Response to Reviewer #1

Arecibo measurements of D-region electron densities during sunset and sunrise: implications for atmospheric composition

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Thank you very much for your review of our manuscript and for the very positive appreciation of our work. We have taken all your comments into account and will answer them point by point in the following.

(1) I couldn't find any statement about the solar and geomagnetic conditions during the measurements, only when it comes to using GCM 2005 data given an equivalent solar condition.
The referee is correct, geomagnetic and information n the suns activity is missing. We add the following passage to the manuscript within Sect. 2: "Geomagnetic activity during the measurement period was low to moderate with Kp index ranging from 0 to 4. The DST index reached a minimal value of -57 nt on September 1st 2016 10:00 UTC at the very end of measurement campaign. This enhanced geomagnetic activity The activity of sun was moderate with radio flux F 10.7 ranging between 80 and 100 sfu. The strongest solar flare was of type C2.2 and occurred on August 31st 20:19 UTC (GOES), but no immediate impact on the D-region is visible in the data."

2) L19: electron density measurement techniques are introduced: in situ, VLF radio wave reflections, ISR measurements. Later on, L33, suddenly MF radar techniques are mentioned if not highlighted as it is in the discussion section. I'm confident the MF techniques, given the system is well capable of it, is more useful and reliable than inferring VLF radio wave propagations...? Perhaps MF techniques could be mentioned already in L21?
The reviewer points to a confusion within the introduction section. The introduction has been reorganized, so that it represents the MF radar capabilities in a better way. We also include a reference of a review on MF radar techniques [Reid, 2015].

3a) Fig1: I suggest to adjust the color scales to higher electron densities max. 5e4 or 1e5 to limit the saturation for the E-region peak, even though it's not in the focus of this paper. But it will beautify the plot. 3b) Fig1: I assume the obvious gaps have been excluded for the subsequent statistics, but couldn't find a note? 3c) Fig1: Judging on that plot the noise floor, so the sensitivity, is near 10-100 el/cm^-3***. Especially with densities below 10, I'd be very careful near that noise floor... From Fig2 and Fig3 it doesn't look like you applied a kind of SNR selection, do you?***

The reviewer indicates that Figure 1 in the manuscript uses a color scale that is to some extent ill-suited for the E-region heights. Figure 1 has been replotted with the suggested color scale, see Figure 1. However, electron density structures at low densities are less pronounced with this color scale. Therefore, we will stick to the original color scale as it highlights regions and times with lowest electron densities which are, as you point out as well, in the focus of this paper. We add a sentence to the caption of the figure, stating that the color bar has been intentionally set like this.

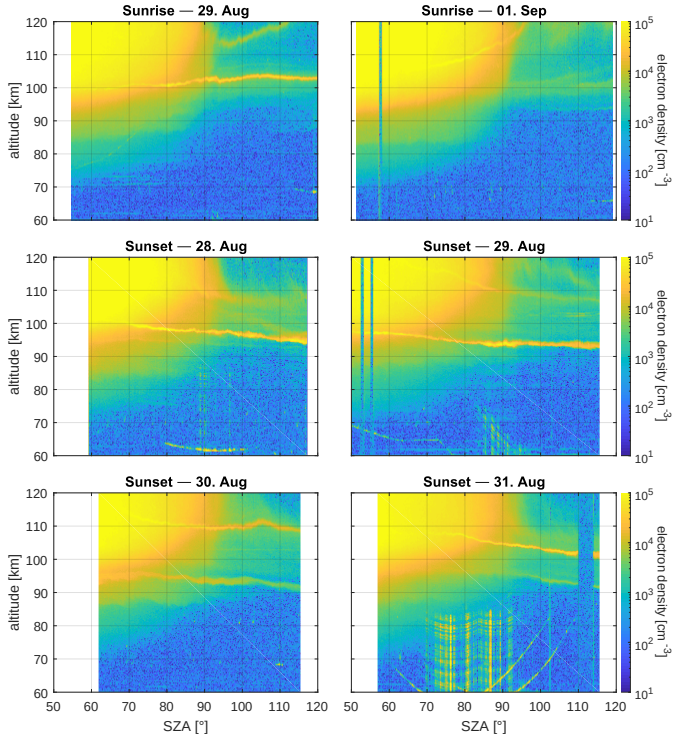

Figure 1: As in the manuscript but with 10^1 to 10^5 cm^{-3} color scale for the measured electron density.

Data gaps are excluded by applying the trimmed mean for the sunset observations. For the sunrise measurements, data gaps did only occur on 31. August very early in the morning, when the sun was still far below the horizon not affecting the analysis.

You are correct, we have not applied a SNR selection method, and you are also right that the sensitivity of the measurement is around 10 - 100 el/cm^-3. That is also mentioned within the text of the manuscript as well. The referee is also right, that Fig. 2 and 3 of the manuscript show electron densities scales down to $1el/cm^-3$, that has been only done to help guide the eye and indicate low or absent signal. We do not draw any conclusions from these values.

4) L102: A "25% trimmed mean" is used to explicitely suppress sporadic E layer echoes. How good does this suppression work considering the echoes are pretty intense. Perhaps adding a plot with an example to the manuscript or only as a reply comparing to e.g. median? Do you apply the same method to suppress the airplane/ship clutter? @ L98

Indeed, the description of the trimmed mean is not really clear. A 25% trimmed mean basically removes the greatest outlier before performing the mean. Given values are the mean of the 3 measurements which are closest to each other. This procedure helps removing not only sporadic E region electron densities but also data gaps and clutter from ships or planes. We have expanded the description for clarification. The sentence now reads: "For the case of the sunset dataset a 25% trimmed mean [e.g. Wilcox, 2011] is shown, doing that removes one strong outlier from the 4 observations either due to sporadic E layers, low altitude interference from ships/planes or data gaps during periods when the transmitter was off."

5) L110: At 80 altitude... -¿ At 80 km altitude...

Thank you, the missing unit has been added.

6) L141: I agree the years 2005 and 2016 were quite similar talking about the solar activity. I guess for that purpose that's sufficient, but what about the dynamics? From my impression WACCM-D is nicely reproducing daily means at late summer for these altitudes, not that sure about the time scales you're looking to, though.

The author is correct about the capabilities of WACCM-D. The scope of this paper is no detailed comparison of WACCM-D to the D-region observations. More specific model runs with lower time resolution are needed to fully assess the D-region sunset and sunrise with WACCM-D. That is subject of an upcomming paper.

7) L152: Nice idea to use multiple longitudes to create a higher SZA resolution... I'd worry about horizontal transport effects (dynamics).?. 1° longitude corresponds to roughly 100km displacement.

The reviewer is correct that the procedure to use data from different longitudes increases the time resolution but also limits the possibility to make statements on the horizontal transport. We have added a sentence to further clarify the issue. In order to assess the full dynamics within WACCM-D during sunset and sunrise model runs with higher time resolution are needed.

"The assumption is that the SZA-driven changes at sunrise/sunset, also on dynamics, are much stronger than any dynamical artifact coming from sampling different longitudes at the same time. Visual inspection of the WACCM-D data shows that no electron density artifacts are present."

8) L240 (, L285 and somewhere earlier): "Both models employ similar ionospheric reaction schemes." I think that's not strictly correct as

you pointed out earlier SIC and WACCM-D incoporate different amount of pos./neg. ions, and thus also possible reactions. I suppose to relax it by "equivalent", but not similar.
We incorporated the suggestion of the reviewer into the manuscript.

"cosmetics": - consistent use of value and ° without a space, L106, L108, L109, L111, L112 - L232: ..."altitudes between 90 and 75 km altitude." -¿ remove the latter
We thank the reviewer pointing out the issue with spaces between numerals and its units as well as the typo. Both errors have been corrected throughout the manuscript.

References

Iain Murray Reid. MF and HF radar techniques for investigating the dynamics and structure of the 50 to 110 km height region: a review. *Progress in Earth and Planetary Science*, 2(1), oct 2015. doi: 10.1186/s40645-015-0060-7.

Rand Wilcox. *Introduction to Robust Estimation and Hypothesis Testing*, chapter 2.2.3 The Trimmed Mean, page 32. Elsevier, 2011. ISBN 9780123870155.