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Comment on acp-2021-331

Anonymous Referee #2

Referee comment on "Self-consistent Global Transport of Metallic Ions with WACCM-X" by Jianfei Wu et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-331-RC3, 2021

This work is an implementation of transports of metallic ions (Mg+, Fe+, and Na+) in WACCM-X for the purpose of understanding the effects of atmospheric motions on their distributions. The work lacks sufficient description of the implementation as well as scientific insights.

The implication of the transport effect, mainly described by equation (2), is questionable. There are terms missing as compared with Chu and Yu (2017), 2nd and 6th term in their eq(6). This is not explained. The effect of neutral wind (6th term) is especially important in the E region.

"Self-consistency" appears in numerous places but there is no explanation of what "self-consistency" really means, and what was not consistent in any previous model works. The difference of this work from that by Langowski et al. (2015) is not clear, except that the model used is WACCM-X instead of WACCM.

Almost all conclusions were drawn based on comparisons of the distributions from model simulations with observations or other model runs. This is a poor way to gain much insight into any physical/chemical processes. Most of the conclusions are speculative, without any quantitative assessments. The benefit of modeling is to enable the examination of individual effects associated with different processes. If only the final results are examined, the value of modeling is not utilized much. Several examples are listed below:

1. The authors argue that the "upward transport of Fe+ does not significantly contribute to changes of Fe," (line 152). To prove this, the contributions of Fe+ transport to the time tendency of Fe need to be calculated separately and compared with other effects.

2. The authors argue that "uplift of metal ions" is "driven by "meridional wind," (line 196-197). This could be supported if the authors can demonstrate that the magnitude of uplift due to the meridional wind is indeed much larger than other wind components.

3. The authors believe that this uplift can "explain the summer maximum occurrence of thermospheric sodium layers." If that were the case, then the contribution of the uplift term to the production of neutral sodium would show being much larger than others. Furthermore, the authors did not even show that the model actually produced a summer

maximum of Na in the thermosphere. In addition, it is not true that thermospheric Na appears mostly in summer. As Cai et al. (2017) stated, the thermospheric sodium appeared at this Southern Hemisphere site mostly in spring and fall and rarely in summer and winter.

Most of the thermospheric Na observed showed a downward phase progression similar to that of diurnal or semidiurnal tides. Since tides are well resolved in WACCM-X, this feature should be reproducible if the model results are to be believed. On the other hand, the thermospheric Fe at high latitude showed variations on much shorter timer scales (Chu and Yu 2017). Comparison with Fe observations with a model that cannot resolve the short-time scale dynamics (gravity waves) is not meaningful.

Other minor points

According to Liu et al. (2018), WACCM-X "neglects the influence of ion-neutral collisions on ion motion perpendicular to B," which is significant "in the E-region where the O+ lifetime is short and transport is unimportant." Since E-region is an area of focus in this study, how does this neglected effect influence the simulation result?

169-170: TIFe and TINa are not defined. In fact, there is no point in using such acronyms as they are mentioned only once and they are not widely accepted.

Figure 3e needs to adopt a different color range to show more structure.

I suggest that the authors cite the following paper, which is the first report of thermospheric Na in the southern hemisphere. Furthermore, the temperature and wind reported in this paper is a rare dataset that can be used to validate model simulations trying to reproduce the thermospheric Na.

Liu, A. Z., Guo, Y., Vargas, F., and Swenson, G. R. (2016), First measurement of horizontal wind and temperature in the lower thermosphere (105–140 km) with a Na Lidar at Andes Lidar Observatory, Geophys. Res. Lett., 43, 2374– 2380, doi:10.1002/2016GL068461.