OBSERVATIONS OF WAVE PHENOMENA IN THE POLAR IONOSPHERE BY S-210JA-19 ROCKET

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Abstract: S-210JA-19 sounding rocket was launched on July 15, 1973 from Syowa Station in order to investigate the auroral hiss in the polar ionosphere. On this day a fairly strong hiss was observed on the ground, but auroral arc was not observed. The hiss was also observed on the rocket above an altitude of 80 km both in the ascending and the descending phases in the frequency range of 1–8 kHz and at 30 kHz. The field intensity had a maximum around an altitude of 100 km.

From these results, it is supposed that in some circumstances auroral hiss is generated at an altitude of about 100 km by auroral particles penetrating into the polar ionosphere.

1. Introduction

One of the observational projects at Syowa Station, Antarctica, during the IMS period is to study the electro-magnetic properties of an auroral arc. In 1973, in order to investigate in detail the auroral hiss event, *in situ* observations by means of S-210JA type sounding rockets were planned. One of the purposes of the experiments was to find out electro-magnetic waves radiated from auroral arcs.

The S-210JA-19 sounding rocket was launched at 22:09:12 LT on July 15, 1973 from Syowa Station with an azimuth angle of 135° and an elevation angle of 82°. The weather at the launching time was fine, the wind velocity was 0 m/s and the temperature was −31.5°C. The rocket performance was good, all equipments operated normally and all observations proved successful.

On this day a fairly strong hiss event was observed on the ground by a hiss recorder at Syowa Station, but auroral arc was not observed during the flight.

The S-210JA-19 rocket payloads consisted of 1) two VLF wide-band receivers both having the same frequency range from 1 to 8 kHz respectively, 2) a tuned receiver of 30 kHz, 3) an antenna impedance meter and 4) an electron density meter. Antennas used were a core-loop type for magnetic field and a whip type of a one meter length for electric field. Only the whip antenna one meter long was used for the tuned receiver of 30 kHz. The antenna impedance meter used was a capacitance bridge to measure the variation of equivalent antenna capacitance of a whip at 17.5 kHz in the ionosphere. The electron density meter used was of the Langmuir type with a sphere probe of 25 mm in diameter.

2. Observation

Figs. 1 and 2 show the variation of the Langmuir probe current versus altitude during the ascent and descent, respectively. These profiles correspond to the distribution of electron density in the ionosphere. Peaks appear at 105 km and 120 km during the ascent and at 120 km during the descent. Especially the peak at 105 km is very sharp.

Corresponding to the peaks in the profile of the electron density, the profile of the field intensity at 30 kHz shown in Fig. 3 also gives a peak at 100 km for both ascending and descending lags. But the peak point is a little lower than

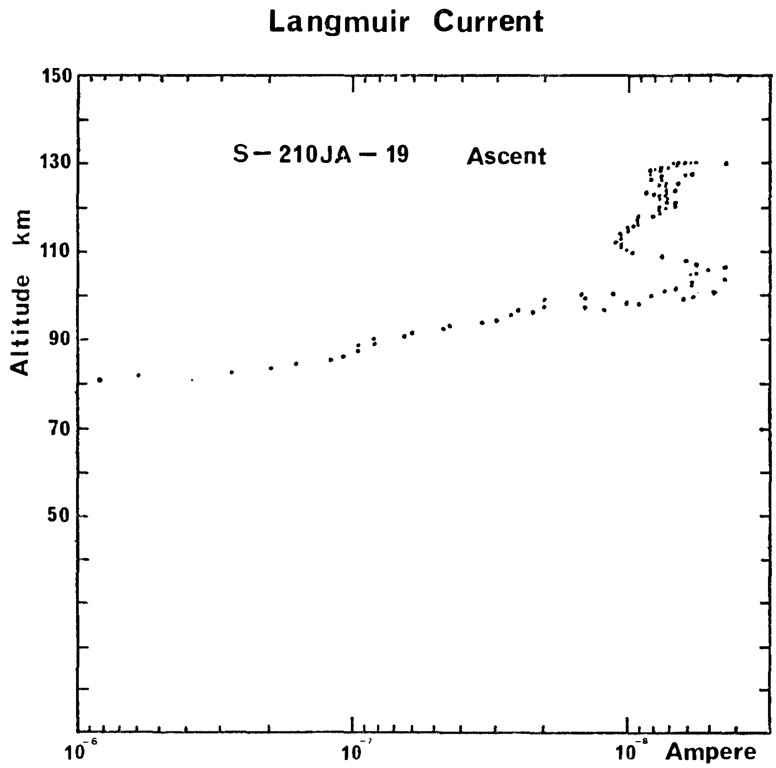

Fig. 1. The profile of the Langmuir probe current with altitude during the ascent.

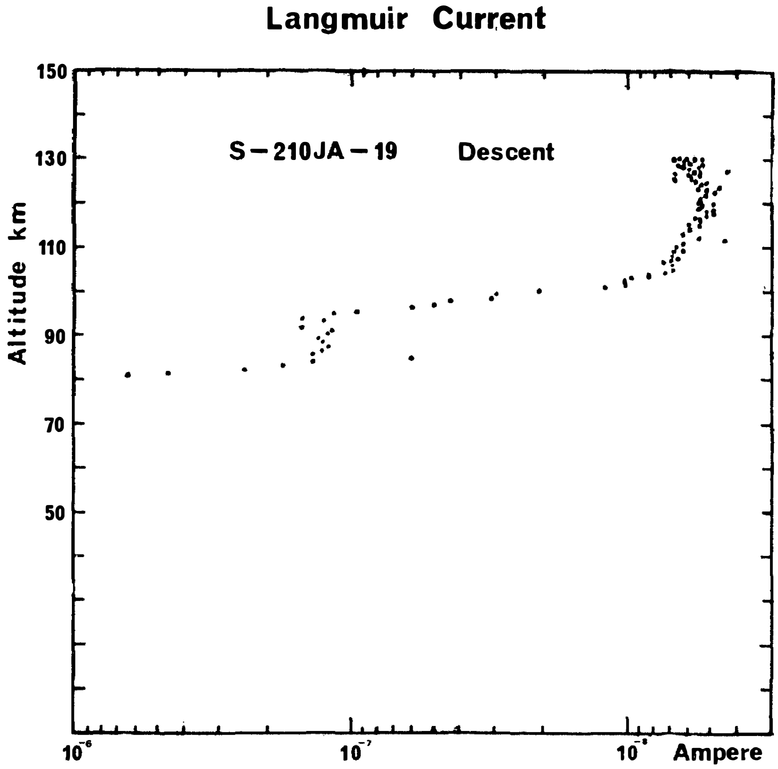

Fig. 2. The same as Fig. 1 during the descent.

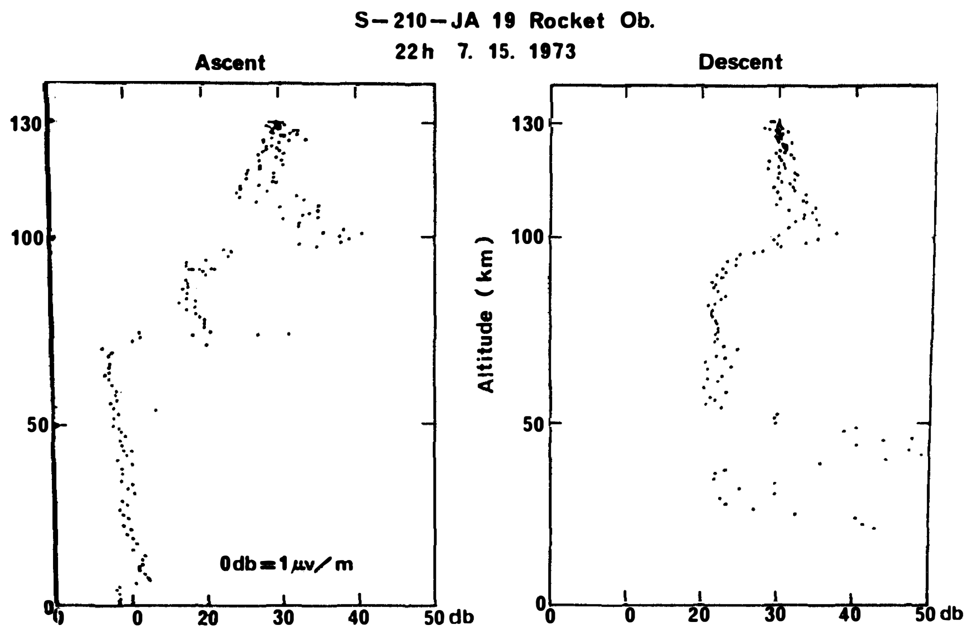

Fig. 3. The profile of the field intensity at 30 kHz with altitude.

that of the Langmuir probe current. In Fig. 3, the field intensity at 30 kHz is calculated in terms of decibel by using the value of the measured antenna impedance at 17.5 kHz.

The equivalent capacity of the 1 meter long whip antenna varied with altitude. The profile of this variation is shown in Fig. 4. At the ascending time, a sharp increase of the equivalent capacity of antenna can be seen at 100 km. It corresponds to the sharp increase of electron density.

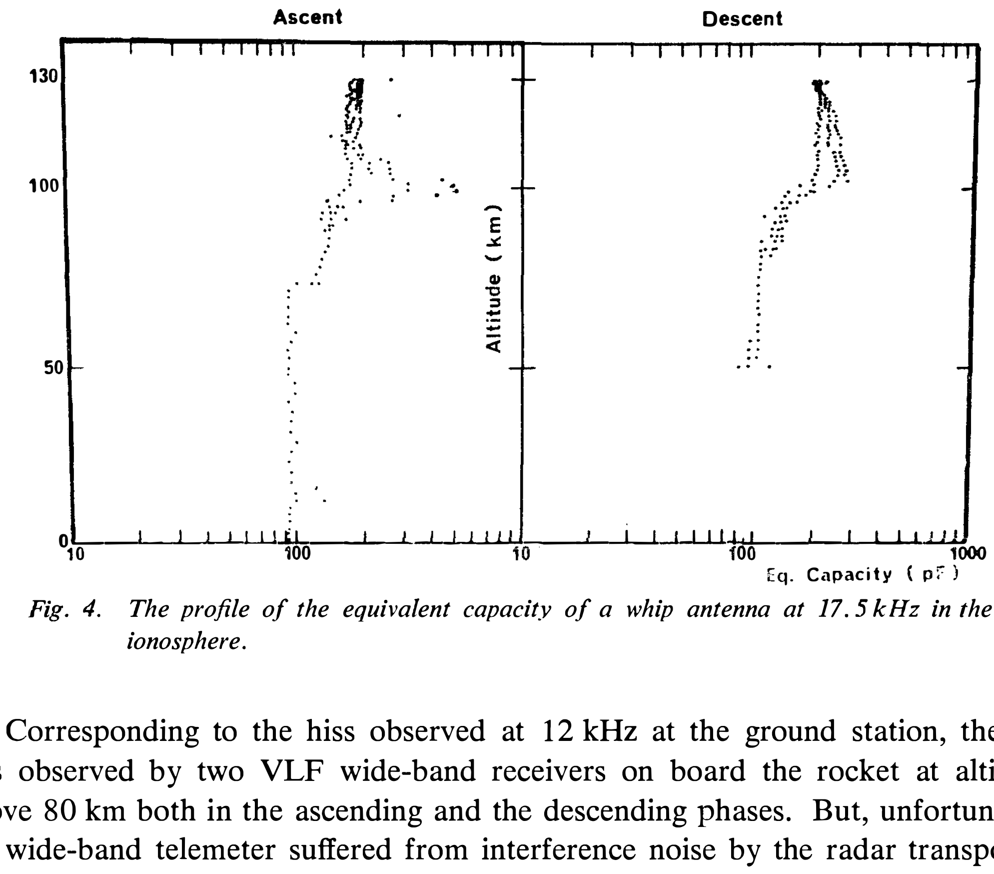

Fig. 4. The profile of the equivalent capacity of a whip antenna at 17.5 kHz in the ionosphere.

Corresponding to the hiss observed at 12 kHz at the ground station, the hiss was observed by two VLF wide-band receivers on board the rocket at altitudes above 80 km both in the ascending and the descending phases. But, unfortunately, the wide-band telemeter suffered from interference noise by the radar transponder at the same time, so that the records were disturbed at the lower and upper parts of the receiving frequency. Figs. 5, 6, 7, 8, 9 and 10 show examples of the frequency versus time analysis data from the output of VLF wide-band receivers (4 to 6 kHz). Here, the spectra in Figs. 5, 6, 7, 8 and 9 are those observed by a loop antenna and the spectrum in Fig. 10 is observed by a whip antenna. The output of a whip antenna was very noisy compared with that of a loop antenna.

Fig. 5 shows a radio noise spectrum received in the altitude range from 60 to 70 km. At this time, hiss was not seen. Fig. 6 shows the spectrum received in an altitude range from 90 to 100 km, in which hiss was seen in the frequency range from 4 to 6 kHz. Fig. 7 shows the spectrum received in an altitude range

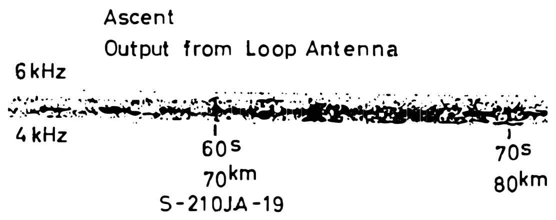

Fig. 5

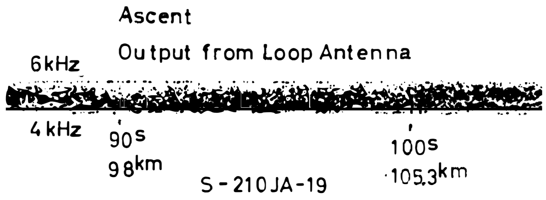

Fig. 6

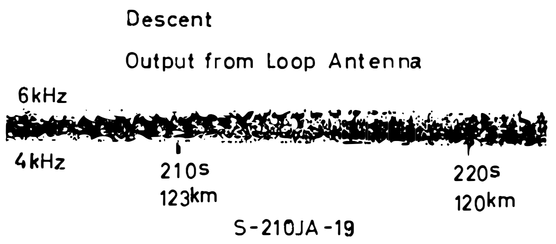

Fig. 7

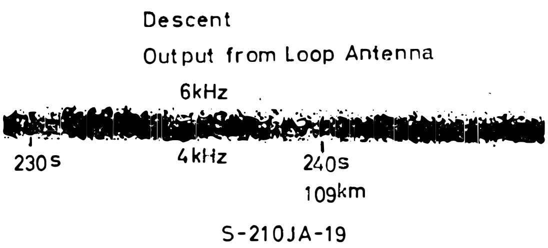

Fig. 8

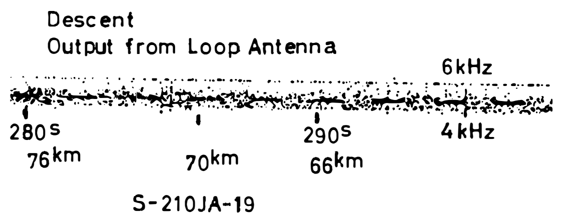

Fig. 9

Figs. 5–9. The frequency vs. time spectrum for the loop antenna output of the VLF wide-band receiver.

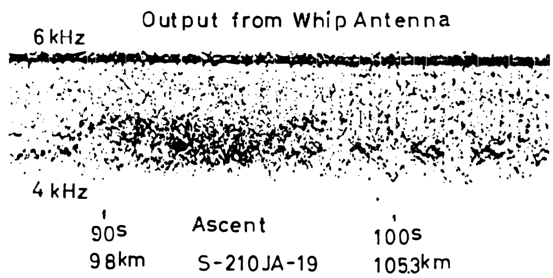

Fig. 10. The frequency vs. time spectrum for the whip antenna output of the VLF wide-band receiver.

from 123 to 120 km in the descending phase. Discrete noises can be seen together with the hiss. These discrete noises suffered from spin moduration and their frequency changed with time. It seems that these noises are not natural ones existed in the polar-ionosphere, but perhaps artificially excited noises. Fig. 8 shows the spectrum received around the altitude of 109 km in the descending phase, where strong hiss can be seen. Fig. 9 shows the spectrum received in an altitude range from 76 km to 66 km in the descending phase, where the hiss can not be seen. Fig. 10 shows the spectrum received by a whip antenna in an altitude range from 98 to 105 km, where a break-up of hiss can be seen. Fig. 11 shows the altitude ranges on the trajectory of S-210JA-19, where hiss was observed. It is found that the hiss was observed extending over almost all altitudes above 80 km

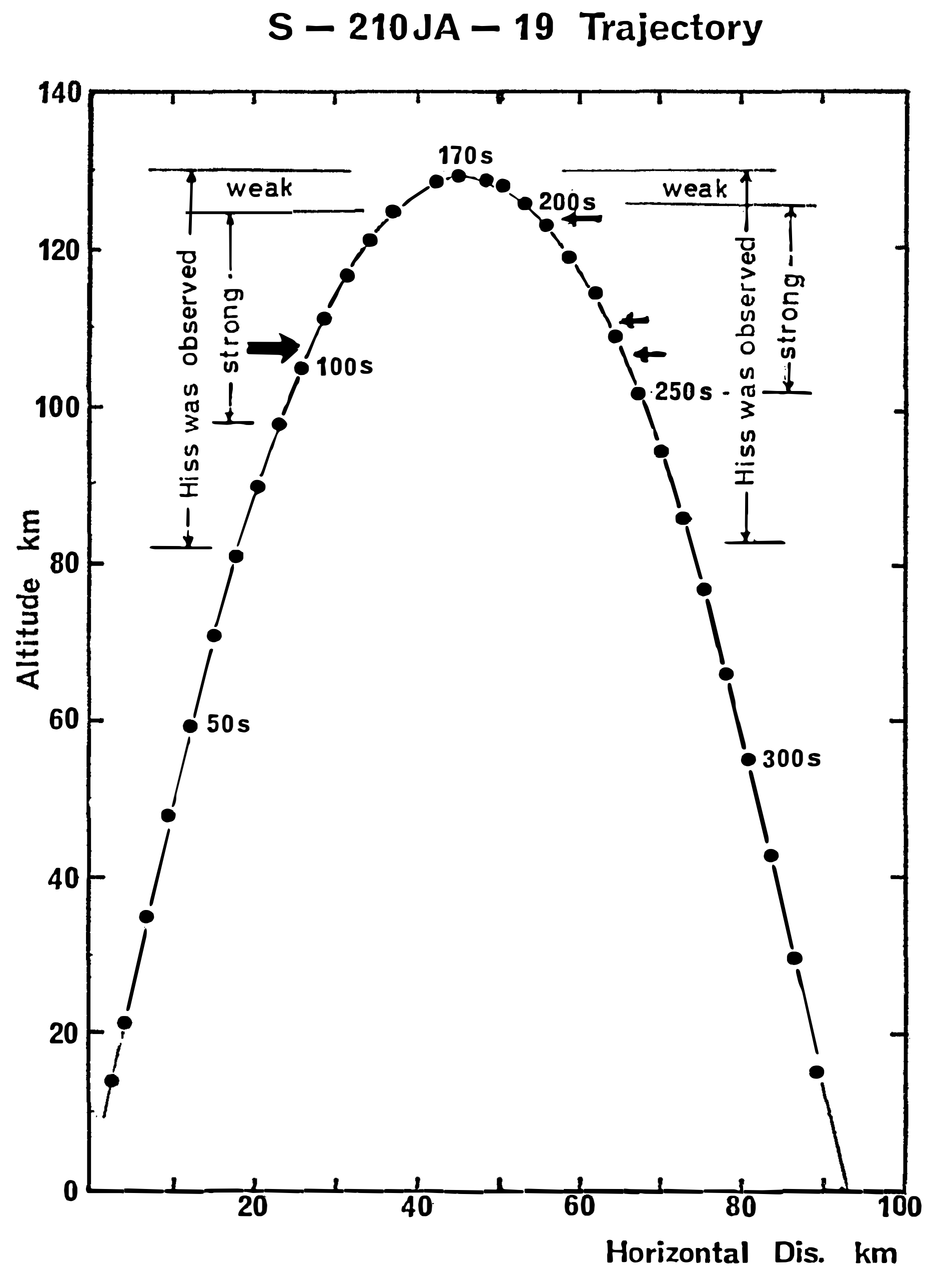

Fig. 11. An aspect of the position where hiss was observed on the trajectory of S-210JA-19.

for the ascending and the descending phases.

3. Discussion

As previously stated, the S-210JA-19 rocket was launched at the same time when hiss was observed at the ground station, but no auroral arc was observed. However, before and after the launching, that is from 20:21 to 21:00 LT and 22:18 to 23:20 LT, an aurora-radar at Syowa Station observed a fairly strong echo from auroral arcs. Therefore, it is supposed that at the launching time, auroral particles were precipitating into the ionosphere, but aurora did not break-up. This supposition is confirmed by the fact that the profiles of the electron density had peaks around 100 km altitude. The field intensity of 30 kHz had also peaks around 100 km altitude. Therefore, it is supposed that there is auroral hiss originated around 100 km altitude as well as the hiss generated in the magnetosphere.

In the case of S-210JA-2, the rocket crossed a weak auroral arc, at which the field intensity of 6–10 kHz was enhanced, and the auroral UV meter on board the rocket recorded fairly strong UV emissions. Therefore, the authors have already concluded that some origin of auroral hiss exists in the auroral arc.

Finally, discrete noises received from 123 to 120 km in the descending phase are thought to be artificially excited noises which were perhaps created by the antenna going in and out a wake of the rocket body. This problem requires further examination.

Acknowledgments

The authors' thanks are due to the members of the 14th Japanese Antarctic Research Expedition. The authors wish to express their sincere thanks to Dr. H. FUKUNISHI for his careful reading and criticism of this paper.

(*Received May 16, 1978*)