Observation of terrestrial gamma rays associated with thunderclouds in winter

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1. Introduction

We show the relation between the instantaneous rise of terrestrial gamma ray and the movement of thundercloud, observed at Noto peninsula in winter. We estimate the emission time and the reaching area to the ground of bremsstrahlung from thundercloud.

2. Measurement

(1) radiation

(a) NaI(Tl) scintillation detector

Dose rate: 50keV-3MeV, Pulse height analysis: 50keV-6.5MeV(1024 channel), and Total counts above 6.5MeV

(b) Ion chamber detector

Dose rate: 50keV-

(2) Meteorology

Wind vane and anemometer, Thermometer, Hygrometer, Precipitation detector, Rain gauge, Pyrheliometer, Balansometer and Thunder detector

(3) Others

Lightning discharge point: LLS by Hokuriku Electric Company, Wind direction and wind velocity at 100 m above sea level: SPEEDI by Nuclear Safety Technology Center

3. Results

We show two representative cases of 17 cases of instantaneous rise of terrestrial gamma ray caused by thundercloud activity.

(1) Case 1 (25-JAN-2004)

Both NaI(Tl) detector and IC detector detected the instantaneous rise of dose rate simultaneously two times at same observation point prior to lightning discharge. From the pulse height analysis, we found that the scattering rays extending for more than 6.5MeV have contributed to the instantaneous rise of dose rate. From the wind direction and wind velocity data obtained by the SPEEDI, we considered that the thundercloud has approached, passed and re-approached to the observation point and dose rate has risen instantaneously when the thundercloud has approached to the observation point. From the LLS, we found that the thundercloud has dissipated by the cloud-cloud discharge after the second instantaneous rise.

(2) Case 2 (15-DEC-2005)

The instantaneous rise of dose rate was detected at the point A, and after two minutes, the instantaneous rises detected simultaneously at two points, where one is the point B located in about 4 km of the northeastern east from the point A, and the other is the point C located in about 5 km of the southeastern east from the point A. The simultaneous detections occurred two times among 4 minutes. From the SPEEDI and the LLS, we considered that the thundercloud has moved in the meandering westward wind with bremsstrahlung, and has dissipated by the cloud-cloud discharge. From the position relation between the point B and the point C and the quantity of dose rate rising, we estimated that the thundercloud has passed the vicinity in 0.5km of the southern southeast from the point B and in 1.9km of the northern northwest from the point C, by the southwestward wind.

The meteorological circumstance in this case was that cold air current synoptically overspreads in the skies over the Sea of Japan. From the data of wind direction and wind velocity at about 10m above ground level, we found that spiral air current has occurred on the ground flowing southward wind. From these conditions, we considered that strong ascent air current has occurred and its current has created the strong thundercloud.

4. Conclusions

We consider that the instantaneous rises of terrestrial gamma ray in winter are due to bremsstrahlung from the thundercloud. We estimated that emission time of bremsstrahlung is 2-10 minutes, and the reaching area to the ground is the area with 2km radius under the thundercloud. Our estimated the emission time and the projection area of bremsstrahlung correspond to the observed lifetime and area of the pocket positive charge in thundercloud on the Japan Sea Coast in winter. In the cases of the remarkable rise of terrestrial gamma ray, strong ascent air current occurred by spiral polar low on the ground, and its current created the strong thundercloud with high electric potential.