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Supplement of

Global OZone Chemistry And Related trace gas Data records for the Stratosphere (GOZCARDS): methodology and sample results with a focus on HCl, H_2O, and O_3

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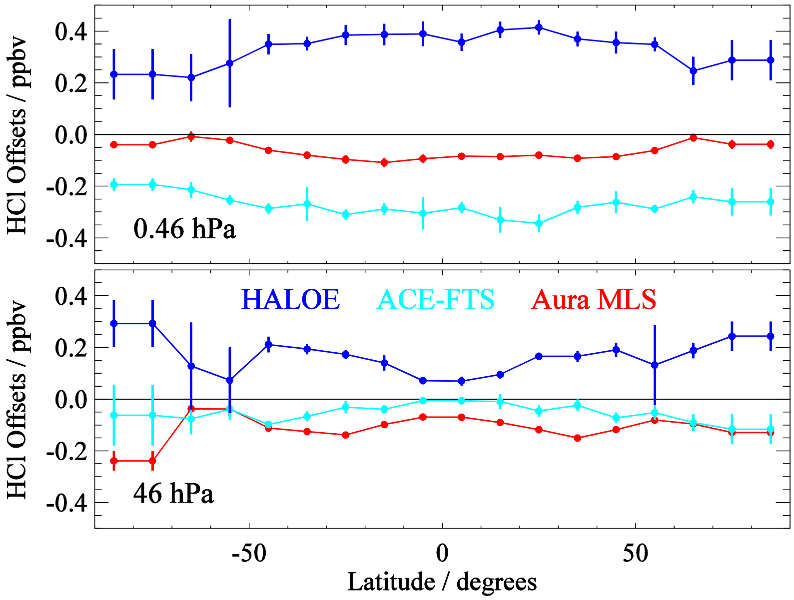

Fig. S1: Illustration of the latitudinal dependence of the HCl offsets for HALOE, ACE-FTS, and Aura MLS at two pressure levels (top panel for 0.46 hPa, bottom panel for 46 hPa). Error bars represent twice the standard error in the derived offsets (based on variability during the overlapping period). Larger standard error values indicate that there were either fewer points of overlap or larger offset variability (standard deviations); we found that both of these factors contribute.

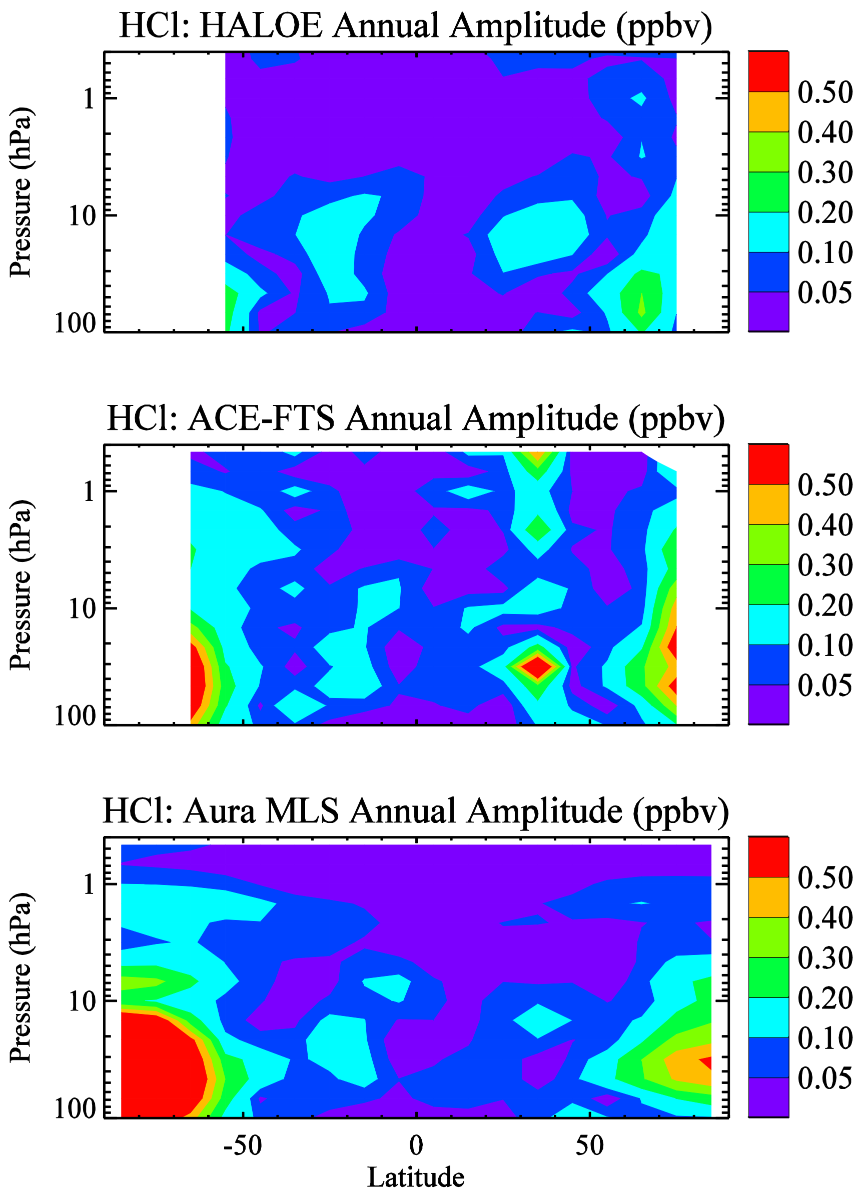

Fig. S2: Latitude/pressure contours of the fitted mean annual amplitudes (ppbv) from HCl time series for HALOE, ACE-FTS, and Aura MLS, based on their respective measurement periods (see text).

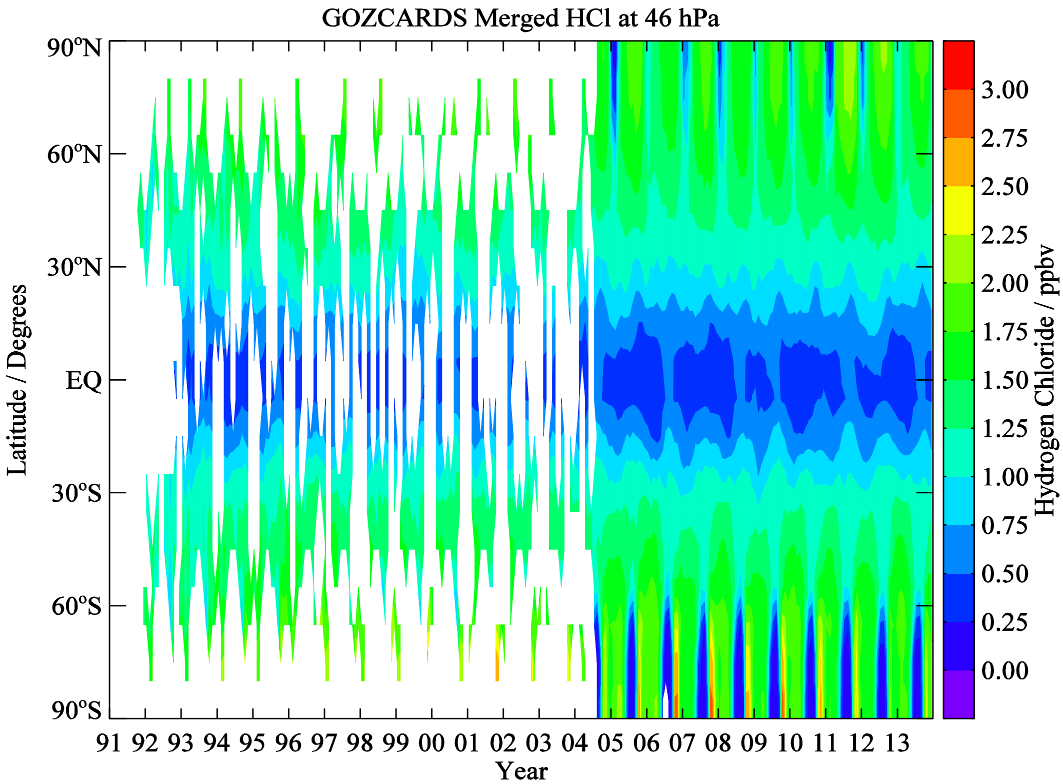

Fig. S3: Time evolution (Oct. 1991 through 2013) versus latitude of GOZCARDS merged HCl (ppbv) at 46 hPa.

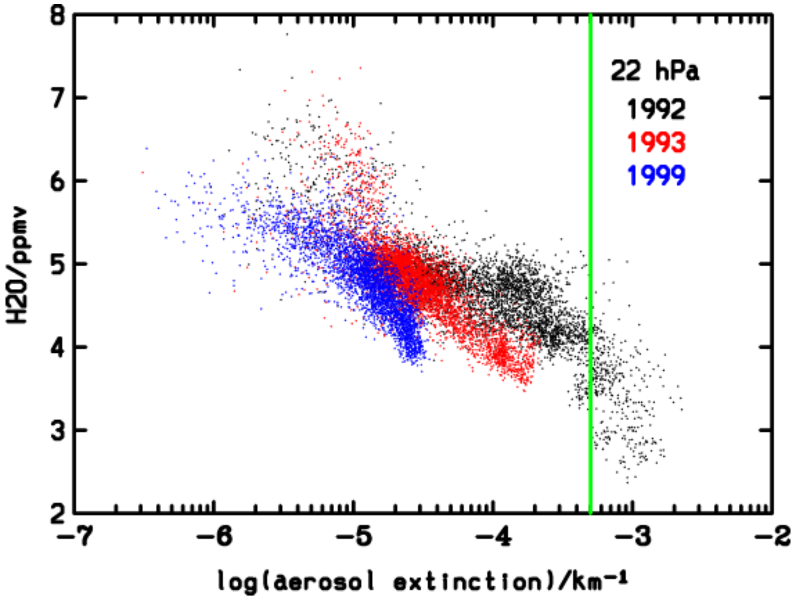

Fig. S4: HALOE sunrise measurements of H_2O versus the 3.46 µm extinction coefficient for 1992, 1993, and 1999 at 22 hPa. The green vertical line represents the aerosol extinction value ($5x10^{-4}$ km^{-1}) used to screen anomalous HALOE H_2O values. It is apparent that anomalously low H_2O values occurred in 1992 when the 3.46 µm aerosol extinction exceeded about $5x10^{-4}$ km^{-1}. These artifacts were confined to 1991 and 1992; for these years, and for pressure levels at and below 22 hPa, the corresponding H_2O data values were excluded. This screening method eliminates about 10% of the global (lower stratospheric) measurements in 1992.

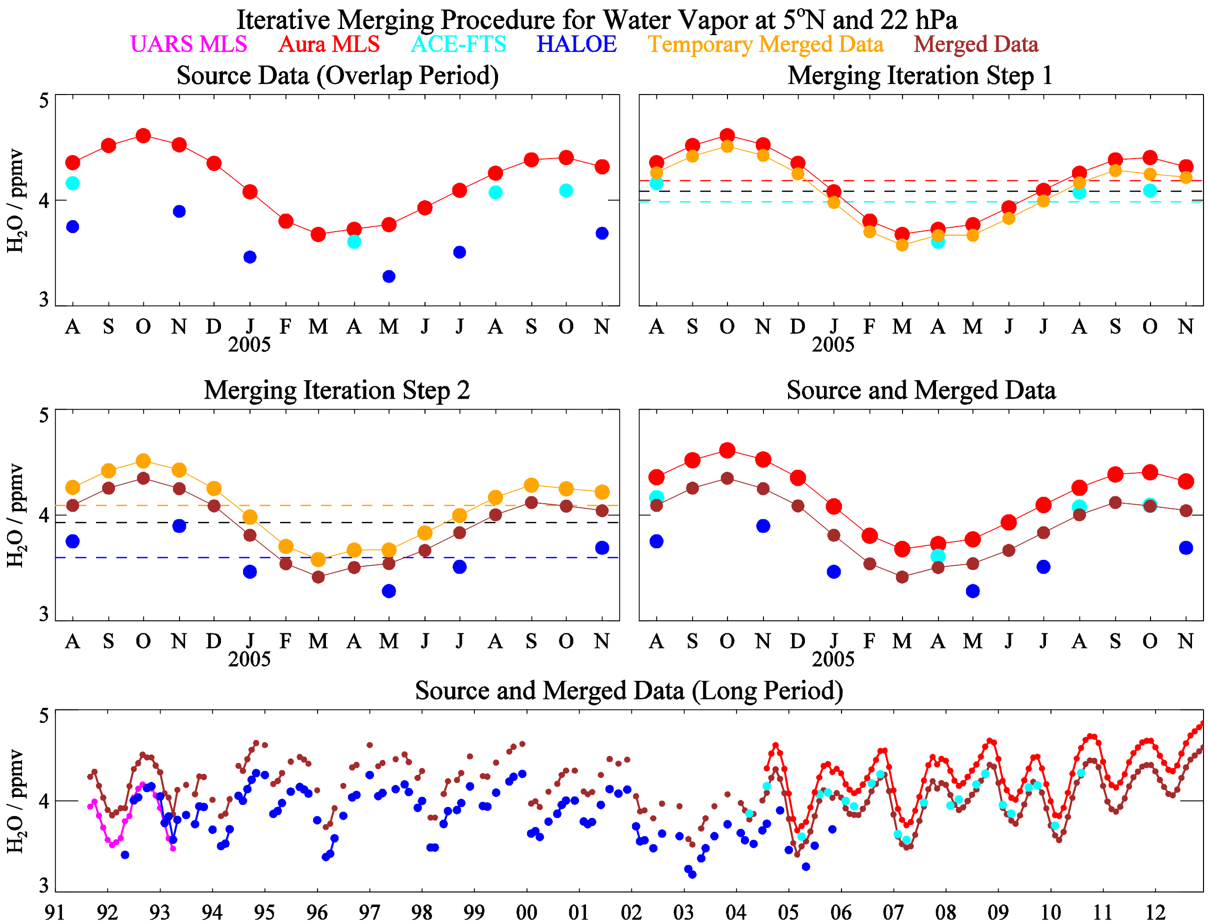

Fig. S5: Merging procedure illustration for H_2O at 5°N and 22hPa. This is similar to Fig. 2 (for HCl), but an additional step is illustrated for the end of this procedure, whereby stratospheric H_2O data from UARS MLS are adjusted to the early portion of the merged time series that was obtained after the 2nd step; this adds more coverage (more brown dots in the bottom panel for 1991-1993).

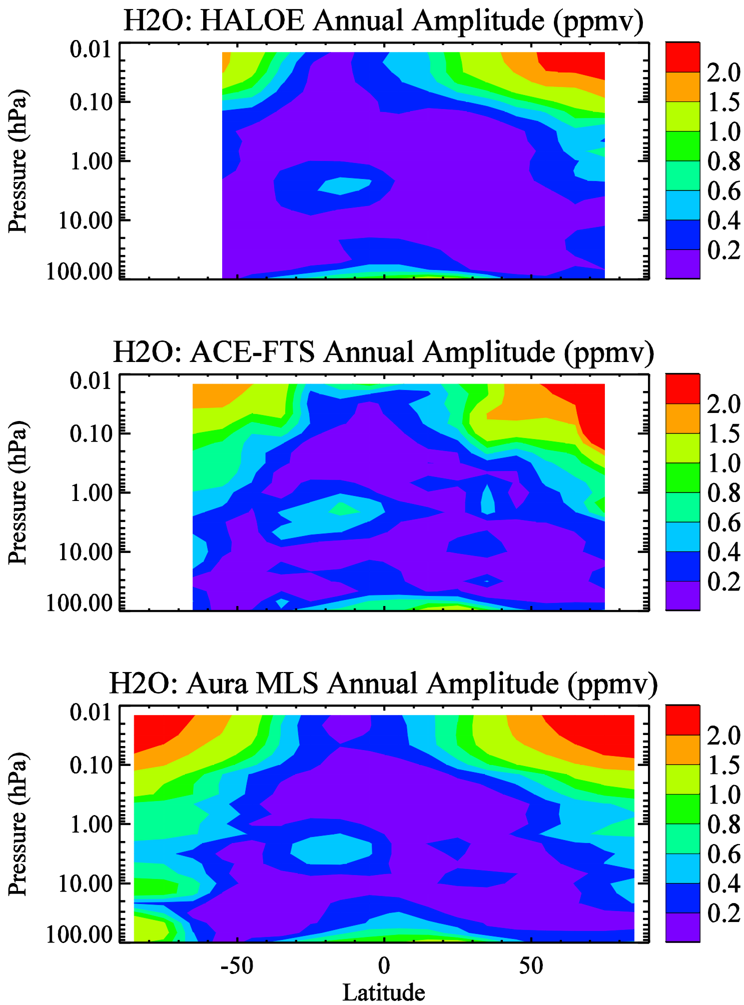

Fig. S6: Latitude/pressure contours of the fitted mean annual amplitudes (ppmv) from H_2O time series for HALOE, ACE-FTS, and Aura MLS, based on their respective measurement periods.

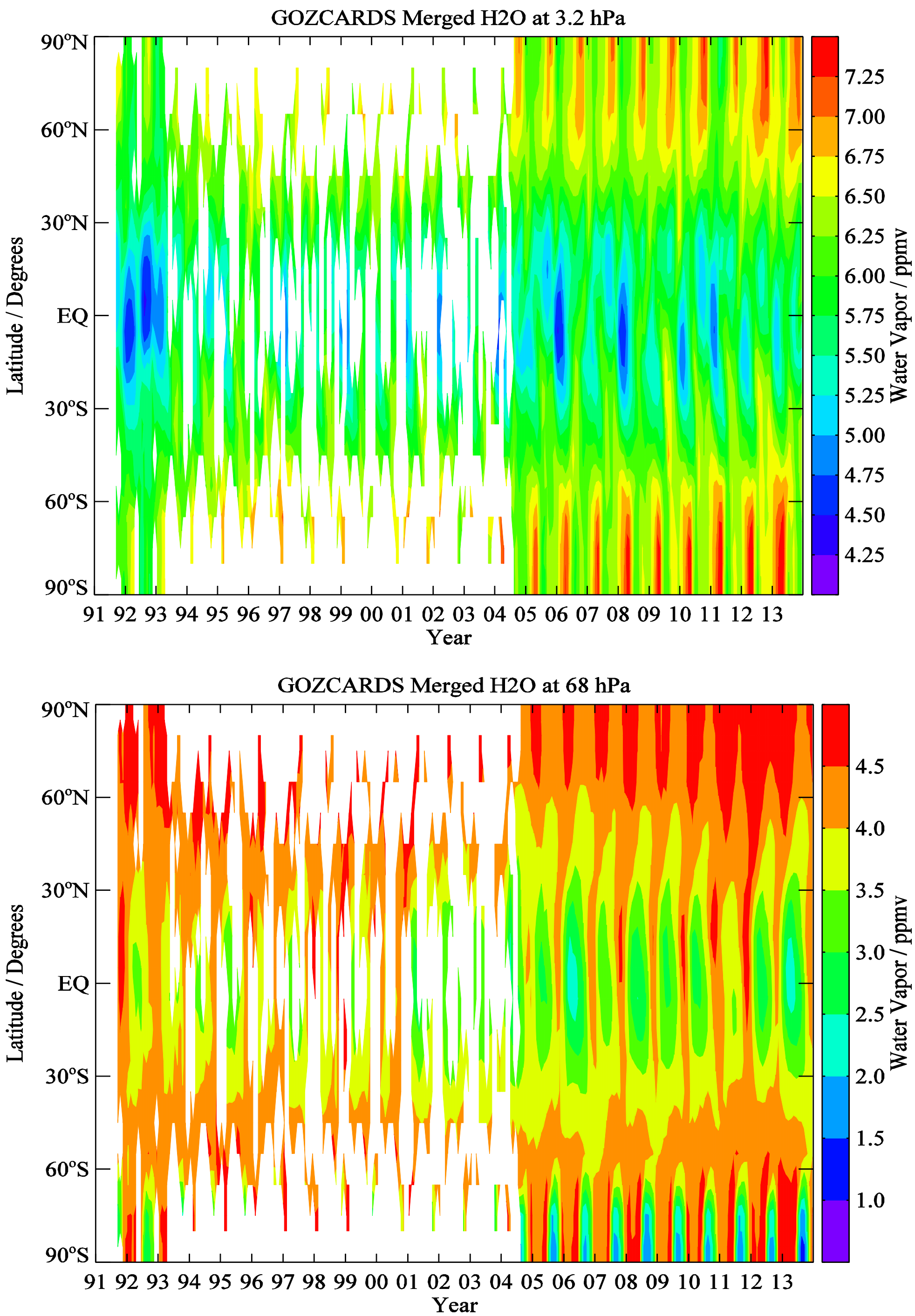

Fig. S7: Time evolution (Oct. 1991 through 2013) versus latitude of GOZCARDS merged H_2O (ppmv) at 3.2 hPa (top panel) and 68 hPa (bottom panel).

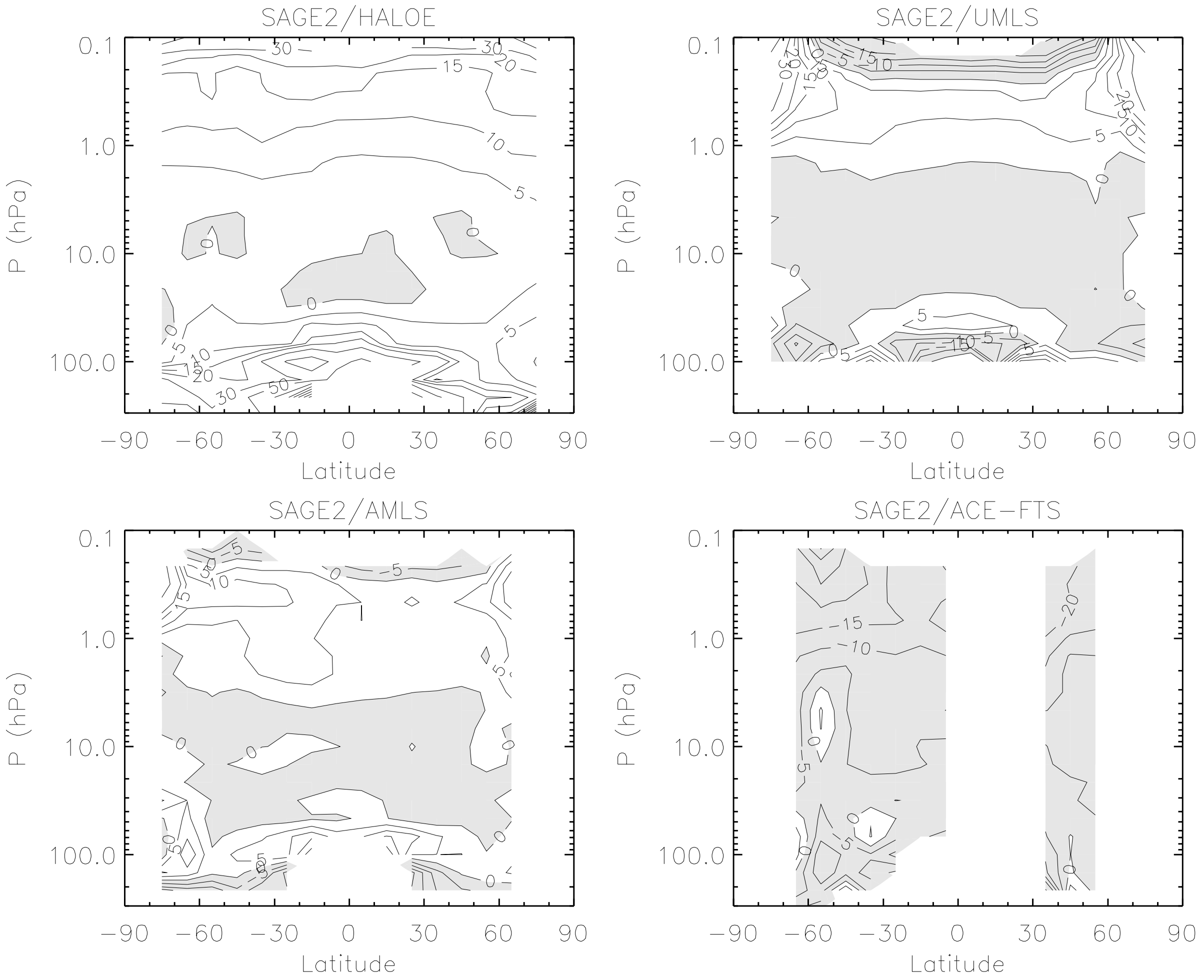

Fig. S8: Monthly zonal mean ozone differences (%) between SAGE II and (a) HALOE, (b) UARS MLS (UMLS for short), (c) Aura MLS (AMLS for short), and (d) ACE-FTS during their respective overlap periods. Differences are expressed (in percent) as 100 x [(SAGE II - Other) / (Other)]. Shaded areas indicate negative values.

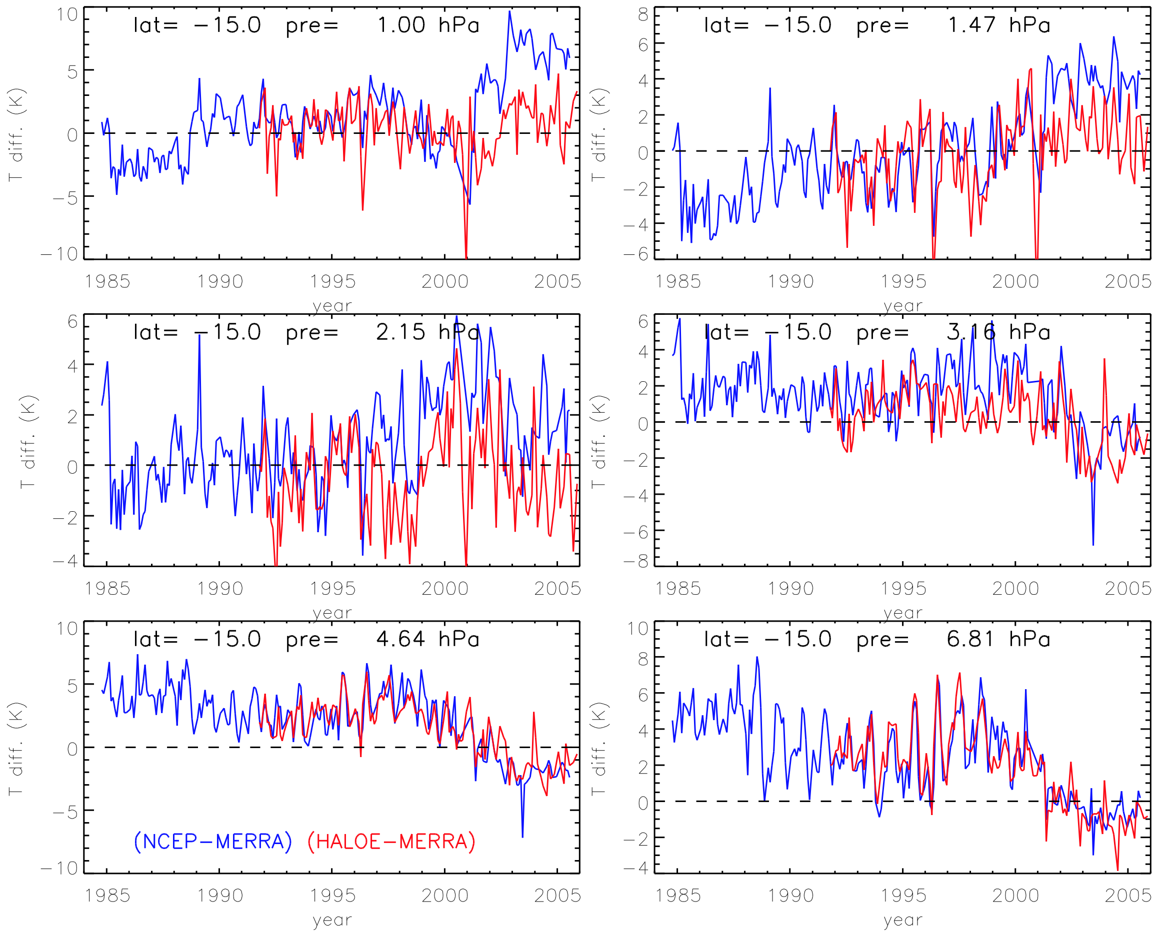

Fig. S9: Monthly zonal mean temperature differences between NCEP (used by SAGE II) and HALOE temperatures relative to MERRA for 10°S - 20°S between 1 and 6.8 hPa, per color-coding indicated in bottom left panel; ‘‘pre‘‘ represents the pressure value. From 1 to 2.1 hPa, differences between NCEP and MERRA are generally within ± 4K before mid-2000. After that time, NCEP temperatures show a sharp increase and are systematically higher than MERRA values by 5 to 10K. However, this divergence and trend are not seen in HALOE temperatures. NCEP temperatures between 3.2 and 6.8 hPa are smaller than MERRA after mid-2000; negative trends (versus MERRA) also occur in the HALOE data at these levels.

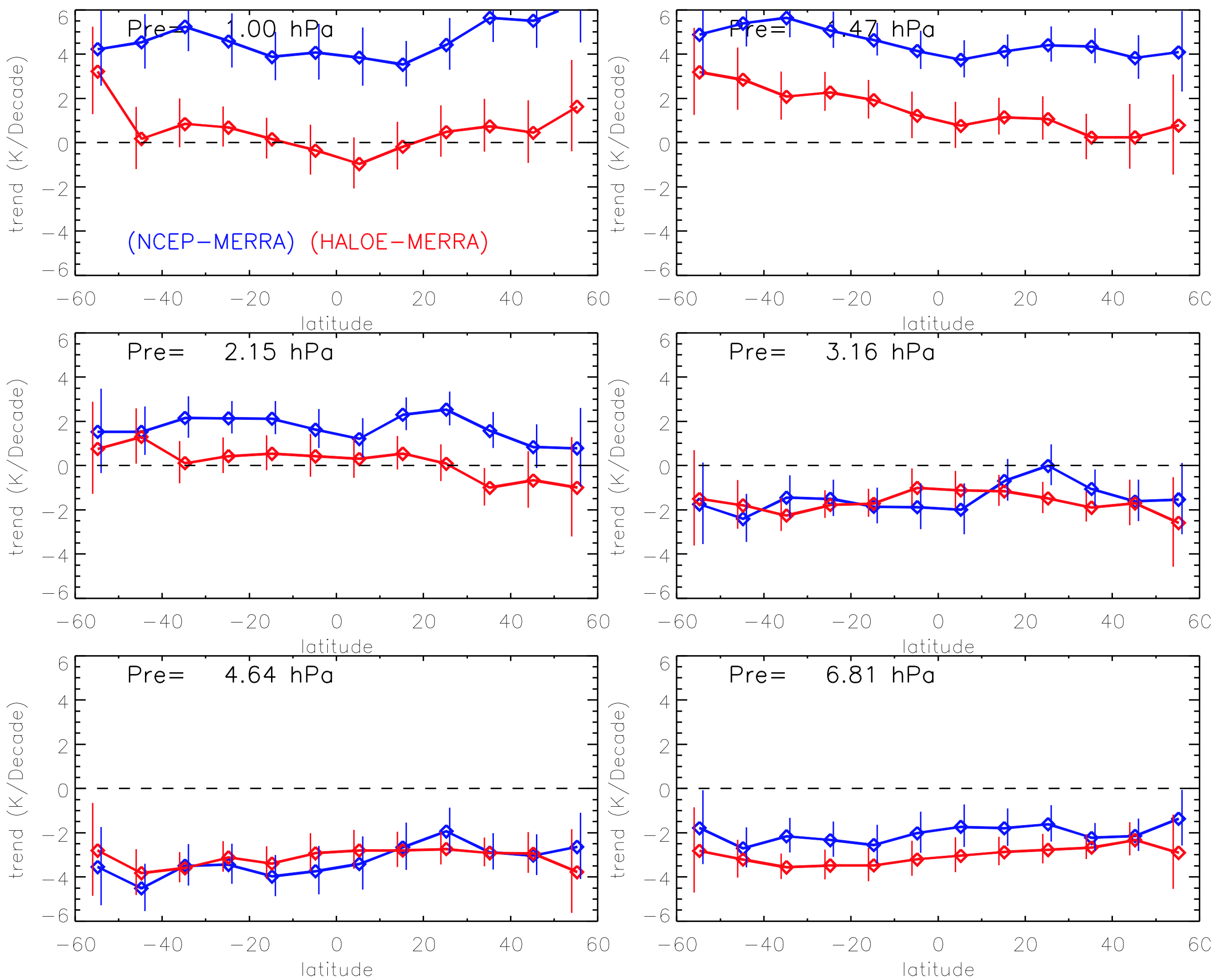

Fig. S10: Relative trends (K/decade) in zonal mean temperature differences for NCEP – MERRA and HALOE – MERRA (color-coded as in Fig. S9) in the upper stratosphere. NCEP temperatures show positive trends versus MERRA of ~2-5 K/decade between 2.1 and 1 hPa for all latitudes. However, HALOE temperatures show no significant trends versus MERRA, except at 1.5 hPa in the southern hemisphere. For pressures between 3.2 and 6.8 hPa, the temperature analyses are not conclusive; although NCEP values show negative trends of ~2-3 K/decade versus MERRA, they agree with HALOE.

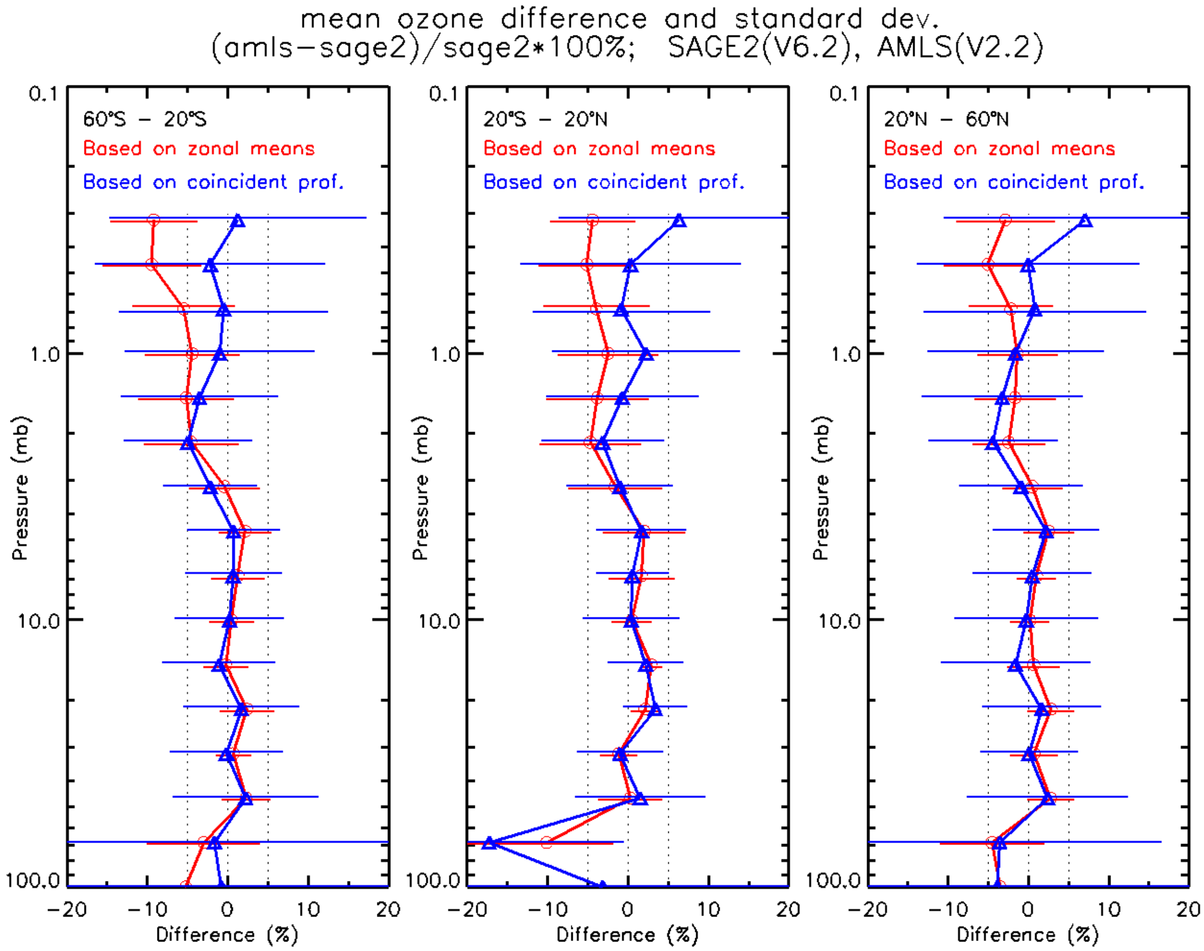

Fig. S11: Mean differences and standard deviations (horizontal bars) between SAGE II and Aura MLS ozone in three different latitude bins: 20°S to 60°S (left panel), 20°S to 20°N (middle panel), and 20°N to 60°N (right panel). Results based on monthly zonal mean and coincident profiles (see text for coincidence criteria) during overlap periods are shown in red and blue, respectively. To choose collocated profiles, coincidence criteria of ±1° in latitude and ±8° in longitude were used; the time difference criterion was chosen as 12 hours, but only nighttime measurements from Aura MLS were used.

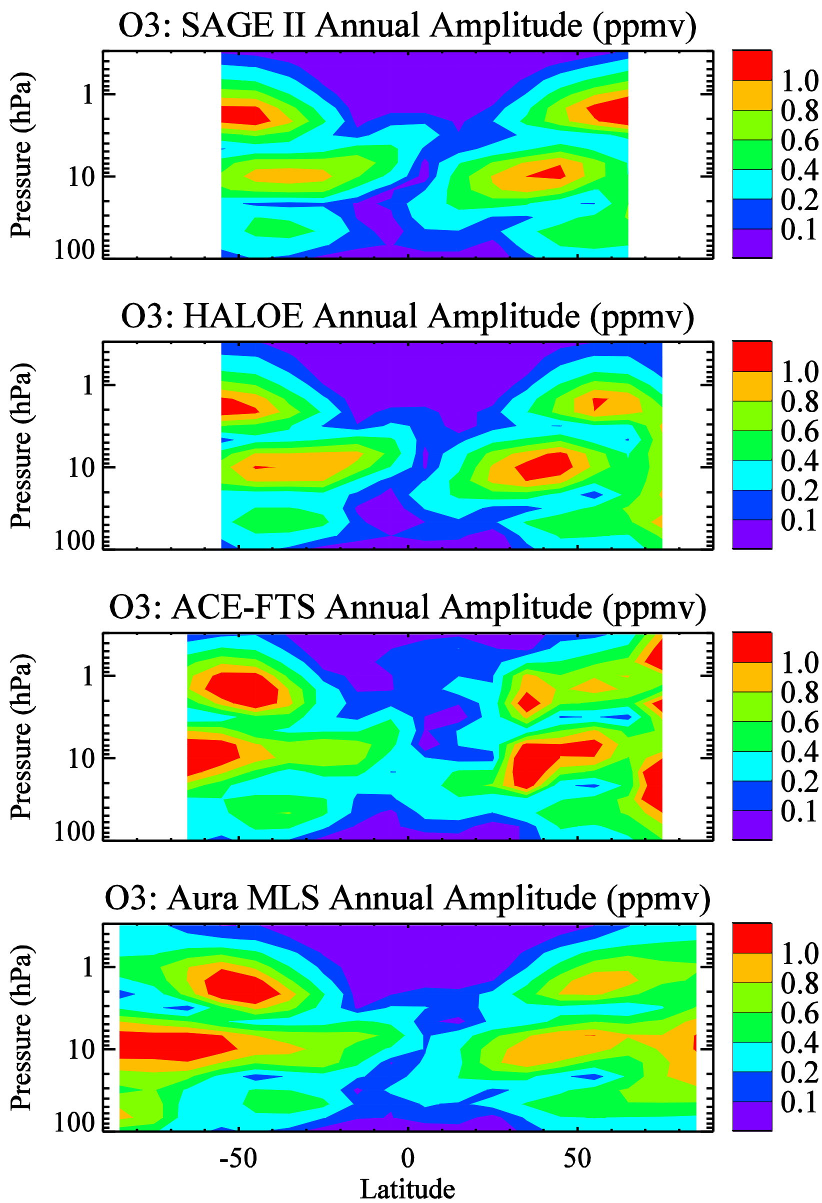

Fig. S12: Latitude/pressure contours of the fitted mean annual amplitudes (ppmv) from O_3 time series for SAGE II, HALOE, ACE-FTS, and Aura MLS, based on their respective measurement periods.

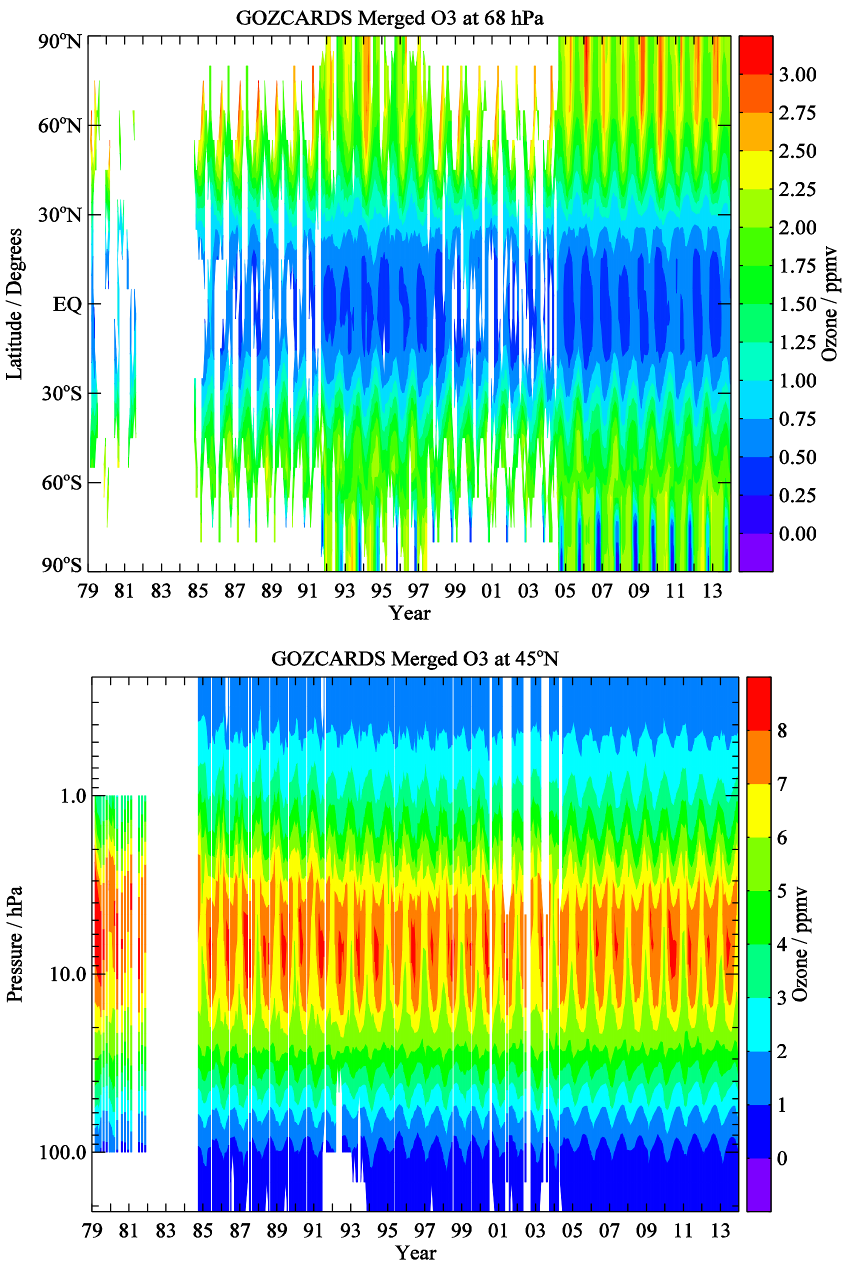

Fig. S13: Illustration of the time evolution of the GOZCARDS merged O_3 data field versus latitude at 68 hPa (top panel) and versus pressure for the 40°N-50°N latitude bin (bottom panel).

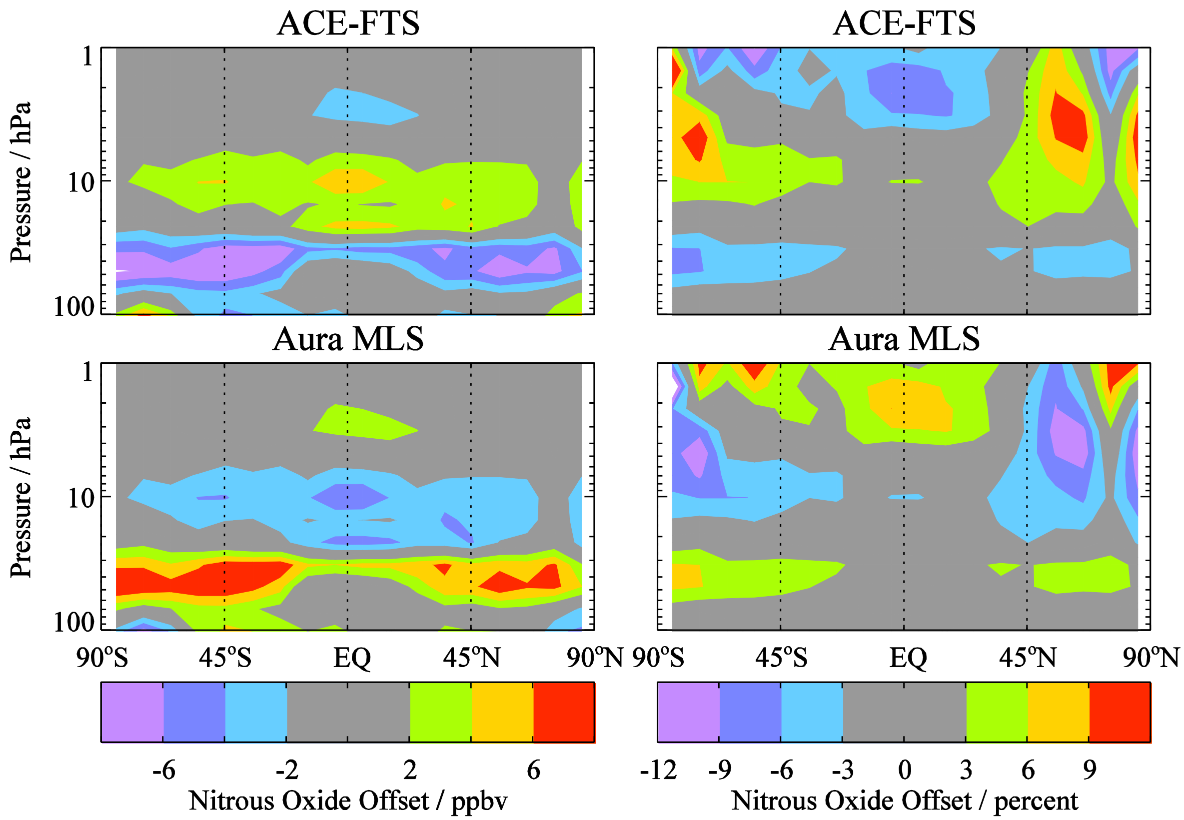

Fig. S14: Offsets applied to the N_2O source datasets (top panels for ACE-FTS, bottom panels for Aura MLS) as a function of latitude and pressure. The left column gives offsets in ppbv and the right column provides offsets as a percent of the zonal average merged mixing ratios during the overlap period (Aug. 2004 – Sep. 2010) used here to compute the average offsets.

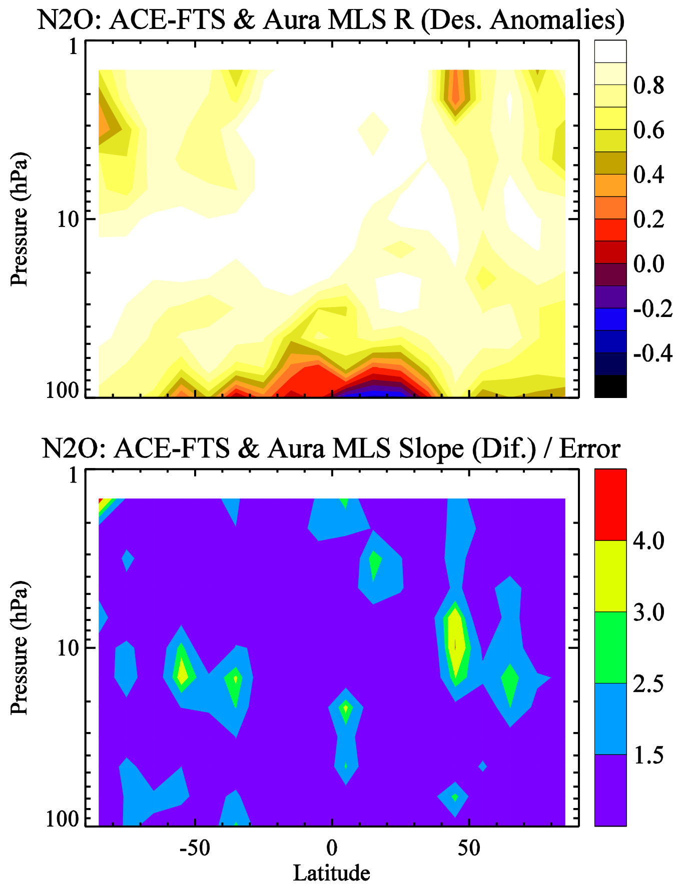

Fig. S15: Latitude/pressure contours of time series diagnostics derived from Aura MLS and ACE-FTS N_2O data comparisons (and obtained from analyses similar to those illustrated in Fig. 6 for HCl). Top panel: Correlation coefficient for the deseasonalized time series. Bottom panel: Ratio of the slope of the difference between deseasonalized series over the error in this slope.

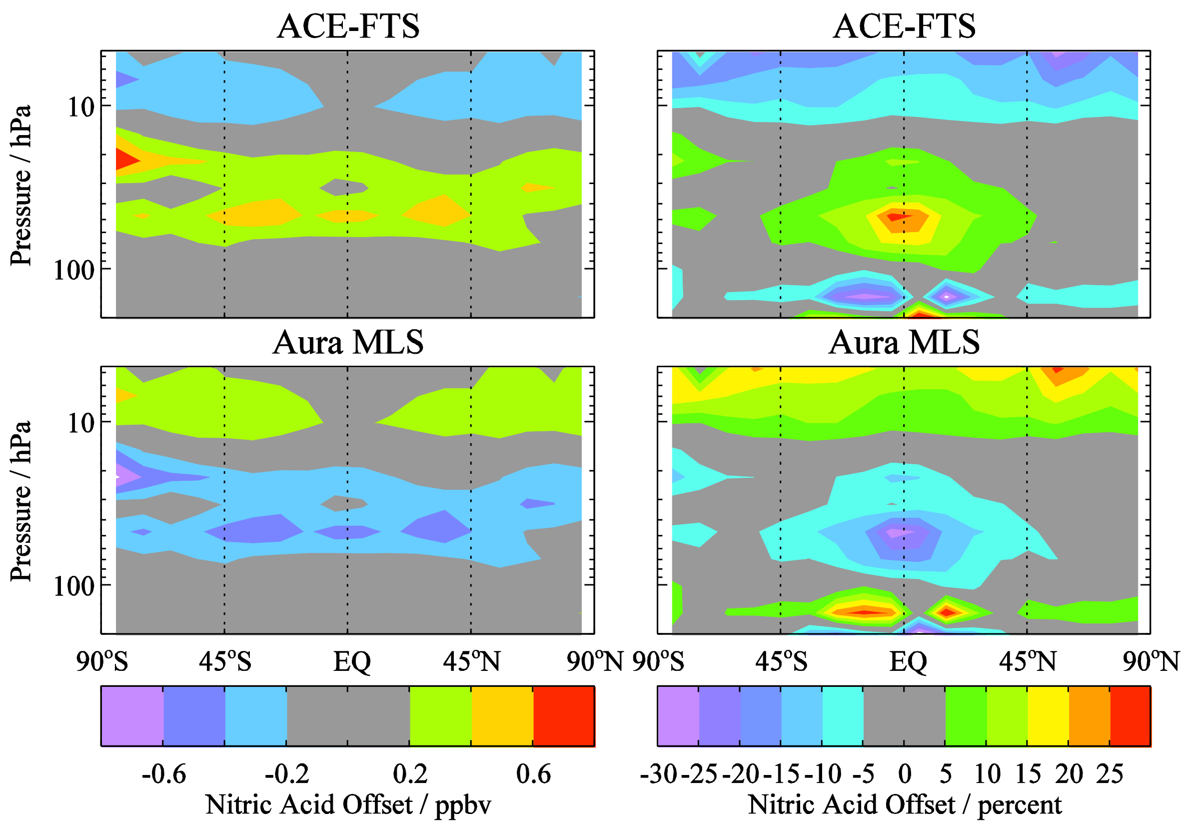

Fig. S16: Offsets applied to the HNO_3 source datasets (top panels for ACE-FTS, bottom panels for Aura MLS) as a function of latitude and pressure. The left column gives offsets in ppbv and the right column provides offsets as a percent of the zonal average merged mixing ratios during the overlap period (Aug. 2004 – Sep. 2010) used here to compute the average offsets.

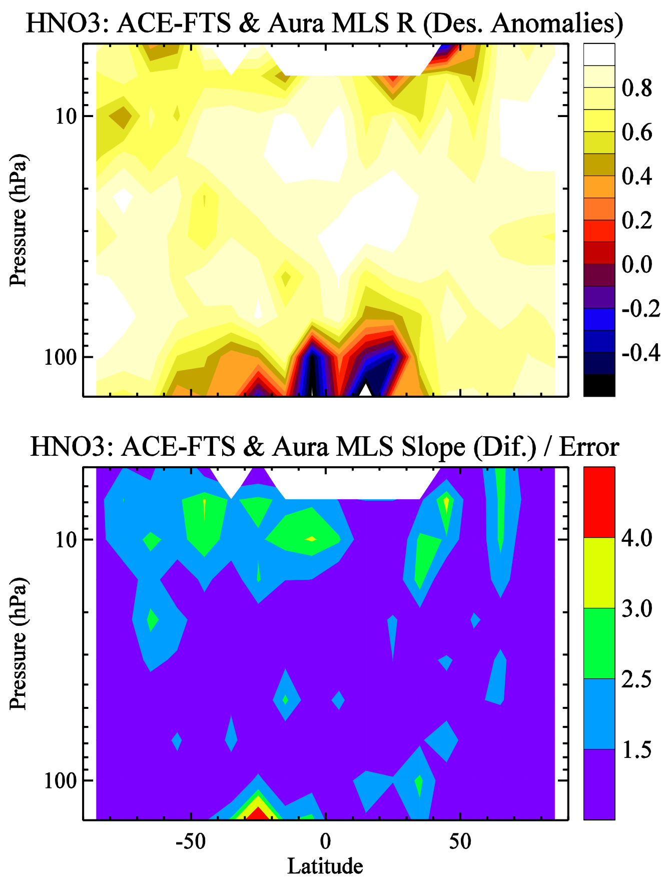

Fig. S17: Latitude/pressure contours of time series diagnostics derived from Aura MLS and ACE-FTS HNO_3 data comparisons (and obtained from analyses similar to those illustrated in Fig. 6 for HCl). Top panel: Correlation coefficient for the deseasonalized time series. Bottom panel: Ratio of the slope of the difference between deseasonalized series over the error in this slope.