# Analyzing seasonal variation and its influence on cosmic ray detection.

Reman Adhikari, Ayad Al Samaray, Ricardo Gonzalez, Dennis Soldin
University of Utah- INSPIRE

## Introduction

Cosmic rays are particles that come from our sun as well as outside the solar system. Our sun gives off low-energy cosmic rays, while cosmic rays that come from outside our solar system are high energy allowing them to travel farther distances. They crash into our atmosphere breaking down into smaller particles such as electrons, muons, etc. which were observed using our cosmic ray detectors.

## Experimental Setup

We created and operated cosmic ray detectors to gather data for the research project. These detectors measure secondary particles from the cosmic ray induced air shower, which then shows up as a light in a PMT (Photomultiplier Tube), converting them into digital signals that we can analyze. We needed at least 2 ½ years of data to see the seasonal effect, therefore we decided to use a detector based in the Netherlands (Utrecht 1006) to analyze multiple years and compare them to test our hypothesis. We wanted to see the event rate after removing the effect of surface pressure.

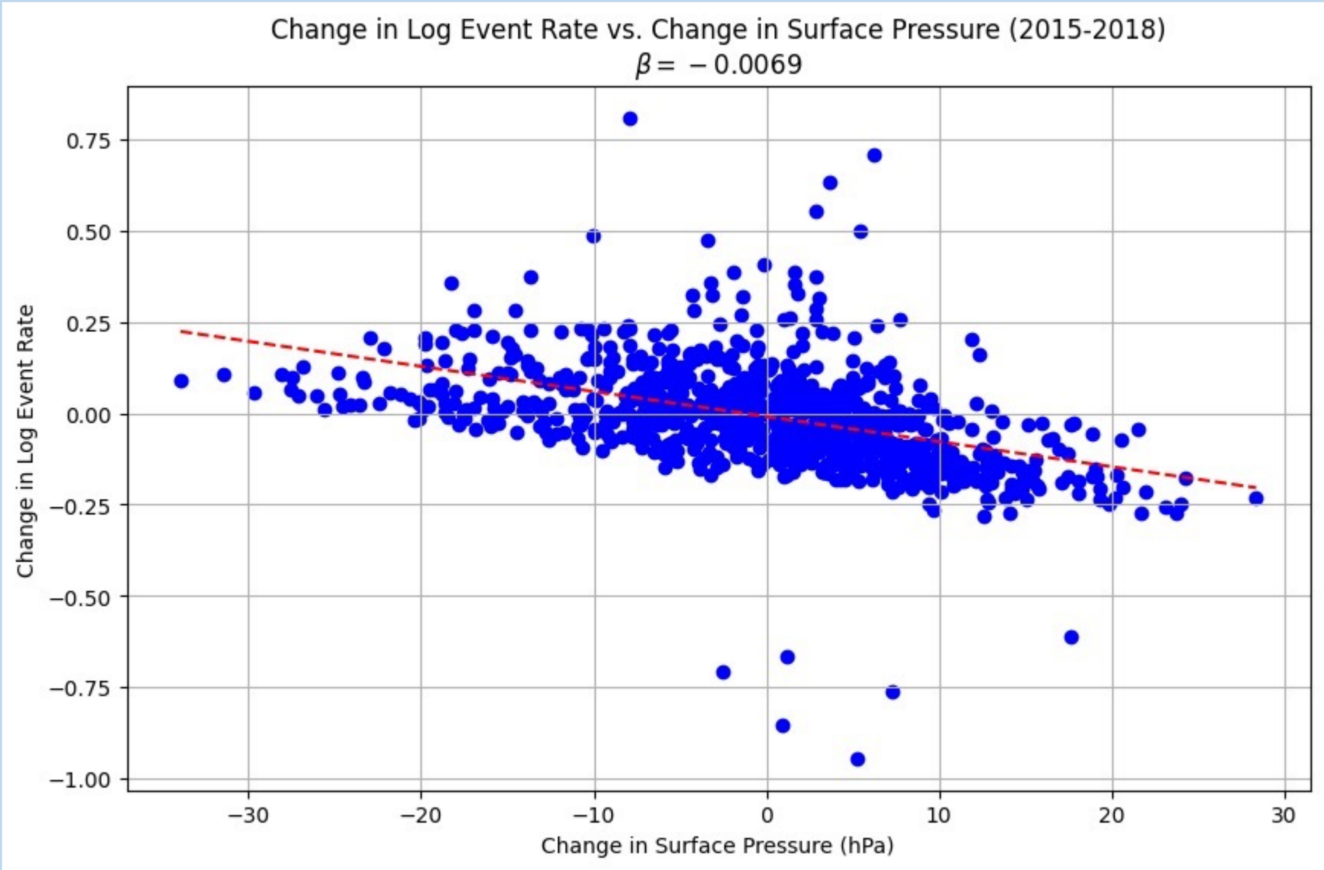


**Figure 1.** Red line represents the beta for the change in event rate compared to surface pressure

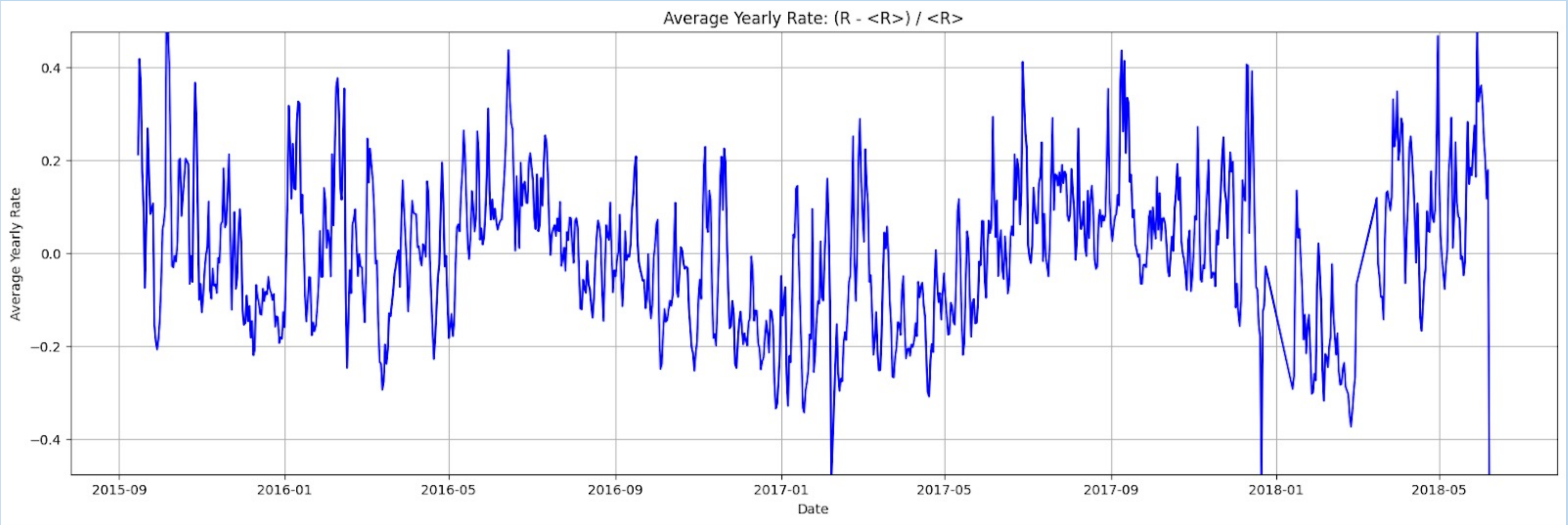


**Figure 2.** Average yearly rate

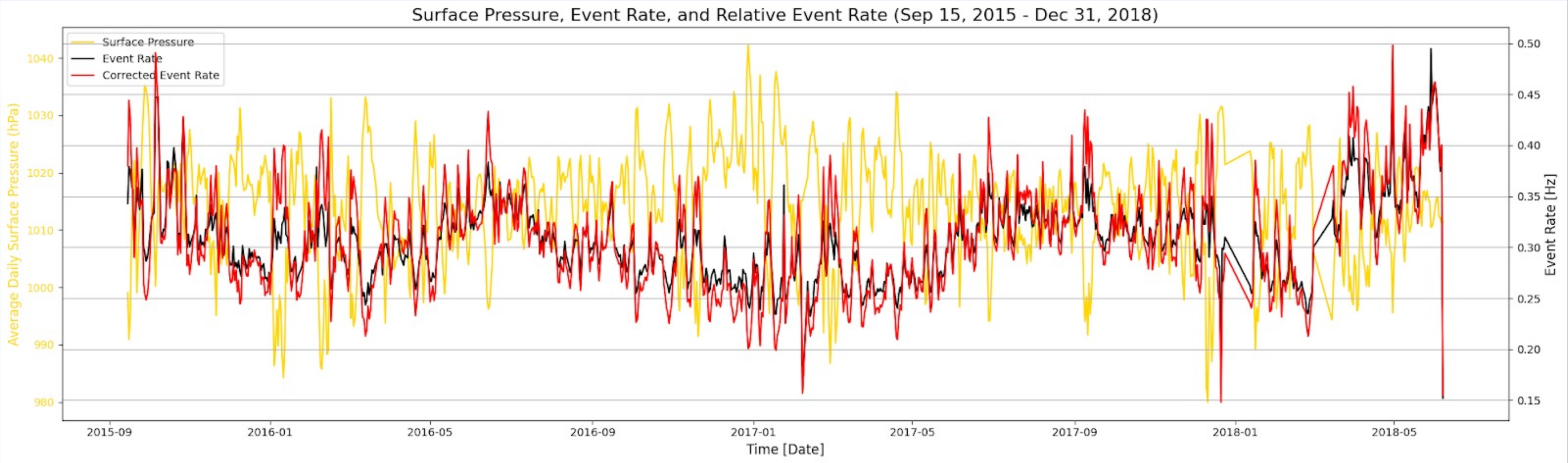


**Figure 3.** Comparison of surface pressure, event rate, and relative event rate.

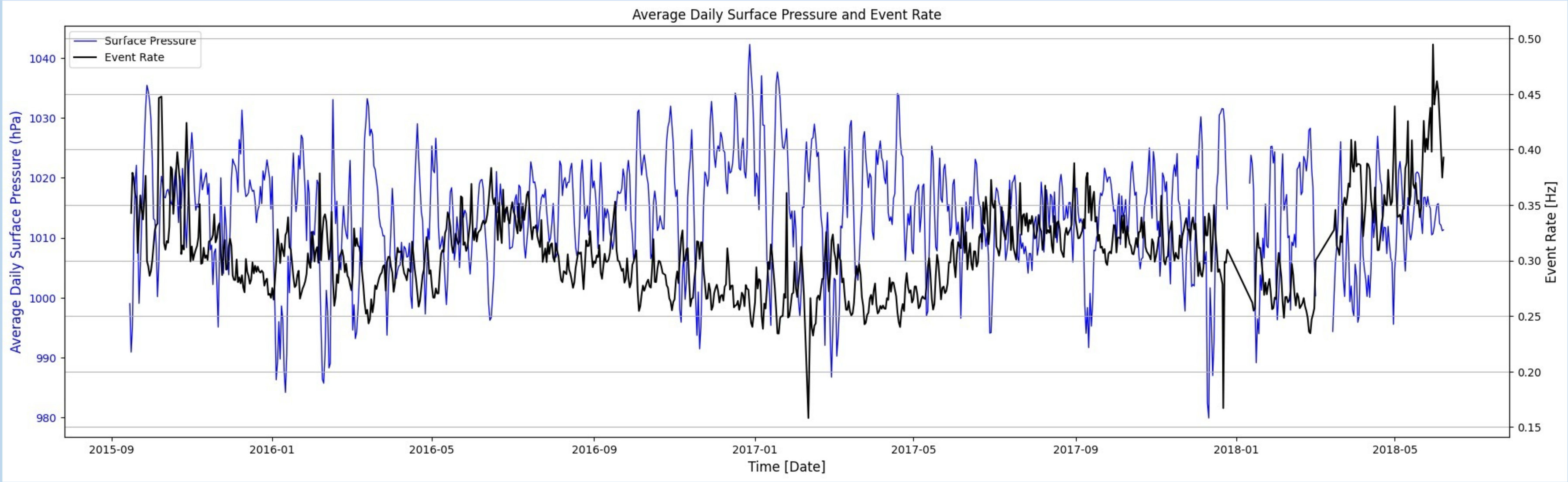


**Figure 4.** Average of Surface pressure and Event rate

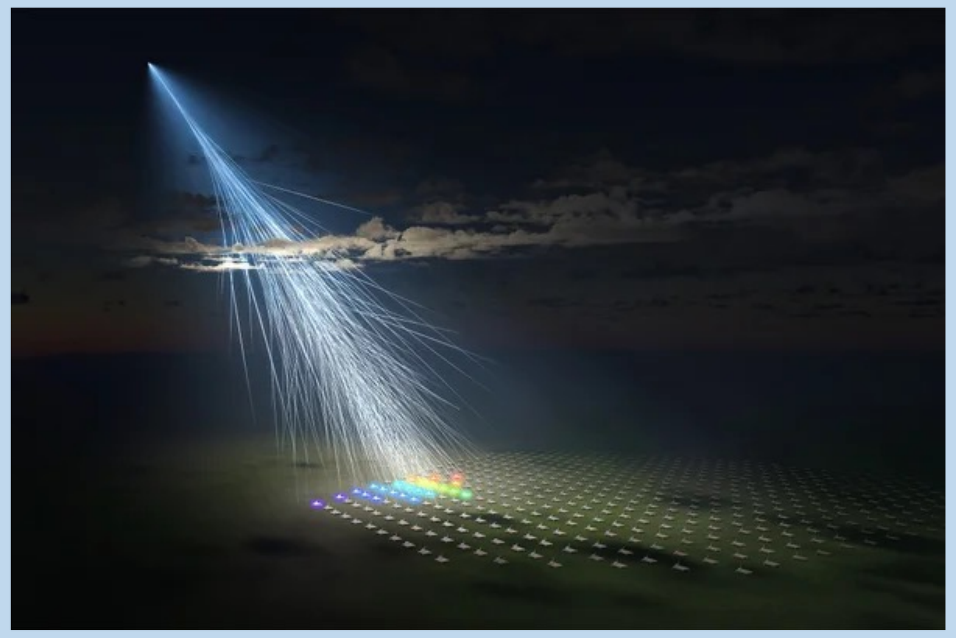

**Figure 5.** Visual representation of particles colliding with our atmosphere

**Figure 6.** Us working on the detector

## Analysis

The three graphs are presented for the years 2015-2017. To get a more accurate result for different seasons, we decided to use 2 1/2 years of data to get a more accurate insight on whether seasons can influence cosmic ray detection or not. We used this formula to find the barometric coefficient :

. $\ln R_1 - \ln R_2 = \beta(P_1 - P_2)$.

We also used the following formula to calculate barometric coefficient: $(\ln R_i - ln_R \ = \beta(P_i - P_0)$.

Lastly, we calculated the relative event rate $(N_i^{corr} = N_i^{meas} \exp(-\beta(P_i - P_0)))$.

## Conclusion

Our research focused on examining the variation in cosmic ray detection rates throughout the seasons. Our hypothesis was that increased heat in the summer led to a higher cosmic ray detection rate because of the atmosphere expanding due to the increased temperatures. To test this theory, we utilized cosmic ray detectors from the Netherlands (Utrecht 1006) and used data from 2015-2017 as our reference point.

We found that there is a difference in detection rates between colder and hotter seasons. In the summer of 2016, the detection rates were 26% more on average than compared to winter. This pattern was similar in 2017, as the detection rate were 7% higher in the summer.

In the future, we plan on using our own detectors that we built and put up in downtown Salt lake city and seeing if the results vary based on region. We hope to use data from our detector to get more accurate results.

## Acknowledgement

This project was funded in part by the National Science Foundation (NSF) award # 2005973. We would like to thank Dr. Tino Nyawelo for giving us the opportunity to participate in this program. We would also like to thank REU for providing us with a workspace.

## Reference

[1] K. van Dam, B. van Eijk, D. Fokkema et al., "The HiSPARC experiment", Nucl. Instrum. Meth. Phys. Res. A 959, 163577, 2020.
[2] K. van Dam, "HiSPARC: A Scintillating Experiment", Dissertation, University of Twente, 2021.
[3] S. Tilav et al., "Atmospheric Variations as observed by IceCube“, Proceedings of the 31st ICRC, Lodz, Poland, July 2009.
[4] IceCube Collaboration, "IceTop: The surface component of IceCube“, NIM A 700, 188, 2013.