The Meteorological Effects of Cosmic Ray Intensity at Sea Level Observed at Multiple EAS Arrays in LAAS Experiments

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Abstract

The cosmic ray (CR) intensity variations are observed by using independent sets of compact extensive air shower (EAS) arrays. The Large Area Air Shower (LAAS) group deploys 9 EAS arrays in hundreds of km baseline scattered over a large part of Japan. The barometric coefficients for EAS counting rates are determined for each array. The atmospheric dynamics becomes the subject by using CR intensity tomography. The cross-correlation functions between intensity data observed at each array are examined to determine both time and spatial scales of atmospheric structures. The barometric coefficients of EAS intensity are about -0.6%/hPa for all arrays, and the cross-correlations in EAS data between arrays are observed and their amplitudes are larger than that of barometric pressure data.

1. Introduction

The cosmic ray (CR) intensity at sea level is not constant. It changes continuously at different time scales and spatial scales. The CRs at sea level comprise

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particles from the EAS. The major components are muons, which are the decay products of pions or kaons from high altitude. The muon intensity at sea level is related to the height of production, and the muon decay effects are explained in terms of the seasonal variation of CR intensity. Electrons are the secondly abundant components, which are the products of electromagnetic cascade process or the decay products of muons. In the ground-base CR observations, such as EAS array, electrons and muons are detected. To determine the correction coefficient of observed data on barometric effect is one of important issues to extract actual galactic CR intensity at the top of Earth's atmosphere. We are more interested in the time scale and spatial scale of CR intensity variations.

The LAAS experiment [1] has made observations of EAS events by using synchronized compact arrays, which are located in large part of Japan, since 1996. The baseline between each array ranges from 100m to about 1000km. Here we have used the data observed before April 2002 at 5 arrays. The barometric coefficients for different arrays and the results of cross correlation analysis between several baselines will be reported.

2. Data Set and Analysis Method

The general features of each data set are summarized in Table 1. On the basis of daily data obtained by each array, we determine barometric coefficients for CR relative intensity variations. Since trigger conditions at each site have been modified slightly in the data period, relative intensity was used in this analysis. The average intensity values determined in every trigger condition at each arrays, were used in calculating relative intensity values. Barometric pressure data at each array were obtained from electric data archives of Japan Meteorological Agency.[2]

The cross correlation of CR intensity between several baselines of arrays corresponds to the time scale and the spatial scale of the atmospheric structure fluctuations. Data sets used in this cross correlation analysis were selected on condition that trigger mode was equal to a 5-Fold coincidence. The data periods for OU-KU(150km baseline), OU-HU(800km baseline) and KU-HU(800km base-

Table 1. The profiles of LAAS arrays and each data period.

Site	Abbr.	Lat.(N)	Lon.(E)	Data period
Okayama Univ. of Science	OUS1	34°42'	133°56'	02/09/96-30/04/02
Okayama Univ.	OU	34°41'	133°55'	12/09/96-30/04/02
Hirosaki Univ.	HU	40°35'	140°29'	13/11/98-29/04/02
Kinki Univ.	KU	34°39'	135°36'	01/09/96-25/04/02
Nara Univ. of Industry	NUI	34°35'	135°41'	26/08/96-30/04/02

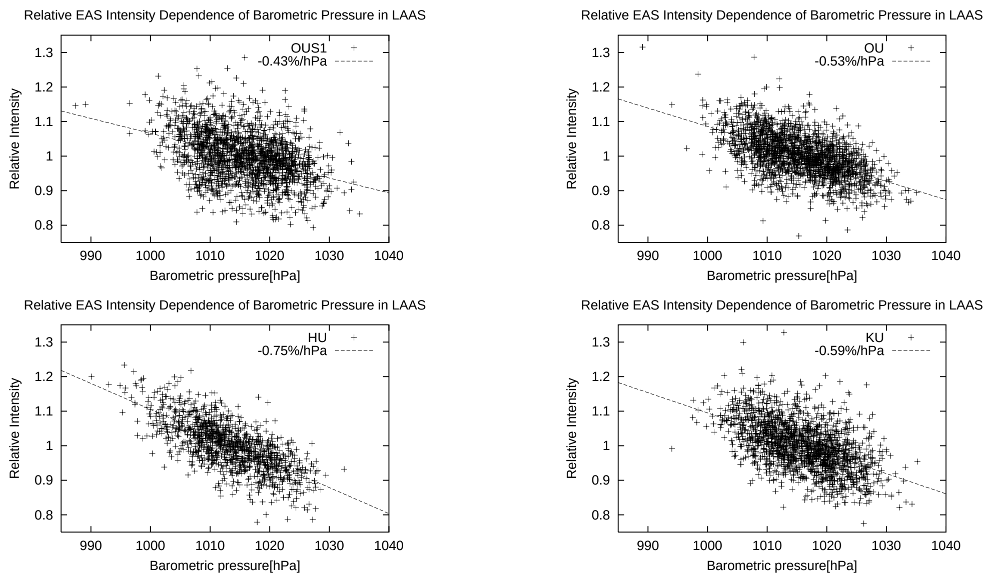

Fig. 1. Barometric coefficients obtained at OU, OUS1, HU and KU.

line) are 01/01/1997 to 12/31/1999, 11/13/1998 to 12/31/1999, and 11/13/1998 to 11/30/2001 respectively.

3. Results and Conclusions

The CR intensity dependence on barometric pressures are shown in Figure 1, and their coefficients are summarized in Table 2. These coefficients are smaller than that observed in solar neutron observations, of which value is about -0.9%/hPa[3]. The primary energy of solar neutron is generally lower than that of EAS event. These coefficient differences between EAS and neutron monitor are consistent with that the fluctuation of atmospheric structure affects mainly the lower energy particles. Our coefficient values are slightly deviated in each site. Our deviations would come from the some changes of a trigger mode at each site.

Figure 2 and 3 show cross correlations of both CR intensity and barometric pressure on the basis of daily data, between arrays. We see the clear correlation at around 0 day of a lag for both data. This correlation is more pronounced for the CR amplitude than that for barometric pressure. The correlation amplitude has a sharp peak at around 0-day of a lag for long (800km) baseline combinations such as OU-HU and KU-HU , relative to that for the 150km baseline combination, OU-KU. These results are consistent with the expectation by the point of view of meteorological atmosphere dynamics. The correlation amplitude of CR intensity is larger than that of barometric pressure data. This result means that it is possible to study the local fluctuations in atmospheric structure by using multiple

Table 2. Barometric coefficients

Array Name	Baro. coefficient
OUS1	-0.43%/hPa
OU	-0.53%/hPa
HU	-0.75%/hPa
KU	-0.58%/hPa
NUI	-0.53%/hPa

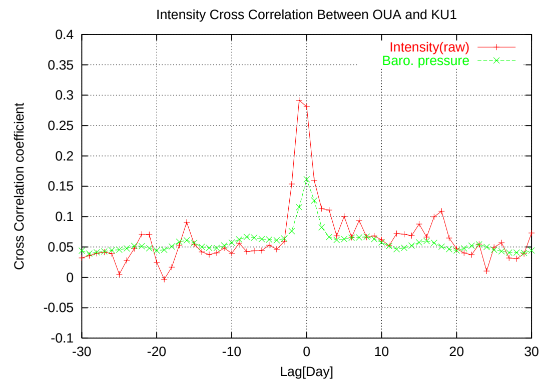

Fig. 2. Cross correlation of CR intensity between OU and KU array.

EAS arrays at several baseline combinations.

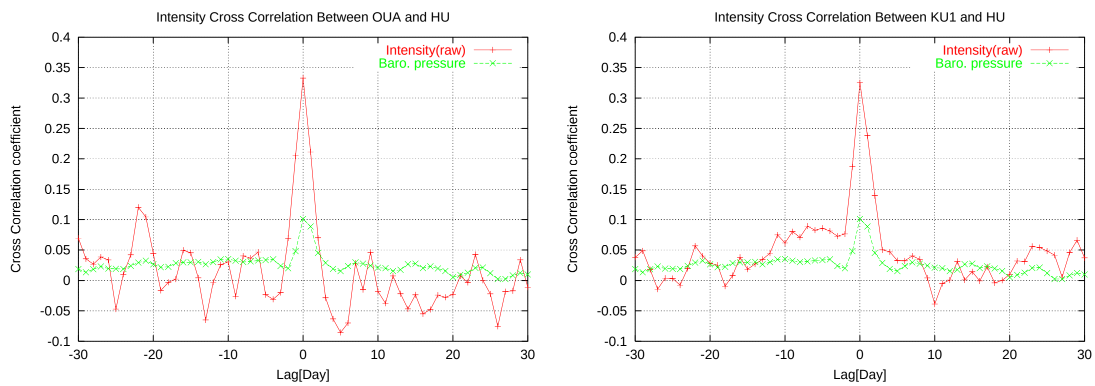

Fig. 3. Cross correlation of CR intensity between OU-HU and KU-HU.

Acknowledgement Part of this works was supported by the Frontier Project of the Ministry of Education, Science, Sports and Culture of Japan.

4. References

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