Dual structure of auroral acceleration regions at substorm onsets as derived from AKR spectra

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Two sources of the auroral kilometric radiation (AKR) and their development prior to and during substorms were derived from high-time-resolution spectrograms provided by Polar/PWI ac electric field observations and were investigated in connection with the auroral acceleration process. One source is a low-altitude source region corresponding to middle-frequency AKR (MF-AKR), and the other is a high-altitude source region corresponding to low-frequency AKR (LF-AKR). The former appears during the substorm growth phase in the altitude range of 4000-5000 km and is active both before and after substorm onset. A few minutes before the onset, the intensity of this source gradually increases, showing precursor-like behavior. It does not change drastically at the onset and is mostly insensitive to it. At Pi 2 onset, in contrast, high-altitude AKR appears abruptly with intense power in a higher and wider altitude range of 6000 to 12,000 km. The increase in its power is explosive (increasing 1000 times within 20 seconds), suggesting the abrupt growth of the parallel electric fields that cause bursty auroral electron beams. The statistically derived probability of both sources existing at substorm onset is about 70%, indicating that this duality of AKR sources is a common feature of substorms. The high-altitude source and related transient acceleration at substorm onset is apparently due to 1) intrinsically local instabilities such as current-driven instabilities, or 2) transient Alfven waves with a shorter wavelength. The low-altitude source, which is fairly stable and insensitive to substorm onset, may belong to the global quasi-static potential distribution over the auroral oval, which involves a large-scale inverted-V structure and a quasi-steady field-aligned current.