Thank you very much for your comments and corrections.

Following are our answers (in blue) to your comments (in black).

In the revised manuscript, the changes which correspond to your remarks will appear in red, together with those corresponding to the comments of Reviewer #2 and to Dr. David Themens.

Line 46: “geomagnetic equator” should be “geomagnetic equator in some longitudinal ranges” – to be more correct.

You are right, since there some longitude ranges where the geomagnetic equator displacement is negligible. We will add: "in some longitudinal ranges", in the revised version of our manuscript.

Lines 92-93: The 15th day of a month need not be good approximation of monthly medians. If the 15th day occurs in the maximum or minimum of the 27-day variation, then it differs significantly from monthly median. Smooth variation in IRI does not mean no variation. However, we can assume that in the case of large number of data as it is the case of long-term trend investigations the effects of maxima and minima of the 27-day variation essentially cancel out. Nevertheless the usage of monthly medians in future work would increase reliability of results.

foF2 modeled by IRI does not include the 27 day variation, but an almost linear variation, which makes the mid-day of the month (around day 15) quite close to the median. As an example, Figure R1 shows the daily foF2 along one year (2000) for a point at 20°N, 30°E, 12 LT.

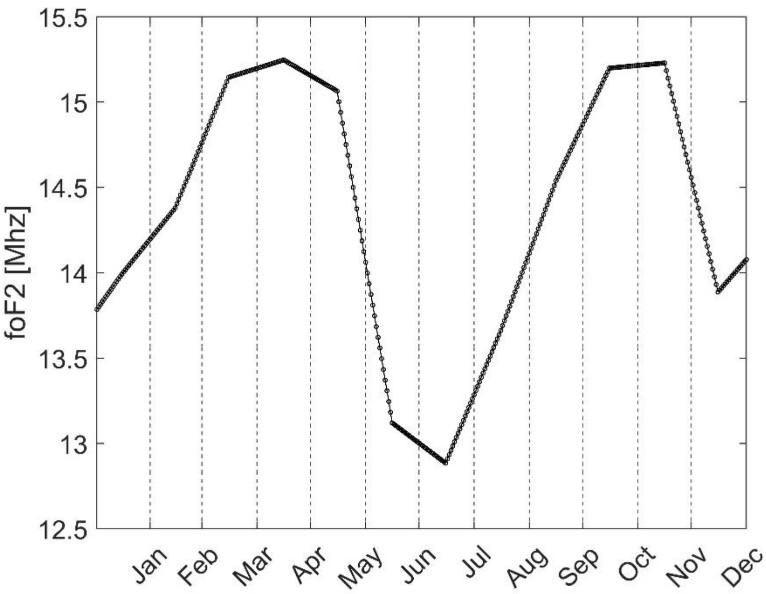

Figure R1. Daily foF2 estimated with IRI model at 20°N, 30°E, 12 LT, year=2000 (January to December). Dashed vertical lines correspond to the end of each month.

In Figure R2, we show the first three months alone, so the daily values can be noted more clearly.

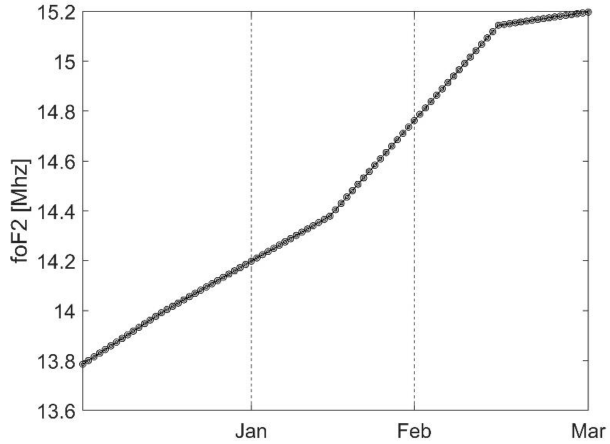

Figure R2. Daily foF2 estimated with IRI model at 20°N, 30°E, 12 LT, year=2000 (January to March). Dashed vertical lines correspond to the end of each month.

However, you are correct in that the foF2 IRI value within a month can differ depending on the chosen day. In order to assess the effect of choosing a given day, as is done in our work in order to save computing time, and of using the median we have done the following "experiment":

We first estimate the daily foF2 values along the period 1960-2022 for a mid-latitude location (20°N, 30°E). From this series, we assessed the annual foF2 value, but instead of using day 15 to represent the foF2 median of each month, we used day 1, then day 2, and so on until day 28 (we did not consider days 29, 30 and 31 due to February's days). In this way we obtained 28 different foF2 annual series. For each of them we estimated the trend after filtering solar activity effect using MgII. The values obtained are shown in Figure R3. We also assessed foF2 trends by considering the annual foF2 value averaging the median value of each month, and the mean of each month.

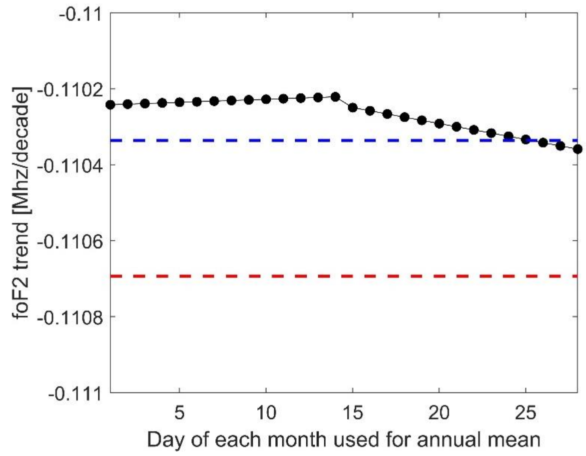

Figure R3. foF2 trend [MHz/decade] (black dots) in terms of the day of the month used to represent the monthly mean, which was then used to estimate foF2 annual mean. Solar activity was filtered with MgII. foF2 trend estimated from annual means obtained by averaging monthly median and monthly means of each month are indicated as a blue and a red dashed line, respectively. Note that the trend standard error is 0.02 MHz/decade, that is higher then the trend difference between black dots and any of the dashed lines.

Even though the trends are not the same, neither between them nor between them and the values obtained considering medians or means, the difference is smaller than the standard error of these trends, which in all the cases is ~0.02 MHz/decade. Note that the difference is around 0.006 Mhz/decade (an order of magnitude smaller than the error).

As an additional possibility we assessed foF2 annual values averaging the 12 monthly values assessed using a random day in each month. For example, for year 1960: day 12 for January, day 27 for February, day 5 for March, and so on for the following months and years. In this last case we made 10,000 random estimations which are shown un the following histogram (Figure R4).

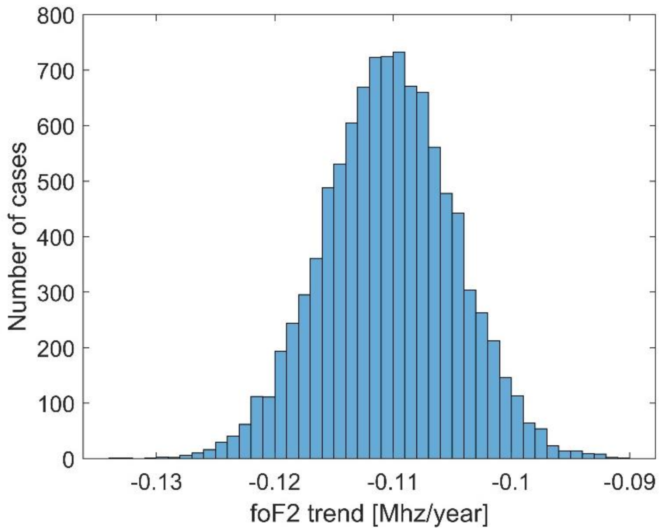

Figure R4. Histogram of 10,000 trends based on annual foF2, 12 LT, at position 20°N, 30°E, estimated considering one random day per month. Solar activity is filtered through Mg II.

The minimum trend value obtained is -0.09 MHz/decade, and the maximum value is -0.13 MHz/decade. Both include within the error interval (±0.02) the value of the trend obtained considering day 15 (which is -0.011024 MHz/decade), and that considering the true foF2 median (which is -0.011069 MHz/decade). The most probable trend values in this running of 10 thousand trend estimations lies between -0.111 and -0.109, and it again includes the value estimated in this work considering day 15.

We will add a comment on this trend variation depending on the day selection in IRI model in the Discussion section of the revised version of our manuscript.

Lines 106-108: Lastovicka and Buresova (2023) recommended F30 as the best solar proxy followed by Mg II used by authors. However, I understand that authors prepared their paper essentially before the paper by Lastovicka and Buresova has been published and Mg II appears also useful solar proxy.

F30 is not available as a solar proxy in IRI-Plas model. However, we estimated the trends with measured foF2 data at the 9 stations included in our work. They do not differ much from those estimated considering MgII, as can be seen in Figure R5 in the annual case at 12 LT, even though there are some cases differing in more than 0.2 MHz/decade (which is the average standard error for most of the trend values assessed with MgII or with F30). We also estimated these trends for the same stations but with foF2 assessed from IRI-Plas model.

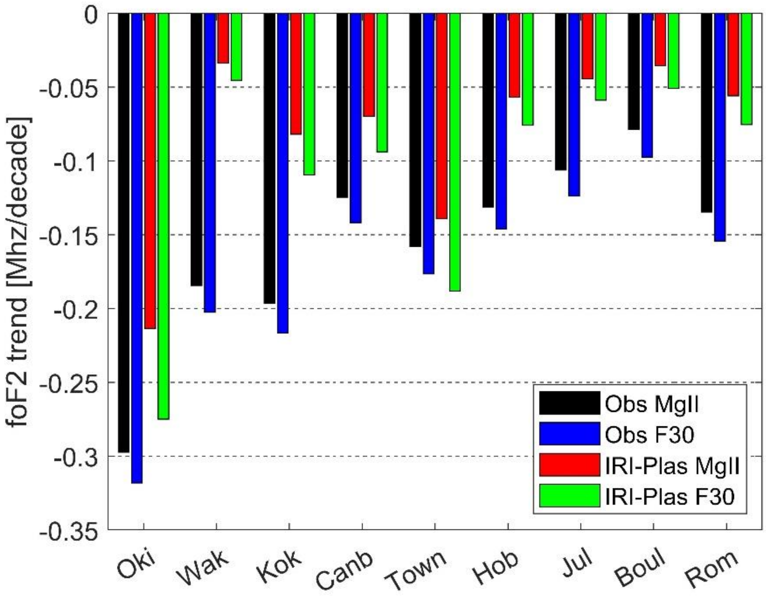

Figure R5. foF2 trend values [MHz/decade], based on annual data at 12 LT, estimated from stations' measured data (Obs, for 'observations') and IRI-Plas assessed data for each station, filtering solar activity effect considering MgII and F30: black: observations filtered with MgII, blue: observations filtered with F30, red: IRI-Plas estimations (using MgII) filtered with MgII, green: IRI-Plas estimations (using MgII) filtered with F30.

We perform the same estimation for each month along the period 1960-2022 (equivalent to Figure 3 of our work), at 12 LT, and we still see a good agreement, as can be seen in Figures R6 and R7, for measured f0F2 and IRI-Plas foF2, respectively.

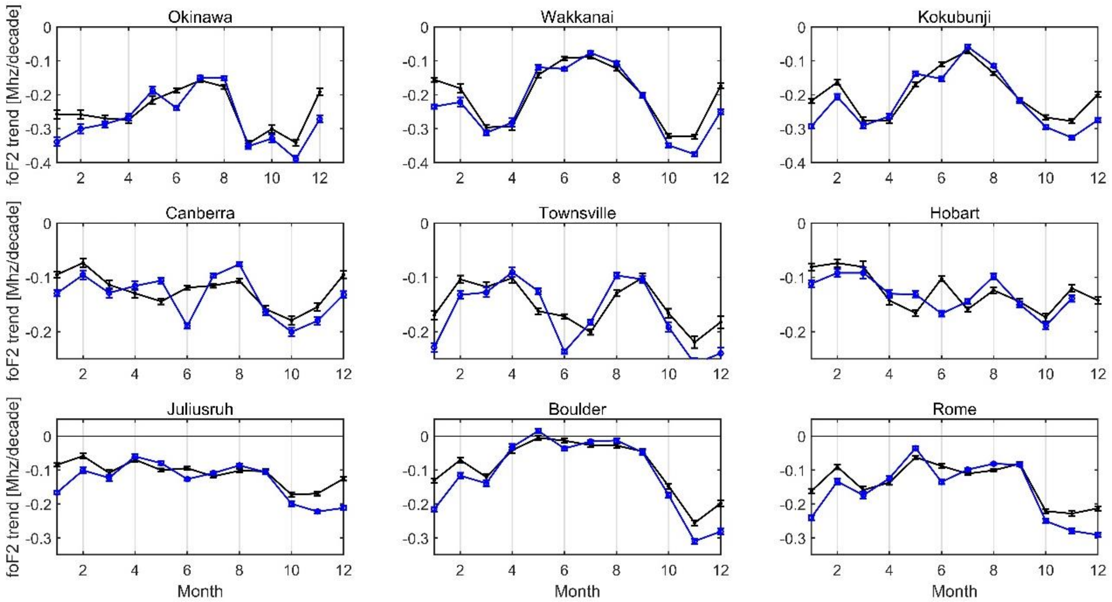

Figure R6. foF2 trend values [MHz/decade] for each month at 12 LT, estimated from stations' measured data filtering solar activity effect considering MgII and F30: black: observations filtered with MgII, blue: observations filtered with F30.

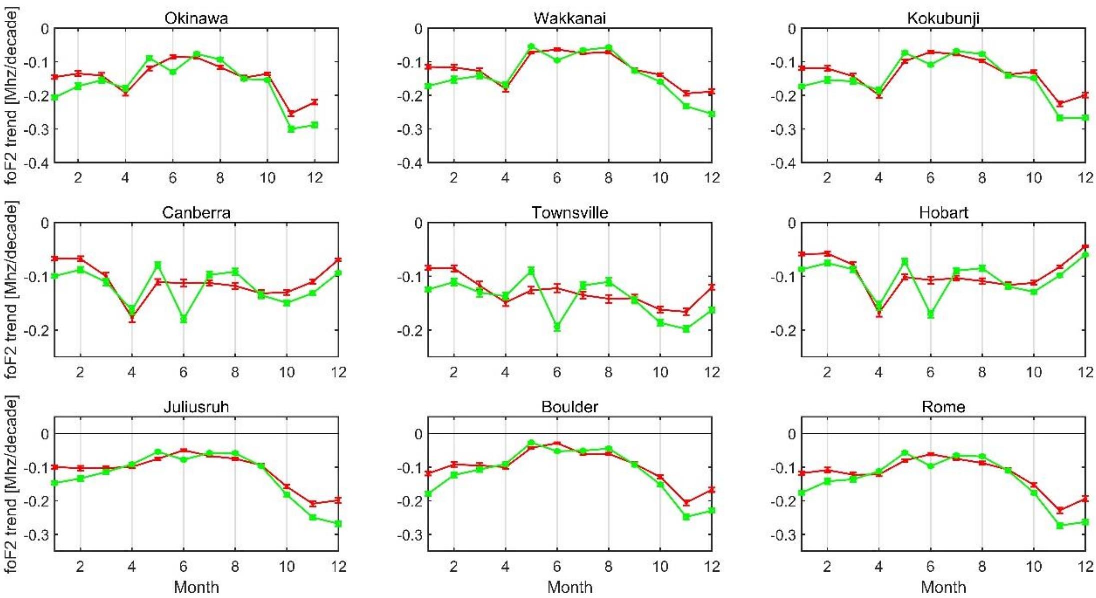

Figure R7. foF2 trend values [MHz/decade] for each month at 12 LT, estimated from IRI-Plas assessed data for each station, filtering solar activity effect considering MgII and F30: red: IRI-Plas estimations (using MgII) filtered with MgII, green: IRI-Plas estimations (using MgII) filtered with F30.

In the revised version of our work we included a comment based on these results in Section 6 (Discussion and conclusions) and added the reference of Lastovicka and Buresova (2023). In fact, we have also worked on F30 adequacy to to filter solar activity from foF2 and compared it to other indices, concluding that both, MgII and F30, are the best for this purpose. However, we could not distinguish if one was better than the other one. Our work (Zossi et al., 2023) was published after we sent this study to ACP, so we just now are including its reference.

Zossi, B.S., Medina, F.D., Tan Jun, G., Lastovicka, J., Duran, T., Fagre, M., de Haro Barbas, B.F., and Elias, A.G.: Extending the analysis on the best solar activity proxy for long-term ionospheric investigations, Proc. R. Soc. A., 479, 202302252. doi:10.1098/rspa.2023.0225

Line 161: “Stronger” should be “Weaker” according to Fig. 2 – trends in February and June are only about -1%/decade.

You are correct. We have change “stronger” fro “weaker” in the revised version of our work.

Page 8, Table 4: Some MREs, particularly for 00 LT, are too high – e.g. for Townsville α is not small at 00 LT (the second highest), nevertheless the corresponding MREs are very high. Please make a comment on that in the paper with possible explanation.

The explanation for this, and other large MRE values is given in the following paragraph, where precisely Townsville at 00 LT value is included:

“The cases with large MRE values correspond to those stations and LT that have an experimental trend value very close to zero. Since this value appears in the denominator of MRE (see Eq. 3), even a small difference in the numerator leads to a big MRE.   However, we can re-estimate MRE's excluding experimental trends equal to zero within the error. Specifically, in the 12 LT case, these would correspond to experimental trend values for Boulder in May; and in the 0 LT case, to Kokubunji in February and December, Townsville in June, Juliusruh in February, and Boulder in September and October. By doing so, the MRE decreases, as indicated by the values presented within brackets in Table 4."

In summary, the reason is the small trend values (close to zero) for these cases. So, if we compare to very close values we will anyway obtain a large MRE due to the division has a denominator close to zero.

Line 218: Delete "(highest values above the geomagnetic equator)" – this is unnecessary and incorrect statement.

Sorry for this mistake. We will delete this comment in the revised version.

Line 269: "represented by" should be "derived from" – this is more accurate.

You are correct. We will make this change.

Wording and misprints:

Line 107: "based in recent" should be "based on recent"

We will make this change.

Line 235 and throughout the paper: "valley" – the term used usually in literature is "trough"

Thank you for this observation. We will change "valley" for "trough" in the 7 places it appears along the manuscript.

Please, notice that after considering the observation made by Dr. David Themens some conclusions and arguments based in IRI model run have changed. They will be clearly stated in the revised version of our work.

Hoping to meet all your requirements,

Bruno S. Zossi, Trinidad Duran, Franco D. Medina, Blas F. de Haro Barbas, Yamila Melendi, and Ana G. Elias