DP2 TYPE ELECTRIC FIELD FLUCTUATIONS OBSERVED BY FM-CW HF RADAR NETWORK

КОЛЕБАНИЯ ЭЛЕКТРИЧЕСКОГО ПОЛЯ ТИПА DP2, НАБЛЮДАЕМЫЕ С ПОМОЩЬЮ СЕТИ ВЧ РАДАРОВ FM-CW

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Колебания DP2 наблюдались и были статистически проанализированы на основе данных радара на станциях PTK (Паратунка) и SAS (Сасагури) и магнитных данных с сети MAGDAS/CPMN. Соотношение амлитуд колебаний электрического поля DP2 на ночной стороне, наблюдаемой на станциях PTK и SAS, к колебаниям магнитного поля, наблюдаемых на дневной стороне экватора, составляет 0,107 мВ/м/нТ и 0,030 мВ/м/нТ, соответственно. Амплитуда колебаний электрического поля DP2 уменьшалась с уменьшением широты в ионосфере на ночной стороне. В наблюдаемых событиях соотношение амплитуды колебаний электрического поля на 26 градусах геомагнитной широты к амплитуде на 46 градусах было примерно 1/4. Используя данные нового радара MNL, такое же сопоставление будет расширено до экваториальной области.

DP2 type geomagnetic fluctuations are characterized by quasi-periodic variations with time scales of about 30 minutes to several hours, and appear coherently in high latitudes and the dayside dip equator [*Nishida*, 1968a]. Southward turnings of the interplanetary magnetic field are main cause of DP2 fluctuations [*Nishida*, 1968a, *Sibeck et al.*, 1998]. Therefore, DP2 type geomagnetic fluctuations are associated with field aligned currents between the magnetosphere and the polar ionosphere. Field aligned currents impose a dawn-to-dusk and/or a dusk-to-dawn electric fields on the polar ionosphere. These electric fields penetrate instantaneously to the middle, low, and equatorial ionosphere and cause east-west electric field fluctuations in both the dayside and the nightside ionosphere. It shows an energy transfer process from the magnetosphere to the low-latitude ionosphere through the polar region.

In order to observe ionospheric electric field variations even in the nighttime, the direct observation of the ionosphere by the HF radar is needed. The FM-CW (Frequency Modulated Continuous Wave) HF radar chain has been developed along the 210 magnetic meridian (Figure 1). Our first radar was installed at Sasaguri (Geomagnetic Latitude = 26), Japan in 2002. The second radar was installed at Paratunka (Geomagnetic Latitude = 46), Kamchatka, Russia in 2006. And the third radar

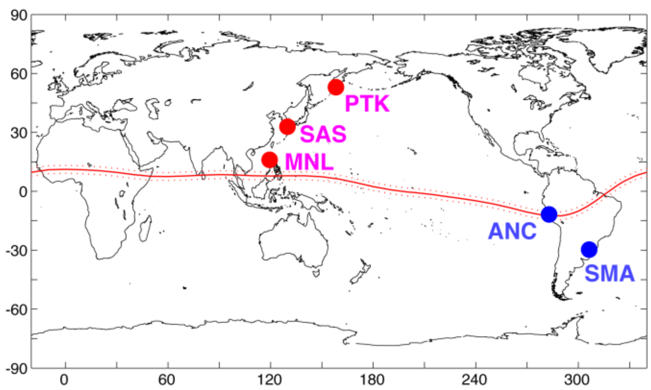

Figure 1. FM-CW HF radars are located at the mid-latitude station PTK, Russia, the low latitude station SAS, Japan, and the near equatorial station MNL, Philippine. Geomagnetic latitude are 46, 26, and 6 degrees, respectively.

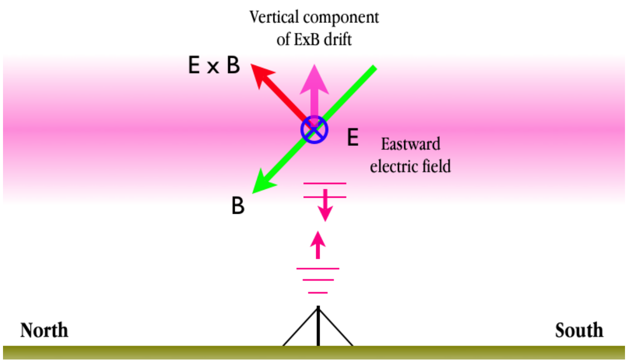

Figure 2. The FM-CW HF radar observes the vertical drift velocity of the reflecting layer in the ionosphere by using the Doppler shift of the received wave frequency. When the eastward electric field is imposed in the ionosphere, ionospheric plasma moves north upward by E x B drift. It causes upward motion of the ionosphere.

was installed at Manila (Geomagnetic Latitude = 6), Philippine in 2009. The MAGDAS FM-CW radar network covered widely from 6 to 46 degrees geomagnetic latitudes.

The FM-CW HF radar is a kind of the ionosonde. The radar transmits high frequency wave to the ionosphere and observes the Doppler shift of the received wave frequency which is reflected by the F region ionosphere (Figure 2). The magnitude of the Doppler shift of the received wave frequency corresponds to the vertical drift velocity of the reflecting layer in the ionosphere. The ionospheric plasma is moving by the E x B drift, where B is the local ambient magnetic field. The east-west electric field becomes a possible source of the vertical drift of the ionospheric plasma in the low latitude ionosphere. According to this feature of the low latitude ionosphere, the FM-CW HF radar can observe east-west electric field fluctuations.

Our FM-CW HF radar observes ionospheric fluctuations continuously. Observed data is processed automatically at the station. Processed data is sent in real time to the data server of Space Environment Research Center, Kyushu University through the internet. Detailed information of the radar network is shown on the SERC web page at the following address.

http://denji102.geo.kyushu-u.ac.jp/radar/radar.html

As the first example of observational results of FM-CW radar, DP2 events occurred on April 1, 2007 are shown in Figure 3. The FM-CW radar at Sasaguri station was not in operation during this period. Then the electric field data observed by the Paratunka radar is only shown in this figure. DP2 type magnetic fluctuations were observed clearly in the H component of magnetic data at the dip equator station Ancon (ANC), Peru in the dayside hemisphere during this period. The amplitude enhancement of DP2 fluctuations was also seen at ANC. The positive intensification of DP2 fluctuations at ANC implies that the eastward electric field is imposed into the dayside equatorial ionosphere. DP2 type fluctuations of the electric field in the F region ionosphere were observed by the FM-CW radar at PTK located in the nightside. Peak to peak amplitudes of electric field fluctuations were about 4 mV/m.

DP2 fluctuations of magnetic H component at dayside equator ANC and westward electric field at nightside mid latitudes PTK were well correlated. It seems that the dawn to dusk

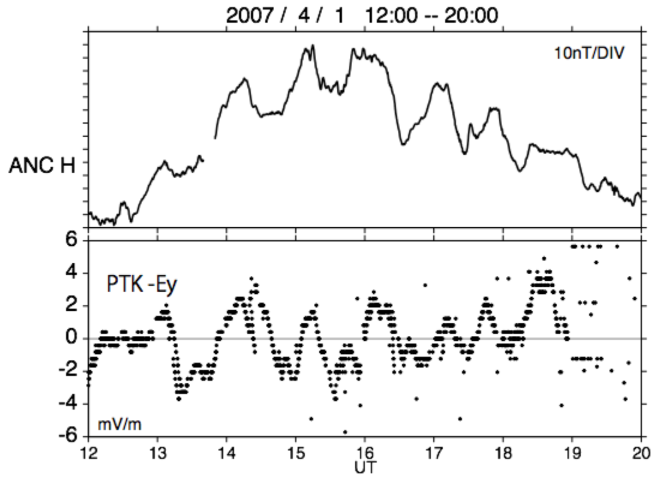

Figure 3. The magnetic H component at ANC, and the westward ionospheric electric field at PTK. DP2 type fluctuations were coherently seen.

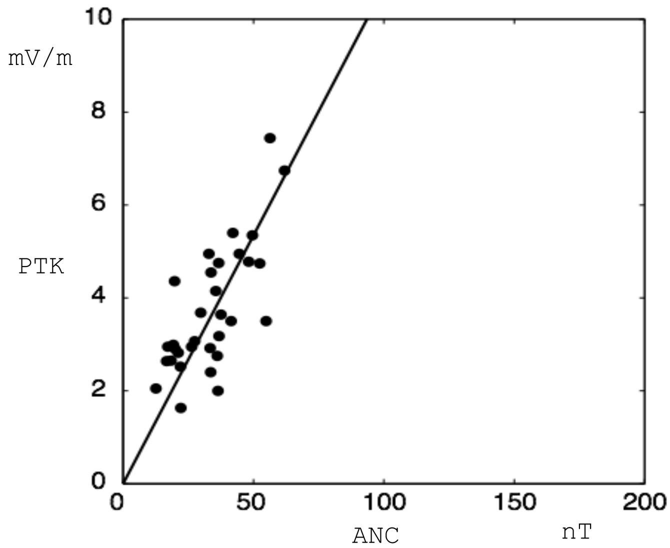

Figure 4. Scatter plot of DP2 amplitude at PTK in the nightside and those at ANC in the dayside.

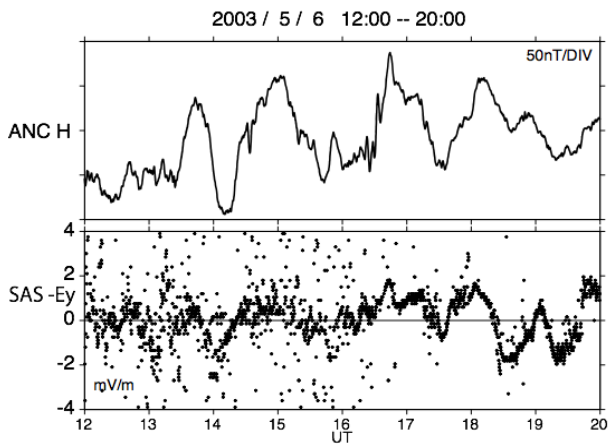

Figure 5. The magnetic H component at ANC, and the westward ionospheric electric field at SAS. DP2 type fluctuations were coherently seen.

electric field was imposed at both dayside equator and nightside mid latitudes.

Amplitude of magnetic fluctuations observed at ANC and electric field fluctuations observed at PTK were compared. For example, observed amplitudes of the DP2 fluctuation around 1400 in Figure 3 are 33nT at ANC, and 5.0 mV/m at PTK, respectively. Figure 4 shows the scatter plot of DP2 amplitudes of the ionospheric electric field at PTK in the nightside and those of magnetic field variation at ANC in the dayside. 32 DP2 events were observed both at ANC and PTK simultaneously, by using observed data from 2006 to 2008. Mean amplitude ratio of the electric field fluctuations at PTK is 0.107 mV/m to 1.0 nT of magnetic amplitude at ANC.

Similar DP2 type fluctuations of the westward electric field in the F region ionosphere and the magnetic field H component on the ground were observed at the low latitude station Sasaguri (SAS, geomagnetic latitude = 26 degrees) and at the equatorial station ANC, respectively, on May 6, 2003 (Figure 5). SAS and ANC were located in the nightside and the dayside, respectively, during this period. Peak to peak amplitudes of electric field fluctuations at SAS are about 2 mV/m in this event. As the previous event, DP2 fluctuations of the magnetic H component at dayside equator ANC and the westward electric field at nightside low latitudes were well correlated.

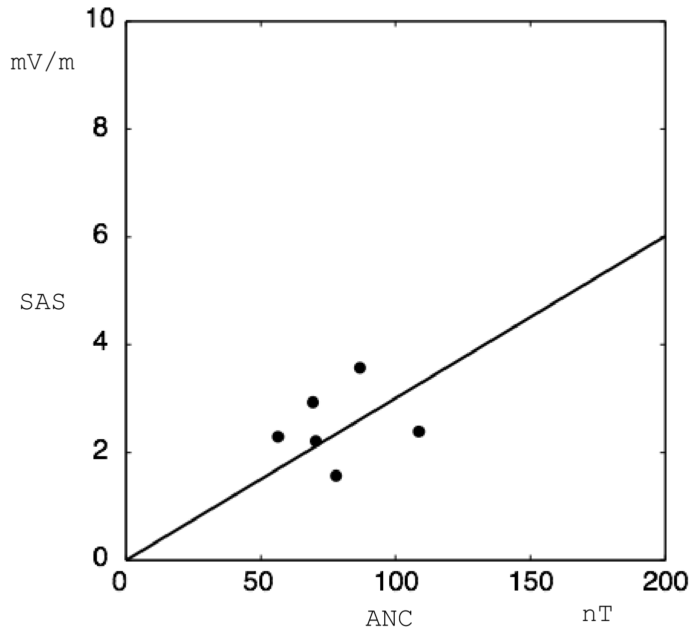

Figure 6. Scatter plot of DP2 amplitude at SAS in the nightside and those at ANC in the dayside.

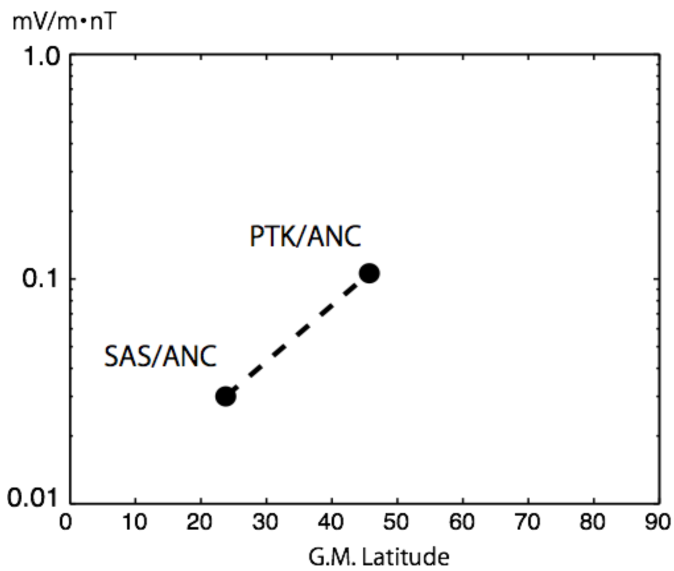

Figure 7. The amplitude ratio of DP2 fluctuations between PTK and ANC and that between SAS and ANC were shown as a function of geomagnetic latitude.

Amplitudes of magnetic fluctuations observed at ANC and electric field fluctuations observed at SAS were compared. For example, observed amplitudes of DP2 fluctuations around 1800 in Figure 5 are 69 nT at ANC, and 2.9 mV/m at SAS, respectively. Figure 6 shows the scatter plot of DP2 amplitudes at SAS in the nightside and those at ANC in the dayside. 6 DP2 events were observed both at ANC and SAS simultaneously, by using observed data from 2003 to 2005 and 2007 to 2008. Due to smaller amplitude of electric field fluctuations at SAS, the number of detectable DP2 events in this station pair became small. It is not enough to discuss statistically the amplitude ratio between SAS and ANC. However, mean amplitude ratio of the electric field fluctuations at SAS is estimated from these data about 0.030 mV/m to 1.0 nT of magnetic amplitude at ANC. It seems that the amplitude of electric field fluctuations at SAS is smaller than those at PTK.

DP2 fluctuations were observed and were statistically analyzed by using the FM-CW radar data at PTK and SAS stations and the magnetic data observed ANC by the MAGDAS/CPMN network. The amplitude ratio of DP2 type electric field fluctuations in the nightside observed by the FM-CW radar at PTK and SAS to magnetic field fluctuations observed at the dayside equator ANC are 0.107 mV/m nT and 0.030 mV/m nT, respectively. The amplitude of DP 2 electric field fluctuations decreased with decreasing latitude in the nightside ionosphere. From these observed events, amplitude ratio of electric field fluctuations in the ionosphere at 26 degrees geomagnetic latitude to those at 46 degrees was estimated about 0.28. This ratio means the attenuation of the electric field from 46° to 24° geomagnetic latitude in the nightside.

Kikuchi et al. [1978] estimated the geometrical attenuation of penetration electric field from polar region to the equator with decreasing latitude. Our observational result of attenuation of DP2 electric field amplitude in the nightside is comparable to their result.

In May, 2009, the third FM-CW radar was installed at near equatorial station at Manila, Philippine. By using this new radar data, similar comparison of amplitude attenuation will be extended to the equatorial region.

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OBSERVATIONS OF THE IONOSPHERIC DISTURBANCES AND GEOMAGNETIC PULSATIONS IN THE FAR-EASTERN RUSSIA AND JAPAN
НАБЛЮДЕНИЯ ИОНОСФЕРНЫХ ВОЗМУЩЕНИЙ И ГЕОМАГНИТНЫХ ПУЛЬСАЦИЙ НА ДАЛЬНЕМ ВОСТОКЕ РОССИИ И ЯПОНИИ

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Мы проводили стандартные измерения среды геокосмоса на широтах Дальнего Востока России и Японии с 2007 года используя панорамные камеры свечения атмосферы и индукционных магнитометров в сотрудничестве с Институтом Космофизических Исследований и Распространения Радиоволн, Дальневосточное Отделение Российской Академии Наук. С помощью наблюдений с получением изображений свечения атмосферы на 630 нм, в ночное время часто регистрируются средне масштабные перемещающиеся ионосферные возмущения (MSTIDs). MSTIDs в основном распространяются в южном направлении над Японией, в то время как над Дальнем Востоком России некоторые MSTIDs распространяются в северном направлении, указывая на то, что направление распространения имеет широтную разницу. Индукционные магнитометры измеряют геомагнитные пульсации Pc1, которые распространяются он высоких широт к низким, меняя параметры поляризации. В этом представлении мы даем обзор этих недавних результатов, полученных от наблюдений на Дальнем Востоке России и в Японии..

1. Introduction

In order to measure ionospheric/atmospheric disturbances and geomagnetic pulsations in the longitudes of Far-East Asia, we have newly installed two all-sky airglow imagers and two induction magnetometers at Stecolny near Magadan (MGD, 60.05N, 150.73E, November 4, 2008-) and Paratunka (PTK, 52.97N, 158.25E, August 17, 2007-). The stations are shown in Figure 1. The circles indicate the field-of-view of the airglow imagers (r=500 km). The induction magnetometers were installed at MGD, PTK, Moshiri (MSR, 44.37N, 142.27E, July 14, 2007-), and Sata (STA, 31.02N, 130.68E, September 5, 2007-). MGD and PTK are in the field-of-view of the SuperDARN Hokkaido radar which is located at Rikubetsu (RIK, 43.5N, 143.8E).

From these observations, several new results were obtained. In this presentation, we show some results regarding the medium-scale traveling ionospheric disturbances (MSTIDs) and Pc1 geomagnetic pulsations.