lasintensity: Correcting for atmospheric intensity attenuation in Lidar images

rapidlasso GmbH — fast tools to catch reality

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1 Introduction

Traveling through the air light is attenuated due to multiple scattering and absorption processes. This attenuation is depended on the distance the light travels through the air. The intensity of the laser detected by the lidar scanner is therefore dependent on the path the laser takes through the air. *lasintensity* aims to remove this path dependency of the light rays from the data.

2 Method

The attenuation of the light intensity in a medium is described by the Lambert-Beer law

$$I(\lambda) = I_0(\lambda)e^{-\int \mu(x,\lambda)dx} \tag{1}$$

where λ is the wavelength and μ the position and wavelength dependent attenuation coefficient. For light traveling through the atmosphere μ is generally expanded into many different terms describing effects like (only naming some)

- absorption and scattering on aerosols τ_a
- absorption by uniformly mixed gasses τ_g
- Raman scattering τ_{RS}
- Rayleigh scattering τ_{rs}
- Water vapor absorption τ_w

With this and neglecting possible position dependent concentration variations Lambert-Beers law reads omitting the wavelength dependency[1]

$$I = I_0 e^{-(\tau_a+\tau_g+\tau_{RS}+\tau_{rs}+\tau_w+...)\Delta x} \tag{2}$$

By solving this equation for I_0 we get the initial intensity without attenuation caused by the light traveling through the air

$$I_0 = Ie^{(\tau_a+\tau_g+\tau_{RS}+\tau_{rs}+\tau_w+...)\Delta x} \tag{3}$$

[1] Often τ is defined differently, but here the explicit dependency on Δx is intended.

3 *lasintensity* Usage

The intensity of the lidar data may be dependent on the light path the laser took to detect a certain point. This path changes not only with the scanners altitude, but also with its scan angle. In order to remove the path dependency *lasintensity* makes use of Eq. (3). It further assumes that the laser is propagating in a straight line and position independent attenuation coefficient. Therefore, it will not yield correct results for high altitude lidar systems, where the laser rays will not propagate on a straight line and attenuation coefficients may change with altitude. For simplicity a low altitude approximation for the attenuation coefficient is used which describes fog and haze in the atmosphere.

lasintensity can be called with different parameters. The most straight forward way would be to specify the laser wavelength, the visibility range and the lidar scanners altitude

- -v : visibility range in $[km]$ (default: $10km$)
- -w : laser wavelength in $[\mu m]$ (default: $0.905\mu m$)
- -scannerHeight : scanner altitude in $[km]$ (**required to specify**)

with the scanner altitude being Δx in Eq. (3). The model computes an effective attenuation coefficient from these values and uses it to compute the required attenuation factor which is needed to correct the intensities in the data.

If it is required, that a user specified attenuation parameter is used you may will have to call *lasintensity* with the following parameters

- -a : attenuation coefficient in $[km^{-1}]$
- -scannerHeight : scanner altitude in $[km]$ (**required to specify**)

The last option is to apply a linear correction factor (even this is not a physical approach) which corrects the intensities as follows

$$I_0 = I/(1 - 2a\Delta x) \tag{4}$$

For this the parameters to set are

- -la : attenuation coefficient in $[km^{-1}]$
- -scannerHeight : scanner altitude in $[km]$ (**required to specify**)

Beware at large scanner altitudes and large attenuation coefficient the intensity in this model becomes negative, which means that this may only be valid for a very limited range of cases.