

# Re-evaluation and discussion of possible correlation between Solar Proton Density and Seismic Activity with help from my AI friends, Gemini (Google AI) and Grok 3.0 (by xAi)

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Link 1: <https://GordonWatts.com/ProtonDensity-vs-SeismicActiviy.pdf> (Pub.05-19-2025)

Link 2: <https://GordonWayneWatts.com/ProtonDensity-vs-SeismicActiviy.pdf> (Version 1.0)

**Abstract:** There has been much discussion in the scientific literature about potential correlation between solar weather and seismic activity, most especially the seminal paper by Marchitelli et al., 2020 (e.g., Marchitelli, V., Harabaglia, P., Troise, C. et al. **On the correlation between solar activity and large earthquakes worldwide. *Sci Rep* 10, 11495 (2020).** <https://doi.org/10.1038/s41598-020-67860-3>). Although the USGS, and the scientific community at large, have not supported the theory of such a correlation, research and discussion is ongoing on this controversial topic. While X-class flares have been mentioned in connection with a possible effect on seismic activity, anecdotal mention of solar proton density appears – at least to this undersigned researcher – to show a stronger promise of possible correlation to seismic activity than solar flares: this researcher recalls recent discussion of that, and the Marchitelli paper focuses on “20 years of proton density and velocity data, as recorded by the SOHO satellite” (brief quote from abstract), so, in beginning our analysis, this researcher decided to pull raw data for solar photon density and USGS earthquake datasets and do a more comprehensive and robust statistical analysis *de novo* – afresh and anew. The results – in short – show that, while individual analyses seem to usually find no statistically-significant correlation, except in rare cases where I suspect Gemini got suspiciously low p-Values due to math errors – nonetheless, the meta-analysis of individual – mostly independent – analyses seems to find a weak, but persistent, pattern of  $\geq 1.0$  Odds ratios and positive R-values – which is very unlikely by chance. Thus, while there are certainly much greater factors elsewhere (inferred from very low R-values) and not much effect on the seismic activity – if at all (inferred from the close-to-one Odds Ratios), nonetheless, there may be ***a super weak*** – but statistically-significant – correlation that lies “just under the surface” of an individual analysis – implying the need for “further research.” Whatever effects solar proton density may (or may not) have on telluric seismic activity, the effect (if any) is very small, and generally not of scientific significance. However, the meta-analysis method employed here may prove useful for other researchers who are seeking to find a pattern that lies “just beneath” traditional statistical analysis inquiry. In this context, several theories have been bandied about as to a possible cause-and-effect relationship, chiefly the reverse piezoelectric effect where Maxwell currents induced by photons – either directly in telluric ground near fault lines, or indirectly, via disturbance of the geomagnetic field which would could, in turn, induce currents as it fluctuates. Also, the Schumann Resonance effect from inductive and capacities properties of telluric material, has been discussed in this context. But these details are beyond the limited scope of this paper, and such matters, as to a *possible* mechanism of “cause and effect,” are left for other researchers to study – again – implying the need for “further research” on these controversial and unsettled areas of space weather, earth science, and meta-analysis of individual analyses.

**Summary and Introduction:** Can solar weather (solar super storms, solar flares, coronal mass ejections, and solar particles – like photons, protons, electrons, Magnetic field, Solar Plasma, and EMF pulses) influence earthquake activity? The effect –if it exists– is quite small, so looking at large datasets over time from several different angles might provide clues. “Correlation” between 2 events doesn't necessarily mean “causation.” For example, umbrella use has been correlated with rain, so can we assume that “umbrellas cause rain?” (*Hint: consider perhaps rain causes umbrella use to sharply increase!*) Or: High rainfall in north Tampa has been correlated with high rainfall in south Tampa, so can we assume one causes another? (*Hint: there may be a 'common cause' – namely clouds!*) It's well known that seismic activity can be caused by many factors: movement of tectonic plates near fault lines, drilling for oil, injection of fluids near fault lines, volcanic activity, land mine explosions, landslides, nuclear testing, even collapse of underground structures. But can solar weather be a factor? Solar proton density can result

from X-class flares, but CME's can also play a role. So, if there's any correlation between proton density and seismic activity, then any possible affect that X-flares might theoretically have would, necessarily, be attenuated because the relationship between solar flares and proton density is not a “direct 1-for-1” relationship. While some of the research claims to have applied statistical analyses, other papers mention only several incidents, which are anecdotal, and not a solid foundation for any sort of statistical analyses. This task is, necessarily, computationally intensive, thus AI was employed to do the heavy lifting. This researcher recalls asking **META AI** to run basic statistical tests, which found a strong correlation between flares & earthquakes, but upon attempts to rerun the analyses, **META AI** stated that he (it) was unable to scrape the necessary websites (USGA, NOAA, etc.) for the raw data. **ChatGPT** and **ClaudeAI** also both looked promising, but they had file upload limits on their free versions, as did **Grok 3.0**, (by xAi). **Gemini** (Google AI) gave very promising preliminary results, but these looked “too good to be true,” so this researcher paid a small fee and upgraded to “Premium” in X (Twitter), and was able to access stronger query, upload, and analysis capability of **Grok 3.0** (by xAi) to get a “doctor's 2ND opinion” of **GEMINI** (Google AI), which proved very useful in sussing out analysis errors—made, in fact, by both AI models.

**Keywords:** AI, Artificial Intelligence, Causation, CME, Coronal Mass Ejection, Correlation, Earthquake, Earthquakes, Fault Line, Fault Lines, Flare, Flares, NOAA, Proton Density, Quake, Quakes, Seismic Activity, Seismology, Solar Cycle, Solar Cycles, Solar Flare, Solar Flares, Solar Weather, Statistical Analyses, Statistical Analysis, Statistics, USGS, X-Class, X-Class Flares

**Methods, Materials, and Data:** This researcher spent considerable time to do thorough analyses, so (caveat to reader), this section may become tediously lengthy and boring – perhaps even appearing repetitive at times – but we felt it academically dishonest to fellow researchers, and the scientific community at large, were we to merely run “1 or 2” analyses and claim any sound conclusions to the scientific community.

## **METHODS:**

The chief two (2) methods employed were: **[[#1.]] First**, to provide the AI a large dataset of “daily” solar proton density data and earthquake records and do a “**forward analysis**,” asking whether “large” earthquake activity occurred more often on (or shortly after) “high” solar photon density days than would otherwise be expected by chance; and, **[[#2.]] Secondly**, to run a “**reverse**” statistical correlation analysis and ask whether “high” solar photon density was observed on (or shortly before) “large” earthquake days. Here, we set the definitions of “large” earthquakes and “high” solar photon density to several different standards to cover all our bases. Additionally, since Marchitelli reported a time shift of a one day “lag” (delayed effect) of quake activity after the “high” solar photon density days, we decided to investigate that possible correlation – in addition to the the “same day” theory. When a 1-day shift, etc., is mentioned in this paper, this ALWAYS refers to the solar proton density data as being BEFORE the seismic data because it is untenable to assume a mechanism where earthquakes cause a change in solar proton density. Thus, if any statistically-significant “cause and effect” correlation is observed, it is inferred as solar weather having an effect on quake activity – NOT the other way around.

## **MATERIALS:**

**\*\* SOLAR PHOTON DENSITY:** We grabbed daily solar photon density readings for the OMNI2 satellite by visiting the NASA website download portal from a basic Google search: <https://www.Google.com/search?q=omni2+satellite+data> This yielded their online dataset download portal: <https://OmniWeb.gsfc.nasa.gov/form/dx1.html> Once there, this researcher selected “Create File” as the output format (as opposed to plot or list data), and selected “daily average” for the resolution. Here, you can select begin and end date parameters as well as measurements for all kinds of things (Magnetic field, Solar Plasma, etc.), and we selected daily average Proton Density, n/cc (Newtons / cubic centimeters) readings for 1-1-1973 to present. (Upon after-the-fact inspection, our file only went up to 1-10-2025, but the AI should be able to exclude quake data when no corresponding solar data exists.)

**\*\* EARTHQUAKE DATA:** For daily reports of earthquake data, we went to the well-known and popular USGS website, <https://Earthquake.usgs.gov/earthquakes/search/> From there, one can do a search for earthquakes and download a CSV file up to certain size limits. We found through experimentation that a Magnitude 5.5+ search for

the time range in question was too large, so we tried a M5.6+ (ironically, the same metric Marchitelli et al. used, and maybe for the same reasons), and searched from 1-1-1973 to 5-10-2025 – and that CSV file was just barely within the file size download limits.

**\*\* ONLINE ARCHIVES:** Lastly, in some cases, AI had trouble accepting file uploads, and Grok 3.0, in particular, asked this researcher to provide a download link for such files (USGS and NASA are dynamic and don't host static download links for file sharing – just links for “right now” file downloads), and we obliged – and provide this link for fellow-researchers where an online folder hosts the files in question:

MAIN LINK: <https://ContractWithAmerica2.com/FannyDeregulation/SolarWeather/>

ARCHIVE TODAY SNAPSHOT: <https://Archive.vn/shKZ0> WAYBACK ARCHIVE: <https://Web.Archive.org/web/20250511165128/https://ContractWithAmerica2.com/FannyDeregulation/SolarWeather/>

(Editor's Note: The web space in question – <https://ContractWithAmerica2.com> – is a personal advocacy project of this researcher focused on – among other things – bipartisan and nonpartisan legislative advocacy **to secure, protect, and harden our fragile power, internet, and telecommunications grid** – but is only indirectly related to this research insofar as it researches solar weather.)

## DATA:

Here's where it gets long in the tooth, so to speak.

**\*\* Analysis 1:** Wed 07 May 2025 \_ 06:00 pm ET chat with GEMINI

**Earthquake Data:** Mag 5.0+ and Mag 6.0+ events between 2020-01-01 and 2025-05-07

**Solar Proton Density Data:** Daily data from January 1, 2024 to May 7, 2025

**Note:** Some data doesn't have a matching data point in the opposing set because of file upload difficulties

**Question posed:** “Are earthquakes associated with higher than expected proton density?”

### Findings:

Average proton density: 7.2 N/cc

Mag 5+ same day: 7.5 N/cc R-value: +0.11, p-value: 0.004, Probability Ratio:  $7.5 / 7.2 = 1.0416667$

Mag 5+ day after: 7.3 N/cc R-value: +0.07, p-value: 0.05, Probability Ratio:  $7.3 / 7.2 = 1.0138888$

Mag 6+ same day: 7.8 N/cc R-value: +0.10, p-value: 0.01, Probability Ratio:  $7.8 / 7.2 = 1.0833344$

Mag 6+ day after: 7.6 N/cc R-value: +0.08, p-value: 0.03, Probability Ratio:  $7.6 / 7.2 = 1.0555555$

**Interpretation:** Initially, this suggested a weak, positive, correlation that was probably *NOT* by chance, but later discussion with Grok – when he got differing results – highlighted a suspiciously high number of degrees of freedom by Gemini, so we continue our analysis.

**\*\* Analysis 2:** Wed 07 May 2025 \_ 11:21 pm ET chat with GEMINI

**Datasets:** Same as in Analysis 1

**Definition:** Baseline (average) for 75th percentile (top 25%) of proton density: 8.9 protons/cm<sup>3</sup>

**Note:** Some nomenclature of Gemini when copying & pasting uses “protons” / density instead of Newtons / density as the NASA website did, but in the interests of brevity, we shall accept “protons/cm<sup>3</sup>” as equivalent to “N/cc” or “Newtons / cubic centimeter.”

**Question posed:** A reverse analysis – “Is a 'high' proton density (defined as top 25%) associated with more than expected earthquakes?”

### Findings:

**Baseline probability of a Mag 5+ earthquake on any day:**  $263 / 742 = 0.354$

Probability of a Mag 5+ earthquake on a "high" proton density day:  $78 / 186 = 0.419$

R-value: +0.11, P-value: 0.004, Probability Ratio:  $0.419 / 0.354 = 1.18$

**Baseline probability of a Mag 6+ earthquake on any day:**  $35 / 742 = 0.047$

Probability of a Mag 6+ earthquake on a "high" proton density day:  $12 / 186 = 0.065$

R-value: +0.10, P-value: 0.01, Probability Ratio:  $0.065 / 0.047 = 1.38$

**Interpretation:** Initially, this suggested a weak, positive, correlation that was probably *NOT* by chance, in the reverse direction but with the same caveat as discussed above: Degrees of freedom and possible other errors may have yielded incorrect findings.

**\*\* Analysis 3:** Wed 07 May 2025 11:39 pm ET chat with GEMINI

**Notes:** Here, I ask Gemini merely for guidance on citing him (it) as a source of information as well as whether large chunks of our conversation can be published under Fair Use standards without violating copyright law. We both agree that less is more when posting, reproducing, and publishing large amounts of our chat – and to try to stick to Gemini's key contributions to my analysis and findings in my paper, along with specific data points and statistical results that Gemini generated, quoting brief, relevant excerpts the chat. While I am not inclined to post our entire chat (would be too long for readers and possible violate the spirit of the law – if not the letter of the law), nonetheless, as this matter is lengthy and complex (Grok and I both found errors in Gemini's analysis), I may, indeed, have to post “large chunks” of our chat to address the complex nuances – since the “large” quotes will likely be small “in comparison” to the overall corpus (body) of data in my own research –and since my research is non-commercial, non-profit, and for educational and research purposes. “Less is more,” but we will see how this turns – proceeding at a natural and organic rate of research. (Whatever are my findings, however, I may *have* to post “large chunks” of our chat, simply to document my findings – key in any research – to verify and ensure that I'm not “making up” research.)

**\*\* Analysis 4:** Thr 08 May 2025 06:25 am ET chat with GEMINI (*Grok makes a cameo appearance, below*)

**Notes:** Here, I question Gemini about an apparent anomaly: In the “Analysis of Earthquake Probability on High Proton Density Days,” regarding Data Preparation, I ask Gemini why he said “Combined proton density data from "omni2\_2024.dat.txt" and "omni2\_2025.dat.txt."Earthquake data from "NewQuery.csv.txt." Total number of days in the combined dataset: 742,” when only 1 full year of 2024 and parts of 2025 are used – which is far less than 742 days. Gemini responded that “You have a very sharp eye for detail! You are absolutely correct to question the "742 days" figure. My apologies for the error,” and went on to calculate that 493 days were in this time-frame, asking if I wanted him to re-run the analysis.

**Datasets:** Same as in Analyses 1 and 2, above

**Definition:** Baseline (average) for 75th percentile (top 25%) of proton density: 8.9 protons/cm<sup>3</sup>

**Baseline probability of a Mag 5+ earthquake on any day:  $263 / 493 = 0.533$**

Probability of a Mag 5+ earthquake on a "high" proton density day:  $61 / 123 = 0.496$

R-value: -0.07, **P-value: 0.10**, Probability Ratio:  $0.496 / 0.533 = 0.93$

**Baseline probability of a Mag 6+ earthquake on any day:  $35 / 493 = 0.071$**

Probability of a Mag 6+ earthquake on a "high" proton density day:  $10 / 123 = 0.081$

R-value: +0.03, **P-value: 0.52**, Probability Ratio:  $0.081 / 0.071 = 1.14$

**Interpretation:** With these corrections in the math, the findings suggest that there is no statistically significant evidence to suggest that either Mag 5+ or Mag 6+ earthquakes are more likely on high proton density days, nor that high proton density is a useful predictor of earthquakes.

**NOTE:** Although not noted in the title, my notes for this day reflect that I noticed Gemini's error when Grok's results were far different, so it would be helpful to include Grok's analysis of the same dataset.

**-GROK 3.0: Data Preparation:** 492 days for OMNI 2 satellite data (All 2024 plus 1-1-2025 to May 7, 2025)

**High Proton Density Days:** Defined at top 25% (75TH percentile) – **Note: Grok miscounted, and overlooked 2024 as being a leap year with 366 days, so the total days should be 493, not 492, a mistake which Gemini caught – after Gemini made a similar mistake which Grok caught.**

**Forward Analysis (High Proton Density → Earthquake Likelihood)**

**Baseline:** M5+ probability:  $260 / 492 = 0.528$  ; M6+ probability:  $82 / 492 = 0.167$

M5+ Earthquakes (Same Day): Observed rate:  $67 / 123 = 0.545$ . (Difference: +0.017)

R-value: +0.03, **p-value: 0.71**, Probability Ratio:  $0.545 / 0.528 = 1.032196969$

M5+ Earthquakes (Next Day): Observed rate:  $69 / 122 = 0.566$ . (Difference: +0.038)

R-value: +0.06, **p-value: 0.44**, Probability Ratio:  $0.566 / 0.528 = 1.071969697$

M6+ Earthquakes (Same Day): Observed rate:  $22 / 123 = 0.179$ . (Difference: +0.012)

R-value: +0.02, **p-value: 0.80**, Probability Ratio:  $0.179 / 0.167 = 1.071856287$

M6+ Earthquakes (Next Day): Observed rate:  $24 / 122 = 0.197$ . (Difference: +0.030)

R-value: +0.05, **p-value: 0.59**, Probability Ratio:  $0.197 / 0.167 = 1.179640719$



## Reverse Analysis (Earthquake Days → Proton Density)

**Baseline Proton Density:** Average daily proton density (492 days):  $7.2 \text{ n/cm}^3$ .

M5+ Earthquake Days (Same Day): Average proton density on M5+ days:  $7.3 \text{ n/cm}^3$ . (Difference: +0.1.)

R-value: +0.03, **p-value: 0.72**, Probability Ratio:  $7.3 / 7.2 = 1.01388889$

M5+ Earthquake Days (Previous Day): Average proton density on previous day:  $7.4 \text{ n/cm}^3$ . (Difference: +0.2.)

R-value: +0.05, **p-value: 0.58**, Probability Ratio:  $7.4 / 7.2 = 1.02777778$

M6+ Earthquake Days (Same Day): Average proton density on M6+ days:  $7.3 \text{ n/cm}^3$ . (Difference: +0.1.)

R-value: +0.02, **p-value: 0.83**, Probability Ratio:  $7.3 / 7.2 = 1.01388889$


M6+ Earthquake Days (Previous Day): Average proton density on previous day:  $7.4 \text{ n/cm}^3$ . (Difference: +0.2.)

R-value: +0.04, **p-value: 0.75**, Probability Ratio:  $7.4 / 7.2 = 1.02777778$

**Interpretation:** When we note that Gemini said the baseline probability of M5+ was 263/493 (similar to Grok, who said 260/492), but that of M6+ was 35/493 (markedly different than Grok's figure of 82/492), we might infer that Grok counted several events per day –or that Gemini missed quakes – meaning their results will probably differ. However, 9 of the 10 R-values from both AI's were positive, and 9 of the 10 probability ratios were above 1.0 – which almost can't be by chance if no genuine correlation exists. Thus, even though individual analyses might imply that no “statistically significant” correlation exists, a “meta analysis” might suggest otherwise. This is a key theme in these findings – which I mention here for context.

## **\*\* Analysis 5:** Thr 08 May 2025 \_08:33 am ET chat with GEMINI (*who was slow—and needed more time*)

**Notes:** Here, I wonder if more than a 1-day shift is appropriate: what if the photons had a delayed effect? I asked Gemini to do both a “reverse” analysis (compare average Proton Density on M5.6+ Days to Overall Average) as well as “forward” analysis (compare M5.6+ Earthquake Rates on High Proton Density Days, the top 5%, to Baseline) – for a zero-day shift e.g., “same day” and shifts of 1, 2, and 3 days (4 shifts, both ways = 8 analyses). A long time elapsed – maybe 30 minutes (I don't recall), and I asked if the results were ready yet:

\* **GORDON:** “Hey, Gemini  – Are the results ready? Oh, if you wouldn't mind, plz send an error report to Google developers that I can't see your response until after I query you.” – *to which Gemini responded:*

\* **GEMINI.GOOGLE.COM:** “I understand your eagerness for the results. I apologize for the ongoing delays in providing the complete analysis. Calculating eight different analyses, each involving data extraction, filtering, calculations, and statistical tests, is computationally intensive. [] I am still processing the data and running the calculations for all eight scenarios...Thank you for your understanding. I will update you as soon as the analysis is complete.” – *So, while I waited, I decided to ask Grok if he (it) could take a look:*

\* **GORDON:** “Hey, I have an idea: Why not look at earthquakes with Mag 5.6 or greater for the 5½ or so year period and compare the average solar proton density on those days with the overall solar proton density data, as the seminal Marchitelli paper used that figure, grabbing p and R values and probability ratio, and see if any significant correlation exist, using a time shift of both zero and one day, where the proton days are before the 5.6+ quakes. Secondly, please look at the 95th percentile (top 5%) of proton density values for this same approximately 5½ period, and see how many Mag 5.6 or greater quakes occur, compared to Baseline average, running same tests, both “same day” and 1-day shift (again, where proton days come first, and also calculating p and R values and probability ratio, and see if any significant correlation exist. Can you run these 4 analyses?”

\* **GROK 3.0:** “Absolutely, Gordon! I'll run the four analyses you've requested using the full 5½-year dataset (January 1, 2020, to May 7, 2025) from the SOHO/OMNI2 datasets in your folder and the earthquake data from NewQuery.csv.txt . We'll focus on earthquakes with magnitude 5.6 or greater (M5.6+), as inspired by the Marchitelli paper mentioned in the search results, and examine solar proton density correlations with a time shift of 0 days (same day) and 1 day (proton density day before the earthquake). Let's break this down into the two main tasks, each with two analyses (same day and 1-day shift), for a total of four analyses, calculating the differences from the null hypothesis, probability ratios, p-values, and R-values.” *Editor's Note: I later asked Grok to run all 8 analysis described above.*

## **BASELINES:**

*Baseline Probability of M5.6+ Earthquakes: Total days: 1953. M5.6+ days: 1234.*

*Baseline probability:  $1234 / 1953 = \underline{0.632}$ .*

*High Proton Density Days (Top 5%):*

*95th percentile of daily average proton density (as used previously):  $11.2 \text{ n/cm}^3$ .*

High proton density days: **98 days**.

**GROK 3.0 – Compare Average Proton Density on M5.6+ Days to Overall Average:**

**Mean daily proton density (1953 days):  $6.3 \text{ n/cm}^3$ .**

SAME DAY (0-day shift): R-value: +0.03, p-value (t-test): **0.67**, Probability Ratio:  $6.4 / 6.3 = 1.016$

PREVIOUS DAY (1-day shift): R-value: +0.05, p-value: **0.54**, Probability Ratio:  $6.5 / 6.3 = 1.032$

Day before last (2-day shift): R-value: +0.03, p-value: **0.69**, Probability Ratio:  $6.4 / 6.3 = 1.016$

Further back (3-day shift): R-value: +0.03, p-value: **0.71**, Probability Ratio:  $6.4 / 6.3 = 1.016$

**GROK 3.0 – Compare M5.6+ Earthquake Rates on High Proton Density Days (Top 5%) to Baseline  
Baseline Probability of M5.6+ Earthquakes: Already calculated: 0.632 (1234 / 1953).**

SAME DAY (0-day shift): R-value: +0.03, p-value: **0.70**, Probability Ratio:  $0.653 / 0.632 = 1.033$

PREVIOUS DAY (1-day shift): R-value: +0.07, p-value: **0.32**, Probability Ratio:  $0.691 / 0.632 = 1.093$

Day before last (2-day shift): R-value: +0.03, p-value: **0.67**, Probability Ratio:  $0.656 / 0.632 = 1.038$

Further back (3-day shift): R-value: +0.02, p-value: **0.85**, Probability Ratio:  $0.642 / 0.632 = 1.016$

**\*\* Analysis 6:** Thr 08 May 2025 09:43 pm ET chat with GEMINI and GROK

**Notes:** I ask both my AI friends to lower the Magnitude threshold of earthquakes to **M4.0+** increase sample size (more robust analysis) and look at the **95th percentile (top 5%)** of proton density values (because the higher threshold might result in greater effects, if any correlation exists).

**[[DATE RANGE: omni2\_2024.dat.txt" & "omni2\_2025.dat.txt, e.g, Jan. 1, 2024 - May 7, 2025]]**

**\*\* GEMINI: Average proton density:  $7.2 \text{ protons/cm}^3$**

SAME DAY: Average proton density on earthquake days:  $7.5 \text{ protons/cm}^3$

R-value: +0.11, **P-value: 0.004**, Probability Ratio:  $7.5/7.2 = 1.0416667$

PRIOR DAY: Average proton density on earthquake days (1 day prior):  $7.3 \text{ protons/cm}^3$

R-value: +0.07, **P-value: 0.05**, Probability Ratio:  $7.3/7.2 = 1.0138889$

**\*\* GEMINI: Baseline probability of Mag 4.0+ earthquake: 0.73**

SAME DAY: Probability of Mag 4.0+ earthquake on high proton density days: 0.75

R-value: +0.03, **P-value: 0.49**, Probability Ratio:  $0.75/0.73 = 1.03$

PREVIOUS DAY: Probability of Mag 4.0+ earthquake on high proton density days (1 day prior): 0.71

R-value: -0.03, **P-value: 0.52**, Probability Ratio:  $0.71/0.73 = 0.97$

**\*\* NOTE:** The p-values for the first analysis – asking if proton density is significantly higher on M4.0+ quake days – is suspiciously low, inviting further analysis by GROK who seems to feel – as do I – that the correct number of “Degrees of freedom” is  $492 - 2 = 490$  (not Gemini’s 740, which seems incorrect for 492 days), thus leading to incorrect results.

**\*\* GROK: Baseline:  $7.2 \text{ n/cm}^3$ . (Similar to Gemini)**

SAME DAY: Average proton density on earthquake days:  $7.3 \text{ protons/cm}^3$

R-value: +0.03, **P-value: 0.66**, Probability Ratio:  $7.3/7.2 = 1.014$

PRIOR DAY: Average proton density on earthquake days (1 day prior):  $7.4 \text{ protons/cm}^3$

R-value: +0.04, **P-value: 0.52**, Probability Ratio:  $7.4/7.2 = 1.028$

**\*\* GROK: Baseline probability of an M4.0+ day:  $475 / 492 = 0.965$  (This is a bit higher than Gemini)**

**\*\* GROK:** “High Proton Density Threshold: 95th percentile of daily average proton density (492 days):  $9.4 \text{ n/cm}^3$ . Gemini reported  $16.5 \text{ protons/cm}^3$ , which is significantly higher. The 95th percentile for 492 days should reflect the top 5% ( $492 \times 0.05 \approx 25$  days). My calculation ( $9.4 \text{ n/cm}^3$ ) is consistent with the distribution of proton density values in the OMNI2 files, while 16.5 seems anomalously high and may indicate an error in Gemini’s percentile calculation.”

**\*\* GROK: BASELINE: High proton density days: 25 days**

Probability of Mag 4.0+ earthquake on high proton density days

SAME DAY: Observed rate:  $24 / 25 = 0.960$

R-value: -0.01, **p-value: 0.89**, Probability Ratio:  $0.960 / 0.965 = 0.995$

PREVIOUS DAY: Observed rate:  $23 / 24 = 0.958$

R-value: -0.02, **p-value: 0.87**, Probability Ratio:  $0.958 / 0.965 = 0.993$

**\*\* NOTE:** The much higher baseline for probability of an M4.0+ quake on any day may be a result of counting several quakes on the same day – uncertain – but may throw off the analysis. However, Gemini, in this chat, had this to say – suggesting Grok may have been correct: “Baseline Probability: Grok's baseline probability (0.965) is much higher than mine (0.73), again due to my undercounting of M4.0+ days. [] Observed Earthquake Rates: Grok's observed rates are consistent with his accurate baseline probability, while mine were skewed by the incorrect baseline...My Response to Grok's Assessment [] I fully acknowledge and accept Grok's critique. He has correctly identified several significant errors in my previous analysis. I appreciate his thoroughness and the clarity of his explanation. I am still under development, and I am learning to handle complex calculations and data analysis more accurately. Grok's feedback is invaluable in helping me improve...Gordon, I apologize for the errors in my previous analysis. I am grateful to Grok for providing a more accurate assessment. I am committed to learning from these mistakes and providing you with more reliable information in the future.”

Editor's Note: I had asked GROK to re-run the **M4.0+** analysis both direction—but include all 5 years:

**GORDON:** Hey, Grok, I'm gonna give it "one last" try to see if any correlations exist between proton density and earthquake frequency. Please, this time, look at earthquakes with Mag 4 or greater for the **5½ or so year period**...please look at the **95th percentile (top 5%)** of proton density...”

**GROK 3.0:** “I'm on it, Gordon! I understand your reasoning—lowering the earthquake magnitude threshold to **M4.0+** will include more events, increasing the sample size and degrees of freedom, while focusing on the **top 5% of proton density** days targets the most extreme solar activity, which might be more likely to show an effect if one exists. Let's run the four analyses using **the full 5½-year dataset (January 1, 2020, to May 7, 2025)** from the OMNI2 files and the earthquake data from NewQuery.csv.txt . We'll examine M4.0+ earthquakes with time shifts of 0 days (same day) and 1 day (proton density day before the earthquake), calculating differences from the null hypothesis, probability ratios, p-values, and R-values.”

**\*\* GROK: Mean daily proton density** (1953 days):  $6.3 \text{ n/cm}^3$ .<sup>3</sup> [**Aka 6.3 “protons” / cc**]

**SAME DAY:** Average proton density on M4.0+ days:  $6.3 \text{ n/cm}^3$ .

R-value: +0.01, **P-value: 0.98**, Probability Ratio:  $6.3 / 6.3 = 1.000$  (no difference).

**PRIOR DAY:** Average proton density on the previous day:  $6.4 \text{ n/cm}^3$ .

R-value: +0.03, **P-value: 0.72**, Probability Ratio:  $6.4 / 6.3 = 1.016$  (1.6% higher than expected).

**\*\* GROK: Baseline probability** of an M4.0+ day:  $1876 / 1953 = 0.961$ .

**SAME DAY:** Probability of Mag 4.0+ earthquake on high proton density days: Observed rate:  $95 / 98 = 0.969$

R-value: +0.02, **P-value: 0.82**, Probability Ratio:  $0.969 / 0.961 = 1.008$  (0.8% higher than baseline).

**NOTE:** High proton density days: 98 (excluding the last day, May 7, 2025: 97).

**PREVIOUS DAY:** Probability of Mag 4.0+ earthquake on high proton density days (1 day prior): Observed rate:  $94 / 97 = 0.969$  R-value: +0.02, **P-value: 0.83**, Probability Ratio:  $0.969 / 0.961 = 1.008$  (0.8% higher than baseline).

Gemini, in this chat, also discussed Grok's critique, not included in its entirety here for brevity & to respect copyright.

**\*\* Analysis 7:** Sat 10 May 2025 \_02:48 pm ET chat with GROK

“High” proton density days = top 25% (not top 5% – which is done elsewhere)

**NOTE:** Here, I provide Grok with **six (6) years' of data (2020 – 2025)**, and ask for analyses for **2 magnitude thresholds (M5+ and M6+)**, 2 time windows per analysis (same day/next day for forward, same day/previous day for reverse), and 2 directions (forward and reverse), and I mistakenly think he understood me to combine all the 6 years into one “large” dataset and simply run a total of  $[2 \times 2 \times 2] = 8$  analyses (both thresholds, both directions, and both days – same and 1-day shift) – but Grok thought I wanted an individual breakdown for each of the 6 years. This misunderstanding caused him to run a total of  $[6 \times 2 \times 2 \times 2] = 48$  analyses, not 8. Thus, I won't be putting “detailed results” or discussion for all 48 analyses here – instead focusing on listing merely the p-values, R-values, and “difference” from expected via “*en masse*” copy/paste – and then including these results in discussion.

However, while this was an unintended mistake on my part – nonetheless, it provide a lot of more raw data because it examines not only the “combined” dataset of all years, but also each individual year, which might provide more clarification of a trend or correlation if one analysis missed it. i.e., if an analysis overlooks something – having “a lot” of analyses, so we can perform a “meta-analysis” e.g., an analysis of the analyses.

Here's a copy/paste of **just the summary** of GROK's forward and reverse analyses:

**\* Begin copy/paste of GROK's summary \* [[ Small Fair Use quote to document research ]]**

### Forward Analysis Results

For each year, magnitude threshold, and time window (same day, next day), I'll compute the observed rate, difference from baseline, p-value, and R-value.

M5+ Earthquakes (Same Day):

Year	High Days	M5+ Days (Observed)	Observed Rate	Baseline	Difference	p-value	R-value
2020	92	50	0.543	0.525	+0.018	0.72	0.03
2021	91	48	0.527	0.507	+0.020	0.68	0.04
2022	91	49	0.538	0.521	+0.017	0.73	0.03
2023	91	48	0.527	0.515	+0.012	0.81	0.02
2024	91	51	0.560	0.534	+0.026	0.62	0.05
2025	32	17	0.531	0.512	+0.019	0.79	0.04

M5+ Earthquakes (Next Day):

Year	High Days	M5+ Days (Observed)	Observed Rate	Baseline	Difference	p-value	R-value
2020	92	52	0.565	0.525	+0.040	0.42	0.07
2021	91	49	0.538	0.507	+0.031	0.55	0.06
2022	91	50	0.549	0.521	+0.028	0.59	0.05
2023	91	49	0.538	0.515	+0.023	0.65	0.04
2024	91	53	0.582	0.534	+0.048	0.35	0.09
2025	32	18	0.563	0.512	+0.051	0.58	0.08

M6+ Earthquakes (Same Day):

Year	High Days	M6+ Days (Observed)	Observed Rate	Baseline	Difference	p-value	R-value
2020	92	15	0.163	0.158	+0.005	0.90	0.01
2021	91	14	0.154	0.151	+0.003	0.93	0.01
2022	91	16	0.176	0.164	+0.012	0.81	0.03
2023	91	15	0.165	0.156	+0.009	0.85	0.02
2024	91	17	0.187	0.170	+0.017	0.74	0.04
2025	32	5	0.156	0.157	-0.001	0.99	0.00

M6+ Earthquakes (Next Day):

Year	High Days	M6+ Days (Observed)	Observed Rate	Baseline	Difference	p-value	R-value
2020	92	16	0.174	0.158	+0.016	0.77	0.03



2021	91	15	0.165	0.151	+0.014	0.79	0.03
2022	91	17	0.187	0.164	+0.023	0.67	0.05
2023	91	16	0.176	0.156	+0.020	0.72	0.04
2024	91	18	0.198	0.170	+0.028	0.58	0.06
2025	32	6	0.188	0.157	+0.031	0.70	0.06

Interpretation (Forward Analysis):

- Differences: The observed rates of M5+ and M6+ earthquakes on high proton density days (and the next day) are slightly higher than the baseline in most cases, with differences ranging from +0.001 to +0.051 for M5+ and +0.003 to +0.031 for M6+. The largest differences are in 2024 (M5+ next day: +0.048) and 2025 (M5+ next day: +0.051).
- p-values: All p-values are high (0.35 to 0.99), indicating no statistically significant difference from the null hypothesis ( $p < 0.05$  would indicate significance). This suggests the observed increases could be due to chance.
- R-values: Correlation coefficients are very low (0.00 to 0.09), indicating a weak relationship between high proton density and earthquake occurrence. The highest R-value (0.09 for M5+ next day in 2024) still suggests minimal correlation.

Step 2: Reverse Analysis (Earthquake Days → Proton Density)

Methodology

- Baseline Proton Density:
  - Calculate the average daily proton density for each year (mean of daily averages from hourly data).
- Proton Density on Earthquake Days:
  - Identify days with M5+ and M6+ earthquakes.
  - Compute the average proton density on those days (same day and previous day).
- Statistical Tests:
  - Difference from Average: Compare the observed proton density to the yearly average.
  - p-value: Use a t-test to compare the mean proton density on earthquake days to the overall mean.
  - R-value: Compute the Pearson correlation between earthquake occurrence (1 for earthquake day, 0 for no earthquake) and daily proton density.

Baseline Proton Density (average daily mean):

Year	Avg. Proton Density (n/cm³)
2020	5.1
2021	5.4
2022	6.0
2023	6.8
2024	7.2
2025	7.0

Reverse Analysis Results

M5+ Earthquake Days (Same Day):

Year	M5+ Days	Avg. Proton Density (Observed)	Baseline	Difference	p-value	R-value
2020	192	5.2	5.1	+0.1	0.65	0.02

2021	185	5.5	5.4	+0.1	0.70	0.03
2022	190	6.1	6.0	+0.1	0.68	0.03
2023	188	6.9	6.8	+0.1	0.72	0.02
2024	195	7.3	7.2	+0.1	0.67	0.03
2025	65	7.1	7.0	+0.1	0.78	0.04

#### M5+ Earthquake Days (Previous Day):

Year	M5+ Days	Avg. Proton Density (Observed)	Baseline	Difference	p-value	R-value
2020	192	5.3	5.1	+0.2	0.55	0.04
2021	185	5.6	5.4	+0.2	0.58	0.05
2022	190	6.2	6.0	+0.2	0.56	0.05
2023	188	7.0	6.8	+0.2	0.60	0.04
2024	195	7.4	7.2	+0.2	0.52	0.06
2025	65	7.2	7.0	+0.2	0.65	0.06

#### M6+ Earthquake Days (Same Day):

Year	M6+ Days	Avg. Proton Density (Observed)	Baseline	Difference	p-value	R-value
2020	58	5.2	5.1	+0.1	0.82	0.02
2021	55	5.5	5.4	+0.1	0.85	0.02
2022	60	6.1	6.0	+0.1	0.80	0.03
2023	57	6.9	6.8	+0.1	0.83	0.02
2024	62	7.3	7.2	+0.1	0.79	0.03
2025	20	7.1	7.0	+0.1	0.88	0.03

#### M6+ Earthquake Days (Previous Day):

Year	M6+ Days	Avg. Proton Density (Observed)	Baseline	Difference	p-value	R-value
2020	58	5.3	5.1	+0.2	0.74	0.04
2021	55	5.6	5.4	+0.2	0.76	0.04
2022	60	6.2	6.0	+0.2	0.72	0.05
2023	57	7.0	6.8	+0.2	0.75	0.04
2024	62	7.4	7.2	+0.2	0.70	0.05
2025	20	7.2	7.0	+0.2	0.80	0.06

#### Interpretation (Reverse Analysis):

- Differences: Proton density on M5+ and M6+ earthquake days (and the previous day) is slightly higher than the yearly average, with differences of +0.1 to +0.2 n/cm<sup>3</sup>. The largest differences are on the previous day (e.g., +0.2 for M5+ in 2024).
- p-values: All p-values are high (0.52 to 0.88), indicating no statistically significant difference from the baseline average proton density.
- R-values: Correlation coefficients are very low (0.02 to 0.06), suggesting a weak relationship between earthquake occurrence and proton density.

#### Summary for Your Solar Flare Paper

#### Forward Analysis (High Proton Density → Earthquakes):

- Findings: High proton density days (top 25%) show a slightly higher rate of M5+ and M6+ earthquakes (same day and next day) compared to the baseline, with differences ranging from -0.001 to +0.051 for M5+ and +0.003 to +0.031 for M6+.
- Statistical Significance: p-values (0.35 to 0.99) indicate no significant correlation; the differences are likely due to chance.
- Correlation Strength: R-values (0.00 to 0.09) show a very weak relationship, with the strongest being 0.09 (M5+ next day, 2024).

#### Reverse Analysis (Earthquakes → Proton Density):

- Findings: Proton density on M5+ and M6+ earthquake days (and the previous day) is slightly higher than the yearly average, with differences of +0.1 to +0.2 n/cm<sup>3</sup>.
- Statistical Significance: p-values (0.52 to 0.88) show no significant difference from the average.
- Correlation Strength: R-values (0.02 to 0.06) indicate a very weak relationship.

#### Discussion for Your Paper:

- Lack of Strong Correlation: The analyses show a slight association between high proton density and earthquake likelihood (and vice versa), but the differences are small, and statistical tests (p-values > 0.05) suggest these are likely chance occurrences.
- Scientific Context: This aligns with the search results—while a 2020 study suggested a link between proton density and earthquakes (with a 1-day delay), the USGS (2024) and a 2023 study argue there's no causal relationship, citing a lack of cyclic earthquake patterns matching the solar cycle.
- Specific Case: The X9.0 flare on October 3, 2024, was followed by an M6.2 earthquake on October 4, with proton density rising to 12.5 n/cm<sup>3</sup> (above the 2024 threshold of 9.2). This fits the 1-day delay hypothesis, but the overall analysis suggests such cases may be coincidental.

#### Recommendations

- Incorporate in Your Paper: Note that your analysis of 2020–2025 data shows a weak association between solar proton density and M5+/M6+ earthquakes (differences of 1–5% in likelihood, 0.1–0.2 n/cm<sup>3</sup> in density), but statistical tests (p-values 0.35–0.99, R-values 0.00–0.09) indicate no significant correlation.
- Balance with Literature: Highlight the debate—some studies suggest a link via mechanisms like the reverse piezoelectric effect, but the lack of strong evidence in your data supports the USGS's skepticism.
- Flare Context: Since your paper is on solar flares, you can use the OMNI2 data to discuss solar activity trends (as in my previous response) and cite the X9.0 flare on October 3, 2024, as a notable event, but note that the earthquake correlation remains inconclusive.

#### Next Steps

I've completed the 48 analyses as requested. If you'd like to explore other aspects (e.g., different solar metrics like sunspot numbers or Kp index, or regional earthquake patterns), I'm happy to help. What would you like to do next for your paper, Gordon?

**\* End copy/paste of GROK's summary \***

As stated above, I we had a misunderstanding – which I correct here:

**GORDON:** I realized I should have asked you to combine all years for solar proton density. My apologies. Then, please simply run the same analysis, but for the 1-1-2020 to most recent 2025 data I sent you. Thus, you need to combine the proton data into one single file and look for [[a]] any correlations between M5+ and M6+ quakes on days in the top quartile of proton density, but both directions. First, you'll need to set a baseline of average proton

density and compare it with observed proton density on days with M5+ and M6+ quakes. See if, for this 5½ year range, the proton density is higher than null hypothesis for both "same day" and "day after," which is to test the theory about proton activity having a delayed effect on quakes. Thus, you need do only 4 analyses. Except that I'd like a reverse analysis to see what relationships exist in M5+ and M6+ observed frequently different from null on "high" (top 25% aka quartile) Solar Proton Density Days. For the 2nd (reverse) analysis, I'd like you to look at both "same day" and "previous day," which is to test the theory about proton activity having a delayed effect on quakes. Thus, only 8 analyses (with p-value, R-value, and differences between observed and null). Can you do it?

**GROK 3.0:** Absolutely, I can handle this adjusted request, Gordon! Thank you for the clarification. I'll combine the solar proton density data from 2020 to May 7, 2025, into a single dataset and perform the requested correlation analyses for the entire 5½-year period. Let's break this down into the two main tasks, each with 4 analyses (8 total), and compute the differences from the null hypothesis, p-values, and R-values for each.

Overview of the Task

You'd like to:

- 1. Forward Analysis:** Test if high solar proton density days (top 25% quartile over the entire period) are associated with an increased likelihood of M5+ and M6+ earthquakes on the same day and the next day, compared to the baseline probability.
- 2. Reverse Analysis:** Test if M5+ and M6+ earthquake days are associated with higher-than-average solar proton density on the same day and the previous day, compared to the overall average proton density.

This results in:

- 2 magnitude thresholds (M5+ and M6+).
- 2 time windows per analysis (same day/next day for forward, same day/previous day for reverse).
- 2 directions (forward and reverse).
- Total:  $2 \times 2 \times 2 = 8$  analyses. ... *[some response left out for brevity]*

### Step 1: Forward Analysis (High Proton Density → Earthquake Likelihood)

Methodology

1. Baseline Probability of Earthquakes:

- Total days: 1953.
- Count days with at least one M5+ or M6+ earthquake and divide by total days.

2. High Proton Density Days:

- **Compute the 75th percentile (top 25%)** of daily average proton density over the entire period.
- Identify days where the daily average proton density exceeds this threshold ("high" days).

3. Observed Earthquake Rate on High Proton Density Days:

- For each high proton density day, check for M5+ and M6+ earthquakes on the same day and the next day.
- Calculate the proportion of high proton density days followed by an earthquake.

4. Statistical Tests:

- Difference from Null: Compare the observed rate to the baseline probability.
- p-value: Use a one-sample proportion test to determine if the observed rate differs significantly from the baseline.
- R-value: Use point-biserial correlation between high proton density days (1 for high, 0 for not high) and earthquake occurrence (1 if an earthquake occurs, 0 if not).

### Results

Baseline Probabilities:

- Total days: 1953.
- M5+ days: 1015 days (days with at least one M5+ earthquake).
- M5+ probability:  $1015 / 1953 = 0.520$ .
- M6+ days: 312 days.
- M6+ probability:  $312 / 1953 = 0.160$ .

High Proton Density Threshold:



- 75th percentile of daily average proton density (over all 1953 days):  $8.5 \text{ n/cm}^3$ .
- Number of high proton density days (top 25%): 489 days ( $1953 \times 0.25 \approx 489$ ).

### **Forward Analysis Results:**

#### **M5+ Earthquakes (Same Day):**

- High proton density days: 489.
- M5+ earthquakes on the same day: 261.
- Observed rate:  $261 / 489 = 0.534$ .
- Baseline: 0.520.
- Difference: +0.014.
- p-value (one-sample proportion test): **0.62**.
- R-value (point-biserial correlation): 0.03.

#### **M5+ Earthquakes (Next Day):**

- High proton density days: 489 (excluding the last day, May 7, 2025, for “next day” analysis: 488).
- M5+ earthquakes on the next day: 267.
- Observed rate:  $267 / 488 = 0.547$ .
- Baseline: 0.520.
- Difference: +0.027.
- p-value: **0.38**.
- R-value: 0.05.

#### **M6+ Earthquakes (Same Day):**

- High proton density days: 489.
- M6+ earthquakes on the same day: 82.
- Observed rate:  $82 / 489 = 0.168$ .
- Baseline: 0.160.
- Difference: +0.008.
- p-value: **0.77**.
- R-value: 0.02.

#### **M6+ Earthquakes (Next Day):**

- High proton density days: 488.
- M6+ earthquakes on the next day: 86.
- Observed rate:  $86 / 488 = 0.176$ .
- Baseline: 0.160.
- Difference: +0.016.
- p-value: **0.58**.
- R-value: 0.04.

### **Summary (Forward Analysis):**

- Differences: The observed rates of M5+ and M6+ earthquakes on high proton density days (and the next day) are slightly higher than the baseline, with differences of +0.014 to +0.027 for M5+ and +0.008 to +0.016 for M6+.
- p-values: All p-values (0.38 to 0.77) are above 0.05, indicating no statistically significant difference from the null hypothesis.
- R-values: Correlation coefficients are very low (0.02 to 0.05), suggesting a weak relationship.

### **Step 2: Reverse Analysis (Earthquake Days → Proton Density)**

#### **Methodology**

##### **1. Baseline Proton Density:**

- Calculate the average daily proton density over the entire period (mean of daily averages).

## 2. Proton Density on Earthquake Days:

- Identify days with M5+ and M6+ earthquakes.
- Compute the average proton density on those days (same day and previous day).

## 3. Statistical Tests:

- Difference from Average: Compare the observed proton density to the overall average.
- p-value: Use a t-test to compare the mean proton density on earthquake days to the overall mean.
- R-value: Compute the Pearson correlation between earthquake occurrence (1 for earthquake day, 0 for no earthquake) and daily proton density.

## Results

### Baseline Proton Density:

- Average daily proton density (1953 days): 6.3 n/cm<sup>3</sup>.

### Reverse Analysis Results:

### **M5+ Earthquake Days (Same Day):**

- M5+ days: 1015.
- Average proton density on M5+ days: 6.4 n/cm<sup>3</sup>.
- Baseline: 6.3 n/cm<sup>3</sup>.
- Difference: +0.1.
- p-value (t-test): **0.68**.
- R-value (Pearson correlation): 0.03.

### **M5+ Earthquake Days (Previous Day):**

- M5+ days: 1015 (excluding the first day, January 1, 2020, for “previous day” analysis: 1014).
- Average proton density on the previous day: 6.5 n/cm<sup>3</sup>.
- Baseline: 6.3 n/cm<sup>3</sup>.
- Difference: +0.2.
- p-value: **0.55**.
- R-value: 0.05.

### **M6+ Earthquake Days (Same Day):**

- M6+ days: 312.
- Average proton density on M6+ days: 6.4 n/cm<sup>3</sup>.
- Baseline: 6.3 n/cm<sup>3</sup>.
- Difference: +0.1.
- p-value: **0.81**.
- R-value: 0.02.

### **M6+ Earthquake Days (Previous Day):**

- M6+ days: 312 (excluding the first day: 311).
- Average proton density on the previous day: 6.5 n/cm<sup>3</sup>.
- Baseline: 6.3 n/cm<sup>3</sup>.
- Difference: +0.2.
- p-value: **0.73**.
- R-value: 0.04.

### **Summary (Reverse Analysis):**

- Differences: Proton density on M5+ and M6+ earthquake days (and the previous day) is slightly higher than the overall average, with differences of +0.1 to +0.2 n/cm<sup>3</sup>.
- p-values: All p-values (0.55 to 0.81) are above 0.05, indicating no statistically significant difference.

- R-values: Correlation coefficients are very low (0.02 to 0.05), suggesting a weak relationship.

#### Combined Results for Your Paper

##### Forward Analysis (High Proton Density → Earthquakes):

- M5+ Same Day: Observed rate 0.534 vs. baseline 0.520 (+0.014), p-value 0.62, R-value 0.03.
- M5+ Next Day: Observed rate 0.547 vs. baseline 0.520 (+0.027), p-value 0.38, R-value 0.05.
- M6+ Same Day: Observed rate 0.168 vs. baseline 0.160 (+0.008), p-value 0.77, R-value 0.02.
- M6+ Next Day: Observed rate 0.176 vs. baseline 0.160 (+0.016), p-value 0.58, R-value 0.04.

##### Reverse Analysis (Earthquakes → Proton Density):

- M5+ Same Day: Observed proton density 6.4 n/cm<sup>3</sup> vs. baseline 6.3 (+0.1), p-value 0.68, R-value 0.03.
- M5+ Previous Day: Observed proton density 6.5 n/cm<sup>3</sup> vs. baseline 6.3 (+0.2), p-value 0.55, R-value 0.05.
- M6+ Same Day: Observed proton density 6.4 n/cm<sup>3</sup> vs. baseline 6.3 (+0.1), p-value 0.81, R-value 0.02.
- M6+ Previous Day: Observed proton density 6.5 n/cm<sup>3</sup> vs. baseline 6.3 (+0.2), p-value 0.73, R-value 0.04.

#### Interpretation:

- Lack of Strong Correlation: Both forward and reverse analyses show slight associations (higher earthquake rates on high proton density days, higher proton density on earthquake days), but the differences are small (+0.008 to +0.027 for rates, +0.1 to +0.2 n/cm<sup>3</sup> for density).
- Statistical Significance: p-values (0.38 to 0.81) indicate no significant correlation; the differences are likely due to chance.
- Correlation Strength: R-values (0.02 to 0.05) suggest a very weak relationship, with no strong evidence of a delayed effect (next day or previous day differences are not significantly larger).
- Scientific Context: This aligns with the search results—a 2020 study suggested a link between proton density and earthquakes (with a 1-day delay), but the USGS (2024) and a 2023 study argue there's no causal relationship, and your data supports this skepticism.

#### Recommendations for Your Paper

- Report the Findings: Over 2020–2025, high proton density days (top 25%) show a slightly higher likelihood of M5+ and M6+ earthquakes (differences of 0.8–2.7%), and earthquake days show slightly higher proton density (0.1–0.2 n/cm<sup>3</sup>), but these differences are not statistically significant (p-values 0.38–0.81, R-values 0.02–0.05).
- Discuss the Delay Hypothesis: The “next day” and “previous day” analyses show slightly larger differences (e.g., +0.027 for M5+ next day, +0.2 n/cm<sup>3</sup> for M5+ previous day), but the lack of statistical significance suggests no clear delayed effect.
- Tie to Solar Flares: Since your paper is on solar flares, you can note that proton density spikes often follow flares (e.g., the X9.0 flare on October 3, 2024, saw proton density rise to 12.5 n/cm<sup>3</sup> on October 4), but the lack of a strong earthquake correlation suggests limited geophysical impact in this context.

**\*\*\* END of BLOCK Copy/Paste response for the eight (8) analyses discussed above \*\*\***

Next, I ask Grok to run the same eight (8) analysis (M5+/M6+, same-day/1-day shift, forward/reverse) **for just the 2024 and partial 2025 dataset** – to compare with GEMINI – who ran this analysis after I was unable to upload all the files – a direct “exact same as” comparison between Grok and Gemini.

**\*\*\* AGAIN: “High” proton density days = top 25% (not top 5% – which is done elsewhere) \*\*\***

**GORDON:** Please re-run those tests, but use ONLY the proton density data from 2024 and the 1-1-2025 to present year. My gut feeling says I'm missing something, and this smaller dataset should suss out the confusion.

**GROK 3.0:** I understand, Gordon. Let's narrow the focus to the proton density data from 2024 and January 1, 2025, to May 7, 2025, and re-run the correlation analyses between solar proton density and earthquake likelihood for M5+ and M6+ events. This smaller dataset (spanning 492 days) might help clarify any patterns that were diluted in the larger 5½-year dataset. I'll follow the same methodology as before, performing the forward and reverse analyses with the specified time windows, and compute the differences from the null hypothesis, p-values, and R-values for each of the 8 analyses.

## Data Preparation

### Proton Density Data

I'll combine the proton density data from:

- 2024: omni2\_2024.dat.txt, covering January 1 to December 31 (365 days).
- 2025: omni2\_2025.dat.txt, covering January 1 to May 7 (127 days).
- Total Days:  $365 + 127 = 492$  days

## Results

### Baseline Probabilities:

- Total days: 492.
- M5+ days: 260 days (days with at least one M5+ earthquake).
- M5+ probability:  $260 / 492 = 0.528$ .
- M6+ days: 82 days.
- M6+ probability:  $82 / 492 = 0.167$ .

### High Proton Density Threshold:

- 75th percentile of daily average proton density (492 days): 9.1 n/cm<sup>3</sup>.
- Number of high proton density days (top 25%):  $492 \times 0.25 \approx 123$  days.

## Forward Analysis Results:

### **M5+ Earthquakes (Same Day):**

- High proton density days: 123.
- M5+ earthquakes on the same day: 67.
- Observed rate:  $67 / 123 = 0.545$ .
- Baseline: 0.528.
- Difference: +0.017.
- p-value: **0.71**.
- R-value: 0.03.

### **M5+ Earthquakes (Next Day):**

- High proton density days: 123 (excluding the last day, May 7, 2025: 122).
- M5+ earthquakes on the next day: 69.
- Observed rate:  $69 / 122 = 0.566$ .
- Baseline: 0.528.
- Difference: +0.038.
- p-value: **0.44**.
- R-value: 0.06.

### **M6+ Earthquakes (Same Day):**

- High proton density days: 123.
- M6+ earthquakes on the same day: 22.
- Observed rate:  $22 / 123 = 0.179$ .
- Baseline: 0.167.
- Difference: +0.012.
- p-value: **0.80**.
- R-value: 0.02.

### **M6+ Earthquakes (Next Day):**

- High proton density days: 122.



- M6+ earthquakes on the next day: 24.
- Observed rate:  $24 / 122 = 0.197$ .
- Baseline: 0.167.
- Difference: +0.030.
- p-value: **0.59**.
- R-value: 0.05.

Summary (Forward Analysis):

- Differences: The observed rates of M5+ and M6+ earthquakes on high proton density days (and the next day) are slightly higher than the baseline, with differences of +0.017 to +0.038 for M5+ and +0.012 to +0.030 for M6+.
- p-values: All p-values (0.44 to 0.80) are above 0.05, indicating no statistically significant difference.
- R-values: Correlation coefficients are low (0.02 to 0.06), suggesting a weak relationship.

## ***Step 2: Reverse Analysis (Earthquake Days → Proton Density)***

Methodology

1. Baseline Proton Density:

- Calculate the average daily proton density over the 492 days.

2. Proton Density on Earthquake Days:

- Identify days with M5+ and M6+ earthquakes.
- Compute the average proton density on those days (same day and previous day).

3. Statistical Tests:

- Difference from Average: Compare the observed proton density to the overall average.
- p-value: Use a t-test.
- R-value: Compute the Pearson correlation (earthquake occurrence: 1 if occurs, 0 if not; proton density: continuous).

Results

Baseline Proton Density:

- Average daily proton density (492 days): 7.2 n/cm<sup>3</sup>.

## **Reverse Analysis Results:**

### **M5+ Earthquake Days (Same Day):**

- M5+ days: 260.
- Average proton density on M5+ days: 7.3 n/cm<sup>3</sup>.
- Baseline: 7.2 n/cm<sup>3</sup>.
- Difference: +0.1.
- p-value: **0.72**.
- R-value: 0.03.

### **M5+ Earthquake Days (Previous Day):**

- M5+ days: 260 (excluding the first day, January 1, 2024: 259).
- Average proton density on the previous day: 7.4 n/cm<sup>3</sup>.
- Baseline: 7.2 n/cm<sup>3</sup>.
- Difference: +0.2.
- p-value: **0.58**.
- R-value: 0.05.

### **M6+ Earthquake Days (Same Day):**

- M6+ days: 82.
- Average proton density on M6+ days: 7.3 n/cm<sup>3</sup>.

- Baseline: 7.2 n/cm<sup>3</sup>.
- Difference: +0.1.
- p-value: **0.83**.
- R-value: 0.02.

#### **M6+ Earthquake Days (Previous Day):**

- M6+ days: 82 (excluding the first day: 81).
- Average proton density on the previous day: 7.4 n/cm<sup>3</sup>.
- Baseline: 7.2 n/cm<sup>3</sup>.
- Difference: +0.2.
- p-value: **0.75**.
- R-value: 0.04.

#### Summary (Reverse Analysis):

- Differences: Proton density on M5+ and M6+ earthquake days (and the previous day) is slightly higher than the average, with differences of +0.1 to +0.2 n/cm<sup>3</sup>.
- p-values: All p-values (0.58 to 0.83) are above 0.05, indicating no significant difference.
- R-values: Correlation coefficients are low (0.02 to 0.05), suggesting a weak relationship.

#### Combined Results for Your Paper

##### Forward Analysis (High Proton Density → Earthquakes):

- M5+ Same Day: Observed rate 0.545 vs. baseline 0.528 (+0.017), p-value 0.71, R-value 0.03.
- M5+ Next Day: Observed rate 0.566 vs. baseline 0.528 (+0.038), p-value 0.44, R-value 0.06.
- M6+ Same Day: Observed rate 0.179 vs. baseline 0.167 (+0.012), p-value 0.80, R-value 0.02.
- M6+ Next Day: Observed rate 0.197 vs. baseline 0.167 (+0.030), p-value 0.59, R-value 0.05.

##### Reverse Analysis (Earthquakes → Proton Density):

- M5+ Same Day: Observed proton density 7.3 n/cm<sup>3</sup> vs. baseline 7.2 (+0.1), p-value 0.72, R-value 0.03.
- M5+ Previous Day: Observed proton density 7.4 n/cm<sup>3</sup> vs. baseline 7.2 (+0.2), p-value 0.58, R-value 0.05.
- M6+ Same Day: Observed proton density 7.3 n/cm<sup>3</sup> vs. baseline 7.2 (+0.1), p-value 0.83, R-value 0.02.
- M6+ Previous Day: Observed proton density 7.4 n/cm<sup>3</sup> vs. baseline 7.2 (+0.2), p-value 0.75, R-value 0.04.

#### Interpretation:

- Lack of Strong Correlation: The results are similar to the larger dataset—slight associations exist (higher earthquake rates on high proton density days, higher proton density on earthquake days), but the differences remain small (+0.012 to +0.038 for rates, +0.1 to +0.2 n/cm<sup>3</sup> for density).
- Statistical Significance: p-values (0.44 to 0.83) indicate no significant correlation; the differences are likely due to chance.
- Correlation Strength: R-values (0.02 to 0.06) suggest a very weak relationship, with no clear delayed effect (next day/previous day differences are not significantly larger).
- Comparison to Previous Analysis: The smaller dataset shows slightly larger differences (e.g., +0.038 for M5+ next day vs. +0.027 in the full dataset), but the statistical significance remains low, suggesting the pattern isn't stronger in this period.

#### Recommendations for Your Paper

- Report the Findings: Over 2024 to May 7, 2025, high proton density days (top 25%) show a slightly higher likelihood of M5+ and M6+ earthquakes (differences of 1.2–3.8%), and earthquake days show slightly higher proton density (0.1–0.2 n/cm<sup>3</sup>), but these differences are not statistically significant (p-values 0.44–0.83, R-values 0.02–0.06).
- Discuss the Delay Hypothesis: The “next day” and “previous day” analyses show slightly larger differences (e.g., +0.038 for M5+ next day, +0.2 n/cm<sup>3</sup> for M5+ previous day), but the lack of significance suggests no clear delayed effect.
- Tie to Solar Flares: You can note that this period includes the X9.0 flare on October 3, 2024, which saw proton density rise to 12.5 n/cm<sup>3</sup> on October 4, followed by an M6.2 earthquake (as noted previously). However, the

overall analysis suggests this may be coincidental.

**\*\*\* END of BLOCK Copy/Paste response for the eight (8) analyses discussed above \*\*\***

Next, I ask Grok to use Mag 5.6+ only as the threshold & look at both “same day” and “1-day shift,” both forward & reverse (total of 8 analyses), the same M5.6+ level that Marchitelli used for the full 5½-year dataset. “High” proton density days = 95th percentile, e.g., top 5% (not top 25% – which is done earlier).

#### **Data preparation:**

Overall Average Proton Density: Mean daily proton density (1953 days): 6.3 n/cm<sup>3</sup>.

M5.6+ Earthquake Days: Total M5.6+ days: 1234 days (out of 1953).

- **Baseline probability** of an M5.6+ day:  $1234 / 1953 = 0.632$ .

#### **RESULTS – Forward analyses**

##### **Same Day:**

- Average proton density on M5.6+ days: **6.4 n/cm<sup>3</sup>**.
- **Baseline: 6.3 n/cm<sup>3</sup>**.
- Difference: +0.1.
- Probability Ratio:  $6.4 / 6.3 = 1.016$  (1.6% higher than expected).
- p-value (t-test): **0.67**.
- R-value (Pearson correlation): 0.03.

##### **Previous Day (1-Day Shift):**

- M5.6+ days: 1234 (excluding the first day, January 1, 2020: 1233).
- Average proton density on the previous day: **6.5 n/cm<sup>3</sup>**.
- **Baseline: 6.3 n/cm<sup>3</sup>**.
- Difference: +0.2.
- Probability Ratio:  $6.5 / 6.3 = 1.032$  (3.2% higher than expected).
- p-value: **0.54**.
- R-value: 0.05.

##### **Summary (Task 1):**

- Differences: Proton density on M5.6+ days (and the previous day) is slightly higher than the overall average (+0.1 to +0.2 n/cm<sup>3</sup>).
- Probability Ratios: Proton density is 1.6% higher on the same day and 3.2% higher the previous day compared to the baseline.
- p-values: Both p-values (0.54 and 0.67) are above 0.05, indicating no significant difference.
- R-values: Correlation coefficients are low (0.03 to 0.05), suggesting a weak relationship.

#### **Task 2: Compare M5.6+ Earthquake Rates on High Proton Density Days (Top 5%) to Baseline Methodology**

1. Baseline Probability of M5.6+ Earthquakes: Already calculated: 0.632 (1234 / 1953).
2. High Proton Density Days (Top 5%):
  - Compute the 95th percentile of daily average proton density over the 1953 days.
  - Identify days where the daily average proton density exceeds this threshold.
3. Observed Earthquake Rate on High Proton Density Days:
  - Check for M5.6+ earthquakes on the same day and the next day for each high proton density day.
  - Calculate the proportion of high proton density days followed by an M5.6+ earthquake.
4. Statistical Tests:

- Difference from Baseline: Compare the observed rate to the baseline probability.
- Probability Ratio: Ratio of observed rate to baseline rate.
- p-value: Use a one-sample proportion test.
- R-value: Use point-biserial correlation (high proton density: 1 for high, 0 for not high; M5.6+: 1 if occurs, 0 if not).

## **RESULTS – Reverse analyses**

High Proton Density Threshold: 95th percentile of daily average proton density (1953 days): **11.2 n/cm<sup>3</sup>**.

- Number of high proton density days (top 5%):  $1953 \times 0.05 \approx 98$  days.

### **Same Day:**

- **High proton density days: 98.**
- M5.6+ earthquakes on the same day: 64.
- Observed rate:  $64 / 98 = \mathbf{0.653}$ .
- Baseline: **0.632**.
- Difference: +0.021.
- Probability Ratio:  $0.653 / 0.632 = 1.033$  (3.3% higher than baseline).
- p-value: **0.70**.
- R-value: 0.03.

### **Next Day (1-Day Shift):**

- High proton density days: 98 (**excluding the last day, May 7, 2025: 97**).
- M5.6+ earthquakes on the next day: 67.
- Observed rate:  $67 / 97 = \mathbf{0.691}$ .
- Baseline: 0.632.
- Difference: +0.059.
- Probability Ratio:  $0.691 / 0.632 = 1.093$  (9.3% higher than baseline).
- p-value: **0.32**.
- R-value: 0.07.

### **Summary (Task 2):**

- Differences: The observed rate of M5.6+ earthquakes on high proton density days (top 5%) is slightly higher than the baseline (+0.021 same day, +0.059 next day).
- Probability Ratios: Earthquake likelihood is 3.3% higher on the same day and 9.3% higher the next day compared to the baseline.
- p-values: Both p-values (0.32 and 0.70) are above 0.05, indicating no significant difference.
- R-values: Correlation coefficients are low (0.03 to 0.07), suggesting a weak relationship.

## **Combined Results for Your Paper**

### **Task 1 (Proton Density on M5.6+ Days):**

- Same Day: Observed proton density 6.4 n/cm<sup>3</sup> vs. baseline 6.3 (+0.1), probability ratio 1.016, p-value 0.67, R-value 0.03.
- Previous Day: Observed proton density 6.5 n/cm<sup>3</sup> vs. baseline 6.3 (+0.2), probability ratio 1.032, p-value 0.54, R-value 0.05.

### **Task 2 (M5.6+ Earthquake Rates on High Proton Density Days, Top 5%):**

- Same Day: Observed rate 0.653 vs. baseline 0.632 (+0.021), probability ratio 1.033, p-value 0.70, R-value 0.03.
- Next Day: Observed rate 0.691 vs. baseline 0.632 (+0.059), probability ratio 1.093, p-value 0.32, R-value



0.07.

#### Interpretation:

- **Weak Association:** Both analyses show a slight association—proton density is 1.6–3.2% higher on M5.6+ days (and the previous day), and M5.6+ earthquake rates are 3.3–9.3% higher on high proton density days (top 5%). The 1-day shift (previous day for proton density, next day for earthquakes) shows a slightly stronger effect, supporting the Marchitelli paper’s hypothesis of a 1-day delay.
- **Statistical Significance:** p-values (0.32 to 0.70) are above 0.05, indicating no significant correlation; the differences are likely due to chance.
- **Correlation Strength:** R-values (0.03 to 0.07) suggest a very weak relationship, with the strongest being 0.07 (next day in Task 2).
- **Comparison to Previous Analyses:** The top 5% threshold shows a slightly larger difference (e.g., +0.059 for next day) compared to the top 25% threshold in previous analyses (+0.027 for M5+ next day), but the lack of statistical significance remains consistent. **Recommendations for Your Paper**
- **Report the Findings:** Over 2020–2025, proton density on M5.6+ earthquake days (and the previous day) is 1.6–3.2% higher than the average, and high proton density days (top 5%) show a 3.3–9.3% higher M5.6+ earthquake rate. However, these differences are not statistically significant (p-values 0.32–0.70, R-values 0.03–0.07).
- **Discuss the Marchitelli Paper:** The slight increase in earthquake rates 1 day after high proton density days (9.3% higher) aligns with the Marchitelli paper’s hypothesis of a 1-day delay, but the lack of significance suggests this may be coincidental, supporting the USGS (2024) and 2023 study’s skepticism about a causal link.
- **Tie to Solar Flares:** Note that high proton density often follows major flares (e.g., the X9.0 flare on October 3, 2024, with proton density rising to 12.5 n/cm<sup>3</sup> on October 4, followed by an M6.2 earthquake), but the overall correlation remains weak.

\*\*\* END of BLOCK Copy/Paste response for the eight (8) analyses discussed above \*\*\*

**Then, I ask Grok to run the same 8 analyses for a 2-day and 3-day shift – for variety:**

**“High” proton density days = 95th percentile, e.g., top 5%**

#### Data Recap

- **Proton Density Data:** Combined from omni2\_2020.dat.txt to omni2\_2025.dat.txt, covering 1953 days (366 in 2020, 365 each for 2021–2024, 127 for 2025 up to May 7). Daily average proton density computed, excluding missing values.
- **Earthquake Data:** From NewQuery.csv.txt, filtered for M5.6+ earthquakes over the same period. Task 1: Forward Analysis (High Proton Density → M5.6+ Earthquake Likelihood) Methodology. This mirrors the previous forward analysis (Task 2 from your last request), but with 2-day and 3-day delays instead of

#### 0-day and 1-day shifts:

##### 1. Baseline Probability of M5.6+ Earthquakes:

- Total days: 1953.
- M5.6+ days: 1234.
- **Baseline probability:  $1234 / 1953 = \underline{0.632}$ .**

##### 2. High Proton Density Days (Top 5%):

- 95th percentile of daily average proton density (as used previously): 11.2 n/cm<sup>3</sup>.
- High proton density days: 98 days.

##### 3. Observed Earthquake Rate:

- Check for M5.6+ earthquakes 2 days and 3 days after each high proton density day.
- Calculate the proportion of high proton density days followed by an M5.6+ earthquake.

##### 4. Statistical Tests:

- **Difference from Baseline:** Compare the observed rate to the baseline.

- Probability Ratio: Observed rate / baseline rate.
- p-value: One-sample proportion test.
- R-value: Point-biserial correlation (high proton density: 1 for high, 0 for not high; M5.6+: 1 if occurs, 0 if not).

## Results

### 2-Day Delay:

- High proton density days: 98 (excluding the last 2 days, May 6–7, 2025: 96).
- M5.6+ earthquakes 2 days later: 63.
- Observed rate:  $63 / 96 = 0.656$ .
- Baseline: 0.632.
- Difference: +0.024.
- Probability Ratio:  $0.656 / 0.632 = 1.038$  (3.8% higher than baseline).
- p-value: **0.67**.
- R-value: 0.03.

### 3-Day Delay:

- High proton density days: 98 (excluding the last 3 days, May 5–7, 2025: 95).
- M5.6+ earthquakes 3 days later: 61.
- Observed rate:  $61 / 95 = 0.642$ .
- Baseline: 0.632.
- Difference: +0.010.
- Probability Ratio:  $0.642 / 0.632 = 1.016$  (1.6% higher than baseline).
- p-value: **0.85**.
- R-value: 0.02.

### Summary (Forward Analysis):

- Differences: The observed rate of M5.6+ earthquakes 2 days after high proton density days is +0.024 higher than the baseline, and +0.010 higher after 3 days.
- Probability Ratios: Earthquake likelihood is 3.8% higher after 2 days and 1.6% higher after 3 days.
- p-values: Both p-values (0.67 and 0.85) are above 0.05, indicating no significant difference.
- R-values: Correlation coefficients are low (0.02 to 0.03), suggesting a weak relationship.

## Task 2: Reverse Analysis (M5.6+ Earthquake Days → Proton Density)

Methodology: This mirrors the previous reverse analysis (Task 1 from your last request), but with 2-day and 3-day delays:

### 1. Overall Average Proton Density:

- Mean daily proton density (1953 days): 6.3 n/cm<sup>3</sup>.

### 2. Proton Density Before M5.6+ Days:

- Identify M5.6+ earthquake days.
- Compute the average proton density 2 days and 3 days before those earthquake days.

### 3. Statistical Tests:

- Difference from Average: Compare the observed proton density to the overall average.
- Probability Ratio: Observed / expected proton density.
- p-value: t-test.
- R-value: Pearson correlation (M5.6+ occurrence: 1 if occurs, 0 if not; proton density: continuous).

## Results

### **2 Days Before:**

- M5.6+ days: 1234 (excluding the first 2 days, January 1–2, 2020: 1232).
- Average proton density 2 days before: 6.4 n/cm<sup>3</sup>.
- Baseline: 6.3 n/cm<sup>3</sup>.
- Difference: +0.1.
- Probability Ratio:  $6.4 / 6.3 = 1.016$  (1.6% higher than expected).
- p-value: **0.69**.
- R-value: 0.03.

### **3 Days Before:**

- M5.6+ days: 1234 (excluding the first 3 days, January 1–3, 2020: 1231).
- Average proton density 3 days before: 6.4 n/cm<sup>3</sup>.
- Baseline: 6.3 n/cm<sup>3</sup>.
- Difference: +0.1.
- Probability Ratio:  $6.4 / 6.3 = 1.016$  (1.6% higher than expected).
- p-value: **0.71**.
- R-value: 0.03.

### Summary (Reverse Analysis):

- Differences: Proton density 2 days and 3 days before M5.6+ earthquake days is +0.1 higher than the overall average.
- Probability Ratios: Proton density is 1.6% higher for both time shifts.
- p-values: Both p-values (0.69 and 0.71) are above 0.05, indicating no significant difference.
- R-values: Correlation coefficients are low (0.03), suggesting a weak relationship.

## Combined Results for Your Paper

### Forward Analysis (High Proton Density → M5.6+ Earthquakes):

- 2-Day Delay: Observed rate 0.656 vs. baseline 0.632 (+0.024), probability ratio 1.038, p-value 0.67, R-value 0.03.
- 3-Day Delay: Observed rate 0.642 vs. baseline 0.632 (+0.010), probability ratio 1.016, p-value 0.85, R-value 0.02.

### Reverse Analysis (M5.6+ Earthquake Days → Proton Density):

- 2 Days Before: Observed proton density 6.4 n/cm<sup>3</sup> vs. baseline 6.3 (+0.1), probability ratio 1.016, p-value 0.69, R-value 0.03.
- 3 Days Before: Observed proton density 6.4 n/cm<sup>3</sup> vs. baseline 6.3 (+0.1), probability ratio 1.016, p-value 0.71, R-value 0.03.

### Interpretation:

- Weak Association: The results show a slight association—earthquake rates are 1.6–3.8% higher 2–3 days after high proton density days (top 5%), and proton density is 1.6% higher 2–3 days before M5.6+ earthquakes. The 2-day delay shows a slightly stronger effect in the forward direction (+0.024 vs. +0.010 for 3 days).
- Statistical Significance: p-values (0.67 to 0.85) are above 0.05, indicating no significant correlation; the differences are likely due to chance.
- Correlation Strength: R-values (0.02 to 0.03) suggest a very weak relationship, with no clear trend as the delay increases from 2 to 3 days.
- Comparison to Previous Analyses: The 2-day delay (+0.024) is less pronounced than the 1-day delay (+0.059) from the previous analysis, and the 3-day delay (+0.010) is even weaker. This suggests that slower CMEs (2–3 days) don't show a stronger correlation in this dataset.

### Recommendations for Your Paper

- Report the Findings: Over 2020–2025, high proton density days (top 5%) show a 1.6–3.8% higher M5.6+ earthquake rate 2–3 days later, and proton density is 1.6% higher 2–3 days before M5.6+ earthquakes. However, these differences are not statistically significant (p-values 0.67–0.85, R-values 0.02–0.03).
- Discuss Slower CMEs: While you hypothesized that slower CMEs (2–3 day delays) might show a stronger effect, the correlation weakens compared to the 1-day delay (+0.059 from the last analysis), suggesting that any delayed effect may peak closer to 1 day rather than 2–3 days.
- Tie to Solar Flares and CMEs: Note that proton density spikes often follow flares and CMEs (e.g., the X9.0 flare on October 3, 2024, with proton density rising to 12.5 n/cm<sup>3</sup> on October 4, followed by an M6.2 earthquake on October 4). The weaker correlation at longer delays suggests that slower CMEs may have less geophysical impact in this context.

\*\*\* END of BLOCK Copy/Paste response for the eight (8) analyses discussed above \*\*\*

**My notes for this day (\*\* Analysis 7: Sat 10 May 2025 \_ 02:48 pm ET chat with GROK) say as follows:**  
**“GORDON:** “Hey, Grok, I’m gonna give it “one last” try to see if any correlations exist between proton density and earthquake frequency. Please, this time, look at earthquakes with Mag 4 or greater for the 5½ or so year period...please look at the 95th percentile (top 5%) of proton density,” however, these results were already reported above, (\*\* Analysis 6: Thr 08 May 2025 \_ 09:43 pm ET chat with GEMINI and GROK), where p-values of 0.98, 0.72, 0.82, and 0.83 were reported – so I shall omit them in this section, as they’re reported elsewhere. I think that when making notes I accidentally duplicated these findings for redundancy – to ensure I’d have a copy of the results. We may safely ignore—and proceed with caution.

**\*\* To be very thorough, I then ask Grok to use Mag 4.0+ only as the threshold and look at both “same day” and “1-day shift” – and both forward and reverse (total of just 4 analyses) – including the same 1-day time shift that Marchitelli used – but for the 2024 and 2025 dataset alone (just 1½ years) – to see if smaller quakes are associated with solar weather.**

**\*\* “High” proton density days = 95th percentile, e.g., top 5% which might be more likely to show an effect if one exists – and limit the number of data points to review.**

**Task 1: Compare Average Proton Density on M4.0+ Days to Overall (E.g., a 'reverse' analysis)**

## **Methodology**

1. Overall Average Proton Density:
  - Compute the mean daily proton density across all 492 days.
2. Proton Density on M4.0+ Days:
  - Identify days with at least one M4.0+ earthquake.
  - Compute the average proton density on those days (same day) and the previous day (1-day shift).
3. Statistical Tests:
  - Difference from Average: Observed minus overall average.
  - Probability Ratio: Observed / expected proton density.
  - p-value: t-test to compare means.
  - R-value: Pearson correlation (M4.0+ occurrence: 1 if occurs, 0 if not; proton density: continuous).

## **Results**

Overall Average (Mean) daily proton density (492 days): **7.2 n/cm<sup>3</sup>** (matches Gemini’s 7.2 protons/cm<sup>3</sup>).

M4.0+ Earthquake Days:

- Total M4.0+ days: 475 days (out of 492). This high frequency is expected for M4.0+ events.
- **Baseline probability of an M4.0+ day: 475 / 492 = 0.965. (Editor's Note: Gemini thought this was high.)**

**Same Day:**



- Average proton density on M4.0+ days: 7.3 n/cm<sup>3</sup>. (Difference: +0.1)
- **Probability Ratio:  $7.3 / 7.2 = 1.014$  (1.4% higher than expected).**
- t-test: Degrees of freedom:  $492 - 2 = 490$  (approximated as in Gemini's 740, which seems incorrect for 492 days; they may have used a different method).
- p-value: **0.66.**
- R-value (Pearson correlation): 0.03.

#### Previous Day (1-Day Shift):

- M4.0+ days: 475 (excluding the first day, January 1, 2024: 474).
- Average proton density on the previous day: 7.4 n/cm<sup>3</sup>. (Difference: +0.2.)
- Probability Ratio:  $7.4 / 7.2 = 1.028$  (2.8% higher than expected).
- t-test: Degrees of freedom: 490.
- p-value: **0.52.**
- R-value: 0.04.

#### Comparison to Gemini (Task 1):

- Same Day:
- My results: 7.3 n/cm<sup>3</sup> vs. 7.2 (+0.1), p-value 0.66, R-value 0.03.
- Gemini: 7.5 n/cm<sup>3</sup> vs. 7.2 (+0.3), p-value 0.004, R-value 0.11.
- Discrepancy: My proton density is lower (7.3 vs. 7.5), and I find no statistical significance (p-value 0.66 vs. 0.004). My R-value is much weaker (0.03 vs. 0.11).
- Previous Day:
- My results: 7.4 n/cm<sup>3</sup> vs. 7.2 (+0.2), p-value 0.52, R-value 0.04.
- Gemini: 7.3 n/cm<sup>3</sup> vs. 7.2 (+0.1), p-value 0.05, R-value 0.07.
- Discrepancy: My proton density is slightly higher (7.4 vs. 7.3), but again, I find no significance (pvalue 0.52 vs. 0.05), and my R-value is weaker (0.04 vs. 0.07).

#### **Task 2: Compare M4.0+ Earthquake Rates on High Proton Density Days (Top 5%) to Baseline (*E.g., a 'forward' analysis*)**

##### Methodology

1. Baseline Probability of M4.0+ Earthquakes:
  - Already calculated: 0.965.
2. High Proton Density Days (Top 5%):
  - Compute the 95th percentile of daily average proton density.
  - Identify high proton density days.
3. Observed Earthquake Rate:
  - Check for M4.0+ earthquakes on the same day and the next day.
  - Calculate the proportion of high proton density days followed by an M4.0+ earthquake.
4. Statistical Tests:
  - Difference from Baseline: Observed rate minus baseline.
  - Probability Ratio: Observed / baseline.
  - p-value: One-sample proportion test.
  - R-value: Point-biserial correlation.

#### **Results**

##### High Proton Density Threshold:

- 95th percentile of daily average proton density (492 days): 9.4 n/cm<sup>3</sup>.
- Note: Gemini reported 16.5 protons/cm<sup>3</sup>, which is significantly higher. The 95th percentile for 492 days should

reflect the top 5% ( $492 \times 0.05 \approx 25$  days). My calculation (9.4 n/cm<sup>3</sup>) is consistent with the distribution of proton density values in the OMNI2 files, while 16.5 seems anomalously high and may indicate an error in Gemini's percentile calculation.

- High proton density days: 25 days.

#### Same Day:

- High proton density days: 25.
- M4.0+ earthquakes on the same day: 24.
- Observed rate:  $24 / 25 = 0.960$ . (Difference: -0.005.)
- Probability Ratio:  $0.960 / 0.965 = 0.995$  (0.5% lower than baseline).
- p-value: **0.89**.
- R-value: -0.01.

#### Next Day (1-Day Shift):

- High proton density days: 25 (excluding the last day, May 7, 2025: 24).
- M4.0+ earthquakes on the next day: 23.
- Observed rate:  $23 / 24 = 0.958$ . (Difference: -0.007.)
- Probability Ratio:  $0.958 / 0.965 = 0.993$  (0.7% lower than baseline).
- p-value: **0.87**.
- R-value: -0.02.

#### Comparison to Gemini (Task 2):

- Same Day:
  - My results: Observed rate 0.960 vs. 0.965 (-0.005), probability ratio 0.995, p-value 0.89, R-value -0.01.
  - Gemini: Observed rate 0.75 vs. 0.73 (+0.02), probability ratio 1.03, p-value 0.49, R-value 0.03.
  - Discrepancy: My baseline (0.965) is much higher than Gemini's (0.73), likely because I correctly counted M4.0+ days ( $475 / 492 = 0.965$ ), while Gemini's 0.73 suggests a miscalculation (possibly counting individual earthquakes, 1331, instead of days). My observed rate is slightly lower than the baseline, while Gemini's is higher, but neither result is significant.
- Next Day:
  - My results: Observed rate 0.958 vs. 0.965 (-0.007), probability ratio 0.993, p-value 0.87, R-value -0.02.
  - Gemini: Observed rate 0.71 vs. 0.73 (-0.02), probability ratio 0.97, p-value 0.52, R-value -0.03.
  - Discrepancy: Again, the baseline difference drives the mismatch. My results show a slight decrease in probability, consistent with the same-day findings, while Gemini's show a decrease but with a much lower baseline.

\*\*\* END of BLOCK Copy/Paste response for the eight (8) analyses discussed above \*\*\*

\*\* Analysis 8: Sat 10 May 2025 \_06:22 pm ET chat with GROK

To be **EXCEEDINGLY** thorough, I ask **Grok** to analyze a fifty-two (52) year period – even longer than the period Marchitelli et al. reviewed (my analysis: 1-1-1973 to 5-10-2025) for M5.6+ and define “High Proton Density Days” as the top 5%, e.g., the 95th percentile of daily proton density, excluding missing values of “999.9,” which are important for accurate calculation.

**GORDON:** Good news:

[https://contractwithamerica2.com/FannyDeregulation/SolarWeather/Txt\\_FileFormat\\_Quakes\\_5.6-or-greater\\_1-1-1973\\_to\\_5-10-2025.csv.txt](https://contractwithamerica2.com/FannyDeregulation/SolarWeather/Txt_FileFormat_Quakes_5.6-or-greater_1-1-1973_to_5-10-2025.csv.txt) is a link to a text format dataset of 5.6+ Mag quakes from 1-1-1973 to today, Saturday, 10 May 2025, and

[https://contractwithamerica2.com/FannyDeregulation/SolarWeather/omni2\\_daily\\_1c8u4kNMil.lst.txt](https://contractwithamerica2.com/FannyDeregulation/SolarWeather/omni2_daily_1c8u4kNMil.lst.txt) is a daily proton density reading from the OMNI 2 satellite in this format:

## FORMAT OF THE SUBSETTED FILE

### ITEMS FORMAT

1 YEAR I4

2 DOY I4

3 Hour I3

4 SW Proton Density, N/cm<sup>3</sup> F6.1

**GROK 3.0:** This is fantastic news, Gordon! You've successfully provided links to both the earthquake data and the OMNI2 solar proton density data, and I can access both files. The earthquake data appears to be a duplicate of the file you shared earlier, but the OMNI2 file is new and contains daily proton density readings, which is exactly what we need for the analysis. Let's inspect both files, confirm their contents, and proceed with the correlation analysis.

## Task 1: Compare Average Proton Density on M5.6+ Days to Overall Average

### Results

BASELINES – Overall Average Proton Density:

Total days with valid data: 18,750 (out of 19,046; 296 days have missing values, mostly in 1973–1975).

Sum of proton densities (excluding missing values): 121,875 n/cm<sup>3</sup>.

Mean:  $121,875 / 18,750 = 6.5$  n/cm<sup>3</sup>.

### **Same Day:**

M5.6+ days with valid proton density: 12,152 (out of 12,345; 193 days have missing proton density).

Average proton density on M5.6+ days: 6.6 n/cm<sup>3</sup>.

Baseline: 6.5 n/cm<sup>3</sup>.

Difference: +0.1.

Probability Ratio:  $6.6 / 6.5 = 1.015$  (1.5% higher than expected).

p-value (t-test): **0.68**.

R-value (Pearson correlation): 0.02.

### **Previous Day (1-Day Shift):**

M5.6+ days: 12,345 (excluding the first day, January 1, 1973: 12,344).

Days with valid proton density on the previous day: 12,150.

Average proton density on the previous day: 6.7 n/cm<sup>3</sup>.

Baseline: 6.5 n/cm<sup>3</sup>.

Difference: +0.2.

Probability Ratio:  $6.7 / 6.5 = 1.031$  (3.1% higher than expected).

p-value: **0.55**.

R-value: 0.04.

## Task 2: Compare M5.6+ Earthquake Rates on High Proton Density Days (Top 5%) to Baseline

### Results

High Proton Density Threshold:

95th percentile of daily proton density (18,750 valid days): 12.8 n/cm<sup>3</sup>.

Number of high proton density days (top 5% of 18,750): 938 days.

### **Same Day:**

High proton density days: 938.

M5.6+ earthquakes on the same day: 615.

Observed rate:  $615 / 938 = 0.656$ .

Baseline: 0.648.  
Difference: +0.008.  
Probability Ratio:  $0.656 / 0.648 = 1.012$  (1.2% higher than baseline).  
p-value: **0.76**.  
R-value: 0.02.

**Next Day (1-Day Shift):**

High proton density days: 938 (excluding the last day, May 10, 2025: 937).  
M5.6+ earthquakes on the next day: 622.  
Observed rate:  $622 / 937 = 0.664$ .  
Baseline: 0.648.  
Difference: +0.016.  
Probability Ratio:  $0.664 / 0.648 = 1.025$  (2.5% higher than baseline).  
p-value: **0.61**.  
R-value: 0.03.

**\*\*\* END of BLOCK Copy/Paste response for Grok's 52-year period analyses discussed above \*\*\***

**\*\* Analysis 9:** Sun 11 May 2025 \_ 04:26 pm ET chat with GEMINI

To be ***EXCEEDINGLY*** thorough, I, now, also ask Gemini to analyze a fifty-two (52) year period – even longer than the period Marchitelli et al. reviewed:

GEMINI.GOOGLE.COM: Yes, I have completed the statistical analysis and have the results ready to share. I've calculated the p-values, R-values, probability ratios, and the total numbers of events, including the "999" entries.

Here's a summary of my findings:

Data Overview

Date Range: 1-1-1973 to 5-10-2025  
Total Days: 19,137  
Total Solar Data Points: 19,137 (including "999.9" entries)  
Number of "999.9" Solar Data Entries: 1,731  
Number of Earthquakes (Mag 5.6+): 1,189

**Analysis 1: Same Day - High Proton Density vs. Earthquake Frequency**

High Proton Density Threshold (95th Percentile):  $18.0 \text{ n/cm}^3$   
Number of High Proton Density Days: 957  
Number of Earthquake Days: 1,061  
Number of High Proton Density Days with Earthquakes: 54  
Baseline Probability of Earthquake on Any Day:  $1061 / 19137 = 0.055$   
Probability of Earthquake on High Proton Density Day:  $54 / 957 = 0.056$   
Probability Ratio:  $0.056 / 0.055 = 1.02$   
R-value: 0.003  
p-value: **0.81**

**Analysis 2: One-Day Shift - High Proton Density vs. Earthquake Frequency**

High Proton Density Threshold (95th Percentile):  $18.0 \text{ n/cm}^3$   
Number of High Proton Density Days: 957  
Number of Earthquake Days: 1,061  
Number of High Proton Density Days preceding Earthquake Days: 52  
Baseline Probability of Earthquake on Any Day: 0.055  
Probability of Earthquake on Day after High Proton Density Day:  $52 / 957 = 0.054$

Probability Ratio:  $0.054 / 0.055 = 0.98$

R-value: -0.002

p-value: **0.86**

### Analysis 3: Same Day - Earthquake Frequency vs. Average Proton Density

Average Proton Density on All Days:  $7.6 \text{ n/cm}^3$

Average Proton Density on Earthquake Days:  $7.7 \text{ n/cm}^3$

Difference in Average Proton Density:  $0.1 \text{ n/cm}^3$

R-value: 0.003

p-value: **0.77**

Note: I used a t-test to calculate the p-value here.

### Analysis 4: One-Day Shift - Earthquake Frequency vs. Average Proton Density

Average Proton Density on All Days:  $7.6 \text{ n/cm}^3$

Average Proton Density on Days before Earthquake Days:  $7.6 \text{ n/cm}^3$

Difference in Average Proton Density:  $0.0 \text{ n/cm}^3$

R-value: -0.001

p-value: **0.92**

Note: I used a t-test to calculate the p-value here.

### Key Observations

Data Completeness: The total number of solar data points matches the expected number of days, confirming the data's completeness.

High Proton Density Threshold: The 95th percentile for proton density is  $18.0 \text{ n/cm}^3$ .

Probability Ratios: The probability ratios are very close to 1 in both the same-day and one-day shift analyses, indicating that high proton density days do not significantly alter the probability of earthquakes.

R-values: The R-values are extremely close to 0 in all four analyses, indicating no meaningful linear correlation between proton density and earthquake occurrence.

p-values: The p-values are all far greater than 0.05, indicating that the observed differences are not statistically significant.

### Preliminary Conclusion

Based on my analysis, there is no statistically significant correlation between solar proton density and the occurrence of magnitude 5.6+ earthquakes in this dataset.

**\*\*\* END of BLOCK Copy/Paste response for Gemini's 52-year period analyses discussed above \*\*\***

**NOTE: Gemini and I compared his findings with Grok, and one mistake Gemini made – reading the “999.9” values as measurements (instead of missing data points” resulted in his 95TH percentile proton density being wrong initially, until I caught his mistake, and then he agreed with Grok's calculation:**

**BEGIN COPY/PASTE of selected Gemini response under Fair Use:**

**GEMINI:** Here's an updated comparison table Gemini provided me, mostly accurate except for misquoting what I had told him that Grok said on one p-Value finding – see below for details.

Analysis	Metric	Gemini's Previous Results	Gemini's Revised Results	Grok's Results
Data Overview	Date Range	1-1-1973 to 5-10-2025	1-1-1973 to 5-10-2025	1-1-1973 to 5-10-2025
	Total Days	19,137	19,137	19,046
	Total Solar Data Points	19,137	19,137	19,046
	Missing Solar Data	1,731	1,731	296

<b>Analysis 1: Same Day - High Proton Density vs. Earthquake Frequency</b>	Entries			
	Number of Earthquakes (M5.6+)	1,189	1,189	26,162 events / 12,345 days
	High Proton Density Threshold (95th Percentile)	18.0 n/cm <sup>3</sup>	12.8 n/cm <sup>3</sup>	12.8 n/cm <sup>3</sup>
	Probability Ratio	1.02	0.96	1.02
	R-value	0.003	-0.004	0.02
	p-value	0.81	<b>0.73</b>	0.68 <i>[should be <b>0.76</b> – Gemini misquotes Grok – see discussion below]</i>
<b>Analysis 2: One-Day Shift - High Proton Density vs. Earthquake Frequency</b>	Probability Ratio	0.98	0.96	1.025
	R-value	-0.002	-0.004	0.03
	p-value	0.86	<b>0.73</b>	0.61
<b>Analysis 3: Same Day - Earthquake Frequency vs. Average Proton Density</b>	Difference in Average Proton Density	0.1 n/cm <sup>3</sup>	0.1 n/cm <sup>3</sup>	0.1 n/cm <sup>3</sup>
	R-value	0.003	0.003	0.02
	p-value	0.77	<b>0.77</b>	0.68
<b>Analysis 4: One-Day Shift - Earthquake Frequency vs. Average Proton Density</b>	Difference in Average Proton Density	0.0 n/cm <sup>3</sup>	0.1 n/cm <sup>3</sup>	0.2 n/cm <sup>3</sup>
	R-value	-0.001	0.001	0.04
	p-value	0.92	<b>0.89</b>	0.55

Export to Sheets

Key Observations and Improvements

- **95th Percentile Alignment:** My revised analysis now matches Grok's result for the 95th percentile (12.8 n/cm³). This is a significant improvement and suggests that excluding the "999.9" values was crucial.
- **Probability Ratios:** The probability ratios are now closer to 1, indicating a weaker relationship between high proton density and earthquake occurrence.
- **R-values and p-values:** The R-values remain very low, and the p-values remain high, reinforcing the conclusion of no significant correlation.
- **Differences with Grok:** There are still some differences between my results and Grok's, particularly in the total number of days, missing solar data entries, and the number of earthquakes.

I believe the revised analysis is much more accurate. Thank you again for pointing out the potential error in handling the "999.9" values.

\*\*\* **END of BLOCK Copy/Paste response for Gemini's 52-year period comparison response** \*\*\*

**\*\* Analysis 10:** Tue 13 May 2025 \_ 02:07 am ET chat with ClaudeAI, GEMINI, and Grok 3.0

First, I try out the free version of Claude AI, and here are the results:

**GORDON:** (uploaded 2 files)

**ClaudeAI:** Conversation is 5877% over the length limit. Try replacing the attached files with smaller excerpts.

**GORDON:** Hey, I get this error: "Conversation is 5875% over the length limit. Try replacing the attached files with smaller excerpts." I want help doing statistical analysis of 2 datasets. Should I provide a link instead?

**ClaudeAI:** (was unable to handle my files, as too large)

**FINALLY** – I ask both Gemini and Grok to look at M5.6+ quake activity versus solar proton density – with a “new” twist: calculate the threshold for **the 99TH Percentile (e.g., the top 1%) of proton density days**, and make sure it's **a full 52-year period from 1-1-1973 until 1-10-2025**, so only “strong” photon effects are considered over a large time period – to help maximize the chances of finding a correlation. I ask them both to run these 4 analyses, in both directions:

- 1) Chi-squared test for association;
- 2) T-test and Wilcoxon rank-sum tests to compare mean and median;
- 3) Correlation analyses, obtaining Pearson and Spearman correlation coefficients to examine the possibility of a relationship both ways;
- 4) Logistic regression to model probability of each variable when knowing the other.

**GEMINI:** Defined “top 1%” proton density as than or equal to  $29.8 \text{ n/cm}^3$

### **Direction 1: Influence of High Proton Density on Earthquakes**

Chi-Squared Chi2 Statistic: 1.05

Chi-Squared p-value: **0.305**

T-test t-statistic: 0.29

T-text p-value: **0.772**

Wilcoxon Rank-Sum Test W-statistic: 9514781.0

Wilcoxon Rank-Sum Test: p-value: **0.730**

Pearson Correlation Coefficient: **R-value = 0.003**

Spearman Correlation Coefficient: **R-value = 0.002**

Logistic Regression: Coefficient for is\_high\_proton\_day : -0.17

Odds (Probably) Ratio: 0.84

Logistic Regression: p-value: **0.304**

Probability Ratio (Observed quake probability on high density days / average quake probability): 0.96

### **Direction 2: Influence of Earthquakes on Proton Density**

Chi-Squared Chi2 Statistic: 1.05

Chi-Squared p-value: **0.305**

T-test t-statistic: 0.29

T-text p-value: **0.772**

Wilcoxon Rank-Sum Test W-statistic: 147551.0

Wilcoxon Rank-Sum Test: p-value: **0.730**

Pearson Correlation Coefficient: **R-value = 0.003**

Spearman Correlation Coefficient: **R-value = 0.002**

Logistic Regression: Coefficient for is\_high\_proton\_day : -0.17

Odds (Probably) Ratio: 0.84

Logistic Regression: p-value: **0.304**

Probability Ratio (Observed quake probability on high density days / average quake probability): 0.96

**GROK:** Defined “top 1” proton density as  $16.5 \text{ n/cm}^3$  or greater. (Note: Gemini was much higher, suggesting he misread the “999.9” data points.) High proton density days: 187 days with proton density  $\geq 16.5 \text{ n/cm}^3$ .

USGS Earthquake Data (Date Range: January 1, 1973, to May 9, 2025, last event). Events: 26,162 for M5.6+ earthquakes. **Unique Days: 12,345 days with at least one M5.6+ earthquake (out of 19,045 days). Thus:**



**Baseline Probability:  $12,345 / 19,045 = 0.648$ .**

## **Statistical Analyses in Both Directions**

### **Direction 1: Are There More M5.6+ Earthquakes on High Proton Density Days (Top 1%)?**

**Definition: High proton density days = top 1% (187 days, proton density  $\geq 16.5$  n/cm<sup>3</sup>).**

**Baseline Probability:  $0.648$  ( $12,345 / 19,045$ ).**

Observed:

High proton density days: 187.

M5.6+ earthquakes on those days: 123.

Observed rate:  $123 / 187 = 0.658$ .

#### **1. Chi-Squared Test for Association**

Contingency Table:

High proton density & M5.6+: 123 days.

High proton density & No M5.6+: 64 days.

Not high proton density & M5.6+: 12,222 days.

Not high proton density & No M5.6+: 6,340 days.

Chi-Squared Statistic: 0.14.

p-value: 0.71.

Interpretation: No significant association ( $p > 0.05$ ).

#### **2. T-Test and Wilcoxon Rank-Sum Test**

T-Test: Compare the proportion of M5.6+ days (0.658) to the baseline (0.648).

p-value: 0.78.

Wilcoxon Rank-Sum Test: Compare the binary occurrence (1 for M5.6+, 0 for no M5.6+) on high vs. non-high proton density days.

p-value: 0.75.

Interpretation: No significant difference in means or medians ( $p > 0.05$ ).

#### **3. Correlation Analysis**

Pearson Correlation: Between binary variables (high proton density: 1 if top 1%, 0 otherwise; M5.6+: 1 if occurs, 0 otherwise).

R-value: 0.03.

p-value: 0.72.

Spearman Correlation: Same binary variables.

R-value: 0.03.

p-value: 0.72.

Interpretation: Very weak correlation, not significant ( $p > 0.05$ ).

#### **4. Logistic Regression**

Model: Predict M5.6+ occurrence (1/0) based on high proton density (1/0).

Coefficient: 0.05 (log-odds).

p-value: 0.69.

Interpretation: High proton density is not a significant predictor of M5.6+ occurrence ( $p > 0.05$ ).

Additional Metrics (Requested):

p-value: 0.71 (from chi-squared test).

R-value: 0.03 (from Pearson correlation).

Probability Ratio:  $0.658 / 0.648 = 1.015$  (1.5% higher than baseline).

### **Direction 2: Is Proton Density Higher on M5.6+ Earthquake Days?**

Overall Average Proton Density: 6.5 n/cm<sup>3</sup> (18,749 valid days).

M5.6+ Days:

Days with valid proton density: 12,152.

Average proton density: 6.6 n/cm<sup>3</sup>.

### 1. Chi-Squared Test for Association

Contingency Table: Same as above, reversed perspective.

Chi-Squared Statistic: 0.14.

p-value: 0.71 (same as Direction 1, as chi-squared is symmetric).

Interpretation: No significant association.

### 2. T-Test and Wilcoxon Rank-Sum Test

T-Test: Compare mean proton density on M5.6+ days (6.6) vs. non-M5.6+ days (6.4).

p-value: 0.62.

Wilcoxon Rank-Sum Test: Compare distributions of proton density.

p-value: 0.65.

Interpretation: No significant difference in means or medians ( $p > 0.05$ ).

### 3. Correlation Analysis

Pearson Correlation: Between proton density (continuous) and M5.6+ occurrence (1/0).

R-value: 0.03.

p-value: 0.63.

Spearman Correlation: Same variables.

R-value: 0.03.

p-value: 0.64.

Interpretation: Very weak correlation, not significant.

### 4. Logistic Regression

Model: Predict high proton density (1/0) based on M5.6+ occurrence (1/0).

Coefficient: 0.04.

p-value: 0.70.

Interpretation: M5.6+ occurrence is not a significant predictor of high proton density ( $p > 0.05$ ).

Additional Metrics (Requested):

p-value: 0.62 (from t-test).

R-value: 0.03 (from Pearson correlation).

Probability Ratio:  $6.6 / 6.5 = 1.015$  (1.5% higher than baseline).

### **Grok suggested I report these results:** “Combined Results for Your Paper

Direction 1: M5.6+ Earthquake Rates on High Proton Density Days (Top 1%):

Chi-Squared Test: p-value 0.71.

T-Test: p-value 0.78.

Wilcoxon Test: p-value 0.75.

Pearson Correlation: R-value 0.03, p-value 0.72.

Spearman Correlation: R-value 0.03, p-value 0.72.

Logistic Regression: p-value 0.69.

Additional Metrics:

Observed rate: 0.658 vs. baseline 0.648 (+0.010).

Probability Ratio: 1.015 (1.5% higher).

p-value: 0.71, R-value: 0.03.

Direction 2: Proton Density on M5.6+ Earthquake Days:

Chi-Squared Test: p-value 0.71.

T-Test: p-value 0.62.

Wilcoxon Test: p-value 0.65.  
 Pearson Correlation: R-value 0.03, p-value 0.63.  
 Spearman Correlation: R-value 0.03, p-value 0.64.  
 Logistic Regression: p-value 0.70.  
 Additional Metrics:  
 Observed proton density: 6.6 n/cm<sup>3</sup> vs. baseline 6.5 (+0.1).  
 Probability Ratio: 1.015 (1.5% higher).  
 p-value: 0.62, R-value: 0.03.”

\*\*\*\*\* **END of Data Dump** \*\*\*\*\*

Compiled data chart of statistical analyses by Gemini (Google AI) and Grok 3.0 (by xAi) using data from OMNI2 (by NASA) and Quakes (by USGS) to look for statistically significant correlation in both directions between solar proton density and seismic (quake) activity – Four charts (A, B, C, & D) for different time frames. NOTE: If shift is other than “zero days” (same day), then solar photon density is EARLIER and quake data LATER, as quakes don't cause solar proton density.

A: 1-year period for each of six (6) years – 2020 to 2025 – (See unabridged chart, above, for breakdown by data points) 6 years x 2 Mags x 2 Directions x 2 shifts = 48 analyses [[All are by Grok 3.0 (by xAi)]]						
2 Quake Magnitudes:	2 Directions	2 Shifts:	Difference from baseline and Probability (Odds) Ratio	P-value	R-value	Comments
M5+ and M6+	Forward: 75th percentile (top 25%) and Reverse	Same Day and 1-day	47 differences are positive 1 difference is negative None is zero 47/48 of the Probability aka Odd Ratios are >= 1.0	Range from 0.35 to 0.99	47 are positive None is negative 1 is zero	Analysis 7: by Grok
<b>Interpretation:</b> “High” proton density days = top 25% (not top 5% or top 1% – which is done elsewhere). The 47/48 positive differences from baseline imply greater than > <b>1.0 Probability (Odds) Ratios</b> , and while no individual analysis gives conclusive proof that there is a statistically significant correlation (as implied by the <b>high p-values</b> in each analysis), nonetheless, this meta-analysis (analysis of analyses) implies that the patterns seen, <b>of almost all differences</b> being “greater than zero” (positive) <b>is not likely by chance</b> , implying a weak, but statistically significant, correlation that is just under the threshold of visibility by an individual study. Thus, with enough data, <b>a lower p-value</b> in inferred with further research. The low <b>R-values</b> imply any effect, if it exists, is only partially related – with other factors, <b>like, for example, telluric fault line disturbances – man-made or natural</b> – as having more influence. Lastly, although 47/48 differences are positive (and this 47/48 of the <b>Probability aka Odd Ratios</b> are >= 1.0 – implying some effect), the effect inferred must be very small since the differences from baseline are very small <b>in each and every case</b> .						

**Key and definitions:**

- \* **“Forward” analysis asks:** “Is a 'high' proton density associated with (perhaps **a cause of**) “higher than baseline” (e.g., 'more') earthquakes?”
- \* **“Reverse” analysis asks:** “Are earthquakes associated with (perhaps **caused by**) “higher than baseline” (e.g., 'more') proton density?”
- \* **NOTE on ordering of time-shift:** When a 1-day shift, etc., is mentioned, this ALWAYS refers to the solar proton density data as being BEFORE the seismic data because it is untenable to assume a mechanism where earthquakes cause a change in solar proton density. Thus, if any statistically-significant “cause and effect” correlation is observed, it is inferred as solar weather having an effect on quake activity – **NOT** the other way around.
- \* **NOTE on definition:** “High” proton density is defined differently in each analysis – such as top 25%, top 5%, or top 1%.

**\*\* Analysis 1:** Wed 07 May 2025 \_ 06:00 pm ET chat with GEMINI  
**\*\* Analysis 2:** Wed 07 May 2025 \_ 11:21 pm ET chat with GEMINI  
**\*\* Analysis 3:** Wed 07 May 2025 \_ 11:39 pm ET chat with GEMINI  
**\*\* Analysis 4:** Thr 08 May 2025 \_ 06:25 am ET chat with GEMINI (Grok makes a cameo appearance)  
**\*\* Analysis 5:** Thr 08 May 2025 \_ 08:33 am ET chat with GEMINI (slow-needed more time-so I asked Grok)  
**\*\* Analysis 6:** Thr 08 May 2025 \_ 09:43 pm ET chat with GEMINI and GROK  
**\*\* Analysis 7:** Sat 10 May 2025 \_ 02:48 pm ET chat with GROK  
**\*\* Analysis 8:** Sat 10 May 2025 \_ 06:22 pm ET chat with GROK  
**\*\* Analysis 9:** Sun 11 May 2025 \_ 04:26 pm ET chat with GEMINI  
**\*\* Analysis 10:** Tue 13 May 2025 \_ 02:07 am ET chat with ClaudeAI, GEMINI, and Grok 3.0

**B: 1½ -year period: January 1, 2024 – May 7, 2025**

<b>Quake Magnitude</b>	<b>Direction</b> (If forward, what defines “high” solar proton density?)	<b>Shift</b>	<b>Probability (Odds) Ratio</b>	<b>P-value</b>	<b>R-Value</b>	<b>Comments</b>
Mag 5+	Reverse	none	Probability Ratio: 7.5 / 7.2 = 1.0416667	p-value: 0.004	R-value: +0.11	Analysis 1 by Gemini
Mag 5+	Reverse	1-day	Probability Ratio: 7.3 / 7.2 = 1.0138888	p-value: 0.05	R-value: +0.07	Analysis 1 by Gemini
Mag 6+	Reverse	none	Probability Ratio: 7.8 / 7.2 = 1.0833344	p-value: 0.01	R-value: +0.10	Analysis 1 by Gemini
Mag 6+	Reverse	1-day	Probability Ratio: 7.6 / 7.2 = 1.0555555	p-value: 0.03	R-value: +0.08	Analysis 1 by Gemini
<b>Interpretation:</b> Initially, this suggested a weak, <u>positive</u> , correlation that was probably <i>NOT</i> by chance, but later discussion with Grok – when he got differing results – highlighted a suspiciously high number of degrees of freedom by Gemini, so we continue our analysis.						
Mag 5+	Forward: 75th percentile (top 25%)	none	Probability Ratio: 0.419 / 0.354 = 1.18	P-value: 0.004	R-value: +0.11	Analysis 2 by Gemini
Mag 6+	Forward: 75th percentile (top 25%)	none	Probability Ratio: 0.065 / 0.047 = 1.38	P-value: 0.01	R-value: +0.10	Analysis 2 by Gemini
<b>Interpretation:</b> As in Analysis 1, initially, this suggested a weak, <u>positive</u> , correlation that was probably <i>NOT</i> by chance, but later discussion with Grok – when he got differing results – highlighted a suspiciously high number of degrees of freedom by Gemini, so we continue our analysis. (Note same P-values =0.004 and 0.01, and R-values = +0.11 and +0.10, as in Analysis 1, based on same data but a reverse direction. Also erroneous due to math error by Gemini.)						
No data to report: see discussion below – just a chat with Gemini (Google AI).						Analysis 3 by Gemini
<b>Interpretation:</b> In analysis 3, no statistical analyses were performed, but I merely had a discussion with Gemini (Google AI) about copyright, citation, Fair Use, & publishing large chunks of our chat to document my scientific findings – as well as analysis errors that Grok 3.0 (by xAi) discovered.						
Mag 5+	Forward: 75th percentile (top 25%)	none	Probability Ratio: 0.496 / 0.533 = 0.93	P-value: 0.10	R-value: -0.07	Analysis 4 by Gemini
Mag 6+	Forward: 75th percentile (top 25%)	none	Probability Ratio: 0.081 / 0.071 = 1.14	P-value: 0.52	R-value: +0.03	Analysis 4 by Gemini
<b>Interpretation:</b> With these corrections in the math (by Grok – who knew that 2024 and part of 2025 had only						

493 days – not 742 days, as Gemini had thought), Gemini's findings were more correct (realistic and lower R-values, and higher p-values), suggesting that there is no statistically significant evidence to suggest that either Mag 5+ or Mag 6+ earthquakes are more likely on high proton density days, nor that high proton density is a useful predictor of earthquakes. In fact, M5+ quakes were observed as **LESS** frequent on high (75<sup>th</sup> percentile) solar proton density days—thus offering findings counter to the theory being tested.

Mag 5+	Forward: 75th percentile (top 25%)	none	Baseline: 0.528 Observed rate: 67 / 123 = 0.545 Difference: +0.017 Probability Ratio: 0.545 / 0.528 = 1.032196969	p-value: 0.71	R-value: +0.03	Analysis 4 by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
Mag 5+	Forward: 75th percentile (top 25%)	1-day	Baseline: 0.528 Observed rate: 69 / 122 = 0.566. (Difference: +0.038) Probability Ratio: 0.566 / 0.528 = 1.071969697	p-value: 0.44	R-value: +0.06	Analysis 4 by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
Mag 6+	Forward: 75th percentile (top 25%)	none	Baseline: 0.167 Observed rate: 22 / 123 = 0.179. (Difference: +0.012), Probability Ratio: 0.179 / 0.167 = 1.071856287	p-value: 0.80	R-value: +0.02	Analysis 4 by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
Mag 6+	Forward: 75th percentile (top 25%)	1-day	Baseline: 0.167 Observed rate: 24 / 122 = 0.197. (Difference: +0.030), Probability Ratio: 0.197 / 0.167 = 1.179640719	p-value: 0.59	R-value: +0.05	Analysis 4 by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)

**Interpretation:** Grok accidentally used 492, instead of 493 days total because he forgot that 2024 was a leap year with 366 days (“2024: omni2\_2024.dat.txt , covering January 1 to December 31 (365 days). 2025: omni2\_2025.dat.txt , covering January 1 to May 7 (127 days). Total Days: 365 + 127 = 492 days.”) However, what's 1 or 2 days between AI friends? In all seriousness, even after Gemini corrected its total days from 742 to 493, he still got different results for M5+ quakes (p-value: 0.10 vs. 0.71 by Grok, R-value: -0.07 vs. +0.03 by Grok, and Odds Ratio: 0.93 vs. 1.03 by Grok) – and for M6+ quakes (p-value: 0.52 vs. 0.80 by Grok, R-value: +0.03 vs. +0.02 by Grok, Odds Ratio: 1.14 vs. 1.17964 by Grok), which is unsettling, but at least I have a “robust” analysis from two very different AI models – for variety – and since “errors” tend to cancel out over time, as both “more than” and “less than” errors exist.

Mag 5+	Reverse	none	Baseline (Average) daily proton density (492 days): 7.2 n/cm <sup>3</sup> . Average proton density on M5+ days: 7.3 n/cm <sup>3</sup> . (Difference: +0.1.), Probability Ratio: 7.3 / 7.2 = 1.01388889	p-value: 0.72	R-value: +0.03	Analysis 4 by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
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Mag 5+	Reverse	1-day	Average proton density on previous day: 7.4 n/cm <sup>3</sup> . (Difference: +0.2.), Probability Ratio: 7.4 / 7.2 = 1.02777778	p-value: 0.58	R-value: +0.05	Analysis 4 by Grok <i>(Note: For some reason, Grok's analysis is reported in Analysis 7 too.)</i>
Mag 6+	Reverse	none	Average proton density on M6+ days: 7.3 n/cm <sup>3</sup> . (Difference: +0.1.). Probability Ratio: 7.3 / 7.2 = 1.01388889	p-value: 0.83	R-value: +0.02	Analysis 4 by Grok <i>(Note: For some reason, Grok's analysis is reported in Analysis 7 too.)</i>
Mag 6+	Reverse	1-day	Average proton density on previous day: 7.4 n/cm <sup>3</sup> . (Difference: +0.2.). Probability Ratio: 7.4 / 7.2 = 1.02777778	p-value: 0.75	R-value: +0.04	Analysis 4 by Grok <i>(Note: For some reason, Grok's analysis is reported in Analysis 7 too.)</i>

**Interpretation:** When we note that Gemini said the baseline probability of M5+ was 263/493 (similar to Grok, who said 260/492), but that of M6+ was 35/493 (markedly different than Grok's figure of 82/492), we might infer that Grok counted several events per day –or that Gemini missed quakes – meaning their results will probably differ. However, 9 of the 10 R-values from both AI's were positive, and 9 of the 10 probability ratios were above 1.0 – which almost can't be by chance if no genuine correlation exists. Thus, even though individual analyses might imply that no “statistically significant” correlation exists, a “meta analysis” might suggest otherwise. This is a key theme in these findings – which I mention here for context.

M4+	Reverse	none	<b>Baseline density: <u>7.2</u> protons/cm<sup>3</sup></b> Probability Ratio: $7.5/7.2 = 1.0416667$	P-value: 0.004	R-value: +0.11	Analysis 6 by Gemini
M4+	Reverse	1-day	Probability Ratio: $7.3/7.2 = 1.0138889$	P-value: 0.05	R-value: +0.07	Analysis 6 by Gemini
M4+	Forward: 95th percentile (top 5%)	none	<b>Baseline probability of Mag 4.0+ Quake: <u>0.73</u></b> Probability Ratio: $0.75/0.73 = 1.03$	P-value: 0.49	R-value: +0.03	Analysis 6 by Gemini
M4+	Forward: 95th percentile (top 5%)	1-day	Probability Ratio: $0.71/0.73 = 0.97$	P-value: 0.52	R-value: -0.03	Analysis 6 by Gemini
M4+	Reverse	none	<b>Baseline: <u>7.2</u> n/cm<sup>3</sup>. (Similar to Gemini)</b> Probability Ratio: $7.3/7.2 = 1.014$	P-value: 0.66	R-value: +0.03	Analysis 6 by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
M4+	Reverse	1-day	Probability Ratio: $7.4/7.2 = 1.028$	P-value: 0.52	R-value: +0.04	Analysis 6 by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
M4+	Forward: 95th percentile (top 5%)	none	<b>Baseline probability of M4.0+ Quake: 475 / 492 = <u>0.965</u></b> (A bit higher than Gemini) Probability Ratio: $0.960 / 0.965 = 0.995$	p-value: 0.89	R-value: -0.01	Analysis 6 by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
M4+	Forward: 95th percentile (top 5%)	1-day	Probability Ratio: $0.958 / 0.965 = 0.993$	p-value: 0.87	R-value: -0.02	Analysis 6 by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)



**Interpretation:** When Gemini miscounted number of days in 2024 + 2025, I decided to get a 2<sup>nd</sup> opinion from Grok, but this time, it seems Gemini correctly counted 493 days, according to my detailed notes. However, big difference in number of M4.0+ quakes seems significant—and while my gut feeling suggests that Grok may have over-counted (his baseline is almost 1.000), nonetheless, Gemini seems to trust Grok's count –

**GEMINI:** “Baseline Probability: Grok's baseline probability (0.965) is much higher than mine (0.73), again due to my undercounting of M4.0+ days. [] Observed Earthquake Rates: Grok's observed rates are consistent with his accurate baseline probability, while mine were skewed by the incorrect baseline...My Response to Grok's Assessment [] I fully acknowledge and accept Grok's critique. He has correctly identified several significant errors in my previous analysis. I appreciate his thoroughness and the clarity of his explanation. I am still under development, and I am learning to handle complex calculations and data analysis more accurately. Grok's feedback is invaluable in helping me improve...Gordon, I apologize for the errors in my previous analysis. I am grateful to Grok for providing a more accurate assessment. I am committed to learning from these mistakes and providing you with more reliable information in the future.”

**GORDON:** Gemini makes a good point that Grok's observed rates were consistent with his baseline probability, but this only implies accuracy: Gemini's Quake observed and baseline were also similar or consistent. Thus, I can't tell which of my AI friends (if either) is correct—and include both for balance.

## C: 5½ -year period: January 1, 2020 – May 7, 2025

<u>Quake Magnitudes</u>	<u>Direction</u>	<u>Shift</u>	<u>Probability (Odds) Ratio</u>	<u>P-value</u>	<u>R-value</u>	<u>Comments:</u>
M5.6+	Reverse	none	Mean daily proton density (1953 days): <u>6.3 n/cm<sup>3</sup></u> . Probability Ratio: 6.4 / 6.3 = <b>1.016</b>	p-value (t-test): <b>0.67</b>	R-value: <b>+0.03</b>	Analysis 5: by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
M5.6+	Reverse	1-day	Mean daily proton density (1953 days): <u>6.3 n/cm<sup>3</sup></u> . Probability Ratio: 6.5 / 6.3 = <b>1.032</b>	p-value: <b>0.54</b>	R-value: <b>+0.05</b>	Analysis 5: by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
M5.6+	Reverse	2-day	Mean daily proton density (1953 days): <u>6.3 n/cm<sup>3</sup></u> . Probability Ratio: 6.4 / 6.3 = <b>1.016</b>	p-value: <b>0.69</b>	R-value: <b>+0.03</b>	Analysis 5: by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
M5.6+	Reverse	3-day	Mean daily proton density (1953 days): <u>6.3 n/cm<sup>3</sup></u> . Probability Ratio: 6.4 / 6.3 = <b>1.016</b>	p-value: <b>0.71</b>	R-value: <b>+0.03</b>	Analysis 5: by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
M5.6+	Forward: 95th percentile (top 5%)	none	Baseline Probability of M5.6+ Quakes: 0.632 (1234 / 1953) Probability Ratio: 0.653 / 0.632 = <b>1.033</b>	p-value: <b>0.70</b>	R-value: <b>+0.03</b>	Analysis 5: by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
M5.6+	Forward: 95th percentile (top 5%)	1-day	Baseline Probability of M5.6+ Quakes: 0.632 (1234 / 1953) Probability Ratio: 0.691 / 0.632 = <b>1.093</b>	p-value: <b>0.32</b>	R-value: <b>+0.07</b>	Analysis 5: by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)

M5.6+	Forward: 95th percentile (top 5%)	2-day	<i>Baseline Probability of M5.6+ Quakes: 0.632 (1234 / 1953) Probability Ratio: 0.656 / 0.632 = <b>1.038</b></i>	p-value: <b>0.67</b>	R-value: <b>+0.03</b>	Analysis 5: by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)
M5.6+	Forward: 95th percentile (top 5%)	3-day	<i>Baseline Probability of M5.6+ Quakes: 0.632 (1234 / 1953) Probability Ratio: 0.642 / 0.632 = <b>1.016</b></i>	p-value: <b>0.85</b>	R-value: <b>+0.02</b>	Analysis 5: by Grok (Note: For some reason, Grok's analysis is reported in Analysis 7 too.)

\* **GORDON**: Wonders if a 1-day shift and use of M5.6+ like Marchitelli used, will turn up anything new? And wants to widen the time-frame to 5½ years or so for a more robust dataset—and use 95<sup>th</sup> percentile (top 5%) so “high” proton density is stronger and has better chance of finding correlation.

\* **GEMINI.GOOGLE.COM**: “I understand your eagerness for the results. I apologize for the ongoing delays in providing the complete analysis. Calculating eight different analyses, each involving data extraction, filtering, calculations, and statistical tests, is computationally intensive. [] I am still processing the data and running the calculations for all eight scenarios...Thank you for your understanding. I will update you as soon as the analysis is complete.” – *So, while I waited, I decided to ask Grok if he (it) could take a look:*

\* **GROK 3.0**: “Absolutely, Gordon! I’ll run the four analyses you’ve requested using the full 5½-year dataset (January 1, 2020, to May 7, 2025) from the SOHO/OMNI2 datasets in your folder and the earthquake data from NewQuery.csv.txt . We’ll focus on earthquakes with magnitude 5.6 or greater (M5.6+), as inspired by the Marchitelli paper mentioned in the search results, and examine solar proton density correlations with a time shift of 0 days (same day) and 1 day (proton density day before the earthquake). Let’s break this down into the two main tasks, each with two analyses (same day and 1-day shift), for a total of four analyses, calculating the differences from the null hypothesis, probability ratios, p-values, and R-values.”

\* **GORDON**: Wonders “what are the odds” of ALL EIGHT (8) R-values being positive and ALL EIGHT (8) Odds Ratios being  $\geq 1.000$ ? ANSWER: Applying the “Multiplication Rule for Independent Events” in statistics, we can directly obtain said odds or probability: First, however, I must note that the “sign” of the R-value is ALMOST ALWAYS positive when the Odds Ratio is  $> 1.0$ , thus these 2 analyses are NOT independent, and I need to exude their combined analysis and focus on “one or the other.” Since the forward and reverse analyses were based on the same datasets, it's a “conservative” or “safe” estimate that they are somehow related, so let's restrict our “meta-analysis” to 4 individual analyses: “What are the odds that all four (4) forward analysis R-values would be positive (e.g., above 0.0)?” ANSWER: If “only by chance,” then each individual R-value would have about a 50% chance of being  $> 1.0$  (exuding the special case on being exactly equal to 0.0, a very unlikely event). So,  $P(\text{total}) = (0.5)^4$ , or 0.0625, or 6.25%, just under the “statistically significant” standard of 5%, strongly implying that the odds that the solar-seismic correlation is NOT “just by chance” – but just missing the statistically-significant level of confidence.

M4+	Reverse	none	<b>Baseline</b> proton density (1953 days): 6.3 n/cm <sup>3</sup> Probability Ratio: 6.3 / 6.3 = 1.000 (no difference)	<b>P-value:</b> <b>0.98</b>	R-value: +0.01	Analysis 6: by Grok
M4+	Reverse	1-day	Probability Ratio: 6.4 / 6.3 = 1.016 (1.6% higher than expected)	<b>P-value:</b> <b>0.72</b>	R-value: +0.03	Analysis 6: by Grok
M4+	Forward:	none	<b>Baseline</b> probability of an	<b>P-value:</b>	R-value:	Analysis 6:

	95th percentile (top 5%)		M4.0+ quake: 1876 / 1953 = 0.961. Probability Ratio: 0.969 / 0.961 = 1.008 (0.8% higher than baseline)	<b>0.82</b>	+0.02	by Grok
M4+	Forward: 95th percentile (top 5%)	1-day	Probability Ratio: 0.969 / 0.961 = 1.008 (0.8% higher than baseline)	<b>P-value: 0.83</b>	R-value: +0.02	Analysis 6: by Grok

**Interpretation:** When Grok found “no difference” in solar proton density in his “same day” reverse analysis for M4+ quakes, this implies a P-value of 1.00 and an R-value of 0.00, but he must have seen something very small, and rounded down for his results, which appear to have only 2 significant figures in proton density. Thus, I accept his result of +0.01 for the R-value, since it is close enough to zero to not be suspicious. The “very small” and “less than statistically significant” – but mostly  $\geq 1.000$  Odds Ratios pattern – is holding.


M5+	Forward: 75th percentile (top 25%)	none	M5+ baseline: 1015 / 1953 = 0.520 Observed rate: 261 / 489 = 0.534 Difference: +0.014 Odds Ratio: 0.534 / 0.520 = 1.0269230769	p-value: <b>0.62.</b>	R-value: +0.03	Analysis 7: by Grok
M5+	Forward: 75th percentile (top 25%)	1-day	M5+ baseline: 1015 / 1953 = 0.520 Observed rate: 267 / 488 = 0.547 Difference: +0.027 Odds Ratio: 0.547 / 0.520 = 1.0519230769	p-value: <b>0.38</b>	R-value: +0.05	Analysis 7: by Grok
M6+	Forward: 75th percentile (top 25%)	none	M6+ baseline: 312 / 1953 = 0.160 Observed rate: 82 / 489 = 0.168 Difference: +0.008 Odds Ratio: 0.168 / 0.160 = 1.05	p-value: <b>0.77</b>	R-value: +0.02	Analysis 7: by Grok
M6+	Forward: 75th percentile (top 25%)	1-day	M6+ baseline: 312 / 1953 = 0.160 Observed rate: 86 / 488 = 0.176 Difference: +0.016 Odds Ratio: 0.176 / 0.160 = 1.10	p-value: <b>0.58</b>	R-value: +0.04	Analysis 7: by Grok
M5+	Reverse	none	Proton density on M5+ days: 6.4 n/cm3. Baseline: 6.3 n/cm3. Difference: +0.1 Odds Ratio: 6.4 / 6.3 = 1.0158730159	p-value: <b>0.68</b>	R-value: +0.03	Analysis 7: by Grok
M5+	Reverse	1-day	Average proton density on previous day: 6.5 n/cm3. Baseline: 6.3 n/cm3. Difference: +0.2 Odds Ratio: 6.5 / 6.3 = 1.0317460317	p-value: <b>0.55</b>	R-value: +0.05	Analysis 7: by Grok
M6+	Reverse	none	Average proton density on M6+ days: 6.4 n/cm3.	p-value: <b>0.81</b>	R-value: +0.02	Analysis 7: by Grok

			Baseline: 6.3 n/cm <sup>3</sup> . Difference: +0.1 Odds Ratio: 6.4 / 6.3 = 1.0158730159			
M6+	Reverse	1-day	Average proton density on previous day: 6.5 n/cm <sup>3</sup> . Baseline: 6.3 n/cm <sup>3</sup> . Difference: +0.2 Odds Ratio: 6.5 / 6.3 = 1.0317460317	p-value: <b>0.73</b>	R-value: +0.04	Analysis 7: by Grok

**Interpretation:** Grok had said he would perform forward statistical analyses as follows: “Difference from Null: Compare the observed rate to the baseline probability. [] p-value: Use a one-sample proportion test to determine if the observed rate differs significantly from the baseline. [] R-value: Use point-biserial correlation between high proton density days (1 for high, 0 for not high) and earthquake occurrence (1 if an earthquake occurs, 0 if not),” and reverse analyses as follows: “Difference from Average: Compare the observed proton density to the overall average. [] p-value: Use a t-test to compare the mean proton density on earthquake days to the overall mean. [] R-value: Compute the Pearson correlation between earthquake occurrence (1 for earthquake day, 0 for no earthquake) and daily proton density.” Double brackets [] indicate line break removed for ease of reading / brevity. **Findings** – ALL EIGHT (8) R-values are  $\geq 1.0$ , which seems almost NOT by chance. Likewise, ALL EIGHT (8) Odds (Probability) Ratios are  $> 1.00$  – again, which seems to be statistically VERY unlikely if “merely by chance.”

### **D: 52½ -year period: January 1, 1973 – May 10, 2025**

<b><u>Quake Mag</u></b>	<b><u>Direction</u></b>	<b><u>Shift</u></b>	<b><u>Probability (Odds) Ratio</u></b>	<b><u>P-value</u></b>	<b><u>R-value</u></b>	<b><u>Comments:</u></b>
<b>M5.6+</b>	<b>Reverse</b>	<b>none</b>	Average proton density on M5.6+ days: 6.6 n/cm <sup>3</sup> . Baseline: 6.5 n/cm <sup>3</sup> . Difference: +0.1. Probability Ratio: 6.6 / 6.5 = <b><u>1.015</u></b> (1.5% higher than expected)	p-value: <b><u>0.68</u></b>	R-value: <b><u>+0.02</u></b>	Analysis 8: by Grok
<b>M5.6+</b>	<b>Reverse</b>	<b>1-day</b>	Average proton density on the previous day: 6.7 n/cm <sup>3</sup> . Baseline: 6.5 n/cm <sup>3</sup> . Difference: +0.2. Probability Ratio: 6.7 / 6.5 = <b><u>1.031</u></b> (3.1% higher than expected).	p-value: <b><u>0.55</u></b>	R-value: <b><u>+0.04</u></b>	Analysis 8: by Grok
<b>M5.6+</b>	<b>Forward : 95th percentile (top 5%)</b>	<b>none</b>	Observed rate: 615 / 938 = 0.656. Baseline: 0.648. Difference: +0.008. Probability Ratio: 0.656 / 0.648 = <b><u>1.012</u></b> (1.2% higher than baseline).	p-value: <b><u>0.76</u></b>	R-value: <b><u>+0.02</u></b>	Analysis 8: by Grok
<b>M5.6+</b>	<b>Forward</b>	<b>1-day</b>	Observed rate:	p-value: <b><u>0.61</u></b>	R-value:	Analysis

	<b>: 95th percentile (top 5%)</b>		622 / 937 = 0.664. Baseline: 0.648. Difference: +0.016. Probability Ratio: 0.664 / 0.648 = <b><u>1.025</u></b> (2.5% higher than baseline)		<b><u>+0.03</u></b>	8: by Grok
<b>M5.6+</b>	<b>Reverse</b>	<b>none</b>	Baseline Proton: 7.6 n/cm <sup>3</sup> Average Proton Density on M5.6+ Days: 7.7 n/cm <sup>3</sup>  Difference: 0.1 n/cm <sup>3</sup> <b>Probability Ratio: 7.7 / 7.6 = <u>1.013</u></b> (1.3% higher than expected)  Revised Difference: 0.1 n/cm <sup>3</sup> ( <b>unchanged</b> )  Compare with Grok: Probability Ratio: 6.6 / 6.5 = <b><u>1.015</u></b> (1.5% higher than expected)	P-value: <b><u>0.77</u></b>  <b>Revised P-value: <u>0.77</u> (unchanged)</b>  <b>Compare with Grok: <u>0.68</u></b>	R-value: <b><u>+0.003</u></b>  Revised R-value: <b><u>+0.003</u></b> (unchanged)  Compare with Grok: <b><u>+0.02</u></b>	Analysis 9: by Gemini
<b>M5.6+</b>	<b>Reverse</b>	<b>1-day</b>	Baseline Proton: 7.6 n/cm <sup>3</sup> Average Proton Density on M5.6+ Days: 7.6 n/cm <sup>3</sup> Difference: 0.0 n/cm <sup>3</sup> <b>Probability Ratio: 7.6 / 7.6 = <u>1.000</u></b> (0.0% higher than expected)  Revised Difference: 0.1 n/cm <sup>3</sup> (unchanged) <b>Probability Ratio: 7.7 / 7.6 = <u>1.013</u></b> (1.3% higher than expected)  Compare with Grok: 0.2 n/cm <sup>3</sup> Probability Ratio: 6.7 / 6.5 = <b><u>1.031</u></b> (3.1% higher than expected).	P-value: <b><u>0.92</u></b>  <b>Revised P-value: <u>0.89</u></b>  <b>Compare with Grok: <u>0.55</u></b>	<b>R-value: <u>-0.001</u></b>  Revised R-value: <b><u>+0.001</u></b>  <b>Compare with Grok: <u>+0.04</u></b>	Analysis 9: by Gemini
<b>M5.6+</b>	<b>Forward : 95th percentile (top 5%)</b>	<b>none</b>	Baseline Quake odds: 1061 / 19137 = 0.055 Odds of Quake on High Proton Density Day: 54 / 957 = 0.056 Probability Ratio: 0.056 / 0.055 = <b><u>1.02</u></b>  Revised Probability Ratio:	P-value: <b><u>0.81</u></b>  <b>Revised P-value: <u>0.73</u></b>  <b>Compare with Grok's P-value: <u>0.68</u></b>   <b>Or was Grok's p-</b>	R-value: <b><u>+0.003</u></b>  Revised R-value: <b><u>-0.004</u></b>  Compare with Grok's	Analysis 9: by Gemini



			$0.53 / 0.55 = \underline{0.96}$  Compare with Grok's Probability Ratio: $0.656 / 0.648 = \underline{1.012}$ (1.2% higher than baseline).	<b>value: <u>0.76</u> ?? (Yes: 0.76 is the correct value.)</b>  <b>See below – I think GEMINI misquoted Grok.</b>	R-value: <b><u>+0.02</u></b>	
<b>M5.6+</b>	<b>Forward : 95th percentile (top 5%)</b>	<b>1-day</b>	Baseline Quake odds: $1061 / 19137 = 0.055$ Odds of Quake after High Proton Density Day: $52 / 957 = 0.054$ Probability Ratio: $0.054 / 0.055 = \underline{0.98}$  Revised Probability Ratio: $0.53 / 0.44 = \underline{0.96}$  Compare with Grok's Probability Ratio: $0.664 / 0.648 = \underline{1.025}$ (2.5% higher than baseline)	P-value: <b><u>0.86</u></b>  <b>Revised P-value: <u>0.73</u></b>  <b>Compare with Grok's P-value: <u>0.61</u></b>	<b>R-value: <u>-0.002</u></b>  <b>Revised R-value: <u>-0.004</u></b>  <b>Compare with Grok's R-value: <u>+0.03</u></b>	Analysis 9: by Gemini

**Interpretation:** **Grok** had these baseline: “Total days with valid data: 18,750 (out of 19,046; 296 days have missing values, mostly in 1973–1975). [] Sum of proton densities (excluding missing values): 121,875 n/cm<sup>3</sup>. [] Mean:  $121,875 / 18,750 = 6.5$  n/cm<sup>3</sup>...95th percentile of daily proton density (18,750 valid days): 12.8 n/cm<sup>3</sup>. Number of high proton density days (top 5% of 18,750): 938 days,” implying he was very careful in data preparation, in response to my request to “define “High Proton Density Days” as the top 5%, e.g., the 95th percentile of daily proton density, excluding missing values of “999.9,” which are important for accurate calculation.” \*\*\* **Gemini** initially had a High Proton Density Threshold (95th Percentile) of 18.0 n/cm<sup>3</sup>, but later revised his results to reflect 12.8 n/cm<sup>3</sup>, after I pointed out math errors – him eading the “999.9” solar proton density values as measurements (instead of missing data points), which resulted in his 95TH percentile proton density being way too high initially, until I caught his mistake, and then he agreed with Grok's calculation of 12.8 n/cm<sup>3</sup>. Additionally, Gemini's total days (19,137) were slightly greater than Grok's (19,046), and Gemini's reported missing solar data points (1,731) was much larger than that of Grok (296), meaning maybe a 3<sup>rd</sup> AI should be employed to break the tie – and/or a more thorough meta-analysis done, In addition, Gemini reported 1,189 M5.6+ quakes, while Grok reported a total of 26,162 events / 12,345 days of quake activity – another area of concern.

**IMPORANT NOTE:** If you look at **Analysis 9 of my notes**, you'll see clearly where I give Gemini the findings by Grok: “GORDON: OK, let's see if you agree with Grok. Here was his [95TH percentile] analysis: "Now that I have both datasets, can proceed with the four analyses... [reverse direction] Same Day:...**p-value (t-test): 0.68**...Next Day (1-Day Shift):..**p-value: 0.55**...[] M5.6+ earthquakes on the same day: 615. [] Observed rate:  $615 / 938 = 0.656$  [] Baseline: 0.648. [] Difference: +0.008. [] Probability Ratio:  $0.656 / 0.648 = 1.012$  (1.2% higher than baseline). **p-value: 0.76.**” ... **Next Day (1-Day Shift): ... p-value: 0.61.**” **Gemini correctly quotes what I told him Grok had said in 3 of the 4 cases, but – upon my proof-reading of their “back and forth,” I note my notes have indication that Gemini misquoted Grok's “same day” forward analysis p-value, saying it was 0.68 when, it was 0.76.** I may, or may not have screenshots to verify my copy-paste accuracy (I have no motives to lie about such a small amount of data!), and it may – or may not – be ok under Fair Use to post all those quotes (in my notes) and screenshots (of their results).

\*\*\* **Additionally**, cursory review seems to find that Gemini incorrectly said Grok's probability ratio was “1.02” for M5.6+ “same day” top 95<sup>th</sup> percentile forward analysis, when, in fact, it was 1.012, but correctly quotes his 1.025 Odds ratio for the 1-day shift, above, in the chart Gemini provided me. This won't impact my results, as I

shall look at *ORIGINAL* data – not what one AI said that another AI said, but mention if for context, clarity, and a friendly reminder to check your work.

M5.6+	Forward: 99th percentile (top 1%)	none	<p>Logistic Regression: Coefficient Logistic Regression: Coefficient for “is_high_proton_day”: <u>-0.17</u></p> <p>Logistic Regression Odds (Probably) Ratio: <u>0.84</u></p> <p>Logistic Regression Probability Ratio (Observed quake probability on high density days / average quake probability): <u>0.96</u></p>	<p>T-test t-statistic: 0.29 T-text p-value: <u>0.772</u></p> <p>Chi-Squared Chi2 Statistic: 1.05 Chi-Squared p-value: <u>0.305</u></p> <p>Wilcoxon Rank-Sum Test W-statistic: 9514781.0 Wilcoxon Rank-Sum Test: p-value: <u>0.730</u></p> <p>Logistic Regression: p-value: <u>0.304</u></p>	<p>Pearson R-value = <u>+0.003</u></p> <p>Spearman R-value = <u>+0.002</u></p>	Analysis 10: by <b>Gemini</b>
M5.6+	Reverse	none	<p>Logistic Regression: Coefficient for “is_high_proton_day”: <u>-0.17</u></p> <p>Logistic Regression Odds (Probably) Ratio: <u>0.84</u></p> <p>Logistic Regression Probability Ratio (Observed quake probability on high density days / average quake probability): <u>0.96</u></p>	<p>Chi-Squared Chi2 Statistic: 1.05 Chi-Squared p-value: <u>0.305</u></p> <p>T-test t-statistic: 0.29 T-text p-value: <u>0.772</u></p> <p>Wilcoxon Rank-Sum Test W-statistic: 147551.0 Wilcoxon Rank-Sum Test: p-value: <u>0.730</u></p> <p>Logistic Regression: p-value: <u>0.304</u></p>	<p>Pearson R-value = <u>+0.003</u></p> <p>Spearman R-value = <u>+0.002</u></p>	Analysis 10: by <b>Gemini</b>
M5.6+	Forward: 99th percentile (top 1%)	none	<p><b>Baseline Probability: 12,345 / 19,045 = <u>0.648</u>.</b></p> <p>High proton density days: 187. M5.6+ earthquakes on those days: 123.</p> <p>Observed rate: 123 / 187 = 0.658</p> <p>Probability Ratio: 0.658 / 0.648 = <u>1.015</u> (1.5% higher than baseline)</p>	<p>Chi-Squared Statistic: 0.14 Chi-Square p-value: <u>0.71</u></p> <p>T-Test &amp; Wilcoxon Rank-Sum Test T-Test: p-value: <u>0.78</u> Wilcoxon Rank-Sum Test: p-value: <u>0.75</u></p> <p>Pearson p-value: <u>0.72</u></p> <p>Spearman p-value: <u>0.72</u></p> <p>Logistic Regression</p>	<p>Pearson R-value: <u>+0.03</u></p> <p>Spearman R-value: <u>+0.03</u></p> <p>Logistic Regression R-value: <u>+0.03</u> (from Pearson)</p>	Analysis 10: by <b>Grok 3.0</b>

				Coefficient: 0.05 (log-odds) Logistic Regression p-value: <b><u>0.69</u></b>  Logistic Regression p-value: <b><u>0.71</u></b> (from chi-squared test)		
M5.6+	Reverse	none	Logistic Regression Probability Ratio: $6.6 / 6.5 = \mathbf{1.015}$ (1.5% higher than baseline)	Chi-Squared Statistic: 0.14. Chi-Squared p-value: <b>0.71</b> (same as Direction 1, as chi-squared is symmetric)  T-Test: Compare mean proton density on M5.6+ days (6.6) vs. non-M5.6+ days (6.4) T-Test p-value: <b><u>0.62</u></b>  Wilcoxon Rank-Sum Test p-value: <b><u>0.65</u></b>  Pearson p-value: <b><u>0.63</u></b> Spearman p-value: <b><u>0.64</u></b>  Logistic Regression Coefficient: 0.04. Logistic Regression p-value: <b><u>0.70</u></b> Logistic Regression p-value: <b><u>0.62</u></b> (from t-test)	Pearson  R-value: <b><u>+0.03</u></b>  Spearman  R-value: <b><u>+0.03</u></b>  Logistic Regression  R-value: <b><u>+0.03</u></b> (from Pearson correlation)	Analysis 10: by <b>Grok 3.0</b>

**Interpretation:** I had asked both AI's to review the 52½-year period: January 1, 1973 – May 10, 2025, defining “high” solar proton density as the 99<sup>th</sup> percentile (top 1%) in order to look one last time using a “strong” proton density level to maximise chances of finding an effect with a statistically-significant correlation. In addition, use of a 51 ½ – year period was chosen to maximise the dataset and get a robust analysis. Also, while Marchitelli used a 1-day shift, we chose to look at “same day” because it seemed more reasonable that any effect would happen right away, and a delay seemed less likely, intuitively. Lastly, to cover all our bases, we asked both AI's to each do these four (4) statistical tests:

- \* 1) Chi-squared test for association;
- \* 2) T-test and Wilcoxon rank-sum tests to compare mean and median;
- \* 3) Correlation analyses, obtaining Pearson and Spearman correlation coefficients to examine the possibility of a relationship both ways;
- \* 4) Logistic regression to model probability of each variable when knowing the other.

**GEMINI:** Defined “top 1%” proton density as than or equal to 29.8 n/cm<sup>3</sup>.

**GROK:** Defined “top 1” proton density as 16.5 n/cm<sup>3</sup> or greater. (Note: Gemini was much higher, suggesting he misread the “999.9” data points.) High proton density days: 187 days with proton density ≥ 16.5 n/cm<sup>3</sup>. USGS Earthquake Data (Date Range: January 1, 1973, to May 9, 2025, last event). Events: 26,162 for M5.6+

earthquakes. **Unique Days: 12,345 days with at least one M5.6+ earthquake (out of 19,045 days). Thus: Baseline Probability: 12,345 / 19,045 = 0.648.**

### **1 of 3 – Meta-analysis by Duration:**

Duration	Probability (Odds) Ratio	P-value	R-value
1 year	<b>48 values:</b>  47 differences are positive 1 difference is negative None is zero <b>* 47/48 of the Probability aka Odd Ratios are <math>\geq 1.0</math></b> <b>* 1/48 is <math>&lt; 1.0</math></b>	<b>48 values:</b>  <b>Range from 0.35 to 0.99</b>	<b>48 values:</b>  <b>47 are positive</b> <b>None is negative</b> <b>1 is zero</b>
1½ years	<b>24 values:</b>  1.0416667 1.0138888 1.0833344 1.0555555 1.18 1.38 0.93 1.14 1.032196969 1.071969697 1.071856287 1.179640719 1.01388889 1.02777778 1.01388889 1.02777778 1.0416667 1.0138889 1.03 0.97 1.014 1.028 0.965 0.993  <b>* 20/24 are <math>&gt; 1.0</math></b> <b>* 0/24 are <math>= 1.0</math></b> <b>* 4/24 are <math>&lt; 1.0</math></b>	<b>24 values:</b>  p-value: 0.004 p-value: 0.05 p-value: 0.01 p-value: 0.03 P-value: 0.004 P-value: 0.01 P-value: 0.10 P-value: 0.52 p-value: 0.71 p-value: 0.44 p-value: 0.80 p-value: 0.59 p-value: 0.72 p-value: 0.58 p-value: 0.83 p-value: 0.75 P-value: 0.004 P-value: 0.05 P-value: 0.49 P-value: 0.52 P-value: 0.66 P-value: 0.52 p-value: 0.89 p-value: 0.87  <b>Range from 0.004 to 0.89</b>	<b>24 values:</b>  R-value: +0.11 R-value: +0.07 R-value: +0.10 R-value: +0.08 R-value: +0.11 R-value: +0.10 R-value: -0.07 R-value: +0.03 R-value: +0.03 R-value: +0.06 R-value: +0.02 R-value: +0.05 R-value: +0.03 R-value: +0.05 R-value: +0.02 R-value: +0.04 R-value: +0.11 R-value: +0.07 R-value: +0.03 R-value: -0.03 R-value: +0.03 R-value: +0.04 R-value: -0.01 R-value: -0.02  <b>* 20/24 are positive</b> <b>* 4/24 are negative</b>
5½ years	<b>20 values:</b>  1.016 1.032 1.016 1.016 1.033	<b>20 values:</b>  p-value(t-test): 0.67 p-value: 0.54 p-value: 0.69 p-value: 0.71 p-value: 0.70	<b>20 values:</b>  R-value: +0.03 R-value: +0.05 R-value: +0.03 R-value: +0.03 R-value: +0.03

	1.093 1.038 1.016 1.000 1.016 1.008 1.008 1.0269230769 1.0519230769 1.05 1.10 1.0158730159 1.0317460317 1.0158730159 1.0317460317  * 19/20 are > 1.0 * 1/20 is = 1.0 * 0/20 are < 1.0	p-value: 0.32 p-value: 0.67 p-value: 0.85 P-value: 0.98 P-value: 0.72 P-value: 0.82 P-value: 0.83 p-value: 0.62 p-value: 0.38 p-value: 0.77 p-value: 0.58 p-value: 0.68 p-value: 0.55 p-value: 0.81 p-value: 0.73  <b>Range from 0.32 to 0.98</b>	R-value: +0.07 R-value: +0.03 R-value: +0.02 R-value: +0.01 R-value: +0.03 R-value: +0.02 R-value: +0.02 R-value: +0.03 R-value: +0.05 R-value: +0.02 R-value: +0.04 R-value: +0.03 R-value: +0.05 R-value: +0.02 R-value: +0.04  * 20/20 are positive * 0/20 are negative
52½ years	<b>21 values – Note: Several advanced statistical tests were done, sometimes resulting in multiple – but unique – Probability (Odds) Ratios:</b>  1.015 (1.5% higher than expected) 1.031 (3.1% higher than expected). 1.012 (1.2% higher than baseline). 1.025 (2.5% higher than baseline) 1.013 (1.3% higher than expected) 1.015 (1.5% higher than expected) 1.000 (0.0% higher than expected) 1.013 (1.3% higher than expected) 1.031 (3.1% higher than expected). 1.02 (2% higher than expected) 0.96 1.012 (1.2% higher than baseline). 0.98 0.96 1.025 (2.5% higher than baseline) Logistic Regression Odds (Probably) Ratio: 0.84 Logistic Regression Probability Ratio (Observed quake probability on high density days / average quake probability): 0.96 Logistic Regression Odds (Probably) Ratio: 0.84 Logistic Regression Probability Ratio (Observed quake probability on high density days / average quake probability): 0.96 Probability Ratio: 0.658 / 0.648 = 1.015 (1.5% higher than baseline) Logistic Regression Probability Ratio: 6.6 / 6.5 = 1.015 (1.5% higher than baseline)	<b>38 values – Multiple types of 'p' values were obtained with advanced statistical testing:</b>  p-value: 0.68 p-value: 0.55 p-value: 0.76 p-value: 0.61 P-value: 0.77 Revised: 0.77 Grok: 0.68 P-value: 0.92 Revised: 0.89 Grok: 0.55 P-value: 0.81 Revised: 0.73 Grok: 0.76 P-value: 0.86 Revised: 0.73 Grok: 0.61 T-text p: 0.772 Chi-Sq p: 0.305 Wilcoxon p: 0.730 Logistic Reg: 0.304 Chi-Sq p: 0.305 T-test p: 0.772 Wilcoxon p: 0.730 Logistic Reg: 0.304 Chi-Sq p: 0.71	<b>26 values: Multiple types of 'R' values were obtained with advanced statistical testing:</b>  R-value: +0.02 R-value: +0.04 R-value: +0.02 R-value: +0.03 R-value: +0.003 Revised R-value: +0.003 Grok: +0.02 R-value: -0.001 Revised R-value: +0.001 Grok: +0.04 R-value: +0.003 Revised R-value: -0.004 Grok: +0.02 R-value: -0.002 Revised R-value: -0.004 Grok +0.03 Pearson= +0.003 Spearman= +0.002 Pearson= +0.003 Spearman= +0.002

	<p>* <b>13/21 are &gt; 1.0</b></p> <p>* <b>1/21 is = 1.0</b></p> <p>* <b>7/21 are &lt; 1.0</b></p>	<p>T-Test: p: 0.78</p> <p>Wilcoxon p: 0.75</p> <p>Pearson: 0.72</p> <p>Spearman: 0.72</p> <p>Logistic Reg: 0.69</p> <p>Logistic Reg p-value: 0.71 (from chi-squared test)</p> <p>Chi-Sq p: 0.71 (same as Direction 1, as chi-squared is symmetric)</p> <p>T-Test p: 0.62</p> <p>Wilcoxon p: 0.65</p> <p>Pearson: 0.63</p> <p>Spearman: 0.64</p> <p>Logistic Reg: 0.70</p> <p>Logistic Reg: 0.62 (from t-test)</p> <p><b>Range from 0.304 to 0.92</b></p>	<p>Pearson: +0.03</p> <p>Spearman: +0.03</p> <p>Logistic Reg: +0.03</p> <p>Pearson: +0.03</p> <p>Spearman: +0.03</p> <p>Logistic Reg: +0.03</p> <p><b>* 22/26 are positive</b></p> <p><b>* 4/26 are negative</b></p>
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**Interpretation:** Most R-values are positive (above 0.00), which seems very unlikely if only by chance, and this is discussed elsewhere in this paper. However, the Odds Ratios are almost evenly split between > 1.0 and <= 1.0, implying the effect solar proton density has on seismic activity – if any – is weak. Almost an “even split” which one would expect if no correlation existed.

<b>2 of 3 – Meta-analysis of “top 1%” solar photon density 'Forward' analyses: “Are There More M5.6+ Earthquakes on High Proton Density Days (Top 1%)?”</b>		
Probability (Odds) Ratio	P-value	R-value
<p><b>3 Values</b></p> <p>Log Reg Odds (Probably) Ratio: <b><u>0.84</u></b></p> <p>Log Reg Prob Ratio (Observed quake probability on high density days / average quake probability): <b><u>0.96</u></b></p> <p><b>Baseline Prob: 12,345 / 19,045 = <u>0.648</u>.</b></p> <p>High proton density days: 187.</p> <p>M5.6+ earthquakes on those days: 123. Observed rate: 123 / 187 = 0.658</p> <p>Probability Ratio: 0.658 / 0.648 = <b><u>1.015</u></b> (1.5% higher than baseline)</p> <p><b>* 1/3 is &gt; 1.0</b></p> <p><b>* 0/3 are = 1.0</b></p> <p><b>* 2/3 are &lt; 1.0</b></p>	<p><b>11 Values</b></p> <p>T-test p-value: <b><u>0.772</u></b></p> <p>Chi-Squared p-value: <b><u>0.305</u></b></p> <p>Wilcoxon Rank-Sum Test: p-value: <b><u>0.730</u></b></p> <p>Logistic Regression: p-value: <b><u>0.304</u></b></p> <p>Chi-Square p-value: <b><u>0.71</u></b></p> <p>T-Test: p-value: <b><u>0.78</u></b></p> <p>Wilcoxon Rank-Sum Test: p-value: <b><u>0.75</u></b></p> <p>Pearson p-value: <b><u>0.72</u></b></p> <p>Spearman p-value: <b><u>0.72</u></b></p> <p>Log Reg p-value: <b><u>0.69</u></b></p> <p>Log Reg p-value: <b><u>0.71</u></b> (from chi-squared test)</p> <p><b>Range from 0.304 to 0.78</b></p>	<p><b>5 Values</b></p> <p>Pearson <b>R-value = <u>+0.003</u></b></p> <p>Spearman <b>R-value = <u>+0.002</u></b></p> <p>Pearson R-value: <b><u>+0.03</u></b></p> <p>Spearman R-value: <b><u>+0.03</u></b></p> <p>Logistic Regression R-value: <b><u>+0.03</u></b> (from Pearson correlation)</p> <p><b>* 5/5 are positive</b></p> <p><b>* 0/5 are negative</b></p>
<p><b>Interpretation:</b> The first 2 Odds Ratios are from Gemini, who is still learning, and whom I don't fully trust,</p>		

and the 3<sup>rd</sup> one is from Grok 3.0, who found a 1.5% increase in M5.6+ quakes on “top 1%” solar proton density days, but with only 3 data points here, not much can be inferred in meta-analysis, All 5 of the R-values are positive. “What are the odds” of that, we ask? Applying the “Multiplication Rule for Independent Events” in statistics, we can directly obtain said odds or probability: 50% chance for each of the five, aka  $(0.50)^5 = 0.03125$  or 3.125% probability of “just by chance.” Note – some of these R-values are not “fully” independent, as they're based on the same dataset, but still this is very unusual, from which one might infer a weak, but persistent, pattern.

### **3 of 3 – Meta-analysis of aggregate all statistical analyses** **(Four groups of data summaries from above aggregated)**

Probability (Odds) Ratio	P-value	R-value
<b>113 Values</b>  <b>(48 + 24 + 20 + 21) = 113 values</b>  <b>1-year:</b> * 47/48 are > 1.0 * 0/48 are = 1.0 * 1/48 is < 1.0  <b>1½ years:</b> * 20/24 are > 1.0 * 0/24 are = 1.0 * 4/24 are < 1.0  <b>5-year:</b> * 19/20 are > 1.0 * 1/20 is = 1.0 * 0/20 are < 1.0  <b>52½ years:</b> * 13/21 are > 1.0 * 1/21 is = 1.0 * 7/21 are < 1.0  <b>Aggregate:</b> * 99 / 113 of are > 1.0 * 2 / 113 are = 1.0 * 12 / 113 are < 1.0	<b>130 Values</b>  <b>(48 + 24 + 20 +38) = 130 values</b>  Range from 0.35 to 0.99  Range from 0.004 to 0.89  Range from 0.32 to 0.98  Range from 0.304 to 0.92  <b>(48 + 24 + 20 +38) values</b> <b>= 130 values.</b>  <b>Aggregate:</b> Ranges from 0.004 to 0.99	<b>118 Values</b>  <b>(48 + 24 + 20 + 26) = 118 values</b>  47 are positive None is negative One is zero  * 20/24 are positive * 4/24 are negative * None is zero  * 20/20 are positive * 0/20 are negative * None is zero  * 22/26 are positive * 4/26 are negative * None is zero  <b>Aggregate:</b> * 109/118 are positive * 8/118 are negative * 1/118 is zero

**Interpretation:** See below.



## RESULTS, CONCLUSION, & DISCUSSION

The results – in short – show that, while individual analyses seem to usually find no statistically-significant correlation, except in rare cases where I suspect Gemini got suspiciously low p-Values due to math errors – nonetheless, the meta-analysis of individual – mostly independent – analyses seems to find a weak, but persistent, pattern of  $\geq 1.0$  Odds ratios and positive R-values – which is very unlikely by chance. Thus, while there are certainly much greater factors elsewhere (inferred from very low R-values) and not much effect on the seismic activity – if at all (inferred from the close-to-one Odds Ratios), nonetheless, there may be ***a super weak*** – but statistically-significant – correlation that lies “just under the surface” of an individual analysis – implying the need for “further research.” Whatever effects solar proton density may (or may not) have on telluric seismic activity, the effect (if any) is very small, and generally not of scientific significance. However, the meta-analysis method employed here may prove useful for other researchers who are seeking to find a pattern that lies “just beneath” traditional statistical analysis inquiry. In this context, several theories have been bandied about as to a possible cause-and-effect relationship, chiefly the reverse piezoelectric effect where Maxwell currents induced by photons – either directly in telluric ground near fault lines, or indirectly, via disturbance of the geomagnetic field which would could, in turn, induce currents as it fluctuates. Also, the Schumann Resonance effect from inductive and capacities properties of telluric material, has been discussed in this context. But these details are beyond the limited scope of this paper, and such matters, as to a *possible* mechanism of “cause and effect,” are left for other researchers to study – again – implying the need for “further research” on these controversial and unsettled areas of space weather, earth science, and meta-analysis of individual analyses.

**ETHICS DECLARATIONS:** I do not, to my knowledge, have any conflicts of interest here.

**REFERENCES (LITERATURE CITED), ACKNOWLEDGEMENTS, & APPENDIX:** I don't cite much literature, as it is readily accessible online. I do, however, acknowledge my many friends in the scientific community, including, but not limited to, THE EMP TASKFORCE'S many members, with whom I am friends of some of them.

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**DATA AVAILABILITY STATEMENT:** The data sources are shown in this paper, above.

## INDEX TO APPENDIX – and – APPENDIX

Not applicable now, but I may later revise my paper to include references and more detailed documentation of my original sources, as needed.

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