in the whistler mode. As these signals are transmitted through the magnetosphere, they normally suffer a doppler frequency shift due to continuous changes in the effective electrical path length. This frequency shift can be as much as two or three parts in 100,000. The accepted method of observing these signals is to use a receiver with a number of narrow-band channels that span a frequency band of about 0.5 hertz on either side of the carrier frequency of the transmitting station.

The N. Z. equipment (code name, "LEDA") uses 25 channels and the data are continuously recorded on 35-millimeter film. The antenna system is designed and oriented to reject signals arriving by the subionospheric path.

During the 1972-1973 austral summer, LEDA equipment was installed at Siple Station. The winter 1973 results were sparse and disappointing. During the 1973-1974 summer, however, equipment adjustments and modifications were made. Film records for 1974 are now being analyzed.

Data acquired over several years in New Zealand relate to transmissions from station NLK (Seattle, Washington; magnetic latitude, 53°N.) on 18.6 kilohertz. The receiving station, near Wellington, New Zealand, is at 47°S. magnetic latitude, and the magnetic conjugate of Seattle is 2,500 kilometers southeast of Wellington, New Zealand.

The VLF signals received at Siple are from station NAA (Cutler, Maine; magnetic latitude, about 58°N.) on 17.8 kilohertz, and the receiver is at about 61°S. magnetic latitude. The magnetic conjugate of Cutler, however, is only about 500 kilometers north of the receiver site. The Seattle-Wellington path is some 6 hours earlier in solar time relative to the Cutler-Siple path. Further, VLF background noise at the two receiving stations is likely to be very different.

Examination of 1974 Siple records shows a large number of whistler-mode activity periods and some pronounced diurnal patterns. The next stage will compare the Siple records with those from the Wellington station, looking for similarities and differences in periods of occurrence, in diurnal and seasonal patterns, and in types of signals received (particularly the frequency band spread).

The 1974 operations were very encouraging and justified the project's continuation. The work is being done in close collaboration with R. A. Helliwell and John Katsufrakis, both of Stanford University, and we are grateful for their continuing interest and help, and for the assistance of Stanford's teams that operated the equipment at Siple. This research was partially supported by the National Science Foundation.

High-latitude ionospheric absorption

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Observations of ionospheric absorption above Siple Station continued in 1974 using a solid-state riometer. Data are recorded on an eight-channel paper chart recorder with simultaneous observations of the magnetic field, magnetic micropulsations, and various very low frequency (VLF) receiving systems. This recording method makes it possible to compare phenomena observed on different channels without any uncertainty regarding the relative timing of events.

Since Siple is a low-latitude station (L=4), events are recorded there only during geomagnetically disturbed periods (Kp≥4); unlike the situation at higher latitudes, therefore, events tend to be well separated from each other, thus reducing confusion. A typical event occurred on 3 April 1973, and three channels of the paper chart are reproduced in figure 1. This is an N event, as described by Morozumi (1965) from observations made at Byrd during 1963, because the full record reveals that a

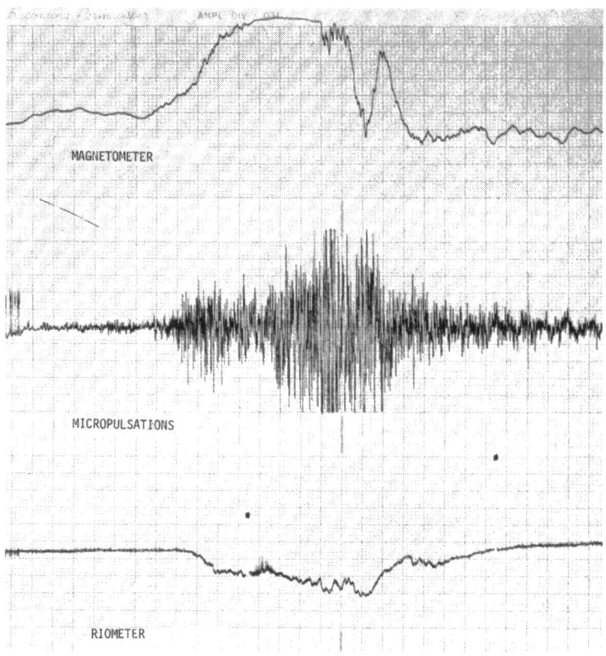

Figure 1. Typical night event recorded at Siple on 3 April 1973 around 0500 Greenwich Mean Time (GMT).

burst of VLF chorus activity preceded the disturbances on the other channels. The absorption event occurs simultaneously with a magnetic bay and a burst of micropulsation activity. Although details are not well correlated, it is clear that the envelope of micropulsation activity follows the general form of both the magnetic bay and the riometer absorption event. From the higher latitude station at Byrd, Morozumi obtained sufficient events to be able to differentiate between three different kinds of night events and a day event; but as expected, few of these were recorded at Siple. With the fast time response of the new riometer, however, it is now possible to follow accurately the rapid pulsations in absorption (~1 minute) that are features of some events. At times there is a close correlation between slow micropulsations (Pc) and riometer absorption, as shown in figure 2. Because of the slow rate, these fluctuations also appear on the magnetometer record, although no major bay disturbance of the magnetic field occurs at this time.

Other types of pulsation events recorded so far seem to be an admixture of the two extremes typified in figures 1 and 2. An example is shown in figure 3, where the average level of absorption follows the envelope of micropulsation activity and closer examination reveals that individual micropulsations coincide with modulation of the absorption pattern. Even in events where the micropulsation frequency is faster than the response time of the riometer (0.25 second), it has been noted that changes in micropulsation frequency are accompanied by coincident changes in absorption. Although the modulation in absorption is often well correlated with the micropulsation record, note that in some cases several cycles of micropulsation activity precede the onset of absorption. In these events, then, it appears that the micropulsation phenomenon acts as a trigger for the absorption.

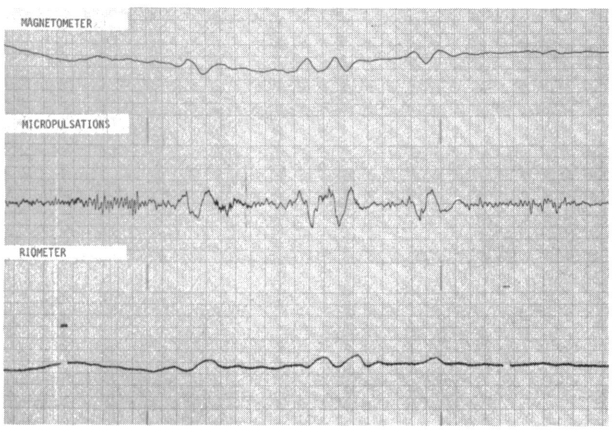

Figure 2. Slow pulsation event observed at Siple on 20 April 1973 near 2000 GMT.

Now that the 1974 records are available, further analysis of the relationship between absorption pulsations and micropulsations is possible. A preliminary explanation for the phenomena that have been described is that the pitch angle distribution of the electrons responsible for the absorption is gradually modified by the magnetospheric oscillations causing the micropulsations. In some events the electrons oscillate between hemispheres without precipitation first taking place, and in other events the pitch angle distribution is sufficiently modified by the first cycle of oscillation that precipitation takes place immediately. During 1975-1976 we hope to make riometer observations at Roberval, Quebec (Canada), Siple's conjugate in the Northern Hemisphere, to examine the correlation of absorption pulsations between hemispheres. Observations also will be made at South Pole and McMurdo stations to establish whether the absorption pulsations occur at high-latitude stations where the magnetic field lines are swept back into the tail of the magnetosphere.

This research was supported by National Science Foundation grant OPP 72-05746.

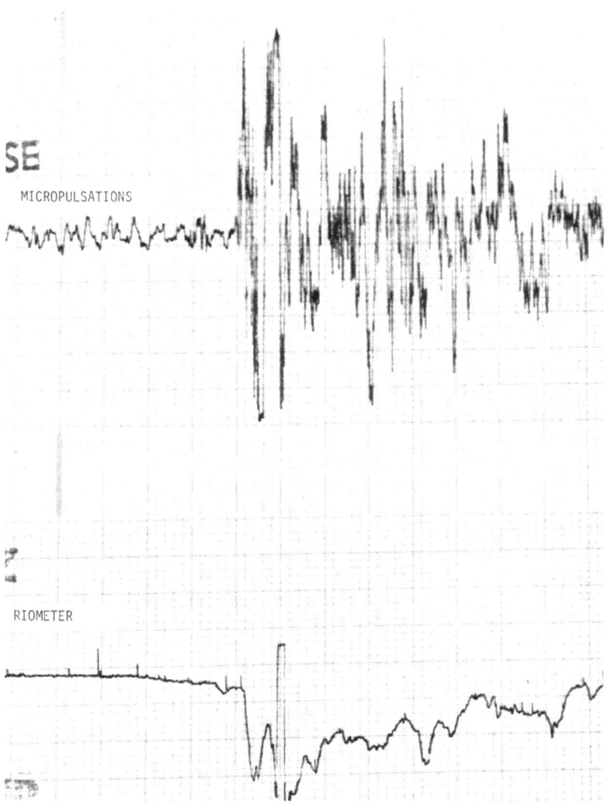

Figure 3. N event with modulation in absorption recorded at Siple on 28 June 1974 near 0110 GMT.

Reference

Morozumi, H. M. 1965. Diurnal variation of aurora zone geophysical disturbances. *Report of Ionosphere and Space Research in Japan,* 19(3): 286-298.

Midlatitude optical observations from Siple Station, Antarctica, and Roberval, Quebec

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Siple Station is a unique location for the study of magnetospheric wave phenomena. There are several experiments at Siple to study various aspects of wave particles and related phenomena. The Lockheed Palo Alto Research Laboratories have been involved in optical diagnostics of particles that precipitate from various regions of the magnetosphere. At higher magnetic latitudes than Siple the intense fluxes of these particles cause visible auroras. At lower latitudes, there are also interesting phenomena that have very weak but detectable optical signatures. These signatures were monitored at Siple throughout the 1974 austral winter.

In the Siple vicinity, the magnetospheric cold background plasma undergoes an abrupt reduction in number density. This is known as the plasmapause. The locations of these regions are monitored by very low frequency (VLF) techniques developed by Stanford University. Following a period of magnetic activity, the enhanced energetic particles are thought to interact with the cold plasma-generating waves. These waves are also thought to cause a type of optical emissions known as stable auroral red (SAR) arcs. Simultaneous monitoring of VLF and optical data permits investigation of the relative location of red arcs and the plasmapause. Preliminary analysis of the Siple 1974 data shows that in a sample case the SAR arc occurs just inside the high density plasma (i.e., equatorward of the plasmapause).

A promising technique is to probe the magnetosphere by means of the artificial injection of waves. The Stanford University transmitter at Siple has been successful in exciting many interesting magnetospheric wave modes. Several experiments are planned to investigate the effectiveness of these excited waves in perturbing high energy particles and causing them to precipitate in the atmosphere. In one of these the precipitating particles would be detected optically by measuring the emitted (auroral) light. In the first of a series of experiments in 1975 we are deploying a special high-sensitivity instrument at Roberval, Quebec (Canada), the magnetic conjugate of Siple. In the experiment, the Siple transmitter produces a pulsed wave train. This wave train interacts with the particles. The optical detector is switched on, after a slight delay following the transmitter pulse, to receive the optical signatures of the transmitter generated wave. The optical signals are added for many transmitter pulses to produce signal-to-noise ratio enhancement. This should bring us closer to understanding production mechanisms in both natural and artificial phenomena, and eventually to artificial control of these phenomena.

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Cosmic ray intensity variations

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The fact that transient intensity decreases are observed in the polar regions implies that galactic cosmic rays are modulated by interplanetary plasmas of solar origin. Generally, these decreases are ascribed to some sort of magnetic barrier moving outward from the sun and sweeping the incoming cosmic radiation. Several modulation mechanisms involving different magnetic configurations have been proposed. Our studies, in which the antarctic observations are absolutely crucial (Nagashima *et al.,* 1968; Duggal and Pomerantz, 1970, 1971; Pomerantz and Duggal, 1972), have established that north-south anisotropy is an integral feature of every cosmic ray storm, and it is clear that this phenomenon is of key significance in theoretical studies of the relevant plasma dynamics.

We have investigated cosmic ray storms in a search for correlations between the north-south asymmetry and solar and space data. The most recent, and successful, attempt has focussed on the relationship between the direction of north-south anisotropy and the inclination of associated shock