Thank you very much for your comments and corrections.

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

The changes in the revised manuscript which correspond to your remarks will appear in red, together with those corresponding to the comments of Reviewer #1 and to Dr. David Themens.

The major issue that was not clear to me is the role of greenhouse gases in these trends (also raised in the comment by David Themens). The authors state at line 247 "The overall negative trends in both, foF2 and hmF2, is in agreement with that expected from increasing greenhouse concentration. Taking into account that IRI model does not include any forcing linked to these gases, the trends observed can be attributed to the data." What does this second sentence mean? What is the "data" being referred to? If the IRI model is periodically fitted to ionosonde observations, which are affected by greenhouse gas-induced changes, then it must already implicitly incorporate the effect of greenhouse gases. Although you state at line 80: "According to IRI general specifications, we expect it to somehow force variations linked to changes in the geomagnetic field, since it uses the IGRF model to specify geomagnetic poles and equator, but not those variations expected from the increasing greenhouse gases concentration." This is all very unclear.

We will explain now in more detail the sources of the trends when they are estimated considering foF2 and hmF2 obtained from IRI.

And precisely regarding your specific comment: "If the IRI model is periodically fitted to ionosonde observations, which are affected by greenhouse gas-induced changes, ...", it is not the IRI coefficients which are periodically adjusted for each year, but the solar activity proxy used, that is the IG index which carries the observations' information.

The trends expected from the secular variation of the Earth's magnetic field are clearly due to the interpolation coefficients with which foF2 and hmF2 are calculated, since they depend on the magnetic field inclination, and are obtained from IGRF. So, its secular variation is seen in foF2 and hmF2, which depends on location.

In the revised version of our work we will include the following paragraphs which explain in detail how IRI assess foF2 and hmF2:

"A key aspect in the present study is how IRI determines the F2 parameters for a given location. To begin, foF2 is obtained from CCIR (Consultative Committee on International Radio) maps that are based on a procedure of numerical mapping of a set of coefficients (CCIR Atlas of Ionospheric Characteristics, 1991) determined from a fitting to observed monthly median foF2 data from a worldwide network of ionosonde stations (~150 in total). From these maps of coefficients, IRI model reproduces the diurnal, seasonal and solar activity variation of foF2 in terms of latitude and longitude through Fourier time series. First, there is a set of functions in terms of geographic coordinates and the modified dip latitude used to describe the variation of the Fourier coefficients for a given number of harmonics defining the diurnal variation. Then, the seasonal variation is taken into account through a set of these coefficients (988 in total) for every month of the year. And finally, the solar activity dependence is considered by having all these monthly coefficients that account for the diurnal and geographic variation for two different activity levels: IG12=0 and IG12=100. From a linear fit between these two extremes (and also out of this range), the harmonic coefficients for any solar activity level can be estimated. IG was originally computed using 13 globally distributed ionosonde stations that included two of the 9 stations here analyzed: Kokubunji and Canberra (Liu et al., 1983). The distribution of these stations was a compromise between good global coverage and reliable long operating ionosonde stations. Due to station closings and data unavailability, the number of stations used in IG has decreased to four, but still includes the two stations which are included in the present study (Brown et al., 2018). Therefore, this proxy, being obtained from ionospheric measurements, includes foF2 variations not covered by a solar index.

Specifically, when a given solar proxy is selected among the IRI-Plas 8 options, it is automatically converted to other related indices used by the different modules procedures (Gulyaeva et al., 2018). In this way, foF2 interannual variation is obtained from the IG12 of the selected date. This index value is which finally defines the CCIR maps coefficient values that are assessed, as already mentioned, from the linear interpolation between the two coefficient sets, one for IG12=0 and the other for IG12=100.

Turning to the case of hmF2, the default option is considered in this study, and corresponds to the AMTB-2013 model (standing for Altadill-Magdaleno-Torta-Blanch) (Altadill et al., 2013). This model is based on quiet ionosphere data from 26 digisondes collected between 1998 and 2006. The monthly averages of the global hmF2 variations are represented by spherical harmonics including modified dip latitude and longitude for two selected levels of Rz12 (0 and 100, as in the case of IG). The interannual variation of hmF2 is obtained then from a linear fit of these two levels considering the Rz12 value of the corresponding date. The same procedure is applied in the cases of the other two options for hmF2 modeling. Thus in hmF2 case, the proxy used is only reflecting solar activity variability. Nevertheless, we include its long-term trend analysis considering that the correlation between IG and Rz is higher than 0.99, and that for a given location and hour, foF2 and hmF2 interannual variation highly correlates. Moreover, IG correlates the highest with Rz exceeding 0.99 along the period 1960-2022. The linear correlation between IG and MgII, F10.7 or Lyman-α, for example, are 0.975, 0.985 and 0.970 respectively."

Since the IRI model is fitted to ionosonde data, it is surely to be expected that there will be good agreement with the ionosonde data shown in Figs. 3 and 4. It seems rather circular, so I don't understand what the comparison really tests. It would be very helpful to provide a deeper description for the reader of exactly how the IRI model is fitted to ionosonde data e.g. how often the fitting takes place, over how many stations, are satellite measurements also used?

Thank you for this observation, which complements that of David Themens. We will explain now the process of how IRI assesses the time variation of foF2 or hmF2 for a certain location (included in the answer to your previous comment). This makes clear that, even though this ionospheric model uses foF2 measurements, it does it through a global index which is "processed" to finally give the selected location data.

In addition, even though it can be "circular", the fact is that the stations data is very sparse compared to the whole planet. So, the utility of the model is precisely "circular" at the stations whose data was included, but it is useful for the estimation at locations where there is no measured data.

Note that the case of hmF2 is different, and our conclusions regarding hmF2 trends, even though we obtain values according to expected ones, we cannot argue that they are due to the greenhouse cooling.

Minor points and corrections

line 75: "used to fix solar..."

The idea of the sentence is that IRI uses a given solar proxy which you cannot change. Not that the model fixes the solar activity level.

We have written this idea clearer in the revised version.

line 78: "we decided to ..."

We will make this correction in the revised version of our work.

line 90: define CCIR maps

We will include now the definition and additional explanation of CCIR maps in Section 2 (On some aspects of the IRI model), together with additional explanation on how IRI model takes into account the Earth's magnetic field (as included in our answer to your first comment).

line 162: Figure 2 does not contain upper and lower panels

You are correct. They correspond to left and right panels. We will make this correction to the revised version.

line 169: "generally good agreement"

We will make this change in the revised version of our manuscript.

line 205: "in the NmF2 trend case..."

We will make this correction in the revised version of our work.

line 214: "hmF2, the Cnossen (2020)..."

We will make this correction in the revised version of our work.

line 241: "...the Cnossen (2020) negative band"

We will make this correction in the revised version of our work.

line 254: "...to the hmF2 case."

We will make this correction in the revised version of our work.

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