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Significant sources of bias in temperature measurements by rotational Raman lidar, and mitigation in the French mobile system WALI

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Lidars using rotational Raman backscattering to monitor the temperature profile in the low troposphere offer enticing perspectives for applications in weather prediction, as well as studies of aerosol and water vapor interactions, when deriving simultaneously relative humidity and aerosol optical properties. We describe the technical choices made during the design and calibration of the new temperature Raman channels for the mobile Weather and Aerosol Lidar (WALI), going over the sources of bias and uncertainty stemming from the different optical elements of the instrument. The impacts of interference filters and non-common-path differences between Raman channels, and their mitigation, are particularly investigated; without countermeasures, we find the theoretical magnitude of the highlighted biases can be much larger than the targeted absolute accuracy of 1°C defined by the World Meteorological Organization (WMO). Effective measurement errors are quantified using numerical end-to-end simulations and numerous radiosoundings launched close to the lidar location. Our aim is to fully discuss design choices and sources of bias which have been little reported in the literature. An application of the WALI measurements during heat wave conditions in the summer of 2020 will also be presented, and compared to ERA5 weather model reanalyses.