Why NASA Needs Solar Cycle Predictions

W. Dean Pesnell
NASA, Goddard Space Flight Center
Project Scientist, Solar Dynamics Observatory
Member, Solar Cycle 24 Prediction Panel
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 wrong, but the mandate is still there.
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

- Drag affects every object in low-Earth Orbit
- Operating satellites may require boosting to stay in a usable orbit (ISS, Hubble)
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.
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
A CME strikes the Earth’s magnetosphere. Both prompt (SEPs) and delayed (magnetospheric storms) radiation increases are possible.
F10.7 Observations and Predicts

Observations

Schatten et al. Predicted in advance

Year

Radio Flux, F10.7
Who Wouldn’t Want to Solve a Century-old Puzzle

- 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
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?
Backup Slides Follow
Babcock-Leighton model
Physical basis for solar and geomagnetic precursor techniques

Solar Dynamo

(a) polarfields
(b) rotation
(c) SolarMin
(d) active regions
(e) SolarMax
(f)