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Trends and variability in stratospheric mixing: 1979–2005

H. Garny[1], G. E. Bodeker[2], and M. Dameris[3]
[1]Meteorological Institute, University of Munich, Munich, Germany
[2]National Institute of Water and Atmospheric Research, Lauder, New Zealand
[3]DLR-Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany

Abstract. Changes in climate are likely to drive changes in stratospheric mixing with associated implications for changes in transport of ozone from tropical source regions to higher latitudes, transport of water vapour and source gas degradation products from the tropical tropopause layer into the mid-latitude lower stratosphere, and changes in the meridional distribution of long-lived trace gases. To diagnose long-term changes in stratospheric mixing, global monthly fields of Lyapunov exponents were calculated on the 450 K, 550 K, and 650 K isentropic surfaces by applying a trajectory model to wind fields from NCEP/NCAR reanalyses over the period 1979 to 2005. Potential underlying geophysical drivers of trends and variability in these mixing fields were investigated by applying a least squares regression model, which included basis functions for a mean annual cycle, seasonally dependent linear trends, the quasi-biennial oscillation (QBO), the solar cycle, and the El Niño Southern Oscillation (ENSO), to zonal mean time series of the Lyapunov exponents.

Long-term positive trends in mixing are apparent over southern middle to high latitudes at 450 K through most of the year, while negative trends over southern high latitudes are apparent at 650 K from May to August. Wintertime negative trends in mixing over northern mid-latitudes are apparent at 550 K and 650 K. Over low latitudes, within 40° of the equator, the QBO exerts a strong influence on mixing at all three analysis levels. This QBO influence is strongly modulated by the annual cycle and shows a phase shift across the subtropical mixing barrier. Solar cycle and ENSO influences on mixing are generally not significant. The diagnosed long-term changes in mixing should aid the interpretation of trends in stratospheric trace gases.

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