403 nm) and $T_{\text{anal.}} = 254.5$ K at a reference temperature of $T_{\text{Pt100}} = 255.2$ K (at 366 nm). In both cases the deviation between derived- and reference temperature is less than 1 K. This means that the analytical model needs further development, in particular, the consideration of different temperature values before it is useful for realistic temperature retrievals. For an improvement concerning the parameterization process it is foreseen to utilize several Tenti S6 line shapes calculated for different wavelengths, scattering angles and temperature- and pressure values in order to find improved values for the parameters needed to evaluate Eq. (6). In case that this approach leads not to an improvement, a new approach can be explored based on deriving the analytical model for a fixed wavelength and scattering angle, just depending on temperature and pressure.

As an alternative, an analytical RB line shape model, recently developed by Ma *et al.* [21, 22] and based on the superposition of three Voigt-functions, was shown to deliver improved performance in temperature retrieval over the three-Gaussian model, especially at pressure values larger than 1000 hPa [21]. The temperature in this V3-model are directly derived from the Brillouin shift as it is usually done with RB spectra measured in the hydrodynamic regime (e.g. in gases with pressures larger than 5 bar, liquids or solid states). However, as discussed in [21], the temperature derived from a simulated reference RB spectrum at a pressure of 1000 hPa and temperature of 292 K has an offset of 8.4% with respect to the reference value. Thus, also this V3 analytical model needs further improvement before it can be used for temperature retrievals from RB spectra at atmospheric conditions.

In case it turns out that analytical models do not deliver the desired accuracy for the temperature retrieval, a Tenti S6 line shape based look-up table might be used to end up with a faster processing time while keeping the accuracy demonstrated here.

Table 2. Overview of experimental conditions and retrieved temperature values.

T_{Pt100} (K)	T_{Tenti} (K)	$I_{\text{par,Tenti}}$ (%)	T_{Pt100}-T_{Tenti} (K)	$T_{\text{anal.}}$ (K)	$I_{\text{par,anal.}}$ (%)	T_{Pt100}-$T_{\text{anal.}}$ (K)	p (hPa)	λ (nm)
296.0	296.1	0.66	-0.1	292.5	0.68	+3.5	1005	402.987
256.6	254.7	0.41	+1.9	257.0	0.35	-0.4	880	402.995
295.5	294.6	0.41	+0.9	292.8	0.34	+2.7	1010	402.985
309.2	311.1	0.41	-1.9	305.5	0.38	+3.7	1011	402.995
330.3	328.4	0.75	+1.9	320.4	0.82	+9.9	1014	402.993
284.7	284.0	0.34	+0.7	282.6	0.41	+2.1	955	402.997
279.6	279.7	0.48	-0.1	279.7	0.43	-0.1	870	402.997
320.3	320.9	0.27	-0.6	313.9	0.24	+6.4	1013	402.996
255.2	254.9	0.34	+0.3	254.5	0.16	+0.7	643	366.840
276.8	278.6	0.34	-1.8	278.1	0.27	-1.3	703	366.840
297.2	297.6	0.48	-0.4	293.4	0.42	+3.8	726	366.650
317.7	317.0	0.41	+0.7	310.9	0.46	+6.8	776	366.650
338.2	339.1	0.55	-0.9	330.2	0.62	+8.0	826	366.650

5. Summary and conclusion

Rayleigh-Brillouin (RB) scattering measurements in air ($\lambda = 403$ nm, $T = 257$ K to 330 K, $p = 871$ hPa to 1013 hPa) were performed and used to verify the performance of two different temperature retrieval algorithms, one based on the Tenti S6 line shape model [8], and one based on an analytical model [13, 14]. Furthermore, previously performed RB measurements (air, $\lambda = 366$ nm, $T = 255$ K to 335 K, $p = 643$ hPa to 826 hPa) [11] were used for additional validation.

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With both data sets it is demonstrated that absolute temperature can be derived from RB spectra obtained in air at atmospheric conditions with high accuracy. In particular, it is shown that the accordance of the derived temperature to the reference temperature is better than 2 K in case of the Tenti S6 model-based retrieval algorithm. This outcome is of great relevance for future high spectral resolution lidar systems that might use RB spectra for deriving atmospheric temperature profiles as it was recently shown by Witschas *et al.* [23]. The retrieval based on the analytical model leads to discrepancies between retrieved- and reference temperature of up to 9.9 K and is thus not useful at its present stage. It is discussed that these discrepancies are explained by a poor temperature-parameterization within the model which has to be improved for successful future use.

The present high-quality experimental data demonstrate that temperatures can be retrieved from RB line shapes at an accuracy of 2 K. It is worth mentioning that this accuracy is depending on the instrument resolution and signal-to-noise ratio of the measured RB spectra. Thus, this has to be considered when estimating the accuracy for realistic atmospheric lidar measurements. Also the effect of aerosol scattering will be decisive under real atmosphere conditions.

While the present study has shown that the Tenti S6 model best describes the line shapes in RB-scattering, future studies should reveal how accurate temperature retrieval procedures can become for certain values of resolution, signal-to-noise ratio and aerosol contributions.

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