North-south asymmetry of Saturn's auroral radio emissions: The seasonal variation of their fluxes in half Kronian year

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The observations by Cassini from 2004 to 2017 is revealing its strange seasonal variation seen in the magnetic field and upper atmosphere. It was first found in the radio emissions, Saturn Kilometric Radiation (SKR), from the northern and southern polar regions in 3-1200 kHz. SKR is generated by field-aligned energetic electrons on the magnetic field lines connecting to the auroral region. For the Saturn’s magnetic field direction, the right-handed circularly polarized (RH) emissions are from the northern region and the left-handed (LH) ones from the southern one. Therefore, we can separately evaluate the SKR variation from Northern and Southern polar regions.
Saturn's rotation period has been evaluated by the modulation period of SKR, because the SKR source is fixed in the planetary magnetic field with highly anisotropic beaming and forms a corotating searchlight of radio emission. Cassini observations in the southern summer (2004-2009) showed that the period of SKR daily variation is variable. It was slightly longer in the southern (summer) hemisphere, but close to each other near the equinox (September 2009).
We also studied the flux variation between northern and southern SKR in 2004-2010, and showed that the LH (summer, south) is stronger than the RH (winter, north) in average [Kimura et al., 2013]. Those characteristics could be related to the north-south asymmetry in the polar ionospheric conductivities, which are related to the seasonal variations of the solar EUV flux illuminating to the polar region. However, its comprehensive explanation has not yet been established. After the equinox in 2010-2013, the northern early summer does not show the clear separation of northern and southern SKR periods [Provan et al., 2014; Fischer et al., 2015]. At last, from the fall of 2014, both SKR periods becomes to be separated [Provan et al., 2016].
In this study, we extend our SKR flux variation study to cover the half Kronian year, from southern summer (2004) to northern summer (2015 DOY264). In this case, the simple extension of the analysis method used in our previous study was not adequate because of the bias in the Cassini orbit. Since the SKR is stronger in the dawn side, we only used the data for 2004-2010 when Cassini was at the dawn side (2-10h LT). However, because of Cassini’s apokrone after 2007 was gradually shifted from dawn to dusk, the same criteria prevents from collecting enough dataset for the analysis after that. For this study to cover 2004-2016, we relaxed this condition and used the data in all local time. In order to avoid the dawn-dusk assymmetry effect, we we selected the data when Cassini was in the latitude within +-5deg. In this condition, both northern and southern SKR are observed simultaneously and the flux ratio between them can be used to evaluate the seasonal effect. We also limit the data with the distance from Saturn in 10-100 Rs, in order to avoid the visibility effect of SKR caused by its propagation. From those data, the SKR flux was evaluated by a running median with a window of +-35 days, enough longer than the daily modulation of SKR (about 11h) and the solar variation by its rotation (about 27 days). In this result, the intensity of LH component in 2004-2009 (south, summer) was ~+10 dB stronger than RH (north, winter), which is consistent with the result in Kimura et al. (2013). In 2010-2012, the both SKR intensities got close to each other. After 2013, RH (north, summer) was slightly stronger by a few dB than LH (south, winter). The flux ratio between Northern and Southern SKR after 2010 seems to be linked with those of

the Northern and Southern SKR periods. The flux ratio was more than 10 in southern summer but only 2.5~5 in northern summer, in the analyzed term, even in 2014-2015. On the other hand, in order to check the LT dependence effect, we divided the data with 4 LT sectors (3-9h, 9-15h, 15-21h, 21-3h). We could confirm that the flux ratio changed from 10 to 0.2 in the 3-9h and 9-15h sector and became below or above 1 in 15-21h and 21-3h sector. It shows that the seasonal variation is more effective in the dawn side.
In this paper, we will also investigate the correlations of the SKR flux variations to the solar wind and solar EUV flux, as the extension of the results in 2004-2010 [Kimura et al., 2013].

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