OBSERVATION OF AURORAL HISS BY THE S-310JA-6 SOUNDING ROCKET

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Abstract: S-310JA-6 sounding rocket was launched along the geomagnetic field line from Syowa Station, Antarctica at 005600 LT on August 28, 1978 by the Japanese Antarctic Research Expedition party. That rocket hit active auroral arcs and brought satisfactory results for investigating the wave phenomena in the aurora. A strong hiss was observed on board from an altitude of 110 km on its ascent up to 150 km on its descent. However, no hiss was observed on the ground during the period.

The hiss activity observed on board corresponded well to the auroral arc's activity. Included among the hiss were the LHR hiss, the electro-static waves, etc.

These data will be valuable to investigate the wave-particle interaction in the polar ionosphere.

1. Introduction

One of the IMS projects in Antarctica is to examine the problem of the wave-particle interaction in the auroral ionosphere. For that purpose, a series of rocket experiments are planned and carried out.

In 1978, four rocket experiments for that purpose by S-310JA sounding rockets were carried out with a great success by the 19th Japanese Antarctic Research Expedition party at Syowa Station.

At 0050 LT on August 28, 1978, active auroral arcs appeared at Syowa Station, followed by the geomagnetic field variation and the hiss event. Our S-310JA-6 rocket was launched along the geomagnetic field line, hit the auroral arcs and brought satisfactory results.

2. Observation

S-310JA-6 sounding rocket was launched along the geomagnetic field line at 005600 LT on August 28, 1978 at Syowa Station. The records of magnetometer, riometer and VLF hiss-meter on the ground are shown in Fig. 1.

From Fig. 1, it is found that hiss activity on the ground dropped down at the launching time and was not observed during the flight of the rocket. However, auroral arcs were observed throughout the flight by an all-sky camera at Syowa Station, as shown in Fig. 2.

On the rocket, the observation started at 56 s after launching. A weak hiss was observed just after the antenna extension at 005656 LT until 005710 LT. This hiss was also observed at the same time by a VLF hiss-meter on the ground. For 5 s after

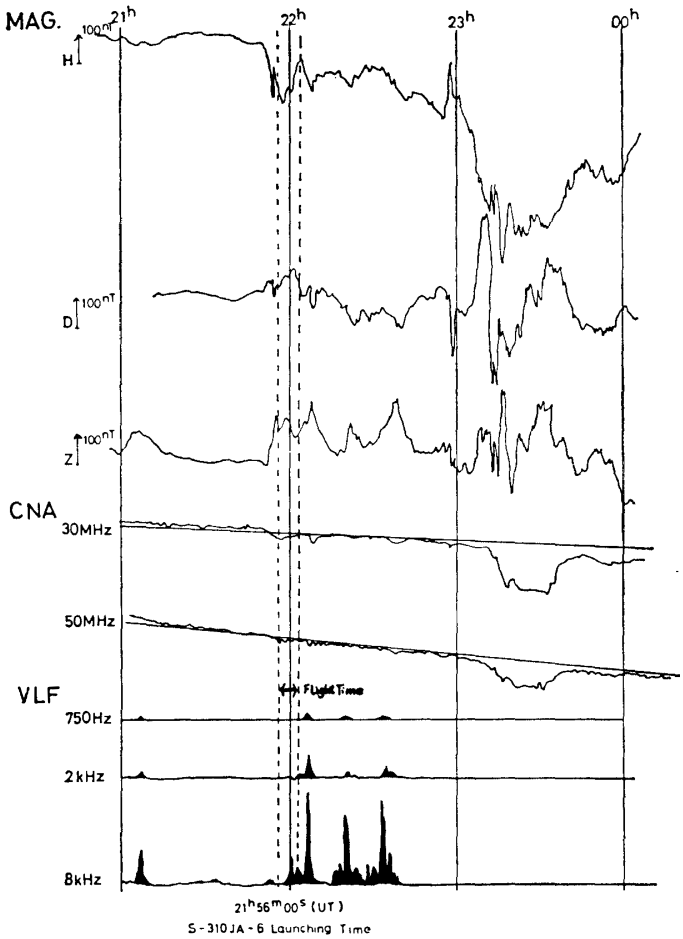

Fig. 1. Ground-based observation of MAG, CNA and VLF on 28 August 1978 at Syowa Station.

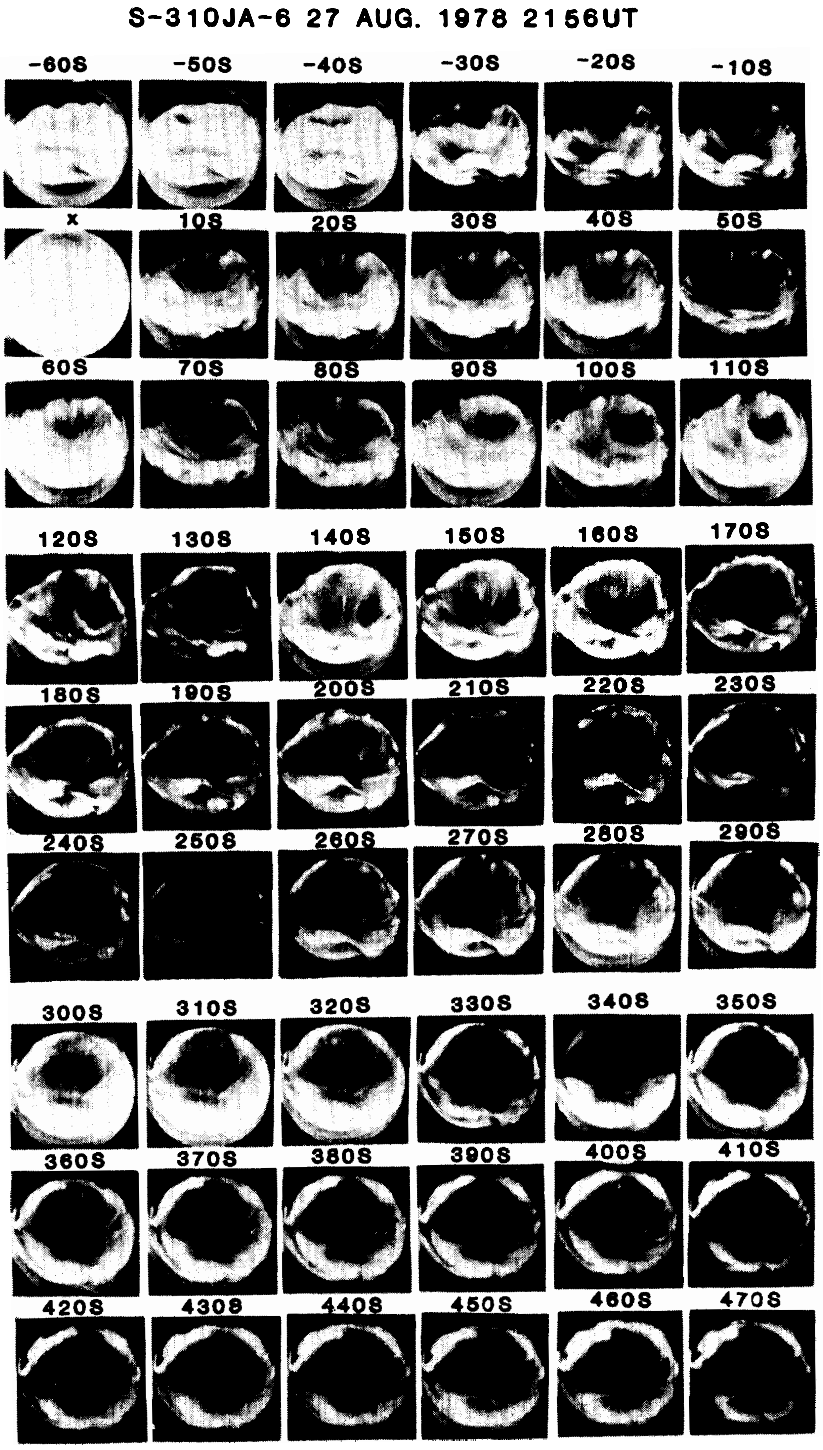

Fig. 2. The data of all-sky camera on 28 August 1978 taken every ten seconds.

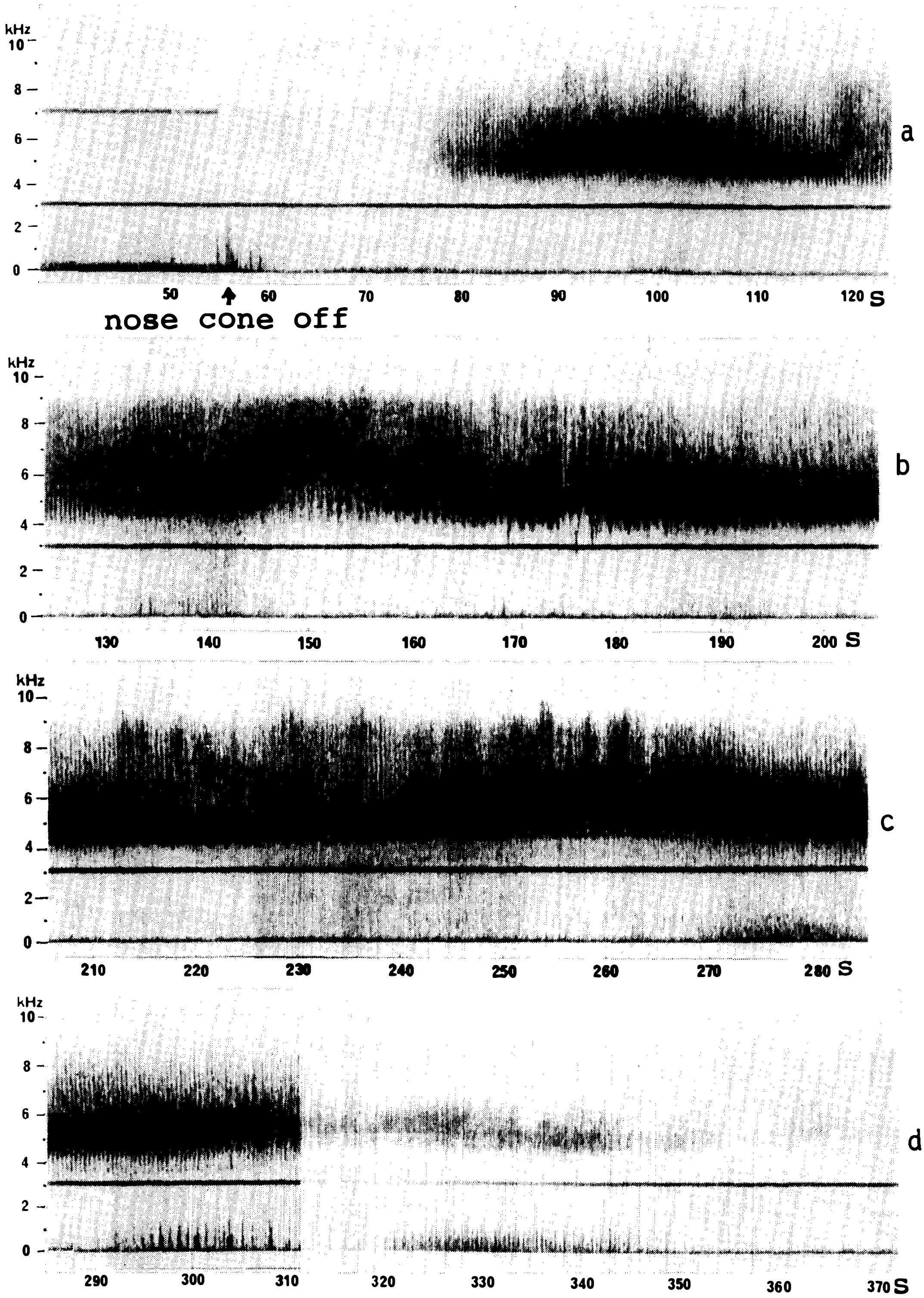

Fig. 3. The VLF hiss spectra by an electric antenna on the rocket.

005710 LT, the hiss was observed neither on the rocket nor on the ground. But, from 005715 LT, a strong hiss suddenly began to be observed on the rocket and continued until 010230 LT. However, no hiss was observed on the ground. Figs. 3a to 3d show the VLF hiss spectra received by an electric antenna of 2 m length (tip to tip) on the rocket during the flight. Though the shielded magnetic loop antenna with 100 mmϕ and 20 turns was loaded on the rocket, that hiss was not clearly observed.

3. Observational Results

The principle and the measuring system of our VLF experiment to be loaded on S-310JA-6 were described in detail by Tanaka *et al.* (1978). Output signals obtained are the polarization ratio at two specific frequencies of 7 and 3 kHz, the Poynting flux direction at 7 kHz and wide-band signals (0–10 kHz) received by both electric and magnetic antennas. The electron number density profile measured on board is shown in Fig. 4. The altitude distributions of the intensity of the wide-band signals from 0 to 10 kHz are shown in Figs. 5 (ascent) and 6 (descent) respectively. It is found from Fig. 5 that the four intensity peaks can be seen at 130, 155, 195 and 235 km altitudes. These peaks correspond to the time of intense auroral arcs, which can be seen by the records of an all-sky camera as shown in Fig. 2. In the descending period, only one intensity peak can be seen at 227 km altitude as shown in Fig. 6. It

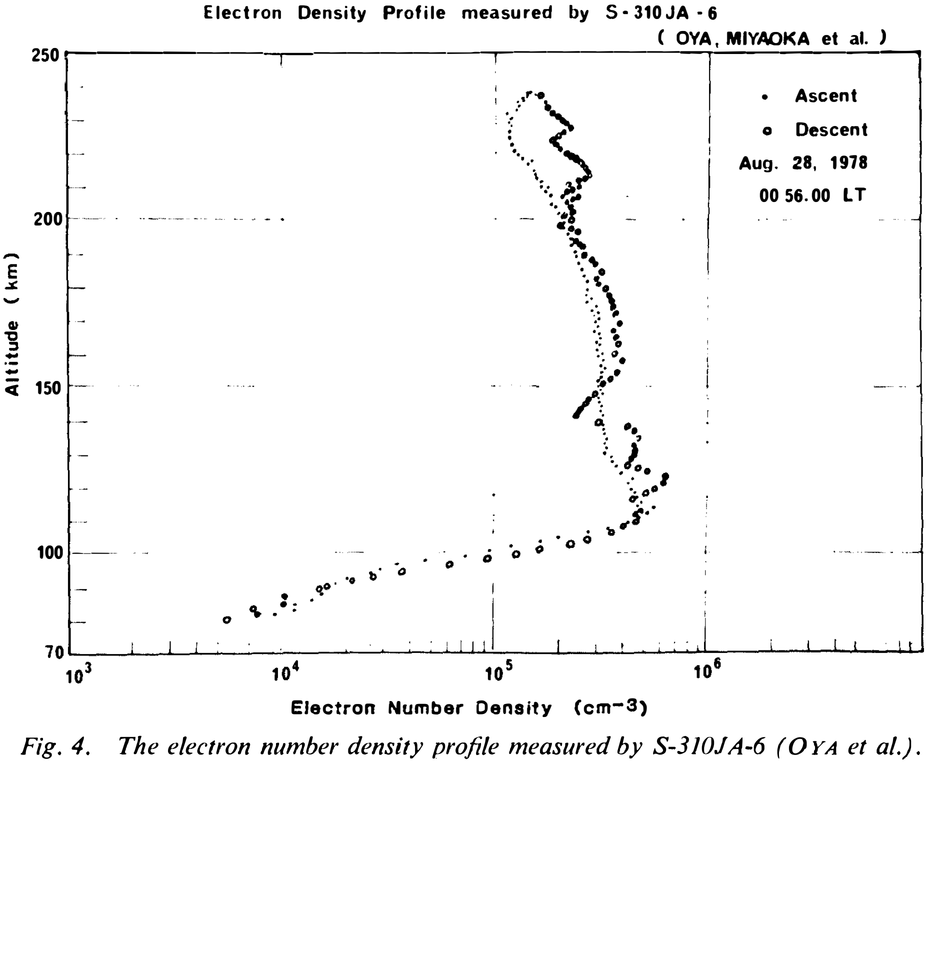

Fig. 4. The electron number density profile measured by S-310JA-6 (Oya et al.).

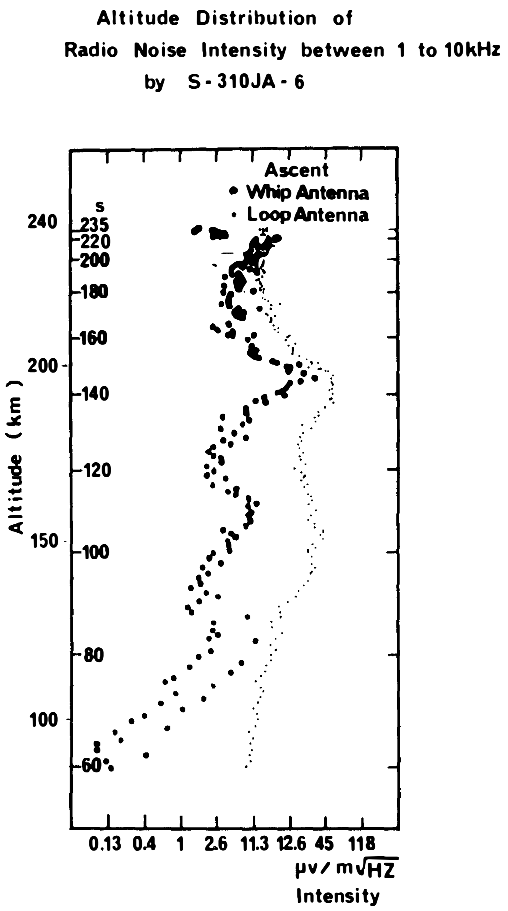

Fig. 5. The altitude distribution of radio noise intensity between 0 and 10 kHz by S-310JA-6 in the ascending time.

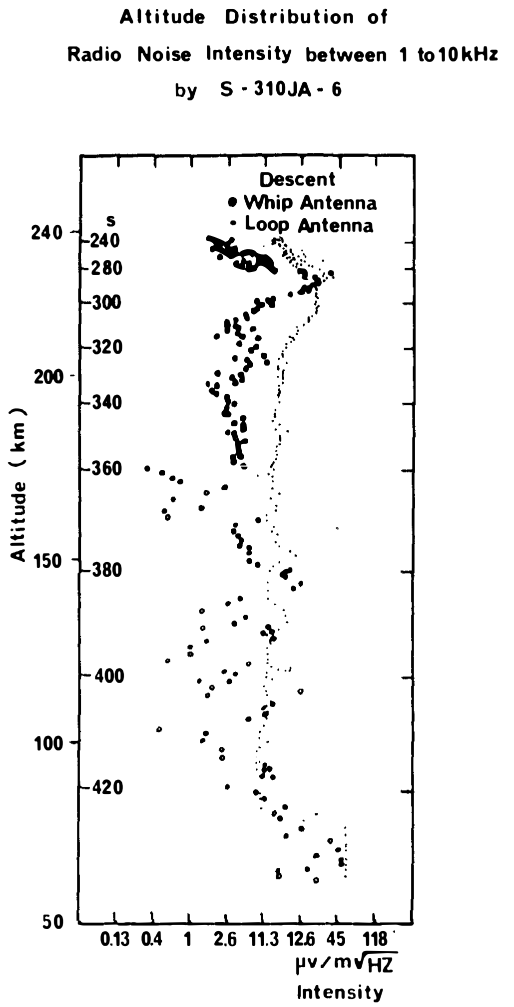

Fig. 6. The same as Fig. 5 in the descending time.

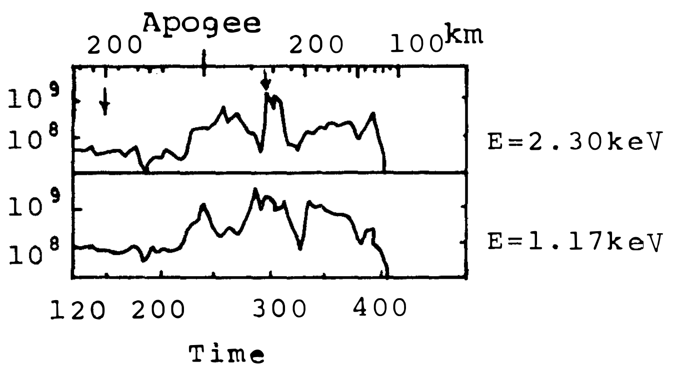

Fig. 7. The particle flux variations with the energy range of 2.30 and 1.17 keV measured by S-310JA-6 (MATSUMOTO and KAYA of Kobe University).

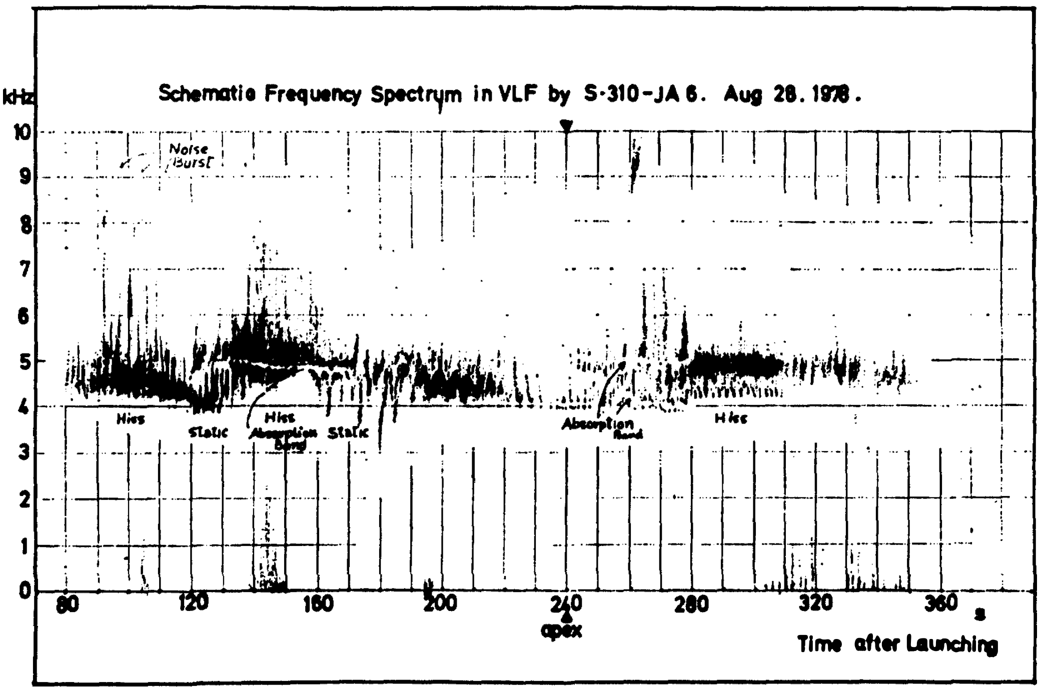

Fig. 8. The schematic frequency diagram of the VLF hiss spectra observed by S-310JA-6.

also corresponds to the time of intense auroral arcs. From the data of particle detectors loaded on the rocket simultaneously (see Fig. 7), no peak particle flux value corresponding to the height having the intensity peaks of VLF waves in an ascending period was indicated, but on the other hand the particle flux value corresponding to the height of 227 km in a descending period clearly indicated a peak value corresponding to the intensity peak of VLF waves. These results may suggest that the hiss observed in the polar ionosphere consisted of the phenomena of different origins.

In order to afford a better understanding of the VLF spectra, we show the schematic frequency diagram in Fig. 8.

In the first place, it is found from Figs. 3 and 8 that the hiss event has a low-frequency cut-off at a frequency of about 4 kHz, and moreover this cut-off frequency changes with the altitude of the rocket. But, calculating from the estimated ion composition for this altitude of the ionosphere, this cut-off frequency did not correspond to the LHR frequency for this ionospheric region. It remains unexplained at present why there exists such a cut-off phenomenon. Secondly, the hiss event may consist of four series of hiss activity; from 75 to 120 s, from 120 to 150 s, from 150 to 220 s and from 240 to 350 s on the ascending leg. These series of hiss activities may be associated with auroral arcs. The facts are confirmed by the video-data taken at the same time by the television camera at Syowa Station. Thirdly, special features can be seen in the third series of hiss. But, it remains unexplained whether this static wave phenomena are excited by the precipitating auroral particles or by the rocket itself. Fourthly, in Fig. 3 can be seen the burst-like hiss events everywhere, the frequency of which is spreading over 4 to 10 kHz. Comparing these events with the auroral data taken by the video camera, it is found that they tend to appear when some bright patches are moving along auroral arcs. So they seem to be accompanied with the auroral particles injected into the polar ionosphere. Fifthly, in Fig. 3 can be clearly seen the absorption bands on the second series of hiss (120–150 s) at about 5.4 kHz and on the fourth series of hiss (240–350 s) at about 6 kHz. The frequency of these absorption bands corresponds respectively to the LHR frequencies at these altitude calculated from the estimated ion composition.

Unfortunately, owing to a bad performance of the polarization meter, we can not observe the polarization ratio. However, the ratio of minimum to maximum signals on wide-band, as the loop antenna rotates, is given by

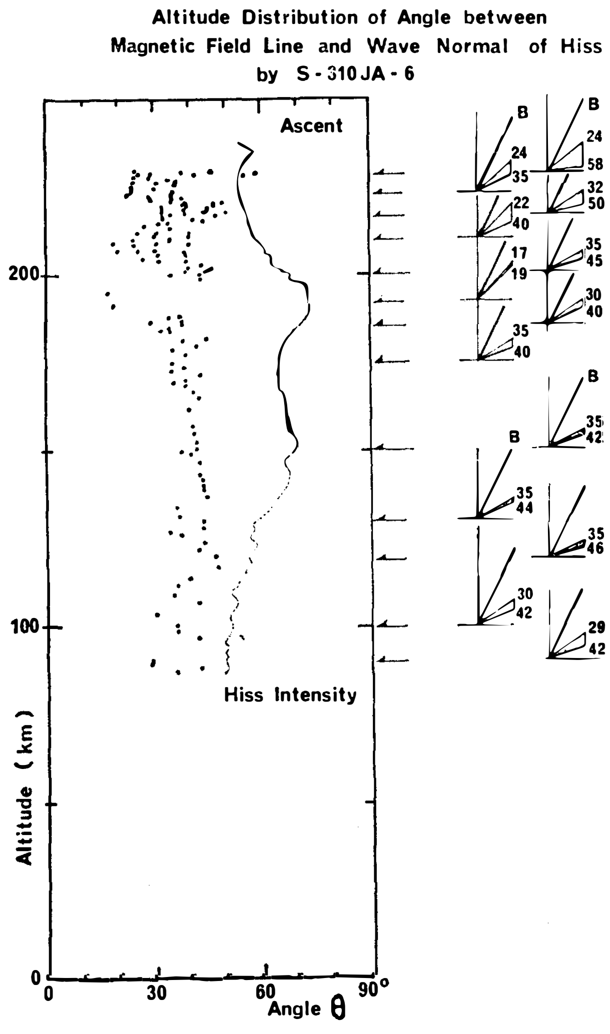

Fig. 9. The altitude variation of the angle between the magnetic field line and the wave normal of hiss.

$$E_{min}/E_{max} = \cos\Phi$$

where Φ is the angle between the rocket spin axis and the wave normal direction. This relation will allow us to find the angle Φ with azimuth ambiguity, although it is not possible to distinguish between up- and down-ward propagations. Fig. 9 shows the altitude variation of its angle obtained by the above treatment.

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References

MATSUO, T., KIMURA, I. and KAMADA, T. (1979): Characteristics of VLF hiss observed by S-310JA-2 rocket. Nankyoku Shiryô (Antarct. Rec.), **64**, 50–56.

TANAKA, Y., HAYAKAWA, M. and NISHINO, M. (1978): An observing plan of wave normal direction of auroral emissions on board a rocket at Syowa Station. Mem. Natl Inst. Polar Res., Spec. Issue, **9**, 76–86.

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