Stratospheric Water Vapor Trends Over Boulder, Colorado: Analysis of the 30-Year Boulder Record

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Trend analyses are presented for 30 years (1980-2010) of balloon-borne stratospheric water vapor measurements over Boulder, Colorado. The data record is broken into four multiple-year periods of water vapor trends, including two that span the well-examined but unattributed 1980-2000 period of stratospheric water vapor growth. Trends are determined for five 2-km stratospheric layers (16-26 km) utilizing weighted, piecewise regression analyses. Stratospheric water vapor abundance increased by an average of 1.0 ± 0.2 ppmv (27 ± 6%) during 1980-2010 with significant shorter-term variations along the way. Growth during Period 1 (1980-1989) was positive and weakened with altitude from 0.44 ± 0.13 ppmv at 16-18 km to 0.07 ± 0.07 ppmv at 24-26 km. Water vapor increased during Period 2 (1990-2000) by an average 0.57 ± 0.25 ppmv, decreased during Period 3 (2001-2005) by an average 0.35 ± 0.04 ppmv, then increased again during Period 4 (2006-2010) by an average 0.49 ± 0.17 ppmv. The diminishing growth with altitude observed during Period 1 is consistent with a water vapor increase in the tropical lower stratosphere that propagated to the midlatitudes. In contrast, growth during Periods 2 and 4 is stronger at higher altitudes, revealing contributions from at least one mechanism that strengthens with altitude, such as methane oxidation. The amount of methane oxidized in the stratosphere increased considerably during 1980-2010, but this source can account for at most 28 ± 4%, 14 ± 4%, and 25 ± 5% of the net stratospheric water vapor increases during 1980-2000, 1990-2000, and 1980-2010, respectively.

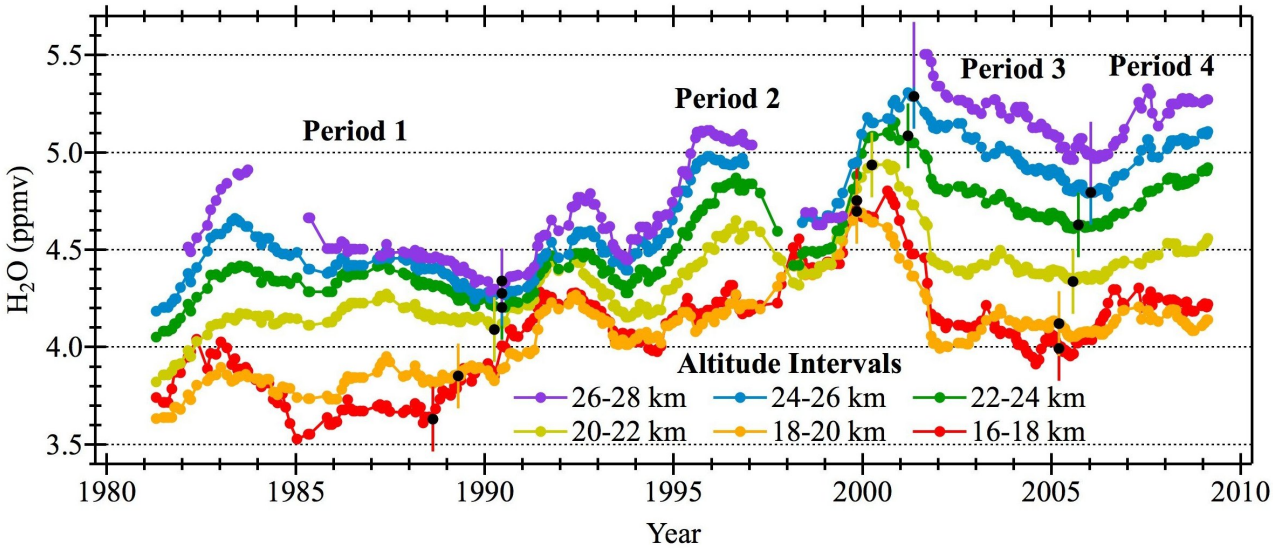

Figure 1. The smoothed 30-year Boulder record of stratospheric water vapor measurements by balloon-borne NOAA frost point hygrometers. Water vapor mixing ratios were binned in 2-km altitude intervals and assessed for trends in four different multiple-year periods using weighted, piecewise regression analyses. Net increases are evident for trend Periods 1, 2 and 4, as well for the entire record (1.0 ± 0.2 ppmv). The rapid downturn in Period 3 has been attributed to an anomalously cold tropical tropopause and increased tropical upwelling. The root cause(s) behind the long-term stratospheric water vapor increase is (are) unknown.