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A Parametric Model of Elliptic Orbits for Annual Evolutions of Northern Hemisphere Stratospheric Polar Vortex and Their Interannual Variability

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The year-to-year varying annual evolutions of the stratospheric polar vortex (SPV) have an important downward impact on the weather and climate from winter to summer and thus potential implications for seasonal forecasts. This study constructs a parametric elliptic orbit model for capturing the annual evolutions of mass-weighted zonal momentum at 60° N (MU) and total air mass above the isentropic surface of 400 K (M) over the latitude band of 60–90° N from 1 July 1979 to 30 June 2022. The elliptic orbit model naturally connects two time series of a nonlinear oscillator. As a result, the observed coupling relationship between MU and M associated with SPV as well as its interannual variations can be well reconstructed by a limited number of parameters of the elliptic orbit model. The findings of this study may pave a new way for short-time climate forecasts of the annual evolutions of SPV, including its temporal evolutions over winter seasons as well as the spring and fall seasons, and timings of the sudden stratospheric warming events by constructing its elliptic orbit in advance.