File Revision Date:
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Data Set Description:

PI:	Dr. Giovanni Martucci
Instrument:	RAman Lidar for Meteorological Observations (RALMO)
Site(s):	Payerne
Measurement Quantities:	Water Vapour mixing ratio Temperature relative humidity Backscatter coefficient

Contact Information:

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Reference Articles:

Martucci, G., Navas-Guzman, F., Renaud, L., Romanens, G., Gamage, S. M., Hervo, M., Jeannet, P., and Haefele, A.: Validation of temperature data from the RAman Lidar for Meteorological Observations (RALMO) at Payerne. An application to liquid cloud supersaturation, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2020-289, in review, 2020.

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Sica, R. J. and A. Haefele, (2016). Retrieval of water vapor mixing ratio from a multiple channel Raman-scatter lidar using an optimal estimation method, Appl. Opt., 55(4), 763-777 doi:10.1364/AO.55.000763.

Sica, R. J. and A. Haefele, (2015). Retrieval of temperature from a multiple-channel Rayleigh-scatter lidar using an optimal estimation method, Appl. Opt.54(8), 1872-1889, doi:10.1364/AO.54.001872.

Dinoev, T., Simeonov, V., Arshinov, Y., Bobrovnikov, S., Ristori, P., Calpini, B., Parlange, M., and van den Bergh, H.: Raman Lidar for Meteorological Observations, RALMO – Part 1: Instrument description, Atmos. Meas. Tech., 6, 1329–1346, https://doi.org/10.5194/amt-6-1329-2013, 2013.

Brocard, E., Philipona, R., Haefele, A., Romanens, G., Mueller, A., Ruffieux, D., Simeonov, V., and Calpini, B.: Raman Lidar for Meteorological Observations, RALMO – Part 2: Validation of water vapor measurements, Atmos. Meas. Tech., 6, 1347–1358, https://doi.org/10.5194/amt-6-1347-2013, 2013.

<u>Instrument Description:</u>
RALMO was installed at the MeteoSwiss station of Payerne (46Â°480 N, 6°560 E, 491 m a.s.l.) in 2007, it was designed and built by the école Polytechnique Fédérale de Lausanne (EPFL) in collaboration with MeteoSwiss. RALMO provides continuous measurements of humidity, temperature and aerosol backscatter in the troposphere and lower stratosphere almost uninterruptedly since 2008 (2011 for the temperature). RALMO has been designed to optimize the quality of the operational measurements and to maximize the signal-to-noise ratio, minimizing the contamination by solar background at all wavelengths.

RALMO uses high-power emission, narrow receiver's field of view and a narrow-band grating polychromator capable to isolate the ro-vibrational Q-branches.

RALMO's Nd:YAG laser emits a fundamental harmonic at 1064~nm, but uses the third harmonic at 355~nm as operational wavelength, the tripled harmonic is optically directed to the LIDAR transceiver optics. A beam expander reduces the beam divergence at the instrument's output and the expanded, minimum-divergent beam is transmitted into the atmosphere. The returned signal is an envelope of the 355-nm elastic- and Raman-backscattered signals, i.e. PRR, water vapour, oxygen, nitrogen and Rayleigh.

<u>Algorithm Description:</u>
ADT- Automatic Data Treatment.
ADT releases (data processing version number):
- 1.0 1.1.2008-31.12.2013
- 2.0 1.1.2014-15.8.2015
- 3.0 16.8.2015-20.6.2018
- 4.0 21.6.2018-16.10.2019
- 5.0 17.10.2019-

WATER VAPOUR MIXING RATIO:

The Water vapour mixing ratio is calculated based on the equation:
WVMR(z)= nC(z)*PH2O(z)/PN2(z)*delta_tau(z), (Dinoev et. al, 2013)

where the signals PH2O(z) and PN2(z) are background corrected and averaged over time and range to reduce the statistical error. C(z) is the lidar calibration function and the coefficient n = 0.485 converts the obtained through lidar measurements water vapor to nitrogen number density mixing ratio to water vapor to dry-air mass mixing ratio, delta_tau(z) is the one-way differential atmospheric transmission at water vapor and nitrogen Raman wavelengths and depends on the profiles of the aerosol differential extinctions
delta_tau(z)_aer(z) = delta_tau_aer_H2O(z)âˆ’delta_tau_aer_N2(z), and
delta_tau(z)_mol(z) = delta_tau_mol_H2O(z)âˆ’delta_tau_mol_N2(z)

The molecular extinction can be calculated from atmospheric pressure and temperature profiles, measured by balloon sounding or derived from an atmospheric model (usually US Standard Atmosphere). The aerosol contribution is below 10% even for hazy conditions (Whiteman, 1992; Whiteman et al., 2001) and usually can be neglected. The aerosol extinction profiles can be obtained from Raman lidar measurements if available (Ansmann et al., 1992).

PRR TEMPERATURE

The high-quantum number, J_high, and low quantum number, J_low, Raman-shifted signals in the Stokes and anti-stokes Q-branches depend on the temperature of the probed atmospheric volume. The ratio of the intensities of the PRR signals J_low and J_high is a function of the atmospheric temperature T at distance z.

dT/dQ ~=(T2-T1)/(Q(T2)-Q(T1)).

Q(z) = J_low(z)/J_high(z).

Based on the method described by Behrendt (2005) the uncertainty of the rotational Raman temperature can be approximated by at two different temperatures. Based on the calculations shown by Behrendt (2005) and for systems that detect only one PRR line in each channel (J_low and J_high), the relationship between T and Q, the ratio of J_low and J_high, takes the simple form of ,

T~=A/(B+log(Q)).

where the approximation symbol indicates that the detection system detects more than one PRR line. The calibration coefficients A and B are a-priori undetermined and can be determined by calibration of the LIDAR using a reference radiosounding system. By performing a linear fit using the simple model y=A/(x+B), where x is the ratio Q and y is the reference temperature provided by the radiosounding along the troposphere, the coefficients A and B can be calculated.

[LIDAR: Include information on unit conversion if pressure or mixing ratios appear in the data file.]

Expected Precision/Accuracy of Instrument:
Water Vapour: within 5 to 10% of radiosonde values up to 8 km at night, and within 3% up to 3 km during the day.

Temperature: ~0.1K bias and 0.5 K stdv in the first 10 km at night, and 0.2 K bias and 0.6K in the first 5 km at daytime.

Instrument History:

2007:	installation
2008:	start measurements of water vapour
2011:	start temperature and aerosol measurements
2015:	change of acquisition system for temperature J_low and J_high channels, from Licel to FastCom
2018:	change of laser source, from Excel to Litron
2020/2021:	implementation of depolarization channel.