z = (\nabla \times \vec{V})_z$ in the magnetotail current sheet (where $B_x = 0$) and field-aligned currents that are generated on the duskside and dawnside of the BBF (shown by blue and red coloured traced magnetic field lines), with the distributions of the R1/R2 FAC densities near the inner boundary, which corresponds to the FACs at ionospheric altitude at simulation time $t = 550$ s. The black arrows on the current sheet indicate the horizontal component (V_{xy}) of the plasma velocity. The red contour line shows the plasma flow reversal $V_x = 0$ between the Earthward and tailward flow regions. The reddish-orange and bluish-cyan block lines, respectively, on the current sheet indicate the magnetic X- and O-topologies.

Movie S2. Temporal evolution of variables in the ionosphere and magnetosphere derived from Vlasiator simulations, covering the simulation times $t = 400$ s to 600 s. Panels (a-d): FACs, Hall conductance (Σ_H), Pedersen conductance (Σ_P) and precipitating electron energy flux (p_e), respectively, are from the Vlasiator ionosphere. Panels (e and f), respectively, show the x-component of flow velocity V_x and the magnitude of the pressure gradient ∇P in the XY plane at $Z=0$. Panels (g and h) present the flow velocity V_x and the magnitude of the pressure gradient, respectively, in the XZ plane at $Y = 6.3R_E$. The solid magenta contour lines in panels (e) and (f) denote the boundaries of the earthward fast flows with $V_x \geq 400$ km/s, whereas the red vertical lines indicate the $Y = 6.3R_E$ plane, which serves as the reference for plots in panels (g and h).