COMESEP Deliverable D7.4

Conference Paper 4

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Conference Paper 4

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CO	Confidential, only for members of the consortium (including the Commission Services)	

NOTICE

DISSEMINATION EVENT

Title of event: Ninth European Space Weather Week

Location: Brussels, Belgium

Date(s): 5-9 November 2012

Title of presentation: Prediction of ICME arrival at Mars

Author(s): : *S. Vennerstrom[1]; T. V. Falkenberg[1], K. Leer[1], T. Rollett[2], A. Veronig[2], M. Temmer[2], B.Vrsnak [3], T. Zic [3], D. Odstrcil [4] ([1]DTU, [2]UNIGRAZ, [3]HVAR, [4]GSFC)*

Name of presenter: Susanne Vennerstrom

Type of presentation: Invited oral

Abstract

Development of prediction methods for ICME arrival at Mars is important in a space weather context for two main reasons. (1) It will be useful for future Mars exploration, and (2) it may increase our understanding of the structure and heliospheric propagation of ICME's in general, thereby potentially improving our ability to predict ICME arrival at Earth. We use ~6 years of observations from the MAG/ER instrument onboard the Mars Global Surveyor in the previous solar cycle to identify events of significantly enhanced solar wind dynamic pressure and a set of ICME events encountering Mars. We investigate the occurrence pattern of the events relative to the heliospheric current sheet and relative to near Earth observations of ICME's. When the solar source of the ICME's can be identified we employ two existing models of ICME propagation: The global MHD model ENLIL and the drag-based model DBM. These are compared with the observations in order to identify key parameters for a successful prediction. The presented work has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n^{o} 263252 [COMESEP] and n^{o} 218816 [SOTERIA].

Acknowledgement - Ninth European Space Weather Week 2640469

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Abstract Title

Prediction of ICME arrival at Mars

Abstract Text

Development of prediction methods for ICME arrival at Mars is important in a space weather context for two main reasons. (1) It will be useful for future Mars exploration, and (2) it may increase our understanding of the structure and heliospheric propagation of ICME's in general, thereby potentially improving our ability to predict ICME arrival at Earth. We use ~6 years of observations from the MAG/ER instrument onboard the Mars Global Surveyor in the previous solar cycle to identify events of significantly enhanced solar wind dynamic pressure and a set of ICME events encountering Mars. We investigate the occurrence pattern of the events relative to the heliospheric current sheet and relative to near Earth observations of ICME's. When the solar source of the ICME's can be identified we employ two existing models of ICME propagation: The global MHD model ENLIL and the drag-based model DBM. These are compared with the observations in order to identify key parameters for a successful prediction. The presented work has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement no 263252 [COMESEP] and no 218816 [SOTERIA].

Topic

06 Session 4b- Space Weather in the Solar System

Presentation Type

Invited oral presentation

List of Authors

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Prediction of ICME Arrival at Mars

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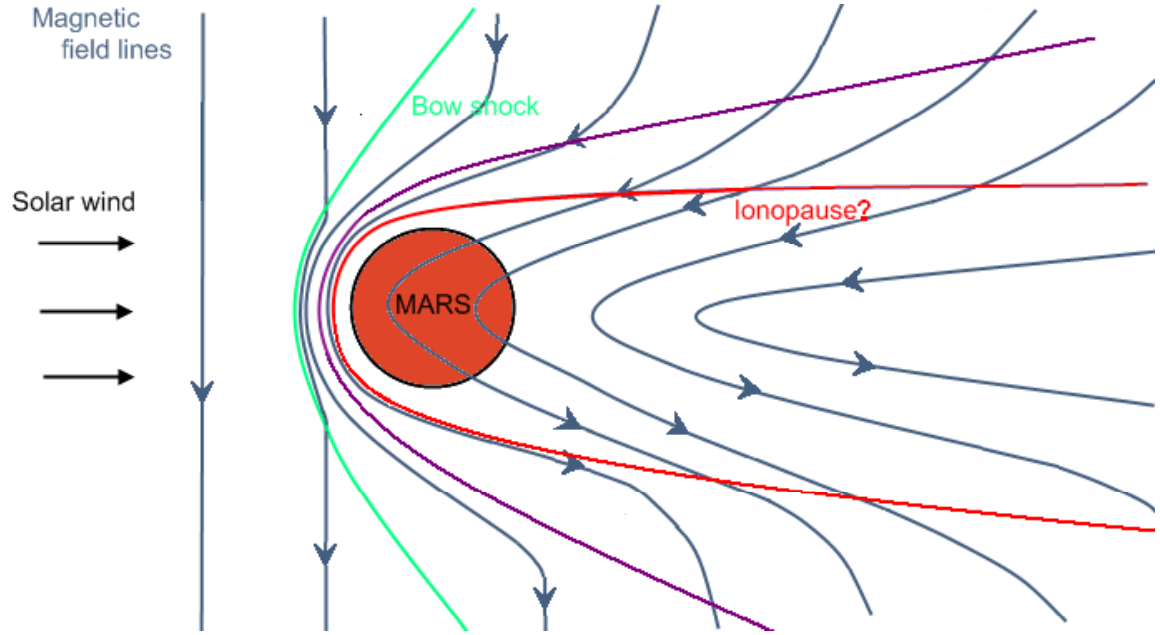
Outline

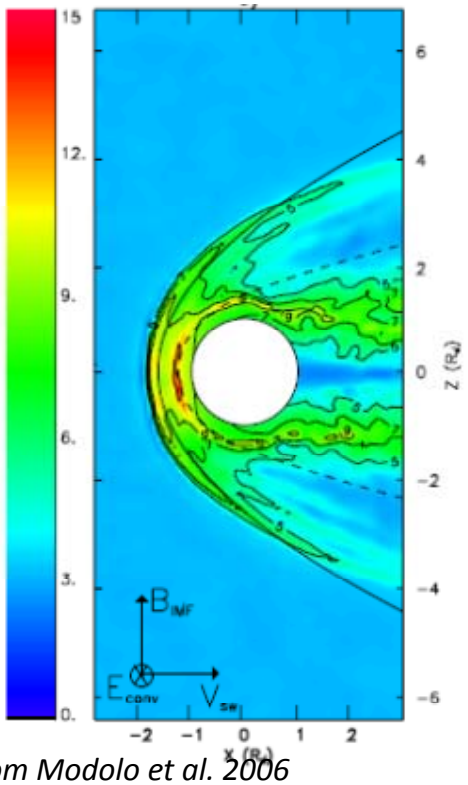
- Characterizing space weather events at Mars as observed by the Mars Global Surveyor magnetometer and electron reflectometer (1999-2006)
- Occurrence pattern
- Solar wind sources
- Predicting storm occurrence
  - Simple propagation from Earth observations
  - Drag based model (ICME)
  - ENLIL global MHD (ICME)

Solar wind – Mars interaction



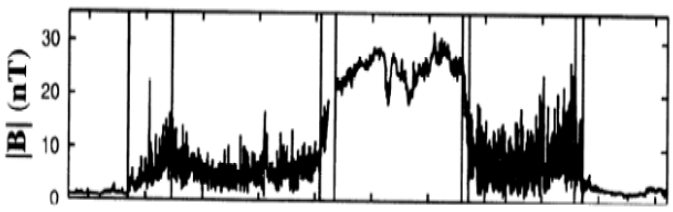
The Martian induced magnetosphere

- Hybrid simulation results



From Modolo et al. 2006

-and MGS observations



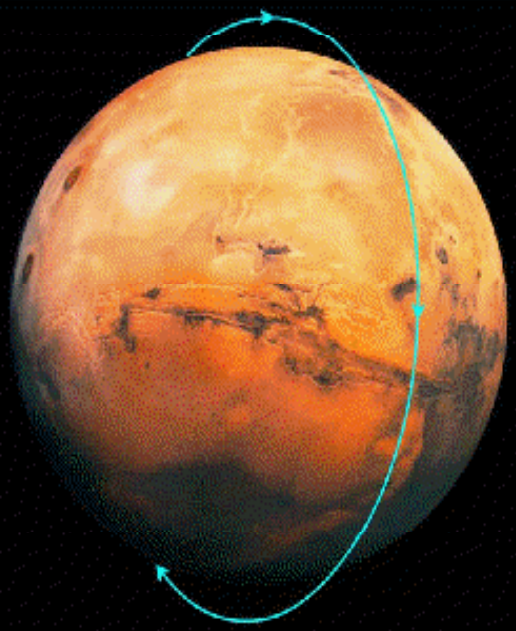
From Vignes et al. 2000

Mars Global Surveyor Project

MGS Mapping Orbit Geometry

JPL

NASA



View From Sun on 1 August 1999

Semi-Major Axis

3775 km (378 km index altitude)

Inclination

92.866°, nearly polar

Eccentricity

0.007, nearly circular

Descending Node

Always at 2:00 p.m. orientation with respect to the fictitious mean Sun

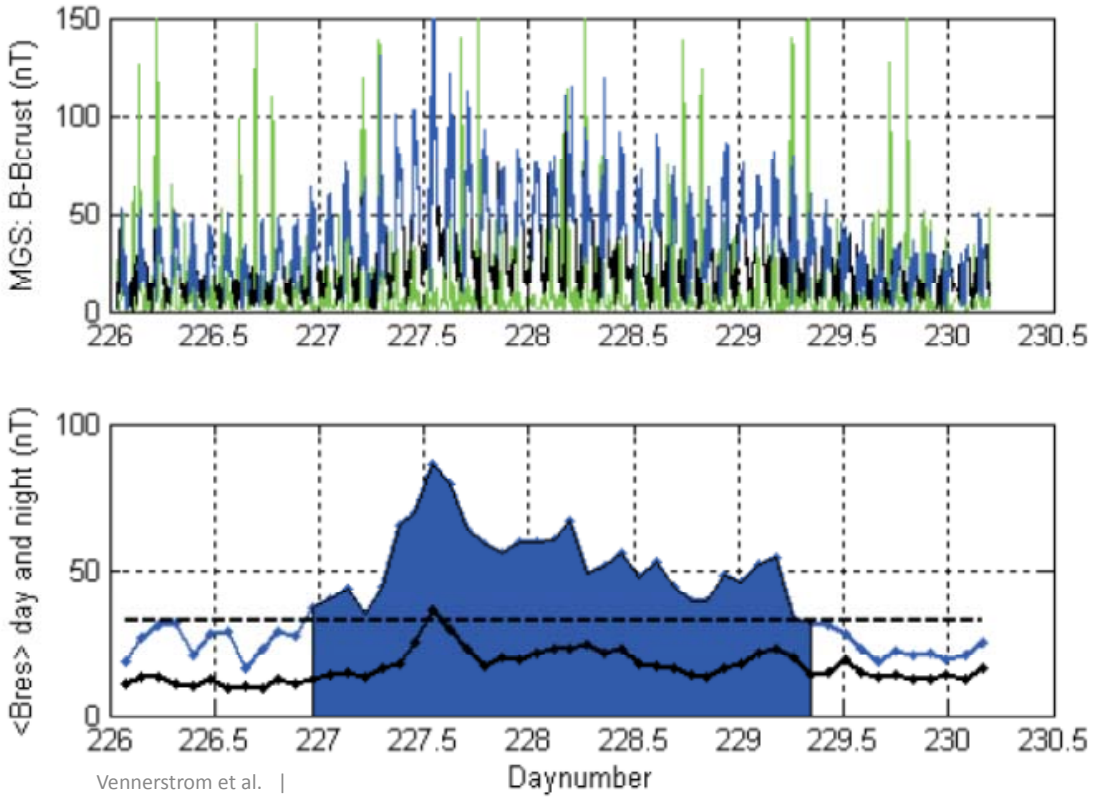
Periapsis

-90.0°, near the Martian south pole

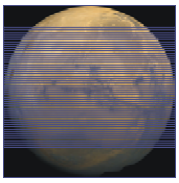
Ground Track Cycle

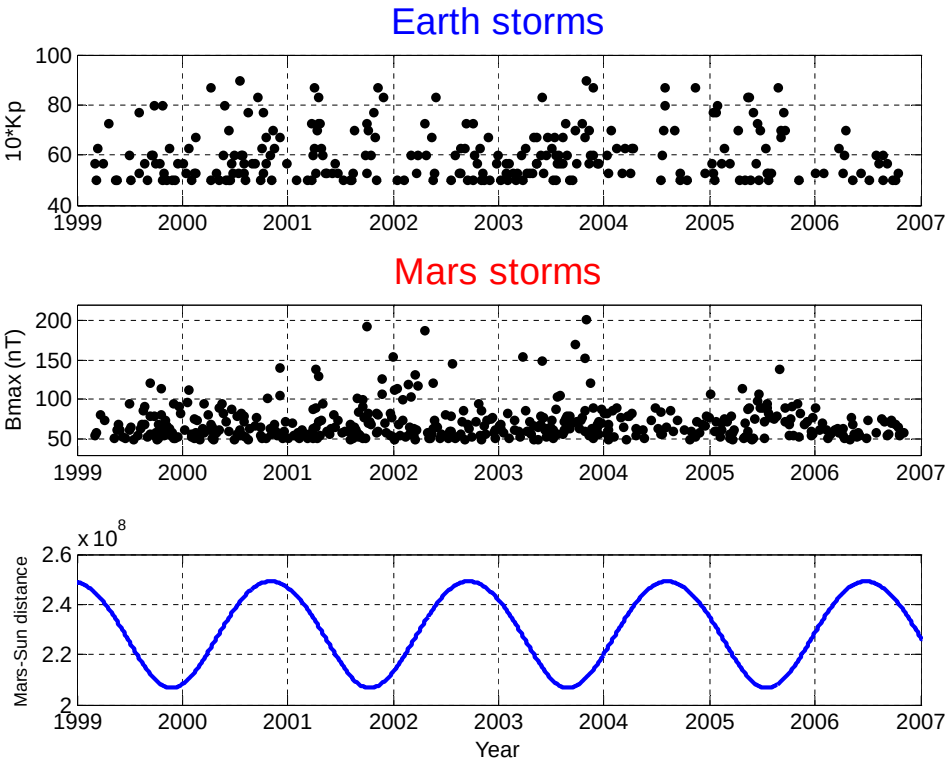
Approximately repeats after 88 revolutions, each orbit lasts for about 118 minutes

How to define magnetic storms at Mars?

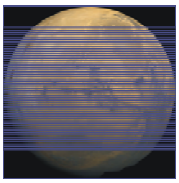


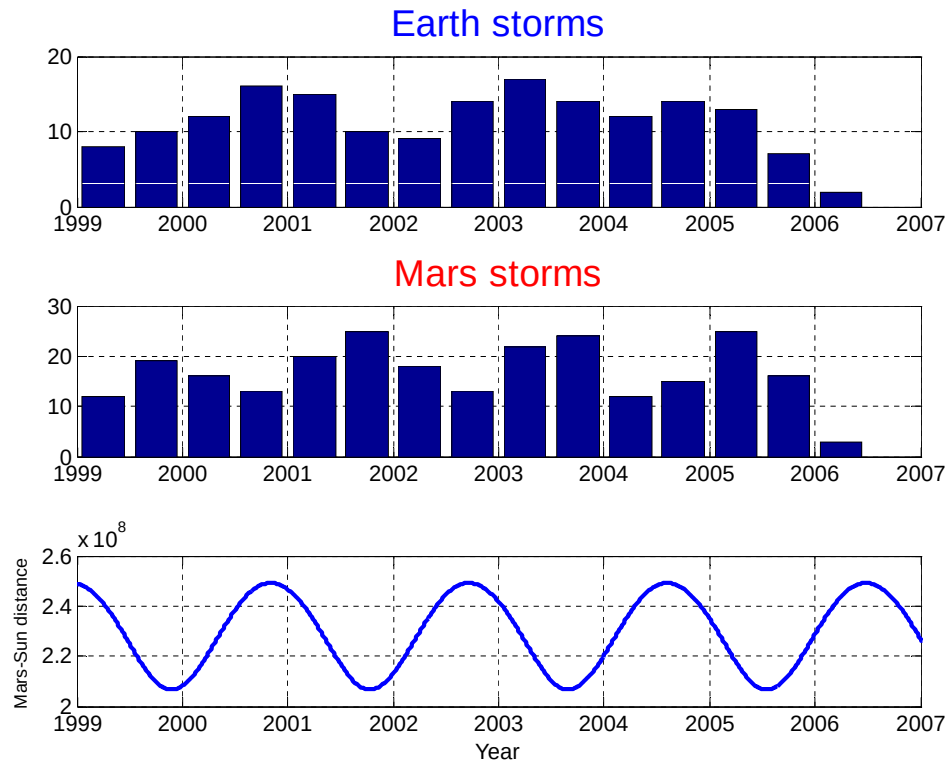
Storm occurrence



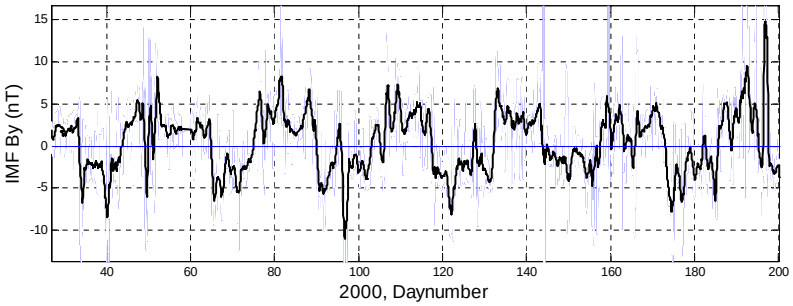


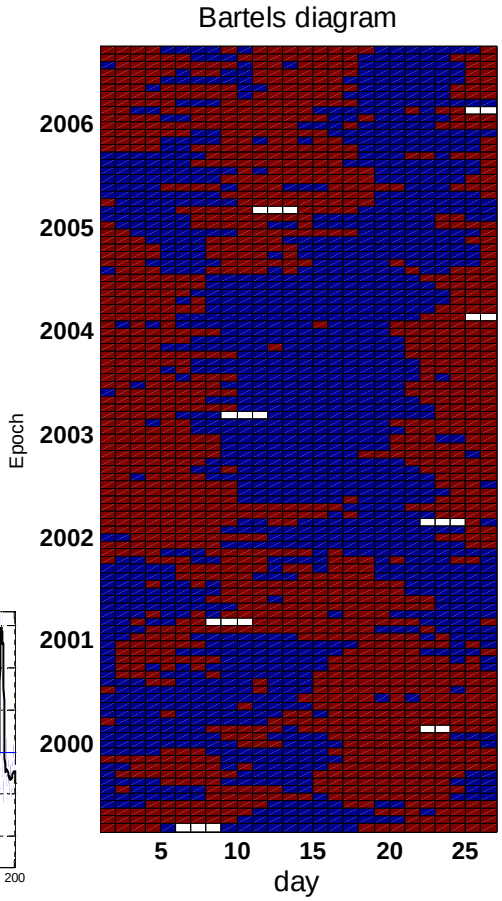
Storm occurrence

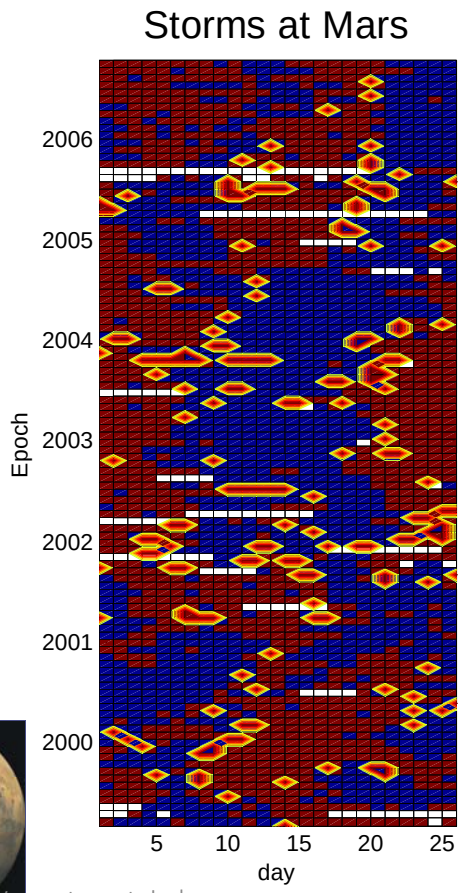


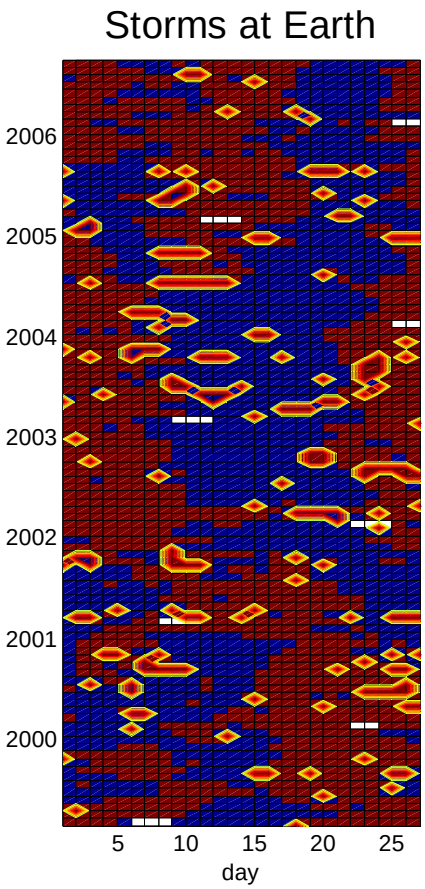


IMF sector structure





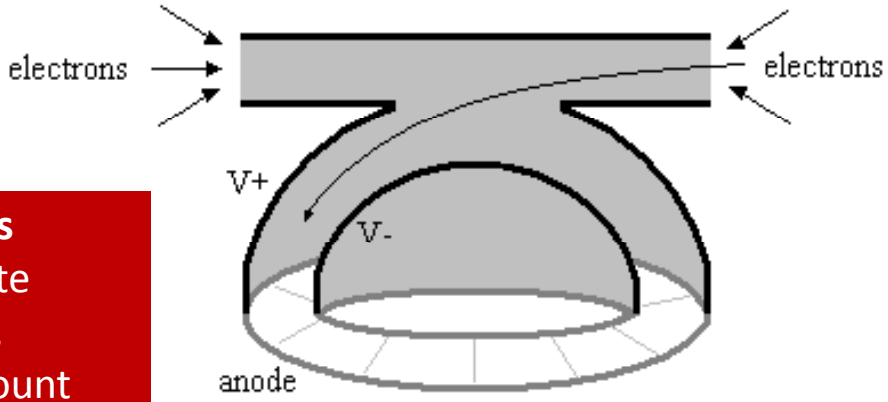




Vennerstrom, Icarus 2011

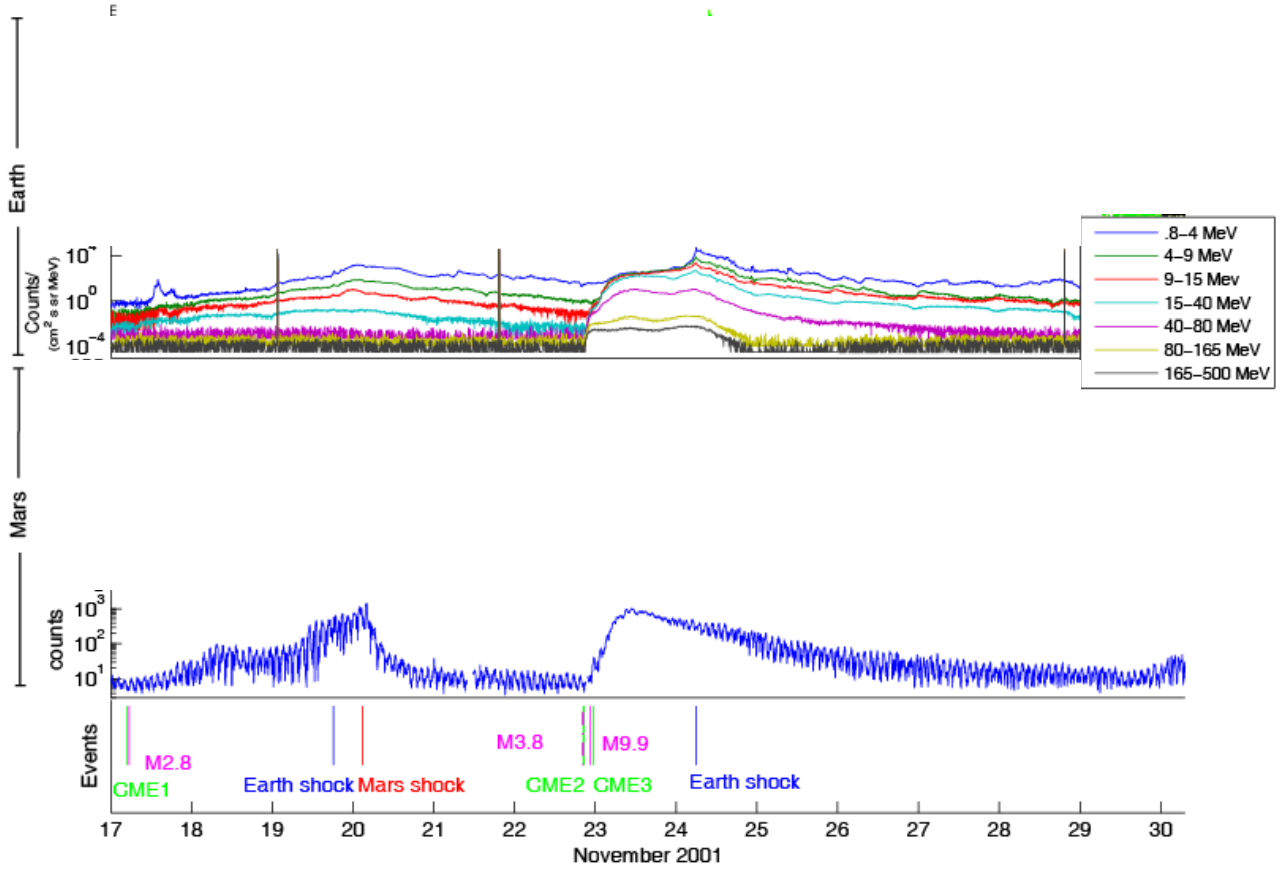
Presence of SEPs can be seen in the data from the MGS Electron Reflectometer

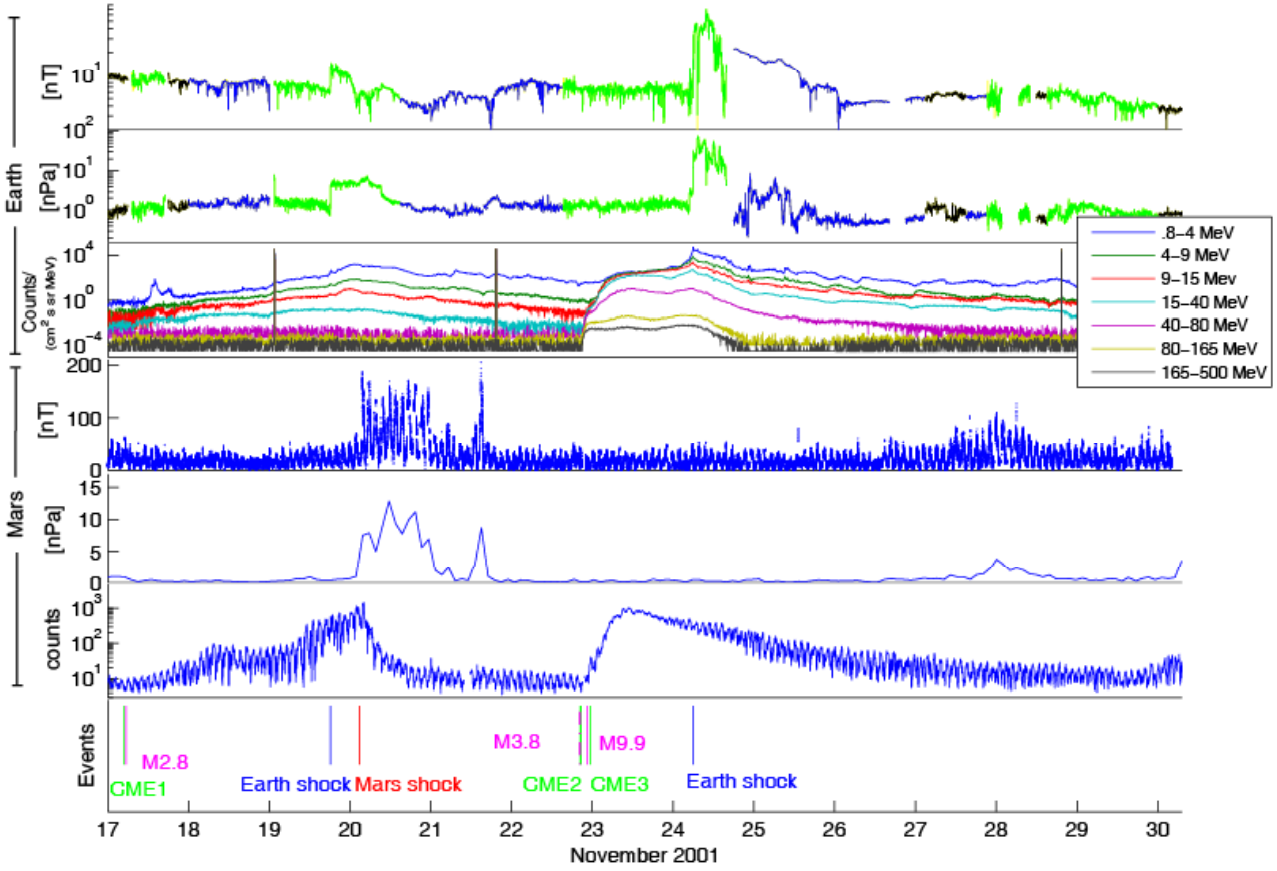
- 19 energy channels 10 eV-20 keV,16 angular sectors.



High energy protons (>30 MeV) penetrate instrument housing, causing increased count rates in all energy channels. Distinguishable in highest energy channels

Delory et al., Space Weather, 2012

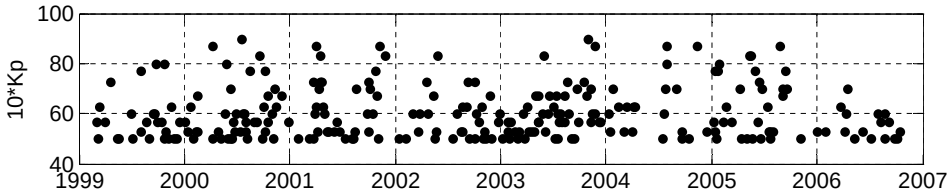


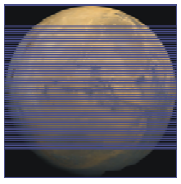


Falkenberg et al. 2011

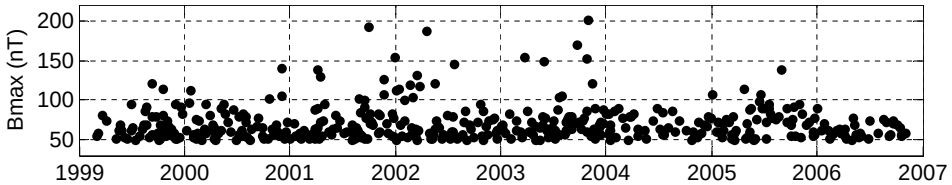
Storm occurrence

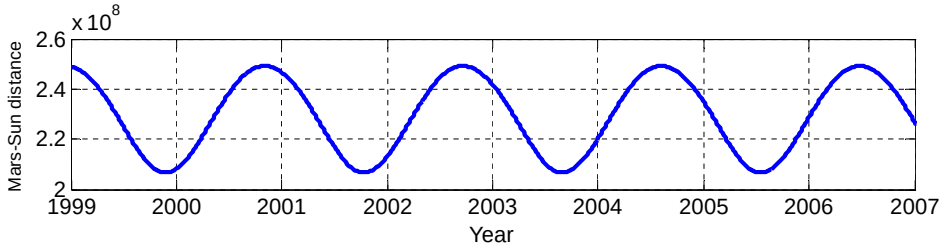
Earth storms



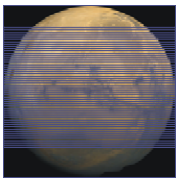


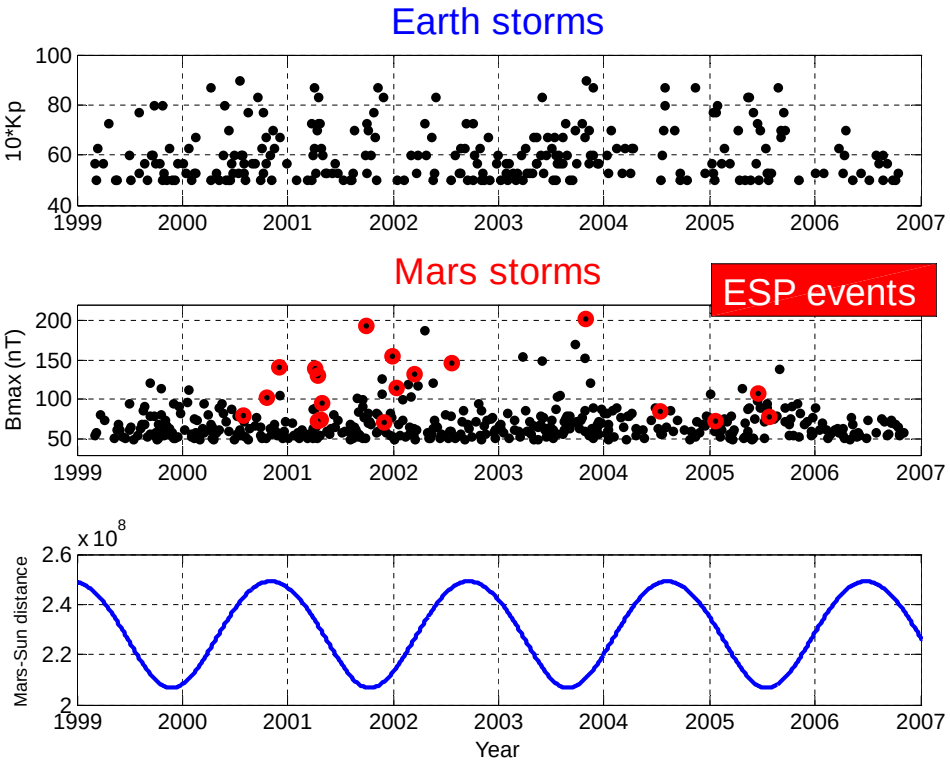
Mars storms



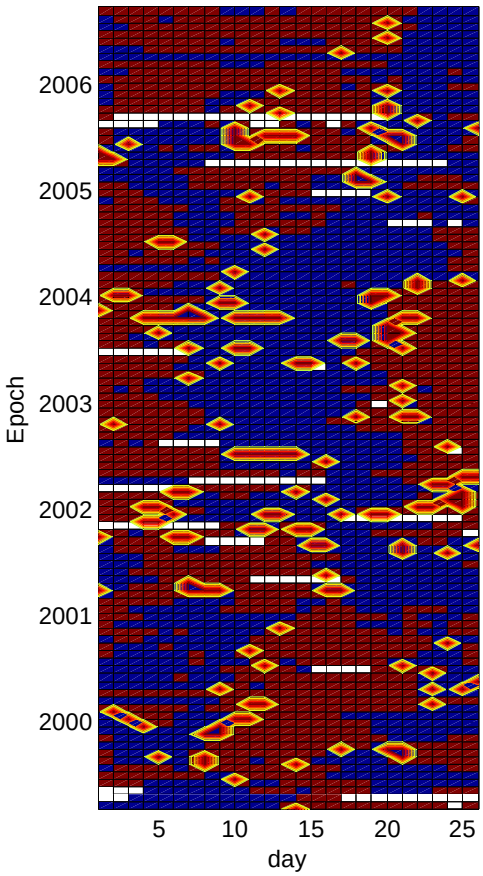


Storm occurrence

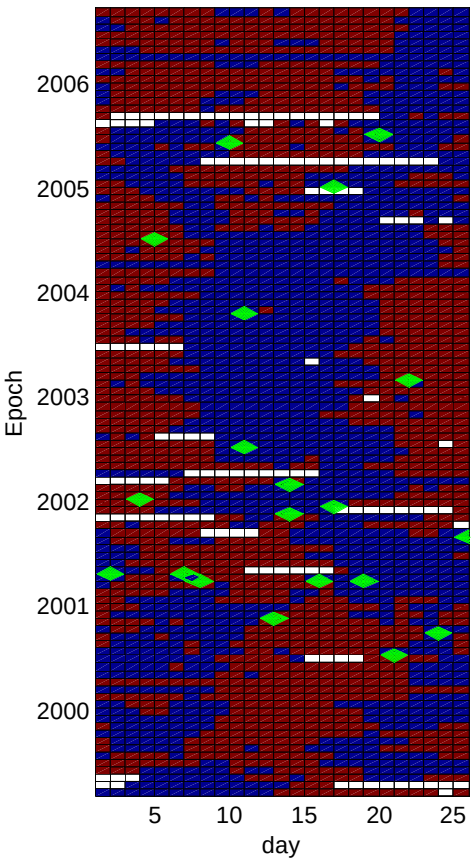




Storms at Mars



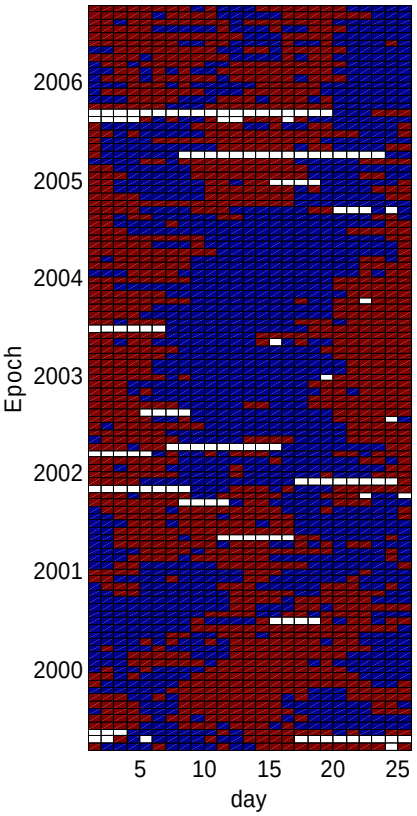
ESP storms at Mars



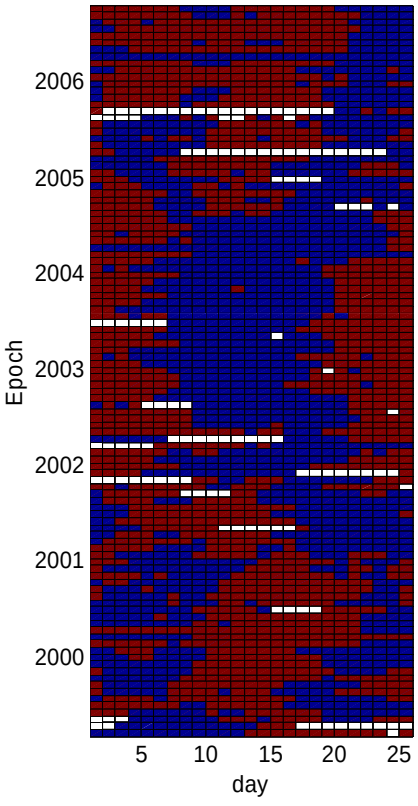
Predictions

Sector structure at Mars

MGS magnetometer



Propagated ACE data



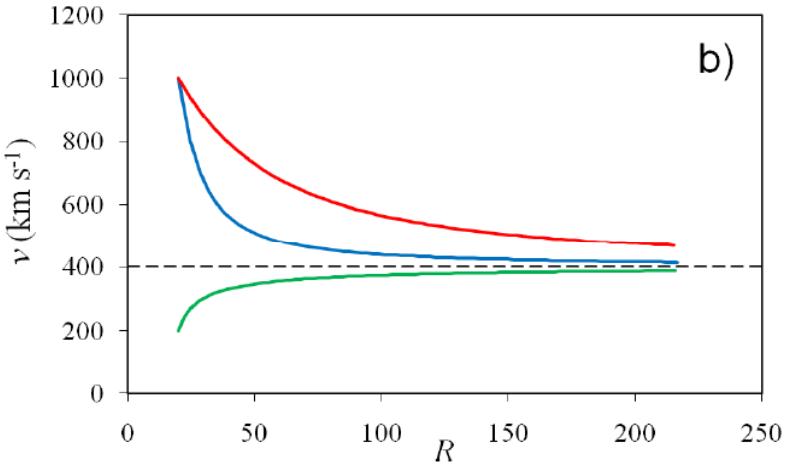
ICME propagation - Drag Based Model (DBM)

Vrsnak et al. A&A 2010

$$a = a_{\mathrm{L}} - g + a_{\mathrm{d}},$$

$$a \approx -\gamma\,(v-w)\,|v-w|,$$

$$\gamma = c_{\mathrm{d}}\,A\rho_{\mathrm{w}}\,/\,m\,,$$



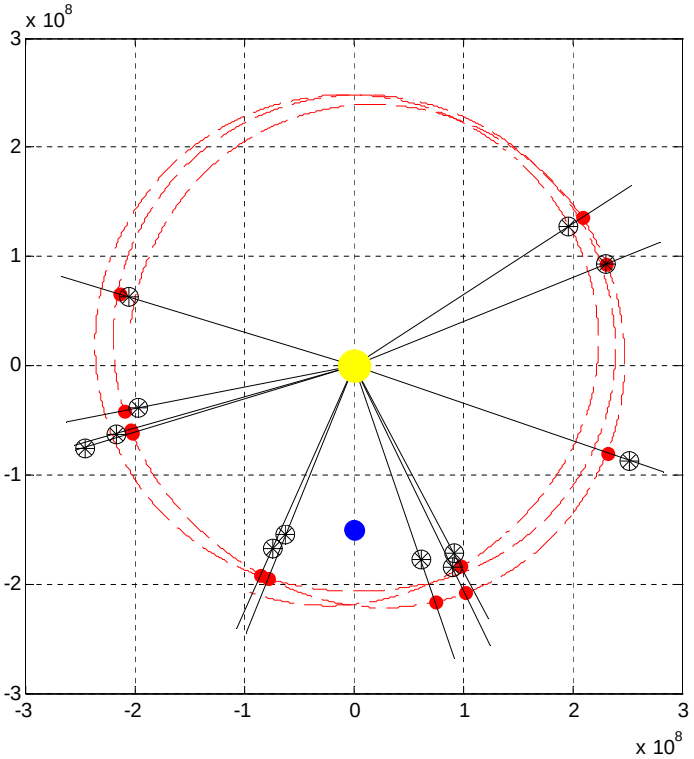
3 parameters:

-drag parameter: γ

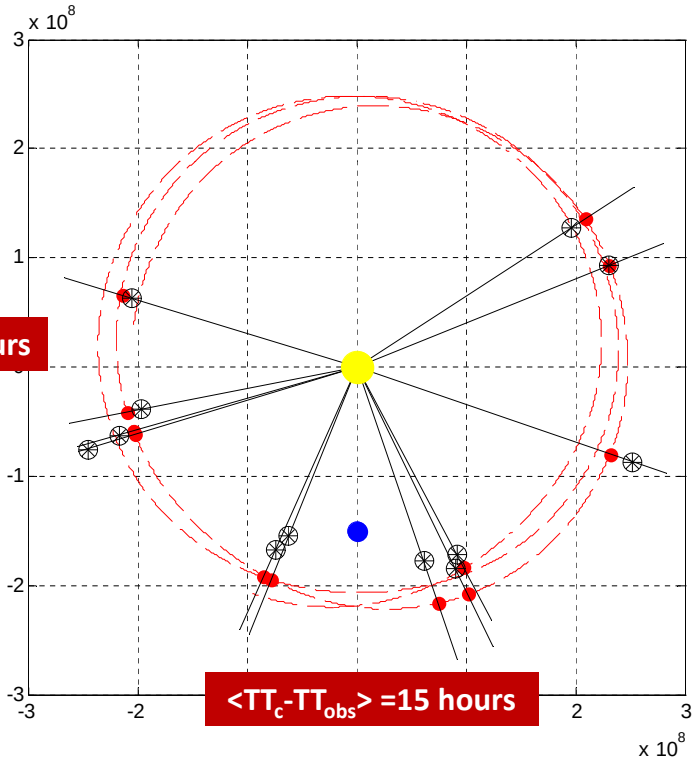
-lift-off speed: v_0

-ambient speed: w_1

Prediction of ICME arrival at Mars (DBM, gamma=0.2)



Prediction of ICME arrival at Mars (DBM, gamma=0.2)



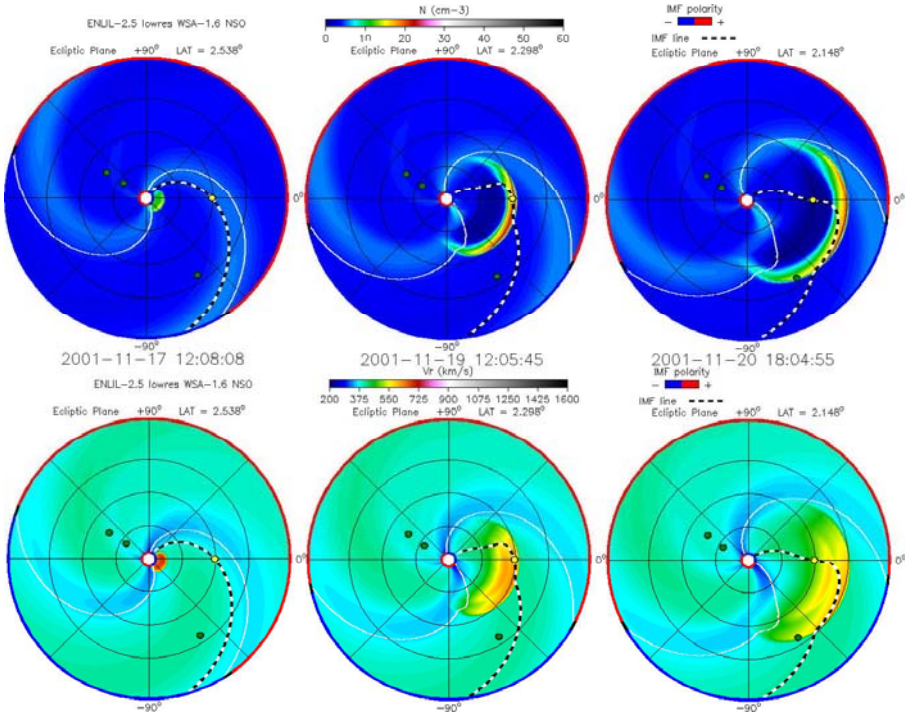
<TT_c-TT_{obs}> = -3 hours

<TT_c-TT_{obs}> =15 hours

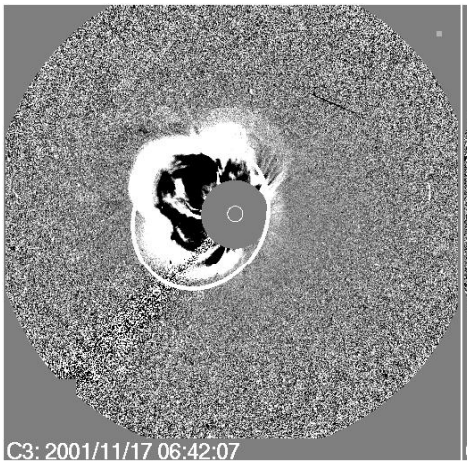
ENLIL

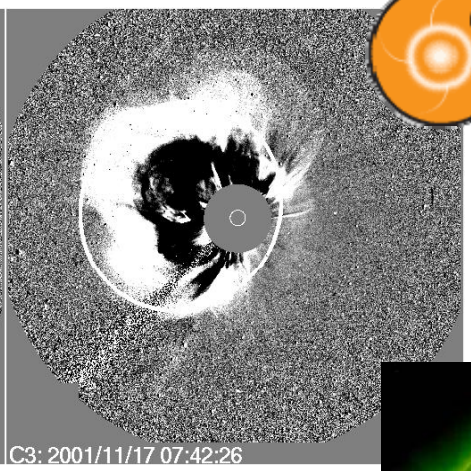
COMMUNITY COORDINATED MODELING CENTER

- 3D Heliosperic full MHD model
- Available online through CCMC (Community Coordinated Modelling Center, at GFSC, NASA
- Developed by Dusan Odstrcil
- Input: Potential Field source model (WSA or MAS) built on magnetograms
- Allows Cone insertion (CME) – no magnetic cloud

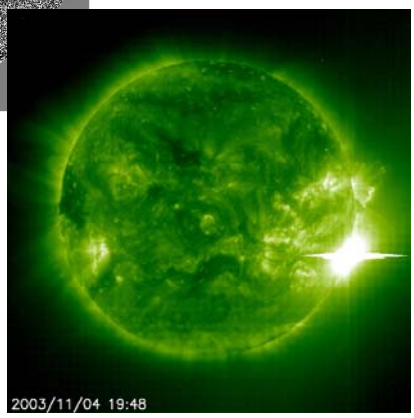


Determining ICME propagation direction

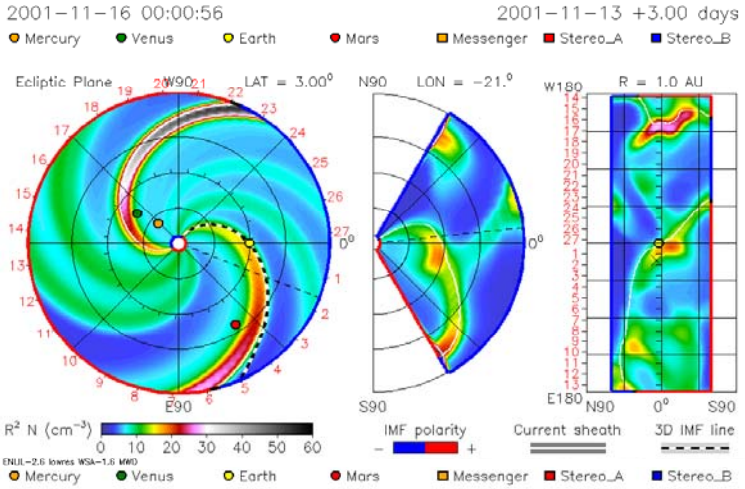




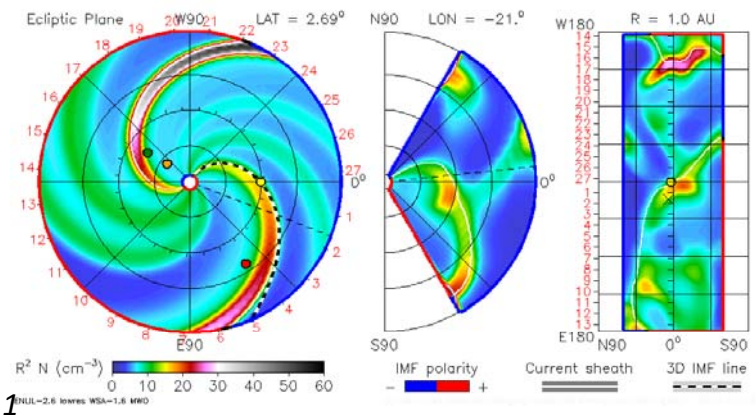
COMMUNITY COORDINATED MODELING CENTER



CME direction determined using LASCO



CME direction determined from flare position.



Falkenberg et al., JGR, 2011

Summary

Examining Mars Global Surveyor MAG/ER data we find:

- Storms at Mars are driven by dynamic pressure enhancements in connection with heliospheric current sheet crossings and/or fast speed streams in the solar wind (ICME/CIR)
- There is a clear Mars-annual variation in the number of storms due to the eccentricity of the Martian orbit
- Storms at Mars mainly occur close to interplanetary sector boundaries, (i.e. they are more predictable) in opposition to storms at Earth.
- The ER data can be used to detect passage of fast ICMEs: Most of the largest events seem to be driven by fast ICMEs, and are not always observed close to sector boundaries
- The drag-based model using LASCO CME-speed as input give reasonable estimates of arrival time (within ~1 day), but there is indication of variation with Earth-Mars longitudinal separation
- ENLIL runs demonstrate that the direction of ICME propagation is an important input parameter, i.e. it can introduce errors in arrival time of ~1 day.