The generation mechanism of the double layer structure on the mid-latitude sporadic-E observed during the SEEK-2 campaign

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Since the first identification of the Quasi-Periodic Echo (QPE) phenomena observed by the VHF radar in the mid-latitude sporadic-E (Es) layer condition (Yamamoto et al., 1991), the generation mechanism of the QPE phenomena was proposed by Woodman et al., [1991] and Tsunoda et al., [1994]. These models require an altitude modulated Es layer due to the atmospheric gravity wave. To verify the generation models of the QP echoes, the SEEK campaign was carried out in 1996 including two sounding rocket experiments. The observation results show the stable Es layers at the altitude of about 100 km in the ascending and descending phases of the rockets. But it is verified that the Es layer plays a significant role to generate the QPE phenomena. After the SEEK campaign, the alternative models are proposed by several researchers (e.g. Ogawa et al., [2002]).

The SEEK-2 campaign was carried out on August 3, 2002, with two sounding rocket experiments of S310-31 and -32. The impedance probe was installed to measure the accurate plasma density of the Es ionosphere. To obtain the high accuracy of the measurement, a new type impedance probe instrument was developed. Two major improvements were taken into account with respect to the frequency synthesis as well as cancellation technique for any stray impedance of the capacitance bridge. As a new trial, a plasma wave receiver is also installed on the S310-32 rocket to detect a possible electromagnetic effect due to the formation of the Es and release of highly active chemical material (TMA) to make a lucent cloud for the wind measurement.

During the SEEK-2 campaign, as it was shown by the previous SEEK campaign, the stable Es phenomena are detected at the altitude of about 100 km in the ascending and descending phases of the two rockets. As the remarkable character of Es layer revealed by the present experiment, the Es shape had complex structure which showed the double Es layer at the altitude of 101-102 km and 103-104 km. In the four electron density profiles obtained by two rockets, double layer Es is detected in three profiles. The lower Es peak was detected stably, however, the higher peak was relatively unstable; that is, large density fluctuation was seen in the higher peak.

In general, Es layer is formed by the combination of neutral wind and geomagnetic field, as it was described by 'Wind Shear Theory (e.g. Whitehead [1960])'. When we compared the electron number density profile and measured neutral wind, it is shown that the wind shear can form the only one layer located at the lower altitude side (101-102km). To form the second layer (103-104km), it is necessary to consider another mechanism. When we take into account the effect of the measured electric field, it is shown that it is necessary to form the complex signature of the measured Es layer.

The difference between the upper and lower layers is also found in the results of plasma wave observation. Strong plasma wave is received during the passage of the Es layer. In particular, the strong waves of 18-20Hz are detected in the upper Es layer for the ascending and descending phase of the rocket.

On the other hand, simultaneous TEC observation shows significant modulation of TEC value during the rocket flight. Because the TEC modulation is well agree with the integrated value of measured electron number density profiles, it is inferred that the horizontal fluctuation in the Es layer affect on the TEC measurement is mainly due to the horizontal variation of the upper Es layer.