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Solar-cycle effect of energetic electron precipitation seen in mesospheric ozone

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Energetic electron precipitation (EEP) from the Earth's outer radiation belt continuously affects the chemical composition of the mesosphere in the polar regions. At altitudes below about 80 km, EEP leads to odd hydrogen enhancement following ionisation and ion chemical reactions, which is expected to contribute to ozone balance in the mesosphere. A recent study considering the 2004-2009 period concluded that EEP significantly affected mesospheric hydroxyl (OH) about 35% of the time. Using 11 years of observations from the Global Ozone Monitoring by Occultation of Stars (GOMOS/ENVISAT), Sounding of the Atmosphere using Broadband Emission Radiometry (SABER/TIMED) and Microwave Limb Sounder (MLS/Aura) instruments, we show that the precipitation-induced increases in OH are typically accompanied by decreases in ozone at altitudes between 60-80 km. The EEP leads to extremely large (up to 90%) short-term (days) ozone depletions in the atmosphere. The magnitude of these short-term effects is comparable to those caused by large but much less frequent solar proton events. On solar cycle scales, we find that EEP causes significant ozone variations of up to 34% at 70-80 km. As ozone is important to atmospheric heating and cooling rates, this level of ozone variation could significantly affect the local mesospheric temperature balance. Our results emphasises the importance of the EEP effects and significantly improves our understanding of energetic particle impacts on the atmosphere.