Geophysical Research Abstracts
Vol. 18, EGU2016-16715, 2016
EGU General Assembly 2016

Enhanced signal-to-noise ratio estimation for tropospheric lidar channels

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This works combines the fields of tropospheric lidar remote sensing and signal processing to come up with a robust signal-to-noise ratio (SNR) estimator apt for elastic and Raman channels. The estimator uses a combined low-pass / high-pass filtering scheme along with high-order statistics (kurtosis) to estimate the range-dependent signal and noise components with minimum distortion. While low-pass filtering is used to estimate the range-dependent signal level, high-pass filtering is used to estimate the noise component with minimum distortion. From this noise component estimate (a random realization) the noise level (e.g., variance) is computed as a function of range along with error bars. The minimum-distortion specification determines the optimal cut-off de-noising filter frequency and, in turn, the spatial resolution of the SNR estimation algorithm.

The proposed SNR estimator has a much wider dynamic range of operation than well-known classic SNR estimation techniques, in which the SNR is directly computed from the mean and standard deviation of the measured noise-corrupted lidar signal along successive adjacent range intervals and where the spatial resolution is just a subjective input from the user's side. Aligned with ACTRIS (http://www.actris.net) WP on "optimization of the processing chain and Single-Calculus Chain (SCC)" the proposed topic is of application to assess lidar reception channel performance and confidence on the detected atmospheric morphology (e.g., cloud base and top, and location of aerosol layers).

The SNR algorithm is tested against the classic SNR estimation approach using test-bed synthetic lidar data modelling the UPC multi-spectral lidar. Towards this end, the Nd:YAG UPC elastic-Raman lidar provides aerosol channels in the near-infrared (1064 nm), visible (532 nm), and ultra-violet (355 nm) as well as aerosol Raman and water-vapour channels with fairly varying SNR levels. The SNR estimator is also used to compare SNR levels between "live" data from the UPC lidar (higher SNR) and a ceilometer (lower SNR).

This research has been financed by H2020 ACTRIS-2 European project; ITARS, European Union Seventh Framework Programme (FP7/2007-2013): People, ITN Marie Curie Actions Programme (2012-2016), GA-289923; and Spanish Ministry of Economy and Competitivity project, TEC2015-63832-P.