ASEN 6519. Lidar Remote Sensing

HWK Projects #4 and #5 – Na Lidar Data Processing for Temperature and Wind

This project is to give everyone a quantitative idea of how lidar raw data look like, to get familiar with the basic procedure of how to obtain necessary information (e.g., date, UT time, range bin, base altitude, zenith or off-zenith angle, azimuth, etc) from raw data, and to get familiar with the basic procedure of how to convert raw photon counts to meaningful physical parameters (temperature, wind and Na density).

We divide this project into two projects:

1) Project #4 for pre-process procedure to obtain normalized photon counts and
2) Project #5 for main process to obtain temperature, wind and Na density.

The lidar raw data can be accessed from our class website, named "NaLidar_AR1102". The folder includes many datasets obtained by a Na wind and temperature lidar for the whole night on April 11, 2002 at Maui Haleakala Mountain. You are required to process "AR1102.001" (zenith pointing) and "AR1102.009" (30 degree off-zenith pointing to East) profiles. (Note: bin resolution "7" in the data header means 160ns of bin width.) The file "TPNDMauiAR1102.dat" contains the MSIS00 temperature, pressure, and number density data. All data shown here are in ASCII format.

Project #4 contains the following assignments –

(1) Draw a flowchart for your data processing code to show the pre-procedure how you process the data.
Note: you may refer to our lecture notes #13, but I do want you to write a flowchart for your own code, because this will help you to keep a clear mind in writing such a complicated code.

(2) Read in the lidar raw data and plot raw-data profiles for three frequencies versus bin number and altitude for both .001 and .009 profiles.
Note: pay attention to how to convert bin number to range (range means the actual distance from lidar to the scatterer) and then to altitude (altitude means the height above mean sea level).

(3) Do PMT/discriminator saturation correction and plot the peak-frequency data profiles after this correction. Sample MatLab code will be provided at website.

(4) Do chopper correction and plot the peak-frequency data profiles after this correction. Note: chopper profiles are in the same folder as the data.

(5) Subtract background and plot the peak-frequency data profiles after this step.

(6) Remove range dependence and plot the peak-freq data profiles after this step.

(7) Add base altitude and then take Rayleigh signal @ 40 km as the Rayleigh normalization signal. Plot the Rayleigh fitting and the Rayleigh signal for the peak-frequency data profiles.

(8) Normalize the entire profile by the Rayleigh normalization signal and plot the normalized profiles for all three frequencies.

Project #5 contains the following assignments –

(1) Draw a flowchart for your data processing code to show the whole procedure how you process the data. This is to add the main procedure to your pre-procedure flowchart.

(2) From the normalized photon count profiles at all three frequencies to derive the temperature and wind ratios R_T and R_W, and then infer temperature and wind from these ratios for each altitude (either by look-up table method or iteration method). Then derive Na density for each altitude.

(3) Use the following metrics to calculate the ratios

$$R_T = \frac{\sigma_{eff}(f_+) + \sigma_{eff}(f_-)}{\sigma_{eff}(f_a)}, \quad R_W = \frac{\ln\left[\sigma_{eff}(f_-)/\sigma_{eff}(f_+)\right]}{\ln\left[\sigma_{eff}(f_-) \times \sigma_{eff}(f_+)/\sigma_{eff}^2(f_a)\right]}$$

(4) Three laser frequencies are f_a = -651.4 MHz, f_+ = -21.4 MHz, and f_- = -1281.4 MHz (relative to the line center), laser linewidth (rms) is 60 MHz, and PDA frequency offset is 10.27 MHz for this night April 11, 2002.

(5) Please show the following plots as your products of the code:
1). Ratio R_T versus altitude for .001 and .009 profiles
2). Ratio R_W versus altitude for .001 and .009 profiles
3). Derived temperature T versus altitude for .001 and .009 profiles
4). Derived radial wind V_R versus altitude for .001 and .009 profiles when PDA frequency offset is 0 MHz.
5). Derived radial wind V_R versus altitude for .001 and .009 profiles when PDA frequency offset is set to 10.27 MHz.
6). Derived zonal wind u versus altitude for .009 profiles when PDA frequency offset is set to 10.27 MHz.
7). Derive Na density versus altitude for .001 and .009 profiles when PDA frequency offset is set to 10.27 MHz.

(6) This is extra task if you are capable of this – process the whole datasets for April 11, 2002 (basically using loop and try to distinguish different pointing directions) and then plot a contour of temperature versus UT time and altitude.

You are required to show your MatLab or equivalent code with your data processing results.