

Climate and Weather of the Sun-Earth System

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IAGA Association Lecture
July 27, 2005



Acknowledgments

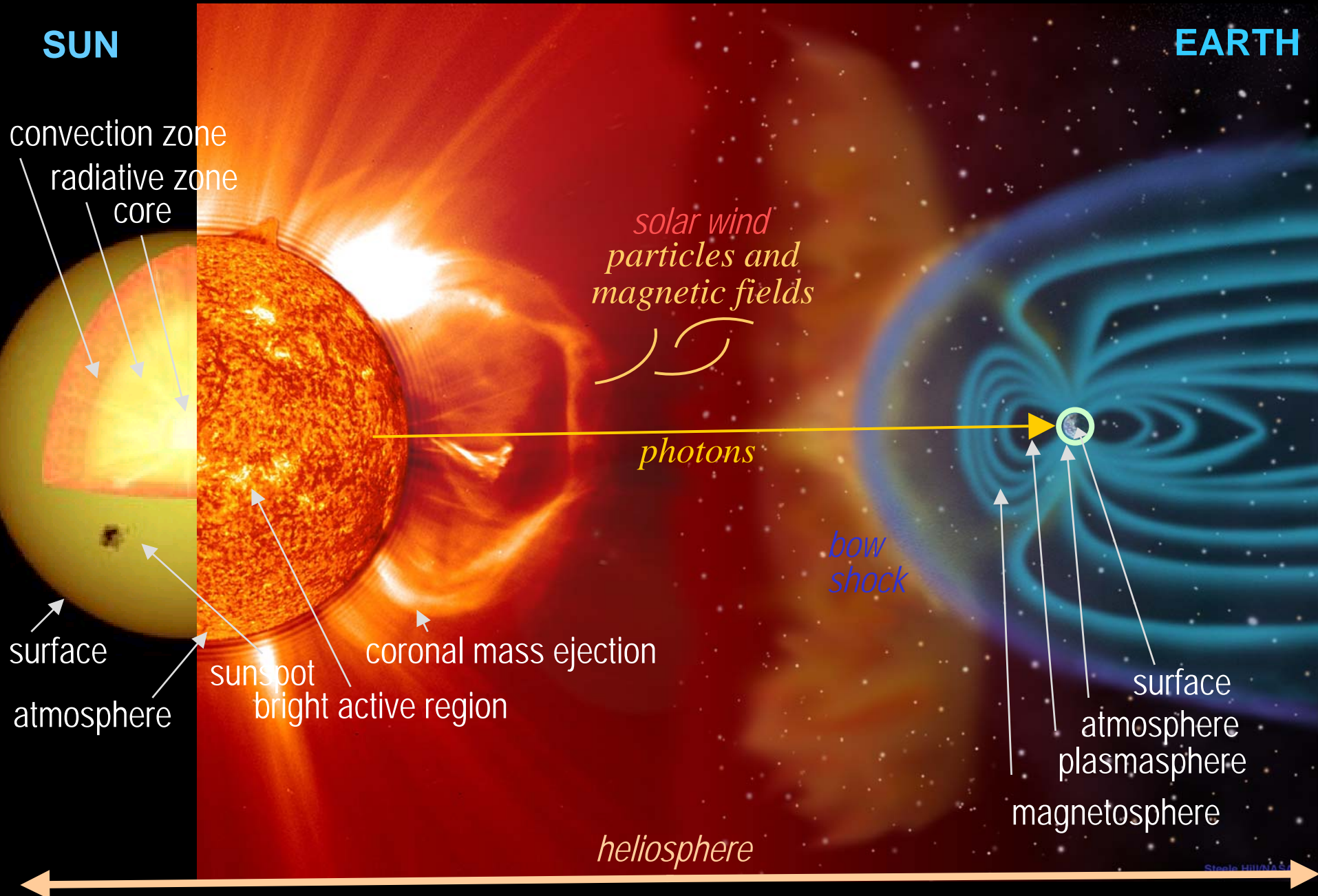
- Dan Baker, LASP
- Santimay Basu, AFRL
- John Foster, MIT
- Jerry Goldstein, SWRI
- Charles Goodrich, BU
- Nat Gopalswamy, NASA
- Joanna Haigh, Imperial College, London
- Jeff Hughes, BU
- Janet Kozyra, U. of Michigan
- Lou Lanzerotti, Lucent Technology
- Judith Lean, NRL
- Jonathan Makela, U. of Illinois
- Larry Paxton, APL/JHU
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- Aaron Ridley, U. of Michigan
- Jogesh Sahai, UNIVAP, Brazil
- Roger Smith, U. of Alaska

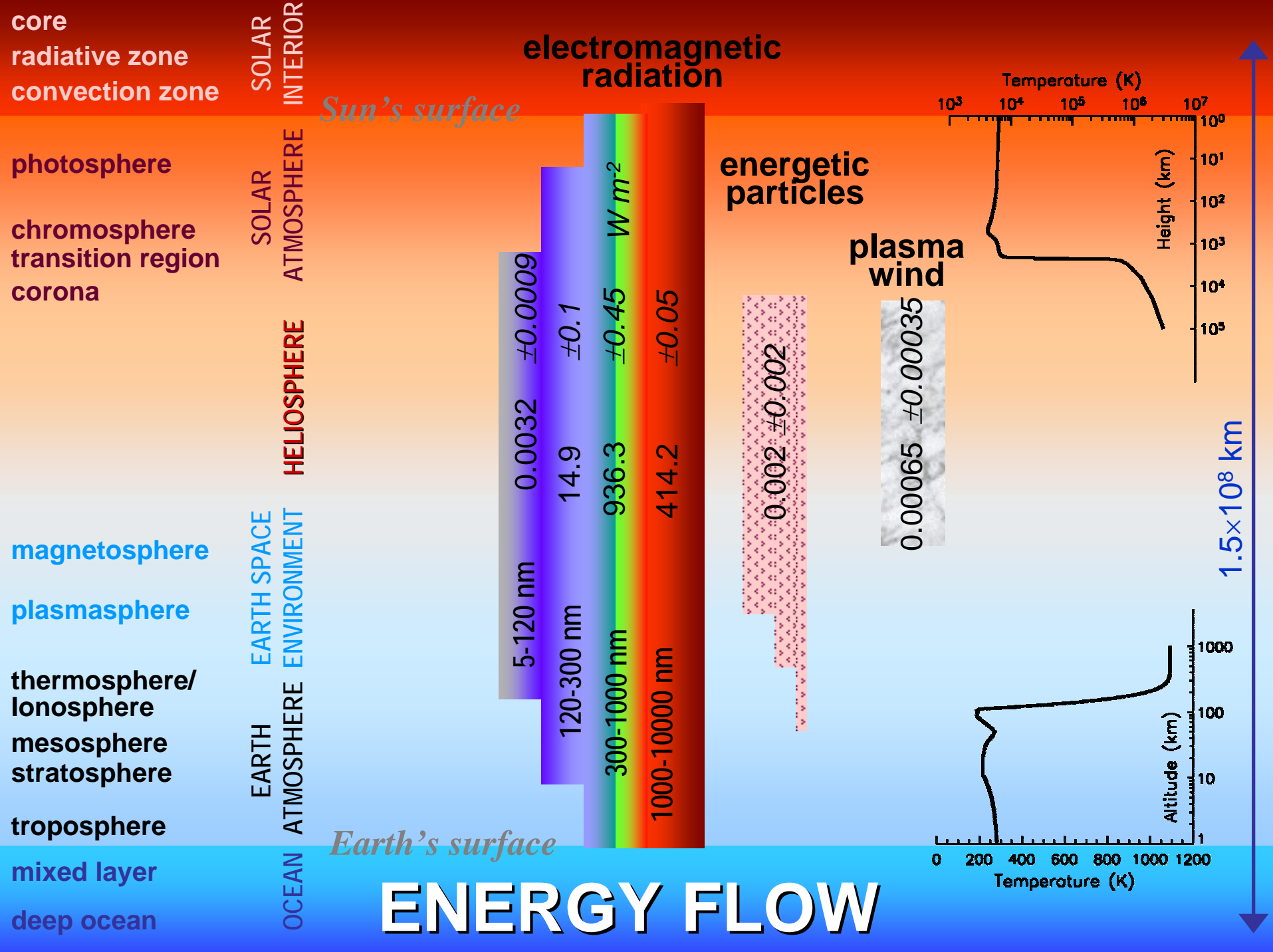
The Sun-Earth System

not to scale

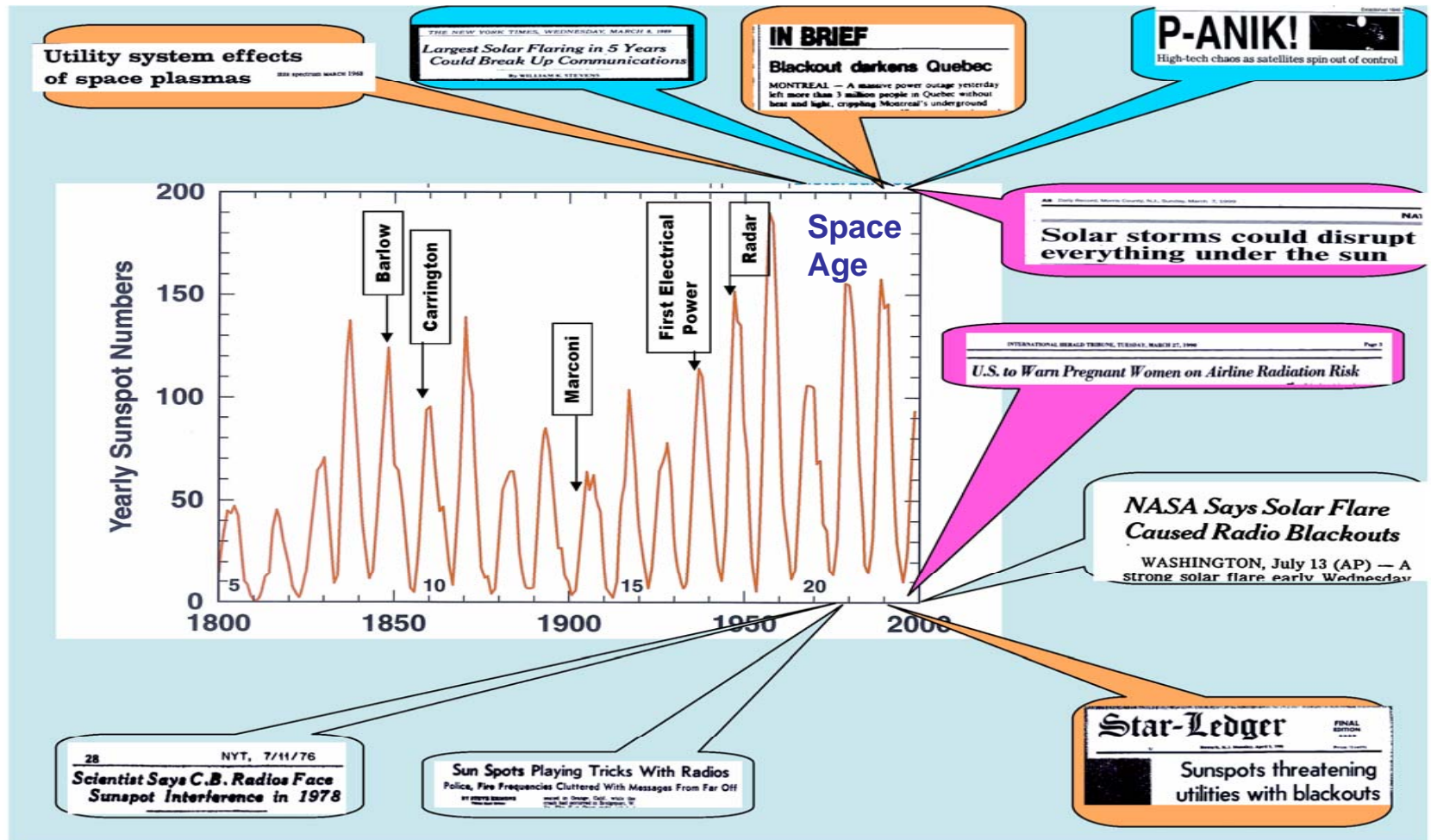
SUN

EARTH



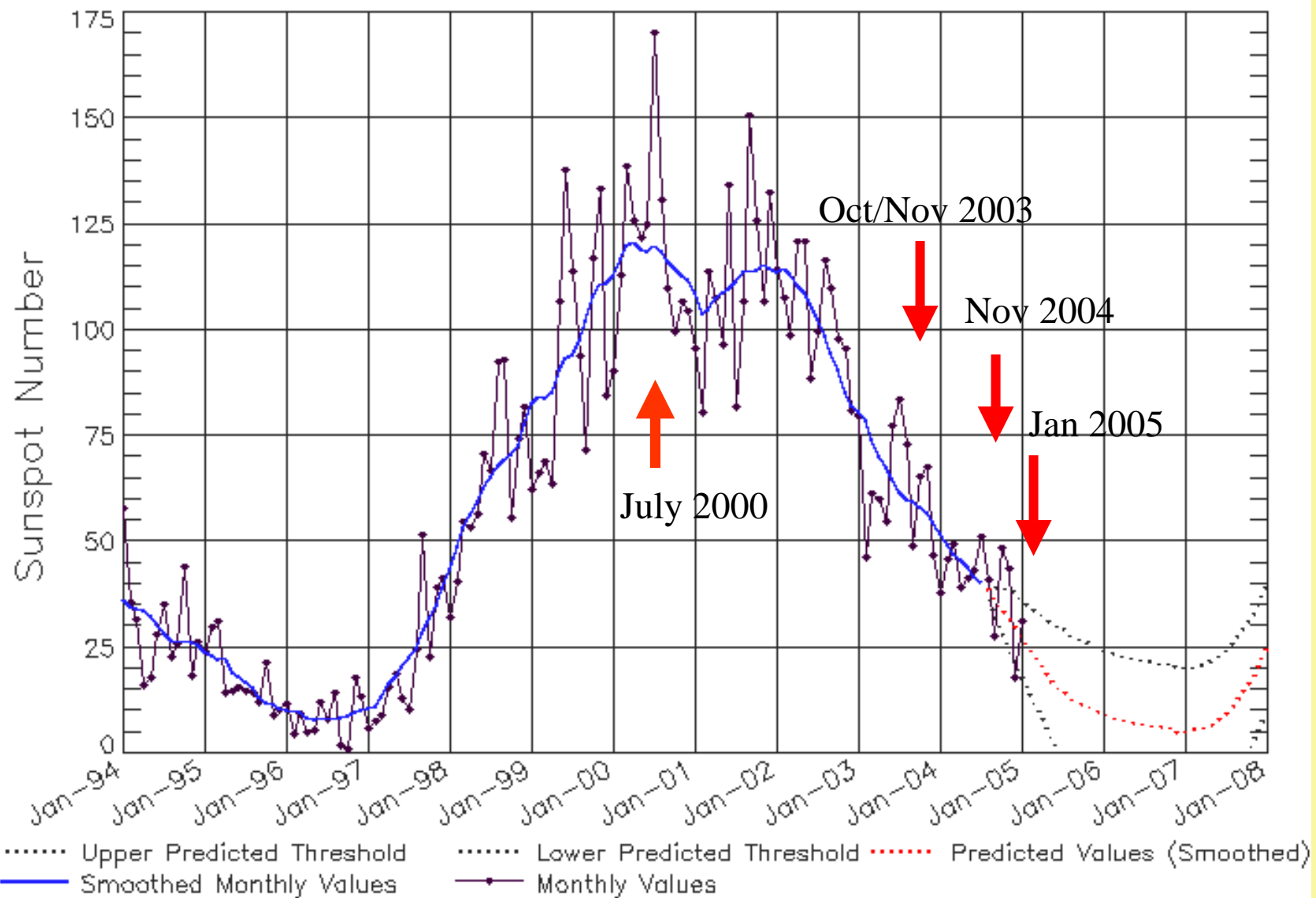


The Sunspot Cycle & Impacts on Technology



ISES Solar Cycle Sunspot Number Progression

Data Through 31 Jan 05



Updated 2005 Feb 1

NOAA/SEC Boulder, CO USA

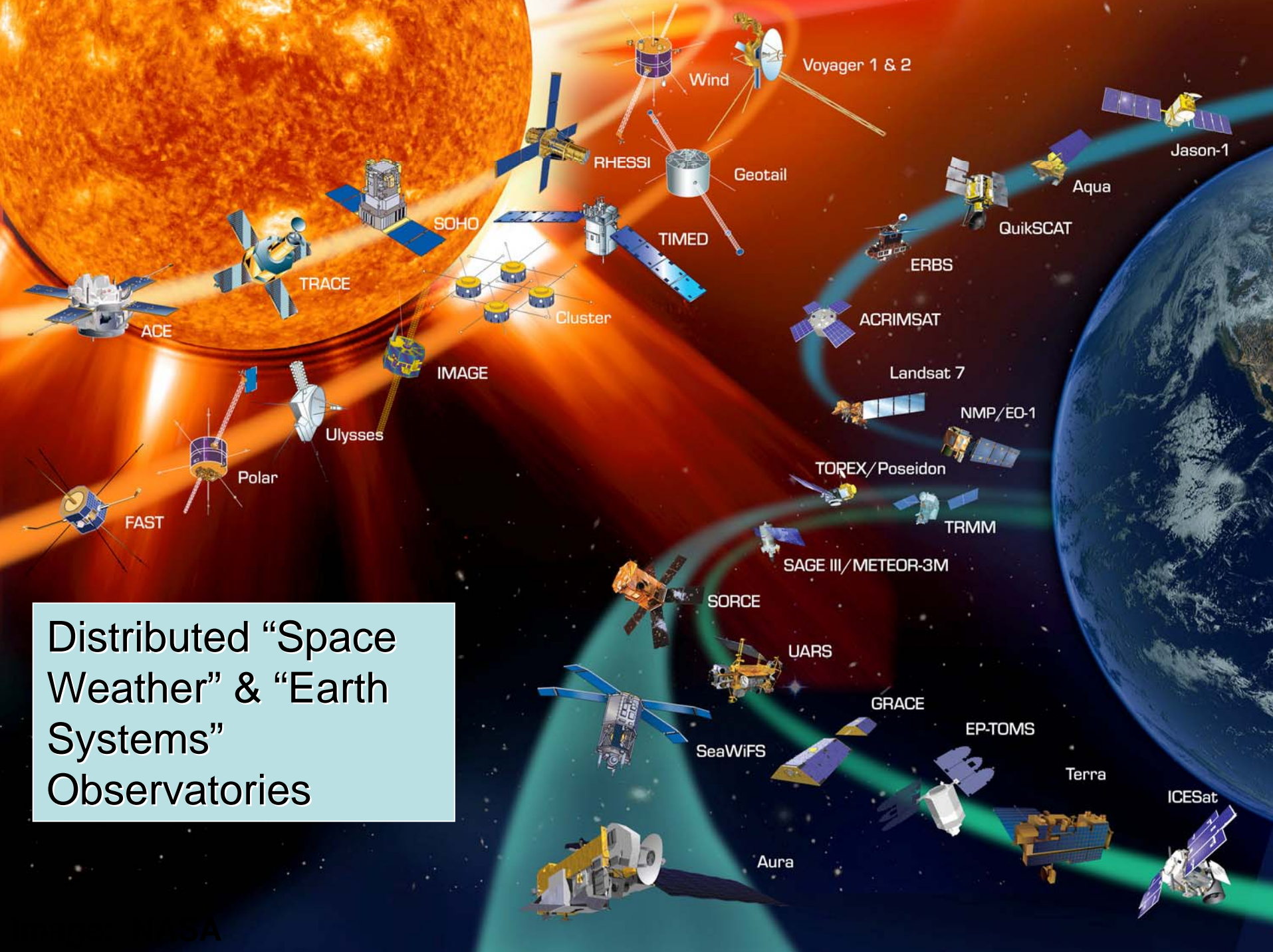
Frontier Science: Sun-Earth as a Complex System



Why Now?

- ★ Distributed observatories in space
- ★ New integrated views from ground-based facilities
(Continuous ground-based solar images, expanded ISR and SuperDARN networks, TEC and ULF wave maps)
- ★ New capabilities in Sun-to-Earth modeling frameworks
- ★ New efforts at data assimilation into physics-based models
- ★ National need to extend the range of useful prediction
- ★ International programs that can be leveraged to enhance our ability to characterize the Sun-Earth system [i.e., CAWSES 2004-2008, ILWS, IHY 2007, eGY 2007, IPY 2007, ICESTAR 2005-2008]

Distributed “Space Weather” & “Earth Systems” Observatories



The 'Halloween Storms' Made History

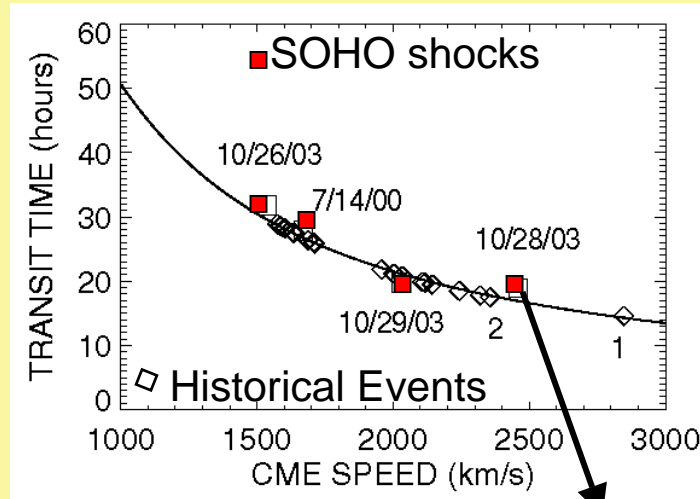
59% of NASA spacecraft affected

80+ CMEs and 11 X-class flares in a 2-week period

Largest geomagnetic storm of solar cycle 23

Most intense solar particle event of solar cycle 23

AGU Journals organized Special sections on the violent Sun-Earth Connection Events of Oct-Nov 2003

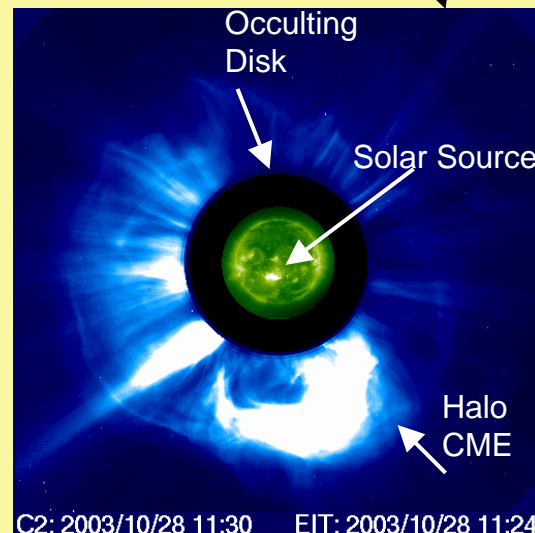


Two of the Halloween shocks had a Sun-Earth transit time < 20 hours.

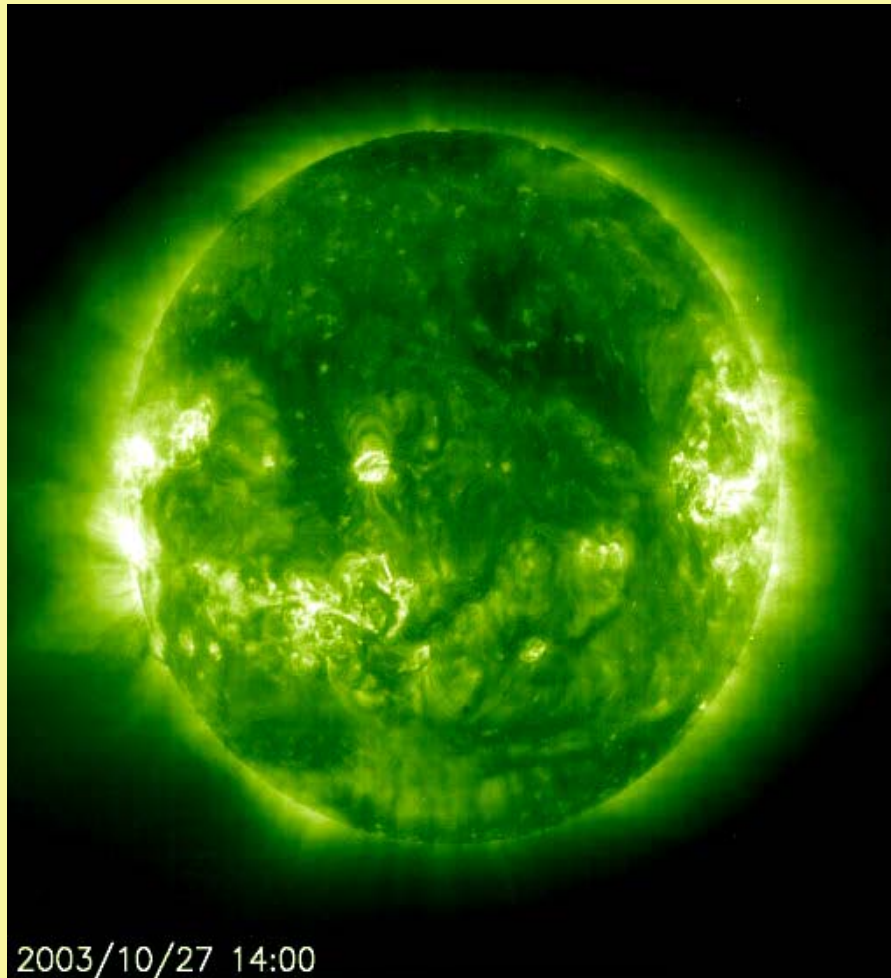
These were only 14h and 15th such occurrences since the discovery of solar flares in 1859

This is the first instance when the storms were comprehensively observed

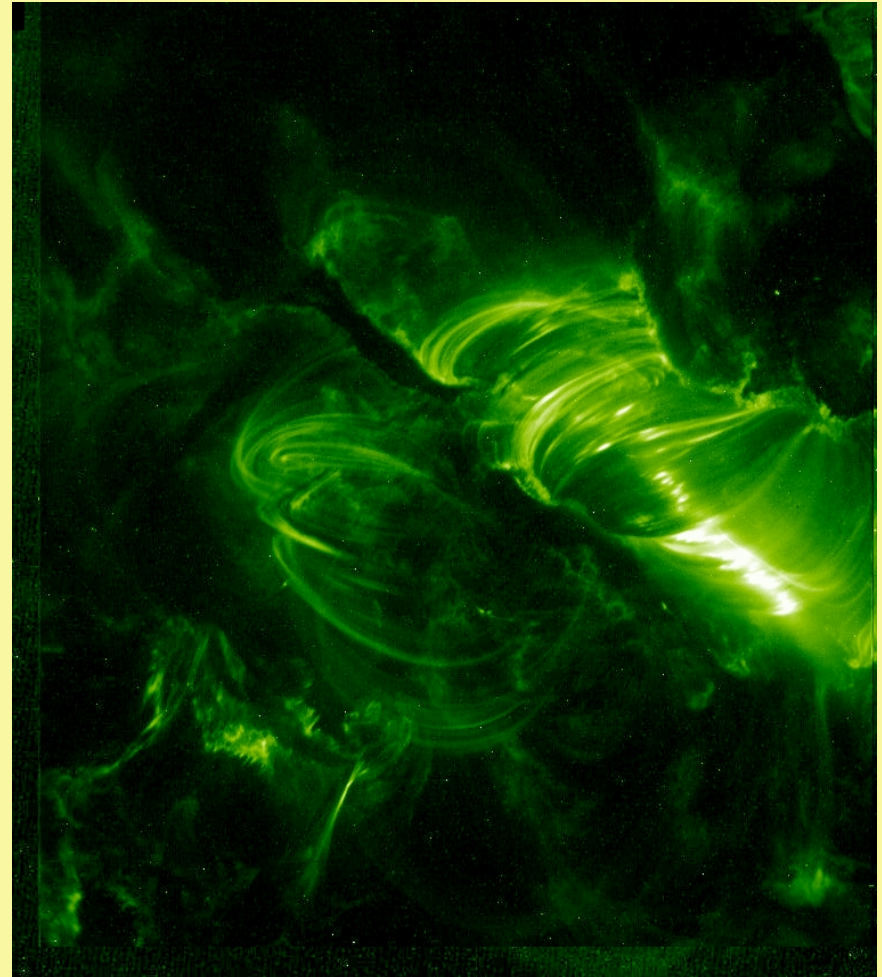
72 scientific papers will appear in AGU journals (JGR, GRL, and Space Weather)



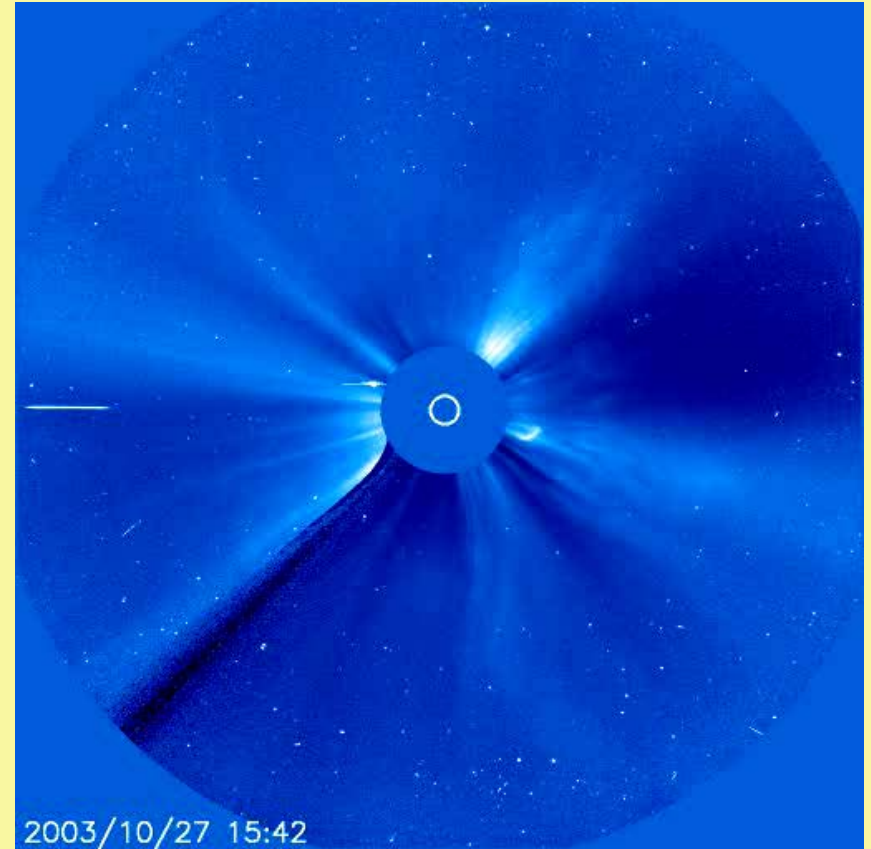
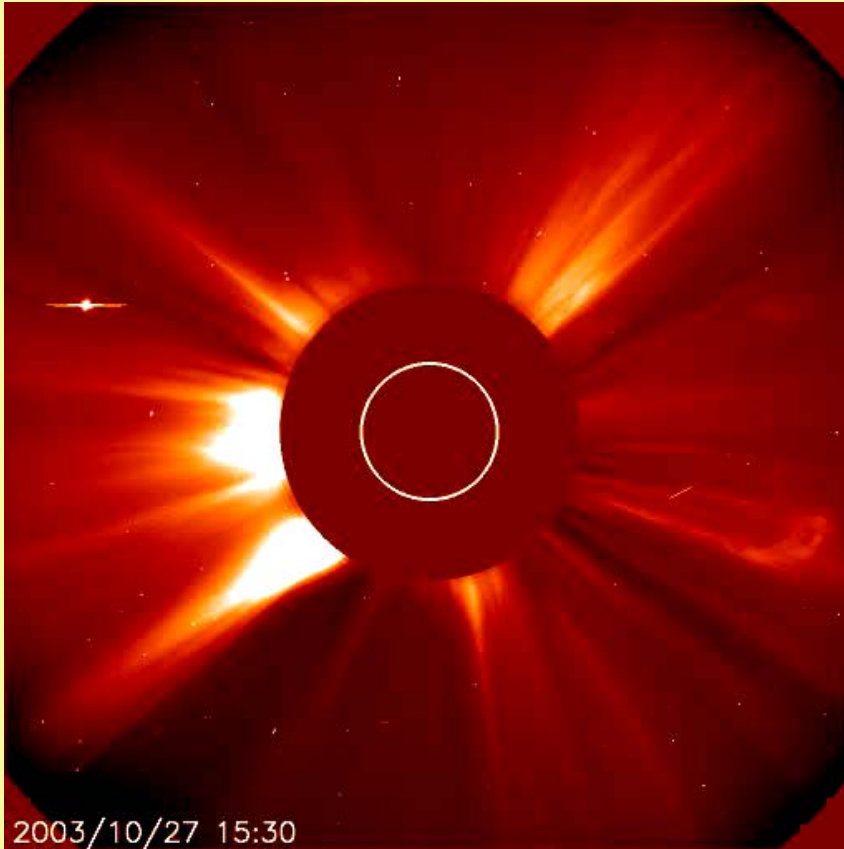
SOHO EUV Imaging Telescope Movie of Halloween Storm



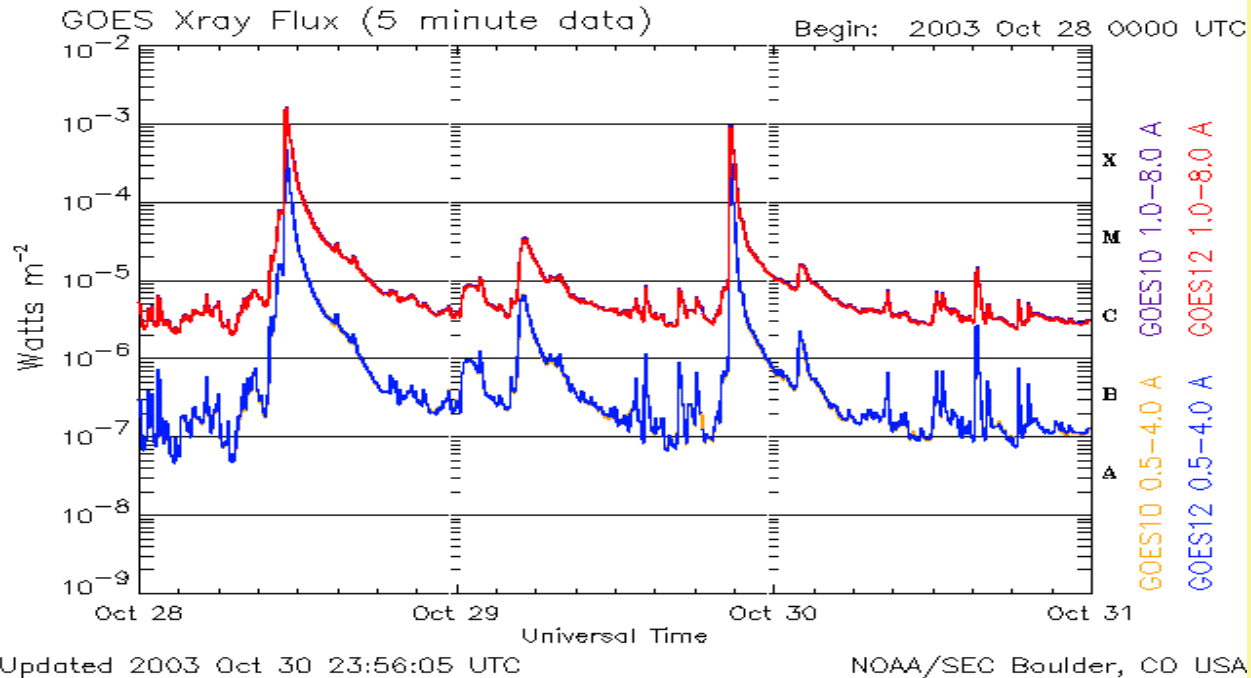
TRACE Image of Solar Flare on Oct 28, 2003 at 12:31 UT



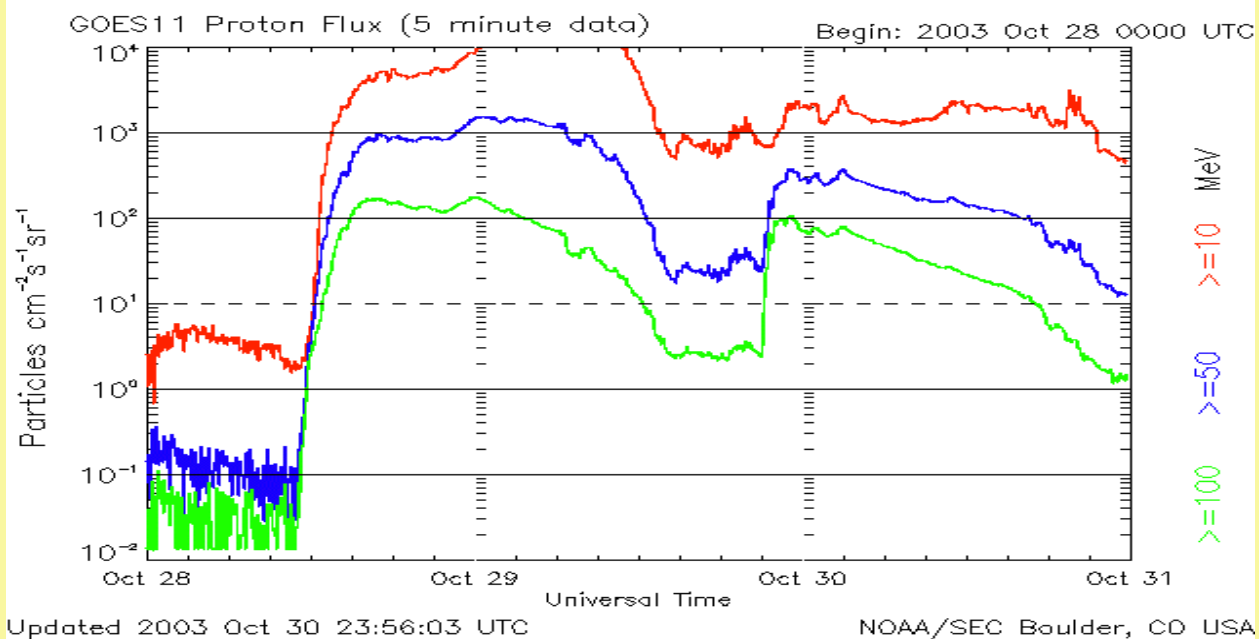
SOHO LASCO C2 and C3 Images of the Solar Corona and Coronal Mass Ejections



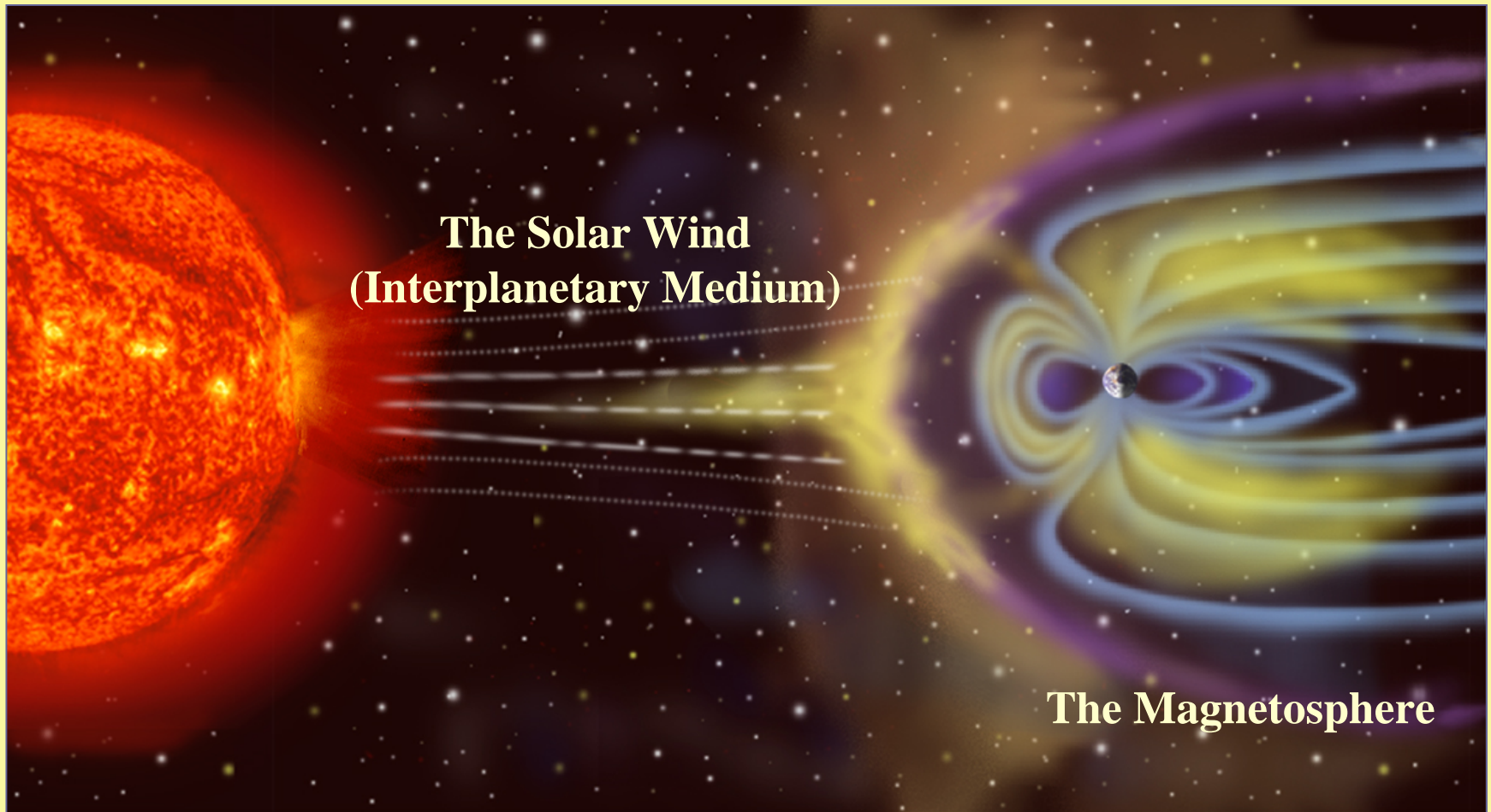
GOES X-ray Flux



GOES Proton Flux

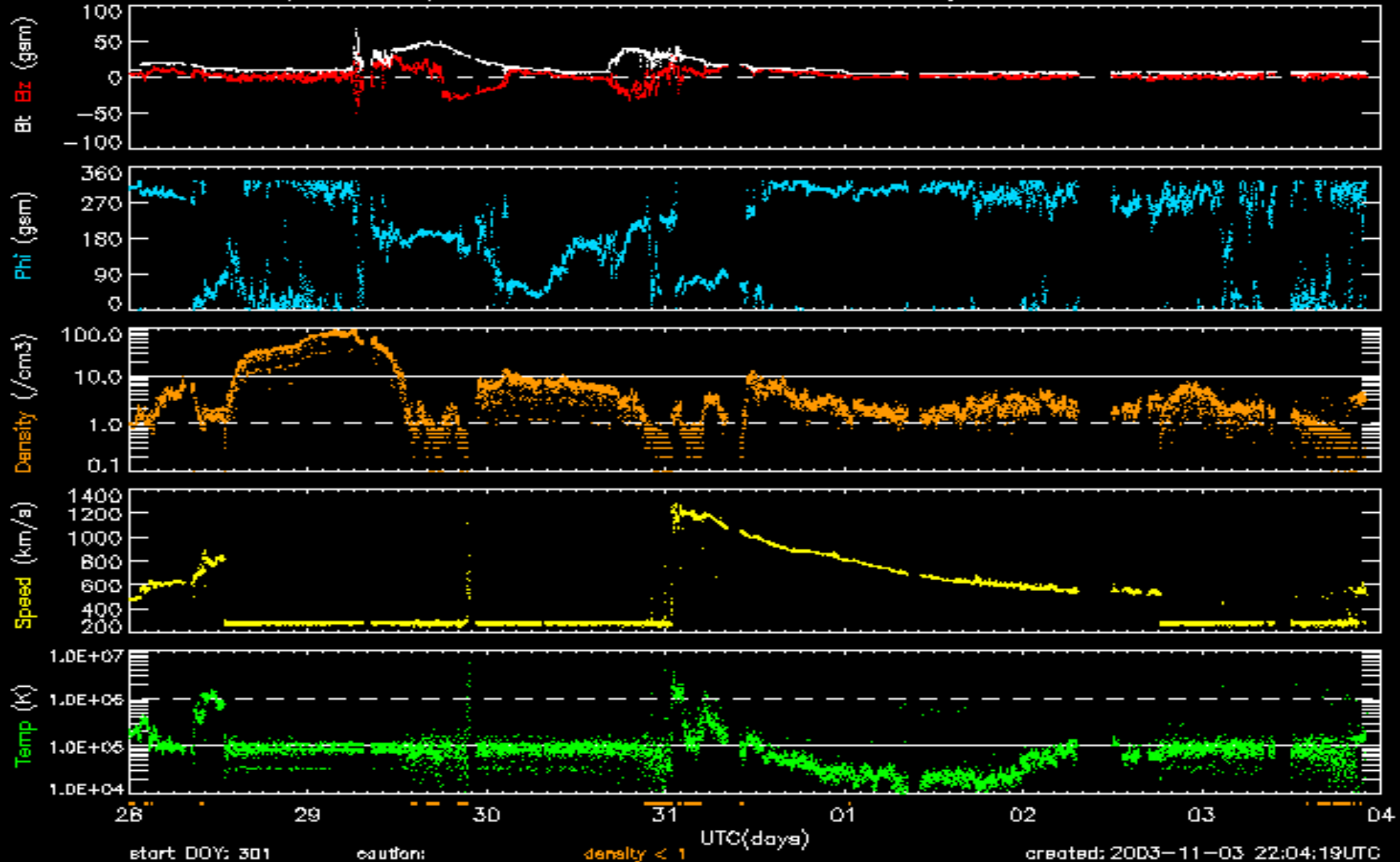


The Sun-Earth System



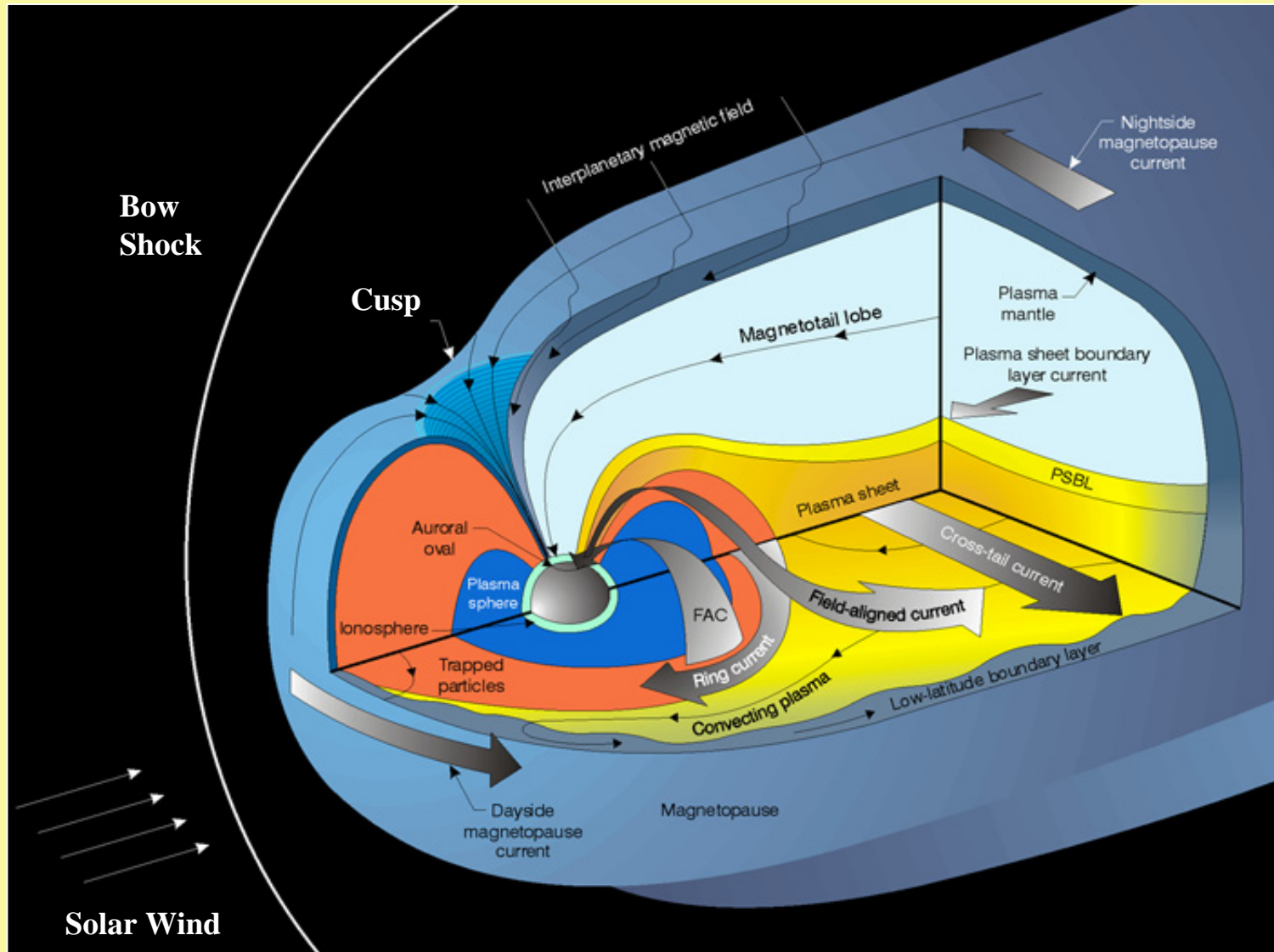
ACE RTSW (Estimated) MAG & SWEPAM

Begin: 2003-10-28 00:00:00UTC



ACE satellite measurements of the interplanetary magnetic field (IMF)
and solar wind at L1

Earth's Magnetospheric Environment



Schematic of Radiation Belts

