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Magnetic-local-time dependency of radiation belt electron precipitation: impact on ozone in the polar middle atmosphere

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The radiation belts are regions in the near-Earth space where solar wind electrons are captured by the Earth's magnetic field. A portion of these electrons is continuously lost into the atmosphere where they cause ionization and chemical changes. Driven by the solar activity, the electron forcing leads to ozone variability in the polar stratosphere and mesosphere. Understanding the possible dynamical connections to regional climate is an ongoing research activity which supports the assessment of greenhouse-gas-driven climate change by a better definition of the solar-driven variability. In the context of the Coupled Model Intercomparison Project Phase 6 (CMIP6), energetic electron and proton precipitation is included in the solar-forcing recommendation for the first time. For the radiation belt electrons, the CMIP6 forcing is from a daily zonal-mean proxy model. This zonal-mean model ignores the well-known dependency of precipitation on magnetic local time (MLT), i.e. its diurnal variability. Here we use the Whole Atmosphere Community Climate Model with its lower-ionospheric-chemistry extension (WACCM-D) to study effects of the MLT dependency of electron forcing on the polar-ozone response. We analyse simulations applying MLT-dependent and MLT-independent forcings and contrast the resulting ozone responses in monthly-mean data as well as in monthly means at individual local times. We consider two cases: (1) the year 2003 and (2) an extreme, continuous forcing. Our results indicate that the ozone responses to the MLT-dependent and the MLT-independent forcings are very similar, and the differences found are small compared to those caused by the overall uncertainties related to the representation of electron forcing in climate simulations. We conclude that the use of daily zonal-mean electron forcing will provide an accurate ozone response in long-term climate simulations.