

State of NOAA-SEC/CIRES STEREO Heliospheric Models

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University of Colorado/CIRES & NOAA/Space Environment Center

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Collaborators

- ✉ Nick Arge – AFRL, Hanscom, MA
- ✉ Chris Hood – University of Colorado, Boulder, CO
- ✉ Jon Linker – SAIC, San Diego, CA
- ✉ Rob Markel – University of Colorado, Boulder, CO
- ✉ Leslie Mayer – University of Colorado, Boulder, CO
- ✉ Vic Pizzo – NOAA/SEC, Boulder, CO
- ✉ Pete Riley – SAIC, San Diego, CA
- ✉ Marek Vandas – Astronomical Institute, Prague, Czech Republic
- ✉ Xuepu Zhao – Stanford University, Standford, CA

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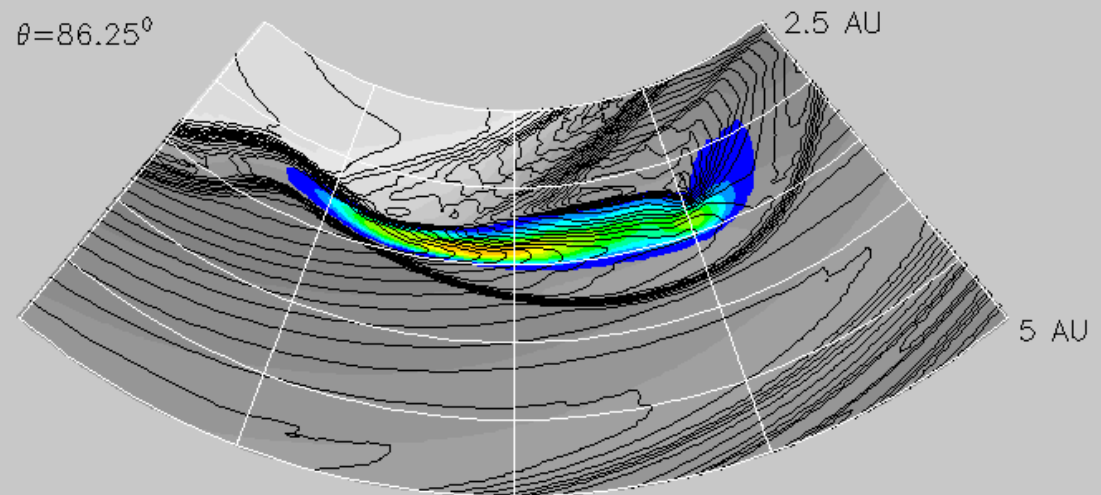
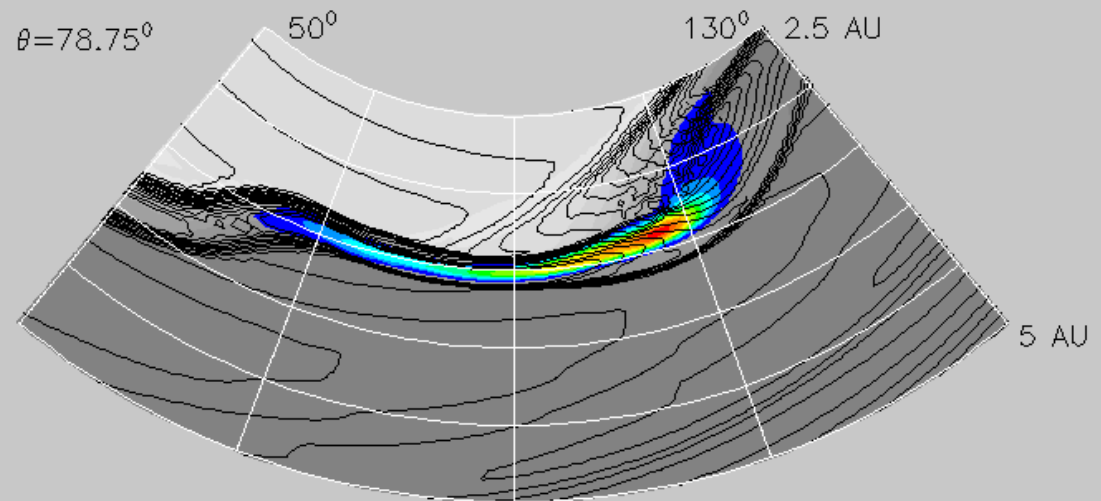
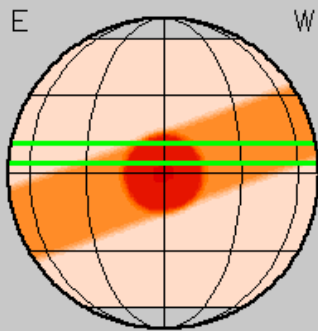
Input Data


- Analytic Models:
 - structured solar wind (bi-modal, tilted)
 - over-pressured plasma cloud (3-D)
 - magnetic flux-rope (3-D in progress)
- Empirical Models:
 - WSA source surface
 - SAIC source surface
 - CME cone model (location, diameter, and speed)
- Numerical Models:
 - SAIC coronal model (ambient + transient outflow)


Analytic Model – Distortion of ICME Study

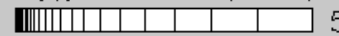
CASE = 1

DAY = 12



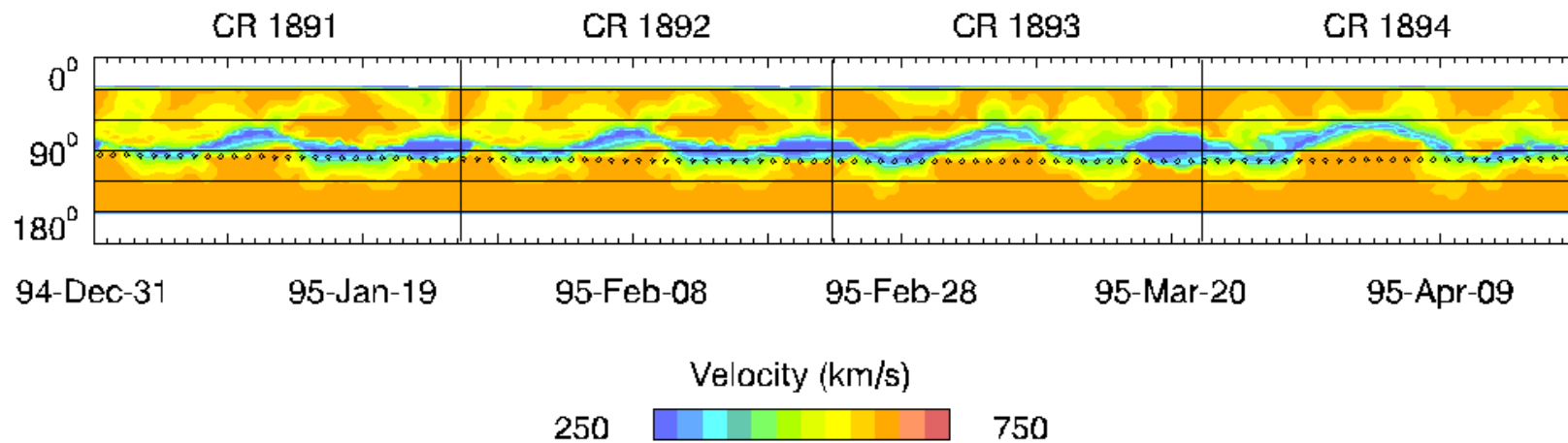
RADIAL VELOCITY (km/s)
300  800

INJECTED DENSITY (cm^{-3})
0.20  8.20

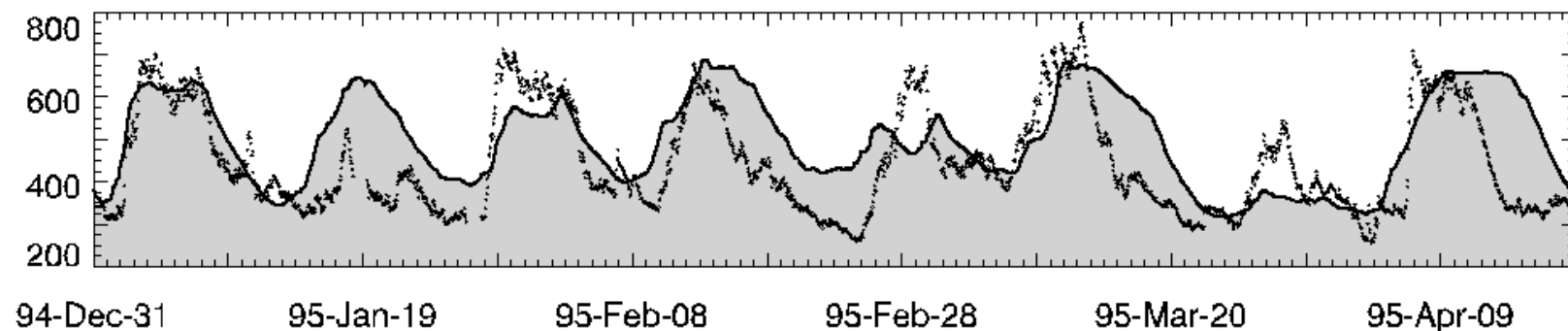
\log_{10} DENSITY (cm^{-3})
0.01  5.01

Empirical model - Ambient Solar Wind

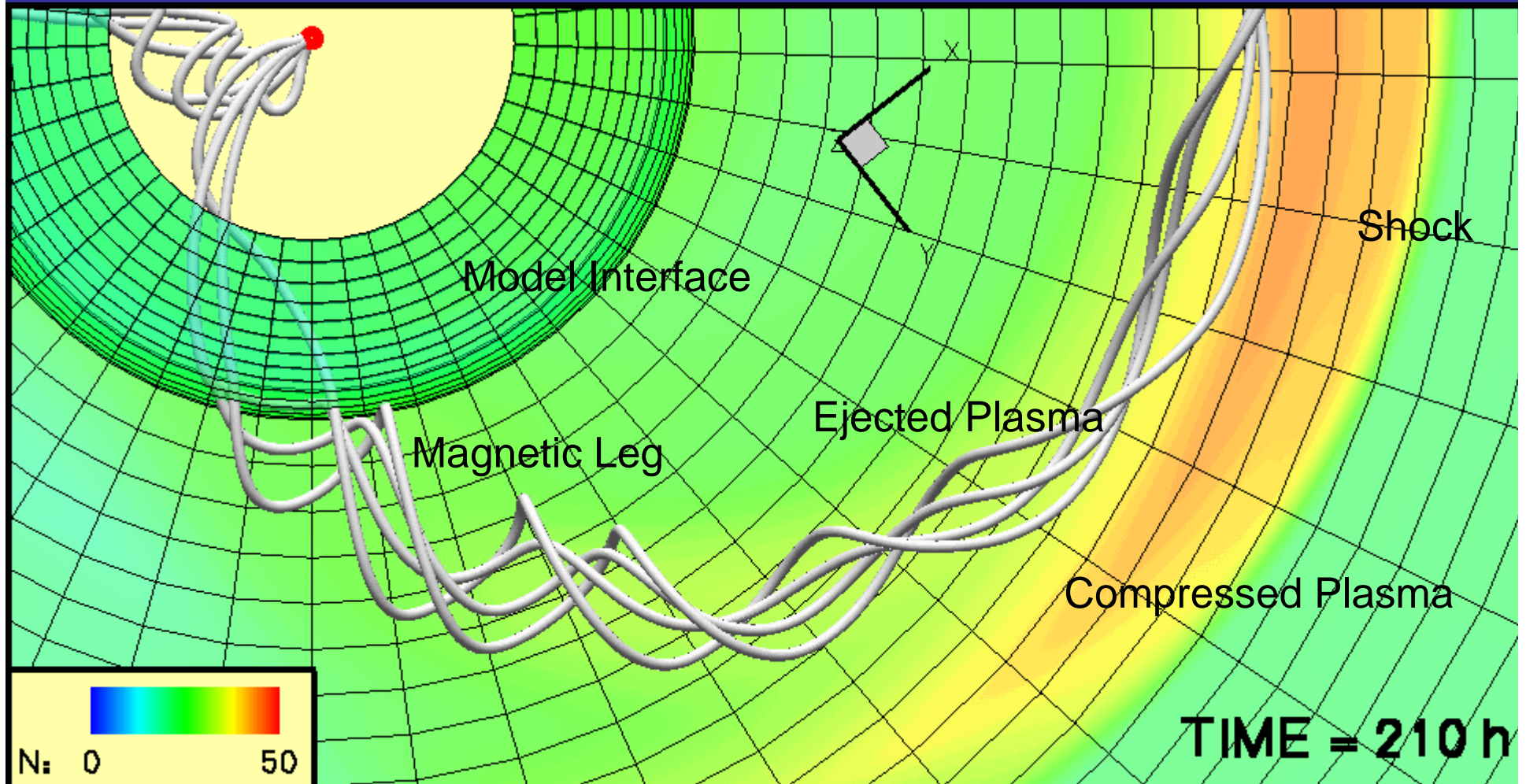
Derived Velocity at Source Surface



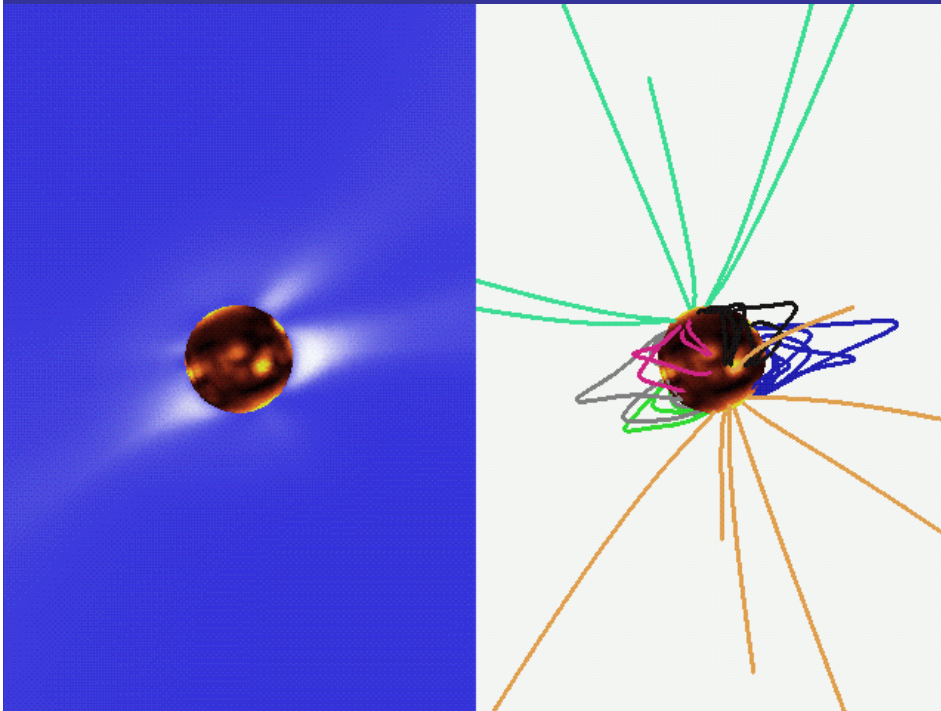
Observed and Predicted Velocity at Earth



Numerical Model -- Magnetic Flux Rope

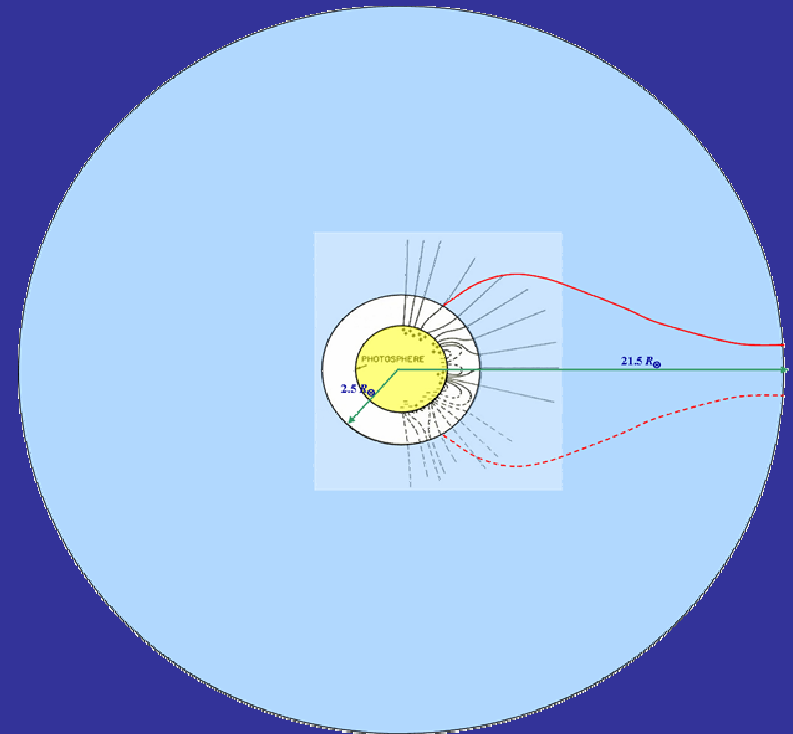


Ambient Solar Wind Models



SAIC 3-D MHD steady state coronal model based on photospheric field maps

[SAIC maps – Pete Riley]



CU/CIRES-NOAA/SEC 3-D solar wind model based on potential and current-sheet source surface empirical models

[WSA maps – Nick Arge]

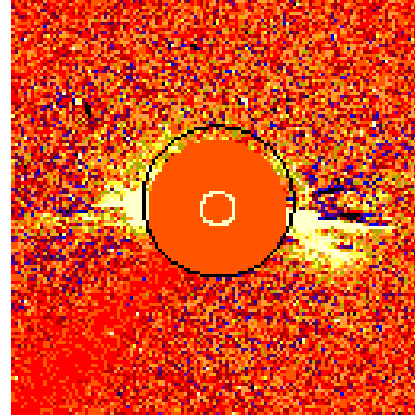
CME Cone Model

Best fitting for May 12, 1997 halo CME

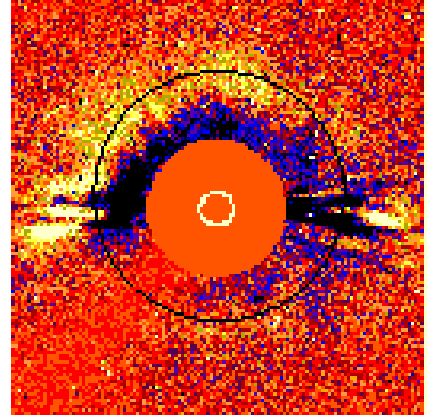
- latitude: N3.0
- longitude: W1.0
- angular width: 50 deg
- velocity: 650 km/s at 24 R_S
(14:15 UT)
- acceleration: 18.5 m/s²

[Zhao et al., 2001]

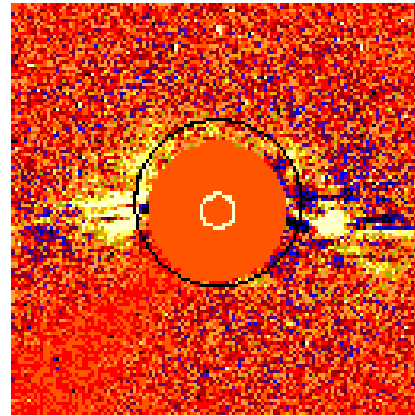
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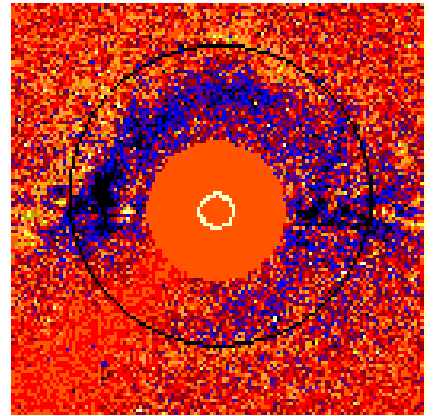
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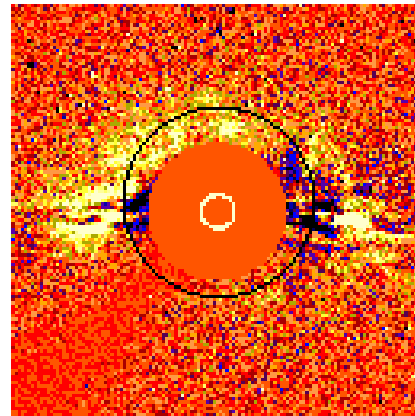
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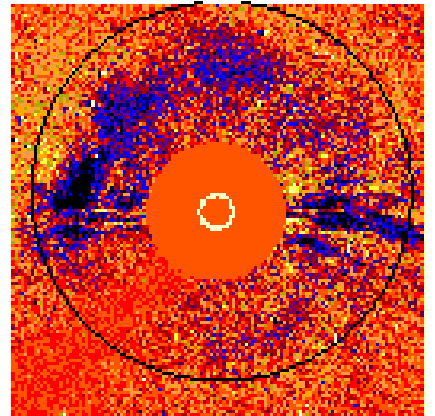
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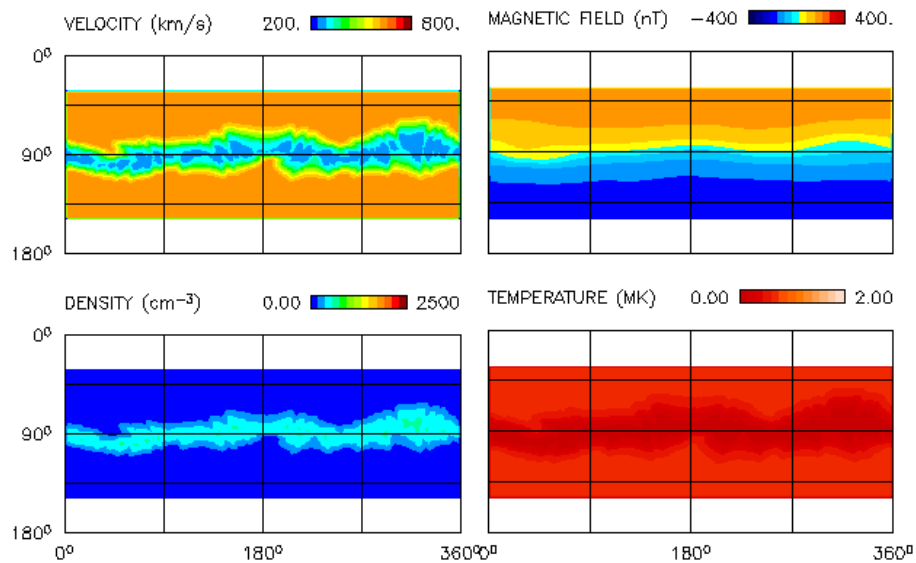
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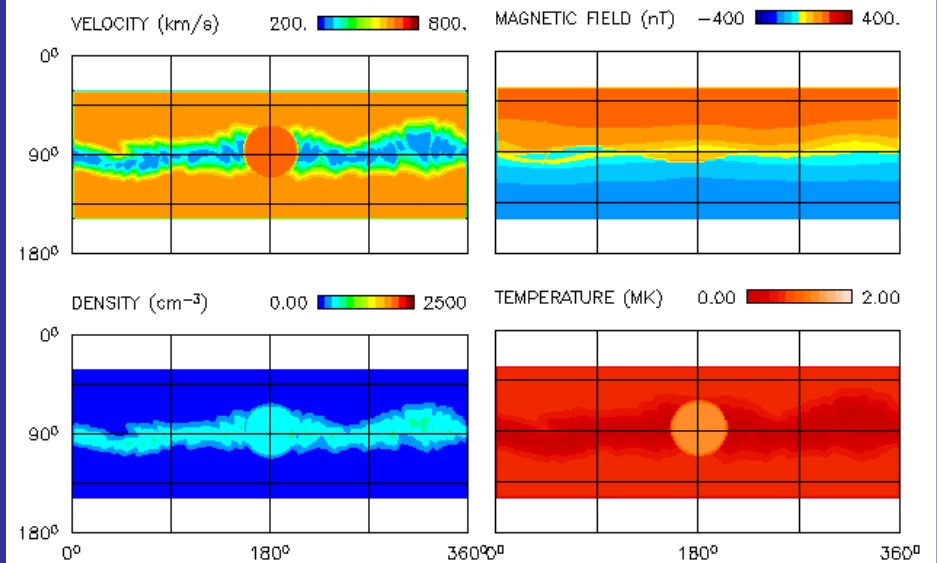
Time=14:21:00 r=24.0 lon=0.0 lat=1.00 vlat=0.00



Boundary Conditions

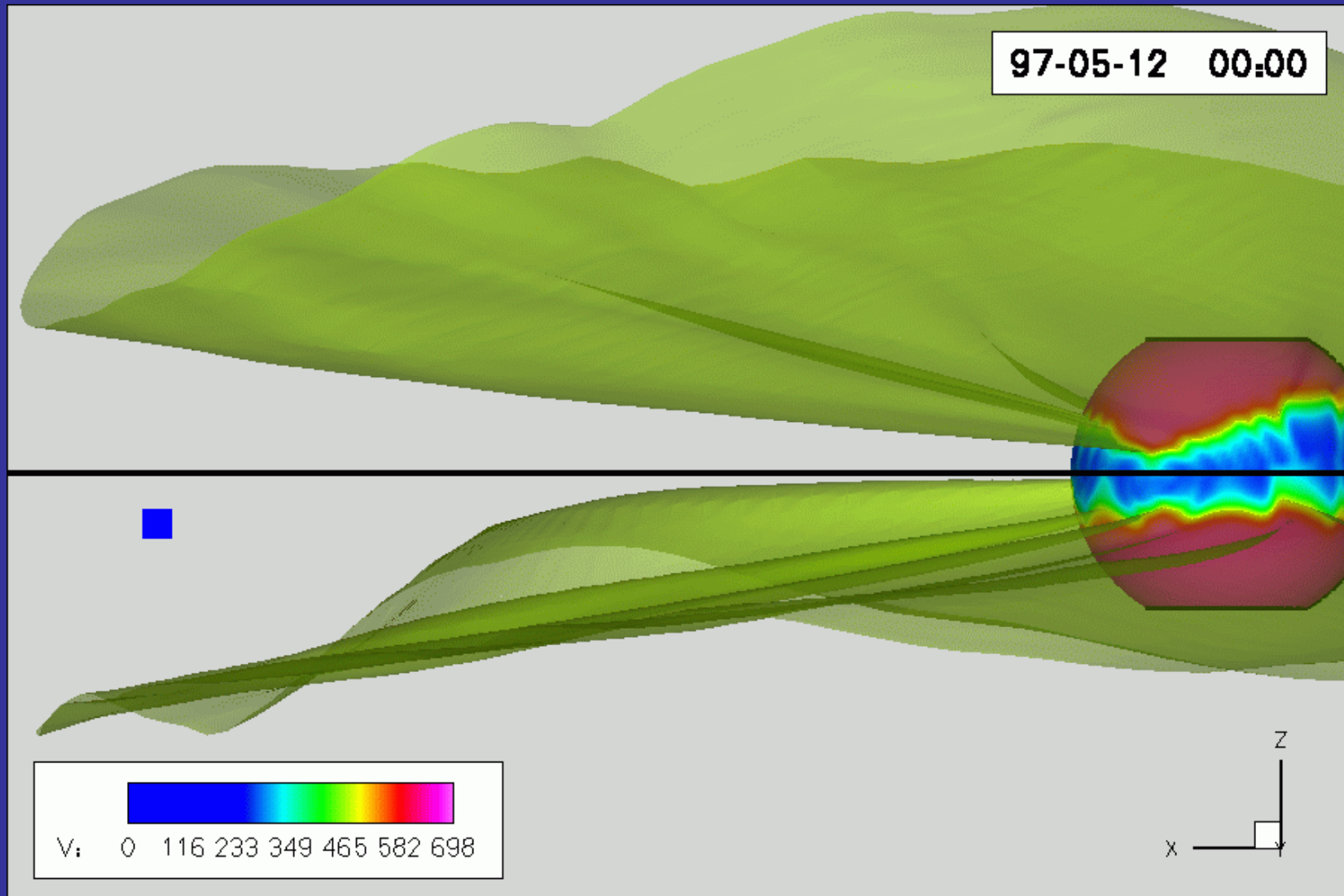


Ambient Solar Wind



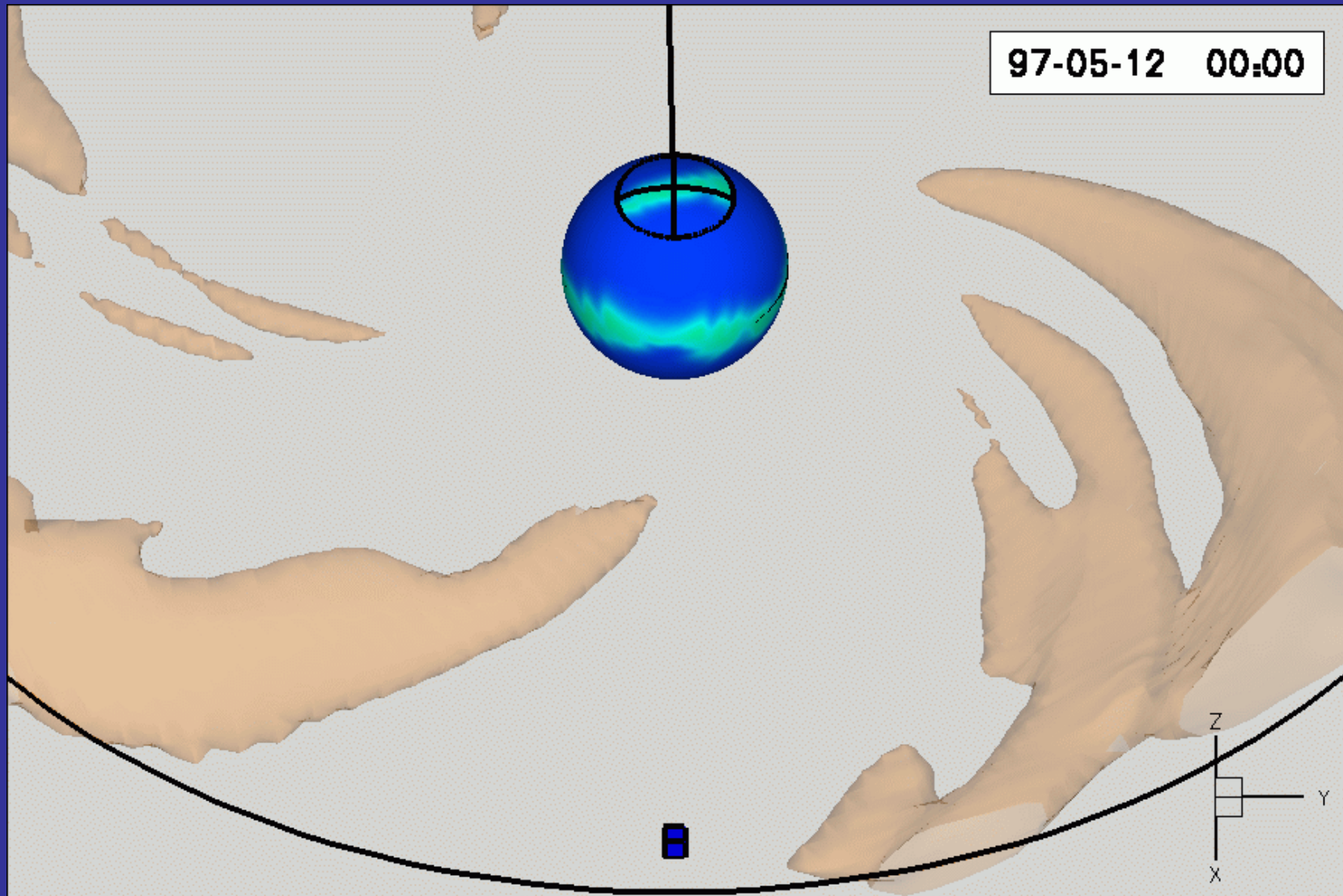
Ambient Solar Wind
+
Plasma Cloud

Latitudinal Distortion of ICME Shape



ICME propagates into bi-modal solar wind

Evolution of Density Structure

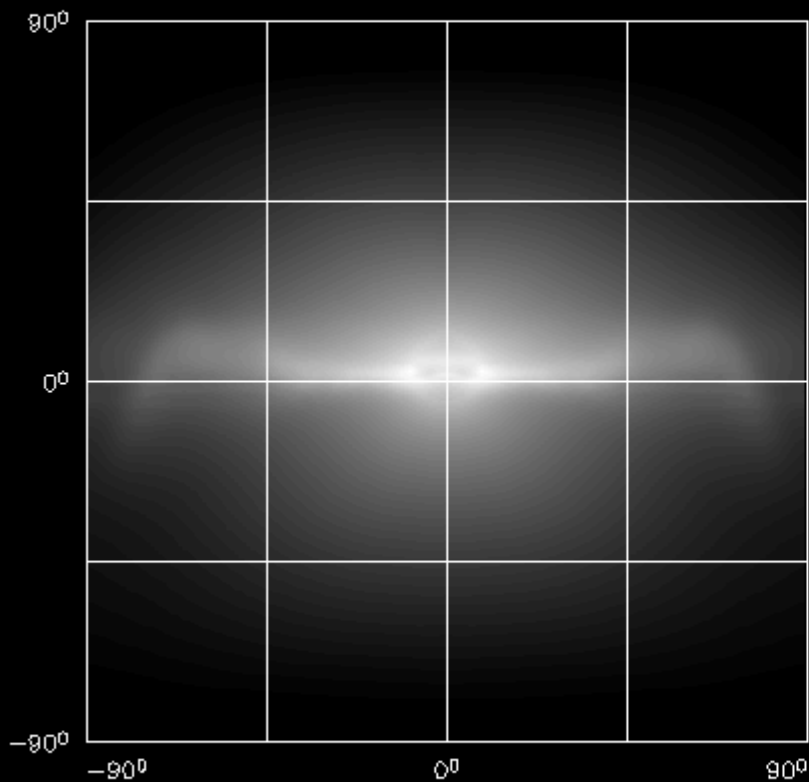


ICME propagates into the enhanced density of a streamer belt flow

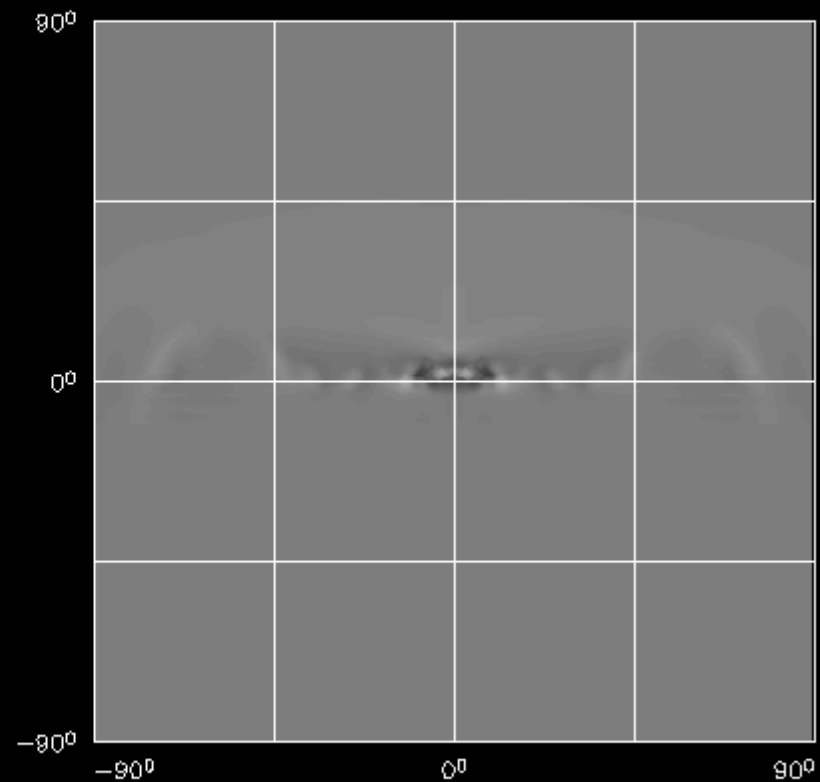
Synthetic White-Light Imaging

97-05-12 06:00

Total Brightness

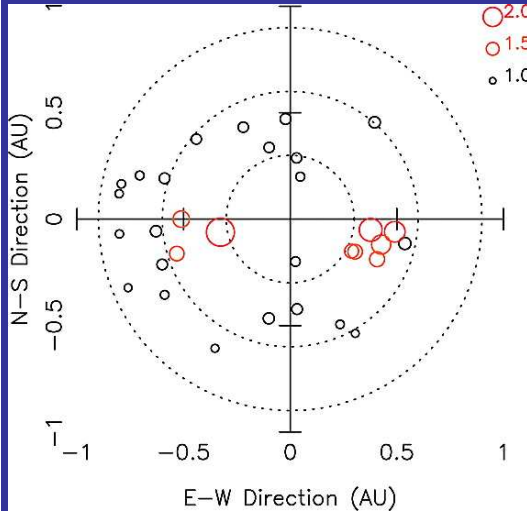


Running Difference

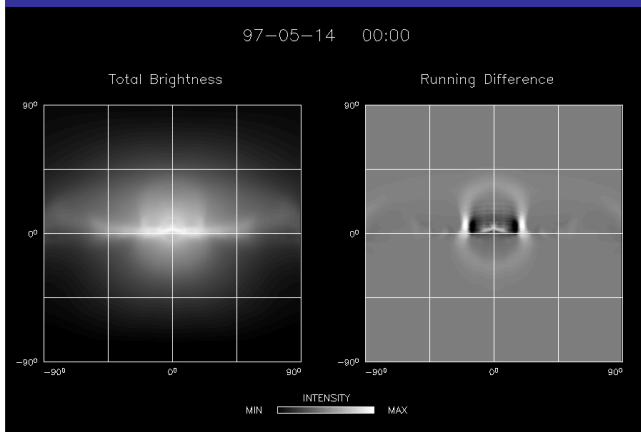
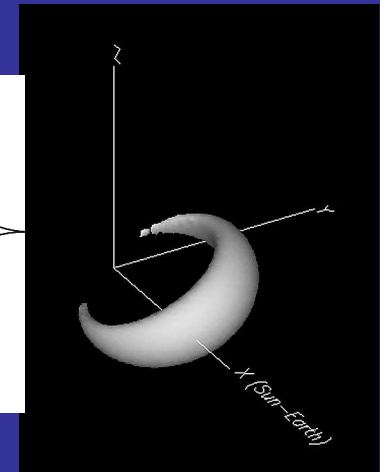
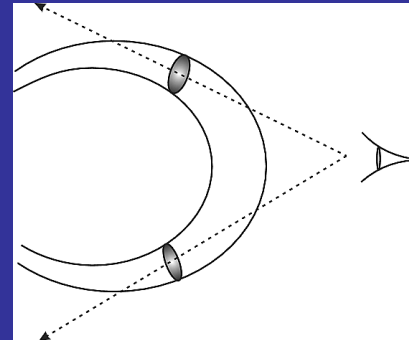


INTENSITY
MIN  MAX

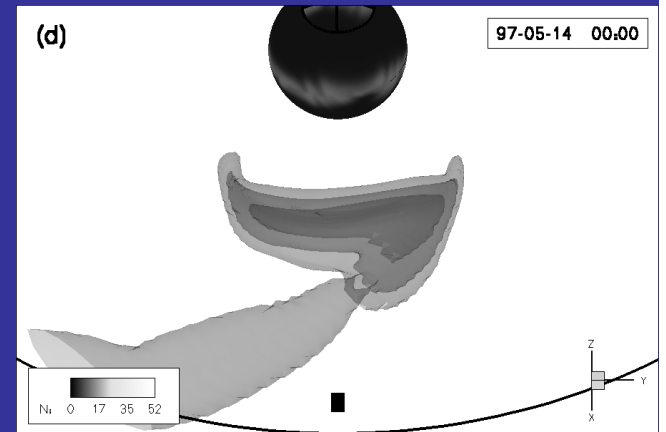
Appearance of Transient Density Structure



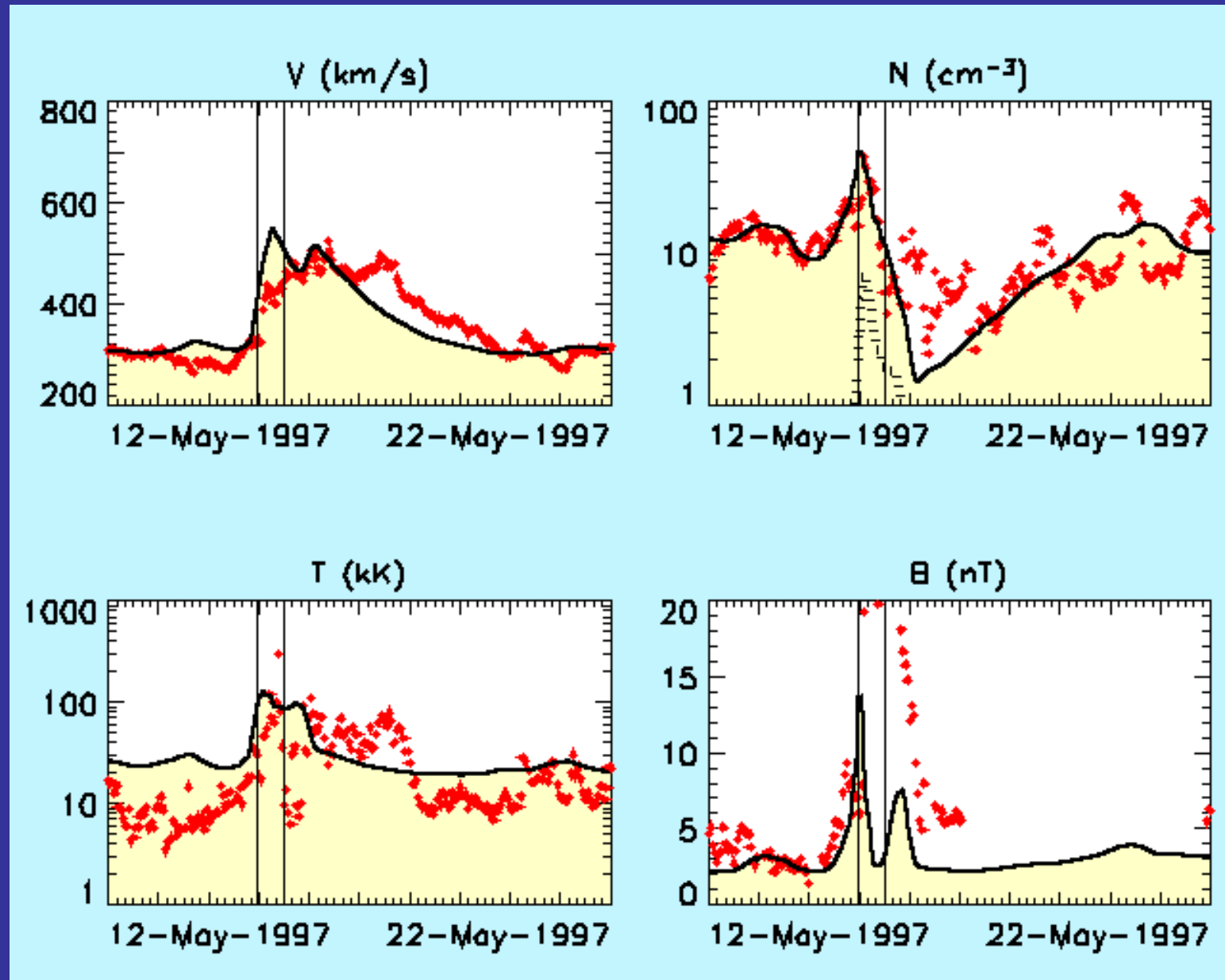
IPS observations detect interplanetary transients that sometime show two enhanced spots instead of a halo ring [Tokumaru et al., 2003]



MHD simulation shows a dynamic interaction between the ICME and ambient solar wind that: (1) forms an arc-like density structure; and (2) results in two brighter spots in synthetic images



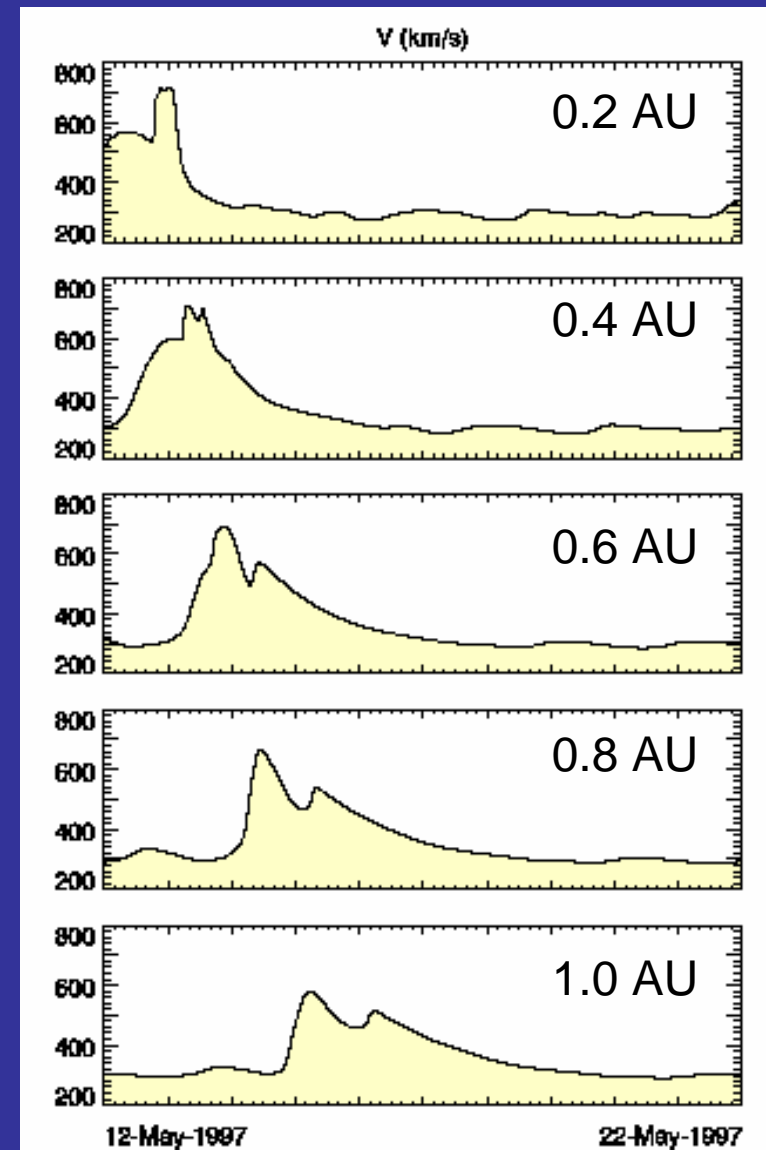
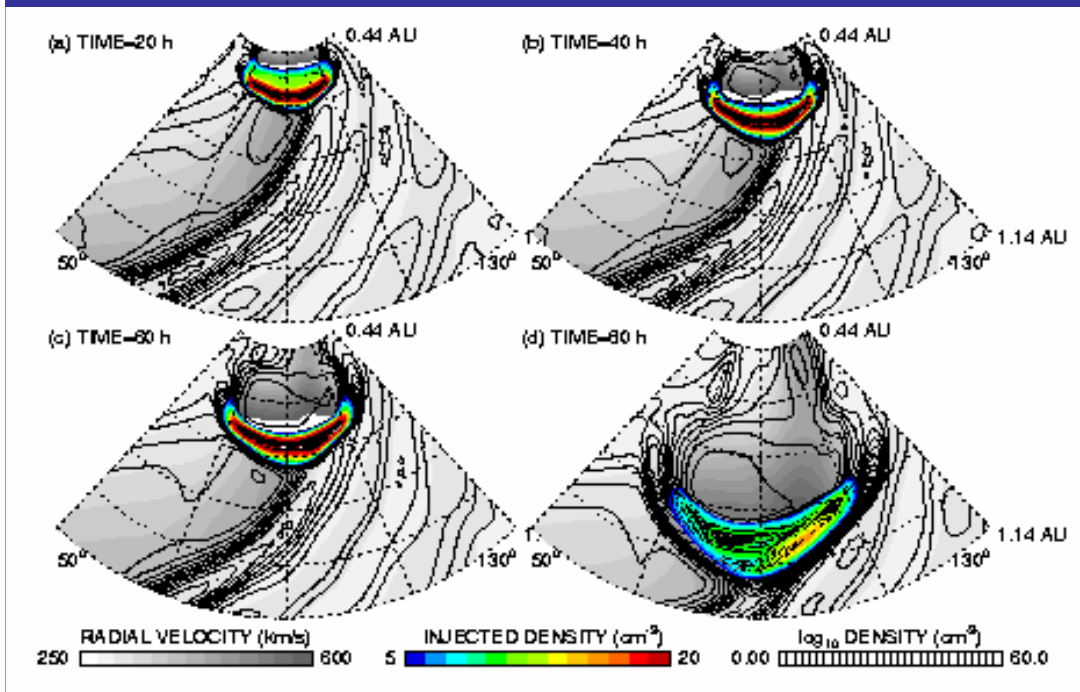
Evolution of Parameters at Earth



May 12, 1997 – Interplanetary Shock

Distribution of parameters in equatorial plane

Evolution of velocity on Sun-Earth line



- Shock propagates in a fast stream and merges with its leading edge

Case A1

Case A3

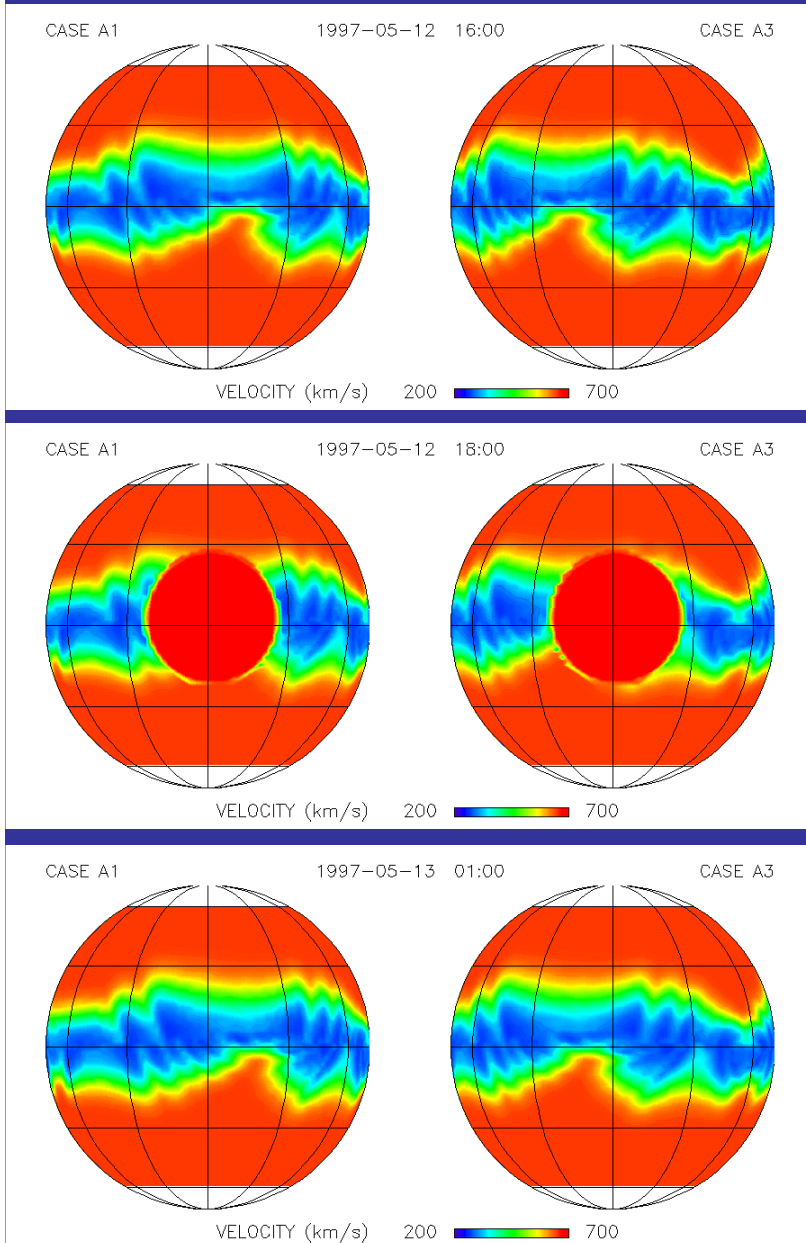
Fast-Stream Position

[SAIC maps -- Pete Riley]

Ambient state before the CME launch

Disturbed state during the CME launch

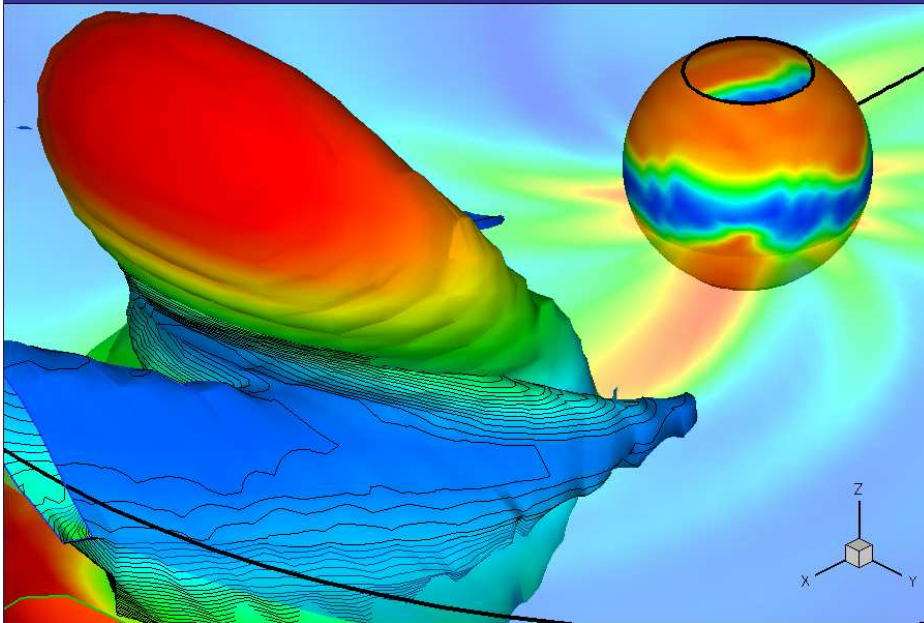
Ambient state after the CME launch



Effect of Fast-Stream Position

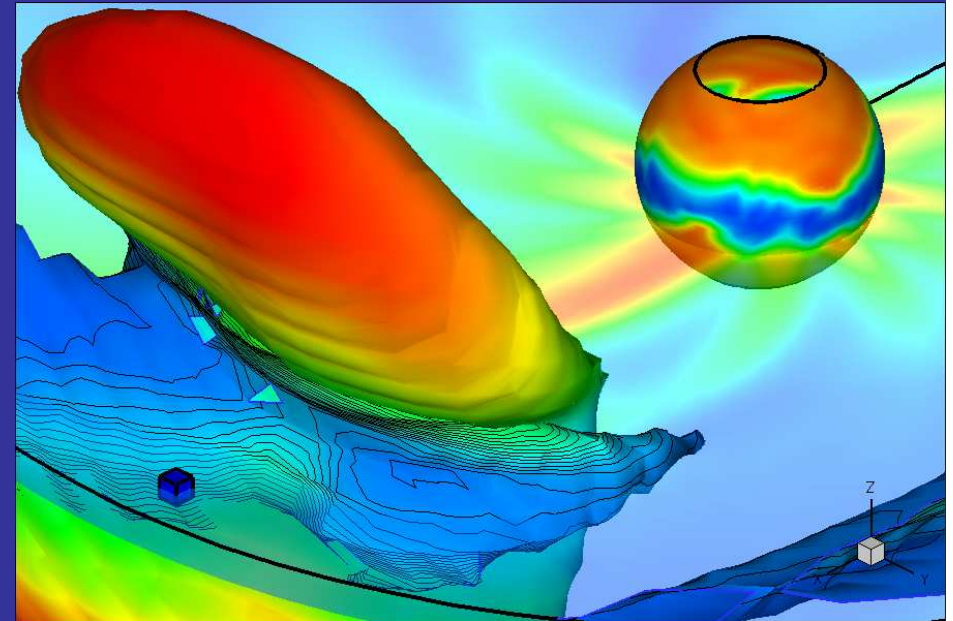
[SAIC maps -- Pete Riley]

Case A1



Earth : Interaction region followed by shock and CME (*not observed*)

Case A3



Earth : Shock and CME (*observed but 3-day shift is too large*)

Case A2

Case B2

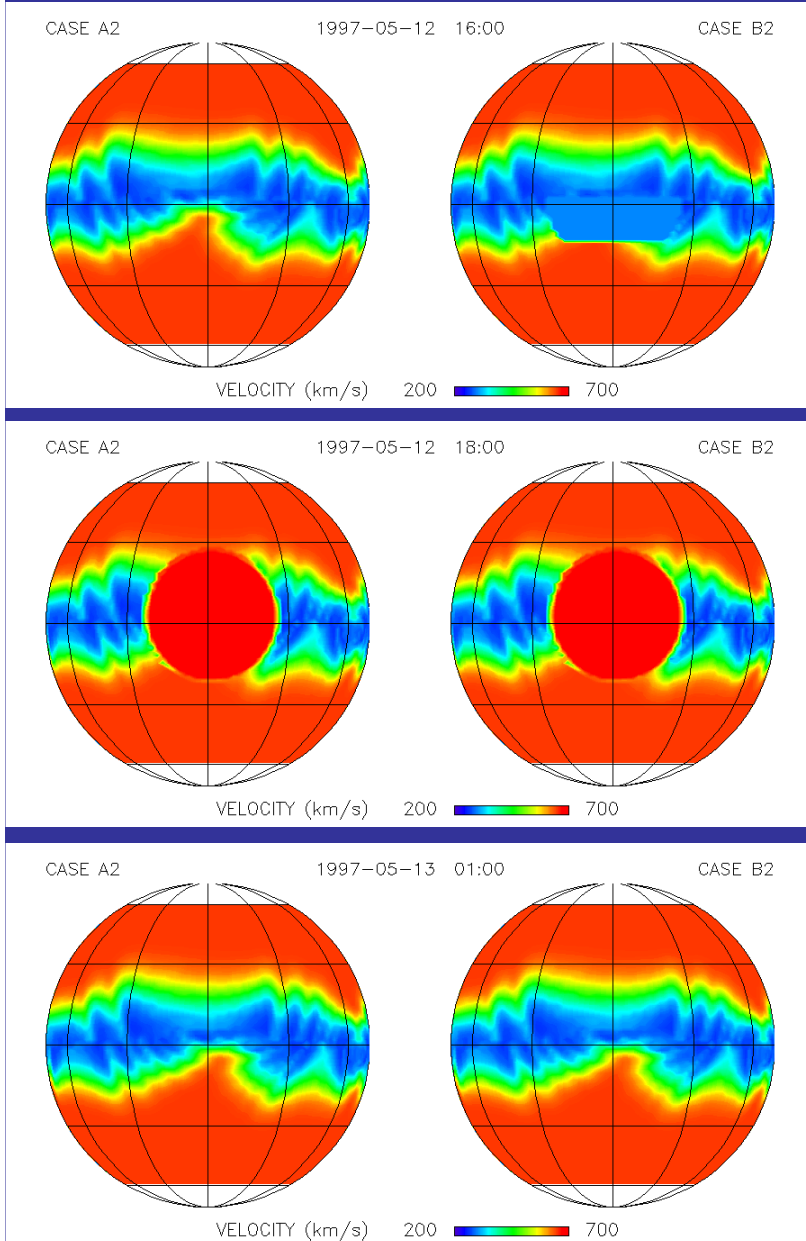
Fast-Stream Evolution

[SAIC maps -- Pete Riley]

Ambient state before the CME launch

Disturbed state during the CME launch

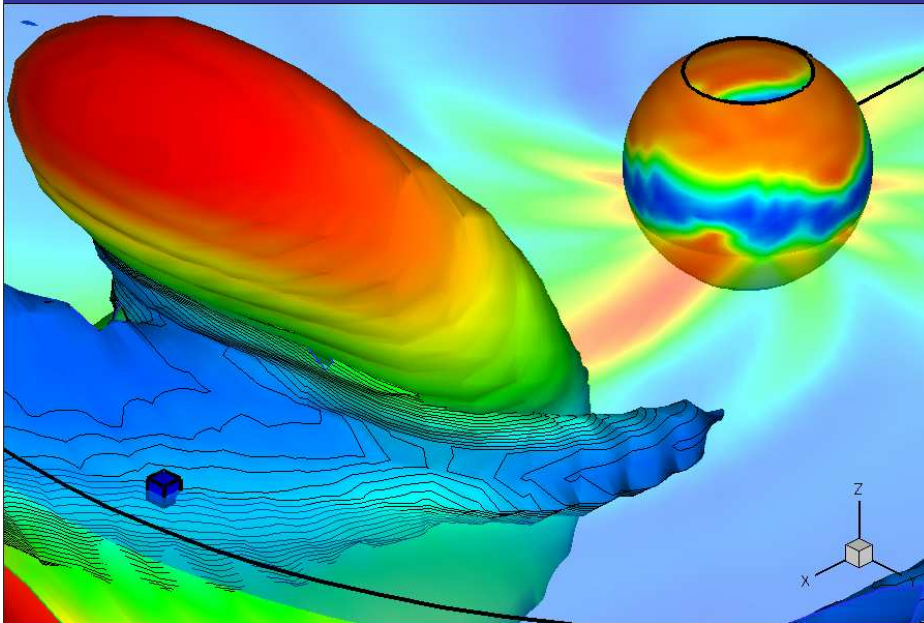
Ambient state after the CME launch



Effect of Fast-Stream Evolution

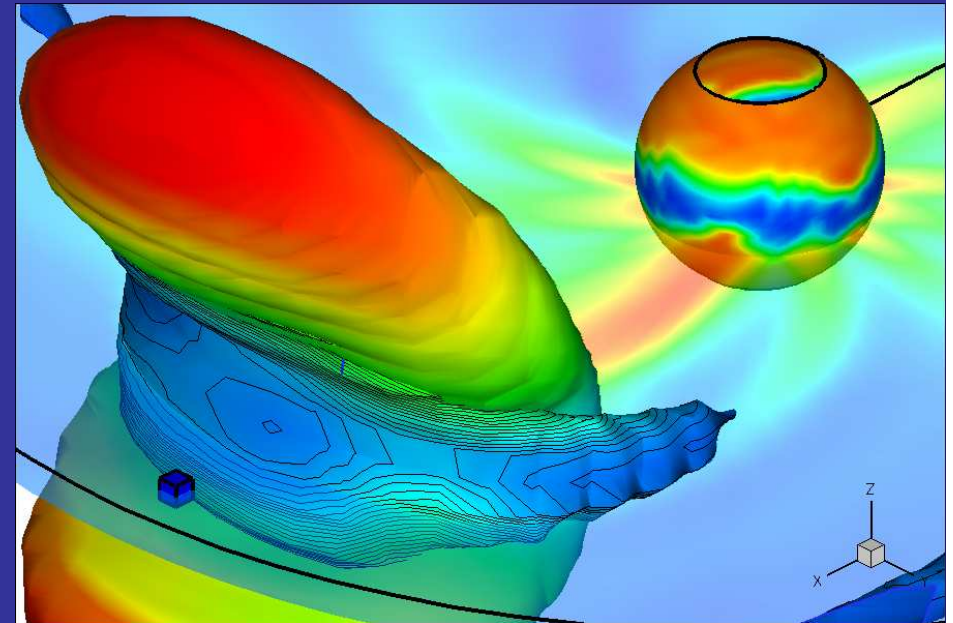
[SAIC maps -- Pete Riley]

Case A2



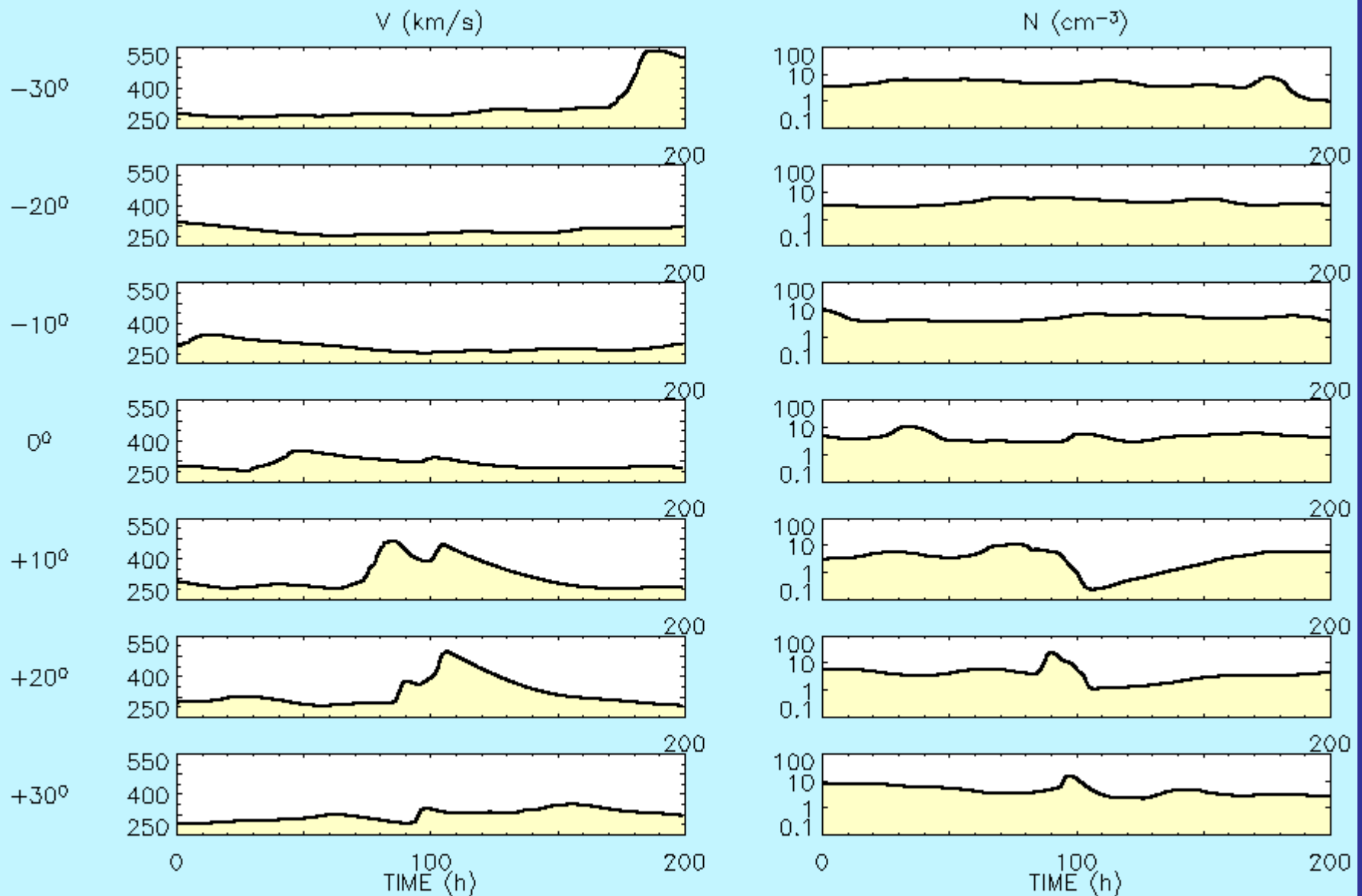
Earth : Interaction region followed
by shock and CME (*not observed*)

Case B2

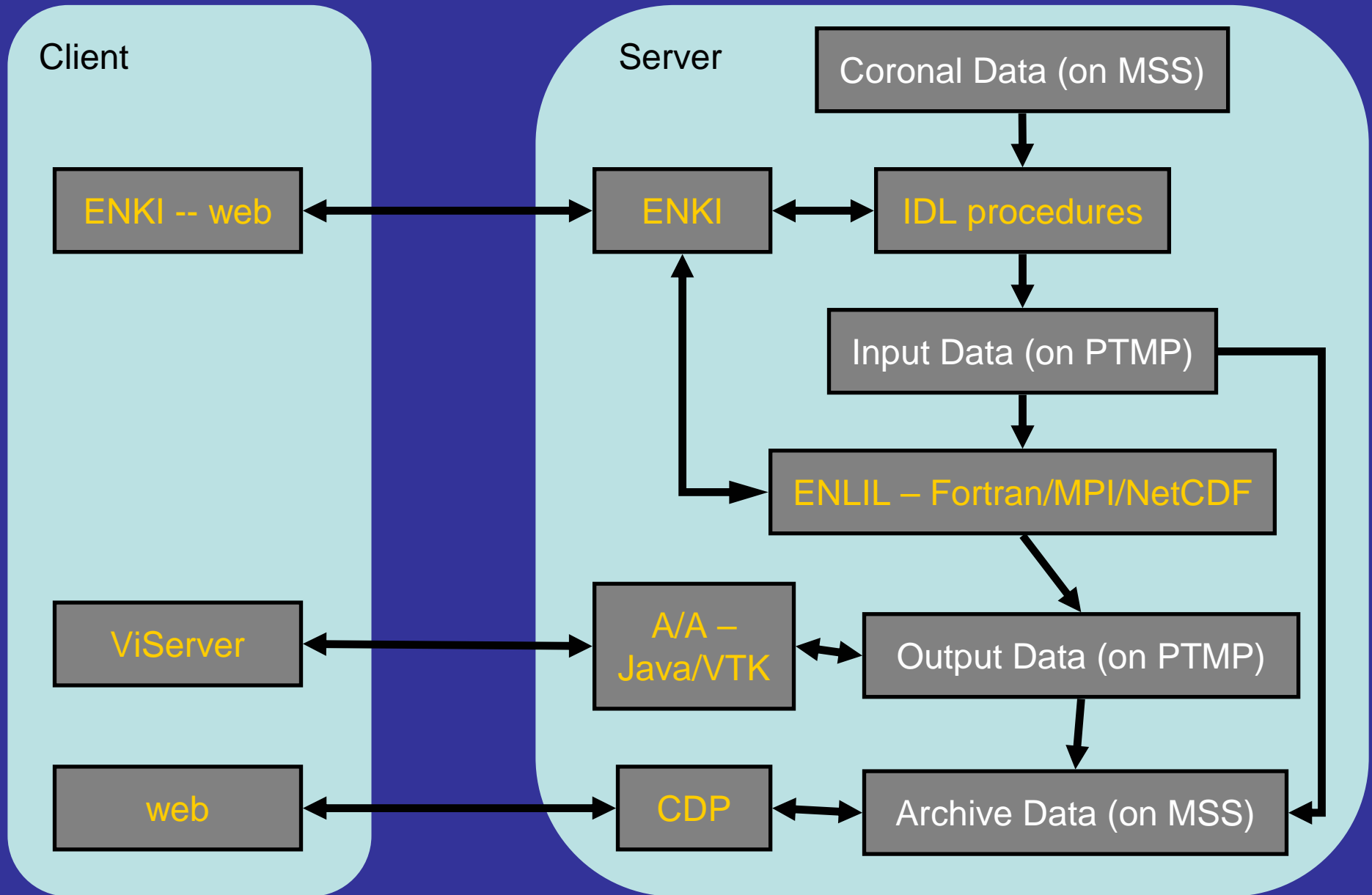


Earth : Shock and CME (*observed*
but shock front is radial)

Evolution of Parameters at Earth



Remote Access



ENKI – Interface to ENLIL

Project saic_cr on Blackforest – Input for ini-saic_cr.pro

Name

Computational Region

R_min (AU) <input type="text" value="0.14"/>	R_max (AU) <input type="text" value="1.10"/>	N_r <input type="text" value="240"/>	Guard Cells <input type="checkbox"/> 1 <input type="checkbox"/> 2
Theta_min (deg) <input type="text" value="30"/>	Theta_max (deg) <input type="text" value="150"/>	N_theta <input type="text" value="60"/>	Grid Spacing <input type="checkbox"/> uniform <input type="checkbox"/> sin <input type="checkbox"/> sin^0.5
Phi_min (deg) <input type="text" value="0"/>	Phi_max (deg) <input type="text" value="360"/>	N_phi <input type="text" value="180"/>	Grid Spacing <input type="checkbox"/> uniform <input type="checkbox"/> sin <input type="checkbox"/> sin^0.5

Select CR Number

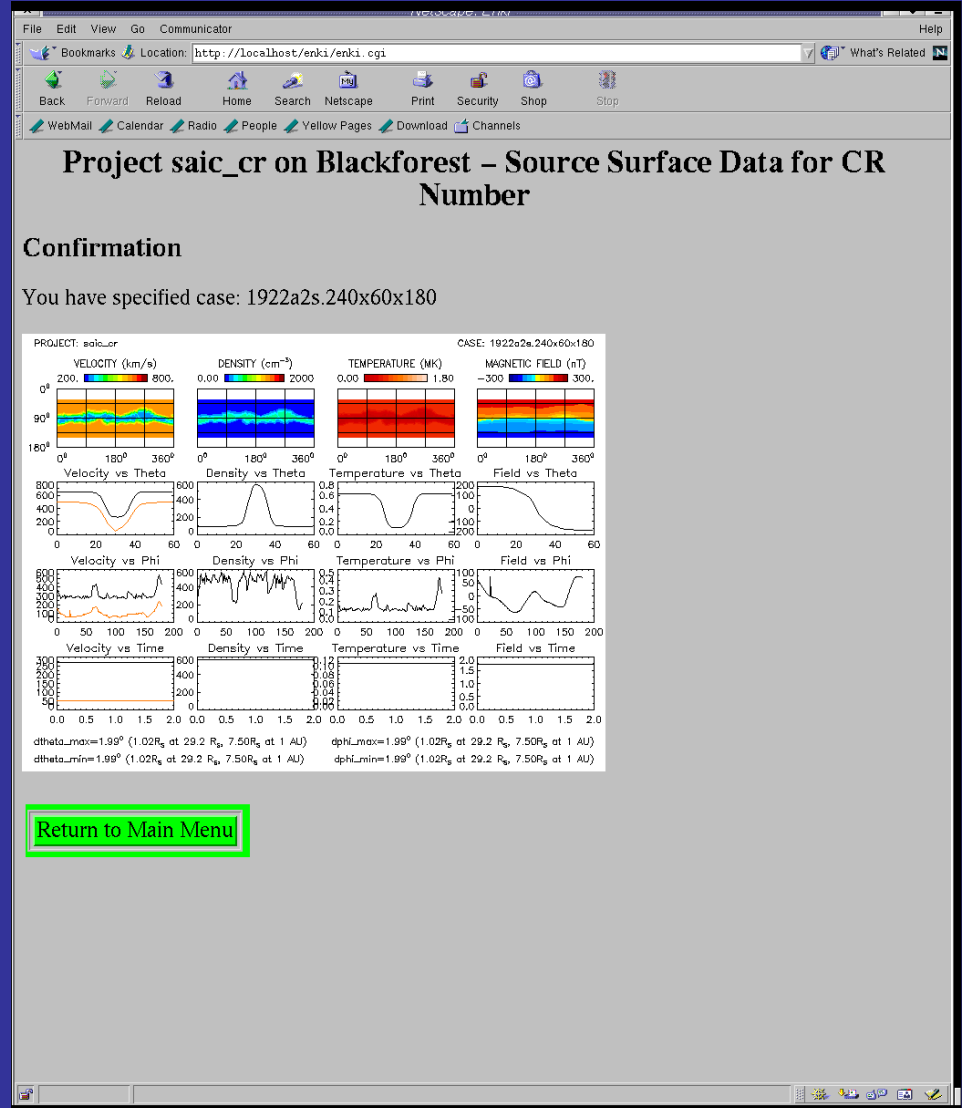
Directory saic

Solar Wind Parameters

Density_slow (cm-3) <input type="text" value="600d0"/>	Temperature_slow (MK) <input type="text" value="0.1d0"/>	Flux <input type="checkbox"/> NV^1 <input type="checkbox"/> NV^1.5 <input type="checkbox"/> NV^2
-----------------------------------------------------------	-------------------------------------------------------------	--------------------------------------------------------------------------------------------------

Parameters

Rotation (days) <input type="checkbox"/> 0 <input type="checkbox"/> 25 <input type="checkbox"/> 27	Shift (days) <input type="checkbox"/> 0 <input type="checkbox"/> 1.5		
Gamma <input type="checkbox"/> 1.2 <input type="checkbox"/> 1.5	Ionization <input type="checkbox"/> 0 <input type="checkbox"/> 1	Mean Mass <input type="checkbox"/> 0.5 <input type="checkbox"/> 1 <input type="checkbox"/> 2	Polarity Tracing <input type="checkbox"/> yes <input type="checkbox"/> no



ENKI – Interface to ENLIL

Project saic_cr on Blackforest – Numerical Code: Specification

Name and Grid Size

Name: Grid size (N1xN2xN3):
x x

Compilation and Diagnostics

Optimize: <input type="checkbox"/> yes <input type="checkbox"/> no	Check: <input type="checkbox"/> yes <input type="checkbox"/> no	Diagnostics: <input type="checkbox"/> yes <input type="checkbox"/> no	Trace: <input type="checkbox"/> yes <input type="checkbox"/> no	Vampir: <input type="checkbox"/> yes <input type="checkbox"/> no	HPM: <input type="checkbox"/> yes <input type="checkbox"/> no	Paramesh: <input type="checkbox"/> yes <input type="checkbox"/> no	Max blocks: (Only for Paramesh) <input type="text" value="1"/>
--------------------------------------------------------------------------	-----------------------------------------------------------------------	-----------------------------------------------------------------------------	-----------------------------------------------------------------------	------------------------------------------------------------------------	---------------------------------------------------------------------	--------------------------------------------------------------------------	----------------------------------------------------------------------

Mathematical Description

Physical model: <input type="checkbox"/> con <input type="checkbox"/> hyd <input type="checkbox"/> mhd	Volumetric heat: <input type="checkbox"/> yes <input type="checkbox"/> no	Electric resistivity: <input type="checkbox"/> yes <input type="checkbox"/> no	Energy equation: <input type="checkbox"/> total <input type="checkbox"/> thermal	Cloud tracing: <input type="checkbox"/> yes <input type="checkbox"/> no	Polarity tracing: <input type="checkbox"/> yes <input type="checkbox"/> no
Geometry: <input type="checkbox"/> cartesian <input type="checkbox"/> cylindrical <input type="checkbox"/> spherical	Momentum source terms: <input type="checkbox"/> grad <input type="checkbox"/> div	Energy source terms: <input type="checkbox"/> grad <input type="checkbox"/> div	Magnetic field source terms: <input type="checkbox"/> grad <input type="checkbox"/> div	Gamma array: <input type="checkbox"/> yes <input type="checkbox"/> no	

Method of Solution

Spatial integration: <input type="checkbox"/> splitted <input type="checkbox"/> multidimensional	Differencing: <input type="checkbox"/> upwind <input type="checkbox"/> centered	Mode of non-planar limiter: <input type="checkbox"/> primitive <input type="checkbox"/> conservative	Slope limiter: <input type="checkbox"/> minmod <input type="checkbox"/> roe <input type="checkbox"/> woodward
Div(B) correction:	Field mesh:	CFL condition:	

Project saic_cr on Blackforest – Specify Run Parameters

Current Settings

Case: Code:

Specify New

Name: Label:

Batch Job Parameters

Core file size limit:
 128 MB 256 MB 512 MB

Wall clock limit:
 10 min 30 min 1 h 3 h 6 h

Units

Time: sec hour day

Space: m Mm Re Rs AU

Time Interval

Start computations at or after this time: Stop computations at or after this time:

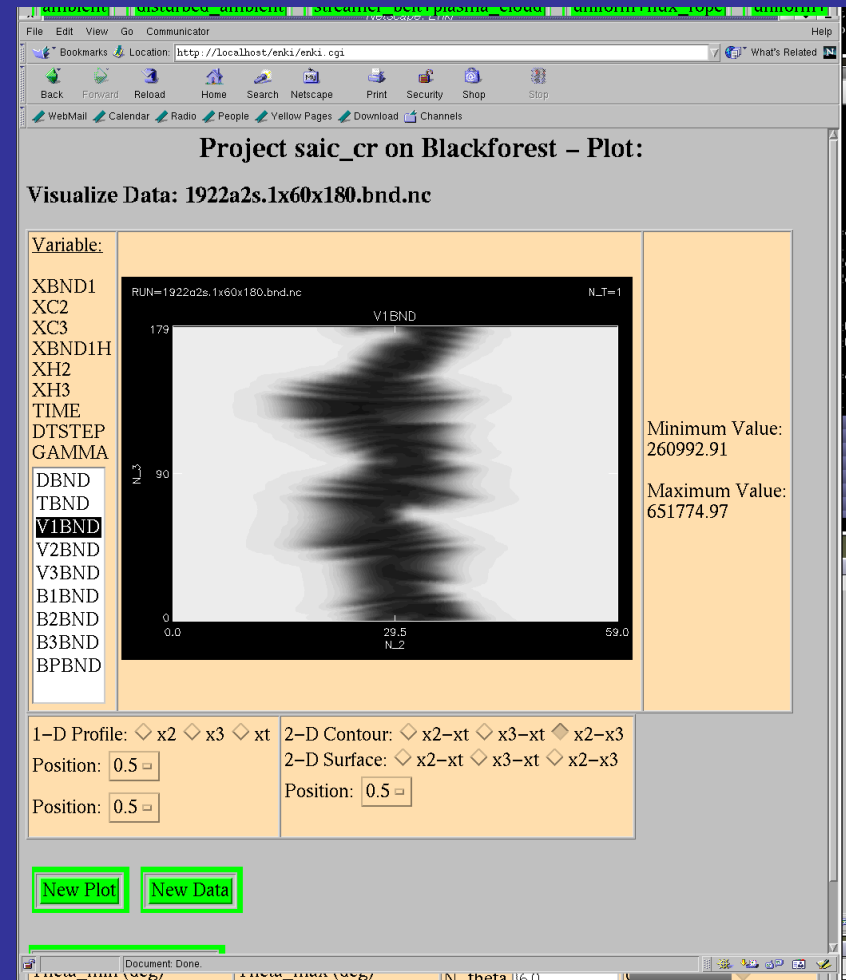
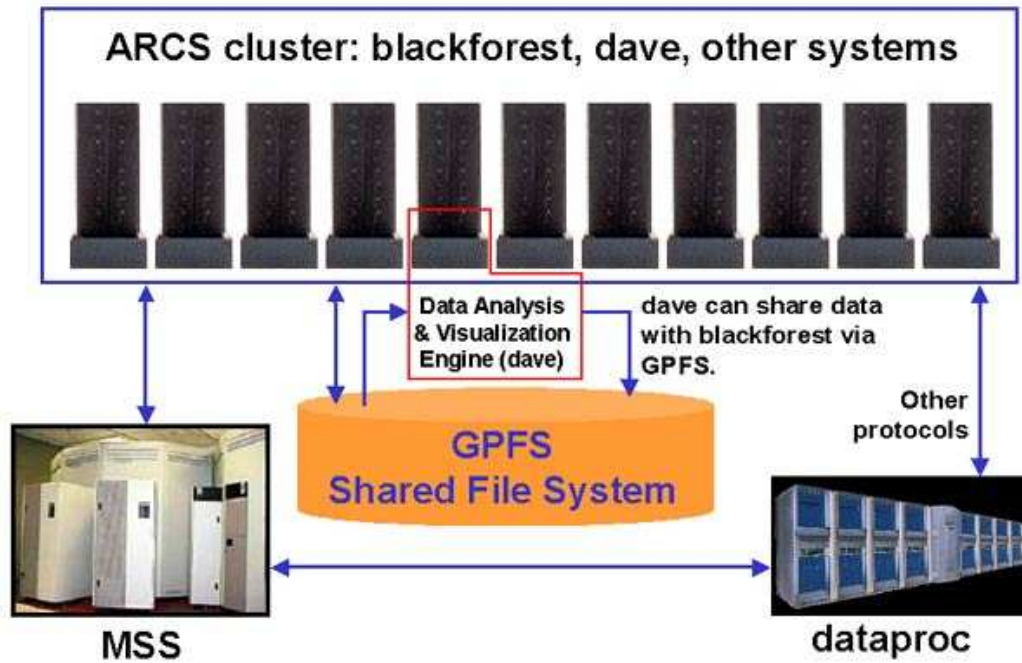
Output of Values for (Eventual) Restart (*.res.nc)

Frequency:

Output of 3-D Arrays at Given Times (*.tim.nc)

Remote Visualization: ENKI--IDL

dave-blackforest integration



Preview of data before downloading processing and visualization, archiving, etc.

Plot 1-D profiles and 2-D contours or surfaces of 1-D, 2-D, or 3-D data

Interplanetary Disturbances

