

To the editor and reviewers, our sincere thanks for the time dedicated to corrections of this article, and the comments and suggestions that undoubtedly were essential for the improvement of this work.

This article presents an application of non-decimated wavelets to GPS ionospheric data. Their main result is given in Fig. 6, which successfully isolates the non-periodic component attributed to scintillation events by removing a daily periodic component. I recommend the article be accepted for publication, pending major, moderate, and minor issues to be addressed below.

MAJOR

The wavelet-transform (WT) application must be compared to a simpler Fourier-transform (FT). Otherwise, claims such as “hidden patterns cannot be detected” remain unconvincing. As the application relies mostly on the global wavelet spectrum, which is non-localized in time, it is unclear whether or not the more complicated WT is warranted for the application at hand. It'd seem entirely feasible to extract the largest-power sinusoid, then subtract this no-scintillation S4 behavior to isolate the scintillation events in S4 time series. Although the data gaps would be problematic for FFT-based methods, many other FT methods exist (e.g., Lomb-Scargle, etc.). Even fitting a single sinusoid to S4 at the expected 1-day period would seem appropriate.

This is an important point. We tried to clarify the advantage of using wavelets instead of some Fourier based methods. SLEX analysis or Lomb-Scargle periodograms could be used to detect periodicities even with missing data, but greatest difficulty is not to identify the periodicities in frequency domain, but the non-stationarity in time caused by sudden spikes that change part of the U-shapes: sometimes in the beginning, middle and/or end of the U-shape, with different magnitudes. From wavelet multiscale decomposition, it is possible to analyze and to identify in which scale the repeatability occurs (multipath and other effects that repeat every day). Because of this, we cannot fit a sinusoid to only 1-day period, because the daily effect will be overestimated, mainly when with the occurrence of scintillation effects in the edges of the U-shape.

Authors should cite and review more of previous related studies (decimated and undecimated wavelets, to ionospheric and other GPS signals), especially but not limited to those published in TEMA.

We agree and in the section “Introduction” were cited studies related.

Fig.1: who authored these figures? (Watch for plagiarism.)

The Source of the figures was put.

The Abstract should include a summary of results and findings.

Corrected.

MODERATE

The S4 index should be defined mathematically, including a citation to the literature. For improved interpretation, please note that it is a type of coefficient of variation, as utilized in statistics (i.e., it is the intensity standard deviation divided by absolute mean value of intensity), therefore it's a unitless ratio.

We defined the S4 index and improved the text for a better interpretation.

"Each coefficient of (2.4) is represented through...": you seem to be describing a figure which is missing.

We removed it from the text.

First paragraph in section 3 needs to be rewritten: avoid weasel words ("so significant", "most critical", "great relevance", "extreme importance"); cite a reference about the project.

We rewrote the text.

"The amplitude index S4 is the indicator of ionospheric scintillation [IS]": this definition is only true after removal of non-IS effects in S4. In other words, the S4 index is not synonymous with ionospheric scintillation activity, as it includes multipath, etc.

We agree and changed the phrase.

Authors assume that daily variations exhibited by S4 are dominated by multipath. This assumption is not necessarily true. There are many other daily effects unrelated to multipath, such as the nearly repeatable time-of-day in satellite rising and setting on the horizon and the correlation between ionospheric activity and time-of-day; also the antenna gain pattern depends on the satellite elevation angle; etc. Authors should not conclude that multipath has been removed, only that daily component was removed.

Corrected.

"It is important to eliminate or separate such [daily] behavior... we propose in this paper [to] estimate

Corrected.

"It is important to eliminate or separate such [daily] behavior... we propose in this paper [to] estimate this behavior, which is evidenced at smoother scales of the wavelet periodogram and subtract it from the TS. The estimation will be performed by multiscale decomposition of the period ... with low scintillation index": this discussion is critically important for explaining authors' intentions. It needs to be introduced much, much earlier, starting with the Abstract.

We introduced this discussion in the abstract.

“index presents gaps caused by the lack of data when the satellites are not being tracked”: this is a circular definition; daily gaps occur because the satellite is invisible, below the horizon; longer intermittent gaps (~ week-long) are likely data outages/failures (please confirm).

Corrected.

“The MOWT was applied...”: start a new section, 3.1, “Results”.

Corrected.

Fig. 5 has multiple x-axis labels: Translate, Index, Dia; please use a single form, preferably multiplying the sample index by the sampling interval (e.g., in decimal days).

Corrected.

Please compare and contrast Fig.5b and Fig.5d: is Fig.5b the cumulative sum of Fig.5d over increasing resolution levels?

Fig 5b. is a multiscale decomposition of the period of weak scintillation to identify in which scales the repeatability occurs (three smoothest scales). Fig5d is the periodogram of the daily periodic effect estimated from reconstruction of the three smoothest scales.

MINOR

It is unclear why some equations were numbered and others were not.

It is norm of the TEMA to number only equations that will be referenced.

Please avoid single-sentence paragraphs.

Corrected.

Fig.1b has labels which are too small to read; the legend says “cycle 24” but it actually shows two cycles.

We removed it from the text.

Fig.1a: please highlight the station utilized (PRU1).

We highlight the station PRU1.

The various other names for NDWT can be mentioned in the Introduction, not in the Abstract.

Corrected.

In the first paragraph of the Introduction section, please cite a general book on wavelets.

We cited.

“most known” → “most well known”

Corrected.

Cite a reference for Mallat's pyramid algorithm.

We cited.

When introducing "the origin", please emphasize that it is related to time or the independent coordinate.

It was clarified that is related to time.

The expression "artificial satellite" can be replaced with the simpler "GPS satellite".

Corrected.

"shift vector" → "shifted vector" (numerous occurrences)

Corrected.

Fourth paragraph in the Introduction: the algorithm implementation might be a pre-requisite for its application, but it cannot be the application motivation.

Corrected.

"Its possible implement" → "It is possible to implement"

Corrected.

Fifth paragraph in the Introduction: cite a book about GPS.

Corrected.

Sixth paragraph in the Introduction: rewrite first sentence.

It was rewritten.

"'privileged'" → "favored"

Corrected.

"which assumes" → "which assume"

Corrected.

"F layer": either define it or remove jargon.

It was removed.

First equation (unnumbered) : "e" → "and"

Corrected.

Second equation (unnumbered): what is the domain of the l index? If this a recurrence relation, please state so.

We explained.

In the first equation (unnumbered), the variable t is continuous, whereas in the second equation, t would seem to be discrete valued (corresponding to the observed times); please clarify notation.

We stated the second equation is in discretized form.

Fifth equation (unnumbered): please define ι (iota).

It is l , and it was replaced by k .

“The coefficients described in (2.1) ... by wavelets and scaling filters” →

“The coefficients c , d described in (2.1) ... by wavelets and scaling parent filters”

Corrected.

“will be in the sense” → “will be used”

Corrected.

Start a new sub-section, 2.1 “NDWT”, immediately before paragraph “The great motivation for the use of the NDWT...”

Corrected.

In the expression $l \bmod N$, the operator mod should be typeset upright and the variables in italic, thus $l \bmod N$; furthermore, as this expression is reused multiple times and in small-font subscripts, I'd recommend defining an auxiliary variable, e.g., $l' = l \bmod N$.

Corrected.

“after it has been upsample” → “after it has been upsampled”

Corrected.

“gotten” → “obtained”

Corrected.

“has more energy” → “has the most energy”

Corrected.

Eq.(2.5) introduces a third index n for W , which is absent in the definition of W as per eq.(2.3).

We removed it from the equation.

“specific high frequency” → “high sampling rate”

Corrected.

"receptors" → "receivers"

Corrected.

"The receiver, a Septentrio... fathering intervals up to 50 Hz": information seems duplicated from previous paragraphs.

We removed one from the text.

"OXCO": either define it or remove jargon.

We removed it from the text.

No need to introduce sigma-phi as it's not used.

We removed it from the text.

"The amplitude index S4 is the indicator of ionospheric scintillation" →

"The amplitude index S4 is the indicator of ionospheric scintillation utilized"

"The amplitude index S4 is one type of indicator of ionospheric scintillation"

Corrected.

"day where there are data" → "day when there are data" (check other occurrences of "where")

Corrected.

"has a shape of "U"" → "has a shape of inverted "U""

Corrected.

"behavior that not characterizes" → "behavior that does not characterize"

Corrected.

Briefly define "elevation angle" given this journal's audience (hint: horizon, overhead, etc.).

It was briefly defined.

"3 smoothest scales" → "three smoothest scales"

Corrected.

"equação" → "equation"

Corrected.

"multiscale, was plotted" → "multiscale, it was plotted"

Corrected.

"that refers to this level" → "" [delete]

Deleted.

"more relevant" → "is the greatest one" or "has the largest magnitude"

Corrected.

Fig.5d: its textual caption should mention the global spectrum too; and the axis label "global" should be replaced with "PSD" (for power spectral density), as in any periodogram

Corrected.