

We thank the reviewer for a very thorough evaluation of the manuscript and for very constructive comments. In the revised manuscript we have responded to all comments, which led to a significantly improved paper. In the following, our responses to the reviewers' comments are marked in blue italics, whereas the additions to the manuscript are marked in blue.

Reviewer #1 Evaluations:

The paper "Storm-time energy budget in the high latitude lower thermosphere-ionosphere: Quantification of energy exchange and comparison of different drivers in TIE-GCM" provides a detailed assessment of TIE-GSM heating and cooling terms relevant for neutrals, ions, and electrons, during a major geomagnetic storm. Two simulation runs are compared, one driven by the Weimer (2005) model of high latitude electric potential, the other by AMIE data.

Understanding and properly quantifying the energy budget in the ionosphere-thermosphere is certainly a major topic, likewise the related improvement of the simulation codes and boundary conditions. As soon as the few issues listed below and in the attached annotated manuscript are fixed, I shall be happy to recommend publication.

1. As far as I can judge, the main point that requires clarification is the direct Joule heating of the neutrals. This is invoked several times, as well as indicated in Figures 2 and 3. I am a bit confused, since Joule heating implies the effect of the electric field, which is obviously not directly felt by the neutrals. As aptly mentioned by the authors, the energy is passed to the ions by Joule heating, then transferred to the neutrals by collisions. But obviously there is also another mechanism, indicated in Figure 2 by the direct red arrow between the q_J box (q_{Ω} in the figure - typo?) and in Figure 3 by the gray 'Joule heating' box (incidentally, the 'Joule heating' and 'Ions' boxes have somewhat different mutual roles in Figure 3 compared to Figure 2). I presume that the 'direct Joule heating' to neutrals and the Joule heating via ions are indeed related to specific terms of TIE-GCM. Perhaps the 'direct Joule heating' is related to the neutral wind term of Eq. (5), $u_n \times B$, i.e., to the (macroscopic) convection motion of the neutrals, whereas the ion term, related to the temperature difference (pointed out by the authors), is rather a (microscopic) conduction effect? Or, as suggested by Eq. (11), there is a 'prompt' energy transfer (the 'direct' Joule heating of neutrals?) versus a 'delayed' transfer (see the annotated pdf)? Please clarify.

We thank the reviewer for bringing this point up, that allows us to clarify this important point. Joule heating arises from the frictional dissipation of ion motion driven by the electric field, where collisions with neutrals convert this kinetic energy into thermal energy. A substantial portion of this energy is deposited into the neutral gas, with additional energy initially increasing ion temperature and then being transferred to the neutrals via collisional coupling. This collisional energy transfer mechanism plays an important role in the thermospheric energy balance in the lower thermosphere, where ion-neutral collision frequencies are high. We agree with the reviewer's comment that, as suggested by Eq. (11), there is a 'prompt' energy transfer (the 'direct' Joule heating of neutrals) versus a 'delayed' transfer. We further discuss this point in the responses to comments A26, A28, A53, A54, A55 (Eq. 11), A56, A60, A64, A65, A67. Below we have added suggestions for corresponding changes to the manuscript to clarify this point.

2. Another point that I regard as important is the reason behind the difference of the Weimer and AMIE results, in particular at / near the maximum phase of the storm (Figure 1). This is attributed mainly to the sub-grid variability, apparently better captured by AMIE, because of better spatial resolution (e.g., L567-569, 576-578). The better capturing of the actual conditions by AMIE is at least as important and should

be emphasized better. To my understanding, AMIE takes (much?) better into account the actual conditions, as compared to a statistical model, like Weimer (2005), which provides some sort of 'average' behavior. The more disturbed are the conditions, the farther off are the various parameters from some 'average' and the more important is to drive the simulation by (as close as possible to) actual boundary conditions. I think that some elaboration of the discussion and conclusions would be welcomed.

We agree that the AMIE model generally captures the actual conditions better than Weimer, as it incorporates time-dependent observations and thus better reflects the actual, event-specific electrodynamic state of the system. This comment is also further discussed in our responses to comments A01, A12, A14, A69, A95, A101.

3. Besides the two points above, please see the annotated manuscript, attached, for various other remarks, mostly minor issues.

We thank the reviewer for the thorough review; all comments have been addressed, as discussed below.

Annotated Comments on Manuscript

A1. L12: Not surprising, AMIE will provide better / more trustful results, since it reflects actual, not average conditions - see point 2 of the Report. Clearly visible in Figure 1, where the AMIE Joule heating is well above Weimer and empirical - since these both are average statistical results.

***Response:** As also discussed above, we agree with the reviewer that the AMIE model generally captures the actual conditions better than Weimer. This is included together with the small-scale variability in the text in the Summary and Conclusions section, as follows:*

“Importantly, the discrepancies are not solely related to spatial resolution, but also to the fundamental differences of the forcing models. The Weimer (2005) model represents a statistical, climatological average response to given solar wind and IMF conditions, whereas AMIE incorporates time-dependent observations and thus better reflects the actual, event-specific electrodynamic state of the system. During the storm maximum, when the magnetosphere–ionosphere system departs significantly from an average behavior, deviations from climatological patterns become substantial. Under such highly disturbed conditions, the use of boundary conditions that closely represent the instantaneous electrodynamic becomes particularly critical. The enhanced Joule heating in the AMIE-driven simulation therefore likely reflects a more realistic representation of the storm-time energy input.”

A2. L24: “which can greatly exceed the energy input from solar EUV radiation”

Does it? Perhaps locally, but not globally? Provide some numbers? To my knowledge, the solar wind carries of the order of 1 millionth of the energy flux in the solar radiation. If that's roughly true, it would be hard to compete, even under extremely disturbed geomagnetic conditions. Perhaps the authors mean the contribution to the dynamics? Geomagnetic variations are certainly more important for the dynamics than the variations of the solar radiation (on considerably longer time scales).

***Response:** Even though Joule heating is not known quantitatively, and even though there are large discrepancies between models, the fact that during geomagnetic storms Joule heating can exceed the largest energy source for the system, which is the solar EUV radiation, has been reported in past studies (e.g., Knipp et al. 2005, Verkhoglyadova et al 2016). This can also be observed in Figure 3, where in the*

left-hand side plot EUV is the largest heating term, whereas in the right-hand side Joule heating is much larger. A relative comment is added in the text.

A3: L29: ‘Joule heating is the most thermodynamically important process’ Provide Ref? This is an outcome of the paper, but it would be good to point also to prior work, in the Intro.

Response: *See response to A2 above. The above-mentioned references to Knipp et al. (2005) and Verkhoglyadova et al (2016) have been added in the text.*

A4: L31-32: ‘It is thought that, during active times, the effects of Joule heating on the upper atmosphere are more significant than those of EUV or energetic and auroral particle precipitation (e.g., Zhang et al. (2017))’. In absolute terms this surprises me a bit, see above L24.

Response: *See responses to A2 and A3 above. The above-mentioned references to Knipp et al. (2005) and Verkhoglyadova et al (2016) have been added in the text. The reference to Zhang et al. (2017) has been removed, as the above references are more appropriate.*

A5. L70: “commonly used models” → “common models”

Response: *Changed according to the reviewer’s comment*

A6. L71: “effects in the energetics” → effects ON the energetics

Response: *Changed according to the reviewer’s comment*

A7-A8. L81-81: ‘minimum Dst index of approximately -223 nT’. L86: ‘A minimum Dst of -190.7 nT’. - 190 or -223 ?

Response: Indeed the -190.7 nT was a typo. The minimum value of Dst during St Patrick’s storm was at -223nT. Corrected accordingly.

A9. L126: ‘Consequently’ → ‘Subsequently’

Response: *Changed according to the reviewer’s comment*

A10. L131 ‘are kept...’ → remained

Response: *Changed according to the reviewer’s comment*

A11. L133: “WEIMER” → Weimer driver?

Response: *Changed according to the reviewer’s comment*

A12. L133: ‘While there are large differences...’ See comment at o. 1 and point 2 of the Report

Response: See response to comment A1 above.

A13. L133: “model resultls” → model results

Response: Corrected

A14. L135: “it has high correlation with the Joule heating calculated with the AMIE run.” → Not surprising, both capture the actual state - unlike the empirical and Weimer results, based on statistics.

Response: See response to comment A1 above.

A15. L136: “which is closer..” → closest

Response: Changed according to the reviewer’s comment

A16. L160: Weimer 2005 → Weimer-2005

Response: Changed according to the reviewer’s comment

A17. L160: “(Weimer (2005))” → (Weimer, 2005) => use \citep instead of (\cite) to avoid double brackets. I guess this depends on your local LaTeX environment, but \citep is easy to get by one of the standard packages. The same for quite a few references below (some of which are highlighted) showing double brackets - (name (year)).

Response: Changed to \citep according to the reviewer’s comment

A18. L169: (Weimer (2005))

Response: Changed to \citep according to the reviewer’s comment

A19. L171: (Richmond and Kamide (1988))

Response: Changed to \citep according to the reviewer’s comment

A20. L174: “ionospheric” → as well as ionospheric

Response: Changed according to the reviewer’s comment

A21. L174: “self-consisting” → self-consistent

Response: Changed according to the reviewer's comment

A22: L197: “oweever” → However

Response: Corrected

A23: Figure 2: Replace q_{Ω} by q_{Joule}

Response: Indeed, this is a typo; it has been corrected in the revised manuscript

A24: Figure 2: Please expand a bit, to ease the read of the figure.

Response: We have expanded the text to describe Figure 2 as follows:

“In brief, these processes include external heating processes, energy transfer between the neutrals, ions and electrons, and heating or cooling of the neutrals due to various other Thermosphere processes. External heating processes include Joule heating, which is deposited to the neutrals either promptly during active times, or indirectly through the initial heating of the ions and the subsequent energy exchange between ions and neutrals; Energetic Particle Precipitation, including energetic protons, which deposits energy directly to the neutrals, and energetic electrons, which ionize the neutral particles and create photoelectrons which subsequently get thermalized; solar extreme ultraviolet (EUV) radiation, which is the most significant heating energy source in the LTI, on long-term averages. Energy transfer can occur from the ions to the neutrals, between ions and electrons, and from the electrons to the neutrals. Finally, other neutral heating processes include molecular diffusion, ion chemistry, O₂ recombination, photo-electron heating, horizontal diffusion; eddy diffusion, horizontal advection and adiabatic heating, which can lead to either heating or cooling; radiative cooling from CO₂, NO and O(3P); and cooling due to conduction to the middle atmosphere.”

A25: L211: (Vasyliunas and Song (2005))

Response: Changed to \citep according to the reviewer's comment

A26: L215: “Joule heating is deposited directly into the neutral gas...”. See point 1 of the Report.

Response: We agree with the reviewer's comment that, as also suggested by Eq. (12), there is a 'prompt' energy transfer (the 'direct' Joule heating of neutrals) versus a 'delayed' transfer. This has been changed into “Joule heating is deposited promptly ...”, as discussed above reviewers' general comment #1. Thus, Joule heating is deposited promptly into the neutral gas, which is shown in Figures 2 and 3 as a direct arrows from Joule heating (q_J) to the neutrals, whereas an additional amount of energy is initially deposited to the ions, increasing ion temperature, and is subsequently transferred to the neutrals via collisional coupling; this is shown in Figure 2 as a red arrow initially from q_J to the ions and subsequently from the ions to the neutrals, and in Figure 3 as a red arrow from the ions to the neutrals. The calculation of this term in TIEGCM is done according to Eq. (12).

A27: L217: ‘represented’ → derived

Response: Changed to \citep according to the reviewer’s comment

A28: L222: “..to the neutrals either directly or...” -→ What is the direct way? See also above L215.

Response: See response to comment A26 above; “directly” and “indirectly” have been removed, and this has been changed in the text as:

“either promptly, or through the heating ...”

A29: L228: “as discussed in...” → as discussed by...

Response: Changed according to the reviewer’s comment

A30: L230: “...in Tourgaidis et al. (2025a).” → by Tourgaidis et al. (2025a).

Response: Changed according to the reviewer’s comment

A31: L233: “Together with heating..” → Joule heating?

Response: Changed according to the reviewer’s comment

A32: L234-235: (Verronnen et al. (2015))

Response: Changed to \citep according to the reviewer’s comment

A33: L235: “and this heats..” → and this also heats

Response: Changed according to the reviewer’s comment

A34: L263-264: “and thus on altitude dependent in the LTI...” → Please rephrase

Response: Changed as follows”

“ and consequently to altitude in the LTI”

A35: L275-276: “..if electrons do not drift far enough...” → Don't understand, please clarify.

Response: *This refers to the eastward drift of electrons vs. westward drift of the ions after, e.g., a substorm injection in the midnight or pre-midnight regions; however this discussion is too detailed for this paper, and we have decided to remove it, and merge with the following sentence. This now reads as follows:*

“Nevertheless, it has been found that, at times, proton precipitation can dominate over electrons in some regions; furthermore, studies have shown that medium-energy (10s of kev) precipitating protons can carry more energy flux than electrons (Tian et al., 2020)”.

A36: L286: EUV radiation and also...” → delete and

Response: *Changed according to the reviewer’s comment*

A37: L287: “..indirect processes that driven by” → delete that?

Response: *Changed according to the reviewer’s comment*

A38: L292: “heating source in a global scale” → “heating source on a global scale”

Response: *Changed according to the reviewer’s comment*

A39: L306: “else $T_e > T_i > T_n$ ” → Namely $T_e > T_i > T_n$

Response: *Changed according to the reviewer’s comment*

A40: L308-309: “The ion-neutral heat transfer rate is given by:” → add reference

Response: *The following reference has been added:*

“see Eq. 14 in Sarris et al., 2023b”

Sarris TE, Tourgaidis S, Pirnaris P, Baloukidis D, Papadakis K, et al., (2023b) Daedalus MASE (mission assessment through simulation exercise): A toolset for analysis of in situ missions and for processing global circulation model outputs in the lower thermosphere-ionosphere. Front. Astron. Space Sci. 9:1048318. doi: 10.3389/fspas.2022.1048318

A41: L315: “..to a lack of a quantitative ...” → “..to a lack of quantitative ...”

Response: *Changed according to the reviewer’s comment*

A42: L325 “ according to:...” → add reference

Response: The following reference has been added:

“see Eq. 15 in Sarris et al., 2023b”

A43: L327: “..is given by:” → add reference

Response: The following reference has been added:

“see Eq. 16 in Sarris et al., 2023b”

A44: L342-343: “are included and are presented below.” → are included. (delete “and are presented below”)

Response: Changed according to the reviewer’s comment

A45: L353: “...up and down...” → Up and down is a bit at odds with horizontal winds. Parallel and anti-parallel? Along and against?

Response: Indeed, we agree that “up and down” sounds strange for horizontal winds; this has been changed in the text as:

“along and against”

A46: L368: “according to equation:” → add reference

Response: The following reference to the TIEGCM manual has been added:

TIEGCM Model Description: TIEGCM V1.94 Model Description, Tech. rep., HAO/NCAR, Boulder, CO, USA, https://www.hao.ucar.edu/modeling/tgcm/doc/description/model_description.pdf, version 1.94 documentation, 2018.

A47: L377: “by the by the Earth’s magnetic field” → delete second “by the”

Response: Changed according to the reviewer’s comment

A48: L377: “At the **heat** of the significance..” → At the **heart** the heat of the significance

Response: Changed according to the reviewer’s comment

A49: L378: “from low density to high density...” → Usually it works in the opposite direction, from high to low density (against the gradient).

Response: Indeed, that was a typo; this has been corrected in the manuscript.

A50: L391: "...primarily in the..." → primarily at the or primarily near the

Response: *This has been changed to*

"primarily near.."

A51: L395: " Q_{tot} " → Q_{tot}

Response: *This has been corrected*

A52: L401: " L_{tot} " → L_{tot}

Response: *Corrected*

A53: L411-412: "(i.e., the Joule heating that is directly deposited to the neutrals..." → See point 1 of the Report.

Response: *See responses to comments A26 and A28 above; this has been changed in the text as:*

"(i.e., the Joule heating that is promptly deposited to the neutrals..."

A54: L421: "that goes directly to the neutrals..." → Same as above, L411-412. Also L222 and 215.

Response: *See responses to comments A26, A28 and A53 above; this has been changed in the text as:*

"that goes promptly to the neutrals..."

A55: Equation 11 → Explain ? For $m_n = 0$ (much smaller than m_i), it follows that nothing goes 'directly' to the ions, while the opposite holds if $m_i = 0$ - everything goes directly to the ions. This suggests that the fractions that go 'directly' to the ions and neutrals are related to some temporal scales, for 'prompt' energy transfer ion → neutrals versus 'delayed' energy transfer (while eventually all the energy is transferred to the neutrals).

Response: *We completely agree with the reviewers' comments on this equation, and we have addressed this throughout the text, as discussed above in response to comments A26, A28, A53 and A54, as well as other comments below.*

A56: L429: 'where Q_{Ti} is the part of the Joule heating directly deposited to the ions,' → See point 1 of the Report.

Response: *We agree that this is not clearly stated, and have changed this sentence as follows (see also discussion in response to the reviewers' general comment #1):*

‘where Q_J^{Ti} is the part of the Joule heating that leads to the temperature increase of the ions,’

A57: L433: “negligible” → negligibly

Response: *Corrected*

A58: Equation 13 → Are the signs of the heating and cooling terms correct? => apparently opposite to Eq. (10).

Response: *A reference to the TIEGCM manual (where this equation is from) has been added. It is noted that Equation 10 refers to the neutral thermodynamic equation, whereas Equation 13 is the thermodynamic equation of the electrons.*

A59: L451: “The later time is...” → The latter time is...

Response: *Corrected*

A60: L463: “Energy flow according to the neutrals” → Energy flow (for ? to / from ?) Neutrals

Response: *“According to” has been added here to emphasize that different heating and cooling mechanisms or channels are associated with each species, and hence the energy budget should be looked at separately for each species; we would thus prefer to maintain this term.*

The following sentence has been added in the abstract to emphasize this point:

“The energy budget is investigated individually for neutrals, ions and electrons, as different heating and cooling mechanisms are associated with each species.”

A61: L465-466: “by Joule heating due to the differential velocity between the neutral winds and the ions under the effects of electric fields...” → Does this mean the $u_n \times B$ term of Eq. (5)? (see also point 1 of the Report)

Response: *As also discussed above in response to point #1 of the report, this is not related to $u_n \times B$ term of Eq. (5); instead, the Joule heating arises from the frictional dissipation of ion motion driven by the electric field, where collisions with neutrals convert this kinetic energy into thermal energy. A substantial portion of this energy is deposited into the neutral gas, with additional energy initially increasing ion temperature and then being transferred to the neutrals via collisional coupling.*

A62: L473-474: Supplementary Material S1 → I was not able to find S1, but I could access the zenodo data / movies at <https://zenodo.org/records/16993755>.

Response: *Indeed, this can be found through the above zenodo link, and not through supplementary material; references to S1, S2 and S3 have been removed from the manuscript, and have been replaced by the corresponding zenodo references.*

A63: L478: “1with” → 1 with

Response: Corrected

A64: L481: “the part of the Joule heating directly deposited to the neutrals...” → See point 1 of the Report.

Response: See responses to comments A26, A28, A53, A54 above; this has been changed in the text as:

“the part of the Joule heating promptly deposited to the neutrals...”

A65: L482-483: “half of the total Joule heating is directly deposited to the neutrals..” → See point 1 of the Report.

Response: See responses to comments A26, A28, A53, A54, A64 above; this has been changed in the text as:

“half of the total Joule heating is promptly deposited to the neutrals...”

A66: L:488: “...during...” → at

Response: Corrected

A67: L490: “Joule heating directly deposited to the neutrals...” → See point 1 of the Report.

Response: See responses to comments A26, A28, A53, A54, A64, A65 above; this has been changed in the text as:

“Joule heating promptly deposited to the neutrals...”

A68: L491: “ $q\Delta_{Tin}$ ” → $q\Delta_{Tin}$

Response: Corrected

A69: L492-493: “This, as discussed below, is attributed to the inclusion of smaller scales in the AMIE model, enabled by the long-term assimilation of multiple datasets” → Also actual vs. average / statistical boundary conditions ? See point 2 of the Report.

Response: Indeed, as discussed in point 2 above, this is also due to the actual vs. average / statistical boundary conditions. This sentence has been changed as follows in the revised manuscript:

“This, as discussed below, is attributed to the inclusion of smaller scales in the AMIE model, and also due to the fact that the AMIE model incorporates time-dependent observations and thus better reflects the state of the system.”

A70: L463: “Energy flow according to the ions” → Energy flow (for ? to / from ?) ions

Response: See response to comment A60

A71: L508: Supplementary Material S2 → I was not able to find S2, but I could access the zenodo data / movies at <https://zenodo.org/records/16993755>.

Response: See also response to comment A62 above; references to S1, S2 and S3 have been removed from the manuscript, and have been replaced by the corresponding zenodo references.

A72: L509: “..before the peak of the storm...” → delete “the peak of”

Response: Corrected

A73: L510: “..is a small fraction of the joule heating” → about 10%

Response: This has been added as follows:

“..is a small fraction (~10%) of the joule heating”

A74: L512 : “..during the peak...” → at the peak

Response: Corrected

A75: L514: “Energy flow according to the electrons” → Energy flow (for ? to / from ?) electrons

Response: See response to comment A60

A76: L508: Supplementary Material S3 → I was not able to find S3, but I could access the zenodo data / movies at <https://zenodo.org/records/16993755>.

Response: See also response to comment A62 above; references to S1, S2 and S3 have been removed from the manuscript, and have been replaced by the corresponding zenodo references.

A77: L531: “...collisions become large...” → Instead of large larger ?
The numbers are still quite small compared to ions and neutrals.

Response: Corrected

A78: L531: “during...” → at

Response: Corrected

A79: L532: “..infer that during the peak...” → infer that at the peak...

Response: Corrected

A80: L533: “...due to enhanced EPP...” → Figure 5 (middle and right) shows EUV and EPP together
=> split ?

Response: We agree that it would be better to split these inputs, however it is noted that this is an output parameter of TIEGCM, and a significant change in the TIEGCM source code would be needed in order to output them separately, which unfortunately was not possible for this paper.

A80-85: Figure 5:

- “ Terms in red...” → Terms with red...
- “..to heating of the ions..” → heating of the electrons
- “..terms in blue...” → terms with blue
- “..of the ions.” → of the electrons
- “Three electric potential....” → Two electric potential
- “Heelis” → delete Heelis

Response: All corrected

A86: L537: “...processes processes...” → delete duplicate

Response: Corrected

A87: L551: “...a revisit to the joule heating...” → ..a revisit of the joule heating

Response: Corrected

A88: L552: “... even basic principles...” → even basic assumptions =

Response: Changed according to the reviewer’s comment

A89: L553: “... AE dataset...” → AE-C and AE-E ? Just AE is a bit confusing with Auroral Electrojet, used as well in the paper.

Response: This has been changed to

“Atmosphere Explorer C, D and E datasets”

A90: L554: “..has shown..” → have shown

Response: Corrected

A91: L554: “..are times where...” → are times when

Response: Corrected

A92: L560: “During the peak...” → At the peak...

Response: Corrected

A93: L563: “ the peak of storm..” → the peak of the storm....

Response: Corrected

A94: L567: “...~1...” → ~1 h

Response: Corrected

A95: L576-578: “Moreover, the use of higher resolution electric fields from assimilative techniques instead of empirical models, compensates part of the small-scale variability but nevertheless, residual underestimation persists (i.e. scales below 1o)” → Small scale variability is just part of the explanation. The use of boundary conditions better tuned to the actual data is another part - see point 2 of the Report.

Response: This has been added in the Summary and Conclusions section, according to the response to the reviewer’s comment A1.

A96: L583: “..in the altitudes...” → near the altitudes

Response: Changed according to the reviewer’s comment

A97: L584: “profiles with sufficient statistical” → ... profiles down to a couple of atmospheric scale heights under the spacecraft. This is essential for an LTI missions and would enable sufficient... (?)

The key point of Vogt et al. (2023) is the extrapolation under the spacecraft, at altitudes difficult to reach (because of thermal stress), but essential for the Joule heating - those altitudes where the ionospheric current and the Joule heating maximize.

Response: Indeed, we agree; this has been added, and the text now reads as follows:

“As demonstrated by Vogt et al. (2023), a twin-spacecraft mission with altitudinal separation and with comprehensive instrumentation that performs measurements near the altitudes of interest would be able to provide the altitude profiles down to a couple of atmospheric scale heights under the spacecraft. This is

essential for an LTI mission and would enable measurements with sufficient statistical significance, so as to derive the climatological characterization of Joule heating as a function of altitude, while also resolving the open question of the significance of Joule heating at small scales.”

A98: L592-593: “CO₂, are also significantly different for the two runs” → Presumably because of the same reason, actual conditions versus statistical / average - see also above, L576-578, and point 2 of the Report.

Response: Indeed, we agree with the reviewer; the following sentence has been added:

“..., due to the different external drivers and the resulting different neutral temperatures of the LTI regions.”

A99: L596: “but are not included in the presented analysis.” → Because they are small / negligible ?

Response: Indeed, their contribution is small/negligible with respect to the other terms.

A100: L608: “from the viewpoint of the neutrals” → Because of the impact on density, I suppose, with further effect on drag, orbits / debris, etc - as pointed out below, L618.

Response: Indeed, that is possibly the reason.

A101: L613: “as higher fields will give higher Joule heating; “ → And AMIE is indeed expected to provide higher electric fields - tuned to actual conditions - as compared to Weimer 2005 or other statistical models, which can only capture 'average' values.

*Response: Indeed, the AMIE model provides higher electric fields. Also in response to the second reviewer's comment, the following text has been added, together with the new **Figure 6**:*

“These discrepancies are attributed to the average electric field that is estimated by each of the model drivers, as higher fields will give higher Joule heating. In **Figure 6** the high-latitude electric potential for the two models and for the two time-steps used in this study are presented. The Weimer-2005 model gives higher potential at the baseline timestep, while the AMIE model gives higher potential at the peak of the storm. At the baseline, the potential patterns of the two models are spatially different, while at the peak of the storm both models capture the two-cell structures quite similarly.”

A102: L638-639 “Acknowledgements. The authors acknowledge the use of data obtained from [SuperDARN (<http://vt.superdarn.org/tiki-index.php>), Super-MAG (<https://supermag.jhuapl.edu>), and AMPERE (<http://ampere.jhuapl.edu>)] for the period of 15-21 March 2015.” → Are these data used in the paper ?

Response: These were used for test-runs with other models, which ended up not being used, and have been removed.