TITLE

"EMPIRICAL EVIDENCE OF SPURIOUS CORRELATIONS AMONG SPACE WEATHER VARIABLES"

Comment:
The title is strong but too broad. The manuscript specifically focuses on **Forbush Decreases (FDs) and solar-cycle filtering effects**, not general space weather variables. Consider narrowing it to reflect the methodological contribution (solar-cycle removal and regression reassessment).

Suggested refinement:

> *Empirical Evidence of Solar-Cycle-Induced Spurious Correlations in Forbush Decrease Studies*

ABSTRACT

Comment 1:
The abstract is too long and contains grammatical inconsistencies. It should clearly state:

- ✔ What gap exists
- ✔ What exact statistical method was used
- ✔ What is new compared to previous studies
- ✔ A quantitative summary of main findings

Comment 2:
You claim "for the first time" several times. This must be supported carefully. Similar detrending approaches and solar-cycle filtering have been used before. This claim needs either citation support or softening.

Comment 3:
The phrase:

> "Most of the results are statistically significant at 95% confidence level."

This is not strong enough scientifically. Statistical significance alone does not prove causality. The abstract should clarify the conceptual implication.

INTRODUCTION

Comment 4:
The introduction is extremely long and overloaded with citations. It reads more like a review article than a focused research paper.

You need:

- ✔ A sharper problem statement.
- ✔ A clear paragraph stating:
  "This paper tests whether solar-cycle oscillations artificially inflate FD–geomagnetic correlations."

Comment 5:
There are grammar and structural issues:

Example:

"complex interdependencies of nature of geophysical phenomena"

This needs correction.

Comment 6:
The motivation for using regression instead of mutual information is not clearly justified. You cite advanced methods (AI, MI, CMI), but you only apply linear regression.

This mismatch weakens the conceptual framework.

DATA SECTION

Comment 7:
The data description lacks critical reproducibility details:

- ✔ What exact filtering method removed the solar cycle?
- ✔ Was it polynomial detrending?
- ✔ FFT-based subtraction?
- ✔ Moving average?
- ✔ Band-pass filtering?

You mention "rolling means" but this is insufficient.

This is a **major reproducibility weakness**.

Comment 8:
You state:

Solar cycle 23 (1996–2008)

But you do not justify why only one cycle was analyzed. Is the method robust across cycles?

METHOD

Comment 9:
The regression framework is simple Pearson product-moment correlation.

Given the strong autocorrelation in CR and solar wind data, did you:

- ✔ Check stationarity?
- ✔ Apply pre-whitening?
- ✔ Adjust for autocorrelation bias?
- ✔ Test residual independence?

Otherwise, your regression results may themselves suffer from spurious regression (Granger & Newbold problem).

Comment 10:
You mention multifractal detrended fluctuation analysis in Section 4, but no detailed method description is given earlier.

This creates inconsistency.

FD CATALOG DIFFERENCES

Comment 11:
The drastic difference in FD counts before and after filtering (e.g., 353 vs 52 large FDs) is extremely large.

This suggests that:

- ✔ Either the filtering is too aggressive,
- ✔ Or the thresholding method is unstable.

This needs methodological justification.

RESULTS

Comment 12:
The strongest claim:

r ~ -0.79 and -0.85 for FD-SWS after filtering

This is very high. Such strong correlation demands:

- ✔ Scatter plots
- ✔ Residual plots
- ✔ Cross-validation
- ✔ Stability tests

Without these, the result may reflect overfitting.

Comment 13:
Some p-values are reported as significant even when > 0.05 (e.g., 0.79). This is contradictory.

Comment 14:
Interpretation is slightly overstated. Correlation change after detrending does not automatically imply "spurious correlation".

It could also imply:

- ✔ Over-detrending
- ✔ Removal of physically meaningful low-frequency components

This nuance must be discussed.

DISCUSSION

Comment 15:
The manuscript does not sufficiently discuss:

- ✔ Physical mechanism behind stronger post-filtering correlations.
- ✔ Why solar-cycle oscillation suppresses large-FD–SWS coupling.
- ✔ Whether this effect should also appear in other neutron monitors.

Comment 16:
The claim:

"CR flux intensity changes are not attributed to space weather phenomenon at the time of small FD events"

This is too strong and not fully supported by the presented regression.

FIGURES 1 & 2

Comment 17:
The figures show dome-shaped distributions, but no statistical quantification of this pattern is provided.

Consider:

- ✔ Spectral power comparison before/after filtering
- ✔ Lomb–Scargle periodogram
- ✔ Wavelet power spectrum

SUMMARY & CONCLUSION

Comment 18:
The conclusion repeats results but does not:

- ✔ Clearly define theoretical implications
- ✔ Clarify forecasting implications
- ✔ Propose testable next steps

Comment 19:
The recommendation of FFT anisotropy separation feels disconnected from the main regression theme.

IMPORTANT REVIEW COMMENTS (MAJOR)

These are the most critical points that must be addressed before acceptance:

1. **Filtering methodology not clearly described** (major reproducibility issue).
2. No treatment of time-series autocorrelation → possible spurious regression.
3. Over-reliance on p-values without effect size interpretation.
4. Very large change in FD counts after filtering requires deeper justification.
5. No robustness tests (cross-validation, bootstrapping).
6. Overstated claims regarding causality.
7. Only one solar cycle analyzed.
8. Grammar and clarity need professional editing.
9. Inconsistent methodological narrative (AI/MI cited but not used).
10. Physical interpretation underdeveloped.

MINOR COMMENTS

1. Typographical errors (many).
2. Some references repeated.
3. Inconsistent table numbering (Table 1 mentioned twice).
4. SI and SSN acronyms should be defined once.

5. Use consistent units (GV, nT, km/s).

OVERALL REVIEW DECISION

Decision: Major Revision

The paper has:

- ✔ A strong scientific idea
- ✔ Important space weather relevance
- ✔ Valuable dataset

But requires:

- ✔ Methodological strengthening
- ✔ Clearer statistical rigor
- ✔ Language correction
- ✔ Reduced overstatement