Supporting Information for "Auroral, Ionospheric and Ground Magnetic Signatures of Magnetopause Surface Modes"

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Contents of this file

1. Table S1 to S2

Additional Supporting Information (Files uploaded separately)

1. Captions for Movies S1 to S3

Introduction

This supporting information provides tables detailing statistics of the current systems which control the ground magnetic field, as well as full details of the simulation run used. Movies of the simulation output in the magnetosphere, ionosphere, and on the ground are also described.

Movie S1.

Movie of perturbations in the near-equatorial plane $Z_{GSM} = 2\,\mathrm{R_E}$. Shown are (left) perpendicular velocities where colours indicate magnitude and arrows indicate directions, both using logarithmic scales; (middle) field-aligned vorticity on a bisymmetric log scale; (right) field-aligned current on a bisymmetric log scale. The last closed field line, a proxy for the magnetopause, is given by the black line in each panel.

Movie S2.

Movie of perturbations in the northern ionosphere in an orthographic projection covering latitudes 60°–90° looking down on the pole. (Left) Radial component of the field-aligned currents into and out of the ionosphere. (Right) Ionospheric velocities where arrow lengths and colours are logarithmically scaled. In both panels the projection of the open–closed field line boundary (black dot) and inner/equatorward edge of the magnetopause boundary (black dashed) are shown.

Movie S3.

Movie of magnetic field perurbations covering latitudes 60°–90° looking down on the north geomagnetic pole. (Left) projection of the perpendicular magnetic field perturbations at $r = 3.5\,\mathrm{R_E}$ onto their ground magnetic footpoints. Arrow lengths and colours are logarithmically scaled. (Middle) Horizontal magnetic field perturbations on the ground in the same format. (Right) Vertical component of the ground magnetic field perturbations. In all panels the projection of the open–closed field line boundary (black dot) and inner edge of the magnetopause boundary (black dashed) are shown.

Box model

Current contributions to $\delta\mathbf{B}_g$	Mean	Median	Lower Quartile	Upper Quartile
Magnetopause	-0.66	-0.75	-0.80	-0.65
Pederson	-0.37	-0.41	-0.59	-0.15
Hall	0.92	0.96	0.88	0.99
Magnetopause + Pedersen	0.08	0.04	0.01	0.12

Global MHD Simulation

Current contributions to $\delta\mathbf{B}_g$	Mean	Median	Lower Quartile	Upper Quartile
Magnetosphere	0.01	0.01	-0.02	0.03
Gap	-0.46	-0.44	-0.55	-0.34
Pedersen	-0.46	-0.47	-0.62	-0.28
Hall	0.43	0.51	0.22	0.71
Gap + Pedersen	-0.04	-0.08	-0.18	0.10
Magnetosphere + Gap + Pedersen	-0.03	-0.08	-0.18	0.08

Table S1. Spatial statistics of the Coefficient of Determination R^2 associated with the Biot–Savart contributions from different current systems to the ground magnetic field perturbations. Note these values do not necessarily sum to unity across the different current systems since R^2 is computed independently at each location.

Solar wind		
	Ambient	**1 min Density Pulse**
n (cm^{-3})	6	14
T (K)	116,174.0	49,788.8
$\mathbf{v}_{GSM}$ ($\mathrm{km\,s}^{-1}$)	(-450,0,0)	(-450,0,0)
$\mathbf{B}_{GSM}$ (nT)	(0,0,5)	(0,0,5)
GSM normal		(1,0,0)
Magnetosphere		
Dipole GSM Orientation		(0,0,1)
Dipole Update		No
Inner boundary r		$2.5\,\mathrm{R_E}$
Current coupling r		$3\,\mathrm{R_E}$
Resolution ($2.5\,\mathrm{R_E} < r \leq 5\,\mathrm{R_E}$)		$1/16\,\mathrm{R_E}$
Resolution (elsewhere considered)		$1/8\,\mathrm{R_E}$
Ionosphere		
Altitude		110 km
Resolution (latitude × longitude)		$1^\circ \times 2^\circ$
Pedersen conductance		5 S (uniform)
Hall conductance		5 S (uniform)
Ground		
Resolution (latitude × longitude)		$2^\circ \times 5^\circ$

Table S2. Details of the SWMF global MHD simulation run used in this paper.