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Stochastic Modeling of Stratospheric Temperature

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This study suggests a stochastic model for time series of daily zonal (circumpolar) mean stratospheric temperature at a given pressure level. It can be seen as an extension of previous studies which have developed stochastic models for surface temperatures. The proposed model is a combination of a deterministic seasonality function and a Lévy-driven multidimensional Ornstein–Uhlenbeck process, which is a mean-reverting stochastic process. More specifically, the deseasonalized temperature model is an order 4 continuous-time autoregressive model, meaning that the stratospheric temperature is modeled to be directly dependent on the temperature over four preceding days, while the model's longer-range memory stems from its recursive nature. This study is based on temperature data from the European Centre for Medium-Range Weather Forecasts ERA-Interim reanalysis model product. The residuals of the autoregressive model are well represented by normal inverse Gaussian-distributed random variables scaled with a time-dependent volatility function. A monthly variability in speed of mean reversion of stratospheric temperature is found, hence suggesting a generalization of the fourth-order continuous-time autoregressive model. A stochastic stratospheric temperature model, as proposed in this paper, can be used in geophysical analyses to improve the understanding of stratospheric dynamics. In particular, such characterizations of stratospheric temperature may be a step towards greater insight in modeling and prediction of large-scale middle atmospheric events, such as sudden stratospheric warming. Through stratosphere–troposphere coupling, the stratosphere is hence a source of extended tropospheric predictability at weekly to monthly timescales, which is of great importance in several societal and industry sectors.