Generation mechanism of Es QP echoes as inferred from radar observations

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Based on results from MU radar and ionosonde observations of E region field-aligned irregularities (FAI) and sporadic E layers (Es) in the summer nights, we propose a new model for the generation of quasi-periodic (QP) radar echoes. In the model, polarized electric fields originated from localized regions within an Es play an important role to produce altitude-extended irregularity region and very complicated plasma motions associated with QP echoes. The model also predicts that strong radar echoes occur within and around the localized high density regions in Es.

In August 1999 and June 2000 we conducted nighttime MU radar observations of E region field-aligned irregularities (FAI) associated with sporadic E layers (Es). Simultaneous observations of the ionosphere using ionosondes at Shigaraki and Sabae (130 km north of Shigaraki) were made to know Es parameters. The results and implications from this multi-instrument study have been reported elsewhere and are as follows:

1. FAI occurrence and strength are strongly dependent on the difference between foEs and fbEs (i.e., foEs-fbEs) while they are poorly correlated with foEs. When Es is structured, fbEs represents the electron density of background Es while foEs does that of locally enhanced density region. Then foEs-fbEs can be a measure indicative of the strength of electron density gradients within Es. Our results indicate that FAI is enhanced with increasing foEs-fbEs, suggesting that the FAI generation is closely related to the localized density-gradients in Es.

2. Heights where quasi-periodic (QP) radar echoes are maximal correspond well to the Es heights determined from an FM-CW sounder (FCS) at Sabae. This suggests that the strongest irregularities coexist with Es, being a very reasonable result. However, a height variation (100-130 km) of the QP echoes is different from that of the Es height variation (100-110 km) observed by the FCS. This fact means that existing models for QP echo occurrence, which require a deep modulation of Es height comparable to QP echo height interval (30 km in our case), are not applicable to our case.

3. Spatial and temporal variations of Doppler velocities of radar echoes do not always have one-to-one correspondence to those of echo intensities.

In this paper we propose a new model to explain our results in which polarized electric fields originated from localized regions within an Es are mapped upward to some extent along the geomagnetic field to produce relatively weak irregularities above the Es through the combined action of these fields and in-situ density gradients.