**Reply to Reviewer #3 Comments**

The manuscript titled "Simultaneous OI 630 nm imaging observations of thermospheric gravity waves and associated revival of fossil depletions around midnight near the EIA crest" presents a possible interaction between thermospheric gravity waves (GWs) and fossil equatorial plasma bubbles (EPBs) over Ranchi, India, on 16 April 2012. The authors argue that after the interaction, the EPBs return to the growth stage.

However, the present manuscript contains some unclear data analysis and incomplete reasoning, which necessitates significant revision and clarification before it can be considered acceptable for publication. Only a few detailed comments are listed below.

**Reply:** We sincerely thank the esteemed Reviewer for his tremendous encouragement and invaluable insight into our submission. His critical comments have provided us with insightful perspectives to enhance the clarity and robustness of our findings. We have tried our level best to address his concerns in this Revised Version.

1. Regarding the new findings, the author claims to be the first to report the interaction between Gravity Waves (GW) and Equatorial Plasma Bubbles (EPBs) leading to latitudinal growth. However, Wrasse et al. (2021) (http://www.eppcgs.org//article/doi/10.26464/epp2021045?pageType=en ) presented observational evidence of an interaction between EPBs and wave-like perturbations known as Medium-Scale Traveling Ionospheric Disturbances (MSTID) at low latitudes over the Brazilian sector. Wrasse et al. (2021) argued that electric fields associated with MSTID can intensify the growth of EPBs, leading to latitudinal and height expansion. Therefore, the authors should conduct an extensive bibliography review to properly address the novel findings presented in the study.

   **Reply:** We sincerely thanks Reviewer for this critical comment. We have included in this Revised Version the above-mentioned Reference as well as other similar works.

**Correction:**

**In Introduction Section:** Lately, Wrasse et al. (2021) presented an interesting event wherein a fossil EPB merged with other ones after interacting with an electrified MSTID and turned into an active bubble.

**In Discussions Section:** We know that the electric field perturbations associated with MSTIDs can influence the growth of irregularities. Otsuka et al. (2012) and Shiokawa et al. (2015) reported the disappearance of an EPB upon interaction with MSTIDs and large-scale traveling ionospheric disturbances (LSTIDs), respectively. Authors suggested that the electric field associated with MSTIDs/LSTIDs can move ambient plasma into the bubble across the geomagnetic field line through **E x B** drift which will result in the filling and subsequent disappearance of the depletion. Studies by Miller et al. (2009), Taori et al. (2015) and Takahashi et al. (2020) suggest that MSTIDs can directly seed EPBs. Simulation studies by Krall et al. (2011), further, indicates that the electric field associated with electrified MSTIDs can enhance the growth of EPBs. Lately, Wrasse et al. (2021) presented an interesting observations of the interaction of a fossil EPB with an electrified MSTID over 13.3° S. After interaction with the MSTID, concerned fossil EPB merged with other four EPBs, developed poleward and bifurcated. Using detrended TEC data, Takahashi et al. (2021) studied the large scale wave structures over Latin America and found them to be effective in seeding EPBs.

**In References Section:**

Wrasse, C. M., Figueiredo, C. A. O. B., Barros, D., Takahashi, H., Carrasco, A. J., Vital, L. F. R., Rezende, L. C. A., Egito, F., Rosa, G. M., and Sampaio, A. H. R.: Interaction between Equatorial Plasma Bubbles and a Medium-Scale Traveling Ionospheric Disturbance, observed by OI 630 nm airglow imaging at Bom Jesus de Lapa, Brazil. Earth Planet. Phys., 5(5), 397–406. https://doi.org/10.26464/epp2021045, 2021.

Takahashi, H., Wrasse, C. M., Figueiredo, C. A. O. B., Barros, D., Paulino, I., Essien, P., et al.: Equatorial plasma bubble occurrence under propagation of MSTID and MLT gravity waves. J. Geophys. Res.: Space Physics, 125, e2019JA027566. https://doi.org/10.1029/2019JA027566, 2020.

Takahashi, H., Essien, P., Figueiredo, C. A. O. B., Wrasse, C. M., Barros, D., Abdu, M. A., Otsuka, Y., Shiokawa, K., and Li, G. Z.: Multi-instrument study of longitudinal wave structures for plasma bubble seeding in the equatorial ionosphere. Earth Planet. Phys., 5(5), 368–377. https://doi.org/10.26464/epp2021047, 2021.

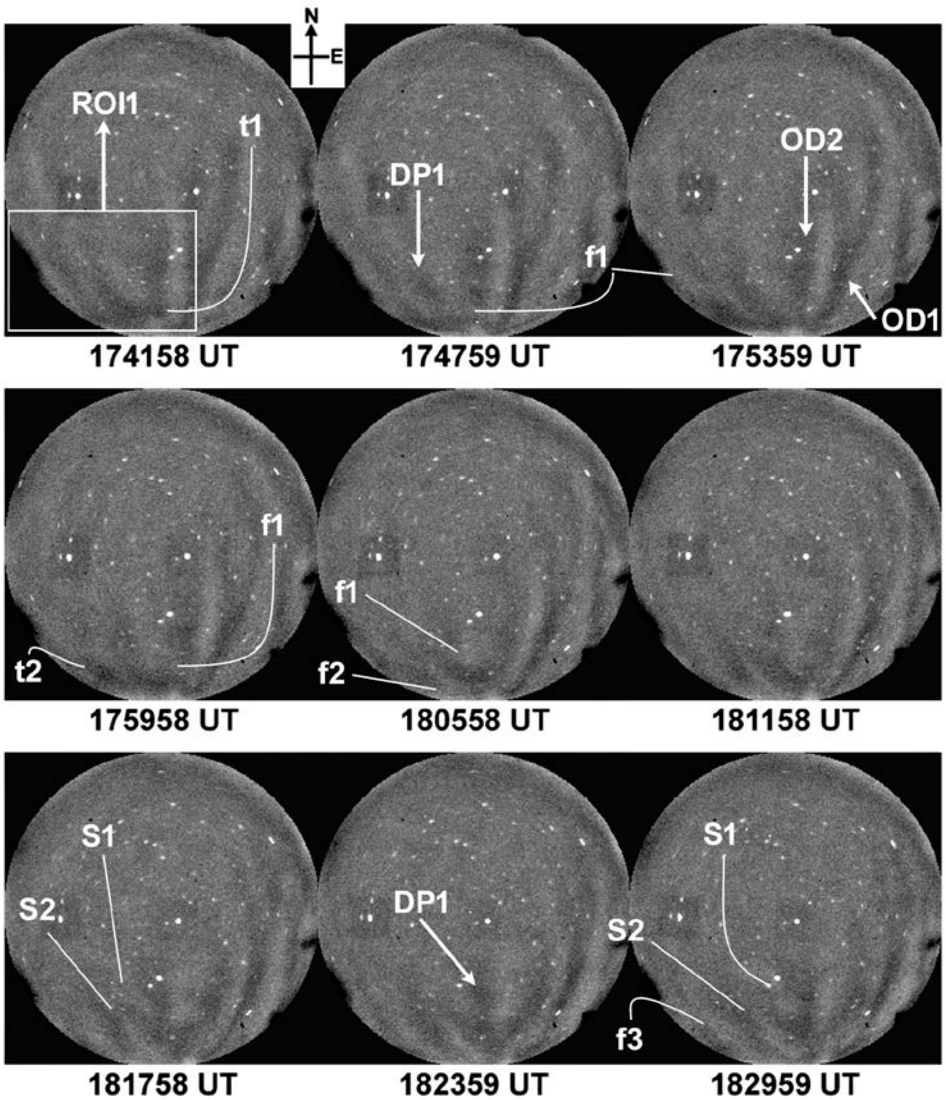
Krall, J., Huba, J. D., Ossakow, S. L., Joyce, G., Makela, J. J., Miller, E. S., and Kelley, M. C.: Modeling of equatorial plasma bubbles triggered by non-equatorial traveling ionospheric disturbances. Geophys. Res. Lett., 38(8), L08103. https://doi.org/10.1029/2011GL046890, 2011.

2. Regarding Figures 1 and 2, no clear signature of thermospheric gravity waves (GWs) can be observed in the OI 630 nm images. Additionally, there is no evident northward development visible in the equatorial plasma bubble (EPBs) structures. It is suggested that the authors include an OI 630 nm movie for the complete night of observation as "Supporting Information." This would enable a thorough assessment of the presence or absence of GWs, the evolution of EPBs, and the nature of their interaction throughout the observation period. Furthermore, the authors should consider employing alternative techniques to emphasize the interaction between GWs and EPBs, such as the detrended unwarped image technique demonstrated by Wrasse et al. (2021).

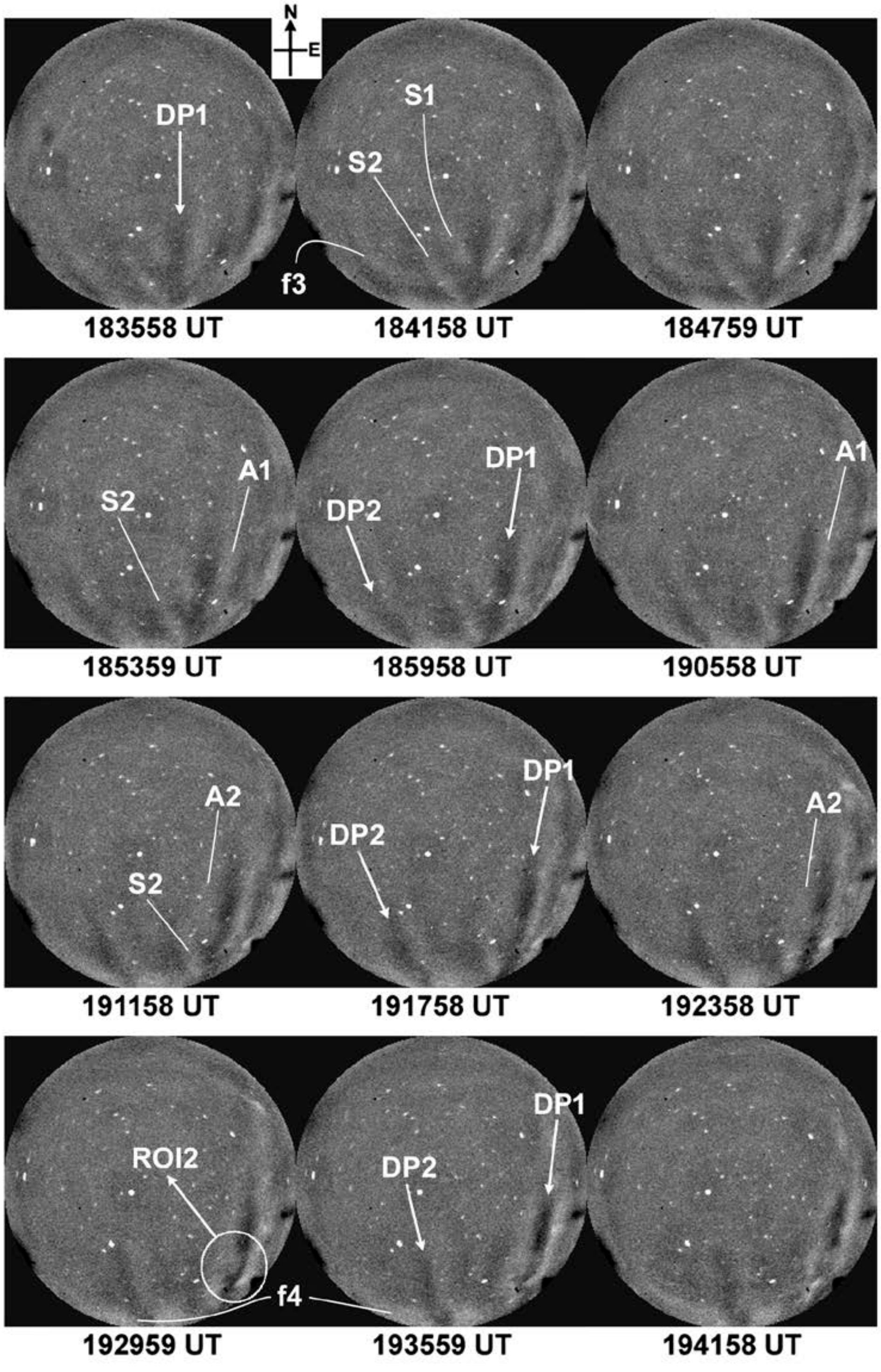
**Reply:** We sincerely thank the Reviewer for this critical comments and for suggesting us this crucial Reference on the detrending technique to improve our presentation. We have corrected Figure 1 and 2 following the technique described by Wrasse et al. (2021). We have, also, added a new figure (Figure 3) of time difference images that shows GW fronts. As suggested, we have added an OI 630 nm movie too.

**Correction in 'Instrumentation and data' Section:** Airglow images were flat-fielded to reduce the inhomogeneous contribution at lower elevations due to van Rhijn effect and non-uniform sensitivity of CCD detector at different pixels. Next, following the technique described by Wrasse et al. (2021), we detrended the individual images to enhance the contrast of airglow features using an hour running average image. Using known astral positions and assuming OI 630 nm emission peak at 250 km, the geographic coordinates of each pixel was determined following the technique of Garcia et al. (1997). Using this information, all-sky images were unwarped.

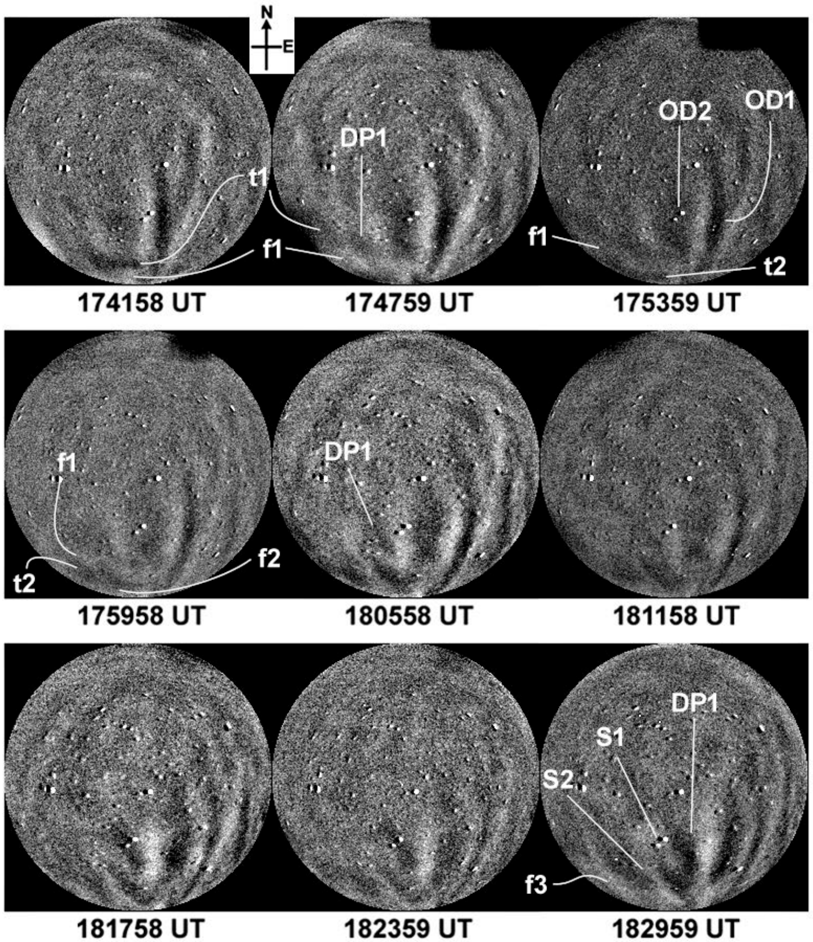
**Corrected Figure 1:**

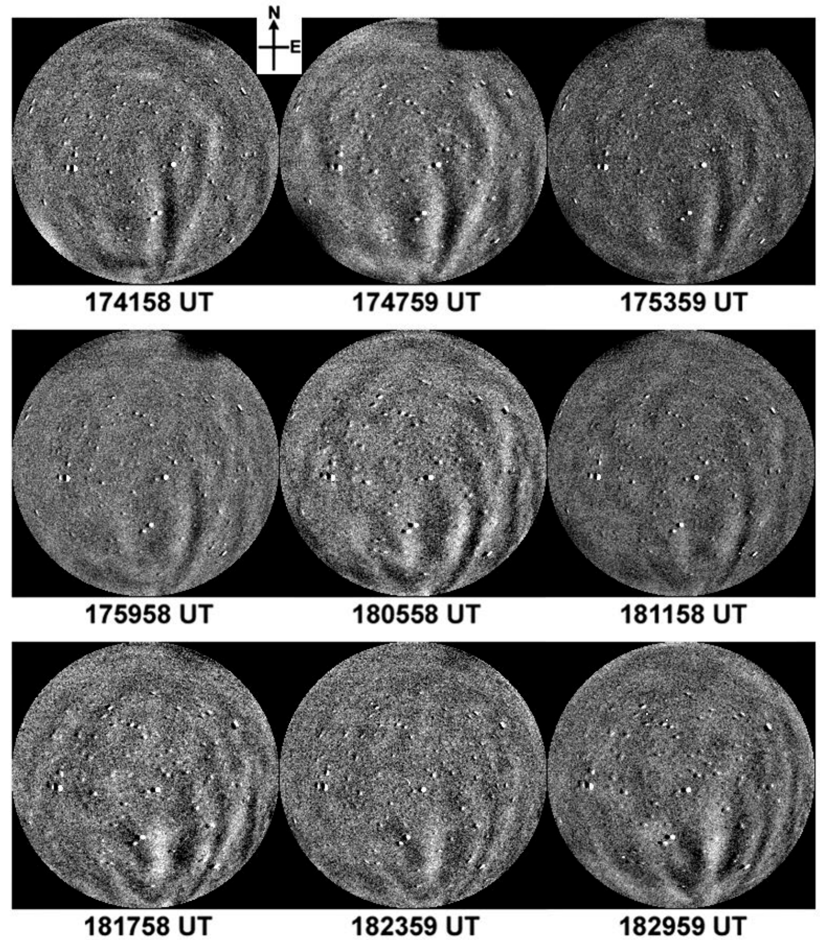


**Corrected Figure 2:**



**New Figure 3:** We generated such time difference images and present below some of them during 1742-1830 UT showing faint fronts of GWs. We present labelled and unlabelled sequence of OI 630 nm images, respectively, on the left and right for the kind preview of Reviewer.



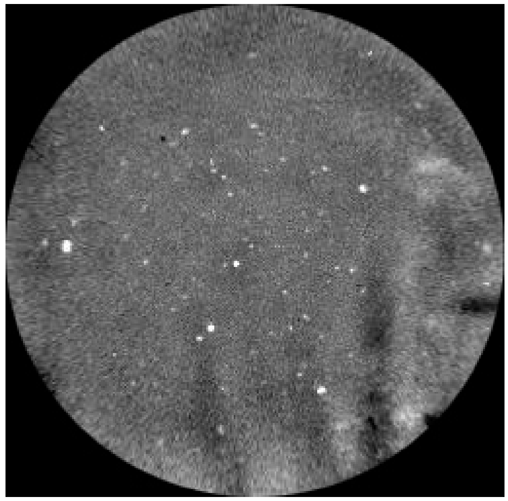



**Correction in ‘Observations’ Section:**

As the faint airglow features were getting lost in the unwarping process, warped all-sky images are presented. Supplementary material S1 shows the movie created from these images that feature this event.

3. The GWs signature in the TEC GPS IPP tracks are associated to a fluctuation of about 1-5% of the TEC level (e.g., Otsuka et al., 2013; Figueiredo et al., 2018; Takahashi et al., 2021/ https://angeo.copernicus.org/articles/31/163/2013/; https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017JA025021; http://www.eppcgs.org/en/article/doi/10.26464/epp2021047). Figure 3e and 3f present a TEC oscillation of about 10 TECU (see GPS PRN 28). This kind of TEC fluctuations are usually associated to EPBs signature (Barrros et al., 2018/https://angeo.copernicus.org/articles/36/91/2018/ ). Same interpretation can be done for Figure 3a and 3b, the north-south keograms clearly show EPBs signatures with their bifurcation. Therefore, the author should consider employing multiple GNSS receivers positioned near the event, or utilize various GNSS constellations (including GPS, GLONASS, Galileo, BeiDou), to accurately determine satellite IPP tracks corresponding to the same location as the OI 630 nm event. To achieve this, generating unwrapped images of OI 630 nm emissions is essential.

**Reply:** We sincerely thank the Reviewer for these critical References and suggestions on GNSS based analysis of this event. Presently, due to lack of expertise in GNSS data analysis, we are unable to address this comment of the reviewer. We indeed generated unwarped airglow images and a typical example at 192358 UT in presented below:



Regarding the bifurcations seen in NS keograms, we wish to state that these observed bifurcations are of a preceding depletion OD1 (shown in Figure 1).

4. The author should make an effort to present new analyses to thoroughly discuss the physical mechanisms underlying a possible revival of the EPBs. For instance, analysis of any enhancement of the polarization electric field inside the EPBs could be beneficial, with the assistance of ionosonde data collected near the event.

**Reply:** We greatly agree with these critical comments of Reviewer. Under ***CAWSES India Phase II Programme***, Campaign-based Nightglow experiments were carried out at a temporary site Ranchi. Owing to this complementary experiments e.g. ionosonde and GPS were not available. Following this, we are unable to carry out the analysis suggested by Reviewer.