

STEREO AND SPACE WEATHER

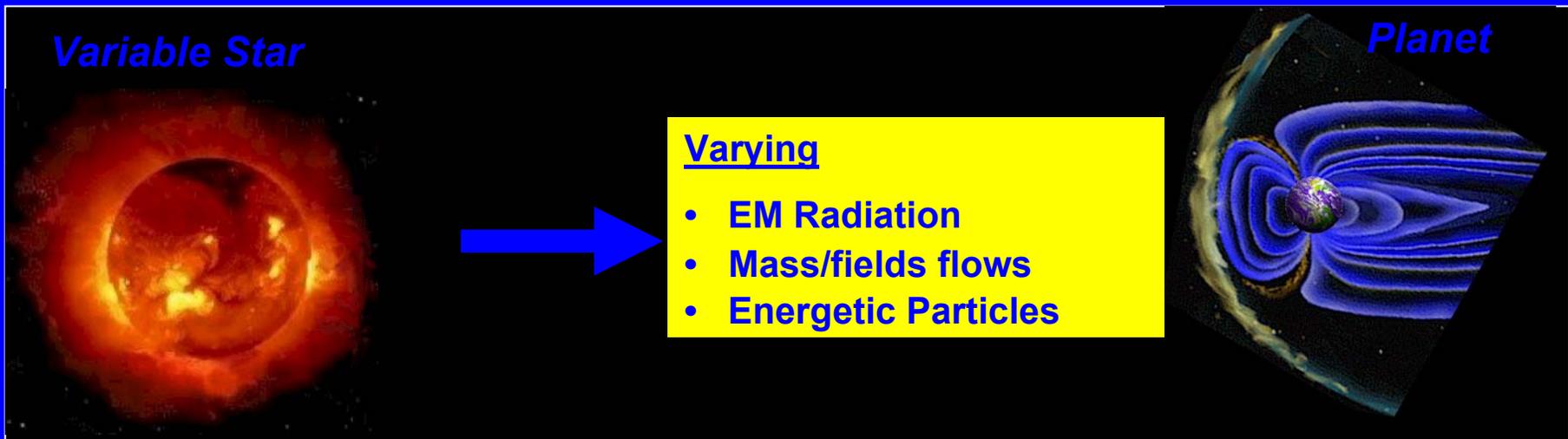
S. K. Antiochos

Naval Research Laboratory

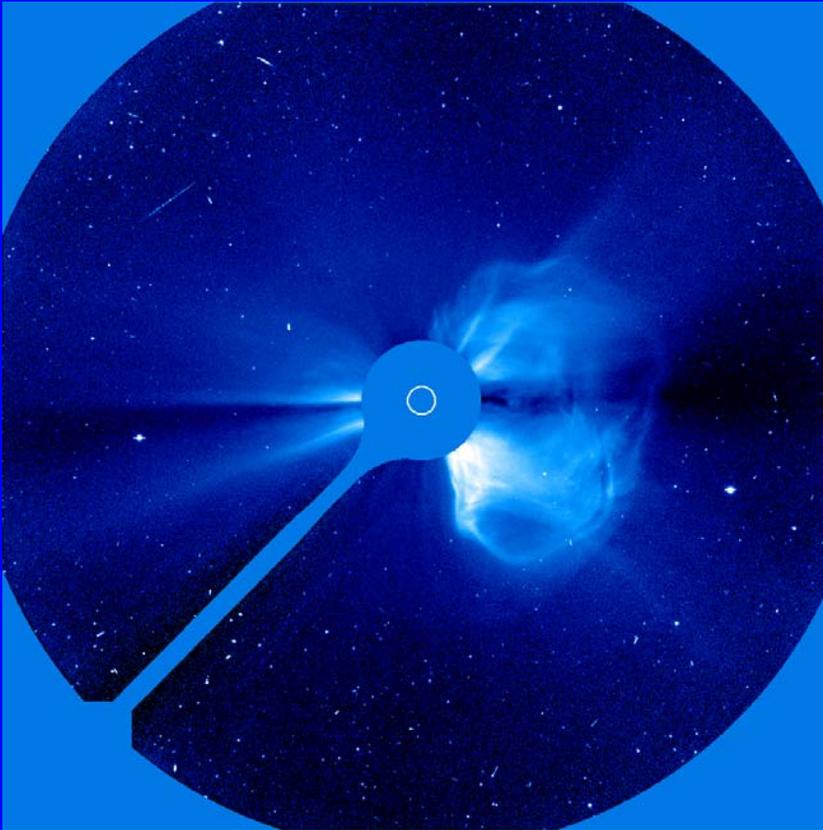
<http://solartheory.nrl.navy.mil>

Space Weather: *Variable conditions in space that can have adverse effects on human life and society*

- Multi-agency program, NASA, NSF, DoD, NOAA, ...
- Goal is to enable physics-based prediction capability



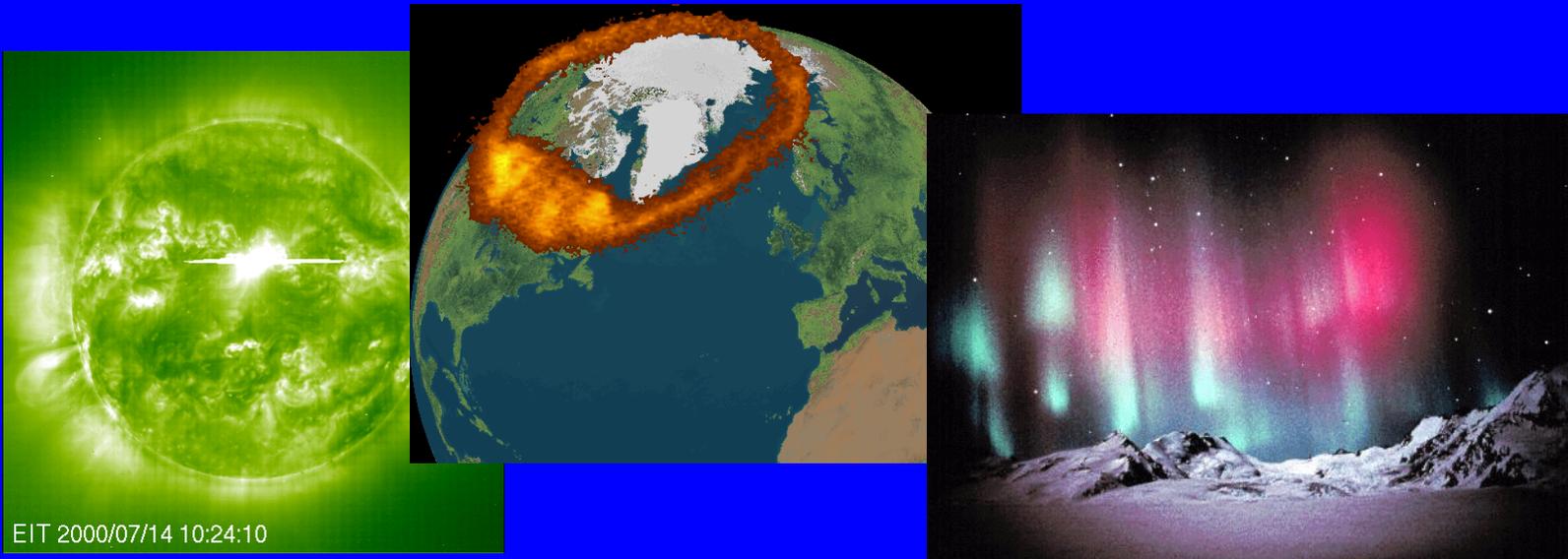
Stereo Science Objectives



1. Characterize the propagation of CMEs through the heliosphere
2. Understand the causes and mechanisms of CME initiation
3. Discover the mechanisms and sites of energetic particle acceleration in the low corona and the interplanetary medium
4. Develop a 3D time-dependent model of the magnetic topology, temperature, density, and velocity structure of the ambient solar wind

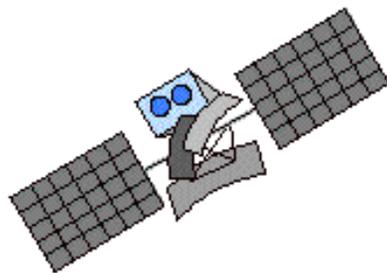
STEREO AND SPACE WEATHER

- Examples of STEREO ++ contributions
- July 14, 2000 Space Weather Event
 - Due to coronal mass ejection/eruptive flare





The Bastille Day 2000 Solar Eruption

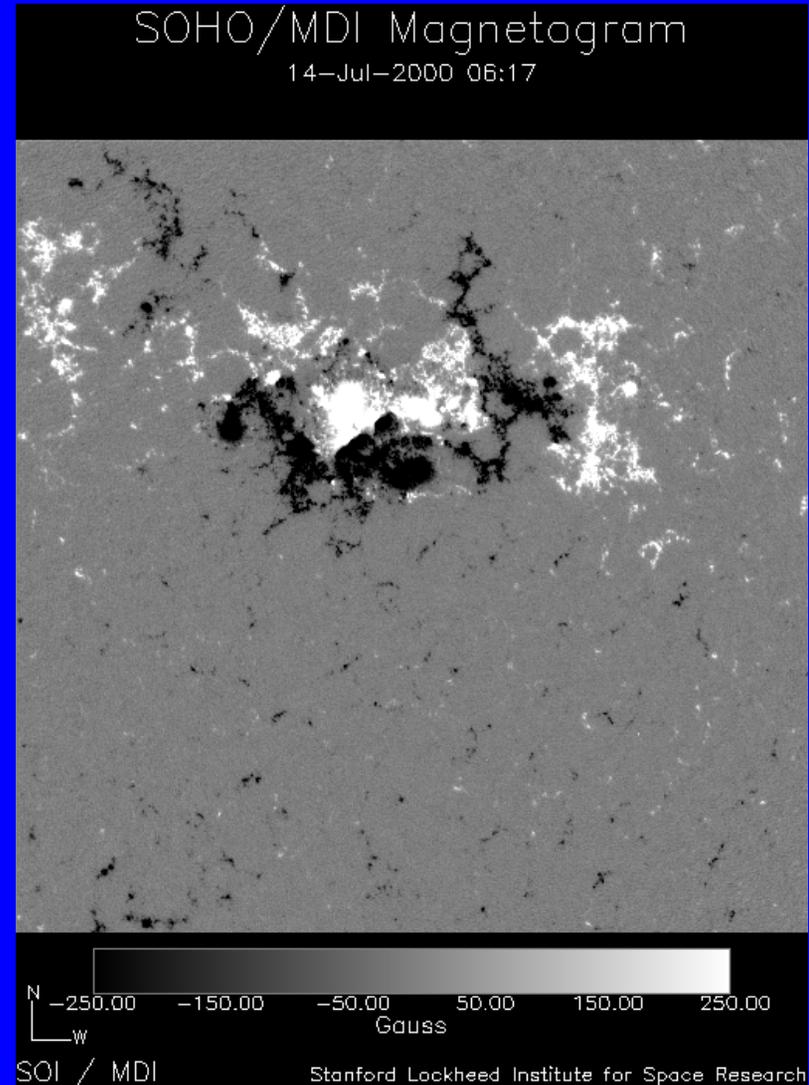
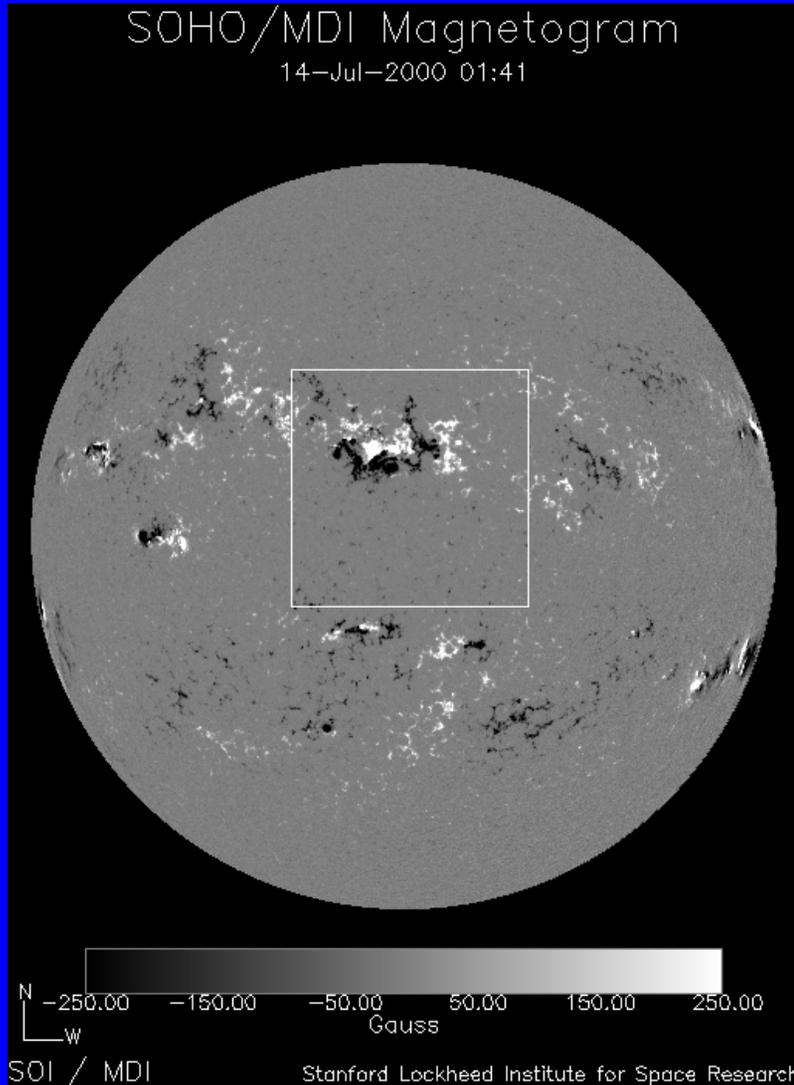


Research Satellites

Research Satellites	Japan's Orbiting X-ray Observatory	Went into "safe mode" and lost a lot of altitude drained back-up batteries due to poor solar panel orientation: unable to regain control of craft. Expected to reenter Earth's atmosphere in 2001.
	SOHO	Permanent solar panel degradation equivalent to 1 year of normal degradation
	Wind Spacecraft	~25% permanent loss of transmitter power

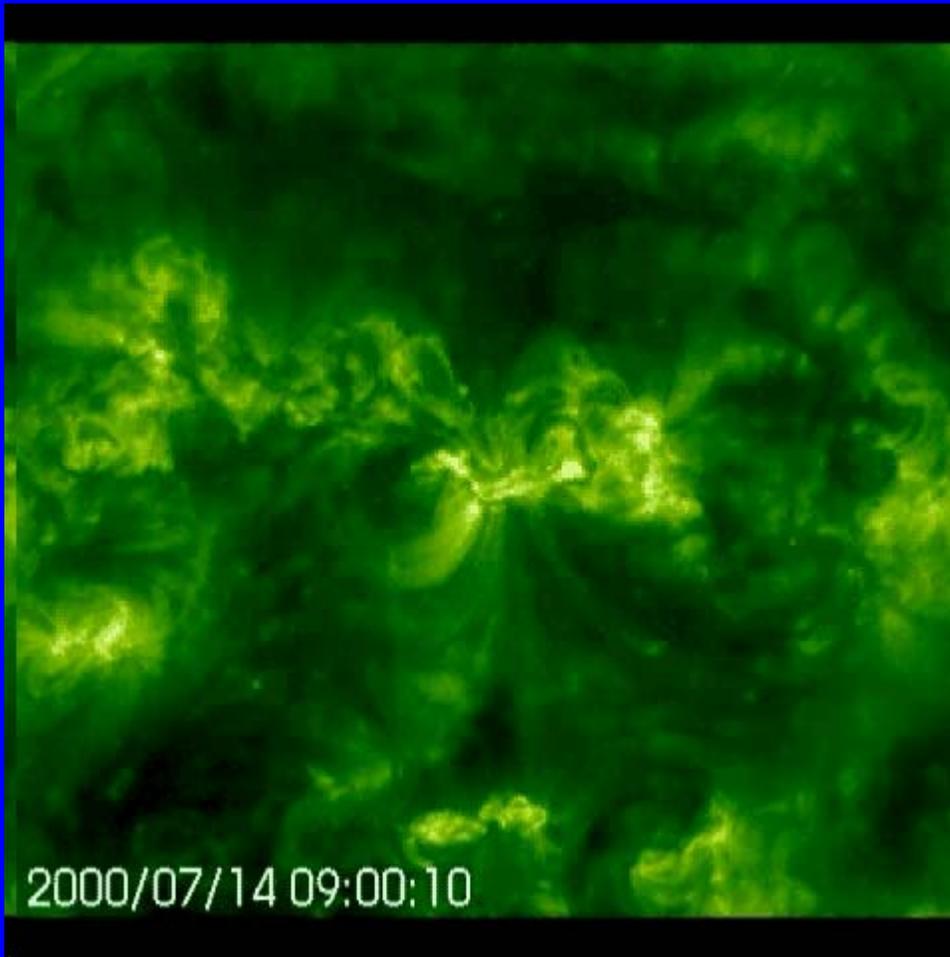
Magnetic Origins of July 14 Event

- Will an active region produce a fast eruption?*



MDI Observations of magnetic field at photosphere

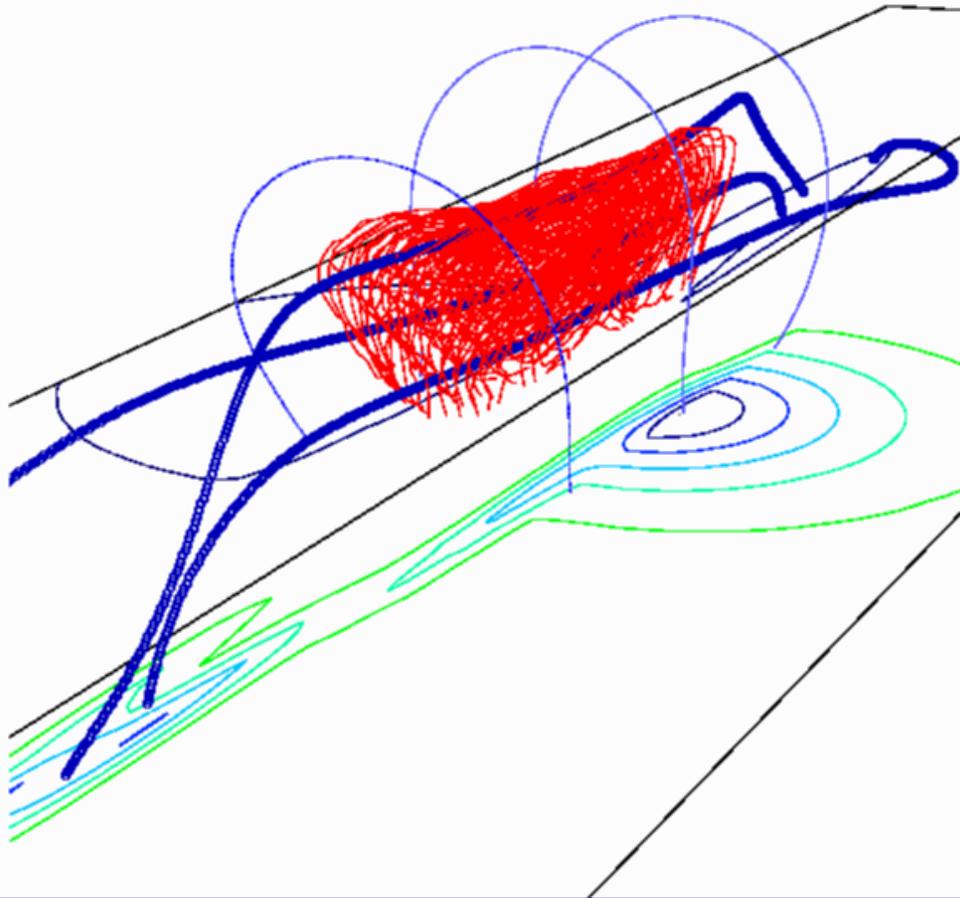
Pre-Eruption Coronal Structure



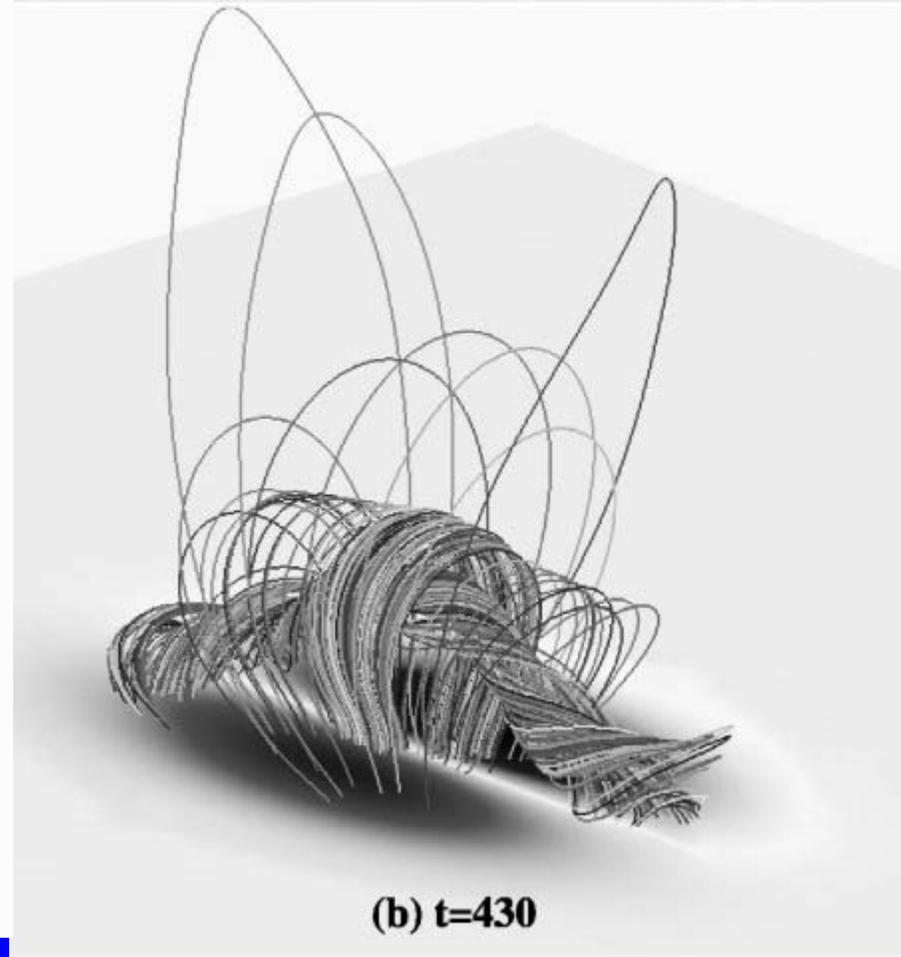
- Energy for eruption stored in coronal magnetic field
- But structure not defined by July 14 observations
- Still do not know the topology of filament channel field!

The 'Bastille Day' Event

Models of 3D Coronal Magnetic Topology



Sheared 3D Arcade (DeVore & Antiochos)

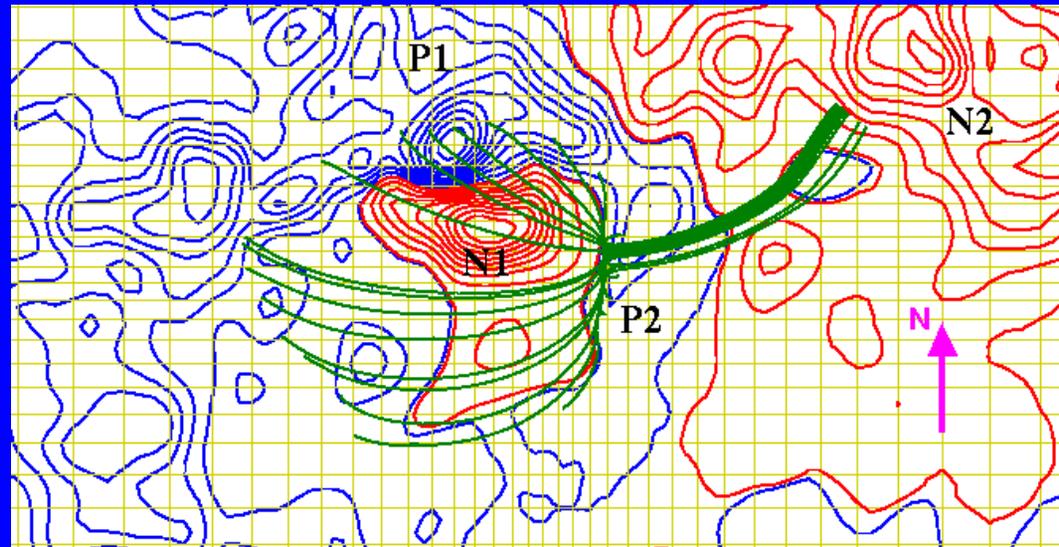


Flux Rope (Amari, Mikic & Linker)

STEREO & Pre-eruption Structure

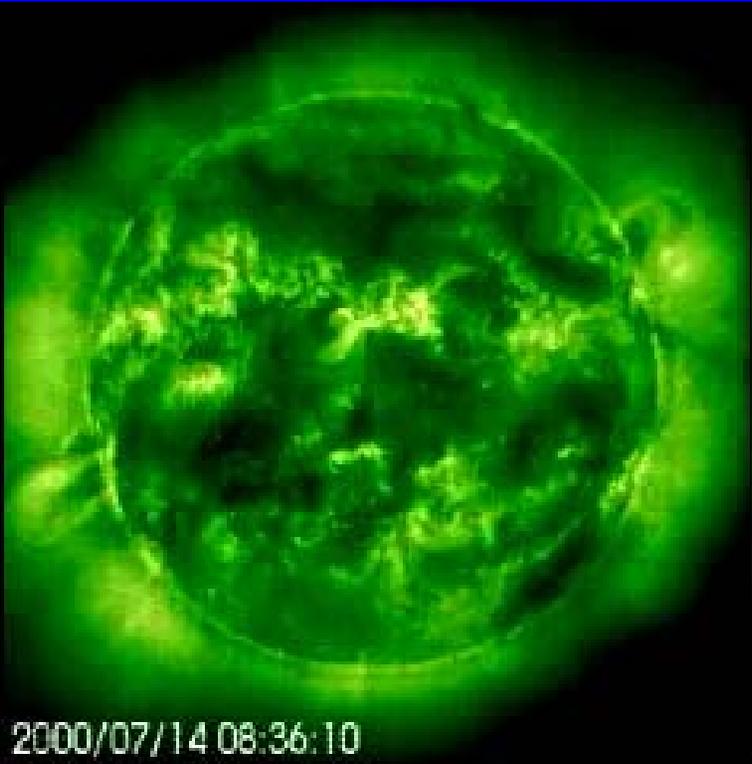
- STEREO++ will provide first opportunity to determine pre-eruption field – necessary capability for prediction
- THEMIS / Solar-B will measure detailed vector field along AR neutral lines
- STEREO will observe filament and coronal structures in 3D
- 3D numerical modeling will couple photospheric and coronal observations

Aulanier et al

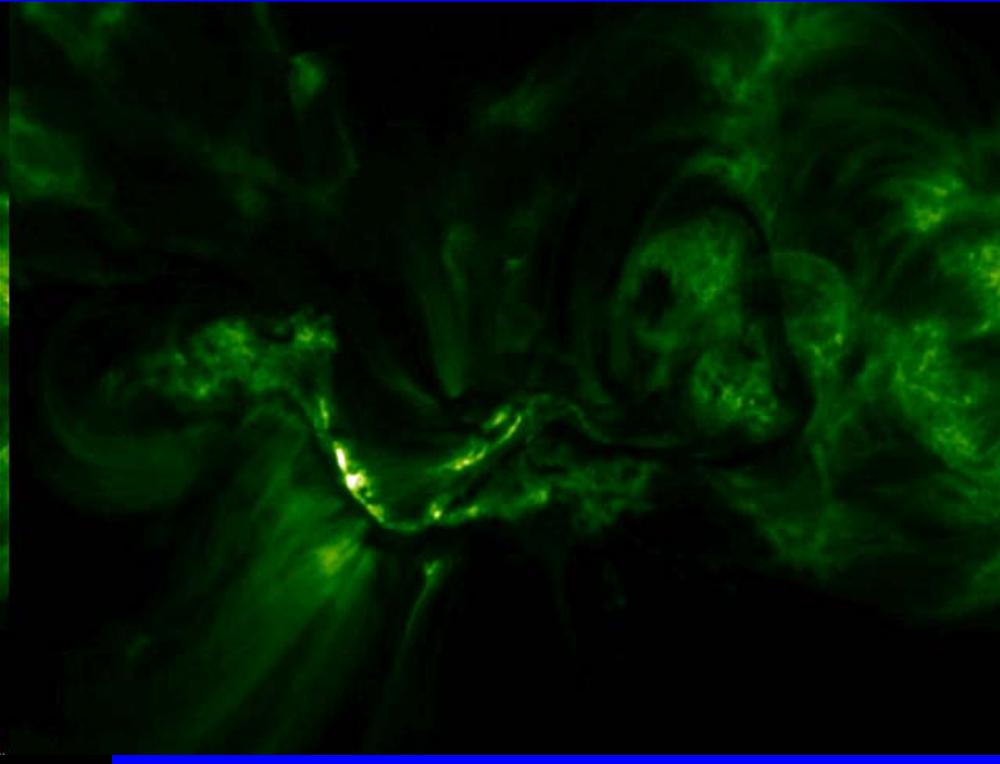


Initiation of July 14 Event

- *When will a CME/eruptive flare occur ?*



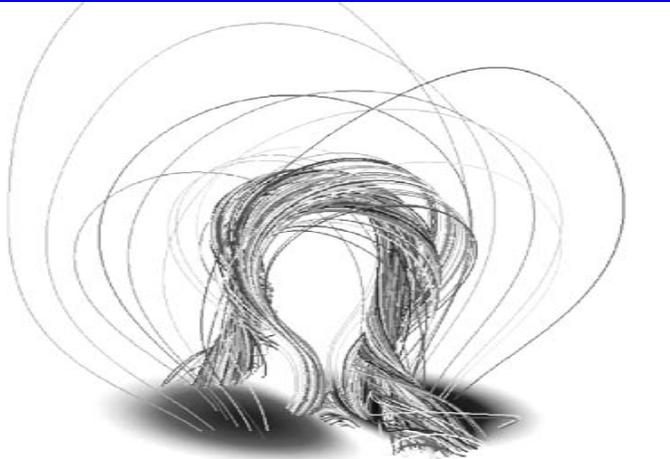
EIT observations



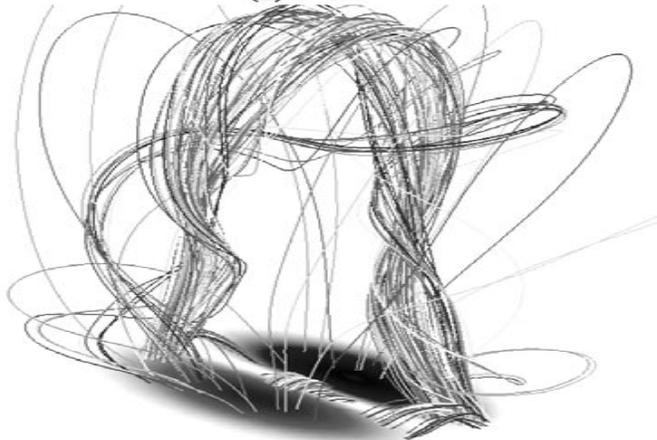
TRACE observations

STEREO & CME Initiation

- Models must be developed to use real data and predict observables
- STEREO will produce definitive tests of models
- Iterate to determine observable predictors of initiation

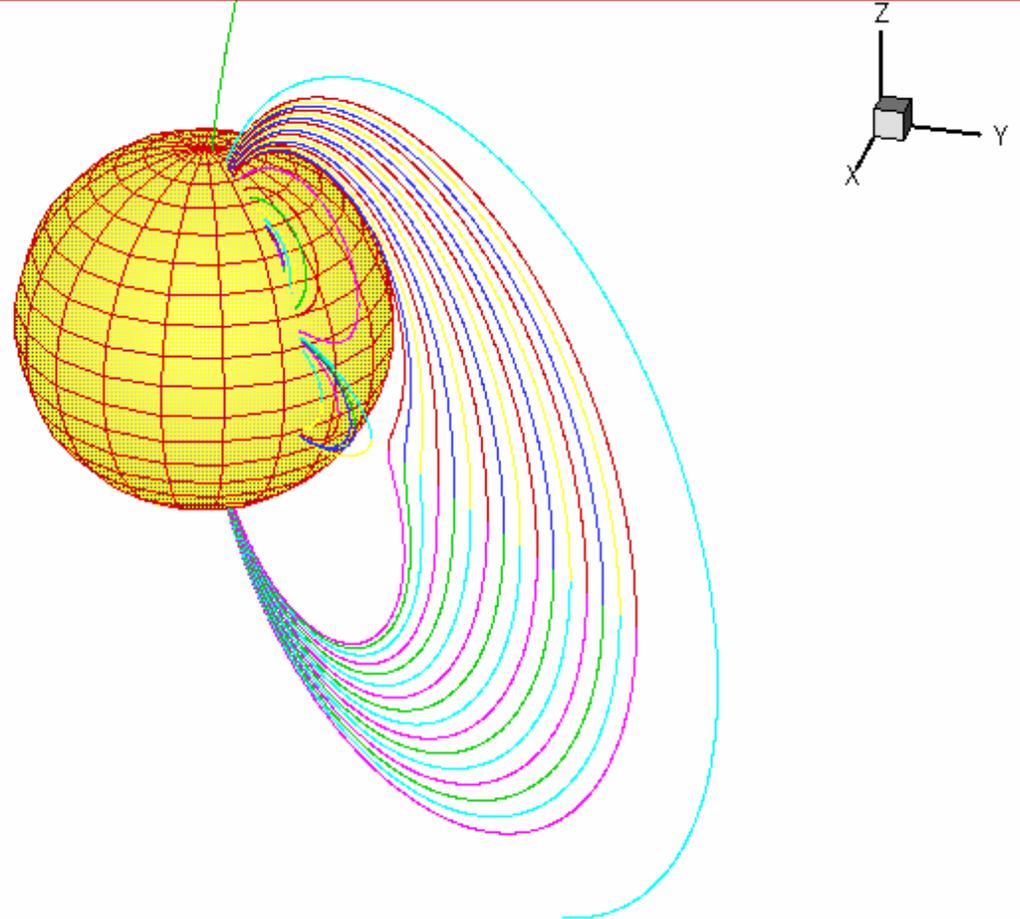


(a) $t=450$



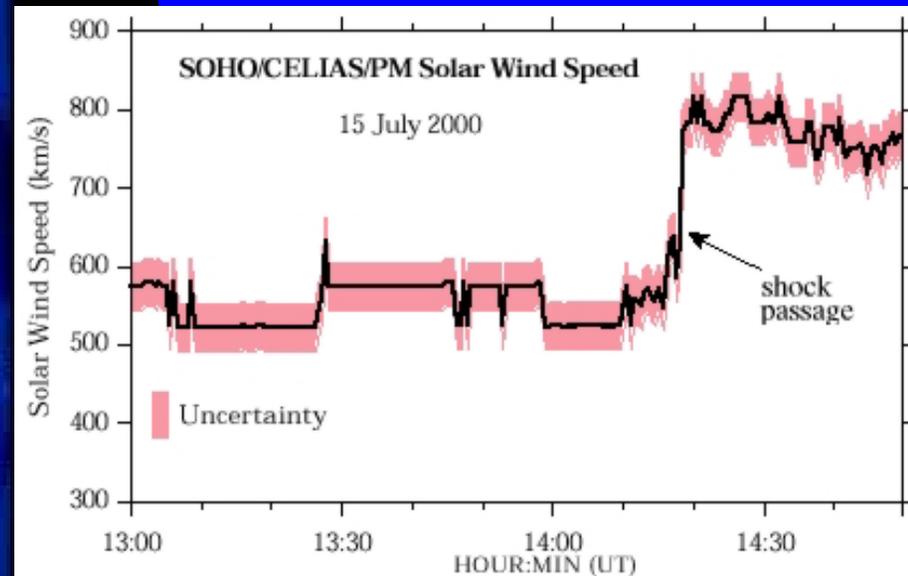
(b) $t=490$

Frame 001 | 4 May 2001 | FieldLines time = 0.E+0



July 14 Development and Propagation

- What will be the geo-effectiveness of a CME?

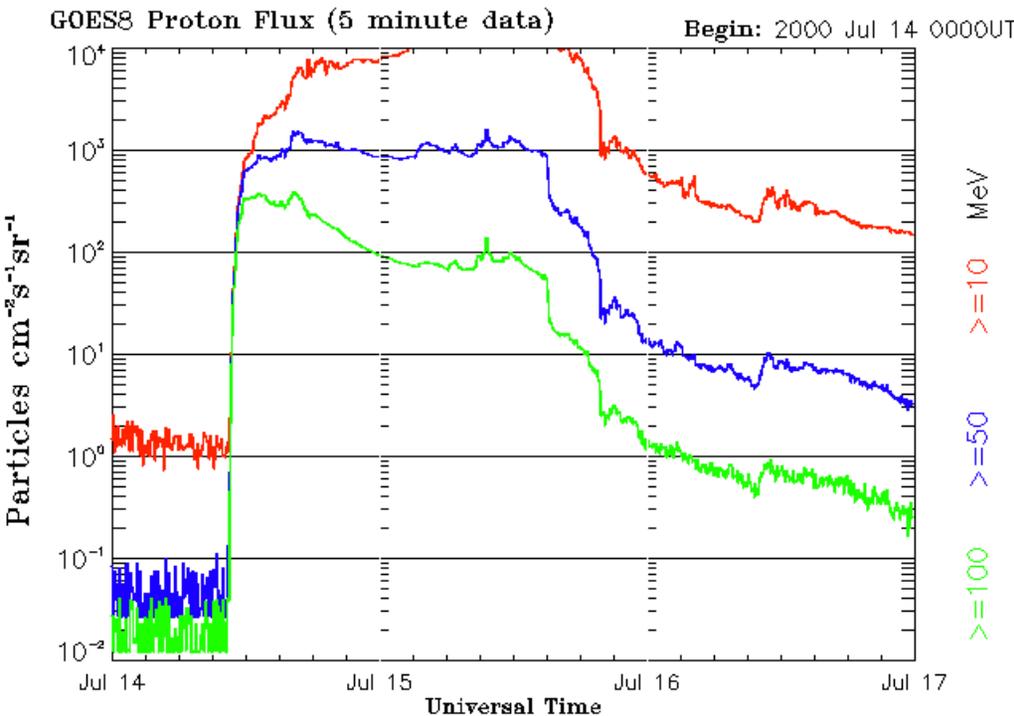
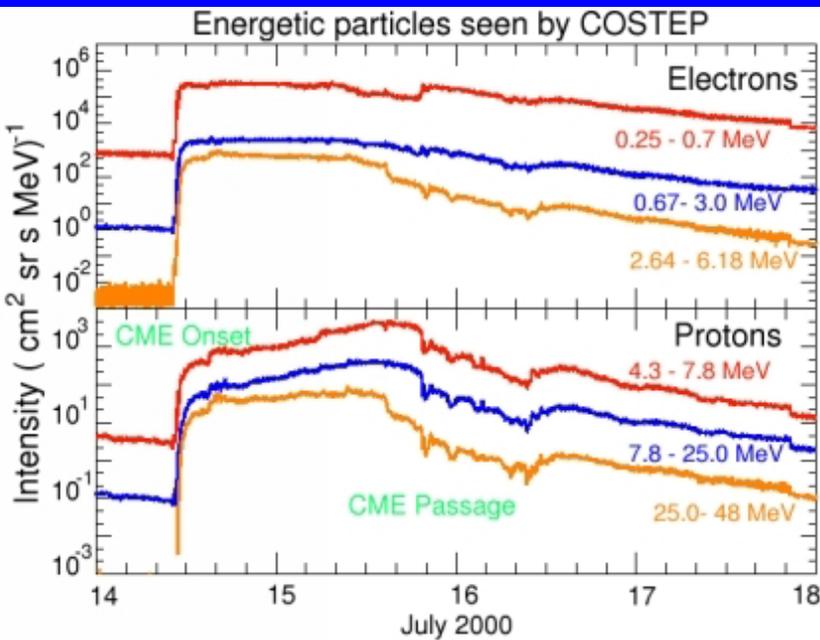


STEREO & CME Geo-Effectiveness

- Must have 3D model of complete corona
 - Requires STEREO, Themis, Solar-B, ---
- Must have detailed 3D model of heliosphere
 - Requires STEREO
- Must have accurate propagation models
 - Test and refine with STEREO data
- STEREO will observe 3D coronal lift-off
- Will observe complete propagation to 1 AU
 - Measure velocity evolution
 - Direct comparison with in situ particles and fields

July 14 Proton Storm

- What will be the particle radiation from a CME?



Updated 2000 Jul 16 23:56:03

NOAA/SEC Boulder, CO USA

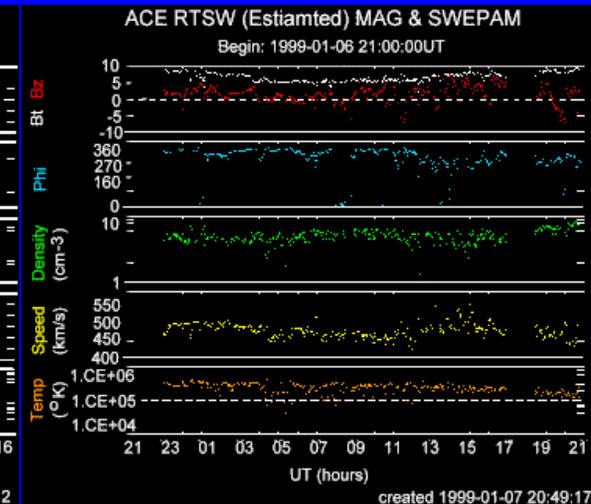
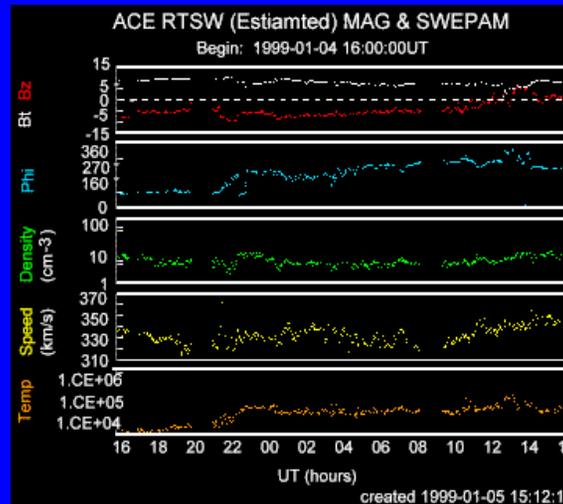
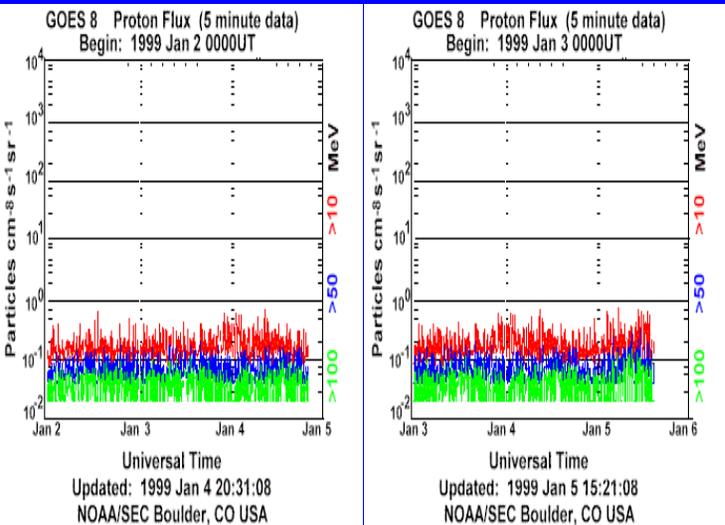
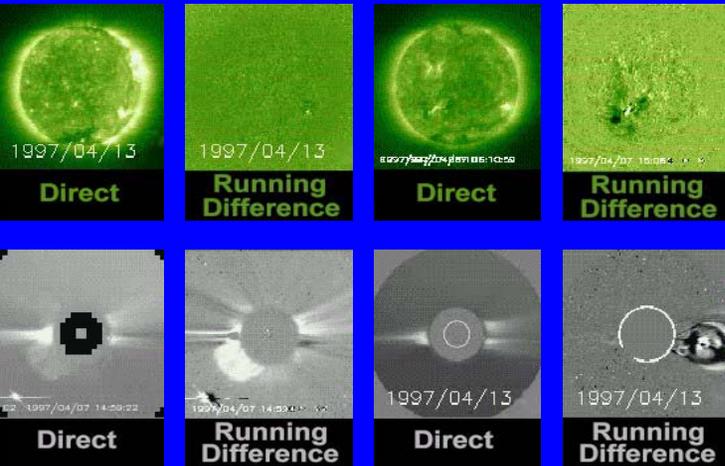


STEREO & Energetic Particles

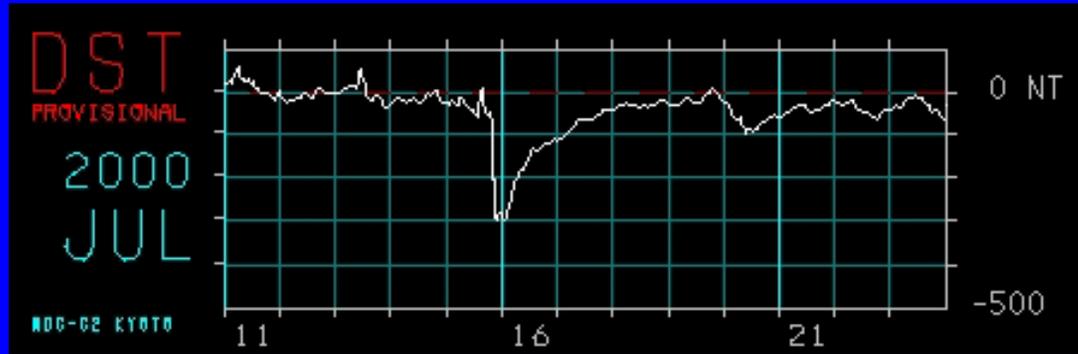
- Must understand mechanism for flare particle acceleration
 - Will have HESSI + STEREO + Solar-B + ...
- Must have IP shock formation/propagation model
 - Natural part of ICME model
- Must have particle acceleration + propagation/diffusion model
 - Key role of multi-point measurements
- Will measure scale of acceleration
- Detailed tests of acceleration and diffusion models

Real-Time Space Weather

- STEREO data will be available on line from SSC to support modeling
- 24 hr real-time transmission of reduced data available



July 14 Terrestrial Impact



Conclusions

- Must do space weather in order to do our science
 - Requires STEREO, Themis, Solar-B, ---
- STEREO will succeed only if have complete international science program
 - Other space missions, ground-based observations, data analysis, theory
- STEREO science advances will requires new level of coupled modeling – observations
- Basic science challenge is to understand scale coupling in complex systems