Investigating the influence of the 11-year solar cycle on middle atmosphere dynamics with the high vertical resolution NRL-CHEM2D model

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The NRL-CHEM2D model is a zonally averaged (2D) middle atmosphere model with coupled radiation, dynamics, and photochemistry. Previous modeling studies have found that an accurate treatment of the equatorial winds throughout stratosphere, including the quasi-biennial oscillation (QBO) and semi-annual oscillation (SAO), is important for simulating an extratropical response to solar UV forcing over the 11-year cycle. This extratropical response is thought to be a likely feedback mechanism for translating solar UV variations into a global climate response. However, there are still significant discrepancies between the modeled and observed solar cycle variations in middle atmosphere composition (e.g., ozone) and dynamics (e.g., winds, temperatures) that remain unresolved. For example, an earlier CHEM2D study has shown that there is a slight modulation of the QBO over the 11-year solar cycle that is qualitatively consistent with observations, i.e. a shorter westerly phase of the QBO during solar maximum. However the modeled effect was much smaller ($\sim$1 month) than indicated by observations (3-6 months). We present results from a series of 50-year model simulations using a new high-vertical resolution version of the CHEM2D model. These 50-year experiments include external forcing by decadal variations in solar UV irradiance, and internal forcing through an imposed decadal variation in planetary wave amplitudes, consistent with observations. We examine the sensitivity of the modeled solar-QBO modulation to the vertical resolution of the model, and present a statistical analysis of the modeled interannual variability in ozone and temperature to characterize and quantify the components of decadal variability attributed to external solar forcing and internal dynamical forcing.