

Reviewer #3 (Comments to Author):

We would like to thank the reviewer for his/her constructive comments of the paper. We have addressed all the comments and issues below.

This is a novel contribution to the study of SAO by using two VLF receivers during nighttime. The authors conclude that:” the main source of the SAO in the nighttime D-region is due to NO_x molecules transport from the lower levels of the thermosphere, resulting in enhanced ionization and the creation of free electrons in the nighttime D region, thus modulating the SAO signature”. The weaknesses are the bad graphical presentation, no explicit discussion of the robustness or influences of the used data processing methods and finally the physical interpretation of the link between the seasonal dependence of NO transport and VLF amplitudes is not examined in detail, like a simple model of the NOSC waveguide programs and comparisons with experimental data. A better understanding is needed, too.

In this form I do not recommend this work for publication; may be after major and minor revisions.

Major comments:

M1- All figures are presented in unreadable form. Figure 1: Tick label too small. Connecting line is too small. Improvement needed. Figure 2: Tick labels and axes description are unreadable. Improvement needed. It is hard to count months in upper plots. Vertical lines are needed related to one or two months. Figure 3, 4: as Fig. 2 need improvement!

We agree with the reviewer's comment regarding Figure 1, and we have fixed it accordingly. However, we have not found problems with reading Figures 2-4 (including ticks, labels, etc.). It should be mentioned that these figures were already fixed after prior comments, and were approved.

M2- It is known that the nighttime measurements of VLF phase and amplitude are highly variable. So the motivation or some robustness tests of methodical capabilities should be discussed in relation to the SAO, AO, SC behavior.

We agree with the reviewer and therefore performed robustness tests to examine our nighttime data and methodology. This was made in two ways:

1. Removal of 20% of the raw data's measured points (not NaNs).

2. Addition of Gaussian noise into the raw data's measured points, with a standard deviation equal to the raw data's standard deviation.

Each of these methods was performed over each dataset 100,000 times in order to examine in how many of these runs, the SAO and AO were spectrally statistically significant, and if the SC trend keeps its sign.

The results showed that both the SAO and SC passed these robustness tests in 100% of the runs, and therefore strengthen our analysis findings. The AO passed the robustness tests in 100% of the runs for the DN-NWC dataset, but did not prove to be statistically significant for the MH-NSY dataset, as only 91% of the data removal runs and 58% of the noise addition runs kept this oscillation statistically significant.

A paragraph regarding these robustness tests was added to the text.

M3- Furthermore the interpretation should be improved: how the “normal two parameters” like high and sharpness used in propagation models (McRae and Thomson, 2000; e.g., MODESRCH Long Wave Propagation Capability) influencing the amplitudes and phases as function of seasonal cycle, including SC (trend like) or AO or SAO in order to understand the physical link in a better way.

We have performed many Long Wave Propagation Capability runs in order to find equivalent changes in h' (ionospheric base) and β (electron density profile sharpness) needed in order to gain the SAO amplitude changes found in our measurements, in comparison with the standard nighttime values given by *Ferguson* [1980] ($h'=87$ km, $\beta=0.66$ km⁻¹ and 0.46 km⁻¹ for DN-NWC and MH-NSY, respectively). We found that the nighttime SAO amplitude changes are equivalent to h' change of no more than 1.8 km and 1.3 km in DN-NWC and MH-NSY, respectively (see example plot attached), or 0.13 km⁻¹ and 0.15 km⁻¹ in β , respectively. We believe that the actual solution is a combination of changes in h' and β (NO transport affects the region down to ~ 85 km, which causes different electron density slope and lowers the reflection height), but as we do not have reliable phase measurements, the actual solution cannot be calculated.

The results here might explain some of the differences between the h' and β parameters' values obtained by *Ferguson* [1980], *Cummer et al.* [1998], and *Thomson et al.* [2007], as measurements were taken during different seasons.

A few sentences regarding these LWPC runs were added to the text.

Minor comments:

-m1 p2 118: NB should be defined

Fixed.

-m2 p3 115: EUV should be defined

Fixed.

-m3 p3 121: VLF is used for 3-30 kHz range, but MH-NSY uses 45.9 kHz, out of range!?

3-30 kHz is very arbitrary definition, and many authors use data from transmitters broadcasting up to ~50 kHz in their VLF definitions and studies.

-m4 p5 12: Why is the magnetic field measured not EM?

Our antenna only measures magnetic field and not electric.

-m5 p5 125 –p7 111: The procedure of data filtering is explained but the influence on SAO not really quantified ! Numbers are needed here!

We have not quantified this effect, but it is irrelevant for the results and conclusions of the paper.

-m6 p8 115: Is it a significant correlation, because the phasing is not so good, as written (see Fig. 2), and are missing data examined?

All the correlations found are statistically significant (P value < 0.05). The phasing difference is between the two data sets used, and this issue was discussed -in Section 4.2.

Missing data were not examined (no interpolation was used during whole of the analysis process).

-m7 p8 127: what means “normally expected”, this is not clear

In many of the studies on this topic, the SAO (in thunderstorm activity, TEC, etc.) peaked around the equinox. We have added references into the text.

-m8 p10 18: Why MJO is not considered?

MJO has a time period of ~50 days. This 241 days oscillation might be an MJO harmonic, but in that case, we would expect the lower harmonics to be pronounced as well.

-m9 p14 124: What about lunar tides they are larger in the ionosphere?

We agree, but we are not familiar with a SAO detected in lunar tides' amplitudes.

-m10 Figure caption of Fig. 2.: “30 days” is that correct, or “31 days”, should be seven!

Our choice was to use 30-days.