A Biaxial Rayleigh- and Raman-LIDAR System for Application in Atmospheric Sounding and SLR

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ABSTRACT

Precise orbit determinations in SLR and LLR require corrections for the contribution of the atmosphere to the effective index of refraction. Despite the fact that the range measurements are obtained consistently, there is a discrepancy of approximately 4 cm reported in the comparison between optical and microwave based range measurements for the same GPS satellite target. As a conclusion from earlier work, the knowledge of the water vapor content of the atmosphere at least for some selections of the operation wavelength seems important.[1] To overcome the lack of sensitivity for the measurement of water vapor profiles in the Earth's troposphere by means of remote sensing a biaxial Rayleigh- and Raman-LIDAR has been set up on the Fundamentalstation Wettzell, making use of the still existing equipment of a former SLR facility. By operating the station as a Rayleigh-LIDAR its geometrical characteristics and the overall sensitivity of this setup as a LIDAR system could be established and optimised. Observations in the spectral range of 607±0.5 nm and 660±0.5 nm are probing the troposphere for nitrogen and water molecules. By combining this information water vapor profiles of the lower troposphere were obtained.

Keywords: Rayleigh-LIDAR, Raman-LIDAR, refractive index, satellite laser ranging

1. DISCUSSION

For a number of profiles of the water vapor concentration in the lower troposphere we have generally obtained a good agreement between the relative humidity measurement at the laser ranging facility and our LIDAR measurements. However at larger heights above the facility we usually find substantial discrepancies between the water vapor contents prediction of the Marrini-Murray model and our measured profiles. For the shown sample plot the concentration of water vapor was overestimated, while in other cases we found considerable underestimations as well as cases of reasonable agreement. Essentially this is in good agreement with the results of our earlier reported simultaneous range measurements[3] at a wavelength of 0.532 μm and 1.064 μm. Unfortunately there are no simultaneous observations of dual color ranging and our LIDAR available. This comparison remains to be done.

Over a number of such water vapor profiles we have noted an inherent shortcoming of the use of meteorological stations on the ground. Quite often there is a big difference in the concentration of the water vapor in the planetary boundary layer compared to the rest of the lower troposphere. This means that the value for the relative humidity at the ground normally is not a representative starting value for a model function of the tropospheric distribution of the water vapor. In one of the measurements which was taken towards the end of the night, we note in comparison to earlier measurements of the same night that the concentration of the water vapor reduces everywhere in the lower troposphere, while in the boundary layer the concentration increases by more than 20% at the same time.

2. CONCLUSIONS

We have converted an old laser ranging instrument into an atmospheric sounding LIDAR in order to measure the tropospheric water vapor content. For emission and reception of the frequency doubled laser pulses a biaxial telescope system was used. The elastically backscattered signal provided a characterisation of the system, while the inelastic backsattering signal provided information about the temperature and the water vapor content of the lower atmosphere. Unfortunately the overall system sensitivity was not sufficient to obtain profiles of up to 5 km of range mostly because of low laser power. Despite this we have seen that the Marrini-Murray model for the correction of the

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refractive index of the atmosphere suffers from an inadequate input value for the relative humidity, since it is based on a gound measurement. Given that the assumption is correct that the refractive index for the laser wavelength of $\lambda = 1.064\mu m$ requires a better knowledge of the tropospheric water vapor content, a Raman-LIDAR can provide this additional information. In that case the system design would need some adjustments, in order to obtain the Rayleigh- and the two Raman- measuremnts at the same time. In the here presented work all the measurements were only possible at nighttime and required more than one hour to collect the data.

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