Vital Statistics of Solar Activity Cycle 23

Joe Kunches

NOAA Space Environment Center

Boulder, Colorado

Joseph.Kunches@noaa.gov

Robert Lilley

Illgen Simulation Technologies, Inc.

Santa Barbara, California

rlilley@illgen.com

International Loran Association
30th Annual Convention
St. Germain-en-Laye, France
October 7-10, 2001

U.S. Department of Commerce
National Oceanic and Atmospheric Administration

National Weather Service

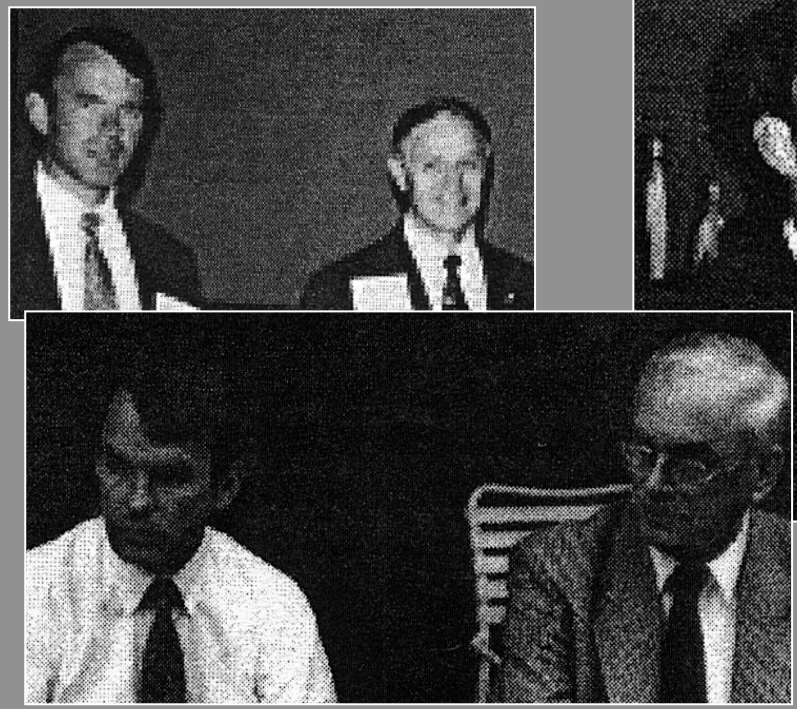
National Centers for Environmental Prediction (7 centers)

Office of Atmospheric Research

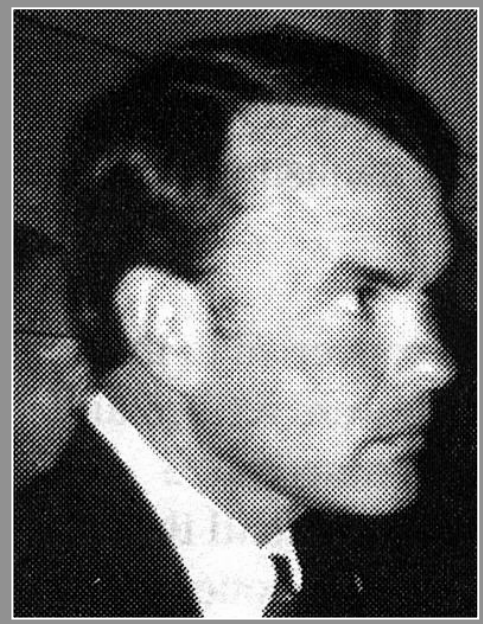
Environmental Research Laboratories (12 laboratories)

Space Environment Center

By 1998, concern was building over the upcoming Cycle 23 Solar Max...



1996...



1998...

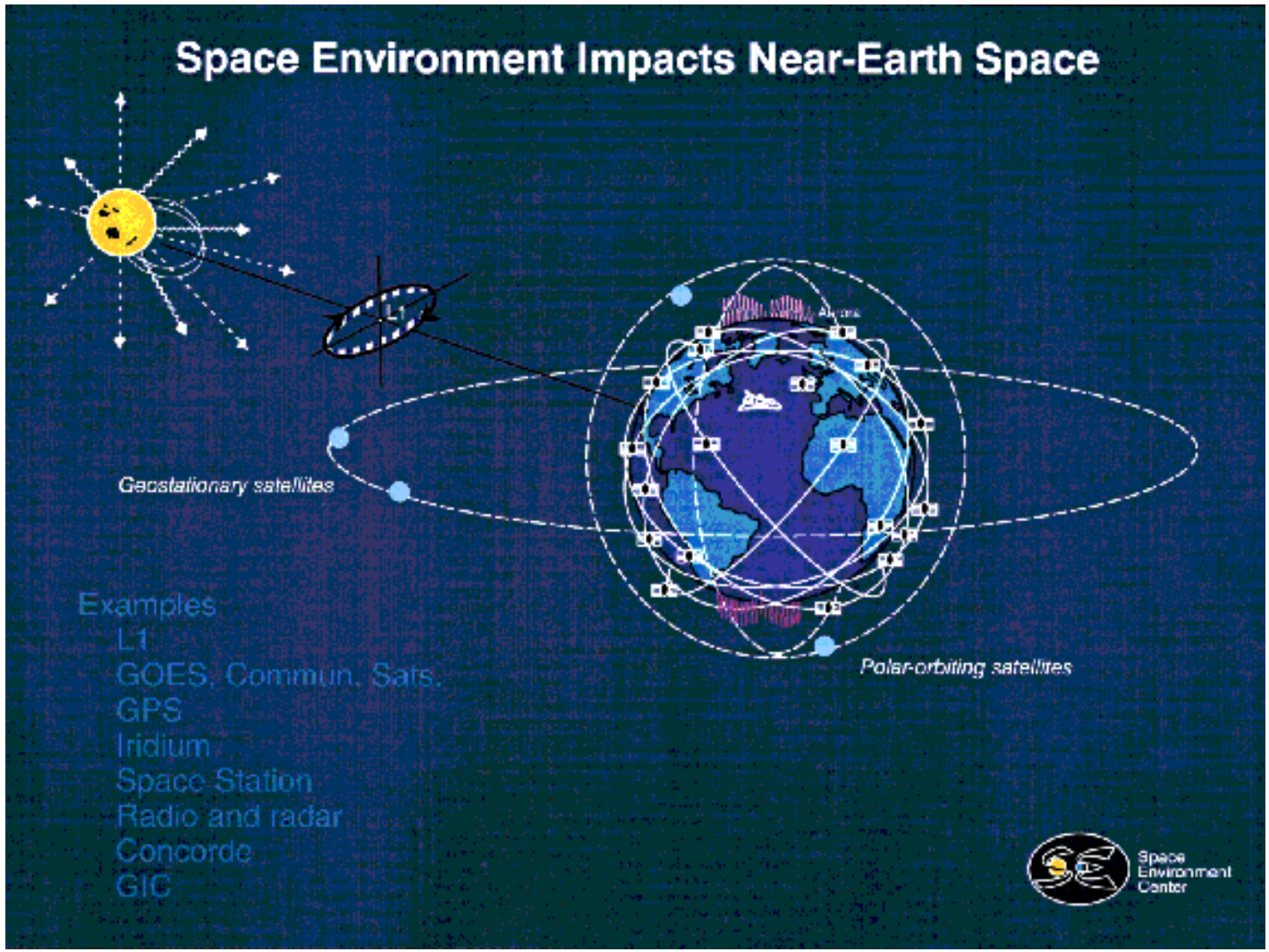
More recently, Cycle 23 must be meeting expectations;

the mood looks much more relaxed!

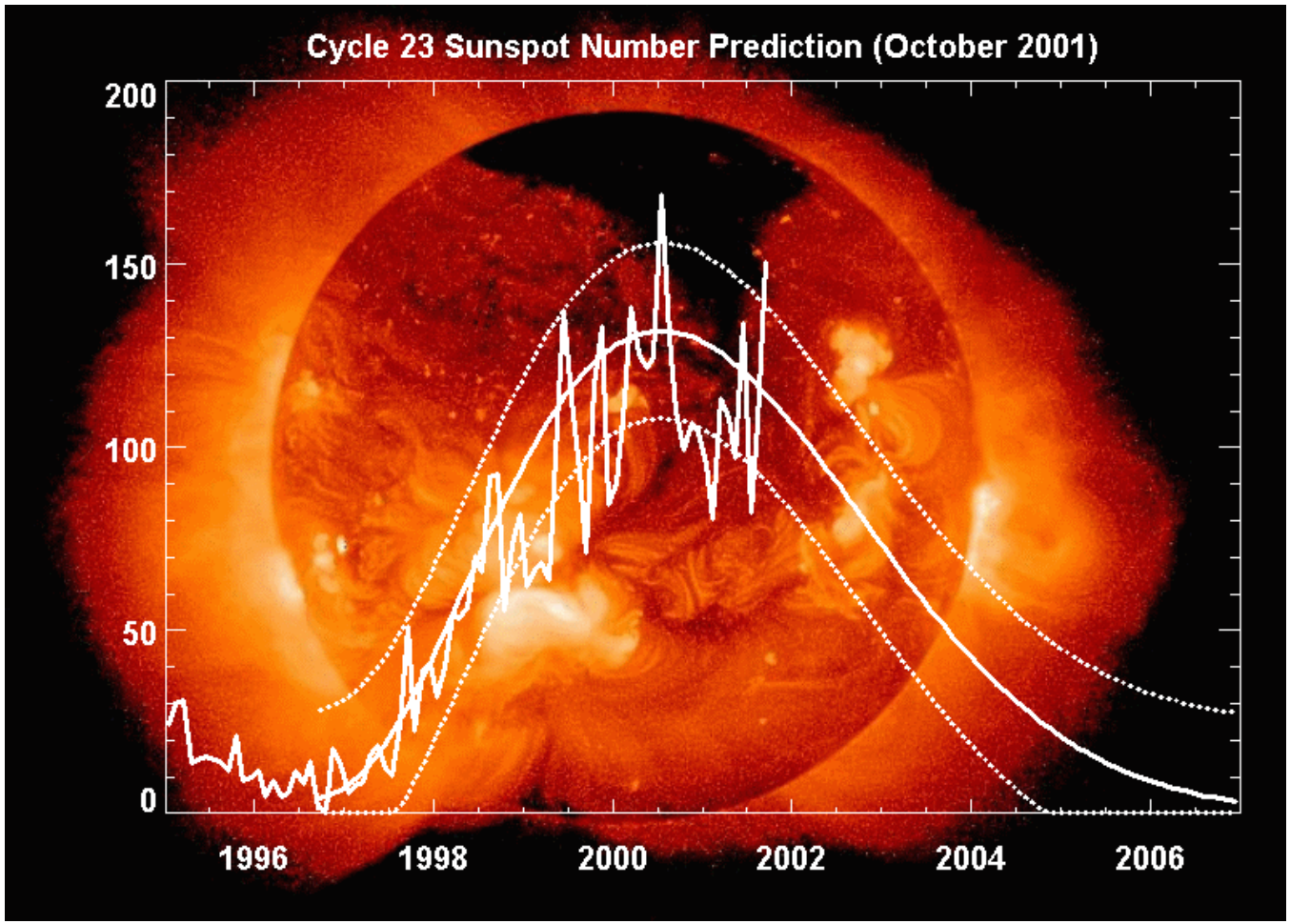
David Skaggs Research Center, NOAA, Boulder, Colorado

Space Weather Operations

Here is the secret to near-real-time solar weather reporting



Solar Cycle 23, September 2001



Courtesy NASA Spaceweather.com

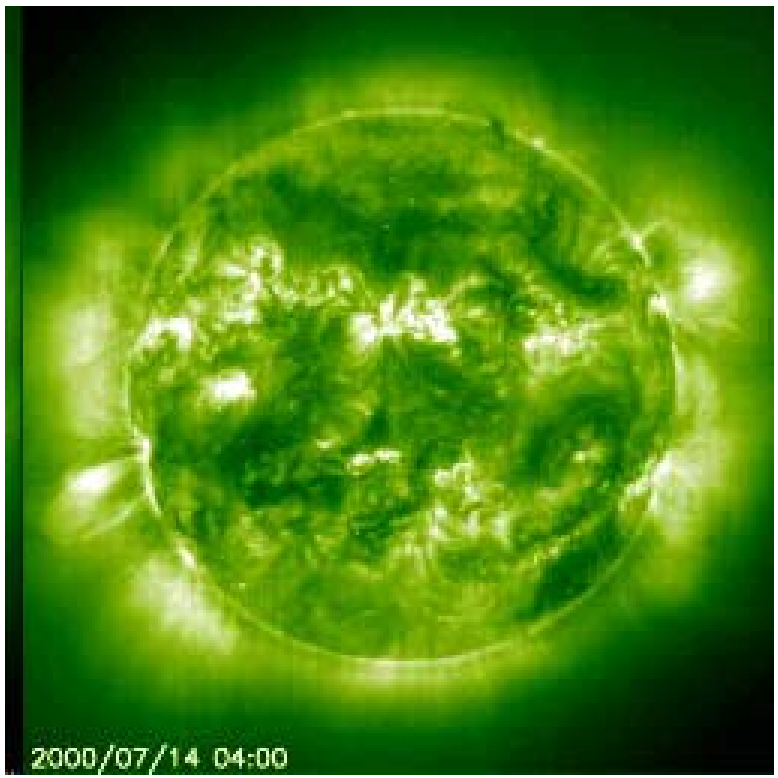
NOAA Space Environment Center

A solar coronal mass ejection

in the direction of the earth, is detected by the SOHO satellite orbiting at L1, about 1.5 million km from earth. The white “halo” indicates an ejection in the direction of the sensor. The sensor is affected soon after by impacts from high-energy protons. The shield in the center shields the sensor from the bright solar disk, rendering the corona visible as in an eclipse. These images are helpful in predicting effects on earth, with about 30-45 minutes warning time prior to onset of an ionospheric storm. -- very compressed time scale; video lasts 22 hours in real time.

Extreme ultraviolet solar image

Note flare at center preceded by increasing mass movement nearby, followed by high-speed events appearing to move toward upper left; mass following magnetic field lines at limbs, pairs of sunspots reflected across equator. Following detection of the flare, sensor may be affected by the increase in X-rays.Video covers a 15-hour time period. Solar disk is approximately 850,000 miles in diameter (earth is 8,000+ miles)

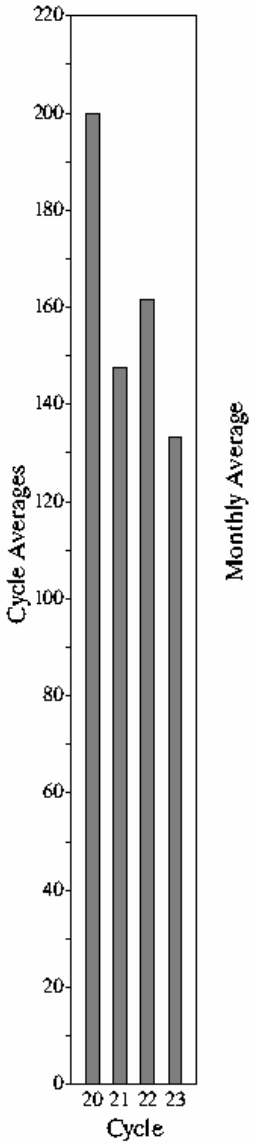


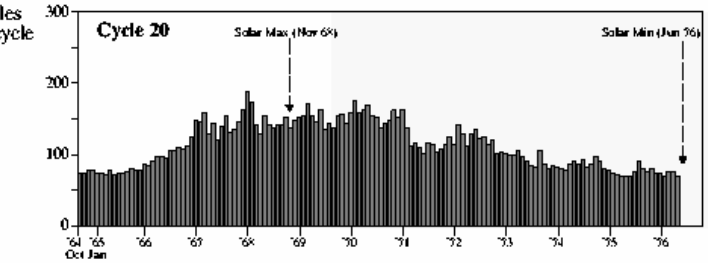
Solar Radio Flux (10.7 cm)

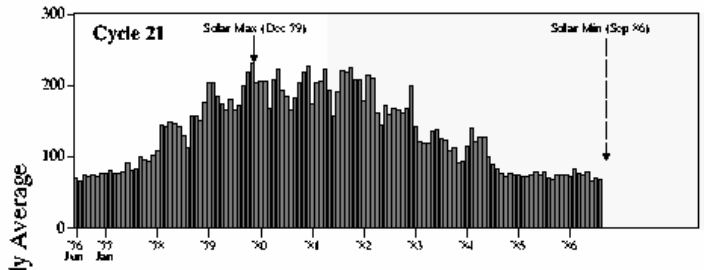
Space Environment Center

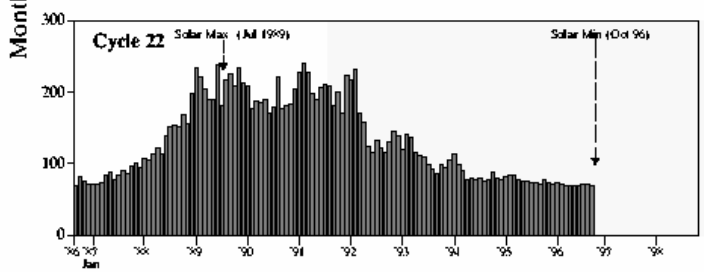
July 2001
(Month 58)

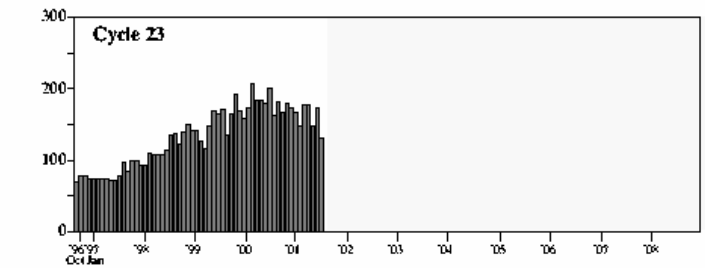
Preliminary data











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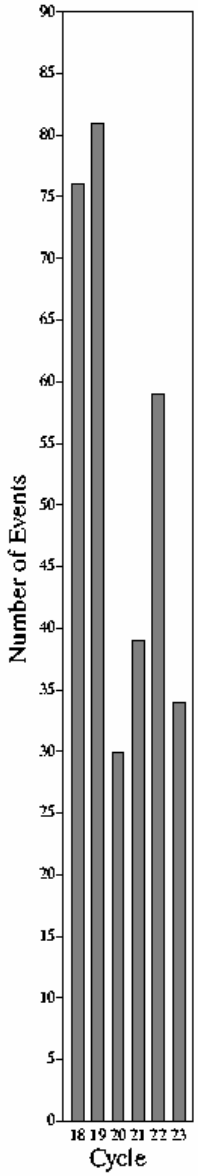
Geomagnetic Activity (Ap > 50)

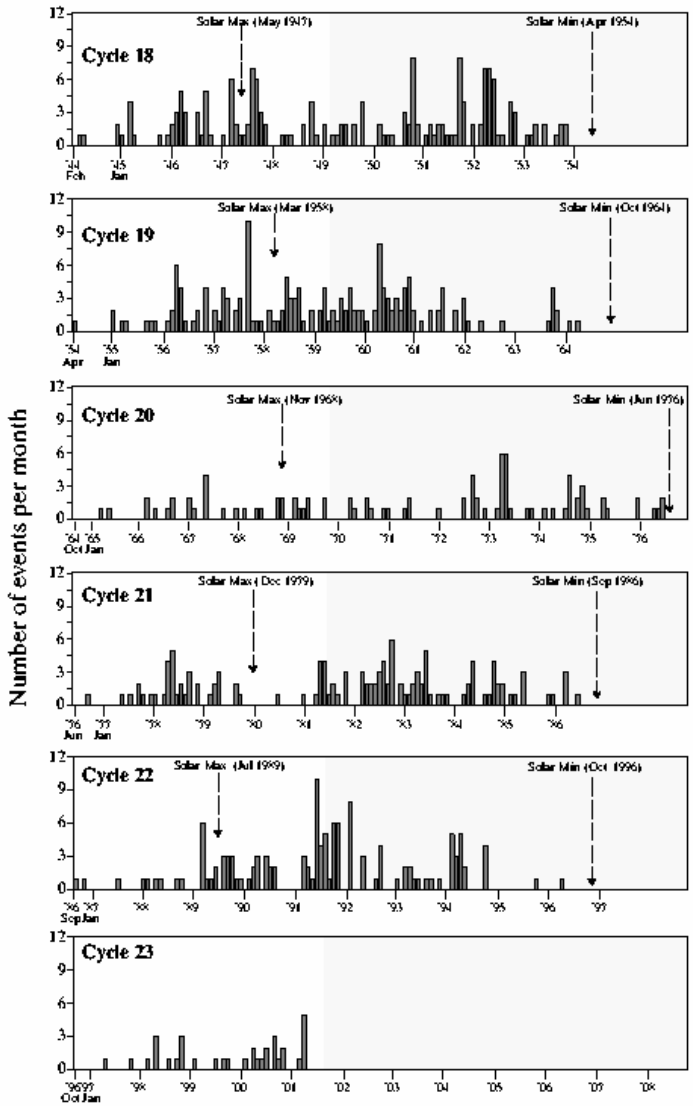
Space Environment Center

July 2001
(Month 58)

Preliminary data

Comparison of Cycles at current month in cycle





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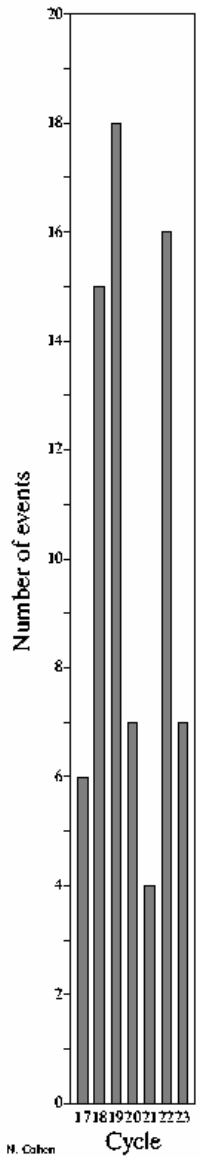
Severe Storm (Ap≥100) Geomagnetic Conditions

Space Environment Center

August 2001
(Month 59)

Preliminary data

Comparison of Cycles at current month in cycle



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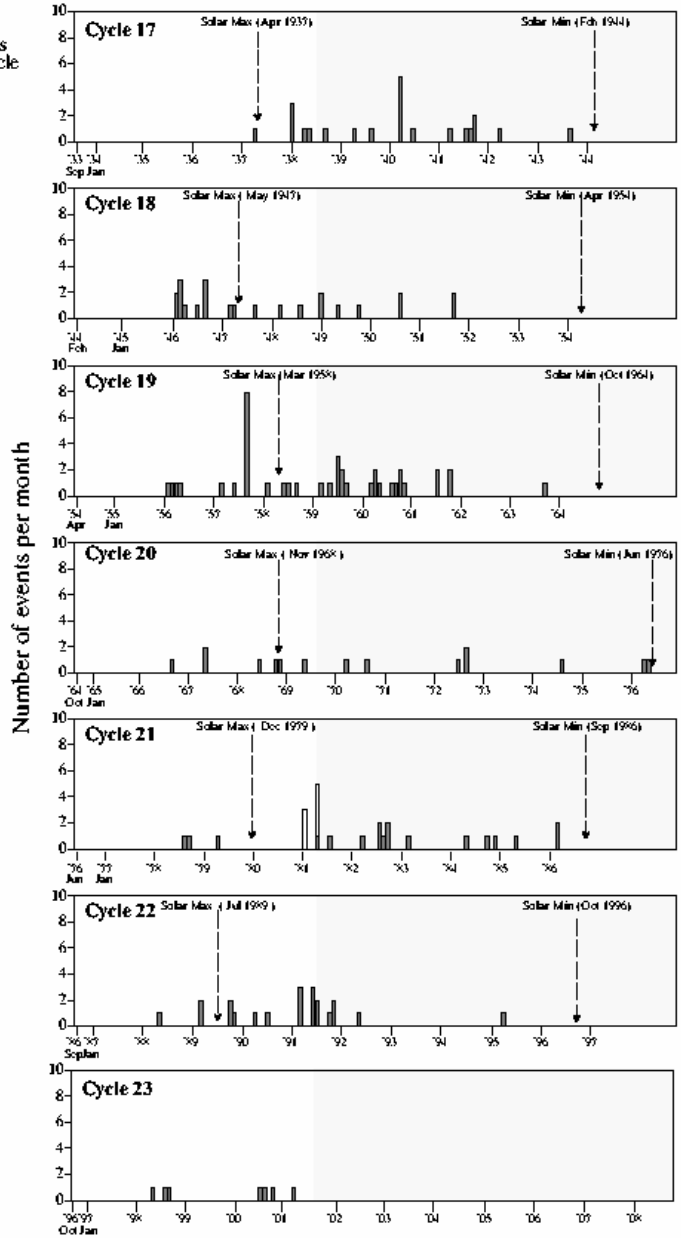
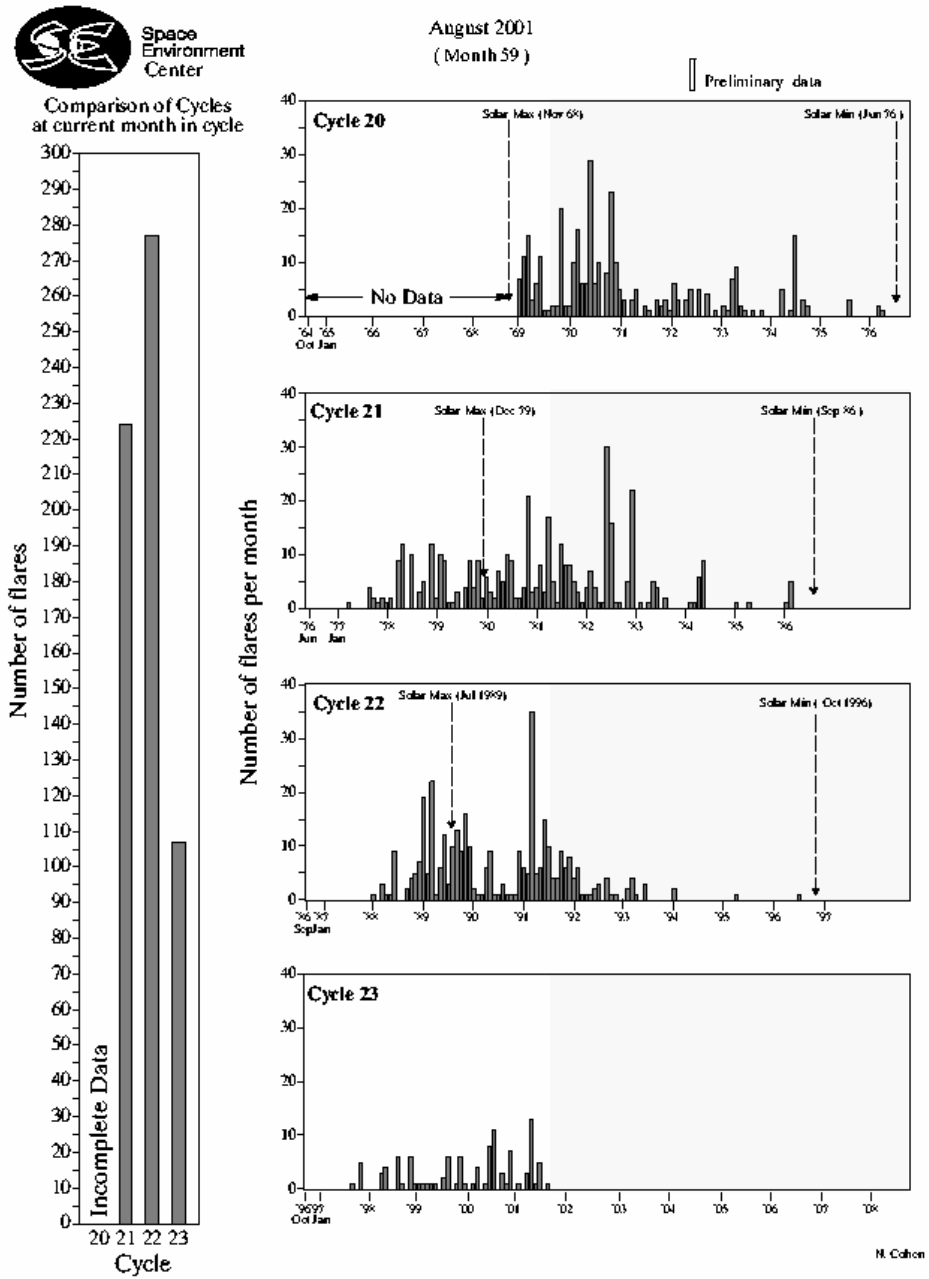
Number of events per month



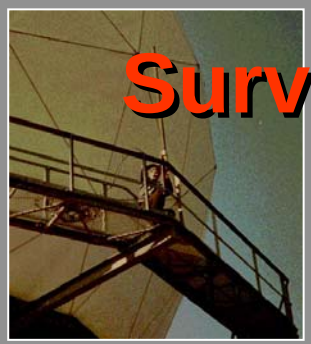
M5 or Greater X−Ray Flares



Navigation, operating in the FAA context

Availability
Continuity
Accuracy
Integrity

Navigation



Surveillance

National Airspace System

Communications

Ionospheric Effects Summary

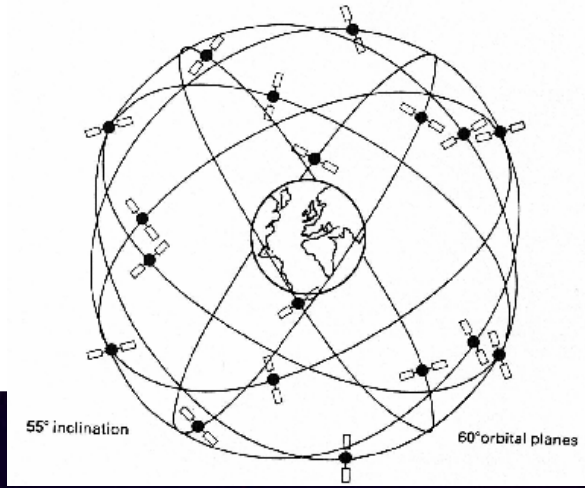
Loran-C - groundwave /skywave

- SID x-ray and ultraviolet emission can cause low iono altitude - several minutes during solar flare
- PCA - high-energy protons - several days, high latitudes.

GPS/WAAS - propagation through ionosphere

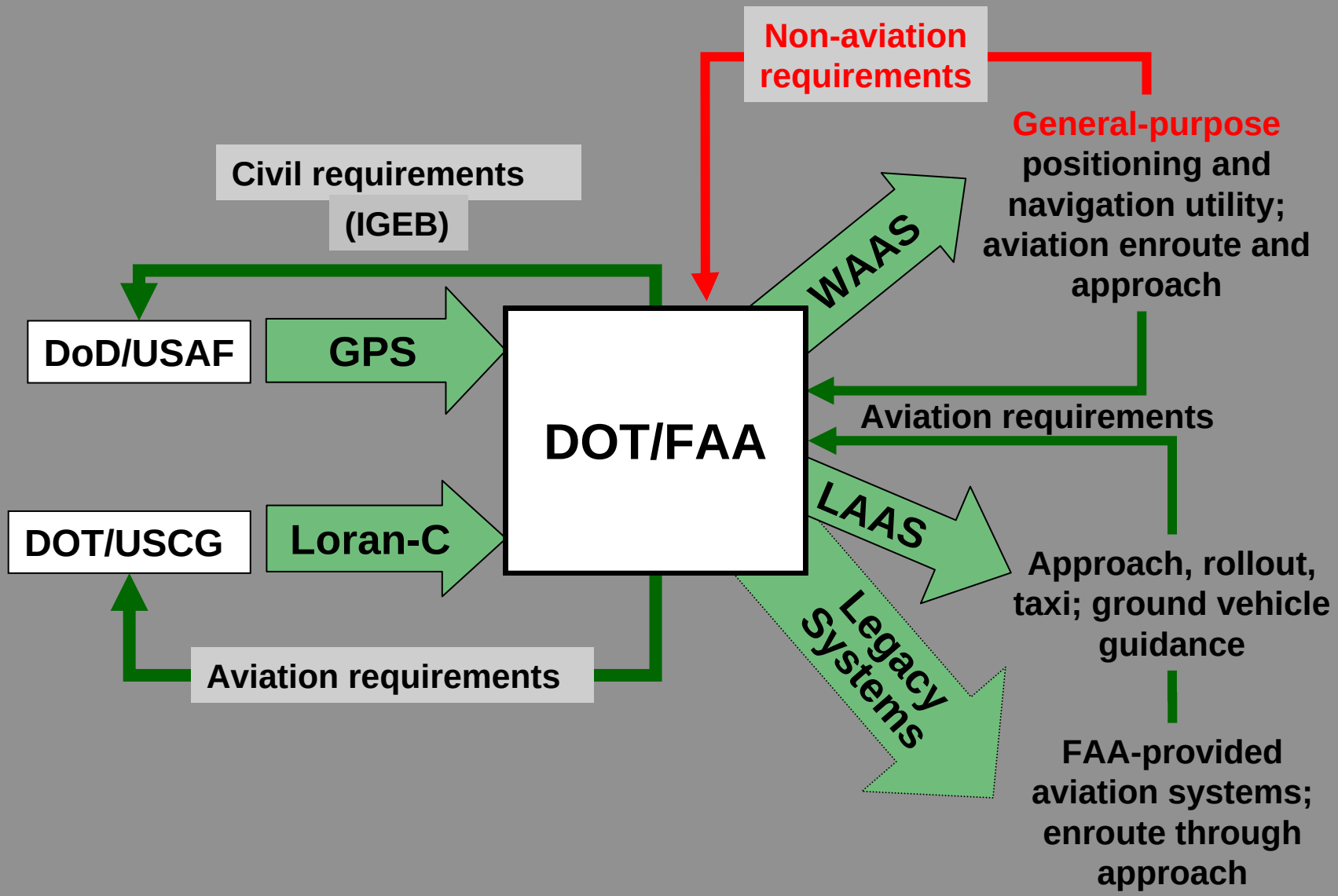
- Scintillation - receiver lock lost intermittently on specific satellites -- patchy phenomenon.
- Most severe near magnetic equator (e.g. Southern Japan, less severe in Hawaii and Alaska, even less in CONUS). Generally absent during PCA or SID events.
- Electron density changes - GPS iono correction accuracy affected. Potential precision-approach availability reduction.

We have bought into the need for ionosphere weather reports with satellite positioning, timing and navigation...



Man-made stuff in orbit...

FAA and the Other Statesman-Agencies



Summary

- **Solar Cycle 23 is well into its decline (April 2000 sunspot maximum).**
- **Space weather events affecting LORAN and GPS have been relatively infrequent.**
- **Expect space weather to become increasingly "fair" over the next few years.**
- **Geomagnetic storms, however, will persist even in the decay phase of the solar cycle.**
- **Get space weather data at:**

http://sec.noaa.gov