cluded low, centered approximately 1200 nautical miles northeast of McMurdo moving southeast away from McMurdo. Extensive residual cloudiness was present west of the storm to Cape Adare. That evening a new low pressure center developed just east of Hallett Station and Cape Adare and moved southsoutheast into McMurdo. The storm, though weak, produced southeasterly flow gusting to 64 knots in McMurdo. By 9 February the system was slowly dissipating south of McMurdo and sky and wind conditions had improved.

Aerial ice reconnaissance flights were restricted to flights of opportunity. No dedicated ice reconnaissance flights were flown due to the significant absence of sea ice in the Ross Sea. POLAR STAR commenced the 31-mile channel break-in to McMurdo Station on 9 January. Fast ice generally ranged from 1.1 to 2.3 meters thick with snow cover from 1.5 to 47.5 cm. Brash remained in the channel, turn basin, and Winter Quarters Bay through the summer support season. Finally, during the period 20-21 February, significant amounts of ice were blown out to sea, leaving blue water adjacent to McMurdo Station.

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Magnetosphere, ionosphere

VLF direction finding from Palmer Station

D. L. CARPENTER

Radioscience Laboratories
Stanford University
Stanford, California 94305

The Palmer Station direction finding (DF) system provides information on the arrival bearing of signals propagating to the station from signal sources on the Earth's surface and from points at which downcoming whistler-mode signals emerge from the lower ionosphere.

The position of an exit point can be estimated by combining arrival bearing information from the direction finder with analysis of the dispersion characteristics of the received signal (e.g., Seely, 1977). These characteristics provide information on the equatorial radius or endpoint latitude of the geomagnetic-field-aligned signal path.

In 1978, valuable new information was obtained on the scattering of energetic particles in the magnetosphere by whistler signals originating in northern hemisphere lightning. Prior to the Palmer Station experiments, it had been found that whistlers propagating in the magnetosphere can resonantly interact with energetic magnetospheric electrons, thus perturbing their orbits and causing some of them to precipitate into the lower ionosphere (Helliwell, Katsufrakis, and Trimpi, 1973). The precipitating particles produce locally enhanced ionization at an altitude of about 80 kilometers. When this occurs at night, the propagation characteristics of the earth-ionosphere waveguide at very low frequency (VLF), may be measurably affected.

Examples of resulting amplitude perturbations in the 21.4-kilohertz NSS signal propagating from Annapolis, Maryland, to Palmer Station are shown in figure 1. The perturbations appear as a series of sudden amplitude increases. Each relatively fast increase (T = about 1 second) is followed by recovery on a time scale of about 1 minute.

We were able to confirm that amplitude anomalies may occur equatorward of the relatively low magnetic latitude (about 49°) of Palmer Station and also to obtain detailed information on relationships between the great circle paths of the perturbed signals and the whistler-mode signals involved in the particle scattering.

Directional data acquired on 3 October 1978 confirmed the presence of an active whistler path with ionospheric exit point in the near vicinity of the great circle path from NSS to Palmer Station. Figure 2 displays the output of the tracking receiver/direction finder. The top panel shows frequency time records of a series of whistlers, each with two principal components. The middle panel shows a replica of the center frequency of a frequency-tracking filter used to isolate signals of interest within a 340-hertz band. The bottom record shows in magnetic coordinates the apparent arrival bearing of the whistler signals. There are two relatively well-defined directions, one close to north and the other close to west. These represent, respectively, the first and second of the two principal whistler components.

Figure 3 shows a plot in geographic coordinates of the positions of Palmer and Siple stations. The ionospheric

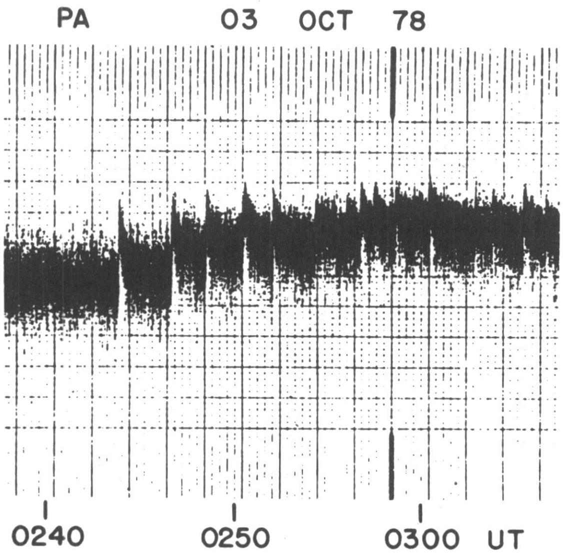

Figure 1. Fast amplitude variations of 21.4 kilohertz NSS signals propagating from Annapolis, Maryland, to Palmer Station.

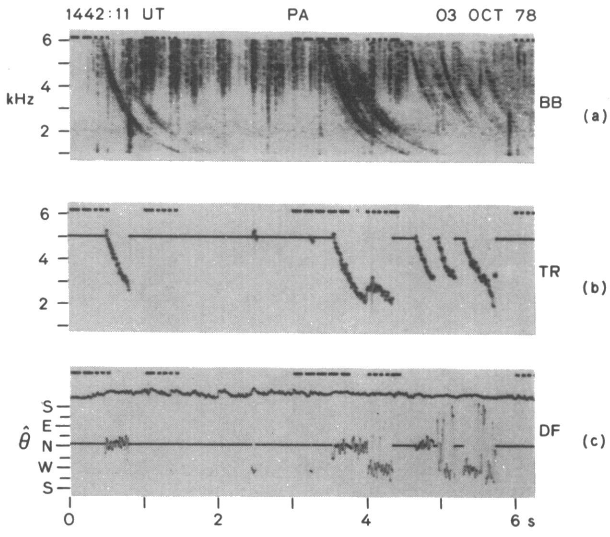

Figure 2. VLF direction-finding analysis of whistlers observed during a period of fast amplitude variations in the NSS signal propagating to Palmer Station. Key: (a) = Broadband VLF spectrum showing series of component whistlers; (b) = tracking filter center frequency; (c) = directional information determined from signal in tracking filter passband.

projections of field lines extending to various equatorial radii in the range 2 to 4 are shown. The great circle path from NSS to Palmer Station is indicated, as well as wedge-shaped regions that are estimated to contain the ionospheric endpoints of the two whistler paths. The region located roughly 100 kilometers north of Palmer Station is believed to represent the principal area of particle precipitation affecting the NSS path.

Data of this kind and additional studies now being conducted will allow a more refined description of the amplitude anomalies. This description will provide the basis for numerical analysis of the effect, both in terms of earth-ionosphere waveguide propagation and particle scattering from the Earth's radiation belts.

A remarkable result has been obtained from other applications of the direction finder. This is an anomaly of order 50° in the apparent arrival bearing at Palmer Station of the signal propagating directly from the Siple Station VLF transmitter. The terrain between Siple and Palmer Stations, including land ice, shelf ice, and complex coastal topography, evidently gives rise to a strongly distorted wave structure over Palmer Station. Studies of this anomaly are continuing.

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Our work also involved joint campaigns with colleagues doing DF studies at Halley Bay (United Kingdom), Belgrano (Argentina and France), and Sanae (South Africa).

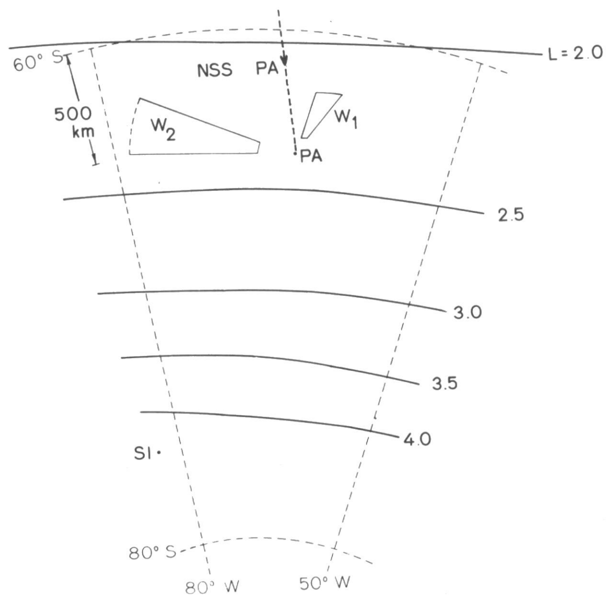

Figure 3. Area of Palmer Station (PA) showing regions within which two whistler components (figure 2) were estimated to emerge from the ionosphere.

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