Firstly, we thank the referee for providing useful comments on our manuscript. Following the referee's comments, we will carefully go through the manuscript and revise it. Herewith, we provide the answers to the referee's comments:

Answers to the Anonymous Referee #2

The paper presents observations of type II bursts during the ascending phase of SC25 achieved with e-CALISTO instruments as well as some associations of these type II bursts with space weather features. The paper presents potentially interesting events but needs some major improvements before publication. The conclusions on the type II analysis should be more emphasized (**what is new with these observations with respect to previous observations?**) and the link with the space weather effects should be investigated in more details (**the fact that effects are seen at the same time as the type II burst does not explain the physical link between both observations**).

Answer:

The current study reports on the first observation of type II solar radio bursts using ground data in solar cycle 25 with the emphasize of diagnosing the status of the progress of the solar activity. Type II radio observations are among the quick indicators of the solar activity as they provide clues to diagnose space weather hazards such as geomagnetic storms and radiation effects.
It is still difficult to predict space weather phenomena on a practical basis, but continuous monitoring of solar radio bursts plays an important role due to their origin and characteristics of being associated with space weather drivers. The ground observation of type II bursts (in metric) with large ground coverage contributes to early warning of solar activity status for associated geoeffective CMEs erupting in the corona and interplanetary medium.

Here are some detailed comments and questions:

Abstract

Line 3 : The authors mention solar storm disturbances, but they should precise which kind of disturbances since in the following of the paper they mention TEC enhancement, radio blackouts, polar cap absorption, etc.

Answer: The authors intended to refer to geomagnetic storms and subsequent effects in the magnetosphere and ionosphere such as radiation storms, when they used the term "solar storm disturbances." Therefore, the line is modified as follows: Being electromagnetic radiation that travels at the speed of light, type II radio bursts can serve as proxy to provide early alerts of incoming solar storm disturbances such as geomagnetic storms and radiation storms, which may lead to ionospheric effects.

Line 12: The authors mention solar proton enhancements and solar particle events. What is the difference ?

Answer: There is no difference between the two in the context of the current work. As a result, solar proton enhancement will be retained while the other is eliminated.

Observations

- **In the section, "Derivation of shock characteristic parameters', the authors quote the papers by Vrsnak et al. (2001, 2002) to estimate the density jump across the shock. However, in these papers, the BDW used in equation 2 refers to the instantaneous band splitting of the type II emission and not to the instantaneous bandwidth mentioned in equation 1. The authors should give clearer explanations of the description of the observations and the use of the relations derived from these papers. Do they observe band-splitting for all the type II bursts they analyzed? They should also correct the wording in section 2 as well as Figure 1's caption.**

Answer: The band-splitting of type II bursts is an important feature for calculating the coronal magnetic field. The bandwidth (BDW) is the width of the fundamental or harmonic band caused by the presence of a band-splitting type II burst. Cho et al. (2007) (ApJ,665:799), for example, used the width measured on the fundamental band of a band-splitting type II burst. Because all of the type II bursts examined lacked the band-splitting feature, we linked the width of the fundamental band to the ambient density jump to ensure consistency in computation; otherwise, we should have chosen only band-splitting type II bursts. However, the paraphrasing of Section 2 will be done in the revised version.

- **The authors assume a density variation as r-6.13 as used in Gopalswamy (2011). Given that the different e-CALLISTO instruments observe in different frequency bands (i.e. radio emission produced at different coronal heights), is this choice of density model relevant for all the events?**

Answer: The density model chosen is applicable to all type II bursts studied because it describes the variation within 1 - 3 solar radii (Rs) coronal height, and all of our events fall within that range.

- **In equation 6, the authors should indicate the units.**

Answer: Equation 6 is as follows: $B(G) = 5.1 \times 10^{-5} f_l(MHz) V_A(km/s) G$

- **The end of section 2.2 contains information on GPS data and is not relevant to the derivation of shock characteristic parameters. A new section should be created for the discussion of the GPS data.**

Answer: Section 2.3 is created for this part.

GPS data from ground-based GPS receiver stations around the world were used to analyze the ionospheric total electron content (TEC) for disturbed days identified by type II radio burst observations in this study. As GPS data are usually provided in Receiver Independent EXchange (RINEX) format, TEC were derived from Rinex files using the GPS TEC software developed at Boston college, assuming a thin shell ionosphere at the altitude of 350 km. Details on the software used to derive TEC are provided in Seemala & Valladares, 2011; Uwamahoro et al., 2018, and references therein.

1. Seemala, G., & Valladares, C. (2011). Statistics of total electron content depletions observed over the South American continent for the year 2008. Radio Science, 46, RS5019. https://doi.org/10.1029/2011RS004722.

2. Uwamahoro, J. C., Giday, N. M., Habarulema, J. B., Katamzi-Joseph, Z. T., & Seemala, G. K.(2018). Reconstruction of storm-time total electron content using ionospheric tomography and artificial neural networks: A comparative study over the African region. Radio Science, 53. https://doi.org/10.1029/2017RS006499

Results and discussions

(a) The e-CALLISTO network consists of many stations working in different frequency bands. The authors should specify in table 1 the name of the instrument(s) which observed the different type II bursts. Only a small number of the listed type II bursts starts at frequencies above 100 MHz. This may be linked to the instrument or reveal different characteristics of type II bursts. The authors should also discuss how the CME parameters are derived.

Answer: Given its size, Table 1 might become overloaded with additional data. As a result, we can make a new table that lists the instruments that were used, their locations, and their frequency ranges.

SN	File ID	Country	Lat(^{0})	Long(^{0})	Obs. Frequency Range (MHz)	# of events
1	Australia_ASSA	South Australia	-30.00	136.21	15 - 87	11
2	Arecibo_Observatory	Puerto Rico, USA	18.22	-66.59	15 - 87	9
3	GREENLAND	Greenland	67.00	-50.72	10 - 110	3
4	ALASKA_HAARP	ALASKA	64.84	-147.72	5 - 87	2
5	ALMATY	Kazakhstan	43.22	76.83	45 - 165	1

6	BIR	Ireland	16.61	77.51	10 - 100	1
7	INDIAN_OOTY	India	11.41	76.69	45 - 165	1
8	KASI	South Korea	36.35	127.38	150 - 400	1
9	MEXICO_LANCE	MEXICO	19.81	-101.69	50 - 90	1
10	SWISS-Landschlacht	Switzerland	47.63	9.25	15 - 87	1

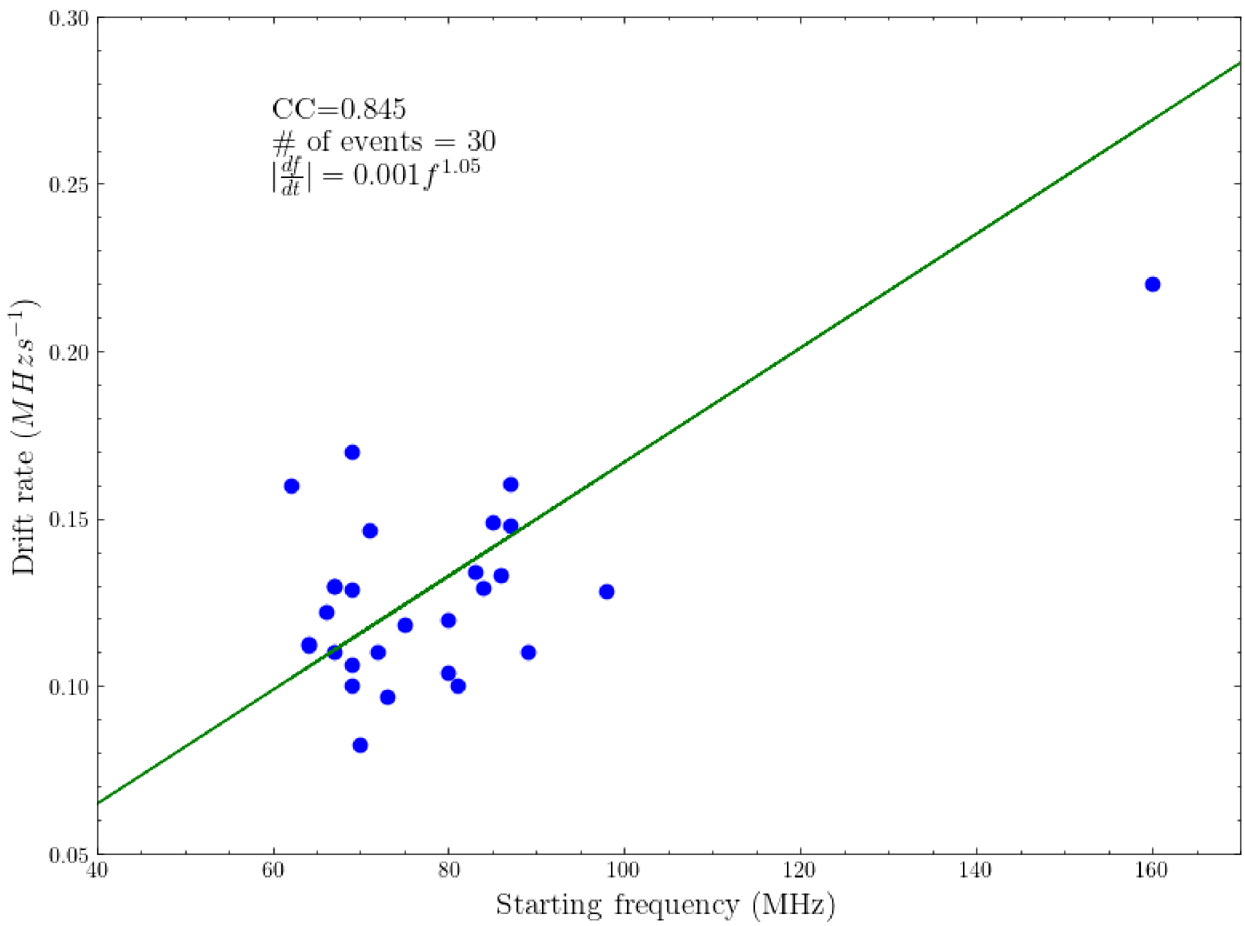
We compared the values of the derived shock parameters (shock speeds and Alfven speeds) with the speeds of the CME parameters, which were taken from the catalog.

(b) Line 102: The authors use a relationship published by Gopalswamy et al (2013) to derive the shock formation height of type II. They should discuss how this relationship was found and whether it can be used on another sample of data (like the present one).

Answer: According to Gopalswamy et al. (2013), the correlation between the starting frequencies of type II radio bursts and CME heights is best fit by a power-law: $f(r) = 307.87r^{-3.78} - 0.14$. It was established for a sample of 32 metric type II bursts at 1.20–1.93 solar radii (Rs). Umuhire et al., 2021 (Sol. Phys. 296:27), used this relation on a sample of 40 metric type II bursts at 1.16–1.90 Rs. As a result, we used this relationship to estimate the shock formation height for our sample of 31 metric type II bursts.

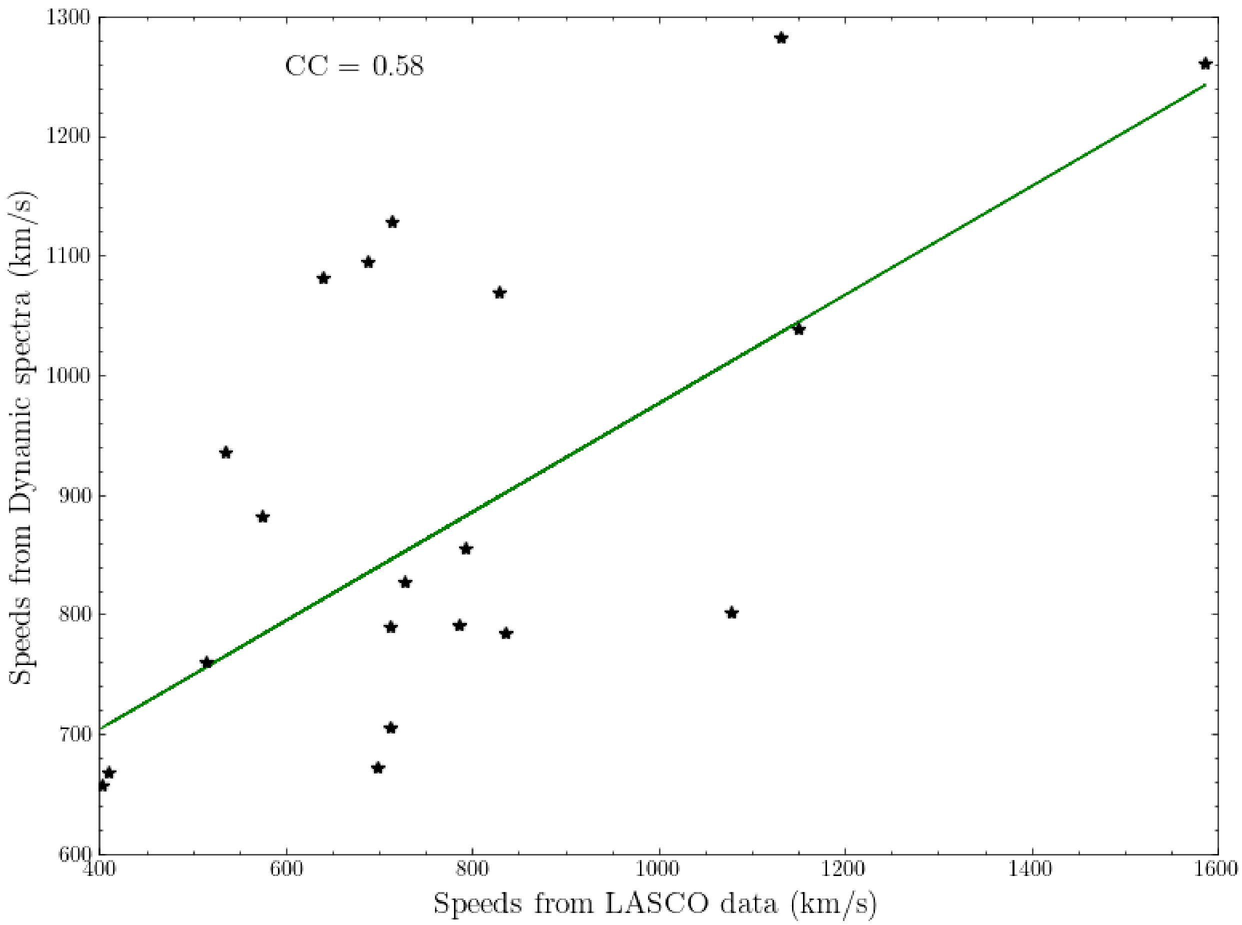
(c) Figure 2: Most of the type II bursts have starting frequencies below 100 MHz. Is the correlation coefficient different if only type II bursts with starting frequencies below 100 MHz are considered ? Same questions with the relationship between the frequency drift rate and the starting frequency ?

Answer: When only type II radio bursts with starting frequencies less than 100 MHz are considered, a very weak correlation (CC = 0.522) between frequency drift rates and frequencies is obtained because the observation is dominated by points with nearly equal values. This also has an impact on their relationship. However, considering type II with starting frequencies less than 200 MHz yields a different correlation coefficient (CC = 0.845), which is still a good correlation between the two parameters, and the relationship between the frequency drift rates and the frequencies becomes: $|\frac{df}{dt}| = 0.001f^{1.05}$ for 30 events out of 31. Therefore, figure 3 is modified as follows



(d) Figure 3: It would be interesting to plot v derived from the dynamic spectrum with respect to v derived from the CME.

Answer: Figure 3 is replaced by the following.



Section 3.2 : Associated Space Weather implication

(e) Figure 5 bottom : is this plot showing a prediction or real observations? Is this HF absorption linked to the arrival of protons or to the ionizing flux from the flare ? How can the type II burst observations explain this HF absorption ?

Answer: (i) The observation of the bottom of Figure 5 is real, that is why some of the type II bursts are associated with immediate effects.

(ii) The HF absorption is linked to the ionizing flux from the flare. Typically, the amount of ionizing radiation is measured in terms of the flux of particles or photons per unit area per unit time.

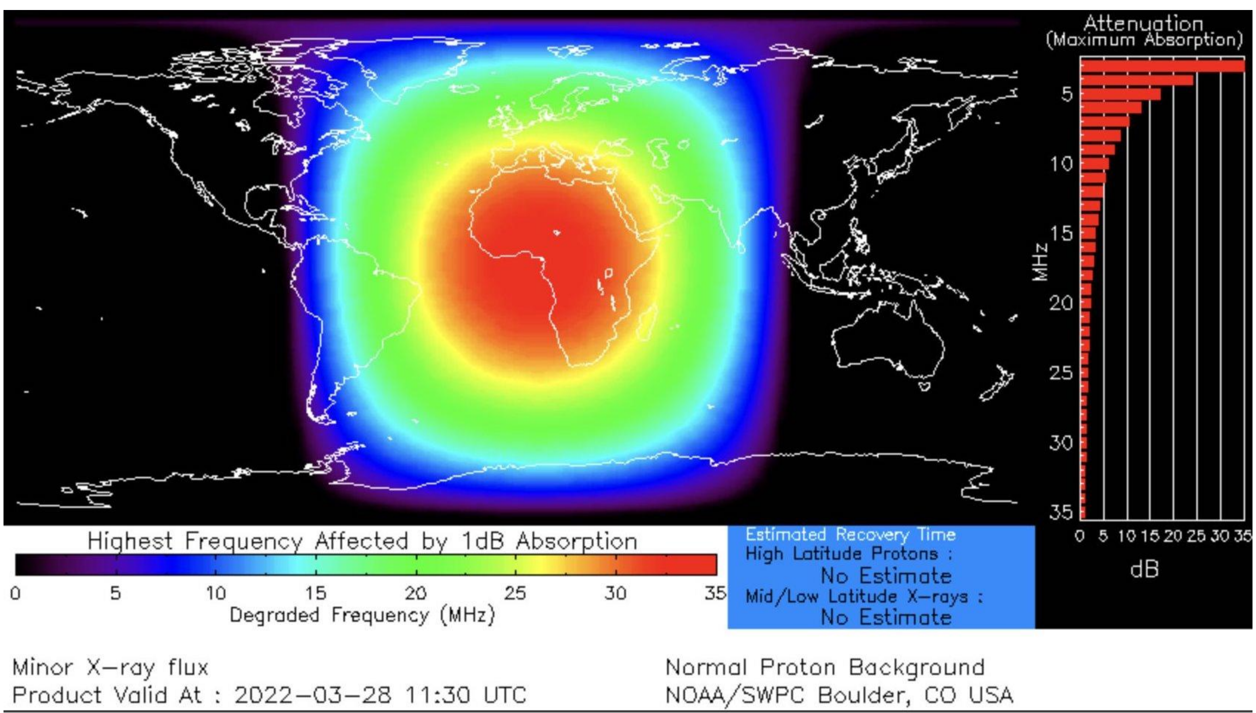
(iii) Type II bursts act as an alarm for space agencies to track incoming solar events. From Figure 5, the absorption was recorded later than type II, so type II is a proxy.

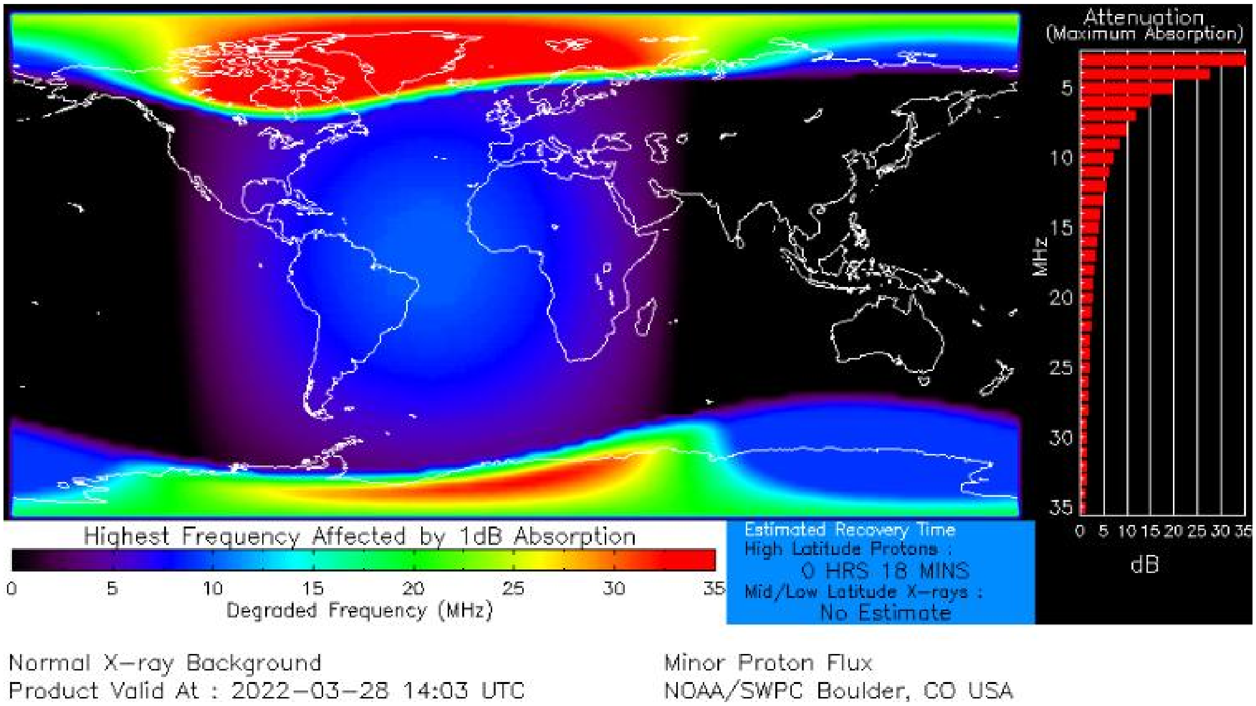
(f) Correct the time of the type IV burst time in line 179 as well as in the caption of figure 7

Answer: The type IV burst time is now 11:26 UT to 11:36 UT**.**

(g) Similar question for figure 8 as the one asked for figure 5. Are the times the same for figure 8 top and bottom?

Answer: The top and bottom times of Figure 8 differ. The bottom image shows a polar cap absorption event (protons ejected towards the pole), while the top image shows a radio blackout (an increase in proton fluxes across the entire continent of Africa caused by a flare). The text makes the distinction, and the images are included here with the dates and times of their records.





(h) There are a lot of acronyms from lines 187 to 195 (SPE,SEP,PCAE). Please precise their meaning.

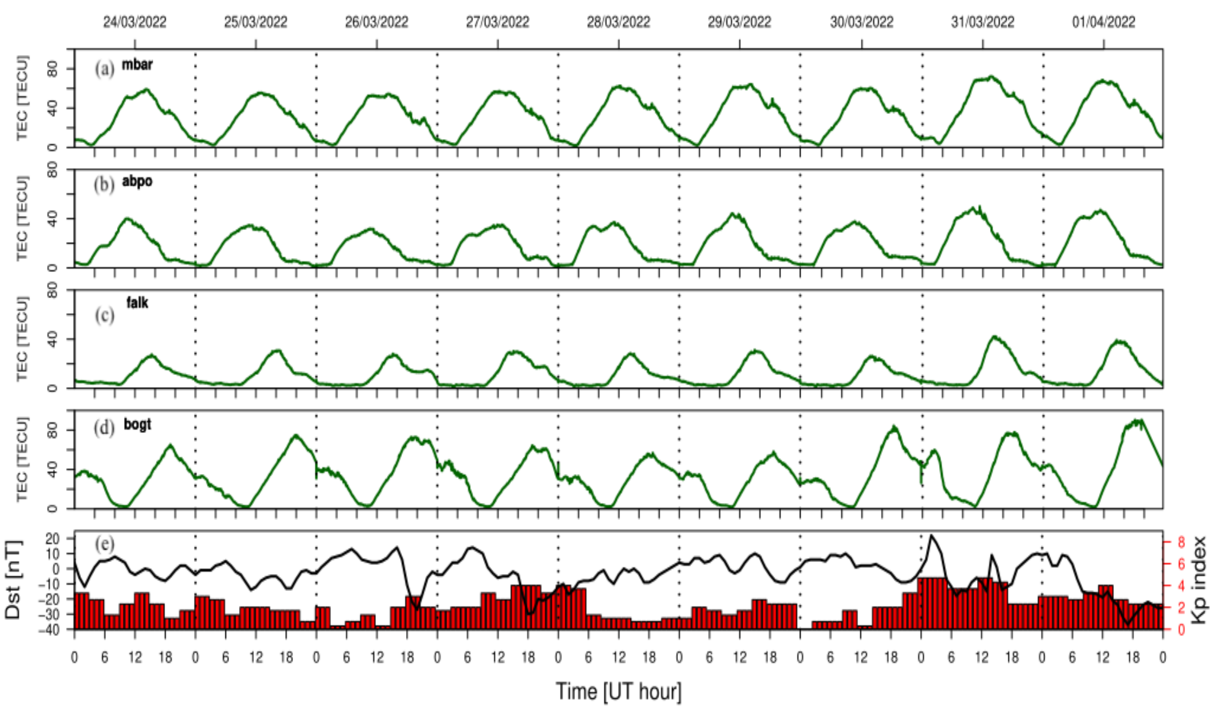
Answer: The acronyms stand for solar proton event (SPE), solar energetic particles (SEPs), and polar cap absorption event (PCAE) or polar cap absorption (PCA) event. However, the SEPs will be removed for the sake of consistency of the current work.

(i) Figure 9 : The authors should precise the link between the TEC enhancements in the different stations and the many type II bursts reported during this period.

Answer: In the current study, type II solar radio bursts were used as selection criteria for disturbed days due to their connection to solar phenomena (e.g., radio blackouts). By choosing GNSS stations in equatorial, mid-latitude, and high-latitude regions of the affected areas, the TEC was examined on 25 type II radio bursts, which are linked to both solar flares and CMEs.

In particular, the TEC enhancements of 24 March – 1 April 2022 are described in Figure below (New Figure 9 due to data gap), where four type II radio bursts were observed in the aforementioned range (as listed in Table 1 of the manuscript). The four bursts are associated with CMEs of mean speed of 691 km/s and estimated shock speed of 990 km/s. However, no CME has reached the magnetosphere because no geomagnetic storm in the selected interval. With the help of the solar monitor website (https://www.solarmonitor.org), there is a presence of large coronal holes and one can expect a corotating interaction, as a result of substorms on 26, 27 of March 2022, and 1 April 2022 (**panel e of figure below**). Using the line plots, Figure…. shows the diurnal variation of TEC over four different stations (**mbar**: Mbarara, **abpo**: Madagascar, **falk**: Falkland Islands and **bogt**: Bogota). Because the radio bursts are associated with radio blackouts, the stations were selected in the affected areas to ensure strong diurnal variation.

Panel (a): The trend of TEC variation shows a decrease of 10 TECU on 26 March 2022, compared to normal TEC (normal maximum TEC=65 TECU), and an increase of 8 TECU on 31 March 2022. The solar flare is responsible for the decrease in TEC on March 26, 2022, and CIR (Kp=5) is the cause of the increase in TEC on 31 March 2022.



Panel (b): This GNSS station experienced 5 TECU drop on 26 March 2022 and TEC enhancements of 8 and 12 TECU on 29 March and 31 March 2022, respectively. Such drop and enhancements are caused by solar flares and CIR (Kp=5), respectively. **Panel (c)**: TEC is enhanced on 31 March 2022 compared to other days. **Panel (d)**: The diurnal variation of TEC is increased by more than 24 TECU on a daily basis on March 25, 26, 30, 31, and April 1, 2022, due to CIR (kp=4), solar flare, and CIR (Kp=5), respectively, over Bogota station. The variations of TEC over these stations are attributed to the ionizing flux from flares and CIR. The diurnal variation is prominent at all stations, which corresponds to the same feature plotted on the contour maps by taking the entire range at each station.

(j) Last part of section 3.2 : the authors claim that 15/31 events have immediate space weather effects but this is not really shown in the paper. More generally, the discussion between the type II observations and the space weather effects is vague. It is not clear how the observations of type II bursts can predict TEC enhancements since they may be due to the flare ionized flux or to the arrival of energetic particles. Furthermore, it is not clear why some type II bursts sare associated with space weather effects and why others are not.

Answer: In the current study, 15 of the 31 type II radio events were linked to immediate space weather phenomena, such as radio blackouts or polar cap absorption events caused by the solar proton enhancement phenomenon. However, 18 of the 31 type II radio events are diagnostic of space weather, 10 of which have band-splitting characteristics, and the remaining 8 are preceded or followed by type III or IV radio bursts.

The prediction of TEC necessitates the development of a model, which is beyond the scope of this work. We only used type II radio bursts to select disturbed days and analyze their TEC to see the behaviour in comparison to the days where we did not have any type II bursts. Therefore, given that Type II bursts are EM, travelling at speed of light , continuous monitoring / observations and record of their data is useful and can be used in various models to predict TEC during disturbed days. The TEC modelling is out of scope of the current paper.