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" SPRING COLLEGE ON GEOMAGNETISM AND AERONOMY "

(2 - 27 March 1987)

" Impacts of space processes on technology "

presented by :

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IMPACTS OF SPACE PROCESSES ON TECHNOLOGIES

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REFERENCES

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EARTH-BASED SYSTEMS

I. Problems of Long Conductors

A. Cable Systems

1. Magnetic storm outages
2. Geomagnetically-induced noise

(3. Tidal & Water-flow effects)

4. Fire

B. Power Systems

1. Disruptions
2. Fluctuations in Control systems

C. Pipelines

1. Disruptions of corrosion surveys

II. Exploration Matters

A. Deep Earth Induction Studies

B. "Noise" in geophysical exploration

C. Archeological surveys and geomagnetic noise

III. Ionosphere

A. Radio Transmissions at high latitudes

B. Meteor-burst communications

SPACE-BASED SYSTEMS

I. Ionosphere
   A. Scintillations at 100's MHz
   B. Scintillations at GHz

II. Atmosphere
   A. Rainfall patterns and attenuation
      (extra-atmosphere influence on rainfall?)

III. Magnetosphere and Solar Particles
   A. Radiation damage to electronics
   B. Radiation damage to surfaces
   C. Electrostatic charging of surfaces
   D. Threats to human habitation

Telecommunications

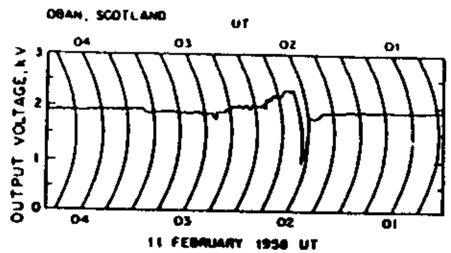


Fig. 1. Output voltage of the power feed equipment at the Oban, Scotland, end of the Oban–Clarenville, Newfoundland, cable. The voltage variation in North America was somewhat larger, leading to a total variation of about 2700 V across the cable (from Axe, 1968).

Telecommunications disruptions

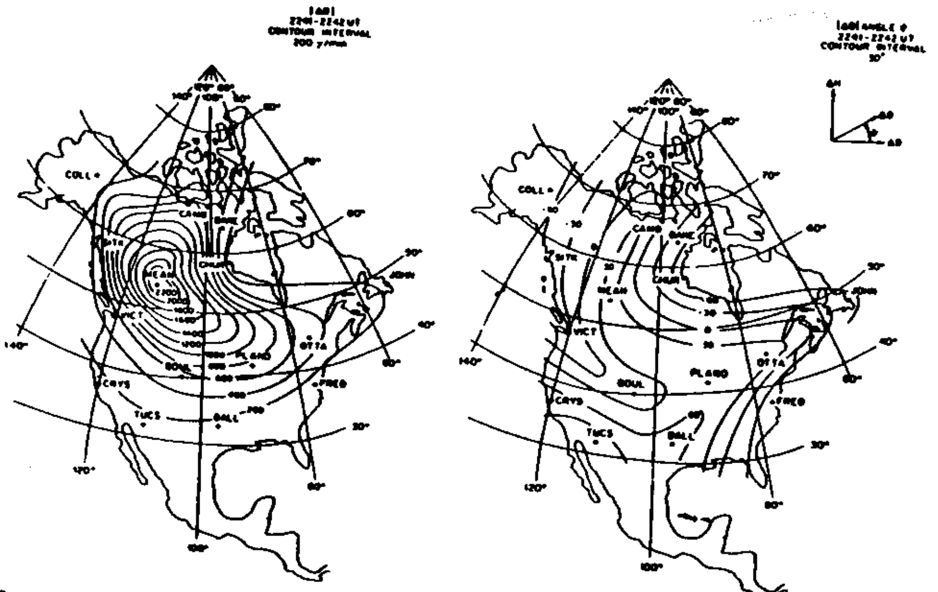


Fig. 2. Rate of change of magnetic field intensity and direction over North America for the one-minute interval 2241 to 2242 UT on August 4 1972 [5]. (Reprinted with permission from the Bell System Technical Journal, Copyright 1974, the American Telephone and Telegraph Company.)

Magnetosphere configuration at time of telecommunications disruptions

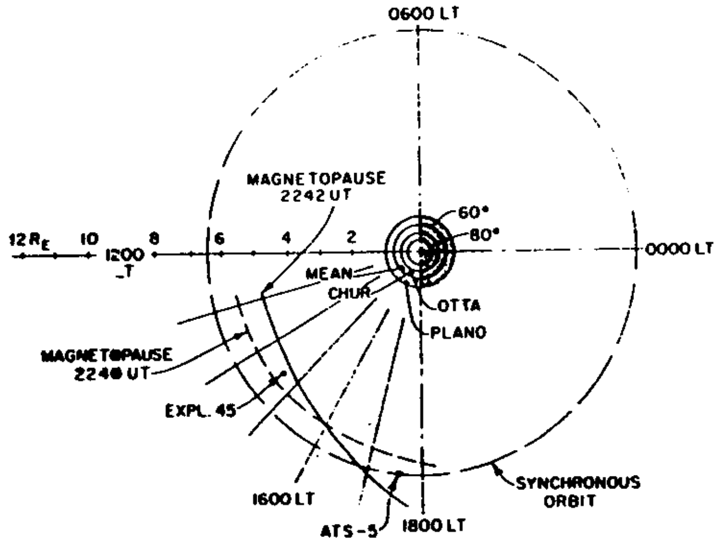


Fig. 3. Equatorial plane view of earth and magnetospheric boundary in afternoon sector at 2240 UT and 2242 UT on August 4, 1972. The locations of the ATS-5 and Explorer 45 satelites are shown, as are several ground stations: Churchill (CHUR), Meanook (MEAN), Ottawa (OTTA) and Plano [5]. (Reprinted with permission from the Bell System Technical Journal, Copyright 1974, the American Telephone and Telegraph Company.)

Cable for Ocean Tide Measures

Disturbance of tidal signal by geomagnetic activity

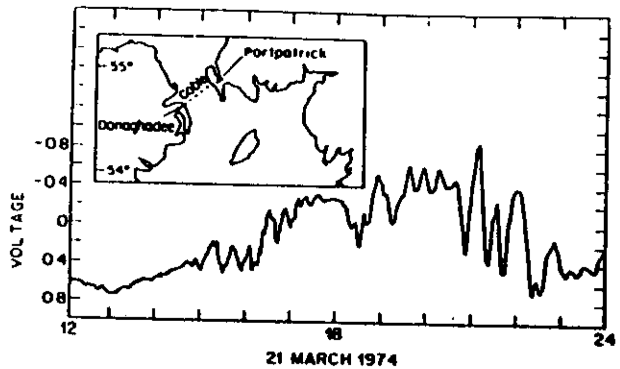


Fig. 4. Cable voltage on the Donaghadee–Port Patrick cable on a geomagnetically disturbed day (from Prandle and Harrison, 1975).

Use of cable as measuring Instrument: deduction of average Earth Conductivity

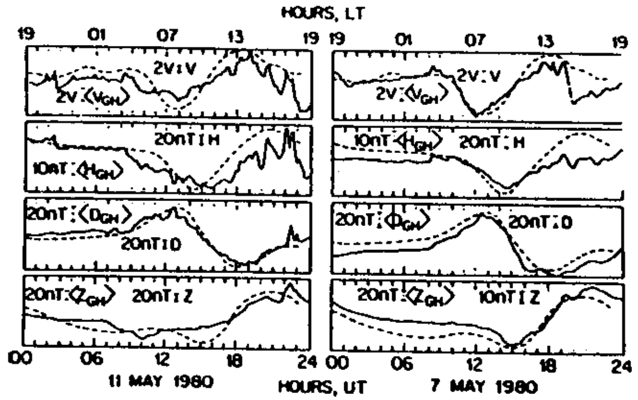


Fig. 3. Solid line: geomagnetic and induced voltage variations in the TAT-6 cable on two days with moderate geomagnetic activity. Dashed line: average quantities for five geomagnetically quiet days in May 1980 (from Lanzerotti *et al.*, 1982).

Power
Telecommunications } disruptions

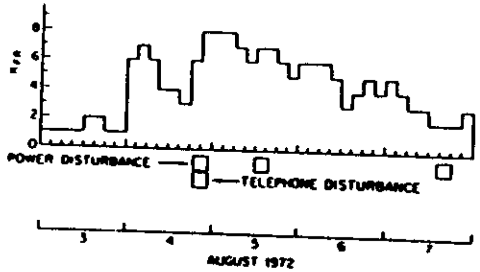


Fig. 5. Geomagnetic activity index from the Fredericksburg Geomagnetic Observatory during the period of intense geomagnetic activity in August, 1972. Times of disruptions of power and communications systems are indicated (from Albertson and Thorson, 1974).

Power systems

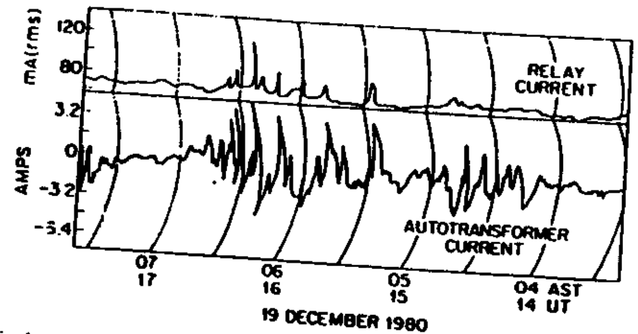
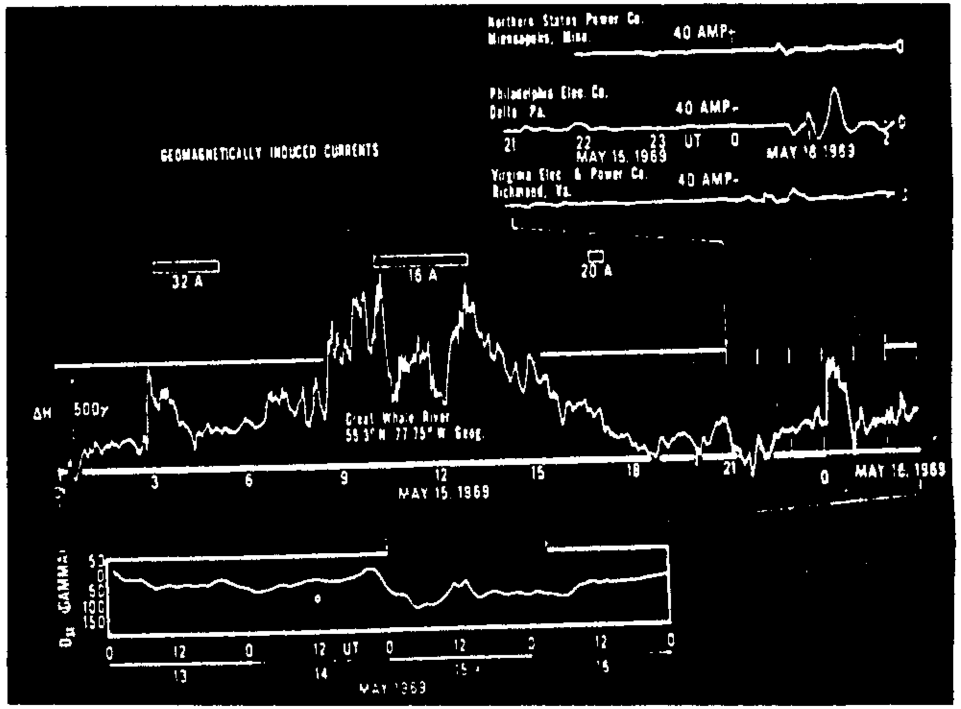


Fig. 6. Simultaneous recordings of geomagnetic induction effects observed as current surges in a protective relay system andLan auto transformer in a power substation near Fairbanks, Alaska, on 19 December, 1980 (from Akasofu and Aspnes, 1982).

Power systems



'ig. 4. The world-wide geomagnetic activity index D_{st} is shown in the lower position of the figure. The central position of the figure shows, o
xpanded time scale, a magnetogram trace obtained at Great Whale River during the geomagnetic storm shown on the D_{st} plot. Units are in gan
$1\gamma = 10^{-9}$ tesla). Time and magnitudes of the currents induced in transformer windings are indicated. The top position of the figure shows t
induced current traces obtained during the time period indicated in the magnetogram trace.

Pipeline

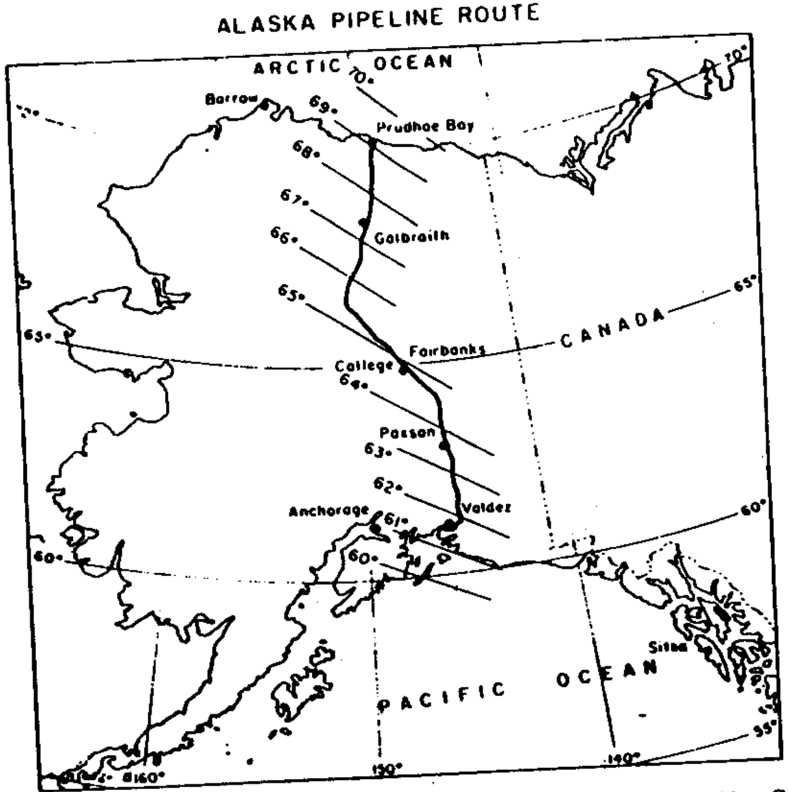


Fig. 12. Alaska oil pipeline shown as a dark line connecting Prudhoe Bay to Valdez. Geomagnetic latitudes along this route are indicated by line segments every degree from 60° to 70°. Location of geomagnetic observatories at Barrow, College, and Sitka are appropriately marked (from Campbell [18]).

Currents on a pipeline

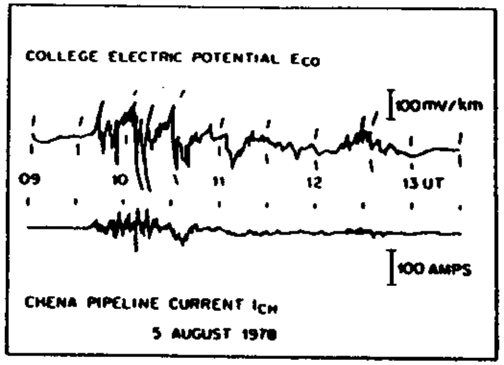


Fig. 7. Comparison of the Earth currents measured near Fairbanks and the induced currents measured in the Alaskan pipeline at the Chena test site (near Fairbanks) on 5 August, 1978 (from Campbell and Zimmerman, 1980).

* Also important at lower latitudes: mid- to equatorial

Corrosion; interference with corrosion surveys

Modeling of pipeline current effects

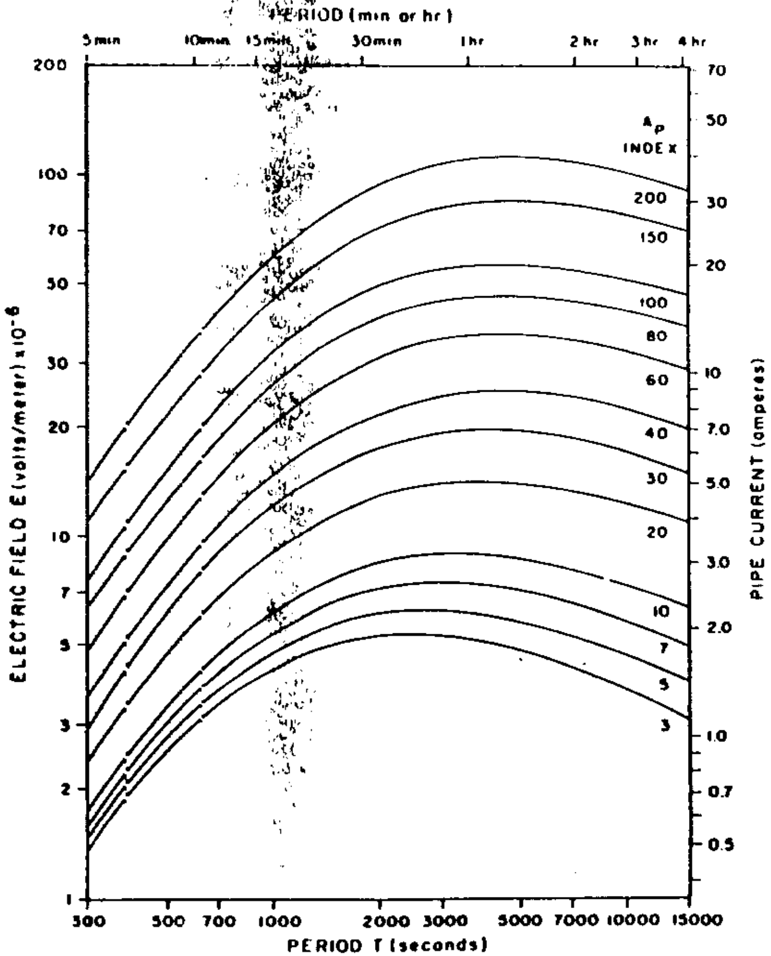


Fig. 13. Electric fields (10^{-6} V/m) as a function of period T (sec) obtained from a layered ear h conductivity model and a spectral analysis (four hour samples) of high latitude geomagnetic disturbances. Separate curves represent values for geomagnetic activity level indices, *Ap*, shown at the right. On the right margin is the equivalent pipeline current, *I* (amperes). Momentary surges of field and current at the time of maximum disturbance reach amplitudes 5 to 10 times the magnitudes shown in this figure (from Campbell [18]).

Pipeline corrosion problem

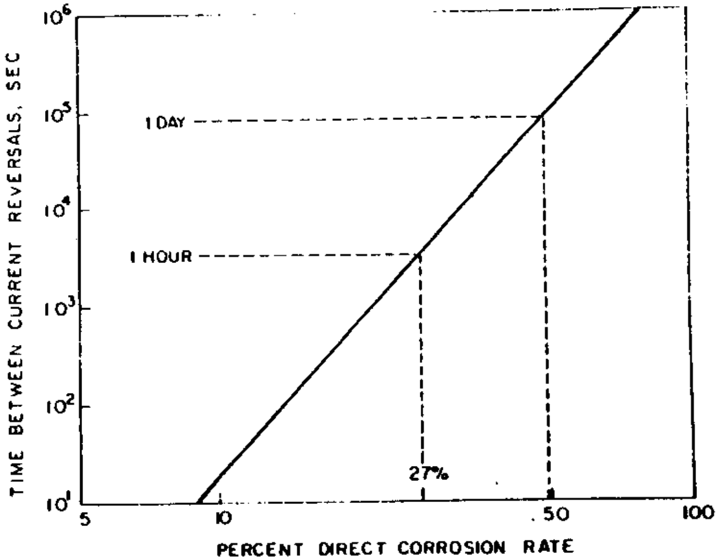


Fig. 11. Percentage of direct current corrosion rate as a function of the period of the induced current (from McCollum and Ahlborn [45].

Problems of non-localized sources in geophysical surveys

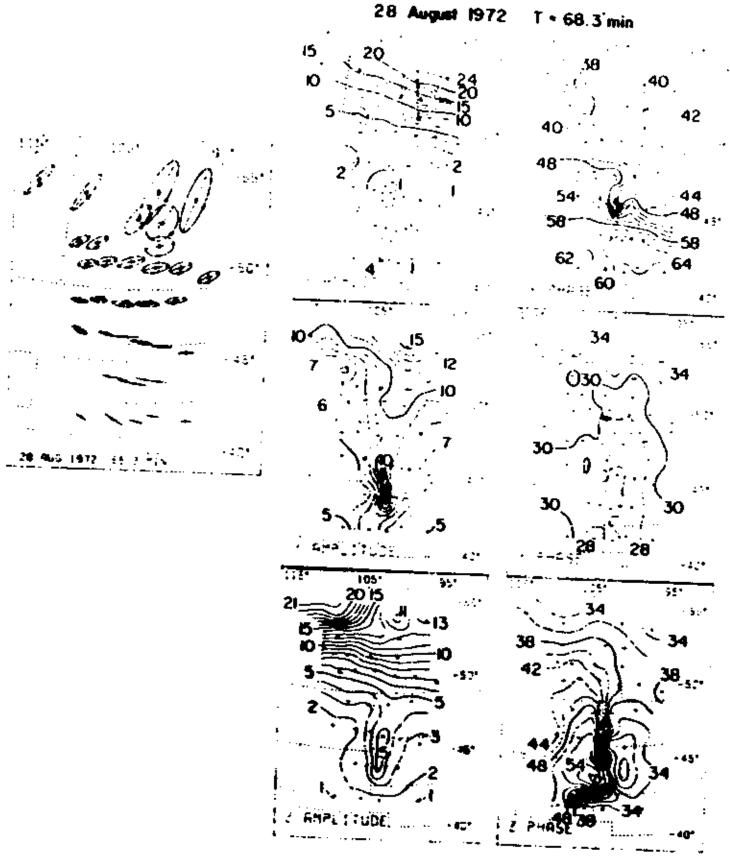


Fig. 10. Perturbation of the field of a magnetospheric substorm by the North American Central Plains conductivity anomaly. In each map the crosses indicate the locations of magnetometers in an array. The polarization of the horizontal field at a period of 68.3 min is mapped on the left. The other six maps show amplitudes and phases of the Fourier transforms of the substorm field components at the spectral period of 68.3 min. The northern border of the array was close to the ionospheric part of the source current, as shown by the *X* amplitude and polarization maps. The conductivity anomaly is best seen in *Y* and *Z* amplitudes and *Z* phase. Amplitudes are in nT, phases in minutes. After Alabi et al. [1]

Need for data corrections in geophysical surveys

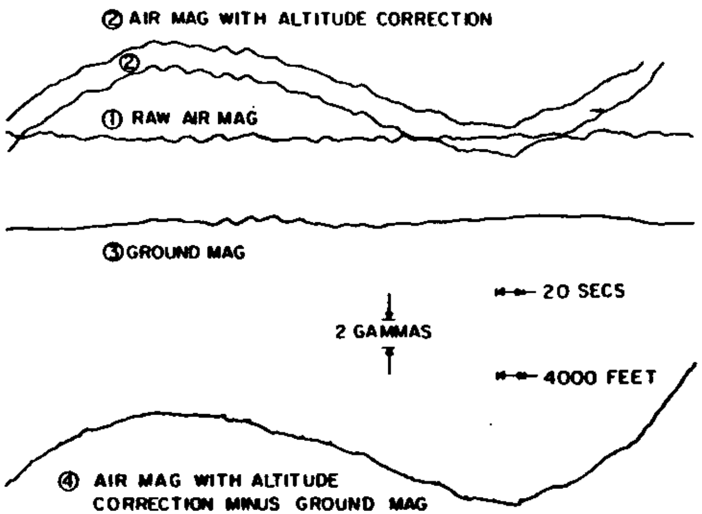


Fig. 15. Aeromagnetic survey over the Gulf of Mexico and ground "base" station data taken to help eliminate the magnetic fluctuations.

Scintillations at GHz frequencies: satellite telecommunications

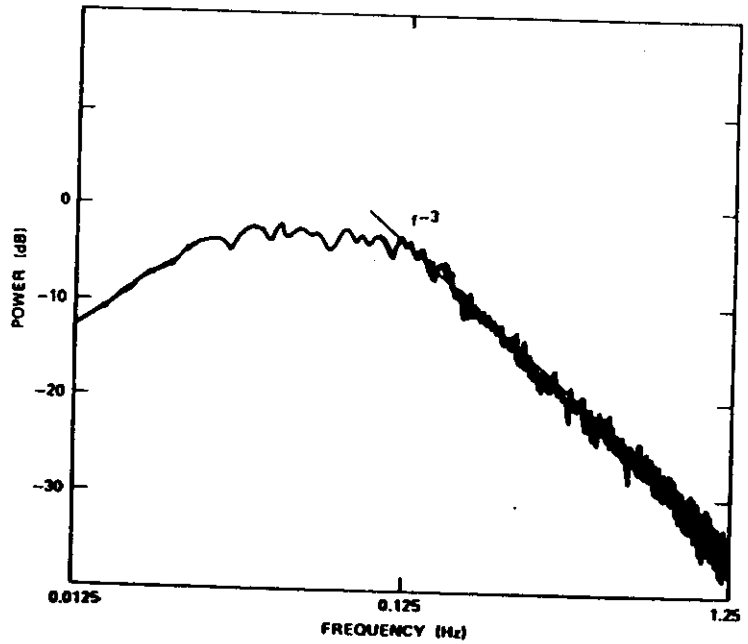


Fig. 1. Power spectrum of 4 GHz ionospheric scintillation event measured at the Hong Kong earth station in September 1973.

Very important in equatorial regions: science not fully exploited as yet.

Spacecraft

Solar Cell damage by enhanced radiation belt particles.

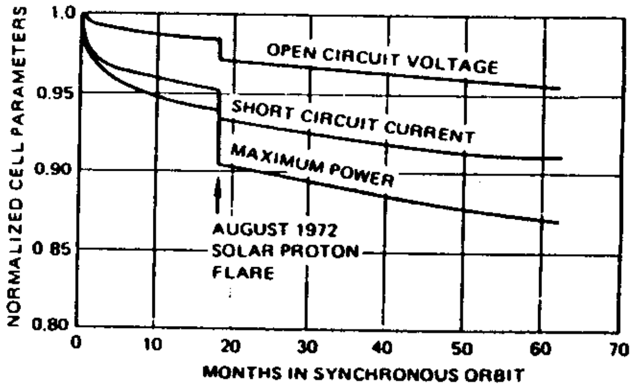


Fig. 6. Performance of a solar cell array as a function of time after launch. The long-term decrease in performance is attributable to damage by energetic electrons: the step function decrease is the effect of one large solar proton event [28].

"Economics"

1. What is the real situation with respect to solar activity on short (few day) and long (yrs to 10's of yrs) time scales?
   - A. General circulation (short)
   - B. Localized circulation (short)
   - * C. Climate (long)

Mechanism(s)?

- Solar "Constant"?
- Solar UV?
- Solar Wind Coupling?
- Atmosphere $\vec{E}$-field?
- Atmosphere Gravity waves?
- Trigger and/or non-linear processes?