

Disturbances to Propagation

CQ DX?

Where'd everybody go?



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Presented at the 2003 Northwest DX
Convention in Vancouver, British Columbia

Topics

- Review the new WWV format
- Tie the WWV report to disturbances
 - Coronal mass ejections (CMEs)
 - Proton events
 - Solar flares
- Track a CME and a proton event
- Look at log data for a CME and a flare

New WWV Format

- Changed on March 12, 2002
- Same three sections
 - Current indices
 - Summary of past 24 hours
 - Forecast for next 24 hours
- New format is more specific in terms of disturbances to propagation

Old Format

Solar terrestrial indices for 7 February follow

Solar flux 192 and Boulder A-index 17

The Boulder K-index at 1800 UTC on February 8 was 3

Solar terrestrial conditions for the last 24 hours follow

Solar activity was low

The geomagnetic fields was quiet to unsettled

The forecast for the next 24 hours follows

Solar activity will be moderate

The geomagnetic field will be disturbed

Old Format

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New Format

Solar terrestrial indices for 23 May follow

Solar flux 180 and mid-latitude A-index 43

The mid-latitude K-index at 1500 UTC on May 24 was 1

Space weather for the past 24 hours has been strong

*Geomagnetic storms reaching the **G3** level occurred*

*Solar radiation storms reaching the **S2** level occurred*

*Radio blackouts reaching the **R1** level occurred*

Space weather for the next 24 hours is expected to be minor

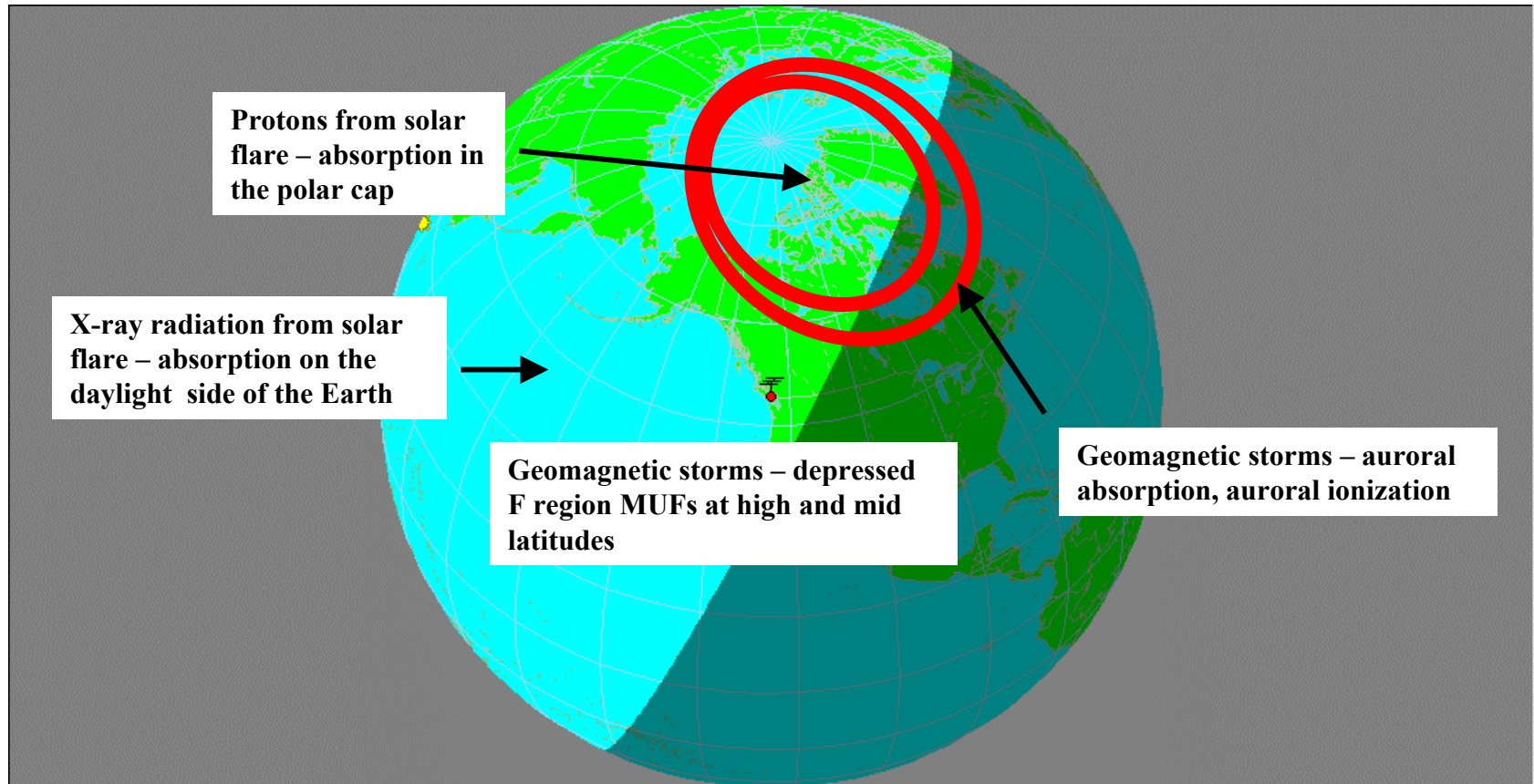
*Solar radiation storms reaching the **S1** level are expected*

*Radio blackouts reaching the **R1** level are expected*

G, S, and R

- G refers to G geomagnetic storms
 - Caused by gusts in solar wind from CMEs
 - Can cause auroral absorption, auroral-E, depleted F region
- S refers to S solar radiation storms
 - Caused by energetic protons from flares
 - Can increase D region absorption in the polar cap (PCA)
- R refers to R radio blackouts
 - Caused by X-ray flares (1-8Å wavelengths) of X or big M class
 - Can increase D region absorption on daylight side of Earth
- For all three, scale is 1 to 5
 - 1 is minor and 5 is extreme, and correspond to specific criteria
 - Details at sec.noaa.gov/Data/info/WWVdoc.html

Disturbances – the Big Picture

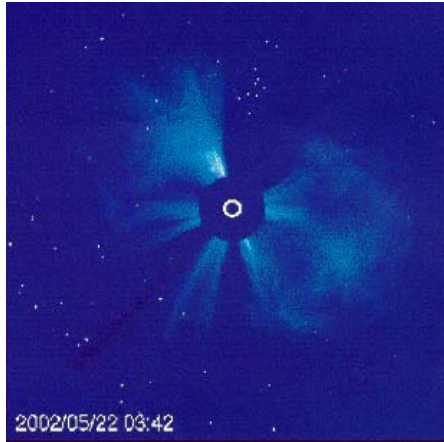


Geomagnetic Storms

from LASCO on SOHO

Large Angle
Spectrometric
Coronagraph

Solar and
Heliospheric
Observatory



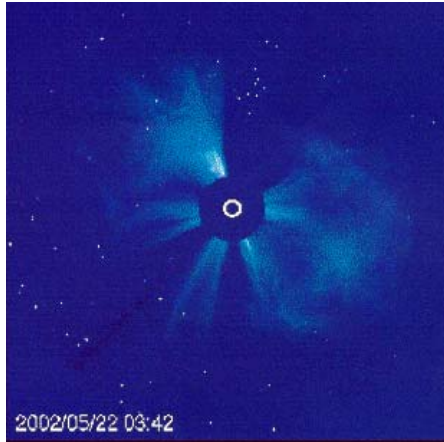
A 'halo' event indicates
it's headed toward Earth

halo CME at 0342 UTC on May 22, 2002

Geomagnetic Storms

from LASCO on SOHO

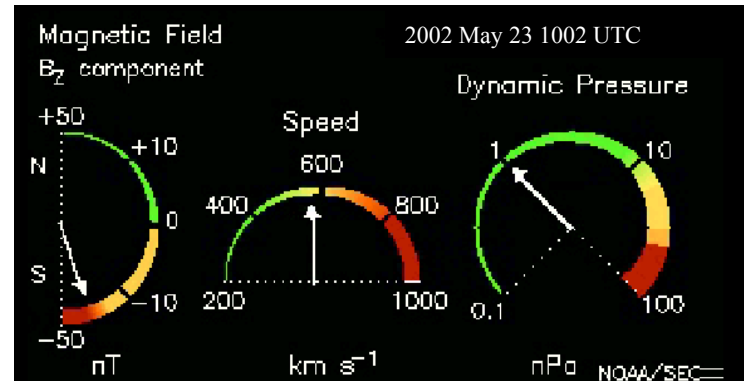
Large Angle Spectrometric Coronagraph
Solar and Heliospheric Observatory



halo CME at 0342 UTC on May 22, 2002

from ACE

Advanced Composition Explorer



dials at 1002 UTC on May 23, 2002

The ACE satellite is sitting
1,000,000 miles from Earth
on the line to the Sun

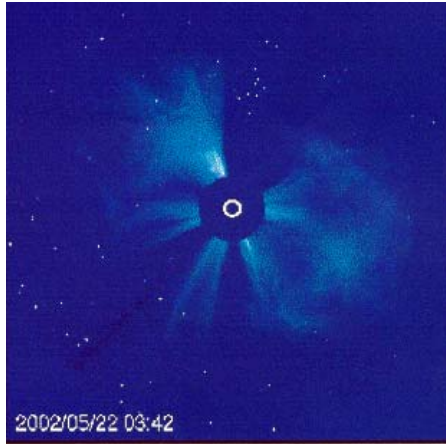
Shock wave took about 30
hours to get to the ACE
satellite

Southward IMF (what
the first dial measures)
usually means trouble

Geomagnetic Storms

from LASCO on SOHO

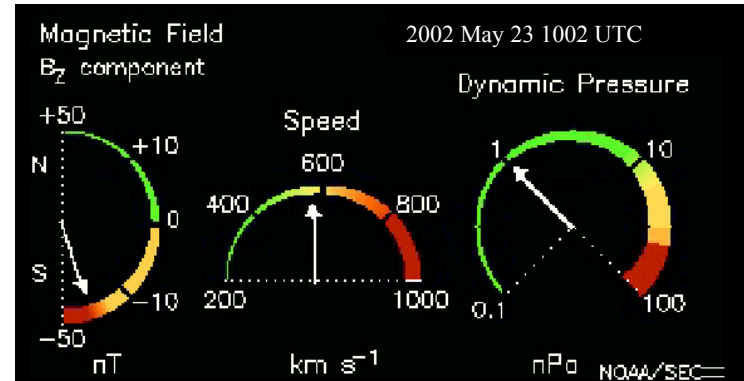
Large Angle Spectrometric Coronagraph
Solar and Heliospheric Observatory



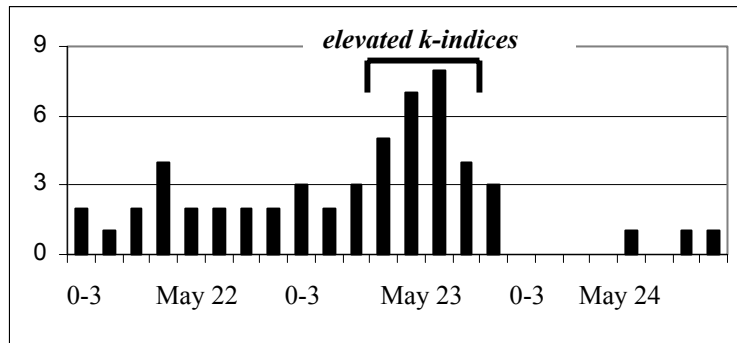
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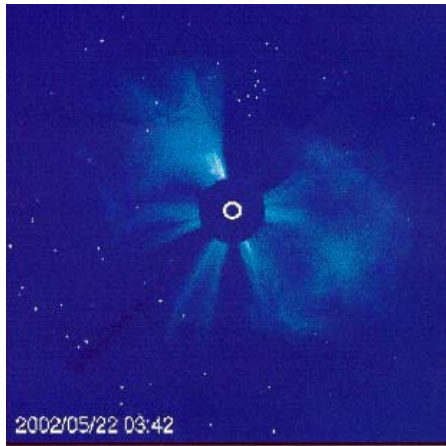
Meanook (Canada) k indices

Takes about 30 min to 1 hour for shock wave to get from ACE to Earth

Geomagnetic Storms

from LASCO on SOHO

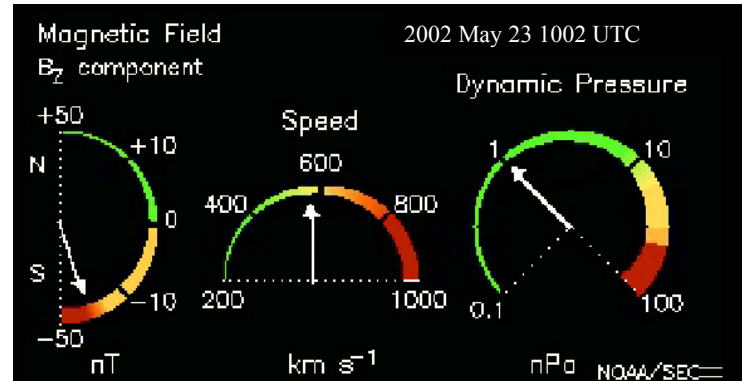
Large Angle Spectrometric Coronagraph
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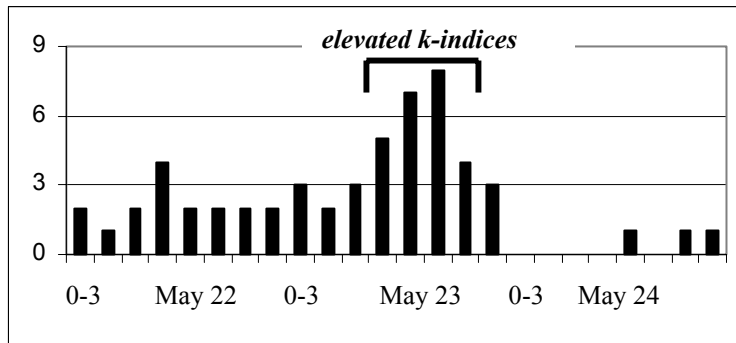
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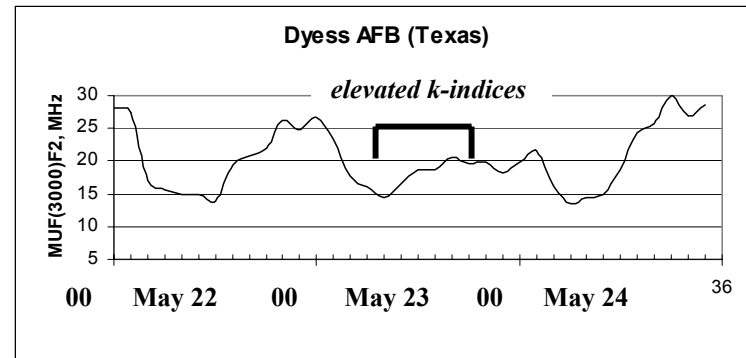
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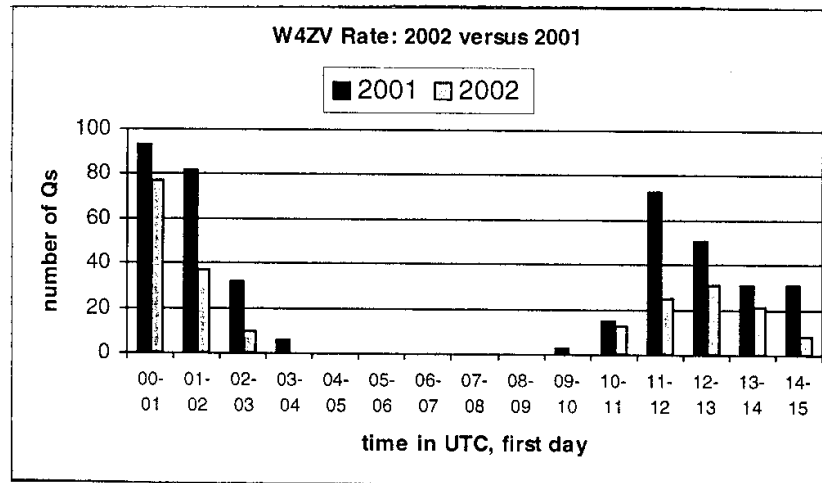


MUF(3000)F2 at mid-latitude

W4ZV WPX CW 2002

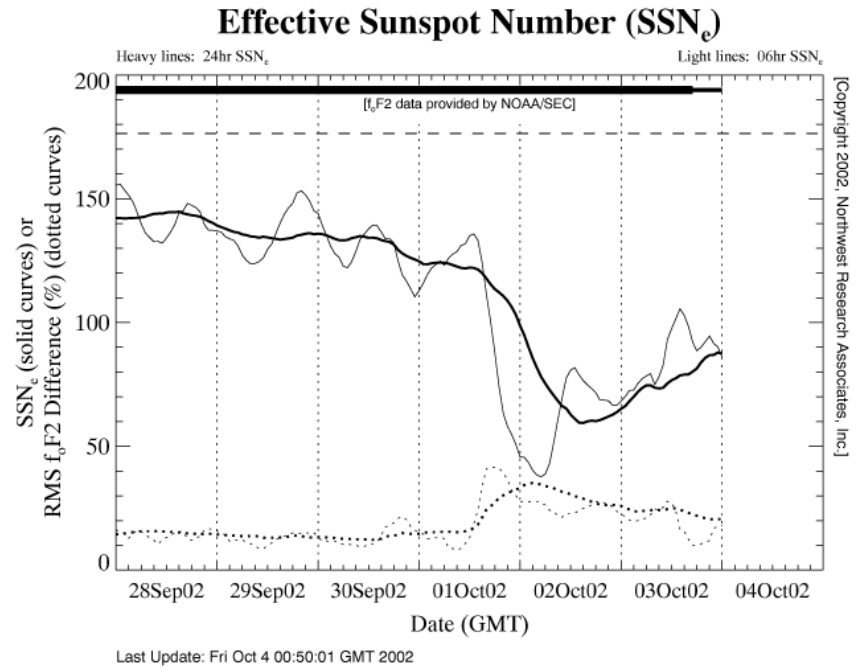
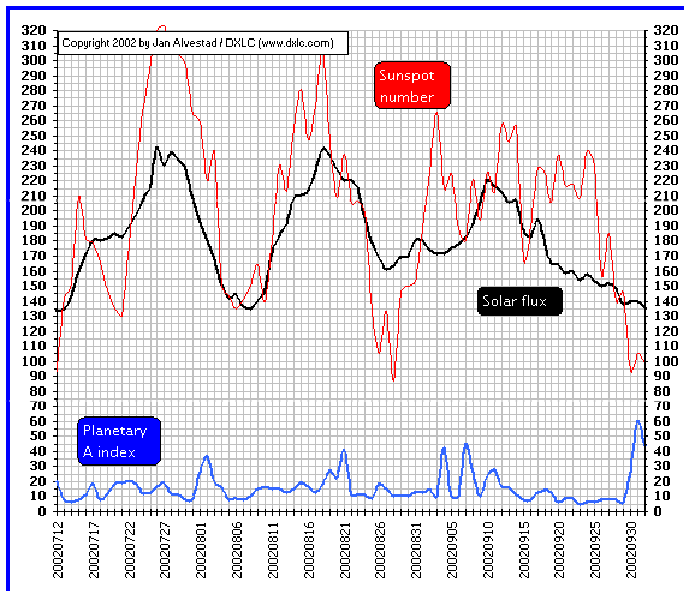
W4ZV set single-op 10m record in 2001 - planned to make a run at it in 2002

Multiple CMEs occurred May 22, 2002 – 10m propagation to EU was poor



details of this event are in the March 2003 issue of CQ

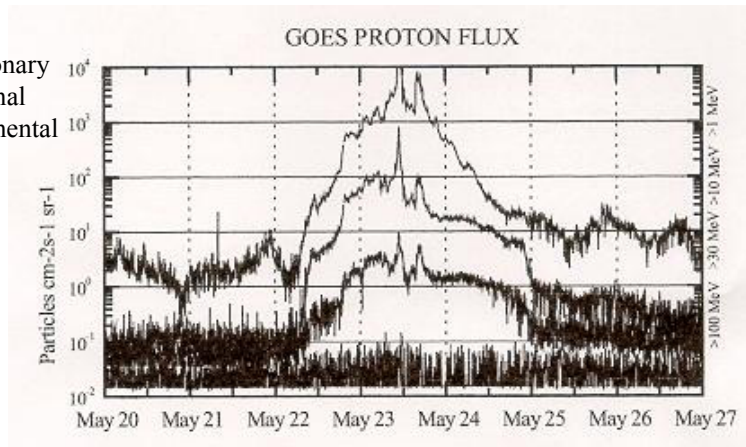
“Real-Time” View of F Region Depletion



- **CME on Monday 9/30 => storm hit Earth on Tuesday 10/1**
- **Higher bands took big dip due to F region depletion**
- **SSNe available at www.nwra-az.com/spawx/ssne24.html**
 - also see July/August 2003 NCJ for more on SSNe

Solar Radiation Storms

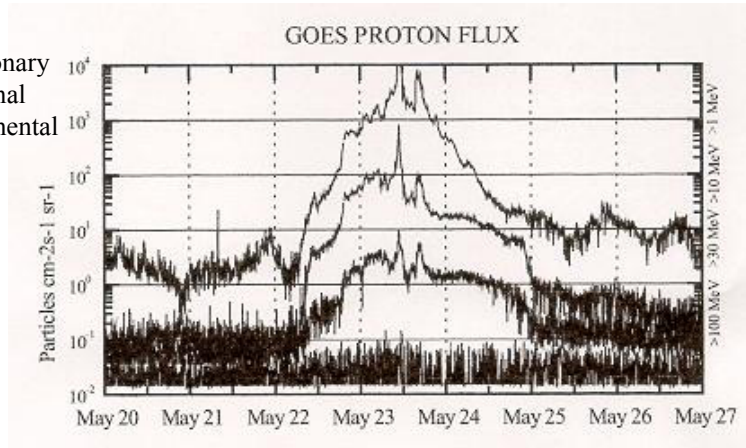
Geostationary
Operational
Environmental
Satellite



Proton flux

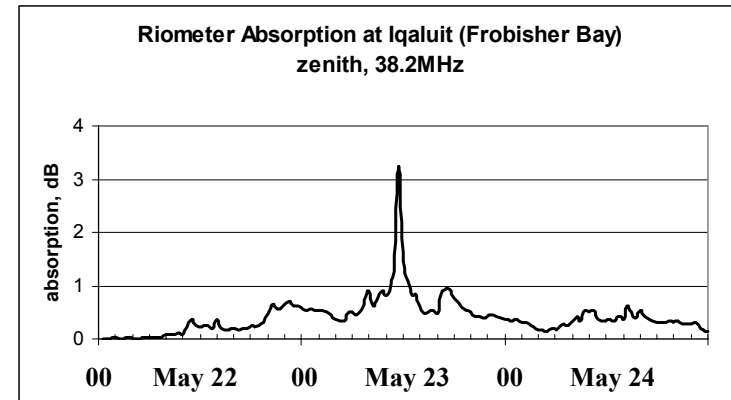
Solar Radiation Storms

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Proton flux

relative ionospheric opacity meter

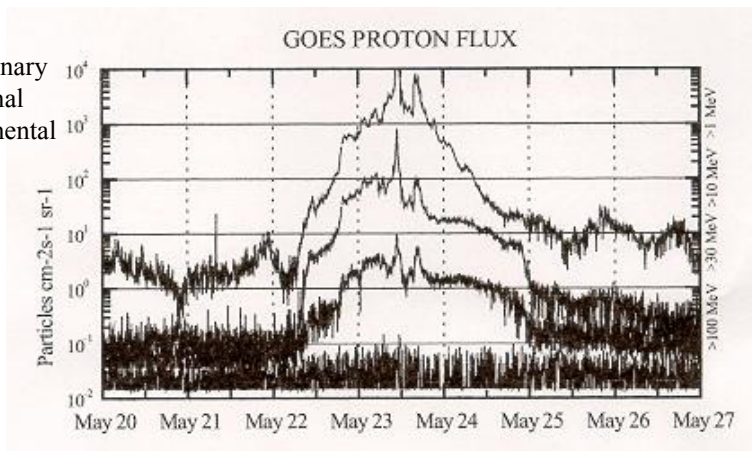


riometer absorption

Energetic protons are fast, so the ionosphere could be affected in an hour or two

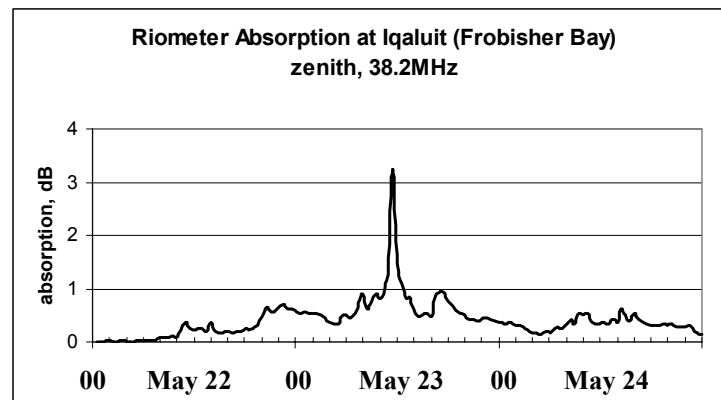
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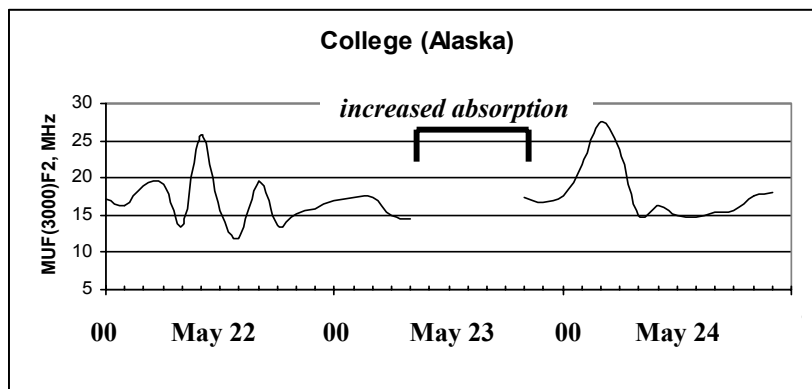


Proton flux

relative ionospheric opacity meter



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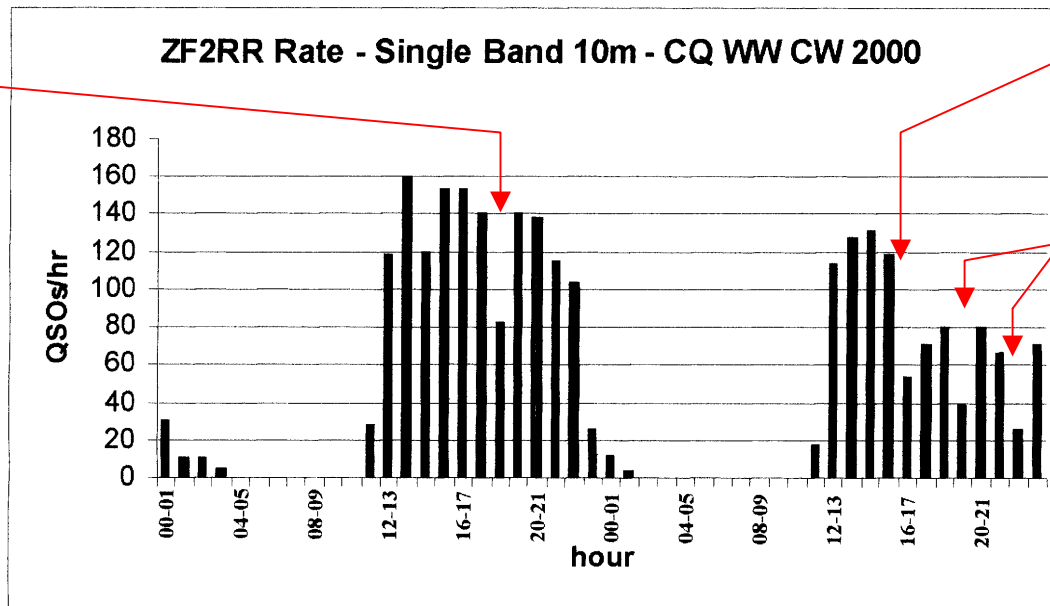


MUF(3000)F2 at high latitude

Polar Cap
Absorption
(PCA)

Radio Blackouts

**X1.9 flare at
1836 UTC**



**X4.0 flare at
1638 UTC**

**looking
for mults**

Dan N9XX/ZF2RR single band 10m low power

Summary

- G = geomagnetic storms
 - Caused by CMEs
 - Peak activity lags solar cycle by a couple years
- S = PCAs
 - Caused by energetic protons from flares
 - Peak activity pretty much tracks solar cycle
- R = blackouts
 - Caused by X-ray radiation from big flares
 - Peak activity pretty much tracks solar cycle

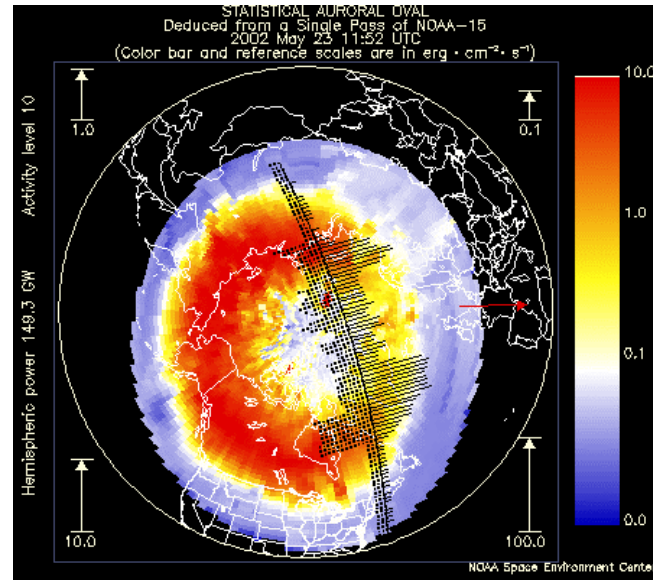
Summary

- In order of “least” impact to “most” impact
 - Blackout (R)
 - No warning, but usually short duration
 - PCA (S)
 - A couple hours warning, can last a day or two
 - Geomagnetic storm (G)
 - Day or two warning, can last for days
- In general we want G, S, R rating to be 1 or less

Summary

- Are all geomagnetic storms bad?
-- NO --
- VHFer's love them!
- And gradually evolving storms, driven by slowly increasing southward IMF, can increase nighttime low latitude F region ionization

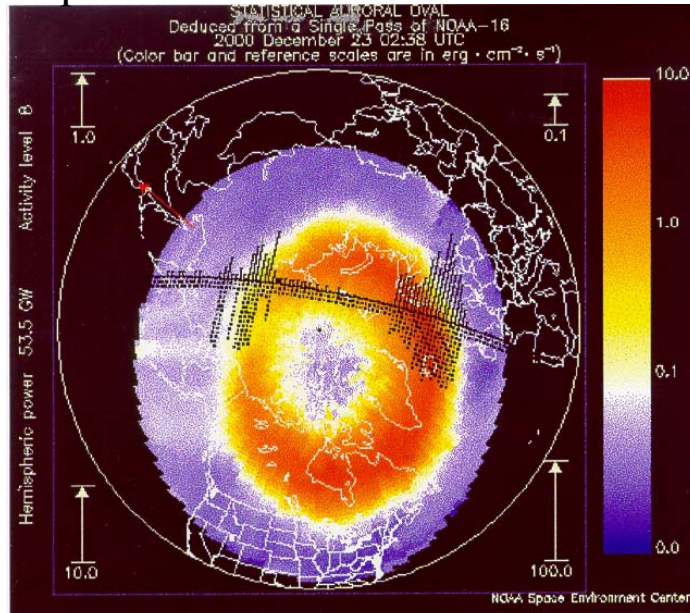
Auroral Ovals at sec.noaa.gov/pmap



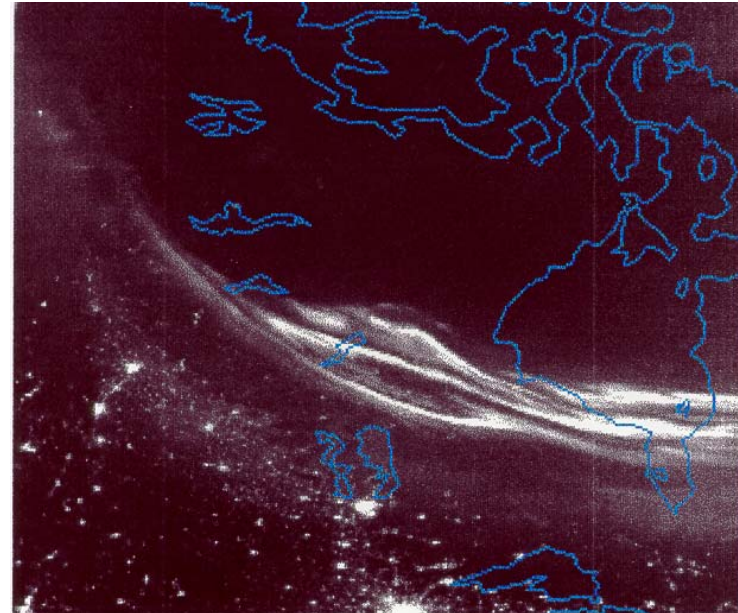
- Each pass estimates total power into polar area => pull 1 of 10 canned pictures
- Detector measures particles up to $\sim 20\text{KeV}$ => down to 100km, visible aurora
- Higher energy electrons that get down to D region are not measured
- These pictures **do not directly tell us anything about absorption or auroral-E**

Where Are the Problems?

Kp=4



DMSP photo (Defense Meteorological Satellite Program)



same night, same time (evening in the Midwest)

- **Bright discrete auroral forms => lots of E region ionization**
- **Absorption usually equatorward of these forms**
- **Auroral zone is **not necessarily full of ionization that degrades HF****