Evaluation of the interactive stratospheric ozone (O3v2 module) for the E3SM version 2 Earth System Model

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Abstract. Stratospheric ozone affects climate directly as the predominant heat source in the stratosphere and indirectly through chemical feedbacks controlling other greenhouse gases. The U.S. Department of Energy's Energy Exascale Earth System Model version 1 (E3SMv1) implemented a new ozone chemistry module that improves the simulation of the sharp tropopause gradients, replacing a version based partly on long-term average climatologies that poorly represented heating rates in the lowermost stratosphere. The new O3v2 module extends seamlessly into the troposphere and preserves the naturally sharp cross-tropopause gradient, with 20-40% less ozone in this region. Additionally, O3v2 enables the diagnosis of stratosphere-troposphere exchange flux of ozone, a key budget term lacking in E3SMv1. Here, we evaluate key features in ozone abundance and other closely related quantities in atmosphere-only E3SMv1 simulations driven by observed sea surface temperatures (SSTs, years 1990-2014), comparing with satellite observations and the University of California, Irvine chemistry transport model (UCI CTM) using the same stratospheric chemistry scheme but driven by European Centre forecast fields for the same period. In terms of stratospheric column ozone, O3v2 shows improved mean bias and northern mid-latitude variability, but not quite as good as the UCI CTM. As expected, SST forcing does not match the observed quasi-biennial oscillation, which is mostly matched with the UCI CTM. This new O3v2 E3SM model retains mostly the same climate state and climate sensitivity as the previous version, and we recommend its use for other climate models that still use ozone climatologies.