Potential Influence of Elevated Stratopause Events on the Lower Atmospheric Circulation

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The reformation of a separated elevated stratopause after strong stratospheric warmings is an important phenomenon in the coupling between the stratosphere and mesosphere-lower thermosphere. Since such events, called as the Elevated Stratopause Events (ESEs), are closely linked to the downward transport of NOx produced in the mesosphere and thermosphere via the Energetic Particle Precipitation (EPP), they could contribute to catalytic ozone destruction in the stratosphere. This is a notable case of the so called EPP indirect effect. Here, we analyze the polar stratospheric ozone loss due to ESEs and its impact on the lower atmospheric circulation in the Earth System Model of Meteorological Research Institute (MRI-ESM). By introducing the energetic particle forcing in the MRI-ESM, the EPP indirect effect is examined for multiple ESEs. In simulations which are nudged toward reanalysis data in the troposphere and stratosphere while being unconstrained above, ozone reduces by up to 40% in the upper stratosphere for several weeks after ESEs due to the NOx enhancements. The reduction of stratospheric ozone causes cooling anomalies of the polar-cap temperature and westerly anomalies of the zonal-mean zonal wind during the period of sunlit. Further, it is revealed that such anomalies can modulate the behavior of the stratospheric final warming by conducting a series of ensemble simulations, without the nudging, for a case of the largest ESE accompanied by large EPP. Thus, this study presents the possible coupling between the upper-to-middle atmosphere and lower atmosphere via the ESE.

Key words: elevated stratopause event, energetic particle precipitation, sudden stratospheric warming, chemistry climate model, stratospheric ozone