Geophysical Research Abstracts
Vol. 15, EGU2013-8391, 2013
EGU General Assembly 2013
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Stratospheric ozone time series analysis using dynamical linear models

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We describe a hierarchical statistical state space model for ozone profile time series. The time series are from satellite measurements by the SAGE II and GOMOS instruments spanning years 1984-2012. The original data sets are combined and gridded monthly using 10 degree latitude bands, and covering 20-60 km with 1 km vertical spacing. Model components include level, trend, seasonal effect with solar activity, and quasi biennial oscillations as proxy variables.

A typical feature of an atmospheric time series is that they are not stationary but exhibit both slowly varying and abrupt changes in the distributional properties. These are caused by external forcing such as changes in the solar activity or volcanic eruptions. Further, the data sampling is often nonuniform, there are data gaps, and the uncertainty of the observations can vary. When observations are combined from various sources there will be instrument and retrieval method related biases. The differences in sampling lead also to uncertainties. Standard classical ARIMA type of statistical time series methods are mostly useless for atmospheric data. A more general approach makes use of dynamical linear models and Kalman filter type of sequential algorithms. These state space models assume a linear relationship between the unknown state of the system and the observations and for the process evolution of the hidden states. They are still flexible enough to model both smooth trends and sudden changes.

The above mentioned methodological challenges are discussed, together with analysis of change points in trends related to recovery of stratospheric ozone. This work is part of the ESA SPIN and ozone CCI projects.