Extending the Useful Range of Florescence LIDAR Data by Applying the Layered Binning Technique

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Resonance florescence LIDARs are used for measuring temperature and wind speeds in the upper atmosphere, as well as the atmospheric densities of target constituents. Calculations using physical processes such as Doppler broadening or Boltzmann distributions are used to determine the temperatures and wind speed, but these calculations are more sensitive to noise than determining constituent densities directly from photon counts. This sensitivity limits the range over which the temperatures and wind speeds can be calculated to areas with high densities of the target constituents. The layered binning technique is a method for extending that range by increasing the signal to noise ratio of the data.

A standard approach for increasing the signal to noise ratio, and extending the range for temperature and wind measurements, is to increase the bin size used in the calculation by integrating over a larger time range, altitude range, or both. However, by using this approach the extended range comes at the cost of having a lower resolution, which can hide finer features in the data set. Another common method is to use a default value for wind and temperature when they cannot be calculated, this is normally done at points where the data is just reaching the limit of the signal to noise ratio to fill in sporadic missing data points, this method tends to skew the data towards the chosen default values for the temperature and wind speed, which could be somewhat hidden when using a smoothing function on top of it.

The layered binning technique is a solution that enables the high resolution of small bins, the extended data range of larger bins, and without skewing the data towards default values. With this technique data is binned at multiple resolution levels, starting from the highest resolution that is needed for the features that are being investigate, to a largest bin size that still allows both temperature and wind speed to be calculated for all bins. The temperature and wind speed are calculated for the largest bin size first and those results becomes the new localized default for the next level of smaller bin sizes. For each set of smaller bin sizes, any bin for which temperature or wind speed cannot be calculated will use the localized default value of the corresponding larger bin. This is then repeated for each bin size iteration down to the finest detail needed. The result is higher resolution data layered on top of the lower resolution data, where at any point the highest resolution possible is used.

This method has been shown to significantly extend the useful range, allowing for analysis from 75km to 145km with a data set that was previously limited from 75km to 120km. However, a downside to this method is that as the data extends further into the extended range, resolution will start to degrade. Additional modifications of this method are in work, which will attempt to retain higher resolution in these extended areas.