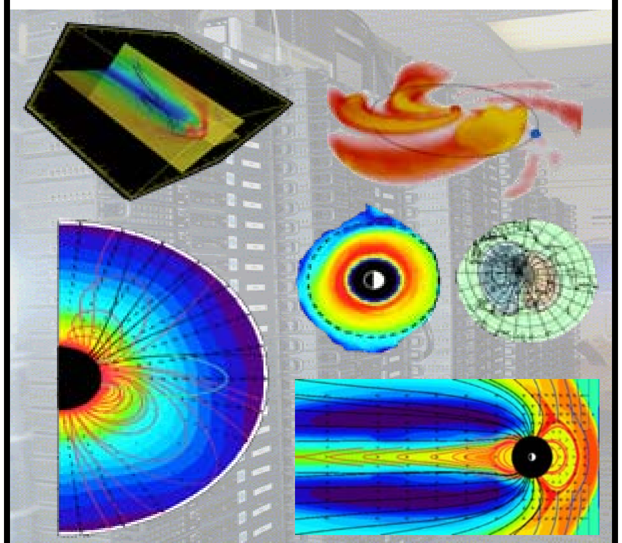
Community Coordinated Modeling Center



On-Line Education Material at CCMC

George Siscoe,

M. Kuznetsova, A. Chulaki, D. Berrios A. Taktakishvili, A. Pulkkinen, L. Rastaetter, M. Hesse M. Maddox, P. MacNeice

Outline

- CCMC Support of Heliophysics Summer School
- General Purpose Runs for Education and Research
- Idea of On-line Educational Courses on Space Physics and Space Weather that Use CCMC Simulations
- DEMO of the First of the Series of Modules on Earth's Magnetosphere (George Siscoe, Anna Chulaki)

Detecting, Forecasting and Modeling of the 2002/04/17 Halo CME

Results of ENLIL with cone model simulation

Run Number	Event Carrington Rotation	Carrington Rotation Start Time	Carrington Rotation End Time	Model	Validation Level
CCMC_CCMC_042208_SH_2	1988	2002/03/30 01:04:39.3600	2002/04/26 07:32:35.5200	ENLIL with cone model	0

Results of global MHD model BATSRUS driven by SW predicted by ENLIL and by ACE data

Run Number	Key Words	Model	Model Version	Grid	Event Date	Start Time	End Time
George_Siscoe_051608_1	Heliophysics summer school: BATSRUS driven by ACE	BATSRUS	v7.73	2M	2002-04-19	2002/04/19 00:00	2002/04/20 00:00
George_Siscoe_061808_1	Heliophysics summer school: BATSRUS driven by ENLIL	BATSRUS	v7.73	--	2002-04-19	2002/04/19 00:03	2002/04/20 00:01

Heliophysics Summer School 2008 George Siscoe

Detecting, Forecasting and Modeling of the 2002/04/17 Halo CME

Tutorial and Exercises

Sandro Taktakishvili

- What is a CME/ICME?
- CME detection by SOHO instruments (EXERCISE 1)
- CME velocity estimate (EXERCISE 2)
- ICME detection by ACE satellite (EXERCISE 3)
- Estimate of ICME arrival time (EXERCISE 4)
- ENLIL cone model for CME/ICME propagation (EXERCISE 5)
- Prediction of the magnitude of ICME impact on the magnetosphere by ENLIL cone model (EXERCISE 6)
- Magnetopause standoff distance prediction (EXERCISE 7)
- CME deceleration (EXERCISE 8)

- Complete TUTORIAL (in Powerpoint format)

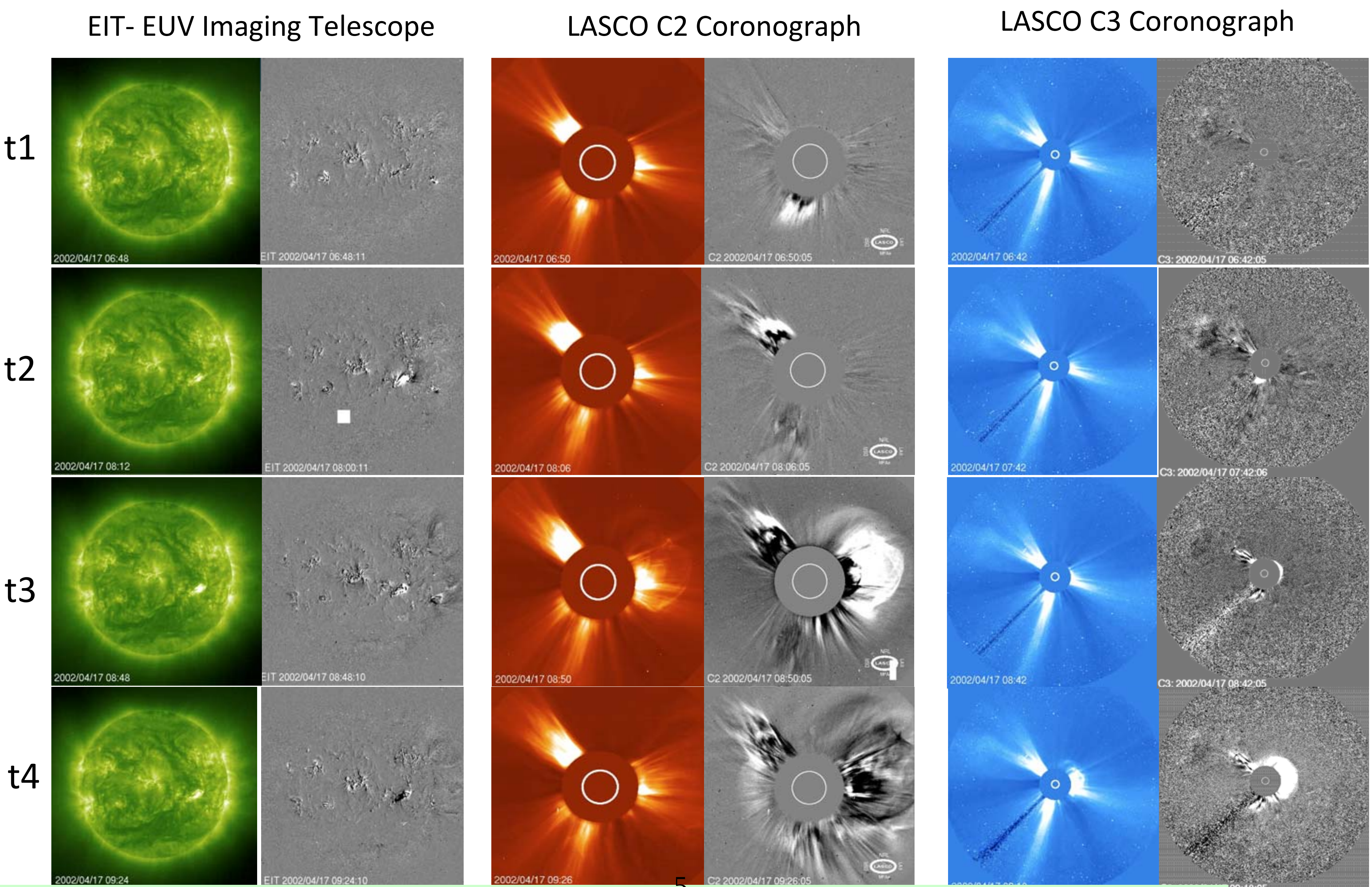
- Shock Arrival Time Results (in Powerpoint format)

Geomagnetically Induced Currents

Antti Pulkkinen

- Modeled global geoelectric field (gif movie)
- The global GIC proxy computed from the global geoelectric field
- The GIC modeled to one of the North American power grid nodes
- The GIC observed at one of the North American power grid nodes (the same station as for the modeled one above)
- Tutorial on calculating GIC (in PDF format)
- GIC Exercises (in PDF format)

SOHO Satellite Instrument Images for 4 Moments of time t1<t2<t3<t4.



Exercise 1: Which instrument has detected the CME appearance first and when?

Average CME Speed from the Catalog at IACS CUA

(http://cdaw.gsfc.nasa.gov/CME_list/)

(Exercise 4)

There were 8 halo CMEs in March and April of 2002 listed in this catalog.

CME date	Catalog POS speed At 2 Rs (km/sec)
2002/03/10	1429
2002/03/11	950
2002/03/14	907
2002/03/15	957
2002/03/18	989
2002/03/20	603

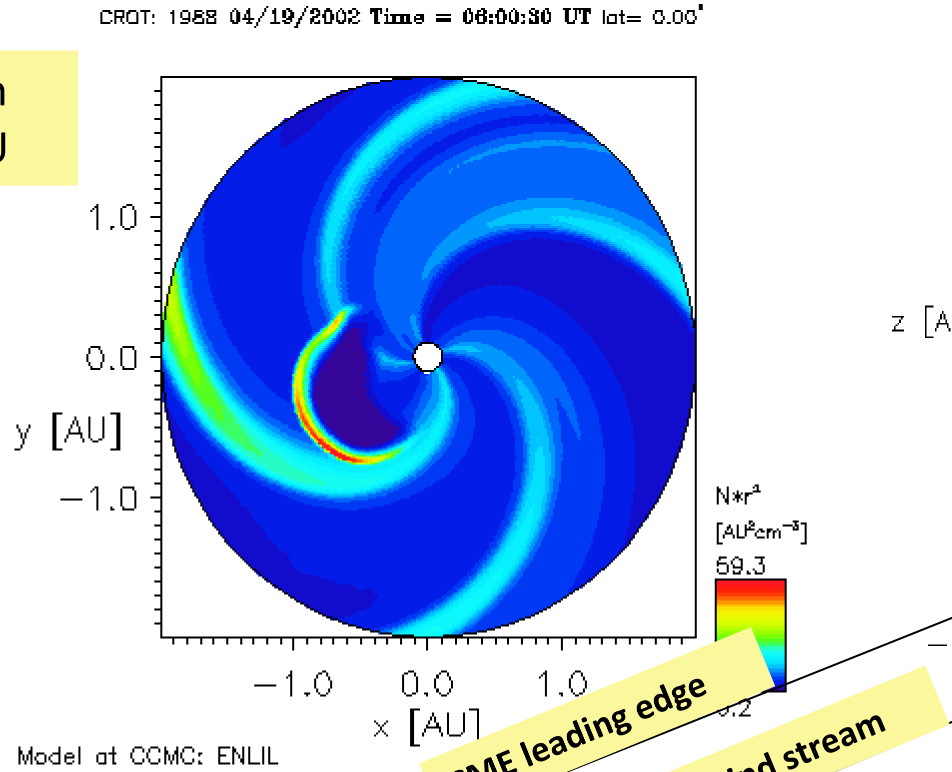
The table shows halo CMEs in March and April 2002 listed in the catalog, just before 2002/04/17 CME occurred. One of the ways of forecasting CME arrival times is to estimate the propagation time of an "average" speed CME.

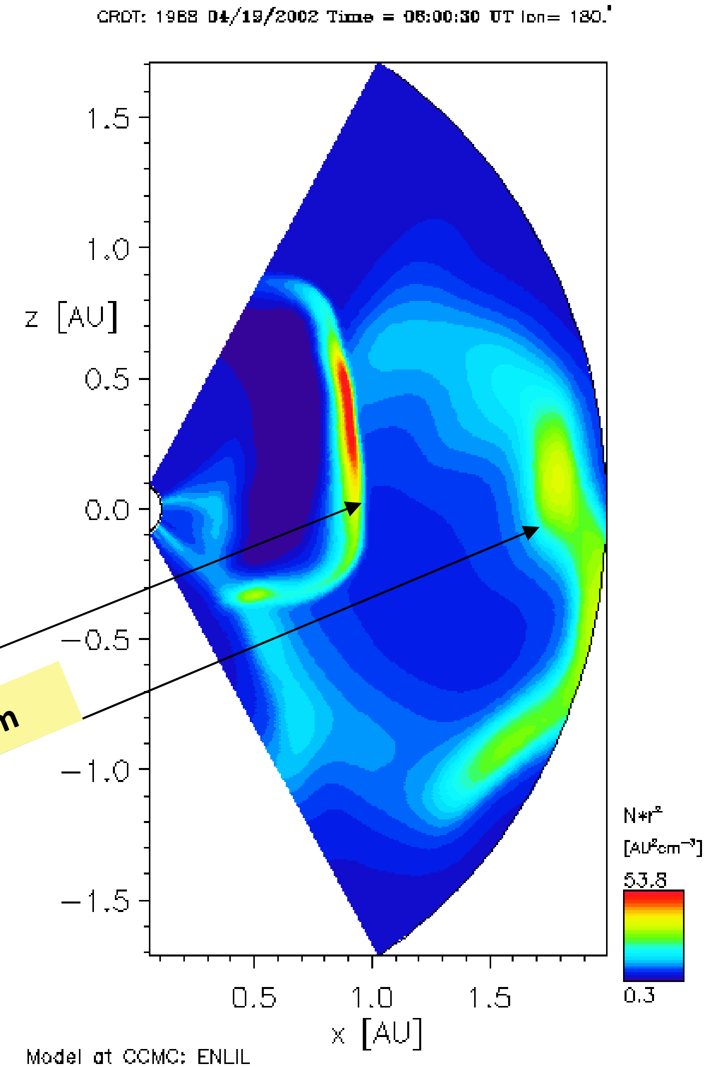
Exercise 4:

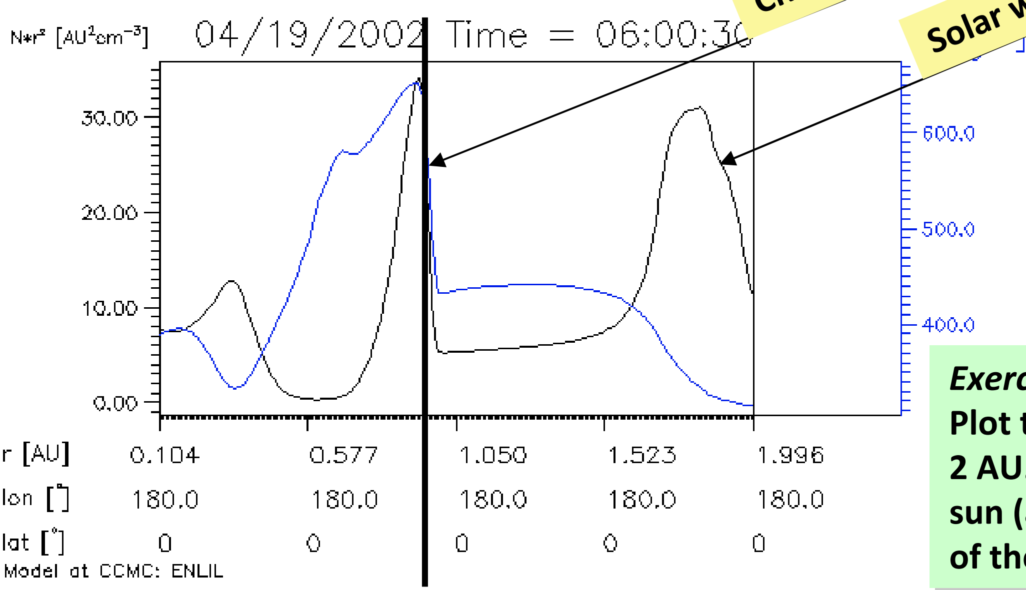
Taking the average of halo CME speeds listed in the Table estimate the arrival time of the "average" speed CME to the Earth and compare it to the observed arrival time and the arrival time obtained in the Exercise 3.

Which of the estimates worked better?

The CME when it reaches 1 AU







Exercise 8:

Plot the progress of the CME leading edge from its origin to 2 AU. Obtain the velocity as a function of distance from the sun (also as a function of time). Estimate the deceleration of the CME as a function of distance.

Shock Arrival Time Results

CME Detection by ACE Satellite

Apr 19, 08:00

$\Delta T = 48$ h

Climatology Model

Apr 19, 00:00

$\Delta T = 40$ h

LASCO C2 Image Analysis

1.Apr 18, 20:00

$\Delta T_1 = 36$ h

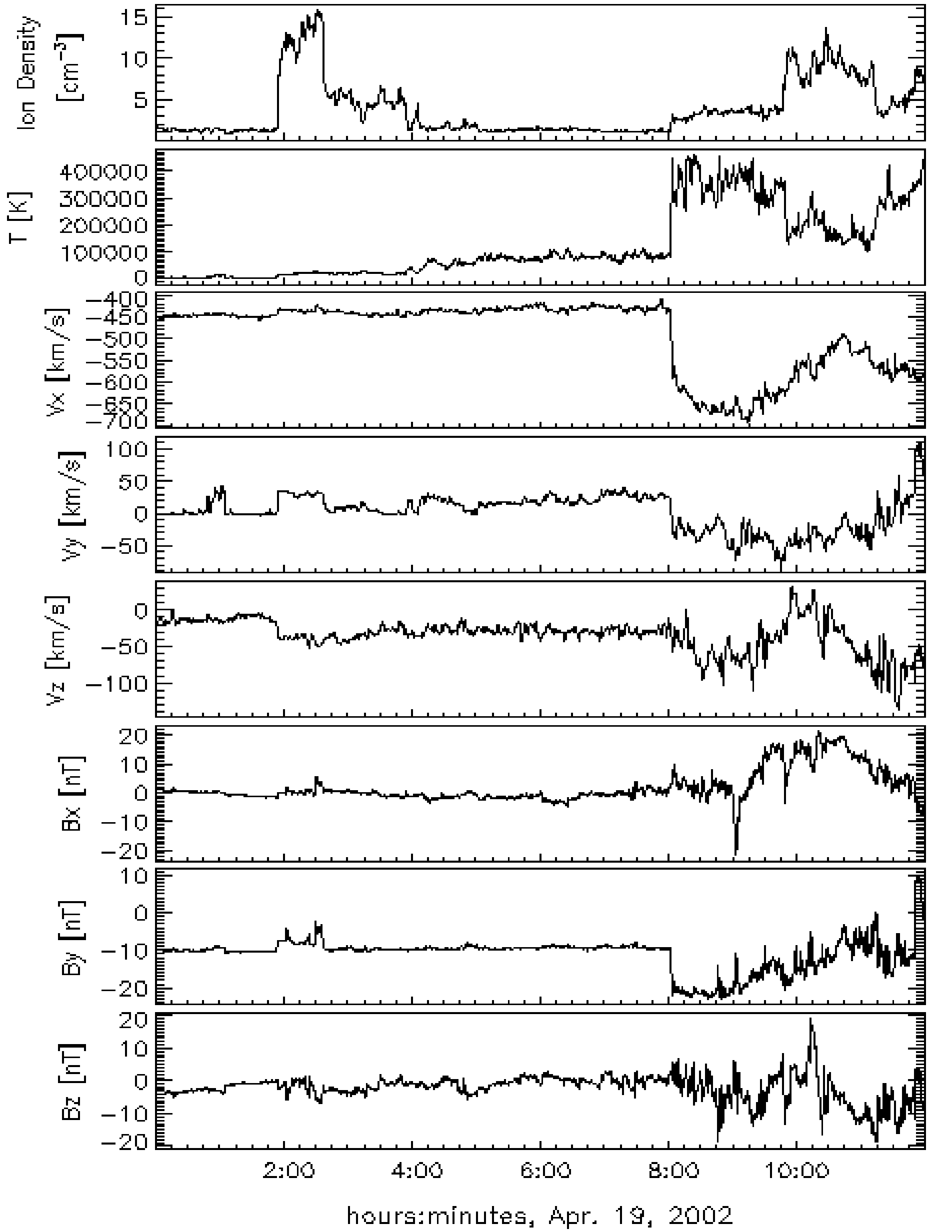
2. Apr 19, 05:00

$\Delta T_2 = 45$ h $\Delta T_2 = (5/4)\ \Delta T_1$

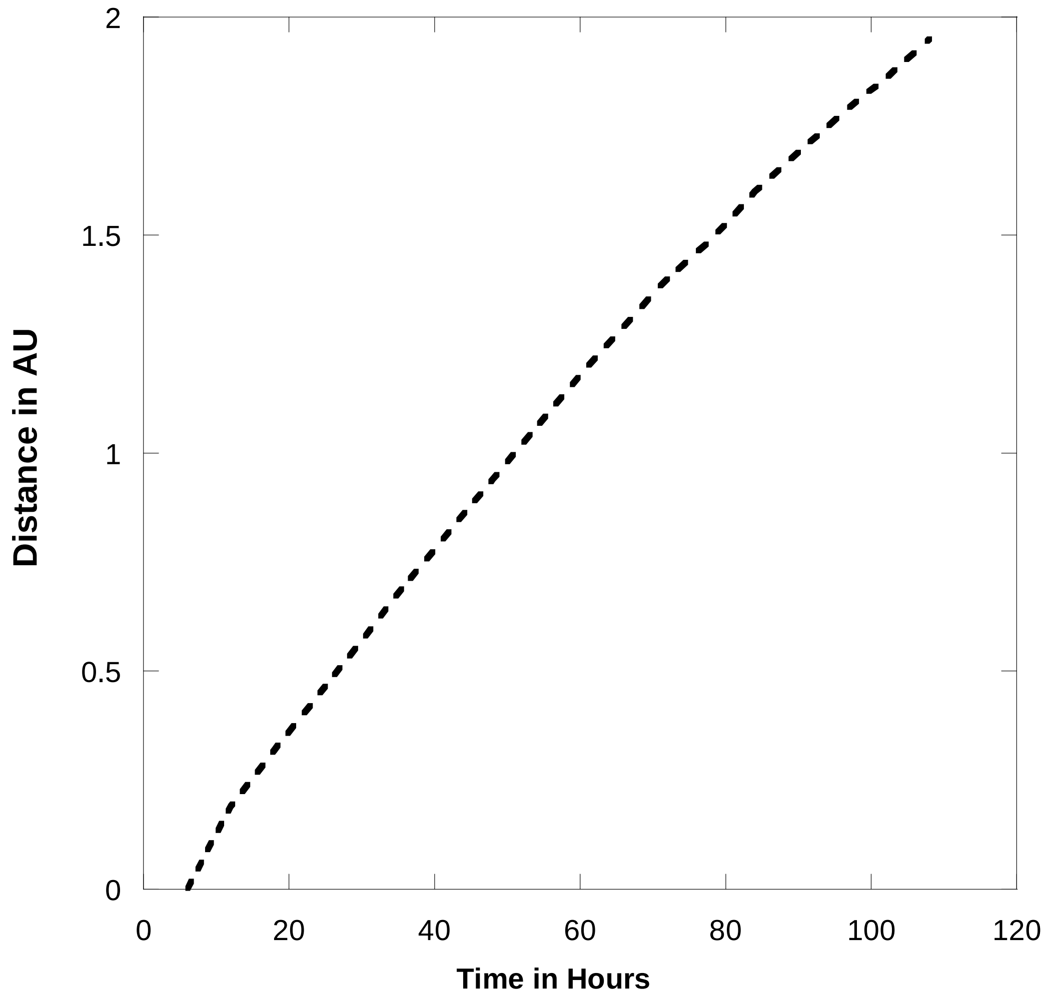
Enlil Cone Model

Apr 19, 07:00

$\Delta T = 47$ h



CME Leading Edge Position



General Purpose Runs for Education and Research

MAGNETOSPHERE: Models BATSRUS, OpenGGCM
I. Generic Steady-State Magnetosphere
Vy=Vz=0, Temp: 20 eV, No Corotation
Ionosphere conductance model notation: p = Pedersen, h = Hall

> 100 runs

Sort by: Model | Vx | IMF Clock Angle | SW Density (N) | IMF Magnitude (|B|) | IMF Bz | IMF By | Conductance Model

Total Number of Runs in the Database: 1660
Number of Educational Runs in this Database: 37

Model	Model Version	V_x	N	|B|	IMF Clock Angle	B_x	B_y	B_z	Conductance Model	Diploe Tilt	Run Number
OpenGGCM	2.1-1	-400.00000	5.00000	5.00000	0.00000	0.00000	0.00000	5.00000	uniform(p=5;h=5)	0.00	CCMC_CCMC_111605_2
BATSRUS with RCM	v7.73	-400.00000	5.00000	5.00000	0.00000	0.00000	0.00000	5.00000	uniform(p=5;h=5)	0.00	CCMC_CCMC_111605_1
BATSRUS with RCM	v7.73	-400.00000	5.00000	5.00000	90.00000	0.00000	5.00000	0.00000	uniform(p=5;h=5)	0.00	CCMC_CCMC_111605_3
OpenGGCM	2.1-1	-400.00000	5.00000	5.00000	90.00000	0.00000	5.00000	0.00000	uniform(p=5;h=5)	0.00	CCMC_CCMC_111605_4
BATSRUS with RCM	v7.73	-400.00000	5.00000	5.00000	180.00000	0.00000	0.00000	-5.00000	uniform(p=5;h=5)	0.00	CCMC_CCMC_111605_5
OpenGGCM	2.1-1	-400.00000	5.00000	5.00000	180.00000	0.00000	0.00000	-5.00000	uniform(p=5;h=5)	0.00	CCMC_CCMC_111605_6
BATSRUS	v7.73	-400.00000	5.00000	5.00000	0.00000	0.00000	0.00000	5.00000	uniform(p=5;h=5)	0.00	CCMC_CCMC_111705_1
OpenGGCM	2.1-1	-400.00000	30.00000	5.00000	0.00000	0.00000	0.00000	5.00000	uniform(p=5;h=5)	0.00	CCMC_CCMC_112305_1
OpenGGCM	2.1-1	-400.00000	5.00000	20.00000	0.00000	0.00000	0.00000	20.00000	uniform(p=5;h=5)	0.00	CCMC_CCMC_120505_1
OpenGGCM	2.1-1	-400.00000	5.00000	20.00000	180.00000	0.00000	0.00000	-20.00000	uniform(p=5;h=5)	0.00	CCMC_CCMC_120505_2
BATSRUS	v7.73	-400.00000	5.00000	5.00000	90.00000	0.00000	5.00000	0.00000	uniform(p=5;h=5)	0.00	CCMC_CCMC_121205_1
BATSRUS	v7.73	-400.00000	5.00000	5.00000	180.00000	0.00000	0.00000	-5.00000	uniform(p=5;h=0)	0.00	CCMC_CCMC_011006_1
BATSRUS	v7.73	-400.00000	15.00000	5.00000	180.00000	0.00000	0.00000	-5.00000	uniform(p=5;h=0)	0.00	CCMC_CCMC_011006_2
BATSRUS	v7.73	-400.00000	30.00000	5.00000	180.00000	0.00000	0.00000	-5.00000	uniform(p=5;h=0)	0.00	CCMC_CCMC_012006_1
BATSRUS	v7.73	-700.00000	5.00000	5.00000	180.00000	0.00000	0.00000	-5.00000	uniform(p=5;h=0)	0.00	CCMC_CCMC_012006_2
BATSRUS	v7.73	-700.00000	15.00000	5.00000	180.00000	0.00000	0.00000	-5.00000	uniform(p=5;h=0)	0.00	CCMC_CCMC_012006_3
BATSRUS	v7.73	-1000.00000	5.00000	5.00000	180.00000	0.00000	0.00000	-5.00000	uniform(p=5;h=0)	0.00	CCMC_CCMC_012506_1
BATSRUS	v7.73	-1000.00000	15.00000	5.00000	180.00000	0.00000	0.00000	-5.00000	uniform(p=5;h=0)	0.00	CCMC_CCMC_020906_1
BATSRUS	v7.73	-1000.00000	30.00000	5.00000	180.00000	0.00000	0.00000	-5.00000	uniform(p=5;h=0)	0.00	CCMC_CCMC_020906_2

On-line Educational Courses on Space Physics and Space Weather

- Combine CCMC simulations with tutorials.
- Can be utilized by teaches, researchers.
- Repository of lectures.
- Cool features of on-line tools. Flexibility: user/student can stop, restart, go back, click on links with supplemental material.
- Cannot ask question. Frequently asked questions (asked through the e-mail) can be periodically updated.
- Feedback/Ideas/Participation are invited.

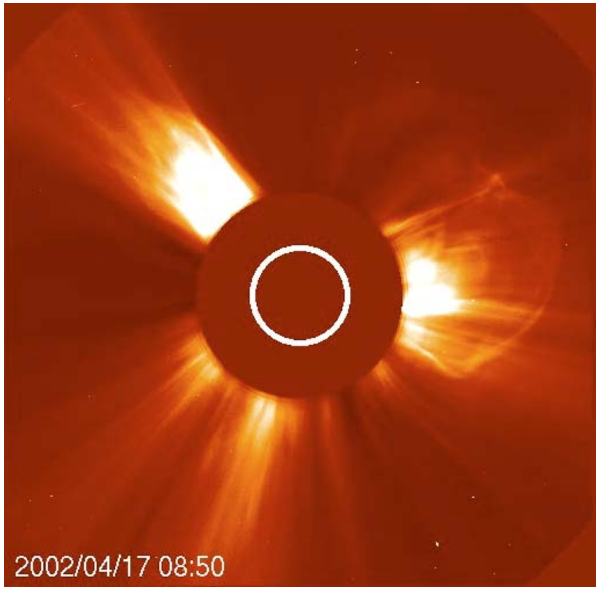
Supplementary Slides

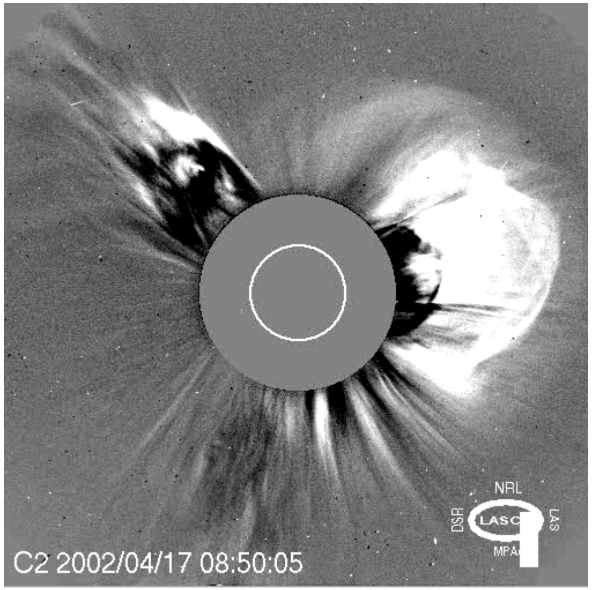
CME Velocity Estimate

C2 Coronograph Image for the Moment of Time t3

The CME is very prominent in C2 image, but yet barely noticeable in C3 image.

t3





Exercise 2:

Estimate the projection of speed of the CME on the plane of sky V. Assume that the CME leading edge reached the C2 window edge in horizontal direction (4Rs, solar radius Rs=700,000 km) at the moment of time 2002/04/17 08:50 UT. The CME start time 2002/04/17 08:00 UT.

What is a CME/ICME ?

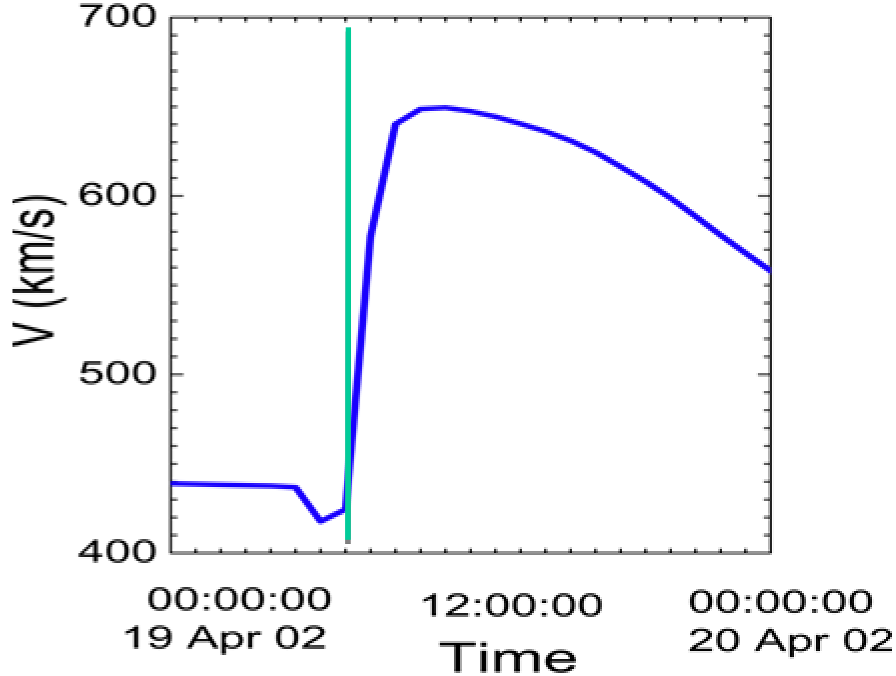
A coronal mass ejection (CME) is an ejection of material from the solar corona, detected remotely with a white-light coronagraph.

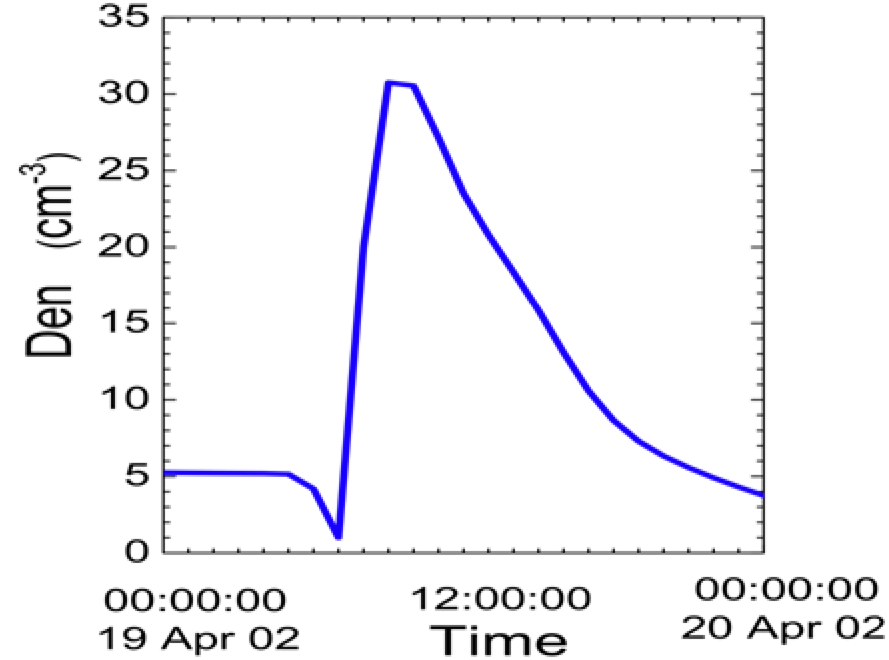
When the CME reaches the Earth as an ICME (Interplanetary CME), it may disrupt the Earth's magnetosphere, compressing it on the dayside and extending the nightside tail.

The most severe geomagnetic storms are caused by CME events. CMEs can result in damage to satellites, disruption of radio transmissions, damage to electrical transmission lines and power outages. That is why knowing the arrival time of CMEs at the Earth accurately and it’s possible magnitude of impact is of crucial importance in predicting space weather.

Here we are studying a CME that was ejected from the sun on April 17, 2002 and reached the Earth approximately 48 hours later.

ENLIL Cone Model SAT Prediction

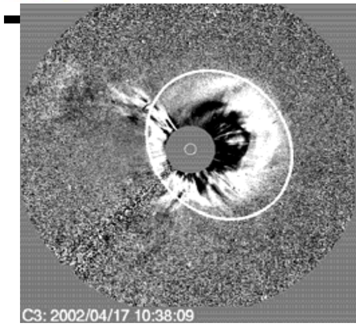


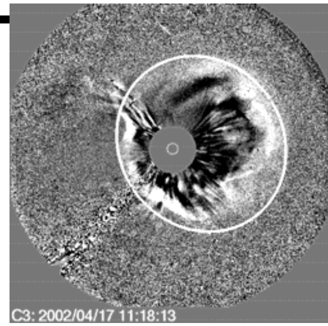


ENLIL: Density and velocity magnitude of the solar wind at the ACE position
(R=0.99 AU, Latitude=0 deg, Longitude=180 deg)

Enlil Cone Model
Apr 19, 07:00
$\Delta T = 47$ h

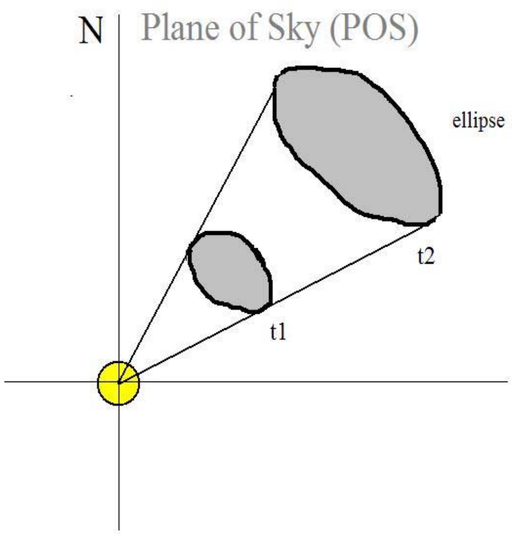
Cone Model for Halo CME





The concept:

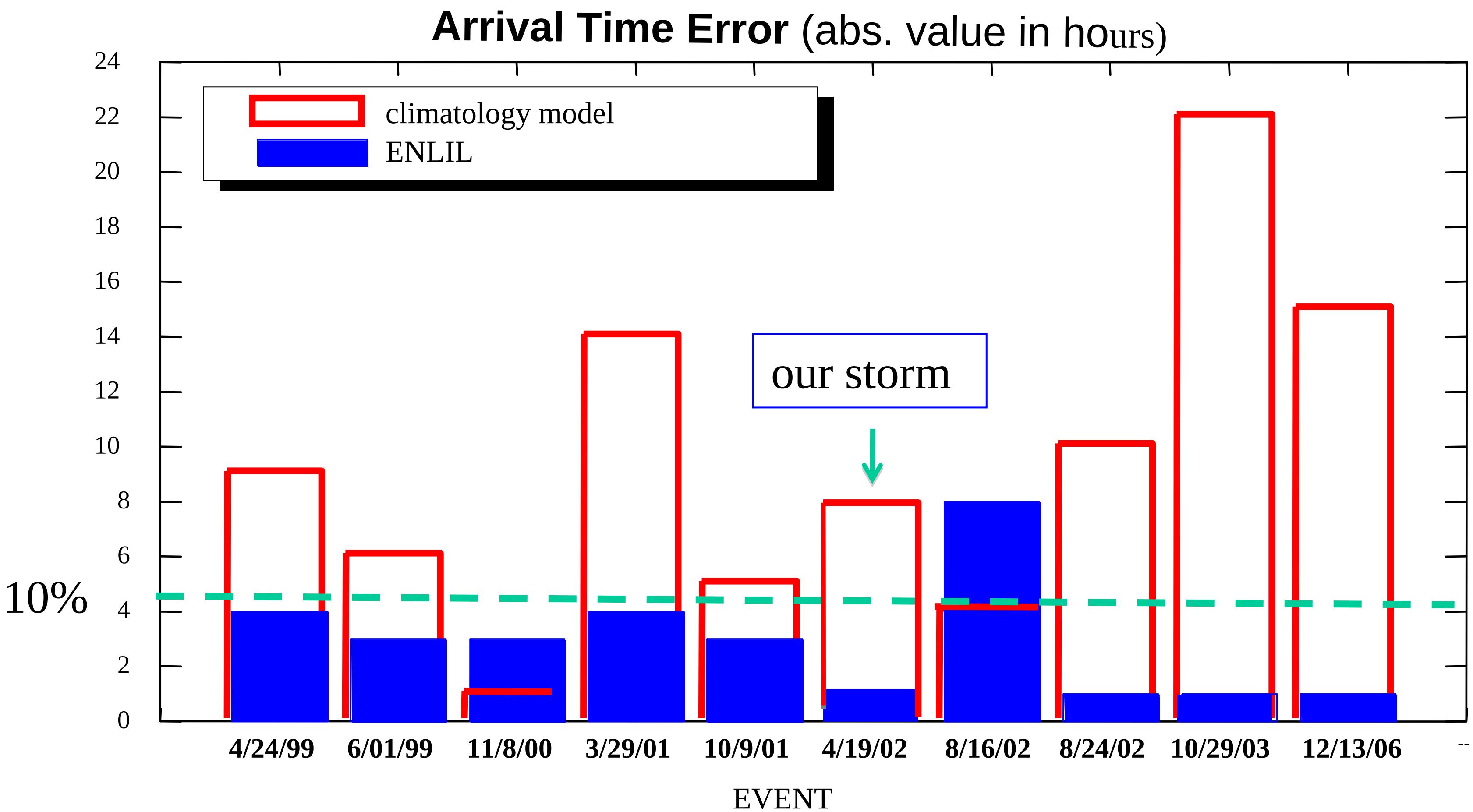
- CME propagates with nearly constant angular width in a radial direction
- The source is near the solar disc centre
- CME bulk velocity is radial and the expansion is isotropic



Analytical method:

- The projection of the cone on the POS is an ellipse
- From two ellipses of two consecutive C3 running difference images we can derive the CME radial speed and the cone orientation – input to the ENLIL heliosphere model

Shock Arrival Time Error For 10 CMEs
Enlil Cone Model vs. Climatology



Enlil Cone Model: < 10% error in 90% of events