

How often is Lightning to blame for RFI in HERA data?

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Summary

We documented the severity of lightning near the HERA telescope and compared it to the dates where bright broadband interference was reported. This was done in order to produce evidence as to whether or not lightning is causing the interference. Lightning is sometimes bad enough to be classified as interference, but there are several instances of strong interference which are not associated with lightning.

Introduction

The HERA telescope has occasionally been experiencing broadband radio frequency interference starting in December and continuing through January. Some interferers were observed to be fixed in position while others appeared to move. One source of interference could be lightning storms in the area. In order to test this, we documented the severity of the lightning ranging from September 23, 2022 to February 6, 2023 using an animated map of lightning strikes in South Africa. This information was then compared to the dates where RFI was considered bright to see if there was any correlation.

Lightning Activity Classification

To begin, a boundary was selected in order to consistently judge whether or not there was lightning during an observation period. This boundary was created with a radius of over 100 miles with Calvinia and De Aar at opposite ends of the diameter. Despite HERA not being in the center of this circle, this region was still chosen due to the limits of the data being used. It was important to create a boundary that was easy to visualize and keep consistent while each rating was determined.

Observed Region

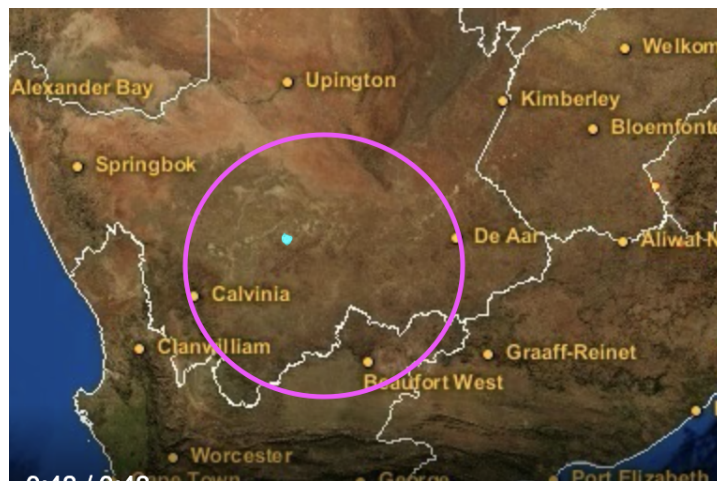





Figure 1: Map showing the area observed for lightning strikes circled in pink. The cyan dot marks the location of HERA.

Each observation received two rankings, one for the first half of the night (19:00-00:00 SAST) and one for the second half (00:00-05:00). The rankings were selected based on the length of the storm, how close they were to HERA, and most importantly the number of strikes.

System of Lightning Rankings

Lightning Rating	Corresponding Value	Example
none	0	
negligible	1	
low	2	

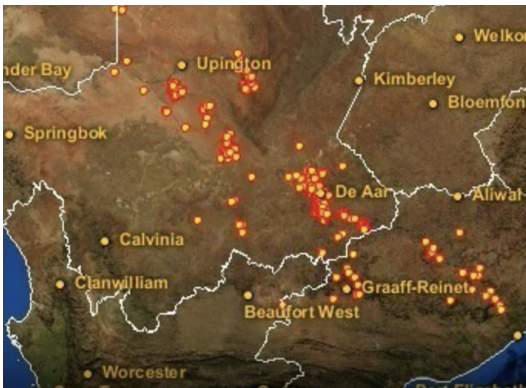
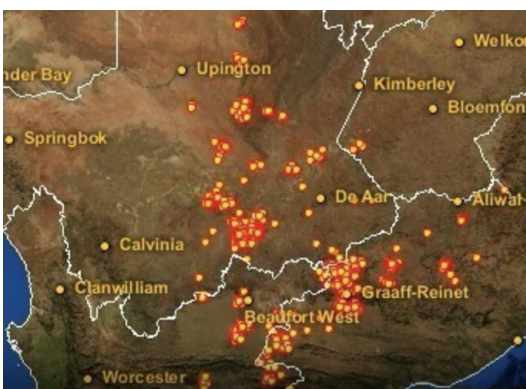
high	3	
extreme	4	

Table 1: Table showing the values each half of an observational period had the potential to be assigned, along with an example image of what that value could look like in a given moment.

Summary of Lightning Count Findings

Over the course of the five months where data was collected, there was on average more lightning in the evenings than there was in the mornings. For the half of the observation period ranging from 19:00 to midnight, the average amount of times per month where lightning was given a high or extreme ranking was 2.5. For the second half of the observation period ranging from midnight to 5:00, the average amount of times was about 1.33. There was also much more lightning during the months of December and January then there was during the other months. This could be attributed to the seasons in South Africa during this time.

Monthly Totals of High/Extreme Nights

Month	19:00-00:00	00:00-05:00
September	1	1
October	2	1
November	0	1
December	5	3

January	5	2
February	2	0

Table 2: Table showing the amount of times that part of an observational period was ranked as “high” or “extreme” during each month.

For the selected region surrounding HERA, there were many more nights with little to no lightning than there were nights with high lightning. This can be seen in figure 2, which simply takes a count of all of the average ratings for each observational period.

Count of Nights vs Lightning Rating

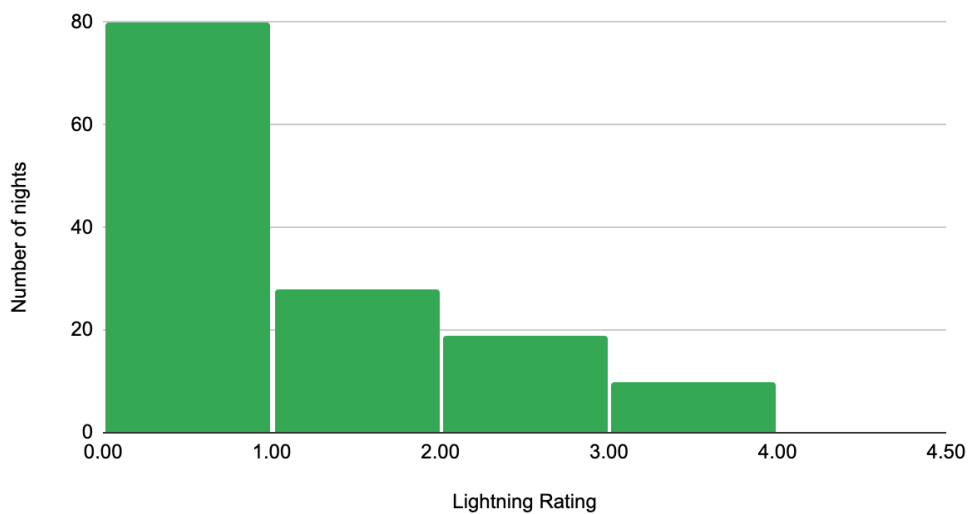


Figure 2: This shows a histogram counting the number of nights for each of the lightning rankings.

Does RFI come from lightning?

Previously, HERA autocorrelation waterfall plots had been systematically inspected for broadband RFI and a set of times with notable activity were identified. These times were then compared to their corresponding date on the lightning list. The RFI time ranges were cataloged with a start and stop time while the lightning time ranges were fixed into two halves of the observing session. If the interference lasted the entire observational period, then an average of the two values was taken and assigned to the date, otherwise the RFI was assigned to the nearest relevant lightning time bin. The result is two sets: the lightning counts during RFI events and the converse; counts during times when no RFI was observed in the radio data.

Amount of Nights with RFI vs Lightning Rating

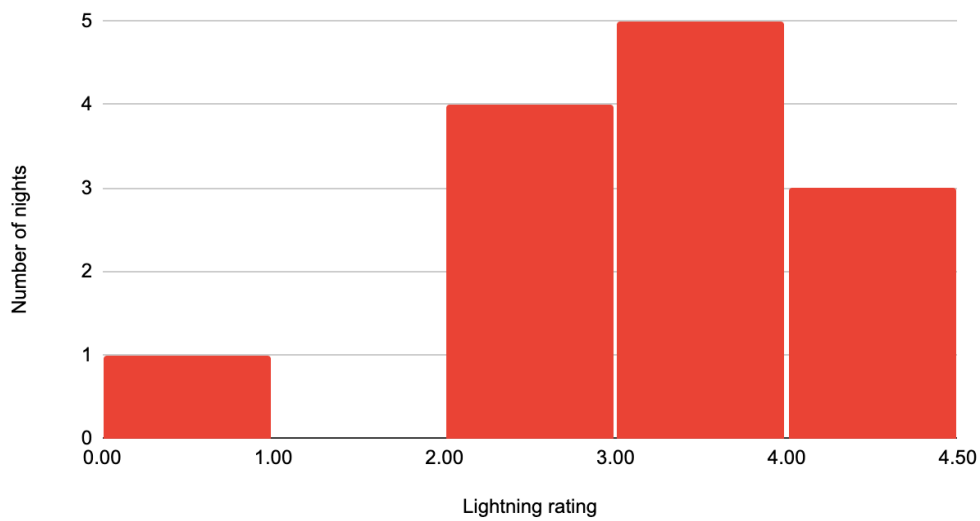


Figure 3: A histogram counting the number of nights with bright interference for each of the lightning rankings. Lightning rating of 0 means no lightning, a rating of 4 is extreme. Lightning is commonly associated with RFI, but not always.

After this, an average of the two halves of the observation period was taken for all of the remaining dates that did not experience bright interference.

Amount of Nights Without RFI vs Lightning Rating

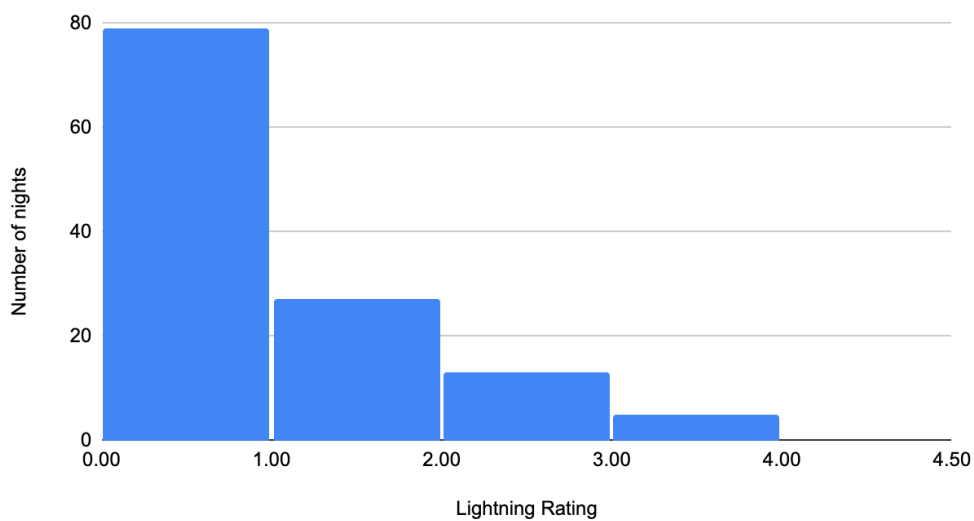


Figure 4: This shows a histogram counting the number of nights without bright interference for each of the lightning rankings. Lightning is relatively uncommon and does not always cause bad RFI.

Percentage of Nights with Each Lightning Rating

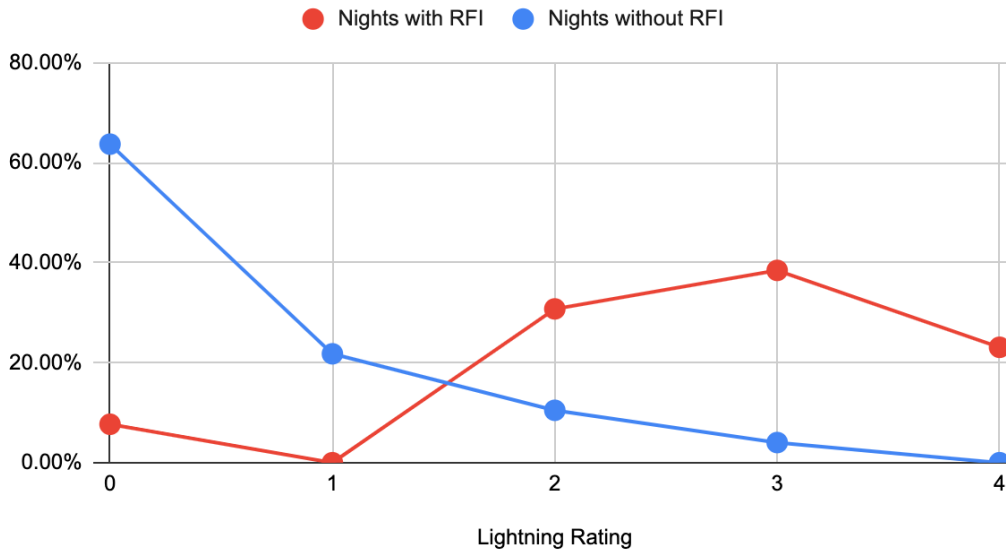


Figure 5: This figure compares the percentage of both types of nights with each of their lightning ratings. Data that have RFI show a relatively uncommon amount of lightning.

Conclusion

It can be seen by this data that the distribution of nights with bright RFI is quite different from the distribution of nights without it. It appears that the majority of the nights without broadband interference had little to no lightning, while the nights with it tended to have lightning. This leads to the conclusion that lightning could be the cause of some of the interference. However, this does not explain why there are some nights with bad lightning that had no interference, and one night with no lightning and bad interference. In regards to the nights with heavy lightning and no interference, it is possible that the radius of the boundary was too large, such that the lightning observed by the lightning detection network was not visible to HERA. The converse is also likely true, when we observed RFI on a night with no lightning, there was likely another possible source of the interference.

References

Animated lightning maps of southern africa historical. South African Weather WX, Rainfall, Forecast, Maps, Satellite and Storm Reports. (n.d.). Retrieved February 25, 2023, from https://afriwx.co.za/storms-lightning/lightning_storm_animations_southern_africa_daily_historical/