Trends and Variability of Mid Latitude Stratospheric Water Vapor Deduced From the Re-evaluated Boulder Balloon Series and HALOE

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Introduction

We present an updated trend analysis of water vapor in the lower mid latitude stratosphere from the Boulder balloon-borne NOAA frostpoint hygrometer measurements (NOAA FP) [Scherer et al., 2008]. Two corrections for instrumental bias are applied to homogenize the frostpoint data series, and a quality assessment of all soundings after 1991 is presented. The drop in water vapor mixing ratios in 2001 in each of the time series is investigated in relation to possible changes in water vapor entering the stratosphere in the tropics.

Data Corrections

Two previously unaccounted instrumental sources of bias have been identified:

- **An error to the fit in the mirror thermistor calibration for measurements of frostpoint temperatures colder than -79ºC. This led to a warm (high) bias in profiles after 1990.**
- **A second calibration error related to the reading of the resistance at the warmest calibration temperature at 0ºC. This led to a cold (low) bias at temperatures colder than -79ºC when the fit is applied to the calibration data.**

Application of the corrections leads to reduction in the linear trend compared to previous estimates (Fig. 1).

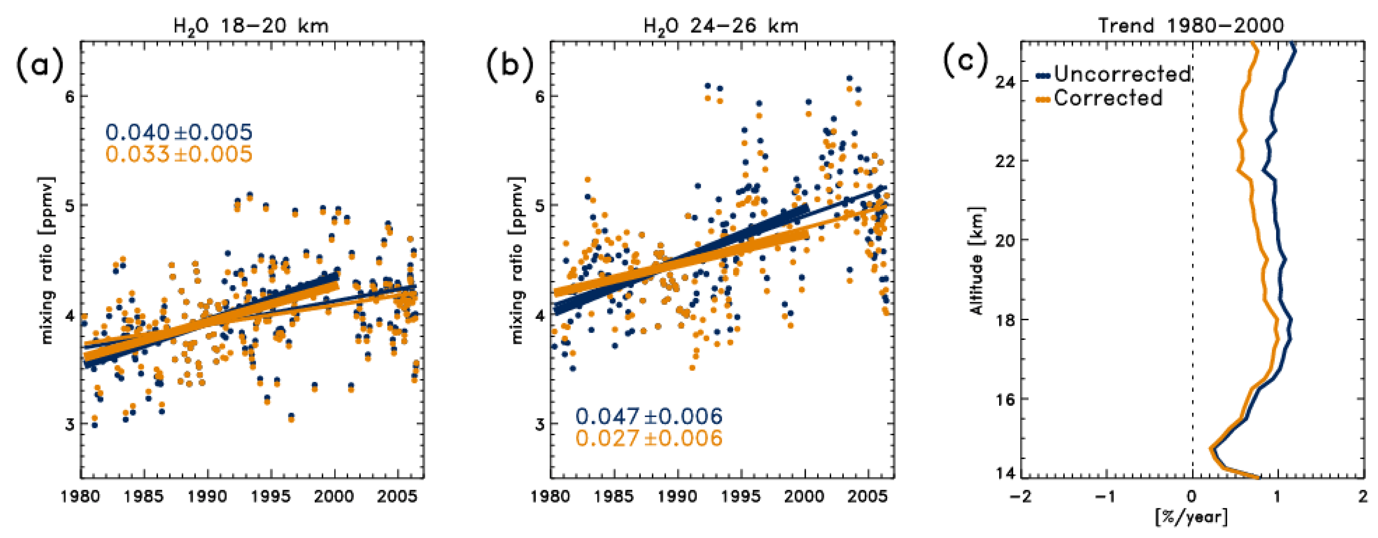


Figure 1: Linear trend estimates of stratospheric water vapor from NOAA FP measurements at (a) 18-20 km and (b) 24-26 km. Trend with altitude (c) in percent/year for the period 1980-2000 (the period covered in Oltmans et al, 2000). Blue symbols are for the uncorrected data and yellow for the corrected data.

(1)

Quality checks

- **Feedback control of the frost deposit on the mirror. Excessive oscillations in the frostpoint temperature measurement may indicate poor control (and data).**
- **Agreement between descent and ascent: Descent measurements are taken ahead of contamination sources (e.g. balloon), and should not exceed the values of ascent. Larger amounts on descent are indicative of instrument problems.**

-> flagged 44 of the 191 profiles (for digital data after 1991 at higher temporal resolution) .

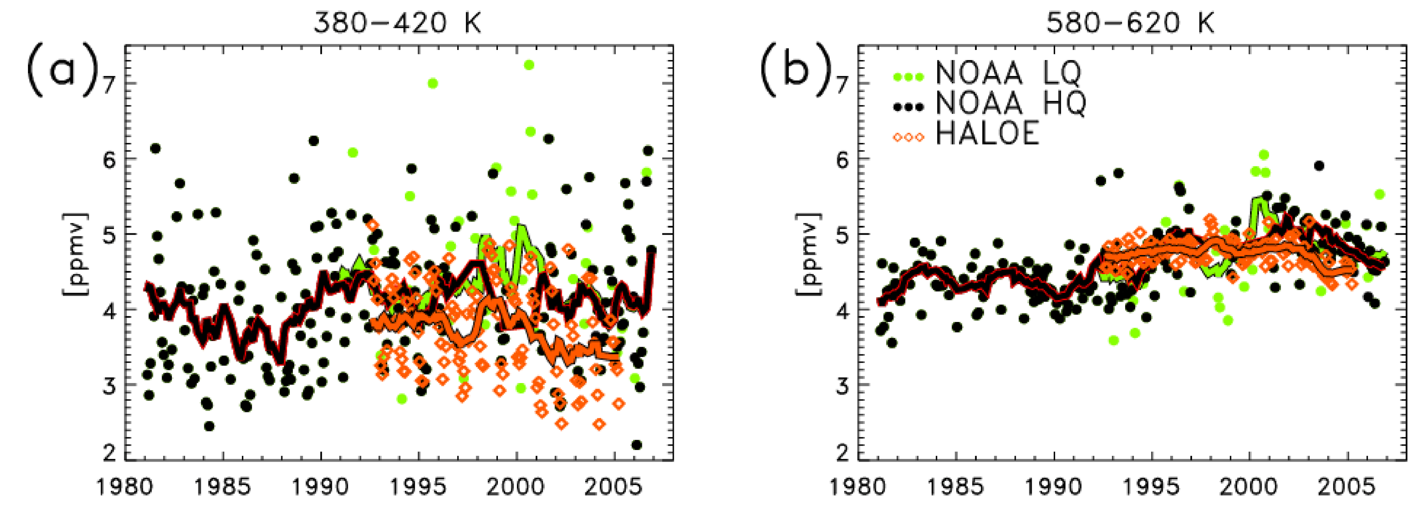


Figure 2: Water vapor averaged over two layers (~14-16 km and ~22-24 km). Black and green symbols are the higher and lower quality NOAA FP data respectively and orange symbols are for HALOE data. Solid lines are 12 month moving averages.

Generally the lower quality measurements (green dots) fall within the range of the higher quality measurements (black dots); larger differences occur around 2000. Differences to HALOE remain.

Trends

Linear trends (Fig. 3) based on NOAA FP higher quality data for 1981-2006 show trends ranging from 0.012+/-0.005 to 0.031+/-0.005 ppmv/year. For the period 1992-2005, NOAA FP trends are not significant below about 500K.
For both periods, the trends based on all NOAA FP profiles are generally higher than those based on the higher quality profiles only. In contrast to the NOAA FP data, HALOE data suggest negative trends that peak at 420 K with −0.04±0.02 ppmv/yr, but the tendency towards more positive trends with height is similar to that found in the NOAA FP data.

(2)

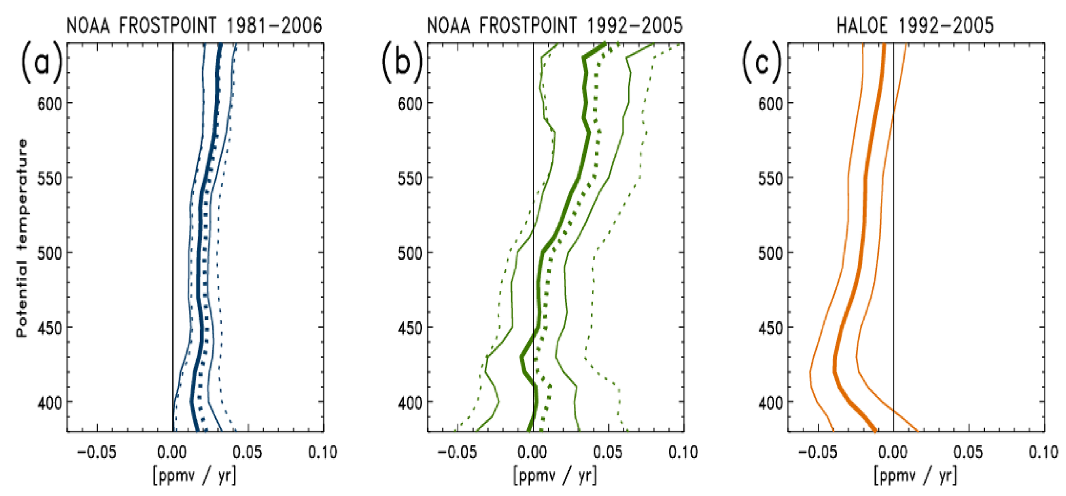
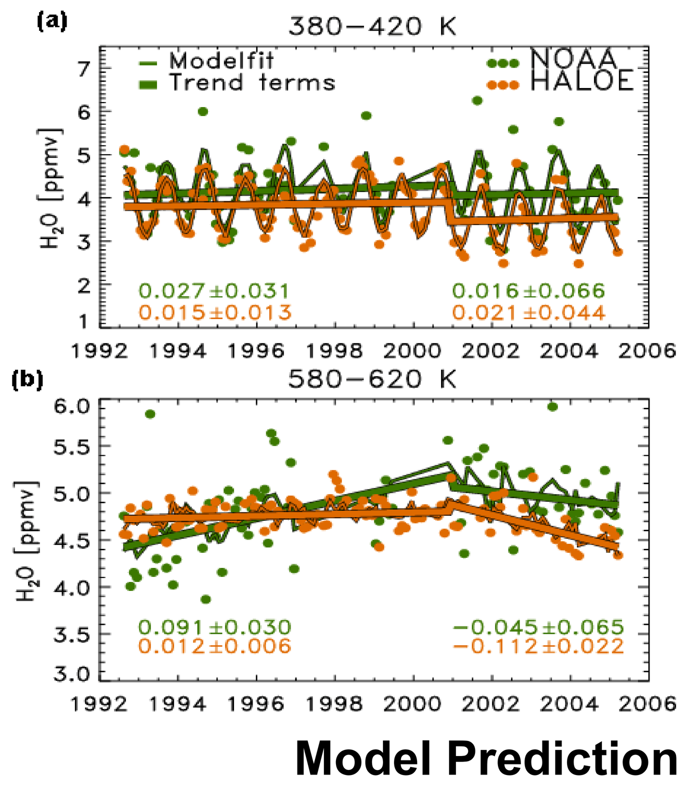


Figure 3: Trends (thick lines) with the 2ó confidence intervals (thin lines) for (a) NOAA 1981-2006, (b) NOAA 1992-2005, and (c) HALOE 1992-2005. The solid lines in (a) and (b) are for the higher quality soundings, the dotted lines for all soundings.



Decrease in 2001

We calculated trends with a statistical model that allows a discontinuity. In the layer 380-420K (Fig. 4a) small increases were seen for each period in both the NOAA FP and HALOE data. This suggests a drop rather than a continuing decrease. In the higher layer (Fig. 4b) there is a smoother decline after 2000, as expected from the broader age spectrum there.

Figure 4: Trend estimates before and after January 1, 2001. NOAA FP results are for the higher quality data subset.

Model Prediction of Water Vapor Over Boulder

Figure 5 shows predictions of water vapour over Boulder based on the model of Fueglistaler and Haynes [2005]. Generally, agreement with HALOE is better, common to both NOAA FP and HALOE is a over/under-estimation at the beginning/end of the timeseries.

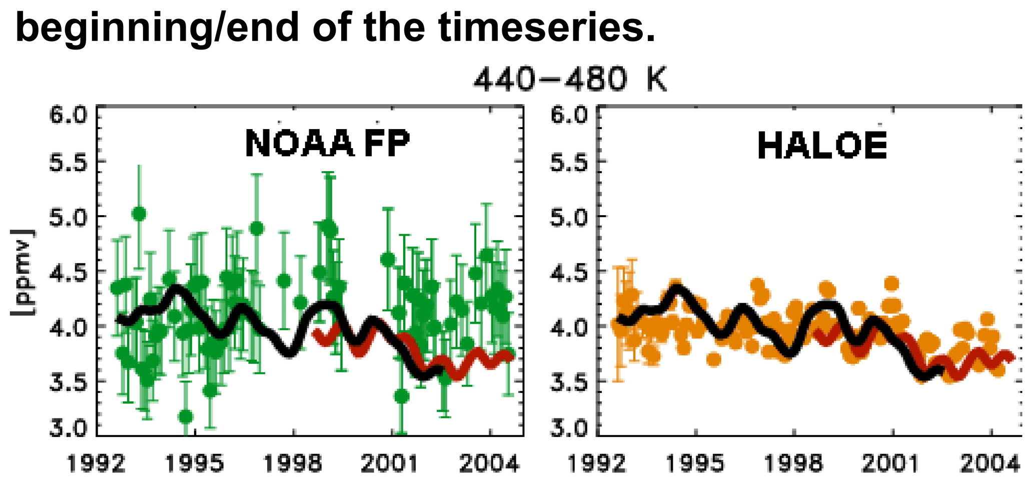


Figure 5: Observations and model compared for the 440-480 K layer. The black line uses a model tropical water vapor entry value. The red line is the HALOE measured tropical 400 K value.

(3)

Conclusions

- **The re-evaluated NOAA FP data at Boulder show smaller stratospheric water vapor increases than earlier estimates, with largest changes at the highest altitude of the balloon measurement (~25 km).**
- **The discrepancies between the HALOE measurements over Boulder and the NOAA FP series remain with the re-evaluated data set.**
- **The decrease in water vapor over Boulder in 2001 reflects a rapid drop of water entering the stratosphere, with persistently low values until 2005 (end of analysis presented here). In the altitude region where mixing ensures rapid transport from the tropics to the extratropics (I.e. up to about 450K), this drop in entry mixing ratios results in an offset, whereas higher up mixing results in a more gradual decline from 2001 onward.**
- **Model predictions based on ERA-40 data agree better with HALOE data, and appear to have a systematic trend bias. However, uncertainties in the reanalysis temperatures and transport combined with uncertainties in the observations prevent a quantitative inference about changes in water vapor entering the stratosphere in the tropics based on the mid latitude observations.**

References:

Scherer, M. et al. (2008), Trends and variability of midlatitude stratospheric water vapour deduced from the re-evaluated Boulder balloon series and HALOE, Atmos. Chem. Phys., 8, 1391-1402.
Oltmans, S.J. et al. (2000), The increase in stratospheric water vapor from balloonborne frostpoint hygrometer measurements at Washington, D.C. and Boulder, CO, Geophys. Res. Lett., 27, 3453-3456.
Randel, W.J. et al. (2006), Decreases in stratospheric water vapor after 2001: Links to changes in the tropical tropopause and the Brewer-Dobson circulation, J. Geophys. Res., 111, D12312.
Fueglistaler, S. and P.H. Haynes (2005), Control of interannual and longer-term variability of stratospheric water vapor, J. Geophys. Res., 110, D24108.

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