sensitivity of middle atmospheric ozone to solar proton events: comparison between climate model and satellites

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Energetic particle precipitation (EPP) impact on the middle atmospheric ozone chemistry plays potentially an important role in the connection between space weather and Earth’s climate system. A variant of the Whole Atmosphere Community Climate Model (WACCM-D) implements a detailed set of ionospheric D-region chemistry instead of a simple parameterization used in the earlier WACCM versions, allowing to capture the impact of EPP in more detail, thus improving the model for long-term climate studies. Here, we verify experimentally the ion chemistry of the WACCM-D by analysing the middle atmospheric ozone response to the EPP forcing during well-known solar proton events (SPEs). We use a multi-satellite approach to derive the middle atmospheric sensitivity for the SPE forcing as a statistical relation between the solar proton flux and the consequent ozone change. An identical sensitivity analysis is carried out for the WACCM-D model results, enabling one-to-one comparison with the results derived from the satellite observations. Our results show a good agreement in the sensitivity between satellites and the WACCM-D for nighttime conditions. For daytime conditions, we find a good agreement for the satellite data sets that include the largest SPEs (max proton flux >10⁴ pfu). However, for those satellite data-sets with only minor and moderate SPEs, WACCM-D tends to underestimate the sensitivity in daytime conditions. In summary, the comparisons WACCM-D ion chemistry, combined with the transportation, demonstrates a realistic representation of the SPE sensitivity of ozone, and thus provides a conservative platform for long-term EPP impact studies.