RICC Usage Report for Fiscal Year 2013

Project Title:

Generation of cosmic ray air showers at a large statistics

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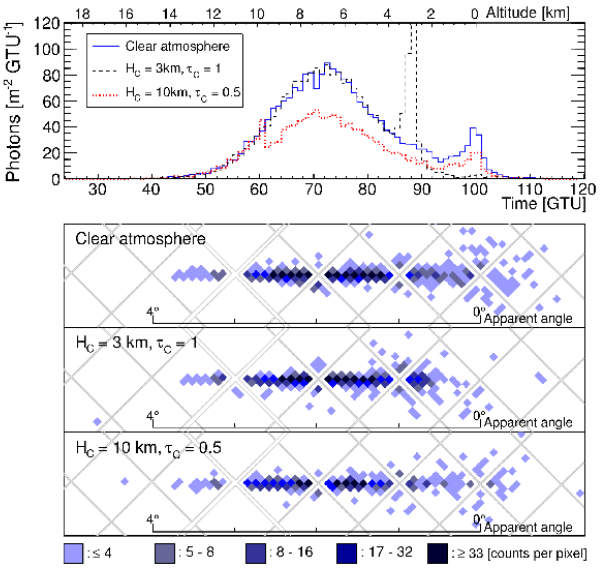
Background and purpose of the project: JEM-EUSO (Extreme Universe Space Observatory on the Japanese Experiment Module) mission is an international collaboration effort towards to establish the astronomy using ultra-high energy cosmic ray (UHECR) channel. The observation of UHECR depends upon the indirect measurement of air shower phenomenon initiated in the atmosphere. Each event of such a phenomenon involves an order of hundred billions of particles and ~10^{15} fluorescence and Cherenkov photons, starting with a single extremely energetic particle. The phenomenon takes in the atmosphere, while JEM-EUSO is the first UHECR observation project from the outer Space. The observed properties of air showers highly vary dependant on many factors. The evaluation of JEM-EUSO performance thus requires a large amount of computing power.

Relationship of the project with other projects: In JEM-EUSO collaboration, several users, domestic and abroad, utilize RICC system in Quick Use Category. RICC is also used for data sharing and software development for JEM-EUSO mission.

Specific usage status of the system and calculation method: So far ~5% of assigned CPU-time has been used. In this fiscal year, we analyzed the distribution of clouds in the region where JEM-EUSO observation is conducted. As well, a large amount of air shower simulations has been also carried out using EUSO Analysis and Simulation Framework (ESAF), focusing on the efficiency of UHECR observation by JEM-EUSO in the cloudy conditions.

Result: Key results obtained through the present project are partly described.



The above figure shows an example of simulation results for the observed time profile and images on signals from the air shower with and without cloud.

The data analysis of cloud distribution over the globe. By analyzing the TOVS satellite data, the distribution of occurrences as a function of cloud types were estimated as is tabulated below.

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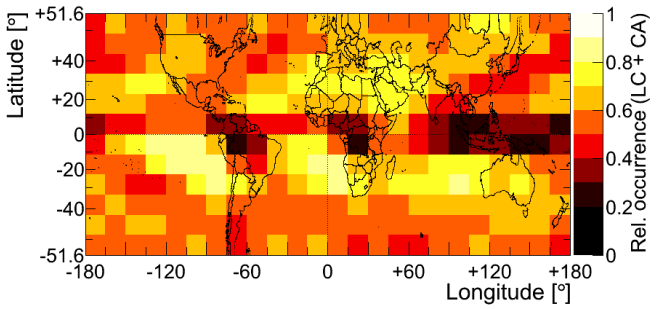
Table 2 Relative occurrence of cloud categories over the ISS orbit, taken from the TVOS and CALIPSO presented as a matrix of cloud-top altitude versus optical depth. For CALIPSO analysis, the cases with $\tau_C < 0.1$ are all summed up as clear atmosphere. The analysis of TOVS is from Ref. [7].

Cloud-top altitude H_C	Relative occurrence (TOVS)				Relative occurrence (CALIPSO)			
	Optical depth τ_C							
	<0.1	0.1–1	1–2	>2	<0.1	0.1–1	1–2	>2
>10 km	1.2%	5.0%	2.5%	5.0%	38%	4.7%	4.7%	4.7%
6.5–10 km	<0.1%	3.2%	4.2%	8.5%		4.5%	4.8%	6.0%
3.2–6.5 km	<0.1%	2.0%	3.0%	6.0%		3.2%	1.7%	6.4%
<3.2 km	31%	6.4%	6.0%	16%		2.8%	0.9%	17%

Table 3 Comparison of clouds occurrence results from TOVS and CALIPSO data. Types of cloudy condition are assumed: (a) for low-cloud or $\tau_C < 0.1$, (c) for high-cloud with $\tau_C > 1$ and (b) for any other intermediate.

Cloud-top altitude	Relative occurrence (TOVS)				Relative occurrence (CALIPSO)		
	Optical depth τ_C						
	<0.1	0.1–1	>1	Type	>1	0.1–1	<0.1
HC (H_C > 6.5 km)			20%	(c)	20%		
MC (H_C = 3.2 – 6.5 km)		19%		(b)		21%	
LC (H_C < 3.2 km)	61%			(a)			59%

The global distribution of clouds, taking into account the efficiency for UHECR observation is mapped as shown in the below figure.



Conclusion: Combining the detector simulation of JEM-EUSO instrument, the overall efficiency of UHECR observation by the mission was evaluated. The key results are submitted to the Experimental Astronomy and recently accepted for publication.

Schedule and prospect for the future: As quick use category, we plan to keep investigation on the performance of JEM-EUSO mission, following the progress of hardware development. It should be also note that the calculation carried out in RICC is also utilized to improve data analysis software and hardware development.

If no job was executed, specify the reason: Not applicable

Fiscal Year 2013 List of Publications Resulting from the Use of RICC

[Publication]

Adams, J.H. Jr et al. for JEM-EUSO Collaboration, "JEM-EUSO observation in cloudy condtions", Experimental Astronomy, Special Issue (accepted; Feb. 2014).

Adams, J.H. Jr et al. for JEM-EUSO Collaboration, "JEM-EUSO observation in cloudy condtions", Experimental Astronomy, Special Issue (accepted; Feb. 2014).

Bertaina, M. et al. for JEM-EUSO Collaboration, "Performance and air-shower reconstruction techniques for the JEM-EUSO mission", Advances in Space Research (accepted, Feb. 2014).

Acknowledgement of RICC utilization has been omitted due to collaboration policy. The all papers are still in print. Copies, therefore are not attached in the present report.

[Proceedings, etc.]

Shinozaki, K. et al., "Estimated exposure of UHECR observation by the JEM-EUSO mission", Proceedings of 33rd International Cosmic Ray Conference (Rio de Janeiro), ID1250, July 2013.

[Oral presentation at an international symposium]

Presentation delivered by A. Santangelo for Shinozaki, K. et al., "Estimated exposure of UHECR observation by the JEM-EUSO mission", Proceedings of 33rd International Cosmic Ray Conference (Rio de Janeiro), ID1250, July 2013.

[Others]