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Energetic radiation associated with thunderstorm activity

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Intense gamma rays likely associated with lightning and/or thunderstorm activities have been detected in recent years, at various altitudes ranging from the ground level to the ionosphere. However, neither the source of this radiation nor its nature has been clarified. We report gamma rays lasting for several minutes attributed to both winter and summer thunderstorms in Japan. Our findings in winter thunderstorm indicate that the gamma rays were emitted continuously from a downward hemispherical surface, the bottom of which was about 300 m above sea level, and this source of gamma rays moved from north to south above the observation site at a speed of about 7 m/s. The radiation source probably moved along with the charged region of the cloud at a height of around 1 km, because the estimated migration of the radiation source was consistent with the observed movement of atmospheric electric field variation between ground-based observation sites and with the wind speed and direction at about 1 km altitude. This movement implies that the intense electric field produced by the charged region in the thundercloud generated a radiation source beneath the charged region. On the other hand, gradual energetic radiations probably caused by a summer thunderstorm have been observed at the top of Mt. Fuji, Japan. The largest of such variation was gradual and lasted for about 20 minutes, and was found to be high-energy gamma rays having a continuous energy spectrum up to 10 MeV or more. Both the observations help explain probably the lightning initiation urged by the radiation.