Response to referees

Inferring thermospheric composition from ionogram profiles: A calibration with the TIMED spacecraft by Scott et al.

The authors would like to thank the referee for their valuable comments which we address in more detail below;

This paper revisited a technique that deduces thermospheric composition from ionospheric data, as the ionospheric profile in the transition region between F1 and F2 peaks depends on ion production rate and loss rates via ion-atom interchange reactions and dissociative recombination of molecular ions. However, their results show that a linear relationship between √G and the molecular/atomic composition ratio, with a gradient of 2.55 ±0.40; however this gradient became to be 4.75 ± 0.4 as hmF1 is used. Supposedly, besides neutral temperature, the dynamic effect also could contribute to the formation of this transition region. The authors should discuss this issue.

While we had mentioned the impact of atmospheric dynamics in passing in the discussion, we agree that it is important to address this earlier in the paper. We have therefore added the following paragraph;

"While the general behaviour of the F1-F2 transition is therefore controlled by thermospheric composition, transient features generated by atmospheric dynamics, such as Travelling Ionospheric Disturbances (TIDs), have long been known to temporarily affect electron concentration gradients within the ionospheric profile (e.g. Munro, 1950, Rawer, 1959). While caution should therefore be used when interpreting the shape of any individual ionospheric profile, the transient nature of a TID is revealed by viewing an ionogram in the context of the diurnal time series. In this way, the impact of TIDs can be minimised in any investigation for which a sufficiently large data set is available, though their presence would add to the scatter into any quantitative relationship between estimates of the G parameter and thermospheric composition."

And added the following references;

Munro, G. H.: Travelling disturbances in the ionosphere, Proc. Roy. Soc., A202, 208-223, 1950.

Rawer, K.; Irregularities and movements in the F-region, J. Atmos. Terr. Phys., 15, 38-42, 1959.

In addition, after discussion with the TIMED GUVI instrument team, we have also tweaked the abstract and introduction sections slightly to further emphasise how our technique potentially adds to current measurements of the thermosphere.

The abstract now begins;

"We present a method for augmenting spacecraft measurements of thermospheric composition with quantitative estimates of daytime thermospheric composition below 200 km, inferred from ionospheric data, for which there is a global network of ground-based stations. Measurements of thermospheric composition via ground-based instrumentation are challenging to make and so details about this important region of the upper atmosphere are currently sparse.."

And the introduction section now contains the following sentences;

“Far-ultraviolet remote sensing provides information on the integrated column O/N_2 ratio or height profiles of O and N_2 concentrations (via observations of the airglow profile on the limb of the Earth).”

and

“Observations of the Limb and Disk (GOLD) instrument (Eastes et al, 2017), hosted by the STS-14 commercial spacecraft, was launched into a geostationary orbit from where it makes column-integrated measurements of the thermosphere over an entire hemisphere and height profiles at the limb. Despite these advances, information about thermospheric composition is limited to dayside above around 200 km. This paper proposes a method of augmenting these spacecraft measurements with estimates of thermospheric composition below 200 km via a global network of ground-based ionospheric observatories.”

We have also added the following references for the TIMED spacecraft and the GUVI measurement techniques used within our paper;

Christensen, A.B., L. J. Paxton, S. Avery, J. Craven, G. Crowley, D. C. Humm, H. Kil, R. R. Meier, C.-I. Meng, D. Morrison, B. S. Ogorzalek, P. Straus, D. J. Strickland, R., M. Swenson, R. L. Walterscheid, B. Wolven, and Y. Zhang, (2003), Initial Observations with the Global Ultraviolet Imager (GUVI) in the NASA TIMED Satellite Mission, J. Geophys. Res., 108 (A12), 1451, doi:10.1029/2003JA00991.

Christensen, A.B., R.L. Walterschied, M.N. Ross, C. Meng, L. Paxton, D. Anderson, G. Crowley, S. Avery, R. Meier, and D. Strickland, (1994), Global Ultraviolet Imager for the NASA TIMED Mission, SPIE Optical Spectroscopic Techniques and Instrumentation for Atmospheric and Space Research, 2266, 451-466.

Paxton, L. J., Schaefer, R. K., Zhang, Y., & Kil, H. (2017). Far ultraviolet instrument technology. Journal of Geophysical Research: Space Physics, 122(2), 2706-2733.

Strickland, D. J., J. S. Evans, and L. J. Paxton(1995), Satellite remote sensing of thermospheric O/N2 and solar EUV 1. Theory, J. Geophys. Res., 100, 12,217–12,226, doi:10.1029/95JA00574.

NB in preparing the manuscript for publication, it was realised that figures 3, 4 and 5 were erroneously duplicated. We have regenerated the all the analysis figures and corrected this issue, which does not alter the quantitative values or the conclusions quoted in the text. We report this here after consultation with the topical editor.