SI-traceable validation of a balloon-borne spectrometer for water vapor measurements in the upper atmosphere

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Supplementary material
Figure S1: Absolute frequency scale determination. Top: measured normalized spectrum recorded using pure N$_2$O with 260 ppm H$_2$O content. The two neighboring N$_2$O transitions were used for the frequency scale determination. The measured position of each line along with their tabulated values in the HITRAN2020 database, as well as their differences, are listed in the inset table. Bottom, left panel: normalized Ge-etalon transmission spectrum as function of sampling points. The solid circles indicate the etalon fringe positions. Bottom, right panel: laser tuning curve (i.e., free spectral range (FSR) index vs. etalon fringe position index). The FSR value (0.02429 cm$^{-1}$) was first estimated using the definition $FSR = 1/(2n(\lambda , T)L)$, where $n(\lambda , T)$ is the refractive index and $L (= 2$ in) is the length of the Ge-etalon, followed by an iterative optimization using the N$_2$O transitions.
Figure S2. Comparison of accuracy assessed using the polynomial-baseline (open circles/dashed line) and the empty-cell spectrum (solid circles/solid line) normalization approaches. The relative differences in H$_2$O amount fraction ($\Delta$H$_2$O), between the ALBA-TROSS retrievals and the reference values are shown as function of pressure and H$_2$O amount fraction (color-coded as in Figure 8).

All measurements are retrieved using the qSDVP line shape model with the molecular parameters derived by the multi-spectrum fitting (MSF) method (see Table 2). For the polynomial-baseline normalization, the laser intensity is described by a 4th order polynomial function (see e.g. Graf et al., 2021).