Long-term Changes in the Atmosphere and Ionosphere caused by Secular changes of geomagnetic fields and Anthropogenic Emissions

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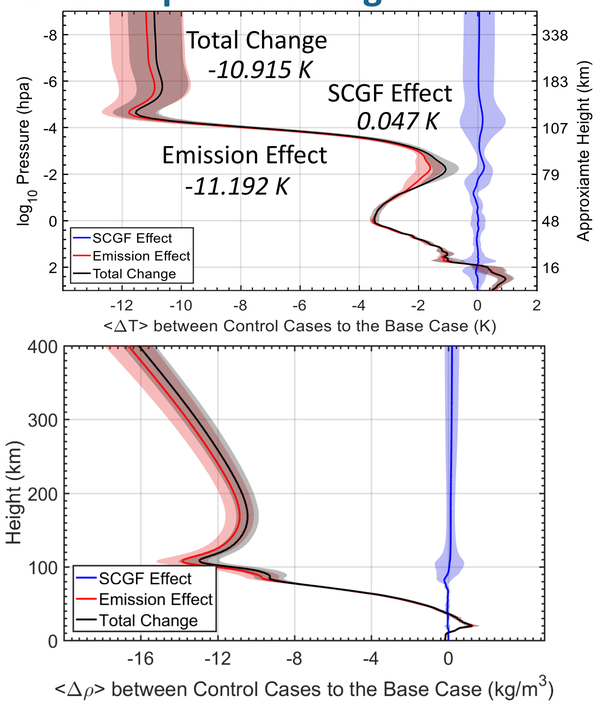
Abstract This work performs several simulations to evaluate atmospheric and ionospheric changes caused by secular changes of geomagnetic fields (SCFG) and anthropogenic changes in the entire atmosphere during past 35 years (1970s to 2010s), based on the Whole Atmosphere Community Climate Model-eXtended (WACCM-X) v2.1. The results show the emission effect is the dominant factor to long-term changes of global mean neutral temperature and density, but SCGF has no obvious contribution to them in the whole atmosphere. Although regional changes caused by the SCGF effect are shown in the atmosphere, they are insignificant and inconvincible because atmospheric intra-annual variability is much larger and known physical mechanisms are unable to explain them. In the ionosphere, SCGF hardly affect the global mean Ne neither at noon nor at midnight, and the emission effect enable lead to more significant changes of global mean Ne at noon (HmF2 descends ~7 km and NmF2 decreases ~ 0.33 × 10^5 cm^{-3}) than at midnight. Besides, SCGF enable shift the EIA structure northward in the American-African sector, and the changes of anthropogenic emissions decrease the strength the EIA structure and alter the phase of annual/semiannual variations of NMF2.

1 Model Settings

Solar minimum (F10.7 = 70 s.f.u) & geomagnetic quiet condition (Kp = 0.33)

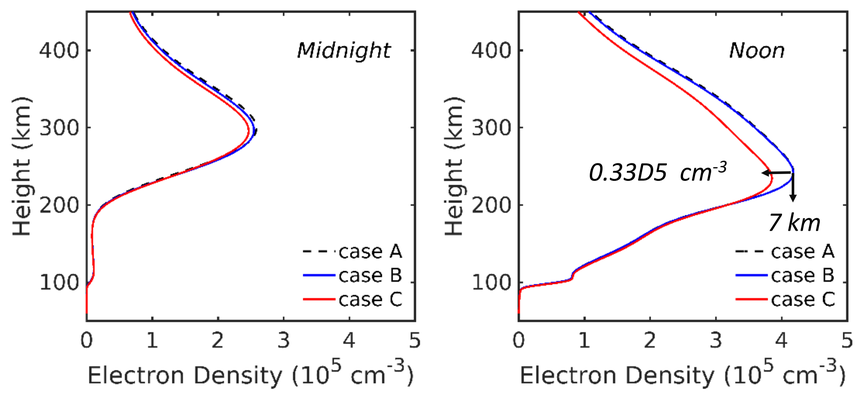
Cases	Case A	Case B	Case C	Case D
Emission Periods	1976-1980	1976-1980	2011-2015	2011-2015
Geomagnetic Field	MF1978	MF2013	MF1978	MF2013
<CO_2> at surface	335	335	395	395
Dipole Mom. (×10^{22} Am^2)	7.9030	7.7245	7.9030	7.7245

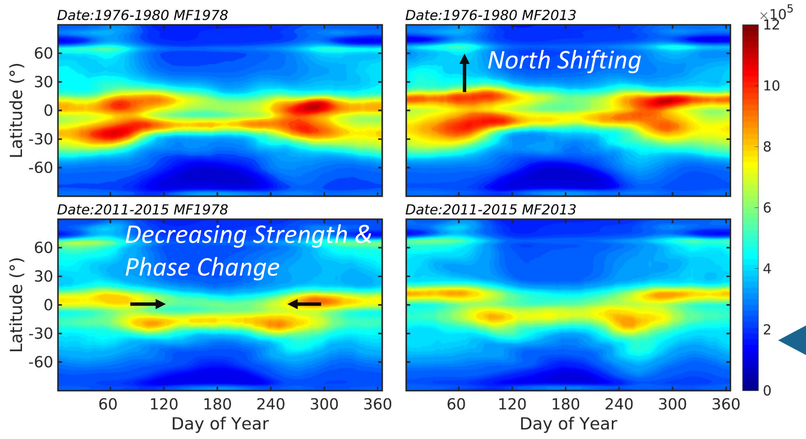
2 Atmospheric Changes

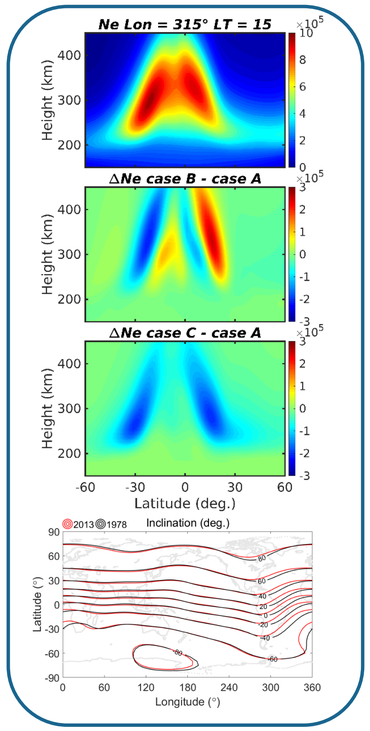


- SCGF during last ~35 years unable significantly affects global mean neutral temperature and mass density;
- Anthropogenic Emission is the dominant driver to the global climate change in last ~35 years;
- In these simulations, it is difficult to capture the feature of regional changes caused by SCGF because large intra-annual variability exists in the atmosphere and no convincible heating sources are found (not shown)

3 Ionospheric Changes







Annual & Semiannual variation of **NMF2** @ *Noon*
LT = 12; Long. = 315; UT = 15;
30-d moving average

4 Conclusion

- To global mean variables in the atmosphere-ionosphere system, anthropogenic emission is the primary driver, and SCGF do not play a significant role;
- Spatial distribution of ionosphere is affected by SCGF, and annual/semiannual variation of ionosphere is changed by different level of anthropogenic emission.