

Predictions of ICME Signatures using the SAIC/SEC Model

Pete Riley, J. A. Linker, R. Lionello, and Z. Mikic
Science Applications International Corporation, San Diego, CA

and

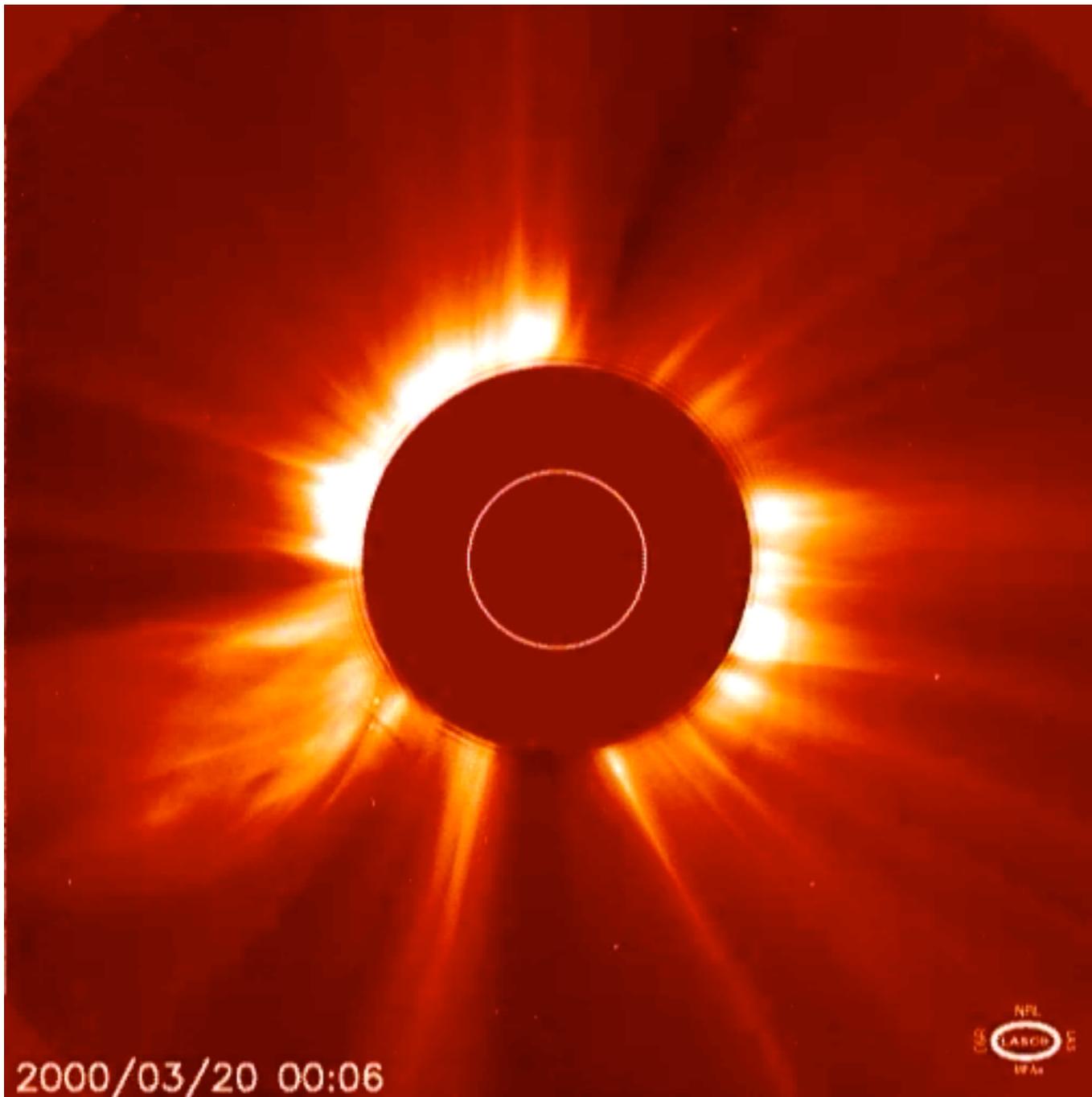
D. Odstrcil

Center for Integrated Research in Environmental Sciences, University of Colorado and SEC, NOAA, Boulder, CO

Overview

- Initiation and evolution of CME from the Sun to 1 AU
- Dynamic interaction of CME with ambient solar wind
- CMEs without flux ropes: Selection effects?
- Signatures of reconnection - at the Sun and in the solar wind
- Distinguishing features between two “popular” models
- Even more speculation

SOHO/LASCO Observations of Coronal Mass Ejections



MHD EQUATIONS (POLYTROPIC MODEL)

$$\nabla \times \mathbf{B} = \frac{4\pi}{c} \mathbf{J}$$

$$\nabla \times \mathbf{E} = -\frac{1}{c} \frac{\partial \mathbf{B}}{\partial t}$$

$$\mathbf{E} + \frac{1}{c} \mathbf{v} \times \mathbf{B} = \eta \mathbf{J}$$

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0$$

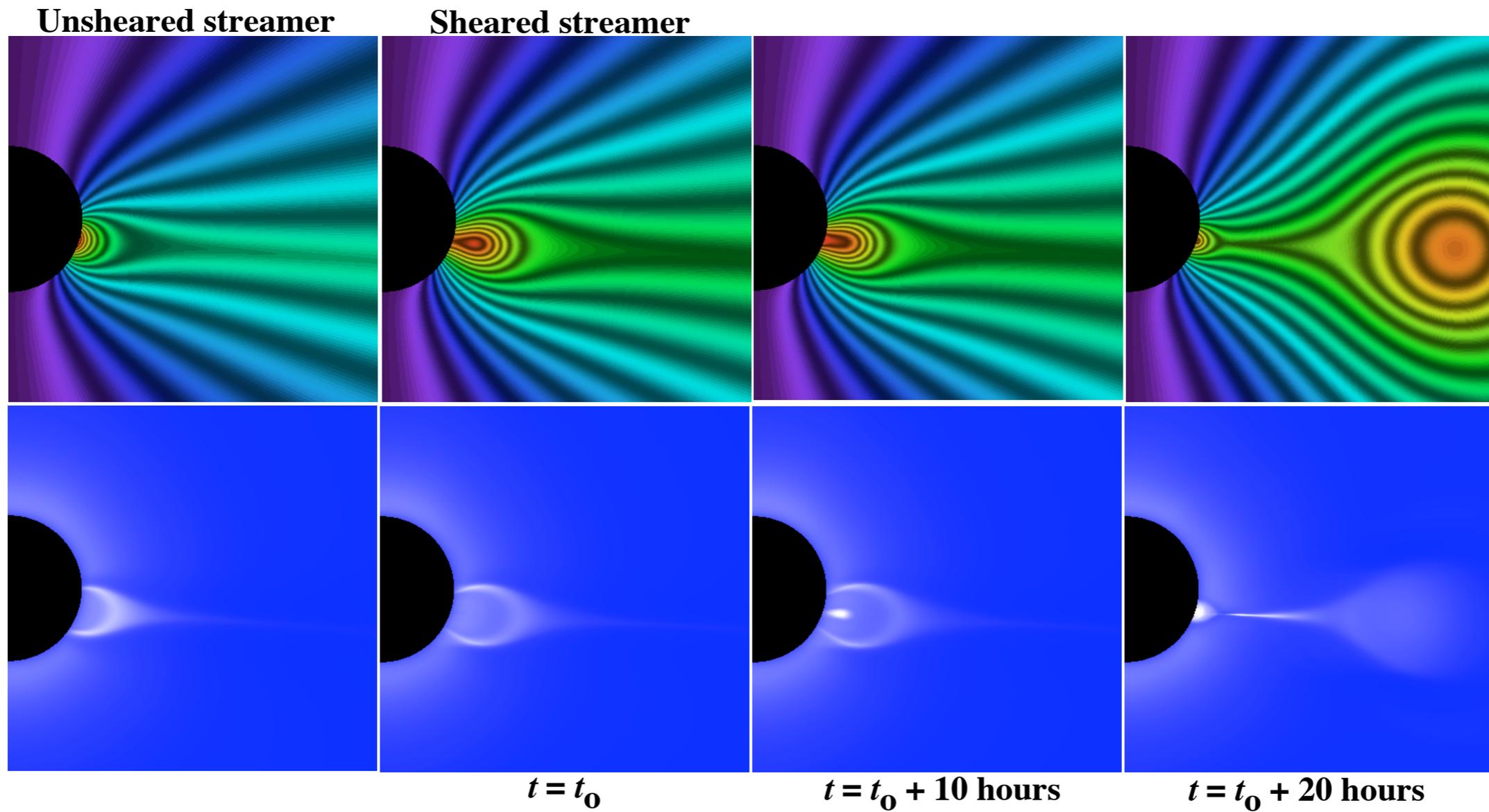
$$\rho \left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v} \right) = \frac{1}{c} \mathbf{J} \times \mathbf{B} - \nabla p + \rho \mathbf{g} + \nabla \cdot (\nu \rho \nabla \mathbf{v})$$

$$\frac{\partial p}{\partial t} + \nabla \cdot (p \mathbf{v}) = -(\gamma - 1)p \nabla \cdot \mathbf{v}$$

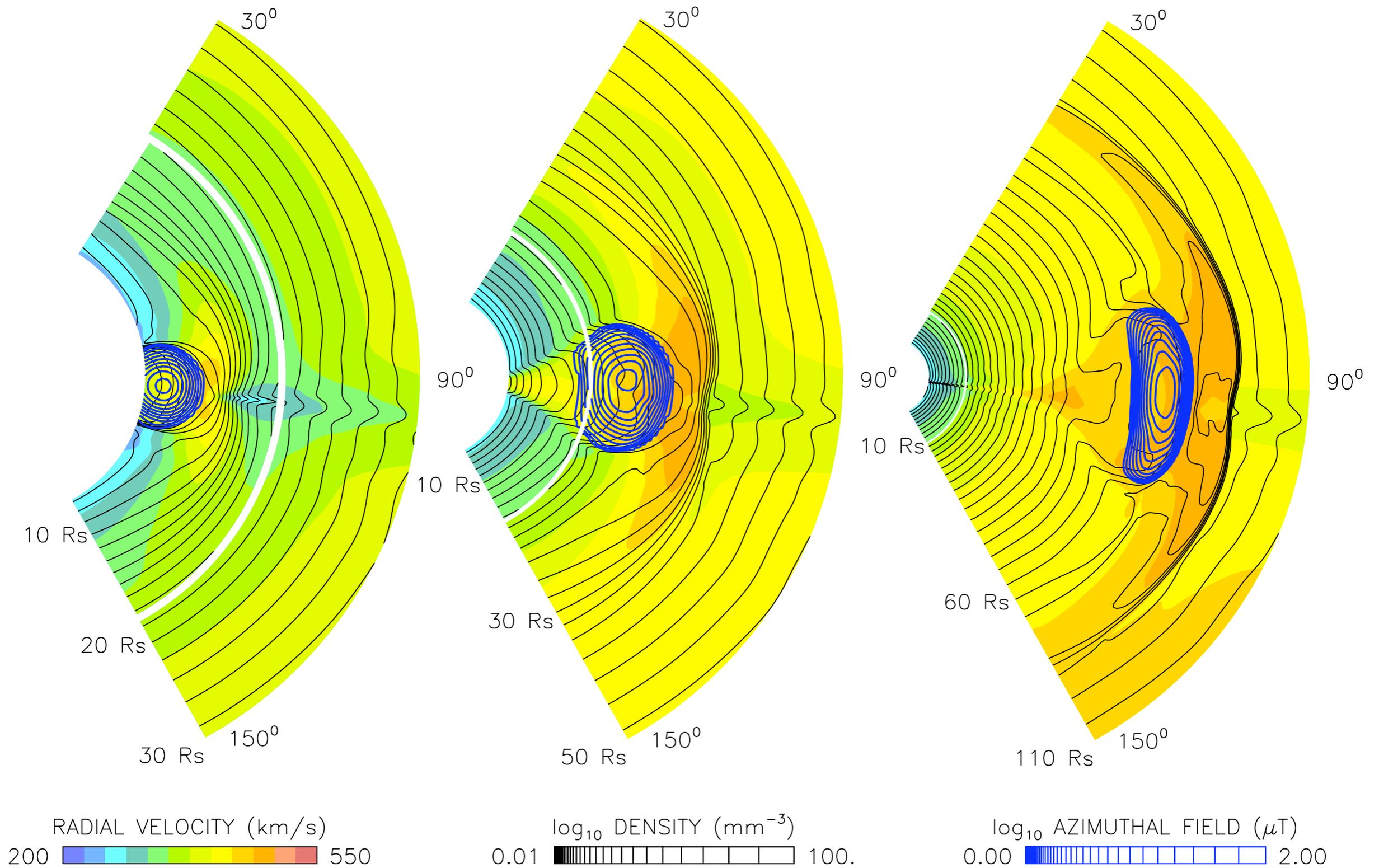
$\gamma = 1.05$ for coronal solution;

$\gamma = 1.5$ for heliospheric solution

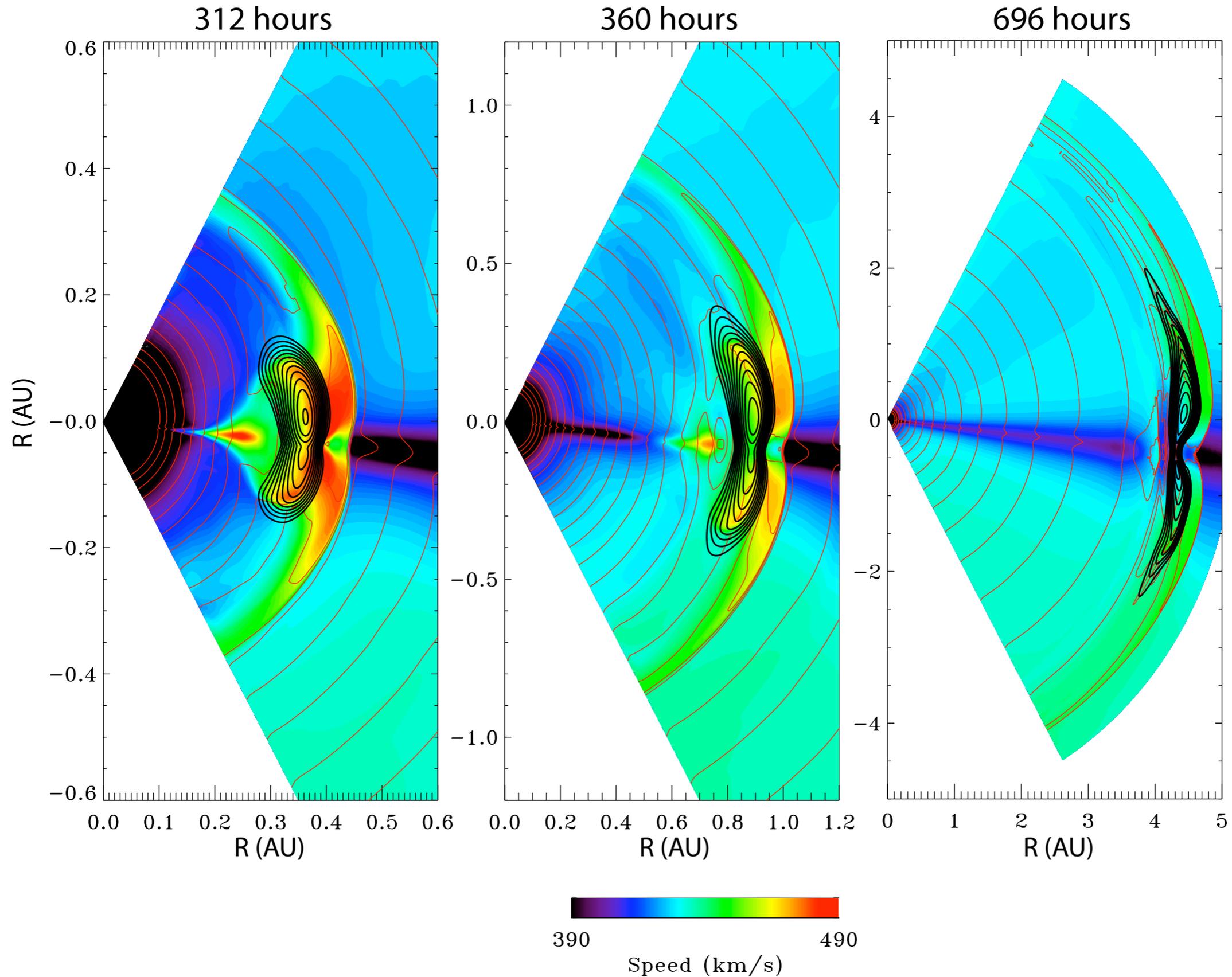
Flux Rope Eruption at Sun



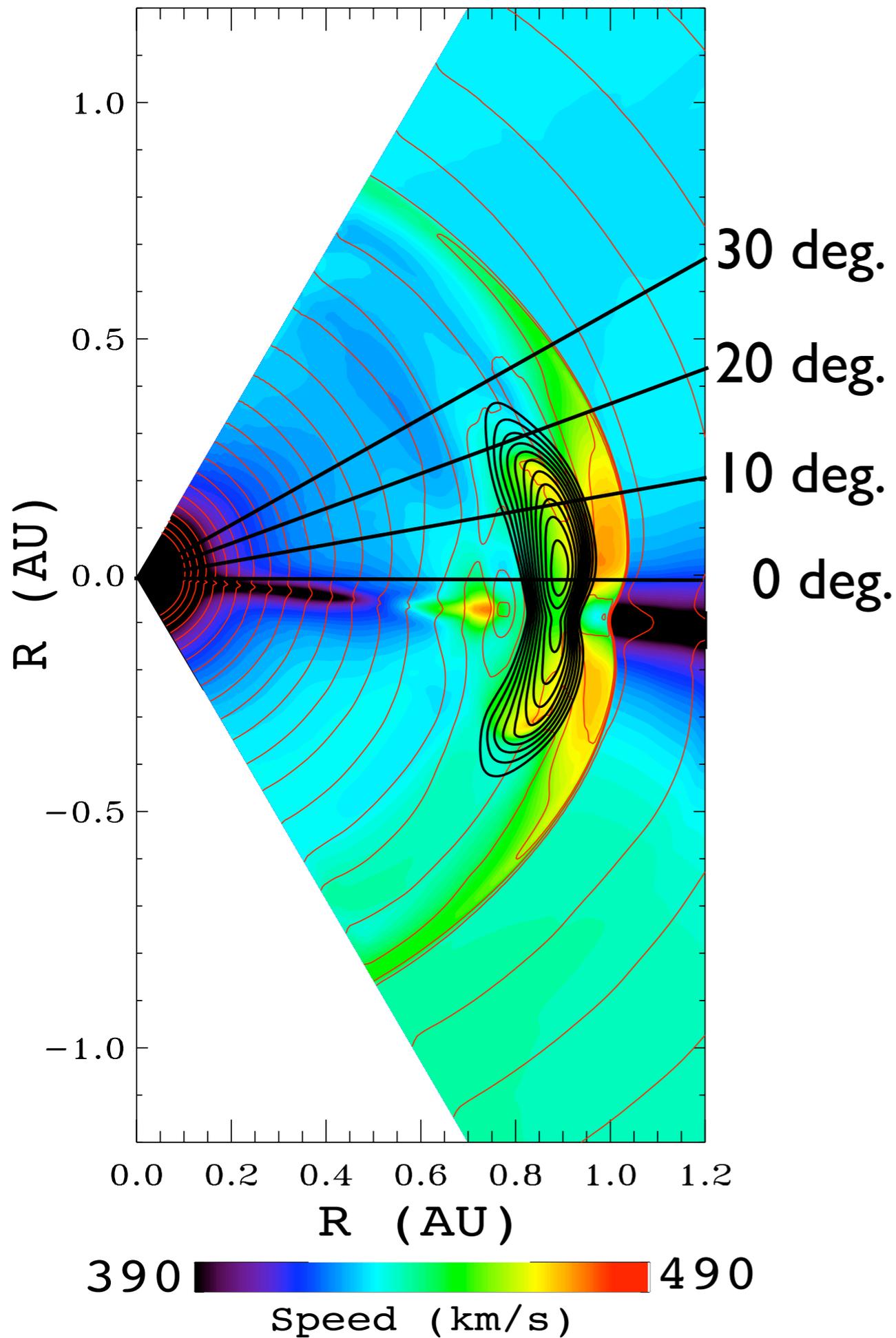
ICME Evolution: Near the Sun



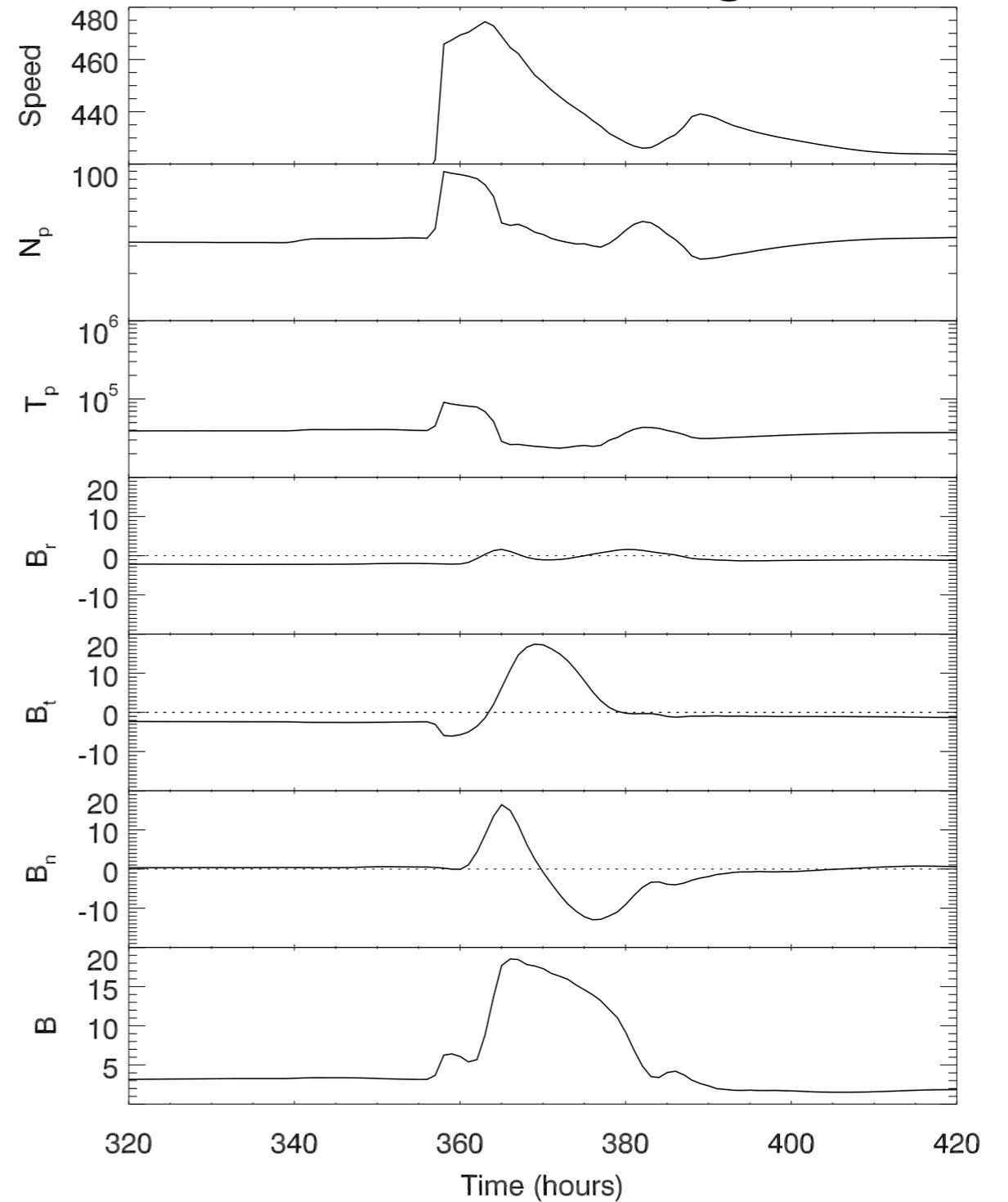
ICME Evolution: Far from Sun



Selection Effects

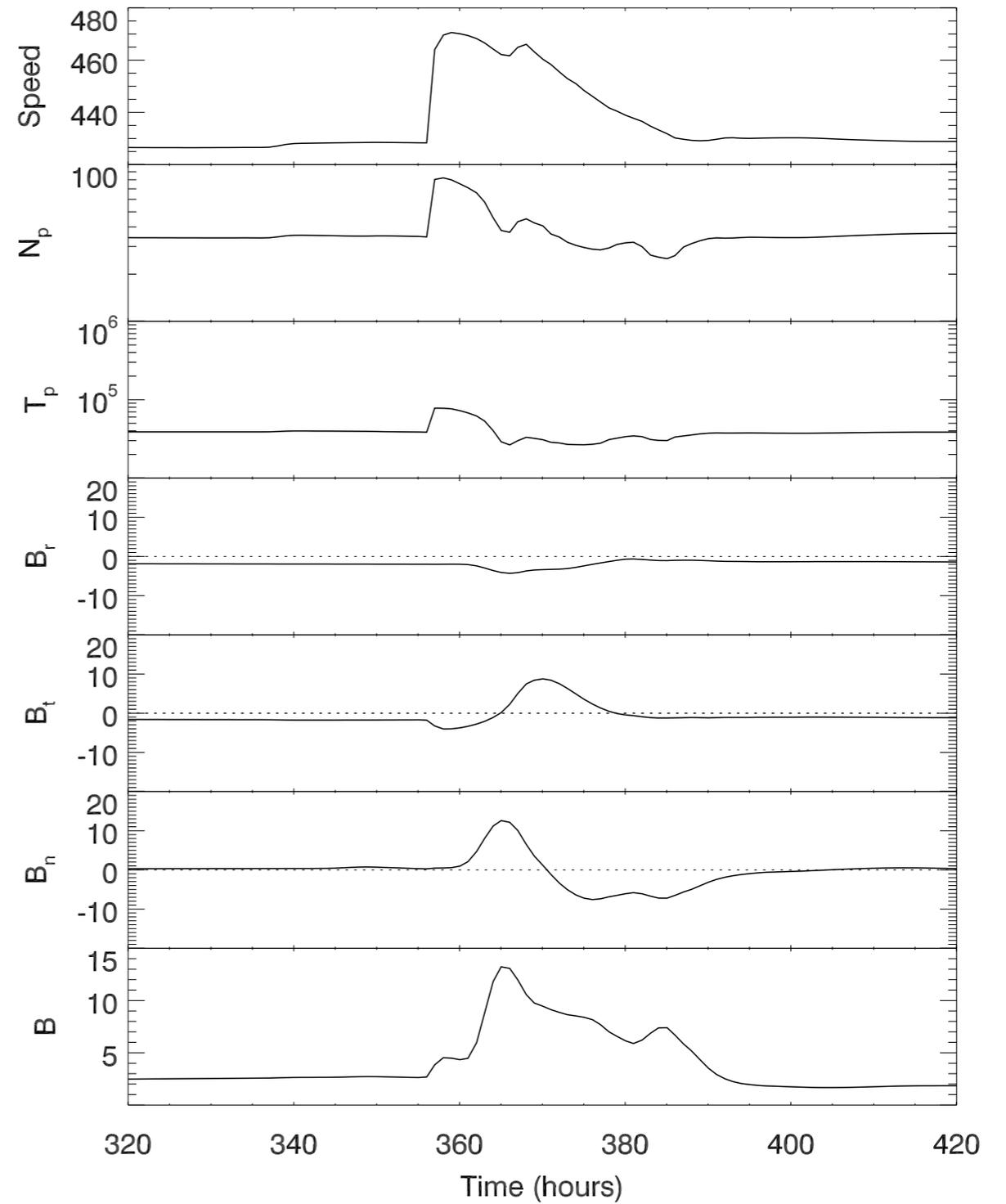
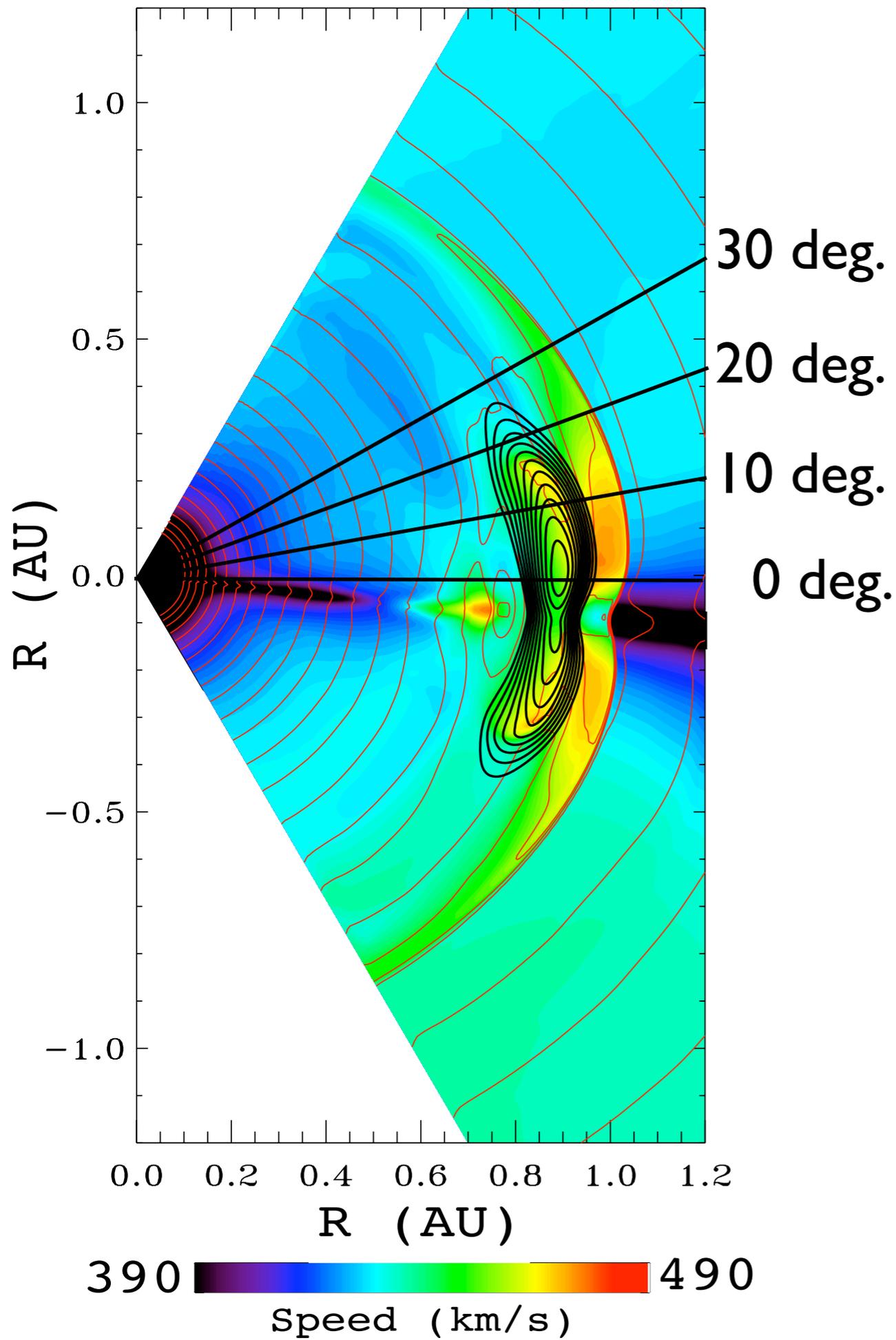


Latitude = 0 deg.



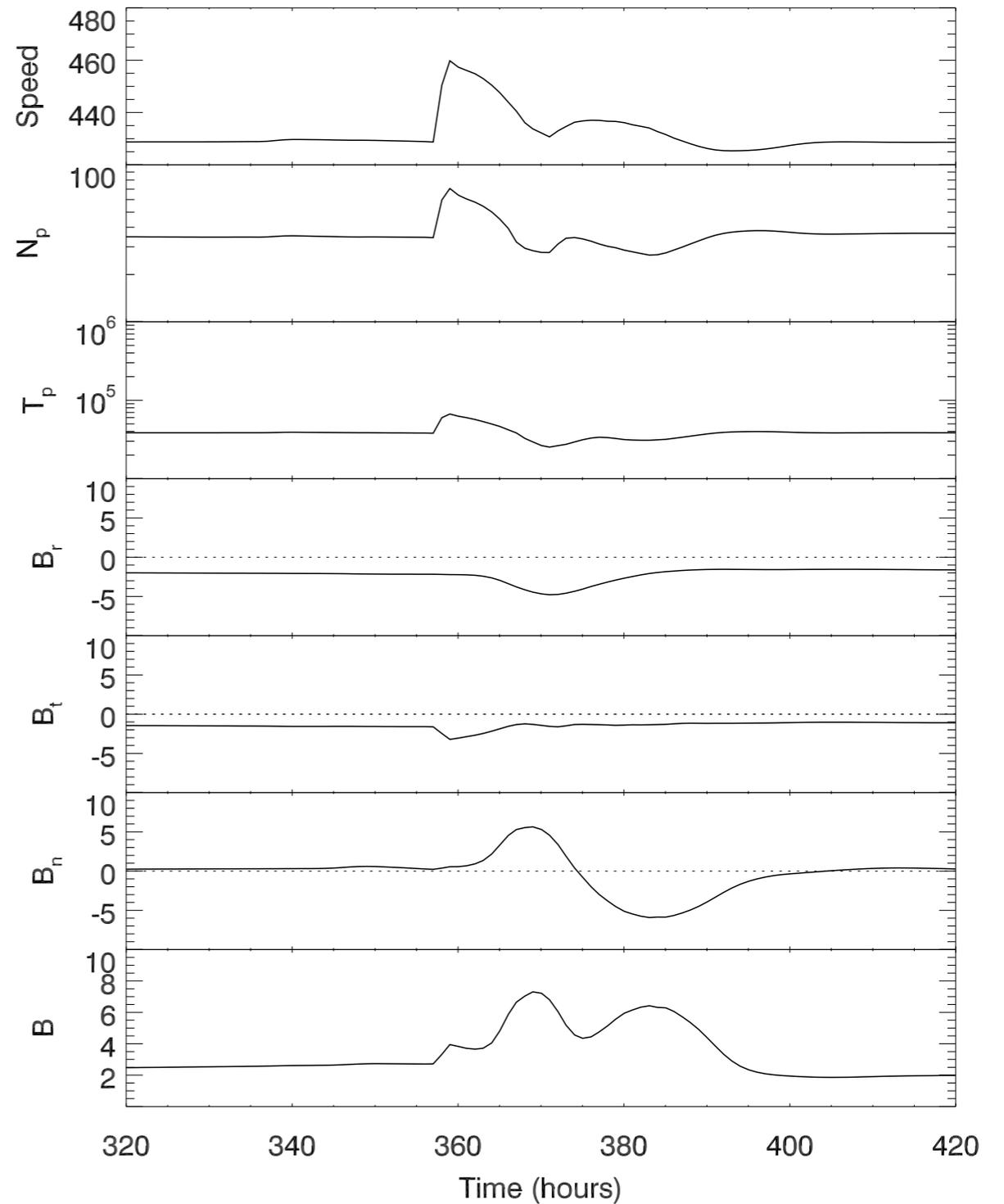
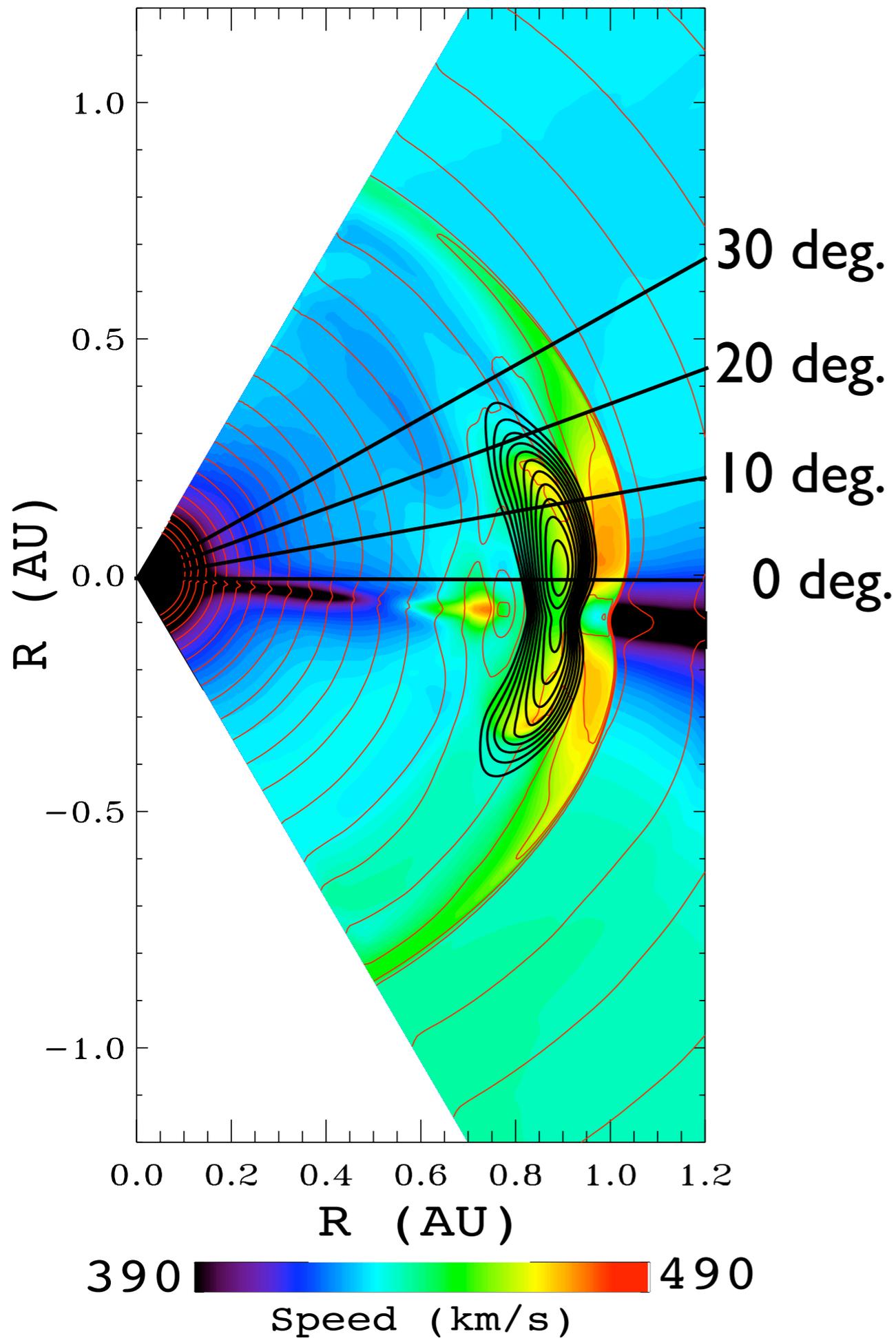
Selection Effects

Latitude = 10 deg.



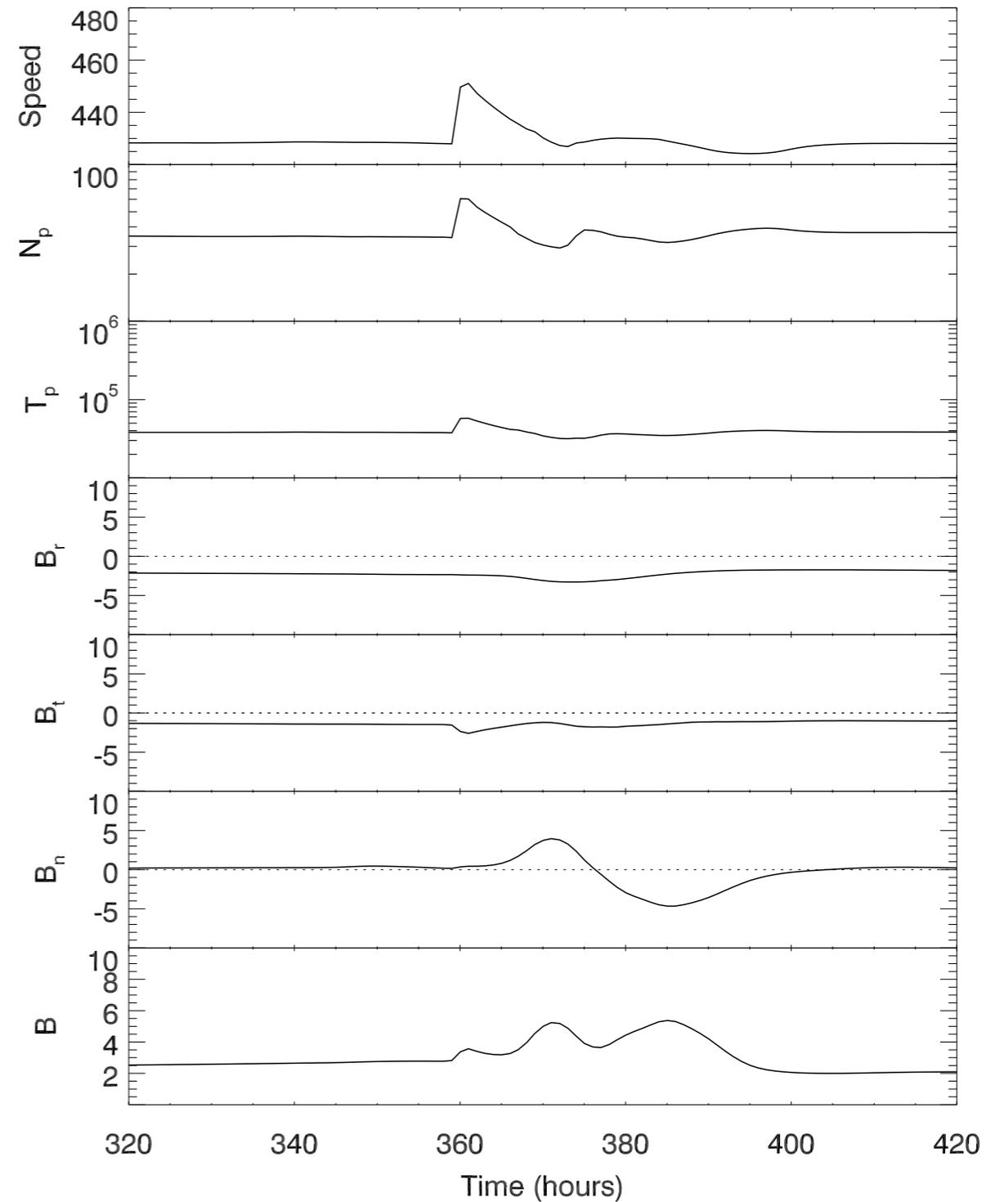
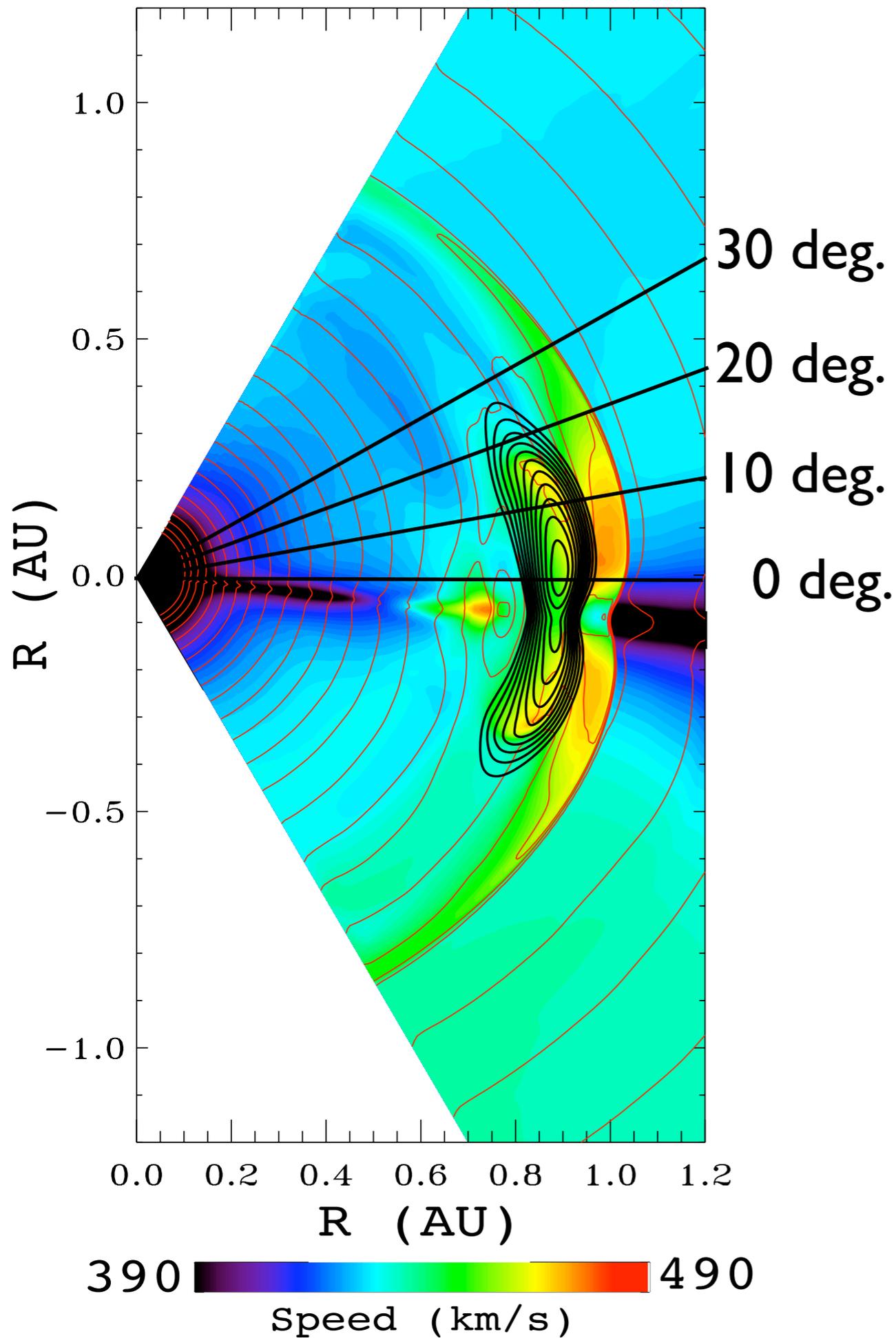
Selection Effects

Latitude = 20 deg.

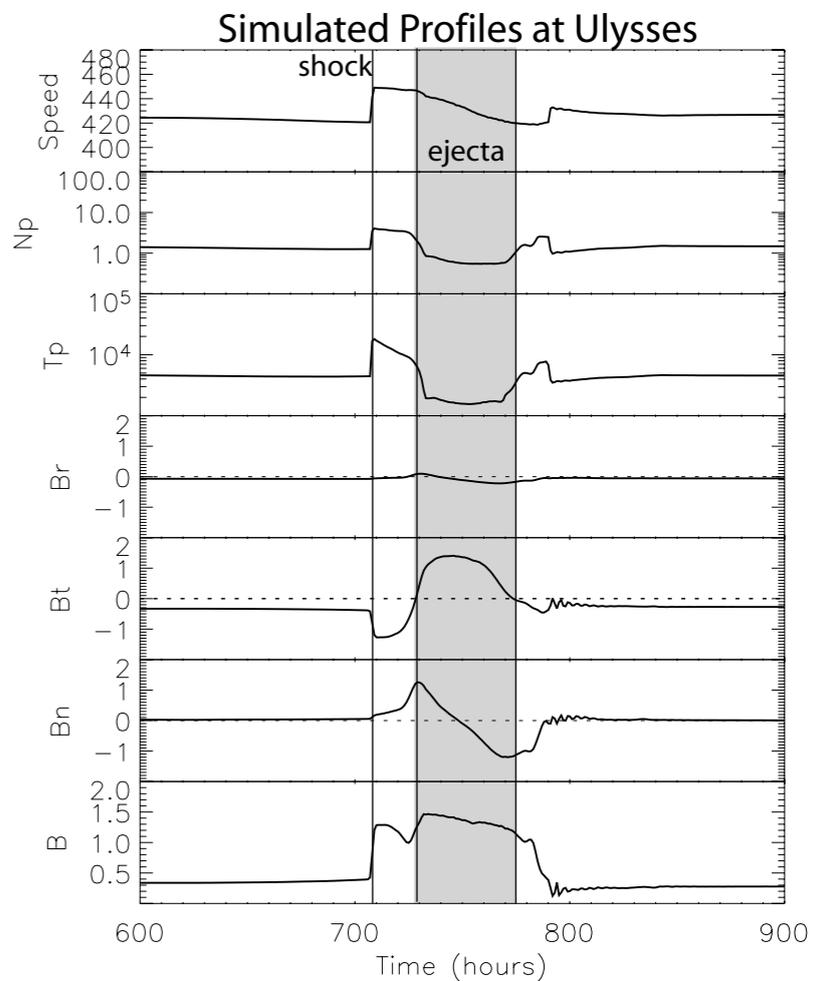
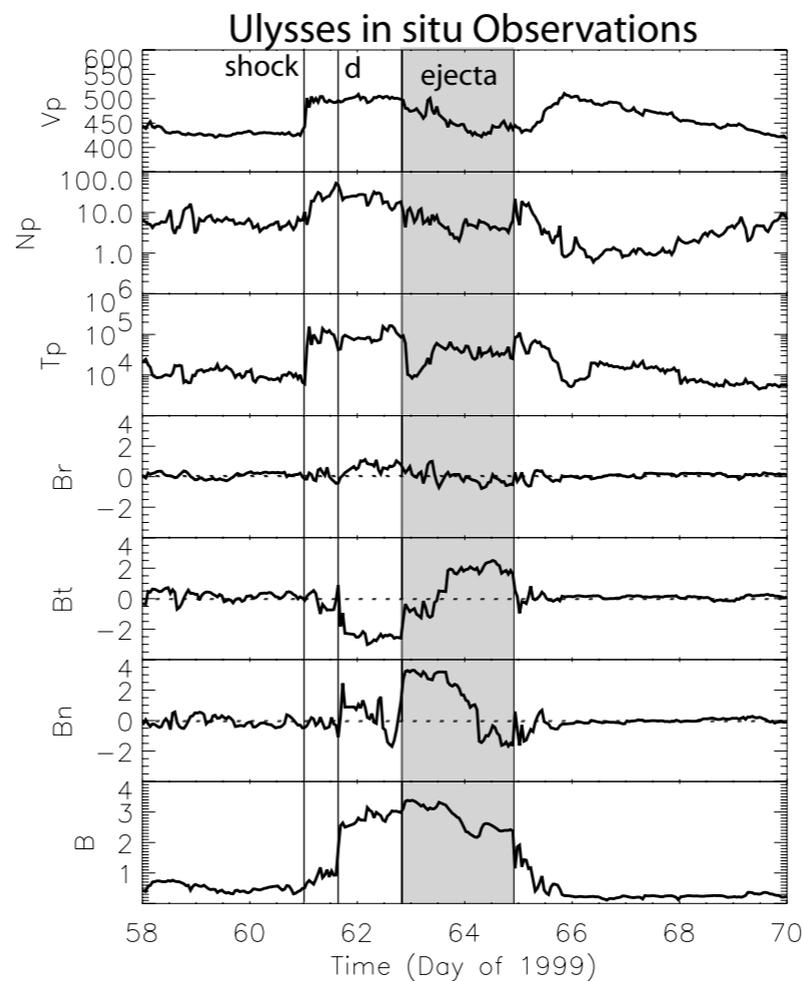
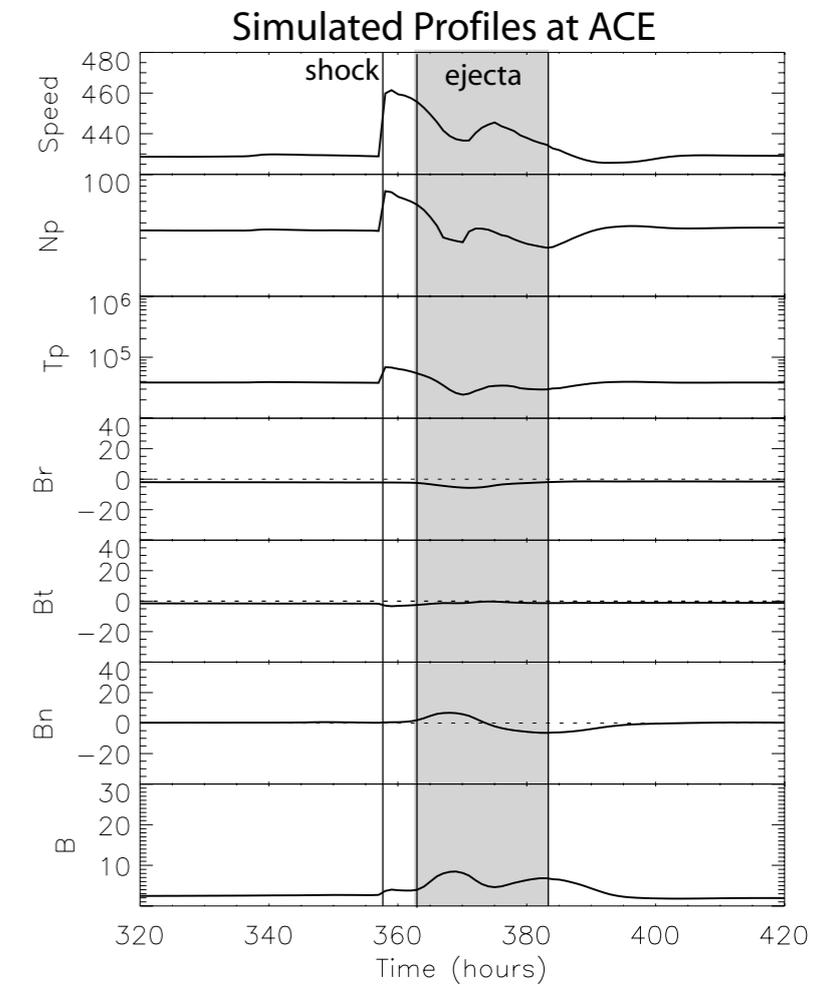
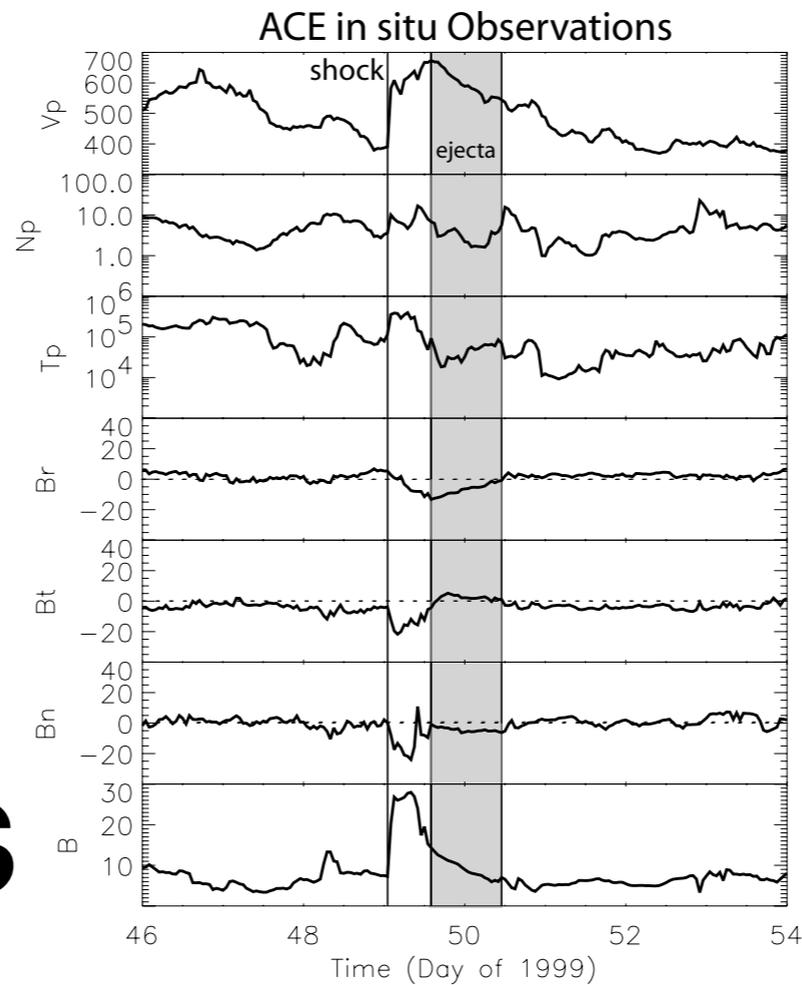


Selection Effects

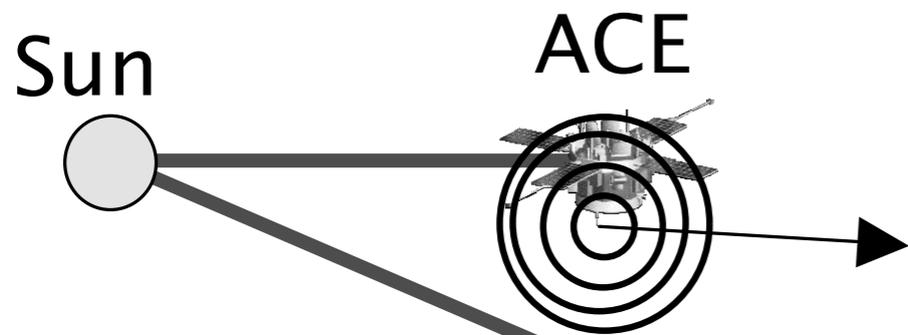
Latitude = 30 deg.



Comparison with in situ observations

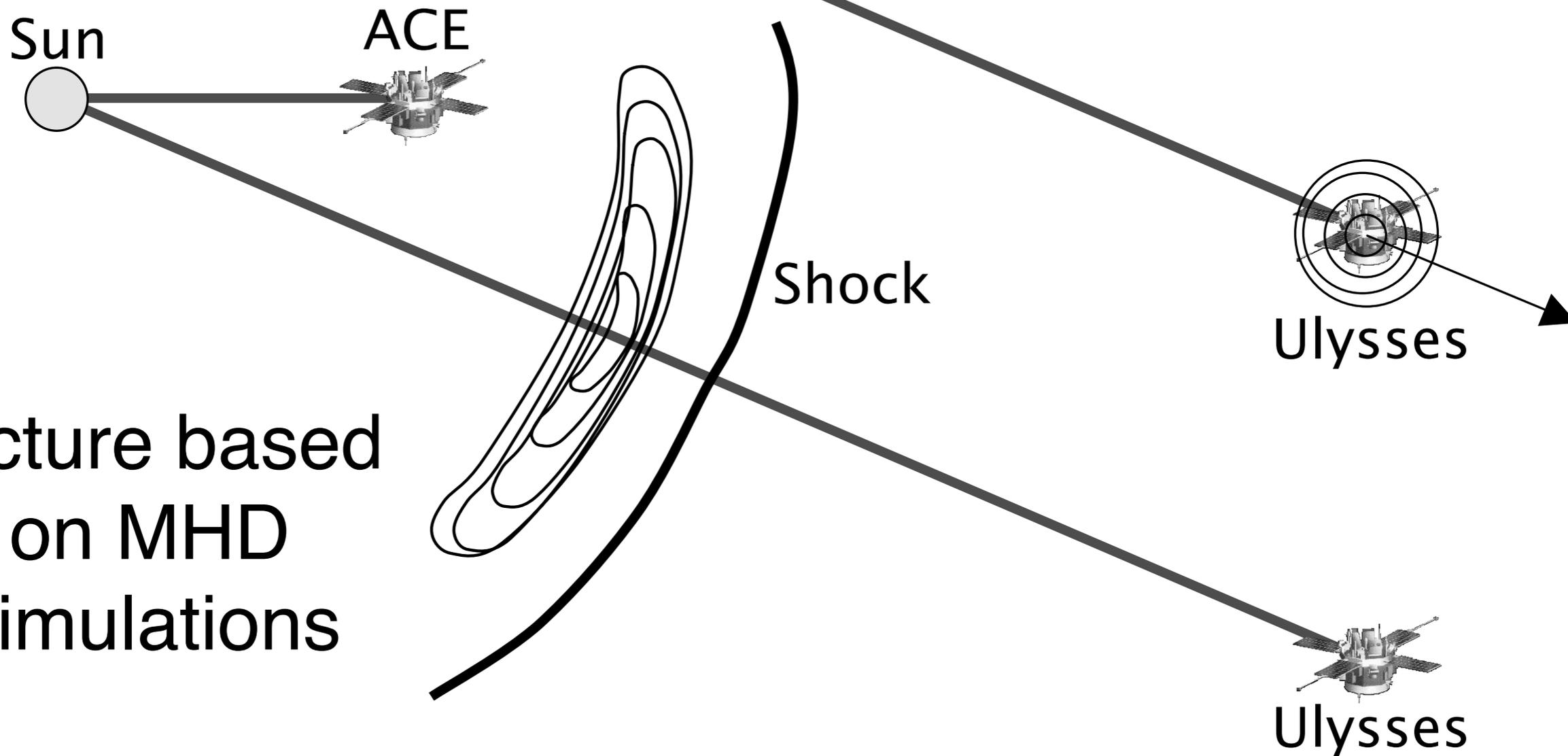


(a)



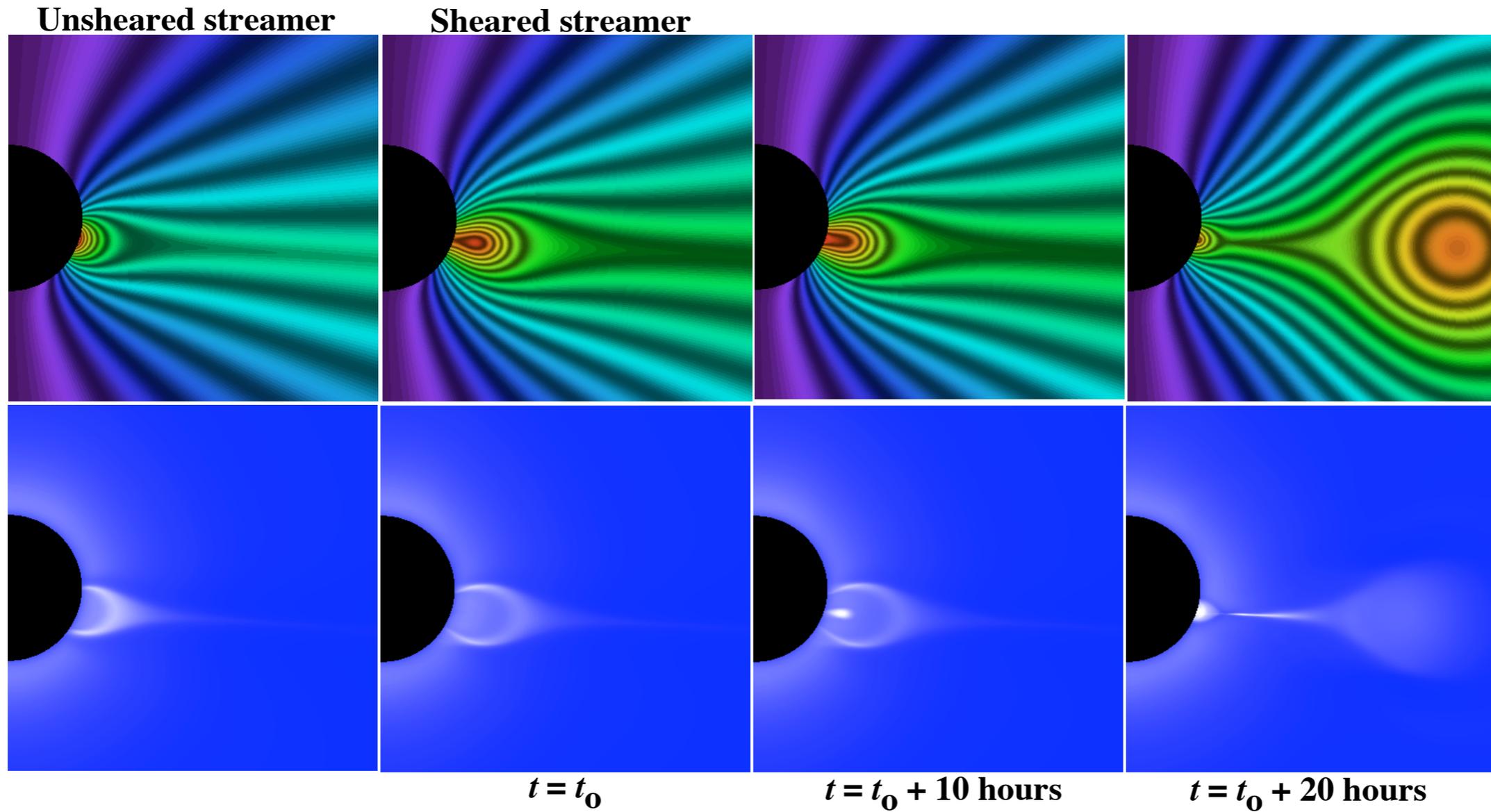
Picture based on in situ observations alone

(b)

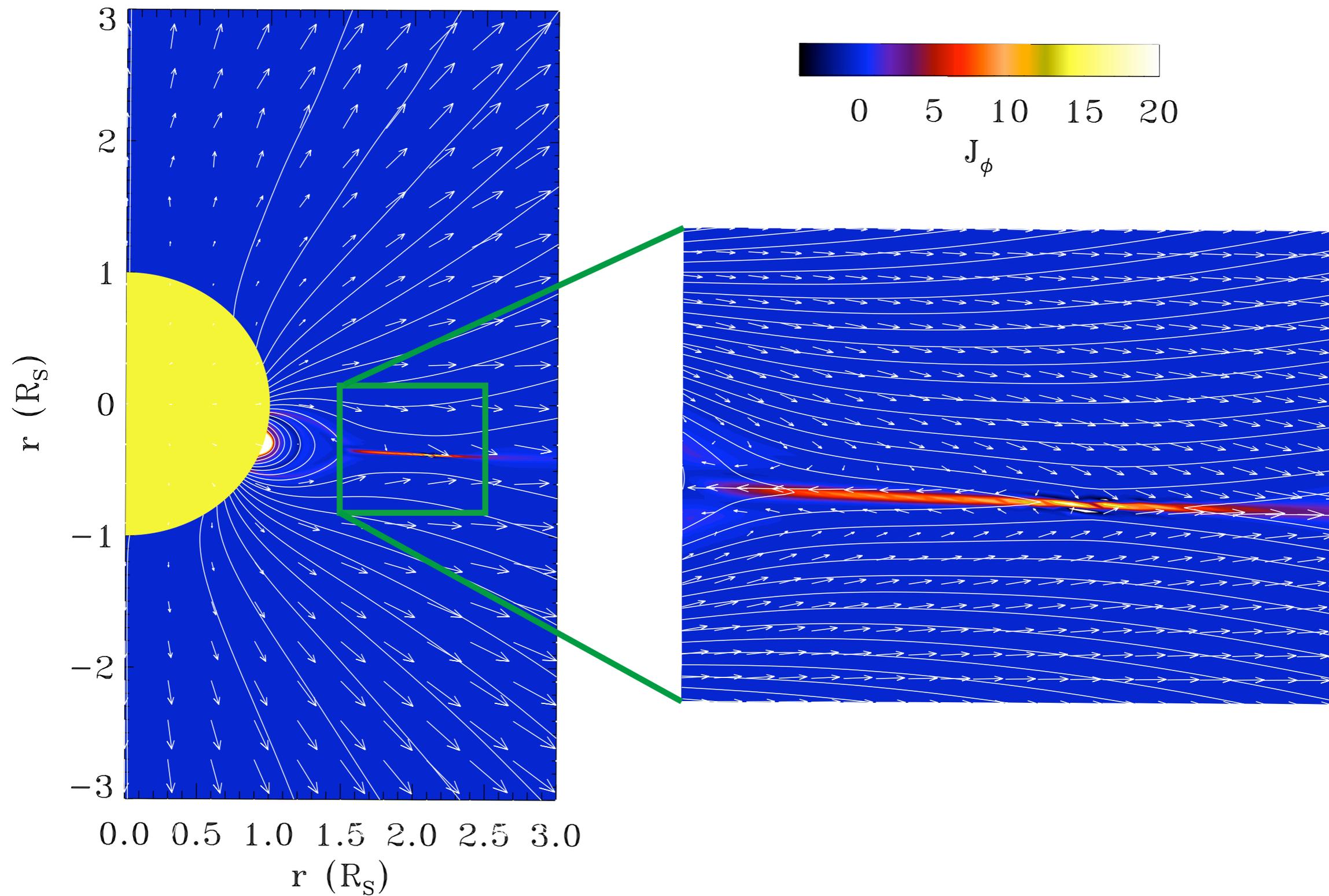


Picture based on MHD simulations

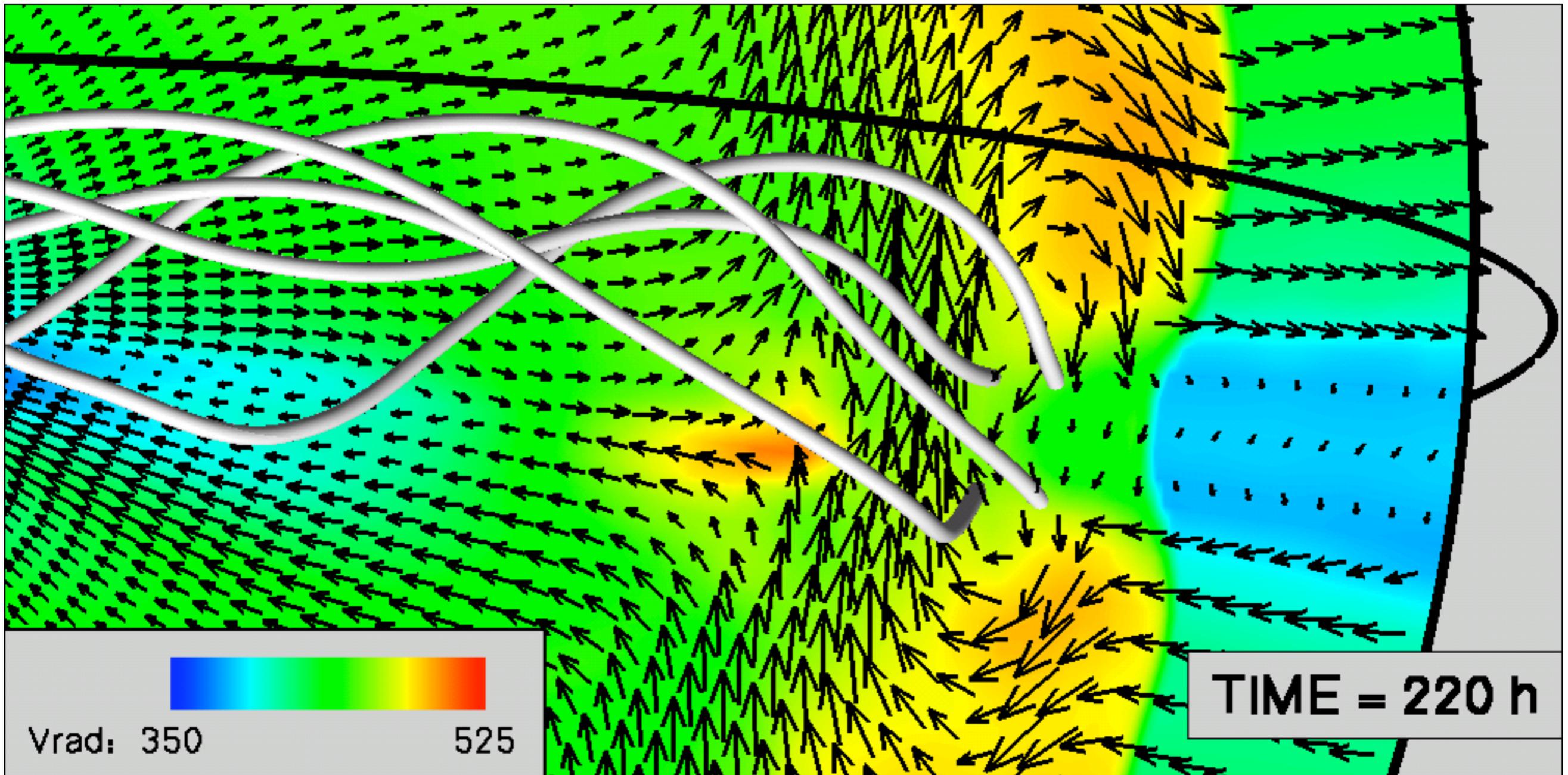
Reconnection Signatures



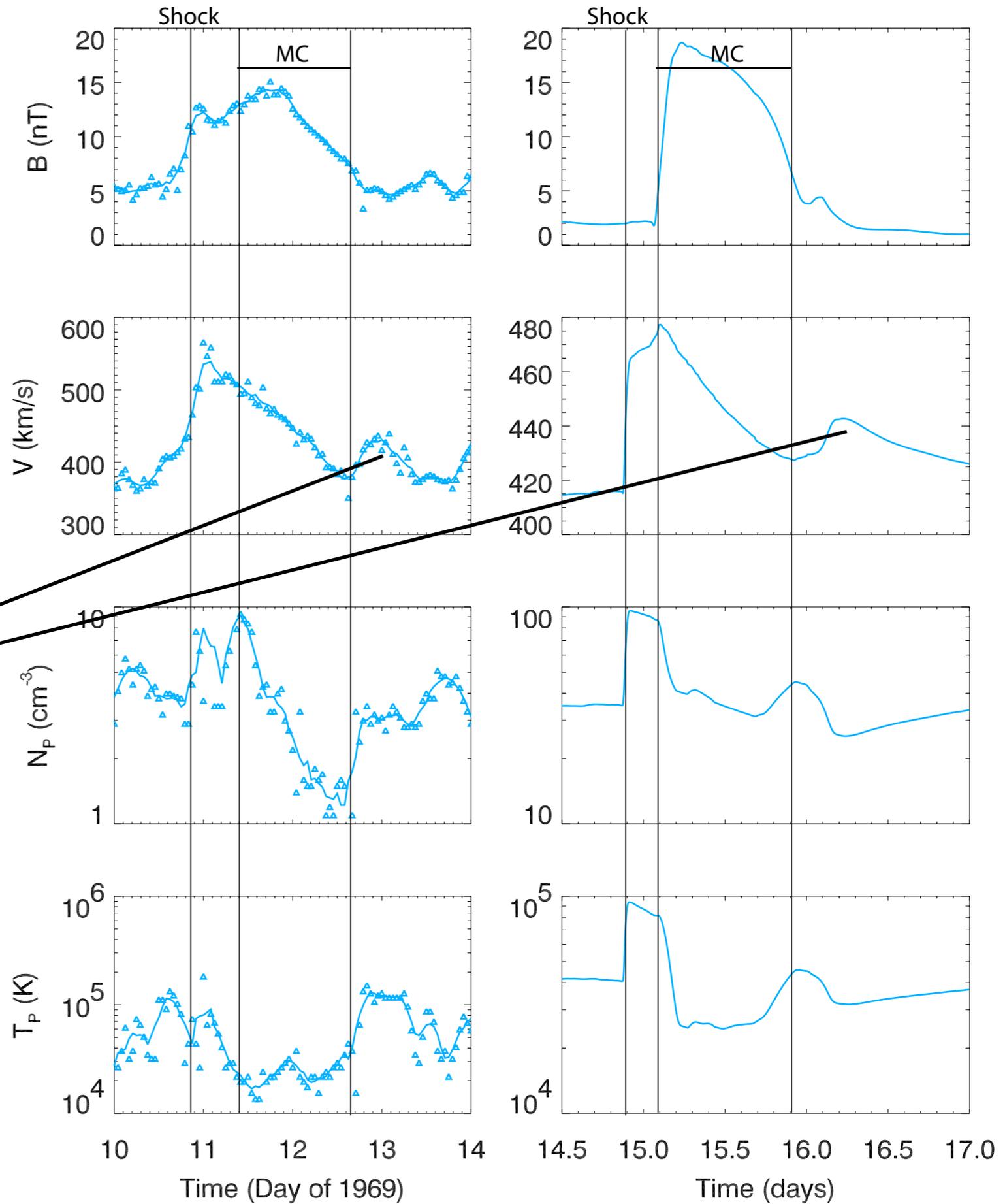
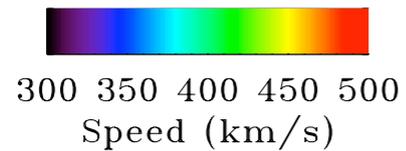
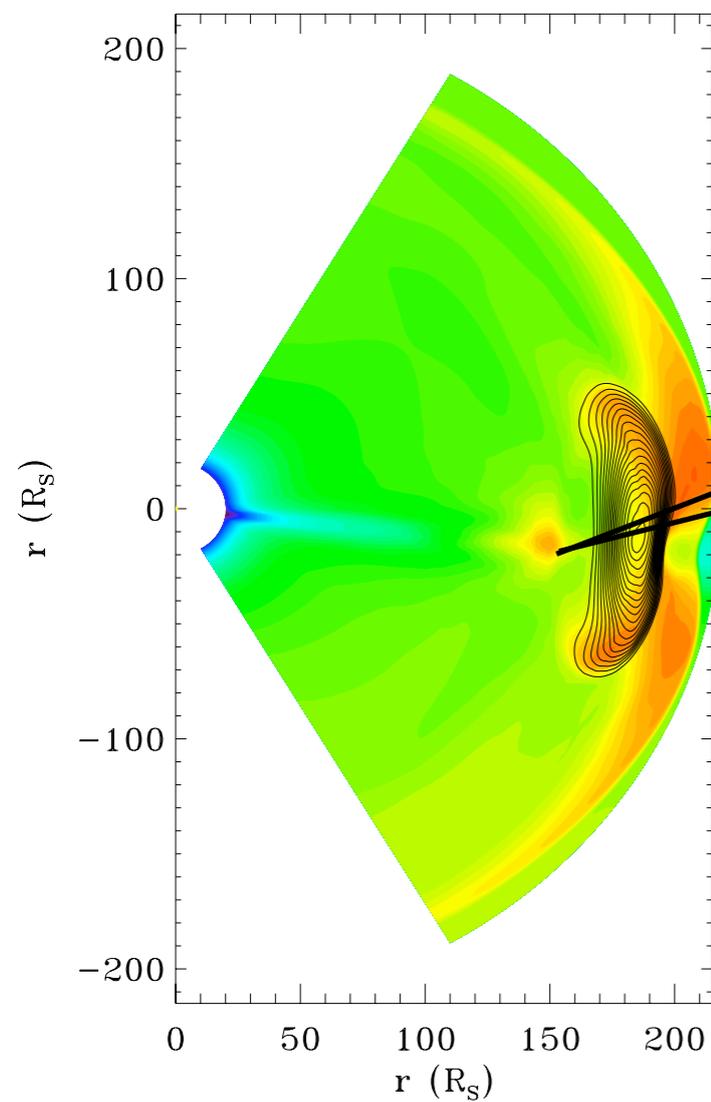
Post-eruption Reconnection Site



Velocity Enhancement associated with Post eruption reconnection



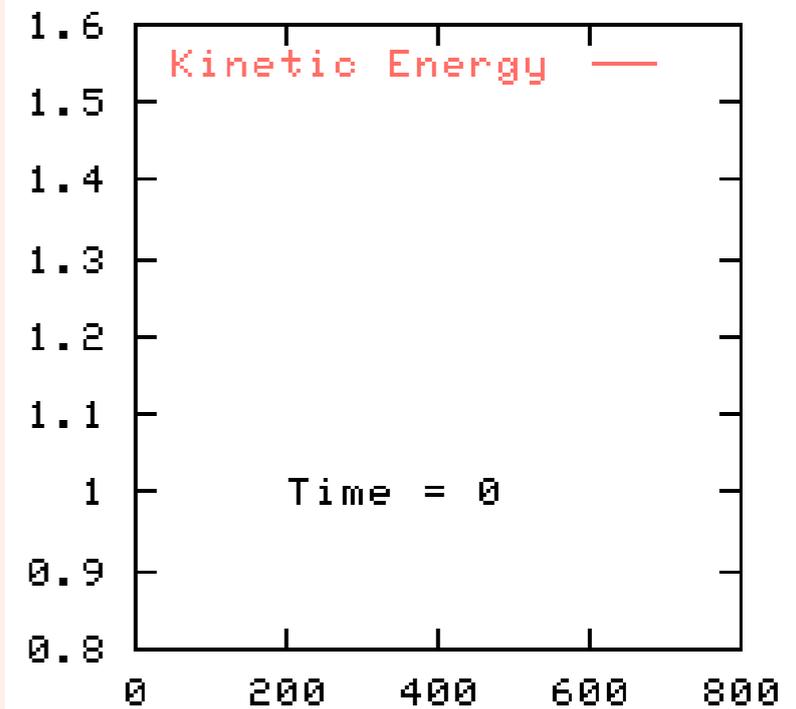
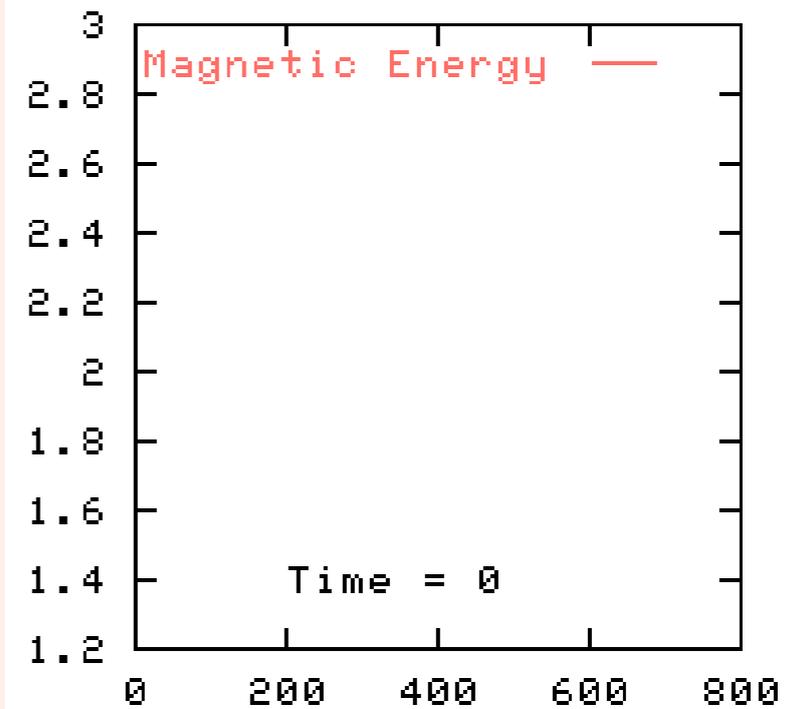
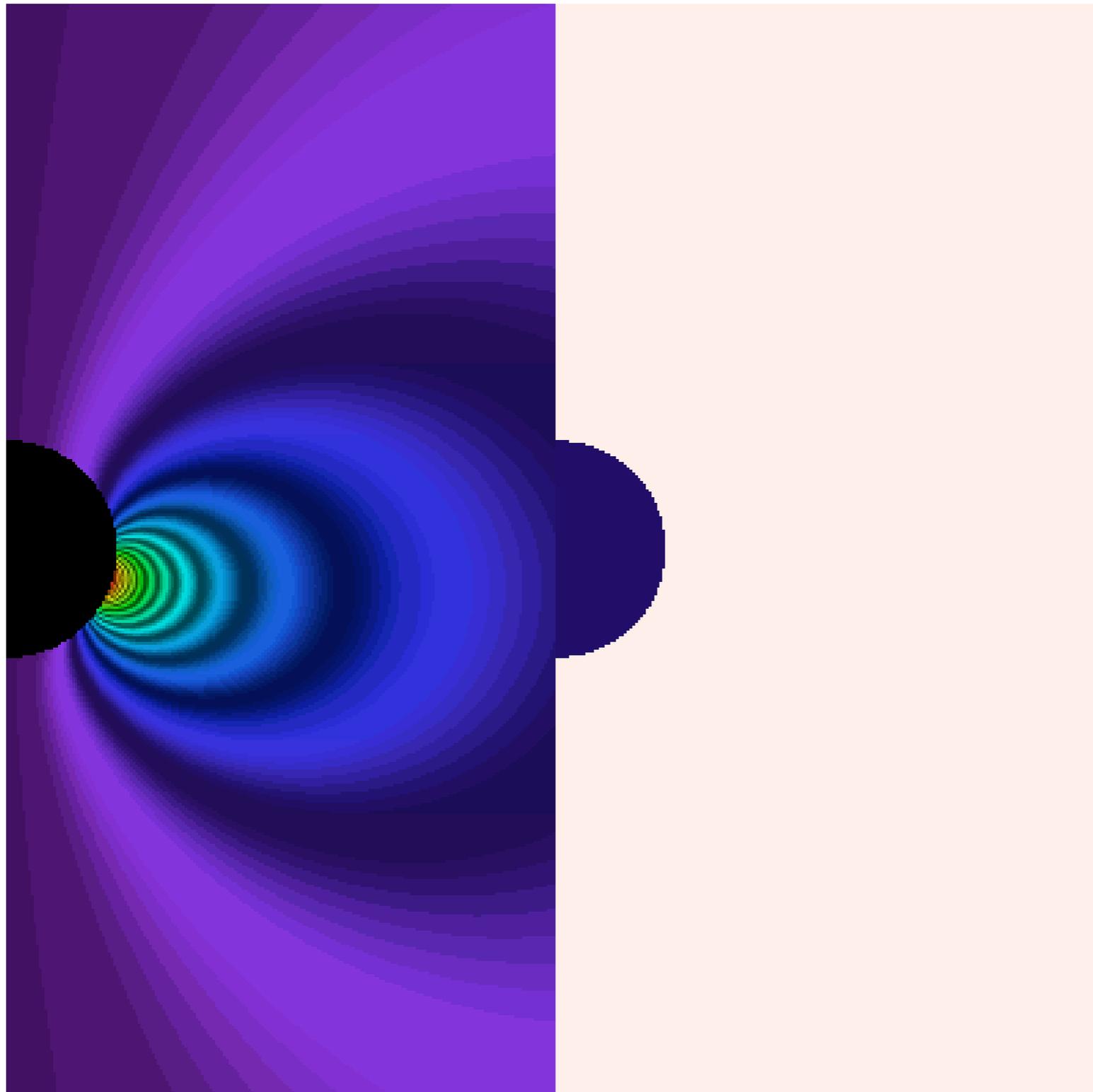
Comparison with observations



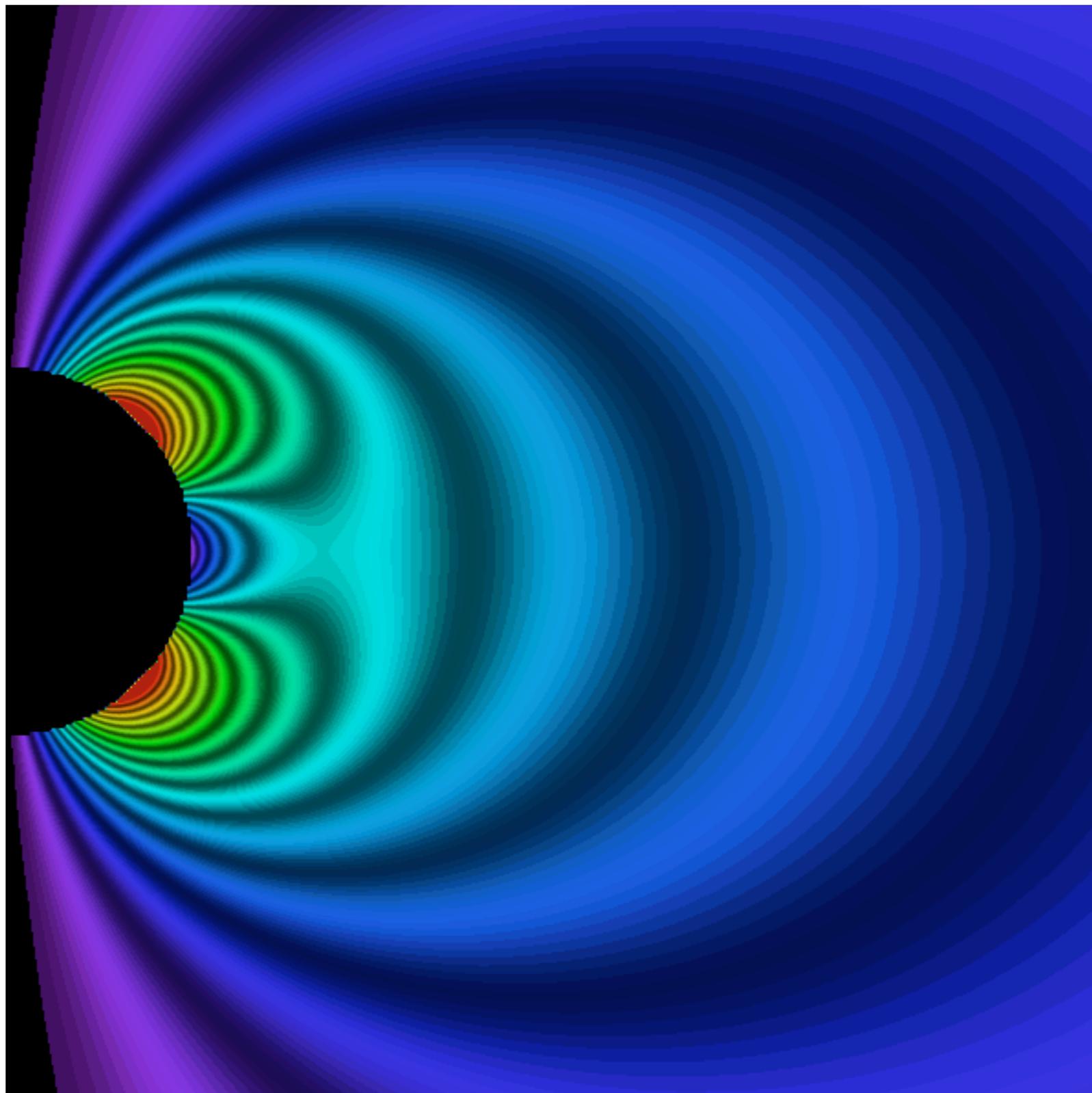
Model Comparisons

- SAIC's Flux Cancellation Model
- NRL's Breakout Model

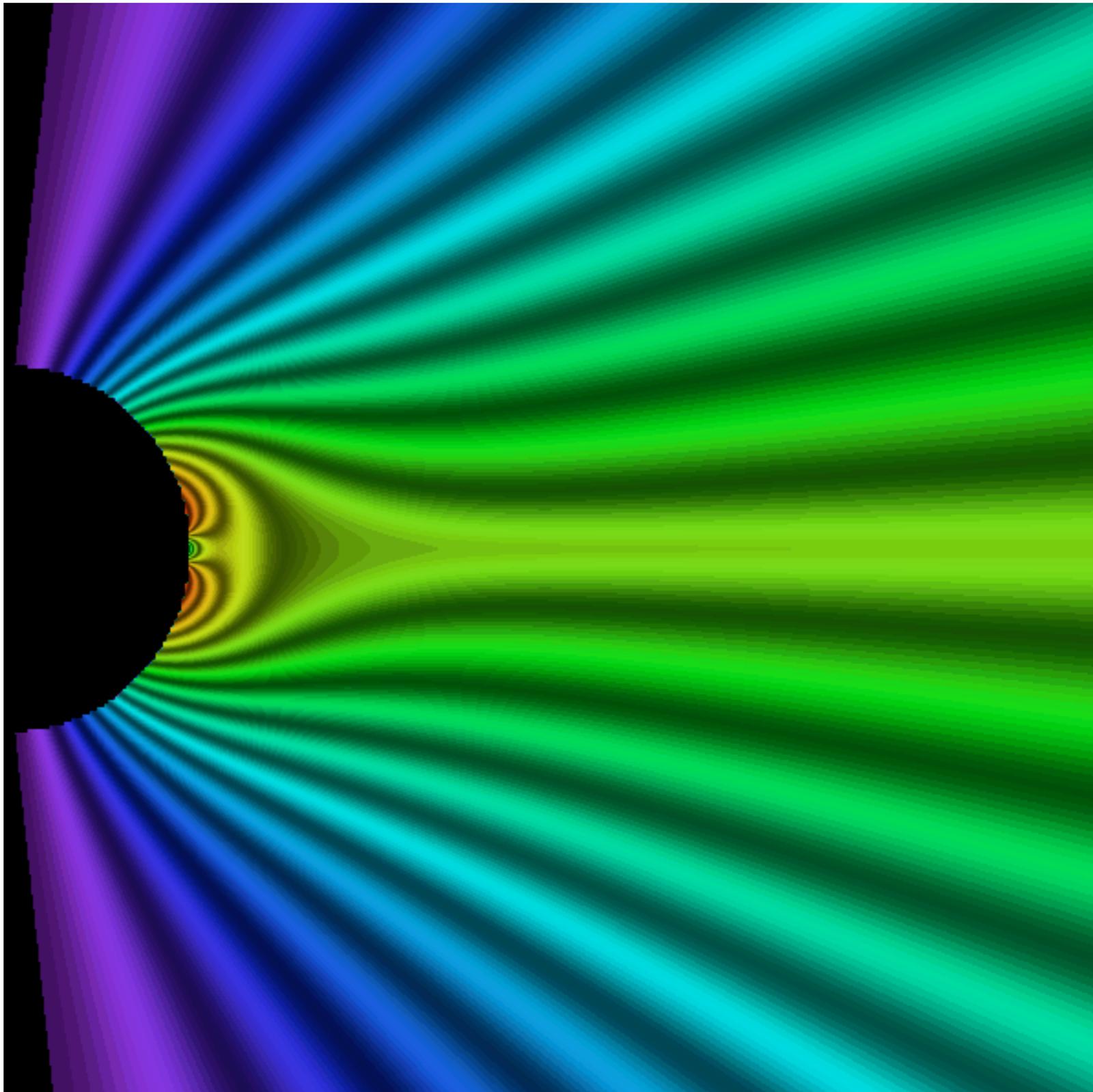
SAIC's Flux Cancellation Model



NRL's Breakout Model: 1

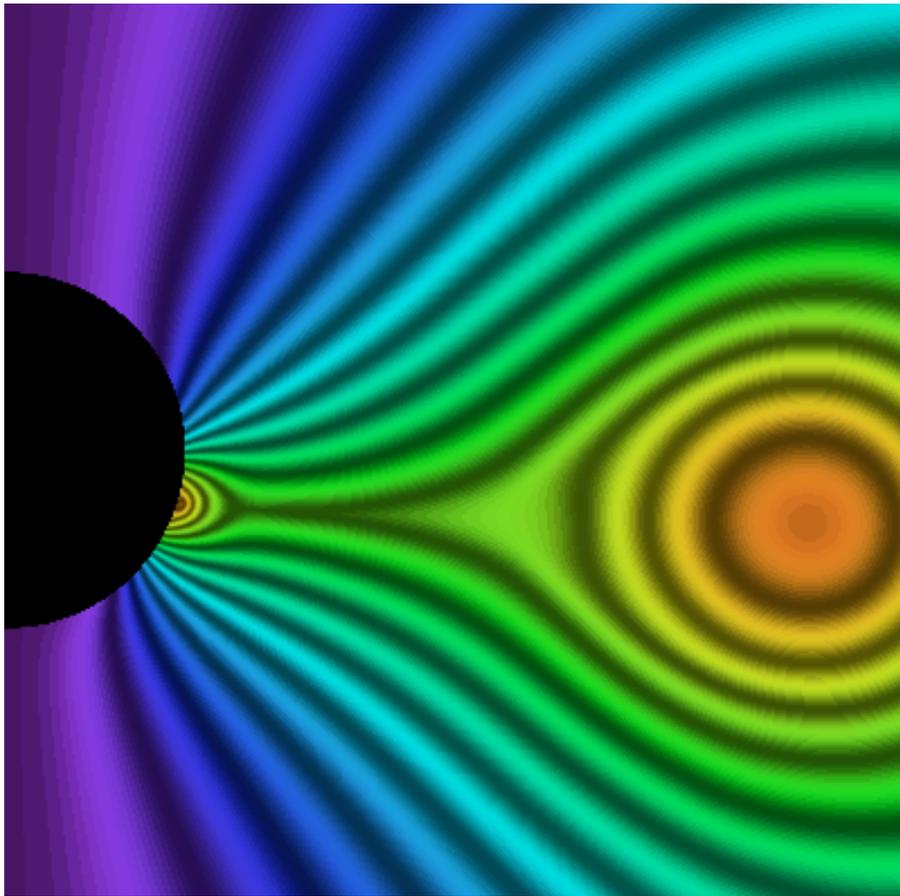


NRL's Breakout Model: 2

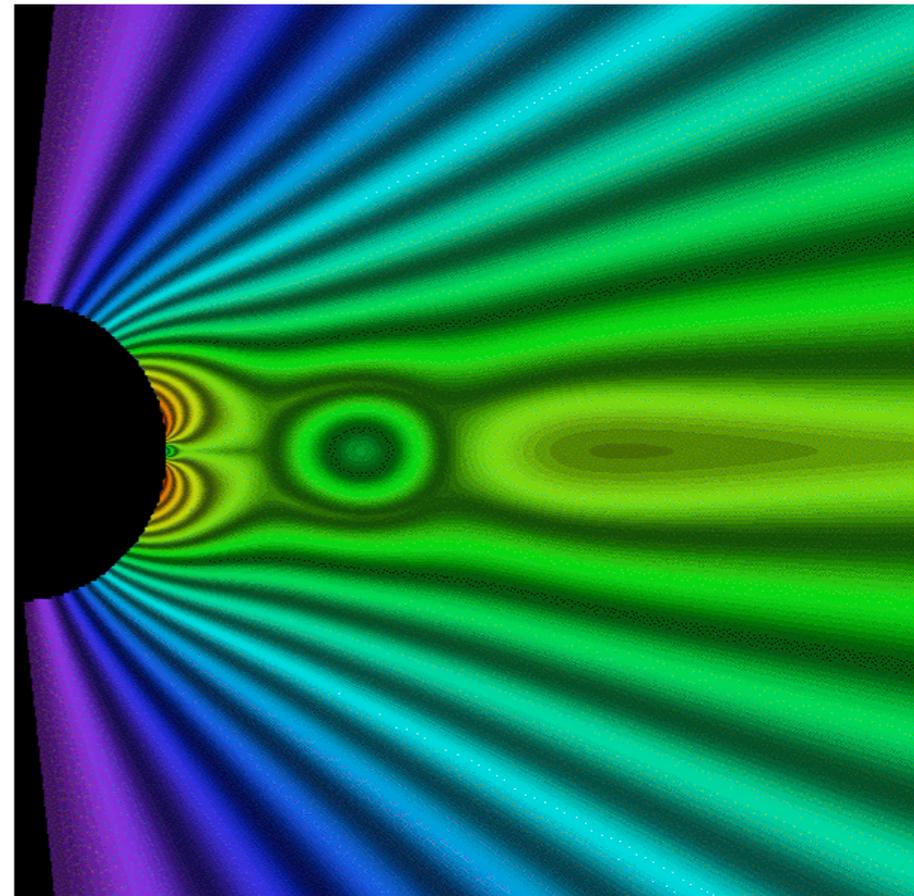


Model Comparisons

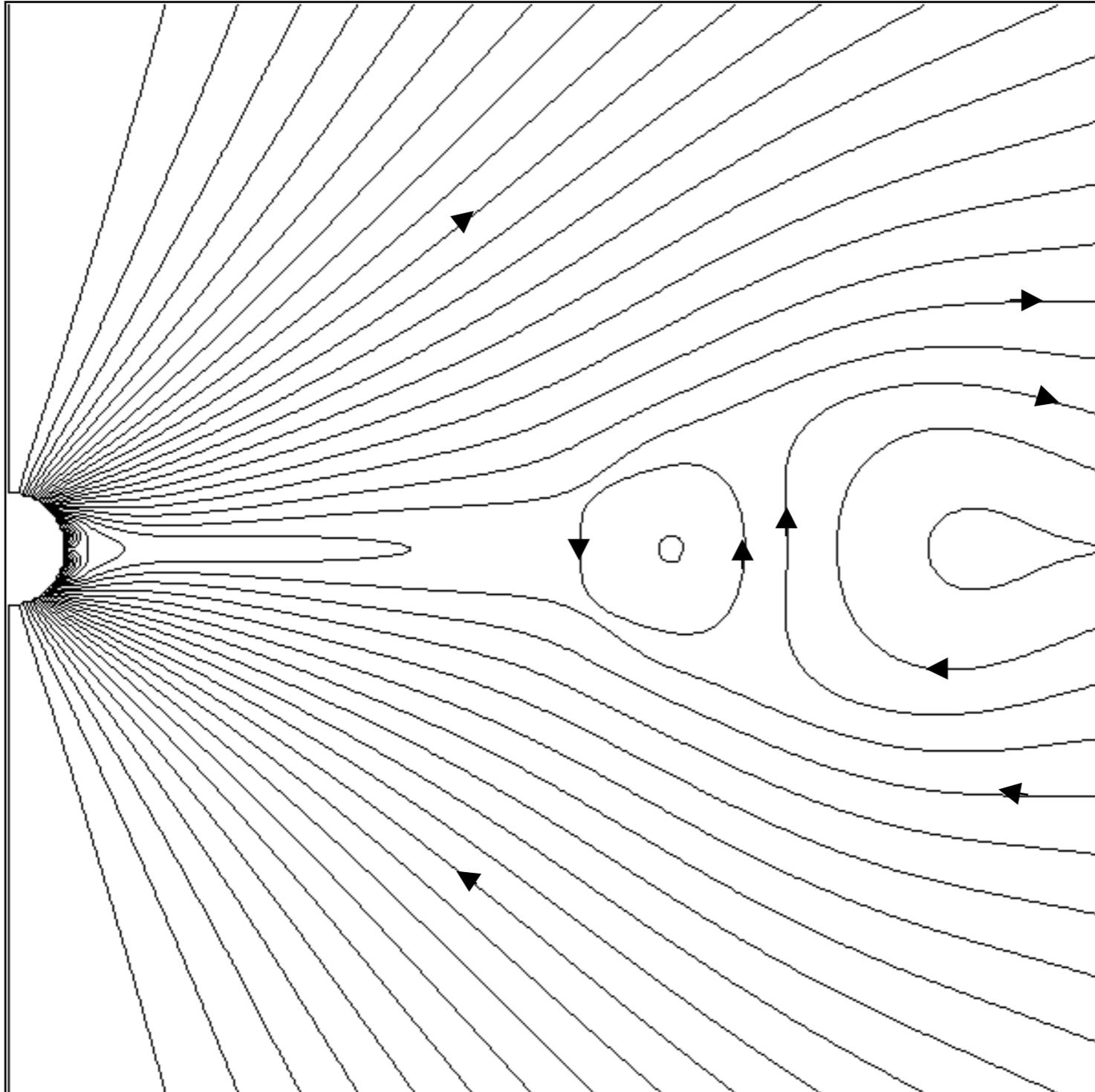
Flux Cancellation

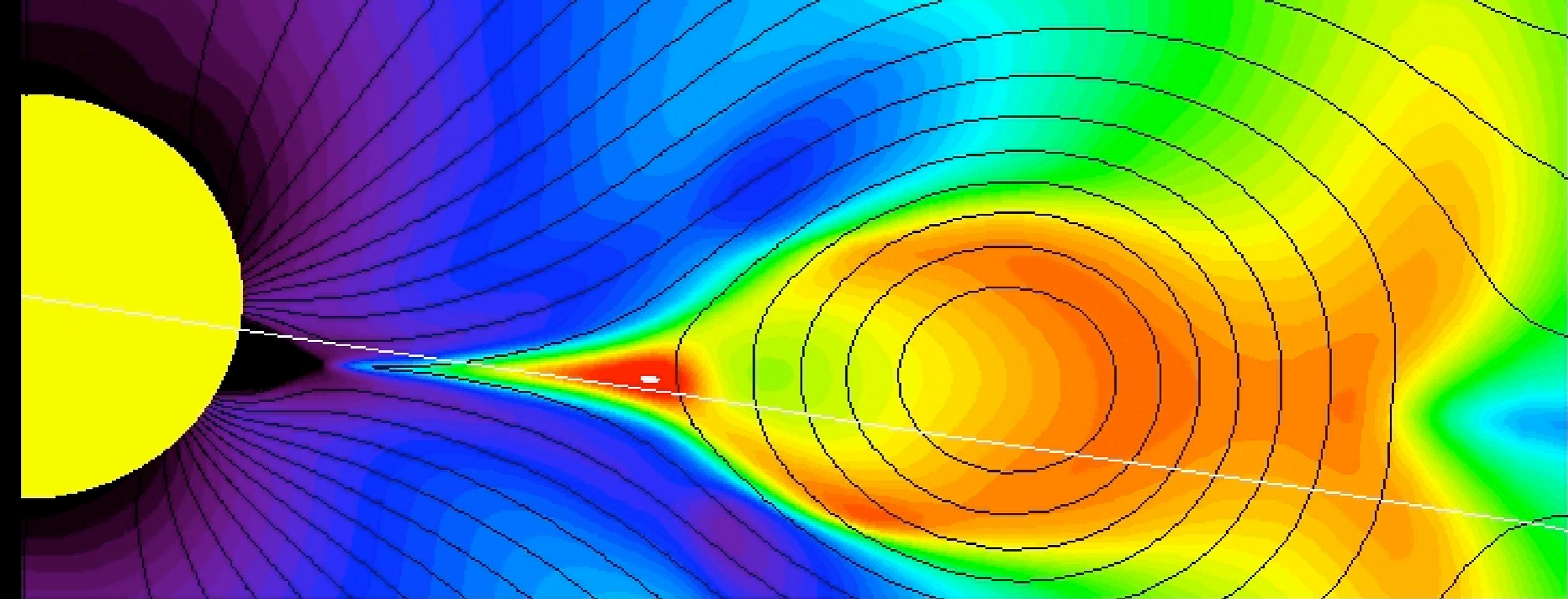


Breakout

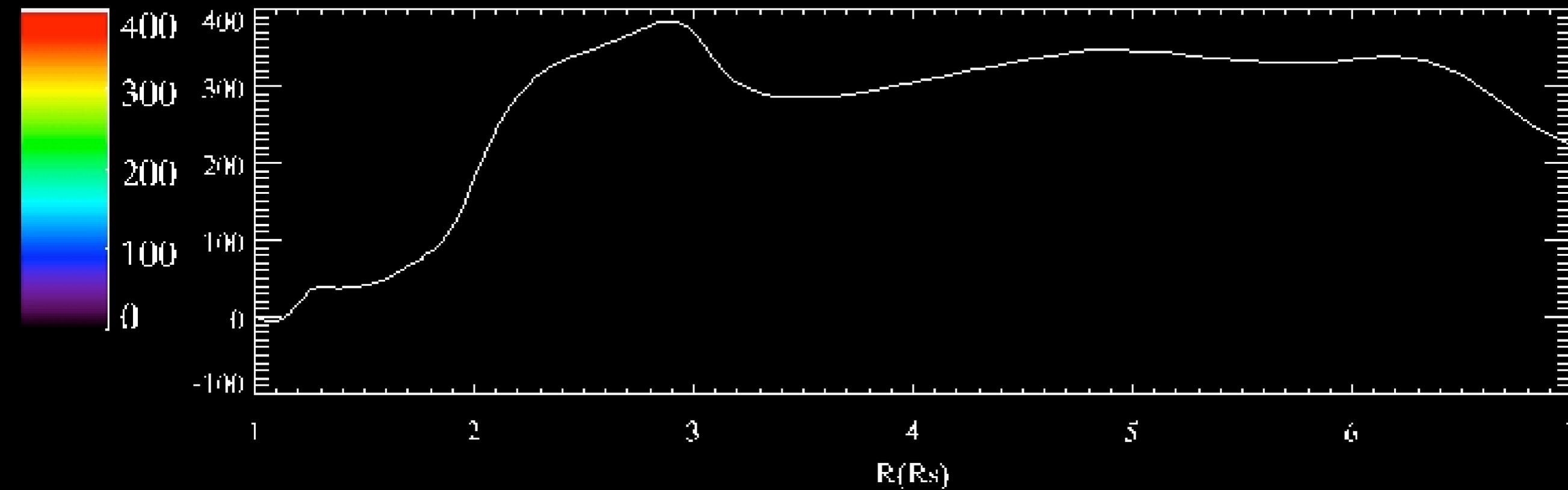


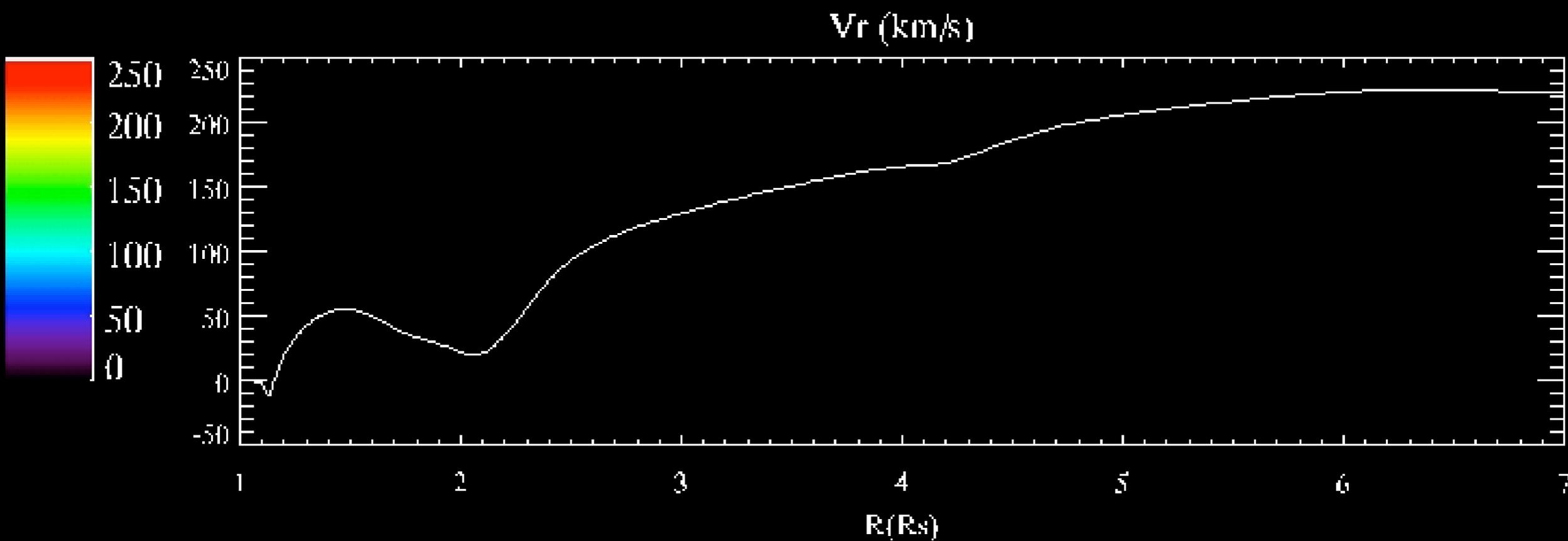
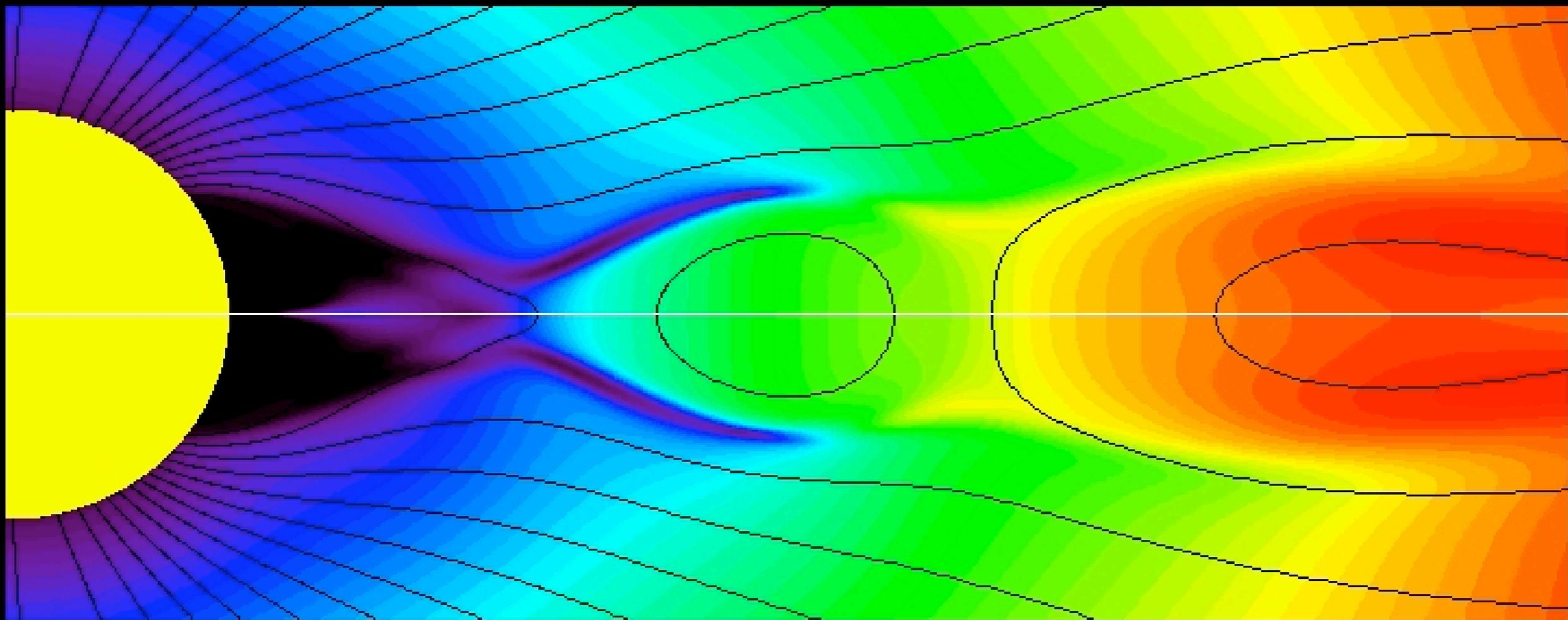
Solar Wind Implications for Breakout Model?





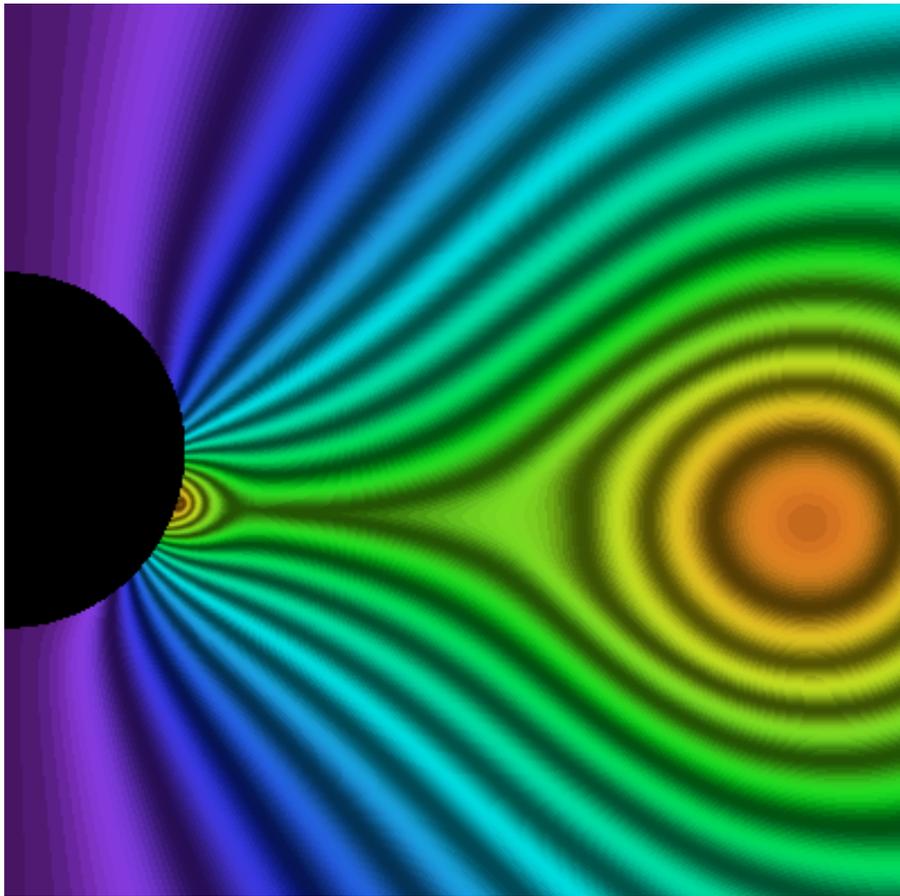
V_r (km/s)



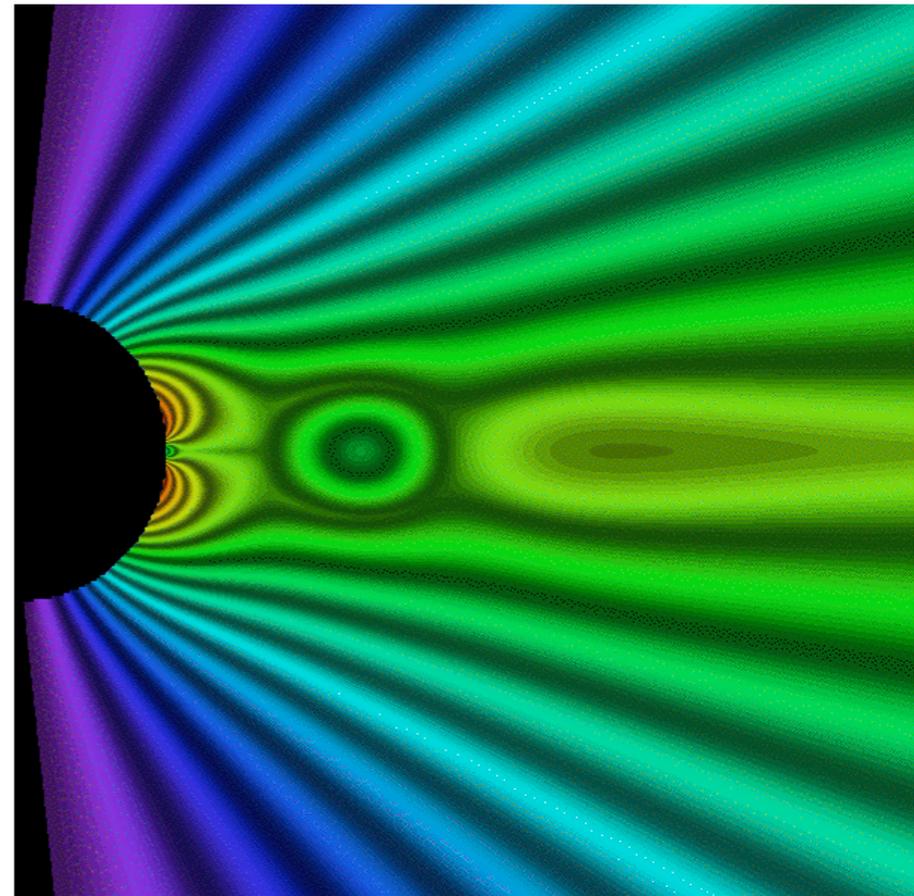


Model Comparisons

Flux Cancellation



Breakout



“Conclusions”

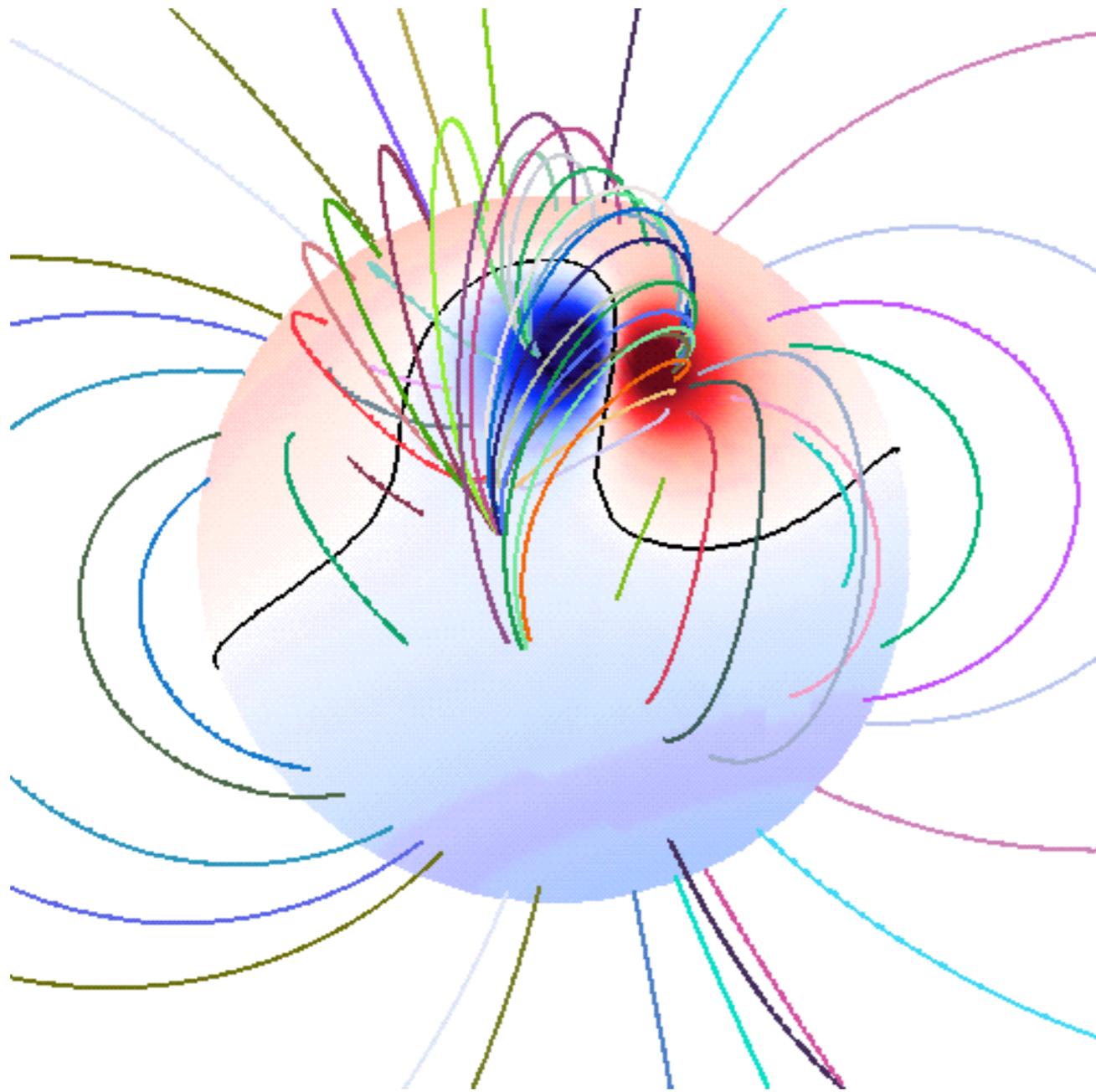
- All of the models are very idealized; concrete predictions about interplanetary signatures are difficult
- More realistic modeling of real events is needed to make progress
- Multi-point observations of in situ ejecta may clarify issues

Future Directions

- Better models
- Better observations
- Better interpretation
- Better get started...

3D Models of Active-Region Magnetic Fields

Case 1: Single Neutral Line



Case 2: Two Neutral Lines

