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Model analysis of 27-day solar-induced variability of chemical dynamics in the equatorial upper and middle atmosphere

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The effect of solar variability on the atmosphere remains poorly understood. This study explored the impact of 27-day rotation of sunspots on the equatorial upper and middle atmospheric photochemistry from Whole Atmosphere Community Climate Model 3 (WACCM3) output. WACCM3 was driven with observed solar and greenhouse gas forcing for a period during the last solar maximum which included 1999, 2000, and 2001. Fourier and wavelet analysis were applied to determine the magnitude and phase responses to the solar-induced forcing on ozone (O_3), temperature, hydrogen species (OH, HO_2, H), molecular oxygen $(O(^3P))$, water vapor (H_2O), and shortwave heating. Wavelet analysis demonstrated that the response of these atmospheric constituents to the 27-day forcing is largely intermittent and depends on the magnitude of solar forcing. Fourier and phase analysis demonstrated that the largest responses of ozone occurred around 80 and 40 km. The former is attributed to increased production of odd hydrogen (HO_X) from photolysis of water vapor at Lyman-α, while the latter is attributed to increased O_3 production in the stratopause from increased UV. The analysis also demonstrated that the largest responses of temperature occurred around 70 km and 40 km. They are attributed to increased UV at those altitudes. The amplitude of these responses compared well with data from models and observations. Phase difference, on the other hand, did not. Internal modes of variability close to 27 days and the realistic forcing mechanisms used to drive the model may contribute to this.