Revisiting the Modulations of Ionospheric Solar and Lunar Migrating Tides during the 2009 Stratospheric Sudden Warming by using Global Ionosphere Specification

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In this study, Global Ionosphere Specification (GIS) based on the Gauss-Markov Kalman filter assimilating the TECs observed from ground-based GPS receivers and space-based radio occultation (RO) instrumentations is applied for investigation of ionospheric day-to-day tidal variability during the 2009 stratospheric sudden warming (SSW) period. With the benefit of GIS improving the temporal and spatial resolution of global electron density distribution, we can retrieve the daily solar tidal solution by using least square fitting. We found that the solar semidiurnal migrating tide (SW2) reveals a prominent reduction followed by enhancement after the peak warming, with recurrent phase decreases and increases occurring at the low magnetic latitude on a period of about 15 days. Previously this SW2 oscillation was considered as a potential driver of the SSW-related ionospheric variation, but the oscillation is indeed close to the beating period (15.13 day) between SW2 and lunar semidiurnal (M\textsubscript{2}) tides, suggesting that the M\textsubscript{2} should be further considered. Our tidal analyses on the daily GIS clearly prove the intensification of M\textsubscript{2} only exists during the SSW period. It also illustrates that the combined impact of amplitudes and phases of the SW2 and M\textsubscript{2} on the semidiurnal variation in the ionosphere. If one considers the SW2 solely, the resulting ionospheric perturbation shows the phase decreases, on the other hand, combined M\textsubscript{2} and SW2 show oscillating amplitudes and phase shifts. Our results indicate that the M\textsubscript{2} variability is important to contribute to the equatorial vertical drift modulation during the SSWs.