サブストームオンセット前に見られるオーロラアークの不安定化

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Destabilization of initial brightening arcs before substorm onset

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The nature of the mechanism that initiates the explosive onset of aurora breakup is still one of the outstanding questions under debate. Recently, attention has been drawn to the temporal evolution of the initial brightening arc during a few minutes before the onset, because it could illustrate the process that triggers the auroral breakup. Several ground-based optical observations have shown that, in a few minutes before the onset, the initial brightening arc becomes unstable and forms an azimuthally arrayed structure. As time progresses, this feature evolves into larger scale undulation, and eventually leads to the poleward expansion of aurora (i.e., auroral breakup). Past studies suggested that the formation of such structure may be due to plasma instabilities in the magnetosphere (e.g., ballooning/interchange instability) or ionospheric feedback instability in the M-I coupling region. Thus far, however, no definitive conclusion has been reached. In order to better understand what process destabilize the initial brightening arcs immediately before the onset, it is highly desirable to combine observations with numerical simulations in the framework of M-I coupling system.

In most cases, the temporal evolution of the initial brightening arc is, as it is, too much complicated to be directly compared with numerical simulations. In this sense, some systematic and coordinated efforts are needed to establish a close collaboration between observations and simulations. As a first step, we have been estimating the following three characteristic parameters describing the temporal evolution of the initial brightening arcs by using high-time resolution all-sky camera observations of substorm in Tromsoe in Norway, Tjornes in Iceland and Syowa Station in Antarctica: (1) speed of the equatorward motion of the growth phase arcs and its relationship with the background plasma convection, (2) time constant of the temporal evolution of the initial brightening arc luminosity, (3) azimuthal and meridional wave numbers of the wave-like structures within the initial brightening arcs and the time constant of their temporal evolution. All the derived parameters will be discussed in comparison with recent numerical simulations of the development of auroral arcs. It will also be discussed how the estimated relationship between the speed of the growth phase arc and the background convection could be utilized for determining the initial setup of the numerical simulations of ionospheric feedback instability.