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Different origin of magnetic disturbances evaluated by AL index in course of the growth and expansion substorm phases

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According to spacecraft measurements, several field-aligned current (FAC) systems act independently in the magnetosphere. The main is R1 FAC system, uninterruptedly operating on the pole-ward boundary of auroral oval, irrespective of IMF orientation and season of year [1]. Intensity of the R1 system is determined by coupling function $E_{KL} = V_X(B_Y^2+B_Z^2)^{1/2}\sin^2\Theta/2$, which presents the optimal combination of all geoeffective solar wind parameters permanently affecting the magnetosphere. The R1 system, acting within the closed magnetosphere, generates in polar cap the DP0/DP2 magnetic disturbances, whose intensity depends on solar wind velocity (DP0) and southward B_{ZS} IMF component (DP2). Basing on the always available DP2 disturbances the polar cap magnetic activity (*PC*) index has been put into operation [2]. The *PC* index follows the E_{KL} field variations and well correlates with development of magnetic storms and substorms [3]. Taking into account these specific features of *PC* index, it was endorsed by the International Association of Geomagnetism and Aeronomy (IAGA) as a proxy of the solar wind energy input into magnetosphere (IAGA Resolutions, 2013). The substorm growth phase is related to R2 FAC system, which is formed on the equator side of auroral zone under conditions enhanced auroral precipitation. As a result, the DP12 disturbances, with westward and eastward auroral electrojets in the morning and evening sectors of auroral zone, are developed in course of the substorm initial phase. The substorm expansion phase is related to formation of “substorm current wedge” (SCW) FAC system generating the powerful westward electrojet in the midnight auroral zone and corresponding DP11 disturbances. The SCW FAC system is a specific system, which ensures closure of the magnetotail plasma sheet currents through the auroral ionosphere [4].

Research carried out in AARI on the base of the 1-min *AL* and *PC* indices data for 1998-2017 demonstrates the principally distinctive character of the substorm development in course of the growth and explosive phases. The DP12 disturbances, generated by R2 FAC system operating within the closed magnetosphere, are developed in strong relation to the PC index [5]. As this takes place, the DP11 disturbances demonstrate quite another relationship between the 1-min *PC* and *AL* values: the sudden leaps of the *AL* value (*ALpeaks*) might occur, time and again, at any value of *PC* index and with quite different delay times relative to moment of substorm sudden onset. It means that processes in the tail plasma sheet, leading to formation of “substorm current wedge” are determined, first of all, by state of the magnetotail plasma sheet itself. The solar wind influence (evaluated by *PC* index) affects but does not control processes in the magnetotail, unlike to processes in the inner magnetosphere. In spite of different nature of the DP12 disturbances, related to R2FAC system, and DP11 disturbances, related to SCW FAC system, the disturbance progressing in course of a substorm is estimated by a single *AL* index. To allow for effects of solar wind influence and magnetotail processes on dynamics and intensity of substorms it is necessary to put into practice two different indices, evaluated correspondingly by data of magnetic observations in the morning and midnight sectors of auroral zone.

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