End-to-end Simulator of a space-borne Raman Lidar for the thermodynamic profiling of the atmosphere

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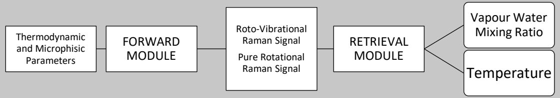
ABSTRACT

An end-to-end model has been developed in order to simulate the expected performance of a space-borne Raman Lidar, with a specific focus on the Atmospheric Thermodynamics LidAr in Space – ATLAS proposed as a “mission concept” to the ESA in the frame of the “Earth Explorer-11 Mission Ideas” Call. The numerical model includes a forward module, which simulates the lidar signals with their statistical uncertainty, and a retrieval module able to provide vertical profiles of atmospheric water vapour mixing ratio and temperature based on the analyses of the simulated signals.



$$\text{Simulated Signal: } N_\lambda(z) = \frac{E_0}{E_{phot}} \Delta z \frac{A}{z^2} \xi(\lambda) O_\lambda(z) \beta^{Ram}(z) T_{\lambda_0}(z) T_\lambda(z)$$

$$\text{Background contribution: } bg = b_{atm} + b_{surf} + b_{clouds}$$

$$\text{Shot noise: } N_\lambda^{Noise}(z) = \sum_{i=1}^{N_{shots}} N_i(z)$$

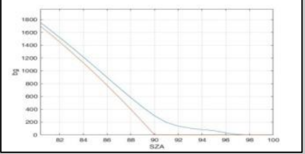
$$\chi(z) = C \frac{P_{H_2O}(z)}{P_{ref}(z)} \frac{T_{ref}(z)}{T_{H_2O}(z)}$$

$$R(z) = \frac{P_{HiJ}(z)}{P_{LoJ}(z)}$$

$$T(z) = \frac{a}{\ln(R(z)) - b}$$

$$BIAS(z) = 100 \times \frac{\bar{q}(z) - q_{inp}(z)}{q_{inp}(z)}$$

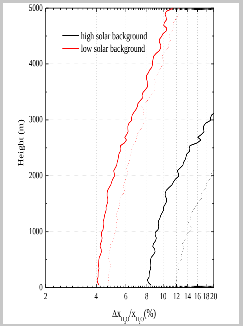
$$RMS(z) = \sqrt{\frac{\sum_{i=1}^{N} [q_i(z) - \bar{q}(z)]^2}{N}}$$

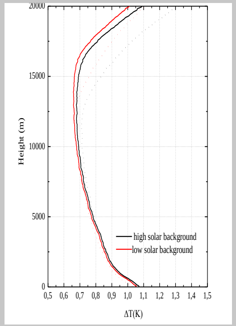


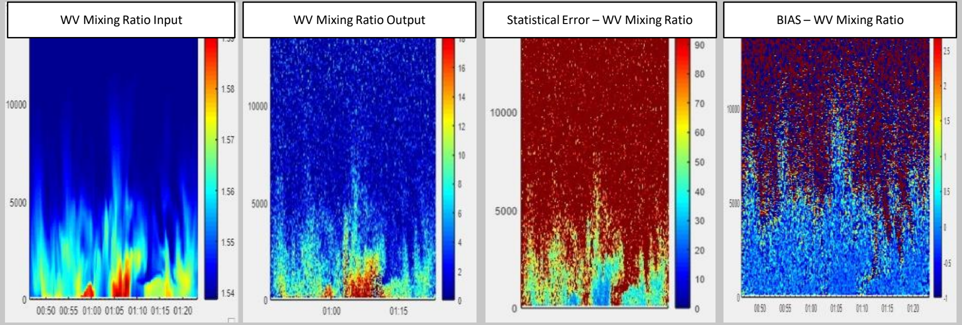
RESULTS

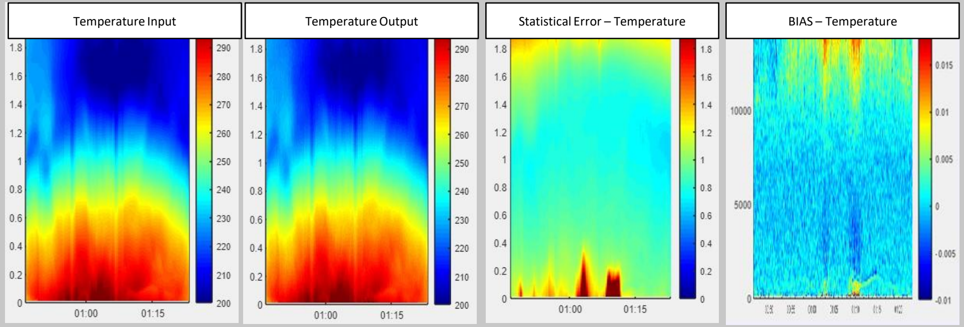
The simulation results show a statistical uncertainty on water vapour mixing ratio of 4-10% up to 5km for low background condition and of 10% up to 2km for high background.

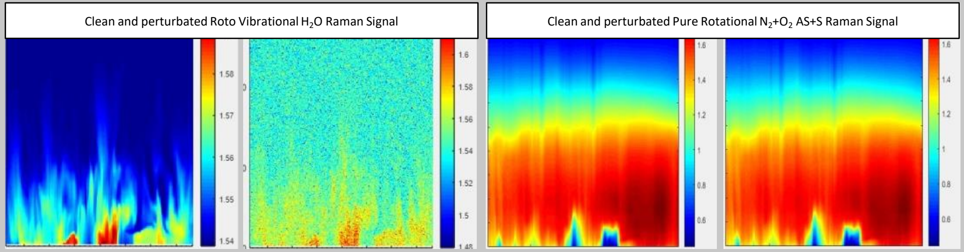
The absolute error on temperature measurements is between 0.65 and 1.1K up to 18km.











References

1 - P.Di Girolamo et al., "Spaceborne profiling of atmospheric temperature and particle extinction with pure rotational Raman lidar and of relative humidity in combination with differential absorption lidar: performance simulations"Appl.Opt. 45, 2474-2494(2006)

2 - P.Di Girolamo et al., "Space-borne profiling of atmospheric thermodynamic variables with Raman lidar: performance simulations”,Opt.Express 26, 8125-8161(2018)