

This manuscript deals with the study of ionospheric perturbations due to Sudden Stratospheric Warming Events, using complex networks and information theory approaches.

In my opinion, it is an interesting idea, and in line with various current studies on complexity approaches to geophysical phenomena. However, in the manuscript, the physical phenomena is not clear, the need for complexity approaches is not properly established, the methodology is not well described, and conclusions are, thus, not clear from the results obtained. Thus, I think this manuscript should be rejected.

1. Page 2, Introduction, paragraph 1: “The increasing number of extreme weather events is caused by climate change”. Please replace with a less categorical sentence, such as “is thought to be caused”, or “is associated with”, or “is likely caused”, etc.. Although this is not the main issue in the manuscript, and there is scientific consensus on the effects of human activity on climate, attributing such a direct causality seems beyond what the current consensus can provide.
2. Page 4, paragraph 2: “Notably”. This is not particularly notable. It is expected that the dynamics changes with time, given its dependence on solar wind conditions.
3. Page 4, paragraph 3: “the European-African sector needs special attention”. This claim should be justified.
4. Page 5, paragraph 1: “due to the emerging influence of the SSW over this sector”. What is special about the influence of SSW in this sector, with respect to other zones on the planet?
5. Page 6, paragraph 2: “Notably”. Why is this notable?
6. Page 7, paragraph 1: “leading to instability and divergence from its initial state”. Unstable is different from chaotic. The latter implies sensitivity to initial conditions, not necessarily instability.
7. Page 7, paragraph 1: “due to its continuous response”. I would not say that this is the only reason to consider the ionosphere as a dynamical system.
8. Page 7, paragraph 1: “disorderliness (chaotic)”. Disorder is not the same as chaos. This occurs in many places along the text, and should be clarified. Both concepts are not equivalent.
9. Page 7, paragraph 1: “Therefore, it is crucial to examine...”. It is not clear that, due to the arguments above, it is crucial to study what the authors state in the following sentence. Thus, “therefore” is not a proper word here.
10. Page 7, paragraph 2: “a theoretically robust method”. What do the authors mean with this?

11. Page 14, paragraph 2: “the Sq(H) current can be regarded as an observational”. Being an “observational time series” should depend only on being observed and being a time series. No relationship to changing dynamical behavior.
12. Page 14, before Eq. (2): “the average value between 24:00 and 1:00”. It is not clear that (2) represents a useful average, as it takes two particular hours within the day.
13. Page 15, paragraph 2: “the inherent characteristics of the transformed time series”. Some inherent characteristics, rather. This largely depends on what one is interested in studying. It is an abstraction, so it cannot keep all features of the time series.
14. Page 15, paragraph 2: “preserving topological information”. Not all topological information is preserved. This depends on the questions one is interested in asking.
15. Page 16, paragraph 1: “the HorizontalVG class, which represents one of the types of visibility graphs, namely the ‘Horizontal Visibility Graph’”. This is already implied by what has been said before.
16. Page 16, paragraph 1: “a network where each point in the series becomes a node, and edges are formed based on the visibility criteria between points”. This has already been said.
17. Page 16, paragraph 2: “entropy indicates a more chaotic structure”. Entropy is not the same as chaos. This occurs in many places along the text, and should be clarified. Both concepts are not equivalent.
18. Page 18, paragraph 2: “after applying the Horizontal Visibility Graph (HVG)”. Does this mean that the fuzzy entropy is calculated for the graph, not for the time series? This should be clarified.
19. Page 19, paragraph 1: “panel (b) is the detrended time series of solar quiet current transformed through Horizontal Visibility Graph (HVG)”. This should be explained. HVG yields a graph, not a time series.
20. Page 19, paragraph 1: “solar quiet current transformed through HVG”. Same as above. HVG yields a network, not a time series.
21. Page 19, paragraph 1: “These distinct features of entropy changes obtained in Fuzzy Entropy after HVG transformation of the solar quiet time series was not obvious in the results of Fuzzy Entropy obtained without HVG transformation method.” This could say that the Fuzzy Entropy is not a good metric for this phenomenon. Then, why should one trust a further abstraction such as the HVG, applied to a first abstraction which does not yield clear results?

It would be different if the HVG were directly applied to observed data.

22. Page 19, paragraph 1: “indicates that the HVG transformation method captures the dynamical characteristics”. At most, it suggests something, but the evidence of the usefulness of the HVG for this issue, so far, is inconclusive.
23. Page 19, paragraph 2: “across Europe and Africa”. How are these values, representing a region on the Earth’s surface, obtained from single point measurements at specific locations?
24. Page 19, paragraph 2: “The contour map depicts”. What is the meaning of the countour if one axis is time and the other is space?

There are also some formal issues which should be addressed:

1. “A consistent low entropy values”: Consistent low entropy values
2. “was found”: were found
3. “described by an atmospheric phenomenon”: described as
4. “force that drive”: drives
5. “can propagate forcing that can reshape the plasma density variability”: please rephrase
6. “These reshape”: This reshaping (?)
7. “this influences”: these
8. “The main mechanism responsible for the connections”: Please rephrase
9. “SSW can infer”: induce?
10. “imaging system”: imaging of what?
11. “They exhibit”: It exhibits? Does it refer to ”the dynamics”?, then it is singular.
12. “from the aspect of chaos theory”: perspective?
13. “Implementing the concept of nonlinear dynamics, informed by information theory and graph theory”: Please rephrase.
14. “INVESTGATED”:
15. “L”: L
16. “ $S_q(H)_t$ is the solar quiet current considered in minutes.”: This has just been said before Eq. (3).
17. “Given a time series X_i , Eq. (4)”: This line break should not exist.

18. “using the fuzzy function.”: colon instead of period.
19. “n and r”: n and r
20. “1.2 \sim 0.8”: It is better to write the lower number first.
21. “0.8 \sim 0.6”: Lower number first.
22. “most of the station”: stations
23. “changes in entropy reveals”: reveal
24. “during the phases of 2009 SSW. The phases of SSW are categorized into six namely: precondition phase, ascending phase, peak phase, descending phase, after SSW phase and no SSW phase”: This was said before.
25. “most of the station”: stations
26. “Figure 7”: This plot, and similar plots after this one, can barely be understood. Vertical axes cannot be read clearly, the labels D1, D2, etc. are almost invisible, and the meaning of each of the 31 frames is not clear.