



Geomagnetic activity effects on CO₂-driven trend in the thermosphere and ionosphere: ideal model experiments with GAIA

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We examine impacts of geomagnetic activity on CO₂-driven trend in the Ionosphere and Thermosphere (IT) using the GAIA whole atmosphere model. The model reveals three salient features. (1) Geomagnetic activities usually weakens the CO₂-driven trend at a fixed altitude. Among the IT parameters analyzed, the thermosphere mass density is the most robust indicator for CO₂ cooling effect even with geomagnetic activity influences. (2) Geomagnetic activities can either strengthen or weaken the CO₂-driven trend in hmF2 and NmF2, depending on local time and latitudes. This renders the widely used linear fitting methods invalid for removing geomagnetic effects from observations. (3) An interdependency exists between the efficiency of CO₂ forcing and geomagnetic forcing, with the former enhances at lower geomagnetic activity level, while the latter enhances at higher CO₂ concentration. This could imply that the CO₂-driven trend would accelerate in periods of declining geomagnetic activity, while magnetic storms may have larger space weather impacts in the future with increasing CO₂. These findings provide a preliminary model framework to understand interactions between the CO₂ forcing from below and the geomagnetic forcing from above.