Why NASA Needs Solar Cycle Predictions

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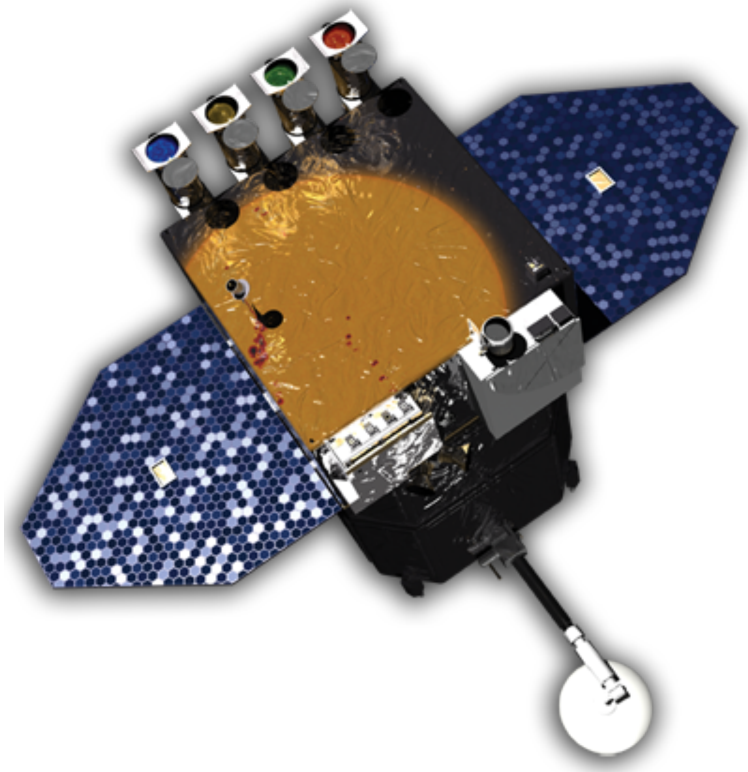

W. Dean Pesnell

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Project Scientist, Solar Dynamics Observatory

Member, Solar Cycle 24 Prediction Panel

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NASA’s mandate is to build, fly, and operate spacecraft in the hostile environment of space. Our success comes from trying to understand what *can* go wrong and building and operating appropriate payloads.

Things go right, things go worng, but the mandate is still there.

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Solar Cycle Predictions are needed to

- Anticipate orbital decay and needs for reboosting
- Anticipate radiation exposure for upcoming missions

Solar Cycle Predictions are needed to

- Anticipate orbital decay and needs for reboosting
- Anticipate radiation exposure for upcoming missions
- Satisfy our scientific curiosity

Mission Operations must Understand Atmospheric Drag

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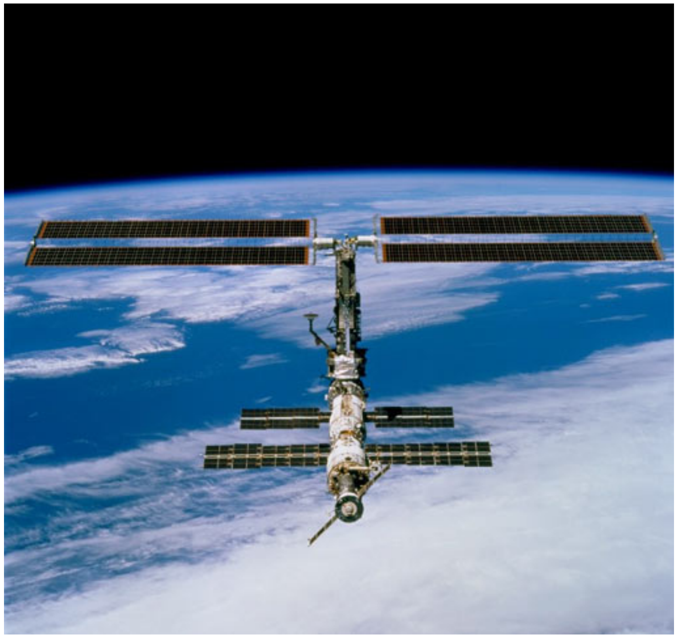
- Drag affects every object in low-Earth Orbit
- Operating satellites may require boosting to stay in a usable orbit (ISS, Hubble)



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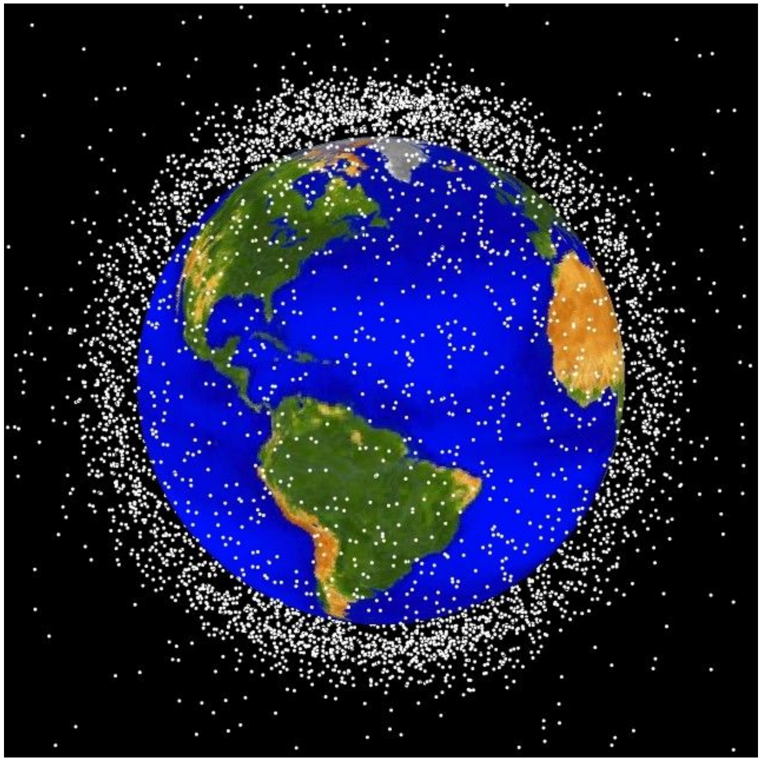
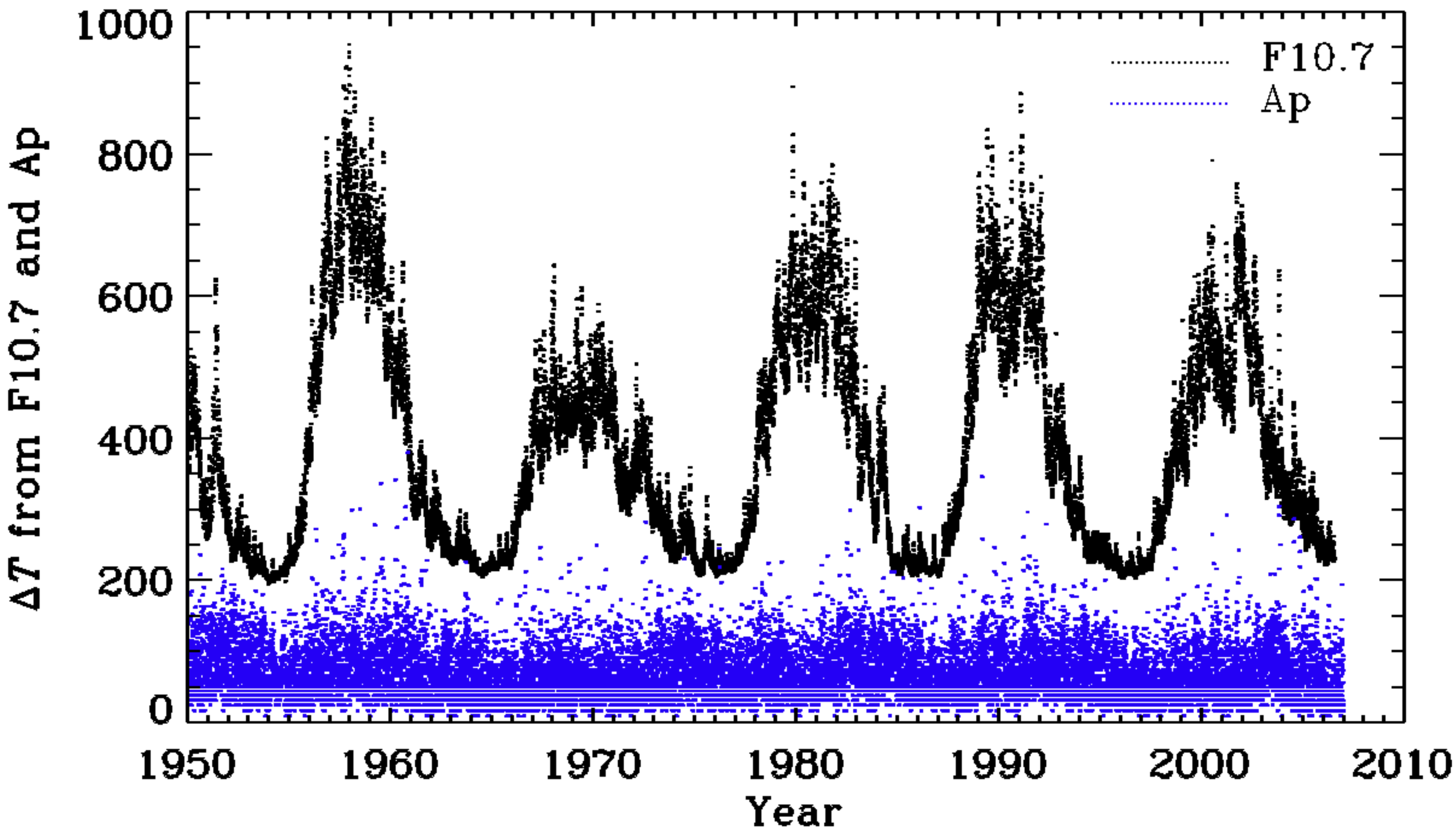
Mission Operations must Understand Atmospheric Drag

- Large satellites without propulsion must be monitored to assure a safe re-entry (UARS)

- Knowledge of orbital debris is also required (rated as one of the biggest hazards to spaceflight)



Mission Planning must Allow for Atmospheric Drag



Changes of the Jacchia model exospheric temperature with solar and geomagnetic activity. Mission planners must have some way to estimate future activity.

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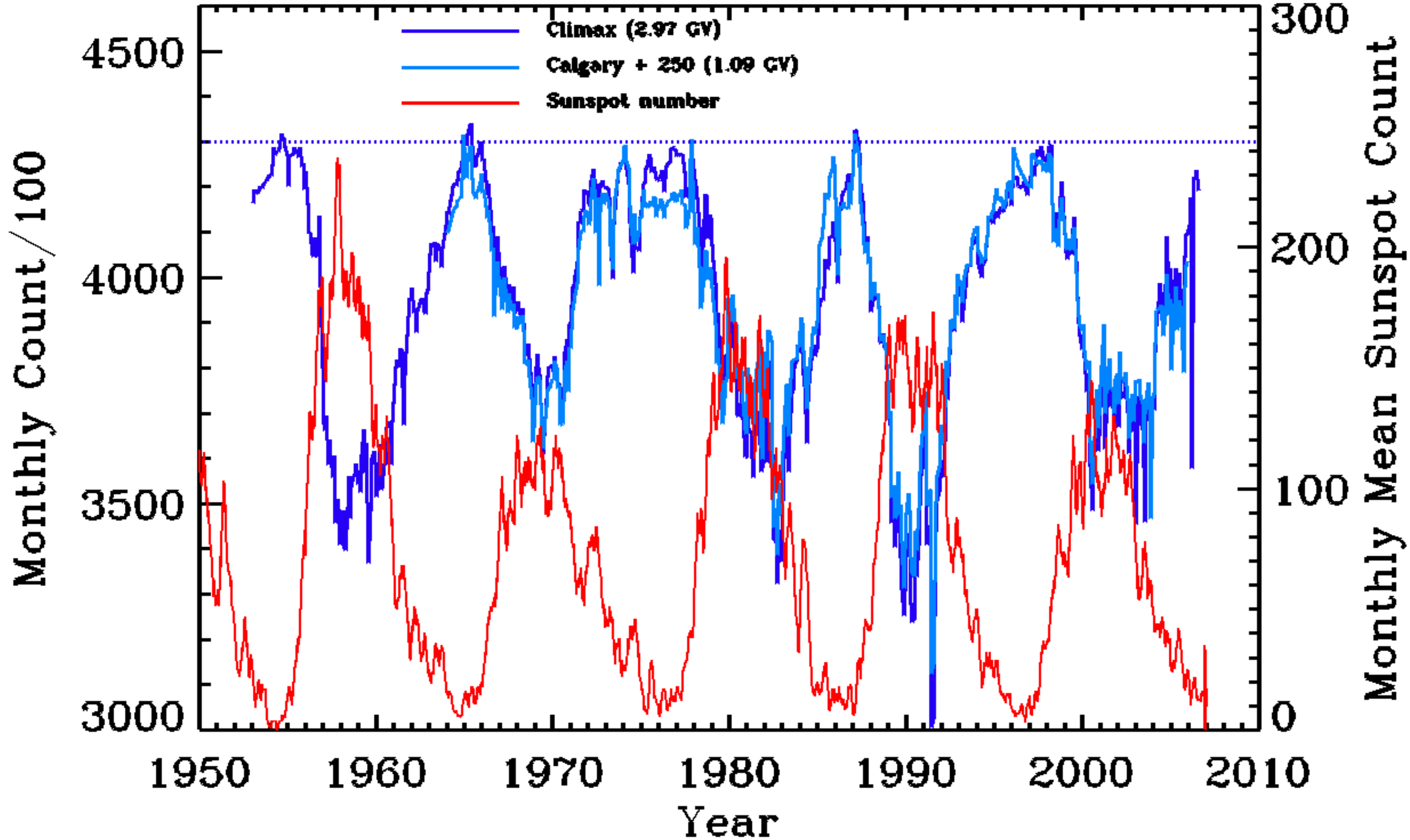
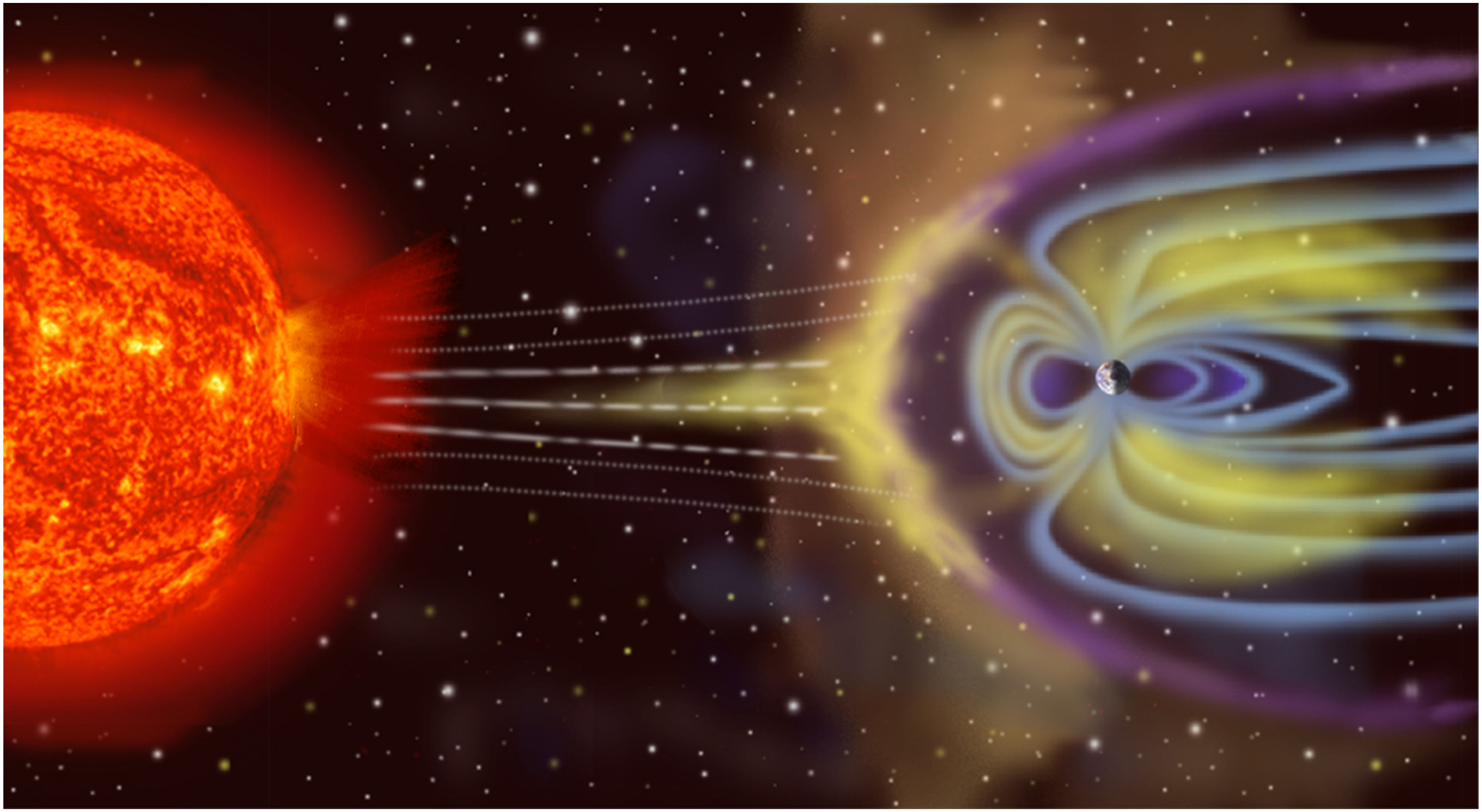
Radiation Hazards must be Understood to be Mitigated

- Radiation hazard is different for every orbit and duration
  - Incident particles range from cosmic rays to highly-relativistic electrons to solar protons
- Missions can have a 10-year leadtime, the Heliophysics Roadmap shows missions out to 2020!
- An understanding of the hazard in each of various study orbits may determine how the mission is designed
- Near-real-time knowledge of radiation hazard is also required
  - This requires short-term predictions of activity

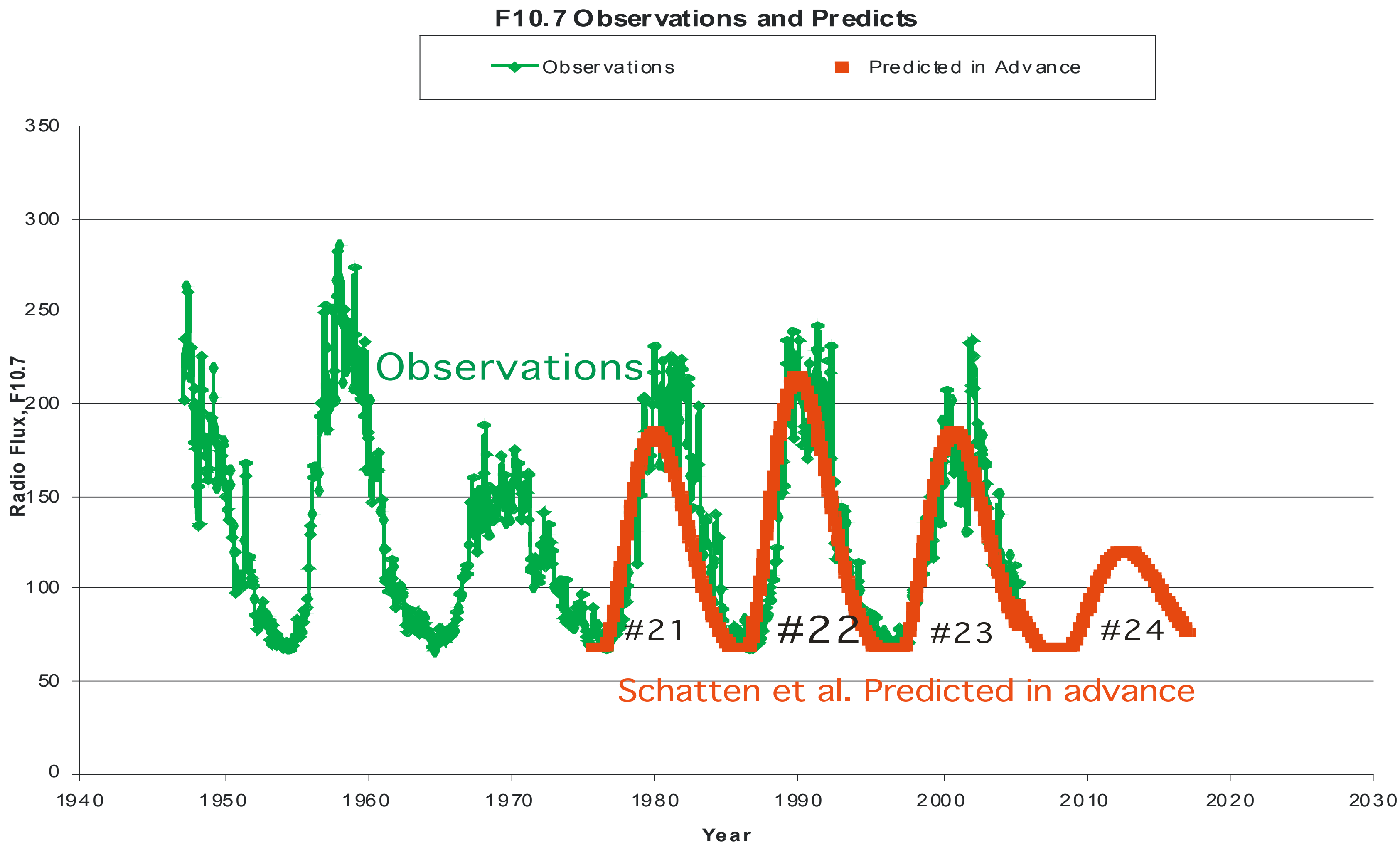
Cosmic Rays and the Solar Cycle



Other Radiation Comes from the Sun and Magnetosphere



A CME strikes the Earth's magnetosphere. Both prompt (SEPs) and delayed (magnetospheric storms) radiation increases are possible.


F10.7 Observations and Predicts
Observations
Predicted in Advance
Observations
#21
#22
#23
#24
Schatten et al. Predicted in advance
Radio Flux, F10.7
Year
0
50
100
150
200
250
300
350
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030

Who Wouldn't Want to Solve a Century-old Puzzle

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- Flares and coronal mass ejections are the origins of space weather—but we still don't know how to predict either!
- Simple timeseries analysis has not produced accurate predictions, additional information is required
- Solar activity comes from the dynamo within the convection zone and reaches out through the photosphere into the corona
- Many models of the solar dynamo exist but none are complete
- We have seen part of the solution: helioseismology and large-scale numerical models

Flows in the Solar Convection Zone

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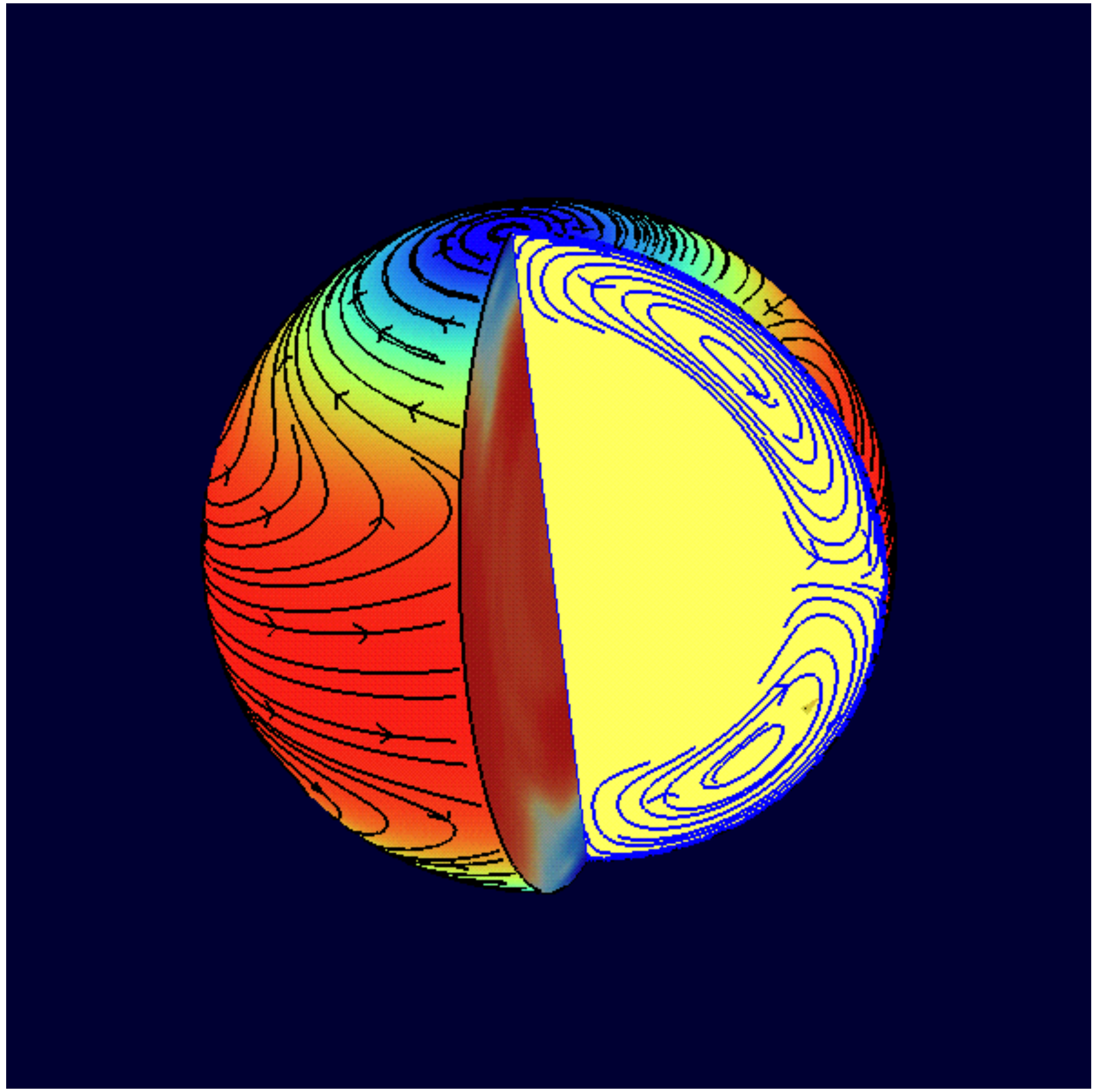
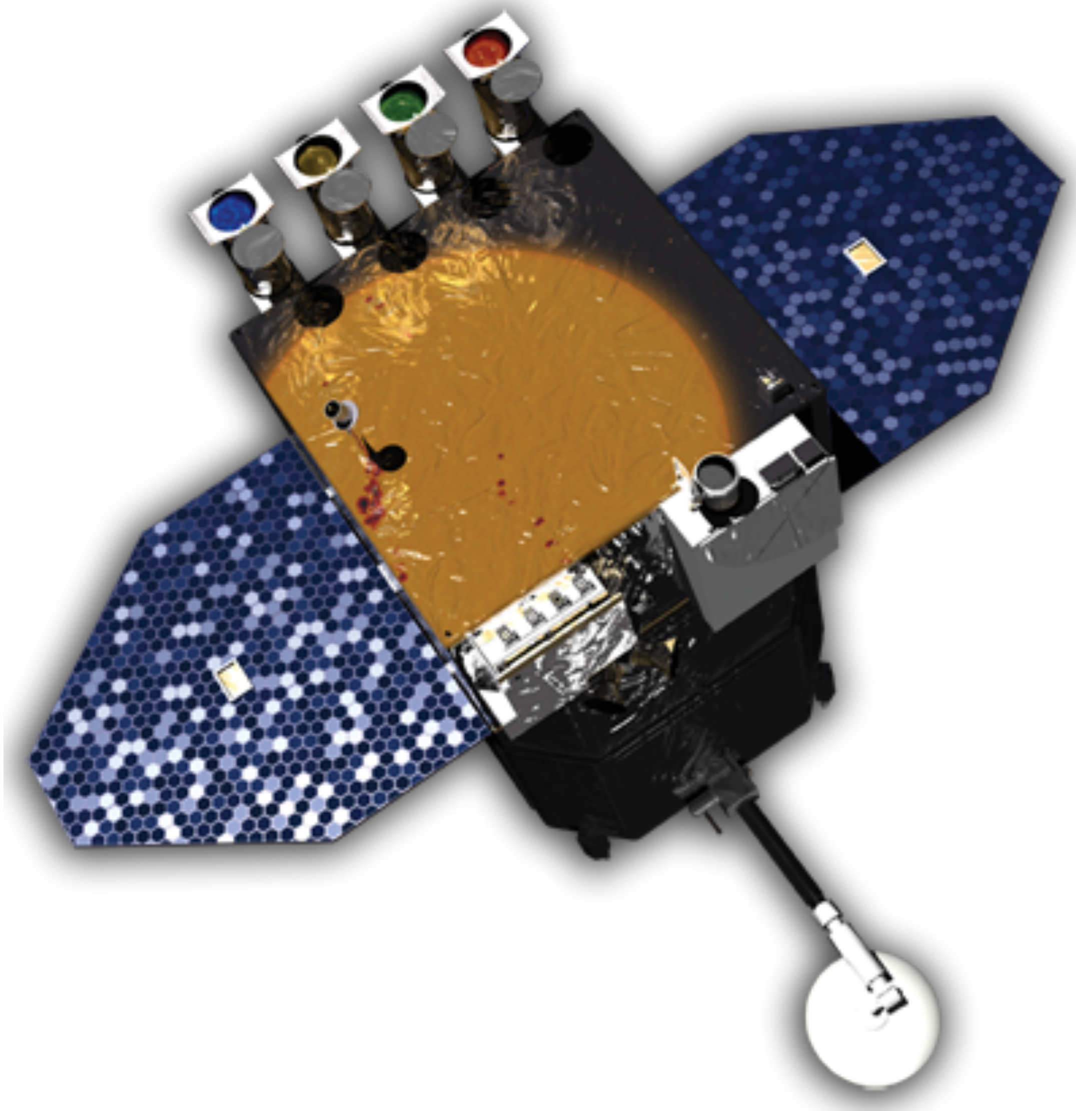
These flows, which are being resolved by helioseismology, have been observed for one solar cycle. They constantly change with the cycle and may be the clue to the solar dynamo.



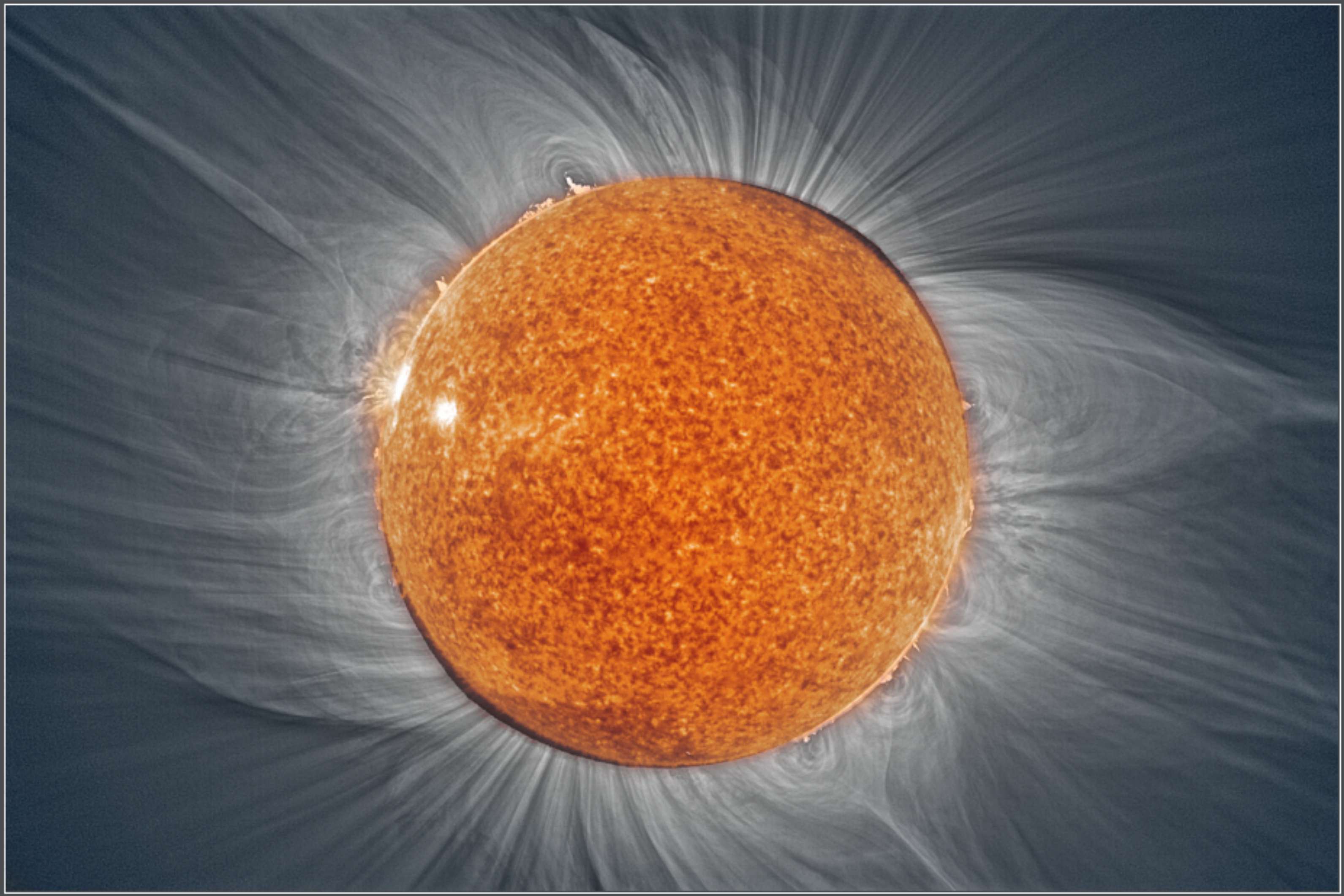
The Solar Dynamics Observatory

SDO, the first mission of *Living With a Star*, will provide the data needed to understand the solar convection zone and how magnetic field is assembled and dissipated in the solar atmosphere.



But that's another story!

Questions?



Total Solar Eclipse 2006

Backup Slides Follow

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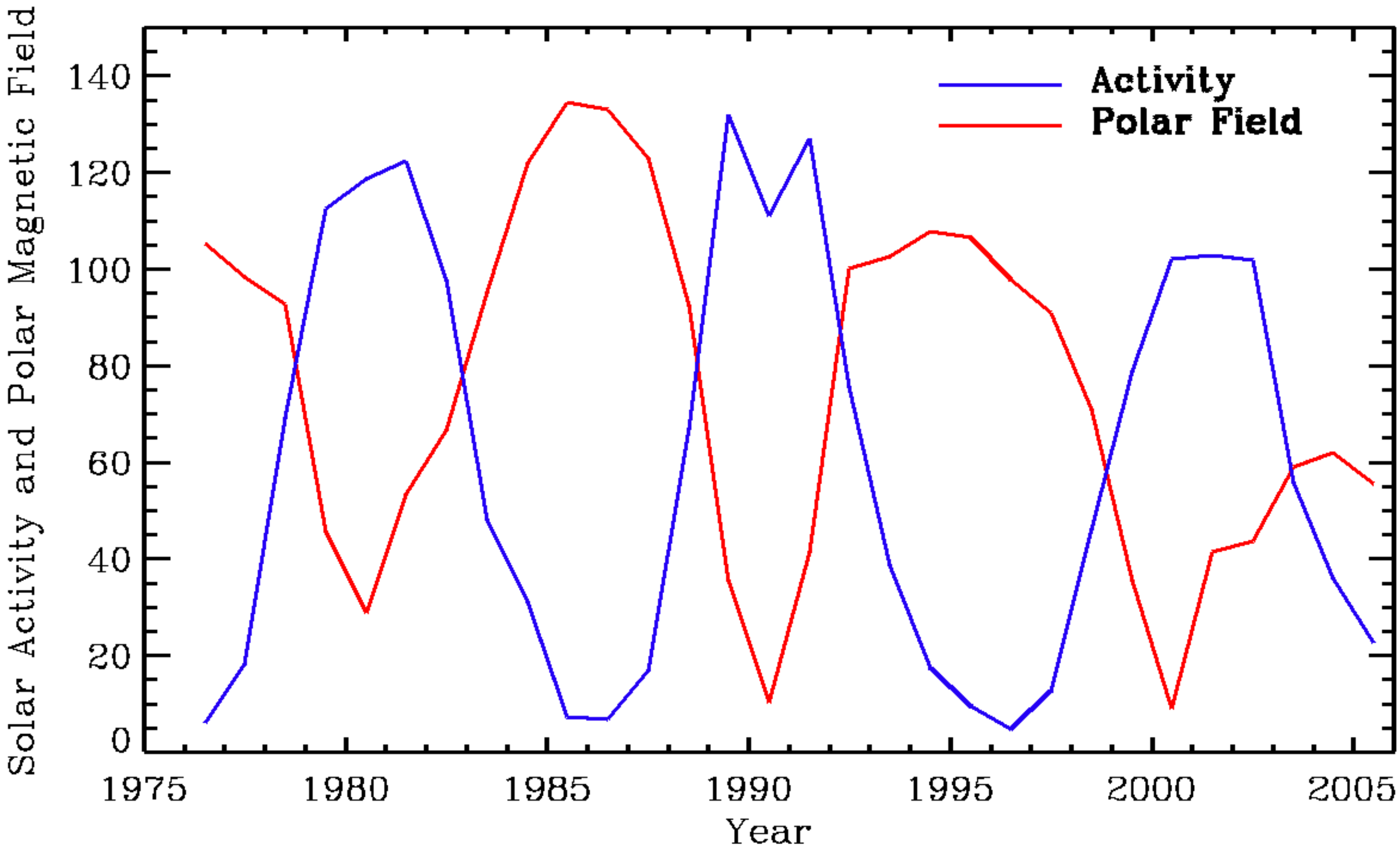
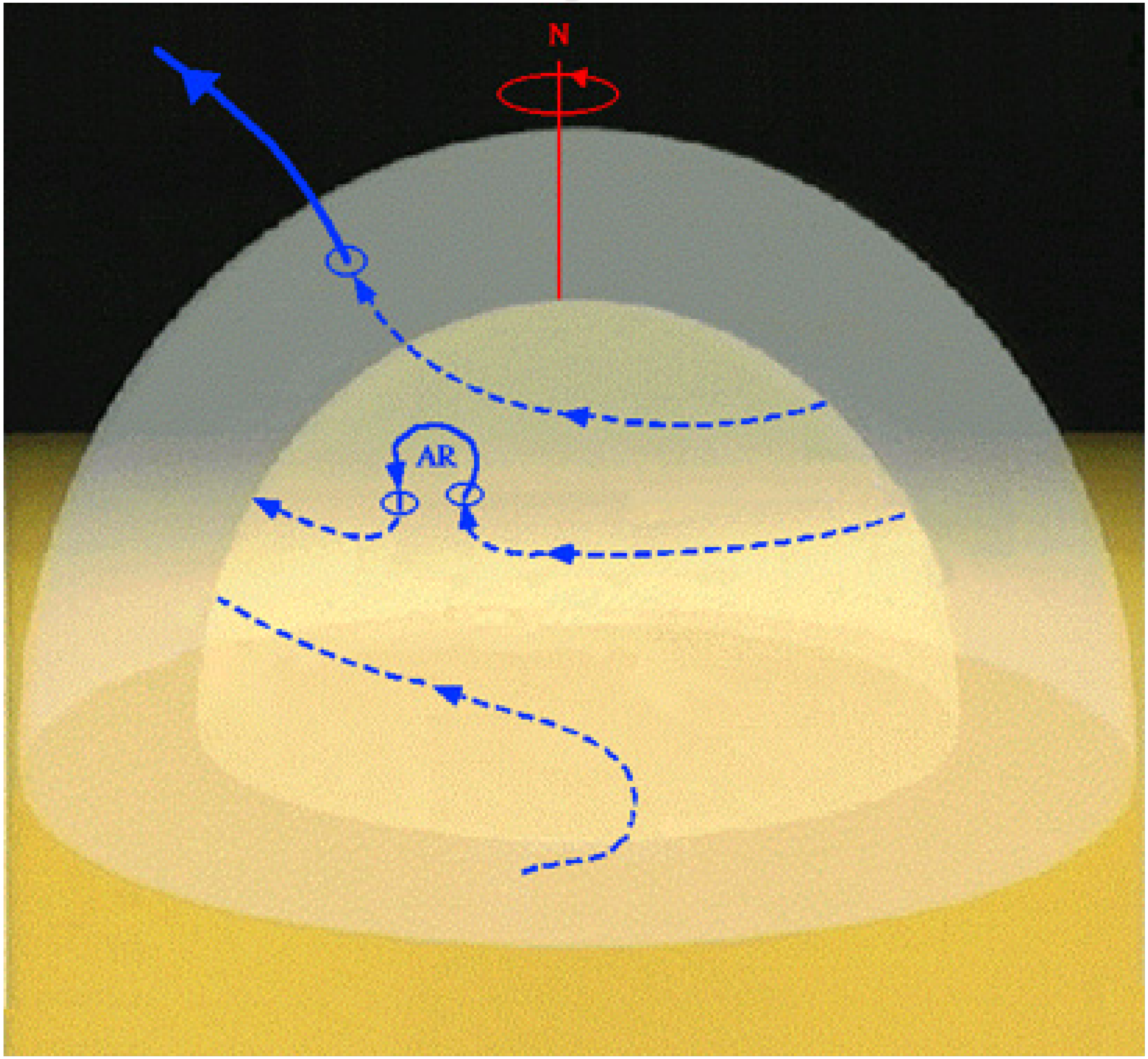
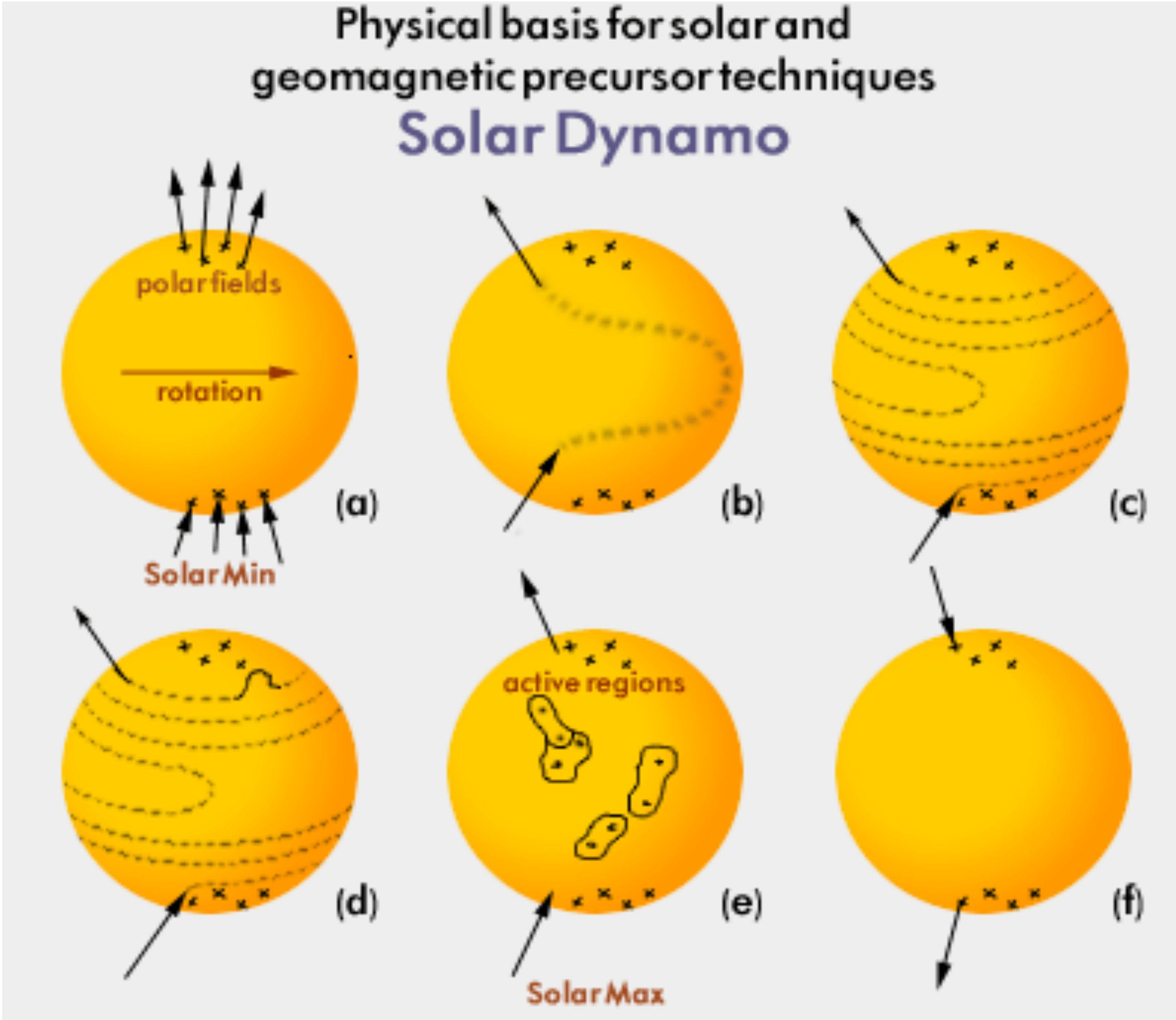


Babcock-Leighton model




Physical basis for solar and
geomagnetic precursor techniques
Solar Dynamo
polar fields
rotation
Solar Min
(a)
(b)
(c)
(d)
active regions
(e)
Solar Max
(f)

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