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Electric field roles in day-to-day variations of sporadic E layers at geomagnetic mid-latitudes

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This study investigates the effects of the electric fields (E-fields) on day-to-day variations in geomagnetic mid-latitude sporadic E layers (EsLs) using a numerical ionospheric model. It is considered that geomagnetic mid-latitude EsL dynamics depend largely on wind shear variations. In contrast, E-field effects on geomagnetic mid-latitude EsLs have not been investigated extensively. Previous observations have reported that E-fields change EsL heights by only several kilometers at geomagnetic mid-latitudes. However, no studies have investigated E-field effects on day-to-day EsL variations. Recently, our numerical ionospheric model succeeded generally in reproducing day-to-day EsL variations driven by winds at geomagnetic mid-latitudes. In this study, using the ionospheric model, we conducted EsL simulations including both E-fields and winds to elucidate E-field roles in day-to-day EsL variations at geomagnetic mid-latitudes. We found that zonal and meridional/vertical E-fields change the vertical EsL dynamics above ~110 km. Above ~130 km, E×B drifts by zonal E-fields control vertical ion dynamics. Below ~130 km, where most Es layers appear, vertical/meridional E-fields are more effective for EsL dynamics than zonal E-fields. In the daytime, E-fields transport metal ions from the lower ionosphere to more than 110 km. The E-field transportation facilitates daytime EsLs formations by the semi-diurnal tides. In the evening, E-fields drive downward ion motion, which prompts descending EsL motions. E-fields affect day-to-day EsL variations at geomagnetic mid-latitudes by altering background metal ion distribution and transportation.