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NEW-TYPE ECHOES OBSERVED WITH THE 50 MHZ AURORAL DOPPLER RADAR AT SYOWA STATION (EXTENDED ABSTRACT)

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VHF Doppler radars have been used for the study of auroral E-region irregularities (HALDOUPIS, 1989). The Doppler spectra of radar echoes, which give important information for investigating the plasma instabilities responsible for irregularities, are categorized into four types, type 1–4: type 1 is produced by a two-stream instability, type 2 by a gradient-drift instability, type 3 presumably by an ion-cyclotron instability, and type 4 by the two-stream instability on anomalous electron heating conditions. In addition to these types, a new type of echoes was found in 1990 with the 50 MHz Doppler radar at Syowa Station (geographic lat. 69°00′S, long. 39°35′E) in Antarctica (TANAKA *et al.*, 1990). This type has a narrow spectral peak well below ion cyclotron frequencies in the E-region. In this paper, we call this type "new-type echoes".

The Syowa Station radar has two antenna beams: one beam (GMS beam) directs the magnetic south and the other (GGS beam) 32.8° west from the GMS beam. See a paper by IGARASHI *et al.* (1982) for the detailed description of the radar system. Each beam has a vertical beam width of about 30°, and an azimuthal beam width of about 4°. The range resolution is 15 km. The pulse repetition frequency is 333 Hz and therefore the maximum unaliasing Doppler frequency is ±166.5 Hz. One Doppler spectrum is calculated from a 128-point FFT, and then 20 spectra are averaged over 7.7 s. The frequency resolution of the spectrum is 2.6 Hz.

An example of new-type echoes obtained with the GMS beam is discernible in Fig. 1, in which each panel displays the echo power (left) and normalized Doppler spectrum (right) at each range. The type 2 echoes, which have broad spectral widths, are seen around 255–270 km ranges in each panel. The new-type echoes are clearly recognized at 225 km range as indicated by arrows. The peak frequencies (about 10 Hz) of these echoes are almost stable with time.

Statistical analyses have been performed by using data set at 240 km range on the GMS beam during the period from April 25 to October 10, 1984. In the analyses, the echoes having narrow spectral peaks located at frequencies less than ±20 Hz are regarded as new-type echoes. The diurnal variation in the occurrence rate of new-type echoes is shown by a solid curve in Fig. 2. The occurrence rate was calculated as follows: in each one hour bin, the number of days on which new-type echoes appeared is divided by the number of days on which the radar was operated. Magnetic local time

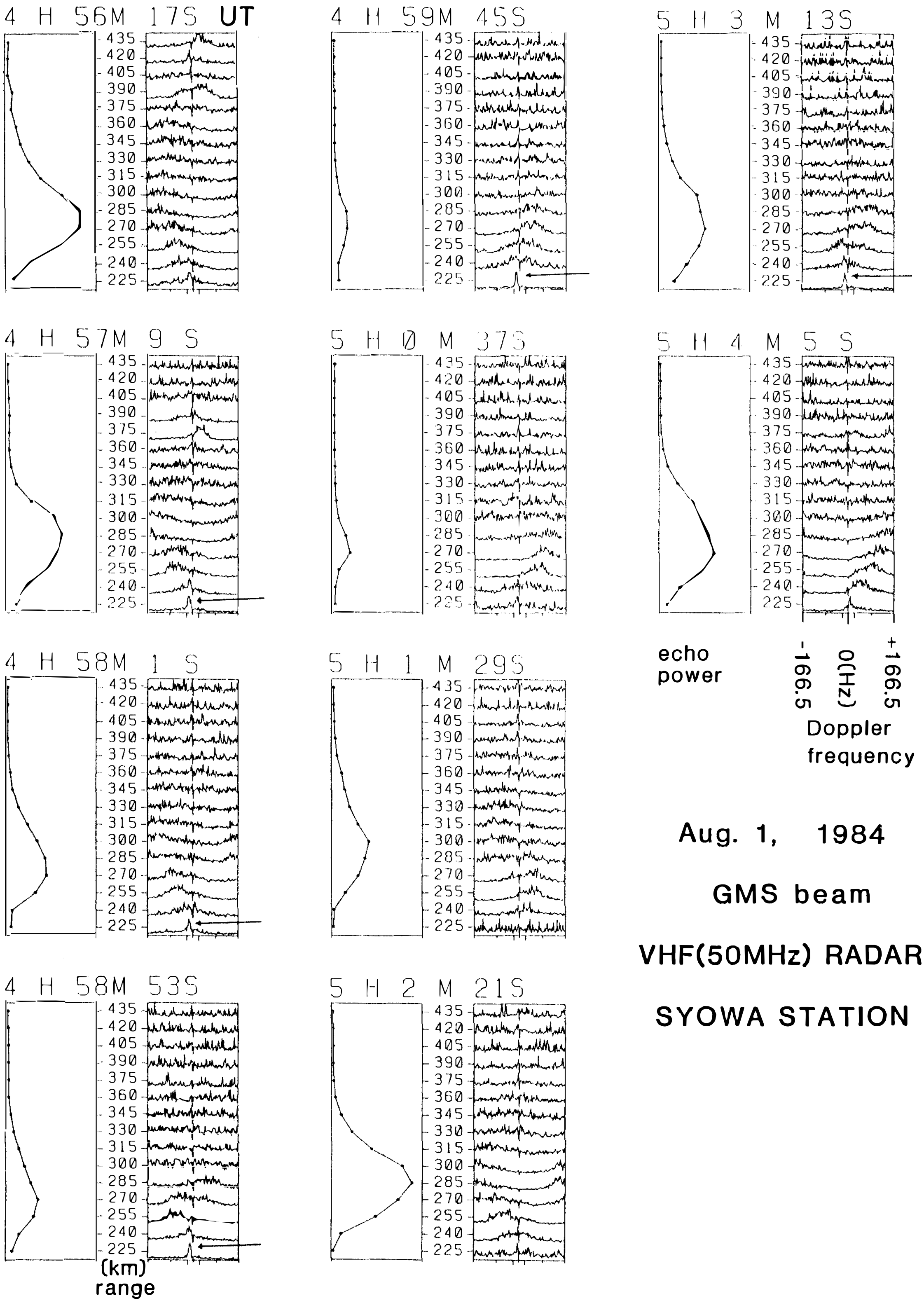

Fig. 1. Time profile of echo power (left) and normalized Doppler spectrum (right) along slant range on the GMS beam. The Doppler frequency of ±166.5 Hz corresponds to a velocity of ±500 m/s.

(MLT) at Syowa Station is almost the same as universal time (UT). The new-type echoes have an occurrence maximum in the morning (5–6 h). The occurrence rate of all radar echoes in 1984 was obtained by OHTAKA and TANAKA (1993) and is shown by a dotted curve in Fig. 2. The occurrence pattern of the new-type echoes is different from that of all the radar echoes. The durations of the new-type echoes range from a few tens

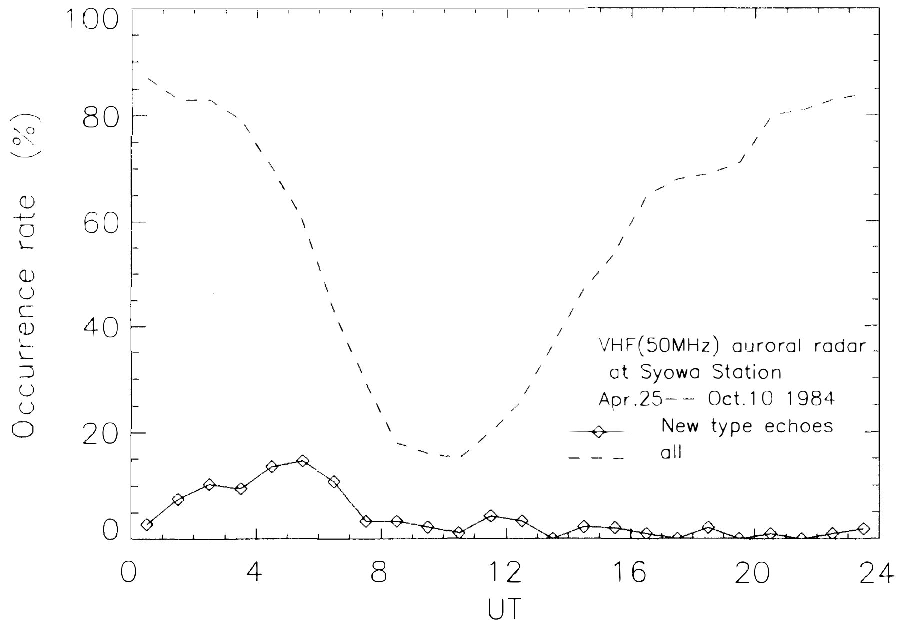

Fig. 2. Occurrence rates of new-type echoes (solid curve) and all radar echoes (broken curve) in 1984 (OHTAKA and TANAKA, 1993).

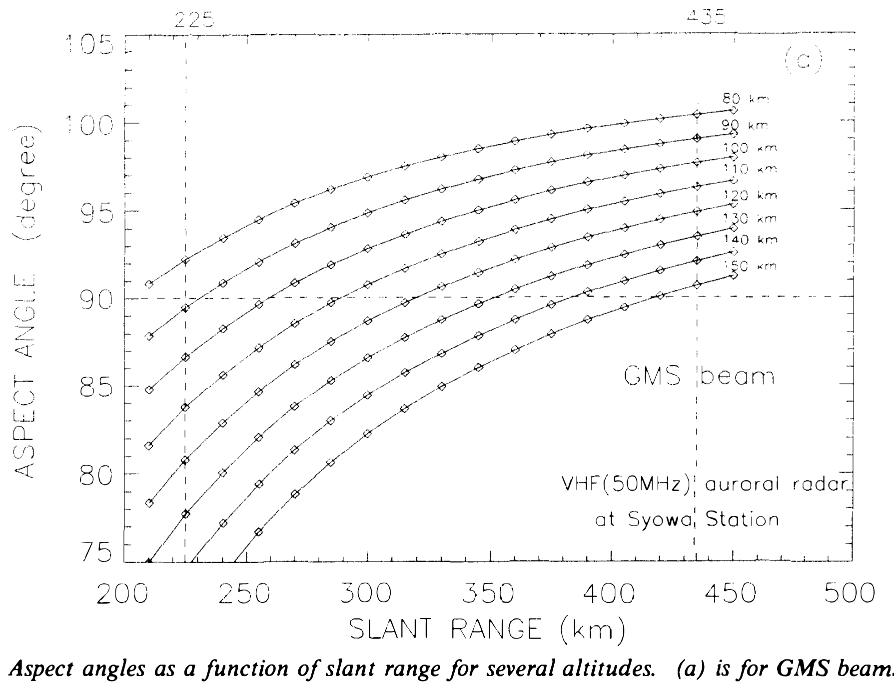

Fig. 3. Aspect angles as a function of slant range for several altitudes. (a) is for GMS beams, (b) is for GGS beams.

of seconds to a few tens of minutes. The spectral peaks of the new-type echoes appear on the negative frequency side for 56.1% cases, and on the positive frequency side for 22.4% cases, while on both sides for 21.5% cases.

Preliminary results obtained by a small data set show that there are some preferred ranges for the new-type echoes: 225 km to 240 km for the GMS beam, and 225–285 km for the GGS beam. It is noted that the ranges explored by the radar are limited between 225 km and 435 km, and therefore it is impossible to know whether or not the new-type echoes appeared at ranges less than 225 km.

The aspect angle, which is the cross angle between the radar beam and the geomagnetic field, is an important parameter for understanding the origin of the new echoes. Figures 3a and 3b show the relations between the aspect angle and range at several altitudes for the GMS and GGS beams, respectively. When the altitudes of the echo regions are assumed to be at 90–110 km, the 225–240 km ranges on the GMS beam correspond to the aspect angles from 84° to 91°, and the 225–285 km ranges on the GGS beam correspond to the aspect angles from 80° to 90°. Therefore, if some electrostatic waves existing between 90 and 110 km altitudes are responsible for the new-type echoes, these waves do not propagate perpendicularly to the geomagnetic field.

As another cause of the new-type echoes, we discuss a possibility of specular back-scatter reflection. If there exist ionization sheets having near-critical electron densities or appreciable density gradients over the radar wavelength, a strong specular reflection can occur (SOFKO *et al.*, 1985). If the sheets are field-aligned, specular reflections are expected at the ranges of 225–240 km at the altitudes from 90 to 95 km for the GMS beam (Fig. 3a), and at the ranges of 225–285 km at the altitudes from 75 to 90 km for the GGS beam (Fig. 3b). Such field-aligned sheets at lower altitudes may produce the specular reflections resulting in narrow spectral peaks near zero Hz. Unfortunately, our radar system cannot determine the echoing altitudes, so that a

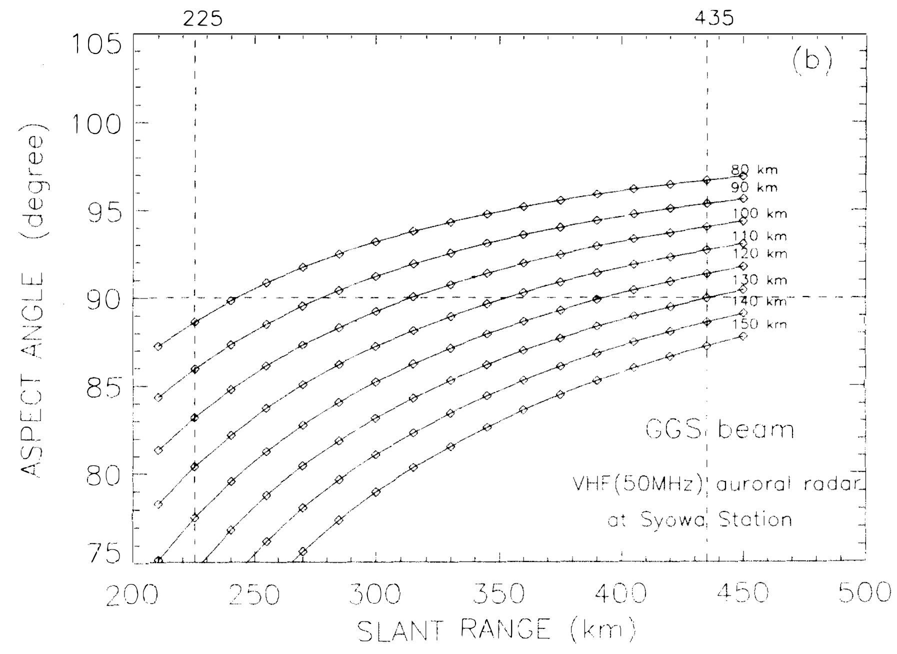

Fig. 3b.

hypothesis of the specular reflection cannot be tested. Then, we discuss a possibility of range aliasing. If some strong ionization sheets appeared horizontally, the sheets could result in forward reflection of the transmitter beam down to the ground, ground scattering back to the ionization sheet, and reflection from the sheet to the receiver (SOFKO *et al.*, 1985). However, in Antarctica, the ground is covered with ice and snow. The backscatter from ice or snow is much weaker than that from the ground. Meteor trails may be a candidate of the new-type echoes. In general, the meteor echoes have narrow spectral peaks at the Doppler frequencies near zero Hz (PRIKRYL *et al.*, 1986). However, the durations (less than one second) of usual meteor echoes are extremely less than those (a few tens of seconds to a few tens of minutes) of the new-type echoes. If over dence meteors, whose echoes have long durations, impinge on the upper atmosphere successively, some of the new-type echoes might be contaminated by such a kind of meteor echoes. However, it is difficult to explain the preferred ranges of new-type echoes with meteor echoes.

In conclusion, a new type of auroral echoes has been detected by the Syowa Station 50 MHz auroral Doppler radar. Preliminary statistical analyses indicate that these echoes (almost appearing at nearest radar ranges) have narrow spectral peaks located at the frequencies less than ± 20 Hz and frequently occur in the morning with the durations of a few tens of seconds to a few tens of minutes. The diurnal occurrence rate is very different from that of usual radar echoes. The new-type echoes do not seem to belong to the echo types (type 1–4) that have been found until now. At this stage, however, we do not know the mechanism(s) causing these new echoes. More analytical and theoretical work is indeed needed to understand the new-type echoes fully.

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