Atmospheric cloud monitoring Infrared Camera onboard NASA stratospheric balloon for Extensive Air Shower experiments

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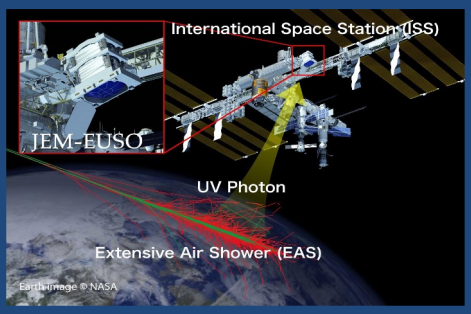
Abstract: The new generation of experiments for the indirect detection of cosmic radiation by observing Extensive Air Showers (EAS) in the atmosphere, requires continuous observation of the atmospheric physical properties in their Fiel of View. For this purpose, these experiments on ground and in space use large atmospheric volumes as calorimeters. One of the key points is the determination of the presence of clouds in the FoV of the infrared camera. The presence of clouds in the atmospheric detection volume modifies the transmissivity of the atmosphere producing scattering and attenuation of the fluorescence radiation generated by the secondary particles of the Extensive Air Shower on their way to the detector. We have developed a thermal space infrared camera capable of detecting the presence of clouds, determining their temperature and obtaining the Cloud Top Height (CTH). This parameter is essential for data analysis when an EAS is detected. This paper shows the analysis of the data obtained during 667N test flight of the stratospheric balloon launched by the CSBF/NASA in New Mexico.

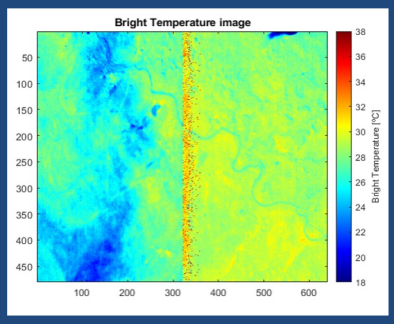


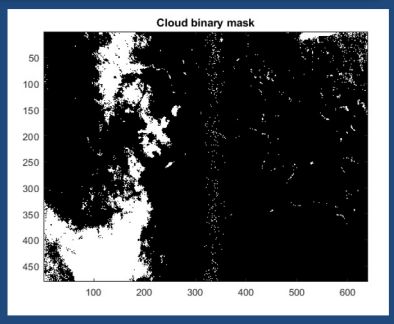
The Stratospheric NASA Balloon is a pathfinder mission for **JEM-EUSO (Extreme Universe Space Observatory)** designed to observe Ultra-High Energy Cosmic Rays propagating in the Earth's atmosphere by detecting from a higher position the UltraViolet (UV) photons emitted from Ultra High Energy extensive air showers. The UV data are complemented with IR images taken by the IR camera launched by the Spanish consortium led by the Space and Astroparticle Group of Universidad de Alcalá.

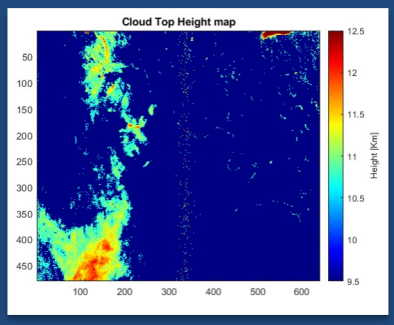
Methodology and results: The IR camera is bispectral with two spectral filters at 10.3 - 11.3 μm and 11.5 - 12.5 μm bands. The data collected by the IR camera is calibrated in Analogic Digital Counts (ADC) format. These ADC data was converted to bright temperatures using parametric curves obtained from the response of the IR camera's sensor after being exposed to calibrated black bodies, whose temperature is known. The bright temperatures were corrected taking to account the shutter and window temperature.

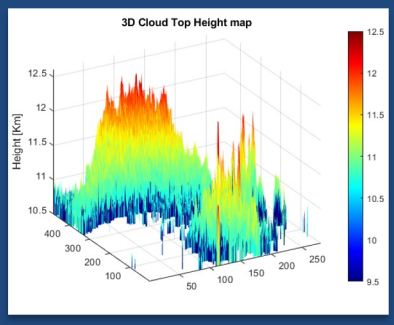
The data obtained by the GPS on-board the NASA-Balloon were employed in georeferencing the bright temperature images. Once these calibrations are implemented, the final images were obtained for both filters (left upper panel). The horizontal and vertical axes correspond to the image dimension (640x480 pixels). For each image, the high temperature of the ground was contrasted with the clouds' temperature. The later is much lower, enabling us to elaborate a binary mask (right upper panel).

The clouds optical depths were stimated from mean values of cirrus clouds. This parameter is used to determine the real temperature of the clouds which, in addition to the ground temperature, allows us to obtain the Cloud Top Height (CTH) of each pixel (lower left panel). Here we also show a 3D figure (right lower panel) of the CTH achieved by the different sections of the clouds for the filter centered on 10.8 μm.









Conclusions and future work: This project intends to contribute to understand the absorption and deviation of cosmic radiation from Extensive Air Showers from the study of the atmospheric conditions and clouds properties. We conclude that the images collected during the NASA-Balloon flight allow us to perform such analyses, thanks to both filters, centered on 10,8μm and on 12μm. The CTH map returns heights in the range (10-13) km, which is in agreement with cirrus clouds at such altitudes. For future work would be desirable to implement Machine Learning techniques for the cloud recognition procedure in order to differentiate them from lakes, fields and so on, in multiple images in an optimized way.

References:

[1] Díez, J., Moreno, G., Del Peral, L., Adams, J. J .Jr, Rodríguez-Frías, M. D., and Manjón, J. L., Fuligo Septica Spores Onboard of a Stratospheric NASA Balloon and its complete In Vitro Life Cycle. *Astrobiology*, Vol. 20 Issue 3: March 2, 2020 DOI 10.1089/ast.2019.2097

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