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Radiation Profiles During a Quiescent Sun

Samantha Carlson, Rhiannon Fleming, Samuel Reams, Dr. Richard Clark PhD

Abstract

Vertical profiles of high energy radiation will be investigated during a period of quiescent, calm, sun. New and previously obtained vertical profiles acquired during solar minimum, were the sun is at lowest activity, will be studied in order to document the structure of the radiation. Data will be collected during high altitude balloon ascents, routinely attaining altitudes of 35,000 meters, with onboard radiation probes and meteorological sensors. The balloon carries a payload containing a data storage device and three probes, two measuring bandwidths of ultraviolet radiation, UVA and UVB, and the third measuring X-ray and gamma radiation. Once the radiation package is retrieved, the data from the device is downloaded and processed through a program to be studied and interpreted. Primarily, the research is conducted to understand radiation profiles over southeastern Pennsylvania while also developing research, data processing, and professional presentation skills in students.

Introduction

The function of this research is to improve upon previously collected data of past solar radiation atmospheric height profiles while simultaneously studying the radiation levels of the atmosphere based on the time of year. Profiles denote a study into how radiation changes with height, about 300 meter increases UV radiation burns by 4 percent (IARC, 2012). Research into atmospheric solar-based radiation is important. Radiation has constant presence and harmful effects on humans and technology. For instance, cancer has been linked to UV radiation and satellites are sensitive to high energy radiation and must be protected. The sun has intensified over the last 4.5 billion years resulting in an increase in flux of all wavelengths received and total energy of UV photons, light particles (Karam, 2003). The research mentioned is utilized to teach students how to use the equipment properly, process data, and present in a professional environment.

Method

The research was conducted on different days of the year for a more complete inspection of radiation due to change in axial tilt of the Earth, “[s]easonal variation in terrestrial UV irradiance, especially UVB, at the Earth’s surface is significant in temperate regions. . .” (IARC, 2012). Gamma and X-ray radiation is less impactful to the surface of the planet due to scattering, and the effects of these types of radiation are greatly affected by the lack of solar activity. Solar weather is and less frequent and quieter during a quiescent, quiet, sun. Finally, the launches for the research were conducted on clear or scattered conditions as moisture in clouds affects the data and the balloon, as the research demands the highest possible altitude.

Above: exterior of radiation package and assembly of attachment.

To begin the process of data collecting for the experiment, high altitude weather balloons were launched to a range of 30,000–40,000 meters before the balloon burst, deploying a parachute slowing the package's descent. The balloon is a 600 gram latex rubber and must be handled with care due to oils on the skin weakening the material. To launch, a cradle is used to fill the high-altitude weather balloon with helium.

The radiation package is an orange styrofoam cooler with three sensors inside and a data storage device. The LabQuest 2 data storage device is a portable computer. The sensors are a UVA probe, UVB probe, and radiation monitor. The UVA sensor detects light waves from 320 microns to 390 microns while the UVB sensor measures light waves ranging from 290 microns to 320 microns ("Vernier UVA Sensor" and "Vernier UVB Sensor", 2019). A micron, or micrometer, is 0.000001 of a meter. The radiation monitor measures alpha, beta, X-rays, and gamma waves, working as a Geiger-Müller tube counting the points of radiation ("Vernier Radiation Monitor", 2019). Also attached is a Vaisala radiosonde, a meteorological instrument, capable of recording the surrounding air temperature, relative humidity, wind speed/direction, and pressure as well as the altitude, via GPS, and transmitting the information back ("Viasala: Radiosonde RS41", 2018). A GPS system is the final component to easily recover the instruments after they fall.

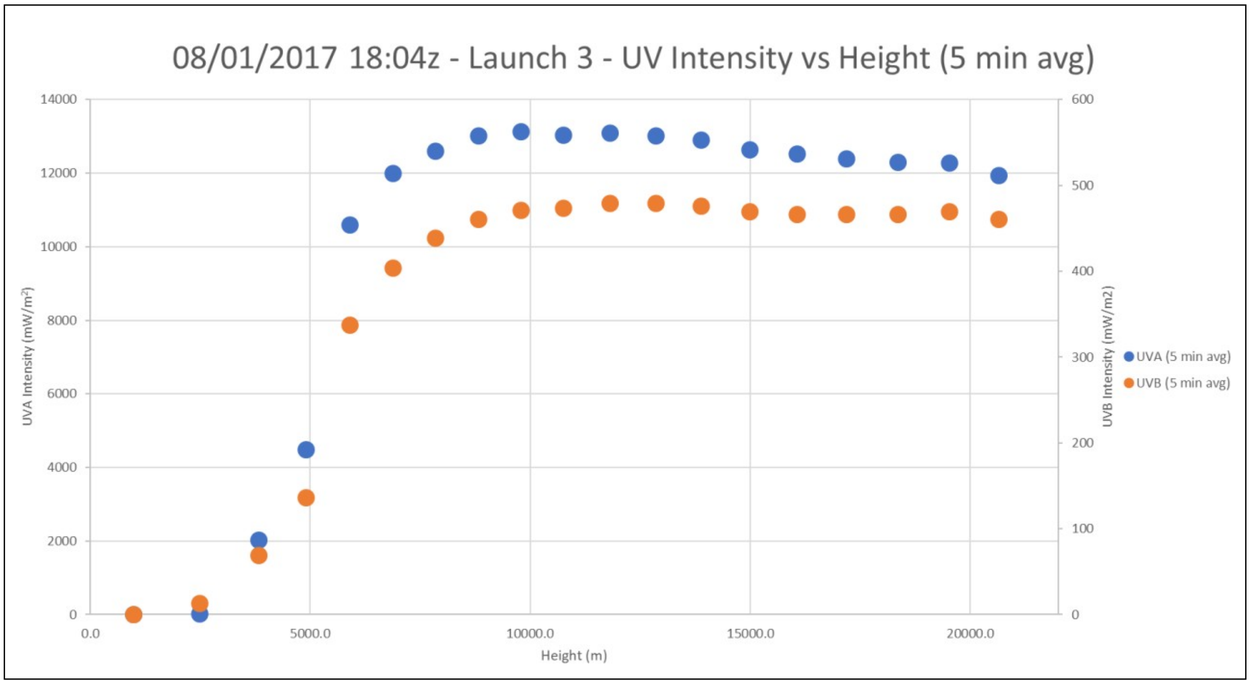
Above: launched balloon (Fleming 2018)

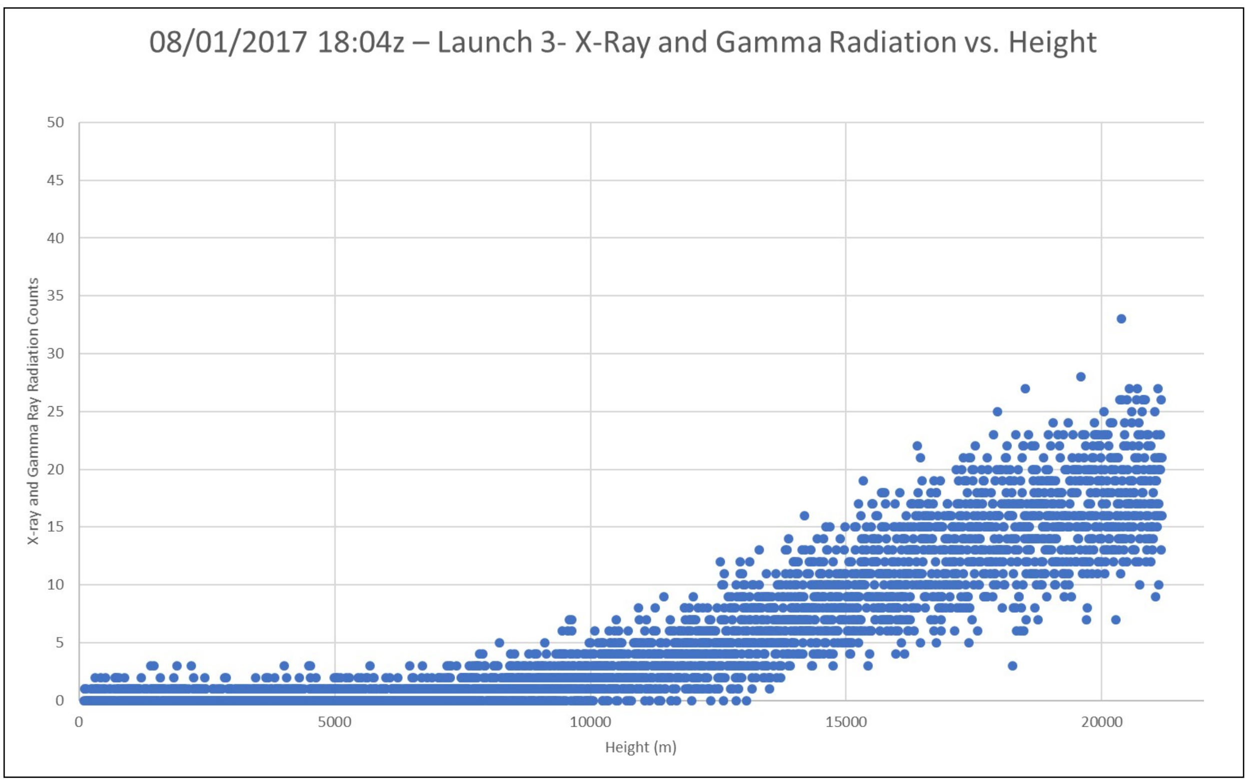
After the balloon retrieval, the data, coming from the sensors as raw numbers, was processed. First, the data was run through a python-based program, assembling the numbers into interpretive data. From there, a graph of the atmosphere was plotted from the radiosonde and compared to the altitude measured by the radiosonde to the radiation recorded by the probes. From that comparison, graphs were made of height versus UVA/UVB readings and height versus the more intense radiation (X-ray and gamma) readings. Further, the numerous graphs were compared, viewing differences and similarities based on the time of year. Finally, the data allowed additional conclusions to be drawn from how radiation works within the atmosphere.

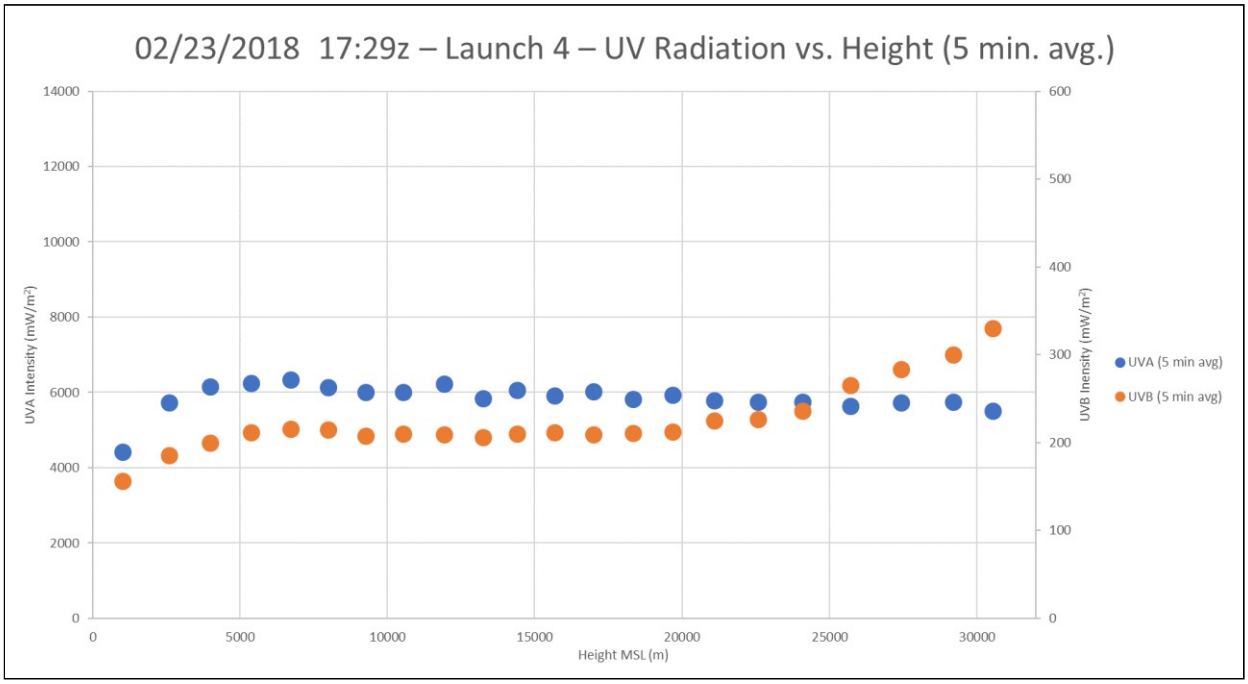
Results and Conclusion

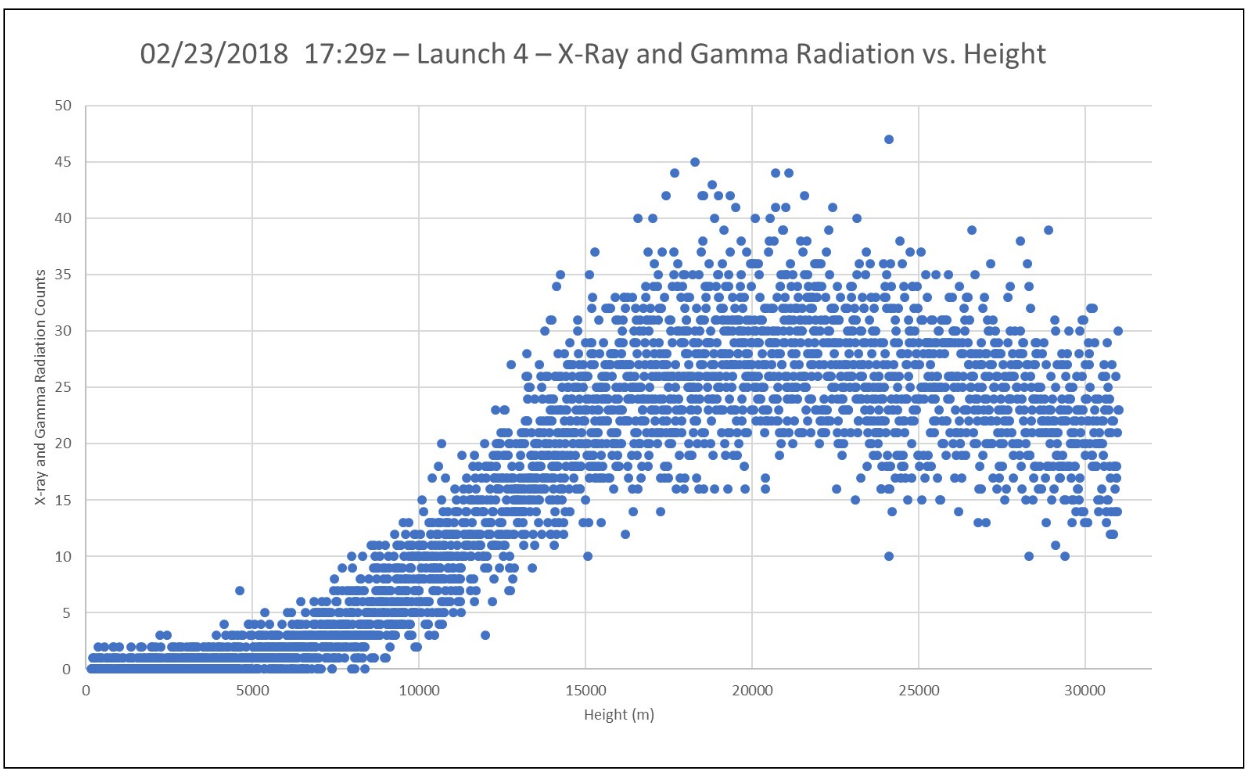
Conclusions from the research project were expected to yield a result of radiation increasing with height. The higher intensity X-rays and Gamma rays are expected to only appear in quantity above an elevation of 2300 meters. A difference between overall winter versus summer radiation levels are expected as well because the Earth is tilted away from the sun in winter and towards the sun in summer.

The data returned expected and slightly unexpected results. First, the UV radiation and X-ray/Gamma radiation data showed a definite increase as height increased. Furthermore, there is an obvious shift in seasonal change of UV radiation to height between late summer (August 1) and late winter (February 23). However, when compared, the X-ray/Gamma radiation data between the two profiles differs significantly, in count and shape. In addition, UVB is seen to be in higher concentrations higher in the atmosphere (~25000 m and up) during February whereas UVB levels are higher than UVA radiation levels in August. The research lead to a conclusion of an increased UVB radiation dose in August over February.


08/01/2017 18:04z - Launch 3 - UV Intensity vs Height (5 min avg)
UVA Intensity (mW/m²)
UVB Intensity (mW/m2)
Height (m)
UVA (5 min avg)
UVB (5 min avg)
0
2000
4000
6000
8000
10000
12000
14000
0.0
5000.0
10000.0
15000.0
20000.0
0
100
200
300
400
500
600


08/01/2017 18:04z – Launch 3- X-Ray and Gamma Radiation vs. Height
X-ray and Gamma Ray Radiation Counts
Height (m)
0
5
10
15
20
25
30
35
40
45
50
0
5000
10000
15000
20000


02/23/2018 17:29z – Launch 4 – UV Radiation vs. Height (5 min. avg.)
UVA Intensity (mW/m²)
UVB Inensity (mW/m²)
Height MSL (m)
UVA (5 min avg)
UVB (5 min avg)


02/23/2018 17:29z – Launch 4 – X-Ray and Gamma Radiation vs. Height
X-ray and Gamma Radiation Counts
Height (m)

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