

Auxiliary Material for

Electrodynamics of the Martian dynamo region near magnetic cusps and loops
using the Martian Multifluid Magnetohydrodynamic Model (M^4)

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Introduction

This addendum elaborates on the numerical treatment of initial and boundary conditions in the Mars Multifluid Magnetohydrodynamic Model (M^4). The justifications and implications of our choices in initial and boundary conditions are detailed in the text file “text01.pdf”. The initial atmospheric profiles used in the simulations presented in this work are provided in “fs01.pdf”. The effects of the treatment of the boundary conditions are displayed for the case of the magnetic cusp configuration in “fs02.pdf”.

1. text01.pdf Details about the initial and boundary conditions of the M^4 approach introduced in *Riousset et al.* [2013].
2. fs01.pdf Initial atmospheric profiles used in the M^4 approach, reproducing *Riousset et al.*'s [2013, Figure 1] profiles, but these have been extended down to 80 km. All densities, pressures, and temperatures are assumed to be horizontally uniform at $t=0$ s, and correspond to the dust conditions of Mars Year 24, under average solar conditions, for 0° latitude, 0° longitude, 0° solar zenith angle (SZA), for solar latitude 180° (Northern autumnal equinox) [*RJ Lillis*, 2011,

private communication].

2.1 Panel a, electron, O_2^+ , CO_2^+ , and O^+ density profiles (solid, dashed, dash-dotted, and dotted lines, respectively).

2.2 Panel b, CO_2 and O neutral density profiles (solid and dashed lines, respectively).

2.3 Panel c, neutral (T_g), ions ($T_i=T_{\text{O}_2^+}=T_{\text{CO}_2^+}=T_{\text{O}^+}$), and electron (T_e) temperatures (solid, dashed, and dotted lines, respectively).

2.4 Panel d, electron, O_2^+ , CO_2^+ , and O^+ pressure profiles (solid, dashed, dash-dotted, and dotted lines respectively). The pressure for each species α is calculated as $p_\alpha=n_\alpha k_B T_\alpha$.

3. fs02.pdf Magnitude (color map) and projected direction (solid black arrows) of the electric current density \vec{J} in three cut planes created after $t \approx 27$ s in the case of the magnetic cusp presented in the paper. Dark blue corresponds to null current, while values at or above the maximum of the color bar are shown in dark red.

3.1 Panel a, cut plane at $y=0$ km, across the center of the simulation domain.

3.2 Panel b, cut plane at $z=80$ km, corresponding to the lower boundary of the simulation domain.

3.3 Panel c, cut plane at $x=0$ km, across the center of the simulation domain.

Reference

Riousset, J. A., C. S. Paty, R. J. Lillis, M. O. Fillingim, S. L. England, P. G. Withers, and J. P. M. Hale (2013), Three-dimensional multifluid modeling of atmospheric electrodynamics in Mars' dynamo region, *J. Geophys Res.*, 118(6), 3647--3659, doi:10.1002/jgra.50328.