



The crustal magnetic fields influences on the space environment of Mars: MHD simulation

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Undergraduate Research Presentation

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➤ Introduction

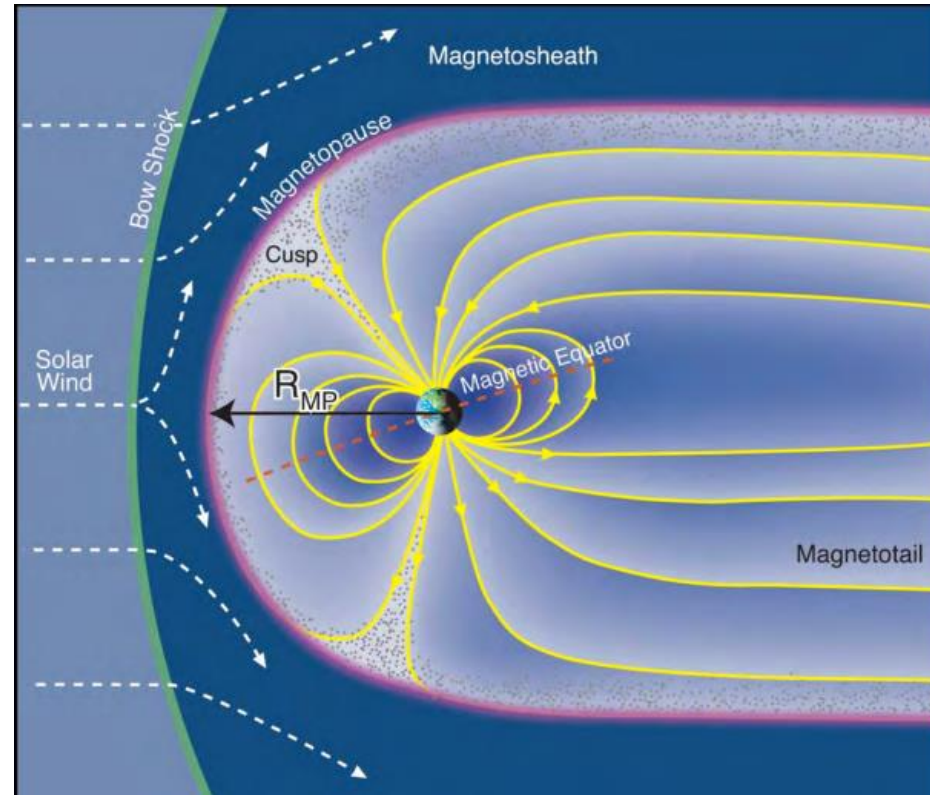
➤ Research work

- Overview of Martian space environment
- Model descriptions
- Results

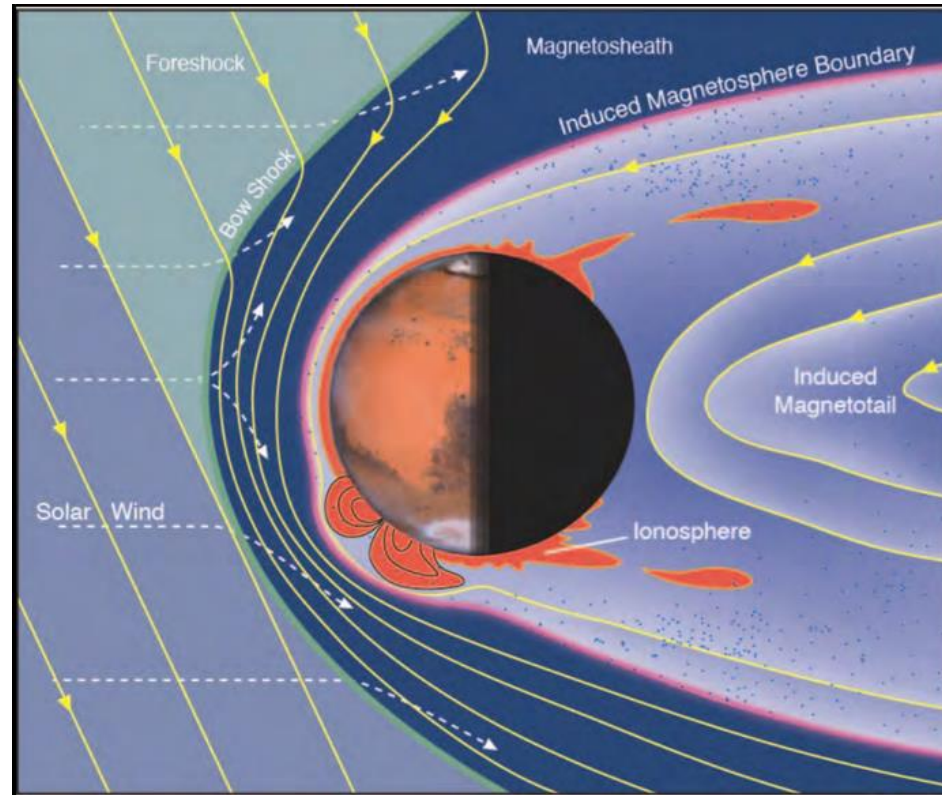
➤ Question & Answer.

➤ Discussion.

Introduction

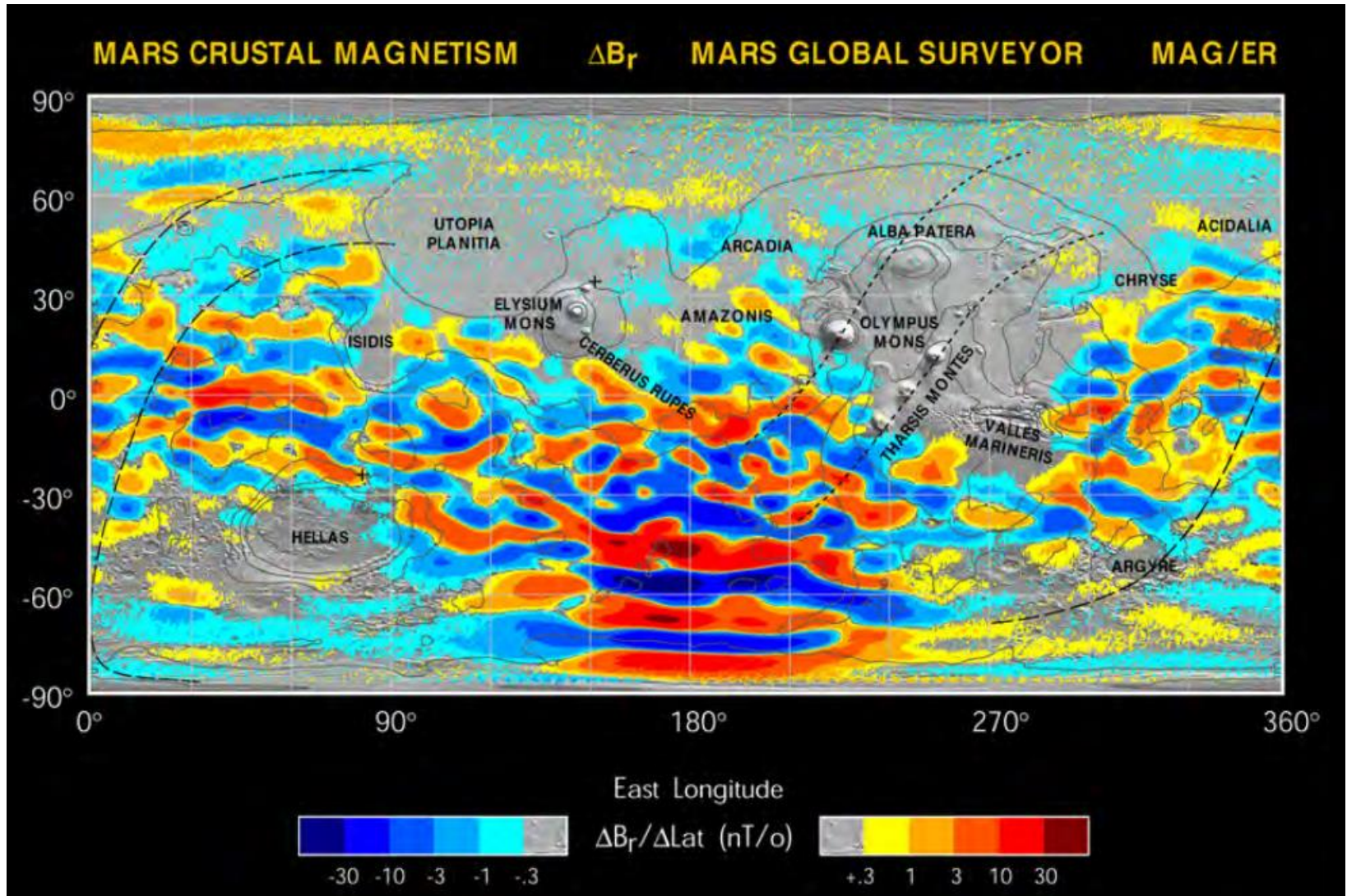


Bagenal et al., (2015)



Brain et al., (2015)

Introduction

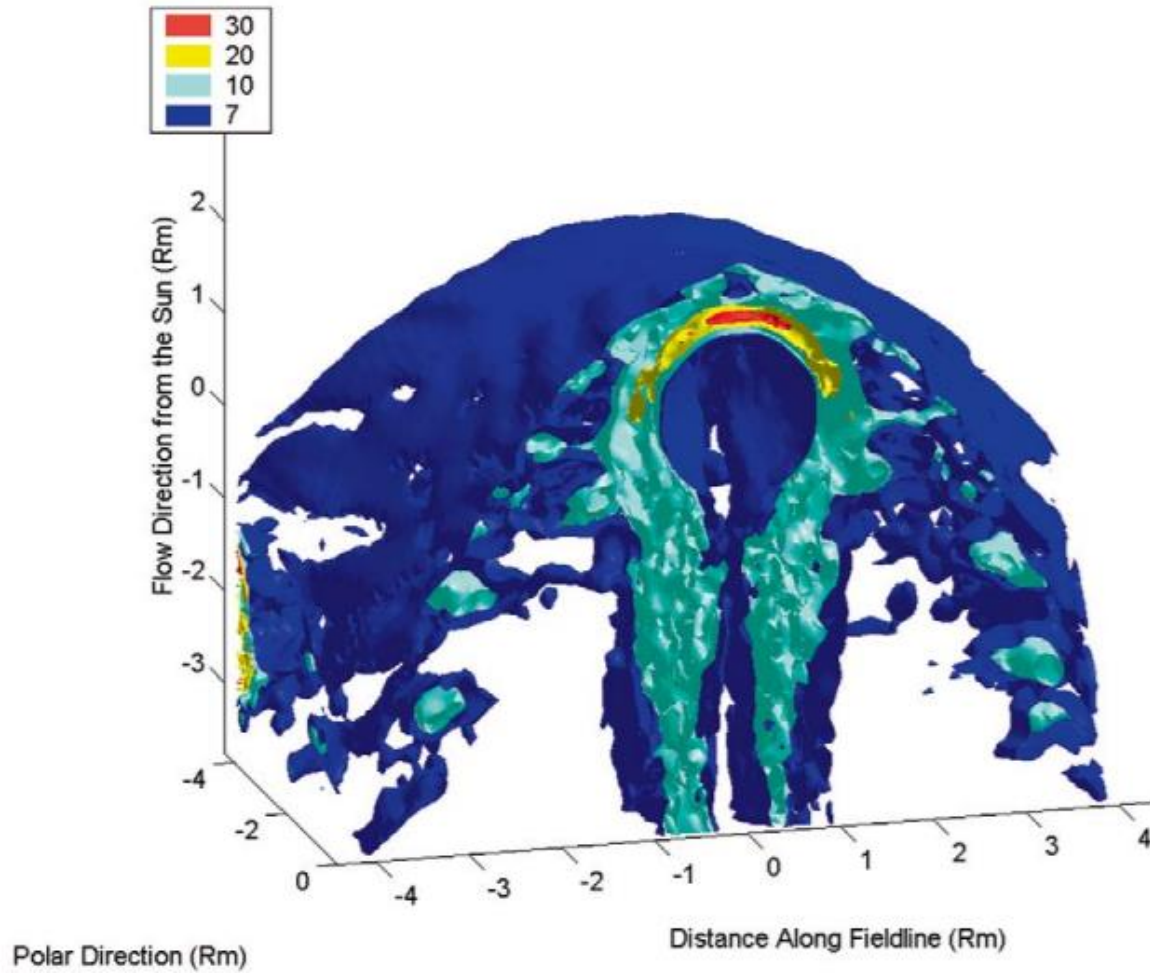


Connerney et al., PNAS, 2005

Global Models of the Solar Wind-Mars Interaction

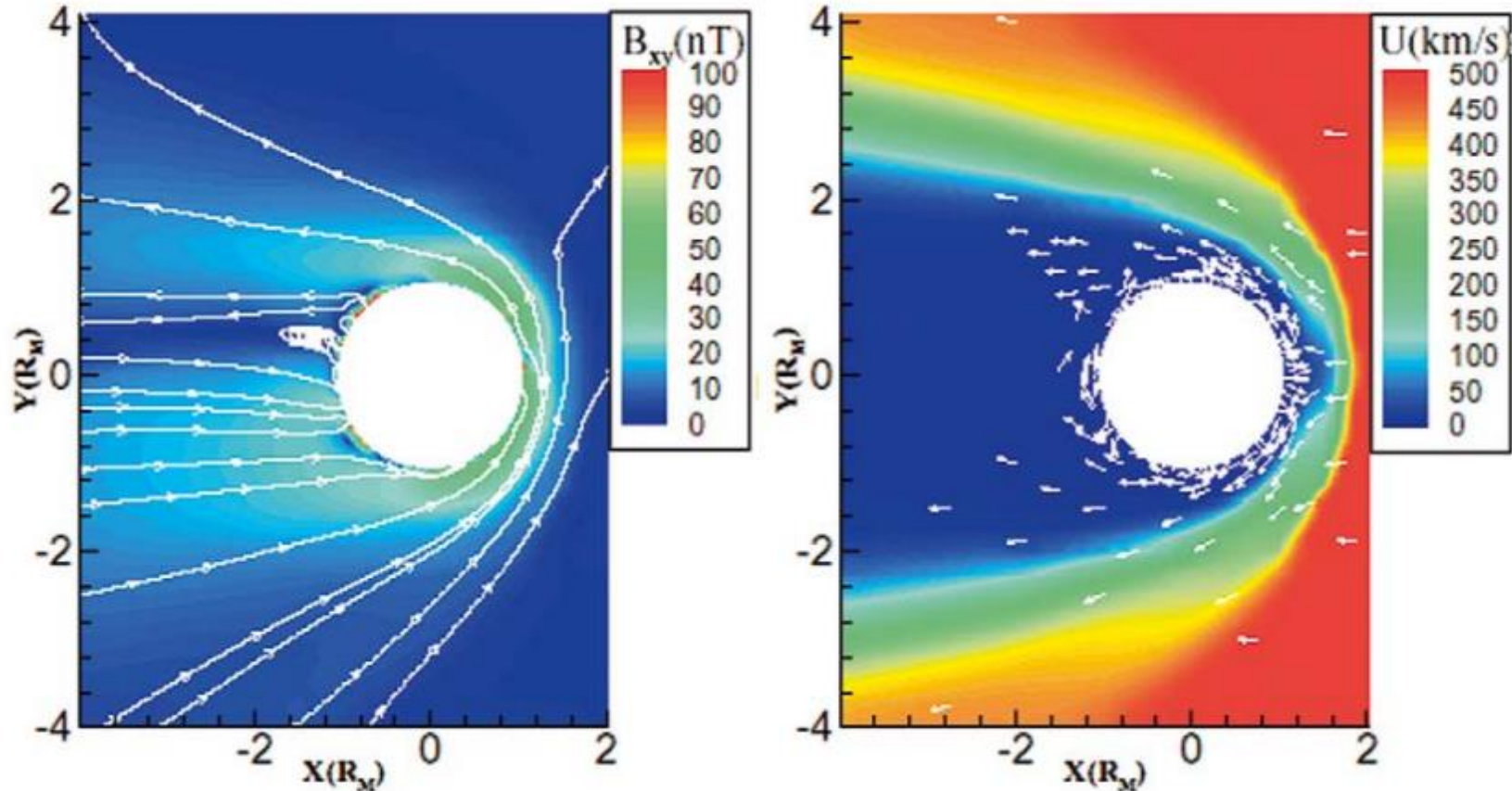
- (i) The semi-kinetic model developed by Brecht;
- (ii) The multi-species, single fluid MHD model developed by Nagy and Ma
- (iii) The two-fluid MHD model developed by Sauer and colleagues.

The Semi-Kinetic Model



A 3D surface plot of the Martian bow shock cut through the ecliptic plane

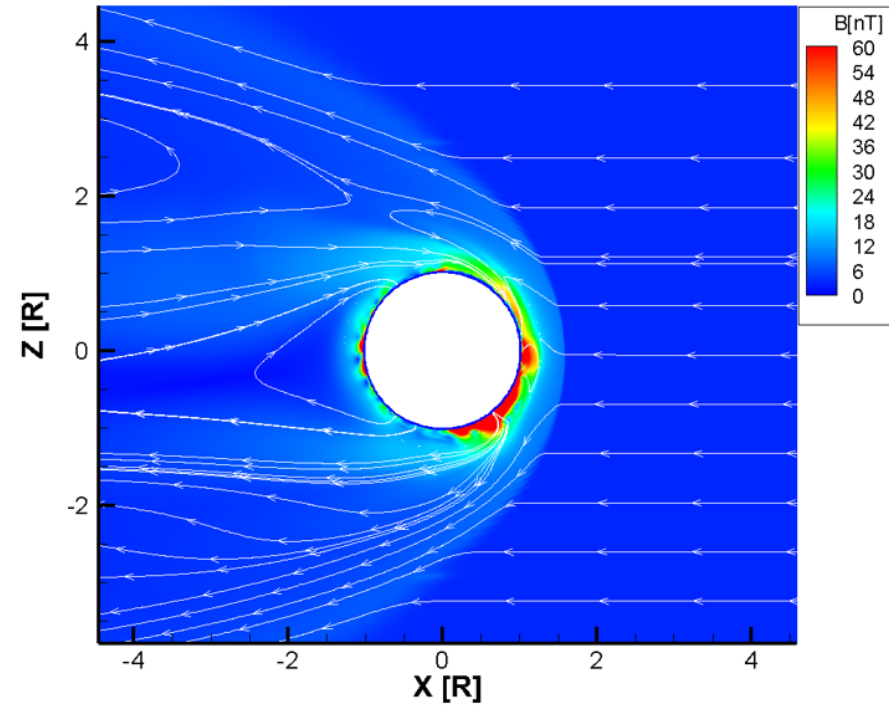
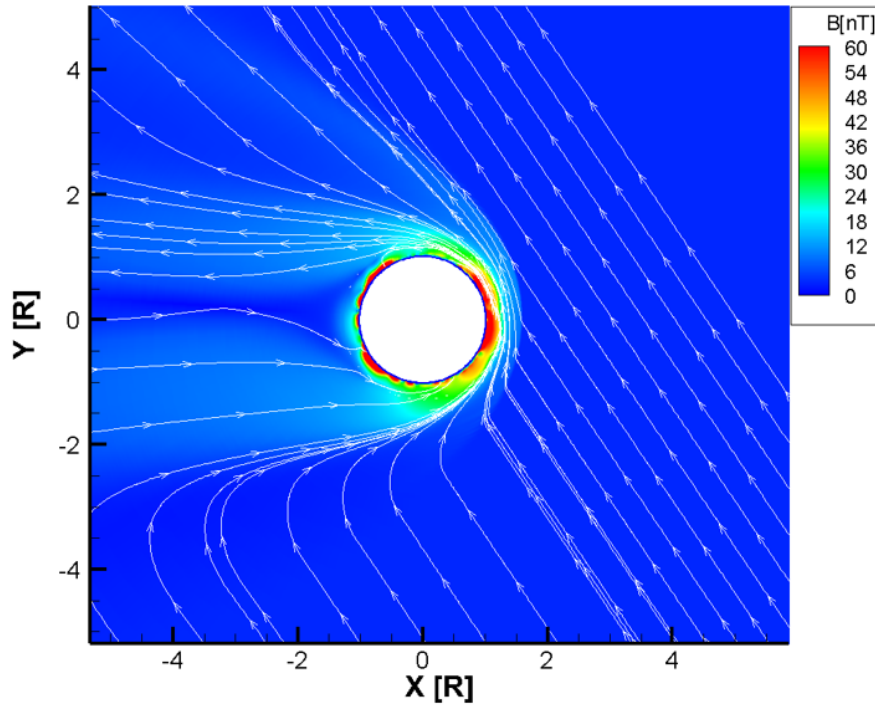
The multi-species, single fluid MHD model



The component of the calculated magnetic field (left) and velocity magnitudes (right) in the xy plane.

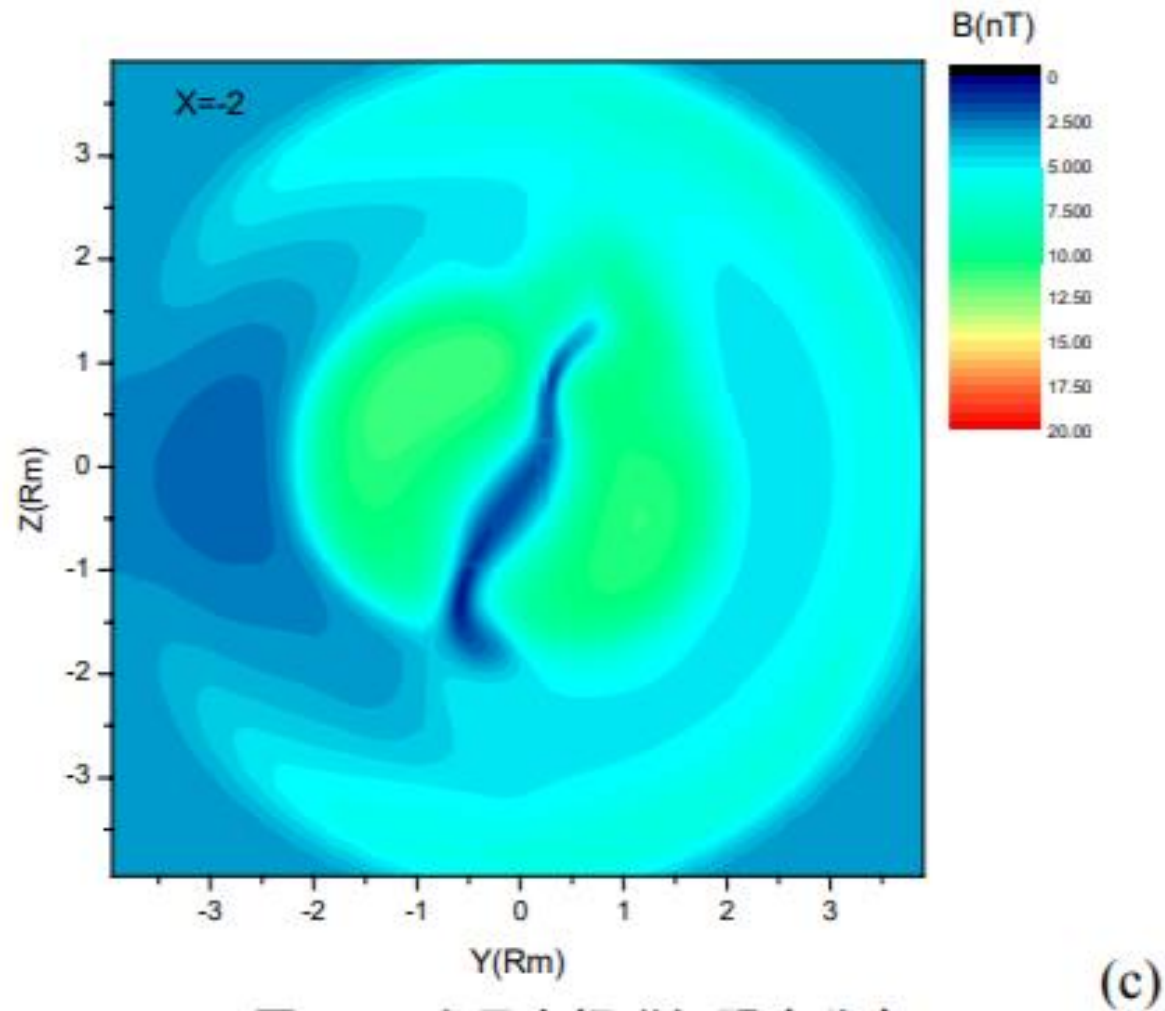
Ma et al., (2002)

Research work



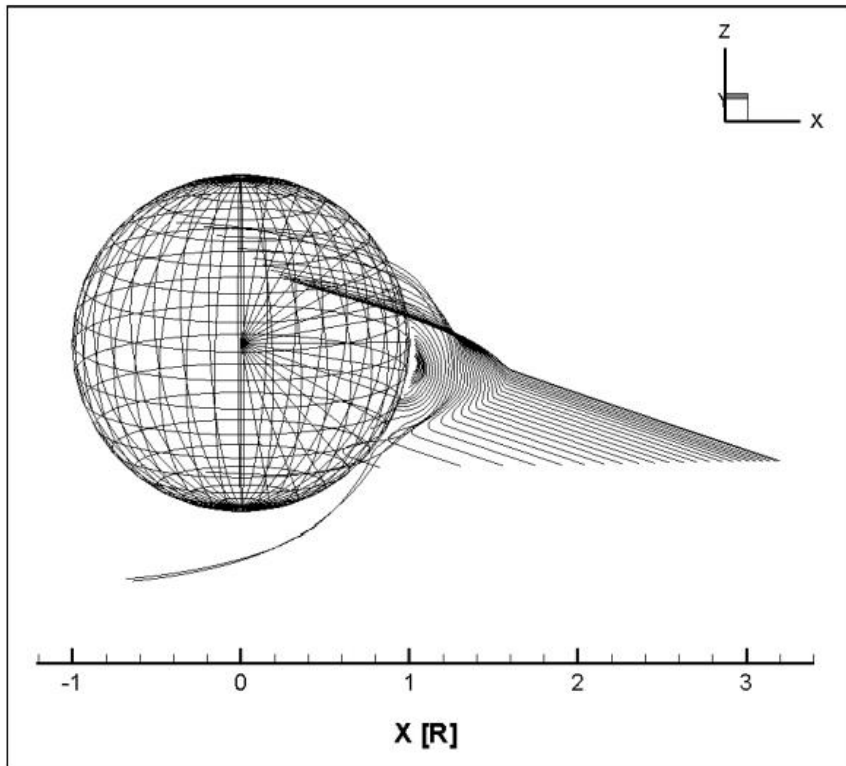
Global view of the Martian magnetic field

Research Experience and Projects

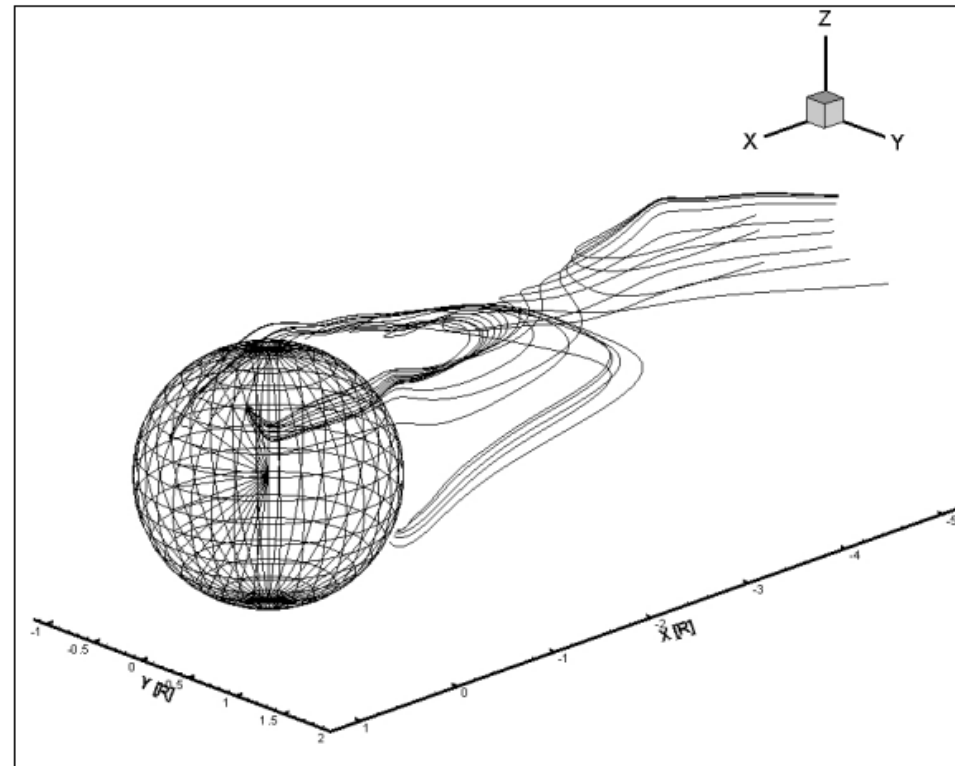


Global view of the Martian magnetic field

Constructed magnetic topology with test particle method

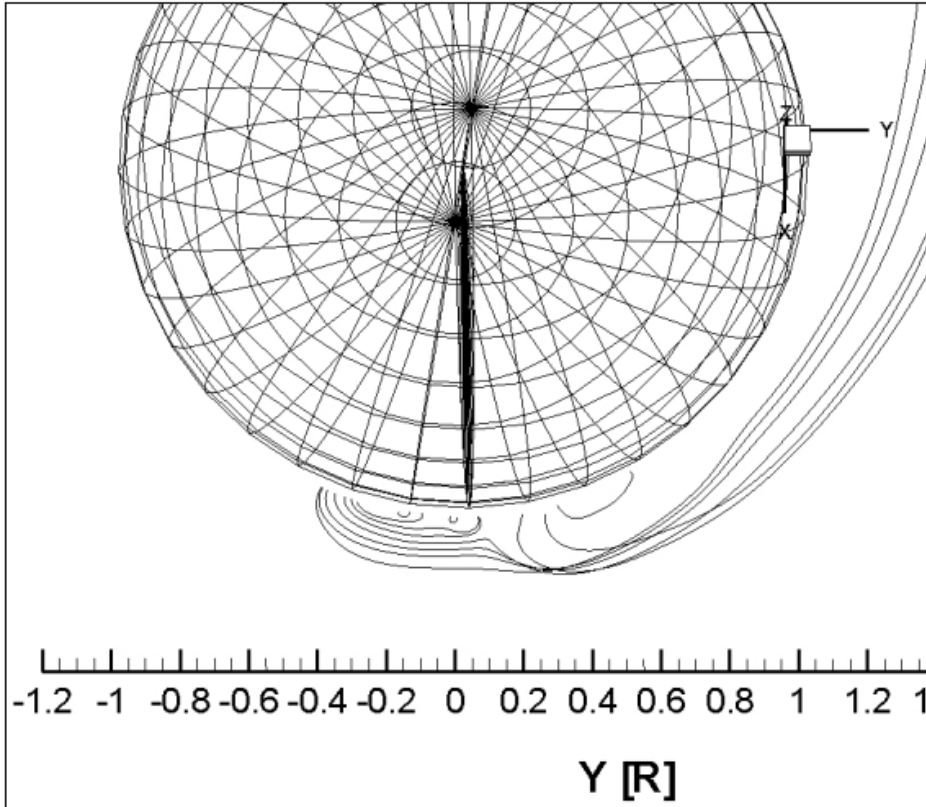
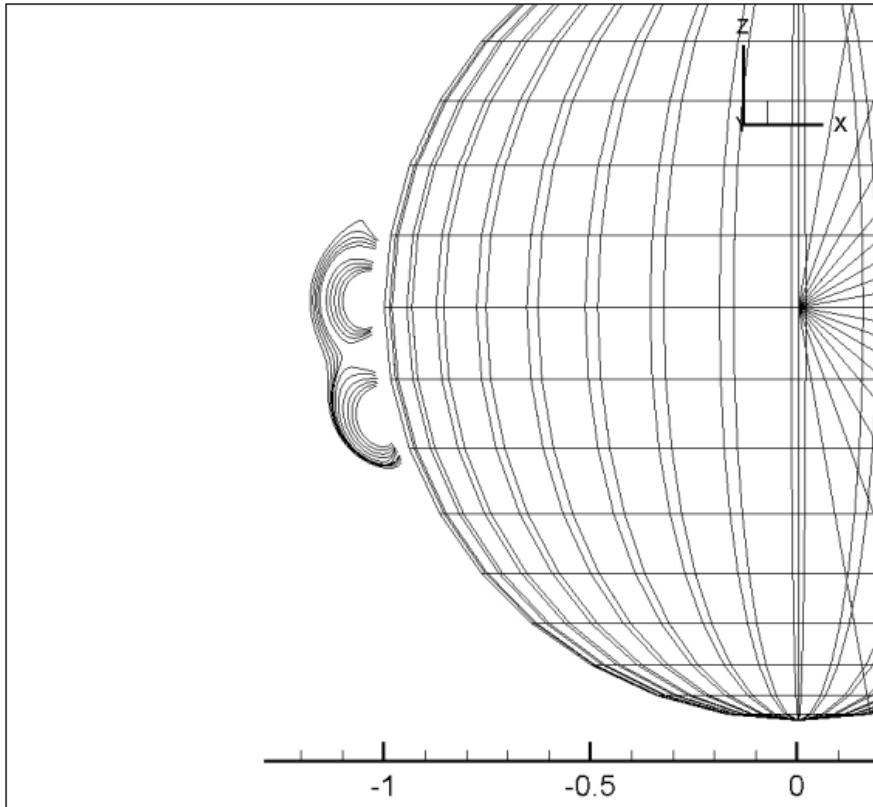


Magnetic anomalies at subsolar point



Magnetic anomalies at polar region

Crustal fields effects on magnetic topology



Magnetic anomalies with near locations

Multiple magnetic anomalies

Magnetic reconnection in Martian space environment

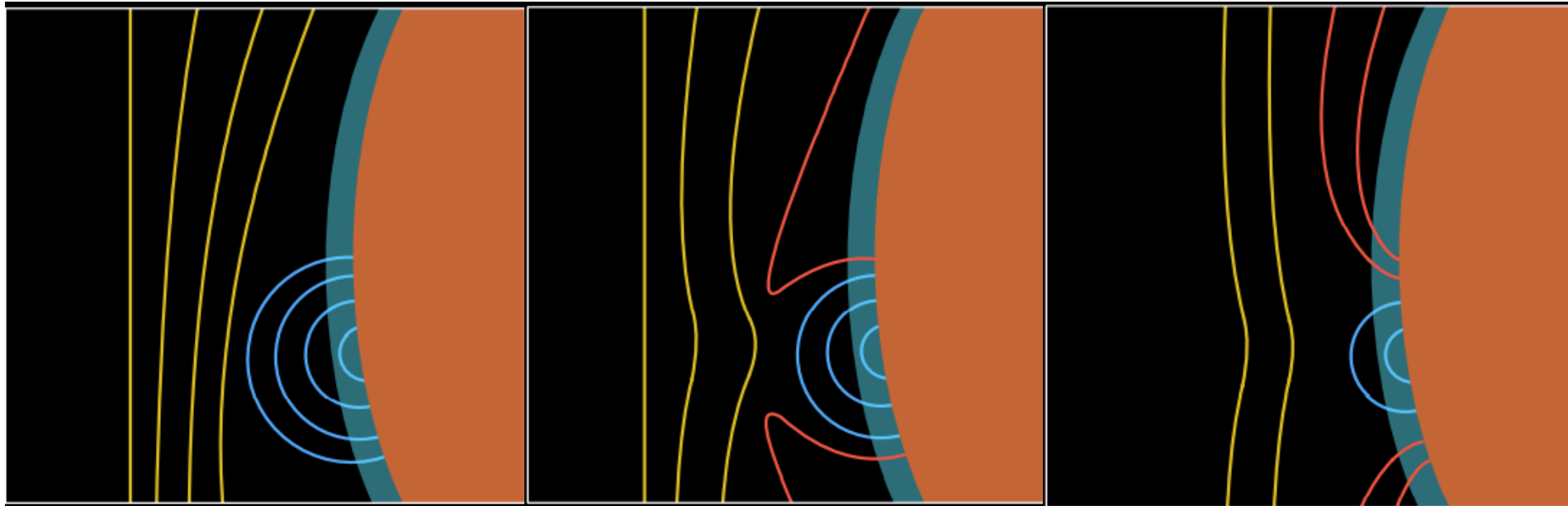
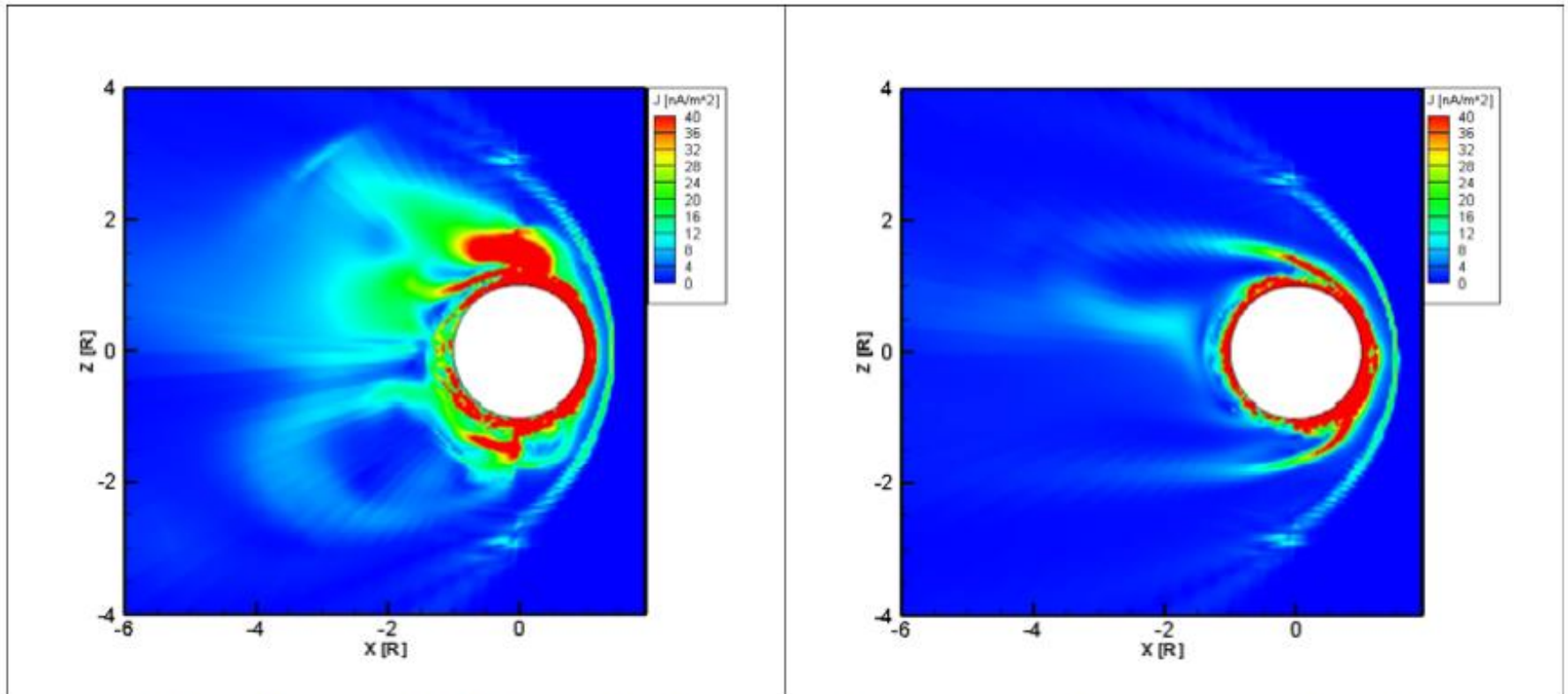


Image Credit: Tristan Weber/University of Colorado

Research work

Derived current density in the vicinity of Mars

$$\mathbf{J} = \frac{1}{\mu_0} \nabla \times \mathbf{B}$$

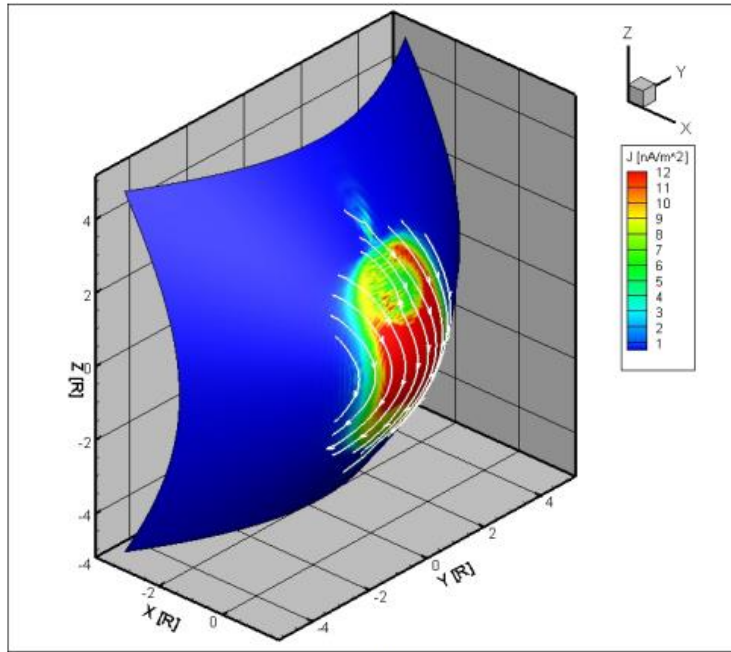


Global current system of Mars. Left: without Crustal fields. Right: with crustal fields

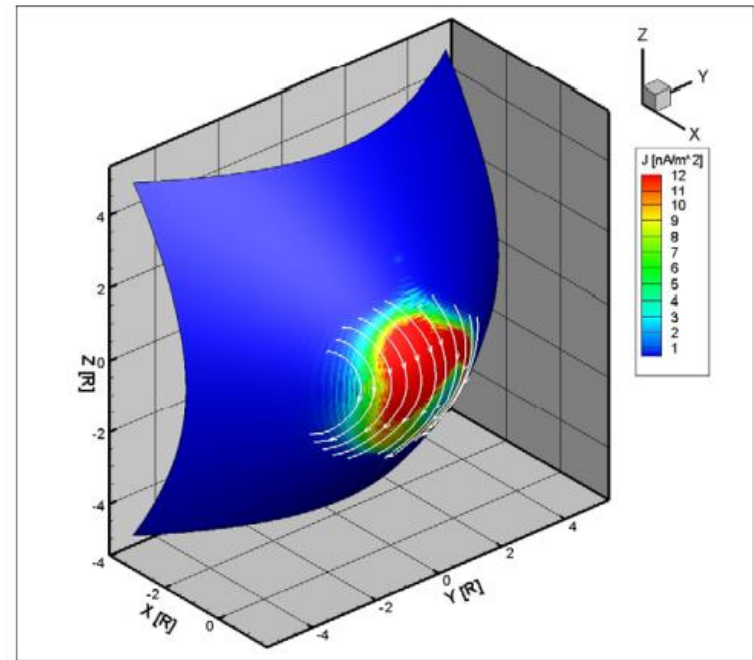
Constructed 3D model of Martian space environment

- Based on Vignes et al., (2000)
- Bow shock: $r = \frac{l}{1+e\cos\theta}$, $X_O = 0.64R_M$, $e = 1.03$, $l = 2.04R_M$
- MPB: $r = \frac{l}{1+e\cos\theta}$, $X_O = 0.78R_M$, $e = 0.90$, $l = 0.96R_M$
- Tail region: $\frac{(y\cos\theta+z\sin\theta)^2}{a^2} + \frac{(y\sin\theta-z\cos\theta)^2}{b^2} = 1$, $a = 2.0R_M$, $b = 1.5R_M$,
 $\theta = -15^\circ$
- Ionosphere

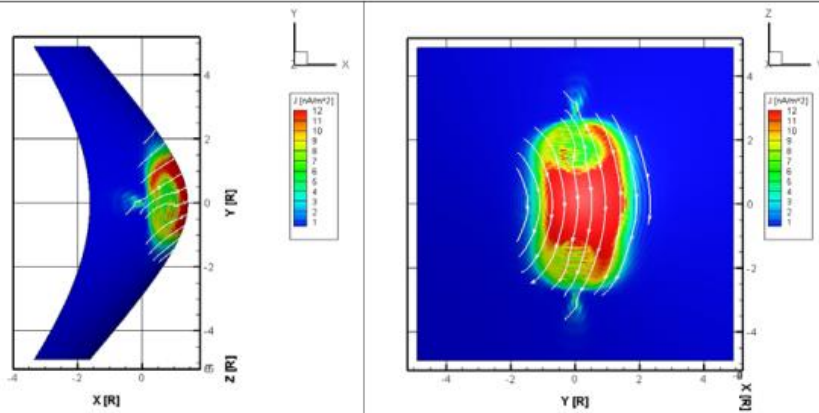
Research work



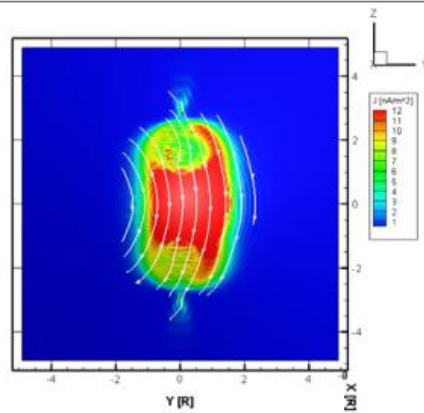
(a)



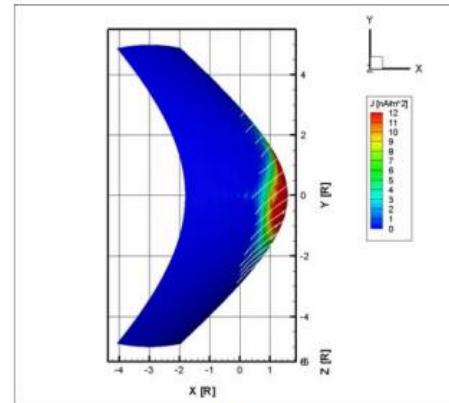
(b)



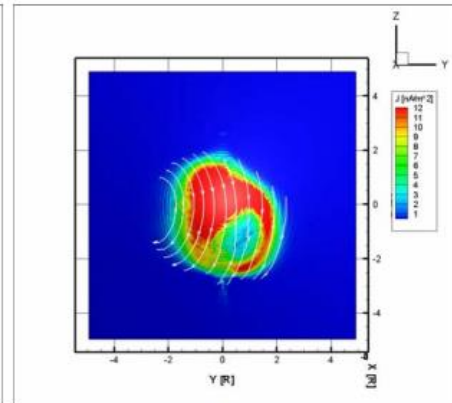
(c)



(d)

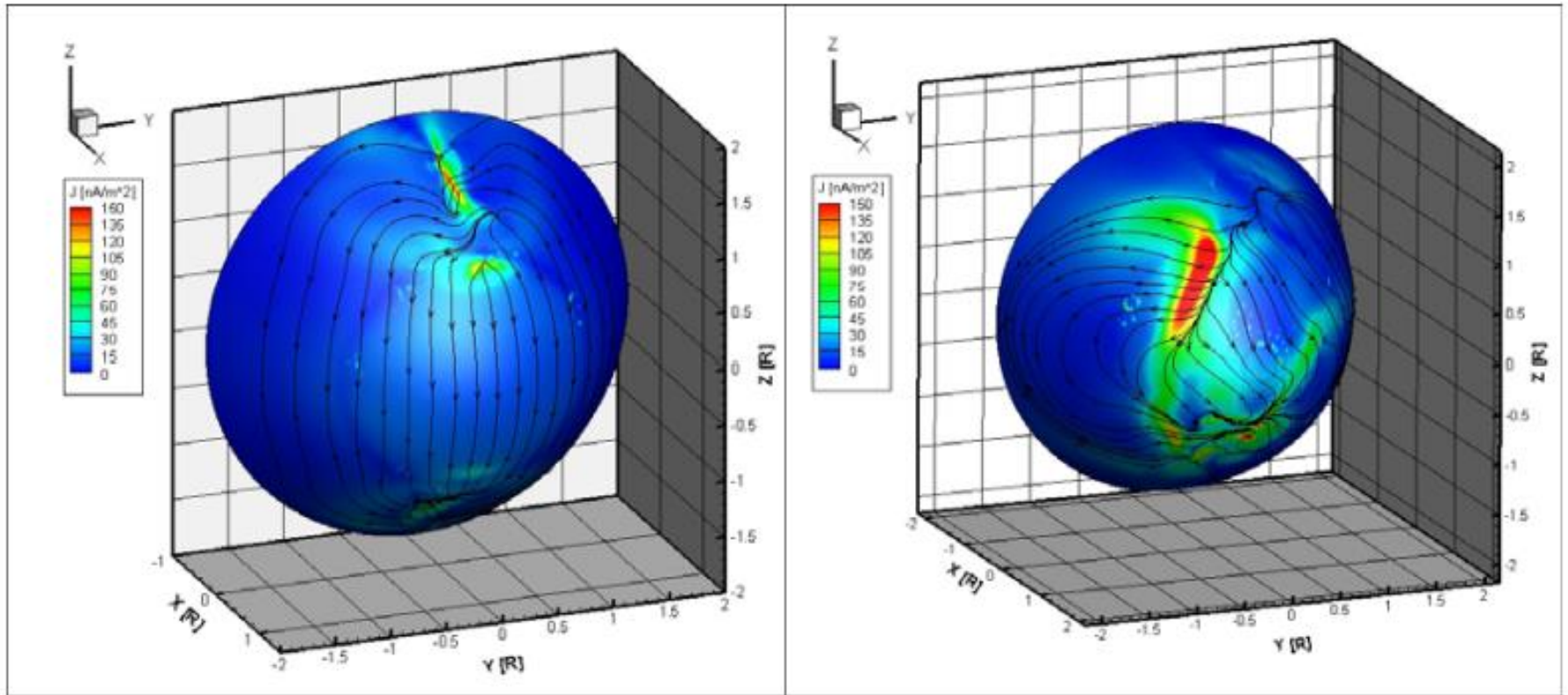


(e)



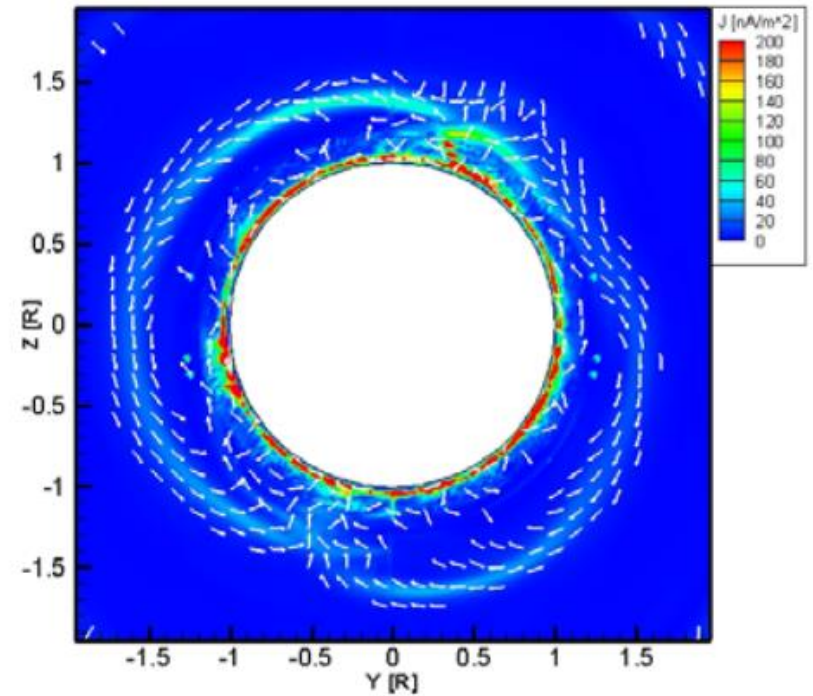
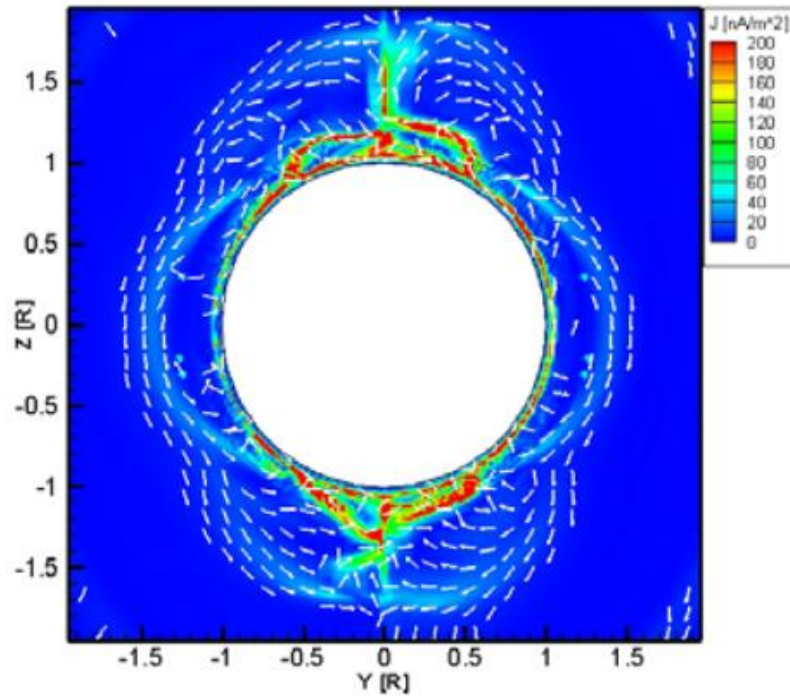
Current density at bow shock. Right: without crustal fields. Left: with crustal fields 15

MPB current system



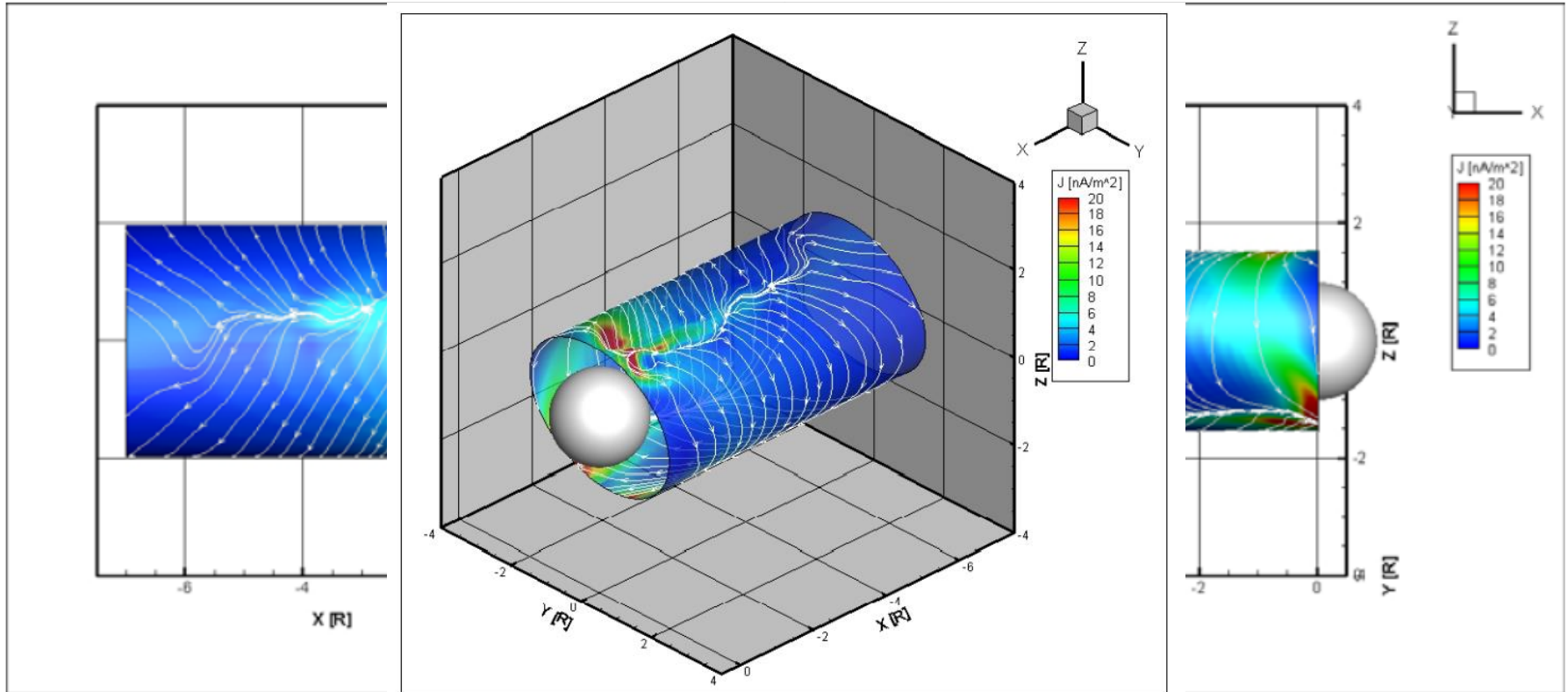
3D MHD model of MPB's current stream lines. Left: without crustal fields. Right: with crustal fields

MPB current system



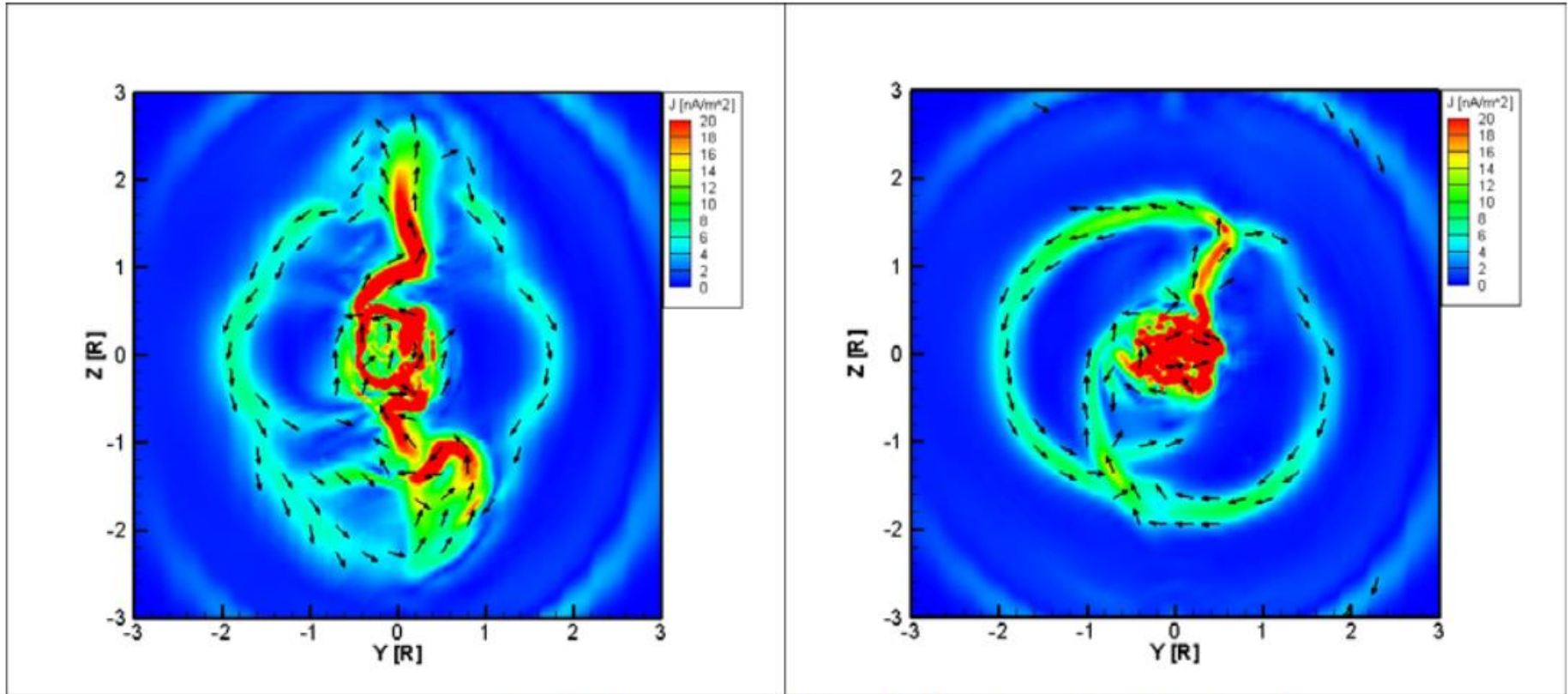
Slice of the current density vector. Left: without crustal fields. Right: with crustal fields.

Magnetotail current system



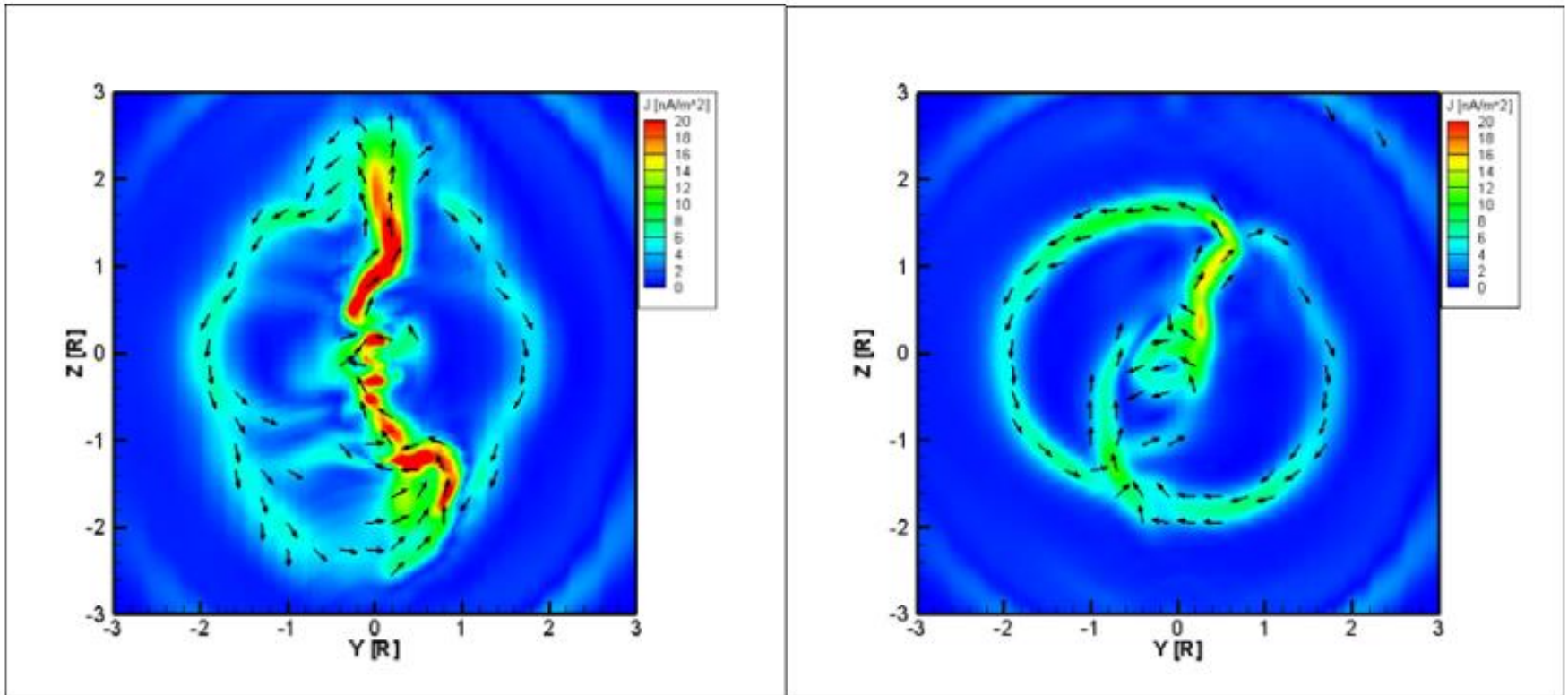
Current system coupling between MPB and magnetotail

Research work



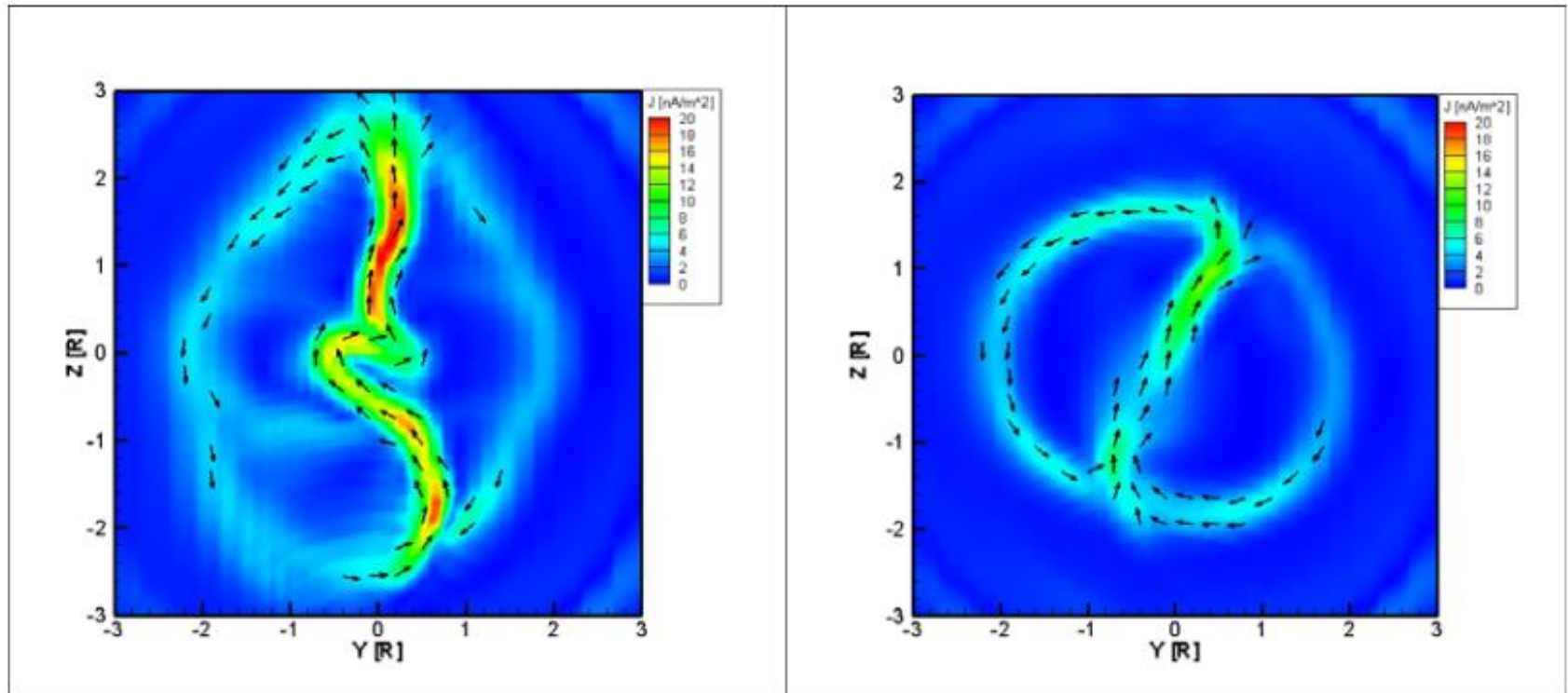
Slice of the current density vector at $X = -1.1 R_M$. Left: without crustal fields. Right: with crustal fields.

Research work



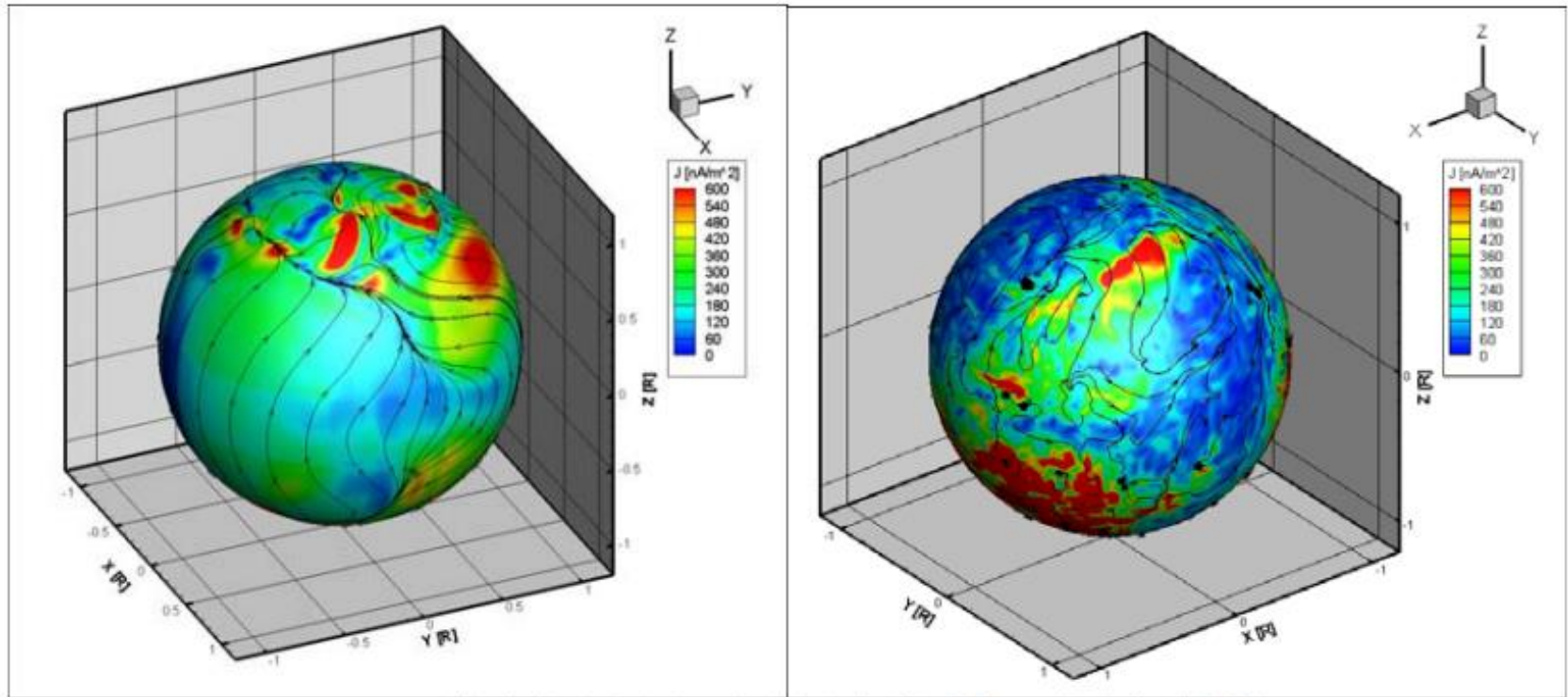
Slice of the current density vector at $X=-1.3 R_M$. Left: without crustal fields. Right: with crustal fields.

Research work



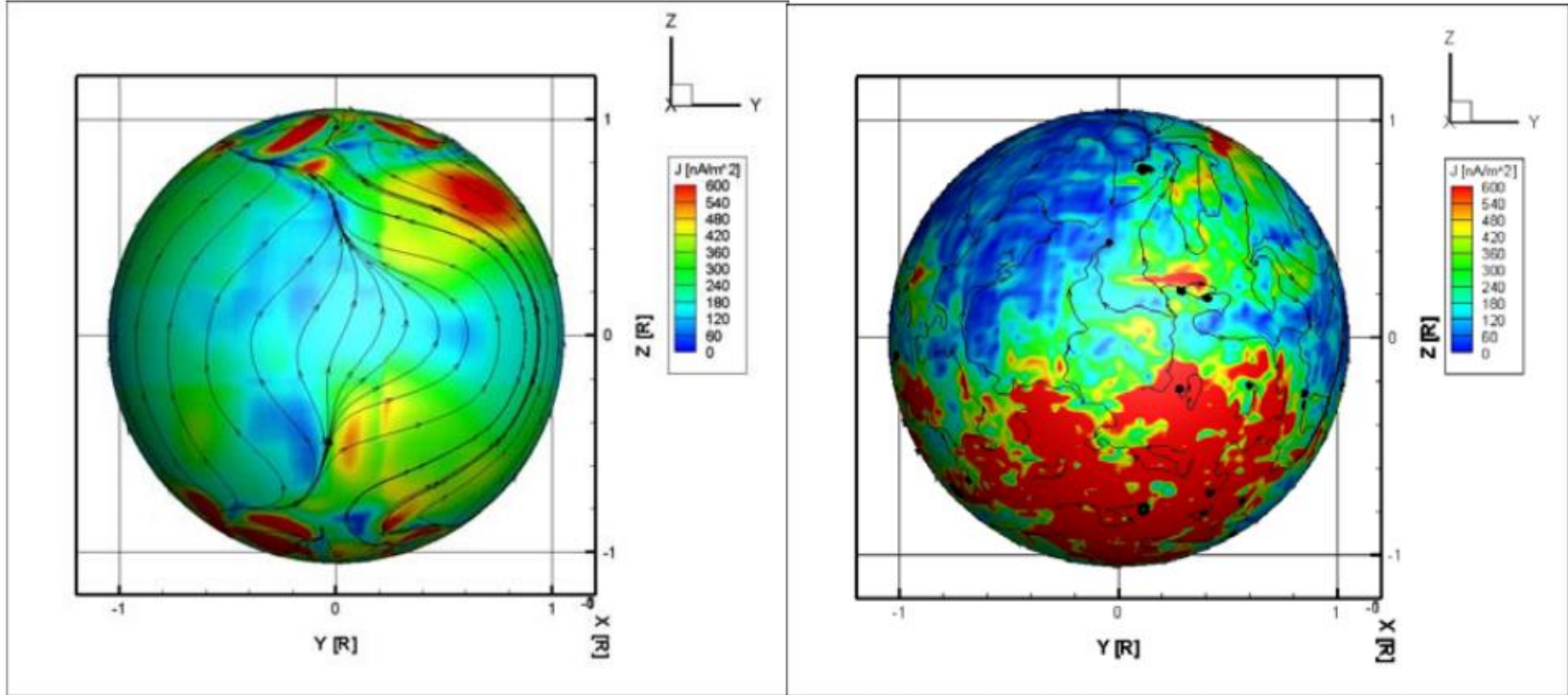
Slice of the current density vector at $X = -1.8 R_M$. Left: without crustal fields. Right: with crustal fields.

Ionospheric current system



3D model of ionospheric current system. Left: without crustal fields. Right: with crustal fields.

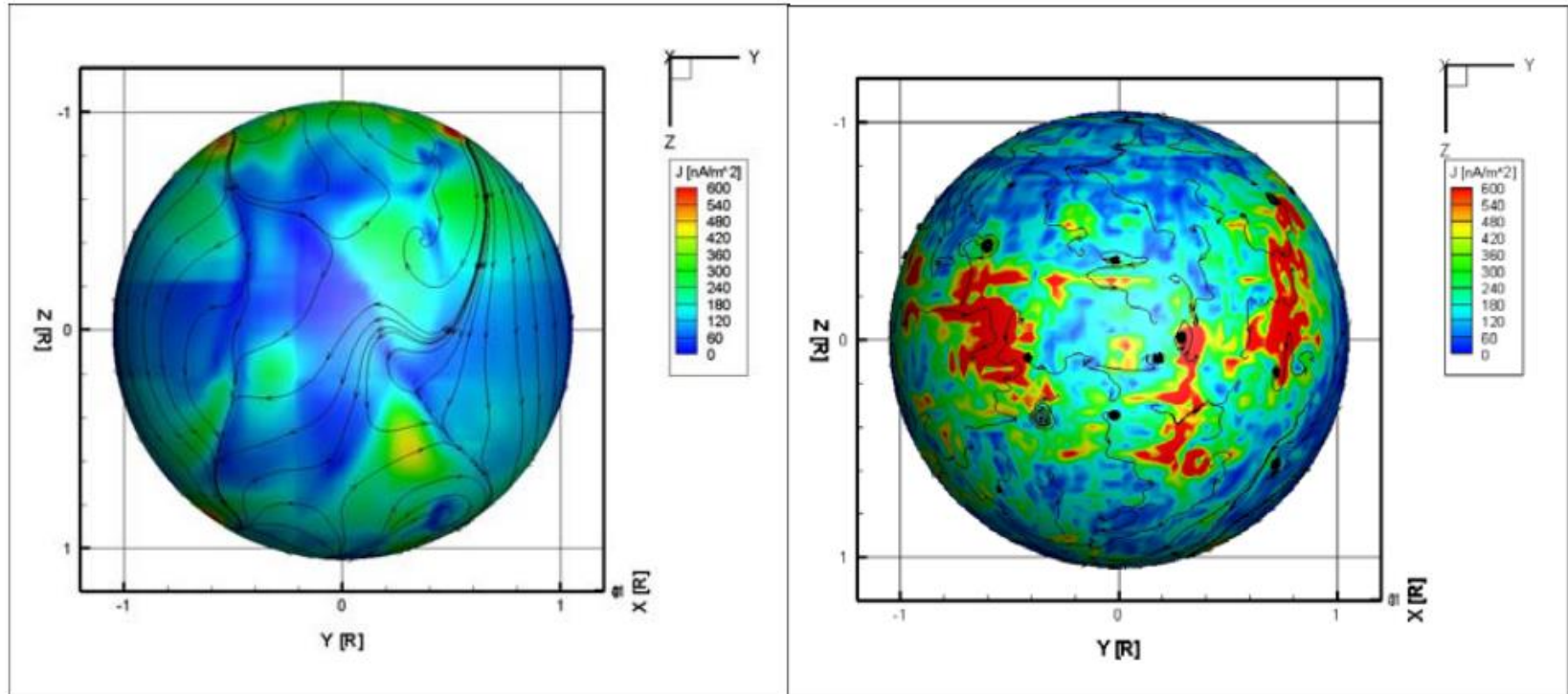
Ionospheric current system



3D model of ionospheric current system. Left: without crustal fields. Right: with crustal fields.

Currents system

Ionospheric current system



3D model of ionospheric current system. Left: without crustal fields. Right: with crustal fields.

The global current system of Mars

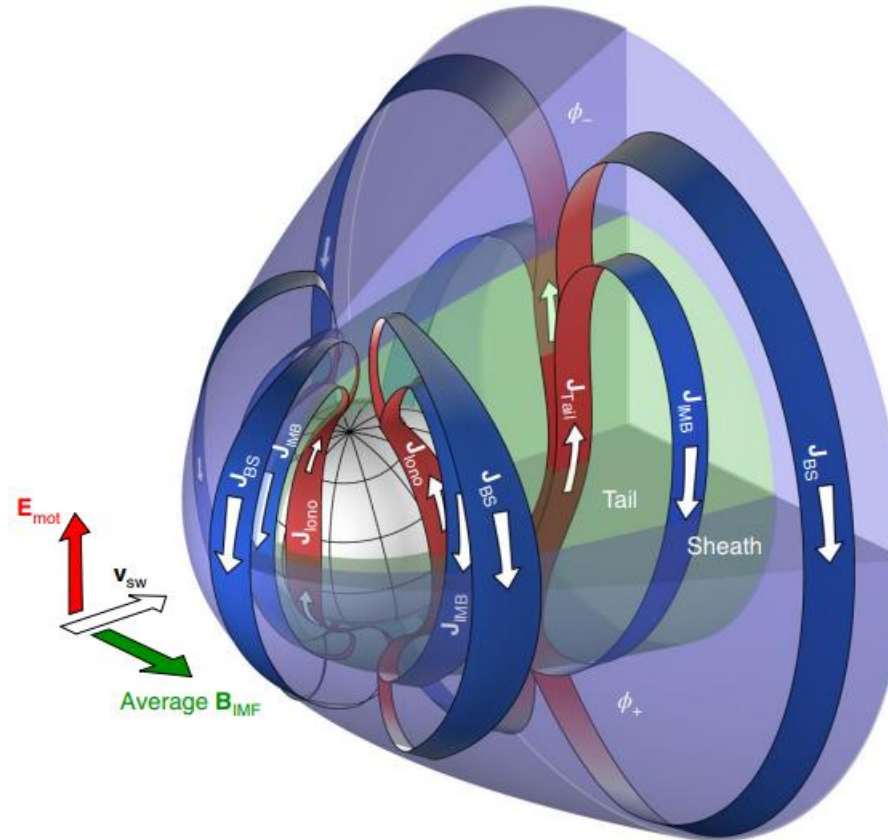
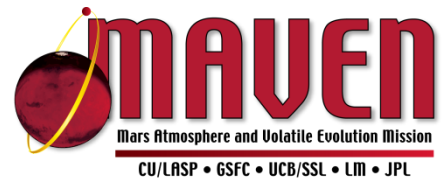


Illustration of the formative current systems in the Martian induced magnetosphere.
Ramstad et al., (2020)

Question & Answer



Thanks for your attention! Any question?

Acknowledgements to Dr. Yiteng Zhang for the supervision