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ПУЛЬСАЦИИ ГЕОМАГНИТНОГО ПОЛЯ И АВРОРАЛЬНОГО СВЕЧЕНИЯ В ДИАПАЗОНЕ 1–4 мГц В ПОЛЯРНОЙ ШАПКЕ И ВБЛИЗИ ПОЛЯРНОЙ ГРАНИЦЫ АВРОРАЛЬНОГО ОВАЛА. «БЕСТРИГГЕРНЫЕ» СУББУРИ И ПРЕДВЕСТНИКИ СУББУРЬ

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1–4 mHz GEOMAGNETIC AND AURORAL LUMINOSITY PULSATIONS IN THE POLAR CAP AND NEAR THE POLAR BOUNDARY OF THE AURORAL OVAL. ‘’NON-TRIGGER’’ SUBSTORMS AND SUBSTORM PRECURSORS

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Изучены параметры геомагнитных пульсаций и пульсаций авроральной светимости в частотном диапазоне 1–4 мГц (Pc5/Pi3) в периоды низкой возмущенности, предшествующие изолированным суббурям, и в магнитоспокойные дни. Сопоставлены спектральные параметры пульсаций авроральной светимости и геомагнитного поля в полярной шапке и на полярной границе аврорального овала. Для сравнительного анализа данных сети магнитометров IMAGE и меридионального сканирующего фотометра (о. Шпицберген) был использован кросс-спектральный анализ, а для выделения специфических вариаций, связанных с подготовкой суббури («предвестника суббури») – метод наложенных эпох (SPE, SuperPosed Epoch).

We study parameters of the polar auroral and geomagnetic pulsations in the frequency range 1–4 mHz (Pc5/Pi3) during quiet geomagnetic intervals preceding isolated auroral substorms and non-substorm background variations. The spectral parameters of pulsations of auroral luminosity in the polar cap and near the polar boundary of the auroral oval are studied and compared with those for the geomagnetic pulsations in the same frequency range. Cross-spectral analysis is used to analyze the time series of the geomagnetic data from IMAGE magnetometer network, and the data on auroral luminosity measured by Meridian Scanning photometer (Svalbard) and superposed epoch (SPE) analysis is applied to reveal pre-substorm variations (substorm precursors).

1. Introduction

The intense energy transfer of the solar wind with the Earth’s magnetosphere under southward B_z leads to the development of a geomagnetic substorm. A typical substorm follows IMF turning.

However, several reports on occurrence of substorms under moderate IMF and the solar wind parameters without any clear triggers have been published [Liu, 2010]. A method of quantitative analysis of geomagnetic noises [Yagova, 2010, Yagova, 2015] applied to high latitude geomagnetic pulsations in 1–4 mHz (Pc5/Pi3) frequency range has shown that their spectral content is controlled mostly by the inner parameters of particle precipitation.

In the present study we concentrate on the inner processes in the magnetosphere/ionosphere system and study magnetically quiet intervals preceding substorms occurring at almost undisturbed background without an evident external trigger (“non-trigger” substorms). Under undisturbed foreshock conditions a substorm can develop from inner instabilities in the magnetosphere [Liu, 2010], and thus the analysis of spectral parameters of the ULF geomagnetic and auroral luminosity pulsations/noises may demonstrate a systematic difference between a magnetically quiet interval followed and not followed by a substorm.

2. Observations and data processing

MSP – Meridian-Scanning Photometer – is applicable for learning dayside aurora motion and position of the cusp. Time resolution: 16 seconds to assemble meridian scan. Spatial resolution: 1 angular degree Spectral resolution: Typically 0.4 nm Time resolution for a given point – 80 s. IMAGE is a European magnetometer network equipped with 3-component flux-gate magnetometers. It is located approximately along the Magnetic Meridian 100 and covers magnetic latitudes from 78 to 40. The LYR station is located at the same observatory with the MSP photometer and MSP data are also available for the two stations of the network (NAL and HOP) under corresponding scanning angle. Photometer data is digitized for the two channels (557.7 and 630.0 nm) for the scanning angle corresponding to the northernmost stations of the IMAGE network NAL. The scheme of data processing in the present study is as follows:

– the MSP data are digitized for the position corresponding to the NAL MM100 stations;

– cross spectra for the time series of the two geomagnetic horizontal components and two MSP channels at NAL are calculated;

– substorms at MM100 occurred during intervals with the solar wind and interplanetary magnetic field (IMP) parameters typical for geomagnetically quiet days (“non-trigger”substorms) are selected.

– variations of spectral parameters of the geomagnetic and auroral luminosity pulsations during intervals preceding “non-trigger” substorms are compared with those during background quiet days.

3. Results

3.1 An example of a substorm with no external trigger (''non-trigger” substorm'). Day 2011 351

A substorm may occur without any evident external trigger under the interplanetary parameters typical for undisturbed days. Solar wind and IMF parameters for a day with a “non-trigger” substorm together with the same

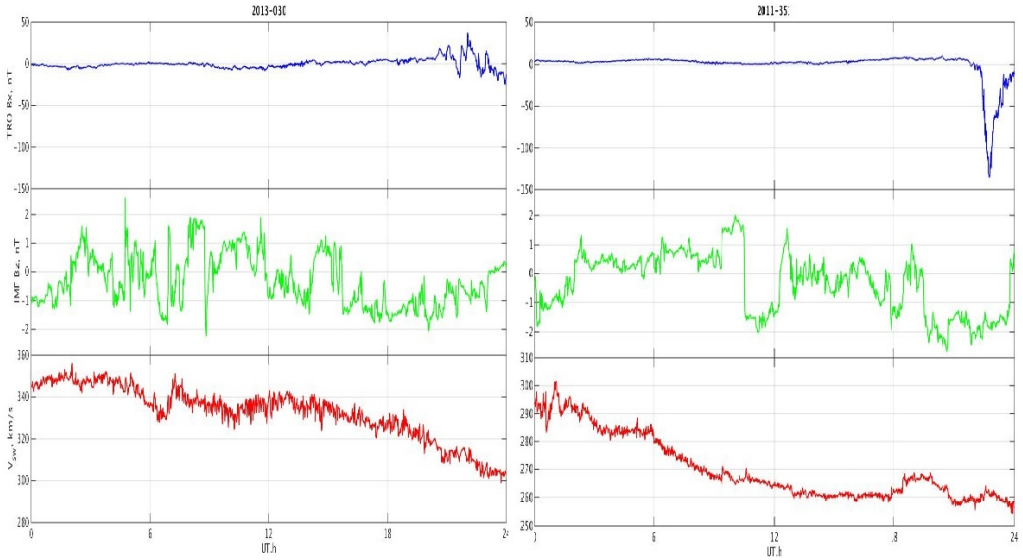

Fig. 1. Magnetometer data (B_x components) from the auroral station Tromso (top), the B_z component of the interplanetary Magnetic Field, (middle) and the Solar Wind velocity (bottom) measured by the ACE-satellite for a non-disturbed day (left) and an isolated substorm (right).

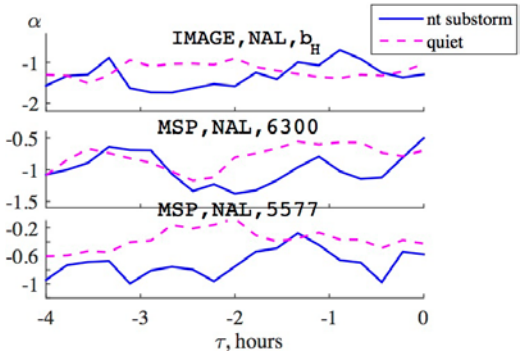

Fig. 2. SPE results for the spectral slope of geomagnetic H-component and two channels of auroral luminosity pulsations in the 1–4 mHz frequency range at NAL. The pre-substorm variations are shown with magenta dashed lines, and the background variations are shown with blue lines.

set of parameters for an undisturbed day are shown in fig. 1. The variations of both B_Z and V_X are similar for both days. However, a moderate (ΔB~150 nT at TRO) substorm takes place on day 2011351 at MM100, and no substorm occurs on day 2013030.

3.2. SPE results for pre-substorm and non-substorm intervals.

Superposed Epoch (SPE) analysis of spectral parameters of the geomagnetic and auroral luminosity pulsations is carried out for the intervals preceding "non-trigger" substorms and background undisturbed days. The results for the spectral slope are shown in fig. 2 for the H-component of the geomagnetic field and the two MSP channels at NAL. Pre-substorm and background variations of the spectral slope are given in the Figure from top to bottom for the magnetic field H-component, MSP 6300A and 5577A channels. The spectral slope $-\alpha$ grows at about 0.5 at 3–2 hours before a substorm in comparison with the background both for the geomagnetic and auroral luminosity pulsations for the 5577A MSP channel. The difference between substorm and background variations for the 6300A MSP channel is maximal at about 1.5–2 hours before the onset.

4. Discussion and conclusion

Even for rare non-trigger substorms specific presubstorm variations ("substorm precursors") occur during last pre-substorm hours. They are characterized by the growth of the absolute value of the spectral slope in 1–4 mHz frequency range in comparison with undisturbed days. This effect is seen in the H-component magnetic and 5577A luminosity pulsations.

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