Substorm occurrence rate for over two decades covering Solar Cycles 22 and 23

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We studied long-term variations of substorm occurrence rate during 26 years (1983-2008) which cover the entire Solar Cycles 22 and 23. Substorm occurrence rate is evaluated by number of Pi2 pulsations observed at the Kakioka observatory (27.4 degrees geomagnetic latitude, 208.8 degrees geomagnetic longitude) at 2100-0100 magnetic local time. Pi2 pulsations with a peak-to-peak amplitude larger than 0.6 nT were selected from the 1-second geomagnetic field data by an automated detection program. We found that the daily number of substorms (i.e., Pi2 pulsations) shows long-term variations with minima around 1990 and 2002 as well as maxima around 1986, 1994, and 2004. There seems no clear correlation or a weakly negative correlation between the substorm occurrence rate and the solar activity measured by the F10.7 radio flux. Considering that the substorm occurrence rate may be controlled by an amount of energy supplied from the solar wind to the magnetosphere, we normalized the substorm occurrence rate by the energy coupling function proposed by Kan and Lee [1979, GRL, 577-580]. The normalized daily number of substorms (Pi2 pulsations) is also changing in long-term, and has peaks around 1986, 1996, and 2008, as well as troughs around 1990 and 2000-2002. We found a negative correlation (r˜-0.6) between the normalized substorm occurrence rate and the F10.7 index. This may indicate that the substorm triggering is suppressed during the solar maximum, because the plasma sheet becomes rich of heavy ions as confirmed by the Geotail/EPIC observations.

We also found a long-term variation of periods of Pi2 pulsations. The Pi2 periods is both negatively correlated with the Kp index and positively correlated with the plasma ion mass of the plasma sheet. This result strongly suggests that Pi2 pulsations are not caused by the BBF driven process, but by the cavity mode resonance.