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Measurements of NO, NO_y, N_2O, and O_3 during SPURT: implications for transport and chemistry in the lowermost stratosphere

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Abstract. We present measurements of NO, NO_y, O_3, and N_2O within the lowermost stratosphere (LMS) over Europe obtained during the SPURT project. The measurements cover all seasons between November 2001 and July 2003. They span a broad band of latitudes from 30° N to 75° N and a potential temperature range from 290 to 380 K. The measurements represent a comprehensive data set of these tracers and reveal atmospheric transport processes that influence tracer distributions in the LMS. Median mixing ratios of stratospheric tracers in equivalent latitude-potential temperature coordinates show a clear seasonal cycle related to the Brewer-Dobson circulation, with highest values in spring and lowest values in autumn. Vertical tracer profiles show strong gradients at the extratropical tropopause, suggesting that vertical (cross-isentropic) mixing is reduced above the tropopause. Pronounced meridional gradients in the tracer mixing ratios are found on potential temperature surfaces in the LMS. This suggests strongly reduced mixing along isentropes. Concurrent large gradients in static stability in the vertical direction, and of PV in the meridional direction, suggest the presence of a mixing barrier. Seasonal cycles were found in the correlation slopes $\Delta O_3/\Delta N_2O$ and $\Delta NO_y/\Delta N_2O$ well above the tropopause. Absolute slope values are smallest in spring indicating chemically aged stratospheric air originating from high altitudes and latitudes. Larger values were measured in summer and autumn suggesting that a substantial fraction of air takes a "short-cut" from the tropical tropopause region into the extratropical LMS. The seasonal change in the composition of the LMS has direct implications for the ozone chemistry in this region. Comparisons of measured NO with the critical NO value at which net ozone production changes from negative to positive, imply ozone production up to 20 K above the local tropopause in spring, up to 30 K in summer, and up to 40 K in autumn. Above these heights, and in winter, net ozone production is negative.

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